# Noise Barrier Acceptance Criteria: Analysis

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U.S. Department of Transportation
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## Foreword

The purpose of this report is to examine the feasibility and reasonableness factors in the Federal Highway Administration (FHWA) noise regulation in 23 Code of Federal Regulations (CFR) Part 772 as implemented in the individual state highway agency (SHA) noise policies individually and in combination with each other to identify optimized combinations of values. The report specifically addresses the requirements of Tasks 3.1 through 3.5 of the FHWA Task Order No. DTFH61-D-00028-T12-002, *23 CFR 772 Streamlining, Analysis, and Outreach* and Task 3 of the FHWA Task Order No. DTFH61-D-00028-0005, *23 CFR 772 Streamlining, Analysis, and Outreach, Phase II.*

### CONTENT SUMMARY

This report is comprised of the following four chapters:

- Chapter 1 contains the introduction.
- Chapter 2 analyzes the feasibility and reasonableness factors for all but the consideration of viewpoints criterion, both singularly and in combination, focusing on the values contained in various SHA noise policies in use throughout the country.
- Chapter 3 examines feasibility, benefited noise reduction, cost reasonableness, and Noise Reduction Design Goals (NRDGs), individually and in combination with each other to identify optimized combinations of values. Included are both a sensitivity analysis and a testing of the findings regarding four actual highway project study areas previously evaluated for noise abatement.
- Chapter 4 inventories and examines the consideration of viewpoints criterion in the SHA policies. It reviews and compares policies for all SHAs and includes details on six SHA policies based on telephone interviews with their noise program leaders.
- Chapter 5 contains conclusions and recommendations.

### INTERESTED AUDIENCE

The initial report, completed in September 2013, did not contain the information on the Viewpoints reasonableness criterion. That report was prepared for and reviewed by FHWA and the project's Technical Working Group (TWG), first as a draft report and then as an interim report. It addressed comments received from FHWA and the TWG during the review process. This updated version of the report includes the information on the Viewpoints reasonableness criterion. The intended audience includes analysts and policy-makers within FHWA and SHAs who specialize in highway traffic noise and National Environmental Policy Act (NEPA) implementation policies, processes and procedures.

### PREVIOUS PRINTINGS

This is the second printing of this report, and includes a new Chapter 4.

## PUBLICATION STATUS

The initial report was the first of two *Final Task 3 Deliverable Documents under* Task Order No. DTFH61-D-00028-T12-002. This revised report is one of two *Final Task 3 Deliverable Documents* under Task Order No. DTFH61-D-00028-0005.

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16. Abstract:
This report examines the feasibility and reasonableness factors in the FHWA noise regulation (23 CFR 772) as implemented in the individual state highway agency noise policies. The first part of the report studies these factors:

- Feasibility: noise reduction and quantity of impacted receptors achieving that reduction
- Reasonableness: benefited noise reduction; noise reduction design goal and quantity of benefited receptors achieving that goal; cost effectiveness (allowable cost or barrier area per benefited receptor)

The analysis examines how changes in the permissible ranges for each factor – while the others factors remain static – affect noise abatement decisions. Also examined is how changes to multiple factors in combination affect decisions. The range in potential decisions based on the combinations permitted under the regulation is examined to provide an aid for future policy guidance and planning. A sensitivity analysis on the factors identifies outcomes of possible combinations of factors. Actual highway projects are also used to identify the effects on the likelihood of abatement. The last part of this report analyzes how state highway agencies address the consideration of viewpoints reasonableness criterion in 23 CFR 772. Reported under separate cover is the development of tools to evaluate the effects of policy changes on abatement feasibility and reasonableness.


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## LIST OF ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| % 1R, %1 | - | Percentage of first-row (impacted or benefited) receptors (see P1) |
| % ALL, %A | - | Percentage of all (impacted or benefited) receptors (see PA) |
| % | - | Percentage |
| # | - | Number (integer) |
| # 1R | - | Number of first-row |
| # All | - | Number of all (impacted or benefited) receptors |
| $ | - | Cost (in dollars) |
| 1R | - | First-row |
| ADOT | - | Arizona Department of Transportation |
| AHTD | - | Arkansas Highway and Transportation Department |
| APBR | - | Area per benefited receptor |
| APBR calc | - | Calculated APBR |
| Ben, BR | - | Benefited receptor |
| Caltrans | - | California Department of Transportation |
| CE | - | Cost effectiveness |
| CFR | - | Code of Federal Regulations |
| CPBR | - | Cost per benefited receptor |
| Crit | - | Criterion |
| dB | - | Decibel |
| dB(A), dBA | - | Decibel unit for A-weighted sound level |
| DelDOT | - | Delaware Department of Transportation |
| DHV | - | Design hour volume |
| DOT | - | Department of Transportation |
| DOTD | - | Louisiana Department of Transportation and Development |

| | | |
|---|---|---|
| FAQ | - | Frequently Asked Questions |
| FDOT | - | Florida Department of Transportation |
| Feas | - | Feasibility |
| FHWA | - | Federal Highway Administration |
| FHWA TNM | - | FHWA Traffic Noise Model Version 2.5 |
| IDOT | - | Illinois Department of Transportation |
| $L_{eq}$, $L_{eq}(h)$ | - | Equivalent sound level in dB(A), one-hour $L_{eq}$ |
| MassDOT | - | Massachusetts Department of Transportation |
| MaxSF/BR | - | Maximum amount (square footage) per benefited receptor |
| MDSHA | - | Maryland State Highway Administration |
| MDOT | - | Michigan Department of Transportation |
| Mn/DOT | - | Minnesota Department of Transportation |
| NAC | - | Noise Abatement Criteria |
| NCDOT | - | North Carolina Department of Transportation |
| NDOR | - | Nebraska Department of Roads |
| NEPA | - | National Environmental Policy Act |
| NR | - | Noise reduction |
| NRDG | - | Noise reduction design goal |
| NYSDOT | - | New York State Department of Transportation |
| PennDOT | - | Pennsylvania Department of Transportation |
| P1 | - | Percentage of first-row (impacted or benefited) receptors (see % 1R) |
| PA | - | Percentage of all (impacted or benefited) receptors (see % ALL) |
| Reas | - | Reasonable by… |
| RFP | - | Request for Proposal |

| | | |
|---|---|---|
| SHA | - | State highway agency |
| SF | - | Square foot (feet) |
| TDOT | - | Tennessee Department of Transportation |
| TEPM | - | *Tennessee Environmental Procedures Manual* |
| TNM | - | FHWA Traffic Noise Model Version 2.5 |
| TxDOT | - | Texas Department of Transportation |
| TWG | - | Technical Working Group |
| VDOT | - | Virginia Department of Transportation |
| WSDOT | - | Washington State Department of Transportation |

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# CHAPTER 1. INTRODUCTION

This report examines the noise abatement feasibility and reasonableness factors in the Federal Highway Administration (FHWA) noise regulation in 23 Code of Federal Regulations (CFR) Part 772 (the "regulation') as implemented in individual state highway agency (SHA) noise policies.

Feasibility and reasonableness are determined based on the effect the abatement measure has on adjacent noise "receptors." A receptor is an activity area on a parcel of property being studied for noise impacts from a nearby highway project. Receptors can be residential or non-residential land uses.

The way that non-residential receptors are treated in a project noise study – how their intensity of use and placement on the property are determined – can have a significant effect on the feasibility and reasonableness of a noise abatement measure. Task 2 of this research, reported separately, examined receptors on non-residential land uses and addressed alternative methods to quantify the number of receptors at these locations. The focus of Task 3 is on residential receptors only.

The feasibility and reasonableness factors that have been studied include:

- Feasibility
  - ***Feasibility Noise Reduction:*** A noise reduction of at least 5 decibels (dB) that must be achieved for a noise abatement measure to be feasible.
  - ***Feasibility Quantity:*** The minimum number or percentage of impacted receptors that must achieve the feasibility noise reduction.
- Reasonableness
  - ***Benefited Noise Reduction:*** The minimum noise reduction for a receptor to be counted as benefited by a noise abatement measure.
  - ***Noise Reduction Design Goal (NRDG):*** The noise reduction that must be achieved for a noise abatement measure to be reasonable.
  - ***NRDG Quantity:*** The minimum number or percentage of benefited receptors that must achieve the NRDG.
  - ***Cost Effectiveness (CE):*** The allowable cost per benefited receptor (CPBR) or the allowable barrier area per benefitted receptor (APBR). Abatement measure unit cost is a determining factor for CPBR.
  - ***Viewpoints of benefited residents and property owners:*** How the viewpoints are obtained, weighed and used by a SHA in making an abatement decision.

The analysis examines how changes in the permissible ranges for all of the factors affect noise abatement decisions while the other factors remain static. The analysis also examines how changes to multiple factors in combination affect decisions. The goal was to identify

combinations of factors that are likely to result in inclusion of noise abatement or exclusion of noise abatement

The first subtask was to examine each factor individually and in combination with each other to identify optimized combinations of values. The first objective of this subtask was to identify the range in potential decisions based on the combinations permitted under the regulation. A second objective of this subtask was to aid in future guidance and planning.

The second subtask was to apply the results of the first subtask. This work included performing a sensitivity analysis on the feasibility and reasonableness factors to identify outcomes of possible combinations of factors. It also included applying the combinations to actual highway projects to identify the effects of changes in these factors individually and in combination with the likelihood of abatement.

The viewpoints criteria are not included in the above analysis because the viewpoints of benefited owners and residents are not solicited until after a noise barrier analysis has shown that a barrier is feasible and reasonable through application of the feasibility criterion and the NRDG and CE reasonableness criteria.

The viewpoints criteria and the current voting processes for obtaining those viewpoints were separately examined in the second phase of this research. Included are an inventory, compilation, and analysis of the viewpoints criteria through a review of all of the SHA policies. Additionally, representatives from six SHAs with whom the researchers had worked or were familiar with their programs were contacted to learn firsthand of their experiences. Of interest were the perceived positive and negative features, experiences in implementing and applying the process, and any revisions or plans to improve their policies within the current framework of 23 CFR 772. Finally a study of the effects on decisions of changes in the voting patterns and viewpoints factors is presented for a real-world case.

The study results include all digital files developed for this analysis, including noise prediction model runs and spreadsheets, which have been delivered to FHWA.

Another part of this research was the development of two tools to evaluate the effects of policy changes on the feasibility and reasonableness of noise abatement. That work is included in a separate report. These two tools allow users to evaluate various combinations of factors to determine the effects of policy changes on the feasibility and reasonableness of abatement. One of the tools also includes the capability for testing variations in the factors comprising the viewpoints criterion.

# CHAPTER 2. EXAMINATION OF FEASIBILITY AND REASONABLENESS FACTORS, EXCLUDING THE VIEWPOINTS CRITERION

## 2.1 FACTORS AND FACTOR COMBINATIONS AFFECTING NOISE ABATEMENT DECISIONS

The first objective of this study is to identify the potential range in noise abatement decisions that could result from using the various combinations of factors permitted under the regulation. The study included a review of the feasibility and reasonableness values used by all fifty states, the District of Columbia, and Puerto Rico to identify current ranges in the factors.

The starting point was a compilation of the SHA factors in spreadsheet format provided by FHWA. The spreadsheet did not include the unit costs used for barrier cost calculations. Therefore, the SHA policies were reviewed to obtain unit cost data and update and otherwise expand upon the spreadsheet.

The following sections describe the ranges in values for the feasibility and reasonableness factors identified in Chapter 1. The sections include numerous summary tables. A yellow highlighted value in a table indicates that the factor or combination of factors appears in one or more of the SHA policies, with the value being the number of policies using that factor or combination of factors.

The data used in developing the summary tables are contained in spreadsheets with individual worksheets where the data are sorted by one or more of the factors. The individual worksheets show data in alphabetical order by state sorted by:

- Feasibility Noise Reduction and Feasibility Quantity
- Noise Reduction Design Goal (NRDG) and Feasibility Quantity
- NRDG and NRDG Quantity
- NRDG and Benefited Noise Reduction
- Benefited Noise Reduction and Feasibility Quantity
- Cost per Benefited Receptor (CPBR)
- CPBR and Benefited Noise Reduction
- CPBR and NRDG
- Area per Benefited Receptor (APBR)

### 2.1.1 Feasibility Noise Reduction

For a noise abatement measure to be feasible, the regulation requires that the specified feasibility noise reduction criterion be met at a minimum of either 1) a number of impacted receptors[1] or 2) a percentage of impacted receptors (to be called "feasibility quantity" in this report).

A receptor is identified as impacted per the regulation when its future design-year worst-hour equivalent sound level ($L_{eq}(h)$):

- Approaches or exceeds the Noise Abatement Criteria (NAC) for a particular land use, or
- Substantially exceeds the existing worst-hour sound level.

As of March 2013, all of the SHAs use 5 dB for the feasibility noise reduction criterion. The Request for Proposal (RFP) for this research stated that "feasibility is static," based on the use of the 5 dB minimum noise reduction. However, the number or percentage of impacted receptors that must meet the 5 dB is not static as described the following section.

### 2.1.2 Feasibility Quantity

Table 1 shows the combinations of feasibility quantities and noise reductions used by SHAs. As shown, there is a substantial range in the values for feasibility quantity from only one impacted receptor to 80% of all impacted receptors. Thirteen of the SHAs specify a minimum number of impacted receptors, ranging from 1 to 3.

Nearly three-quarters of the SHAs specify a minimum percentage of impacted receptors. This minimum percentage has been defined in two ways:

- Percentage of *all* impacted receptors (21 SHAs).
- Percentage of *first-row* (also called front-row in some policies) impacted receptors (16 SHAs).

The percentage values of *all* impacted receptors range from 40% to 80% while the percentage values of *first-row* impacted receptors range from 50% to 80%. The latter range includes one SHA that specifies 80% of *first-row* impacted and 67% of *all* impacted (Kansas DOT).

[1] In the ensuing discussions, the term "impacts" is sometimes used as a shorter form of the term "impacted receptors." Likewise, the term "benefits" is sometimes used to mean "benefited receptors."

**Table 1. Combinations of Feasibility Quantity and Feasibility Noise Reduction.[2]**

| Feasibility Quantity (Number or Percent of Impacted Receptors) | Number of SHAs by Feasibility Reduction |
|---|---|
| | 5 dB |
| 1 | 13 |
| 2 | 1 |
| 3 | 1 |
| 40% | 1 |
| 50% of first-row impacted | 3 |
| 50% | 5 |
| >50% of first-row impacted | 3 |
| >50% | 10 |
| 60% of first-row impacted | 2 |
| 67% of first-row impacted | 2 |
| 67% | 1 |
| 70% | 1 |
| 75% of first-row impacted | 4 |
| 75% | 2 |
| 80% of first-row impacted | 1 |
| 80% of first-row and 67% of all impacted | 1 |
| 80% | 1 |

### 2.1.3 Benefited Noise Reduction

The regulation requires that the SHA define the noise reduction required for a receptor to be considered benefited, and stipulates that the value cannot be less than 5 dB and no more than the NRDG. Table 2 summarizes the benefited noise reductions used by SHAs.

As shown, benefited noise reduction values range from 5 dB to 9 dB with forty-four SHAs using 5 dB. None use a benefited noise reduction of 6 or 10 dB, which the regulation does allow.

It is important to note that a receptor does not have to be impacted to be counted as "benefited;" although, one SHA (Delaware DOT (DelDOT)) bases its criterion on those "benefited that are also impacted." Although noise abatement measures are designed to provide the desired noise reduction for impacted receptors, the abatement measure often provides noise reduction for other non-impacted receptors located farther back from the road (i.e. second-row). These receptors would be counted as "benefited" in the reasonableness analysis if their reductions are at or above the minimum benefited noise reduction in the SHA policy. Two SHAs (DelDOT and New Jersey

[2] Yellow shading will be used in all similar tables to highlight that the value or combination of values occurs in one or more SHA policies, with the number of policies also indicated.

DOT) give less weight (25% and 50%, respectively) to receptors that are benefited but not impacted.

**Table 2. Benefited Noise Reduction Values.**

| Benefited Noise Reduction | Number of SHAs by Benefited Noise Reduction |
|---|---|
| 5 dB | 44 |
| 6 dB | -- |
| 7 dB | 4 |
| 8 dB | 3 |
| 9 dB | 1 |
| 10 dB | -- |

### 2.1.4 Noise Reduction Design Goal (NRDG)

Noise Reduction Design Goal (NRDG) is one of three factors that must be met for a noise abatement measure to be reasonable. The regulation permits NRDGs to be between 7 and 10 dB. As shown in Table 3, all SHAs have NRDG values within that range. Nearly three-quarters of the SHAs use 7 dB, and approximately one-quarter use 8, 9 or 10 dB. One SHA (Michigan DOT (MDOT)) specifies 10 dB at one benefited receptor *and* 7 dB at 50% of all benefited receptors. Of those using 7 dB, six specify the value as a "minimum" goal, with a stated desirable value of 10 dB in five cases (Maine DOT, Maryland State Highway Administration (MDSHA), New Hampshire DOT, New York State DOT (NYSDOT) and Washington State DOT (WSDOT)) and greater than 7 dB in one case (Pennsylvania DOT (PennDOT)).

**Table 3. Noise Reduction Design Goal (NRDG).**

| NRDG | Number of SHAs by NRDG |
|---|---|
| 7 dB | 38 * |
| 8 dB | 4 |
| 9 dB | 3 |
| 10 dB | 7 ** |

*Six SHAs specify the value as a "minimum" goal, with a stated desirable value of 10 dB in five cases and greater than 7 dB in one case.
**MDOT uses 10 dB at one benefited receptor and 7 dB at 50% of all benefited receptors.

### 2.1.5 Noise Reduction Design Goal (NRDG) Quantity

The regulation requires that the SHAs specify either a number or percentage of *benefited* receptors that must meet the NRDG criterion. Two SHAs (DelDOT and Virginia DOT (VDOT)) base the quantity on *impacted* receptors instead of benefited receptors. Table 4 shows the combinations of NRDG and NRDG Quantity used by the SHAs. As shown, just under half of the SHAs use a numerical quantity. Nineteen specify one benefited receptor and four specify one *first-row* benefited receptor, while one uses a mixed quantity - meeting a 10 dB NRDG at one benefited receptor *and* a 7 dB reduction at 50% of all of benefited receptors.

**Table 4. Combinations of NRDG and NRDG Quantity.**

| NRDG Quantity (Number or Percent of Benefited Receptors) | Number of SHAs by NRDG | | | |
|---|---|---|---|---|
| | 7 dB | 8 dB | 9 dB | 10 dB |
| 1 | 14 [1] | 2 [2] | 2 [3] | 1 |
| 1 first-row | 3 [4] | -- | -- | 1 |
| 1 at 10 dB and 50% of all at 7 dB | -- | -- | -- | 1 [5] |
| 10% | 2 | -- | -- | -- |
| 10% of first-row benefited | 1 | -- | -- | -- |
| 25% | 1 | -- | 1 [6] | -- |
| 40% of first-row benefited | 1 | -- | -- | -- |
| 40% | 2 | -- | -- | -- |
| 50% of first-row benefited | 3 | -- | -- | -- |
| 50% | 4 [5] | -- | -- | 1 |
| >50% of first-row benefited | 1 | -- | -- | -- |
| >50% | 3 | -- | -- | 1 |
| 60% of first-row benefited | 2 | -- | -- | -- |
| 65% | -- | -- | -- | 1 |
| 67% of first-row benefited | 1 | -- | -- | -- |
| 67% | 1 | -- | -- | -- |
| 75% of first-row benefited | 2 | 1 | -- | -- |
| 80% of first-row benefited | -- | -- | -- | 1 |
| 80% | -- | 1 | -- | -- |

[1] VDOT's policy says one *impacted* receptor.
[2] Illinois DOT's policy says one and as many others while staying within CE criterion.
[3] The Arkansas Highway and Transportation Department (AHTD) policy says 9 dB at "at least 1 benefited receptor that is impacted."
[4] Idaho DOT's policy says at the one receptor that is closest to the road centerline.
[5] MDOT's policy says 10 dB at one benefited receptor and 7 dB at 50% of all benefited receptors.
[6] DelDOT's policy says 25% of *impacted* receptors.

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There is a wide range in percentage quantities used by the SHAs for the NRDG, just as with feasibility quantities: from a low of only 10% of the *first-row* benefited receptors to a high of 80% of *all* benefited receptors. Combining both the numerical and percentage quantities, the range is even larger: from a single benefitted receptor to 80% of all benefited receptors.

As noted in the previous section, almost all of the policies use 7 or 10 dB for the NRDG, with a few using 8 or 9 dB. By far the most common – and most easily achieved – combination is a 7 dB NRDG at one benefited receptor (14 SHAs). The most difficult combinations to achieve are an 8 dB NRDG at 80% of *all* benefited receptors, a 10 dB NRDG at 65% of *all* benefited receptors, and a 10 dB NRDG at 80% of the *first-row* benefited receptors.

As will be seen, there are issues with the use of *all* benefited receptors instead of only *first-row* benefited receptors in the NRDG calculation. Also, as will be seen, there are issues in the reasonableness analysis with the use of benefited receptors of any type instead of impacted receptors.

### 2.1.6 Cost Effectiveness (CE)

There is a wide range in percentage quantities used by the SHAs for the NRDG, just as with feasibility quantities: from a low of only 10% of the *first-row* benefited receptors to a high of 80% of *all* benefited receptors. Combining both the numerical and percentage quantities, the range is even larger: from a single benefitted receptor to 80% of all benefited receptors.

As noted in the previous section, almost all of the policies use 7 or 10 dB for the NRDG, with a few using 8 or 9 dB. By far the most common – and most easily achieved – combination is a 7 dB NRDG at one benefited receptor (14 SHAs). The most difficult combinations to achieve are an 8 dB NRDG at 80% of *all* benefited receptors, a 10 dB NRDG at 65% of *all* benefited receptors, and a 10 dB NRDG at 80% of the *first-row* benefited receptors.

As will be seen, there are issues with the use of *all* benefited receptors instead of only *first-row* benefited receptors in the NRDG calculation. Also, as will be seen, there are issues in the reasonableness analysis with the use of benefited receptors of any type instead of impacted receptors.

Cost Effectiveness (CE) is the second of three factors that must be met for a noise abatement measure to be reasonable. This criterion can expressed in terms of cost per benefited receptor (CPBR) or area per benefited receptor (APBR).

CPBR represents the allowable number of dollars per benefited receptor and is calculated by dividing the cost of the noise abatement measure by the number of benefited receptors. APBR represents the allowable barrier area per benefited receptor and is calculated by dividing the area of the noise abatement measure by the number of benefited receptors.

Table 5 shows the CE criteria in SHA policies. It is stated in 23 CFR 772.13(d)(2) that the "highway agency shall re-analyze the allowable cost for abatement on a regular interval, not to exceed 5 years."

**Table 5. Cost Effectiveness (CE) Criteria.**

| **CPBR and APBR Used by SHAs** |
|---|
| **CPBR: Cost in Dollars per Benefited Receptor** |
| $20,000 |
| $21,000 |
| $23,000 |
| $24,000 base, $37,000 maximum |
| $24,250 base, $48,250 maximum |
| $25,000 |
| $25,000 (residences post-date highway) / $30,000 (residences pre-date) |
| $30,000 |
| $30,000/$37,500 (51% prior) |
| $30,000/$40,000 (severe impacts) |
| $31,000 |
| $32,000 |
| $35,000 |
| $36,000 |
| $36,127 base / $71,222 maximum (or 780 – 1380 SF) |
| $40,000 |
| $42,509 |
| $42,244 |
| $43,500 |
| $45,000 or 1,500 SF |
| $49,000 |
| $50,000/$55,000 (severe impacts) |
| $55,000 |
| $60,000 |
| **Dollars per Benefited Receptor (BR) per dB of Noise Reduction** |
| $4,900 / (Average NR x BR) |
| $6,800 / BR / dB Reduction |
| $8,400 / dB Insertion Loss / BR |
| **APBR: Barrier Surface Area (SF) per Benefited Receptor** |
| Sliding scale from 250 to 950 SF for residences post-dating original highway and SHA policy revision date, and from 1,500 to 2,400 SF for residences pre-dating original highway |
| 1,400 SF (uses $42,000 based on current unit cost) |
| 1,600 SF |

Continued on next page

**Table 5. Cost Effectiveness (CE) Criteria.**

| CPBR and APBR Used by SHAs |
|---|
| 2,000 SF |
| 2,000 SF for wall / $80,000 for earth berm or building insulation |
| 2,500 SF + 35 SF/dB(A) increase |
| 2,700 SF * |

* MDSHA also uses 3,700 SF for Common Noise Environment average when trying to qualify areas that fall outside of the 2,700 criterion.

The range in CPBR is $20,000 to $71,222. One SHA (NYSDOT) uses 2,000 SF/Benefited Receptor for walls and $80,000/Benefited Receptor for berms and insulation.

Some SHAs use a sliding scale in determining the allowable CPBR for each noise study area along a highway project. Factors that affect or adjust the allowable CPBR include:

- Future noise level with the project.
- Amount of noise level increase over existing levels.
- Whether the community pre-dates or post-dates the original highway construction.
- Whether the local government has some type of noise-compatible planning or development program in place.

As shown in Table 5, the resulting ranges in allowable CPBR for SHAs using a sliding scale are:

- $24,000 base with a maximum of $37,000.
- $24,250 base with a maximum of $48,500.
- $25,000 for residences post-dating the highway and $30,000 for residences pre-dating the highway.
- $36,127 base with a maximum of $71,222 (WSDOT allows use of either CPBR or APBR, with a scale based on the Build condition noise levels or the increase over existing noise levels when the increase is greater than 10 dB).

Some SHAs also choose to factor in the amount of noise reduction that receptors receive. The resulting CE is typically expressed in terms of CPBR per dB of noise reduction, or CPBR times the amount of noise reduction in dB received by those receptors. In the calculation, as the noise reduction increases, the calculated CE would decrease and the more likely that the calculated value will fall below the criterion, making the abatement measure reasonable by this criterion. The term “insertion loss” is also used to describe the noise reduction provided by the abatement measure.

The resulting CBR values using this approach include:

- $4,900 / (Average NR x benefited receptors) (Montana DOT)
- $6,800 / benefited receptor / dB Reduction (Colorado DOT)
- $8,400 / dB Insertion Loss / benefited receptor (Massachusetts DOT)

Comparing these values to the straight CPBR is difficult because the same barrier design (same cost) could result in different noise reductions depending on the receptor locations behind the barrier, and in different numbers of benefited receptors.

By far, the most common abatement measure is the noise barrier wall. One major difficulty in comparing different CPBR values is the fact that the cost of the barrier is dependent on the *unit* cost used by the SHA. The unit cost, in terms of dollars per square foot (SF), is multiplied by the barrier area to arrive at the total barrier cost. Dealing with changing unit costs can be a challenge for SHAs that are trying to make consistent decisions using their CPBR values.

As indicated in Table 5, a number of SHAs have opted to use APBR instead of CPBR, which eliminates the issues associated with estimating noise abatement costs. Five SHAs use straight APBR values ranging from 1,400 SF/ benefited receptor[3] to 2,700 SF/ benefited receptor.

Two SHAs use a sliding scale for APBR based on similar factors used for the sliding scale CPBRs, in addition to WSDOT, which allows use of either APBR or CPBR:

- Sliding scale from 250 to 950 SF/ benefited receptor for residences post-dating the original highway and SHA policy revision date, and from 1,500 to 2,400 SF/ benefited receptor for residences post-dating the original highway (Tennessee DOT (TDOT)).
- 2,500 SF/ benefited receptor + 35 SF/dB(A) increase over existing level (North Carolina DOT (NCDOT)).

### 2.1.7 Noise Reduction Design Goal (NRDG) and Feasibility Quantity

Table 6 shows the combinations of NRDG and feasibility quantity used by SHAs. For the 38 SHAs that use a 7 NRDG, the range in feasibility quantity is from one impacted receptor to 67% of all impacted receptors and 75% of first-row impacts – a very wide range. Likewise, the range is large for those SHAs using an 8 dB NRDG – from one impacted receptor to 75% of all impacted receptors. The three SHAs that use a 9 dB NRDG use either one or three impacted receptors as the feasibility quantity.

Finally, the range for SHAs using a 10 dB NRDG is from 50% to 80% of impacted receptors. Two of these SHAs use a 10 dB NRDG at 80% of first-row impacted receptors. The SHA that requires 10 dB at one first-row benefited receptor and 7 dB at 50% of all benefited receptors has a feasibility quantity of 75% of all impacted receptors.

[3] Florida DOT uses 1,400 SF as a basis and multiplies this value by its current unit cost of $30/SF to get a CPBR of $42,000 for use in reasonableness evaluations.

**Table 6. Combinations of Noise Reduction Design Goal (NRDG) and Feasibility Quantity.**

| Feasibility Quantity (Number or Percent of Impacted Receptors) | Number of SHAs by NRDG | | | |
|---|---|---|---|---|
| | 7 dB | 8 dB | 9 dB | 10 dB |
| 1 | 10 | 1 | 2 | -- |
| 2 | 1 | -- | -- | -- |
| 3 | -- | -- | 1 | -- |
| 40% | 1 | -- | -- | -- |
| 50% of first-row impacted | 3 | -- | -- | -- |
| 50% | 5 | -- | -- | -- |
| >50% of first-row impacted | 3 | -- | -- | -- |
| >50% | 8 | -- | -- | 2 |
| 60% of first-row impacted | 2 | -- | -- | -- |
| 67% of first-row impacted | 2 | -- | -- | -- |
| 67% | 1 | -- | -- | -- |
| 70% | -- | -- | -- | 1 |
| 75% of first-row impacted | 2 | 2 | -- | -- |
| 75% | -- | 1 | -- | 1 * |
| 80% of first-row impacted | -- | -- | -- | 1 |
| 80% of first-row and 67% of all impacted | -- | -- | -- | 1 |
| 80% | -- | -- | -- | 1 |

* MDOT policy says 10 dB at one benefited receptor and 7 dB at 50% of all benefited receptors.

### 2.1.8 Benefited Noise Reduction and Feasibility Quantity

Table 7 shows the combinations of benefited noise reductions and feasibility quantities used by the SHAs. For the 45 SHAs that specify a benefited noise reduction of 5 dB, the feasibility quantities range from one impacted receptor to 75% of all impacted receptors (with one SHA using 80% of first-row impacts and 67% of all impacts). This range is very wide.

For the three SHAs that specify a benefited noise reduction of 7 dB, the feasibility quantities are 50% of all impacts, 67% of first-row impacts, and 80% of all impacts.

For the three SHAs with a benefited noise reduction of 8 dB, the feasibility quantities range from one impacted receptor to 80% of first-row impacted receptors, a very wide range.

The SHA that uses a 9 dB benefited noise reduction uses a feasibility quantity of three impacts.

**Table 7. Combinations of Benefited Noise Reduction and Feasibility Quantity.**

| Feasibility Quantity (Number or Percent of Impacted Receptors) | Number of SHAs by Benefited Noise Reduction | | | | | |
|---|---|---|---|---|---|---|
| | 5 dB | 6 dB | 7 dB | 8 dB | 9 dB | 10 dB |
| 1 | 12 | -- | -- | 1 | -- | -- |
| 2 | 1 | -- | -- | -- | -- | -- |
| 3 | -- | -- | -- | -- | 1 | -- |
| 40% | 1 | -- | -- | -- | -- | -- |
| 50% of first-row impacted | 3 | -- | -- | -- | -- | -- |
| 50% | 4 | -- | 1 | -- | -- | -- |
| >50% of first-row impacted | 3 | -- | -- | -- | -- | -- |
| >50% | 10 | -- | -- | -- | -- | -- |
| 60% of first-row impacted | 2 | -- | -- | -- | -- | -- |
| 67% of first-row impacted | 1 | -- | 1 | -- | -- | -- |
| 67% | 1 | -- | -- | -- | -- | -- |
| 70% | 1 | -- | -- | -- | -- | -- |
| 75% of first-row impacted | 3 | -- | -- | 1 | -- | -- |
| 75% | 2 | -- | -- | -- | -- | -- |
| 80% of first-row impacted | -- | -- | -- | 1 | -- | -- |
| 80% of first-row and 67% of all impacted | 0 | -- | 1 | -- | -- | -- |
| 80% | -- | -- | 1 | -- | -- | -- |

As shown, the most frequent combinations include a 5 dB reduction at one impacted receptor (fourteen SHAs) and a 5 dB reduction at 50% of all impacted receptors (nine SHAs)

### 2.1.9 Noise Reduction Design Goal (NRDG) and Benefited Noise Reduction

Recall that the minimum noise reduction for a receptor to be considered benefited may be as low as 5 dB and may not be higher than the SHA's NRDG.

Table 8 shows the combinations of NRDG and benefited noise reduction used by the SHAs. An "A" means a combination allowed in the regulation that is not used by any SHA. Nearly three-quarters specify an NRDG of 7 dB combined with a benefited noise reduction of 5 dB. In contrast, one SHA uses 9 dB as both NRDG and benefited noise reduction.

**Table 8. Combinations of Noise Reduction Design Goal (NRDG) and Benefited Noise Reduction.**

| NRDG | Number of SHAs Using Benefited Noise Reduction | | | | | |
|---|---|---|---|---|---|---|
| | 5 dB | 6 dB | 7 dB | 8 dB | 9 dB | 10 dB |
| 7 dB | 36 | A* | 2 | -- | -- | -- |
| 8 dB | 3 | A | A | 1 | -- | -- |
| 9 dB | 1 | A | A | 1 | 1 | -- |
| 10 dB ** | 4 | A | 2 | 1 | A | A |

* A= allowable combination in the regulation, but not used by SHAs

** Includes one SHA (MDOT) using 10 dB at one benefited receptor and 7 dB at 50% of all benefited receptors.

Whether or not one combination of these two factors is easier to achieve than another combination depends heavily on the NRDG quantity. For example, achieving 7 dB at 75% of all benefited receptors where 5 dB is the minimum value to be benefited could be more difficult than achieving 9 dB at only one receptor where 9 dB is also the minimum value for being benefited. Table 9 relates these three factors: 1) NRDG; 2) NRDG quantity and benefited noise reduction; and 3) in a similar manner Table 6. The following differences are observed:

- For an NRDG of 7 dB and a benefited noise reduction of 5 dB, the NRDG quantity ranges from one benefited receptor to 75% of all benefited receptors.
- For a 7 dB NRDG and a 7 dB benefited noise reduction, the NRDG quantity ranges from one benefited receptor to 67% of first-row benefits.
- For an 8 dB NRDG, the NRDG quantity ranges from one benefited receptor to 80% of all benefited receptors for a 5 dB benefited noise reduction, and 75% of first-row benefits for an 8 dB benefited noise reduction.
- For a 9 dB NRDG, the NRDG quantity ranges from one benefited receptor for 5 dB and 8 dB benefited noise reductions to 25% of all *impacted* receptors for a 9 dB benefited noise reduction (the latter being DelDOT).
- For a 10 dB NRDG and a 5 dB benefited noise reduction, the NRDG quantity ranges from one benefited first-row receptor to 65% of all benefits.
- For a 10 dB NRDG and a 7 dB benefited noise reduction, the NRDG quantity is 50% of all benefits, while for an 8 dB benefited noise reduction, the NRDG quantity is 80% of first-row benefits.

An abatement measure is much more likely to be reasonable when the SHA requires a 7 dB NRDG be met at only one benefited receptor when the benefited noise reduction is 5 dB, than when the SHA requires a 10 dB NRDG be met at 80% of first-row benefited receptors when the benefited noise reduction is 8 dB.

Conversely, it may be easier for an SHA to meet a 10 dB NRDG at only one benefited receptor when the benefited noise reduction is 5 dB than for an SHA that needs to meet an 8 dB NRDG at 75% of first-row benefited receptors when the benefited noise reduction is 8 dB.

**Table 9. Combinations of Noise Reduction Design Goal (NRDG), NRDG Quantity, and Benefited Noise Reduction.**

| NRDG Quantity | Number of SHAs by NRDG and Benefited Noise Reduction | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7 dB NRDG | | 8 dB NRDG | | 9 dB NRDG | | | 10 dB NRDG | | |
| **Benefited Noise Reduction =>** | **5 dB** | **7 dB** | **5 dB** | **8 dB** | **5 dB** | **8 dB** | **9 dB** | **5 dB** | **7 dB** | **8 dB** |
| 1 | 13 [1] | 1 | 2 [2] | -- | 1 [3] | 1 | -- | 1 | -- | -- |
| 1 first-row | 3 [4] | -- | -- | -- | -- | -- | -- | 1 | -- | -- |
| 1 at 7 dB/50% of all at 10 dB | 1 [5] | -- | -- | -- | -- | -- | -- | 1 [5] | -- | -- |
| 10% | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 10% of first-row benefited | 1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 25% | 1 | -- | -- | -- | -- | -- | 1 [6] | -- | -- | -- |
| 40% | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 50% of first-row benefited | 3 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 50% | 1 | -- | -- | -- | -- | -- | -- | -- | 1 | -- |
| >50% of first-row benefited | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| >50% | 3 | -- | -- | -- | -- | -- | -- | 1 | -- | -- |
| 60% of first-row benefited | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 65% | -- | -- | -- | -- | -- | -- | -- | 1 | -- | -- |
| 67% of first-row benefited | -- | 1 | -- | -- | -- | -- | -- | -- | -- | -- |
| 67% | 1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 70% | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 75% of first-row benefited | 2 | -- | -- | 1 | -- | -- | -- | -- | -- | -- |
| 75% | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 80% of first-row benefited | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 |
| 80% | -- | -- | 1 | -- | -- | -- | -- | -- | -- | -- |

[1] VDOT's policy says one *impacted* receptor.
[2] Illinois DOT's policy says one and as many others while staying within CE criterion.
[3] AHTD's policy says 9 dB at "at least 1 benefited receptor that is impacted.".
[4] Idaho DOT's policy says at the one receptor that is closest to the road centerline.
[5] MDOT's policy says 10 dB at one benefited receptor and 7 dB at 50% of all benefited receptors.
[6] DelDOT's policy says 25% of *impacted* receptors.

### 2.1.10 Cost per Benefited Receptor (CPBR) and Benefited Noise Reduction

Table 10 presents the CBPR and APBR criteria used in the SHA policies in terms of the benefited noise reduction criterion, without any normalization based on abatement unit cost. Section 2.1.12 presents the results after normalization.

The most common benefited noise reduction is 5 dB. The corresponding CPBR range is from $20,000 to $71,222 (the maximum for the sliding scale starting at $36,127). All of the SHAs that use a CPBR above $40,000 specify 5 dB as the benefited noise reduction. The three policies using CPBR/dB noise reduction also specify 5 dB as the benefited noise reduction, as do the seven SHAs using APBR.

None of the SHAs specify a 6 dB benefited noise reduction.

The SHAs specifying benefited noise reductions of 7 dB or more all have CPBRs at or below $40,000:

- Three SHAs specify a 7 dB benefited noise reduction, with a CPBR range of $20,000 to $40,000.
- Three SHAs also specify an 8 dB benefited noise reduction, with a CPBR range of $20,000 to $30,000.
- Only one SHA specifies a 9 dB benefited noise reduction, with a CPBR of $25,000.

**Table 10. Combinations of Cost per Benefited Receptor (CPBR), Area per Benefited Receptor (APBR) and Benefited Noise Reduction.**

| CPBR, APBR | Number of SHAs by Benefited Noise Reduction | | | | |
|---|---|---|---|---|---|
| | 5 dB | 6 dB | 7 dB | 8 dB | 9 dB |
| **CPBR: Cost in Dollars per Benefited Receptor** | | | | | |
| $20,000 | 1 | -- | -- | 1 | -- |
| $21,000 | 1 | -- | -- | -- | -- |
| $23,000 | 1 | -- | -- | -- | -- |
| $24,000 base with a $37,000 maximum value | 1 | -- | -- | -- | -- |
| $24,250 base with adjustments up to $48,250 | 1 | -- | -- | -- | -- |
| $25,000 | 3 | -- | -- | -- | 1 |
| $25,000 (residences post-date highway) / $30,000 (residences pre-date) | 1 | -- | -- | -- | -- |
| $30,000 | 2 | -- | 1 | 2 | -- |
| $30,000/$37,500 (51% prior) | | -- | 1 | -- | -- |
| $30,000/$40,000 (severe impacts) | 1 | -- | -- | -- | -- |
| $31,000 | 1 | -- | -- | -- | -- |
| $32,000 | 1 | -- | -- | -- | -- |
| $35,000 | 2 | -- | -- | -- | -- |
| $36,000 | 1 | -- | 1 | -- | -- |
| $36,127 base with a $71,222 maximum value (or 780 – 1380 SF) | 1 | -- | -- | -- | -- |
| $40,000 | 5 | -- | 1 | -- | -- |
| $42,509 | 1 | -- | -- | -- | -- |
| $42,244 | 1 | -- | -- | -- | -- |
| $43,500 | 1 | -- | -- | -- | -- |
| $45,000 or 1,500 SF | 1 | -- | -- | -- | -- |
| $49,000 | 1 | | | | |
| $50,000/$55,000 (severe impacts) | 1 | -- | -- | -- | -- |
| $55,000 | 3 | -- | -- | -- | -- |
| $60,000 | 1 | -- | -- | -- | -- |
| **Dollars per Benefited Receptor (BR) per dB of Noise Reduction** | | | | | |
| $4,900 / (Average NR x BR) | 1 | -- | -- | -- | -- |
| $6,800 / BR / dB Reduction | 1 | -- | -- | -- | -- |
| $8,400 / dB Insertion Loss / BR | 1 | -- | -- | -- | -- |

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**Table 10. Combinations of Cost per Benefited Receptor (CPBR), Area per Benefited Receptor (APBR) and Benefited Noise Reduction.**

| CPBR, APBR | Number of SHAs by Benefited Noise Reduction | | | | |
|---|---|---|---|---|---|
| | 5 dB | 6 dB | 7 dB | 8 dB | 9 dB |
| **APBR: Barrier Surface Area (SF) per Benefited Receptor (BR)** | | | | | |
| Sliding scale from 250 to 950 SF for residences post-dating original highway and SHA policy revision date, and from 1,500 to 2,400 SF for residences pre-dating original highway | 1 | -- | -- | -- | -- |
| 1,400 SF (uses $42,000 based on current unit cost) | 1 | -- | -- | -- | -- |
| 1,600 SF | 1 | -- | -- | -- | -- |
| 2,000 SF | 1 | -- | -- | -- | -- |
| 2,000 SF for wall / $80,000 for earth berm or building insulation | 1 | -- | -- | -- | -- |
| 2,500 SF + 35 SF/dB(A) increase | 1 | -- | -- | -- | -- |
| 2,700 SF * | 1 | -- | -- | -- | -- |

* MDSHA also uses 3,700 SF for Common Noise Environment average when trying to qualify areas that fall outside of the 2,700 criterion

### 2.1.11 Cost per Benefited Receptor (CPBR) and Noise Reduction Design Goal (NRDG)

Table 11 presents the CBPR and APBR criteria used by the SHAs in terms of the NRDG, without any normalization based on abatement unit cost. Section 2.1.13 presents the results after normalization.

The most common NRDG is 7 dB. The corresponding CPBR range is from $20,000 to $71,222, as it was for all policies with the benefited noise reduction criterion of 5 dB. All of the policies with a CPBR above $40,000 specify 7 dB as the NRDG. As with the benefited noise reduction criterion, the three SHAs using CPBR/dB Noise Reduction and the seven SHAs using APBR specify a 7 dB NRDG.

The SHAs that specify an NRDG of 8, 9 or 10 dB, all have a CPBR at or below $41,208:

- Four SHAs specify an 8 dB NRDG with a CPBR range of $24,000 to $37,000 (the maximum for the sliding scale starting at $24,000).
- Three SHAs specify a 9 dB NRDG with a CPBR range of $25,000 to $36,000.
- Six SHAs with a 10 dB NRDG have a CPBR range of $20,000 to $42,509.

**Table 11. Combinations of CPBR, APBR and NRDG.**

| CPBR, APBR | Number of SHAs by NRDG | | | |
|---|---|---|---|---|
| | 7 dB | 8 dB | 9 dB | 10 dB |
| **CPBR: Cost in Dollars per Benefited Receptor** | | | | |
| $20,000 | 1 | -- | -- | 1 |
| $21,000 | 1 | -- | -- | -- |
| $23,000 | 1 | -- | -- | -- |
| $24,000 base with a $37,000 maximum value | -- | 1 | -- | -- |
| $24,250 base with adjustments up to $48,250 | 1 | -- | -- | -- |
| $25,000 | 2 | -- | 1 | 1 |
| $25,000 (residences post-date highway) / $30,000 (residences pre-date) | 1 | -- | -- | -- |
| $30,000 | 1 | 2 | 1 | 1 |
| $30,000 / $37,500 (51% prior) | -- | -- | -- | 1 |
| $30,000 / $40,000 (severe impacts) | 1 | | | |
| $31,000 | 1 | -- | -- | -- |
| $32,000 | 1 | -- | -- | -- |
| $35,000 | 2 | 1 | -- | -- |
| $36,000 | 1 | -- | 1 | -- |
| $36,127 base with a $71,222 maximum value (or 780 – 1380 SF) | 1 | -- | -- | -- |
| $40,000 | 5 | -- | -- | 1 |
| $42,509 | 1 * | -- | -- | 1 * |
| $42,244 | 1 | -- | -- | -- |
| $43,500 | 1 | -- | -- | -- |
| $45,000 or 1,500 SF | 1 | -- | -- | -- |
| $49,000 | 1 | | | |
| $50,000 / $55,000 (severe impacts) | 1 | -- | -- | -- |
| $55,000 | 3 | -- | -- | -- |
| $60,000 | 1 | -- | -- | -- |
| **Dollars per Benefited Receptor (BR) per dB of Noise Reduction** | | | | |
| $4,900 / (Average NR x BR) | 1 | -- | -- | -- |
| $6,800 / BR / dB Reduction | 1 | -- | -- | -- |
| $8,400 / dB Insertion Loss / BR | -- | -- | -- | 1 |

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**Table 11. Combinations of CPBR, APBR and NRDG.**

| CPBR, APBR | Number of SHAs by NRDG | | | |
|---|---|---|---|---|
| | 7 dB | 8 dB | 9 dB | 10 dB |
| **APBR: Barrier Surface Area (SF) per Benefited Receptor (BR)** | | | | |
| Sliding scale from 250 to 950 SF for residences post-dating original highway and SHA policy revision date, and from 1,500 to 2,400 SF for residences pre-dating original highway | 1 | -- | -- | -- |
| 1,400 SF (uses $42,000 based on current unit cost) | 1 | -- | -- | -- |
| 1,600 SF | 1 | -- | -- | -- |
| 2,000 SF | 1 | -- | -- | -- |
| 2,000 SF for wall / $80,000 for earth berm or building insulation | 1 | -- | -- | -- |
| 2,500 SF + 35 SF/dB(A) increase | 1 | -- | -- | -- |
| 2,700 SF ** | 1 | -- | -- | -- |

* MDOT policy uses 10 dB at one benefited receptor and 7 dB at 50% of all benefited receptors, with 5 dB for benefited.
** MDSHA also uses 3,700 SF for Common Noise Environment average when trying to qualify areas that fall outside of the 2,700 criterion.

### 2.1.12 Normalized Cost per Benefited Receptor (CPBR), Area per Benefited Receptor (APBR) and Noise Reduction Design Goal (NRDG)

In order to be able to compare and assess the various CE criteria used in the SHA policies, it was necessary to normalize the CPBR by the abatement unit cost used by each SHA in computing barrier costs. In effect, this reduces the CPBRs to APBRs that can be compared between all SHAs.

Table 12 presents the results of this normalization. The second and third columns show the CPBR and unit costs, respectively used by SHAs. The table also shows the APBR values used by several SHAs in bold in the third column. For those SHAs that allow a range of values for the CPBR or APBR, the upper and lower limits of the range are represented by separate rows in the table. Several SHAs do not provide unit costs in their policies and did not respond to follow-up inquiries by the research team. These SHAs are not represented in this table.

What is striking about this normalized data is the very large range for APBR. For SHAs using a 7 dB NRDG, the lowest value is 250 SF/ benefited receptor, which actually represents the low end of a range for one SHA for the case of a residential area built after the initial road and after a September 2005 policy change regarding in-fill development, with a relatively low future noise level and little or no increase from existing to future noise level. The highest APBR value is 2,750 SF/ benefited receptor, over ten times greater than the lowest value. Disregarding the rather special case of the 250 SF value, the second lowest APBR value is 477 SF/ benefited receptor, one-sixth of the highest value. In essence, one SHA allows nearly six times as much area as another SHA in making a decision on barrier reasonableness. The decision would be very

different for the same project under these two policies. It is important to reiterate that CE alone does not dictate the reasonableness decision. The NRDG must also be met.

The range described above for SHAs with a 7 dB NRDG are not quite as large, but still substantial, for 8 and 9 dB NRDG values:

- 8 dB: APBR varies from 857 to 1,500 SF/ benefited receptor, a ratio of nearly 2:1.
- 9 dB: APBR varies from 1,029 to 1,667 SF/ benefited receptor.

The range for the 10 dB NRDG is small – only 916 to 1,000 SF/benefited receptor.

**Table 12. Combinations of Normalized CPBR or APBR and NRDG, Ranked by APBR.**

| **APBR (or CPBR/Unit Cost), SF allowance** | **Cost per Benefited Receptor (or Area per Benefited Receptor)** [***bold italics*** indicates the upper or lower end of a range] | **Unit Cost, $/SF** | **Number of SHAs by NRDG** | | | |
|---|---|---|---|---|---|---|
| | | | **7 dB** | **8 dB** | **9 dB** | **10 dB** |
| **250** | ***250 base (post-Sep 2005)*** / 2,400 max | **Uses area** | 1 | -- | -- | -- |
| 477 | $21,000 | $44.00 | 1 | -- | -- | -- |
| *700* | ***$36,127 base*** / $71,222 max | $51.61 | 1 | -- | -- | -- |
| 714 | ***$50,000*** / $55,000 (severe impacts) | $70.00 | 1 | -- | -- | -- |
| 786 | $50,000 / ***$55,000 (severe impacts)*** | $70.00 | 1 | -- | -- | -- |
| 800 | $20,000 | $25.00 | 1 | -- | -- | -- |
| 833 | ***$25,000*** / $30,000 | $30.00 | 1 | -- | -- | -- |
| 857 | $30,000 | $35.00 | -- | 1 | -- | -- |
| 909 | $40,000 | $44.00 | 1 | -- | -- | -- |
| 945 | $42,509 | $45.00 | -- | -- | -- | 1 * |
| 960 | ***$24,000 base*** / $37,000 max | $25.00 | -- | 1 | -- | -- |
| 1,000 | $25,000 | $25.00 | -- | -- | -- | 1 |
| 1,000 | $24,250 / ***$48,250 max*** | $24.25 | 1 | -- | -- | -- |
| 1,000 | $25,000 / ***$30,000*** | $30.00 | 1 | -- | -- | -- |
| 1,000 | $30,000 | $30.00 | -- | -- | -- | 1 |
| 1,000 | ***$30,000*** / $37,500 (51% prior) | $30.00 | 1 | | | |
| 1,000 | $31,000 | $31.00 | 1 | -- | -- | -- |
| 1,250 | $30,000 / ***$37,500 (51% prior)*** | $30.00 | | | | |
| 1,000 | $40,000 | $40.00 | 1 | -- | -- | -- |
| 1,029 | $36,000 | $35.00 | -- | -- | 1 | -- |
| 1,053 | $40,000 | $38.00 | 1 | -- | -- | -- |
| 1,137 | $42,244 | $37.16 | 1 | -- | -- | -- |
| 1,167 | $35,000 | $30.00 | 1 | -- | -- | -- |
| 1,200 | $30,000 | $25.00 | 2 | -- | -- | -- |
| 1,200 | ***$30,000*** / $40,000 (severe impacts) | $25.00 | 1 | | | |
| 1,250 | $25,000 | $20.00 | 1 | -- | -- | -- |
| 1,333 | $40,000 | $30.00 | 1 | -- | -- | -- |
| 1,380 | $36,127 base / ***$71,222 max*** | $51.61 | 1 | -- | -- | -- |
| 1,389 | $25,000 | $18.00 | 1 | -- | -- | -- |
| **1,400** | **1,400 SF** (uses $42,000 based on current unit cost of $30/SF) | **Area-based** | 1 | -- | -- | -- |
| 1,400 | $35,000 | $25.00 | 1 | -- | -- | -- |
| 1,400 | $49,000 | $35.00 | 1 | -- | -- | -- |

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**Table 12. Combinations of Normalized CPBR or APBR and NRDG, Ranked by APBR.**

| APBR (or CPBR/Unit Cost), SF allowance | Cost per Benefited Receptor (or Area per Benefited Receptor) [***bold italics*** indicates the upper or lower end of a range] | Unit Cost, $/SF | Number of SHAs by NRDG | | | |
|---|---|---|---|---|---|---|
| | | | 7 dB | 8 dB | 9 dB | 10 dB |
| 1,429 | $40,000 | $28.00 | 1 | -- | -- | -- |
| 1,440 | $36,000 | $25.00 | 1 | -- | -- | -- |
| 1,480 | $24,000 base / ***$37,000 max*** | $25.00 | -- | 1 | -- | -- |
| 1,500 | $45,000 | $30.00 | 1 | -- | -- | -- |
| 1,500 | $30,000 | $20.00 | -- | 1 | -- | -- |
| 1,600 | $30,000 / ***$40,000 (severe impacts)*** | $25.00 | | | | |
| 1,600 | $40,000 | $25.00 | 1 | -- | -- | -- |
| **1,600** | **1,600 SF** | **Uses area** | 1 | -- | -- | -- |
| 1,667 | $30,000 | $18.00 | -- | -- | 1 | -- |
| **1,990** | $24,250 / ***$48,250 max*** | $24.25 | 1 | -- | -- | -- |
| **2,000** | **2,000 SF for wall** / $80,000 for berm or insulation | **Uses area** | 1 | | | |
| **2,000** | **2,000 SF** | **Uses area** | 1 | -- | -- | -- |
| 2,175 | $43,500 | $20.00 | 1 | -- | -- | -- |
| **2,400** | 250 base (post-Sep 2005) / ***2,400 max*** | **Uses area** | 1 | -- | -- | -- |
| **2,500** | **2500 SF + 35 SF/dB Increase** | **Uses area** | 1 | -- | -- | -- |
| **2,700** | **2,700 SF (3,700 SF for Common Noise Environment average)** | **Uses area** | 1 | -- | -- | -- |
| 2,750 | $55,000 | $20.00 | 1 | -- | -- | -- |

* MDOT uses 10 dB at 1 receptor and 7 dB at 50% of all receptors for NRDG, with 5 dB for benefited.

Figure 1 shows a histogram of the normalized APBRs and actual APBRs, including the low and high values for policies with variable costs.[4] The graph illustrates the range in APBR from 250 to 2,750 SF/ benefited receptor. It also shows the predominant values centered between 800 and 1,600 SF/ benefited receptor. Yet, the CPBR corresponding to these values vary substantially depending on the abatement unit cost used by an SHA, which would result in widely disparate decisions for the same noise analysis area.

[4] The bin values for APBR represent all values above the previous bin up to the bin value. For example, there are 10 samples with a value greater than 800 and less than or equal to 1,000.

The actual costs per benefited receptor used in the SHA policies range from a low of $20,000 to a high of $71,222. The variable costs depend on parameters such as whether or not a residential development preceded the highway construction, the amount of the sound level increase over the existing case, or the absolute future sound level. Also note that one SHA (NYSDOT) uses an area criterion of 2,000 SF/benefited receptor for noise barrier walls. It uses a cost criterion of $80,000 per benefited receptor for installation of an earth berm or sound insulation of an impacted property.

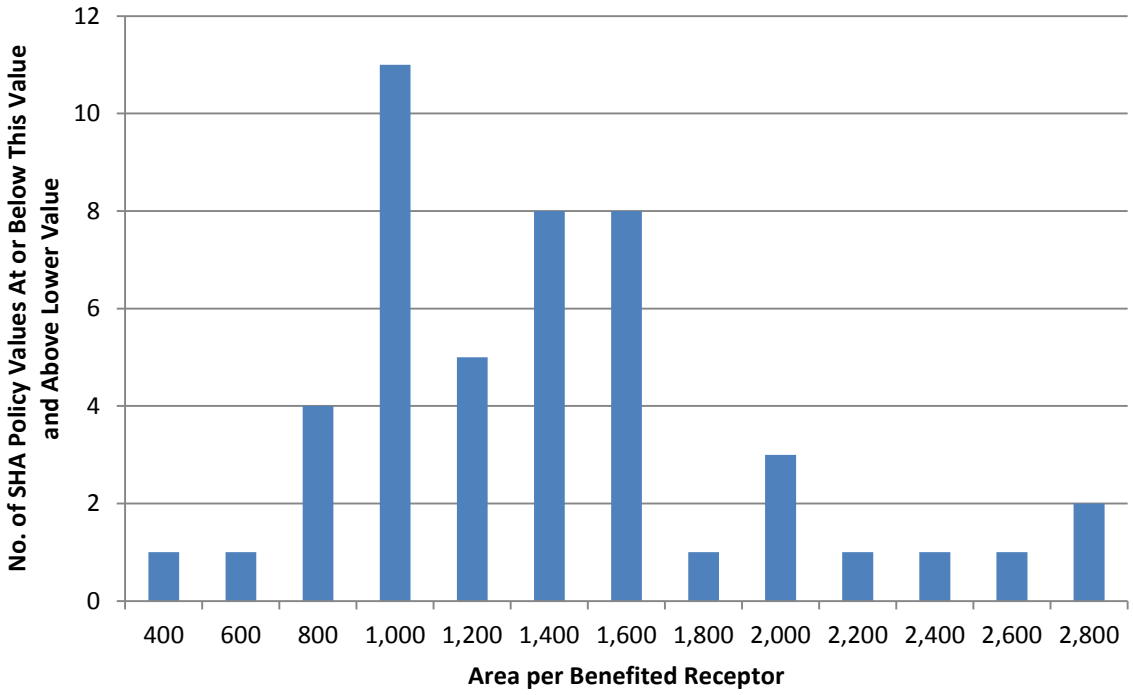


**Figure 1. Number of SHA policy values as a function of Area per Benefited Receptor or normalized Cost per Benefited Receptor (includes low and high values for policies with ranges).**

Figure 2, Figure 3, and Figure 4 are scatter plots showing the relationships between CPBR, APBR, and unit cost. Each point represents a pair of values for a particular SHA's policy. For those policies with a sliding scale, there are separate points for the low and high ends of the scale.

Figure 2 graphs the CPBR and the corresponding APBR calculated from the SHA's unit cost. This figure illustrates how policies with very similar CPBRs – such as in the $50,000 to $60,000 range – can have widely varying allowable areas – from approximately 700 to 2,750 SF/ benefited receptor. SHAs in this grouping could expect to come to very different decisions on the CE reasonableness factor despite the similar cost criteria because their resulting allowable areas are so different. It also shows how SHAs can have very similar allowable barrier areas – for example, around 1,400 SF/benefited receptor – yet have widely varying CPBRs, ranging from $25,000 to over $70,000. SHAs in this latter grouping could expect to come to similar decisions on this reasonableness factor despite the cost criteria differing by a factor of nearly 3.

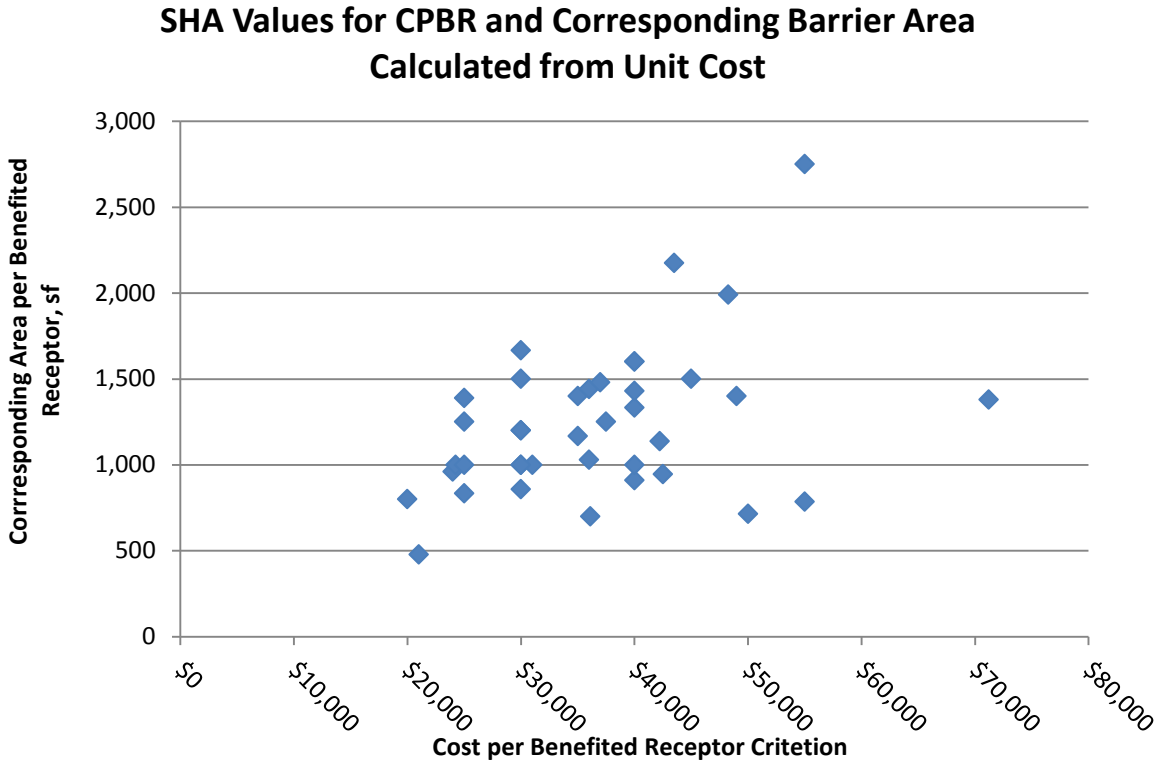


**Figure 2. SHA values for CPBR and corresponding barrier area calculated from unit cost.**

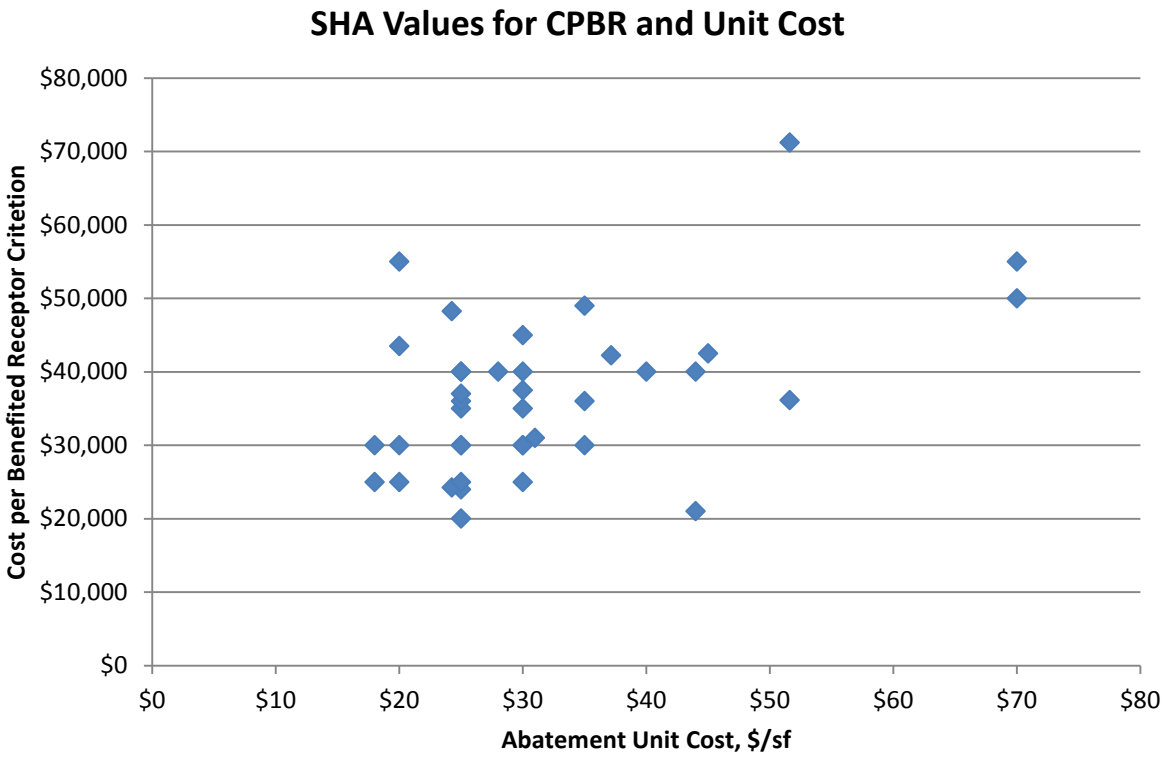


**Figure 3. SHA values for CPBR and corresponding barrier unit cost.**

Figure 3 plots the SHAs' CPBR values against their corresponding unit costs. The graph shows how SHAs with similar unit costs can end up with widely varying CPBRs. For example, for a unit cost of $20.00/SF, the CPBR range is $25,000 to $55,000. Those SHAs with the low CPBRs for any given unit cost would be much less likely to reach a favorable decision on abatement than those SHAs with high CPBRs.

Conversely, there are SHAs with very similar CPBRs, yet their unit costs vary widely. For example, two SHAs with a CPBR criterion around $50,000 have unit costs of $25/SF and $70/SF. The higher the unit cost per given CPBR the less likely that a favorable decision will be reached on barrier reasonableness.

Figure 4 graphs the allowable barrier area calculated from the unit cost against the unit cost itself. As one moves toward the upper left-hand portion of the graph, the likelihood of a barrier being reasonable increases (a higher allowable area at a lower unit cost). As one proceeds to the lower right-hand corner portion of the graph, it is less likely that a positive decision on barrier reasonableness would be reached (a low allowable area at a high unit cost).

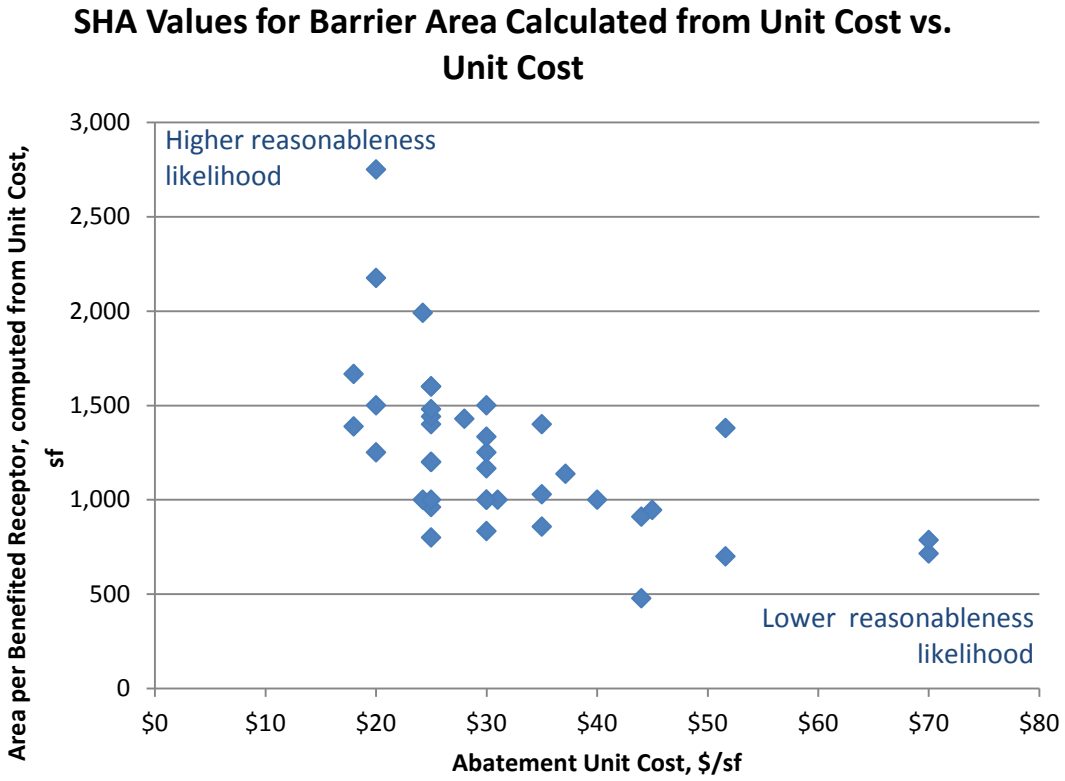


**Figure 4. SHA values for barrier area calculated from unit cost and corresponding abatement unit cost.**

### 2.1.13 Normalized CPBR, APBR and Benefited Reduction

Table 13 presents the combinations of APBR and the benefited noise reduction in dB. The first three columns are the same as the previous table.

For a 5 dB benefited noise reduction criterion, the range in APBR is the full extent of the table – from 250 SF/benefited receptor to 2,750 SF/benefited receptor.

The range for the 7 dB benefited noise reduction is much smaller – 1,000 to 1,600 SF/ benefited receptor. For 8 dB, the range is even less – only 1,500 to 1,667 SF/ benefited receptor.

As already stated in the previous subsection, the large range in APBR will result in widely differing decisions on reasonableness for a given situation.

Focusing on an APBR of 1,500 SF/ benefited receptor, the benefited noise reduction criterion ranges from 5 to 8 dB. The higher the benefited noise reduction criterion, the fewer benefits there would be for a given barrier design. As the number of benefits decreases, the calculated APBR increases, making it less likely to meet the APBR criterion. The final decision on reasonableness

would also depend on the NRDG criterion and the required number or percentage of benefited receptors meeting the NRDG.

**Table 13. Combinations of Normalized CPBR or APBR and Benefited Reduction Used by SHAs, Ranked by APBR.**

| APBR (or CPBR/Unit Cost), SF allowance | Cost per Benefited Receptor (or Area per Benefited Receptor) [***bold italics*** indicates the upper or lower end of a range] | Unit Cost, $/SF | Number of SHAs by Benefited Reduction | | | |
|---|---|---|---|---|---|---|
| | | | 5 dB | 7 dB | 8 dB | 9 dB |
| **250** | ***250 base (post-Sep 2005)*** / 2,400 max | **Uses area** | 1 | -- | -- | -- |
| 477 | $21,000 | $44.00 | 1 | -- | -- | -- |
| *700* | ***$36,127 base*** */ $71,222 max* | $51.61 | 1 | -- | -- | -- |
| 714 | ***$50,000*** / $55,000 (severe impacts) | $70.00 | 1 | -- | -- | -- |
| 786 | $50,000 / ***$55,000 (severe impacts)*** | $70.00 | 1 | -- | -- | -- |
| 800 | $20,000 | $25.00 | 1 | -- | -- | -- |
| 833 | ***$25,000*** / $30,000 | $30.00 | 1 | -- | -- | -- |
| 857 | $30,000 | $35.00 | 1 | -- | -- | -- |
| 909 | $40,000 | $44.00 | 1 | -- | -- | -- |
| 945 | $42,509 | $45.00 | 1 | -- | -- | -- |
| 960 | ***$24,000 base*** / $37,000 max | $25.00 | 1 | -- | -- | -- |
| 1,000 | $25,000 | $25.00 | 1 | -- | -- | -- |
| 1,000 | $24,250 / ***$48,250 max*** | $24.25 | 1 | -- | -- | -- |
| 1,000 | $25,000 / ***$30,000*** | $30.00 | 1 | -- | -- | -- |
| 1,000 | $30,000 | $30.00 | 1 | 1 | -- | -- |
| 1,000 | ***$30,000*** / $37,500 (51% prior) | $30.00 | 1 | -- | -- | -- |
| 1,000 | $31,000 | $31.00 | 1 | -- | -- | -- |
| 1,250 | $30,000 / ***$37,500 (51% prior)*** | $30.00 | 1 | -- | -- | -- |
| 1,000 | $40,000 | $40.00 | 1 | -- | -- | -- |
| 1,029 | $36,000 | $35.00 | 1 | -- | -- | -- |
| 1,053 | $40,000 | $38.00 | 1 | -- | -- | -- |
| 1,137 | $42,244 | $37.16 | 1 | -- | -- | -- |
| 1,167 | $35,000 | $30.00 | 1 | -- | -- | -- |
| 1,200 | $30,000 | $25.00 | 1 | -- | -- | -- |
| 1,200 | ***$30,000*** / $40,000 (severe impacts) | $25.00 | 2 | -- | -- | -- |
| 1,250 | $25,000 | $20.00 | 1 | -- | -- | -- |
| 1,333 | $40,000 | $30.00 | 1 | -- | -- | -- |
| 1,380 | $36,127 base / ***$71,222 max*** | $51.61 | 1 | -- | -- | -- |
| 1,389 | $25,000 | $18.00 | | | | |

Continued on next page

**Table 13. Combinations of Normalized CPBR or APBR and Benefited Reduction Used by SHAs, Ranked by APBR.**

| APBR (or CPBR/Unit Cost), SF allowance | Cost per Benefited Receptor (or Area per Benefited Receptor) [***bold italics*** indicates the upper or lower end of a range] | Unit Cost, $/SF | Number of SHAs by Benefited Reduction | | | |
|---|---|---|---|---|---|---|
| | | | 5 dB | 7 dB | 8 dB | 9 dB |
| **1,400** | **1,400 SF** (uses $42,000 based on $30/SF) | **Area-based** | 1 | -- | -- | -- |
| 1,400 | $35,000 | $25.00 | 1 | -- | -- | -- |
| 1,400 | $49,000 | $35.00 | 1 | -- | -- | -- |
| 1,429 | $40,000 | $28.00 | -- | 1 | -- | -- |
| 1,440 | $36,000 | $25.00 | -- | 1 | -- | -- |
| 1,480 | $24,000 base / ***$37,000 max*** | $25.00 | 1 | -- | -- | -- |
| 1,500 | $45,000 | $30.00 | 1 | -- | -- | -- |
| 1,500 | $30,000 | $20.00 | -- | -- | 1 | -- |
| 1,600 | $30,000 / ***$40,000 (severe impacts)*** | $25.00 | 1 | -- | -- | -- |
| 1,600 | $40,000 | $25.00 | | 1 | -- | -- |
| **1,600** | **1,600 SF** | **Uses area** | 1 | -- | -- | -- |
| 1,667 | $30,000 | $18.00 | -- | -- | 1 | -- |
| **1,990** | $24,250 / ***$48,250 max*** | $24.25 | 1 | -- | -- | -- |
| **2,000** | **2,000 SF for wall** / $80,000 for berm or insulation | **Uses area** | 1 | -- | -- | -- |
| **2,000** | **2,000 SF** | **Uses area** | 1 | -- | -- | -- |
| 2,175 | $43,500 | $20.00 | 1 | -- | -- | -- |
| **2,400** | 250 base (post-Sep 2005) / ***2,400 max*** | **Uses area** | 1 | -- | -- | -- |
| **2,500** | **2500 SF + 35 SF/dB Increase** | **Uses area** | 1 | -- | -- | -- |
| **2,700** | **2,700 SF (3,700 SF for Common Noise Environment average)** | **Uses area** | 1 | -- | -- | -- |
| 2,750 | $55,000 | $20.00 | 1 | -- | -- | -- |

### 2.1.14 Summary of Ranges in the Four Factors

This section examines the feasibility and reasonableness factors used in the SHA noise policies.

The feasibility noise reduction is 5 dB in all of the SHA polices.

The number or percentage of impacted receptors required to meet that reduction varies substantially, from only one impacted receptor to 80% of all impacted receptors. Roughly one-third of the SHAs specify a minimum number of impacted receptors, ranging from 1 to 3. Two-thirds of the SHAs specify a minimum percentage of impacted receptors for feasibility: nineteen SHAs use a percentage of all impacted receptors, while fifteen use a percentage of only the first-

row impacted receptors. The range for the former group is from 40% to 80% of all impacted receptors. For the latter, the range is from 50% to 80% of first-row impacted receptors, and includes one SHA that specifies 80% of first-row impacted and 67% of all impacted. The consequences of the differences in the feasibility quantity could be substantial.

There is a wide variation in the reasonableness abatement evaluation factors.

The benefited noise reduction criterion – the amount of noise reduction needed to count a receptor as benefited – ranged from 5 to 10 dB, with 45 SHAs using 5 dB. A receptor is counted as benefited whether or not it is impacted.

The values used for the NRDG range from 7 to 10 dB, the full extent of values allowed by the regulation. Nearly three-quarters use 7 dB. One SHA specifies 10 dB at one benefited receptor *and* 7 dB at 50% of all benefited receptors.

Twenty-four SHAs specify a minimum *number* of benefited receptors that must meet the NRDG criterion; of those, twenty-one use one benefited receptor, two specify one first-row benefited receptor, and one specifies meeting a 10 dB NRDG at one benefited receptor and a 7 dB reduction at 50% of all of benefited receptors. Twenty-eight SHAs specify a minimum *percentage* of benefited receptors; of those, eight apply the NRDG to only the first-row benefited receptors and the rest apply the percentage to all benefited receptors. The easiest percentage to achieve is 10% of the first-row benefited receptors; the most difficult is 80% of all benefited receptors.

By far the most common pairing of NRDG and NRDG quantity is the one most easily achieved: 7 dB at one or more benefited receptors, which is specified by sixteen SHAs. Five other SHAs pair the single benefited receptor with NRDG values of 8, 9 or 10 dB. The next most common pairing is an NRDG of 7 dB with a percentage of all benefited receptors that is in the range of 40% to “greater than 50%,” used by ten SHAs. Two others use a 10 dB NRDG with a percentage in the same range.

The four most difficult combinations to achieve are: 10 dB NRDG at 80% of the first-row benefited receptors; 7 dB at 75% of all benefited receptors; 8 dB at 80% of all benefited receptors; and 10 dB NRDG at 65% of all benefited receptors.

The pairings of NRDG and the NRDG quantity also have to be viewed in terms of the minimum noise reduction for a receptor to be counted as benefited. Thirty-six of the SHAs pair an NRDG of 7 dB with a benefited noise reduction of 5 dB. While fifteen of these SHAs require the goal to be met at only one benefited receptor, three of them require 67% to 80% of all benefited receptors. The most-difficult-to-achieve parings would appear to be: a 10 dB NRDG at 80% of first-row benefited where 8 dB is required for a receptor to be benefited; an 8 dB NRDG at 75% of first-row benefited receptors with a benefited noise reduction of 8 dB; and a 9 dB NRDG for 25% of all benefited receptors when the benefited noise reduction is 9 dB.

The five SHAs that specify a 10 dB NRDG and a benefited noise reduction of 5 dB require the criterion to be met at as little as one benefited receptor to up to as many as 65% of all benefited receptors. The most difficult to achieve pairing would be the use of 9 dB for both NRDG and benefited noise reduction (one SHA) or a 10 dB NRDG with a benefited noise reduction of 8 dB.

The cost-effectiveness criterion is expressed by most states in terms of CPBR. Some SHAs use CPBR per decibel of noise reduction achieved, which allows higher barrier costs to be reasonable for barrier designs that provide greater amounts of noise reduction. The calculation of this CPBR is dependent on the unit cost for the abatement measure, typically expressed in dollars per square foot of barrier surface area. The unit costs vary substantially across the SHA policies – from $18/SF to $70/SF. The CPBR values likewise vary – from $20,000 per benefited receptor to $71,222 per benefited receptor. The ability to compare different CPBRs is clouded by the unit costs used in their derivation. Also, as unit costs vary, SHAs are faced with the need to reconsider and revise their CPBR criterion if they wish to maintain consistent decision-making on barrier cost-effectiveness. Seven SHAs avoid these problems by using APBR as the cost-effectiveness measure, as allowed in the regulation. The range in allowable APBR is also substantial – from 250 SF/ benefited receptor to 2,700 SF/ benefited receptor.

To compare the CPBR and APBR criteria, the CPBR were normalized into APBR-equivalents by dividing by the SHAs' unit costs. The range increased to 250 to 2,750 SF/ benefited receptor.

When APBR is viewed by NRDG, the widest variation in APBR is for the 7 dB NRDG: from a low of 250 SF/ benefited receptor to a high of 2,750 SF/ benefited receptor. For an 8 dB NRDG, the APBR varies from 857 to 1,500 SF/ benefited receptor. For 9 dB, the range is from 1,029 to 1,667 SF/benefited receptor. For the 10 dB NRDG, the range is small: only 916 to 1,000 SF/ benefited receptor.

## 2.2 IDENTIFYING OPTIMIZED COMBINATIONS OF VALUES

This section examines various combinations of values for the feasibility and reasonableness criteria factors. The previous section detailed how the SHAs have actually combined the factors in the criteria in their policies. In the process, that analysis revealed a wide range of combinations in practice. These widely varying combinations, in turn, are likely to result in very different decisions for the same highway project and adjacent development on the reasonableness of abatement measures and possibly on their feasibility.

### 2.2.1 Factors Influencing Criterion Values

It is useful to examine the underlying factors that affect the criterion values. These underlying factors include:

- Number or percentage of impacted receptors
- Noise reduction provided by the barrier
- Number or percentage of benefited receptors
- Barrier cost
- CPBR or ABPR

#### *2.2.1.1 Number of impacted receptors*

The number of impacted receptors is used in the feasibility noise reduction determination, either in only the first-row or in all rows. A receptor's sound level, and thus the likelihood of being impacted, depends on:

- The volume, speed and mix of traffic, and type of pavement,
- Inversely, the distance from the road to the receptor,
- Inversely, the amount of shielding provided by the terrain, intervening rows of detached houses and their density, and areas of trees, and
- The hardness of the intervening ground.

The *number* of impacted receptors obviously also depends on the overall number of receptors available to be impacted and their distribution between the first-row and subsequent rows, if any. Because of the inverse effects of distance, number of intervening rows of houses, and density of those rows on sound level, second-row impacts are much less likely than first-row impacts and third- row (or more) impacts are typically very unlikely.

The *percentage* of impacted receptors meeting the feasibility noise reduction criterion depends on the number of impacts, the policy choice of first-row or all rows, and possibly the number of impacts in each row.

In general, if the scenario involves impacts beyond the first-row, it is more difficult to meet a given noise reduction at a given percentage of *all* the impacted receptors than at the same percentage of just the first-row impacted receptors. The reason is that, in general, the noise reduction provided by a barrier decreases as the receptor distance from the barrier increases (e.g., as one moves from the first-row to the second row or beyond). However, in most cases the majority of the impacts are in the first-row, and in many cases impacts do not extend beyond the first-row.

Also, for the low range of numbers used by the SHAs (one to three receptors), it is much easier to meet a specified minimum *number* than a specified *percentage* because use of a percentage will usually result in a greater number of impacted receptors at which the criterion must be met.

Figure 5 shows the relationship between the minimum number, the minimum first-row percentage and the minimum percentage of all impacts for a range of total impacts from 1 to 40 receptors. The left portion of the chart assumes all of the impacts occur in the first-row. The center portion of the chart assumes two-thirds of the impacts occur in the first-row. The right portion assumes half of the impacts occur in the first-row. Across the top are percentages from 10% to 90%. The numbers for range of percentages used by the SHAs (40% to 80%) are in bold. The color-shaded numbers are the number of impacted receptors needed to meet the criterion specified by the percentage.

For example, if an SHA uses a criterion of 80% of *all* impacted receptors and there are 40 impacts, the bottom row of the left portion of the chart shows that feasibility noise reduction value would have to be met at 32 or more of the 40 impacts. If the criterion was 80% of *first-row*

impacts and half of the impacts were first-row, then the receptors feasibility noise reduction would have to be met at least 16 of the 40 impacts (80% of half of 40). The potential barrier design for these high numbers of impacts will be much different than for exactly the same highway and receptor scenario in which an SHA's criterion is only one impacted receptor.

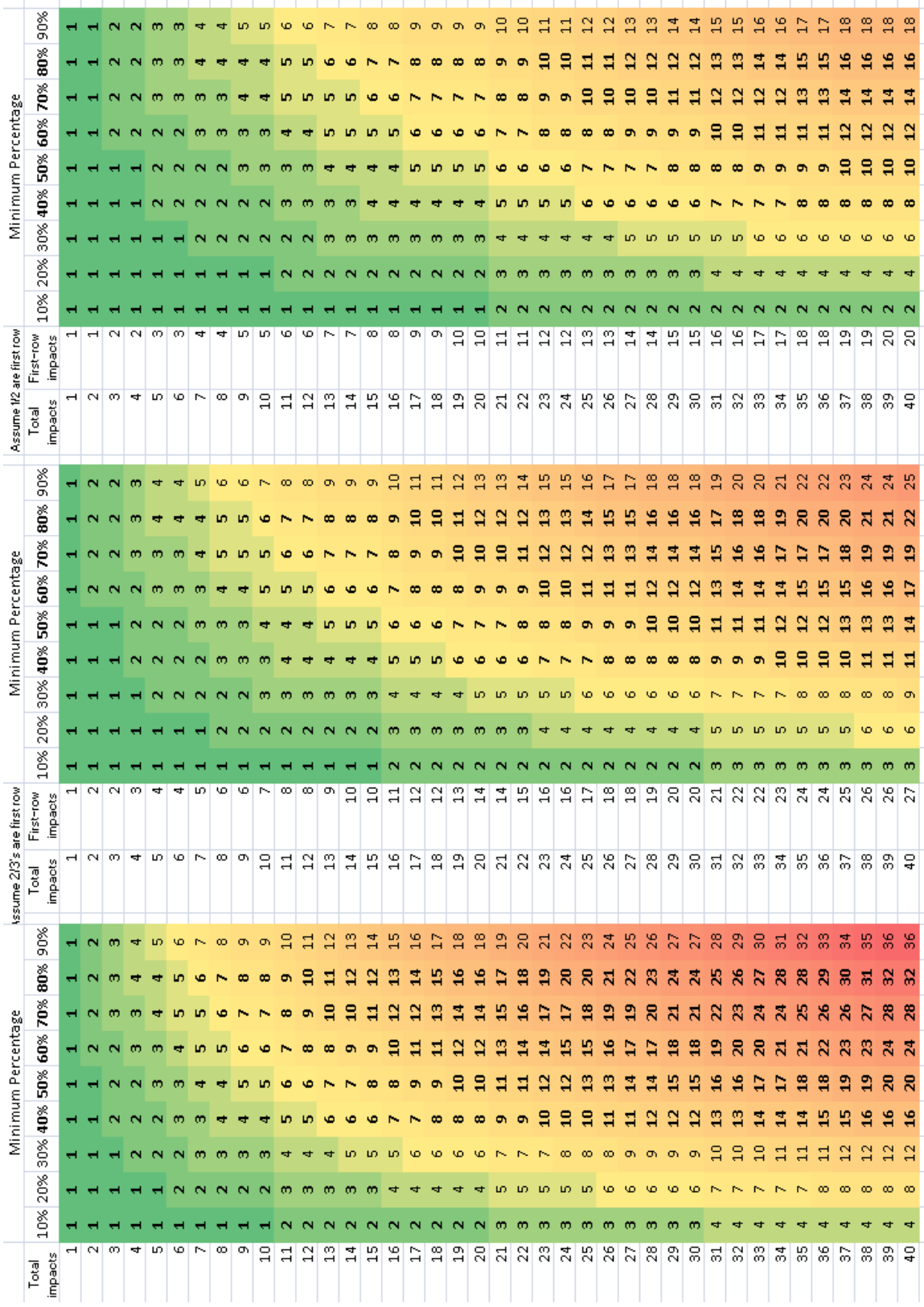


**Figure 5. Relationship between minimum number and percentages of first-row and all impacts.**

#### *2.2.1.2 Noise reduction provided by abatement measure*

The noise reduction provided by an abatement measure is used in the determination of feasibility. It is also used to determine which and how many receptors are benefited, and, hence, if the NRDG and CE criteria will be achieved. The CE criterion is in terms of CPBR or APBR.

The noise reduction is a function of:

- Barrier height
- Barrier length
- Type of barrier (wall or earth berm)
- Offset distance of barrier from the road
- Distance from the barrier back to the receptors
- Proximity of the receptor to the end of the barrier
- Vertical relationship of the roadway surface, barrier top elevation, and receptor elevation
- Type of intervening ground
- Presence of intervening rows of buildings and their density and height
- Width of the road
- Percentage of trucks in the mix of traffic
- Traffic speed

The following relationships generally hold true:

- As barrier height increases, noise reduction increases (to a point), the number of benefited receptors increases (to a point, depending on the number of receptors and number of rows), and likelihood[5] of barrier reasonableness increases.
- As barrier length increases, noise reduction increases (to a point) for some receptors near the end of the barrier, the number of benefited receptors increases (to a point, depending on the number of receptors and number of rows), and likelihood of barrier reasonableness increases.
- As the offset distance of barrier from the road increases, noise reduction first decreases and then, as the barrier gets closer to the receptor, increases.
- As the distance from the receptor to the barrier increases, noise reduction generally decreases, and likelihood of barrier reasonableness decreases.

#### *2.2.1.3 Number or percentage of benefited receptors*

The number of benefited receptors depends on the noise reduction at each receptor, the benefited noise reduction criterion, and the number of receptors available to be benefited. The NRDG may

[5]Note that the word "likelihood" is broader in meaning in this report than the specific "Statement of Likelihood" called for in the noise regulation after a positive decision on an abatement decision has been reached.

also affect the number of benefited receptors: for example, as NRDG increases, the needed height to meet it will increase, which can result in more receptors meeting a given benefited noise reduction.

The percentage of benefited receptors meeting the NRDG depends on the noise reduction at each receptor, the number of benefited receptors, the policy choice of first-row or all rows, and possibly the number of benefited receptors in each row.

While the number or percentage of *impacted* receptors will not change as the barrier design changes, the number and percentage of *benefited* receptors most likely will change , meaning that achieving the NRDG criterion (especially percentage-based) is a dynamic process. This dynamic nature complicates the design process, compared to designing based on impacted receptors, especially if the percentage is based on *all* benefited receptors instead of only *first-row* benefited receptors.

For example, if the NRDG is percentage-based and increasing the barrier height increases the number of benefited receptors, then the *number* of receptors needing to meet the NRDG will increase. However, the barrier height increase may not result in enough additional noise reduction to move more receptors above the NRDG. Additionally, the barrier surface area and cost will increase. If the number of benefited receptors meeting the NRDG does not increase enough, the NRDG may not be met.

The end result could be that in the process of increasing barrier height – and providing more noise reduction to the more seriously impacted receptors – a barrier may become less likely to meet the NRDG. This result is counter-intuitive and counter to the goal of protecting impacted receptors.

SHA noise policies contain wide variations in their definitions of NRDG. For example, many SHAs require only a single receptor to receive a 7 dB reduction while one SHA requires that 80% of the benefitted receptors receive at least an 8 dB noise reduction. This large disparity could result in very different decisions for the same situation.

Consider the high density single-family neighborhood along a section of interstate shown in Figure 6. The interstate is on a fill through most of this area. As a result, the 5 dB noise reduction contour extends several hundred feet back into the neighborhood and includes at least three rows of homes in most locations.

A 6,000-foot long noise barrier averaging 12.5 feet in height for this neighborhood was determined to meet the NRDG in the SHA's noise policy which required 7 dB at 60% of the benefited *first-row* residences. The NRDG was met since 100% of the first-row residences will receive 7 or more dB of noise reduction from the barrier.

An analysis was then completed to determine if the barrier would still meet the NRDG if the SHA's noise policy required 8 dB at 80% of the *all* benefited residences. The results are summarized in Table 14.


**Figure 6. Neighborhood adjacent to highway.**

**Table 14. Noise Reduction Design Goal Example Results.**

| NRDG | Number of Benefited Residences | Number of Benefited Residences Receiving Noise Reduction | Percentage of Benefited Residences Receiving Noise Reduction | NRDG Met? |
|---|---|---|---|---|
| ***Neighborhood as shown on aerial photograph*** | | | | |
| 7 dB at one benefited residence | 115 | 40 | n/a | Yes |
| 7 dB at 60% or more of *first-row* benefited residences | 115 | 40 | 35% | Yes |
| 8 dB at 80% or more of *all* benefited residences | 115 | 40 | 35% | No |
| ***Hypothetical first-row only (2nd and 3rd rows do not exist)*** | | | | |
| 7 dB at one benefited residence | 39 | 39 | n/a | Yes |
| 7 dB at 60% or more of *first-row* benefited residences | 39 | 39 | 100% | Yes |
| 8 dB at 80% or more of *all* benefited residences | 39 | 33 | 85% | Yes |

As shown, a barrier that provides 8 dB for the first-row residences would result in a total of 115 benefits. However, the vast majority of these benefited residences is in the second and third rows, receiving noise reductions between 5 and 7 dB, which is typical for second and third row locations. However, only 40 of the 115 benefited residences are receiving noise reductions of 8 or more dB, representing only 35% of the total benefited residences. This example illustrates the issue associated with setting a NRDG that requires a high percentage and also includes all benefited residences in the calculation.

Now imagine that only the first-row of houses exists in this neighborhood. In this situation, there would be 39 benefited residences and 33 of them would receive noise reductions of 8 or more dB, representing 85% of the total benefited residences. Therefore, the NRDG would be met.

Additionally, a noise barrier for the neighborhood would likely meet the CE criteria in most SHA policies, while a noise barrier would be much less likely to be cost effective if there were not second and third row benefited residences.

Should different decisions result from these two cases? Both neighborhoods are impacted, with sufficient density of residences, and the barriers are clearly reasonable for all but this one criterion. Should the inclusion of additional rows of residences mean that the first row is any less

deserving of abatement, especially when many of the residences beyond the first row receive benefits from the barrier? Acknowledging that FHWA gave the discretion and autonomy to each SHA (with FHWA approval) to determine its own reasonableness and feasibility criteria for noise abatement, this particular example points to a problem with the use of a reasonableness criterion based on percentage of all benefits.

#### *2.2.1.4 Barrier Cost, CPBR and APBR*

Barrier cost is one of the key components of the CE criterion for reasonableness, the other being the number of benefited receptors. Barrier cost is computed from barrier surface area multiplied by barrier unit cost, where barrier surface area is the product of height and length.

CPBR is computed by dividing barrier cost by the number of benefited receptors. APBR is computed by dividing barrier area by the number of benefited receptors.

These relationships hold:

- As height increases, barrier area and cost increase; the change in CPBR or APBR depends on these increases and whether or not the number of benefited receptors increase, which in turn depends on whether or not there were any more non-benefited receptors that could become benefited receptors, The likelihood of barrier reasonableness will increase or decrease depending on the change in the number of benefited receptors: adding no more benefited receptors decreases the likelihood of barrier reasonableness while adding more benefited receptors may increase the likelihood of barrier reasonableness depending on how much more the cost or area has changed.
- As length increases, barrier area and cost increase, and the change in CPBR or APBR and likelihood of barrier reasonableness depend on the same factors as for changes in barrier height.
- As unit cost increases, barrier cost increases, CPBR increases, and likelihood of barrier reasonableness by CPBR decreases.
- APBR and the likelihood of barrier reasonableness by APBR are independent of unit cost.

### 2.2.2 Summarizing the Range of General Relationships of Feasibility and Reasonableness Factors

Table 15 lists the various factors and their components used in the feasibility and reasonableness evaluation of an abatement measure. The table then indicates how the likelihood of a positive decision on the abatement measure would change based on the stated change in that factor. The change assumes other factors remain the same.

**Table 15. Relationships of Feasibility and Reasonableness Factors to Barrier Likelihood.**

| Criterion and Factor | Change in Factor | Resultant Change in Barrier Likelihood | Reason |
|---|---|---|---|
| Feasibility – Noise Reduction, dB | Increases | Decreases | A higher reduction may be more difficult to achieve depending on cross-section (e.g., receptors higher than road). The taller heights needed to achieve the higher reduction will increase barrier area and cost, possibly causing APBR or CBPR to exceed CE criterion. However, taller heights may also lead to more benefited receptors, reducing APBR/CBPR or offsetting the increase in the cost. |
| Feasibility – Number or Percentage | Increases | Decreases | A higher value may be more difficult to achieve, requiring taller and/or longer barrier, increasing area and cost, possibly causing APBR or CBPR to exceed criterion, but also possibly leading to more benefited receptors, reducing APBR/CBPR or offsetting increase in the cost. |
| Feasibility – Number or Percentage | Changes from "all rows" to "first-row only" impacts | Increases | Eliminates need to achieve feasible noise reduction beyond first-row – while this change could result in a barrier with less height, length, area and cost, and a lower APBR/CBPR, it might not lead to sufficient noise reduction for all of the impacted receptors |
| Feasibility – Number or Percentage | Changes from "first-row only" to "all rows" impacts | Decreases | Increases needed number of impacted receptors for multiple row cases. Requires more height, length, area, cost needed to achieve feasible noise reduction beyond first-row – higher APBR/CBPR |
| Benefited Noise Reduction, dB | Increases | Decreases | A higher reduction may mean fewer benefits, raising CPBR/APBR; or a taller/longer wall to achieve needed noise reduction or gain more benefits (if there are more receptors, such as for a 2nd row case), which may or may not increase CPBR/APBR |
| Noise Reduction Design Goal (NRDG), dB | Increases | Decreases | A higher goal may be more difficult to achieve depending on cross-section (e.g., receptors higher than road). The taller heights needed to achieve that goal will increase barrier costs or area and possibly cause CBPR or APBR to exceed CE criterion. However, taller heights may lead to more benefited receptors, reducing the CPBR or APBR or offsetting the increase in the cost. |
| NRDG minus Benefited Noise Reduction, dB | Decreases | Decreases | As difference increases, more benefits are likely for a given design, if there are more receptors to benefit (e.g., 2nd row). |
| NRDG – Number or Percentage | Increases | Decreases | A higher value may be more difficult (or impossible) to achieve, requiring a taller and/or |

Continued on next page

**Table 15. Relationships of Feasibility and Reasonableness Factors to Barrier Likelihood.**

| Criterion and Factor | Change in Factor | Resultant Change in Barrier Likelihood | Reason |
|---|---|---|---|
| | | | longer barrier, increasing area and cost, possibly causing CBPR or APBR to exceed criterion, but also possibly leading to more benefited receptors, thus reducing CPBR or APBR or offsetting increase in the cost. |
| NRDG – Number or Percentage | Changes from "all rows" to "first-row only" benefits | Increases | Eliminates need to achieve criterion beyond first-row – less height, length, area and cost, and a lower CPBR/APBR. |
| NRDG – Number or Percentage | Changes from "first-row only" to "all rows" benefits | Decreases | More height, length, and thus area and cost may be needed to achieve criterion beyond first-row – higher CPBR/APBR. |
| CPBR | Increases | Increases | Allows for a taller/longer wall with a higher cost to meet the CPBR criterion. Fewer benefits are required as CPBR increases. |
| Unit Cost, $/SF | Increases | Decreases | Total cost and CPBR increase, making design more likely to exceed a CPBR criterion. Not a factor for APBR criterion (cost will be dealt with later in the project). |
| APBR or CPBR/Unit Cost | Increases | Increases | Allows for taller/longer wall with a greater area to meet the APBR criterion. Fewer benefits are required as APBR increases. |

Table 16 presents the expected direction of the outcome of a decision on a barrier – more or less likely to be positive - as a function of the magnitude (low or high) of each factor in the feasibility and reasonableness criteria.

**Table 16. Relationships of Feasibility and Reasonableness Factors to Barrier Decision.**

| Factor | Barrier decision is… | |
|---|---|---|
| | **More likely to be positive if factor is...** | **Less likely to be positive if factor is…** |
| Feasibility noise reduction, dB | Low | High |
| Feasibility number | Low | High |
| Feasibility percentage, first-row only | Low | High |
| Feasibility percentage, all rows | Low | High |
| Receptors considered for feasibility | First-row only | All rows |
| Benefited noise reduction, dB | Low | High |
| NRDG, dB | Low | High |
| NRDG number | Low | High |
| NRDG percentage, first-row only | Low | High |
| NRDG percentage, all rows | Low | High |
| Receptor considered for NRDG | First-row only | All rows |
| Difference between NRDG and benefited noise reduction, dB | Higher | Lower |
| Unit Cost, $/SF | Low | High |
| CPBR, $/benefited receptor | High | Low |
| APBR, SF/benefited receptor | High | Low |

Table 17 and Table 18 then present different combinations of high or low values for the various factors that would be more likely to result in a negative or a positive decision on abatement.

Not shown is the case of when the benefited noise reduction *equals* the NRDG. In this case, the type and values of the NRDG quantity (number of benefited receptors, percentage of first-row benefits or percentage of first-row benefits) do not matter. If a receptor meets the benefited noise reduction, it therefore also meets the NRDG. Thus, 100% of all benefited receptors (first-row or otherwise) will always meet the NRDG by that fact that the two level reduction criteria have the same value.

**Table 17. Combinations of Factors More Likely to Result in *Negative* Abatement Decisions.**

| First Factor | Second Factor |
|---|---|
| High feasibility noise reduction (e.g., > 7 dB) and… | High feasibility quantity (e.g., > 60%) → geometry may limit needed noise reductions for high percentages; or more height/length increases area, maybe adds benefits, but may also raise APBR. |
| | Feasibility quantity based on all impacts, rather than first-row only → geometry may limit needed noise reductions for more distant impacts. |
| | High benefited noise reduction (e.g., > 7 dB) → fewer benefits or more area, leading to higher APBR. |
| | Higher NRDG → more height, more area, maybe more benefits, but also maybe higher APBR. |
| | High NRDG percentage based on all benefits, rather than first-row only (e.g., > 60%) → more height, more area, more benefits, but also maybe higher APBR. |
| | Low APBR (e.g., < 1,000) → high feasibility noise reduction leads to more area and higher calculated APBR. |
| High percentage for feasibility based on all impacts (e.g., > 60% of all impacts) and… | High benefited noise reduction (e.g., > 7 dB) → need more benefits, raising area and calculated APBR. |
| | High NRDG percentage based on all benefits, rather than first-row only (e.g., > 60%) → need more height to get more benefits, raising area, leading to more benefits, but also maybe higher APBR. |
| | Low APBR (e.g., < 1,000) → high feasibility percentage of all impacts leads to more area and higher calculated APBR. |
| High NRDG (e.g., > 8 dB) and… | Very high NRDG percentage if based on *first-row* benefits (e.g., > 75%) → need more area to get more first-row benefits with higher noise reductions, possibly increasing APBR. |
| | High NRDG percentage if based on *all* benefits, rather than first-row only (e.g., > 60%) → need more height to get more benefits with higher noise reductions, raising area, leading to more benefits, but also maybe higher APBR. |
| | Same benefited noise reduction → need more height to get more benefits with higher noise reductions, raising area, leading to more benefits, but also maybe higher APBR. |
| | Low APBR (e.g., < 1,000) → need more height to get higher noise reductions, raising area, leading to more benefits, but also maybe higher APBR. |
| High percentage for NRDG based on all benefits (e.g., > 60% of all benefits) and… | High benefited noise reduction → need more height to get higher noise reductions for high percentage, raising area, and possibly raising APBR. |
| | Low APBR (e.g., < 1,000) → need more height to get more benefits, raising area, and possibly raising APBR. |
| High benefited noise reduction (e.g., > 7 dB) and… | Low APBR (e.g., < 1,000) → need more height to get more noise reduction to raise benefit count, raising area, and possibly raising APBR. |

Continued on next page

**Table 18. Combinations of Factors More Likely to Result in *Positive* Abatement Decisions.**

| First Factor | Second Factor |
|---|---|
| Low feasibility noise reduction (e.g., 5 dB) and… | Low feasibility quantity (e.g., 1-3 or < 25%) based on only first-row impacts → easy to achieve in most cases at lower heights and less area, leading to low calculated APBR. |
| | Low benefited noise reduction (e.g., 5 dB) → more benefits and/or lower height / length, lower area, lower APBR. |
| | Low NRDG quantity (e.g., 1-3 or < 25%) based on only first-row benefits → easy to achieve in most cases at lower heights and less area, leading to low calculated APBR. |
| | High APBR (e.g., > 1,800) → low feasibility noise reduction does not force greater heights which would lead to more area and a higher calculated APBR. |
| Low quantity for feasibility based on first-row impacts only (e.g., 1-3 or < 25%) and… | Low benefited noise reduction (e.g., 5 dB) → need less height and area to get needed benefits, and possibly lowering calculated APBR |
| | Low NRDG quantity based on first-row benefits only (e.g., 1-3 or < 50%) percentage → need less height to get lower noise reduction for fewer benefits, lowering area, and possibly lowering calculated APBR. |
| | High APBR (e.g., > 1,800) → low feasibility quantity for first-row impacts only does not force greater heights which would lead to more area and a higher calculated APBR. |
| Low NRDG (e.g., 7 dB) and… | Low NRDG quantity based on first-row benefits only (e.g., 1-3 or < 50%) percentage → need less height to get lower noise reduction for fewer benefits, lowering area, and possibly lowering calculated APBR. |
| | Low benefited noise reduction (e.g., 5 dB) → need less height and area to get needed benefits, and possibly lowering calculated APBR. |
| | High APBR (e.g., > 1,800) → low NRDG means less height and area needed for lower noise reductions, probably leading to lower calculated APBR. |
| Low NRDG number or percentage based on first-row benefits (e.g., 1-3 or <50%) and… | Low benefited noise reduction (e.g., 5 dB) → need less height and area to get needed quantity of benefits, and possibly lowering calculated APBR. |
| | High APBR (e.g., > 1,800) → low NRDG number or first-row percentage means less height and area to get needed quantity of benefits, probably leading to lower calculated APBR. |
| Low benefited noise reduction (e.g., 5 dB) and… | High APBR (e.g., > 1,800) → low benefited noise reduction means more benefits for a given height and area, leading to lower calculated APBR. |

## 2.3 CHAPTER SUMMARY

This chapter examines the range in values for the noise abatement feasibility and reasonableness criteria used in the various SHA noise policies, both individually and in combination. It also examines the relationships between these factors in a qualitative fashion.

One outcome is the realization that when benefited noise reduction in dB is equal to the NRDG in dB, the NRDG quantity is irrelevant- by definition of the equal values, 100% of all benefited receptors will meet the NRDG.

One other important outcome is that the use of a CPBR for the CE reasonableness criteria is problematic. The meaningfulness of the value for the criterion depends entirely on the unit cost of abatement used in determining the total abatement cost of a proposed abatement measure. Two SHAs with identical CPBR criteria will reach different decisions on reasonableness if one uses a low unit cost resulting in a low CPBR while another uses a high unit cost, resulting in a high CPBR, which would be more likely to exceed the allowable amount.

The normalization of the CPBR into a barrier surface area in square feet per benefited receptor by dividing by the unit cost eliminates the variability between different SHAs' policies introduced by varying unit costs. This normalization was necessary in this study to allow comparison of different CE criteria.

Two comments do need to be made on the variation in unit costs and CPBR:

1. When comparing between SHAs, many SHAs do use their own historical data as the basis for their unit cost estimates, which would lead to an accurate representation *for that SHA.* What is good for one SHA may not necessarily be good for another. The normalization into an APBR for the purposes of this study's analysis is not meant to say that one SHA's unit cost or CPBR is better than another's, but that the normalization makes it easier to see and compare the wide range in area-based values between SHAs.

2. Some SHAs, such as WSDOT, account for what it terms "atypical" costs in the reasonableness evaluation: for example, when extra footing costs are needed for a barrier on a steep slope. For this reason, WSDOT has cost effectiveness criteria based on both cost and area. Cost is recommended for evaluation of reasonableness when these "extra" atypical costs are involved. Those costs are added to the numerator in the cost effectiveness formula of [barrier cost / number of benefited receptors], raising the CPBR for the barrier, making it less likely that the values with fall below the CPBR criterion.

Some SHAs use an APBR directly in their policies. In the revision of its noise policy, PennDOT decided to use an area-based criterion (which it called MaxSF/BR). PennDOT identified the following advantages associated with its use,[6]which are worthy of consideration by FHWA and other SHAs:

- "The maximum amount (square footage) of noise barrier provided for each benefited receptor (MaxSF/BR value) remains constant for citizens residing throughout the variety of communities within Pennsylvania, helping to assure 'environmental justice.'[7]"

[6]*Development of PennDOT Feasibility and Reasonableness Criteria*, Working document, PennDOT, September 15, 2010.

[7] While PennDOT uses an area-based criterion, the use of a constant CPBR statewide would also ensure environmental justice compliance. One might argue that a better term than environmental justice might be

- "The MaxSF/BR value is independent of regionally influenced labor or material cost factors."
- "The MaxSF/BR value is not influenced by conditions (and related cost variations) under which the barriers are being constructed, including construction under traffic, time limitations, weather-related conditions, number of construction seasons, accessibility restrictions, timing of barrier construction within the overall project, etc. All of these factors can influence the unit price bid for one or all noise barrier components."
- "The MaxSF/BR value is not influenced by the variation of unit prices of various contractors bidding on the same project. Such variations can be influenced by many factors, including how a particular bidder chooses to establish his cash flow related to the project, how he chooses to "balance" his bid, etc."
- "The MaxSF/BR value remains consistent for all types of projects – those on new location, reconstruction projects, special (demonstration) projects, and Type II projects (should a Type II program ever be initiated)."
- "The MaxSF/BR approach eliminates the comparison (and sometimes perceived inconsistencies) of constant values (both cost per square foot of barrier and maximum cost per benefited receiver) used in determination of barrier reasonableness with the widely variable bid-related values associated with noise barrier construction.
- "The MaxSF/BR approach eliminates the need to assess escalation costs (which can vary widely) related to noise barrier costs."
- "The MaxSF/BR approach eliminates the need to determine which items are and are not included in "reported" cost per square foot values used in the cost effectiveness calculations. Aside from the above-discussed factors which influence reported barrier costs, items such as design costs, mobilization costs, insurance, maintenance and protection of traffic, etc. are sometimes added to the more standard costs associated with production, transportation, and erection of noise barriers. For projects where the main or only purpose is to erect noise abatement devices, the cost per square foot value may actually be reported as the total contract price divided by the sound barrier square footage value. It is usually unclear what specific items are actually included in a reported cost per square foot value."
- "The MaxSF/BR approach is not influenced by "inflated" prices which may be influenced by lack of competition associated with a particular barrier type."
- "The MaxSF/BR value approach lends itself to a more equitable noise barrier cost reasonableness value tracking and inventory process, a requirement of the revised 23 CFR 772. This will also help to assure that any changes in noise policy related to the cost reasonableness value will not be arbitrary, but will be based on the consideration of all factors associated with the initial development of the value."

TDOT and NCDOT use sliding scale forms of APBR which involve the calculation of an APBR for each study area based on the different factors.

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environmental consistency because, sometimes, environmental justice involves doing more for one community than for another.

This chapter also examines the factors that influence the criterion values for feasibility and reasonableness. The results highlight the disparities that can occur based on the different SHA requirements for noise reduction. It is important to point out that FHWA gave the discretion and autonomy to each SHA (with FHWA approval) to determine its own reasonableness and feasibility criteria for noise abatement. Part of the problem is that the SHAs did not have the benefit of research such as that presented in this report to test or see the implications of their decisions on the criteria. Regardless, it may now be beneficial for the FHWA to establish certain limitations on such criteria so that the range of disparities is not as great.

One key feasibility factor is the quantity (either number or percentage) of impacted receptors. Of particular importance is whether the criterion is based on only first-row or all impacted receptors. In general, if the scenario being studied involves impacts beyond the first-row, it is more difficult to meet a given percentage at all of the impacted receptors than at just the first-row impacted receptors.

Another important factor for both feasibility and reasonableness is the amount of noise reduction provided to receptors. Noise reduction depends on many factors, key of which are barrier height and length and distances from the road to the barrier and the barrier to the receptor.

A critical factor for reasonableness is the quantity of benefited receptors, both for the NRDG and CE criteria. For NRDG, it is especially critical when that quantity is expressed as a percentage of all benefited receptors needed to meet the NRDG. As the barrier design changes, the number of *benefited* receptors can change, assuming that one is doing a design based on the NRDG. Some SHAs design based on the feasibility criterion, which is a function of impacted receptors, even though the feasibility noise reduction is limited in the regulation to 5 dB. The goal is to use the feasibility criterion as a mechanism for trying to provide some abatement to all impacts, while using the NRDG to lead to a design that provides greater noise reductions for some of the benefited receptors.

The more typical or traditional interpretation has been that feasibility analysis is simply a screening prior to reasonableness analysis, where the designing occurs. Thus, the number of benefited receptors is identified during the reasonableness analysis. In such a case, with an NRDG criterion based on a percentage of all of the *benefited* receptors, the minimum number needed to meet the criterion becomes a moving target, changing as the design changes. Additionally, as the design changes, the total needed cost or area will change.

Basing the NRDG criterion on the percentage of all benefited receptors can result in counter-intuitive results, such as where a barrier that is reasonable when only one row of houses is present becomes not reasonable when additional rows of houses are introduced even though the noise reductions to the first-row houses do not change. A strong case can be made for basing the NRDG on a percentage of impacted receptors, or, less desirable, a percentage of the benefited *first-row* residences.

This chapter also provided guidance on the expected likelihood of a barrier as the key factors increased or decreased in value individually, as well as for high and low values of pairs of factors.

# CHAPTER 3. TESTING THE RESULTS FOR THE FOUR ABATEMENT FEASIBILITY AND REASONABLENESS FACTORS, EXCLUDING VIEWPOINTS

In this chapter, the results of the findings of Chapter 2, for the four studied feasibility and reasonableness factors, were tested by performing a sensitivity analysis. The purpose was to identify outcomes of possible combinations of factors and apply the combinations in a sampling of existing highway projects with abatement.

## 3.1 SENSITIVITY ANALYSIS

As has been seen, there are a wide variety of combinations of the various factors in the reasonableness criteria. The previous chapter examined them and their relationships in a qualitative fashion. This section presents a more quantitative and analytical examination in the form of a sensitivity analysis.

### 3.1.1 Factors Studied

In order, four factors were studied:

1. Benefited noise reduction
2. NRDG in dB
3. NRDG quantity in terms of the number and percentage of benefited receptors
4. APBR

Ranges were defined for these factors, and the various resulting combinations were identified. Several scenarios were then developed and modeled with the FHWA Traffic Noise Model Version 2.5 (FHWA TNM) noise prediction program, which is specified in the regulation for use on federal and federal-aid highway projects.

The results of these modeling cases were then applied to the combinations of the factors to determine the resulting decision on reasonableness. For a barrier to be reasonable in this analysis,

- The NRDG had to be met for the specified number or percentage of benefited receptors, and
- The APBR had to be met.

The ranges in the factors were as follows:

- Benefited noise reduction: values from 5 dB up to the NRDG (for example, for a 7 dB NRDG, the regulation allows the benefited noise reduction to be 5, 6 or 7 dB)
- NRDG, ranging from 7 dB to 10 dB (7, 8, 9 and 10 dB), as permitted in the regulation
- NRDG quantity in terms of the number and percentage of benefited receptors

  - For the number of benefited receptors, values 1, 2 and 3 were used
  - For the percentage of benefited receptors, two situations were studied:
    - The percentage of *first-row* benefited receptors only, using 10%, 50%, 67% and 80%, and
    - The percentage of *all* of the benefited receptors, using 10%, 25%, 50%, 67% and 80%.
- APBR: A range of values from 500 to 2,800 SF/ benefited receptor (500, 1000, 1,500, 2,000 and 2,800)

The percentage ranges for both the first-row and all receptors were derived from the ranges in values in the SHA policies. The APBR values were also based on the ranges in the values used by the SHAs in their policies.

Use of the above values for these different factors resulted in 1,080 different criteria combinations to be analyzed.

### 3.1.2 Modeled Scenarios

In order to study these combinations for a variety of receptor scenarios with FHWA TNM, a four-lane divided highway model was created. The basic scenario consisted of two travel lanes in each direction. Each travel direction was modeled by a single FHWA TNM roadway with a width computed based on two travel lanes and paved shoulders, not by a FHWA TNM roadway for each travel lane. The difference was not felt to be significant for the purposes of this study. See Figure 7 for a plan view (from above) and a cross-sectional view of the roadway and noise barrier portion of the model.

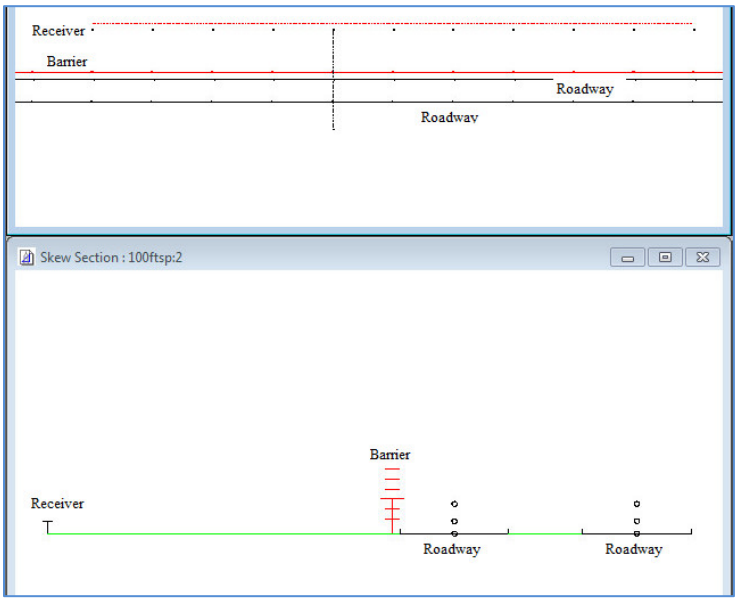



**Figure 7. Plan view (top) and cross-sectional view (bottom) of roadways and noise barrier portion of FHWA TNM model for sensitivity test cases.**

Each FHWA TNM roadway carried 3,600 vehicles per hour per direction. The traffic was divided into 88% automobiles (3,168 veh/hr), and 12% trucks (two-thirds heavy trucks (288 veh/hr) and one-third medium trucks (144 veh/hr)). The travel speed was 65 miles per hour.

The noise barrier was located at the edge of the shoulder.[8] "Lawn grass" ground cover and a flat site (elevation of 0 feet and no roadway grade) were assumed, with a grassy median between the two directions of travel. For each of the cases, a range of six barrier heights was examined: 6, 10, 14, 18, 22, and 26 feet.

Several receptor scenarios were modeled:

- Varying receiver density
- Varying number of rows of receptors
- Different distances back from the barrier to the first-row of receptors

Figure 8 shows that two different distances back from the barrier to the first-row of receptors were used. The assumption was that the barrier was located on the edge of the roadway shoulder and that there was 40 feet of right-of-way space from the barrier to the property line. The distances were:

- 90 feet (thus 50 feet back from the property line)
- 140 feet (thus 100 feet back from the property line)

Eleven FHWA TNM receiver points[9] per row were placed at 200-foot spacing along a line parallel to the roadway over a distance of 2,000 feet. Figure 9 shows the receiver portion of the FHWA TNM model. In the analysis, each receiver was assigned to represent:

- One receptor, for a receptor spacing of 200 feet and a total of 11 receptors per row
- Two receptors, for a receptor spacing of 100 feet and a total of 22 receptors per row
- Four receptors, for a receptor spacing of 50 feet and a total of 44 receptors per row

In each case, levels were calculated at only eleven FHWA TNM receiver points per row.

The shielding provided by the rows of houses was modeled in FHWA TNM by placing a TNM "building row" object between the first and second and between the second and third rows of

[8] A member of the TWG notes that some states rarely place noise barriers on the edge of the shoulder and questions if this locational assumption could affect the results. Barrier placement will most likely affect the results, as will the intervening terrain and the elevations of the roadway and the ground at the receptor and at the barrier (which in turn affects barrier height and cost). It was beyond the scope to test a variety of different cross-sections and barrier locations. The potential effect on the results is acknowledged. It should also be noted that the trends should not change – such as the effects of high or low APBR criteria on reasonableness, as will be discussed

[9] The terminology used is as follows: a "receiver" is a point in an FHWA TNM model at which a sound level is calculated ("predicted"); a "receptor" represents an activity area being studied. A receiver point can, in many cases, represent more than one receptor, such as two or three adjacent houses at the same distance from the road.

receptors. The building row blockage percentages for the three receptor spacings of 50, 100, and 200 feet were chosen as 40%, 60% and 80%, respectively.

Thus, a total of 108 scenarios were studied (3 receptor spacings x 3 building row cases x 2 distances back from the barrier x 6 barrier heights). The result of examining the 1,080 combinations of reasonableness parameters for these 108 cases yielded a total of 116,640 decisions on barrier reasonableness.

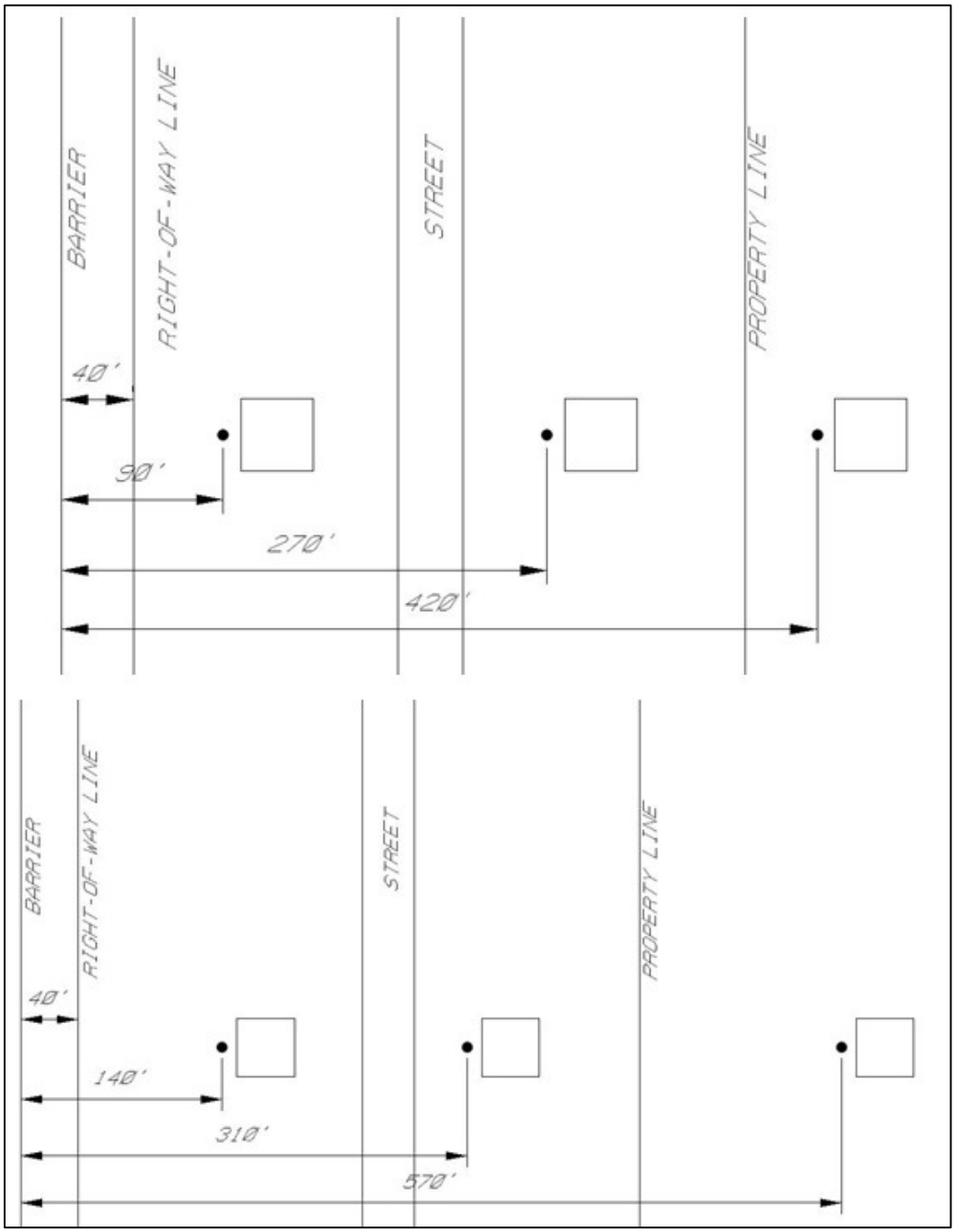



**Figure 8. Sketches of receptor scenarios used in modeling the sensitivity test cases for first-row receptors 90 feet (top) and 140 feet (bottom) from barrier.**

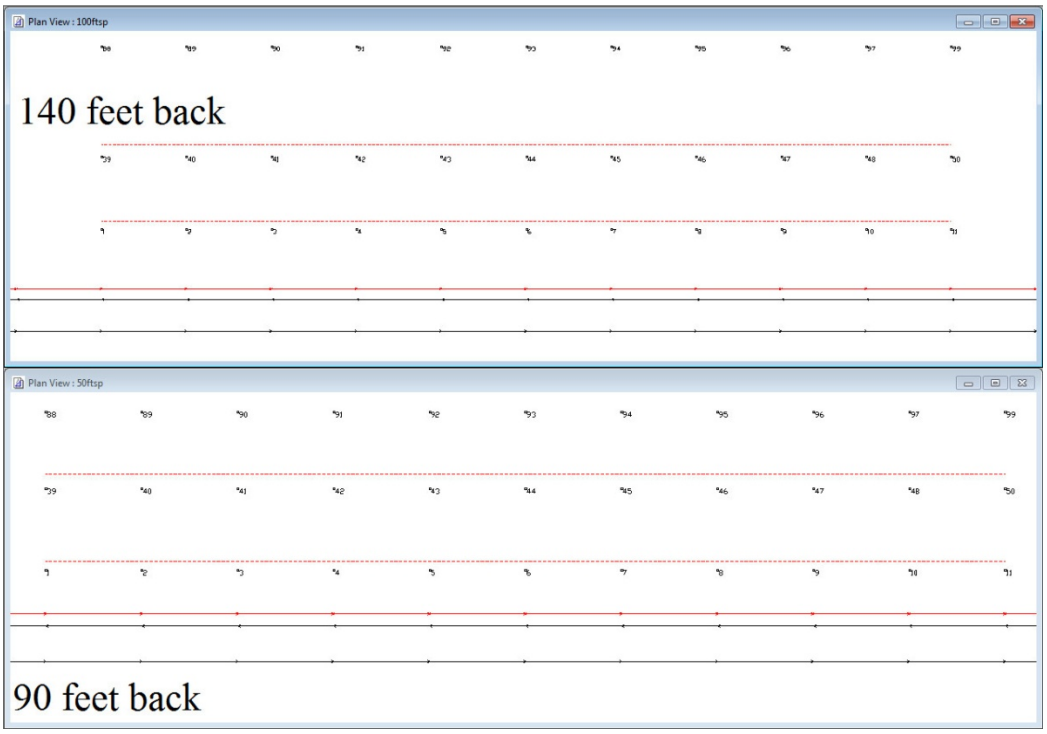



**Figure 9. TNM plan view plots of receptor scenarios in FHWA TNM model for sensitivity test cases: 140 feet back (top) and 90 feet back (bottom).**

### 3.1.3 Outcomes of Possible Combinations of Factors on the Likelihood of Abatement

These results of being reasonable or not being reasonable were arrayed in a color-coded spreadsheet of 1,080 rows by 108 columns, capable of being sorted by different factors. The goal was to be able to use this array to see the trends that emerge in the patterns of the decisions. It was a challenge to display this entire array in report format in a meaningful way, although the resulting series of charts should be useful. The spreadsheet developed for this analysis is available as a deliverable for this task. Some examples of the contents and how they can be used are illustrated below, followed by presentation of the array and discussion of the broader findings.

Figure 10 shows a very small portion of the upper left corner of the spreadsheet. The first five columns represent the reasonableness factors being varied. The rows are sorted first by NRDG, then by benefited noise reduction, then by NRDG type, then by value for the NRDG type, and finally by APBR. For all of the rows shown in this example, the NRDG is 7 dB and the benefited noise reduction is 5 dB. The NRDG type has one of three codes:

- N (in green) to indicate that NRDG number/percent will be the needed *number* of benefited receptors.
- P1 (in yellow) to indicate that NRDG number/percent will be the needed *percentage of first-row* benefited receptors, or
- PA (in red) to indicate that NRDG number/percent will be the needed *percentage of all benefited* receptors

The top rows indicate the scenarios being studied:

- A sequential case number
- The receptor spacing (50, 100 or 200-foot); in this sample all are at 50 feet
- The distance back to the first-row (50 or 100 feet back from the right-of-way line, representing 90 or 140 feet from the barrier); in this example all are at 50 feet
- The number of building rows (1, 2 or 3); in this sample the first six columns are for one row and the last two are for two rows, and
- The barrier height (6 to 26 feet in 4-foot increments)

Then, the green and yellow cells at the intersection of a row (combination of criterion factors) and a column (the scenario being studied) indicate the reasonableness decision of Yes or No, respectively. These answers are further coded by the deciding factor: i.e., number or percentage of receptors (-n, -p1, -pa) or APBR (-c).

Even in this small portion of the array, trends start to emerge. A 6-foot high barrier was shown to be reasonable for none of the combinations of factors (no receptors had a noise reduction at or above the 7 dB NRDG). Also, in none of the cases shown was a barrier reasonable for an APBR of 500 SF/benefited receptor, regardless of the barrier height (there were too few benefited receptors for these six one-row cases and two two-row cases, even at 50-foot spacing to achieve an APBR that low).

| | | | | Case | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Receptor spacing | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| | | | | Distance back | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| | | | | Building rows | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | | | | Height | 6 | 10 | 14 | 18 | 22 | 26 | 6 | 10 |
| **NRDG** | **Ben NR** | **NRDG type** | **NRDG #/%** | **APBR (CPBR/UC)** | **Is barrier reasonable?** | | | | | | | |
| 7 | 5 | N | 1 | 500 | no-n | NO-c | NO-c | NO-c | NO-c | NO-c | no-n | NO-c |
| 7 | 5 | N | 1 | 1000 | no-n | YES-n | YES-n | YES-n | NO-c | NO-c | no-n | YES-n |
| 7 | 5 | N | 1 | 1500 | no-n | YES-n | YES-n | YES-n | YES-n | YES-n | no-n | YES-n |
| 7 | 5 | N | 1 | 2000 | no-n | YES-n | YES-n | YES-n | YES-n | YES-n | no-n | YES-n |
| 7 | 5 | N | 1 | 2800 | no-n | YES-n | YES-n | YES-n | YES-n | YES-n | no-n | YES-n |
| 7 | 5 | N | 2 | 500 | no-n | NO-c | NO-c | NO-c | NO-c | NO-c | no-n | NO-c |
| 7 | 5 | N | 2 | 1000 | no-n | YES-n | YES-n | YES-n | NO-c | NO-c | no-n | YES-n |
| 7 | 5 | N | 2 | 1500 | no-n | YES-n | YES-n | YES-n | YES-n | YES-n | no-n | YES-n |
| 7 | 5 | N | 2 | 2000 | no-n | YES-n | YES-n | YES-n | YES-n | YES-n | no-n | YES-n |
| 7 | 5 | N | 2 | 2800 | no-n | YES-n | YES-n | YES-n | YES-n | YES-n | no-n | YES-n |
| 7 | 5 | N | 3 | 500 | no-n | NO-c | NO-c | NO-c | NO-c | NO-c | no-n | NO-c |
| 7 | 5 | N | 3 | 1000 | no-n | YES-n | YES-n | YES-n | NO-c | NO-c | no-n | YES-n |
| 7 | 5 | N | 3 | 1500 | no-n | YES-n | YES-n | YES-n | YES-n | YES-n | no-n | YES-n |
| 7 | 5 | N | 3 | 2000 | no-n | YES-n | YES-n | YES-n | YES-n | YES-n | no-n | YES-n |
| 7 | 5 | N | 3 | 2800 | no-n | YES-n | YES-n | YES-n | YES-n | YES-n | no-n | YES-n |
| 7 | 5 | P1 | 10% | 500 | no-p1 | NO-c | NO-c | NO-c | NO-c | NO-c | no-p1 | NO-c |
| 7 | 5 | P1 | 10% | 1000 | no-p1 | YESp1 | YESp1 | YESp1 | NO-c | NO-c | no-p1 | YESp1 |
| 7 | 5 | P1 | 10% | 1500 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 10% | 2000 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 10% | 2800 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 50% | 500 | no-p1 | NO-c | NO-c | NO-c | NO-c | NO-c | no-p1 | NO-c |
| 7 | 5 | P1 | 50% | 1000 | no-p1 | YESp1 | YESp1 | YESp1 | NO-c | NO-c | no-p1 | YESp1 |
| 7 | 5 | P1 | 50% | 1500 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 50% | 2000 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 50% | 2800 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 67% | 500 | no-p1 | NO-c | NO-c | NO-c | NO-c | NO-c | no-p1 | NO-c |
| 7 | 5 | P1 | 67% | 1000 | no-p1 | YESp1 | YESp1 | YESp1 | NO-c | NO-c | no-p1 | YESp1 |
| 7 | 5 | P1 | 67% | 1500 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 67% | 2000 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 67% | 2800 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 80% | 500 | no-p1 | NO-c | NO-c | NO-c | NO-c | NO-c | no-p1 | NO-c |
| 7 | 5 | P1 | 80% | 1000 | no-p1 | YESp1 | YESp1 | YESp1 | NO-c | NO-c | no-p1 | YESp1 |
| 7 | 5 | P1 | 80% | 1500 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 80% | 2000 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | P1 | 80% | 2800 | no-p1 | YESp1 | YESp1 | YESp1 | YESp1 | YESp1 | no-p1 | YESp1 |
| 7 | 5 | PA | 10% | 500 | no-pa | NO-c | NO-c | NO-c | NO-c | NO-c | no-pa | NO-c |
| 7 | 5 | PA | 10% | 1000 | no-pa | YESpa | YESpa | YESpa | NO-c | NO-c | no-pa | YESpa |

**Figure 10. Upper left portion of reasonableness decision array for the sensitivity test cases: NRDG of 7 dB, Benefited Noise Reduction of 5 dB, 50-ft receptor spacing, 50-ft distance back to first-row (90 ft from barrier), and mostly one-row cases.**

As a second example, Figure 11 shows the result of zooming out farther for the upper left corner of the decision array. The characters are not meant to be readable in this example, but the colored patterns will be discussed. The figure shows six major blocks of columns of decisions; these are all for the 50-foot receptor spacing. The first three blocks of columns are for the 50-foot distance back for cases of one, two, and three rows of houses, respectively. Then, the second three blocks of columns are for the 100-foot distance back for one, two, and three rows of houses, respectively. Within each block are columns for each of the six barrier heights.

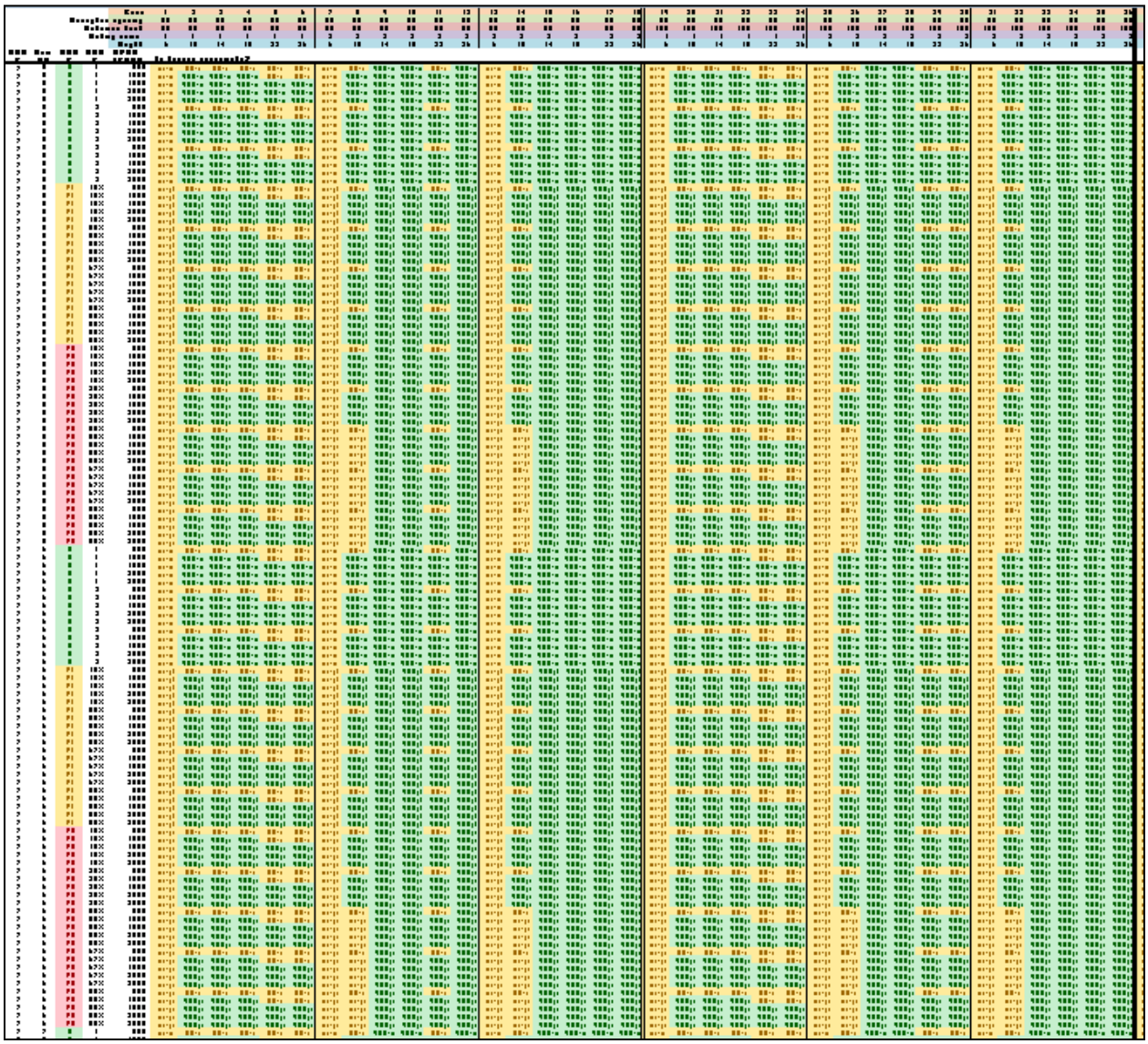


**Figure 11. Decision patterns indicated by color bands in portion of reasonableness array for 50-ft receptor spacing, NRDG of 7 dB and Benefited Noise Reductions of 5 dB (upper half) and 6 dB (lower half).**

Not shown, the array has another set of six blocks of columns to the right for the 100-foot receptor spacing, and then six more blocks for the 200-foot receptor spacing.

The rows shown in this figure are for all of the combinations with an NRDG of 7 dB and benefited noise reductions of first 5 dB and then 6 dB. Results for NRDG of 7 dB and benefited noise reduction of 7 dB would be below these results, followed by the combinations for NRDG values of 8, 9 and 10 dB.

Trends can, again, be seen:

- For none of the combinations shown was the 6-foot high barrier reasonable[10] (vertical yellow pattern; again, the NRDG of 7 dB was not achieved for this low height).
- More cases are reasonable at the taller barrier heights for two rows compared to one row, and more for three rows compared to two rows (more green and less yellow; the taller barriers are picking up second-row benefits in sufficient numbers to drive the APBR below the criterion values).
- For those cases with an APBR of 500 SF/benefited receptor, the "not reasonable" results for a one-row case (yellow horizontal bands) becomes reasonable (green) for the two-row and three-row cases, as more second row benefits are picked up, driving down the APBR.

As a third example, Figure 12 shows a very small portion of the lower right corner of the array, representing all of the combinations of factors for a high NRDG of 10 dB and a high benefited noise reduction of 10 dB. The three major blocks of columns of decisions are all for the 200-foot receptor spacing and the 100-foot distance back. The first block is for one row of houses, the second for two rows, and the third for three rows. Within each block are columns for each of the six barrier heights. For the 200-foot spacing with these high values of NRDG and benefited noise reduction, very few cases are reasonable:

- None for the cases for one-row of receptors (all yellow in the left block) – the 10 dB NRDG cannot be achieved at the lower heights, and there are not enough receptors at this low density that achieve the 10 dB reduction to be benefited to counter the high costs for the taller heights.
- Only those two-row cases at the highest APBR of 2,800 SF/ benefited receptor and barrier heights of 18 and 22 feet (green highlights in the center block) – these tall heights result in enough second-row benefits to meet the liberally high APBR despite the high cost (yet, the cost becomes too high at 26-feet because there are not enough additional benefited receptors to overcome the extra cost), and
- Some of the three-row cases with APBRs of 2,000 and 2,800 SF/ benefited receptor for barrier heights of 18, 22, and 26 feet (green highlights in the right block) – it appears that enough third-row receptors are benefited to drive down the APBR.

[10] The scenario was set up so that in no case did the 6-foot high barrier provide a noise reduction of 6.5 (rounded to 7) or more dB, so that it would not result in a decision of "reasonable."

| | | | Case | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Receptor spacing | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| | | | Distance back | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | | | Building rows | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| | | | Height | 6 | 10 | 14 | 18 | 22 | 26 | 6 | 10 | 14 | 18 | 22 | 26 | 6 | 10 | 14 | 18 | 22 | 26 |
| NRDG | Ben NR | NRDG type | NRDG #/% | APBR (CPBR/U | | | | | | | | | | | | | | | | | |
| 10 | 10 | N | 1 | 500 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | N | 1 | 1000 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | N | 1 | 1500 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | N | 1 | 2000 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | YES-n | YES-n |
| 10 | 10 | N | 1 | 2800 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | YES-n | YES-n | NO-c | no-n | no-n | NO-c | YES-n | YES-n | YES-n |
| 10 | 10 | N | 2 | 500 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | N | 2 | 1000 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | N | 2 | 1500 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | N | 2 | 2000 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | YES-n | YES-n |
| 10 | 10 | N | 2 | 2800 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | YES-n | YES-n | NO-c | no-n | no-n | NO-c | YES-n | YES-n | YES-n |
| 10 | 10 | N | 3 | 500 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | N | 3 | 1000 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | N | 3 | 1500 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | N | 3 | 2000 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | NO-c | YES-n | YES-n |
| 10 | 10 | N | 3 | 2800 | no-n | no-n | NO-c | NO-c | NO-c | NO-c | no-n | no-n | NO-c | YES-n | YES-n | NO-c | no-n | no-n | NO-c | YES-n | YES-n | YES-n |
| 10 | 10 | P1 | 10% | 500 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 10% | 1000 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 10% | 1500 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 10% | 2000 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | YESp1 | YESp1 |
| 10 | 10 | P1 | 10% | 2800 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | YESp1 | YESp1 | NO-c | no-p1 | no-p1 | NO-c | YESp1 | YESp1 | YESp1 |
| 10 | 10 | P1 | 50% | 500 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 50% | 1000 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 50% | 1500 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 50% | 2000 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | YESp1 | YESp1 |
| 10 | 10 | P1 | 50% | 2800 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | YESp1 | YESp1 | NO-c | no-p1 | no-p1 | NO-c | YESp1 | YESp1 | YESp1 |
| 10 | 10 | P1 | 67% | 500 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 67% | 1000 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 67% | 1500 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 67% | 2000 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | YESp1 | YESp1 |
| 10 | 10 | P1 | 67% | 2800 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | YESp1 | YESp1 | NO-c | no-p1 | no-p1 | NO-c | YESp1 | YESp1 | YESp1 |
| 10 | 10 | P1 | 80% | 500 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 80% | 1000 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 80% | 1500 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | P1 | 80% | 2000 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | NO-c | YESp1 | YESp1 |
| 10 | 10 | P1 | 80% | 2800 | no-p1 | no-p1 | NO-c | NO-c | NO-c | NO-c | no-p1 | no-p1 | NO-c | YESp1 | YESp1 | NO-c | no-p1 | no-p1 | NO-c | YESp1 | YESp1 | YESp1 |
| 10 | 10 | PA | 10% | 500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 10% | 1000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 10% | 1500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 10% | 2000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | YESpa | YESpa |
| 10 | 10 | PA | 10% | 2800 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | YESpa | YESpa | NO-c | no-pa | no-pa | NO-c | YESpa | YESpa | YESpa |
| 10 | 10 | PA | 25% | 500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 25% | 1000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 25% | 1500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 25% | 2000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | YESpa | YESpa |
| 10 | 10 | PA | 25% | 2800 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | YESpa | YESpa | NO-c | no-pa | no-pa | NO-c | YESpa | YESpa | YESpa |
| 10 | 10 | PA | 50% | 500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 50% | 1000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 50% | 1500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 50% | 2000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | YESpa | YESpa |
| 10 | 10 | PA | 50% | 2800 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | YESpa | YESpa | NO-c | no-pa | no-pa | NO-c | YESpa | YESpa | YESpa |
| 10 | 10 | PA | 67% | 500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 67% | 1000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 67% | 1500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 67% | 2000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | YESpa | YESpa |
| 10 | 10 | PA | 67% | 2800 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | YESpa | YESpa | NO-c | no-pa | no-pa | NO-c | no-pa | YESpa | YESpa |
| 10 | 10 | PA | 80% | 500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 80% | 1000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 80% | 1500 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c |
| 10 | 10 | PA | 80% | 2000 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | NO-c | YESpa | YESpa |
| 10 | 10 | PA | 80% | 2800 | no-pa | no-pa | NO-c | NO-c | NO-c | NO-c | no-pa | no-pa | NO-c | YESpa | YESpa | NO-c | no-pa | no-pa | NO-c | no-pa | YESpa | YESpa |

**Figure 12. Lower right portion of reasonableness decision array for the sensitivity test cases**: **NRDG of 10 dB, Benefited Noise Reduction of 10 dB, 200-ft receptor spacing, 100-ft distance back to first-row (140 ft from barrier) and one-, two- and three-row cases.**

The above three examples illustrate the content and use of the decision array in its original format, sorted by NRDG. There are many ways that the array can be manipulated and sorted. Following are the results of two sorts, each of which provides a broad picture of how the reasonableness decisions are affected by parameter changes. These two sets of figures could be used by an SHA to access potential effects of policy changes. The spreadsheet containing the array will be made available as one of the tools developed in this research, which are presented in a separate report.

### 3.1.4 Reasonableness Based Solely on NRDG

One desired outcome of this research was an understanding of the sensitivity to the NRDG value and the quantity (number or percentage) of benefited receptors needing to meet the NRDG. The

array was re-run taking APBR out of the decision process, and then sorted by the NRDG quantity. The next three figures present the results. The data are not meant to be read; the patterns of the color shading are what are of importance: green means abatement is reasonable; yellow means it is not reasonable.

Figure 13 is for the needed number of benefited receptors (N) and is divided into three horizontal sections for values of 1, 2, and 3. Each horizontal section is further divided by NRDG, which is further divided by benefited noise reduction (and further by APBR, which is not varied but was not easily removed from the array).

Figure 14 is for the needed percentage of *first-row* benefited receptors, divided into four horizontal sections for values of 10%, 50%, 67%, and 80%, with the above subdivisions by NRDG and benefited noise reduction.

Figure 15 is for the needed percentage of *all* benefited receptors, divided into five horizontal sections for values of 10%, 25%, 50%, 67%, and 80%, with the above subdivisions by NRDG and benefited noise reduction.

As illustrated and discussed for the three previous examples, each figure is divided into three major vertical sections of decisions for: 50-foot receptor spacing, 100-foot receptor spacing, and 200-foot receptor spacing. Each vertical section is divided into two subsections: 50-foot distance and 100-foot distance. Each subsection is divided into three blocks of columns for the cases of one, two, and three rows of houses. Within each block are columns for each of the six barrier heights.

Figure 13, Figure 14, and the top two sections of Figure 15 show the insensitivity of the NRDG reasonableness criterion to the NRDG quantity. The narrow vertical yellow bands are for the 6-foot barrier heights. These bands widen to include the 10-foot barrier when the NRDG increases from 7 and 8 dB to 9 and 10 dB for each of the horizontal sections in Figure 13 (values of N of 1, 2 and 3), in Figure 14 (the four percentages of first-row benefits), and for the 10% and 25% bands for “percentage of all benefited receptors” in Figure 15. This finding holds true no matter the receptor spacing, distance back from the barrier, or number of rows of receptors in the study area, at least for the range of values in the array.

As one moves down into the third horizontal band in Figure 15, the required percentage of all benefited receptors increases to 50%. Some of the 10-foot height cases for NRDG of 7 dB and 14-foot cases for NRDG of 8 dB begin to become “not reasonable” for the two-row and three-row study areas. Moving down to the 67% and 80% bands for “percentage of all benefits,” many more of the two-row and three-row cases become “not reasonable” while the one-row cases stay reasonable. These results confirm exactly what was illustrated earlier in Section 2.2.1.3. A barrier that would be reasonable for a one-row neighborhood suddenly becomes “not reasonable” if that neighborhood was instead a two-row or three-row community. Adding more houses, many of which benefit to some degree from the barrier changes the decision because it is based on “percentage of *all* benefited receptors” instead of “percentage of *first-row* benefits” or even “percentage of *impacted* receptors.”

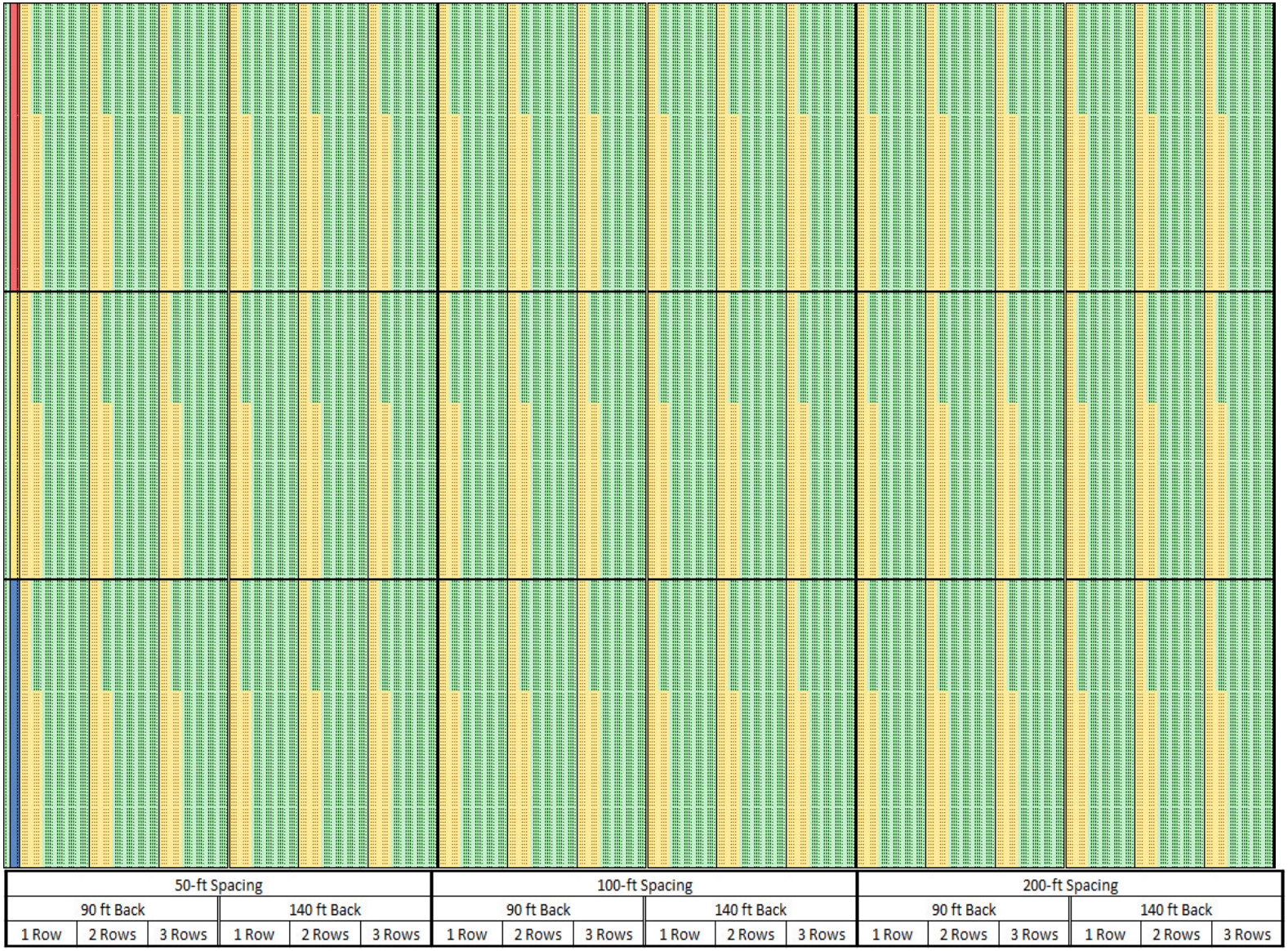



**Figure 13. Reasonableness decision array for NRDG for number of benefited receptors of 1 (top), 2 (middle), or 3 (bottom).**

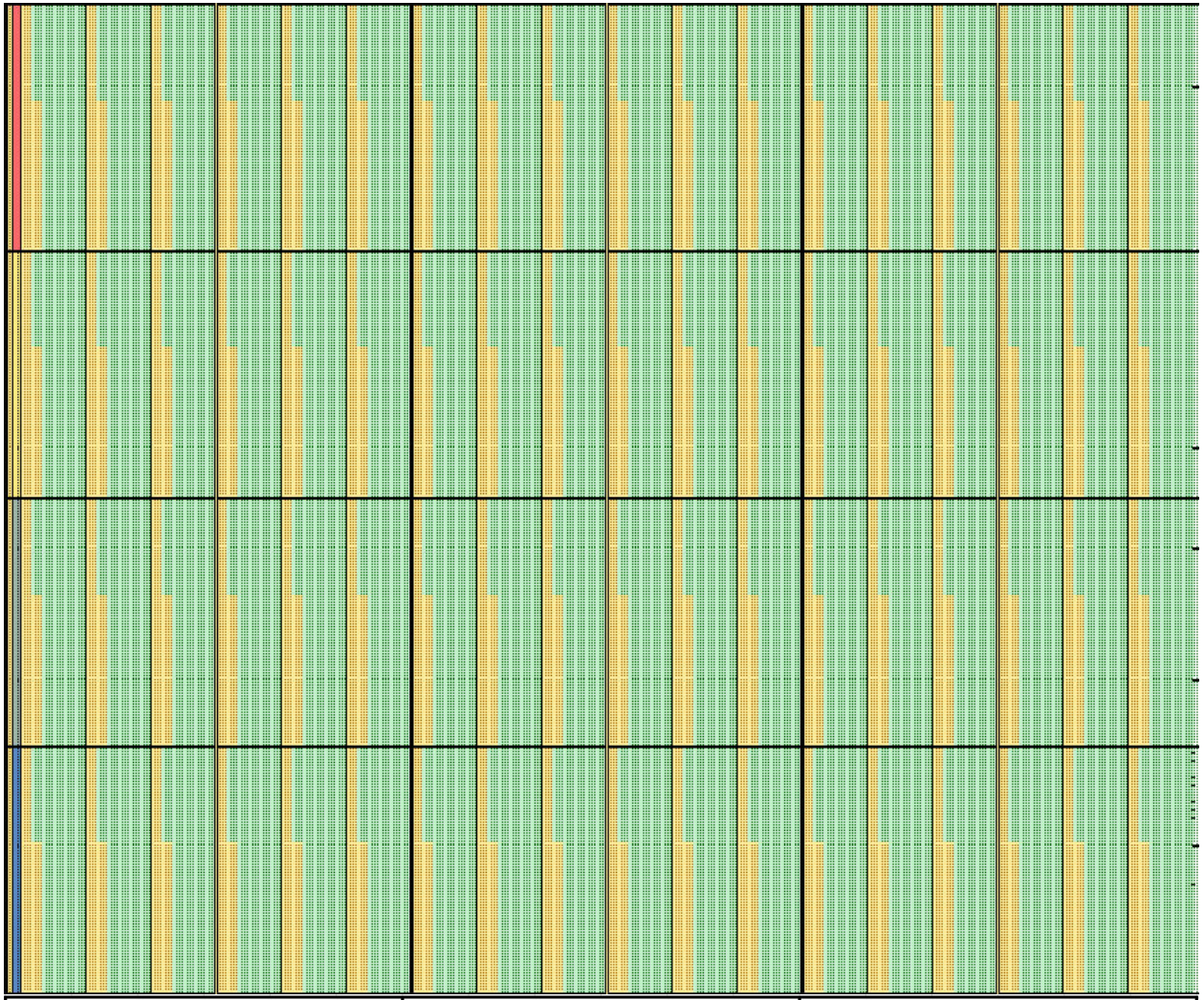



**Figure 14. Reasonableness decision array for NRDG for percentage of first-row benefited receptors, divided into four horizontal sections for values of 10%, 50%, 67%, and 80%.**

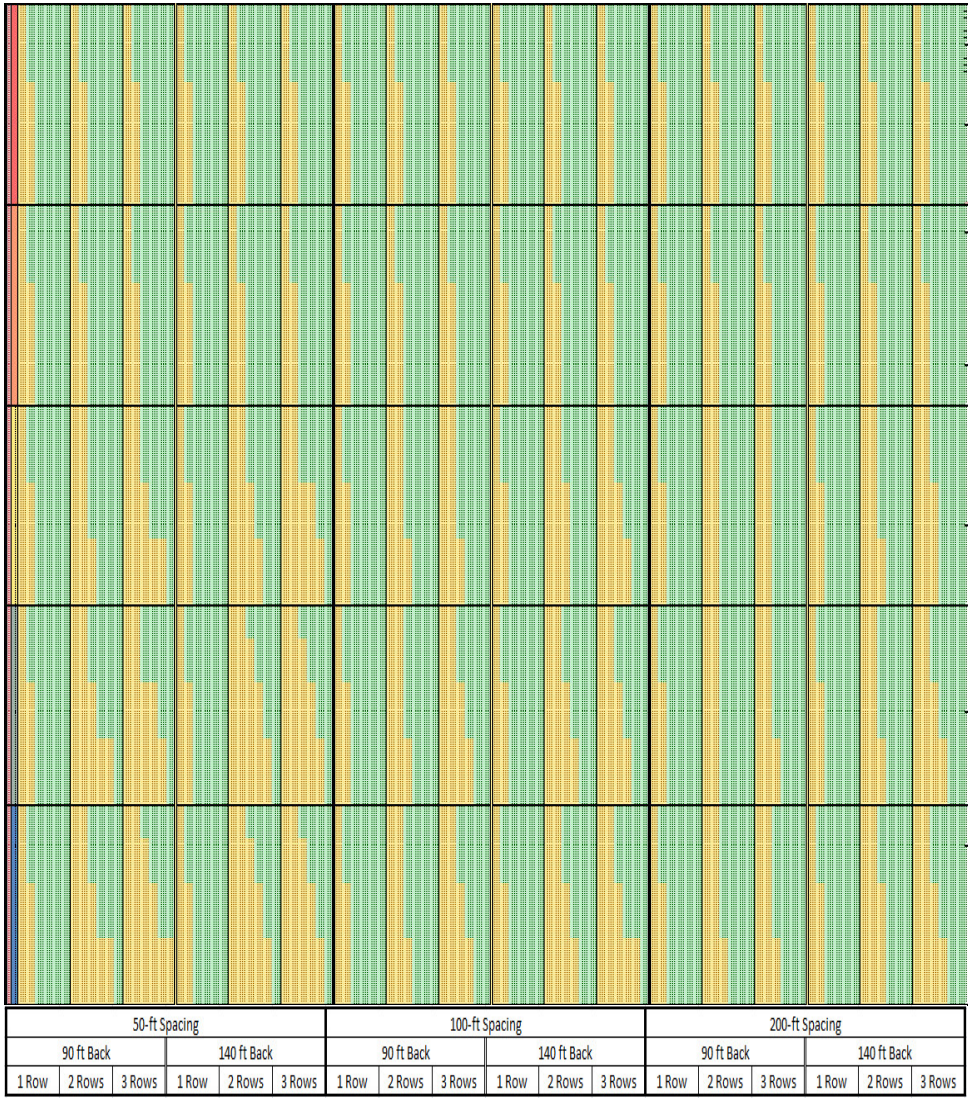



**Figure 15. Reasonableness decision array for NRDG for percentage of all benefited receptors divided into five horizontal sections for values of 10%, 25%, 50%, 67%, and 80%.**

### 3.1.5 Reasonableness Based on NRDG and APBR, Sorted by APBR

This next decision array includes both the NRDG criterion and the APBR criterion. It is divided into five figures based on APBR:

- Figure 16: APBR = 500 SF/benefited receptor
- Figure 17: APBR = 1,000 SF/benefited receptor
- Figure 18: APBR = 1,500 SF/benefited receptor
- Figure 19: APBR = 2,000 SF/benefited receptor
- Figure 20: APBR = 2,800 SF/benefited receptor

Again, the vertical sections and subsections are the same as for the previous figures. The horizontal bands are sorted first by NRDG, then benefited noise reduction, then NRDG type, and finally quantity.

The following trends can be observed while reviewing each figure.

For an APBR of 500 SF/ benefited receptor:

- None of the one-row, two-row, or three-row cases were reasonable for the 100-foot and 200-foot receptor spacings.
- None of the one-row cases were reasonable for the 50-foot receptor spacing
- Several barrier heights were reasonable for 50-foot spacing, but as the NRDG increased (moving down the horizontal bands in the figure), fewer heights were reasonable; the increase in barrier area grew proportionately faster than the number of benefited receptors meeting the NRDG.
- Combinations with high percentages of all benefits for the NRDG quantity were more likely to be “not reasonable”; these cases are evidenced by the yellow intrusions into the vertical green bands.
- For the 10 dB NRDG with the 10 dB benefited noise reduction, none of the cases for any of the receptor spacing at any height were reasonable.

For an APBR of 1,000 SF/ benefited receptor:

- None of the one-row, two-row, or three-row cases were reasonable for the 200-foot receptor spacing.
- None of the one-row cases were reasonable for the 100-foot receptor spacing. The two-row cases became reasonable for the 14- to 18-foot heights, and the three-row cases were reasonable for the 14- to 26-foot heights.

- Many more cases were reasonable for the 50-foot spacing, including for the high NRDG with high benefited noise reduction, although use of the high percentages of all benefits for the NRDG quantity continued to result in "not reasonable" decisions.

For an APBR of 1,500 SF/benefited receptor:

- For the 200-foot receptor spacing, some of the three-row cases at the middle heights of 14 to 18 feet were reasonable. The taller walls were unreasonable based on cost.
- For the 100-foot receptor spacing, the 10-foot height became reasonable for the one-row case for an NRDG of 7 to 8 dB, but no heights were reasonable when the NRDG increased to 9 to 10 dB.
- Many more of the two-row and three-row cases became reasonable for the 100-foot receptor spacing: for the two-row cases, heights from 10 to 26 feet were reasonable for an NRDG of 7 to 8 dB. However, for the NRDG of 10 dB, only the tallest heights for both the two-row and the three-row cases were reasonable; some unreasonable results for criteria combinations required 67% or 80% of all benefited receptors.
- For the 50-foot receptor spacing, many more cases became reasonable at the higher NRDG values and at the taller barrier heights.

For an APBR of 2,000 SF/ benefited receptor:

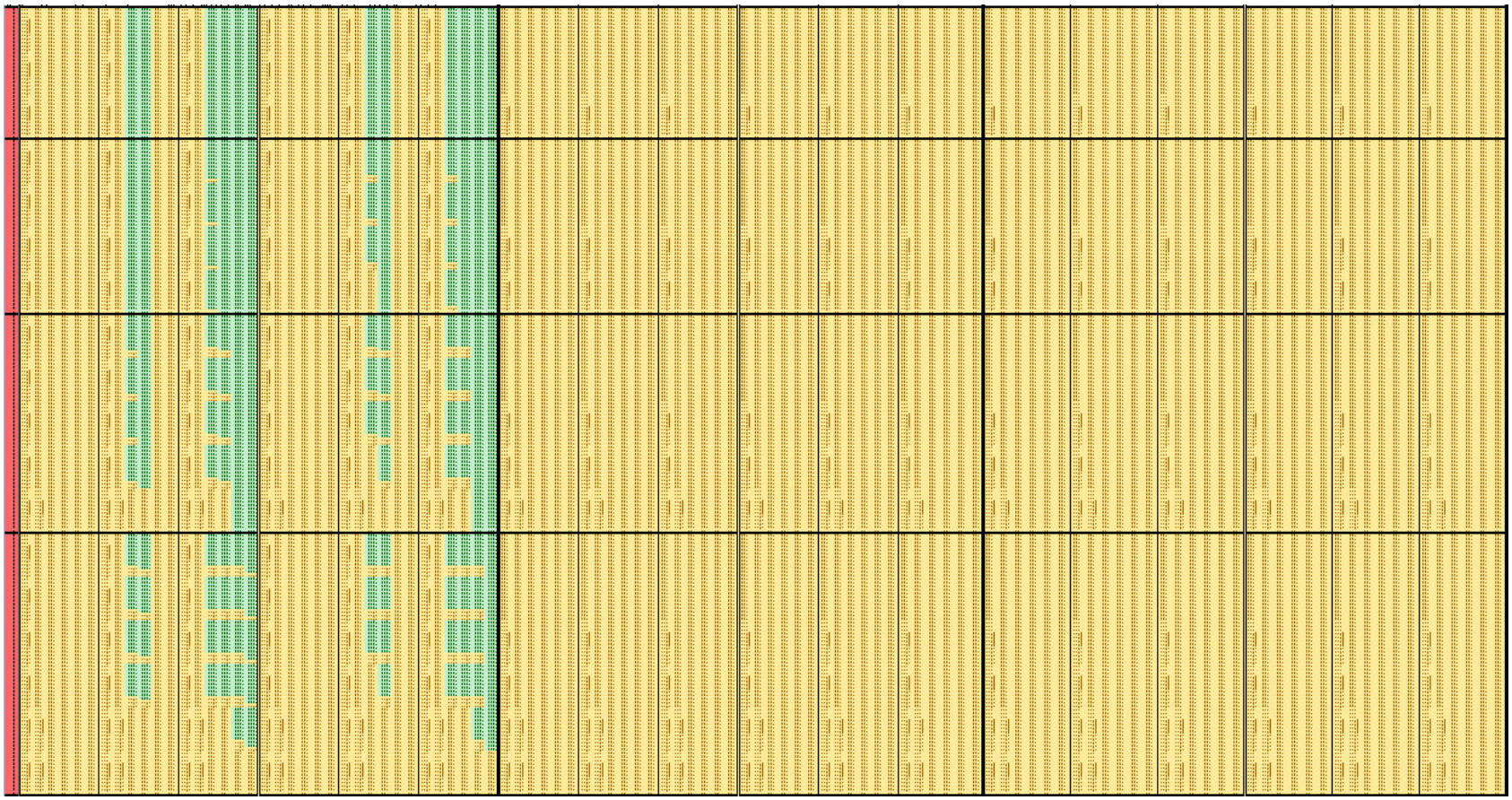
- All of one-row cases were still not reasonable for the 200-foot receptor spacing. Most of the two-row cases in the 14- to 18-foot range were reasonable. For the three-row cases, most of the heights between 14 and 26 feet were reasonable
- For the 100-foot spacing, the one-row cases were reasonable for the 10- to 18-foot range for the NRDG of 7 to 8 dB, but were only reasonable in the 14- to 18-foot range for the NRDG increased to 9 to 10 dB. For the two-row case, heights from 10 to 26 feet were reasonable for all NRDG values. For the three-row case, most of the heights between 10 and 26 feet were reasonable although some started to become unreasonable for the percentage of all rows equal to 67% and 80%
- For the 50-foot receptor spacing, more cases became reasonable at the higher NRDG values and at the taller barrier heights, even for the one-row case. The high values for "percentage of all benefited receptors" continue to result in "not reasonable" decisions.

For an APBR of 2800 SF/benefited receptor:

- For the 200-foot receptor spacing, the one-row cases became reasonable a height of 10 feet for a NRDG of 7 to 8 dB but remained not reasonable for NRDG values of 9 to 10 dB.
- For the 50-foot and 100-foot spacings, more cases at more heights became reasonable, except when the higher percentage of all benefited receptors was applied – the high

percentages continued to return negative decisions, even for cases where all of the other parameter values led to barriers being reasonable.

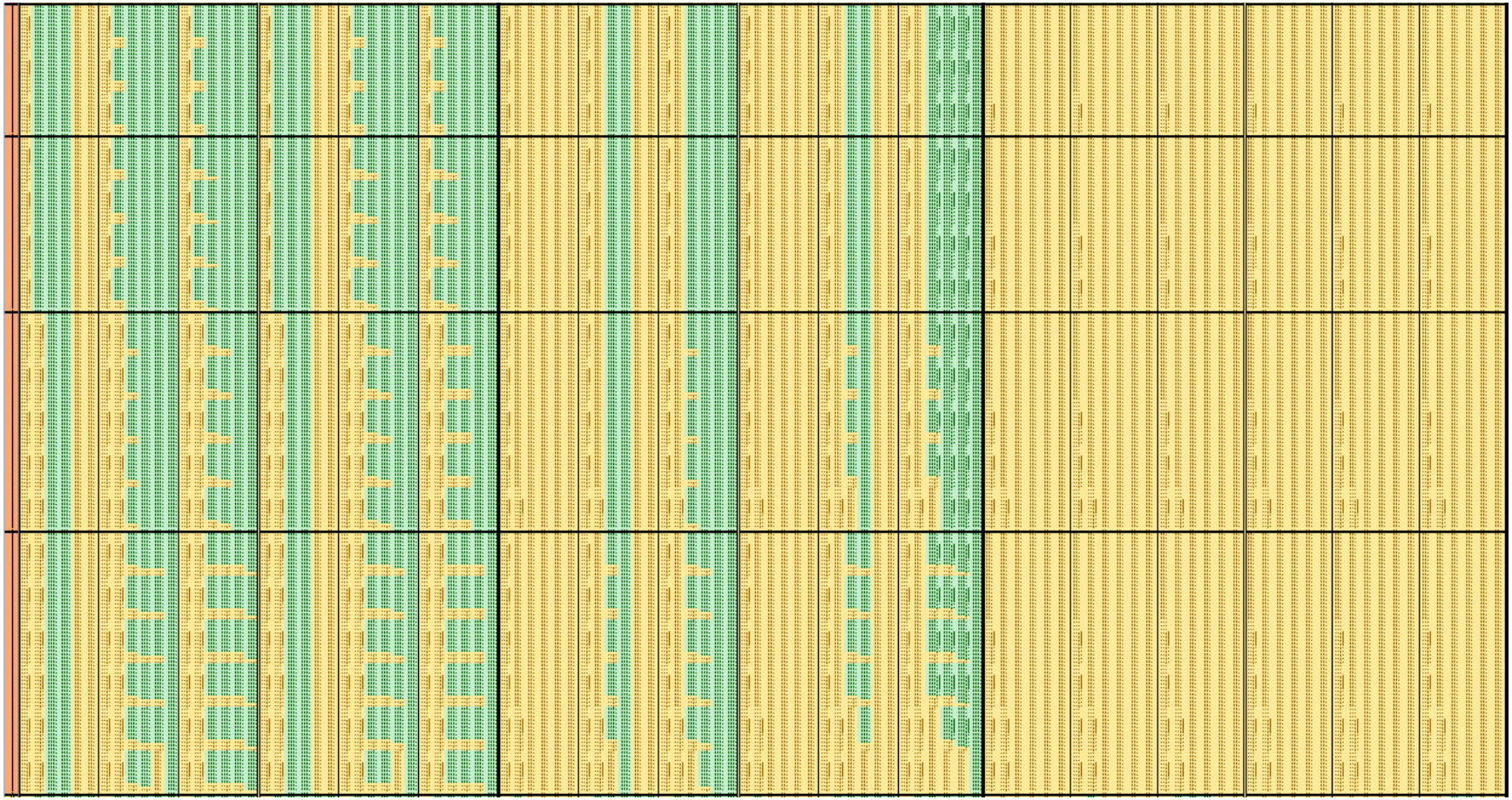
For most of the criteria combinations, the decisions seemed very insensitive to the “distance back” parameter. The extra distance away from the barrier was only 50 feet. It is expected that a larger increase would start to show more differences in the two situations.



| 50-ft Spacing | | | | | | 100-ft Spacing | | | | | | 200-ft Spacing | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 ft Back | | | 140 ft Back | | | 90 ft Back | | | 140 ft Back | | | 90 ft Back | | | 140 ft Back | | |
| 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows |

**Figure 16. Reasonableness Decision Array, APBR = 500 SF/benefited receptor.**

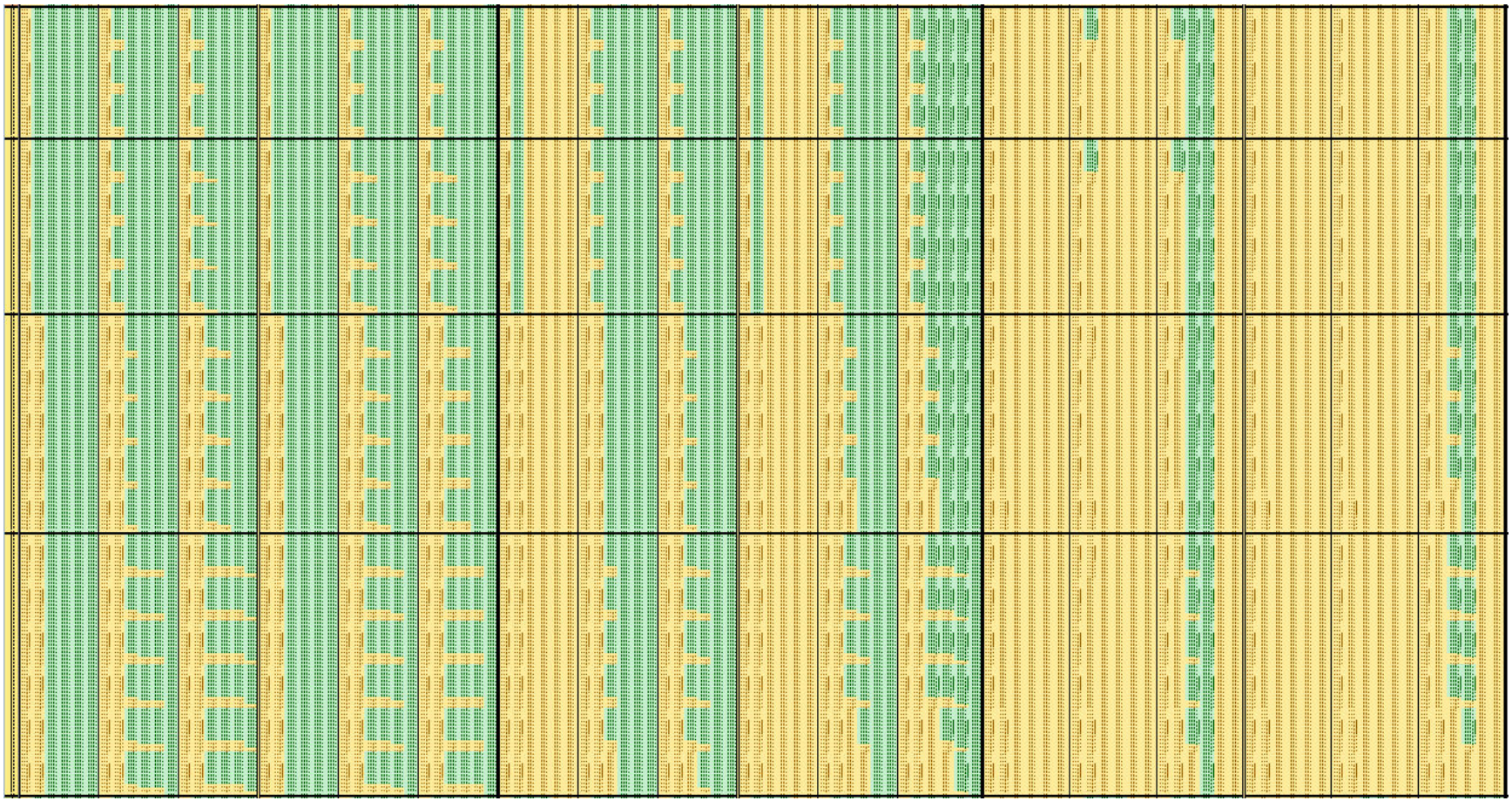
**Horizontal blocks, from top to bottom, are for NRDG of 7, 8, 9, and 10 dB**



| 50-ft Spacing | | | | | | 100-ft Spacing | | | | | | 200-ft Spacing | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 ft Back | | | 140 ft Back | | | 90 ft Back | | | 140 ft Back | | | 90 ft Back | | | 140 ft Back | | |
| 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows |

**Figure 17. Reasonableness Decision Array, APBR = 1,000 SF/benefited receptor.**

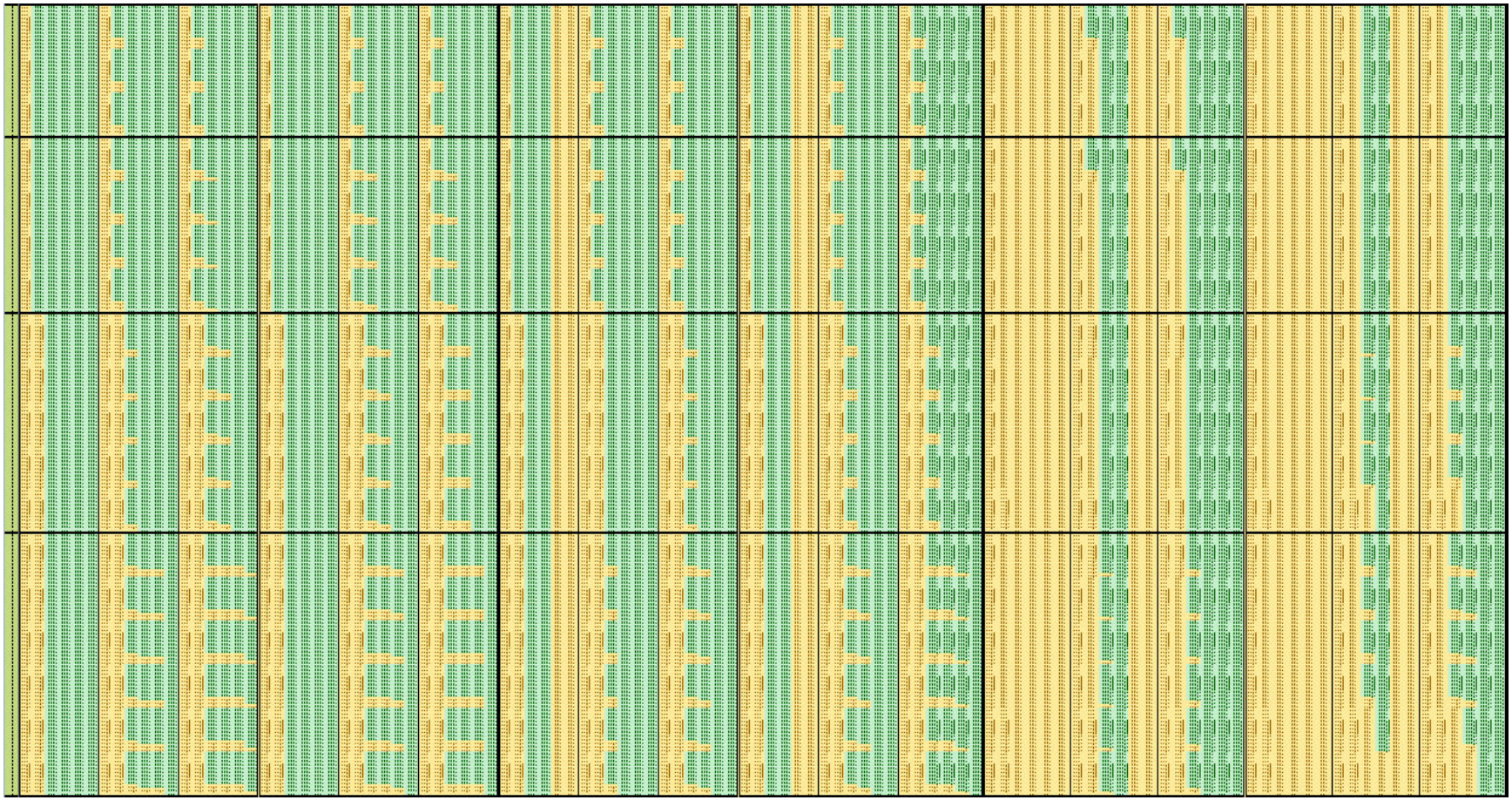
**Horizontal blocks, from top to bottom, are for NRDG of 7, 8, 9, and 10 dB**



| 50-ft Spacing | | | | | | 100-ft Spacing | | | | | | 200-ft Spacing | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 ft Back | | | 140 ft Back | | | 90 ft Back | | | 140 ft Back | | | 90 ft Back | | | 140 ft Back | | |
| 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows |

**Figure 18. Reasonableness Decision Array, APBR = 1,500 SF/benefited receptor.**

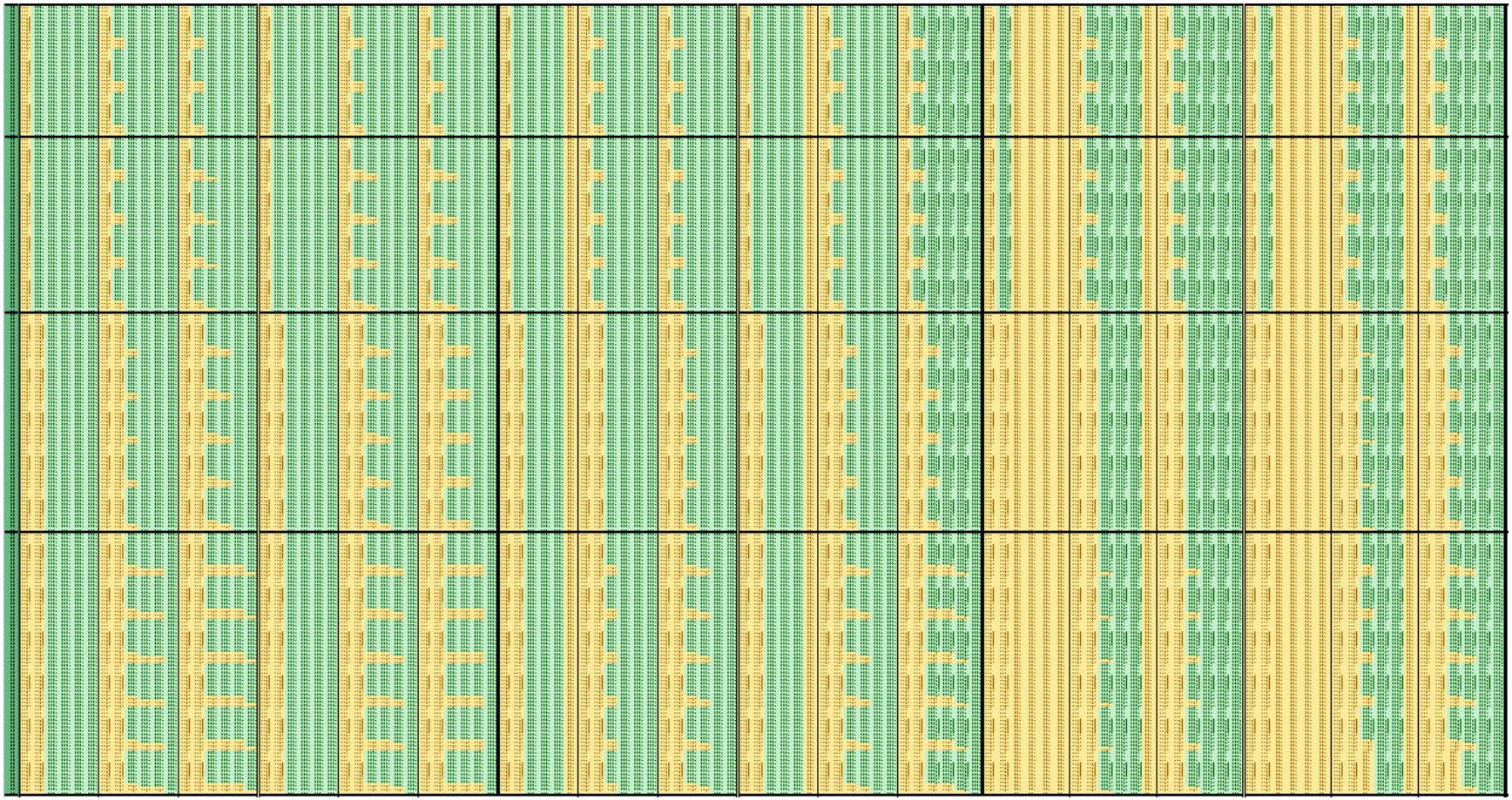
**Horizontal blocks, from top to bottom, are for NRDG of 7, 8, 9, and 10 dB**



| 50-ft Spacing | | | | | | 100-ft Spacing | | | | | | 200-ft Spacing | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 ft Back | | | 100 ft Back | | | 50 ft Back | | | 100 ft Back | | | 50 ft Back | | | 100 ft Back | | |
| 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows |

**Figure 19. Reasonableness Decision Array, APBR = 2,000 SF/benefited receptor.**

**Horizontal blocks, from top to bottom, are for NRDG of 7, 8, 9, and 10 dB**



| 50-ft Spacing | | | | | | 100-ft Spacing | | | | | | 200-ft Spacing | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 ft Back | | | 140 ft Back | | | 90 ft Back | | | 140 ft Back | | | 90 ft Back | | | 140 ft Back | | |
| 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows | 1 Row | 2 Rows | 3 Rows |

**Figure 20. Reasonableness Decision Array, APBR = 2,800 SF/benefited receptor.**

**Horizontal blocks, from top to bottom, are for NRDG of 7, 8, 9, and 10 dB**

### 3.1.6 Findings of Sensitivity Analysis

One desired outcome of this analysis was to identify combinations of factors that are very likely to result in: (1) inclusion of noise abatement or (2) exclusion of noise abatement.

The first finding is that the NRDG reasonableness criterion is insensitive to the NRDG quantity for values of 1, 2, and 3 benefited receptors, for the tested percentages of first-row benefited receptors, and for 10% and 25% of all benefited receptors. As the required percentage of all benefited receptors increases to 50%, some cases begin to become "not reasonable" for the two-row and three-row study areas. As the required percentage of all benefited receptors increases to 67% and 80%, many more of the two-row and three-row cases become "not reasonable" while the one-row cases stay reasonable. These results illustrate how a barrier that would be reasonable for a one-row neighborhood suddenly becomes "not reasonable" if that neighborhood was, instead, a two-row or three-row community if the criterion is based on "percentage of *all* benefited receptors."

Next, the overall reasonableness is very dependent on the APBR.

For an APBR of 500 SF/ benefited receptor, none of the one-row, two-row, or three-row cases were reasonable for the 100-foot and 200-foot receptor spacings, and none of the one-row cases were reasonable for the 50-foot receptor spacing. Combinations with high percentages of all benefits for the NRDG quantity were more likely to be "not reasonable." For the 10 dB NRDG with the 10 dB benefited noise reduction, none of the cases for any of the receptor spacing at any height were reasonable.

As APBR increases, cases become increasingly reasonable, although even at the high values of APBR, the requirements for the higher percentages of all benefited receptors continued to result in negative decisions, even for cases where all of the other parameter values led to barriers being reasonable.

Finally, for most of the criteria combinations, reasonableness was insensitive to the "distance back" parameter, although the difference in distances back was only 50 feet

## 3.2 APPLYING THE COMBINATIONS TO A SAMPLING OF EXISTING HIGHWAY PROJECTS WITH ABATEMENT

The selected combinations of feasibility and reasonableness factors were applied to study areas from actual projects to assess how changes in values would affect noise abatement decisions.

### 3.2.1 Study Areas

Four study areas were selected for testing. The selection process involved reviewing numerous previously-studied areas along actual projects to identify unique but typical cases.

Land use type was a primary consideration in case selection. Comparison of test results would be significantly complicated for study areas with different land use types. Therefore, only areas of single-family residential development were considered.

Study areas were selected to provide different residential development characteristics such as density, distance to first-row residences, and first-row sound levels. Roadway characteristics were also considered including the number of travel lanes, road elevation relative to the adjacent residences (i.e. cut, fill), and design hour volume (DHV).

Table 19 summarizes the key characteristics of Study Areas A through D.

**Table 19. Summary Table of Case Characteristics.**

| Characteristic | Study Area | | | |
|---|---|---|---|---|
| | **A** | **B** | **C** | **D** |
| Density | High | High | Medium | Low |
| Distance to First-Row Residences* | 80 to 110 ft | 160 to 270 ft | 110 to 400 ft | 240 to 330 ft |
| Total Lanes | 10 | 6 | 10 | 8 |
| Road Elevation relative to Residences | Fill | Slight Fill | Mostly Cut | Slight Cut |
| Design Hour Volume (DHV) in vehicles/hr | 11,850 | 6,500 | 19,270 | 7,900 |
| Percent Trucks | 6% | 12% | 6% | 15% |
| Modeled Residences | 115 | 24 | 41 | 41 |
| First-Row $L_{eq}$(1h) dB(A) | 67 to 76 | 67 to 75 | 67 to 79 | 66 to 70 |

* From edge of near travel lane

Density correlates directly to the number of benefited residences and is often the most important factor in the reasonableness determination. Therefore, the study areas include a range of residential densities. Study Areas A and B are high density (small lots); Study Area C is medium density, and Study Area D is low density (large lot). Figures showing aerial photographs of each of the study areas are in the sections describing the results for each area.

The distances to first-row residences also vary. First-row residences in Study Areas A and C are as close as 100 feet of the edge of the near travel lane while residences in Study Areas B and D are a minimum of 160 feet and 240 feet, respectively, from the edge of the near travel lane.

The adjacent roadway has ten travel lanes adjacent to Study Areas A and C, eight lanes adjacent to Study Area D, and six lanes adjacent to Study Area B. The DHVs for Study Areas A and C are also higher than for Study Areas B and D. Truck percentages range from 6% to 15%

Finally, there is a wide range of predicted sound levels for first-row residences in each study area. First-row sound levels in Study Area C are up to 79 dB(A) due to the close proximity of residences, a very high DHV, and the fact the road is in cut. First-row sound levels are comparable for Study Areas A and B. Study Area D has the lowest sound levels due to the higher distances between first-row residences and the edge of the near travel lane.

### 3.2.2 Study Factors

The factors that were studied were developed by examining the range in values used in the SHA policies and the expected likelihood or unlikelihood of a positive decision on a barrier design. These factors include:

- Feasibility Noise Reduction
  - 5 dB (a "static" value, per the RFP)
- Feasibility Quantity
  - Number – one impacted receptor
  - Percentage of first-row impacted receptors – 25%, 50%, 75%
  - Percentage of all impacted receptors – 25%, 50%, 75%
- NRDG and benefited noise reduction (four combinations)
  - 7 dB and 5 dB (most common combination used by SHAs - lowest possible NRDG, with lowest possible benefited value)
  - 7 dB and 7 dB (lowest possible NRDG, with highest possible benefited value)
  - 9 dB and 9 dB (highest combination of equal values used by SHAs – none used 10 dB and 10 dB)
  - 10 dB and 5 dB (second most common combination used by SHAs – highest possible NRDG with lowest possible benefited value)
- NRDG Quantity
  - Number – one benefited receptor (no SHA policies used more than one)
  - Percentage of first-row benefited receptors – 25%, 50%, 75%
  - Percentage of all benefited receptors – 25%, 50%, 75%
- CE in terms of APBR
  - 800 SF/benefited receptor
  - 1,250 SF/ benefited receptor
  - 2,600 SF/ benefited receptor

Feasibility was examined separately from reasonableness, with seven individual cases studied for feasibility. Reasonableness was studied for combinations of values, together resulting in 84 cases: [4 pairs of NRDG and benefited noise reduction] x [7 NRDG quantities (1 numeric value + 3 first-row percentages + 3 all-benefits percentages)] x [3 CE values].

### 3.2.3 Testing Protocol

The test method for each study area involved several steps. First, the study area was rerun in the FHWA TNM with each residence represented by a receiver point that was placed in close proximity to the residence, representing the area of frequent human use. All previous noise barrier designs for the study area were deleted. The barrier segments' height range was set from 10 feet to 26 feet in 2-foot increments. The traffic volumes and speeds for the original TNM run were not changed.

New barrier designs were then developed based on a protocol of designing to meet the NRDG. An important question had to be addressed in developing the design protocol for the study areas: Is achieving the NRDG the ultimate goal of the barrier design, or should the barrier be designed using other goals (i.e. protect all impacted first-row receptors) with the NRDG tested as a minimum threshold for reasonableness? This is an important distinction that is not specifically addressed in the regulation or guidance. However, the interpretation of NRDG has significant implications for barrier design and reasonableness determinations.

As discussed previously, the NRDG is met under 21 SHA policies if the barrier provides the NRDG at one or more benefited residences. Numerous different barrier designs could be developed that would meet this NRDG. Whether these designs provide adequate noise reduction for impacted receptors would depend on the SHAs design philosophy and not the NRDG which simply requires achieving the design goal at one or more benefited receptors.

For example, if the NRDG is 7 dB at only one benefited receptor, an analyst could design a barrier for a single receptor at the far end of the community or for only the residence with the highest sound level and then modify the design until enough benefits are achieved to meet the CE criterion. This design does not consider the number and locations of impacts and might provide very small noise reductions for impacted receptors. While this approach would be contrary to the intent of the regulation, one could argue that such design meets the "letter" of the regulation. This example also illustrates that the NRDG does not address *how* the barrier should be designed. One SHA (VDOT) reports this "mindset" on design-build projects. To ensure that the spirit of the regulation remains intact, VDOT added new language to its guidance manual for consideration in all projects. VDOT's noise specialist notes that, similar to other environmental mitigation features, the goal for noise abatement is to achieve 100% effectiveness, i.e., provide benefits to every impacted noise sensitive receptor. However, as the specialist notes, it is not always possible to benefit every impacted receptor for different reasons.

The noise barriers for the study areas were designed to provide the specified noise reduction for all of the first-row *impacted* receptors and not just the number or percentage specified by the NRDG. Additionally, the NRDG is based on the number of *benefited* receptors. However, SHAs do not typically *design for* benefited receptors, which are the *outcomes of design*.

When a design was developed that met the NRDG criterion, the APBR criterion was tested. If the APBR criterion was not met, the barrier height was increased in an attempt to increase the benefits enough to lower the APBR to meet the criterion value.

This protocol assumes a philosophy of trying to provide abatement where impacts exist, which is in keeping with the stated intent in the regulation:

> **"Sec. 772.13 Analysis of noise abatement.** (a) When traffic noise impacts are identified, noise abatement shall be considered and evaluated for feasibility and reasonableness. The highway agency ***shall*** determine and analyze alternative noise abatement measures ***to abate identified impacts*** by giving weight to the benefits and costs of abatement and the overall social, economic, and environmental effects by using feasible and reasonable noise abatement measures for decision-making." ***[emphasis added]***

The focus is on the first-row because designing to meet the NRDG for more distant receptors generally increases barrier heights over a first-row design, raising the noise reductions for first-row receptors to well above the NRDG. While such a strategy might be employed for areas with very high first-row levels (e.g., worst-hour $L_{eq}$ 75 or more dB(A)), it would not be commonly used for most typical situations (e.g., in the 66 to 74 dB(A) range).

### 3.2.4 Method for Presenting Results

Each study area and its associated results are described below. Two tables are provided for each study area: Feasibility Results (Tables 20, 22, 24, and 26) and Reasonableness Results (Tables 21, 23, 25, and 27).

Each row in each table represents a "case" for the study area (i.e., a particular combination of the criteria and their application to a particular barrier design) and includes the criteria used in the design and the results.

The Feasibility Results table includes the factor "Feas Type." This factor has three possible values (#, P1, and PA) that indicate whether feasibility is based on a number (#), percentage of first-row (P1), or percentage of total impacted receptors (PA). The results include the number of total and first-row impacted receptors (# Impacts ALL, # Impacts 1R), and, depending on Feas Type, the number or percentage of total or first-row impacted receptors that meet the feasibility noise reduction (Feas # 1R, Feas # ALL, Feas % 1R, Feas % ALL). The last column in the table shows the feasibility decision for each case.

Similarly, the Reasonableness Results table includes the factor "NRDG Type." This factor also has three possible values (#, P1, and PA) that indicate whether the NRDG criterion is based on a number (#), percentage of first-row (P1), or percentage of total benefited receptors (PA). The calculated barrier area (Area) is shown. The results include the number of total and first-row benefited receptors (# Ben 1R, # Ben ALL), and, as appropriate, the number or percentage of total or first-row benefited receptors that meet the NRDG criterion (# Ben NRDG 1R, # Ben NRDG ALL, Ben % 1R, Ben % ALL). The decision for NRDG is then shown. The last three columns of the table show the calculated APBR (APBR Calc), whether the calculated APBR is above (No) or below (Yes) the APBR criterion and the overall reasonableness decision (Yes, if both the NRDG and CE criteria are met).

### 3.2.5 Study Area A Description and Results

Study Area A represents a proposed widening to a ten-lane highway. The road is on a slight fill and there are several rows of relatively closely spaced houses, as shown in Figure 21.

This project is one for which abatement should be feasible and reasonable because of the number and density of the receptors.


**Figure 21. Study Area A: Ten-lane highway with dense development close to the highway.**

Table 20 shows the feasibility results for Study Area A, and Table 21 shows the reasonableness results for Study Area A.

**Table 20. Feasibility Results for Study Area A: Ten-Lane Highway with Dense Development Close to the Highway.**

| Case | Feasibility Factors | | | | | Feasibility Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Feas NR | Feas Type | Feas Crit # | Feas Crit % 1R | Feas Crit % All | # Impacts ALL | # Impacts 1R | Feas # 1R | Feas # ALL | Feas % 1R | Feas % ALL | Feasible ? |
| 1 | 5 | # | 1 | -- | -- | 57 | 34 | 32 | 46 | 94% | 81% | Yes-# |
| 2 | 5 | P1 | -- | 25% | -- | 57 | 34 | 32 | 46 | 94% | 81% | Yes-%1 |
| 3 | 5 | P1 | -- | 50% | -- | 57 | 34 | 32 | 46 | 94% | 81% | Yes-%1 |
| 4 | 5 | P1 | -- | 75% | -- | 57 | 34 | 32 | 46 | 94% | 81% | Yes-%1 |
| 5 | 5 | PA | -- | -- | 25% | 57 | 34 | 32 | 46 | 94% | 81% | Yes-%A |
| 6 | 5 | PA | -- | -- | 50% | 57 | 0 | 0 | 46 | 0% | 81% | Yes-%A |
| 7 | 5 | PA | -- | -- | 75% | 57 | 0 | 0 | 46 | 0% | 81% | Yes-%A |

A barrier was feasible for all seven cases of the tested feasibility factors, an expected result given the density of houses and closeness to the road. Even for Case 7 – 75% of all impacts – enough non-first-row impacts received a noise reduction of at least 5 dB.

A barrier was reasonable for all of the cases for the 7 dB NRDG with a 5 dB benefited noise reduction (Cases 1 through 21), even for Case 21 for 75% of all benefited receptors. All of the APBR were under 800 SF/benefited receptor, a result of the large number of benefits. Note that while the APBR values are in a small range, the barrier area increases nearly 25% from 68,000 SF for the easiest case (Case 1) to nearly 84,000 SF for the most difficult case (Case 21). This increase in area is due mainly to the increase in height, which, on this project, resulted in adding enough benefits to offset the increase in area and keep the APBR in a tight range.

While not shown, the results of the increased height are first-row noise reductions well above the NRDG of 7 dB. It is a matter of design and abatement philosophy as to whether an SHA would push the barrier height up in this manner as long as benefits were still being accrued. Some SHAs might be reluctant to do so; instead they might design a barrier that just meets the 7 dB NRDG criterion, then test that design for CE and draw a conclusion on reasonableness. With such an approach, many of the above cases would result in a decision of "not reasonable." Choice of a philosophy also has critical cost implications, as evidenced by the 25% increase in barrier area from Case 1 to Case 21.

Cases 22 through 42 are for the 7 dB NRDG with a 7 dB benefited noise reduction. All of the cases with the 800 SF/benefited receptor APBR criterion were unreasonable; the cases with the higher APBR were reasonable. These barriers were all in the 74,000 to 84,000 SF range, and the APBR could not be reduced to below 932 SF/benefited receptor. The need to achieve 7 dB in

order to count a receptor as benefited required too tall of a barrier to keep the barrier area low enough to reduce the APBR below the 800 SF/benefited receptor criterion.

Cases 43 through 63 are for the 9 dB NRDG with a 9 dB benefited noise reduction ("9 dB/9 dB"). As with Cases 22 through 42, all of the cases with the 800 SF/benefited receptor APBR criterion were unreasonable. While the 9 dB reduction could be achieved at 100% of the benefited receptors, the "penalty" in increase barrier area prevented the reaching of the 800 ABPR value and just barely achieved the 1,250 APBR criterion with a value of 1,249. The barrier height had to be increased substantially to achieve the 1,250 SF/benefited receptor criterion as evidenced by the necessary total area exceeding 100,000 SF. In the process of raising the height, however, more noise reduction was provided.

Cases 64 through 84 are for the 10 dB NRDG with a 5 dB benefited noise reduction ("10 dB/5 dB"). Contrasting with the 9 dB/9 dB cases above, two of these cases (Cases 64 and 67) met the 800 SF/benefited receptor APBR criterion. The NRDG quantities in these two cases were small – one benefited receptor and 25% of first-row benefits. With only a 5 dB benefited noise reduction criterion instead of 9 dB, enough extra benefits were realized to drive down the APBR for these cases. For the higher NRDG percentages, while there were enough benefited receptors to meet the NRDG criterion, there were not enough to meet the 800 APBR criterion. The minimum barrier area for a reasonable design for the 10 dB/5 dB criteria was 72,000 SF. For the higher NRDG percentages with the higher APBR, the barrier area jumped to 105,000 SF. Contrast this amount with the 68,000 SF needed to meet some of the reasonable 7 dB/5 dB designs.

Also, the last three cases for 10 dB/5 dB – where the NRDG criterion was 75% of all benefited receptor – were not reasonable because the NRDG criterion could not be met. In two of these cases, the APBR criterion could not be met either.

Based on experience, it was expected that a noise barrier would be reasonable for Study Area A . The lessons from Study Area A, with the densely developed residential community, include:

- Feasibility was easily demonstrated, even at 75% of all impacted receptors.
- A 7 dB NRDG with a 5 dB benefited noise reduction resulted in reasonable designs regardless of the NRDG quantity and with calculated APBR as low as 756 SF/benefited receptor. If one is satisfied with 7 dB noise reductions, then these criteria can be used successfully with APBRs as low as 800 SF/benefited receptor, even with high NRDG percentages.
- A 7 dB NRDG with a 7 dB benefited noise reduction resulted in "not reasonable" decisions for the 800 SF/benefited receptor APBR cases, regardless of the NRDG quantity. Use of 7 dB/7 dB suggests an APBR of at least 1,000 SF/benefited receptor, which would give reasonable designs even for high NRDG percentages.
- A 9 dB NRDG with a 9 dB benefited noise reduction would require an APBR of at least 1,250 SF/benefited receptor and potentially a bit higher to result in a "reasonable" abatement decision for this project. Moving up to 9 dB for the NRDG increases barrier cost because of the increased height but provides greater noise reduction at the most impacted receptors.

- The 10 dB NRDG with a 5 dB benefited noise reduction would require an APBR of at least 1,300 SF/benefited receptor for reasonable designs, but only if the NRDG quantity was kept to no more than 50% of all benefited receptors. This combination resulted in the greatest barrier areas needed in order to reach the 10 dB NRDG. A noise reduction of 10 dB also affords more protection to the impacted residents.

**Table 21. Reasonableness Results for Study Area A: Ten-Lane Highway with Dense Development Close to the Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 1 | 7 | 5 | # | 1 | 0% | 0% | 800 | 68,078 | 35 | 90 | 35 | 42 | 100% | 47% | Yes-NR-# | 756 | Yes | Yes |
| 2 | 7 | 5 | # | 1 | 0% | 0% | 1,250 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-# | 861 | Yes | Yes |
| 3 | 7 | 5 | # | 1 | 0% | 0% | 2,600 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-# | 861 | Yes | Yes |
| 4 | 7 | 5 | P1 | 0 | 25% | 0% | 800 | 68,078 | 35 | 90 | 35 | 42 | 100% | 47% | Yes-NR-%1 | 756 | Yes | Yes |
| 5 | 7 | 5 | P1 | 0 | 25% | 0% | 1,250 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-%1 | 861 | Yes | Yes |
| 6 | 7 | 5 | P1 | 0 | 25% | 0% | 2,600 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-%1 | 861 | Yes | Yes |
| 7 | 7 | 5 | P1 | 0 | 50% | 0% | 800 | 68,078 | 35 | 90 | 35 | 42 | 100% | 47% | Yes-NR-%1 | 756 | Yes | Yes |
| 8 | 7 | 5 | P1 | 0 | 50% | 0% | 1,250 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-%1 | 861 | Yes | Yes |
| 9 | 7 | 5 | P1 | 0 | 50% | 0% | 2,600 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-%1 | 861 | Yes | Yes |
| 10 | 7 | 5 | P1 | 0 | 75% | 0% | 800 | 68,078 | 35 | 90 | 35 | 42 | 100% | 47% | Yes-NR-%1 | 756 | Yes | Yes |
| 11 | 7 | 5 | P1 | 0 | 75% | 0% | 1,250 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-%1 | 861 | Yes | Yes |
| 12 | 7 | 5 | P1 | 0 | 75% | 0% | 2,600 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-%1 | 861 | Yes | Yes |
| 13 | 7 | 5 | PA | 0 | 0% | 25% | 800 | 68,078 | 35 | 90 | 35 | 42 | 100% | 47% | Yes-NR-%A | 756 | Yes | Yes |
| 14 | 7 | 5 | PA | 0 | 0% | 25% | 1,250 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-%A | 861 | Yes | Yes |
| 15 | 7 | 5 | PA | 0 | 0% | 25% | 2,600 | 64,569 | 35 | 75 | 31 | 38 | 89% | 51% | Yes-NR-%A | 861 | Yes | Yes |
| 16 | 7 | 5 | PA | 0 | 0% | 50% | 800 | 71,751 | 35 | 90 | 33 | 67 | 94% | 74% | Yes-NR-%A | 797 | Yes | Yes |
| 17 | 7 | 5 | PA | 0 | 0% | 50% | 1,250 | 72,580 | 35 | 90 | 33 | 73 | 94% | 81% | Yes-NR-%A | 806 | Yes | Yes |
| 18 | 7 | 5 | PA | 0 | 0% | 50% | 2,600 | 72,580 | 35 | 90 | 33 | 73 | 94% | 81% | Yes-NR-%A | 806 | Yes | Yes |
| 19 | 7 | 5 | PA | 0 | 0% | 75% | 800 | 71,773 | 35 | 90 | 33 | 73 | 94% | 81% | Yes-NR-%A | 797 | Yes | Yes |
| 20 | 7 | 5 | PA | 0 | 0% | 75% | 1,250 | 72,580 | 35 | 90 | 33 | 73 | 94% | 81% | Yes-NR-%A | 806 | Yes | Yes |
| 21 | 7 | 5 | PA | 0 | 0% | 75% | 2,600 | 72,580 | 35 | 90 | 33 | 73 | 94% | 81% | Yes-NR-%A | 806 | Yes | Yes |
| 22 | 7 | 7 | # | 1 | 0% | 0% | 800 | 83,887 | 35 | 90 | 35 | 90 | 100% | 100% | Yes-NR-# | 932 | No | No |
| 23 | 7 | 7 | # | 1 | 0% | 0% | 1,250 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-# | 994 | Yes | Yes |
| 24 | 7 | 7 | # | 1 | 0% | 0% | 2,600 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-# | 994 | Yes | Yes |

Continued on next page

**Table 21. Reasonableness Results for Study Area A: Ten-Lane Highway with Dense Development Close to the Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 25 | 7 | 7 | P1 | 0 | 25% | 0% | 800 | 83,887 | 35 | 90 | 35 | 90 | 100% | 100% | Yes-NR-%1 | 932 | No | No |
| 26 | 7 | 7 | P1 | 0 | 25% | 0% | 1,250 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%1 | 994 | Yes | Yes |
| 27 | 7 | 7 | P1 | 0 | 25% | 0% | 2,600 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%1 | 994 | Yes | Yes |
| 28 | 7 | 7 | P1 | 0 | 50% | 0% | 800 | 83,887 | 35 | 90 | 35 | 90 | 100% | 100% | Yes-NR-%1 | 932 | No | No |
| 29 | 7 | 7 | P1 | 0 | 50% | 0% | 1,250 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%1 | 994 | Yes | Yes |
| 30 | 7 | 7 | P1 | 0 | 50% | 0% | 2,600 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%1 | 994 | Yes | Yes |
| 31 | 7 | 7 | P1 | 0 | 75% | 0% | 800 | 83,887 | 35 | 90 | 35 | 90 | 100% | 100% | Yes-NR-%1 | 932 | No | No |
| 32 | 7 | 7 | P1 | 0 | 75% | 0% | 1,250 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%1 | 994 | Yes | Yes |
| 33 | 7 | 7 | P1 | 0 | 75% | 0% | 2,600 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%1 | 994 | Yes | Yes |
| 34 | 7 | 7 | PA | 0 | 0% | 25% | 800 | 83,887 | 35 | 90 | 35 | 90 | 100% | 100% | Yes-NR-%A | 932 | No | No |
| 35 | 7 | 7 | PA | 0 | 0% | 25% | 1,250 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%A | 994 | Yes | Yes |
| 36 | 7 | 7 | PA | 0 | 0% | 25% | 2,600 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%A | 994 | Yes | Yes |
| 37 | 7 | 7 | PA | 0 | 0% | 50% | 800 | 83,887 | 35 | 90 | 35 | 90 | 100% | 100% | Yes-NR-%A | 932 | No | No |
| 38 | 7 | 7 | PA | 0 | 0% | 50% | 1,250 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%A | 994 | Yes | Yes |
| 39 | 7 | 7 | PA | 0 | 0% | 50% | 2,600 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%A | 994 | Yes | Yes |
| 40 | 7 | 7 | PA | 0 | 0% | 75% | 800 | 83,887 | 35 | 90 | 35 | 90 | 100% | 100% | Yes-NR-%A | 932 | No | No |
| 41 | 7 | 7 | PA | 0 | 0% | 75% | 1,250 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%A | 994 | Yes | Yes |
| 42 | 7 | 7 | PA | 0 | 0% | 75% | 2,600 | 72,580 | 33 | 73 | 33 | 73 | 100% | 100% | Yes-NR-%A | 994 | Yes | Yes |
| 43 | 9 | 9 | # | 1 | 0% | 0% | 800 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-# | 2,503 | No | No |
| 44 | 9 | 9 | # | 1 | 0% | 0% | 1,250 | 101,150 | 35 | 81 | 35 | 81 | 100% | 100% | Yes-NR-# | 1,249 | Yes | Yes |
| 45 | 9 | 9 | # | 1 | 0% | 0% | 2,600 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-# | 2,503 | Yes | Yes |
| 46 | 9 | 9 | P1 | 0 | 25% | 0% | 800 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%1 | 2,503 | No | No |
| 47 | 9 | 9 | P1 | 0 | 25% | 0% | 1,250 | 101,150 | 35 | 81 | 35 | 81 | 100% | 100% | Yes-NR-%1 | 1,249 | Yes | Yes |
| 48 | 9 | 9 | P1 | 0 | 25% | 0% | 2,600 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%1 | 2,503 | Yes | Yes |

Continued on next page

**Table 21. Reasonableness Results for Study Area A: Ten-Lane Highway with Dense Development Close to the Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 49 | 9 | 9 | P1 | 0 | 50% | 0% | 800 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%1 | 2,503 | No | No |
| 50 | 9 | 9 | P1 | 0 | 50% | 0% | 1,250 | 101,150 | 35 | 81 | 35 | 81 | 100% | 100% | Yes-NR-%1 | 1,249 | Yes | Yes |
| 51 | 9 | 9 | P1 | 0 | 50% | 0% | 2,600 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%1 | 2,503 | Yes | Yes |
| 52 | 9 | 9 | P1 | 0 | 75% | 0% | 800 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%1 | 2,503 | No | No |
| 53 | 9 | 9 | P1 | 0 | 75% | 0% | 1,250 | 101,150 | 35 | 81 | 35 | 81 | 100% | 100% | Yes-NR-%1 | 1,249 | Yes | Yes |
| 54 | 9 | 9 | P1 | 0 | 75% | 0% | 2,600 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%1 | 2,503 | Yes | Yes |
| 55 | 9 | 9 | PA | 0 | 0% | 25% | 800 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%A | 2,503 | No | No |
| 56 | 9 | 9 | PA | 0 | 0% | 25% | 1,250 | 101,150 | 35 | 81 | 35 | 81 | 100% | 100% | Yes-NR-%A | 1,249 | Yes | Yes |
| 57 | 9 | 9 | PA | 0 | 0% | 25% | 2,600 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%A | 2,503 | Yes | Yes |
| 58 | 9 | 9 | PA | 0 | 0% | 50% | 800 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%A | 2,503 | No | No |
| 59 | 9 | 9 | PA | 0 | 0% | 50% | 1,250 | 101,150 | 35 | 81 | 35 | 81 | 100% | 100% | Yes-NR-%A | 1,249 | Yes | Yes |
| 60 | 9 | 9 | PA | 0 | 0% | 50% | 2,600 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%A | 2,503 | Yes | Yes |
| 61 | 9 | 9 | PA | 0 | 0% | 75% | 800 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%A | 2,503 | No | No |
| 62 | 9 | 9 | PA | 0 | 0% | 75% | 1,250 | 101,150 | 35 | 81 | 35 | 81 | 100% | 100% | Yes-NR-%A | 1,249 | Yes | Yes |
| 63 | 9 | 9 | PA | 0 | 0% | 75% | 2,600 | 72,580 | 22 | 29 | 22 | 29 | 100% | 100% | Yes-NR-%A | 2,503 | Yes | Yes |
| 64 | 10 | 5 | # | 1 | 0% | 0% | 800 | 71,985 | 35 | 90 | 16 | 16 | 46% | 18% | Yes-NR-# | 800 | Yes | Yes |
| 65 | 10 | 5 | # | 1 | 0% | 0% | 1,250 | 72,580 | 35 | 90 | 16 | 16 | 46% | 18% | Yes-NR-# | 806 | Yes | Yes |
| 66 | 10 | 5 | # | 1 | 0% | 0% | 2,600 | 72,580 | 35 | 90 | 16 | 16 | 46% | 18% | Yes-NR-# | 806 | Yes | Yes |
| 67 | 10 | 5 | P1 | 0 | 25% | 0% | 800 | 71,985 | 35 | 90 | 16 | 16 | 46% | 18% | Yes-NR-%1 | 800 | Yes | Yes |
| 68 | 10 | 5 | P1 | 0 | 25% | 0% | 1,250 | 72,580 | 35 | 90 | 16 | 16 | 46% | 18% | Yes-NR-%1 | 806 | Yes | Yes |
| 69 | 10 | 5 | P1 | 0 | 25% | 0% | 2,600 | 72,580 | 35 | 90 | 16 | 16 | 46% | 18% | Yes-NR-%1 | 806 | Yes | Yes |
| 70 | 10 | 5 | P1 | 0 | 50% | 0% | 800 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%1 | 1,166 | No | No |
| 71 | 10 | 5 | P1 | 0 | 50% | 0% | 1,250 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%1 | 1,166 | Yes | Yes |
| 72 | 10 | 5 | P1 | 0 | 50% | 0% | 2,600 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%1 | 1,166 | Yes | Yes |

Continued on next page

**Table 21. Reasonableness Results for Study Area A: Ten-Lane Highway with Dense Development Close to the Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 73 | 10 | 5 | P1 | 0 | 75% | 0% | 800 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%1 | 1,166 | No | No |
| 74 | 10 | 5 | P1 | 0 | 75% | 0% | 1,250 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%1 | 1,166 | Yes | Yes |
| 75 | 10 | 5 | P1 | 0 | 75% | 0% | 2,600 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%1 | 1,166 | Yes | Yes |
| 76 | 10 | 5 | PA | 0 | 0% | 25% | 800 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%A | 1,166 | No | No |
| 77 | 10 | 5 | PA | 0 | 0% | 25% | 1,250 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%A | 1,166 | Yes | Yes |
| 78 | 10 | 5 | PA | 0 | 0% | 25% | 2,600 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%A | 1,166 | Yes | Yes |
| 79 | 10 | 5 | PA | 0 | 0% | 50% | 800 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%A | 1,166 | No | No |
| 80 | 10 | 5 | PA | 0 | 0% | 50% | 1,250 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%A | 1,166 | Yes | Yes |
| 81 | 10 | 5 | PA | 0 | 0% | 50% | 2,600 | 104,941 | 35 | 90 | 32 | 47 | 91% | 52% | Yes-NR-%A | 1,166 | Yes | Yes |
| 82 | 10 | 5 | PA | 0 | 0% | 75% | 800 | 115,001 | 35 | 90 | 33 | 64 | 94% | 71% | No-NR-%A | 1,278 | No | No |
| 83 | 10 | 5 | PA | 0 | 0% | 75% | 1,250 | 115,001 | 35 | 90 | 33 | 64 | 94% | 71% | No-NR-%A | 1,278 | No | No |
| 84 | 10 | 5 | PA | 0 | 0% | 75% | 2,600 | 115,001 | 35 | 90 | 33 | 64 | 94% | 71% | No-NR-%A | 1,278 | Yes | No |

### 3.2.6 Study Area B Description and Results

Study Area B represents a proposed widening to a six-lane highway facility. The road is at-grade with the community. There are two rows of closely-spaced houses that angle away from the road, with two other houses closer to the road than those in the rows, as shown in Figure 22.

For this project, feasibility and reasonableness are both uncertain due the relatively limited number of receptors and the manner in which they angle away from the road.


**Figure 22. Study Area B: Six-lane highway with two rows of closely-spaced houses angling away from the highway.**

Table 22 shows the feasibility results for Study Area B, and Table 23 shows the reasonableness results for Study Area B.

**Table 22. Feasibility Results for Study Area B: Six-Lane Highway with Two Rows of Closely-Spaced Houses Angling Away from Highway.**

| Case | Feasibility Factors | | | | | Feasibility Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Feas NR | Feas Type | Feas Crit # | Feas Crit % 1R | Feas Crit % All | # Impacts ALL | # Impacts 1R | Feas # 1R | Feas # ALL | Feas % 1R | Feas % ALL | Feasible ? |
| 1 | 5 | # | 1 | -- | -- | 14 | 7 | 3 | 3 | 43% | 21% | Yes-# |
| 2 | 5 | P1 | -- | 25% | -- | 14 | 7 | 3 | 3 | 43% | 21% | Yes-%1 |
| 3 | 5 | P1 | -- | 50% | -- | 14 | 7 | 6 | 10 | 86% | 71% | Yes-%1 |
| 4 | 5 | P1 | -- | 75% | -- | 14 | 7 | 6 | 10 | 86% | 71% | Yes-%1 |
| 5 | 5 | PA | -- | -- | 25% | 14 | 7 | 6 | 10 | 86% | 71% | Yes-%A |
| 6 | 5 | PA | -- | -- | 50% | 14 | 7 | 6 | 10 | 86% | 71% | Yes-%A |
| 7 | 5 | PA | -- | -- | 75% | 14 | 7 | 7 | 14 | 100% | 100% | Yes-%A |

A barrier was feasible for all seven combinations of the feasibility factors, even for Case 7 – 75% of all impacts – which required extra barrier height to reach the 75% value.

A barrier was not reasonable using the APBR criterion of 800 SF/benefited receptor for any of the combinations of NRDG and benefited noise reduction (Cases 1 through 84).

For the 7 dB NRDG and 5 dB benefited noise reduction in Cases 1 through 21, barriers were reasonable for the 1,250 and 2,600 APBR criteria for all options for the NRDG quantity. Area requirements were in the 21,000 to 27,000 SF range for these designs.

Cases 22 through 42 for 7 dB NRDG and 7 dB benefited noise reduction, and Cases 43 through 63 for 9 dB NRDG and 9 dB benefited noise reduction were also unreasonable using the 1,250 SF/benefited receptor APBR criterion. For the 7 dB/7 dB cases, 1,343 SF/ benefited receptor was the lowest APBR for any of the designs; and for the 9 dB/9 dB cases, 2,524 SF/ benefited receptor was the lowest value. However, all of the cases for those two combinations were reasonable for the 2,600 SF/benefited receptor APBR criterion. Square footage requirements were in the 27,000 to 28,000 SF range for the 7 dB/7 dB cases and approximately 33,000 for the 9 dB/9 dB cases. The extra area for the latter cases was necessary to achieve the higher 9 dB NRDG, although fewer receptors were actually counted as "benefited" due to the higher benefited noise reduction criterion.

For the 10 dB NRDG and 5 dB benefited noise reduction in Cases 64 through 84, most of the cases using the 1,250 and 2,600 SF/benefited receptor APBR criteria were reasonable. However, for Case 81, requiring 50% of all benefited receptors to meet the NRDG, only the 2,600 APBR criterion was met. Also, none of the cases requiring 75% of all benefited receptors to meet the NRDG were reasonable for any of the three tested APBR criteria (Cases 82 through 84). The barrier area for the reasonable case was as low as 30,000 SF when only one benefited receptor or only 25% of the first-row benefited receptors had to meet the 10 dB NRDG. The needed area increased to 37,000 when 50% of all benefited receptors were required to meet the NRDG. For

the unreasonable "75% of all" cases even an area of nearly 55,000 SF was not enough to meet the NRDG at the needed number of receptors.

Study Area B was one where the expectation, based on experience, was that a noise barrier was probably necessary based on the high predicted no-barrier levels for the receptors closest to the road. The close spacing of the receptors supported a decision of "reasonable," while the fact that the rows of houses angled away from the road raised the question as to whether sufficient benefits could be obtained. The mixed results bore out these considerations. The lessons from Study Area B include:

- Feasibility was easily demonstrated for all cases.
- An APBR of 800 SF/benefited receptor was too low for reasonableness in any case, even for a 7 dB NRDG and 5 dB benefited noise reduction with only a single benefited receptor needing to meet the NRDG.
- An APBR of 1,400 SF/benefited receptor is probably the lowest that would result in positive decisions on reasonableness for an NRDG of 7 dB.
- An APBR of 2,600 SF/benefited receptor is probably the lowest that would result in positive decisions on reasonableness for an NRDG of 9 dB when the benefited noise reduction is also high.
- However, a lower APBR of 1,300 SF/benefited receptor would appear sufficient a high NRDG of 10 dB when the benefited noise reduction criterion is kept low.
- Requiring a high percentage of all benefited receptors to meet the NRDG is likely to result in a decision of "not reasonable" when the NRDG is high.
- Requiring only one benefited receptor or even up to 50% of first-row or all benefited receptors to meet the NRDG is likely to result in a decision of "reasonable" regardless of the NRDG.

**Table 23. Reasonableness Results for Study Area B: Six-Lane Highway with Two Rows of Closely-Spaced Houses Angling Away from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 1 | 7 | 5 | # | 1 | -- | 27206 | 800 | 21,402 | 11 | 25 | 4 | 5 | 36% | 20% | Yes-NR-# | 856 | No | No |
| 2 | 7 | 5 | # | 1 | -- | -- | 1,250 | 22,002 | 7 | 24 | 5 | 5 | 71% | 21% | Yes-NR-# | 917 | Yes | Yes |
| 3 | 7 | 5 | # | 1 | -- | -- | 2,600 | 22,002 | 7 | 24 | 5 | 5 | 71% | 21% | Yes-NR-# | 917 | Yes | Yes |
| 4 | 7 | 5 | P1 | -- | 25% | -- | 800 | 22,002 | 7 | 24 | 5 | 5 | 71% | 21% | Yes-NR-%1 | 917 | No | No |
| 5 | 7 | 5 | P1 | -- | 25% | -- | 1,250 | 22,002 | 7 | 24 | 5 | 5 | 71% | 21% | Yes-NR-%1 | 917 | Yes | Yes |
| 6 | 7 | 5 | P1 | -- | 25% | -- | 2,600 | 22,002 | 7 | 24 | 5 | 5 | 71% | 21% | Yes-NR-%1 | 917 | Yes | Yes |
| 7 | 7 | 5 | P1 | -- | 50% | -- | 800 | 22,002 | 7 | 24 | 5 | 5 | 71% | 21% | Yes-NR-%1 | 917 | No | No |
| 8 | 7 | 5 | P1 | -- | 50% | -- | 1,250 | 22,002 | 7 | 24 | 5 | 5 | 71% | 21% | Yes-NR-%1 | 917 | Yes | Yes |
| 9 | 7 | 5 | P1 | -- | 50% | -- | 2,600 | 22,002 | 7 | 24 | 5 | 5 | 71% | 21% | Yes-NR-%1 | 917 | Yes | Yes |
| 10 | 7 | 5 | P1 | -- | 75% | -- | 800 | 23,002 | 7 | 24 | 6 | 6 | 86% | 25% | Yes-NR-%1 | 958 | No | No |
| 11 | 7 | 5 | P1 | -- | 75% | -- | 1,250 | 23,002 | 7 | 24 | 6 | 6 | 86% | 25% | Yes-NR-%1 | 958 | Yes | Yes |
| 12 | 7 | 5 | P1 | -- | 75% | -- | 2,600 | 23,002 | 7 | 24 | 6 | 6 | 86% | 25% | Yes-NR-%1 | 958 | Yes | Yes |
| 13 | 7 | 5 | PA | -- | -- | 25% | 800 | 23,002 | 7 | 24 | 6 | 6 | 86% | 25% | Yes-NR-%A | 958 | No | No |
| 14 | 7 | 5 | PA | -- | -- | 25% | 1,250 | 23,002 | 7 | 24 | 6 | 6 | 86% | 25% | Yes-NR-%A | 958 | Yes | Yes |
| 15 | 7 | 5 | PA | -- | -- | 25% | 2,600 | 23,002 | 7 | 24 | 6 | 6 | 86% | 25% | Yes-NR-%A | 958 | Yes | Yes |
| 16 | 7 | 5 | PA | -- | -- | 50% | 800 | 25,004 | 7 | 24 | 7 | 17 | 100% | 71% | Yes-NR-%A | 1,042 | No | No |
| 17 | 7 | 5 | PA | -- | -- | 50% | 1,250 | 25,004 | 7 | 24 | 7 | 17 | 100% | 71% | Yes-NR-%A | 1,042 | Yes | Yes |
| 18 | 7 | 5 | PA | -- | -- | 50% | 2,600 | 25,004 | 7 | 24 | 7 | 17 | 100% | 71% | Yes-NR-%A | 1,042 | Yes | Yes |
| 19 | 7 | 5 | PA | -- | -- | 75% | 800 | 27,206 | 7 | 24 | 7 | 19 | 100% | 79% | Yes-NR-%A | 1,134 | No | No |
| 20 | 7 | 5 | PA | -- | -- | 75% | 1,250 | 27,206 | 7 | 24 | 7 | 19 | 100% | 79% | Yes-NR-%A | 1,134 | Yes | Yes |
| 21 | 7 | 5 | PA | -- | -- | 75% | 2,600 | 27,206 | 7 | 24 | 7 | 19 | 100% | 79% | Yes-NR-%A | 1,134 | Yes | Yes |
| 22 | 7 | 7 | # | 1 | -- | -- | 800 | 27,206 | 7 | 20 | 7 | 20 | 100% | 100% | Yes-NR-# | 1,360 | No | No |

Continued on next page

**Table 23. Reasonableness Results for Study Area B: Six-Lane Highway with Two Rows of Closely-Spaced Houses Angling Away from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 23 | 7 | 7 | # | 1 | -- | -- | 1,250 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-# | 1,343 | No | No |
| 24 | 7 | 7 | # | 1 | -- | -- | 2,600 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-# | 1,343 | Yes | Yes |
| 25 | 7 | 7 | P1 | -- | 25% | -- | 800 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%1 | 1,343 | No | No |
| 26 | 7 | 7 | P1 | -- | 25% | -- | 1,250 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%1 | 1,343 | No | No |
| 27 | 7 | 7 | P1 | -- | 25% | -- | 2,600 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%1 | 1,343 | Yes | Yes |
| 28 | 7 | 7 | P1 | -- | 50% | -- | 800 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%1 | 1,343 | No | No |
| 29 | 7 | 7 | P1 | -- | 50% | -- | 1,250 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%1 | 1,343 | No | No |
| 30 | 7 | 7 | P1 | -- | 50% | -- | 2,600 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%1 | 1,343 | Yes | Yes |
| 31 | 7 | 7 | P1 | -- | 75% | -- | 800 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%1 | 1,343 | No | No |
| 32 | 7 | 7 | P1 | -- | 75% | -- | 1,250 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%1 | 1,343 | No | No |
| 33 | 7 | 7 | P1 | -- | 75% | -- | 2,600 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%1 | 1,343 | Yes | Yes |
| 34 | 7 | 7 | PA | -- | -- | 25% | 800 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%A | 1,343 | No | No |
| 35 | 7 | 7 | PA | -- | -- | 25% | 1,250 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%A | 1,343 | No | No |
| 36 | 7 | 7 | PA | -- | -- | 25% | 2,600 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%A | 1,343 | Yes | Yes |
| 37 | 7 | 7 | PA | -- | -- | 50% | 800 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%A | 1,343 | No | No |
| 38 | 7 | 7 | PA | -- | -- | 50% | 1,250 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%A | 1,343 | No | No |
| 39 | 7 | 7 | PA | -- | -- | 50% | 2,600 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%A | 1,343 | Yes | Yes |
| 40 | 7 | 7 | PA | -- | -- | 75% | 800 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%A | 1,343 | No | No |
| 41 | 7 | 7 | PA | -- | -- | 75% | 1,250 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%A | 1,343 | No | No |
| 42 | 7 | 7 | PA | -- | -- | 75% | 2,600 | 28,206 | 7 | 21 | 7 | 21 | 100% | 100% | Yes-NR-%A | 1,343 | Yes | Yes |
| 43 | 9 | 9 | # | 1 | -- | -- | 800 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-# | 2,524 | No | No |
| 44 | 9 | 9 | # | 1 | -- | -- | 1,250 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-# | 2,524 | No | No |

Continued on next page

**Table 23. Reasonableness Results for Study Area B: Six-Lane Highway with Two Rows of Closely-Spaced Houses Angling Away from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 45 | 9 | 9 | # | 1 | -- | -- | 2,600 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-# | 2,524 | Yes | Yes |
| 46 | 9 | 9 | P1 | -- | 25% | -- | 800 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%1 | 2,524 | No | No |
| 47 | 9 | 9 | P1 | -- | 25% | -- | 1,250 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%1 | 2,524 | No | No |
| 48 | 9 | 9 | P1 | -- | 25% | -- | 2,600 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%1 | 2,524 | Yes | Yes |
| 49 | 9 | 9 | P1 | -- | 50% | -- | 800 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%1 | 2,524 | No | No |
| 50 | 9 | 9 | P1 | -- | 50% | -- | 1,250 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%1 | 2,524 | No | No |
| 51 | 9 | 9 | P1 | -- | 50% | -- | 2,600 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%1 | 2,524 | Yes | Yes |
| 52 | 9 | 9 | P1 | -- | 75% | -- | 800 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%1 | 2,524 | No | No |
| 53 | 9 | 9 | P1 | -- | 75% | -- | 1,250 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%1 | 2,524 | No | No |
| 54 | 9 | 9 | P1 | -- | 75% | -- | 2,600 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%1 | 2,524 | Yes | Yes |
| 55 | 9 | 9 | PA | -- | -- | 25% | 800 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%A | 2,524 | No | No |
| 56 | 9 | 9 | PA | -- | -- | 25% | 1,250 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%A | 2,524 | No | No |
| 57 | 9 | 9 | PA | -- | -- | 25% | 2,600 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%A | 2,524 | Yes | Yes |
| 58 | 9 | 9 | PA | -- | -- | 50% | 800 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%A | 2,524 | No | No |
| 59 | 9 | 9 | PA | -- | -- | 50% | 1,250 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%A | 2,524 | No | No |
| 60 | 9 | 9 | PA | -- | -- | 50% | 2,600 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%A | 2,524 | Yes | Yes |
| 61 | 9 | 9 | PA | -- | -- | 75% | 800 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%A | 2,524 | No | No |
| 62 | 9 | 9 | PA | -- | -- | 75% | 1,250 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%A | 2,524 | No | No |
| 63 | 9 | 9 | PA | -- | -- | 75% | 2,600 | 32,807 | 6 | 13 | 6 | 13 | 100% | 100% | Yes-NR-%A | 2,524 | Yes | Yes |
| 64 | 10 | 5 | # | 1 | -- | -- | 800 | 30,805 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-# | 1,284 | No | No |
| 65 | 10 | 5 | # | 1 | -- | -- | 1,250 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-# | 1,242 | Yes | Yes |
| 66 | 10 | 5 | # | 1 | -- | -- | 2,600 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-# | 1,242 | Yes | Yes |

Continued on next page

**Table 23. Reasonableness Results for Study Area B: Six-Lane Highway with Two Rows of Closely-Spaced Houses Angling Away from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 67 | 10 | 5 | P1 | -- | 25% | -- | 800 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%1 | 1,242 | No | No |
| 68 | 10 | 5 | P1 | -- | 25% | -- | 1,250 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%1 | 1,242 | Yes | Yes |
| 69 | 10 | 5 | P1 | -- | 25% | -- | 2,600 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%1 | 1,242 | Yes | Yes |
| 70 | 10 | 5 | P1 | -- | 50% | -- | 800 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%1 | 1,242 | No | No |
| 71 | 10 | 5 | P1 | -- | 50% | -- | 1,250 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%1 | 1,242 | Yes | Yes |
| 72 | 10 | 5 | P1 | -- | 50% | -- | 2,600 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%1 | 1,242 | Yes | Yes |
| 73 | 10 | 5 | P1 | -- | 75% | -- | 800 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%1 | 1,242 | No | No |
| 74 | 10 | 5 | P1 | -- | 75% | -- | 1,250 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%1 | 1,242 | Yes | Yes |
| 75 | 10 | 5 | P1 | -- | 75% | -- | 2,600 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%1 | 1,242 | Yes | Yes |
| 76 | 10 | 5 | PA | -- | -- | 25% | 800 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%A | 1,242 | No | No |
| 77 | 10 | 5 | PA | -- | -- | 25% | 1,250 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%A | 1,242 | Yes | Yes |
| 78 | 10 | 5 | PA | -- | -- | 25% | 2,600 | 29,804 | 7 | 24 | 6 | 8 | 86% | 33% | Yes-NR-%A | 1,242 | Yes | Yes |
| 79 | 10 | 5 | PA | -- | -- | 50% | 800 | 37,418 | 7 | 24 | 6 | 12 | 86% | 50% | Yes-NR-%A | 1,559 | No | No |
| 80 | 10 | 5 | PA | -- | -- | 50% | 1,250 | 37,418 | 7 | 24 | 6 | 12 | 86% | 50% | Yes-NR-%A | 1,559 | No | No |
| 81 | 10 | 5 | PA | -- | -- | 50% | 2,600 | 37,418 | 7 | 24 | 6 | 12 | 86% | 50% | Yes-NR-%A | 1,559 | Yes | Yes |
| 82 | 10 | 5 | PA | -- | -- | 75% | 800 | 54,646 | 7 | 24 | 7 | 15 | 100% | 63% | No-NR-%A | 2,277 | No | No |
| 83 | 10 | 5 | PA | -- | -- | 75% | 1,250 | 54,646 | 7 | 24 | 7 | 15 | 100% | 63% | No-NR-%A | 2,277 | No | No |
| 84 | 10 | 5 | PA | -- | -- | 75% | 2,600 | 54,646 | 7 | 24 | 7 | 15 | 100% | 63% | No-NR-%A | 2,277 | Yes | No |

### 3.2.7 Study Area C Description and Results

Study Area C represents a proposed widening to an eight-lane Interstate facility. Figure 23 shows the area. The road is in slight cut and there are groupings of houses on two curved residential streets with open area between them.

For this project, feasibility and reasonableness are somewhat uncertain due to the moderate residential density and the fact that the road is primarily in cut.


**Figure 23. Study Area C: Ten-lane highway with medium-density houses curving away from the highway.**

Table 24 shows the feasibility results for Study Area C, and Table 25 shows the reasonableness results Study Area C.

**Table 24. Feasibility Results for Study Area C: Ten-Lane Highway with Medium-Density Houses Curving Away from Highway.**

| Case | Feasibility Factors | | | | | Feasibility Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Feas NR | Feas Type | Feas Crit # | Feas Crit % 1R | Feas Crit % All | # Impacts ALL | # Impacts 1R | Feas # 1R | Feas # ALL | Feas % 1R | Feas % ALL | Feas? |
| 1 | 5 | # | 1 | -- | -- | 26 | 14 | 5 | 5 | 36% | 19% | Yes-# |
| 2 | 5 | P1 | -- | 25% | -- | 26 | 14 | 5 | 5 | 36% | 19% | Yes-%1 |
| 3 | 5 | P1 | -- | 50% | -- | 26 | 14 | 11 | 18 | 79% | 69% | Yes-%1 |
| 4 | 5 | P1 | -- | 75% | -- | 26 | 14 | 12 | 20 | 86% | 77% | Yes-%1 |
| 5 | 5 | PA | -- | -- | 25% | 26 | 14 | 12 | 20 | 86% | 77% | Yes-%A |
| 6 | 5 | PA | -- | -- | 50% | 26 | 14 | 12 | 20 | 86% | 77% | Yes-%A |
| 7 | 5 | PA | -- | -- | 75% | 26 | 14 | 12 | 20 | 86% | 77% | Yes-%A |

A barrier was feasible for all seven combinations of the feasibility factors, just barely meeting the case for 75% of all impacts. If this factor had been 80%, the barrier would not have been feasible in that case.

For almost all of the cases, a barrier was reasonable in terms of the NRDG criterion. The exceptions were for the 10 dB NRDG and 5 dB benefited noise reduction requiring 75% of all benefited receptors (Cases 82 through 84).

However, in terms of the APBR criterion, a barrier was not reasonable for many more cases. Overall, a barrier was reasonable for only 23 of the 84 studied cases, most of them for an APBR of 2,600 SF/benefited receptor.

None of the cases were reasonable for an APBR criterion of 800 SF/benefited receptor.

Three of the cases were reasonable for the 1,250 SF/benefited receptor APBR criterion, all for an NRDG of 7 dB when the benefited noise reduction criterion was 5 dB (“7 dB/5 dB”):

- Case 2: meeting the NRDG at one or more benefited receptor
- Case 5: meeting the NRDG at 25% of first-row benefited receptors
- Case 14: meeting the NRDG at 25% all benefited receptors

Seven of the cases were reasonable for the 7 dB NRDG and 7 dB benefited noise reduction (“7 dB/7 dB”), all for the 2,600 SF/benefited receptor APBR criterion.

None of the cases were reasonable for an NRDG of 9 dB and benefited noise reduction criterion of 9 dB because of the large amount of area needed to meet the 9 dB NRDG while also accumulating enough benefits at a 9 or more dB reduction (“9 dB/9 dB”).

For a 10 dB NRDG and a 5 dB benefited noise reduction ("10 dB/5 dB"), all of the cases for the 2,600 SF/benefited receptor APBR criterion were reasonable except Case 84 requiring 75% of all benefited receptors; the NRDG could only be achieved at 52%.

Square footage requirements were around 35,000 SF for the designs for the 7 dB NRDG and 5 dB benefited noise reduction, 48,000 SF for the designs for the 7 dB NRDG and 7 dB benefited noise reduction, and up to 55,000 SF for the 10 dB NRDG and 5 dB, reflecting the need to achieve the required higher noise reductions.

Study Area C was one where, based on experience, the expectation was that a "reasonable" noise barrier was questionable. The house density was not high, the "first" rows curved away from the road, and there was a small area of undeveloped area in the center of the study area.

The main lessons from Study Area C include:

- Feasibility was demonstrated in all cases, but only barely so for the case of 75% of all impacted receptors.
- APBR was the key criterion for this marginal case, needing to be around:
    - 1,500-1,600 SF/benefited receptor for most for the 7 dB/5 dB cases
    - 2,000 SF/benefited receptor for the 7 dB/7 dB cases
    - 3,250 SF/benefited receptor for the 9 dB/9 dB cases, and
    - 1,700-1,800 SF/benefited receptor for most for the 10 dB/5 dB cases

**Table 25. Reasonableness Results for Study Area C: Ten-Lane Highway with Medium-Density Houses Curving Away from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG? | APBR Calc | Reas. APBR ? | Reas. ? |
| 1 | 7 | 5 | # | 1 | -- | -- | 800 | 34,696 | 13 | 28 | 5 | 11 | 38% | 39% | Yes-NR-# | 1,239 | No | No |
| 2 | 7 | 5 | # | 1 | -- | -- | 1,250 | 34,696 | 13 | 28 | 5 | 11 | 38% | 39% | Yes-NR-# | 1,239 | Yes | Yes |
| 3 | 7 | 5 | # | 1 | -- | -- | 2,600 | 42,159 | 13 | 28 | 12 | 19 | 92% | 68% | Yes-NR-# | 1,506 | Yes | Yes |
| 4 | 7 | 5 | P1 | -- | 25% | -- | 800 | 34,696 | 13 | 28 | 5 | 11 | 38% | 39% | Yes-NR-%1 | 1,239 | No | No |
| 5 | 7 | 5 | P1 | -- | 25% | -- | 1,250 | 34,696 | 13 | 28 | 5 | 11 | 38% | 39% | Yes-NR-%1 | 1,239 | Yes | Yes |
| 6 | 7 | 5 | P1 | -- | 25% | -- | 2,600 | 42,159 | 13 | 28 | 12 | 19 | 92% | 68% | Yes-NR-%1 | 1,506 | Yes | Yes |
| 7 | 7 | 5 | P1 | -- | 50% | -- | 800 | 41,779 | 14 | 30 | 7 | 15 | 50% | 50% | Yes-NR-%1 | 1,393 | No | No |
| 8 | 7 | 5 | P1 | -- | 50% | -- | 1,250 | 41,779 | 14 | 30 | 7 | 15 | 50% | 50% | Yes-NR-%1 | 1,393 | No | No |
| 9 | 7 | 5 | P1 | -- | 50% | -- | 2,600 | 44,452 | 13 | 30 | 12 | 19 | 92% | 63% | Yes-NR-%1 | 1,482 | Yes | Yes |
| 10 | 7 | 5 | P1 | -- | 75% | -- | 800 | 45,163 | 13 | 29 | 11 | 22 | 85% | 76% | Yes-NR-%1 | 1,557 | No | No |
| 11 | 7 | 5 | P1 | -- | 75% | -- | 1,250 | 45,163 | 13 | 29 | 11 | 22 | 85% | 76% | Yes-NR-%1 | 1,557 | No | No |
| 12 | 7 | 5 | P1 | -- | 75% | -- | 2,600 | 44,452 | 13 | 30 | 12 | 19 | 92% | 63% | Yes-NR-%1 | 1,482 | Yes | Yes |
| 13 | 7 | 5 | PA | -- | -- | 25% | 800 | 34,696 | 13 | 28 | 5 | 11 | 38% | 39% | Yes-NR-%A | 1,239 | No | No |
| 14 | 7 | 5 | PA | -- | -- | 25% | 1,250 | 34,696 | 13 | 28 | 5 | 11 | 38% | 39% | Yes-NR-%A | 1,239 | Yes | Yes |
| 15 | 7 | 5 | PA | -- | -- | 25% | 2,600 | 42,159 | 13 | 28 | 12 | 19 | 92% | 68% | Yes-NR-%A | 1,506 | Yes | Yes |
| 16 | 7 | 5 | PA | -- | -- | 50% | 800 | 41,779 | 14 | 30 | 7 | 15 | 50% | 50% | Yes-NR-%A | 1,393 | No | No |
| 17 | 7 | 5 | PA | -- | -- | 50% | 1,250 | 41,779 | 14 | 30 | 7 | 15 | 50% | 50% | Yes-NR-%A | 1,393 | No | No |
| 18 | 7 | 5 | PA | -- | -- | 50% | 2,600 | 44,452 | 13 | 30 | 12 | 19 | 92% | 63% | Yes-NR-%A | 1,482 | Yes | Yes |
| 19 | 7 | 5 | PA | -- | -- | 75% | 800 | 45,163 | 13 | 29 | 11 | 22 | 85% | 76% | Yes-NR-%A | 1,557 | No | No |
| 20 | 7 | 5 | PA | -- | -- | 75% | 1,250 | 45,163 | 13 | 29 | 11 | 22 | 85% | 76% | Yes-NR-%A | 1,557 | No | No |
| 21 | 7 | 5 | PA | -- | -- | 75% | 2,600 | 47,728 | 13 | 30 | 13 | 24 | 100% | 80% | Yes-NR-%A | 1,591 | Yes | Yes |
| 22 | 7 | 7 | # | 1 | -- | -- | 800 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-# | 1,989 | No | No |
| 23 | 7 | 7 | # | 1 | -- | -- | 1,250 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-# | 1,989 | No | No |

Continued on next page

**Table 25. Reasonableness Results for Study Area C: Ten-Lane Highway with Medium-Density Houses Curving Away from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG? | APBR Calc | Reas. APBR ? | Reas. ? |
| 24 | 7 | 7 | # | 1 | -- | -- | 2,600 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-# | 1,989 | Yes | Yes |
| 25 | 7 | 7 | P1 | -- | 25% | -- | 800 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%1 | 1,989 | No | No |
| 26 | 7 | 7 | P1 | -- | 25% | -- | 1,250 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%1 | 1,989 | No | No |
| 27 | 7 | 7 | P1 | -- | 25% | -- | 2,600 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%1 | 1,989 | Yes | Yes |
| 28 | 7 | 7 | P1 | -- | 50% | -- | 800 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%1 | 1,989 | No | No |
| 29 | 7 | 7 | P1 | -- | 50% | -- | 1,250 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%1 | 1,989 | No | No |
| 30 | 7 | 7 | P1 | -- | 50% | -- | 2,600 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%1 | 1,989 | Yes | Yes |
| 31 | 7 | 7 | P1 | -- | 75% | -- | 800 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%1 | 1,989 | No | No |
| 32 | 7 | 7 | P1 | -- | 75% | -- | 1,250 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%1 | 1,989 | No | No |
| 33 | 7 | 7 | P1 | -- | 75% | -- | 2,600 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%1 | 1,989 | Yes | Yes |
| 34 | 7 | 7 | PA | -- | -- | 25% | 800 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%A | 1,989 | No | No |
| 35 | 7 | 7 | PA | -- | -- | 25% | 1,250 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%A | 1,989 | No | No |
| 36 | 7 | 7 | PA | -- | -- | 25% | 2,600 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%A | 1,989 | Yes | Yes |
| 37 | 7 | 7 | PA | -- | -- | 50% | 800 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%A | 1,989 | No | No |
| 38 | 7 | 7 | PA | -- | -- | 50% | 1,250 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%A | 1,989 | No | No |
| 39 | 7 | 7 | PA | -- | -- | 50% | 2,600 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%A | 1,989 | Yes | Yes |
| 40 | 7 | 7 | PA | -- | -- | 75% | 800 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%A | 1,989 | No | No |
| 41 | 7 | 7 | PA | -- | -- | 75% | 1,250 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%A | 1,989 | No | No |
| 42 | 7 | 7 | PA | -- | -- | 75% | 2,600 | 47,728 | 13 | 24 | 13 | 24 | 100% | 100% | Yes-NR-%A | 1,989 | Yes | Yes |
| 43 | 9 | 9 | # | 1 | -- | -- | 800 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-# | 3,248 | No | No |
| 44 | 9 | 9 | # | 1 | -- | -- | 1,250 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-# | 3,248 | No | No |
| 45 | 9 | 9 | # | 1 | -- | -- | 2,600 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-# | 3,248 | No | No |
| 46 | 9 | 9 | P1 | -- | 25% | -- | 800 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%1 | 3,248 | No | No |

Continued on next page

**Table 25. Reasonableness Results for Study Area C: Ten-Lane Highway with Medium-Density Houses Curving Away from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG? | APBR Calc | Reas. APBR ? | Reas. ? |
| 47 | 9 | 9 | P1 | -- | 25% | -- | 1,250 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%1 | 3,248 | No | No |
| 48 | 9 | 9 | P1 | -- | 25% | -- | 2,600 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%1 | 3,248 | No | No |
| 49 | 9 | 9 | P1 | -- | 50% | -- | 800 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%1 | 3,248 | No | No |
| 50 | 9 | 9 | P1 | -- | 50% | -- | 1,250 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%1 | 3,248 | No | No |
| 51 | 9 | 9 | P1 | -- | 50% | -- | 2,600 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%1 | 3,248 | No | No |
| 52 | 9 | 9 | P1 | -- | 75% | -- | 800 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%1 | 3,248 | No | No |
| 53 | 9 | 9 | P1 | -- | 75% | -- | 1,250 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%1 | 3,248 | No | No |
| 54 | 9 | 9 | P1 | -- | 75% | -- | 2,600 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%1 | 3,248 | No | No |
| 55 | 9 | 9 | PA | -- | -- | 25% | 800 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%A | 3,248 | No | No |
| 56 | 9 | 9 | PA | -- | -- | 25% | 1,250 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%A | 3,248 | No | No |
| 57 | 9 | 9 | PA | -- | -- | 25% | 2,600 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%A | 3,248 | No | No |
| 58 | 9 | 9 | PA | -- | -- | 50% | 800 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%A | 3,248 | No | No |
| 59 | 9 | 9 | PA | -- | -- | 50% | 1,250 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%A | 3,248 | No | No |
| 60 | 9 | 9 | PA | -- | -- | 50% | 2,600 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%A | 3,248 | No | No |
| 61 | 9 | 9 | PA | -- | -- | 75% | 800 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%A | 3,248 | No | No |
| 62 | 9 | 9 | PA | -- | -- | 75% | 1,250 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%A | 3,248 | No | No |
| 63 | 9 | 9 | PA | -- | -- | 75% | 2,600 | 55,208 | 11 | 17 | 11 | 17 | 100% | 100% | Yes-NR-%A | 3,248 | No | No |
| 64 | 10 | 5 | # | 1 | -- | -- | 800 | 46,512 | 13 | 31 | 4 | 6 | 31% | 19% | Yes-NR-# | 1,500 | No | No |
| 65 | 10 | 5 | # | 1 | -- | -- | 1,250 | 46,512 | 13 | 31 | 4 | 6 | 31% | 19% | Yes-NR-# | 1,500 | No | No |
| 66 | 10 | 5 | # | 1 | -- | -- | 2,600 | 52,727 | 14 | 32 | 7 | 10 | 50% | 31% | Yes-NR-# | 1,648 | Yes | Yes |
| 67 | 10 | 5 | P1 | -- | 25% | -- | 800 | 46,512 | 13 | 31 | 4 | 6 | 31% | 19% | Yes-NR-%1 | 1,500 | No | No |
| 68 | 10 | 5 | P1 | -- | 25% | -- | 1,250 | 46,512 | 13 | 31 | 4 | 6 | 31% | 19% | Yes-NR-%1 | 1,500 | No | No |
| 69 | 10 | 5 | P1 | -- | 25% | -- | 2,600 | 52,727 | 14 | 32 | 7 | 10 | 50% | 31% | Yes-NR-%1 | 1,648 | Yes | Yes |

Continued on next page

**Table 25. Reasonableness Results for Study Area C: Ten-Lane Highway with Medium-Density Houses Curving Away from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG? | APBR Calc | Reas. APBR ? | Reas. ? |
| 70 | 10 | 5 | P1 | -- | 50% | -- | 800 | 52,727 | 14 | 32 | 7 | 10 | 50% | 31% | Yes-NR-%1 | 1,648 | No | No |
| 71 | 10 | 5 | P1 | -- | 50% | -- | 1,250 | 52,727 | 14 | 32 | 7 | 10 | 50% | 31% | Yes-NR-%1 | 1,648 | No | No |
| 72 | 10 | 5 | P1 | -- | 50% | -- | 2,600 | 52,727 | 14 | 32 | 7 | 10 | 50% | 31% | Yes-NR-%1 | 1,648 | Yes | Yes |
| 73 | 10 | 5 | P1 | -- | 75% | -- | 800 | 55,208 | 14 | 32 | 11 | 16 | 79% | 50% | Yes-NR-%1 | 1,725 | No | No |
| 74 | 10 | 5 | P1 | -- | 75% | -- | 1,250 | 55,208 | 14 | 32 | 11 | 16 | 79% | 50% | Yes-NR-%1 | 1,725 | No | No |
| 75 | 10 | 5 | P1 | -- | 75% | -- | 2,600 | 55,208 | 14 | 32 | 11 | 16 | 79% | 50% | Yes-NR-%1 | 1,725 | Yes | Yes |
| 76 | 10 | 5 | PA | -- | -- | 25% | 800 | 52,727 | 14 | 32 | 7 | 10 | 50% | 31% | Yes-NR-%A | 1,648 | No | No |
| 77 | 10 | 5 | PA | -- | -- | 25% | 1,250 | 52,727 | 14 | 32 | 7 | 10 | 50% | 31% | Yes-NR-%A | 1,648 | No | No |
| 78 | 10 | 5 | PA | -- | -- | 25% | 2,600 | 52,727 | 14 | 32 | 7 | 10 | 50% | 31% | Yes-NR-%A | 1,648 | Yes | Yes |
| 79 | 10 | 5 | PA | -- | -- | 50% | 800 | 55,208 | 14 | 32 | 11 | 16 | 79% | 50% | Yes-NR-%A | 1,725 | No | No |
| 80 | 10 | 5 | PA | -- | -- | 50% | 1,250 | 55,208 | 14 | 32 | 11 | 16 | 79% | 50% | Yes-NR-%A | 1,725 | No | No |
| 81 | 10 | 5 | PA | -- | -- | 50% | 2,600 | 55,208 | 14 | 32 | 11 | 16 | 79% | 50% | Yes-NR-%A | 1,725 | Yes | Yes |
| 82 | 10 | 5 | PA | -- | -- | 75% | 800 | 70,053 | 14 | 33 | 11 | 17 | 79% | 52% | No-NR-%A | 2,123 | No | No |
| 83 | 10 | 5 | PA | -- | -- | 75% | 1,250 | 70,053 | 14 | 33 | 11 | 17 | 79% | 52% | No-NR-%A | 2,123 | No | No |
| 84 | 10 | 5 | PA | -- | -- | 75% | 2,600 | 70,053 | 14 | 33 | 11 | 17 | 79% | 52% | No-NR-%A | 2,123 | Yes | No |

### 3.2.8 Study Area D Description and Results

Study Area D, shown in Figure 24, represents a proposed widening to an eight-lane highway facility. The road is on a slight fill and there are several rows of relatively closely spaced houses, with the closest houses nearly 300 feet from the road, yet still being impacted by the proposed project.


**Figure 24. Study Area D: Eight-lane highway with low-density houses set back from the highway.**

Table 26 shows the feasibility results for Study Area D, and Table 27 shows the reasonableness results for Study Area D.

A barrier was feasible for all seven combinations of the feasibility factors. Even though there were 41 receptors in the study area, there were only 9 impacted receptors due to the distance from the road to the first-row of houses of 240 to 330 feet.

For almost all of the cases, a barrier was reasonable in terms of the NRDG criterion. The exceptions were for the 10 dB NRDG and 5 dB benefited noise reduction requiring:

- 75% of first-row benefited receptors (Cases 73 through 75) and
- 50% and 75% of all benefited receptors (Cases 79 through 84)

However, in terms of the APBR criterion, a barrier was not reasonable for many more cases. The result was that, overall, a barrier was reasonable for only 10 of the 84 studied cases.

Those 10 "reasonable" cases were all for an APBR criterion of 2,600 SF/benefited receptor when the benefited noise reduction criterion was 5 dB:

- NRDG of 7 dB for:
  - One or more benefited receptor (Case 3)
  - 25%, 50%, and 75% of first-row benefited receptors (Cases 6, 9, and 12)
  - 25%, 50%, and 75% of all benefited receptors (Cases 15, 18, and 21)
- NRDG of 10 dB for:
  - One or more benefited receptor (Case 66)
  - 25% and 50% of first-row benefited receptors (Cases 69 and 72)

**Table 26. Feasibility Results for Study Area D: Eight-Lane Highway with Low-Density Houses Set Back from Highway.**

| Case | Feasibility Factors | | | | | Feasibility Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Feas NR | Feas Type | Feas Crit # | Feas Crit % 1R | Feas Crit % All | # Impacts ALL | # Impacts 1R | Feas # 1R | Feas # ALL | Feas % 1R | Feas % ALL | Feasible ? |
| 1 | 5 | # | 1 | -- | -- | 9 | 9 | 1 | 1 | 11% | 11% | Yes-# |
| 2 | 5 | P1 | -- | 25% | -- | 9 | 9 | 9 | 9 | 100% | 100% | Yes-%1 |
| 3 | 5 | P1 | -- | 50% | -- | 9 | 9 | 9 | 9 | 100% | 100% | Yes-%1 |
| 4 | 5 | P1 | -- | 75% | -- | 9 | 9 | 9 | 9 | 100% | 100% | Yes-%1 |
| 5 | 5 | PA | -- | -- | 25% | 9 | 9 | 9 | 9 | 100% | 100% | Yes-%A |
| 6 | 5 | PA | -- | -- | 50% | 9 | 9 | 9 | 9 | 100% | 100% | Yes-%A |
| 7 | 5 | PA | -- | -- | 75% | 9 | 9 | 9 | 9 | 100% | 100% | Yes-%A |

Square footage requirements were in the 79,000 to 93,000 SF range for 7 dB NRDG case and 98,000 to 101,000 SF for the 10 dB NRDG cases. The greater areas were needed for the latter cases in order to achieve the needed higher noise reductions

None of the cases were reasonable when the benefited noise reduction was 7 dB or 9 dB. While the NRDG criterion could be met for these higher noise reductions, the resultant barrier areas were too great to allow the APBR criterion to be met.

Study Area D was one where the expectation was that a "reasonable" noise barrier was questionable, based on experience. While there were first-row impacts, the first-row was far from the road. This distance necessitated a tall and long noise barrier to meet the NRDG criterion and also benefit a sufficient number of receptors at the low 5 dB value for the benefited noise reduction criterion.

The lessons from Study Area D include:

- Feasibility was easily demonstrated for all cases.
- A high APBR (in the 2,400- 2,700 SF/benefited receptor range) was needed for reasonableness.
- Most of the cases met the NRDG criteria of 7, 9, and 10 dB, except for some of the high percentage cases for 10 dB.
- A low (5 dB) benefited noise reduction criterion was needed to meet the APBR criterion.

**Table 27. Reasonableness Results for Study Area D: Eight-Lane Highway with Low-Density Houses Set Back from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 1 | 7 | 5 | # | 1 | -- | -- | 800 | 79,079 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-# | 2,326 | No | No |
| 2 | 7 | 5 | # | 1 | -- | -- | 1,250 | 79,079 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-# | 2,326 | No | No |
| 3 | 7 | 5 | # | 1 | -- | -- | 2,600 | 79,079 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-# | 2,326 | Yes | Yes |
| 4 | 7 | 5 | P1 | -- | 25% | -- | 800 | 79,079 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%1 | 2,326 | No | No |
| 5 | 7 | 5 | P1 | -- | 25% | -- | 1,250 | 79,079 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%1 | 2,326 | No | No |
| 6 | 7 | 5 | P1 | -- | 25% | -- | 2,600 | 79,079 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%1 | 2,326 | Yes | Yes |
| 7 | 7 | 5 | P1 | -- | 50% | -- | 800 | 79,079 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%1 | 2,326 | No | No |
| 8 | 7 | 5 | P1 | -- | 50% | -- | 1,250 | 79,079 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%1 | 2,326 | No | No |
| 9 | 7 | 5 | P1 | -- | 50% | -- | 2,600 | 79,079 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%1 | 2,326 | Yes | Yes |
| 10 | 7 | 5 | P1 | -- | 75% | -- | 800 | 79,078 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%1 | 2,326 | No | No |
| 11 | 7 | 5 | P1 | -- | 75% | -- | 1,250 | 79,078 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%1 | 2,326 | No | No |
| 12 | 7 | 5 | P1 | -- | 75% | -- | 2,600 | 79,078 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%1 | 2,326 | Yes | Yes |
| 13 | 7 | 5 | PA | -- | -- | 25% | 800 | 79,078 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%A | 2,326 | No | No |
| 14 | 7 | 5 | PA | -- | -- | 25% | 1,250 | 79,078 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%A | 2,326 | No | No |
| 15 | 7 | 5 | PA | -- | -- | 25% | 2,600 | 79,078 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%A | 2,326 | Yes | Yes |
| 16 | 7 | 5 | PA | -- | -- | 50% | 800 | 79,078 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%A | 2,326 | No | No |
| 17 | 7 | 5 | PA | -- | -- | 50% | 1,250 | 79,078 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%A | 2,326 | No | No |
| 18 | 7 | 5 | PA | -- | -- | 50% | 2,600 | 79,078 | 16 | 34 | 13 | 18 | 81% | 53% | Yes-NR-%A | 2,326 | Yes | Yes |
| 19 | 7 | 5 | PA | -- | -- | 75% | 800 | 93,362 | 16 | 36 | 16 | 27 | 100% | 75% | Yes-NR-%A | 2,593 | No | No |
| 20 | 7 | 5 | PA | -- | -- | 75% | 1,250 | 93,362 | 16 | 36 | 16 | 27 | 100% | 75% | Yes-NR-%A | 2,593 | No | No |
| 21 | 7 | 5 | PA | -- | -- | 75% | 2,600 | 93,362 | 16 | 36 | 16 | 27 | 100% | 75% | Yes-NR-%A | 2,593 | Yes | Yes |
| 22 | 7 | 7 | # | 1 | -- | -- | 800 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-# | 3,458 | No | No |
| 23 | 7 | 7 | # | 1 | -- | -- | 1,250 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-# | 3,458 | No | No |
| 24 | 7 | 7 | # | 1 | -- | -- | 2,600 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-# | 3,458 | No | No |

Continued on next page

**Table 27. Reasonableness Results for Study Area D: Eight-Lane Highway with Low-Density Houses Set Back from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 25 | 7 | 7 | P1 | -- | 25% | -- | 800 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 3,458 | No | No |
| 26 | 7 | 7 | P1 | -- | 25% | -- | 1,250 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 3,458 | No | No |
| 27 | 7 | 7 | P1 | -- | 25% | -- | 2,600 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 3,458 | No | No |
| 28 | 7 | 7 | P1 | -- | 50% | -- | 800 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 3,458 | No | No |
| 29 | 7 | 7 | P1 | -- | 50% | -- | 1,250 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 3,458 | No | No |
| 30 | 7 | 7 | P1 | -- | 50% | -- | 2,600 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 3,458 | No | No |
| 31 | 7 | 7 | P1 | -- | 75% | -- | 800 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 3,458 | No | No |
| 32 | 7 | 7 | P1 | -- | 75% | -- | 1,250 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 3,458 | No | No |
| 33 | 7 | 7 | P1 | -- | 75% | -- | 2,600 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 3,458 | No | No |
| 34 | 7 | 7 | PA | -- | -- | 25% | 800 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 3,458 | No | No |
| 35 | 7 | 7 | PA | -- | -- | 25% | 1,250 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 3,458 | No | No |
| 36 | 7 | 7 | PA | -- | -- | 25% | 2,600 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 3,458 | No | No |
| 37 | 7 | 7 | PA | -- | -- | 50% | 800 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 3,458 | No | No |
| 38 | 7 | 7 | PA | -- | -- | 50% | 1,250 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 3,458 | No | No |
| 39 | 7 | 7 | PA | -- | -- | 50% | 2,600 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 3,458 | No | No |
| 40 | 7 | 7 | PA | -- | -- | 75% | 800 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 3,458 | No | No |
| 41 | 7 | 7 | PA | -- | -- | 75% | 1,250 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 3,458 | No | No |
| 42 | 7 | 7 | PA | -- | -- | 75% | 2,600 | 93,362 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 3,458 | No | No |
| 43 | 9 | 9 | # | 1 | -- | -- | 800 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-# | 5,838 | No | No |
| 44 | 9 | 9 | # | 1 | -- | -- | 1,250 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-# | 5,838 | No | No |
| 45 | 9 | 9 | # | 1 | -- | -- | 2,600 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-# | 5,838 | No | No |
| 46 | 9 | 9 | P1 | -- | 25% | -- | 800 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 5,838 | No | No |
| 47 | 9 | 9 | P1 | -- | 25% | -- | 1,250 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 5,838 | No | No |
| 48 | 9 | 9 | P1 | -- | 25% | -- | 2,600 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 5,838 | No | No |

Continued on next page

**Table 27. Reasonableness Results for Study Area D: Eight-Lane Highway with Low-Density Houses Set Back from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 49 | 9 | 9 | P1 | -- | 50% | -- | 800 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 5,838 | No | No |
| 50 | 9 | 9 | P1 | -- | 50% | -- | 1,250 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 5,838 | No | No |
| 51 | 9 | 9 | P1 | -- | 50% | -- | 2,600 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 5,838 | No | No |
| 52 | 9 | 9 | P1 | -- | 75% | -- | 800 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 5,838 | No | No |
| 53 | 9 | 9 | P1 | -- | 75% | -- | 1,250 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 5,838 | No | No |
| 54 | 9 | 9 | P1 | -- | 75% | -- | 2,600 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%1 | 5,838 | No | No |
| 55 | 9 | 9 | PA | -- | -- | 25% | 800 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 5,838 | No | No |
| 56 | 9 | 9 | PA | -- | -- | 25% | 1,250 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 5,838 | No | No |
| 57 | 9 | 9 | PA | -- | -- | 25% | 2,600 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 5,838 | No | No |
| 58 | 9 | 9 | PA | -- | -- | 50% | 800 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 5,838 | No | No |
| 59 | 9 | 9 | PA | -- | -- | 50% | 1,250 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 5,838 | No | No |
| 60 | 9 | 9 | PA | -- | -- | 50% | 2,600 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 5,838 | No | No |
| 61 | 9 | 9 | PA | -- | -- | 75% | 800 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 5,838 | No | No |
| 62 | 9 | 9 | PA | -- | -- | 75% | 1,250 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 5,838 | No | No |
| 63 | 9 | 9 | PA | -- | -- | 75% | 2,600 | 157,631 | 16 | 27 | 16 | 27 | 100% | 100% | Yes-NR-%A | 5,838 | No | No |
| 64 | 10 | 5 | # | 1 | -- | -- | 800 | 97,636 | 16 | 37 | 7 | 7 | 44% | 19% | Yes-NR-# | 2,639 | No | No |
| 65 | 10 | 5 | # | 1 | -- | -- | 1,250 | 97,636 | 16 | 37 | 7 | 7 | 44% | 19% | Yes-NR-# | 2,639 | No | No |
| 66 | 10 | 5 | # | 1 | -- | -- | 2,600 | 97,637 | 16 | 38 | 7 | 7 | 44% | 18% | Yes-NR-# | 2,569 | Yes | Yes |
| 67 | 10 | 5 | P1 | -- | 25% | -- | 800 | 97,637 | 16 | 38 | 7 | 7 | 44% | 18% | Yes-NR-%1 | 2,569 | No | No |
| 68 | 10 | 5 | P1 | -- | 25% | -- | 1,250 | 97,637 | 16 | 38 | 7 | 7 | 44% | 18% | Yes-NR-%1 | 2,569 | No | No |
| 69 | 10 | 5 | P1 | -- | 25% | -- | 2,600 | 97,637 | 16 | 38 | 7 | 7 | 44% | 18% | Yes-NR-%1 | 2,569 | Yes | Yes |
| 70 | 10 | 5 | P1 | -- | 50% | -- | 800 | 104,630 | 16 | 39 | 9 | 9 | 56% | 23% | Yes-NR-%1 | 2,683 | No | No |
| 71 | 10 | 5 | P1 | -- | 50% | -- | 1,250 | 100,554 | 16 | 39 | 9 | 9 | 56% | 23% | Yes-NR-%1 | 2,578 | No | No |
| 72 | 10 | 5 | P1 | -- | 50% | -- | 2,600 | 100,554 | 16 | 39 | 9 | 9 | 56% | 23% | Yes-NR-%1 | 2,578 | Yes | Yes |

Continued on next page

**Table 27. Reasonableness Results for Study Area D: Eight-Lane Highway with Low-Density Houses Set Back from Highway.**

| Case | Reasonableness Factors | | | | | | | Reasonableness Results | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NRDG | Ben NR | NRDG Type | NRDG Crit # | NRDG Crit % 1R | NRDG Crit % All | APBR Crit | Area | # Ben 1R | # Ben ALL | # Ben NRDG 1R | # Ben NRDG ALL | Ben % 1R | Ben % ALL | Reas. NRDG ? | APBR Calc | Reas. APBR ? | Reas. ? |
| 73 | 10 | 5 | P1 | -- | 75% | -- | 800 | 157,631 | 16 | 40 | 11 | 18 | 69% | 45% | No-NR-%1 | 3,941 | No | No |
| 74 | 10 | 5 | P1 | -- | 75% | -- | 1,250 | 157,631 | 16 | 40 | 11 | 18 | 69% | 45% | No-NR-%1 | 3,941 | No | No |
| 75 | 10 | 5 | P1 | -- | 75% | -- | 2,600 | 157,631 | 16 | 40 | 11 | 18 | 69% | 45% | No-NR-%1 | 3,941 | No | No |
| 76 | 10 | 5 | PA | -- | -- | 25% | 800 | 108,109 | 16 | 39 | 9 | 10 | 56% | 26% | Yes-NR-%A | 2,772 | No | No |
| 77 | 10 | 5 | PA | -- | -- | 25% | 1,250 | 108,109 | 16 | 39 | 9 | 10 | 56% | 26% | Yes-NR-%A | 2,772 | No | No |
| 78 | 10 | 5 | PA | -- | -- | 25% | 2,600 | 108,109 | 16 | 39 | 9 | 10 | 56% | 26% | Yes-NR-%A | 2,772 | No | No |
| 79 | 10 | 5 | PA | -- | -- | 50% | 800 | 157,631 | 16 | 40 | 11 | 18 | 69% | 45% | No-NR-%A | 3,941 | No | No |
| 80 | 10 | 5 | PA | -- | -- | 50% | 1,250 | 157,631 | 16 | 40 | 11 | 18 | 69% | 45% | No-NR-%A | 3,941 | No | No |
| 81 | 10 | 5 | PA | -- | -- | 50% | 2,600 | 157,631 | 16 | 40 | 11 | 18 | 69% | 45% | No-NR-%A | 3,941 | No | No |
| 82 | 10 | 5 | PA | -- | -- | 75% | 800 | 157,631 | 16 | 40 | 11 | 18 | 69% | 45% | No-NR-%A | 3,941 | No | No |
| 83 | 10 | 5 | PA | -- | -- | 75% | 1,250 | 157,631 | 16 | 40 | 11 | 18 | 69% | 45% | No-NR-%A | 3,941 | No | No |
| 84 | 10 | 5 | PA | -- | -- | 75% | 2,600 | 157,631 | 16 | 40 | 11 | 18 | 69% | 45% | No-NR-%A | 3,941 | No | No |

## 3.3 CHAPTER SUMMARY

In this chapter, the relationships of the different feasibility and reasonableness factors were tested as to their effects on decisions on noise abatement. First a sensitivity test was conducted on 1,080 combinations of values for four factors:

- NRDG in dB
- NRDG Type and Quantity (number of benefited receptors and percentage of first-row and all benefited receptors)
- Benefited noise reduction in dB
- APBR in SF/benefited receptor

These combinations were tested on 108 variations of a noise study area scenario along a hypothetical highway. These variations were based on:

- Spacings between receptors of 50, 100, and 200 feet
- Cases of one, two, and three rows of receptors in the study area
- Distances back from the barrier to the first-row of receptors of 90 and 140 feet
- Barrier heights of 6, 10, 14, 18, 22, and 26 feet

These results were compiled in a color-coded spreadsheet array of 1,080 rows by 108 columns, capable of being sorted by different factors. This array was sorted first by the NRDG quantity, with charts for: number of benefited receptors (equal to 1, 2, or 3); percentage of first-row benefits; and percentage of all benefited receptors. The array was then sorted by APBR into five charts (one per APBR). Both approaches allow trends to be seen in the patterns of the displayed decisions.

The second type of testing was done on four actual highway projects where abatement had been previously evaluated. A total of seven combinations of feasibility factors and 84 combinations of reasonableness factors were studied. The choices for the combinations were derived from both the sensitivity analysis and the range of values in the various SHA policies:

- Seven feasibility quantities: one impacted receptor; 25%, 50%, 75% of first-row impacted receptors; and 25%, 50%, 75% of all impacted receptors, all with a feasibility noise reduction of 5 dB.
- Reasonableness factors:
    - Four combinations of NRDG and benefited noise reduction: 7 dB and 5 dB; 7 dB and 7 dB; 9 dB and 9 dB; and 10 dB and 5 dB.
    - Seven NRDG quantities: one benefited receptor; 25%, 50%, 75% of first-row benefited receptors; and 25%, 50%, 75% of all benefited receptors.
    - Three APBR values: 800, 1,250, and 2,600 SF/ benefited receptor.

The projects were chosen to represent study areas of high and low density with receptors closer to and farther away from the road, as well as for differing numbers of rows of houses.

The results showed the insensitivity of the feasibility decision to the tested range of feasibility quantities. In all cases, the barriers were feasible.

The reasonableness results were mixed, as expected:

- For the high-density, multiple-row Study Area A, where a barrier appeared to be reasonable based on experience, it was difficult to get a reasonable barrier when the APBR was 800 SF/ benefited receptor, especially as the minimum value of benefited noise reduction increased.
- For Study Area B, with two rows of closely-spaced houses angling away from the highway, an APBR of 800 SF/benefited receptor was too low for reasonableness in any case; even an APBR of 1,250 was too low in many cases. For higher APBR, requiring only one benefited receptor or even up to 50% of first-row or all benefited receptors to meet the NRDG is likely to result in a decision of "reasonable" regardless of the NRDG. Requiring a high percentage of all benefited receptors to meet the NRDG is likely to result in a decision of "not reasonable" when the NRDG is high.
- Study Area C, with medium-density houses curving away from the highway, was one where the expectation was that a "reasonable" noise barrier was questionable because house density was low, the "first" rows curved away from the road, and there was a small area of undeveloped area in the center of the study area. While a barrier was reasonable in terms of the NRDG criterion alone for most of the cases, it was only reasonable for less than one-third of the cases in terms of APBR. None of the cases were reasonable for an APBR criterion of 800 SF/benefited receptor. For reasonableness, the minimum APBR needed to be in a range of 1,500 to over 3,000 SF/benefited receptor, depending on the NRDG and benefited noise reduction.
- Study Area D had low-density houses set back from the highway. While a barrier was reasonable in terms of the NRDG criterion alone for most of the cases, it was only reasonable for an eighth of the cases in terms of APBR, all of which were with the benefited noise reduction criterion at 5 dB. Given the distance back to the houses, it was difficult to provide enough reduction at enough receptors to bring the APBR below the criterion.

# CHAPTER 4. CONSIDERATION OF THE VIEWPOINTS CRITERION

This next portion of the study examines the viewpoints criterion, the third of the reasonableness criteria in the FHWA noise regulation in 23 CFR Part 772.

This examination is also a direct outcome of the research conducted in the first phase of this research as described in *Evaluation of 23 CFR 772 for Opportunities to Streamline and Establish Programmatic Agreements*[11]. That report addresses the identification of ways to streamline the requirements and procedural processes of the FHWA noise regulation and establish programmatic agreements between FHWA and SHAs. The report states:

> "SHAs have adopted varying procedures for considering the viewpoints of the benefited property owners and residents. In many states, the property owner and renter are each allowed one vote. For multi-family land uses, the property owner is often allowed one vote per benefited unit.
>
> "It is unclear whether these procedures fairly weigh viewpoints in communities with mixed land uses as well as rental communities. There is concern that some procedures could inadvertently result in one use/property having the power to dictate, through a majority of votes, whether a larger community desires a noise barrier."

The report noted that this topic of the viewpoints reasonableness criterion presented an opportunity for streamlining the process: "Additional guidance could be developed for assessing the viewpoints of the benefited property owners and residents, particularly in rental and mixed-use communities." The opportunity was assigned a "medium" priority in discussions with the project's Technical Working Group and was described as follows: "Evaluate methods for weighing the desires of property owners and residents in rental communities and mixed residential communities." The objective was to "[e]nsure viewpoints are considered fairly," and could lead to FHWA guidance to the SHAs and/or a change to 23 CFR 772.

Currently, Section 772.13 of 23 CFR 7772, *Analysis of Noise Abatement,* states the following:

> *"(d) Examination and evaluation of feasible and reasonable noise abatement measures for reducing the traffic noise impacts. Each highway agency, with FHWA approval, shall develop feasibility and reasonableness factors.*
>
> *(2) Reasonableness:*
>
> *(i) Consideration of the viewpoints of the property owners and residents of the benefited receptors. The highway agency shall solicit the viewpoints of all of the benefited receptors and obtain enough responses to document a decision on either desiring or not desiring the noise abatement measure. The highway agency shall define, and receive FHWA approval for, the number of receptors*

[11] *Evaluation of 23 CFR 772 for Opportunities to Streamline and Establish Programmatic Agreements,* Darlene Reiter, PhD, PE, Bowlby & Associates, Inc. and Kenneth Kaliski, PE, RSG Inc., Task Order DTFH61-11-D-00028-T12-002, Federal Highway Administration, Washington , DC, September 2013.

*that are needed to constitute a decision and explain the basis for this determination.*

*(iv) The reasonableness factors listed in Sec. 772.13(d)(5)(i), (ii) and (iii), must collectively be achieved in order for a noise abatement measure to be deemed reasonable. Failure to achieve Sec. 772.13(d)(5)(i), (ii) or (iii), will result in the noise abatement measure being deemed not reasonable."*

A benefited receptor is one that receives at least a minimum specified noise reduction due to the abatement measure. The regulation requires that the SHA define the reduction required for a receptor to be considered benefited, and stipulates that the value cannot be less than 5 dB and no more than the Noise Reduction Design Goal criterion. As described earlier in this report, 44 of the SHAs have chosen 5 dB for the benefited noise reduction criterion, with four choosing 7 dB, three choosing 8 dB and one choosing 9 dB.

## 4.1 FACTORS PROVIDING FLEXIBILITY IN SHA POLICIES

As with the other feasibility and reasonableness criteria for noise abatement, the SHAs are given flexibility in determining how the viewpoints of the benefited receptors are addressed. The one condition put upon the choice of factors in the criterion is that the viewpoints of both the property owners and the residents have to be considered for Activity Category B land uses. As with the feasibility and other reasonableness criteria described in the previous chapters of this report, there is a wide range in how SHAs have implemented these criteria in their noise policies.

At least two of the SHAs also extend consideration to beyond just those receptors that are benefited:

- Washington State DOT's policy indicates: "Noise sensitive receivers "that can demonstrate a negative effect to their property values from the proposed abatement, but are neither impacted nor benefitted, may be eligible for a maximum 1.0 vote."
- Utah DOT's policy states that ballots are also sent to: "[r]eceptors that border and are directly adjacent to the end of a proposed noise wall that are not, by definition, benefited by the wall."

This report examines the range in values that SHAs have used for the different factors involved in the consideration of viewpoints. A detailed review was conducted of all of the SHA noise policies. The text from each SHA's noise policy on the viewpoints criteria is included alphabetically by state in Appendix A. After this examination, six SHAs' policies on the consideration of viewpoints are studied in more detail, based on discussions with the SHAs' representatives.

The factors to be examined are:

- The percentage of benefited receptors needed for a barrier to be considered reasonable:
  - Defined as a percentage of those who were surveyed or responded to a survey
  - Defined as percentage of all possible votes, not just those who responded
  - Not defined as all possible votes or just those who responded
- The percentage of benefited receptors needed for a barrier to be determined to NOT be considered reasonable:

  - Defined as a percentage of those who were surveyed or responded to a survey
  - Defined as percentage of all possible votes, not just those who responded
  - Not defined as all possible votes or just those who responded
- How non-respondents are counted in the voting process, if at all
- The required or desired minimum response rate to a survey questionnaire or vote that is deemed necessary for the results to be considered as valid
- How the votes of the property owners and residences (both owner-occupied and rental properties) are weighted in comparison to each other
- The number of times benefited receptors will be contacted in an attempt to obtain their vote
- The methods by which the SHAs will make those contacts and collect the votes

Before proceeding with the examination of the above factors, an example will illustrate how different decisions on reasonableness can be achieved for even just a single set of factors for a viewpoints criterion, simply by changes in the voting.

## 4.2 EXAMPLE OF HOW VOTING PARTICIPATION AFFECTS REASONABLENESS DECISIONS

This example of how voting participation affects reasonableness decisions is taken from *Evaluation of 23 CFR 772 for Opportunities to Streamline and Establish Programmatic Agreements.* It consists of a mixed-use residential development that includes both single-family residences and apartments immediately adjacent to a Type I highway project, as shown in Figure 25. A barrier to protect the single-family residences would have to extend a substantial distance past the apartments and vice versa. It is assumed that the barrier would benefit 60 apartments and 20 single-family residences. It is also assumed that the apartments are owned by a single owner.

For the sake of illustration, it is also assumed that the SHA noise policy requires that a simple majority of benefited property owners and residents, based on the votes received, need to vote in favor of the barrier for it to be reasonable. The policy states that votes are to be assigned as follows:

- Owner of the apartments: one vote for each benefited apartment
- Resident of each benefited apartment: one vote
- Owner of each single-family residence: one vote
- Resident of a leased single-family residence: one vote

Thus, there is a total of 140 possible votes.


**Figure 25. Photo of mixed-use residential development.**

Table 28 presents five cases of different voting results. The last two cases differ from the first three in that they assume that only the apartments exist (120 possible votes).

Case 1 assumes that all single-family homes are owner-occupied and that all owners and residents cast ballots. Thus, 140 votes were cast. This scenario is very unlikely and is presented to compare and contrast results for mixed-use communities. In this case, as shown in Table 28, the apartment owner and the apartment residents would each have 43% of the vote (60/140 each, for a total of 120/140), while the owners of the single-family residences would have only 14% of the vote (20/140).

If all of the residents, both in the apartments and the single-family residences (57% of the vote) voted in favor of the barrier, then the barrier would be reasonable. The viewpoint of the apartment owner, while considered, would not dictate the reasonableness determination.

However, voting responses for apartment residents are typically much lower than responses for owner-occupied single-family homes. Case 2 in Table 28 assumes that votes are cast by only half (30) of the apartment residents, for a total of 110 votes cast. In this case, the apartment owner controls 55% of the vote compared to 27% for the apartment residents and 18% for the single-family homeowners. If the apartment owner opposes the barrier, the barrier would not be reasonable even if 100% of the residents who voted, including all of the homeowners, were in favor of the barrier.

**Table 28. Evaluation Results: Viewpoints of Benefited Property Owners and Residents (based on Table 4 of *Evaluation of 23 CFR 772 for Opportunities to Streamline and Establish Programmatic Agreements*).**

| Case | Number of Votes Cast (Possible Votes) | Percent of Votes Cast |
|---|---|---|
| ***Case 1: All owners and residents cast votes. The apartments are fully occupied.*** | | |
| Apartment Owner | 60 (60) | 43% |
| Apartment Residents | 60 (60) | 43% |
| Single-Family Owners | 20 (20) | 14% |
| ***Total*** | ***140 (140)*** | ***100%*** |
| ***Case 2: All owners cast votes. The apartments are fully occupied but only 50% of apartment residents cast votes.*** | | |
| Apartment Owner | 60 (60) | 55% |
| Apartment Residents | 30 (60) | 27% |
| Single-Family Owners | 20 (20) | 18% |
| ***Total*** | ***110 (140)*** | ***100%*** |
| ***Case 3: All owners cast votes. The apartments are 60% occupied and 25% of apartment residents cast votes.*** | | |
| Apartment Owner | 60 (60) | 67% |
| Apartment Residents | 9 (60) | 10% |
| Single-Family Owners | 20 (20) | 23% |
| ***Total*** | ***89 (140)*** | ***100%*** |
| ***Case 4: Apartments only, which are fully occupied.*** | | |
| Apartment Owner | 60 (60) | 50% |
| Apartment Residents | 60 (60) | 50% |
| ***Total*** | ***120 (120)*** | ***100%*** |
| ***Case 5: Apartments only, which are 80% occupied.*** | | |
| Apartment Owner | 60 (60) | 56% |
| Apartment Residents | 48 (60) | 44% |
| ***Total*** | ***108 (120)*** | ***100%*** |

Additionally, rental communities are often not fully occupied, so some benefited apartments may be vacant. In these cases, there would be only one vote for each vacant unit, which would belong to the property owner. As a result, the apartment owner would have more votes than the apartment residents.

Case 3 in Table 28 assumes that the apartments are 60% occupied, and only 25% of the apartment residents cast votes (60 x 60% x 25% = 9 votes cast). In this case, the apartment owner controls 67% of the vote compared to 10% for the apartment residents and 23% for the single-family homeowners. As with Case 2, the barrier would not be reasonable if the apartment owner opposes it, even if all of the residents who voted where in favor.

Case 4 assumes that the apartments are the only residential units in the area ("stand-alone"), for a total of 120 possible votes. If the apartment owner and all apartment residents cast votes, then each would control 50% of the vote. There would be no majority and a reasonableness determination could not be made if the owner and all of the residents disagreed. If the policy, however, said that *50% or more* of the cast votes had to be in favor, instead of a majority, the barrier would be reasonable in terms of the viewpoints.

Case 5 assumes that the apartments are stand-alone (120 possible votes) and 80% occupied. In this case, the apartment owner controls 56% of the vote compared to 44% for the apartment residents, so the viewpoint of the apartment owner would dictate whether the barrier is reasonable, regardless of the voting of the apartment dwellers.

Case 5 also illustrates that, if the criterion is simple majority of all votes with equal weighting to the votes of all renters and all dwelling unit owners (in this case the apartment complex owner for all units), the viewpoint of the property owner will always dictate the reasonableness determination for stand-alone rental communities as long as one of the benefited units is vacant or one renter does not vote. As noted in *Evaluation of 23 CFR 772 for Opportunities to Streamline and Establish Programmatic Agreements*:

> "Whether this is an equitable situation is a point of debate. The owner has a significant financial investment in the property. Rental populations can be transient and tenants might have alternative housing options with lower sound levels. However, there are communities where tenants may be long-term and have a vested interest in their community. While weighing the owner's desires more heavily might seem fair, the residents live with the noise environment so it is reasonable that their viewpoint be considered as well."

## 4.3 PERCENTAGE OF NEEDED VOTES IN FAVOR OR AGAINST ABATEMENT

As noted before the above example, there are two main philosophies by which the voting is interpreted. In the first instance, a barrier is judged to be reasonable if a certain percentage of the benefited receptors vote in favor of it. In the second instance, the barrier is deemed to be *not* reasonable if a certain percentage of the benefited receptors vote *against* it. In the former case, the benefited property owners and residents have to take positive action to demonstrate their desire for the barrier. In the latter case, it is presumed that the barrier is desired unless the needed number or percentage of benefited property owners and residents take action to reject it.

Under both philosophies, some SHAs base their decisions on only the actual number of votes or responses that they receive. Alternatively, some SHAs base their decisions on a needed percentage of all of the possible votes whether or not a formal response is received. Then, there are some SHAs that are not specific in their policies as to whether a decision is based on the percentage of those voting or a percentage of all possible votes. A follow-up inquiry was done for some of those SHAs that do not define what the percentage is based upon and is reflected in this discussion.

Different decisions can easily be reached on reasonableness depending on whether the percentage is based on votes received or all possible votes, with the latter being the more difficult to achieve criterion. Table 29 shows the breakdown by these different philosophies and factors for the 52 SHA policies (50 states plus the District of Columbia and the Commonwealth of Puerto Rico).

**Table 29. Number of SHAs Using the Different Types of Criteria.**

| Type of Criterion | Number of SHAs | SHAs |
|---|---|---|
| Barrier is reasonable based on percentage of votes received | 22 | AK, CT, DC, GA, HI, IL, IN, KS, LA, MO, NE, NJ, NM, NY, ND, OR, PA, TX, UT, VA, WI, WY |
| Barrier is reasonable based on percentage of all possible votes | 7 | AR, ID, MA*, MI*, NH, OH, VT |
| Barrier is reasonable, but policy is unclear if the percentage is of votes received or all possible votes | 3 | AL, PR, RI |
| Barrier is *not* reasonable based on percentage of votes received | 7 | AZ, CA, DE, FL, SD, TN, WA |
| Barrier is *not* reasonable based on percentage of all possible votes | 6 | ME, MD, MN, NC, NV*, SC* |
| Percentage of votes received are given for a barrier to be reasonable AND to be not reasonable | 5 | CO, IA, KY, MT, OK |
| Criteria for both reasonable and not reasonable but policy is unclear if it is in terms of percentage of votes received or all possible votes. | 2 | MS, WV |

*A non-vote counts as being in favor of the abatement measure.

Basically, 32 SHAs require a positive vote in favor. Thirteen SHAs require a negative vote against, five state the requirement both ways, and two use percentages to express a degree of reasonableness.

### 4.3.1 Decision Based on Votes in Favor of the Abatement Measure

#### *4.3.1.1 Percentage of Votes Received*

Table 30 lists the SHAs that base their decisions on a percentage of the votes *received* that are in favor of the barrier.

**Table 30. Number of SHAs Basing Vote in Favor of Barrier on Percentage of Votes Received.**

| Percentage of "Yes" Votes of Votes Received | Number of SHAs | SHAs |
|---|---|---|
| 50% | 4 | DC, LA, PA, VA |
| > 50%, 51%, 50%+1 vote | 11 | GA, IL, IN, MO, NJ, NM, NY, OR, TX, WI, WY |
| 60% | 1 | AK |
| 67% | 2 | CT, HI |
| 70% | 1 | KS |
| 75% | 2 | NE, UT |
| 80% (of front row) | 1 | ND |

As shown in Table 30, 15 of the 22 SHAs that use the percentage of votes received require half or a simple majority of the votes for the barrier to be deemed reasonable. The other seven SHAs require a range of 60% to 80% of the votes received to be in favor of the barrier. For several SHAs, there are further conditions. For example:

- Hawaii's policy stipulates 67% of the "impacted receptor units," implying but not stating that these units are *benefited* receptors that are impacted.

- North Dakota's policy, with the highest required percentage of 80%, applies that percentage to only the voting *front-row* benefited receptors.

#### *4.3.1.2 Percentage of All Possible Votes*

The more stringent criterion for a positive decision on reasonableness can be when the needed percentage of votes is defined as being of *all of the possible* votes, not just of the received votes, unless the non-votes are considered to be in favor of abatement. Six of the seven SHAs (listed in the second row of Table 29) require 50% or a simple majority of all possible votes to be in favor of the barrier for it to be considered reasonable (see Table 31); Massachusetts requires 67%. In the voting process, Arkansas gives an owner-occupant a full vote and nonresident owners and renters 0.5 votes each, while New Hampshire gives an owner-occupant two votes and nonresident owners and renters one vote each.

Idaho's policy requires 50% plus one of the benefited owners, except in the case of a multi-unit rental property (including a mobile home park) where if the owner of the property is opposed to the barrier, a 75% positive vote of the benefited renters would result in a favorable decision, overriding the owner's vote.

Two of the SHAs – Michigan and Massachusetts – are much less stringent than the others because non-votes count in favor of the abatement measure. For example, the Michigan policy states: "The absence of returned surveys or attendees to public meeting may be considered as an affirmative vote for noise abatement."

**Table 31. Number of SHAs Basing Vote in Favor of Barrier on Percentage of All Possible Votes.**

| Percentage of "Yes" Votes of All Possible Votes | Number of SHAs | SHAs |
|---|---|---|
| 50% | 2 | OH, VT |
| > 50%, 51%, 50%+1 vote | 4 | AR, ID*, MI**, NH |
| 67% | 1 | MA** |

*For a multi-unit rental property (including a mobile home park), a 75% positive vote of the benefited renters would override an owner's negative vote.

**A non-vote counts as being in favor of the abatement measure.

#### *4.3.1.3 Percentage Basis Not Defined*

Three SHAs do not indicate in their policies if the percentage of positive votes is of the votes received or of all possible votes:

- Greater than 50% for Puerto Rico
- 67% for Rhode Island
- 70% for Alabama

### 4.3.2 Decision Based on Votes Against the Abatement Measure

#### *4.3.2.1 Percentage of Votes Received*

For the seven SHAs in Table 29 that require a certain percentage of the *received* votes to be negative in order for a barrier to be *not* reasonable, six require a simple majority. As an example, Delaware's policy states: "In considering the receptor viewpoint, only an explicit "no" to noise barrier construction will be considered as opposing the construction of a noise barrier." One of those six – Tennessee – qualifies its percentage as 51% of the *impacted and benefited* receptors needing to vote against the barrier.

The one exception in this group of SHAs is Arizona, which requires a "substantial portion" of the votes to be against the barrier for it to be determined to be not reasonable, without defining "substantial."

Washington State offers an interesting perspective on the interpretation of its policy. According to J. Laughlin of WSDOT, the DOT tries to get as many of the benefitted property owners and residents engaged as possible (e.g., by holding meetings, conducting mailings, giving presentations of what the noise wall would look like, and working with community leaders and representatives). WSDOT may treat each decision on a case-by-case basis, and if it feels that there is sufficient representation of the community responding, it could consider the majority of all who responded. For example, if only 3 people out of 20 residents responded (with two opposed and one in favor), WSDOT would not consider non-votes to be "Yes" votes and would only consider those who responded (i.e., the 67% opposed); however, with such a low response the poll would probably be considered as a failed poll and WSDOT would try to engage the community again, perhaps with a second meeting and poll. If they still felt they did not get enough respondents, they would likely proceed with building the wall even thought there was a majority in opposition among the small number who voted.

Ultimately, Mr. Laughlin noted, the decision rests with the DOT. WSDOT is only *considering* the neighbors' opinion, but it considers other factors as well, for example: the lowering of property values caused by blocking the view, if the sound levels will be high (in the mid to upper 70 dBA range, for example), and how often people move in and out of the neighborhood. WSDOT also weights the first row residents' opinions more than those of second row residents. They have had instances where the second row wants the wall but the first row does not because of their view.

#### *4.3.2.2 Percentage of All Possible Votes*

Five of the six SHAs in this category require a simple majority of all of the possible votes to be *against* the barrier for it to be considered *not* reasonable (Maryland, Minnesota, Nevada, North Carolina and South Carolina). Maryland's policy further qualifies the vote by saying "A vote tally of more than 50% AGAINST the proposed noise abatement is required for the barrier measure to be rejected *as long as no single individual or entity is responsible for all the negative votes."* [italics added]. It goes on to say it "will not consider the percentage requirement met if all negative votes were cast by a single individual or entity. The only exception to this rule shall apply in the case where there is only a single individual or entity eligible to vote." The sixth SHA – Maine – says in its policy that the barrier "will not be considered reasonable if fewer than 75% of the benefitted receptors approve of the construction of a noise barrier." In effect, its policy says that the barrier will be considered *not* reasonable if 25% or more vote against it.

Nevada's policy states that noise barriers "will be constructed as modeled and designed unless the benefitted receptors are opposed to their construction." The policy then specifically addresses non-votes: "If a response is not received from a valid benefitted receptor, it will be recorded as being in agreement with and supporting the proposed traffic noise abatement measure." Similarly, in South Carolina, its voting material explains that a non-response is counted as a supporting vote for the abatement measure, according to H. Robbins of South Carolina DOT,

### 4.3.3 Other Conditions

Five SHAs listed in Table 29 give percentages of votes for a barrier to be considered reasonable *as well as* for the barrier to be considered not reasonable. In all five cases, a simple majority of the votes is stated as being needed to be in favor of the barrier or to be opposed to the barrier.

Finally, two SHAs, Mississippi and West Virginia, use identical systems for determining the degree of reasonableness, based on the percentage of benefited receptors wanting the barrier. Neither states if the percentage is of the votes received or of all possible votes. Both SHAs state that "the construction of a noise barrier is not reasonable unless a majority of residents and property owners of the benefited receptors…want a noise barrier." The vote is qualified as follows:

- < 50% wanting barrier = Not Reasonable
- 50 - 60% wanting barrier = Marginally Reasonable
- 61% - 75% wanting barrier = Fully Reasonable
- >75% wanting barrier = Highly Reasonable

## 4.4 HOW NON-RESPONDENTS ARE COUNTED

As noted above, an important factor in determining the percentages is how the non-respondents are counted. Seven SHAs address this situation in their policies:

- As a "yes" vote: Michigan's policy states that "The absence of returned surveys or attendees to public meeting may be considered as an affirmative vote for noise abatement."
- As "being in agreement with and supporting the abatement measure": Nevada

- Not as a "no" vote: Delaware's policy states "only an explicit 'no' to noise barrier construction will be considered as opposing the construction…"
- As "not interested in the barrier" (but not saying that a non-vote constitutes a "no" vote): Louisiana
- Non-responding benefited receptors are not counted: Kansas, Montana, and North Dakota

Two others provided information not stated in their policies:

- California considers non-votes and indications of not being opposed to the abatement measure (information received from Caltrans' noise specialists)
- Massachusetts' ballot indicates that if a vote is not received, MassDOT will consider that the stakeholder in "in favor of the proposed noise barrier."

## 4.5 REQUIRED OR DESIRED RESPONSE RATES

Another important determinant in the reasonableness decision is whether a certain percentage of the benefited receptors are *required* to vote in order for the overall balloting to be considered valid. Six states include a required percentage of the eligible voters. Two of them specifically say that the barrier will be considered not reasonable if the rate is not achieved, while the other four do not rule out moving forward with the barrier:

- Rhode Island's policy states: "If less than 75% respond, the barrier will not be considered."
- Utah's policy states: "Noise abatement measures will be deemed not reasonable if less than 50 percent of ballots are returned after balloting efforts are completed."
- Hawaii's policy states: "The survey results to determine approval or disapproval shall be deemed reliable if at least one quarter of the deployed surveys were completed."
- New York State's policy indicates: "A response shall be obtained from at least half of the benefited property owners and residents."
- Indiana's policy says: "If the total respondents to the survey do not total a majority (more than 50%) of the benefited receptors and affected property owners, then a second survey will be mailed out to solicit the views of those who did not respond. If a majority of benefited receptors still do not respond, no third survey is required."
- Delaware's policy indicates that it "will not make a decision on reasonableness unless at least 60 (sixty) percent of the total have replied in some manner…If a reply rate of 60 (sixty) percent is not initially achieved, an additional round of public involvement will be implemented."

Utah's policy is unique in also giving votes to "receptors that border and are directly adjacent to the end of a proposed noise wall that are not, by definition, benefited by the wall."

A follow-up with R. Bales of Indiana DOT revealed that if the DOT does not get a 50% rate, then the decision is a project management decision, citing an example where only 48% responded to the survey with a large majority of that 48% being in favor of the barrier. In such a case, Indiana DOT may continue its outreach to secure the number, such as by contacting property owners by phone or visiting the residence.

Four SHA policies have a desired response rate but do not require a certain response rate for the vote to be considered valid:

- Illinois's policy notes: "The goal is to obtain responses from at least one-third of the benefited receptors for each noise abatement measure… If responses from one-third of the benefited receptors are not received after the first attempt, a second attempt shall be made. The desire for the proposed noise abatement can be determined after viewpoints from at least one-third of the responses have been received or after two attempts have been made to obtain the responses."
- Arizona's policy states: "If less than a 50% response rate of property owner and residents is achieved and a substantial portion of the received responses are opposed to the recommended abatement measures, then further outreach will be attempted through the use of public meetings until either a 50% response rate is achieved or it becomes apparent that such a level of response is not possible due to situational concerns."
- Oregon's policy indicates: "If less than 50 percent of the benefited residents and property owners respond to the survey, a second survey will be sent out to the benefited receivers who did not respond to the first survey. The result of the second survey, combined with the results of the first survey, will be considered the opinion of the benefited receivers, even if less than a 50 percent response is obtained."
- Texas' policy says: "If a majority (50%+1) of the total benefitted receptors do not respond by the due date or do not respond after the second attempt, then TxDOT will base the decision on the survey responses received even though those responses do not constitute a majority of the eligible responses.

## 4.6 NUMBER OF ATTEMPTS TO CONTACT ELIGIBLE VOTERS

In an attempt to obtain as many votes as possible, some SHAs, as just noted above, will make multiple contacts with the benefited receptors if they do not receive an initial response. Fifteen SHAs give some indication in their policies of the number of contacts that they will make, as described below.

Missouri's policy says that it will contact the benefited receptors once. Missouri notes on its Official Ballot:

> "**This is your one and only chance to vote.** You will not have this opportunity again, so please take the time to vote now. One (1) vote will be counted per residence. If a ballot is not returned, it will not count. In order for your vote to count, please have it post-marked by (date). You are welcome to return the ballot in person at the resident meeting on (date). Ballots post-marked after (date), or ballots not returned at all, will not count in the final decision."

Louisiana's policy indicates that it will contact the benefited receptors if opposition to the barrier is raised during the public involvement process: "If no relevant objections to the proposed noise abatement are made at this level of public involvement, this [Consideration of Viewpoints] criterion is deemed met and abatement considered reasonable from the viewpoint of benefited receptors. If relevant objections are identified, a follow-up solicitation will occur with property owners and residents of the benefited receptors."

Colorado's policy notes that "At a minimum, one attempt to contact each identified benefited receptor site (both property owner and resident…) must be made and documented."

Tennessee's policy indicates that "The input of the benefited property owners and residents will generally be received at planning, NEPA or design public hearings or public meetings. Input received at these hearings or meetings may be supplemented, as necessary, with formal survey methods on a case-by-case basis as discussed in the TEPM[12]. TDOT will conclude that a community desires the construction of a noise barrier unless a majority (at least 51%) of the benefited property owners and residents indicate that they do not want the proposed noise barrier."

Arkansas' policy indicates that the "input of the benefited property owners and residents will generally be received at planning, NEPA or design public hearings or public meetings. Input received at these hearings or meetings may be supplemented, as necessary, with formal survey methods on a case-by-case basis."

Seven SHAs indicated that they would contact the benefited receptors twice:

- Illinois (as noted previously): If the initial response is less than 33%.
- Indiana and Texas (as noted previously): If the initial less response was less than 50% or not a majority.
- Delaware: "If a reply rate of 60 (sixty) percent is not initially achieved, an additional round of public involvement will be implemented."
- Tennessee: "If significant opposition exists and there is not clear support for the construction of the proposed noise barrier(s) [during the public involvement process], TDOT will conduct a certified mail survey to solicit the views… Benefited residents and/or property owners that do not respond will be contacted a second time."
- Virginia: "A second solicitation may be required depending on the results of the first solicitation."
- Utah: "A second ballot will be sent by Registered Mail to those who have not returned a ballot for ballots sent but not returned by the [stated] deadline."

Four more SHA policies give other indications regarding the number of contacts:

- The District of Columbia will continue to make contact until enough response is obtained, without defining "enough."
- Arizona's policy indicates that it will contact the benefited property owners and residents as needed if there is substantial opposition to the barrier. It notes: "Noise barriers that are otherwise feasible and reasonable will automatically be considered to be desired unless the public involvement aspect of the NEPA process indicates that a substantial portion of benefited receptors are opposed to the barriers. In that case, ADOT will make a good faith effort to determine the preferences…through a survey process." As noted earlier, ADOT strives to get a 50% response rate, using public meetings if needed.
- Wisconsin's policy states: "All reasonable effort should be made to ensure that each eligible voter returns a ballot indicating whether or not they support construction of the noise barrier."

[12] *Tennessee Environmental Procedures Manual.*

- Florida's policy does not state the number of contacts; however, a follow-up email with M. Berrios of FDOT indicates that FDOT will keep trying until no more responses seem likely, which usually means three or four times.

While not stated in its policy, Massachusetts' ballot indicates that its decision will be based on the initial responses to its balloting, with no follow-up for unsubmitted ballots. In contrast, Washington State will follow up on low response rates even though its policy is silent on that follow-up.

### 4.6.1 Input on Aesthetic Preferences for the Barrier

In addition to the voting in favor or against the barrier, four SHAs' policies describe how the benefited receivers also provide input or vote on their aesthetic preferences for the barriers:

- Florida: Benefited receptors "may also be given the opportunity (at the discretion of the District) to provide input regarding their aesthetic preferences from a list of pre-selected options."
- Michigan: "During the PE [Preliminary Engineering] Phase…[t]he viewpoints of property owners and residents will be solicited…on the aesthetics." Then, Section 6.4.2, *Voting on the Color & Texture of the Noise Barrier*, says: **"**The MDOT Roadside Development Unit will coordinate the CSS process in the stakeholder collaboration for the color, texture, landscaping, etc. In general, all stakeholders will have equal votes and status as to the aesthetics of the noise barrier. In the case of conflicting desires, those affected property units that abut the noise barrier, abut the right-of-way (ROW) line, or have an unobstructed view of the noise barrier will receive greater consideration than those receivers that have an obstructed view of the barrier…"
- Ohio: "If noise abatement is feasible and reasonable, the affected receptors may also choose the aesthetic appearance of the receptor side of the noise barrier….A Noise Public Involvement Summary (NPIS) must be prepared which discusses the results and shows them in a tabular fashion and includes aerial mapping showing the benefited receptors that responded and what their response was relative to desire and aesthetics as well as the benefited receptors that didn't respond."
- Pennsylvania: Input is solicited throughout the public involvement process, including on the ballot.

Other SHAs that obtain input on color and/or texture, although not stated in their policy, include: Tennessee, Arkansas and Massachusetts.

## 4.7 WEIGHTING OF VOTES

The weighting of votes for the various stakeholders is the factor that has, by far, the greatest variation in values used by the SHAs.

Seventeen SHAs simply state that the views of the benefited "property owners and residents" [13] will be obtained, without giving any indication of any weighting of the votes assigned to these two cohorts.

Beyond that simple definition of the stakeholders, the assignment of votes or points on a ballot increases in complexity. One differentiation is between owner and renter, in which case the owner is a nonresident owner. Another differentiation is between property owner and resident. In this case, the resident may by the owner (owner-occupant) or a renter. As described in more detail below, some SHAs thus specifically give votes to owners and also to residents. Others specify votes or points for owners living off-site and for their tenants or renters.

Some policies give one vote to an owner-occupied dwelling, and one vote each to both an off-site dwelling owner and the dwelling tenant, resulting in a rental property having twice as many votes as an owner-occupied property. Others split votes on rental units between the owner and the renter so that a rental unit receives the same number of votes as an owner-occupied unit.

Some specify a vote weighting for multi-unit complexes such as apartments, condominiums, and mobile home parks in addition to single-family residence rental units. One SHA gives the owner of a multi-unit complex a single vote and gives the tenants one collective vote. Others give the owner a vote for every rental unit and each tenant gets a vote for each unit. Others specify how to weigh mobile home or trailer parks.

One SHA discounts the vote of an owner of a rental property by 50% if the renter of the property votes differently than the owner. One SHA obtains ballots from both owners and residents but only counts the owner votes toward the decision on reasonableness.

Other SHAs give additional votes or use multipliers if a benefited receptor is: 1) in the "first" or "front" row adjacent to the highway (or abuts the ROW), or 2) is both impacted and benefited. Another gives extra points based on the amount of noise reduction to be provided by the barrier.

The SHA policies have been analyzed in two groups:

1. where there are *no* additional weighting factors by first-row and other row or by impact condition
2. where there *are* additional weighting factors by first-row and other row or by impact condition

The results are presented in a separate table for each grouping. Since the phrasings used in the policies vary, these tables interpret those phrasings with a common terminology. A discussion follows after each table.

### 4.7.1 Policies that Do Not Give Extra Weight for Row or Impact Condition

Table 32 summarizes the weighting of votes for owner-occupied properties and rental properties where there are no additional weighting factors by row away from the road or by impact condition.

[13] Alaska uses the phrase "households and residents" while Vermont uses the phrase "households and property owners."

**Table 32. Weighting of Votes for Owner-occupied Residences and Rental Properties with No Additional Weightings.**

| SHA | Owner-occupant | Rental | | | Note |
|---|---|---|---|---|---|
| | | Total | Owner | Renter | |
| AL, AK, AZ, CT, DC, HI, IA, LA*, MS, NV*, NJ, NM, NY, RI, VT, WV and WY (17) | Not stated (could be implied as 1 or 2) | Not stated (could be implied as 1 or 2) | Not stated (could be implied as 0 or 1) | Not stated (could be implied as 1) | Policies say "property owners and residents." Not stated if every owner gets a vote whether or not a resident, or if every resident gets a vote, whether owner or renter.<br><br>*LA and NV: preference of the property owner takes precedence over renter if different. NV also weights votes by the predicted noise reduction. |
| PR | 1 | 1 | | | Only says "resident" |
| GA, KS, NH, SC (4) | 2 | 2 | 1 | 1 | |
| AR | 1 | 1 | 0.5* | 0.5* | *Not stated in policy. Clarified in a follow-up. |
| CA | 1 | 1 | 0.9* | 0.1* | *Has been interpreted by Caltrans District 7 as 0.9 total votes for the owner of a multi-unit complex and 0.1 vote per renter |
| FL | 1 | 1 | 0.9* | 0.1* | Expressed and 0.9 and 0.1 votes per unit; weightings change to 0.8 and 0.2 for mobile home and trailer parks. |
| MO | 1 | 1 | 0.75* | 0.25* | * Viewpoints of residents and owners evaluated "as a portion of an aggregate" of 25% and 75% of the total, respectively. |

| SHA | Owner-occupant | Rental | | | Note |
|---|---|---|---|---|---|
| | | Total | Owner | Renter | |
| TX | 1 | 1 | 1 | * | *Renters vote for viewpoints, but only owners' votes count toward decision. |
| MI | 1 | 1.5 | 1 | 0.5 | |
| OR | 1 | 2 | 1* | 1* | * For a multi-unit complex: 1 vote for owner for the complex and 1 collective vote of all renters |
| CO, DE, IN, ME, ND, OH, PA, WI (8) | 1 | 2 | 1 | 1 | |
| UT | 5 | 6 | 5 | 1 | |
| ID | 1 | 2 | 1 | 1 | * For a multi-unit land use, need 75% of benefited renters to override owner's vote. |

There are 39 policies in this table. As noted above, 17 of these 39 SHA policies simply state that the views of the benefited "property owners and residents" will be considered. This phrasing duplicates the phrasing used in 23 CFR 772: "consideration of the viewpoints of the *property owners and residents* of the benefited receptors."

The presumption, *not stated and possibly not true for each SHA*, is that every property owner would get a vote whether living in the dwelling or living elsewhere and the resident would get a vote, whether that resident was the owner or a renter. This assignment would mean that owner-occupied residences and rental units would each get two votes, with the rental unit vote split out as one for the nonresident owner and one for the renter.

An alternative interpretation could be that an owner-occupied residence would get one vote (for the owner who is also the occupant) and two for a rental unit (one for the nonresident owner and one for the renter).

Only two of the 17 policies gave some indication of their intentions:

- Louisiana will "give more weight to the desire of the property owner than to the desire of the lessee. (When conflicting responses are received, DOTD will consider the property owner's response over that of the lessee's.)"
- Nevada's policy states: "If opposing views over the traffic noise abatement measure develop between the property owner of a benefitted property and its legal occupant(s), the preference of the property owner will take precedence."

Nevada's policy is also unique in that it gives extra points in the voting based on the amount of noise reduction to be provided by the barrier to benefited receptors: 3 points for 7 or more dB of noise reduction, 2 points for 6 dB of noise reduction, and one point for 5 dB of noise reduction.

Aside from the 17 SHAs that do not distinguish between "property owners and residents", Table 32 shows that:

- 10 SHA policies give equal votes to owner-occupied and rental properties and
- 11 give more votes to rental properties.

Of the ten policies that give equal weight to owner-occupied and rental properties, six give each unit one vote (Arkansas, California, Florida, Missouri, Texas and Puerto Rico), and four give each unit two votes (Georgia, Kansas, New Hampshire, and South Carolina).

New Hampshire's language helps clarify confusion that may arise over nomenclature regarding owners, residents and renters. It refers to the resident's vote as an "occupancy" vote: "One owner and one occupancy point will be given for each receptor." Thus, both rental and non-rental properties get two points (i.e., two votes).

For these ten policies that give equal weight to owner-occupied and rental properties,

- Five give equal weight to the nonresident owner and the renter (Georgia, Kansas, New Hampshire, and South Carolina give one vote to each, and Arkansas gives half a vote to each ),
- Four give more weight to the nonresident owner (Florida, Missouri, and Texas),
- One policy can result in the owner or the renters having the most votes (California), and
- One does not specify (Puerto Rico).

Florida and California split the vote between a nonresident owner and renter on a 90%/10% basis, but in different manners. For Florida, 0.9 of each rental unit vote goes to the owner and 0.1 votes of each unit go to the renter. Thus, in a ten-unit apartment, the owner would have 9 votes and the renters would have, collectively, one vote. Florida also uses a similar division for a mobile home park with an 80%/20% split between the mobile home park owner and the mobile home residents. For California, the owner gets 0.9 of a single vote and the renters each get 0.1 of a vote per unit. Thus, 10 renters could outvote one owner.

Missouri's policy states that the viewpoints of residents will be evaluated as a portion of an aggregate of 25% of the total. The viewpoints of the owners will be evaluated as a portion of an aggregate of 75% of the total.

Texas obtains ballots from both owners and residents but only counts the owner votes toward the decision on reasonableness, noting that "ballots cast by residents will be obtained for viewpoints."

As noted above, eleven policies give more weight to rental properties than owner-occupied properties:

- Eight give the nonresident owner and the renter each one vote, while the owner of an owner-occupied property gets one vote.
- Michigan's policy gives 1.5 votes to a rental unit vs. one to an owner-occupied property and splits the 1.5 votes as one for the nonresident owner and 0.5 for the renter.
- Utah uses a multiplier of 5 for a property owner and then gives a single point to a renter, thus giving 5 points to an owner-occupied property and 6 points to a rental unit (this assignment applies to rental homes, multi-family residences, apartments and mobile home parks where the lot owner is different from the home owner).
- Oregon gives the property owner of a multi-unit complex one vote *for the complex* and gives residents in multi-unit complexes, such as apartments, one *collective* vote.

Oregon's policy contains one of the most detailed descriptions of the vote weighting. In addition to the above specifications for multi-unit complexes, it assigns votes as follows:

- Property owners (one vote)
- Owners and renters of single-family properties (one vote each)
- Condominium owner-occupants (one vote per unit), off-site owners (one vote per unit), and renters (one *collective* vote)
- Mobile home and trailer park residents (one vote each) and property owner (one vote for the park)

Oregon's policy also indicates that for the apartment and condominium renters, the collective vote of "yes" or "no" is determined after all of the individual votes are tallied.

Idaho's policy is unique in its approach when the owner of a group of rental units is opposed to a barrier. Its policy states: "75% of benefited renters must approve a noise barrier" to override an owner who is against the barrier, giving this example: "…if the owner of a Mobile Home Court does not want a noise wall, then benefited renters would be polled to determine their view. If 75% or more wanted the wall, the wall would be considered desirable."

### 4.7.2 Policies that Give Extra Weight for Row or Impact Condition

Table 33 and Table 34 summarize the weighting of votes for owner-occupied properties and rental properties in the 13 SHA policies where there are additional weighting factors for "first-row" (or "front-row") or by impact condition.

**Table 33. Weighting of Votes for Owner-occupied Residences and Rental Properties Including Extra Weighting for First-row Benefited Receptors.**

| SHA | "First-row" ("front-row") | | | | Other row | | | |
|---|---|---|---|---|---|---|---|---|
| | Owner-occupant | Rental | | | Owner-occupant | Rental | | |
| | | Total | Nonresident Owner | Renter | | Total | Nonresident Owner | Renter |
| KY, NC, OK, SD | 4 | 4 | 3 | 1 | 2 | 2 | 1 | 1 |
| IL | 2 | 4 | 2 | 2 | 1 | 2 | 1 | 1 |
| MA | 5 | 5 | 4 | 1 | 3 | 3 | 2 | 1 |
| MN* | 6 | 6 | 4 | 2 | 3 | 3 | 2 | 1 |
| MT | 3 | 3.5 | 2** | 1.5 | 1 | 2 | 1** | 1 |
| NE | 4 | 3 | 2 | 1 | 2 | 2 | 1 | 1 |
| WA | 1.5*** | 1.5*** | Reduce owner vote by ½ if renter disagrees | | 1 | 1.5 | Reduce owner vote by ½ if renter disagrees | |

*MN: stated as abutting or not abutting the highway ROW.

**MT: for multi-family, owner votes are per property, not per unit.

***WA: refers to the entity as the "receiver."

**Table 34. Weighting of Votes for Owner-occupied Residences and Rental Properties Including Extra Weighting for Impacted Benefited Receptors.**

| SHA | Impacted | | | | Not Impacted | | | |
|---|---|---|---|---|---|---|---|---|
| | Owner-occupant | Rental | | | Owner-occupant | Rental | | |
| | | Total | Nonresident Owner | Renter | | Total | Nonresident Owner | Renter |
| MD | 4 | 4 | 2 | 2 | 2 | 2 | 1 | 1 |
| TN | 2 | 2 | 1 | 1 | 1 | 1 | 0.5 | 0.5 |
| VA | 5 | 5 | 3 | 2 | 3 | 3 | 2 | 1 |

Ten SHA's policies give extra weight for a receptor being on the front row (first-row), with Minnesota using the term "abutting the highway" instead of being on the front row.

Five of these policies give only the owner additional points for being a front-row or first-row benefited receptor, not the renter. They also give the same number of points to a receptor regardless if it is owner-occupied or a rental unit.

- Kentucky, North Carolina, South Carolina and Oklahoma all give 4 votes for the front-row properties (3 for the owner and 1 for the resident, whether that resident is the owner or a renter) and 2 votes for properties beyond the front row (1 for the owner and 1 for the resident, whether that resident is the owner or a renter); in all four cases, the renter gets 1 vote regardless of row.
- Massachusetts assigns a front-row property 5 votes and gives 3 votes for other rows regardless if it is owner-occupied or a rental unit; for front-row rental units, the nonresident owner gets 4 votes and the renter gets 1 vote; for the other rows, the owner gets 2 votes and the renter gets 1 vote.

Nebraska assigns up to four votes per dwelling unit: 1 for being a resident, 1 for being an owner; 1 for being the owner of a front-row residence, and 1 if the owner of a front-row dwelling unit also lives there. Thus, it gives a total of 4 points for a front-row owner-occupied dwelling unit. It gives 2 points for an owner occupant not in the first row (1 for being an owner and 1 for being a resident).

Three of the policies give both the owner and renter additional points for being a front-row or first-row benefited receptor.

- Minnesota gives 6 points for a residence that abuts the ROW (6 for an owner-occupant; 4 for a nonresident owner and 2 for a renter) and 3 points if it does not abut the ROW (3 for an owner-occupant; 2 for a nonresident owner and 1 for a renter).
- Illinois assigns 2 votes for a first-row owner-occupant and, for a rental property, 4 for the first-row (2 for the nonresident owner and 2 for a renter). For other rows, it assigns 1 vote for a first-row owner-occupant and 2 for a first-row rental (1 for the nonresident owner and 1 for a renter)
- Montana gives 3 votes for a first-row owner-occupied residence and 3.5 votes for a first-row rental residence (2 for the nonresident owner and 1.5 for the renter); for other rows, the owner-occupant gets 1 vote and a rental property gets 2 votes (1 for the nonresident owner and 1 for the renter). However: "If one property has multiple dwelling units, the owner(s) of the multi-unit dwelling get one vote for the property (not one for each dwelling unit), and the tenants/renters of each unit get one vote each."

Washington State also weights the first row residents' opinions more than those of second row residents and reports that there have been instances where the second row wants the wall but the first row does not because of their view. Washington State gives a nonresident owner 1.5 points if on the first row and 1 point if on another row. It will then reduce those votes by 50% (to 0.75 and 0.5) if the renter of the unit disagrees with the owner's vote: "If eligible receiver locations are not owner-occupied, the opinions of both the renter and property owner shall be considered. When the two opinions differ, the renter's opinion shall reduce the weight of the property owner's response for that unit by one-half. When polling responses are not received from the renter, the property owner's vote will represent the voting unit." Washington State does not give the renter a specific number of votes.

Three SHA policies assign extra votes for benefited receptors that are also impacted:

- Tennessee gives both an owner-occupied receptor and a rental property two votes if either is impacted (for the rental, 1 for the nonresident owner and 1 for the renter. Non-impacted receptors are assigned one vote (1 for owner-occupant and 0.5 each for a nonresident owner and renter).
- Virginia gives 5 points to an owner-occupied residence that is impacted and 3 points to an owner-occupied residence that is not impacted. Rental units also get 5 points if impacted (3 for the nonresident owner and 2 for the renter) and 3 if not impacted (2 for the nonresident owner and 1 for the renter).
- Maryland assigns 4 points for a first-row owner-occupied impacted and benefited receptor and 2 points for a similar rental unit. For other rows, the votes are reduced to 2 for the owner-occupied unit and 1 for the rental unit.

## 4.8 METHODS FOR OBTAINING VIEWPOINTS

The SHA policies indicate that they use a variety of methods for obtaining the viewpoints of the benefited receptors, including:

- Mailed surveys and questionnaires
- Phone calls
- E-mail
- Door-to-door interviews / flyers

- Public involvements, hearings, workshops, etc.
- Website
- Some other outreach technique

Table 35 indicates the number of SHAs stating that they would use one or more of these techniques.

**Table 35. Techniques used by SHAs to Obtain Abatement Viewpoints and Votes.**

| Technique | Number of SHAs |
|---|---|
| Mailed questionnaires, surveys, etc. | 34 |
| Public involvement, meetings, workshops, etc. | 23 |
| Phone calls | 8 |
| Door-to-door interviews / flyers | 8 |
| E-mail | 5 |
| Website | 5 |
| “Other” outreach techniques | 8 |
| None specified | 13 |

Of the 34 SHAs that use mailed questionnaires or surveys, seven send these out by certified mail (District of Columba, Georgia, North Dakota, South Dakota, Tennessee, Vermont, Washington State, and Virginia (which states that certified mail is preferred for the first contact)). Three states indicate that they use registered mail (California, Wisconsin and Utah (for its second ballot)). Maine requires the use of certified or registered mail.

All 23 of the SHAs that use public involvement activities such as meetings and workshops also use mailed questionnaires, surveys or information packets as part of their process. Many specify timelines regarding when mailings take place relative to meeting dates, when ballots are due and final voting deadlines.

Thirteen SHAs do not specify any technique, although one of them, Nevada, does say that the responses must be in writing.

The "other" outreach techniques are unspecified by the SHAs, but are described with terms such as: defensible, targeted, reliable, and acceptable to FHWA and the Department.

## 4.9 EXAMPLES OF SHAS' CONSIDERATION OF VIEWPOINTS

Six SHAs were contacted and discussions held with their noise specialists to learn more about their experiences in implementing their Consideration of Viewpoints criterion. The SHAs are:

- Nebraska Department of Roads (NDOR)
- Florida DOT
- Pennsylvania DOT
- Massachusetts DOT
- California DOT
- Tennessee DOT

The following points provided a background for the discussions. Not every point was touched upon for each SHA:

- Experiences in implementing and applying the voting process (perhaps including a focus on one project)
    - Roughly how many times the process has been applied to projects
    - Types of situations (owner-occupied and rental single family residences and rentals, apartments, condos, nonresidential land uses, undeveloped lands permitted for development)
    - Success of outreach methods to obtain viewpoints and votes
- Outcomes (in favor, opposed)
- Aspects that have worked out particularly well or that could be changed or improved upon
- How the consideration of viewpoints has changed from the prior policy, and if the change has improved the process
- Any plans to revise the policy regarding the viewpoints criterion

### 4.9.1 Nebraska Department of Roads (NDOR)

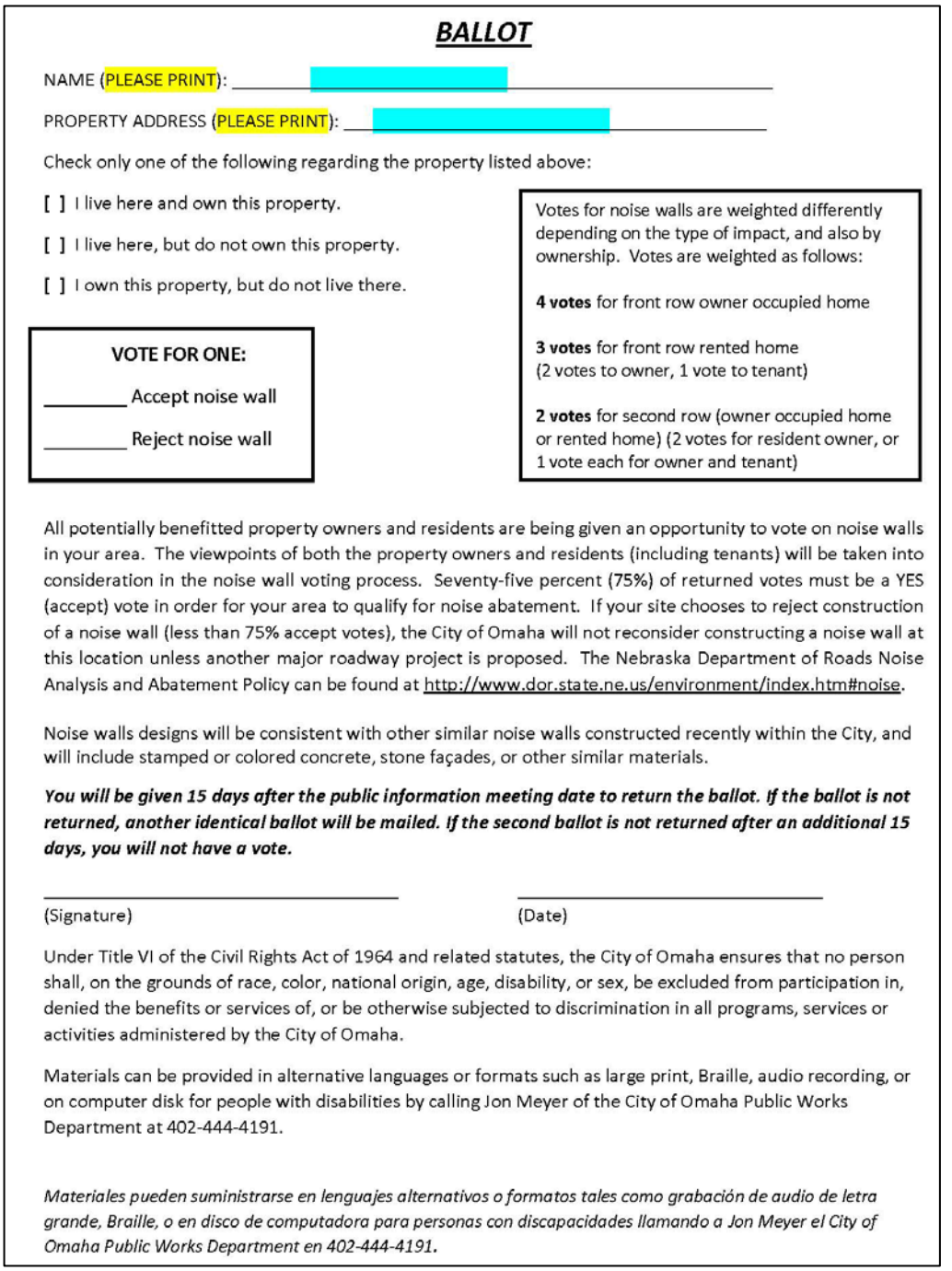
NDOR Environmental Specialist, Will Packard, provided the information used to prepare this section, including the sample ballot and project graphics below. He is in charge of the NDOR noise and air quality program and was actively involved in the development of the NDOR noise policy.

The NDOR voting process has been implemented on a number of federal-aid Local Public Agency projects that are subject to the NDOR noise policy, including three in Omaha, NE and one in Lincoln, NE.

A standard voting timeline typically spans 45 days. Two weeks before a noise abatement stakeholder meeting on a proposed project, NDOR sends out an informational packet with a

ballot. The stakeholders are then invited to attend the noise abatement meeting where a presentation is given on the project including a demonstration using an NDOR customized version of the FHWA Interactive Sound Information System software.

NDOR previously used a simple ballot for all stakeholders. NDOR has since developed a point system where each ballot is personally addressed and mailed to the owner and/or occupant of the benefited receptor, and shows the allotted number of points for that particular receptor on the ballot. The stakeholders are given two weeks after the noise abatement stakeholder meeting to submit their ballot and if ballots are not received a reminder is mailed out to them. They then have 15-days to respond before the voting is closed. Figure 26 shows a typical ballot.



**BALLOT**

NAME (PLEASE PRINT): _____

PROPERTY ADDRESS (PLEASE PRINT): _____

Check only one of the following regarding the property listed above:

[ ] I live here and own this property.

[ ] I live here, but do not own this property.

[ ] I own this property, but do not live there.

**VOTE FOR ONE:**

_____ Accept noise wall

_____ Reject noise wall

Votes for noise walls are weighted differently depending on the type of impact, and also by ownership. Votes are weighted as follows:

**4 votes** for front row owner occupied home

**3 votes** for front row rented home
(2 votes to owner, 1 vote to tenant)

**2 votes** for second row (owner occupied home or rented home) (2 votes for resident owner, or 1 vote each for owner and tenant)

All potentially benefitted property owners and residents are being given an opportunity to vote on noise walls in your area. The viewpoints of both the property owners and residents (including tenants) will be taken into consideration in the noise wall voting process. Seventy-five percent (75%) of returned votes must be a YES (accept) vote in order for your area to qualify for noise abatement. If your site chooses to reject construction of a noise wall (less than 75% accept votes), the City of Omaha will not reconsider constructing a noise wall at this location unless another major roadway project is proposed. The Nebraska Department of Roads Noise Analysis and Abatement Policy can be found at http://www.dor.state.ne.us/environment/index.htm#noise.

Noise walls designs will be consistent with other similar noise walls constructed recently within the City, and will include stamped or colored concrete, stone façades, or other similar materials.

***You will be given 15 days after the public information meeting date to return the ballot. If the ballot is not returned, another identical ballot will be mailed. If the second ballot is not returned after an additional 15 days, you will not have a vote.***

_____ _____

(Signature) (Date)

Under Title VI of the Civil Rights Act of 1964 and related statutes, the City of Omaha ensures that no person shall, on the grounds of race, color, national origin, age, disability, or sex, be excluded from participation in, denied the benefits or services of, or be otherwise subjected to discrimination in all programs, services or activities administered by the City of Omaha.

Materials can be provided in alternative languages or formats such as large print, Braille, audio recording, or on computer disk for people with disabilities by calling Jon Meyer of the City of Omaha Public Works Department at 402-444-4191.

*Materiales pueden suministrarse en lenguajes alternativos o formatos tales como grabación de audio de letra grande, Braille, o en disco de computadora para personas con discapacidades llamando a Jon Meyer el City of Omaha Public Works Department en 402-444-4191.*

**Figure 26. Typical NDOR ballot (courtesy of NDOR).**

One change in procedure that NDOR is considering is to not mail the ballots out with the informational package and announcement of the meeting. Some stakeholders submit the ballot before having had a chance to see the presentation and it is felt that the stakeholders will be able to make more informed decisions if they attend the meeting and see the presentation.

NDOR's point system assigns voting points based on the ownership of the property, whether the owner is the occupant, and whether the property is in the first-row adjacent to the roadway. Figure 27 is a very helpful graphic contained in the policy document.

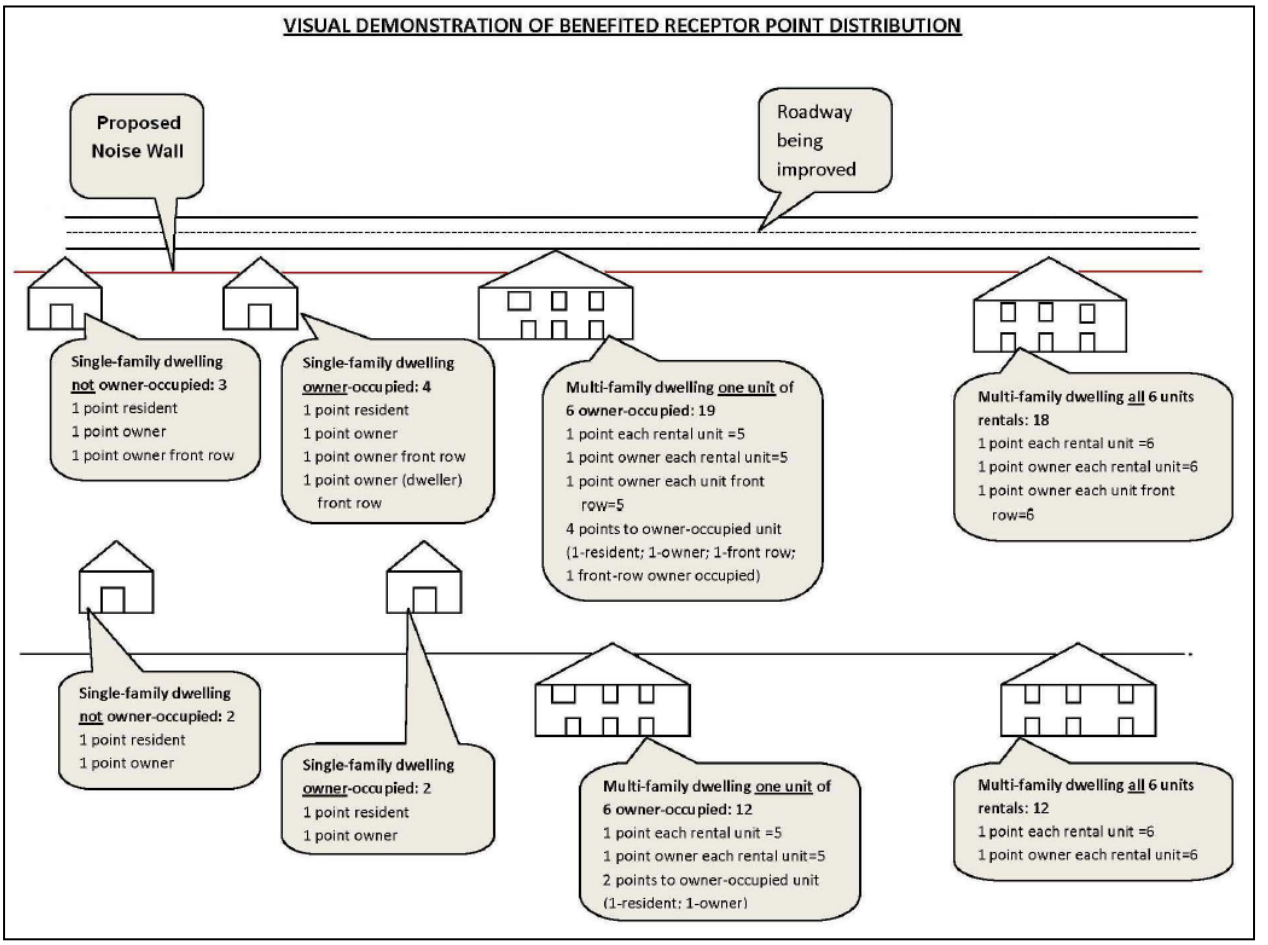



**Figure 27. NDOR's "Visual Demonstration of Benefited Receptor Point Distribution".**

Essentially, for each benefited residence or dwelling unit, the property owner will receive 1 point and the residents of that dwelling unit (whether the owner or renter) will receive 1 point. If the residence or dwelling unit is in the front row, the property owner will receive an additional point and will receive a fourth point if the property owner lives in the dwelling unit.

Thus, a single-family dwelling unit not located on the front row, whether owner-occupied or resident-occupied, will receive 2 points on its ballot: one for the owner and one for the resident.

If that single-family dwelling was on the front row, it would receive 3 points if the owner did not live in the unit (a rental unit) or 4 points if the unit was owner-occupied.

For multi-family dwellings, all of the dwelling units would receive 2 points each (one for the owner and one for the resident, whether that be the owner or a renter). If the multi-family facility was on the front row, the owner would receive 2 points for each unit plus an additional point if he or she lived in the unit and the renter would receive 1 point.

NDOR wanted to be sure that property owners had a large say in the abatement decision due to the transient nature of the occupants living in multi-unit complexes in Nebraska. NDOR patterned its voting method after that of North Carolina DOT adding its own features.

People have generally not questioned their assignment of points, appearing to understand conceptually that an owner might receive more points than a renter and that a front-row dwelling unit might receive more points than a unit farther from the road.

NDOR's viewpoints criterion involves a vote by the benefited property owners and residents in which a 75% favorable vote is required for the barrier to be reasonable. This percentage is one of the highest of all of the SHAs and is what was used by NDOR in the past prior to the policy change. This percentage has not been an issue on any of the local projects due to the strong support in favor of noise abatement by the owners and residents. NDOR has no minimum response rate that is required and observed that the four noted local projects all had a good response rate.

In most situations, the neighborhoods consist of owner-occupied single-family residences with a small number of renters. There was one complication on a project where a 4-unit townhome building had an owner association, but where the designation of the actual property owners was not clear. After discussions with the residents, it was decided that each townhome unit would be considered an owner-occupied residence with each unit getting 4 points on its ballot (owner + resident + owner-occupant + front-row owner).

On one local project, a strong positive vote by the stakeholders was felt to be an important factor in justifying the cost of abatement to city leaders. The project was the widening an arterial – 156th Street – from two lanes to four lanes in the City of Omaha, with seven barriers being evaluated. The City has a "green spaces" ordinance that requires a certain setback from the local roads for trees and a sidewalk. Figure 28 and Figure 29 shows a typical cross-section with the barrier on the right and Figure 29 shows a layout for one of the barriers (green receptors will receive 5 dB or greater noise reduction while purple will receive 7 dB or greater reduction).

The barriers were approved on the basis of all of the feasibility and reasonableness criteria, including viewpoints, being met.

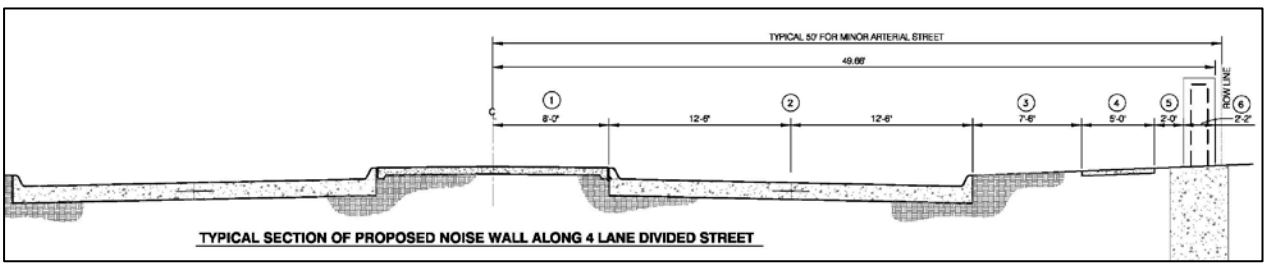



**Figure 28. Typical cross-section for the 156th Street project in Omaha (courtesy of NDOR).**

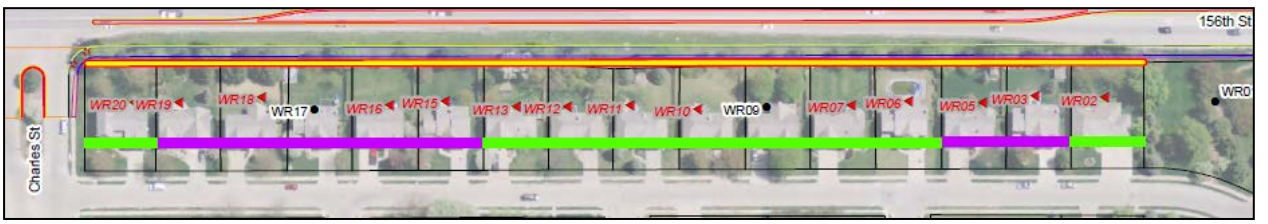



**Figure 29. Layout showing green space between the road and the noise barrier (in yellow) for the 156th Street project in Omaha, NE (courtesy of NDOR).**

On another Omaha project – the 108th Street widening – multiple noise barrier "zones" were studied, as shown in Figure 30 shows the zones. Nine barriers were feasible and reasonable and were voted upon. Two barriers, E3 and E4, were rejected by voters and W5, representing a three-story apartment complex (see Figure 31) was supported by the voters. This example is interesting in the fact that the benefited receptors eligible to vote on Barrier W5 consisted of apartment units on both the first and second floors of the buildings, with outdoor use spaces of patios and balconies. The third-floor apartments were not benefited by the barrier because of their elevation above its top.


**Figure 30 (right). 108th Street study area, Omaha, NE (courtesy of NDOR).**

**Figure 31 (below). Three-story apartments in Zone W5 of 108th Street project (image from www.bing.com/maps/).**

NDOR is satisfied with the viewpoints reasonableness criterion in their policy. Future considerations will be given to not including the ballot in the initial mail-out to the stakeholders.

The full text of the section of the NDOR policy on the consideration of viewpoints is presented in Appendix A.

### 4.9.2 Florida DOT (FDOT)

Mariano Berrios of FDOT provided the information used to prepare this section, including the project graphic and photograph. He is the Environmental Programs Administrator in FDOT's main office and was actively involved in the development of the FDOT noise policy. Florida DOT is characterized by a main office headquarters where noise policy and procedural issues are handled and eight district offices where the project work is conducted and managed. FDOT has a statewide noise task team that consists of the main office noise specialist, the noise specialists in each district, and ten consultants who do a great deal of the technical noise work for FDOT projects. The team meets twice a year to discuss policy and technical noise study issues.

Conceptually, the FDOT DOT noise policy's consideration of viewpoints is essentially a continuation of what was in its past policy, where a majority of the receptors affected by a proposed project vote in favor of a barrier for it to move forward in the process.

The biggest change in how the viewpoints of the benefited receptors are considered is the inclusion of property renters in the new policy. Traditionally, FDOT had given the decision to the owners of the properties. With the changes instituted in 23 CFR 772, FDOT devised a formula for considering the viewpoints of the non-owner occupants of apartments, condominiums and mobile home parks. Specifically:

- An owner-occupied dwelling unit (whether it is a single family residence, condominium or mobile home) gets 100% of a single vote per unit
- For non-owner-occupied single family residences and condominium units, the owner gets 90% of the vote and the renter gets 10% of the vote. Each dwelling unit gets only one vote.
- For mobile homes, the owner of the mobile home lot gets 80% of each lot's vote and the occupant of the mobile home gets 20% of the vote.

If the owner or the occupant does not reply after repeated attempts to obtain a vote, the unit only gets counted for the percentage of the vote returned for that unit.

Going forward, one of the items that FDOT is considering to change is this 90%/10% split in the vote. Some districts have expressed a desire for more weight to be given to the resident.

FDOT has applied the voting process numerous times since the new policy went into effect. It has not had any major complaints about the process from the affected communities. Concern has been expressed by some of FDOT's consultants that the current process of contacting people is requiring too much time, effort and cost. In one case, the attempts to contact the public involved 12 iterations. While the policy does not have a required response rate of the eligible respondents that it needs for a decision, FDOT endeavors to get as many responses as it can.

Part of the reason for the excessive time and effort is that FDOT mainly uses mailed surveys for gathering votes. Some districts have used multiple mailings when not enough responses have been received. Others have gone so far as to knock on doors of benefited receptors or make phone calls to the benefited owners and residents. Occasionally FDOT districts will use public meetings but they have found that it is harder to get enough people to attend these meetings than it is to get a mailed questionnaire and ballot returned.

On most of its projects, the outcome of the voting has been in favor of the barriers. There have been some conflicts, however, with differing viewpoints of the benefited receptors, the rest of the community, the neighborhood homeowners' association (HOA) or local government leaders.

One example was from a widening project for US 1 in the community of Grove Isle in Vero Beach in southeast Florida. Figure 32 from FDOT District 4, shows the site with the proposed barrier location as the blue line close to the road. The benefited receptors voted in favor of the barrier. However, the rest of the community was largely against the barrier because its installation would cause some special common grounds landscaping put in by the neighborhood

to be lost. External to FDOT's involvement, the benefited receptors eventually changed their minds (and their votes) to be no longer in favor of the barrier.


**Figure 32. Proposed barrier location along US 1, Grove Isle in Vero Beach, FL. (courtesy of FDOT).**

On another project (the widening of US 27 from Barry to Lake County Line, Polk County), the benefited receptors in community of Highlands Reserve in Davenport voted in favor of the noise barrier but the neighborhood HOA was opposed to its construction. Figure 33 shows a portion of the study area with the proposed barrier location indicated by the yellow line and the HOA common grounds outlined in red.

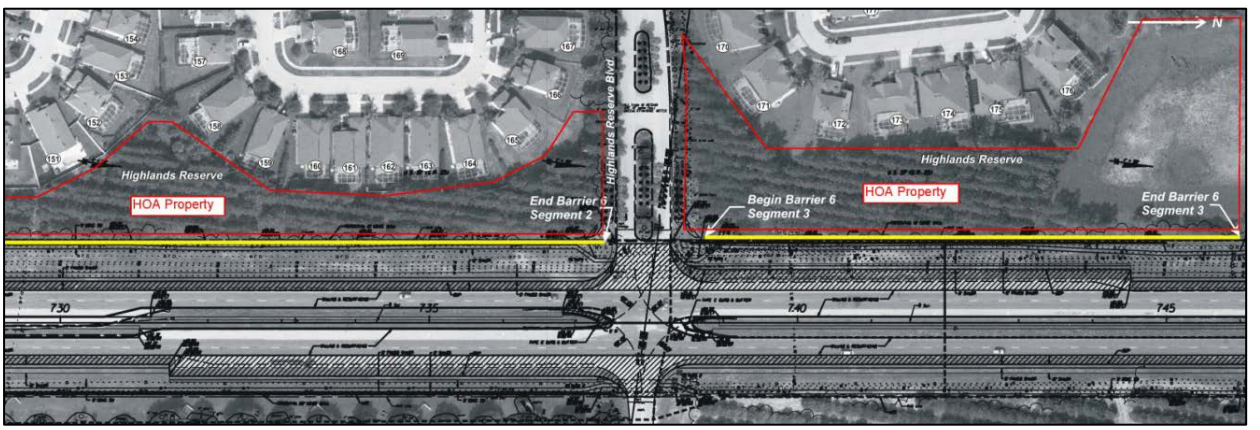



**Figure 33. Portion of study area for the widening of US 27 in Davenport, FL, showing proposed barrier and HOA common grounds. (Courtesy of FDOT).**

In this case, FHWA and FDOT stood by the requirement in 23 CFR 772 and the FDOT noise policy to consider only the viewpoints of the benefited receptors in making the decision. Figure 34 shows two sections of the nearly completed barrier at the entrance to Highlands Reserve (the sections still need to be painted).

**Figure 34. Nearly completed barrier at the entrance to Highlands Reserve along US 27 in Davenport, FL (Courtesy of FDOT).**

FDOT had a similar situation a number of years back where the City of West Palm Beach did not want a barrier near the entrance to the city because City leaders felt that it would detract from the appearance of the gateway to the City. In that case, FDOT again based its decision on the desires of the affected residents and not those of the City.

On another project, the benefited receptors voted in favor of the noise barrier but did not want it to be as tall as designed by FDOT for visual reasons. FDOT was able to design a lower-height wall that would still meet its other feasibility and reasonableness criteria on noise reduction and cost effectiveness. The change in height was approved by a majority of the benefited receptors and was implemented.

FDOT would not honor a request to lower the height of a proposed barrier if that lowering would cause the barrier to be not reasonable based on its noise reduction and cost effectiveness criteria. However, FDOT has implemented a “perimeter wall” concept in instances where noise barriers would not be feasible and reasonable and yet the department wanted to provide some noise relief to the adjacent homeowners. Under this concept, FDOT has a procedure for qualifying an area based on its distance from the highway and an allowable cost criterion, with a maximum wall height of 10 feet being allowed. The perimeter wall would not be considered to be a “noise barrier.”

One question on the application of the FDOT reasonableness criteria in its policy arose in the case of a mobile home park that added spaces for more mobile homes but had not rented out those spaces. As called for in 23 CFR 772 and the FDOT noise policy, a building permit is required by FDOT prior to the date of public knowledge of the highway project for a property to be considered “permitted for development.” If so permitted, then the property should be studied for impact and abatement as if it were developed and should be counted in the reasonableness criteria, including the voting on viewpoints. In this particular case, “building permits” are not issued for mobile home placement in a mobile home park. Upon further investigation, FDOT found that different counties use different types of permits for mobile home location, such as a water use or “hook-up” permit. In the county in question, there are two kinds of permits that are considered equivalent to mobile home building permits: a “New Mobile Home” permit (NMH) or (2) a “Flood Mobile Home” (FMH) permit (where a new mobile home permit within a flood plain that has to meet a minimum floor elevation above the ground). Those permits were then used to determine if the new mobile home spaces should be included in the analysis and voting.

One of the difficulties reported by FDOT in soliciting the viewpoints of the affected property owners and residents is in trying to explain to people why only those undeveloped lots with a building permit issued prior to the date of public knowledge of the project are included in the application of the reasonableness criteria during evaluation of abatement. As an example, on a project in southwest Florida, a developer had an approved subdivision plat. Only a few lots had permits even though plans were moving forward for the development of the rest of the lots. However, not enough permits had been issued for the subdivision to pass the reasonableness criteria tests. The problem was ultimately resolved at a high level in FDOT when a decision was made to not use federal funding on the project, which allowed noise abatement to be added without having to meet the requirements in 23 CFR 772 regarding permitting for development.

In summary, FDOT is generally satisfied with its process for the consideration of viewpoints. Concerns have been raised about the amount of time taken or needed to return to the benefited receptors multiple times in order to obtain a vote. Going forward, FDOT may consider requiring a certain response rate of all eligible respondents for a decision on the abatement measure to be considered valid – and then what to do in terms of continued outreach if that minimum percentage is not achieved. The 90%/10% split of the vote between dwelling unit owners and renter may also be reconsidered.

The full text of the section of the FDOT policy on the consideration of viewpoints is presented in Appendix A.

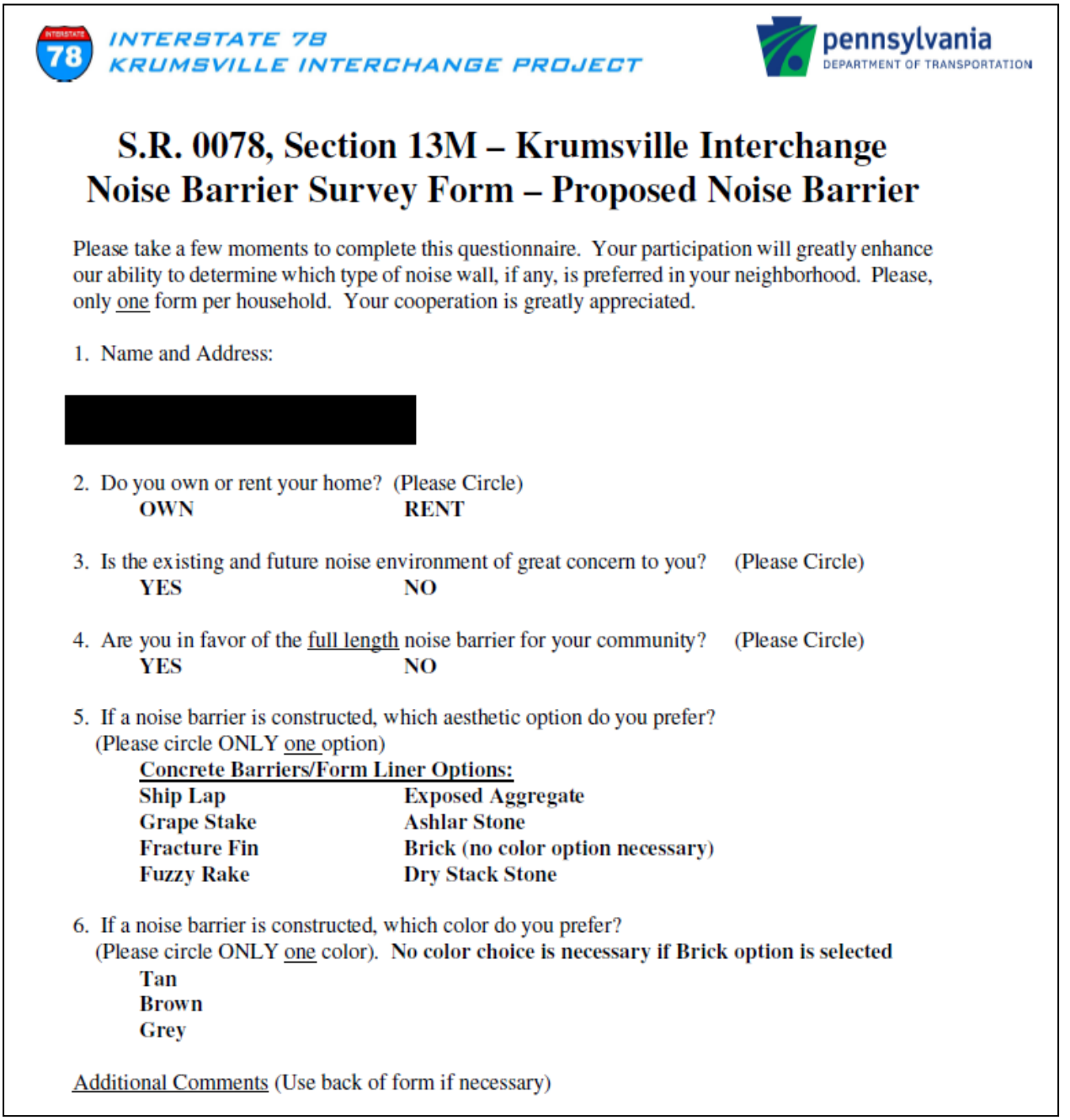
### 4.9.3 Pennsylvania DOT

Danielle Shellenberger (Environmental Planner in charge of noise and air quality, PennDOT Bureau of Project Delivery) and Rob Kolmansberger (consultant to PennDOT at Navarro & Wright Consulting Engineers, Inc.) provided the information used to prepare this section, including the sample ballot and project graphics. PennDOT has had good success in the implementation of the consideration of viewpoints criterion in its noise policy. Its policy requires 50% or more of the received votes to be in favor of the abatement measure for it to be reasonable, with no minimum required response rate for a vote to be considered valid. Owner-occupants of a property get one vote, and in the case of rental units, the owner and renter each get one vote.

PennDOT is decentralized with a number of “Engineering Districts,” where most of the project-related noise study work is done by district specialists and consultants. Most of the need for noise abatement has fallen within only three or four of the districts that include Pennsylvania’s major urban centers. It is roughly estimated that the voting process has been used on 20 to 30 projects a year. In almost all of the cases, the vote of the benefited receptors has been in strongly in favor of the abatement measure and, in most cases, a large majority of the eligible voters are participating in the voting process, even though PennDOT does not have a minimum response rate.

PennDOT has purposely built flexibility into its policy to give each district the maximum opportunity to deal with the circumstances in each situation, which are sometimes unique to a particular project. The desire for flexibility is especially important in terms of the public involvement process. The policy states, “As long as it is documented in the Final Design Highway Traffic Noise Report how benefited receptor unit owners/voted... the method of obtaining votes... shall be determined by the Engineering District on a project-by-project basis.”

Within the framework of that flexibility, there has been some movement to a more standardized process including a presentation of proposed barrier details at a stakeholders meeting and use of a basic template of a voting form, as illustrated in Figure 35. The meetings with the stakeholders can range from formal presentations in an auditorium to "gathering around a kitchen table" when a small number of benefited receptors is involved.



INTERSTATE 78
KRUMSVILLE INTERCHANGE PROJECT

pennsylvania
DEPARTMENT OF TRANSPORTATION

**S.R. 0078, Section 13M – Krumsville Interchange**
**Noise Barrier Survey Form – Proposed Noise Barrier**

Please take a few moments to complete this questionnaire. Your participation will greatly enhance our ability to determine which type of noise wall, if any, is preferred in your neighborhood. Please, only one form per household. Your cooperation is greatly appreciated.

1. Name and Address:

[redacted]

2. Do you own or rent your home? (Please Circle)
   **OWN** **RENT**

3. Is the existing and future noise environment of great concern to you? (Please Circle)
   **YES** **NO**

4. Are you in favor of the full length noise barrier for your community? (Please Circle)
   **YES** **NO**

5. If a noise barrier is constructed, which aesthetic option do you prefer?
   (Please circle ONLY one option)
   **Concrete Barriers/Form Liner Options:**

| | |
|---|---|
| **Ship Lap** | **Exposed Aggregate** |
| **Grape Stake** | **Ashlar Stone** |
| **Fracture Fin** | **Brick (no color option necessary)** |
| **Fuzzy Rake** | **Dry Stack Stone** |

6. If a noise barrier is constructed, which color do you prefer?
   (Please circle ONLY one color). **No color choice is necessary if Brick option is selected**
   **Tan**
   **Brown**
   **Grey**

Additional Comments (Use back of form if necessary)

**Figure 35. A sample PennDOT voting form (courtesy of PennDOT).**

Typically, a certified mailing is made to the benefited receptors. This mailing does not include a ballot because the intent is to try to get as many people as possible to come to the meeting to learn about the proposed abatement measure. When meeting turnouts are low, the districts have the flexibility to follow up as often as possible in a good-faith effort to gain a true sense of the

desires of the benefited receptors. That follow-up could include additional mailings and door-to-door visits.

Ballots distributed at the meeting would typically also contain an opportunity to vote or express preference on the type and color of the barrier surface. There is some support to reduce the number of aesthetic options offered to the benefited owners and residents, in an effort toward more standardization, and there is also support for giving each district as much flexibility as possible to suit the community in the best manner. In some cases, the voting on the aesthetics of a barrier is summarized on a map of the area to get a better sense of who wants which choice in which location.

The PennDOT policy is one of only two SHA policies that addresses the concept of partial traffic noise abatement. The policy states, "When assessing those votes that are not in favor of the proposed noise wall, the Engineering District needs to assess the number and location of these opposing votes on a noise barrier by noise barrier basis. This may result in partial highway traffic noise abatement or the inability of satisfying the request of the opposing votes."

An example was cited of a recent situation on Interstate 78 (section 13M), illustrated in Figure 36. A resident at one end of the proposed barrier was not in favor of the barrier. PennDOT was able to reanalyze the barrier and reduce its length by 200 feet so it would not fully block this receptor while not compromising the performance of the barrier for the other impacted receptors. PennDOT is more willing to consider partial noise abatement in the case of these "end" receptors rather than ones in the middle of a neighborhood because any gap in the middle of a barrier would seriously degrade its performance for nearby receptors. In any case, the reduced-size barrier would still need to meet the feasibility and other reasonableness criteria in the PennDOT policy (including achieving a noise reduction of 7 dB at one benefited receptor and meeting the allowable cost per benefited receptor criterion).

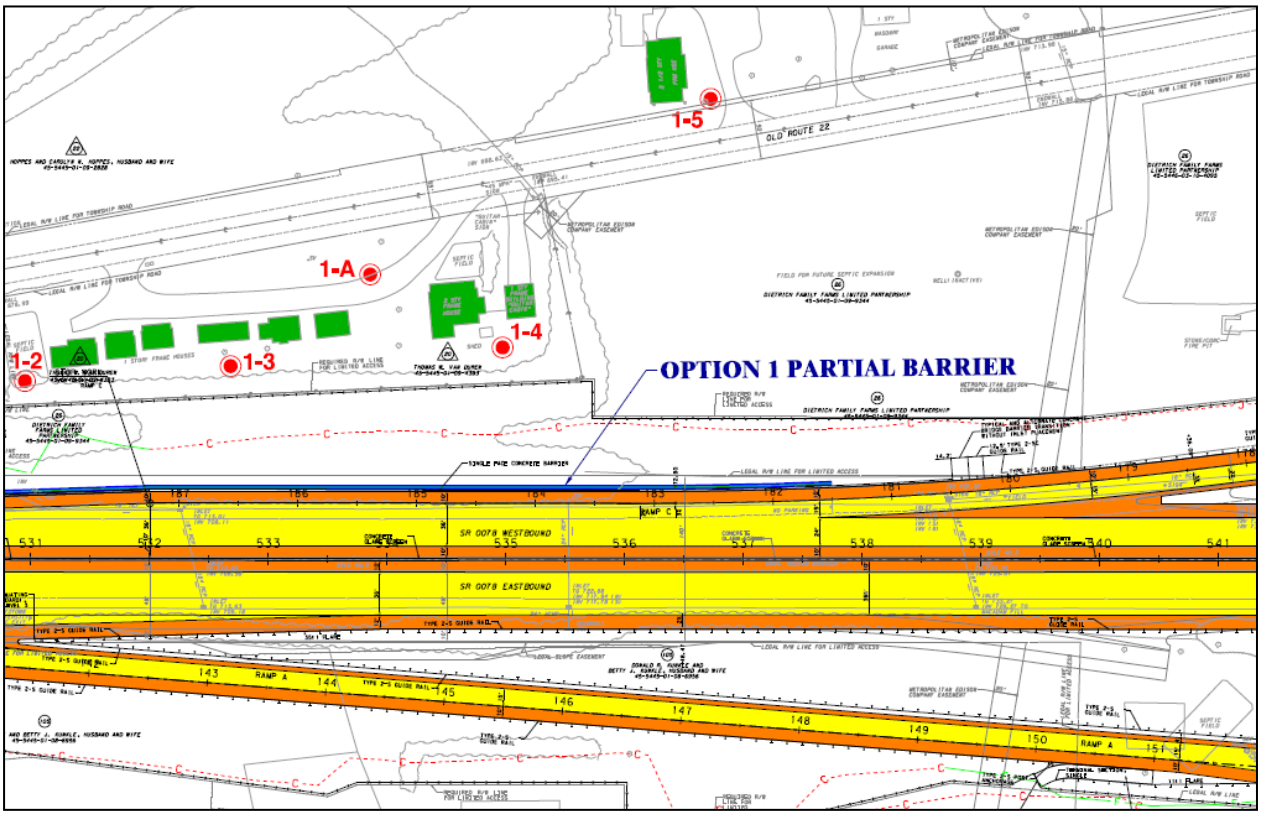



**Figure 36. Interstate 78 project noise study report graphic showing Option 1 of a proposed partial-length noise barrier (courtesy of PennDOT).**

In another section on the same project, PennDOT was able to design two separate options for the barrier: one at the edge of the shoulder of the road and one near the ROW line that would provide a bit more noise reduction but would be more visible to the residents. In the solicitation of viewpoints, PennDOT found the benefited receptors to be in favor of the edge-of-shoulder option because they did not want to have to look at the wall. Figure 37 shows an excerpt from that voting form.

4. Are you in favor of a partial length noise barrier for your community? (Please Circle)
   **YES** **NO**

5. If a partial length noise barrier is constructed, which barrier footprint/option do you prefer? (Please circle ONLY one option)
   **OPTION 1 - PARTIAL LENGTH BARRIER (Near Roadside)**
   **OPTION 2 - PARTIAL LENGTH BARRIER (Near Residences)**

**Figure 37. A sample PennDOT voting form for two options of a partial-length barrier a (courtesy of PennDOT).**

A third situation on this project highlighted the assignment of votes to owner-occupants and renters. The policy states, "The owner of each benefited receptor unit shall receive one vote of equal value for each benefited receptor owned. The renter shall receive one vote for the unit in which they reside." Thus, an owner-occupied residence would receive one vote while a rental residence would receive twice as many votes (one for the owner and one for the renter). In this particular example, the noise analysis area consisted of a single property with eight long-term

rental cottages owned by a single owner (in concept, akin to detached apartments). The owner received one vote for each cottage for a total of eight possible votes. Each renter received one vote, for a total of eight possible votes, meaning, overall, there were 16 possible votes. The owner and three of the renters voted. Thus, there was a total of 11 votes cast. Achieving a percentage of 50% or more required six votes in favor. With the owner voting affirmatively, his eight votes provided the needed margin.

The question arose as to what could have happened in a situation where the owner was the occupant of one of the cottages. Then there would be a total of only 15 votes: one for the owner-occupied cottage, seven for the nonresident owner and seven for the renters. It is unlikely that this change would affect the outcome of the vote. However, a case could arise where a larger number of positive votes by owner-occupants of a group of residences could be outweighed by negative votes from a smaller number of rental properties where the non-occupant owner(s) and their tenants vote against the barrier. Consider 16 properties with 10 owner-occupied units (10 votes) and six rentals (12 votes): the six rental units could carry the vote over the larger number of owner-occupied properties.

PennDOT may consider a change to this section of its policy so that each dwelling unit receives the same number of votes, whether owner-occupied or renter-occupied, splitting the vote between tenant and nonresident owner for rental properties.

In summary, the process by which PennDOT considers the viewpoints of the benefited property owners and the residents has gone well. Flexibility in the process, especially as it relates to public involvement, has been felt to be critical to meet the often unique needs of communities adjacent to highway projects.

The full text of the section of the PennDOT policy on the consideration of viewpoints is presented in Appendix A.

### 4.9.4 Massachusetts DOT (MassDOT)

James Cerbone provided the information, sample letters and ballot used in this section of the report. He is Project Manager in charge of noise in the Environmental Services Section of MassDOT's Highway Division. The MassDOT noise policy requires a two-thirds (67%) positive vote of the weighted total number of residential votes. (The weighting system will be discussed below.) It is important to note that a non-response in the voting is considered a "yes" vote in determining if the 67% requirement has been achieved. There is no minimum response rate in the number of votes received in terms of a percentage of those eligible to vote. The policy is also only one of a few where special mention is made of owners of undeveloped land that has been permitted for development.

The voting process has been used numerous times since 2012 when the new policy went into effect. Approximately 20 barriers, mostly for widenings or interchange modifications, have been approved under the new policy.

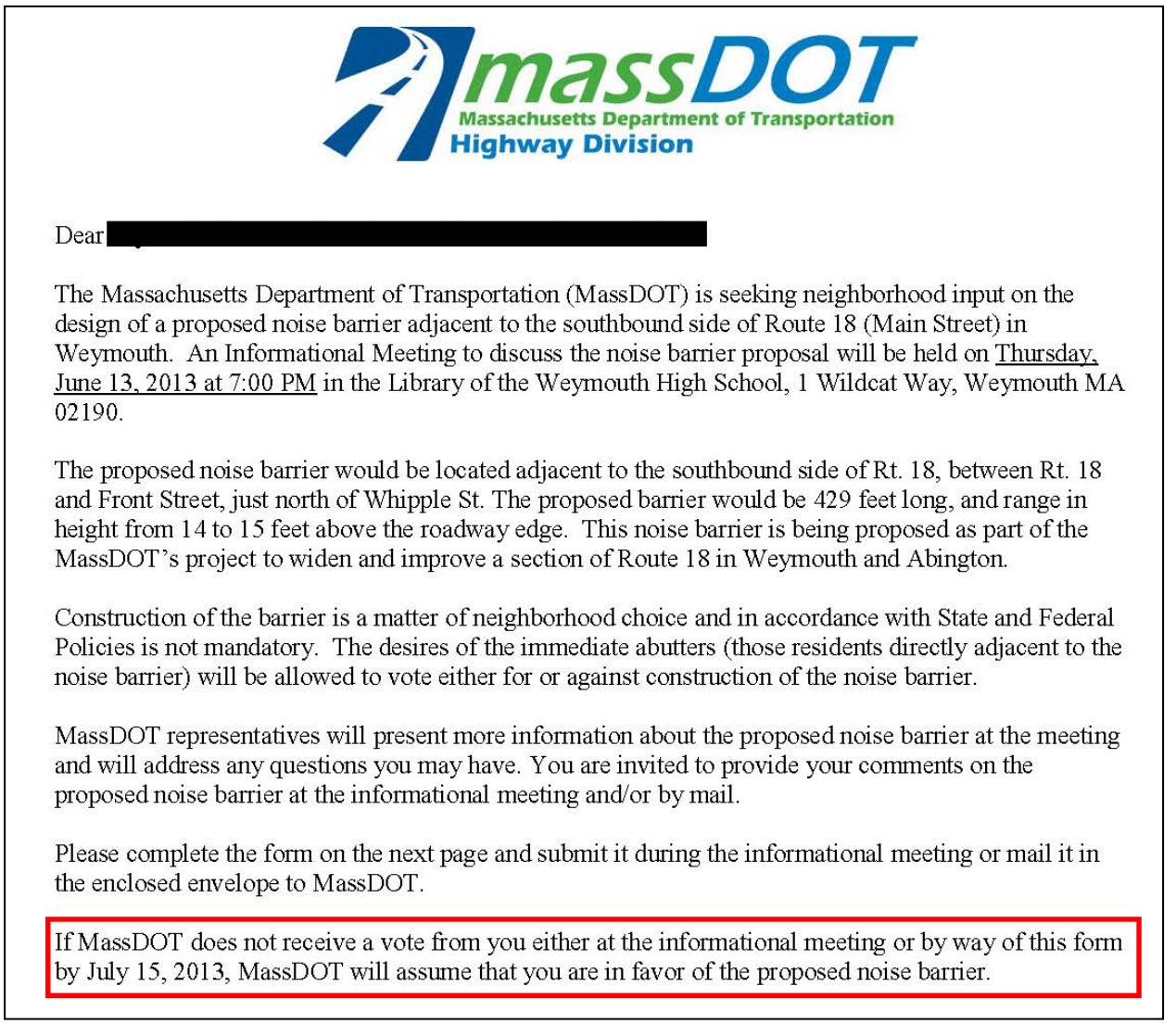
The process involves sending out a letter by certified mail to the benefited property owners and residents. The letter provides notice of a neighborhood meeting and details on the barrier's location, height and length, more recently in the form a fact sheet. The letter also includes a ballot that identifies the recipient by name (if the owner) or as "Resident" (if a renter), along with

the address. The ballot asks the recipient to vote in favor or opposed to the barrier and gives the opportunity to provide comments and to express preference on a color or texture for the barrier.

At the meeting, the proposed barrier is presented, an opportunity is provided for local input into the development of the barrier project, and ballots are collected. After the meeting has been held, MassDOT counts the votes and determines if the two-thirds majority is in favor of the barrier. MassDOT then sends a letter to all of the benefited receptors with the results of the voting along with its decision to move forward or not with the barrier.

MassDOT will accept the votes ahead of the meeting or at the meeting and will accept them by e-mail as well as in person. However, it is clearly stated that this ballot is the only opportunity that the benefited receptors will have to vote.

A sample letter for the informational meeting and ballot (not including an aesthetics preference vote) are shown below as Figure 38 and Figure 39. Figure 40 shows a sample results letter indicating that the barrier did not receive 67% of the vote in favor of it.



massDOT
Massachusetts Department of Transportation
Highway Division

Dear [redacted]

The Massachusetts Department of Transportation (MassDOT) is seeking neighborhood input on the design of a proposed noise barrier adjacent to the southbound side of Route 18 (Main Street) in Weymouth. An Informational Meeting to discuss the noise barrier proposal will be held on Thursday, June 13, 2013 at 7:00 PM in the Library of the Weymouth High School, 1 Wildcat Way, Weymouth MA 02190.

The proposed noise barrier would be located adjacent to the southbound side of Rt. 18, between Rt. 18 and Front Street, just north of Whipple St. The proposed barrier would be 429 feet long, and range in height from 14 to 15 feet above the roadway edge. This noise barrier is being proposed as part of the MassDOT's project to widen and improve a section of Route 18 in Weymouth and Abington.

Construction of the barrier is a matter of neighborhood choice and in accordance with State and Federal Policies is not mandatory. The desires of the immediate abutters (those residents directly adjacent to the noise barrier) will be allowed to vote either for or against construction of the noise barrier.

MassDOT representatives will present more information about the proposed noise barrier at the meeting and will address any questions you may have. You are invited to provide your comments on the proposed noise barrier at the informational meeting and/or by mail.

Please complete the form on the next page and submit it during the informational meeting or mail it in the enclosed envelope to MassDOT.

If MassDOT does not receive a vote from you either at the informational meeting or by way of this form by July 15, 2013, MassDOT will assume that you are in favor of the proposed noise barrier.

**Figure 38. A sample MassDOT invitation to an informational neighborhood noise barrier meeting and transmittal of a ballot (courtesy of MassDOT).**

Please Check One

_____ I am in favor of the proposed noise barrier along Route 18 in Weymouth.

_____ I am **not** in favor of the proposed noise barrier along Route 18 in Weymouth.

Your input is solicited and appreciated. Please return this form, with comments if desired, to a staff member at the meeting, or mail to: James Cerbone, Environmental Services Section, Massachusetts Department of Transportation, 10 Park Plaza, Room 4260, Boston, MA 02116, in the envelope provided.

If MassDOT does not receive a vote from you either at the informational meeting or by way of this form by July 15, 2013, MassDOT will assume that you are in favor of the proposed noise barrier.

Mailed to: [redacted]

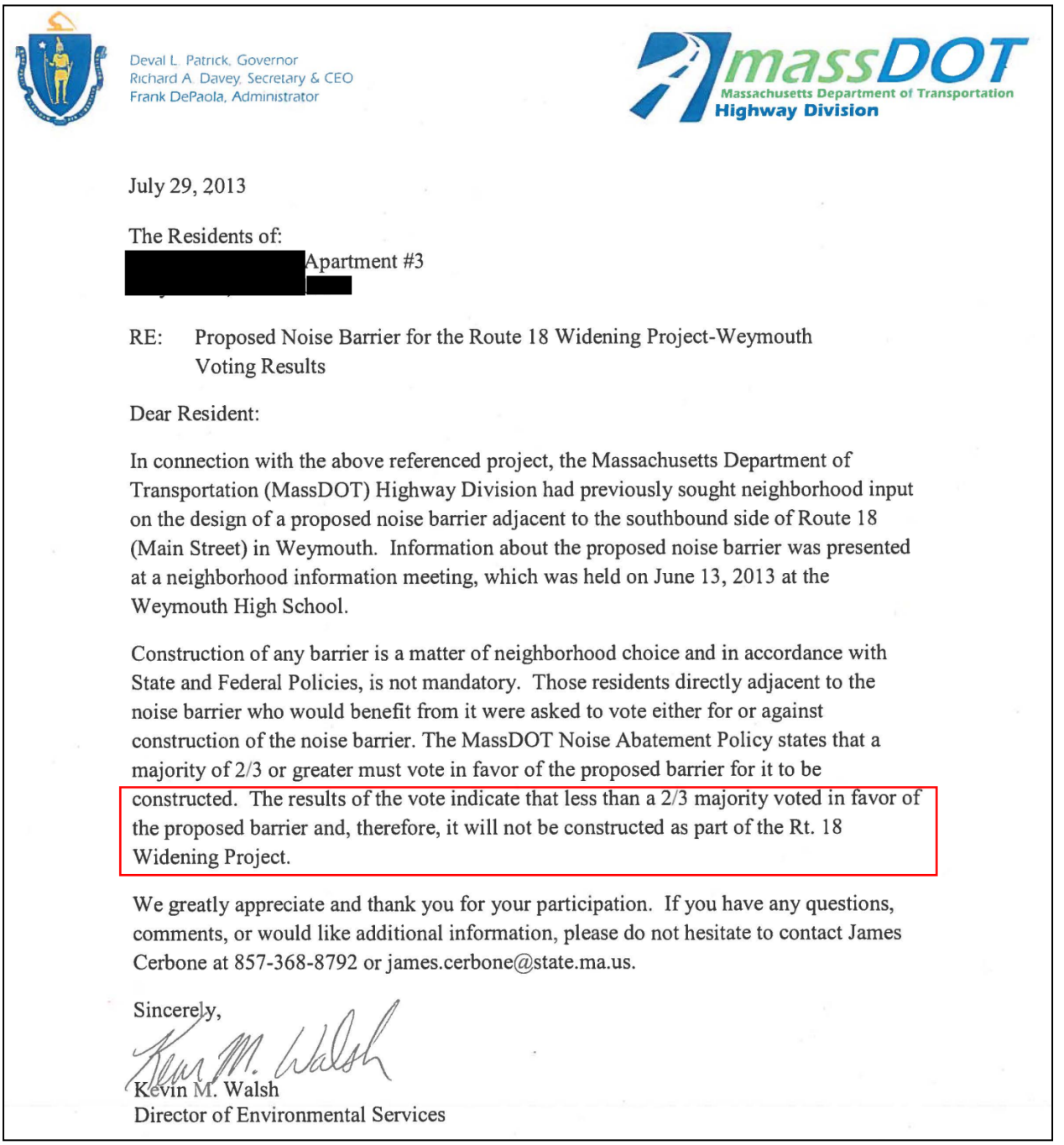
Please provide name and address of person filling out this form:

NAME: _____

ADDRESS: _____

COMMENTS

**Figure 39. A sample viewpoints ballot accompanying the informational letter sent by MassDOT (courtesy of MassDOT).**



Deval L. Patrick, Governor
Richard A. Davey, Secretary & CEO
Frank DePaola, Administrator

MassDOT
Massachusetts Department of Transportation
Highway Division

July 29, 2013

The Residents of:
[redacted] Apartment #3

RE: Proposed Noise Barrier for the Route 18 Widening Project-Weymouth
Voting Results

Dear Resident:

In connection with the above referenced project, the Massachusetts Department of Transportation (MassDOT) Highway Division had previously sought neighborhood input on the design of a proposed noise barrier adjacent to the southbound side of Route 18 (Main Street) in Weymouth. Information about the proposed noise barrier was presented at a neighborhood information meeting, which was held on June 13, 2013 at the Weymouth High School.

Construction of any barrier is a matter of neighborhood choice and in accordance with State and Federal Policies, is not mandatory. Those residents directly adjacent to the noise barrier who would benefit from it were asked to vote either for or against construction of the noise barrier. The MassDOT Noise Abatement Policy states that a majority of 2/3 or greater must vote in favor of the proposed barrier for it to be constructed. The results of the vote indicate that less than a 2/3 majority voted in favor of the proposed barrier and, therefore, it will not be constructed as part of the Rt. 18 Widening Project.

We greatly appreciate and thank you for your participation. If you have any questions, comments, or would like additional information, please do not hesitate to contact James Cerbone at 857-368-8792 or james.cerbone@state.ma.us.

Sincerely,

Kevin M. Walsh
Director of Environmental Services

**Figure 40. A sample voting results letter indicating that the barrier will not be constructed by MassDOT (courtesy of MassDOT).**

The current process has evolved from what is stated in the policy. The policy notes that after the public information meeting, a survey of the property owners and residents of the benefited receptors is conducted by mail. The policy notes that a "second public meeting is held after the noise barrier design progresses further to present more specific project information to the affected area." Currently, as noted above, only one meeting is held, where people both vote on the barrier and the color and texture.

The MassDOT policy specifies the number of votes based on whether or not the dwelling unit is owner-occupied or rented, whether it is first-row or other row, and if it is other than existing residential (Activity Category C or D or undeveloped land permitted for residential development. Figure 41 shows Table 5 from the policy on the vote allocation.

**Table 5 Number of Votes Allocated to Benefited Receptors Surveyed**

| Land Use | Occupancy | Row | Number of Votes |
|---|---|---|---|
| Existing Residential | Owner | First | 5 |
| Existing Residential | Owner | Second, Third, etc. | 3 |
| Existing Residential | Renter | First, Second, Third, etc. | 1 |
| Existing Activity Category C or D | Owner | Not Applicable | 1 |
| Undeveloped Land Permitted for Development (Residential) | Owner | First | 5 |
| Undeveloped Land Permitted for Development (Residential) | Owner | Second, Third, etc. | 3 |

**Figure 41. Table 5 on vote allocation from the MassDOT noise policy.**

As shown, a first row residence will receive five votes and a renter will receive one vote. If the property is owner-occupied the owner would have all five votes. For the rental property, the owner would have four votes and the renter would have one vote. Similarly for rows beyond the first row, the property would get three votes, which would be divided as two for the owner and one for the renter if it is a rental property. No situations involving voting on Activity Category C or D or permitted undeveloped lands have yet to arise.

Two instances of barriers being voted down by the benefited property owners and residents were cited. The first case was along Interstate 93 Southbound at Columbia Road in Boston where the benefited voters were opposed to the view across the road being obstructed. Figure 42 shows the general project area.

The second project was Route 18 in Weymouth-Abbington, MA. A FONSI was issued in 2009, prior to the adoption of the changes in 23 CFR 772 and the new MassDOT noise policy. The noise analysis in the EA documented that most first row receptors along Route 18 would be impacted and that second row receptors for the most part would not be impacted. The analysis then evaluated the feasibility of noise abatement to obtain the required noise reduction. The result of the analysis was that noise barriers would not be feasible for most front-row receptors because of the need for gaps providing safe sight distances for driveways and side streets.

One noise barrier, however, was determined to be feasible and reasonable in terms of noise reduction design goal and MassDOT's cost effectiveness index. Figure 43 shows the area where the barrier would be located, between Route 18 (Main Street) and Front Street This barrier would benefit nine residences. Four of the residences were apartments in one building that were all owned by the same person. There were five other owner-occupied residences.

**Figure 42. General project area of proposed barrier rejected because of expected loss of view, Interstate 93 Southbound at Columbia Road, Boston, MA (image from www.bing.com/maps).**

During the public involvement process to determine the neighbors' viewpoints about the barrier, the apartment owner along with one other property owner did not want the barrier because of the visual impact. With the apartment owner allocated four votes per apartment unit, the vote failed to achieve the needed two-thirds majority even though four of the other property owners were in favor of the barrier. Therefore, this barrier was no longer included in the project.


**Figure 43. Residences along Front Street that would have been benefited by a barrier between Front Street and Route 18, Weymouth/Abbington, MA (image from www.google.com/maps).**

MassDOT will be re-evaluating its noise policy in 2016, but at the moment it does not foresee any changes of the viewpoints criterion or the voting process. The opinion was expressed that this portion of the policy seems to be working well.

The full text of the section of the MassDOT policy on the consideration of viewpoints is presented in Appendix A.

### 4.9.5 California DOT (Caltrans)

Mr. Jin Lee of Caltrans District 7 in Los Angeles and Mr. Jim Andrews in the Headquarters' Division of Environmental Analysis provided the information discussed in this section. Mr. Lee is Branch Chief/Noise & Vibration Branch, Office of Environmental Engineering, Division of Environmental Planning. Mr. Andrews is a Senior Transportation Engineer. Caltrans, like Pennsylvania DOT, consists of a main office headquarters and many districts (12) around the state. Districts with urban centers tend to have many more noise barrier projects than the more rural districts.

The Caltrans noise policy states "that if more than 50% of the votes from responding benefited receptors oppose the abatement, the abatement will not be considered reasonable." Caltrans' goal is to provide noise abatement/benefits to the impacted areas. Caltrans' default position is that noise barriers that are determined to be reasonable and feasible are a benefit to the community to reduce traffic noise. Noise abatement should be provided to impacted areas unless there are clearly stated and active opposition to the recommended abatement measures by a majority of the benefitted receptors. The assumption is that a non-response equates to implied concurrence for and lack of opposition to the abatement measure.

When Caltrans drafted its policy, it was trying to address the concerns of both the tenants in high-density, multi-unit complexes and the property owners. The philosophy was that while tenants frequently change, the property owner has a long-term interest. The intent was that for a given property, the owner had a controlling interest but the tenants should get some voting power. In most cases, barriers that are both feasible and reasonable have benefitted residences from many properties and therefore the tenants of one property may be the swing vote for building the wall even when their owner opposed it. This issue was difficult to resolve to everyone's satisfaction.

The policy states: "For non-owner-occupied dwelling units, the renter gets 10% of one vote and the owner gets 90% of one vote." Currently, District 7 interprets this split as: the owner of the apartment building would get 90% of one vote and each renter would get 10% of one vote. Thus, if there were one owner and 20 renters, the owner would get 0.9 votes and the renters would get a total of 20 x 0.1 votes or 2 votes. This interpretation means that the owner would not automatically control the vote: 10 renters could out-vote the owner.

An alternative interpretation would be that a 20-unit apartment building would have a total of 20 votes, one for each unit. The owner would get 90% of 20 votes for a total of 18 votes where each renter would get 10% of 1 vote for a total of 2 votes. In this arrangement, the owner's vote would always control the result. (In the case of a single-family residence as a rental, the owner would get 90% of one vote or 0.9 votes and the tenant would get 10% of one vote or 0.1 votes. In this case, the owner's vote would also control the result.)

Caltrans' policy is also unique by its inclusion of a discussion of noise abatement located on private property. In such cases, 100% of the owners upon which the abatement would be placed must be in support of the proposed abatement. If no response is received from a property owner, that vote is considered as a vote against abatement. In such cases, Caltrans will make several efforts to contact all of the property owners, even including knocking on doors. It is not uncommon for Caltrans to recommend a noise barrier on a private property. Generally, these situations occur when the houses are up on a hill above a freeway and would have a line-of-sight over any barrier placed on the ROW or near the edge of pavement of the freeway. However, rarely has Caltrans built a barrier on private property. Often, people do have a view that they wish to maintain and even opposition from a single property owner could prevent the barrier from being found reasonable.

The ways in which the consideration of viewpoints is implemented can vary from district to district. In District 7, the general outreach method is first to hold an open house to discuss the proposed barrier project. If there is general consensus in favor of the barrier, Caltrans documents that consensus and conclude the process of soliciting viewpoints.

If opposition to the barrier is expressed at the open house, depending on its degree, District 7 then conducts a survey by certified mail of the benefited receptors (note that while the policy says registered mail, the district has found certified mail to work well). Caltrans will send out an initial letter ballot and allow three to four weeks for a response. Caltrans will then send out a second letter to the non-respondents and, if needed after another response period, a third and final letter. That third letter would indicate that it would be that recipient's last opportunity to vote on the barrier. If no response is received, District 7 considers the non-respondent as voting in favor of the barrier. The language in the policy states: "if more than 50% of the votes from responding benefited receptors oppose the abatement the abatement will not be considered reasonable."

Generally, in most of its applications of this voting process, District 7 has found the benefited property owners and residents to be in favor of the barrier at the open house. As a result, there are not many cases when a survey was needed.

One case was described where the residents did vote against the barrier. The project was the terminus of State Route 2 south of its interchange with Interstate 5 in Los Angeles, CA. A series of noise barriers was recommended along this project and most of the barriers were voted upon favorably by the benefited owners and residents. However, in one section near the end of the project, the noise barrier would have to be added atop an existing retaining wall along Allesandro Street to provide noise reduction to the residences elevated above the roadway. Figure 44 and Figure 45 show views of this neighborhood area.

**Figure 44. View of site of rejected proposed noise barrier atop retaining wall, Route 2 south of I-5, Los Angeles, CA (image from www.google.com/maps).**

**Figure 45. Elevated view of site of rejected proposed noise barrier atop retaining wall, Route 2 south of I-5, Los Angeles, CA (image from www.bing.com/maps).**

Figure 46 shows an excerpt of the ballot sent to the owners and residents under a cover letter that described the project and the proposed barrier. The residents did not want their view blocked by a barrier and voted against the barrier. Figure 47 is an excerpt from the letter sent to the owners and residents informing them of the results of the vote and the Caltrans' decision to not move forward with the proposed barrier.

***SOUNDWALL SURVEY RESPONSE FORM***

Please indicate your opinion regarding the proposed soundwall below and complete the survey by including your name, address, signature, and date. Please return the form in the enclosed self- addressed stamped envelope. For non-owner-occupied dwelling units, the non-owner (i.e., renter) gets 10% of one vote and the property owner gets 90% of one vote. It is important that we receive a response from each affected property (occupant and owner) by **February 27, 2013**. Thank you in advance for your participation.

---

If you are a property owner:

☐ I agree to have a 1000 feet long and 12 to 14 feet high masonry soundwall.
☐ I do not agree to have this soundwall.

If you are a non-owner occupant (i.e., renter):

☐ I agree to have a 1000 feet long and 12 to 14 feet high masonry soundwall.
☐ I do not agree to have this soundwall.

Comments:

Property Owner Name and Property Address:

[redacted]

Property Owner Name and Mailing Address (if different than above):

_____

Non-owner Occupant Name (i.e., renter, if applicable):_____

**Figure 46. Excerpt of ballot sent by Caltrans to owners and residents who would be benefited by a proposed noise barrier (courtesy of Caltrans).**

A soundwall survey was conducted in February 2013 that targeted property owners and occupants of a total of 20 properties along the southbound side of State Route 2. These properties were identified and selected to participate in the survey because the noise level reduction [with the construction of the proposed Soundwall SB1] is projected to be 5 decibels or more at these properties.

The survey asked for your opinion regarding the proposed Soundwall SB1 along Allesandro Way from Oak Glen Place to Lake View Avenue. The survey result concluded that a total of 12 owners did not agree to construct the Soundwall and that constituted a majority vote against the construction of the Soundwall. Therefore, Soundwall SB1 has been removed from the State Route 2 Freeway Terminus Improvement Project.

**Figure 47. Excerpt from noise barrier survey results letter sent by Caltrans to owners and residents who voted on the barrier (courtesy of Caltrans).**

In summary, the Caltrans policy on viewpoints is flexible in how it is interpreted by each of its districts. District 7 has implemented a flexible process where formal voting is not necessary unless opposition to the barrier is raised. The policy features a splitting of owner and renter votes on a 90%/10% basis. The policy is also unique in its specification of a 100% positive vote for any abatement feature located on private property.

The full text of the section of the Caltrans' policy on the consideration of viewpoints is presented in Appendix A.

### 4.9.6 Tennessee DOT

Darlene Reiter, Ph.D., P.E., of Bowlby & Associates, Inc., provided this information on behalf of TDOT. Dr. Reiter has a part-time consultant assistance staff position at TDOT for assisting in managing TDOT's noise and air quality programs. She is also a researcher on this task order.

TDOT's noise policy states that TDOT "will conclude that a community desires the construction of a noise barrier unless a majority (at least 51%) of the benefited property owners and residents indicate that they do *not* want the proposed noise barrier." [italics added] TDOT only considers the votes that are received. One consequence is that a minority of benefited receptors could vote down a barrier if they happen to be in the majority of the received votes when there is a low response rate.

TDOT counts responses from residents or owners of properties that are predicted to be impacted as well as benefited as two votes. Votes for properties that are benefited but not impacted are counted as one vote. If an impacted and benefited residence in occupied by the owner, the owner casts both votes. If the residence is rented, the two votes are split with one for the owner and one for the renter. For properties that are benefited but not impacted, the one vote is split with 0.5 votes for the owner and 0.5 votes for the renter. In either case, if one stakeholder does not vote, that unused portion of the vote is not counted.

TDOT's noise policy also states that "The input of the benefited property owners and residents will generally be received at planning, NEPA or design public hearings or public meetings. Input

received at these hearings or meetings may be supplemented, as necessary, with formal survey methods on a case-by-case basis as discussed in the TEPM." TDOT developed a standard noise barrier questionnaire, which it feels has worked well. TDOT Noise Procedures provide additional guidance on the solicitation of viewpoints stating: "If significant opposition exists and there is not clear support for the construction of the proposed noise barrier(s), TDOT will conduct a certified mail survey to solicit the views of the benefited residents and/or property owners…"

The process has been applied to four projects where barriers were determined to meet the first two reasonableness criteria for noise reduction design goal and cost-effectiveness. Only one of these cases involved significant opposition to the proposed barrier. In this case, the formal survey process outlined in TDOT's Noise Procedures was followed including a certified mailing and a follow-up letter to non-respondents.

TDOT has solicited the viewpoints for the other three other projects at planning, NEPA or design public hearings or public meetings. Surveys were also subsequently mailed to benefited residents and property owners on two of these projects. On one project, the public meeting conflicted with a religious holiday which affected meeting attendance. On the other project, the homeowner's association requested that TDOT send surveys to all of the residents.

The results are summarized in Table 36, with the first column also listing the figure that shows the project area. At TDOT's request, these projects are listed anonymously and referred to as projects TDOT-1 through TDOT-4. These projects provide an excellent mix of community types and ownership: primarily owner-occupied single family homes; single family homes and condos; mobile homes; and rental apartments. The table includes the number of impacted and benefited dwelling units. It also includes the number of responses (and their characteristics), and the voting results and reasonableness decision.

**Table 36: Summary of Viewpoints on TDOT Projects.**

| Project | Type of Community | Ownership | Outreach Method | Impacts and Benefits | Number of Responses | Results |
|---|---|---|---|---|---|---|
| TDOT-1<br><br>(Figure 48) | Mobile Homes | Rental (pads) | Noise questionnaire sent via certified mail. Follow-up reminder letter three weeks later to those that had not responded. | Impacts: 45<br>Benefits: 45<br><br>(90 votes) | 23 (22 residents and the property owner) | Eight residents and the owner opposed (53 votes, 79%) and 14 residents supported (14 votes, 21%). Barrier determined not to be reasonable. |
| TDOT-2<br><br>(Figure 49) | Single-Family and Condos | Primarily Owner-Occupied | Noise questionnaire provided at public meeting and subsequently sent via regular mail. | Impacts: 63<br><br>Benefits: 132<br><br>(195 votes) | 75 owners (58 impacted and benefited; 17 benefited only) | 71 owners supported and 4 opposed. Weighted: 107 support (94%), 7 oppose (6%).<br><br>Barrier determined to be reasonable. |
| TDOT-3<br><br>(Figure 50) | Apartments with shared common areas | Rental | Noise questionnaires provided at public meeting and available in property management office. | Impacts: 73<br><br>Benefits: 100<br><br>(173 votes) | 32 (31 residents and property owner) | Unanimous support. Barrier determined to be reasonable. |
| TDOT-4<br><br>(Figure 51) | Single-Family | Primarily Owner-Occupied | Noise questionnaire provided at public meeting and subsequently sent via regular mail. | Impacts: 31<br><br>Benefits: 48 (79 votes) | 23 owners (20 impacted and benefited; 3 benefited only) | Unanimous support. Barrier determined to be reasonable. |

**Figure 48. Community for which a noise barrier was proposed by TDOT, Project TDOT-1 (image from www.google.com/maps).**

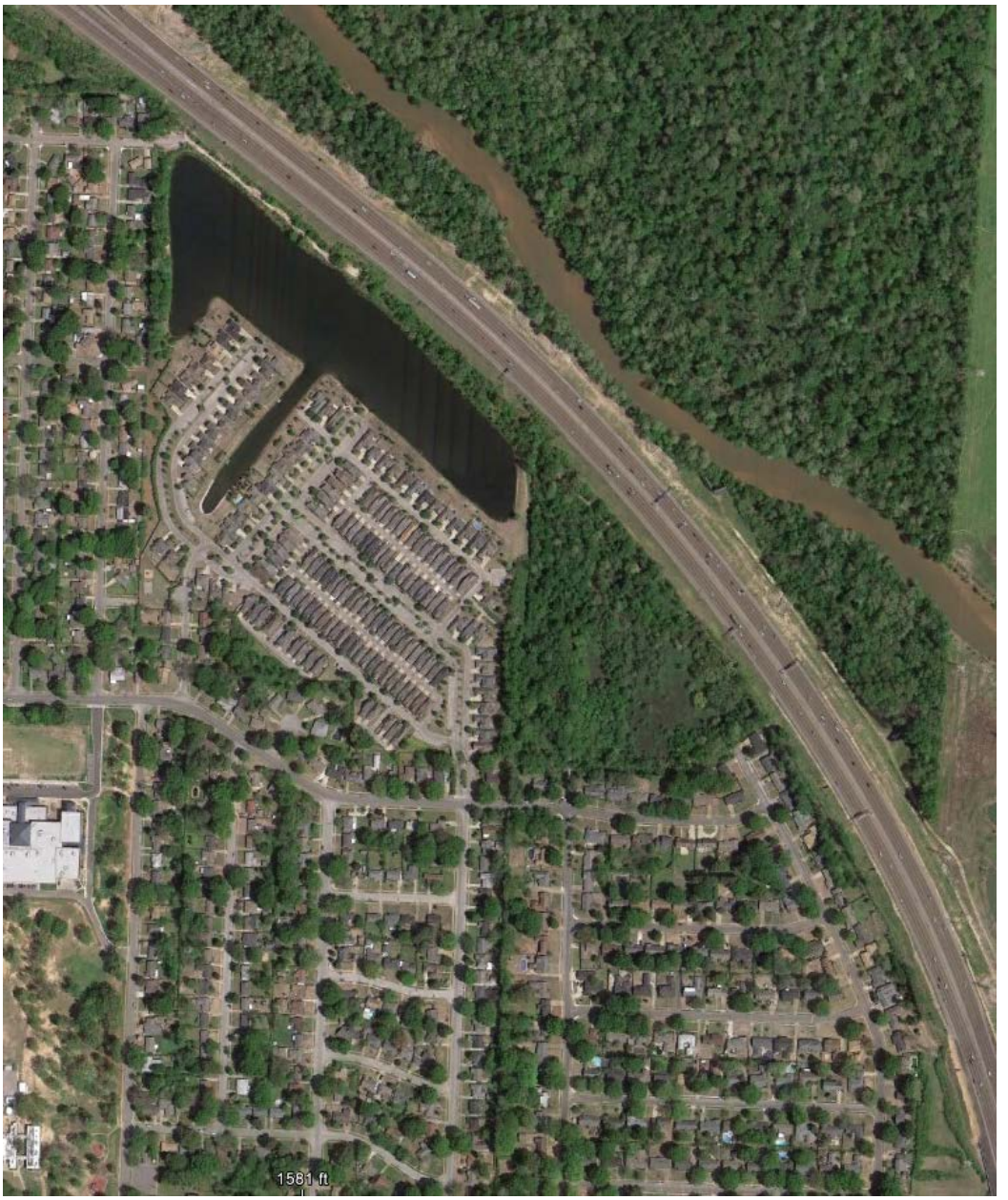



**Figure 49. Community for which a noise barrier was proposed by TDOT, Project TDOT-2 (image from www.google.com/maps).**

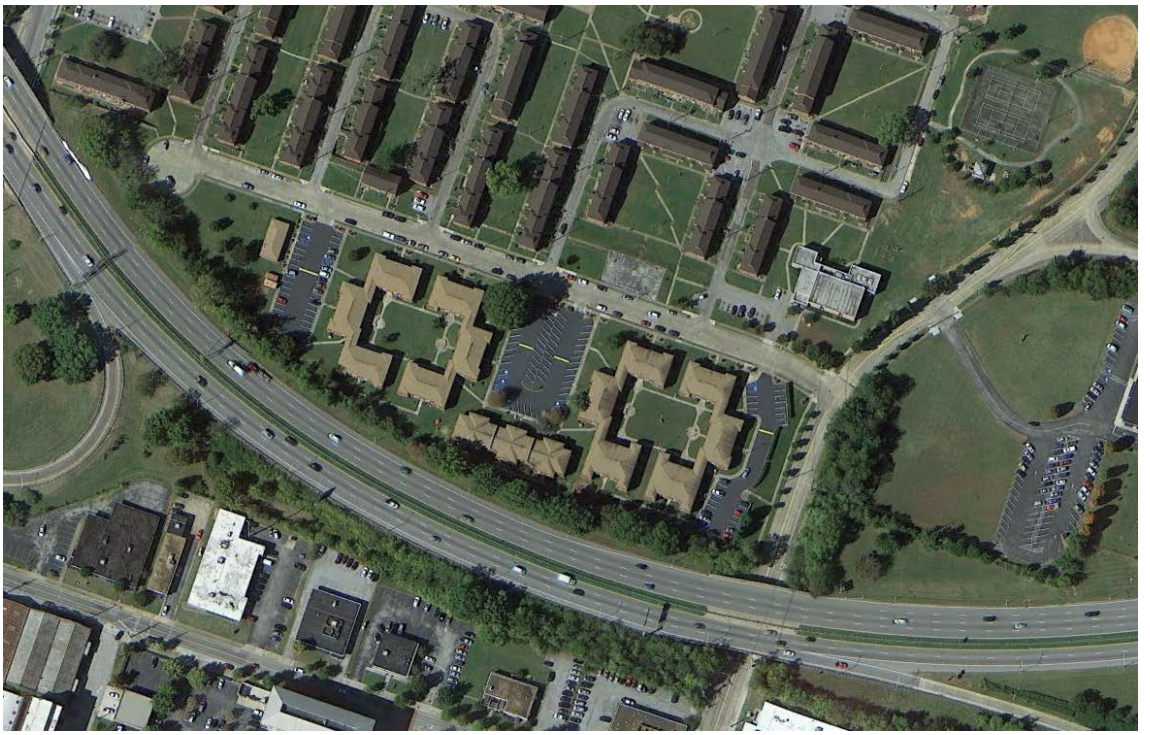


**Figure 50. Community for which a noise barrier was proposed by TDOT, Project TDOT-3 (image from www.google.com/maps).**

**Figure 51. Community for which a noise barrier was proposed by TDOT, Project TDOT-4 (image from www.google.com/maps).**

TDOT has no current plans for revisions to the consideration of viewpoints portion of its policy. However, there is some concern that the application of the 50%/50% split for both owners and

residents of rental communities (apartments and mobile home communities) results in the owner making the decision since they would get one vote for every unit. If a single unit is vacant or a resident does not respond, the owner automatically controls the majority of votes.

A different weighting system for communities where all units are rented (i.e., apartments or mobile home communities) might be considered to ensure that the owner doesn't have complete control of the outcome. An example might be where the property owner of the apartment complex or mobile home park has 40% of the vote for each rental unit and the residents have 60%.

The issue of how to assign votes to commonly used areas of rental communities could also pose a challenge. Units may not have dedicated balconies or patios but instead share common areas (lawns, playgrounds, patios, etc.) with all other units. This situation occurred on Project TDOT-3. However, there was unanimous support (owner and residents) for the barrier, thus it was not an issue.

While TDOT has not encountered this issue, there is also a concern that an apartment owner could dictate the decision for barriers for mixed-use communities that included single-family homes and apartments (as described in the example earlier in this chapter).

TDOT's previous policy did not state specifically how the viewpoints would be considered. It simply said that: "The views and desires of the impacted residents will be considered by TDOT in its final decision. The input of the impacted residents will be received at design public hearings or public noise meetings." The changes made for the new policy, while raising some concerns, have been viewed as a success. By formalizing and standardizing the process, TDOT is achieving community consensus with defendable decisions.

## 4.10 HOW SOME SHA POLICIES ADDRESS NONRESIDENTIAL LAND USES

The focus of this research was on Activity Category B (residential) land uses. However, one-third of the SHA policies contain language on the other Activity Categories in 23 CFR 772. That text is presented below for informational purposes without any analysis.

**Colorado:** "The noise barrier preference survey is normally based on residential areas; however, mitigation for commercial and special-use areas would be based on a survey of the business operators and property management/owners and/or the officials with jurisdiction."

**Florida** weights "offices and businesses (100% owner occupied/80% owner non-occupied)/ 20% renter).

**Illinois:** "The noise abatement evaluation for impacted Activity Category D land use facilities based on the interior NAC should first be evaluated using noise barriers. Noise insulation will only be considered for Activity Category D if noise barriers are determined to be not feasible or not reasonable and there is a noise impact based on an interior evaluation. If the only reason the noise barrier is not considered reasonable is due to the outcome of the solicitation of benefited receptor viewpoints, the consideration of noise insulation should be discussed with the IDOT Noise Specialist and FHWA.

"As an example, if a noise barrier is determined to be feasible, and achieves the reasonableness criteria of the noise reduction design goal and the cost-effective evaluation, the desire of the benefited receptors will be solicited. If the overall viewpoint indicates a desire for the noise

barrier, the noise barrier will be recommended for implementation. However, if the receptor viewpoints indicate an overall lack of desire for the noise barrier, sound insulation will only be considered as a possible noise abatement measure on a case-by-case basis. Noise insulation measures should be discussed with IDOT and FHWA during project development or at coordination meetings."

**Kentucky:** "Properties with special use such as churches, schools, playgrounds etc. shall be weighted in a manner similar to that described under the Cost Effectiveness paragraphs of this section. The voting member shall be identified as the leader or head of the organization such as the school superintendent, park superintendent, etc. For each such property, both a resident and owner ballot shall be solicited, weighted to account for equivalent residences and, if appropriate, further weighted in accordance with the respect to paragraph 5 of this section."

**Maryland:** "If a property, such as a commercial or industrial site, does not have a noise sensitive use, then that property is excluded from the voting."

"Special land use areas (Category C) with identified benefiting noise sensitive use areas are counted based upon the number of equivalent residences (ER) based on an assessment of the linear frontage of the subject activity area divided by 125. The weighting of votes cast involving Category C activities shall follow the same protocols as established and described in the previous section for property owner residents, property owner non-residents, and renter residents."

**Massachusetts:** "While MassDOT will consider commercial and industrial establishments' desire to maintain visibility of their property from the highway, the property owners and renters of these types of land uses are not allocated any votes and, therefore, do not participate in the voting process."

"If noise abatement is proposed for Activity Category C land uses or Activity Category D facilities, then each individual property owner (that is, each owner of the Activity Category C land use or Activity Category D facility) must be in favor of it, otherwise, noise abatement would not be considered as a reasonable noise abatement measure.

**Michigan:** "For Activity Category C areas such as churches, schools, and park/recreational fields, the vote(s) will be accepted only from the governing authority that owns or manages the area in question."

**Minnesota:** "Due to the unique variations of scenarios, the number and placement of non-residential receptor units for designated Activity Categories C and E shall be reviewed by appropriate Mn/DOT staff. See Appendix B [of the Mn/DOT policy, not included in this report] for guidance on assigning receptor units for non-residential land uses such as parks, recreation areas, active sports areas, picnic areas, playgrounds, campgrounds, etc.

**New Jersey:** "In the case of schools, parks, recreation areas and other land uses listed in Category "C" of Table 36, it will be based on the approval of the owners and operators of the facility. In either case if there is no clear consensus, the barrier(s) will not be built."

**North Dakota:** "In some cases, receptors cannot be represented as a residence; therefore the descriptions for different types of frequent human use as described within the FHWA Noise Abatement Criteria are defined with representative locations. Other circumstances with different interpretations for equivalent receptors must be within the spirit of FHWA regulations and intent, and the reasons shall be fully documented in the report. In all cases, the corresponding Activity Category Leq(h), applies. The following equivalent receptors table provides these definitions. [not included in this report]

**Oklahoma:** "For Category C impacted properties, the property owner/official of jurisdiction only will be balloted regarding desire for abatement."

**Rhode Island:** "For special land use sites, the property owner must be in favor of the barrier for it to be considered. This should be determined as early as possible, in order to avoid designing barriers that are not favored."

**South Dakota:** "For Activity Categories A, C, D and E, the views of the property owner or authority having jurisdiction over the property will be considered."

**Texas:** "Generally, residential property owners prefer traffic noise barriers, while commercial property owners prefer to maintain visibility for their business from adjacent roadways. This can cause conflicts in mixed-use developments, as noise barriers may block line of sight to adjacent businesses. When a mutually satisfactory compromise cannot be reached between businesses and residences, noise barriers may be terminated at property line dividing the two areas."

**Utah:** "Nonresidential receptors get 1 vote per owner, except for commercial/industrial businesses, where the owner will have 1 vote per unit and, if applicable, the tenant will have 1 vote for the unit." Also, the following text is in the policy:

- Day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures: The owner will have 1 vote.
- Commercial/industrial businesses: The owner will have 1 vote per unit and, if applicable, the tenant will have 1 vote for the unit.

**Virginia:** Its Table 2 in its Section 12.4.1 includes other Activity Categories in addition to Category B (see Appendix A [of the VDOT policy, not included in this report]). For Categories C, D, and E, receptors that are "Impacted & Benefited" receive more votes than those that are "Not Impacted & Benefited." For Category C receptors, each facility is granted only a single vote.

**Washington State:** Noise sensitive receivers "that can demonstrate a negative effect to their property values from the proposed abatement, but are neither impacted nor benefitted, may be eligible for a maximum 1.0 vote."

## 4.11 VIEWPOINTS FACTORS SENSITIVITY ANALYSIS

To illustrate how differences in policies can yield different results for the same project, the following exercise applies nine different sets of Viewpoints factors to six hypothetical voting "scenarios" for Study Area B (previously described in Section 3.2.6). The NAFRAT spreadsheet tool developed in this research was used to do this testing. This discussion shows one application of the tool for studying the effects of policy changes and sensitivity to voting pattern changes. Figure 52 shows an aerial view of Study Area B with fictitious addresses and roadway names assigned.

The following were assigned as "first-row" receptors: 1, 3, 5, 7, and 9 Oak Drive as well as 26 and 31 Rocky Road. Impacts were predicted to occur for the residences at 1 through 12 Oak Drive along with 26 and 31 Rocky Road. For the purpose of this exercise, the following homes were designated as rental units: 1 through 8 Oak Drive as well as 26 and 31 Rocky Road.

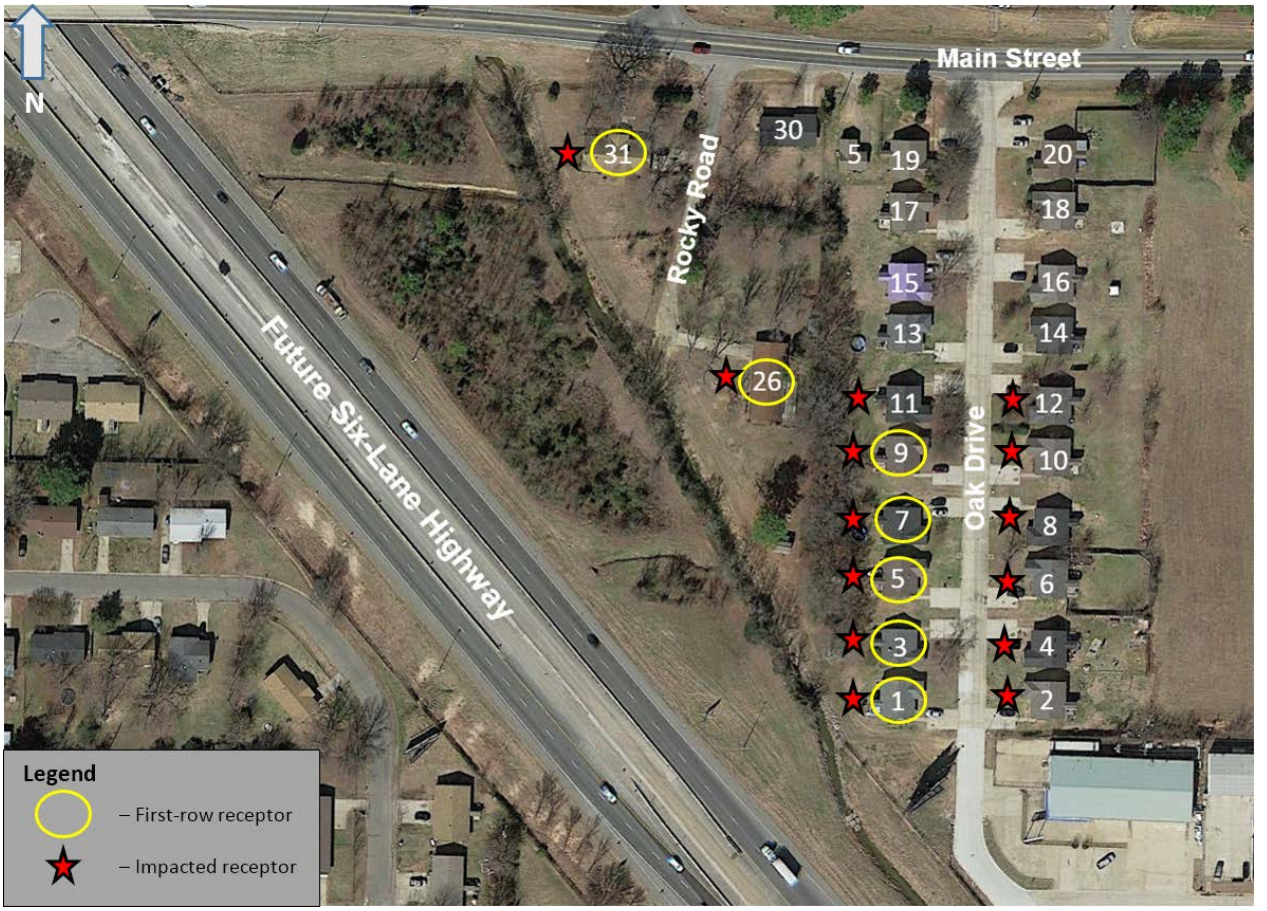



**Figure 52. Study Area B, showing first-row and impacted receptors.**

In this example, the FHWA TNM barrier design attempted to achieve a 7 dB NRDG at 25% of the first-row benefits. The design actually benefited *all* of the receptors by achieving a minimum of 5 dB noise reduction at each residence; consequently, all residents and property owners were eligible to provide a voting response, and the total possible number of responses was 34.

Table 37 shows the nine different sets of Viewpoints factors that were applied. These sets of factors were derived from actual SHA policies. Most of these have a "Votes Needed Criterion" of approximately 50%. Also note that some of these percentages can *equal* the criterion while others must be *greater than* that criterion. At 67%, Set 3 has the highest voting percentage criterion.

All but two of these sets determine voting percentages based on the responses that were actually received, and of those, *only* Set 3 counts the votes of the non-respondents (in this case, as votes in favor of the barrier). Sets 4 and 6 use *all* of the *possible* votes to determine the final voting percentages.

Five of the sets (Sets 2, 3, 6, 7, and 9) consider a barrier to be reasonable if a desired percentage votes in favor of the barrier, while the other four sets consider the barrier to be *not* reasonable if the desired percentage votes *against* the barrier.

**Table 37. Nine Sets of Viewpoints Factors Applied to Hypothetical Voting Scenarios.**

| Set | Votes needed (%) | Vote needed % based on | % is For or Against Barrier | Non-Response is | WEIGHTING FACTORS | | | Additional Weighting Factors | ADDITIONAL WEIGHTING FACTORS (for non-first-row or non-impacted) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Owner-Occupant | Non-Resident Owner | Renter | | Owner-Occupant | Non-Resident Owner | Renter |
| **1** | >50% | Received | Against | | 1 | 0.9 | 0.1 | None | | | |
| **2** | >50% | Received | For | | 2 | 1 | 1 | None | | | |
| **3** | ≥67% | Received | For | For | 5 | 4 | 1 | Row | 3 | 2 | 1 |
| **4** | >50% | All | Against | | 6 | 4 | 2 | Row | 3 | 2 | 1 |
| **5** | >50% | Received | Against | | 4 | 3 | 1 | Row | 2 | 1 | 1 |
| **6** | ≥51% | All | For | | 2 | 1 | 1 | None | | | |
| **7** | ≥50% | Received | For | | 1 | 1 | 1 | None | | | |
| **8** | ≥51% | Received | Against | | 2 | 1 | 1 | Impact Condition | 1 | 0.5 | 0.5 |
| **9** | ≥50% | Received | For | | 5 | 3 | 2 | Impact Condition | 3 | 2 | 1 |

The voting weighting factors for owner-occupant, non-resident owner, and renter vary considerably among the sample sets. For example, Set 1 weighs an owner-occupant's response ten times as much as a renter's, while Set 7 gives equal weighting to each respondent regardless of type of ownership/occupancy.

Sets 1, 2, 6, and 7 use the same weighting factors solely based on occupancy type. However, the other five sample sets have an *additional* set of weighting factors: Sets 3 through 5 have additional weightings based on location (first-row vs. non-first-row), and Sets 8 and 9 provide additional weighting factors based on impact condition (impacted vs. not impacted).

Table 38 shows the six voting scenarios that were tested against the nine sets of viewpoints factors.

In the following six scenarios, different voting results of residents/owners are applied for the same project. In the figure showing the voting for each scenario, a "**Y**", an "**N**", or a "-" is used to illustrate whether the respondent is in favor of the barrier, against the barrier, or did not respond, respectively. A single square is adjacent to each owner-occupied residence and signifies his/her one response. Rectangles containing two squares are adjacent to the rental units, signifying the response from the non-resident owner (on the left-hand side of the rectangle) and the renter (on the right-hand side of the rectangle).

**Table 38. Six Hypothetical Voting Scenarios Applied to the Viewpoints Factor Sets.**

| Scenario | Description |
|---|---|
| 1 | No voting responses are received. |
| 2 | Mixed vote east of Oak Drive; no responses west of Oak Drive. |
| 3 | East of Oak Drive votes "yes"; west of Oak Drive votes "no." |
| 4 | Non-resident owners vote "yes" and their renters vote "no"; no voting responses from other owner-occupants. |
| 5 | Non-resident owners vote "no" and their renters vote "yes"; no voting responses from owner-occupants. |
| 6 | Equally divided response amongst impacted receptors; no voting responses from non-impacted; NOTE: 11 Oak Drive was not designated as first-row receptor, while 9 Oak Drive was designated a first-row receptor. |

Scenario 1

Figure 53 represents a unique baseline scenario where *no* voting responses are received. Even with this non-voting uniformity, the outcomes vary as shown in Table 39:

- Six of the sets would not yield an explicit result (shown as "N/A" within Table 39) since they require at least one vote to be *received* in order to reach a decision.
- Sets 4 and 6 both use a percentage of the total possible vote to reach a conclusion, but yield differing results: Set 4 requires a 50% to be *against* the barrier, while Set 6 require a 51% to be *in favor of* the barrier. Since neither percentage is attained, the barrier would be reasonable for Set 4 and *not* reasonable for Set 6.
- Set 3 is unique in that it counts non-responses as being "in favor" of the barrier. As such, the barrier would be reasonable, receiving a 100% "yes" vote.

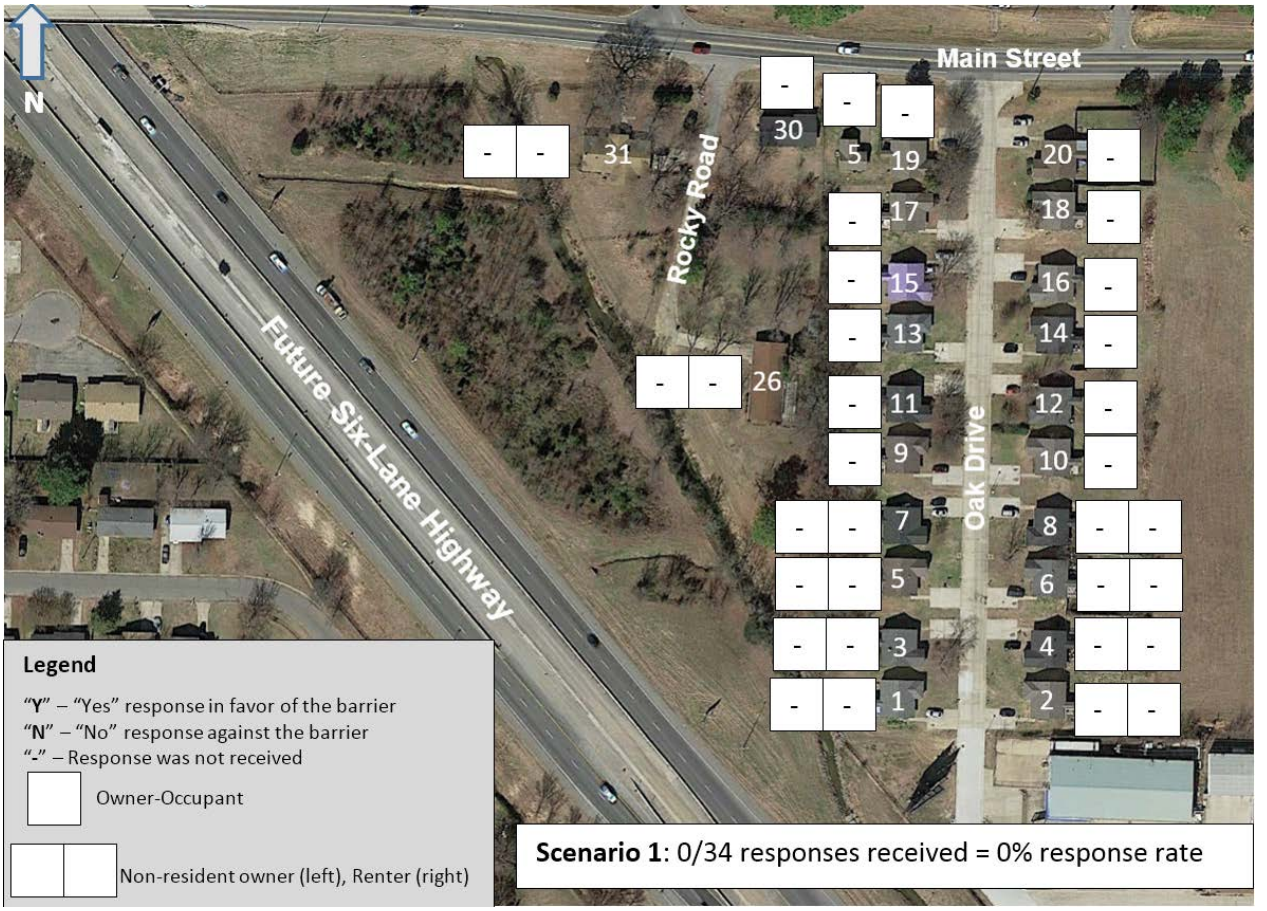



**Figure 53. Study Area B, Voting Scenario 1.**

**Table 39. Study Area B, Results for Voting Scenario 1.**

| **Scenario 1: No voting responses are received.** | | | |
|---|---|---|---|
| **Set** | **% Voting Yes** | **% Voting No** | **Reasonable by Viewpoints?** |
| **1** | N/A | N/A | N/A |
| **2** | N/A | N/A | N/A |
| **3** | 100.00% | 0.00% | **Yes** |
| **4** | 0.00% | 0.00% | **Yes** |
| **5** | N/A | N/A | N/A |
| **6** | 0.00% | 0.00% | **No** |
| **7** | N/A | N/A | N/A |
| **8** | N/A | N/A | N/A |
| **9** | N/A | N/A | N/A |

Scenario 2

Figure 54 illustrates a scenario where no response is received east of Oak Drive and a mixed set of responses are received west of Oak Drive: Most of the impacted, first-row, non-resident owners and their renters vote in favor of the barrier, while the other owner-occupants vote against the barrier. In total, 11 responses were in favor of the barrier, and eight responses were against the barrier. The overall response rate is 56%. The results of this vote are provided in Table 40 and show the following:

- Six of the sets would result in a reasonable barrier, while Sets 1, 2, and 6 would result in a barrier that is not reasonable.
- The percentage of "Yes" votes ranged from approximately 25% (Set 6) to 74% (Set 3). Set 6 uses a percentage of all possible votes, while Set 3 counts non-responses as votes in favor of the barrier.
- Having owner-occupant votes counting 10 times as much as renters, Set 1 results in a barrier that is not reasonable mainly because five of its "yes" votes came from renters.
- Set 3 yields the highest voting percentage of "yes" votes (74%) mainly due to its counting non-responses as being in favor of the barrier. Its higher weighting factors for first-row benefits also a has some significance.
- Set 4 (reasonable) and Set 6 (not reasonable) yield differing results, with neither achieving its required percentages against and for the barrier, respectively.
- The barrier was reasonable for Set 7, which weighs each response equally, regardless of the type of occupancy, impact condition, or location.

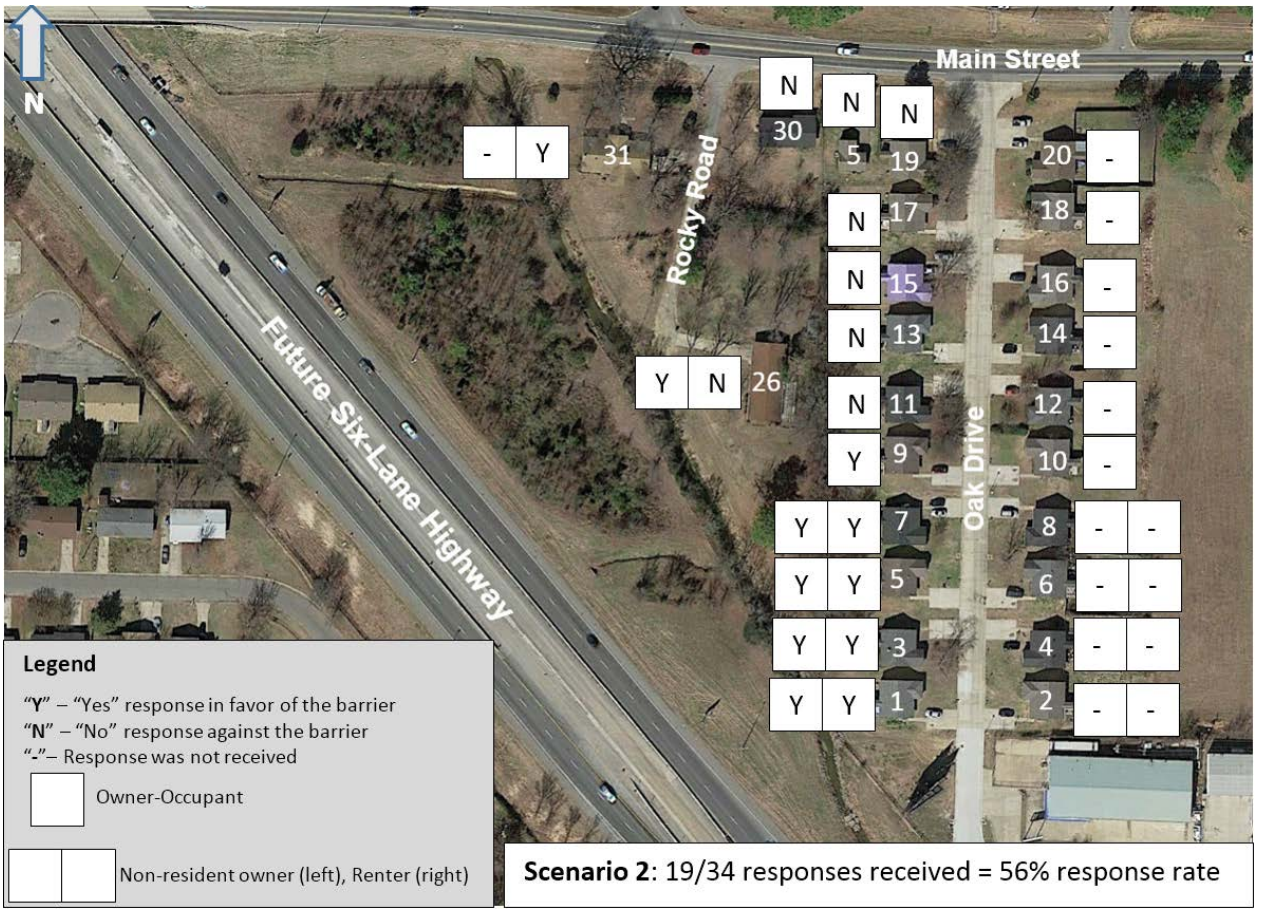



**Figure 54. Study Area B, Voting Scenario 2.**

**Table 40. Study Area B, Results for Voting Scenario 2.**

| **Scenario 2: Mixed vote west of Oak Drive; no responses east of Oak Drive.** | | | |
|---|---|---|---|
| **Set** | **% Voting Yes** | **% Voting No** | **Reasonable by Viewpoints?** |
| **1** | 45.80% | 54.20% | **No** |
| **2** | 44.44% | 55.56% | **No** |
| **3** | 74.42% | 25.58% | **Yes** |
| **4** | 38.71% | 24.73% | **Yes** |
| **5** | 61.54% | 38.46% | **Yes** |
| **6** | 25.00% | 31.25% | **No** |
| **7** | 57.89% | 42.11% | **Yes** |
| **8** | 57.14% | 42.86% | **Yes** |
| **9** | 54.55% | 45.45% | **Yes** |

Scenario 3

Figure 55 illustrates a scenario where everyone west of Oak Drive votes in favor of the barrier, while those east of Oak Drive vote against it. In total, 20 responses were in favor of the barrier, and 14 responses were against the barrier. The overall response rate is 100%. The results discussed below are shown in Table 41:

- Eight out of the nine sets would result in a reasonable barrier.
- The percentage of "Yes" votes ranged from approximately 58% to 68%.
- Only Set 3, which has the highest percentage vote requirement (≥67%), would not result in a barrier that is not reasonable: "Yes" votes comprised only 65% of the votes in this scenario.
- This was the only scenario for which Set 6 resulted in a reasonable barrier.

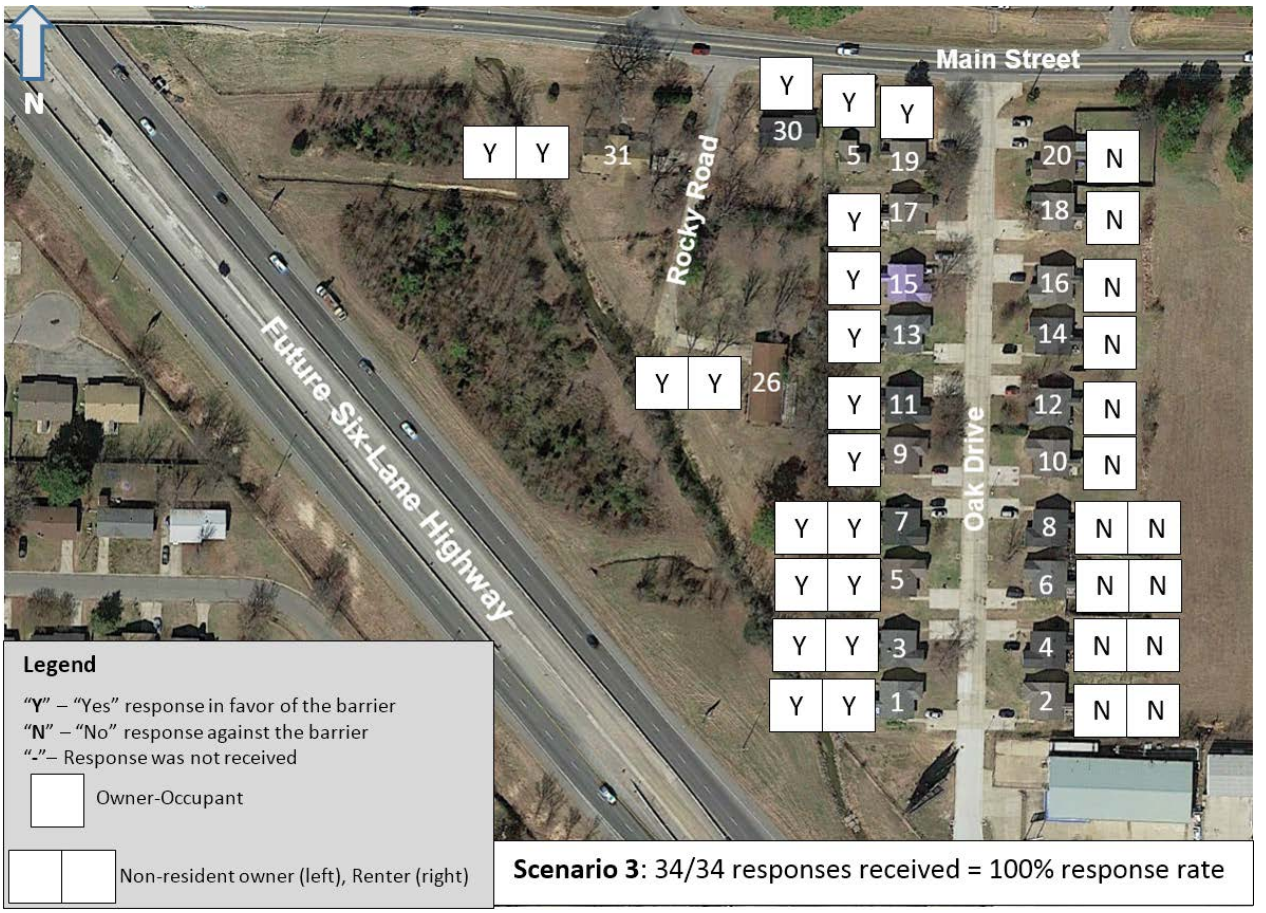



**Figure 55. Study Area B, Voting Scenario 3.**

**Table 41. Study Area B, Results for Voting Scenario 3.**

| **Scenario 3: West of Oak Drive votes "yes"; east of Oak Drive votes "no."** | | | |
|---|---|---|---|
| **Set** | **% Voting Yes** | **% Voting No** | **Reasonable by Viewpoints?** |
| **1** | 58.33% | 41.67% | **Yes** |
| **2** | 58.33% | 41.67% | **Yes** |
| **3** | 65.12% | 34.88% | **No** |
| **4** | 67.74% | 32.26% | **Yes** |
| **5** | 67.74% | 32.26% | **Yes** |
| **6** | 58.33% | 41.67% | **Yes** |
| **7** | 58.82% | 41.18% | **Yes** |
| **8** | 57.89% | 42.11% | **Yes** |
| **9** | 58.00% | 42.00% | **Yes** |

Scenario 4

Figure 56 shows an example of voting responses only from rental units. This scenario depicts all of the non-resident owners voting in favor of the barrier, while their renters vote against it. This scenario assumes that no responses were obtained from owner-occupants. In total, 10 responses were in favor of the barrier, and 10 responses were against the barrier, with an overall response rate of 59%. Table 42 shows the following results:

- Seven out of the nine sets would result in a barrier that is reasonable, generally reflecting more weighting being given to the owners.
- Sets 2 and 6 would result in a barrier that is not reasonable. With its equal weightings for non-resident owners and renters, Set 2 achieves an exactly 50/50 vote, yet fails to be reasonable since the percentage has to be *greater than* 50%. The barrier is not reasonable for Set 6 since it requires 51% of *all* votes to be in favor, and the numerous non-respondents prevent a majority vote.
- Set 1 had the highest percentage of "Yes" votes (90%), and Set 6 had the lowest percentage of "Yes" votes (21%).

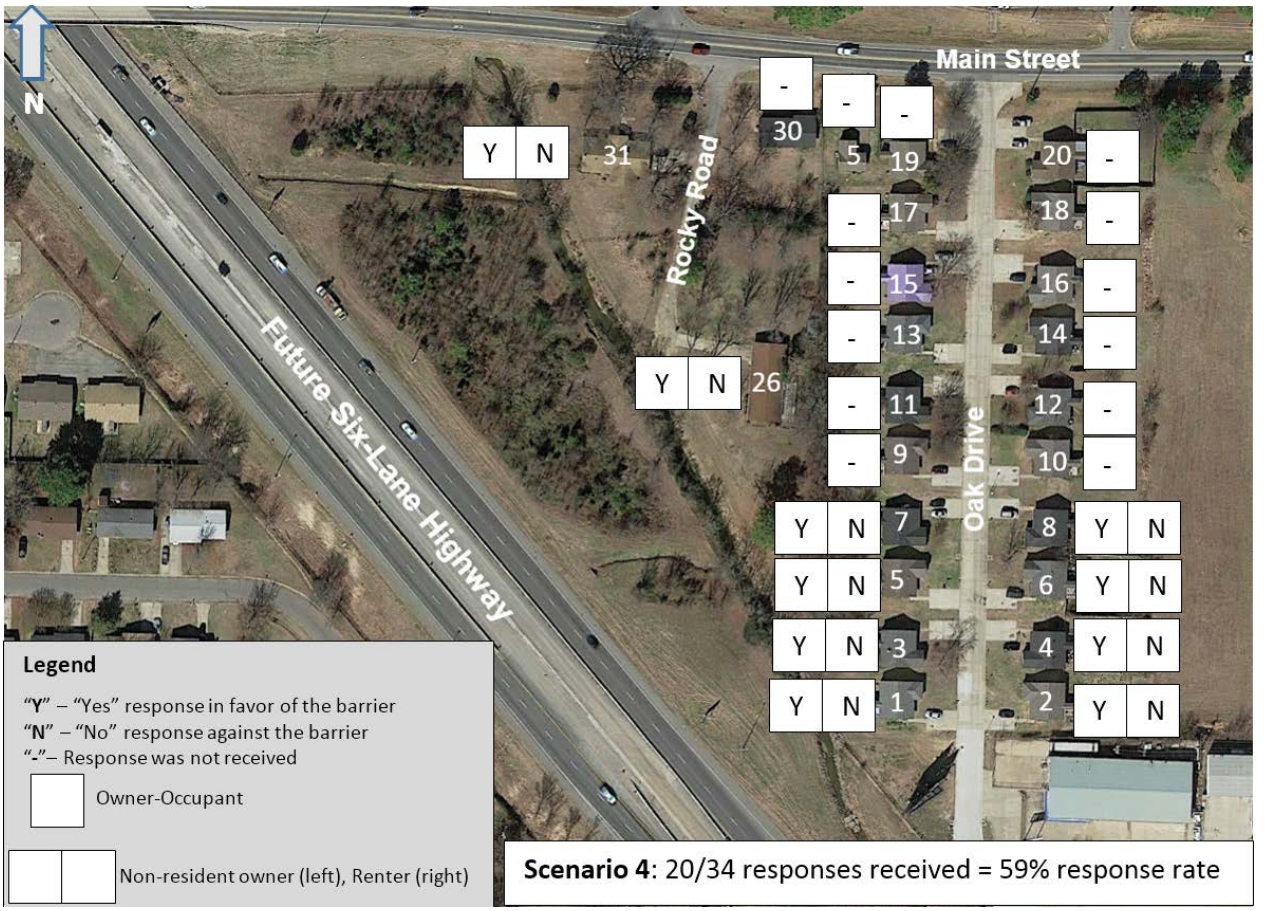



**Figure 56. Study Area B, Voting Scenario 4.**

**Table 42. Study Area B, Results for Voting Scenario 4.**

| **Scenario 4:** | **Non-resident owners vote "yes" and their renters vote "no"; No response from other owner-occupants.** | | |
|---|---|---|---|
| **Set** | **% Voting Yes** | **% Voting No** | **Reasonable by Viewpoints?** |
| **1** | 90.00% | 10.00% | **Yes** |
| **2** | 50.00% | 50.00% | **No** |
| **3** | 88.37% | 11.63% | **Yes** |
| **4** | 34.41% | 17.20% | **Yes** |
| **5** | 68.75% | 31.25% | **Yes** |
| **6** | 20.83% | 20.83% | **No** |
| **7** | 50.00% | 50.00% | **Yes** |
| **8** | 50.00% | 50.00% | **Yes** |
| **9** | 60.00% | 40.00% | **Yes** |

Scenario 5

Similarly to Scenario 4, Figure 57 shows voting responses only from rental units. However, the voting in this scenario is the exact opposite: All of the non-resident owners vote *against* the barrier, while their renters vote *in favor* of it. Again, this scenario assumes that no responses were obtained from owner-occupants. In total, 10 responses were in favor of the barrier, and 10 responses were against the barrier, with an overall response rate of 59%. The results found in Table 43 reveal the following:

- Six out of the nine sets would result in a barrier that is not reasonable, again generally reflecting the higher weighting given to the owners.
- In both opposing scenarios (Scenarios 4 and 5), using Sets 2 and 6 would *still* result in a barrier that is not reasonable. Set 2, with its 50/50 vote in both scenarios, would not result in a barrier that is not reasonable since its percentage has to be *greater than* 50%. Set 6 is not reasonable mainly because of the numerous non-respondents.
- In both opposing scenarios (Scenarios 4 and 5), using Sets 4, 7, and 8 results in a barrier that is reasonable. In both scenarios, Set 4 does not achieve the required percentage of the vote being against the barrier. Sets 7 and 8 both result in a 50/50 split vote, but arrive at the same reasonable conclusion for different reasons: Set 7 barely achieves the "≥50% in favor" criterion, while Set 8 *does not* achieve the "≥51% against" criterion necessary to reject the barrier.

- Only Sets 1, 3, 5, and 9 offer *opposing* conclusions for each of the opposing Scenarios 4 and 5: All four sets result in a barrier that is reasonable for Scenario 4 and not reasonable for Scenario 5.

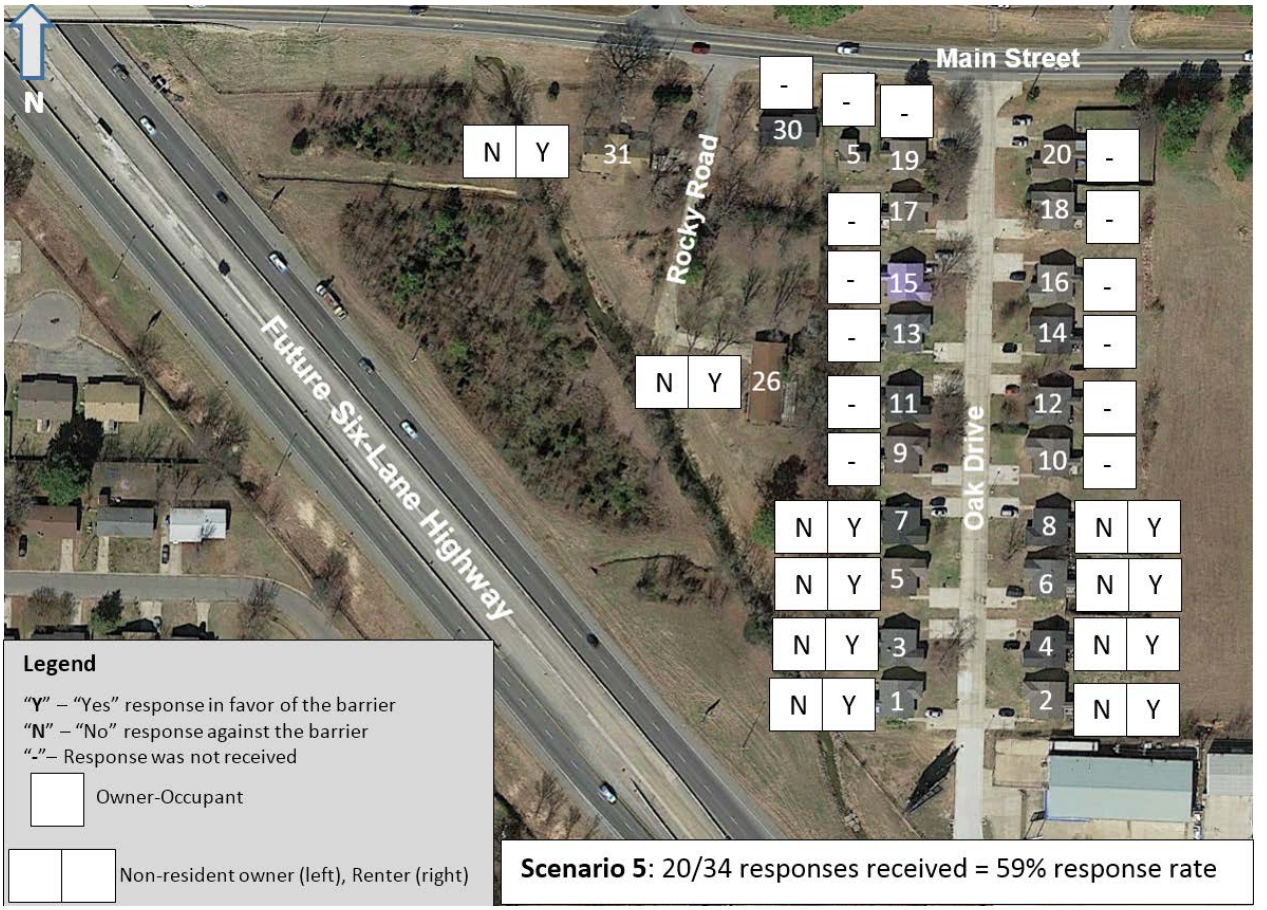



**Figure 57. Study Area B, Voting Scenario 5.**

**Table 43. Study Area B, Results for Voting Scenario 5.**

| **Scenario 5:** | **Non-resident owners vote "no" and their renters vote "yes"; no response from owner-occupants.** | | |
|---|---|---|---|
| **Set** | **% Voting Yes** | **% Voting No** | **Reasonable by Viewpoints?** |
| **1** | 10.00% | 90.00% | **No** |
| **2** | 50.00% | 50.00% | **No** |
| **3** | 62.79% | 37.21% | **No** |
| **4** | 17.20% | 34.41% | **Yes** |
| **5** | 31.25% | 68.75% | **No** |
| **6** | 20.83% | 20.83% | **No** |
| **7** | 50.00% | 50.00% | **Yes** |
| **8** | 50.00% | 50.00% | **Yes** |
| **9** | 40.00% | 60.00% | **No** |

Scenario 6

Figure 58 shows a scenario where the responses are equally-divided among the impacted receptors, and no responses were received from non-impacted receptors. The votes were equally-divided by location *with one exception*: 9 Oak Drive is a first-row receptor, while 11 Oak Drive is not. In total, 12 responses were in favor of the barrier, and 12 responses were against the barrier. The overall response rate is 71%. Table 44 reveals the following:

- Five of the nine sets would result in a reasonable barrier, while four sets would result in a barrier that is not reasonable.
- *Most* of the sets' voting percentages are equally divided between "Yes" and "No" votes.
    - However, Sets 3 through 5 do *not* have equally-divided voting percentages since: 1) they have different weightings based on location, and 2) the votes were not equally-divided by location. Furthermore, Set 3 counts the non-responses as a "Yes" vote.
    - Sets 4 and 6 have equal voting percentages, although each is less than 50% since their calculation is based on all of the possible votes.
- Of the five sets having a 50/50 split vote, only Set 2 would result in a barrier that is not reasonable since its percentage requires *greater than* 50% approval.

- Despite its counting of non-responses as "Yes" votes, Set 3's 67% requirement is not reached, resulting in a barrier that is not reasonable.
- Although not shown, if 11 Oak Drive were simply designated a first-row receptor (using the same responses):
    - Sets 3 and 5 would change its result and the barrier would be reasonable.
    - Using Sets 2 and 4, a barrier would still *not* be reasonable.

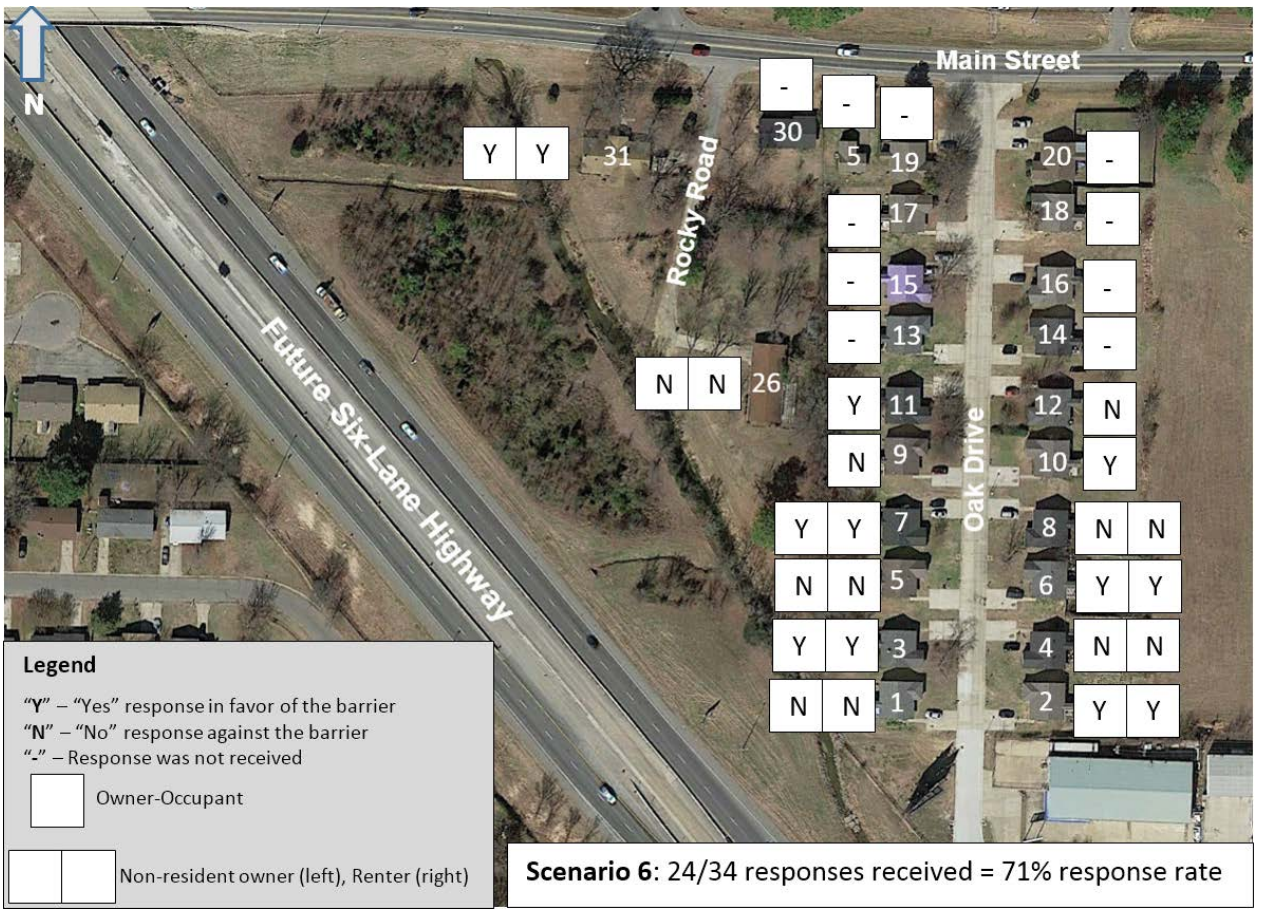



**Figure 58. Study Area B, Voting Scenario 6.**

**Table 44. Study Area B, Results for Voting Scenario 6.**

| **Scenario 6:** | **Equally divided response amongst impacted receptors; no response from non-impacted; NOTE: 11 Oak Drive was not designated as first-row receptor, while 9 Oak Drive was designated a first-row receptor.** | | |
|---|---|---|---|
| **Set** | **% Voting Yes** | **% Voting No** | **Reasonable by Viewpoints?** |
| **1** | 50.00% | 50.00% | **Yes** |
| **2** | 50.00% | 50.00% | **No** |
| **3** | 66.28% | 33.72% | **No** |
| **4** | 32.26% | 35.48% | **Yes** |
| **5** | 47.62% | 52.38% | **No** |
| **6** | 29.17% | 29.17% | **No** |
| **7** | 50.00% | 50.00% | **Yes** |
| **8** | 50.00% | 50.00% | **Yes** |
| **9** | 50.00% | 50.00% | **Yes** |

Summary of Results

Table 45 summarizes the reasonableness decisions for each of the previous six scenarios. As shown in the last column of the table, Set 4's factors - which requires more than 50% of *all possible* votes to be against the barrier – resulted reasonable barrier decisions for *all* of the Scenarios. Similarly, Sets 7, 8, and 9 also had voting results that were typically reasonable.

Sets 1, 3, and 5 resulted in reasonable barriers for half of the - but not all of the same - scenarios. For Set 1, Scenarios 3, 4, and 6 were reasonable; for Set 3, Scenarios 1, 2, and 4 were reasonable; and for Set 5, Scenarios 2, 3, and 4 were reasonable.

Sets 2 and 6 only resulted in a reasonable barrier for only one scenario – Scenario 3. Set 6 had the most prohibiting factors in instances of lower response rates, requiring at least 51% of *all possible* votes to be in favor of the barrier. Set 6 would have had reasonable barriers for Scenarios 4, 5, and 6 – the equally-divided voting Scenarios – if its percentage of votes needed was inclusive of the 50% criterion.

**Table 45. Study Area B, Summary of Voting Results for Six Scenarios.**

| Set | Scenario | | | | | | % of Reasonable Scenarios |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| 1 | N/A | No | Yes | Yes | No | Yes | 50% |
| 2 | N/A | No | Yes | No | No | No | 17% |
| 3 | Yes | Yes | No | Yes | No | No | 50% |
| 4 | Yes | Yes | Yes | Yes | Yes | Yes | 100% |
| 5 | N/A | Yes | Yes | Yes | No | No | 50% |
| 6 | No | No | Yes | No | No | No | 17% |
| 7 | N/A | Yes | Yes | Yes | Yes | Yes | 83% |
| 8 | N/A | Yes | Yes | Yes | Yes | Yes | 83% |
| 9 | N/A | Yes | Yes | Yes | No | Yes | 67% |
| % of Reasonable Sets | 22% | 67% | 89% | 78% | 33% | 56% | |

## 4.12 CHAPTER SUMMARY

There are many ways in which SHAs have chosen to interpret the requirement in 23 CFR 772 for them to develop reasonableness factors that include "consideration of the viewpoints of the property owners and residents of the benefited receptors." There are also widely varying responses to the additional requirement that they "define…the number of receptors that are needed to constitute a decision and explain the basis for this determination."

In fact, there are so many factors that could be considered (and have been used), that it is impossible to say what is "best" and what is right or wrong. Ultimately, the goal is to minimize noise impacts on a project's neighbors if they want the abatement measure that is otherwise determined by the agency to be feasible and reasonable. However, the viewpoint of the owner, especially if not an on-site resident, also merits consideration because an owner has to weigh whether an abatement measure will ultimately help the property attractiveness and value or if it will hurt the marketing and occupancy rate of a property because of its reduced visibility from the road.

On the one extreme, 17 SHAs' policies offer no guidance as to how the SHA will distinguish between the property owners and residents. On the other extreme, some policies (such as those of Massachusetts, Nebraska, Minnesota and Oregon) have very detailed point or vote assignments

based on type of property, its location relative to the highway, the impact status, and the noise reduction provide by the proposed abetment measure.

One key philosophical issue is whether a stated percentage of the benefited stakeholders is needed to *be in favor of* an abatement measure or if a stated percentage is needed to *reject* the abatement measure. Further, the required percentage value itself is critical. While most SHAs require 50% or a simple majority to be in favor or opposed, eight SHAs require a range of 60% to 80% of the votes received to be in favor of the barrier, with three requiring 75% or more. The higher the required percentage in favor, the easier it is for a barrier to not be accepted.

The vote outcome either way is also affected by whether the percentage is figured on *all of the eligible* votes – whether they have been cast or not – or on only the *votes received* by the SHA. If, for example, the outcome is based on the percentage of votes received, a minority of all of the benefited receptors can carry the decision (either for or against) by being the majority of a relatively small sample.

Perhaps in an attempt to avoid that situation, some SHAs specify a *required* voter response rate or the barrier will be considered unreasonable. Others express that response rate as more of a *goal or desired value*. The choice of a response rate as required or desired can affect the abatement decision. Also, the number of repeated efforts to obtain votes from initially nonresponsive benefited property owners has an effect on the response rate and thus the likeliness of a vote in favor or opposed to the barrier. Some SHAs give the eligible voters one chance only – typically by a mailed ballot or at a public meeting, hearing, or at an affected residents' neighborhood meeting

The effect on the outcome becomes even more varied when considering how an SHA weights the vote. In the case of owner-occupant compared to nonresident owner/renter, does each dwelling unit get the same number of votes, one for the owner and one for the resident (who may also be the owner)? Or, does the owner-occupied property only get one vote because the owner and the occupant are the same person(s). Then, for multi-unit apartment complexes, should the property owner get a vote for every unit, which virtually assures that he or she will carry the vote for that complex regardless on the vote of the renters? In such a case, the residents' viewpoints are considered, but not considered to the point where they can affect the outcome.

Some SHAs give more votes or points to the first-row (front-row) dwellings, which will generally be the closest ones to the road. This approach enjoys the logic that those residences most likely will experience the highest sound levels and thus be the most likely to be impacted. Three SHAs simply tie this aspect of the vote weighting to whether or not the analysis shows that the benefited receptor is impacted, which typically means the front-row properties. One SHA assigns points based on the predicted barrier noise reduction – the greater the reduction, the more likely the property has the higher no-barrier sound levels.

A positive take-away from this examination of the viewpoints criterion is finding that in most cases the benefited owners and residents vote in favor of the barrier, often overwhelmingly, regardless of the factors used or points assigned to each stakeholder. However, it is in the cases with split opinions where the choice of the factors and the values assigned to them can result in different voting outcomes and abatement reasonableness decisions. Those SHAs with undefined factors and undefined values for those factors may find difficulty in defending the decisions in a consistent manner.

# CHAPTER 5. SUMMARY AND CONCLUSIONS

This portion of the study, *23 CFR 772 Streamlining, Analysis, and Outreach*, examines the feasibility and reasonableness factors in the FHWA noise regulation in Title 23 CFR Part 772. Those factors are:

- Feasibility
  - Feasibility Noise Reduction: A noise reduction of at least 5 dB that must be achieved for a noise abatement measure to be feasible.
  - Feasibility Quantity: The minimum number or percentage of impacted receptors that must achieve the feasibility noise reduction.
- Reasonableness: NRDG and CE/APBR
  - Benefited Noise Reduction: The minimum noise reduction for a receptor to be counted as benefited by a noise abatement measure.
  - Noise Reduction Design Goal (NRDG): The noise reduction that must be achieved for a noise abatement measure to be reasonable.
  - NRDG Quantity: The minimum number or percentage of benefited receptors that must achieve the NRDG.
  - Cost Effectiveness (CE): The allowable cost per benefited receptor (CPBR) or the allowable barrier area per benefitted receptor (APBR).
- Reasonableness: Viewpoints of the Residents
  - The percentage of benefited receptors needed for a barrier to considered either reasonable or *not* reasonable.
  - How non-respondents are counted.
  - Weighting Factors: multipliers applied to each response to account for type of occupancy/ownership, impact condition, or location.
  - Minimum response rate required.
  - The methods and number of attempts to contact benefited receptors.

As a starting point, the focus was on the range of factors, individually and in combination as contained in the SHA noise policies in use throughout the country.

Then, a sensitivity analysis was performed to test over 1,000 combinations of the factors' values for over 100 cases of one-row, two-row, and three-row communities with receptors spaced at 50, 100, and 200 feet from each other. Two series of reasonableness decision arrays are presented – one considering only the NRDG criterion and one that considers both NRDG and the CE criterion in terms of the APBR.

Finally, the findings were tested on four actual highway project study areas previously evaluated for noise abatement. Seven sets of feasibility factor values were tested, as were 84 combinations of reasonableness criteria values.

## 5.1 FEASIBILITY

All SHAs use 5 dB for the feasibility noise reduction. Feasibility is insensitive to the type of the quantity (number of impacted receptors, percentage of first-row impacted receptors and percentage of all impacted receptors) and its value. Positive decisions on feasibility were returned on all of the values considered, ranging from one impacted receptor to 75% of all impacted receptors.

While not directly studied in this task of this research, one concern of SHAs is the need to analyze abatement for cases of isolated single residences even though such cases will almost always result in a finding of "not reasonable" on the basis of CE. If one establishes in the policy that a noise barrier must achieve a minimum noise reduction of 5 dB at two or more impacted receptors, then any case of an isolated single residence would automatically return a decision of "not feasible" since there are not two or more receptors to be impacted.

In the first phase of this Study the 4 report titled *Evaluation of 23 CFR 772 for Opportunities to Streamline and Establish Programmatic Agreements* addresses this approach as a possible "streamlining" technique. It should be pointed out that such an approach would not work for an SHA that uses the feasibility criterion as a design mechanism instead of a screening mechanism. However, if the NRDG was changed to be based on impacted receptors instead of benefited receptors, as discussed in the next section, then a feasibility criterion based on a number of receptors could be used for isolated receptor screening for those SHAs. The counter-argument for screening out an isolated receptor – and not doing a reasonableness analysis – is that there can be the relatively rare case where a barrier for a receptor very close to the road will be reasonable in terms of both the NRDG and CE criteria

## 5.2 REASONABLENESS: NRDG AND CE/APBR

There are wide ranges of values used by the SHAs for each of the reasonableness factors studied. These ranges lead to very different decisions regarding abatement reasonableness for identical noise study area scenarios.

The decisions are not very sensitive to the NRDG and the NRDG quantity – up to a point. Meeting the NRDG for even a high percentage of first-row benefited receptors or a low-medium percentage of all benefited receptor was generally achievable. However, moving up to a requirement of over 50% of all benefited receptors results in "not reasonable" decisions for many cases that would otherwise be reasonable.

Having the NRDG quantity in terms of *impacted* receptors instead of *benefited* receptors would eliminate the problem of the number of benefited receptors changing in the design process as barrier height and/or length changes. Changing the number of benefited receptors changes the target number needed to meet a criterion based on percentage of all benefited receptors, complicating the design process. As an example of designing for impacted receptors, WSDOT uses its feasibility design goal, which needs to be achieved at greater than 50% of first row receptors, as a design criterion as well as a feasibility determinant.

Also, basing the NRDG decision on percentage of *all* benefited receptors can lead to counter-intuitive – and unfair – decision on reasonableness in cases where there are several rows of benefited receptors. A large number of benefited receptors coupled with a high percentage

requirement for meeting the NRDG can lead to "not reasonable" decisions based on either or both of the NRDG and CE criteria. Yet, if those "extra" rows of houses were removed, then the total number of benefited receptors could not increase once all of the first-row receptors met the benefited noise reduction value, permitting the NRDG and CE criteria to be met. Either restricting the NRDG quantity to be a number or a percentage of *first-row* benefited receptors only or basing the NRDG on the number or percentage of *impacted* receptors will eliminate this problem.

Most SHAs use a CE criterion based on cost (in dollars) per benefited receptor (CPBR) and barrier surface area in square feet per benefited receptor (APBR). Several SHAs use sliding scales for determining the allowable values for either of these parameters. Some others use cost per benefited receptor per decibel of noise reduction.

The CE value in terms of CPBR for a project design is very dependent on the unit cost used by the SHA in developing that criterion and in computing the cost of a proposed abatement measure. As a result, the SHA must be very diligent in ensuring that any change in the unit cost is proportionately reflected in an adjustment to the allowable cost per benefited receptor (CPBR). The APBR approach factors cost out of the equation, as well as the ongoing need to keep unit costs and the CE criterion updated.

For the purposes of this study – in order to assess and characterize differences in the SHA policies – normalization for cost was performed (when abatement unit costs could be obtained from the SHAs) by dividing the CPBR by the unit cost to get an equivalent to the APBR.

The result is a very wide range in APBR criteria values, from the low end of the sliding scale at 250 SF/benefited receptor (for a case of in-fill development along a highway) to 2,750 SF/benefited receptor, a range of over 10:1.

The sensitivity analysis conducted in this research leads to the conclusion that the reasonableness decision is very dependent on the APBR. Values below 1,000 SF/benefited receptor for APBR resulted in "not reasonable" decisions even in many cases of dense receptor spacing. Conversely, high values of APBR resulted in very few "not reasonable" decisions, except when combined with a requirement for a high percentage of benefited receptors needing to meet the NRDG. APBR values no lower than 1,400-1,500 seem appropriate based on the results of this study.

This research has shown that there are a very large number of paths to the same decisions on reasonableness of abatement. There does not appear to a particular set of values for the various factors that is optimum. Instead, if extremes in the factors are avoided, then more uniform decisions from one SHA to the next and from one project to the next can be expected. Changing the feasibility quantity to two impacted receptors would eliminate the need to evaluate abatement unnecessarily in isolated receptor cases. Changing the NRDG quantity to be the percentage of first-row benefited receptors or impacted receptors would improve the design process and eliminate the problems with "not reasonable" decisions in study areas with multiple rows of houses. Not allowing low values for APBR or for normalized CPBR/unit cost will also lead to more consistent abatement decisions.

The charts in this report that display the results of the sensitivity analysis may help SHA analysts and policymakers understand the consequences of changes in the various factors covered by this study. The analysis tools resulting from this work, documented in a separate report, will allow

the SHA analyst to examine the changes in decision-making for an individual project or a group of projects based on change in these factors.

## 5.3 REASONABLENESS: VIEWPOINTS

As with the NRDG and CE/APBR reasonableness criteria, there are multiple factors and a wide range of values used by the SHAs when considering the viewpoints of the benefited property owners and residents. This variability can become more difficult to quantify when attempting to account for omissions, ambiguity, and nuances that exist in many of the policies. The unpredictability in voter response rate, which was demonstrated in Section 4.2 to be a determining factor, further adds to the complexity.

There are two main philosophies by which the barrier is judged to be reasonable:

1. The benefited property owners and residents have to take positive action to demonstrate their desire for the barrier; in this case a certain percentage of the benefited receptors is needed to vote in favor of it.
2. It is presumed that the barrier is desired unless the needed number or percentage of benefited property owners and residents take action to reject it.

Some SHAs base their decisions on the actual number of votes or responses that they receive. Others compute the percentage based on the total number of possible votes. Others are not specific about how the percentage is computed. Different decisions can easily be reached on reasonableness depending on whether the percentage is based on votes received or all possible votes. Regarding non-responses, some SHAs will make multiple contacts with the benefited receptors if they do not receive an initial response; others will not. The approach used can affect the decision that is reached.

Another important decision factor is whether a certain percentage of the benefited receptors are *required* to vote in order for the overall balloting to be considered valid. Some SHAs include such a requirement. In this case, it is more likely that a given barrier will not be built, especially if a strong effort is not made to get the eligible voters to respond.

The factor that has the most variation in values used by the SHAs is if and how the votes of the various stakeholders (typically, owner-occupant, non-resident owner and tenant) are weighted. Seventeen SHAs simply state that the views of the "benefited property owners and residents" will be obtained, without giving any indication of any weighting of the votes assigned to these two cohorts.

Others assign points or extra votes based on the stakeholder. Some policies give one vote to an owner-occupied dwelling, and one vote each to both a non-resident owner and the dwelling's tenant, resulting in a rental property having twice as many votes as an owner-occupied property. Giving rental units more votes over owner-occupied properties is not recommended by this research team.

For multifamily dwellings, most SHAs give the owner a vote for every rental unit in addition to a vote for every tenant; others try to give the tenants more say in the outcome.

Other weighting measures include additional votes or multipliers: 1) if a benefited receptor is in the "first" or "front" row adjacent to the highway; 2) if a benefited receptor is impacted in addition to being benefited; and in one case 3) based on the amount of noise reduction to be provided by the barrier.

Six SHAs were contacted for information on their experiences in implementing their Consideration of Viewpoints criterion. Implementation has been as learning process and several of the SHAs have refined their processes, while generally being satisfied that the voting results are leading to positive decisions on the abatement measure.

While the focus of this research was on residential land uses, it is noted that a third of the SHA policies contain language on the non-residential Activity Categories in 23 CFR 772. Examining these non-residential policy components might be a useful follow-up to this work.

Finally, to illustrate how differences in policies can yield different results for the same project, an exercise was conducted where nine different sets of Viewpoints factors were applied to six hypothetical voting "scenarios" for a relatively simple real-world study area. The results confirmed the overall conclusion of this research that the choice of factors and the values for those factors leads to different decisions.

The bottom line is that the reason for considering the viewpoints of the benefited property owners and residents is to provide abatement where it is wanted and not provide it where it is not wanted. It is concluded that SHAs have taken many different paths toward determining that intent. It is also concluded that these different paths will lead to different decisions on a given project with a given set of voting results simply based on the factors being considered and weights being assigned.

It is further concluded that many of the SHA policies are not specific enough in how votes are assigned, counted (including non-votes), and/or weighted. While ambiguity does offer flexibility, it also opens up the possibility of inconsistent application that could lead to challenges. Follow-up is recommended to see how the non-specific policies are actually applied by the SHAs. Then serious consideration should be given to modifying these policies to make them more specific. This report and the companion NAFRAT (Noise Abatement Feasibility and Reasonableness Analysis Tool) spreadsheet should be helpful in this regard, especially in the areas of weighting and counting votes.

It is also concluded that requiring an abatement measure to be voted *down* is a more difficult test than requiring a vote in favor of it simply because it is unusual to get 100% of the eligible voters to vote. Requiring a vote against an abatement measure is also based on the philosophy that abatement should be provided unless there is sufficient demonstrated opposition to it, a philosophy stated in several of the SHA policies.

Requiring a vote *in favor* to move forward is very much influenced by whether the percentage of positive votes is computed based on all of the possible votes or on only the actual votes received. Further, the decision is affected by how the non-votes are treated.

Should non-votes be considered as being in support of the measure, or are non-votes an indication that the non-voter either does not care or, less likely, is opposed? The preamble to the revised FHWA noise regulation in the July 13, 2010, Federal Register is clear regarding how non-votes should *not* be considered: "It is FHWA's position that the failure to respond to a survey

may demonstrate lack interest in noise abatement, particularly when there is a low response rate from the community, but only explicit 'no' votes should be considered as 'no' votes." This position is restated and expanded in the Frequently Asked Questions (FAQ) on the Noise Regulations and Guidance page of the FHWA web site: "In order to obtain a majority of responses on which to base their decision, highway agencies *should only consider votes that are submitted*, and should not assume a 'no response' is a vote for or against the noise abatement" [italics added].

While none of the SHAs explicitly count a non-vote as a "no" vote, several do count a non-vote as a "yes" vote, which is counter to what is stated in the FAQ. It is concluded that these inconsistencies should be addressed.

As an example, if only four voters respond out of a possible 20 eligible voters and all four are *in favor*, should the sense of the community be taken as only 20% in favor (4/20) or as 100% in favor (4/4, or (4 + 16 non-votes taken as "yes")/20)?

Conversely if only four voters respond out of a possible 20 eligible voters and all four are *opposed* to the measure, should the sense of the community be taken to be as 100% opposed (4/4) or as 80% in favor (16 non-votes taken as "yes" divided by 20 total possible votes)?

In both cases, the reality is likely somewhere in between; yet "in-between" could be in favor *or* opposed. The wide swing in apparent support or opposition in this simple example illustrates the importance of how the viewpoints criterion is specified and then implemented.

Some SHAs attempt to address this ambiguity by having a desired response rate and will make multiple attempts to obtain a vote. The level of effort in trying to obtain a vote from each eligible voter can affect the outcome. Two SHAs gives eligible voters only one opportunity to vote and six give only two opportunities. It is concluded that a single attempt to obtain votes is insufficient if a low response means that abatement will not be provided.

It is further concluded that how the votes are weighted can play a critical role in the decision, such as giving an owner-occupant less votes than a non-resident owner and his or her tenant. Similarly, giving a multi-unit owner the same number of votes as the sum of the benefited tenants virtually assures that the owner's vote will always decide the matter regardless of what the tenants want. This is a philosophical issue of the whether those living in the noisy environment should have a real say in the decision to abate the noise they experience. One SHA addresses this inequity by allowing a positive vote by 75% of the tenants to override an owner's "no" vote.

A multi-unit owner can also have the deciding vote in a noise study area that is a mix of a multi-unit complex and owner-occupied single-family residences. Such an outcome could be viewed as unfair to the single-family owner-occupants who want abatement for both quality of life and value of property. In such a case, it is concluded that there should be some flexibility in the SHA policies to allow the noise study area to be broken into single-family and multi-unit areas that can be separately analyzed, even if it means that a barrier for the single-family area may have to be extended partially in front to the multi-family units for feasibility and reasonableness.

Finally, it is concluded that the use of weighting factors – such as giving more points to those benefited receptors who are impacted, are in the front row closest to the road, or will receive a large noise reduction - is an appropriate way to put the decision more into the hands of those most affected by the noise.

# Appendix A

# STATE HIGHWAY AGENCY (SHA)

# PUBLIC INVOLVEMENT

# Voting Procedure and Viewpoints

**STATE HIGHWAY AGENCY: Alabama Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011 Effective Date

VIEWPOINT LANGUAGE WITHIN POLICY:

Incorporating Viewpoints of Those Benefited. At a minimum, the viewpoints of the benefited property owners and residents (as to whether they support or oppose the measure) will be a consideration by ALDOT in determining the reasonableness of noise abatement measures. When ALDOT has determined the barrier is otherwise reasonable for the project based on the other requirements of reasonableness, ALDOT will meet the benefited property owners and residents and present information as available for the design of the proposed barrier. ALDOT will then solicit the views and opinions of the benefited property owners and residents. A 70% majority will constitute a majority viewpoint (as to whether an option is desired or not).

**STATE HIGHWAY AGENCY: Alaska Department of Transportation & Public Facilities**

DATE OF NOISE POLICY: April, 2011 Submittal to FHWA

VIEWPOINT LANGUAGE WITHIN POLICY:

Views of the property owners and residents (federal mandatory criterion) that benefit from noise abatement measures. To determine the desires of benefited households and property owners, DOT&PF will contact all benefited households and property owners to determine the level of interest for a noise abatement measure. This contact could be in the form of a mail out questionnaire, phone call survey, or door to door interviews whichever is most practical and cost effective for the size of the proposed project. At least 60 percent of households and property owners surveyed* must want the noise abatement measure. The term "household" is used instead of residents because a single dwelling unit could have more or less inhabitants than another. The idea is not to give a dwelling unit with multiple inhabitants more consideration than one with fewer inhabitants. Also, property owners are also included as the dwelling units might be rentals. The property owner should have a say in whether noise abatement is provided to their property.

LANGUAGE IN FEASIBILITY/REASONABLENESS WORKSHEET
Views of Benefited Residents and Property Owners. Do at least 60 percent of the impacted residents and property owners surveyed desire noise abatement?

*Clarifying email from T. Horne, 9-8-15: "DOT&PF considers the policy to require 60 percent of respondents."

**STATE HIGHWAY AGENCY: Arizona Department of Transportation**

DATE OF NOISE POLICY: ADOT NAP Rev 2011-07-13

VIEWPOINT LANGUAGE WITHIN POLICY:

Viewpoints or Preferences of Property Owners and Residents. The preferences of the property owners and residents of the benefited receptors of a noise barrier will be taken into account when determining whether the barrier is considered reasonable. Noise barriers that are otherwise feasible and reasonable will automatically be considered to be desired unless the public involvement aspect of the NEPA process indicates that a substantial portion of benefited receptors are opposed to the barriers. In that case, ADOT will make a good faith effort to determine the preferences of the property owners and/or legal occupants of each benefited receptor location through a survey process. If less than a 50% response rate of property owner and residents is achieved and a substantial portion of the received responses are opposed to the recommended abatement measures, then further outreach will be attempted through the use of public meetings until either a 50% response rate is achieved or it becomes apparent that such a level of response is not possible due to situational concerns. ADOT will make a decision as to the reasonableness of the recommended mitigation based on the results of this process.

**STATE HIGHWAY AGENCY: Arkansas Highway and Transportation Department**

DATE OF NOISE POLICY: Date of Issuance: April 15, 2011; Effective Date: June 5, 2013

VIEWPOINT LANGUAGE WITHIN POLICY:

Three reasonableness factors must all be met, at a minimum, for a noise abatement measure to be considered reasonable.

1) Viewpoints of the property owners and residents of the benefited receptors, where the majority of benefited residents want a noise abatement measure. The input of the benefited property owners and residents will generally be received at planning, NEPA or design public hearings or public meetings. Input received at these hearings or meetings may be supplemented, as necessary, with formal survey methods on a case-by-case basis. At least 51% of the benefited property owners and residents must support the construction of the noise barrier in making a determination as to whether the community desires a noise barrier.

[Follow-up with B. Price of AHTD, 4/17/2015:

- The 51% is of all eligible voters, not just those who vote.
- Weighting for single family residence rental properties: Equal weighting, i.e., ½ pt for owner, ½ for occupant/renter.
- Weighting for multi-family structures: Each dwelling unit in a multi-family residence receives a vote, with ½ owner, ½ occupant/renter.]

**STATE HIGHWAY AGENCY: California Department of Transportation**

DATE OF NOISE POLICY: May 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

Viewpoints of Benefited Receptors. To evaluate the viewpoints of benefited receptors, letters are sent by registered mail to all property owners and non-owner occupants of benefited receptors asking them to provide a position either in favor of or in opposition to the proposed noise abatement by a specified deadline.

If more than 50% of the votes from responding benefited receptors oppose the abatement, the abatement will not be considered reasonable. Votes from property owners and non-owner occupants of benefited receptors will be surveyed. For owner-occupied dwelling units, the property owner gets one vote. For non-owner-occupied dwelling units, the renter gets 10% of one vote and the owner gets 90% of one vote.

Polling of benefited receptors should be completed prior to circulation of the draft environmental document. The results of the polling and the final reasonableness determination must be included in the CE, FONSI, or ROD.

Reasonableness. The noise abatement recommendation is subject to revision after public and environmental review of the project. As part of this, the viewpoints of benefited receptors must be evaluated and documented. To do this, letters are sent via registered mail to all property owners and non-owner occupants of benefited receptors asking them to provide a position either in favor of or in opposition to the proposed noise abatement by a specified deadline.

If more than 50% of the votes from responding benefited receptors oppose the abatement, the abatement will not be considered reasonable. Votes from property owners and non-owner occupants of benefited receptors will be surveyed. For owner-occupied dwelling units, the property owner gets one vote. For non-owner-occupied dwelling units, the renter gets 10% of one vote and the owner gets 90% of one vote.

For noise abatement to be located on private property, 100% of owners of property upon which the abatement is to be placed must support the proposed abatement. In the case of proposed noise abatement on private property, no response from a property owner, after a reasonable number of attempts, is considered a *no* vote.

The results of the polling and the final reasonableness determination must be included in the CE.

**STATE HIGHWAY AGENCY: Colorado Department of Transportation**

DATE OF NOISE POLICY: January 15, 2015

VIEWPOINT LANGUAGE WITHIN POLICY:

**Benefited Receptor Preference Survey**

Once final design of the project and the re-evaluated abatement analyses are completed, a public involvement process shall be utilized to solicit the views of current residential occupants' and property owners' on whether to build noise abatement or not. This final design public involvement process shall be devised by CDOT Construction or Project Management and the CDOT noise specialist responsible for the re-evaluation analyses of the final abatement design. At a minimum, one attempt to contact each identified benefited receptor site (both property owner and resident, see Appendix A [of the CDOT policy, not included in this report]) must be made and documented – utilizing the US Postal Service or commercial mailing services, door-to-door contact, or other defensible, targeted means. Written and spoken communications will be in English and in the dominant secondary language of the community, if applicable. The benefited receptor preference survey process must be thoroughly documented and attached to the Form 1209 for that abatement measure. A vote of equal standing will be provided one resident and one owner per benefited dwelling unit as described above.

The noise barrier preference survey is normally based on residential areas; however, mitigation for commercial and special-use areas would be based on a survey of the business operators and property management/owners and/or the officials with jurisdiction.

Whichever preference option (for or against the abatement action) that receives the most votes will become the stated preference of the affected persons and determine whether or not the abatement measure is built. An example of a preference survey is included in Appendix D [of the CDOT policy, not included in this report]. If the preference survey results in a tie vote, it is understood that no majority has been reached, and therefore, no abatement action would be built.

**Survey Results Example**

As an example of the voting process, suppose an Environmental Assessment recommends sound walls at 2 different locations within the project area. The noise specialist identified 60 dwelling units benefited from Noise Wall #1 and 25 benefited dwelling units from Noise Wall #2. A Benefited Receptor Preference Survey was conducted after the final design noise analytical evaluation was completed. The survey resulted in 35 votes (25 affirmative, 10 negative) from benefited owners/residents received for Noise Wall #1 and only 5 affirmative and 11 negative votes received for Noise Wall #2.

The decisions would be as follows:

- Noise Wall #1 received 35 total responses- a total of 25 of 35 or 71% affirmative votes and 10 of 35 or 29% negative votes from benefited owners and residents. The decision would be to construct Noise Wall #1 as a part of the project.
- Noise Wall #2 received 16 total responses - a total of 5 of 16 or 31% affirmative votes and 11 of 16 or 69% negative votes from benefited owners and residents. The resulting decision is to not construct Noise Wall #2. This wall does not meet the required reasonableness criterion because of this vote and would not be built.

These decisions would be documented and attached to the appropriate CDOT Form 1209 in the project file and NEPA administrative archive.

**STATE HIGHWAY AGENCY: Connecticut Department of Transportation**

DATE OF NOISE POLICY: July 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

Viewpoints of the benefited property owners and residents shall be solicited. For the abatement to be considered, two-thirds of the solicited viewpoints must be in favor of the noise abatement.

**STATE HIGHWAY AGENCY: Delaware Department of Transportation**

DATE OF NOISE POLICY: July 5, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

1. Viewpoints of Property Owners and Residents

One of the factors that must be considered is the viewpoints of the property owners and residents that are either impacted or non-impacted "benefited receptors" (those receptors that will receive a reduction of at least 9 dB(A)) of the proposed noise barrier. The viewpoints of the "benefitted receptors" are quite important as many may find the placement of the noise barrier as being more detrimental to their property than the noise impacts themselves. In soliciting receptor opinions regarding the placement of noise barriers, DelDOT will attempt to describe the nature and extent of the barrier, in order that the individuals may best visualize how the barrier will appear to them, once constructed. Depending on the individual circumstance, DelDOT may also include an option for consideration of a vegetation/privacy fence placement, as opposed to a noise barrier.

In soliciting the viewpoints of identified "benefitted receptors", DelDOT will attempt to contact the owners (and residents, if separate) of each of the properties by mail. The mail package will contain information to allow the owner/resident to be able to develop an informed viewpoint regarding the potential construction of the noise barrier. The mail package will also request a response regarding the desirability of having the noise barrier constructed. A similar package will be delivered to any appropriate local government official and to any appropriate community group. The package will provide contact information for DelDOT representatives who can discuss noise barrier issues.

In order to assure that the viewpoints of the "benefitted receptors" are considered, DelDOT will compute the total number of owners and residents in the "benefitted receptor" category, and will not make a decision on reasonableness unless at least 60 (sixty) percent of the total have replied in some manner. In considering the receptor viewpoint, only an explicit "no" to noise barrier construction will be considered as opposing the construction of a noise barrier. If more than 50 (fifty) percent of the total number of responding "benefitting receptors" oppose the construction of the noise barrier, then construction of the barrier will not be considered reasonable. If a reply rate of 60 (sixty) percent is not initially achieved, an additional round of public involvement will be implemented.

The views and opinions of groups and individuals other than "benefitted receptors" will be documented as to opinions on noise barrier construction; however, such opinions will not have an effect on the determination of reasonableness within this policy.

**STATE HIGHWAY AGENCY: District of Columbia Department of Transportation**

DATE OF NOISE POLICY: April 5, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

**Viewpoints of the benefited receptors:**

The FHWA highway traffic noise regulation requires DDOT to consider the viewpoints of the benefited receptors in determining the reasonableness of noise abatement. A final survey and determination shall occur after the approved final design noise analysis; however, comments will be considered throughout the entire design process. DDOT shall solicit the viewpoints of all benefited receptors through certified mailings and obtain enough responses to document a decision as to whether or not there is a desire for the proposed noise abatement measure. Fifty percent (50%) or more of the respondents shall be required to favor the noise abatement measure in determining reasonableness.

**STATE HIGHWAY AGENCY: Florida Department of Transportation**

DATE OF NOISE POLICY: April 5, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

**17-6.2.1 Viewpoint of the Benefited Receptors**

Prior to the PD&E phase, the public will have an opportunity to raise concerns about traffic noise impacts through the Efficient Transportation Decision-Making (ETDM) process. During the PD&E phase of the project, the viewpoints of potentially benefited receptors will be gathered during workshops, via the website established for the project (if one is used), and the Public Hearing for the project. A more detailed process to obtain the viewpoint of the benefited receptors is invoked during the design phase of the project. Each F.

During the design phase of the project, the FDOT will use either a noise abatement workshop and/or a public survey to determine the wishes of the benefited receptors. The survey effort may include a mailing of information related to the abatement measure along with a survey form to be signed and returned to the FDOT. It is the desire of the FDOT to obtain a response for or against the noise barrier from a majority of the benefited receptors (owners and residents) that respond to the survey. Multiple techniques to solicit input may be used, including multiple mailings, door-to-door follow up, and even telephone solicitation (as needed) to provide adequate information to allow the FDOT to make an informed decision on whether abatement is desired or not.* If a majority of the benefited residents and property owners responding to the survey do not favor construction of a noise barrier, the FDOT will not provide the noise barrier. It is important to note that the viewpoints of the property owner will be considered as having the greatest weight in the decision as to whether the FDOT will provide noise abatement or not. While the viewpoint of the non-owner resident will be considered, their viewpoint will carry less weight, consistent with the formula shown in below:

| Property Type | Owner Occupied Weighting Factor | Owner (non-occupied Weighting Factor | Renter Occupied Weighting Factor |
|---|---|---|---|
| Single Family | 100% | 90% | 10% |
| Multi-family (duplex, apartments) | 100% | 90% | 10% |
| Condominium | 100% | 90% | 10% |
| Mobile Home Park (single owner) | NA | 80% | 20% |
| Offices, Businesses | 100% | 80% | 20% |

For example, if a renter of a single family home wishes to have noise abatement but the owner does not, the opinion of the home owner would prevail. If the owner of the home did not respond for or against the

noise abatement measure, then the renter's opinion would be used to be the equivalent of 10% of the vote of a home owner. This means that 10 renters in favor of the noise abatement would equal the vote of 1 owner occupied home.

### 17-7.2 Community Coordination in Final Design

When noise abatement is anticipated in the final design phase, community coordination will include a survey of benefited property owners and residents to determine their viewpoints regarding abatement. This can be done using any number or combination of techniques (e.g., door-to-door contact, telephone polls, mailed survey form, public workshop, etc.).

The viewpoint of the impacted and benefited receptors related to abatement should be analyzed in the decision-making process. Discussions at public meetings may also include a presentation of material options, physical dimensions, obtainable levels of reduction, and cost factors so the public can aid the FDOT in making a reasonable decision.

In the event that some benefited property owners or residents' desire noise abatement and others do not, further assessment may be necessary in order to determine what impact, if any, this will have on the feasibility and reasonable cost issues as well as the social consequences. Consultation with FHWA (if appropriate) is recommended. When noise abatement measures are being developed during final design, such measures will not be approved without documentation (letters in the file, public hearing transcripts, survey results, etc.) that the benefited property owners or residents have been provided the opportunity to provide input into the final design. The benefited property owners or residents consist of those individuals directly affected by the project-related noise as well the abatement measure.

When noise barriers are proposed, primary emphasis is to be given to the input of the benefited property owners immediately adjacent to the noise barrier(s). If the majority of those responding to the survey do not favor abatement, the FDOT will not provide the proposed abatement measure.

* Clarified in email from M. Berrios, 4-20-15: FDOT does not have any guidance on what size of a response rate is needed from all benefited receptors for the survey to be valid. FDOT usually keeps trying until it seems that it is getting as many responses as possible.

**STATE HIGHWAY AGENCY: Georgia Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

*1. Property Owners and Residents:* The decision to provide abatement will be made in collaboration with the property owner and tenants of a benefited receptor. The outreach strategy will be customized for maximum effectiveness on each project. The minimum outreach method shall be a certified letter survey provided to both property owners and tenants whose facility or home is identified as a benefited receptor. A noise barrier will only be constructed if at a minimum 50% plus one of the respondents vote in favor of noise abatement. Both property owners and dwellers get a vote and their vote must be returned within 30 days to receive consideration. Property owners will receive one vote per unit owned and an additional vote if they reside in the unit, and tenants will receive one vote for the benefited unit they occupy. For some projects, individual meetings, community meetings or other outreach efforts may also be utilized to determine a majority consensus.

The final noise abatement measures cannot be determined until the design plans have sufficiently progressed to a point where the barrier analysis can be conducted; after which, the outreach above can be completed. GDOT will strive for a decision on abatement as soon as possible after this information is available, but no later than the final environmental document that is required for construction authorization.

**STATE HIGHWAY AGENCY: Hawaii Department of Transportation**

DATE OF NOISE POLICY: April 25, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

(i) Consideration of the viewpoints of the property owners and residents of the benefited receptors. The HDOT shall solicit the viewpoints of all of the benefited receptors and obtain enough responses to document a decision on either desiring or not desiring the noise abatement measure. A noise abatement measure shall be constructed or implemented only if at least two thirds of the land owners and residents of impacted receptor units approve of the measure. This percentage will be determined from the responses received from a mail-back or telephone questionnaire survey. The survey results to determine approval or disapproval shall be deemed reliable if at least one quarter of the deployed surveys were completed.

**STATE HIGHWAY AGENCY: Idaho Department of Transportation**

DATE OF NOISE POLICY: May 4, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

- Viewpoints of benefited property owners and residents of the benefited receptors (i.e., 50% +1 of benefited property owners or 75% of benefited renters must approve a noise barrier). [Example, if the owner of a Mobile Home Court does not want a noise wall, then benefited renters would be polled to determine their view. If 75% or more wanted the wall, the wall would be considered desirable. Desirability may be determined at a public hearing, by petition, by mailed questionnaires/surveys, or as otherwise determined acceptable by FHWA and ITD.

Clarification from M. Fikel, 8/25/15:

Re single family residential: "We poll all (renters and owners) and are looking for a majority vote…The non-resident owner gets one vote and the renter gets 1 vote. An owner-occupant gets only 1 vote."

For multi-unit land uses like apartments or mobile home parks, "the renters have to show 75 percent majority, otherwise it defaults to the owner's vote." "We need to receive a 75% response (yes or no) of all the benefited receptors (not just 75 percent of the number of responses we receive). However…it's not so easy to get a response from tenants (for whatever reason)...If we have 100 units and the tenants are at 70 no's then, by default the decision lies with the landowner. In the past, we've conducted meetings for tenants, send out post cards (a follow-up mailing for those that have not responded), and if necessary follow-up phone calls. We show that a good-faith effort is being made to elicit comments from tenants." "Some renters are not so mobile. For example, mobile home parks. These residents are not truly mobile, long term, and own their unit. We were trying to give all an equal opportunity but recognizing the owner vote carries more weight."

**STATE HIGHWAY AGENCY: Illinois Department of Transportation**

DATE OF NOISE POLICY: Assumed to be July 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

*C. Benefited Receptor Viewpoints.* The third component of reasonableness is obtaining the viewpoints of **benefited** receptors.

The viewpoints of benefited receptors shall be solicited for noise abatement measures (e.g., noise barriers) determined to be feasible, cost-effective and achieving the noise reduction design goal. The viewpoints of benefited receptors shall be solicited to determine the desire for implementation of the noise abatement measure. A benefited receptor includes property owners (including non-residential properties) and renters/leasers residing on the benefited property.

The goal is to obtain responses from at least one-third of the benefited receptors for each noise abatement measure (i.e., for each noise barrier being considered). If responses from one-third of the benefited receptors are not received after the first attempt, a second attempt shall be made. The desire for the proposed noise abatement can be determined after viewpoints from at least one-third of the responses have been received or after two attempts have been made to obtain the responses.

Once the responses have been collected, the viewpoints must be tallied. In order for a proposed noise abatement measure to be implemented, greater than 50% of the benefited receptors responding must be in favor of the proposed abatement measures. Viewpoints will be tallied for each individual abatement measure (i.e. for each noise barrier being considered). A response from first row benefited receptors (receptors sharing a property line with the highway right-of-way) will be counted and weighted as two responses. Benefited receptors not in the first row will count as one vote. In the case of rental properties, the tenant shall count as one response and the owner shall count as one response per benefited unit.* See the *IDOT Highway Traffic Noise Assessment Manual* for further guidance and an example viewpoint evaluation. [See below from *Manual*.]

The proposed abatement measures will be presented as likely to be implemented (provided they are deemed feasible and reasonable for noise reduction and cost-effectiveness) as part of the public involvement process. Below is a letter template that Districts may use as the first attempt to obtain the viewpoints from benefited receptors. [See the Policy for the template letter.]

During the NEPA environmental studies, likely abatement measures should be discussed at public meetings and hearings. Information to be presented shall include the preliminary form of barrier, location, height, length, cost, and predicted noise reduction. Published notices advertising these meetings will identify that noise abatement measures are being investigated for potential installation and that the viewpoints of benefited receptors will be solicited as a part of the proposed project. Further details concerning the proposed noise barrier may be made available for review and comment during final design.

ADDITIONAL VIEWPOINT LANGUAGE WITHIN IDOT'S HIGHWAY TRAFFIC NOISE ASSESSMENT MANUAL (JUNE 2011):

The following is an example of the process. A more detailed example is provided in Appendix C [of the IDOT manual, not included in this report]

> As an example, there were 10 benefited receptors used in the cost-effective evaluation example. The goal would be to obtain responses from at least 4 benefited receptors (10 x 33% = 3.3

rounded to 4). Of those four (4) responses received, three (3) of the responses would need to be in favor of the proposed noise abatement measure in order for it to be considered for implementation on the project. If two (2) were in favor of the noise abatement and 2 were opposed, the noise abatement measure would not be recommended for implementation as there was no majority in favor of the noise abatement measure.

This assumes that all responses were received from the same row where each vote was weighted equally. Using the same example, assume there were five (5) responses received, with two (2) from the front row (shared property line with the ROW) and three (3) from the second row. If the two (2) front row receptors were opposed to the wall and the three second row receptors were in favor of the wall, the noise wall would not be implemented as the two first row votes each carry the weight of two "no" votes (for a total of 4 "no" votes) and the three second row "yes" votes only count as three "yes" votes. The majority vote is therefore carried by the 4 "no" votes.

The noise abatement evaluation for impacted Activity Category D land use facilities based on the interior NAC should first be evaluated using noise barriers. Noise insulation will only be considered for Activity Category D if noise barriers are determined to be not feasible or not reasonable and there is a noise impact based on an interior evaluation. If the only reason the noise barrier is not considered reasonable is due to the outcome of the solicitation of benefited receptor viewpoints, the consideration of noise insulation should be discussed with the IDOT Noise Specialist and FHWA.

As an example, if a noise barrier is determined to be feasible, and achieves the reasonableness criteria of the noise reduction design goal and the cost-effective evaluation, the desire of the benefited receptors will be solicited. If the overall viewpoint indicates a desire for the noise barrier, the noise barrier will be recommended for implementation. However, if the receptor viewpoints indicate an overall lack of desire for the noise barrier, sound insulation will only be considered as a possible noise abatement measure on a case-by-case basis. Noise insulation measures should be discussed with IDOT and FHWA during project development or at coordination meetings.

* Clarified in email from K. Runkle, 4/17/15 that a rental property would receive twice as many votes as an owner-occupied unit.

**STATE HIGHWAY AGENCY: Indiana Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

*Consideration and Obtaining Views of Residents and Property Owners*

All communication with the public regarding the potential for noise abatement must be coordinated with INDOT's Office of Communication. If a public hearing is required per the INDOT Public Involvement Manual, the following steps will be taken:

A survey will be mailed to each benefited resident. If the property owner is different from the current resident, both the resident and the property owners are surveyed. The concerns and opinions of the property owner and the unit occupants will be balanced with other considerations in determining whether a barrier is appropriate for a given location.

This survey will include a pre-stamped, self-addressed return postcard, a brief project description of the project and barrier locations under consideration. It will also include a pamphlet on the basics of traffic noise. The decision making process (described below) and pertinent information on the upcoming public hearing will be provided. The survey can be returned via mail or returned in person at the public hearing. All responses expressing opinions for or against barriers must be expressed in writing to INDOT, by letter, email or the response postcard. Extra surveys will be available at the hearing if any are lost or misplaced.

If a public hearing is not required per the INDOT Public Involvement Manual, a survey will be mailed as described above. It will include a set deadline for return of the survey. If the total respondents to the survey do not total a majority (more than 50%) of the benefited receptors and affected property owners, then a second survey will be mailed out to solicit the views of those who did not respond. If a majority of benefited receptors still do not respond, no third survey is required.*

Consideration of noise barriers can cause conflicts in mixed-use developments, as barriers to protect residences may block line of sight to adjacent businesses. If a barrier is proposed directly adjacent to the property line of a business, the business will be solicited for input to determine whether they have any concerns about line of sight. If a mutually satisfactory compromise cannot be reached between business(es) and residences, barriers may be terminated at the property line dividing the two areas. These conflicts can be minimized by noise-compatible planning (see coordination with local government officials).

The viewpoints of the benefited residents and property owners are a major consideration in determining the reasonableness of highway traffic noise abatement measures for proposed highway construction projects. These viewpoints have been determined and addressed during the environmental phase of project development. The will and desires of the public are an important factor in dealing with the overall problems of highway traffic noise. INDOT will incorporate highway traffic noise consideration in on-going activities for public involvement in the highway program, i.e., and will reexamine the residents' and property owners' views on the desirability and acceptability of abatement during project development.

*Clarified in email from R. Bales, 4/21/15, that a majority of respondents need to be in favor. If INDOT do not get a 50% response rate, then it is a project management decision. For example if 48% responded to the survey and of the 48% a large majority was in favor of the barrier, INDOT may continue outreach to secure the number, i.e. contact property owners by phone or visit to home.

**STATE HIGHWAY AGENCY: Iowa Department of Transportation**

DATE OF NOISE POLICY: Assumed July 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

The opinions of the property owners and residents of all benefited receptors as determined by application of Iowa DOT's public involvement policy (PPM 510.02 – Project Development Public Involvement Plan). The Department will solicit the viewpoints of all benefited receptors and will work to obtain as many responses from property owners and residents as is practicable.

A clear majority (more than half) of responses from benefited receptors or property owners will be needed to indicate the public's desiring or not desiring noise abatement measures.

**STATE HIGHWAY AGENCY: Kansas Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

Public Approval

The presence of a noise barrier may present certain concerns such as excessive shading, constricting air-flow, safety risks for exterior activities, and creating a tunnel-like environment for benefited receptors. Therefore, in order to move forward with construction of a noise barrier, viewpoints are solicited in the form of ballots. One ballot is assigned to each property with the following weighted points.

- Benefited owner per residence / unit = 1 point

- Benefited tenant per residence / unit = 1 point

Non-responding benefited receptors are not counted. Support for or opposition of a noise barrier is based from responses received even if responses are low. A noise barrier shall be permitted when 70% or more of the points indicate approval of the barrier.

[Follow-up with M. Fletcher of KDOT, 4/17/2015: Rental property receives 2 points, owner-occupant property receives 2 points.]

**STATE HIGHWAY AGENCY: Kentucky Transportation Cabinet**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

**Desires of Benefitted Receptors:** The views of the benefitted receptors and property owners will be considered in determining the reasonableness of noise barriers. Input from the benefitted receptors and property owners shall be gathered as outlined in this section. When the majority of benefitted receptors and property owners, engaged through the public involvement process, are opposed to construction of a noise barrier, KYTC will give great deference to these opinions in making a final determination regarding the reasonableness of the measure regardless of whether the proposal satisfies all other criteria for consideration. Similarly, where the majority of the benefitted receptors and property owners involved in the public involvement process are in support of noise barrier construction, and the proposal satisfies all other criteria for consideration outlined in this policy, KYTC shall incorporate the abatement measures into the project. It should be noted that if the benefitted receptors reject a noise barrier and then later change their opinion, the project would be considered a Type II project by FHWA. Since KYTC does not have a Type II program, noise abatement would only be considered as described in the Traffic Noise Abatement Considerations for State Funded Retrofit Projects section of this policy.

The public and local officials will be advised through the NEPA public involvement process if traffic noise impacts are expected to occur. A Noise Abatement Public Meeting will be held with benefitted receptors at each location where noise barriers were identified in the final environmental document as feasible, cost effective, and "likely to be constructed." Benefitted receptors shall be identified and notified of the meeting and their opportunity for input into the determination for inclusion of noise mitigation measures into the project. This public meeting will include:

1. A brief program on highway traffic noise to explain and demonstrate the characteristics of highway noise, the effects of noise barriers in attenuating noise, and the types of structural noise barriers being considered.
2. Specific details of the barrier proposed for each affected area including location, design, height, and length.
3. Discussion of alternatives to barrier construction.
4. Responses to questions and suggestions from the property owners.
5. Solicitation of the owners' and residents' preference of noise abatement measures by ballot (see "Kentucky Transportation Cabinet Noise Analysis Calculation Guide"). One owner ballot and one resident ballot shall be solicited for each benefitted receptor. Ballots shall be weighted in accordance with the following:

    3 points/ballot for benefitted front row property owners

    1 point /ballot for all other benefitted property owners

    1 point/ballot for all benefitted residents

Ballots shall be made available at the public meeting for completion by benefitted owners and/or benefitted residents who may attend. Benefitted receptors who do not provide ballot input at the meeting shall be surveyed to determine their preference. Properties with special use such as churches, schools, playgrounds etc. shall be weighted in a manner similar to that described under the Cost Effectiveness paragraphs of this section. The voting member shall be identified as the leader or head of the organization such as the school superintendent, park superintendent, etc. For each such property, both a resident and owner ballot shall be solicited, weighted to account for equivalent residences and, if appropriate, further weighted in accordance with the respect to paragraph 5 of this section.

All benefited residents and property owners shall have a period of thirty (30) days following the Noise Abatement Public Meeting to cast their votes. Barrier walls shall include access doors and/or provisions for fire hydrant hookups spaced as specified after meeting with local fire officials to discuss site specific needs. Barrier walls will only be constructed when a simple majority of affirmative ballots, after appropriate weighting, indicate a preference for the abatement.

**NOTE:** The KYTC Traffic Noise Abatement Calculation Guide provides examples of the tabulation of ballots for several scenarios.

**STATE HIGHWAY AGENCY: Louisiana Department of Transportation and Development**

DATE OF NOISE POLICY: July 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

(a) Consideration of Viewpoints: As part of the NEPA public involvement process, viewpoints from the community, including benefited receptors, will be solicited for all aspects of the project, including noise impacts and abatement. Public Involvement will be tailored to the project. If no relevant objections to the proposed noise abatement are made at this level of public involvement, this criterion is deemed met and abatement considered reasonable from the viewpoint of benefited receptors. If relevant objections are identified, a follow-up solicitation will occur with property owners and residents of the benefited receptors. The abatement measure will be considered reasonable from the viewpoint of benefitting receptors if 50% or more of the responses received are positive. *Follow-up coordination with benefited receptors may occur during the design stage when more detail information is available regarding barrier design.*

Follow-up Coordination with Benefited Receptors during Final Design

For noise barriers, the most common type of abatement, the Department will contact benefited receptors when the barrier design changes substantially from what was presented in the NEPA document. The abatement measure will be considered reasonable from the viewpoint of benefitting receptors if 50% or more of the responses received are positive.

To ascertain desires, property owners and residents may be invited to attend a meeting specifically to discuss the proposed barrier, or they may be asked to complete a survey (paper, electronic, phone, etc.). Contact may be made through a variety of means such as in person, letters, flyers left at the receptor site, public notices, web sites, phone calls, emails or other reliable means or combination of means. Names and/or addresses may be obtained from the tax assessor's roll, clerk of court records, neighborhood associations, local government databases, reliable internet sources, or other reliable sources or combination of sources. Those who do not respond as requested will be deemed as not interested in the barrier. DOTD will give more weight to the desire of the property owner than to the desire of the lessee. (When conflicting responses are received, DOTD will consider the property owner's response over that of the lessee's.)

A contractor may be given the option of using any barrier system on the Qualified Products List (QPL) for construction. The QPL includes both reflective and absorptive systems. Therefore, the contract may choose either an absorptive or a reflective system as long as the system is on the QPL. Using an absorptive barrier when a reflective barrier was assumed for modeling purposes is not considered a substantial change in design for the purposes of soliciting viewpoints of benefited receptors.

**STATE HIGHWAY AGENCY: Maine Department of Transportation**

DATE OF NOISE POLICY: February 1, 2014

VIEWPOINT LANGUAGE WITHIN POLICY:

C. Residents' Desires

A noise barrier will not be considered reasonable if fewer than 75% of the benefitted receptors approve of the construction of a noise barrier. In the case of rental or leased properties, the views of both the owner and the residents will be solicited to determine reasonableness. Maine DOT will establish the approval rate of a noise barrier for benefitted receptors by conducting a survey through certified or registered mail and a self-addressed stamped envelope.*

* Clarified in an email from N. Howard, 4/22/15, that the 75% is based on all benefited receptors regardless if they respond, and that a rental DU gets two votes and an owner-occupied DU gets 1 vote.

**STATE HIGHWAY AGENCY: Maryland State Highway Administration**

DATE OF NOISE POLICY: August 19, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

> Viewpoints of Benefited Property Owners & Residents

The viewpoints of benefited property owners and residents will be solicited during the environmental clearance phase of project development. The SHA will evaluate benefited property owner viewpoints, for individual Noise Sensitive Areas (NSA), during the Public Hearing commenting period of the environmental clearance phase. In the event that SHA receives opposing viewpoints from at least 25% of benefited residents within a NSA, a voting process will be administered. The voting process will require that more than 50% of benefited residents in the NSA be opposed to the noise abatement measure for the abatement to be deemed not reasonable.*

VIEWPOINT LANGUAGE WITHIN JULY 13, 2011 IMPLEMENTATION GUIDELINES:

- Viewpoints of Benefited Property Owners and Residents (Type I projects only)

o The views and opinions of all benefited property owners and residents (those determined to receive at least a 5 dB(A) noise reduction) will be solicited through the Alternates Public Workshop and the Public Hearing phases, "for" or "against" noise abatement for the subject community.

o Votes will be solicited for EACH benefited dwelling unit (residence) and/or equivalent benefited residence. If a property, such as a commercial or industrial site, does not have a noise sensitive use, then that property is excluded from the voting. Voters fall into three categories: property owner resident, property owner non-resident, and renter resident. The votes obtained for impacted and benefited properties will count twice as much as the votes obtained for non-impacted and benefited properties. An owner resident vote also counts twice: once for being an owner and once for being a resident. To ensure that a property owner's viewpoint is fairly considered, a non-resident owner is permitted a vote for each benefited dwelling unit they own. For example, an apartment complex has 12 benefited dwelling units. The non-resident owner would get 12 votes and each of the 12 renter residents would get one vote. Whether a unit is occupied by an individual, a family, or a group of individuals, only one resident vote will be accepted for any benefited residence by a person at least 18 years old who can provide proof of residency (deed, lease, utility bill, driver's license, etc.).

o Special land use areas (Category C) with identified benefiting noise sensitive use areas are counted based upon the number of equivalent residences (ER) based on an assessment of the linear frontage of the subject activity area divided by 125. The weighting of votes cast involving Category C activities shall follow the same protocols as established and described in the previous section for property owner residents, property owner non-residents, and renter residents.

o A vote tally of more than 50% AGAINST the proposed noise abatement is required for the barrier measure to be rejected as long as no single individual or entity is responsible for all the negative votes. SHA will not consider the percentage requirement met if all negative votes were cast by a single individual or entity. The only exception to this rule shall apply in the case where there is only a single individual or entity eligible to vote.

* Clarified in email from K. Polcak, 4-10-15, that it is 50% of all possible votes (not just those responding). The "negative" approach (i.e. more than 50% opposed) places the burden on the opposition to demonstrate and specifically register their objection. If there does appear to be a strong split in the community, SHA will endeavor to get as many returns as possible, so there is as much "registered"

opinion as possible. This is the approach for Type I projects. The feeling is that this is an easier criterion to meet. Unless there is opposition and that is made known somewhere in the planning process, an actual vote can in some cases be avoided. If there is opposition expressed than generally the full voting process will take place. Type II projects require a 75% APPROVAL before preliminary engineering is initiated. Since the program is voluntary, SHA requires that the community clearly demonstrate substantial majority support for pursuit of a noise barrier project.

**STATE HIGHWAY AGENCY: Massachusetts Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

### 7.3 Viewpoints of Property Owners and Residents

A major factor in determining the reasonableness of proposed noise barriers in noise-affected residential areas is the viewpoints of the property owners and of the residents of the benefited receptors. MassDOT will provide noise barriers if at least two-thirds (67 percent) of the weighted total number of residential votes are in favor of it. In the case of rental properties, FHWA requires MassDOT to consider both the views of the owners of the benefited receptors and the views of the renters.

A public informational meeting is held in the municipality(s) of the proposed noise barrier to present and discuss the noise impacts from the project and to provide an opportunity for local input in the development of the noise barrier project. This meeting occurs during the project development phase as part of the public involvement or public hearing process. MassDOT will notify the property owners in each Activity Category in Table 3 of the public informational meeting and of its intent to install a noise barrier in the noise-affected area.

After presenting the project information to the noise-affected area, a survey of the desires of the property owners and of the residents of the benefited receptors is conducted by mail. Owners of undeveloped lands for which residential development is permitted are also invited to participate in the voting process. While MassDOT will consider commercial and industrial establishments' desire to maintain visibility of their property from the highway, the property owners and renters of these types of land uses are not allocated any votes and, therefore, do not participate in the voting process. Table 4 [5] presents the number of votes allocated to each type of residential benefited receptor in the study zone.

At least 67 percent of the weighted total number of votes in the study zone must be in favor of the proposed noise barrier for the noise barrier to be considered for construction; otherwise a noise barrier will not be built. If this requirement is met, continued community coordination will take place during the final design phase of the project. A second public meeting is held, after the noise barrier design further progresses, to present more specific project information to the affected area. If noise abatement is proposed for Activity Category C land uses or Activity Category D facilities, then each individual property owner (that is, each owner of the Activity Category C land use or Activity Category D facility) must be in favor of it, otherwise, noise abatement would not be considered as a reasonable noise abatement measure.

**Table 5 Number of Votes Allocated to Benefited Receptors Surveyed**

| Land Use | Occupancy | Row | Number of Votes |
|---|---|---|---|
| Existing Residential | Owner | First | 5 |
| Existing Residential | Owner | Second, Third, etc. | 3 |
| Existing Residential | Renter | First, Second, Third, etc. | 1 |
| Existing Activity Category C or D | Owner | Not Applicable | 1 |
| Undeveloped Land Permitted for Development (Residential) | Owner | First | 5 |
| Undeveloped Land Permitted for Development (Residential) | Owner | Second, Third, etc. | 3 |

Although not a requirement for construction of a proposed noise barrier, MassDOT will also solicit a written letter from appropriate city/town officials stating their support of the desires of the property owners and of the residents of the benefited receptors for the noise barrier to be constructed.

When the municipality is opposed to noise abatement that is determined to be feasible and reasonable, MassDOT will coordinate with the city/town officials. The purpose of this coordination is to determine if the local government's reasons for the opposition are justified, such as for safety reasons. Municipalities cannot arbitrarily veto and/or restrict the length or height of the mitigation measure that was determined to be feasible and reasonable based on visual quality concerns or any other unjustified reasons. MassDOT's primary responsibility is to provide abatement for impacted noise-sensitive land uses so as not to jeopardize federal funding for its projects.

**STATE HIGHWAY AGENCY: Michigan Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

**2. PE Phase/Final Design**

During the PE Phase, the exact location, abatement types, aesthetic treatments, right-of-way requirements, etc. should be determined and be a part of the final recommendation for highway traffic noise abatement. The viewpoints of property owners and residents will be solicited during this phase on their desire to have the abatement and on the aesthetics.

**6.4 Voting Procedures**

The method of obtaining votes (i.e., flyers, door-to-door, public meeting, etc.) shall be determined by the MDOT Region Office or TSC on a project-by-project basis and must be recorded in the environmental documentation how each benefiting receptor unit owner or resident voted. The method must be conducted in a manner that definitively assures that all benefiting units have had an opportunity to vote and provide comment on any noise abatement measure. The public meeting notices should include a voting method for those who may not be able to attend a public meeting such as return ballots, web based, or any survey technology that also assures that the voter is a benefiting unit property owner or resident.

***6.4.1 Voting on the Construction of the Noise Barrier***

A meeting during the PE Phase shall be conducted, as previously stated, so the property owners or residents of benefiting units will have the opportunity to vote on whether they are in favor of the proposed noise barrier. Only the owners and residents of those receptor units that benefit from noise abatement may vote. This is an essential factor in determining reasonableness of the noise abatement. Only one vote per benefited unit will be accepted with the exception of rental dwelling units (See the following note – *Rental Unit Owner and Tenant, and Special Use Areas Voting*). Of all the votes tallied, 50% or more of the benefiting units must vote in favor of noise abatement. The absence of returned surveys or attendees to public meeting may be considered as an affirmative vote for noise abatement. Final interpretation of the voting results will be made by MDOT and its consultants, considering all the feedback gained during the public involvement process.

**NOTE** – *Voting Against Noise Abatement*

The property owners and residents of benefiting units will be informed before the vote that a decision against noise abatement at a specific location means no future noise abatement, including Type II, will be considered or approved for that specific location. Only a Type I scenario will trigger a future noise abatement assessment at that location.

**NOTE** – *Rental Unit Owner and Tenant, and Activity Category C Areas Voting*:

The property owner and tenant will receive notice of the public meetings regarding noise abatement. The property owner of a rental benefiting dwelling unit(s) will count as one (1) vote per benefiting unit for or against a noise barrier and/or a barrier's aesthetics. The owner may delegate this authority to an office/property manager if one is available. The tenant of an individual benefiting dwelling unit will count as a one-half (0.5) vote. For Activity Category C areas such as churches, schools, and park/recreational fields, the vote(s) will be accepted only from the governing authority that owns or manages the area in question.

**NOTE** – *Condominium Complexes*: Condominium complexes will be viewed the same as any other residential property.

***6.4.2 Voting on the Color & Texture of the Noise Barrier.*** The MDOT Roadside Development Unit will coordinate the CSS process in the stakeholder collaboration for the color, texture, landscaping, etc. In general, all stakeholders will have equal votes and status as to the aesthetics of the noise barrier. In the case of conflicting desires, those affected property units that abut the noise barrier, abut the right-of-way line, or have an unobstructed view of the noise barrier will receive greater consideration than those receivers that have an obstructed view of the barrier. Professional judgment will be required in making this determination. It is recommended that the project team tally the votes and summarize the results on project mapping to facilitate decision making in reconciling conflicting desires. Final interpretation of the voting results will be made by MDOT and its consultants, considering all feedback gained during the public involvement process.

**STATE HIGHWAY AGENCY: Minnesota Department of Transportation**

DATE OF NOISE POLICY: June 1, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

Although the noise analysis must be completed for all reasonable build alternatives under consideration, the solicitation of votes from the benefited receptors shall only be conducted on the preferred alternative. Viewpoints of the property owners and residents of all benefited receptors shall be solicited and considered in reaching a decision on the abatement measures to be provided. Several methods of public interaction are available to solicit viewpoints of benefited receptors including, but not limited to, the following:

- Local public meetings (local home, town hall, local church, etc.)
- Direct mail (letters, flyers, door hangers, fact sheet, return mail ballots)
- Project websites
- Telephone (call in lines or direct call campaign)

Local public meetings and direct mail are more commonly used, however any of these techniques or some combination may be employed, according to the needs and requirements of the specific project as determined by the sponsoring project manager, and with Mn/DOT or FHWA approval. See Appendix E for Guidance on Public Involvement Related to Noise Studies [of the Mn/DOT policy, not included in this report].

The solicitation of viewpoints must include information about the project and provide information regarding proposed noise abatement considerations associated with the project. The input of a benefited receptor must be documented in a manner that ties the input to the benefited receptor's street address (such as on a ballot or sign-in/response sheet). The desires of the benefited property owners and residents regarding the construction of proposed noise abatement will be expressed in a vote that will be weighted as follows:

1. For benefited properties immediately abutting the highway right-of-way of the proposed project, the property owner will receive 4 points for each benefited receptor unit (occupied and unoccupied) and residents will receive 2 points for each benefited receptor unit. An owner/resident of an abutting benefited receptor would receive a total of 6 points.
2. For benefited properties not immediately abutting the highway right-of-way, the property owner will receive 2 points for each benefited receptor unit (occupied and unoccupied) and the residents will receive 1 point for each benefited receptor unit. An owner/resident of a non-abutting benefited receptor would receive 3 points.
3. Due to the myriad of Association structures and the unique characteristics each one possesses, benefitted receptors that are part of an Association with a common land ownership and property units served by an Association with a common land ownership will be weighed on a case by case basis in consultation with Mn/DOT noise staff and FHWA. See Appendix F [of the Mn/DOT policy, not included in this report] for an example of how votes are counted for an Association that has common land ownership.
4. Manufactured home parks will be weighed the same as the property owner and residents noted in #1 and #2.
5. In the case of multi-family residential buildings, such as apartment buildings, only those individual units that are considered to be benefited receptors (receptors receiving a 5 dBA reduction, regardless of upper/lower floor location) have a vote according to the same point system explained above. Non-benefiting units do not receive points.
6. Due to the unique variations of scenarios, the number and placement of non-residential receptor units for designated Activity Categories C and E shall be reviewed by appropriate Mn/DOT staff. See

Appendix B [of the Mn/DOT policy, not included in this report] for guidance on assigning receptor units for non-residential land uses such as parks, recreation areas, active sports areas, picnic areas, playgrounds, campgrounds, etc.

7. Any single benefited receptor will only be able to vote "yes" or "no"; no split votes. (Owner, owner/resident, or resident votes must individually be either all yes or all no points. Votes may not be split (i.e., an owner receives 4 points, he may not vote 3 "no" and 1 "yes"; all 4 points must be either "yes" or "no").
8. Non-benefiting receptors do not receive points.
9. A simple majority (greater than 50%) of all possible voting points (not just the ones that reply) for each potential noise abatement measure must vote "down" the abatement measure to remove it from further consideration. (See Appendix F [of the Mn/DOT policy, not included in this report].)

NOTE: Appendix F [of the Mn/DOT policy, not included in this report] contains a sample letter and example tables that tabulate votes. Data will be reorganized and revised in Appendix G of revised 2014 noise policy, currently under development [not included in this report].

**STATE HIGHWAY AGENCY: Mississippi Department of Transportation**

DATE OF NOISE POLICY: Assumed July 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

The construction of a noise barrier is not reasonable unless a majority of residents and property owners of the benefited receptors (receptors that receive a noise reduction of 5 dBA or more from the noise barrier) want a noise barrier even if all other criteria indicate that a noise barrier is reasonable. During the environmental phase of a project it will be assumed that the benefited receptors want a noise barrier. During the design phase of the project a public meeting will be held for residents and owners of benefited receptors. Local officials will also be invited and encouraged to attend this public meeting. After the public meeting a survey will be conducted to determine if the residents and owners of the benefited receptors want a noise barrier. Local officials will be encouraged to consider highway traffic noise in the land use planning process.

From Noise Barrier Evaluation Form

REASONABLENESS

| Required Factor Related to Viewpoints | Not Reasonable | Marginally Reasonable | Fully Reasonable | Highly Reasonable |
|---|---|---|---|---|
| % of benefited receptors wanting barrier | <50% | 50-60% | 61-75% | >75% |

**STATE HIGHWAY AGENCY: Missouri Department of Transportation**

DATE OF NOISE POLICY: Assumed July 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

Viewpoints of owners and residents of the benefitted receptors will be obtained. These will usually be obtained through mailings or a public forum. The viewpoints of non-owner residents will be evaluated as a portion of an aggregate of 25 percent of the total. The viewpoints of owners will be evaluated as a portion of an aggregate of 75 percent of the total. For noise abatement to be considered reasonable, over 50 percent of the aggregate response must be in favorable.

VIEWPOINT LANGUAGE WITHIN ENGINEERING POLICY GUIDE ARTICLE 127.13:

127.13.10 Noise Wall Public Meeting and Voting
For projects with noise impacts where noise abatement is both reasonable and feasible, a noise wall public meeting is required. If project timing allows, this meeting can be combined with other project public meetings. Required invitees for this meeting are all first-row and benefitted receptors. However, a meeting with non-qualifying impacted area residents is sometimes beneficial. Meeting with different groups of residents can be combined where appropriate.

In most cases, ballots are sent to all first-row and benefitted receptors prior to the public meeting. This practice allows deliberation and the opportunity to ask questions and turn in ballots at the public meeting. A simple majority is required to qualify a noise wall.

**OFFICIAL BALLOT**

«FirstName» «LastName»may lead to an increase in noise levels in your area. Therefore, as part of the environmental mitigation of the road improvements, your area may qualify for a sound wall. If a majority of benefitted property owners and residents vote in favor of a wall, and all other remaining criteria are met, the environmental mitigation study of the noise indicates your property would benefit from a sound wall.

By simple majority the results of this vote will determine whether owners and residents want a wall or not. The viewpoints of non-owner residents will be evaluated as a portion of an aggregate of 25 percent of the total. The viewpoints of owners will be evaluated as a portion of an aggregate of 75 percent of the total. For noise abatement to be considered reasonable, over 50 percent of the aggregate returned responses must be in favorable. Final commitment for MoDOT to build a wall will come when all noise criteria are met.

The design, location and approximate height of the wall have not yet been determined. You are only voting for whether you want a wall or not. **This is your one and only chance to vote.** You will not have this opportunity again, so please take the time to vote now. One (1) vote will be counted per residence. If a ballot is not returned, it will not count. In order for your vote to count, please have it post-marked by (**date).** You are welcome to return the ballot in person at the resident meeting on (date). Ballots post-marked after (**date)**, or ballots not returned at all, will not count in the final decision.

Please return this ballot to: «Address1» If you have any questions, please email.

**If this is no longer the current owner of this property, please cross out the name below and print the new owner's name.

«FirstName» «LastName», «Address1», «City», «State» «PostalCode»

☐ Yes, I want a sound wall in my area ☐ No, I do not want a sound wall in my area

Owner Signature_____

**STATE HIGHWAY AGENCY: Montana Department of Transportation**

DATE OF NOISE POLICY: July 1, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

6.5.3. Public Support of Benefited Receptors

The viewpoints of benefited residents and property owners are considered in the decision to provide noise abatement, especially a visual obstruction such as a barrier or berm. A benefited receptor is one that receives a noise reduction from the abatement measure of at least 5 dB(A), whether or not that receptor has been found to be impacted. To simplify the discussion, viewpoints are counted as votes, with more weight given to property owners and renters of first-row receptors, as illustrated below.

- First row renter — 1.5 votes
- First row property owner (non-residing) — 2 votes
- First row owner-occupied — 3 votes
- Non-first row renter — 1 vote
- Non-first row owner-occupied — 1 vote
- Non-first row property owner (non-residing) — 1 vote

If one property has multiple dwelling units, the owner(s) of the multi-unit dwelling get one vote for the property (not one for each dwelling unit), and the tenants/renters of each unit get one vote each.

MDT will make every effort to solicit responses from affected residents, through neighborhood meetings, mailings and individual follow-up. In order to carry abatement forward, MDT requires approval of over half (51%) of the benefitted receptors. Non-responding benefited receptors will not be counted. Support of noise abatement will be based on the responses received, even if that response rate is very low.

If more than half of the respondents are opposed to the abatement, the abatement proposal will be dropped from consideration, and the area will not be eligible for future Type II noise abatement (23 CFR 772.15(b)(3)), if MDT ever considers a Type II program. This is an important point to make with residents when they are considering their preference for abatement.

**STATE HIGHWAY AGENCY: Nebraska Department of Roads**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

1. Viewpoints of the property owners and residents of the benefited receptors: When it is determined that it would be feasible to provide noise abatement for a site, and a preliminary determination has been made that abatement would be reasonable, a noise abatement public informational meeting will be held as part of the process for a final determination of whether abatement would be reasonable. The benefited property owners and residents will be given an opportunity to vote in the form of a ballot vote (example ballot on pg. 18). NDOR defines a benefited receptor as achieving at least a 5 dB(A) reduction. The benefited property owners and residents will receive a ballot and information packet (map showing the project area and where the proposed noise wall is, a description of the project, anticipated season and year for start of construction, and an example of a completed ballot with how many points the voters ballot will be worth) through certified mail 15 days prior to the public meeting for noise abatement. Ballots are due 15 days after the meeting date and can be mailed back or returned in person. If property owners or residents have not returned a ballot by 15 days after the public meeting date, a second ballot will be mailed. If the second ballot is not returned within 15 days after it is received, the property owner or resident will not have a vote (NDOR will account for delivery time). Ballots will also be available at the public information meeting.

This public outreach (letters and informational meeting) will be conducted in compliance with the most current, approved version of the NDOR Public Involvement Plan. In addition, early in the NEPA process, protected populations within the environmental study area were identified. If protected populations occur within your study area, the project proponent must be able to demonstrate due diligence to engage these populations. For local governments, coordinate with your Local Project Division Project Coordinator who will consult with a Civil Rights Coordinator for guidance on conducting public outreach in protected populations. NDOR employees conducting public outreach in protected population areas will contact the NDOR Civil Rights Coordinator for guidance.

Noise abatement will be provided only if at least 75% of points from returned ballots are in favor of the proposed noise barrier as a strong majority has historically worked well in Nebraska. If the benefited property owners and residents reject the construction of a noise abatement device, their area will not be reconsidered for future noise abatement unless another Type I project is proposed for the area or if there is a re-evaluation on the current project.

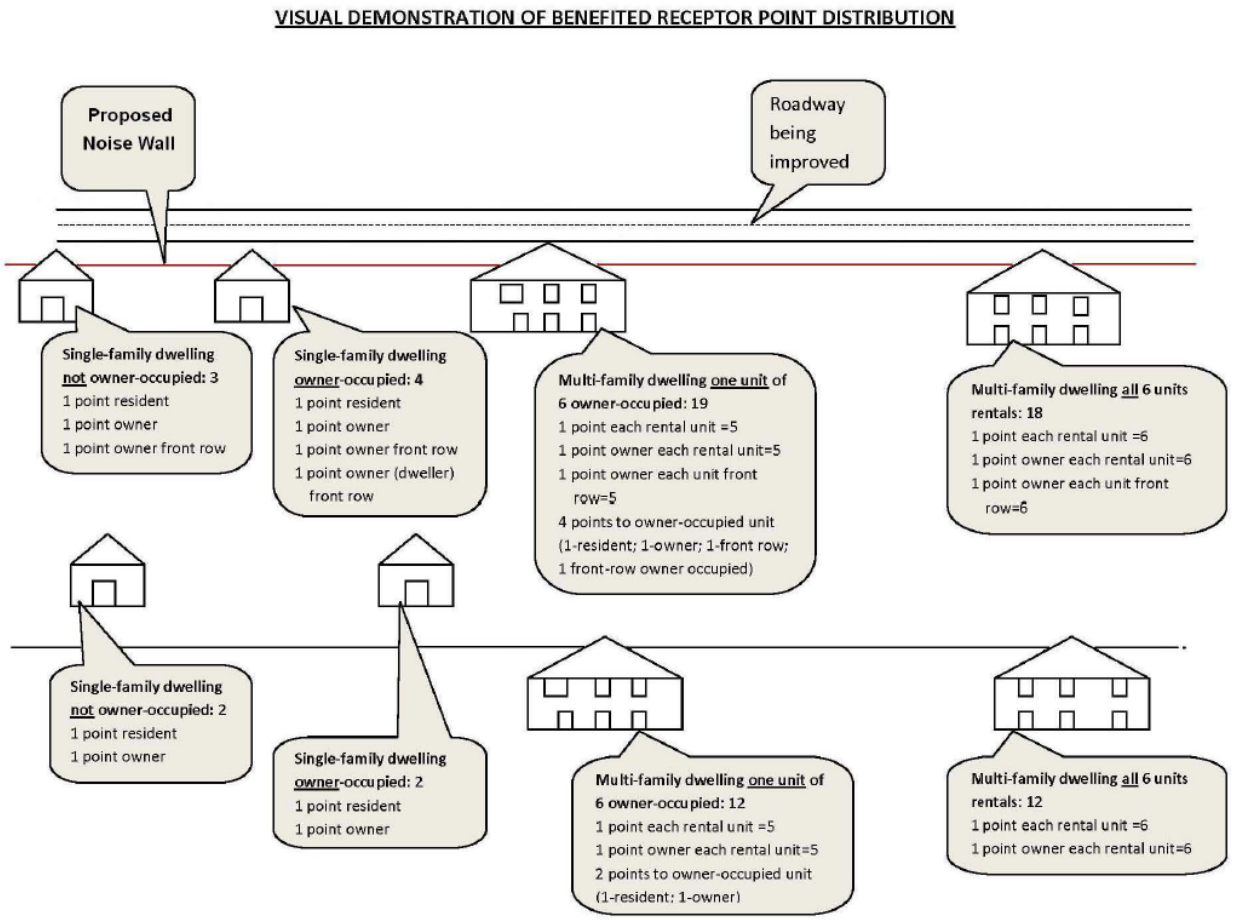
Voting: Consideration of the viewpoints of all the benefited receptors shall be solicited, with weighted voting applied to the first-row owners who live in the residence. Each benefited resident will get one point per ballot. Each owner of a benefited dwelling will also get one point per ballot. Owners who live in a benefited dwelling will receive 1 point per ballot. Owners who live in a benefited first-row dwelling will receive 1 point per ballot. The most points per unit possible are 4. If a unit is un-occupied then this unit will only receive one point by the owner of the unit regardless of where the property is located. See pg 19 of this policy for a visual aid of the voting process. [See diagram on next page.]

***All residences/dwellings/units***
- 1 point per ballot for all residents of a unit or dwelling
- 1 point per ballot for all benefited property owners

***Front row residences/dwellings/units only***
- 1 point per ballot for benefited front row property owners
- 1 point per ballot for benefited front row property owners living in the dwelling or unit

NOTE: Example score sheet is provided in the Policy.

**Nebraska Department of Roads, page 19**:



**STATE HIGHWAY AGENCY: Nevada Department of Transportation**

DATE OF NOISE POLICY: September 26, 2012

VIEWPOINT LANGUAGE WITHIN POLICY:

Noise barriers will be constructed as modeled and designed unless the benefitted receptors are opposed to their construction. As part of the public involvement process, NDOT will solicit input from all the benefitted receptors. To be considered, responses from benefitted receptors shall be in writing and clearly identify the respondent's status with the property and validate their standing to participate. The responses received shall be evaluated according to the following.

The preferences of benefitted receptors will be weighted as follows:

- Those receiving a 7 dB(A) reduction or greater in projected noise levels shall receive three points.
- Those receiving a 6 dB(A) reduction in projected noise levels shall receive two points.
- Those receiving a 5 dB(A) reduction in projected noise levels shall receive one point.

If opposing views over the traffic noise abatement measure develops between the property owner of a benefitted property and its legal occupant(s), the preference of the property owner will take precedence.

To alter the proposed traffic noise abatement measure, two criteria must be met. First, to initiate reconsideration of the proposed measure, a qualifying response from a majority (50%, plus one [1]) of all the valid identified benefitted receptors must be received. If a response is not received from a valid benefitted receptor, it will be recorded as being in agreement with and supporting the proposed traffic noise abatement measure. Second, using the scoring system above, the tallied results must support any change to the proposed traffic noise abatement measure.

**STATE HIGHWAY AGENCY: New Hampshire Department of Transportation**

DATE OF NOISE POLICY: Dated April 2011; Approved by FHWA July 6, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

2. Views of the Benefited Receptors

As part of the National Environmental Policy Act (NEPA) public involvement requirements, viewpoints from the entire project community, including benefited receptors, will be solicited for all aspects of the project, including noise impacts and abatement. If no objections to the proposed noise abatement are found at this level of public involvement, then the noise barrier will be deemed reasonable. If objections are identified, a second, more detailed solicitation will occur with the benefited receptors to determine reasonableness.

Support will be determined by obtaining one vote from each of the benefited receptors. Points will then be applied to each vote to make the final reasonableness determination. One owner and one occupancy point will be given for each receptor. (For example; a single family, owner-occupied receptor, will be given two points, one for ownership and one for occupancy. For a single family rental property, one point will be given to the owner and one point will be given to the rental unit. For a multifamily dwelling, one point will be given to each rental unit and one point per rental unit will be given to the owner.)

At least 51% of the total possible points must be in support of an abatement alternative for it to be considered reasonable.

**STATE HIGHWAY AGENCY: New Jersey Department of Transportation**

DATE OF NOISE POLICY: July 1, 2011

VIEWPOINT LANGUAGE WITHIN PART A- POLICY:

Noise barriers will be built where they are desired by the community and meet the benefit and cost effectiveness criteria set forth in PART-B "NOISE WALL DESIGN GUIDELINES".

VIEWPOINT LANGUAGE WITHIN PART B- NOISE WALL DESIGN GUIDELINES:

The Department will survey owners and residents of properties benefited by the noise barrier to determine the community support for the noise barrier in their area. The determination of the community support will be based by simple majority of the responses received by the Department. The Department will not construct any barrier without the support of the local community based on this poll. In the case of schools, parks, recreation areas and other land uses listed in Category "C" of Table 1, it will be based on the approval of the owners and operators of the facility. In either case if there is no clear consensus, the barrier(s) will not be built.

The Department will then inform the local elected officials of the survey results and request a resolution of support for the abatement proposal based on this survey in order to further document public support for the noise mitigation.

**STATE HIGHWAY AGENCY: New Mexico Department of Transportation**

DATE OF NOISE POLICY: April 25, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

(a) The viewpoints of the property owners and residents of the benefited receptors of proposed noise abatement measures shall be actively solicited and considered. The Department will meet with the benefitted property owners and residents and present a brief program on highway traffic noise to explain and demonstrate the characteristics of highway traffic noise, the effects of noise barriers in attenuating traffic noise, and the types of barriers that may be considered. As available, specific details of noise barriers being studied will be presented in addition to a discussion of alternatives to barrier construction. After completion of design the Department will meet again with the property owners and benefitted residents to present final details and to solicit the residents' final views and opinions. The decision on whether the noise abatement measure is desired or not desired will be based on the preference provided by 51 percent or more of the benefited property owners and residents that respond to the solicitation. The Department will then make a final determination on the noise abatement and advise the property owners and residents of that decision.

**STATE HIGHWAY AGENCY: New York State Department of Transportation**

DATE OF NOISE POLICY: July 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

- Viewpoints - The viewpoints of the property owners and residents of the benefited receptors shall be a major consideration in reaching a decision on the reasonableness of abatement measures. The property owners and residents shall be contacted using one or more of these methods: informational meetings in or near to the neighborhood, direct mailings with return envelopes, telephone or internet surveys, or door-to-door inquiries. A response shall be obtained from at least half of the benefited property owners and residents and a majority of the responses must favor the abatement measure.

Although the viewpoints shall be determined and addressed during the preliminary design phase of project development, the property owner and resident viewpoints on the desirability and acceptability of abatement need to be reexamined periodically during the final design phase prior to PS&E approval.

Table 2 provides an example feasibility and reasonableness worksheet.

**Table 2*: FEASIBILITY AND REASONABLENESS WORKSHEET***
**Highway traffic noise abatement for a project**

| **PIN:** | | | |
|---|---|---|---|
| **Abatement Measure:** | | | |
| | | Yes | No |
| **Feasibility** | | | |
| Engineering Considerations | Can the measure be built? | | |
| Noise Reduction (Acoustic Feasibility) | Does the proposed measure provide a reduction of at least 5 dB(A) to a majority of the impacted receptors? | | |
| **Reasonableness** | | | |
| Viewpoints of Benefited Property Owners and Residents | Were responses obtained from at least half of the benefited property owners and residents? | | |
| | Do a majority of the responses favor the measure? | | |
| Cost Index | **If a berm:** Is the total estimated cost of the proposed berm less than $80,000 per benefited receptor? | | |
| | **If a barrier:** Is the proposed barrier less than 2,000 square feet per benefited receptor? | | |
| Noise Reduction Design Goal | Do a majority of the benefited receptors achieve the Noise Reduction Design Goal of 7 dB(A)? | | |
| **If all the questions can be answered "Yes," then the measure is considered reasonable and feasible.** | | | |

**STATE HIGHWAY AGENCY: North Carolina Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

Viewpoints of the property owners and residents of all benefited receptors shall be solicited. One owner ballot and one resident ballot shall be solicited for each benefited receptor. Points per ballot shall be distributed in the following weighted manner:

- 3 points/ballot for benefited front row property owners
- 1 point/ballot for all other benefited property owners
- 1 point/ballot vote for all residents

Consideration of the noise abatement measure will continue unless a simple majority of all distributed points are returned that indicates the balloted voters do not want the abatement measure.

ADDITIONAL VIEWPOINT LANGUAGE WITHIN AUGUST 22, 2011 TRAFFIC NOISE ANALYSIS AND ABATEMENT MANUAL:

Noise Abatement Measure Voting Process

The viewpoints of the benefited receptors shall be solicited after completion of Design Noise Reports. Each benefited resident will get one vote. Each benefited owner will also get one vote (i.e., an owner who resides at a predicted benefited property will be able to cast two votes). Owners of predicted first-row benefits will receive an additional two votes.

All noise mitigation measures recommended in the Design Noise Report shall be constructed unless a simple majority of opposing votes are received in a timely manner. All benefited residents and property owners shall have a period of fifteen (15) to thirty (30) days to cast their votes to NCDOT.

Consideration of the noise abatement measure will continue unless a simple majority of all distributed points are returned that indicates the balloted voters do not want the abatement measure.

**STATE HIGHWAY AGENCY: North Dakota Department of Transportation**

DATE OF NOISE POLICY: March 2012

VIEWPOINT LANGUAGE WITHIN POLICY:

Viewpoints of Property Owners and Residents of the Benefited Receptors

The benefited receptors of a proposed noise barrier design are required to be notified by certified mail. The notification should include dimensions and location of the proposed noise barrier, and a survey, questionnaire or ballot as appropriate. The notification shall also indicate that after construction of a noise barrier, NDDOT will not consider perceived damages or loss of visibility to properties.

The presence of a noise barrier may present certain concerns such as excessive shading, constricting air-flow, safety risks for exterior activities, and creating a tunnel-like environment for benefited receptors. Therefore, in order to move forward with construction of a noise barrier, viewpoints are solicited in the form of ballots. One ballot is assigned to each property with the following weighted points.

- Benefited owner per residence / unit = 1 point
- Benefited tenant per residence / unit = 1 point

Non-responding benefited receptors are not counted. Support for or opposition of a noise barrier is based from responses received even if responses are low. A noise barrier shall be reasonable when 80% of the front row of benefited receptors respond indicating approval of the barrier.

In some cases, receptors cannot be represented as a residence; therefore the descriptions for different types of frequent human use as described within the FHWA Noise Abatement Criteria are defined with representative locations. Other circumstances with different interpretations for equivalent receptors must be within the spirit of FHWA regulations and intent, and the reasons shall be fully documented in the report. In all cases, the corresponding Activity Category Leq(h), applies. The following equivalent receptors table provides these definitions.

**STATE HIGHWAY AGENCY: Ohio Department of Transportation**

DATE OF NOISE POLICY: February 2015

VIEWPOINT LANGUAGE WITHIN POLICY:

Concerns of local officials will be considered in the noise abatement design, but will not be a determining factor regarding noise barrier construction.

The ODOT communicates with the property owners and residents of the benefited receptors when noise barriers are offered as noise abatement and provides the opportunity for them to indicate whether or not they want noise abatement. If noise abatement is feasible and reasonable, the affected receptors may also choose the aesthetic appearance of the receptor side of the noise barrier. For Type I projects, it is the responsibility of the ODOT to solicit the viewpoints of all of the benefited receptors and obtain enough responses to document a decision on either desiring or not desiring the noise abatement measure. Mailed surveys should include enough information for receptors to determine whether or not they desire a noise barrier, to select from various aesthetic (color and texture) options, and to select vegetation if a noise barrier is not desired. A mailed survey augments data collected from a public meeting and may be used in lieu of a public meeting in some cases. The survey must include information about the project and provide information regarding noise abatement considerations associated with the project. This survey must be pre-stamped and self-addressed for return. Respondents shall be given the opportunity to indicate whether or not they want a noise barrier or if they prefer a vegetative screening. Respondents to surveys must be identified by name and address. As an option to asking receptors to make a selection from various aesthetic color and texture options, ODOT can elect to decide the color and/or texture of the noise barrier for the community and solicit any comments with the choice made by ODOT.

In lieu of an open house noise public meeting, an effective strategy ODOT encourages for noise public involvement is going door-to-door to the benefited receptors (canvassing) and providing them with the mailers and even giving them the option to sign a petition for a noise wall if they choose to. Another effective strategy for noise public involvement is to meet with the community leaders and/or attend scheduled neighborhood association meetings. Other tools include phone call canvassing and email responses. A conference call or meeting between the noise public involvement consultant and ODOT should be held to discuss the proposed noise public involvement strategy, expectations, and deliverables, prior to conducting noise public involvement.

Noise abatement is offered at locations where design year build noise impacts are predicted to occur and noise abatement is determined feasible and reasonable. Consideration for whether or not noise abatement will be constructed is left to the benefited property owners and residences of the receptors. The ODOT does not require installation of noise abatement. Noise abatement is offered to the benefited receptors. For owner-occupied dwellings, one ballot shall be solicited per benefited receptor. Relative to benefited rental properties, one owner ballot and individual resident ballot shall be solicited. The owner will have the same number of votes as there are number of dwelling units and each rental unit will have one vote per unit. An owner-occupied residence of an apartment complex will receive one owner vote (equaling the same number of votes as there are number of dwelling units) plus one additional vote as an occupant. An unoccupied rental that is livable receives 1 vote/tally from the owner. There is no tally for the occupant.

For abatement to be designed and constructed, a minimum of 50% of the benefited property owners and residents should respond in favor of the abatement.* If the first noise public involvement survey does not result in a minimum of 50% of the benefited property owners and residents responding in favor of the noise abatement, a resurvey should be conducted.

A Noise Public Involvement Summary (NPIS) must be prepared which discusses the results and shows them in a tabular fashion and includes aerial mapping showing the benefited receptors that responded and what their response was relative to desire and aesthetics as well as the benefited receptors that didn't respond. NPIS graphics must also show the proposed noise wall and, if applicable, benefited receptors being taken by the project, foreclosures, and/or vacancies. The results of the noise public involvement must be reviewed and approved by ODOT and written recommendations made by the project team on whether or not to construct the noise wall(s), prior to beginning any noise abatement design activity.

After the decision has been made as to whether or not a noise wall will be constructed, a notification should be mailed to the benefited receptors informing them of the decision.

Pre noise wall construction noise public involvement should be conducted to inform the benefited receptors of the upcoming noise wall construction project.

* Clarification, email from N. Alcala, 8/21/15: 50% of ALL of the benefited property owners and residents; not only those who respond.

**STATE HIGHWAY AGENCY: Oklahoma Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

The property owners' and residents' desire for mitigation. Benefitted receptors viewpoints shall receive priority consideration. Details on how the Department will receive the viewpoints of the benefitted property owners and residents are provided in F. Public Involvement.

The viewpoints of the property owners and residents of the benefitted receptors of proposed noise abatement measures shall be actively solicited and considered. The primary method for notices will be by US mail. Flyers or personal contact may be used in the event that mailings are unsuccessful in engaging property owners and /or residents in the public involvement process.

ODOT will hold meetings with the benefitted property owners and residents and present a brief program on highway traffic noise to explain and demonstrate the characteristics of highway traffic noise, the effects of noise barriers in attenuating traffic noise, and the types of barriers that may be considered. As available, specific details of noise barriers being studied will be presented in addition to a discussion of alternatives to barrier construction.

After completion of barrier design, ODOT will meet again with the property owners and benefitted residents to present final details and to solicit the residents' final views and opinions. The decision on whether the noise abatement measure is desired or not desired will be based on the preference provided by 51 percent or more of the benefitted property owners and residents that respond to the solicitation. One owner ballot and one resident ballot shall be solicited for each benefitted receptor. Points per ballot shall be distributed in the following weighted manner:

- 3 points/ballot for benefitted front row property owners
- 1 point/ballot for all other benefitted property owners
- 1 point/ballot vote for all residents

For Category C impacted properties, the property owner/official of jurisdiction only will be balloted regarding desire for abatement.

Consideration of the noise abatement measure will continue unless a simple majority of all distributed points are returned that indicates the balloted voters do not want the abatement measure. The final determination on the noise abatement will be shared with the property owners and residents by letter.

**STATE HIGHWAY AGENCY: Oregon Department of Transportation**

DATE OF NOISE POLICY: June 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

**Viewpoints of the Property Owners and Residents**

Noise abatement survey letters to the benefited residents and property owners must be sent out to determine the viewpoints of the affected noise receptors. A simple majority (51 percent of all responding benefited residents and property owners) is needed to build noise abatement. A log should be kept to indicate the percentage of total responses. The polling should occur during the preparation of the revised EA (REA) (or prior to a FONSI if an REA is not issued) or FEIS but could occur while preparing the EA or EIS or just prior to final design for CE projects. The Region Environmental Project Manager (EPM), the Region Environmental Coordinator (REC), or the Region Environmental Unit Manager should ensure that the noise abatement survey letters are sent out and returned via a preaddressed, postage-paid envelope.

The noise abatement survey letter briefly explains the project and the noise impacts and provides a graphic or explanation of where the abatement will be located. The abatement survey letter must also explain the likelihood of abatement (see "Statement of Likelihood", section 7.7). The residents are then polled to see if they want abatement. If less than 50 percent of the benefited residents and property owners respond to the survey, a second survey will be sent out to the benefited receivers who did not respond to the first survey. The result of the second survey, combined with the results of the first survey, will be considered the opinion of the benefited receivers, even if less than a 50 percent response is obtained. Percent yes is calculated as follows:

Votes from those responding to the noise abatement survey will be counted according to the following manner:

- Each property owner gets one vote.
- Benefited residents in multi-unit complexes (such as apartments) get one collective vote after those individual votes are tallied. A collective vote results in one yes vote or one no vote.
- The property owner of the multi-unit complex gets one vote.
- In the case of condominium complexes where some of the units are owner-occupied and some are rented, the owner-occupied unit gets one unique vote, the renters get a collective vote, and the offsite owners get one vote each.
- For mobile home and trailer parks, each resident gets a unique vote and the property owner gets one vote.
- A renter of a single-family property gets one vote and the owner gets one vote.

Percent yes = (total yes votes) / (total of yes and no votes returned) x 100

Excerpts from: Noise Abatement Evaluation and Recommendation Form

| **1. COMMUNITY SUPPORT (See Section 7.4.1 of the Noise Manual, *Viewpoints of the Property Owners and Residents*)** | | | |
|---|---|---|---|
| | Renters | Owners | |
| Total Number of Votes from returned surveys | | | |
| Total Number of Actual No Votes | | | |
| Total Number of Actual Yes Votes: | | | % Yes Vote (b): |

| **Community Support for Abatement** (% yes or no must be greater than 50%) | Yes | No | |
|---|---|---|---|

**a)** Percent yes calculation:

Percent yes = (total yes votes) / (total of yes and no votes returned) x 100

**STATE HIGHWAY AGENCY: Pennsylvania Department of Transportation**

DATE OF NOISE POLICY: December 12, 2013

VIEWPOINT LANGUAGE WITHIN POLICY:

*3.3.3.3 Consideration of Viewpoints*

As related to the viewpoints of property owners and residences, the viewpoints of all benefited receptors shall be solicited in order to obtain enough responses to document a decision on either desiring or not desiring a noise abatement measure. Although the public may express opinions regarding the desire for or against particular noise abatement measures at any point in the development of a project, the solicitation of viewpoints does not formally occur until information contained within the draft version of the Final Design Noise Analysis Report has been approved for circulation to the public by PennDOT and FHWA. This process assures the public has access to the results of noise analyses prior to making any decision related to the desire for or available choices associated with noise abatement measures. More information is provided in Step 6.

6.3 Affected Receptors

When construction of a noise barrier is being considered in the Final Design Phase, such measures will not be approved without documentation that the affected community has had the opportunity to provide input into the development process. A good community relation effort can often prove to be the most effective highway traffic noise mitigation component. PennDOT Publication No. 295 "Public Involvement Handbook" should be referenced for all projects involving highway traffic noise issues.

Coordination with all receptor unit owners and residents directly affected by highway traffic noise is a very important part of the Final Design Phase. At any time during this process, the impacted community or individual receptor unit owner(s) may express viewpoints related to noise abatement. However, the official viewpoint regarding the desires for or against a noise abatement device will not be accepted by PennDOT until the community has had the opportunity to gain knowledge of the implications of a barrier/no barrier decision based on the information developed at the conclusion of the Final Design noise analysis process.

This allows the community the opportunity to provide input based on the proposed location, type, height, and length of the noise abatement feature. The abatement design is further refined to include the community's comments and to optimize the abatement feature. Subsequent community meetings allow for a refinement of the abatement design, keeping in mind the acoustic, engineering, and safety considerations until agreement is reached.

6.4 Voting Procedures

As long as it is documented in the Final Design Highway Traffic Noise Report how benefited receptor unit owners/residents voted (desire for a barrier, location, and color/), the method of obtaining votes (i.e., flyers, door-to-door, public meeting, etc.) shall be determined by the Engineering Districts on project-by-project bases.

6.4.1 Voting on the Construction of the Noise Barrier

The viewpoints of residents and property owners will be solicited as part of the public involvement process. Both property owners and renters of the receptor units that are benefited by highway traffic noise may vote on whether they are in favor of the proposed noise wall. The owner of each benefited receptor unit shall receive one vote of equal value for each benefited receptor unit owned. The renter shall receive

one vote for the unit in which they reside. In the case of conflicting desires, it is recommended that the project team tally the votes and summarize the results on project mapping. Final interpretation of the voting results will be made by PennDOT and its consultants, considering all feedback gained during the public involvement process.

Of all the votes tallied, 50% or greater must be in favor of the proposed noise barrier in order for the noise barrier to be considered reasonable. When assessing those votes that are not in favor of the proposed noise wall, the Engineering District needs to assess the number and location of these opposing votes on a noise barrier by noise barrier basis. This may result in partial highway traffic noise abatement or the inability of satisfying the request of the opposing votes.

**STATE HIGHWAY AGENCY: Puerto Rico Department of Transportation and Public Works**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

1. Viewpoint of affected residents and property owners

The viewpoint of benefitted residents constitutes an element of the reasonableness criteria. In order to obtain their viewpoints, an interview with them will be conducted. A noise abatement barrier will be constructed, only if a majority or more of the benefitted residents approve such measure, otherwise it will not be constructed. The agency will maintain on its project files, records of such decisions.

**STATE HIGHWAY AGENCY: Rhode Island Department of Transportation**

DATE OF NOISE POLICY: June 2, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

(1) Viewpoints of Affected Residents and Property Owners

Before the Department proceeds with the final design of a noise barrier, viewpoints will be solicited from all property owners and residents of the benefited receptors. At least 75% of all property owners and residents of benefited receptors must state their point of view on the proposed barrier. If less than 75% respond, the barrier will not be considered. RIDOT will provide letters notifying the public of the process and its requirements. Return forms will be self-addressed and stamped. Viewpoints shall be in the form of a written, signed response sent via U.S. Mail and postmarked within 30 days of the date of RIDOT's written request. At least 67% of the property owners and residents of benefited receptors must be in favor of the proposed noise barrier for it to be considered. For multiple-unit dwellings, property owner's viewpoints will be weighted by permitting them to submit one written viewpoint for each dwelling unit they own. For special land use sites, the property owner must be in favor of the barrier for it to be considered. This should be determined as early as possible, in order to avoid designing barriers that are not favored.

When the governing body of the affected community (Town. Council, City Council, etc.) is opposed to noise abatement that is determined feasible and reasonable, RIDOT will coordinate with the town/city officials. The purpose for coordination is to determine if the local government's reasons for opposition are justified. RIDOT will make every effort to work with the community to gain governing body support for noise abatement that is deemed feasible and reasonable.

**STATE HIGHWAY AGENCY: South Carolina Department of Transportation**

DATE OF NOISE POLICY: September 1, 2014

VIEWPOINT LANGUAGE WITHIN POLICY:

*Viewpoints of the property owners and residents of the benefited receptors.* SCDOT shall solicit the viewpoints of all of the benefited receptors and document a decision on either desiring or not desiring the noise abatement measure. The viewpoints will be solicited as part of the public involvement process through a voting procedure. The method of obtaining the votes shall be determined on a project-by-project basis, but may include flyers, door-to-door surveys, a public meeting, or a mailing. The voting ballot will explain that the noise abatement shall be constructed unless a majority (greater than 50% of the benefited receptors) of votes not desiring noise abatement is received.

For non-owner occupied benefited receptors, both the property owner and the renter may vote on whether the noise abatement is desired. One owner ballot and one resident ballot shall be solicited for each benefited receptor.

Home owner associations or local governments cannot be given authority over the desirability for abatement. The viewpoints of the abatement must be solicited from the property owners and tenants.

The viewpoints of the benefited residents and property owners should be a major consideration in determining the reasonableness of highway traffic noise abatement measures for proposed highway construction projects. These viewpoints should be determined and addressed during the environmental phase of project development. The will and desires of the public should be an important factor in dealing with the overall problems of highway traffic noise. SCDOT will make every effort to incorporate highway traffic noise consideration in our on-going activities for public involvement in the highway program.

Once a preferred alternative is recommended, a detailed noise analysis must be completed for any noise abatement that was determined feasible and reasonable during the preliminary noise analysis. The elements of the detailed noise are explained in Section 3.6. If applicable, a public involvement meeting will be held for the benefited receptors to solicit viewpoints. The detailed noise analysis must be completed in order for FHWA to approve the Categorical Exclusion or to provide a Finding of No Significant Impact or a Record of Decision.

**STATE HIGHWAY AGENCY: South Dakota Department of Transportation**

DATE OF NOISE POLICY: June 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

Viewpoints of the Property Owners and Residents of all Benefited Receptors (Activity Category B Land Uses)

When it is determined that it would be feasible to provide noise abatement for a site, and a preliminary determination has been made that abatement would be reasonable, a public informational meeting will be held as part of the process for a final determination of whether abatement would be reasonable. Benefited property owners and residents will be given an opportunity to vote on noise abatement by ballot. An information packet and a ballot will be sent by certified mail to all benefited property owners and residents, at least 14 days before the date of noise abatement meeting.

The votes will be weighed in the following manner:

- 3 points/ballot for benefited first row property owners
- 1 point/ballot for all other benefited property owners
- 1 point/ballot vote for all residents

Consideration of the noise abatement measure will continue unless more than 50% of all distributed points are returned* that indicate the balloted voters do not want the abatement measure. If the benefited property owners and residents vote to reject construction of a noise barrier, their area will not be reconsidered for future noise abatement unless another Type I project is proposed for the area.

For Activity Categories A, C, D and E, the views of the property owner or authority having jurisdiction over the property will be considered.

* Clarification, email on 8/24/15 from A. Whitebird, SDDOT: % based on only those that respond.

**STATE HIGHWAY AGENCY: Tennessee Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

2.3.2.4 Viewpoints of Benefited Property Owners and Residents

The input of the benefited property owners and residents will generally be received at planning, NEPA or design public hearings or public meetings. Input received at these hearings or meetings may be supplemented, as necessary, with formal survey methods on a case-by-case basis as discussed in the TEPM [*Tennessee Environmental Procedures Manual*]. TDOT will conclude that a community desires the construction of a noise barrier unless a majority (at least 51%) of the benefited property owners and residents indicate that they do not want the proposed noise barrier.

VIEWPOINT LANGUAGE WITHIN TENNESSEE ENVIRONMENTAL PROCEDURES MANUAL:

5.3.4.6.9 Views of Benefited Property Owners and Residents

Per TDOT's Noise Policy, the views of benefited property owners and residents will be considered in making final noise abatement decisions. This input will generally be received at planning, NEPA, or design public hearings or public meetings.

If a noise barrier has been determined to be both feasible and reasonable, TDOT will include a note in the public hearing or meeting advertisement indicating that noise barriers are proposed and that public comments will be solicited and received at the meeting or hearing. TDOT will also include a discussion of the noise barrier(s) in the presentation and provide a dedicated space on the comment card for noise barrier comments.

Experience on past projects has indicated that the vast majority of residents have supported TDOT's proposed noise barriers. However, there may be instances where benefited residents or property owners oppose the construction of noise barriers for various reasons including blockage of views, the loss of sunlight due to the shadow created by a noise barrier, and isolation effects.

If significant opposition exists and there is not clear support for the construction of the proposed noise barrier(s), TDOT will conduct a certified mail survey to solicit the views of the benefited residents and/or property owners that would be protected by the barrier(s). If a majority of benefited residents/property owners oppose the construction of a noise barrier, then the barrier will not be included as a "likely" noise abatement measure. Benefited residents and/or property owners that do not respond will be contacted a second time. A final determination will be made based upon the total responses received after the second survey.

Responses from residents or owners of properties that are predicted to be impacted as well as benefited will be counted as two responses. Responses from residents or owners of properties that are predicted to be benefited but not impacted will be counted as one response.*

TDOT will conclude that a community desires the construction of a noise barrier unless a majority (at least 51%) of the impacted [and benefited] property owners and residents indicate that they do not want the proposed noise barrier.

*Clarification from D. Reiter, a consultant specialist at TDOT: The two votes for a rental would be split with one for the owner and one for the renter if impacted, and 0.5 votes each if not impacted. The use of impacted and benefited voters on the decision NOT to build prevents non-impacted (and benefited) residents from deciding that a wall would not be built.

**STATE HIGHWAY AGENCY: Texas Department of Transportation**

DATE OF NOISE POLICY: April 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

a. Views of Benefitted Receptors

If noise abatement is determined to be feasible and cost effective, then benefitted property owners and residents will be surveyed to determine whether or not they desire noise abatement. This survey/ballot will preferably be by prestamped/preaddressed return envelope, and will include a package of material that describes the noise barrier under consideration and the noise effects with and without the barrier. It will also describe the decision making process that TxDOT will follow to assess the survey/ballot results and make a decision on whether to build the barrier. A noise workshop after a public hearing shall be conducted where noise impacts and abatement are discussed.

Ballots cast by residents will be obtained for viewpoints, but only ballots cast by property owners will count towards determining whether a noise barrier will be constructed or not. If the total respondents to the survey/ballot do not total a majority (50% + 1) of the benefitted receptors, then a second attempt will be made to solicit the views of those who did not respond. No third attempt is required if a majority (50% + 1) did not respond.* A majority (50% + 1) of the total benefitted receptors must indicate on the survey/ballot that they want a barrier constructed for it to be considered reasonable.

All survey/ballots must be returned to TxDOT, by a due date. If a majority (50%+1) of the total benefitted receptors do not respond by the due date or do not respond after the second attempt, then TxDOT will base their decision on the survey responses they received even though a majority of responses were not received.

Generally, residential property owners prefer traffic noise barriers, while commercial property owners prefer to maintain visibility for their business from adjacent roadways. This can cause conflicts in mixed-use developments, as noise barriers may block line of sight to adjacent businesses. When a mutually satisfactory compromise cannot be reached between businesses and residences, noise barriers may be terminated at property line dividing the two areas.

* Clarification in an email from R. Umscheid, 4/21/15: TxDOT may solicit responses a third time if there is a response rate of less than 50%+ 1.

**STATE HIGHWAY AGENCY: Utah Department of Transportation**

DATE OF NOISE POLICY: February 13, 2014

VIEWPOINT LANGUAGE WITHIN POLICY:

Viewpoints of Property Owners and Residents – Viewpoints of property owners and residents (non-owners) must be solicited to determine if noise abatement is desired.

1) Balloting –The Department needs to establish whether property owners and residents are in favor of noise abatement measures as part of the final design phase of projects. This process involves sending ballots to the following groups so they can indicate their preference for or against noise abatement measures:

a) All benefited receptors (property owners and residents). A benefited receptor is one that would receive a reduction of 8 dBA or more as a result of noise abatement.
b) Receptors that border and are directly adjacent to the end of a proposed noise wall that are not, by definition, benefited by the wall.

The number of votes is established as follows:

- Owner occupied residences: The owner will have 1 vote.
- Rental homes, multi-family residences and apartments: The owner will have 1 vote per unit and the resident (non-owner) will have 1 vote for the unit.
- Day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures: The owner will have 1 vote.
- Commercial/industrial businesses: The owner will have 1 vote per unit and, if applicable, the tenant will have 1 vote for the unit.
- Mobile home parks: The mobile home owner will have 1 vote. The lot owner, if different than the home owner, will have 1 vote.

2) Assessing Ballots - Property owners' votes will receive a multiplier factor of 5 compared to residents (non-owners) factor of 1 when the votes are counted. Noise abatement will only be recommended if 75 percent of votes counted, favor noise abatement. The denominator used to calculate this percentage will equal the total number of votes. At least 50 percent of the total number of completed ballots must be returned to adequately assess if noise abatement measures are desired. Noise abatement measures will be deemed not reasonable if less than 50 percent of ballots are returned after balloting efforts are completed. Ballots sent by U.S. Mail are deemed by the Department as "due diligence" in notifying the affected property owners and residents of possible noise mitigation measures in their area. Ballots will be sent by U.S. Mail to each property owner of record and each residing household/resident. Each ballot will include a deadline for return to the Department. A second ballot will be sent by Registered Mail to those who have not returned a ballot for ballots sent but not returned by the deadline. There will not be another opportunity to address noise impacts, once a noise wall is deemed to be unfeasible or unreasonable, until such time that another Type 1 project impacts the same area.

Policy contains a Noise Abatement Recommendation Checklist that contains the following questions related to viewpoints:

10. Does the Public Involvement balloting result in at least 75 percent of benefited and end-of-wall receptors voting in "favor" of the proposed noise abatement measure? Yes or No

If yes, proceed to Question #11. If no, noise abatement measures are not considered reasonable; proceed to decision segment of form.

11. Are there any environmental impacts that need special attention as a result of the implementation of the noise abatement? Yes or No

If yes, outline these impacts and discuss with the Environmental Manager or Region Project Manager.

**STATE HIGHWAY AGENCY: Vermont Agency of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

- What are the views of those who would benefit from noise abatement measures? Noise abatement measures may not be reasonable if the majority of benefitted receptors do not desire them. At least 50 percent of benefitted households and property owners surveyed must want the noise abatement measure. Surveys will be conducted in a way that responses can be documented, such as through the use of certified mail.

**STATE HIGHWAY AGENCY: Virginia Department of Transportation**

DATE OF NOISE POLICY: July 14, 2014

VIEWPOINT LANGUAGE WITHIN POLICY:

***3.10.1 Viewpoints of the benefited receptors.***

VDOT shall solicit the viewpoints of all benefited receptors through certified mailings and obtain enough responses to document a decision as to whether or not there is a desire for the proposed noise abatement measure. Fifty percent (50%) or more of the respondents shall be required to favor the noise abatement measure in determining reasonableness.

*Note – A second solicitation may be required depending on the results of the first solicitation. See Section 12.4 for more details.*

**Desires of Those Individuals Impacted by Highway Traffic Noise**

During the Final Design Phase, it is extremely important to determine if 50% or more of the owners and residents of benefited receptor units desire the noise barrier. Certified letters should be sent only to the owners and residents of the properties that were determined to be benefited by the proposed barrier. Any receptor unit owner opposed to the proposed noise barrier must submit a signed letter or indicate on the voting survey form his/her opposition to the proposed noise barrier. This will serve as an indication that he/she thoroughly understands that there will be future noise impacts and that, if a noise barrier is declined by the community at this time, a noise barrier will not be built in the future for the area unless another Type I project occurs.

**12.4 Voting Procedures**

The method of obtaining votes from the owners and residents of benefited receptors (i.e., via certified mailings, public meeting, etc.) shall be determined by the Central Office Noise Abatement Staff on a project-by-project basis. Regardless of method, the vote (whether or not there is a desire for a barrier) of each benefited receptor must be documented. *Note – The preferred method of contacting the owners and/or residents for the first time shall be certified mail. Twenty-one (21) calendar days from the anticipated delivery date is required to provide the recipients ample time to review and respond to the survey.*

**12.4.1 Voting on the Construction of the Noise Barrier**

Only the owners and residents of those receptor units that will be benefited by the proposed mitigation may vote on whether the proposed noise barrier should be constructed. The owner/resident of each benefited receptor unit shall be entitled to one weighted vote, regardless of the number of owners of that receptor unit unless they are the owners of a rental facility or the developer of lands. The weighting system is provided in tabular format below (***Table 2 below)***. Votes will be tallied on a noise barrier by noise barrier basis, so it is recommended that the project team tally the votes and summarize the results on a project map showing votes by location. Final interpretation of the voting results will be made by VDOT and its consultants, considering all feedback gained during the public involvement process.

Of the votes tallied, 50% or more must be in favor of a proposed noise barrier in order for that noise barrier to be considered further. The Noise Abatement Staff will assess the number and location of any opposing votes on a noise barrier by noise barrier basis. This may result in partial highway traffic noise abatement or construction of noise barriers despite opposing votes. The receptor unit owner opposing a proposed noise barrier must submit a signed survey form expressing his/her opposition to the proposed noise barrier, and this must be documented.

*Note – Partial Highway Traffic Noise Abatement: VDOT is dedicated to providing feasible and reasonable noise abatement. If the opposing votes are located in areas where partial highway traffic noise abatement is feasible and reasonable without compromising or jeopardizing the noise barrier's abatement ability for the remaining impacted and benefiting receptors, every reasonable effort must be made to accommodate the needs and wants of every impacted and benefited receptor, despite their approval of or opposition to the proposed noise barrier.*

*Note – Homeowners Associations: If the benefited receptors units are a part of a homeowner's association, only those receptor units benefited by the proposed noise barrier will have a vote.*

*Note – Change of property ownership: If a benefited property changes ownership after the public survey and before construction of the noise barrier only the original owner's vote is considered. Note –If a project is undergoing a written NEPA re-evaluation because it has been inactive for at least 3 years, then the citizens benefited by a previously identified and publicly approved noise barrier should be re-surveyed. However, if a project has been active and steps have been taken to advance the project since the last citizen survey and a re-evaluation is not being conducted because of the passage of time, then the original survey is considered up to date.*

Table 2

**Table 2**
**Public Opinion Survey Weighting System[5]**

| Impact and benefit category | Activity Category[4] | Owner and Resident | Non-Resident Owner | Renter |
|---|---|---|---|---|
| Impacted & Benefited | A | See note below | | |
| Not Impacted & Benefited | | | | |
| Impacted & Benefited | B[1] | 5 | 3 | 2 |
| Not Impacted & Benefited | B[1] | 3 | 2 | 1 |
| Impacted & Benefited | C[2] | | 5 | |
| Not Impacted & Benefited | C[2] | | 3 | |
| Impacted & Benefited | D | | 2 | |
| Not Impacted & Benefited | D | | 1 | |
| Impacted & Benefited | E | | 2 | |
| Not Impacted & Benefited | E | | 1 | |

[1] For activity Category B Receptors only one vote per single family unit will be counted. However the owner of a multiple-family dwelling unit will be granted one vote per benefited unit. Additionally the developer of permitted lands will be granted one vote per benefited lot of the permitted phase where construction has not occurred.

[2] For activity Category C Receptors only 1 vote per facility will be granted.

[3] For activity Category G Receptors the votes will depend on the future land use. The example provided above assumes a residential development.

[4] For permitted land uses defer to the appropriate land use category.

[5] Consult the VDOT external website to obtain the decision making spreadsheet.

**STATE HIGHWAY AGENCY: Washington State Department of Transportation**

DATE OF NOISE POLICY: October 2012

VIEWPOINT LANGUAGE WITHIN POLICY:

Community Polling

Polling should be conducted as early in the design process as possible to verify the opinions of people impacted by the project and benefitting from the proposed barrier. The results of the poll are considered when determining whether a barrier or other practical mitigation is reasonable, and thus implemented.

The presumption is that abatement is desired by the affected community. However, a formal poll of the opinions of eligible property owners and residents shall be conducted if opposition from members of the community within the noise study area is expressed during the public involvement process. Outreach efforts shall clarify that support for the wall is also a waiver of future claims for compensation from any effects to light, view, and air, from the abatement as designed. Noise abatement will not be planned if, after community polling is conducted, it is documented that the majority of the impacted and benefitting receivers within the study area oppose the proposed noise abatement.

Polls, petitions, or surveys of the community's desires will only be considered valid if the following occurs in conjunction with other criteria of this chapter:

- Performed by WSDOT or WSDOT representatives;
- Clarify that there will be no compensation for any effects to light, view, and air, that may be caused by the abatement;
- Contain the address, signature and printed name of property owner and/or residents along with their expressed opinion concerning abatement.

*Receiver Eligibility and Weighting*

The opinions of impacted or benefitted receivers within the noise study area are considered eligible for formal polling. The purpose of abatement is to noticeably reduce noise for those most affected by highway traffic noise. Noise barriers primarily benefit and/or affect those closest to the wall, so weighting of eligible receivers is based on their locations within the noise study area. Specific weighting of polling responses from benefitting receivers is as follows:

- First row eligible receivers are granted 1.5 votes per residential unit.
- Eligible receivers beyond the first row are granted 1.0 vote per residential unit.
- If eligible receiver locations are not owner-occupied, the opinions of both the renter and property owner shall be considered. When the two opinions differ, the renter's opinion shall reduce the weight of the property owner's response for that unit by one-half. When polling responses are not received from the renter, the property owner's vote will represent the voting unit.
- Non-residential units identified as sensitive receivers (churches, schools, public parks, cemeteries, etc) will be evaluated on a residential equivalent basis. Eligible receivers in the first row will receive 1.5 votes for each residential equivalent, and benefitting receivers beyond the first row will be granted 1.0 vote. Eligible receivers will always receive at least one vote.
- After the votes are tallied, the department will evaluate the results in combination with other feasibility and reasonableness considerations to make the final decision about whether noise abatement will be included in the project. Noise abatement will not be planned if the majority of weighted votes oppose the proposed noise abatement. If the weighted votes support the noise abatement, but changes to the project in final design make noise abatement no longer feasible or reasonable, noise abatement will not be included in the project. In the event of a tie, the department may seek input from additional stakeholders.

- Alternative parameters and voting guidelines may be identified for projects with unusual topography, cultural, or historic significance (e.g., structures over water, historic districts) and need to be evaluated by the WSDOT Air Quality, Noise Energy Program on a case-by-case basis. FHWA approval is required for alternative voting procedures used on federal aid projects.

*Documentation of Public Involvement Process*

- The project engineering office or project sponsor will be responsible for ensuring that the opinions of each community are known to the department and that correspondence and written documentation is completed. Polling should be conducted using certified mail to ensure that ballots are received. The same people surveyed shall be notified of the department's final decision regarding abatement.
- Noise sensitive receivers within the study area that can demonstrate a negative effect to their property values from the proposed abatement, but are neither impacted nor benefitted, may be eligible for a maximum 1.0 vote.

**STATE HIGHWAY AGENCY: West Virginia Division of Highways**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

It is state policy that the final determination of reasonableness will be made only after a careful and thorough consideration of a wide range of criteria. However, noise barriers will definitely not be built if a majority of benefited receptors do not want them. During the environmental phase (NEPA) of a project it will be assumed that the benefited receptors will want a noise barrier.

During the design phase of the project after the exact location and design of the project have been determined a public meeting will be held to provide detailed information on the design of the project and possible noise barriers. During the design phase of the project a public meeting will be held for residents and owners of benefited receptors. After the public meeting a survey will be conducted of the benefited receptors to determine if they want a noise barrier. Local officials will also be invited and encouraged to attend this public meeting. After the public meeting a survey will be conducted to determine if the residents and owners of the benefited receptors want a noise barrier. Local officials will be encouraged to consider highway traffic noise in the land use planning process.

The construction of a noise barrier is not reasonable unless a majority of residents and property owners of the benefited receptors (receptors that receive a noise reduction of 5 dBA or more from the noise barrier) want a noise barrier even if all other criteria indicate that a noise barrier is reasonable.

From Noise Barrier Evaluation Form

| | REASONABLENESS | | | |
|---|---|---|---|---|
| Required Factor Related to Viewpoints | Not Reasonable | Marginally Reasonable | Fully Reasonable | Highly Reasonable |
| % of benefited receptors wanting barrier | <50% | 50-60% | 61-75% | >75% |

**STATE HIGHWAY AGENCY: Wisconsin Department of Transportation**

DATE OF NOISE POLICY: July 28, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

20.1 Public Information Meeting

The department shall hold one or more public information meetings, in a location convenient to the locality to be affected by the proposed noise barrier, to provide an opportunity for local participation in the selection and development of the noise barrier installation project. The department shall arrange for published notice of each information meeting. The department shall also give direct written notice of each public information meeting to each person owning real property or leasing a residence in the following locations:

- Within 500 feet in any direction from the proposed noise barrier, or,

- Within the areas directly behind the proposed noise barrier and directly across the highway from the proposed noise barrier where the highest hourly traffic noise level approaches or exceeds the levels in FDM 23-30 Table 2.1, Noise Level Criteria For Considering Barriers.

Exhibits available at the public information meeting should include:

*FDM 23-35 Noise Abatement Measures*

- A Handout Packet that typically it includes the following;

- Cover sheet

- Handout packet contents

- Welcome

- Project location map

- Noise barrier(s) location map

- Purpose of public information meeting including a brief project summary

- Explanation of the noise barrier selection process

- Future actions including project schedule

- Construction time frame if it is determined that the noise barrier will be include in the project

- WisDOT contact information

- Comment sheet

- Aerials showing the location of the barrier(s) including;

- Street names

- Property addresses and lot lines

- Before and after sound levels at receptors

- Barrier section heights

- Conceptual renderings and photos showing the barrier(s) in relation to buildings.

- Pre-approved barrier product samples and brochures that show available barrier systems, colors and textures.

- Extra voting ballots for those owners and tenants of benefited receptors that want to submit a vote at the public information meeting.

- Applicable real estate brochures if real estate acquisition is required as part of the project.

## 20.5 Voting

For a proposed noise barrier project to be considered for construction, the department must receive a vote of support for the project from a simple majority of all votes cast by the owners or residents of the benefitted receptors as follows:

- For each benefited receptor that is an owner-occupied residence, the owner shall have one vote

- For each benefitted receptor that is not an owner-occupied residence, the owner shall have one vote and one resident shall have one vote

The ballot shall be sent to each eligible voter by registered mail, return receipt requested. A self-addressed, stamped envelope shall also be included with the ballot. The Region Office will determine who is responsible for collecting ballots.

The public meeting notice shall be included in the mailing transmitting the ballot. There should be an explanation included in the cover letter that the ballot can be submitted at the public information meeting or by using the self-addressed stamped envelope. A date for returning the ballot of no less than thirty (30) days after the public information meeting should also be included.

The noise barrier selection process needs to be clearly defined in the cover letter included with the ballot sent to the eligible voters. It is important for voters to understand that the selection of the barrier system to be constructed is the sole responsibility of the contractor awarded the project. Owner and resident input will likely be limited to barrier color and texture.

All reasonable effort should be made to ensure that each eligible voter returns a ballot indicating whether or not they support construction of the noise barrier. Such efforts could include phone calls and personal visits to those owners and tenants not returning a ballot by mail or at the public information meeting.

Documentation of the various methods used to gather votes should be included as part of the administrative record.

Documentation of the final vote tally and decision of whether or not to construct the noise barrier(s) should also be included as part of the administrative record.

**STATE HIGHWAY AGENCY: Wyoming Department of Transportation**

DATE OF NOISE POLICY: July 13, 2011

VIEWPOINT LANGUAGE WITHIN POLICY:

1) The viewpoints of the property owners and the residents of benefited receptors shall be considered. Viewpoints of all benefited receptors will be solicited and sufficient response received to estimate the aggregate view of the receptors as to if noise abatement measures are desired or not. 51% of benefited receptors responding must agree to the noise abatement measures.