# RAIL TRANSIT NOISE AND VIBRATION TECHNICAL REPORT FOR NORTH I-25 FINAL ENVIRONMENTAL IMPACT STATEMENT

**August 2011**

**Prepared for:**

Felsburg Holt & Ullevig
6300 South Syracuse Way, Suite 600
Centennial, CO 80111

**Prepared by:**

Harris Miller Miller & Hanson Inc.
77 South Bedford Street
Burlington, MA 01803

# TABLE OF CONTENTS

# LIST OF FIGURES



# LIST OF TABLES

# 1.0 INTRODUCTION TO ANALYSIS

This technical report presents a noise and vibration impact assessment for the commuter rail facilities included within Package A and the Preferred Alternative of the Final Environmental Impact Statement (FEIS) for the North I-25 Corridor, which extends from Fort Collins to Brighton, CO. The objective of the study is to assess the potential noise and vibration impacts of passenger rail operations at sensitive community locations along the project corridor. The analysis was carried out in conformance with the procedures and criteria prescribed in the U. S. Federal Transit Administration (FTA) guidance manual *Transit Noise and Vibration Impact Assessment* (Report FTA-VA-90-1003-06, May 2006).

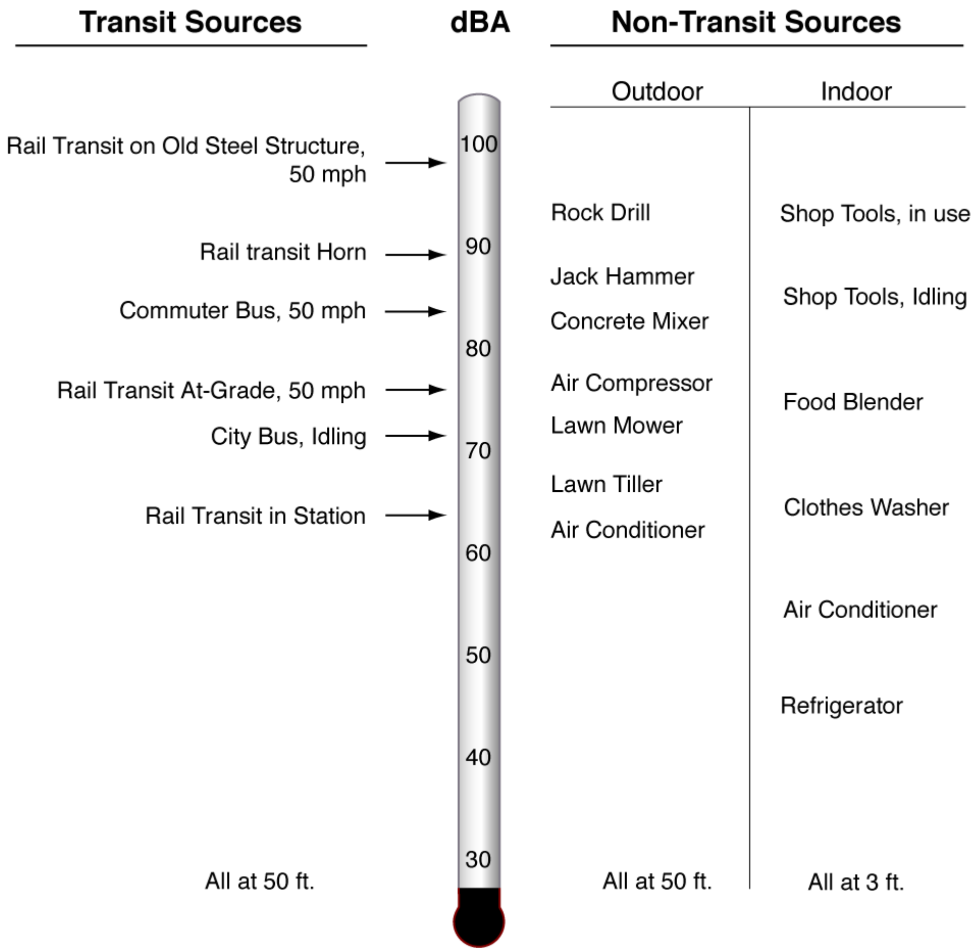
Environmental noise and vibration basics are discussed below followed by a description of the existing baseline noise and vibration conditions in **Section 2.0** (Affected Environment). The methodology and results of the noise and vibration impact evaluation are then described in **Section 3.0** (Environmental Consequences), potential mitigation measures are discussed in **Section 4.0** and supporting documentation is provided in the appendices. **Appendix A** includes photographs of the measurement sites, and detailed noise and vibration measurement data are provided in **Appendix B** and **Appendix C**, respectively. **Appendix D** includes maps showing the locations of projected noise and vibration impacts.

## 1.1 NOISE FUNDAMENTALS AND DESCRIPTORS

Noise is typically defined as unwanted or undesirable sound, where sound is characterized by small air pressure fluctuations above and below the atmospheric pressure. The basic parameters of environmental noise that affect human subjective response are (1) intensity or level, (2) frequency content and (3) variation with time. The first parameter is determined by how greatly the sound pressure fluctuates above and below the atmospheric pressure, and is expressed on a compressed scale in units of decibels. By using this scale, the range of normally encountered sound can be expressed by values between 0 and 120 decibels. On a relative basis, a 3-decibel change in sound level generally represents a barely-noticeable change outside the laboratory, whereas a 10-decibel change in sound level would typically be perceived as a doubling (or halving) in the loudness of a sound.

The frequency content of noise is related to the tone or pitch of the sound, and is expressed based on the rate of the air pressure fluctuation in terms of cycles per second (called Hertz and abbreviated as Hz). The human ear can detect a wide range of frequencies from about 20 Hz to 17,000 Hz. However, because the sensitivity of human hearing varies with frequency, the A-weighting system is commonly used when measuring environmental noise to provide a single number descriptor that correlates with human subjective response. Sound levels measured using this weighting system are called "A-weighted" sound levels, and are expressed in decibel notation as "dBA." The A-weighted sound level is widely accepted by acousticians as a proper unit for describing environmental noise. To indicate what various noise levels represent, **Figure 1-1** shows some typical A-weighted sound levels for both transit and non-transit sources. As indicated in this figure, most commonly encountered outdoor noise sources generate noise levels within the range of 60 dBA to 90 dBA at 50 feet.

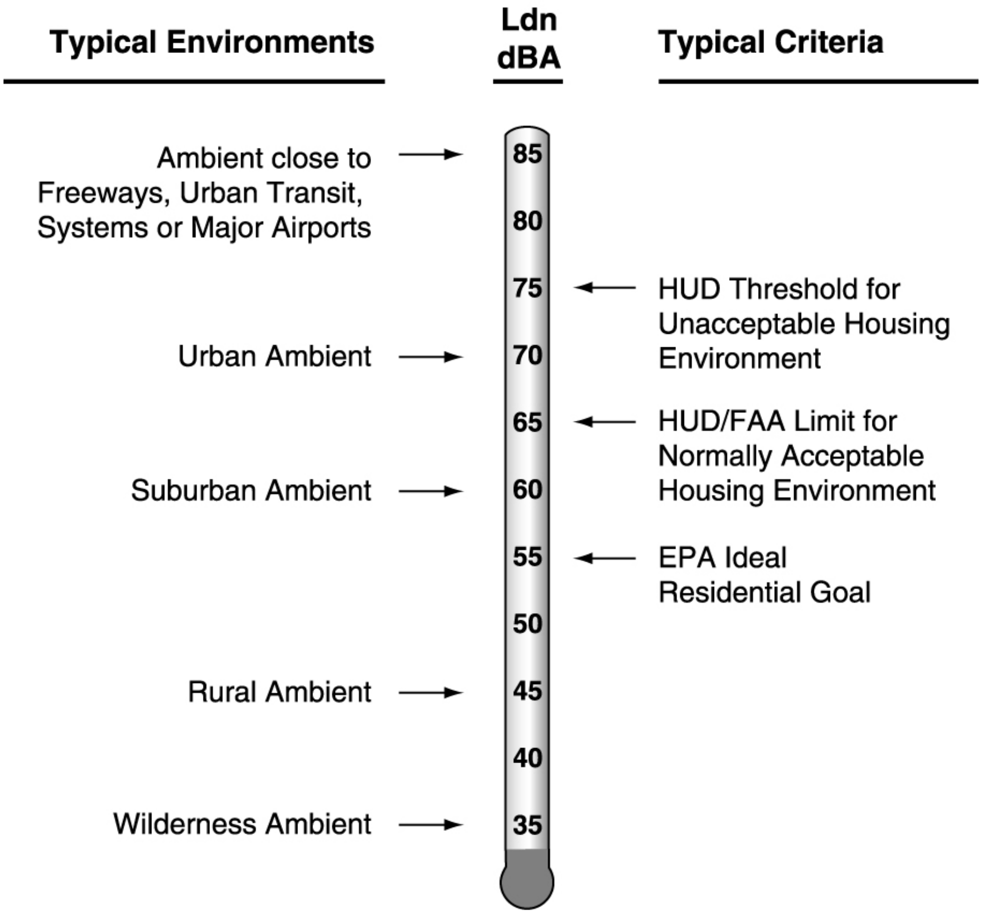
**Figure 1-1 Typical A-Weighted Sound Levels**




Because environmental noise fluctuates from moment to moment, it is common practice to condense all of this information into a single number, called the "equivalent" sound level (Leq). Leq can be thought of as the steady sound level that represents the same sound energy as the varying sound levels over a specified time period (typically 1 hour or 24 hours). Often the Leq values over a 24-hour period are used to calculate cumulative noise exposure in terms of the Day-Night Sound Level (Ldn). Ldn is the A-weighed Leq for a 24-hour period with an added 10-decibel penalty imposed on noise that occurs during the nighttime hours (between 10 PM and 7 AM). Many surveys have shown that Ldn is well correlated with human annoyance, and therefore this descriptor is widely used for environmental noise impact assessment. **Figure 1-2** provides examples of typical noise environments and criteria in terms of Ldn. While the extremes of Ldn are shown to range from 35 dBA in a wilderness environment to 85 dBA in noisy urban environments, Ldn is generally found to range between 55 dBA and 75 dBA in most communities. As shown in **Figure 1-2**, this spans the range between an "ideal" residential environment and the threshold for an unacceptable residential environment according to U.S. Federal agency criteria.

Environmental noise can also be viewed on a statistical basis using percentile sound levels, Ln, which refer to the sound level exceeded "n" percent of the time. For example, the sound level exceeded 90 percent of the time, denoted as L90, is often taken to represent the "background" noise in a community. Similarly, the sound level exceeded 33 percent of the time (L33) is often used to approximate the Leq in the absence of loud, intermittent sources such as aircraft and trains.

**Figure 1-2 Examples of Typical Outdoor Noise Exposure**



# 1.2 VIBRATION FUNDAMENTALS AND DESCRIPTORS

Ground-borne vibration is the oscillatory motion of the ground about some equilibrium position, which can be described in terms of displacement, velocity or acceleration. Displacement refers to the distance an object moves away from its equilibrium position, velocity refers to the rate of change in displacement or the speed of this motion, and acceleration refers to the time rate of change in the velocity of the object. At any given frequency of oscillation, vibration displacement, velocity and acceleration are related by a constant factor. However, vibrations are often more complex in the environment, including components at many different frequencies. Therefore, the relationship between the overall vibration levels in terms of these descriptors depends on the frequency content of the vibration energy.

Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing ground-borne vibration. One reason for this is that most sensors used for measuring ground-borne vibration are designed to provide output signals proportional to either velocity or acceleration. Even more important, the response of humans, buildings and equipment to vibration is more accurately described using velocity or acceleration. Because sensitivity to vibration has typically been found to correspond to a constant level of vibration velocity amplitude within the low frequency range of most concern for environmental vibration (roughly 5-100 Hz), vibration velocity is used in this analysis as the primary measure to evaluate the effects of vibration.

There are several different measures used to quantify vibration amplitude. One of the most common is the peak particle velocity (PPV), defined as the maximum instantaneous positive or negative peak of the vibratory motion. PPV is often used in monitoring blasting vibration since it is related to the stresses experienced by building components. Although PPV is appropriate for evaluating the potential for building damage, it is less suitable for evaluating human response, which relates better to an average vibration amplitude. Because the net average of a vibration signal about its equilibrium position is zero, the root mean square (rms) amplitude is often used to describe the "smoothed" vibration amplitude. The rms amplitude is defined as the average of the squared amplitude of the signal, and is typically evaluated over a one-second period of time.

Although vibration velocity is normally described in units of inches per second in the USA, the decibel notation, which acts to compress the range of numbers required to describe vibration, can also be used. In this notation, the vibration magnitude can be expressed in terms of velocity level, in decibels, defined as follows:

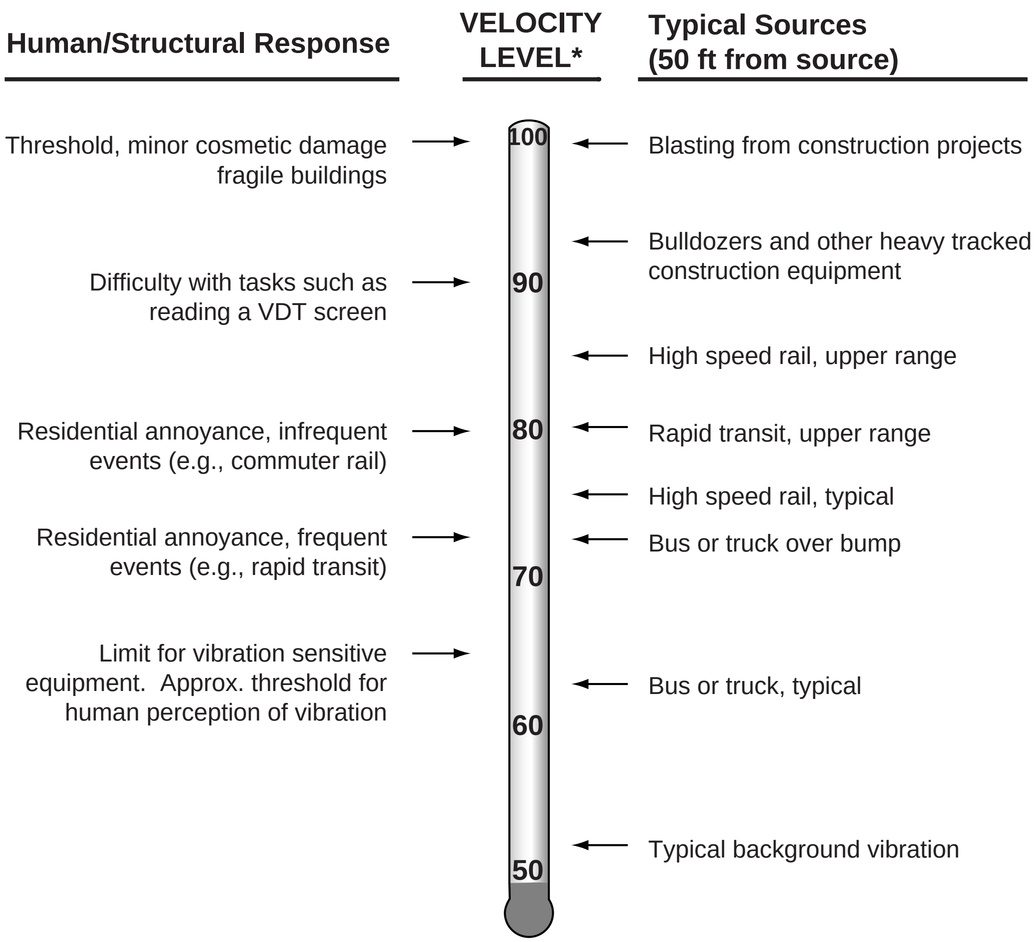
$$L_v = 20 \cdot \log_{10}(v/v_{ref}), \text{ VdB}$$

where: $v$ = rms velocity, inches/second

$v_{ref}$ = $1 \times 10^{-6}$ in./sec

Thus, the descriptor used for this assessment of ground-borne vibration is the rms vibration velocity level, Lv, expressed in vibration decibels (VdB) relative to one micro-inch per second. **Figure 1-3** illustrates typical ground-borne vibration levels for common sources as well as criteria for human and structural response to ground-borne vibration. As shown, the range of interest is from approximately 50 VdB to 100 VdB, from imperceptible background vibration to the threshold of damage. Although the threshold of human perception to vibration is approximately 65 VdB, annoyance is not usually significant unless the vibration exceeds 70 VdB.

**Figure 1-3 Typical Ground-Borne Vibration Levels and Criteria**




** RMS Vibration Velocity Level in VdB relative to $10^{-6}$ inches/second*

# 2.0 AFFECTED ENVIRONMENT

Noise-sensitive and vibration-sensitive receptors along the rail corridor include numerous single-family residences as well as some multi-family residences, schools and parks. The primary sources that contribute to the existing noise environment at most of these locations are freight train operations on the Burlington Northern Santa Fe (BNSF) track, including horns that are sounded in the vicinity of grade crossings, and motor vehicle traffic on major nearby roadways. Other noise sources include aircraft over flights and general residential and commercial activities. BNSF freight train operation is the only significant source of existing ground-borne vibration along the project corridor and represents the dominant source of existing noise and vibration along the segment of the corridor between Fort Collins and Longmont.

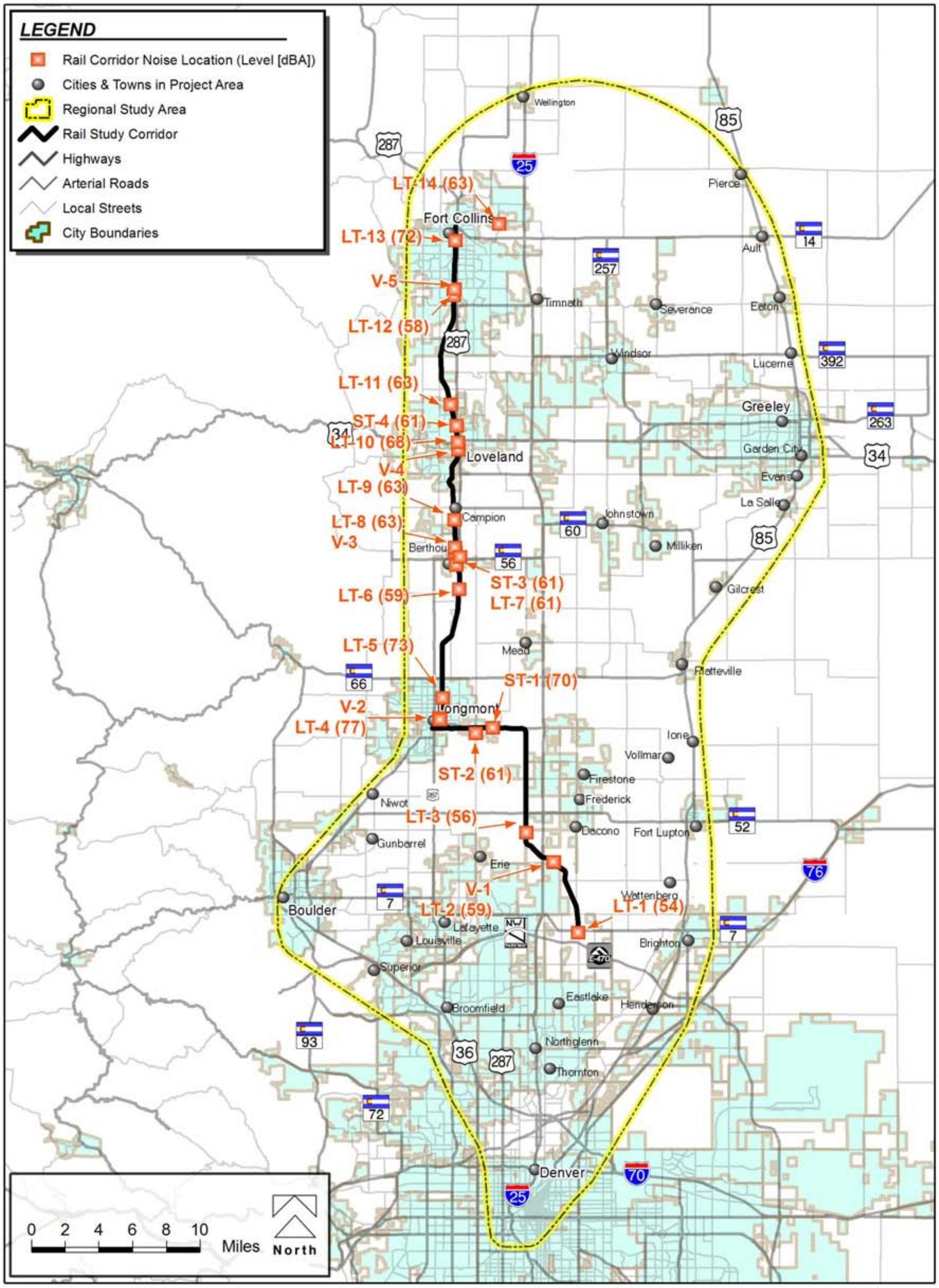
## 2.1 EXISTING NOISE LEVELS

To characterize the existing baseline noise conditions at sensitive receptors along the corridor, a field measurement program was carried out on weekdays during the period from October 18 through October 27, 2006. The measurement program included both long-term and short-term monitoring of the A-weighted sound level at representative noise-sensitive receptor locations. Fourteen sites, designated as Sites LT-1 through LT-14, were selected for long-term (24-hour) monitoring and four (4) sites, designated as Sites ST-1 through ST-4, were selected for short-term (one-hour) monitoring. The general locations of these measurement sites are indicated in **Figure 2-1**, and site photographs are included in **Appendix A**.

At each of the long-term sites, unattended Larson Davis Model 870 or 820 portable, automatic noise monitors were used to continuously sample the A-weighted sound level (with slow response), over one 24-hour period. The noise monitors were programmed to record hourly results, including the maximum sound level (Lmax), the equivalent sound level (Leq) and the statistical percentile sound levels (Ln, denoting the sound level exeeded n-percent of the time). The day-night equivalent sound level (Ldn) was subsequently computed from the hourly Leq data. In addition, the noise monitors at the long-term sites were programmed to collect single-event noise data for train operations, where applicable. At the short-term sites, an attended Larson Davis Model 820 noise monitor was used to obtain the equivalent, A-weighted sound level for 1-minute intervals over one-hour periods. The one-minute Leq data were then combined to obtain the Leq for the 60-minute periods.

All the noise measurement equipment described above conforms to ANSI Standard S1.4 for Type 1 (Precision) sound level meters. Calibrations, traceable to the U.S. National Institute of Standards and Technology (NIST) were carried out in the field before and after each set of measurements using acoustical calibrators. In all cases, the measurement microphone was protected by a windscreen, and supported on a tripod at a height of 4 to 6 feet above the ground. Furthermore, the microphone was positioned to characterize the exposure of the site to the dominant noise sources in the area. For example, microphones were located at the approximate setback lines of the receptors from adjacent roads or rail lines, and were positioned to avoid acoustic shielding by landscaping, fences or other obstructions.

## Figure 2-1 Existing Noise and Vibration Measurement Locations



The results of the existing ambient noise measurements are summarized in **Table 2-1**, and detailed data are included in **Appendix B**. These results serve as the basis for determining the existing noise conditions at all noise-sensitive receptors along the proposed North I-25 Corridor commuter rail alignment. The results at each long-term and short-term monitoring site are described below, from south to north:

- Site LT-1: 15930 Jackson Street – Brighton. This site was in the back yard of a single-family residence in the Sunset Vista Estates development, located south of SH 7 and west of Colorado Boulevard. Although there is an existing Dent Line railroad track located 150 feet east of this home, trains do not currently use this track and thus only road traffic, aircraft and local activity contribute to the existing noise exposure. The measured Ldn of 55 dBA at this site was adjusted down to 54 dBA to exclude the noise from power tools that were used nearby during one hour of the day. This noise level is considered representative of the existing noise exposure for sites at the south end of the alignment along Colorado Boulevard and Weld County Road 13.
- Site LT-2: 4647 Chia Court – Dacono. This site was on vacant city-owned property adjacent to a single-family home in the Sweetgrass residential development. While there are some remnants of the Dent Line railroad track adjacent to this site, the existing noise exposure is mainly affected by traffic on I-25 and local roads as well as by aircraft. The measured Ldn of 59 dBA is taken to be representative of the existing noise environment at the homes in this new development.
- Site LT-4: 514 Atwood Street – Longmont. This site was in front of a residential duplex on the east side of Atwood Street in Longmont, where the existing BNSF railroad track runs along the median of the street. The measured Ldn of 77 dBA at this site was dominated by freight trains that sound their horns near the numerous grade crossings in this area. Five daytime trains and one nighttime train passed by this site during the monitoring period, generating maximum noise levels in the range of 105 dBA to 111 dBA. Without the trains, it is estimated that the Ldn from other ambient noise sources (e.g. local traffic and aircraft) would be only 55 dBA.
- Site LT-5: 1556 Centennial Drive – Longmont. This site was behind a single family home that backs up to the west of the existing BNSF railroad track in the north section of Longmont. The measured Ldn of 73 dBA at this site was dominated by freight trains, particularly by those heading north and approaching the nearby grade crossing at 17th Avenue. Five daytime trains and two nighttime trains passed by this site during the monitoring period, with northbound trains generating maximum noise levels of 102 dBA to 113 dBA from their horns; southbound trains generated maximum noise levels of 82 dBA to 91 dBA from their locomotives. Without the trains, it is estimated that the Ldn from other ambient sources would be only 51 dBA.

## Table 2-1 Summary of Existing Ambient Noise Measurement Results

| Site No. | Measurement Location Description | Dist. from BNSF Track (feet) | Start of Measurement | | Meas. Dur. (hr) | Outdoor Noise Exposure | | |
|---|---|---|---|---|---|---|---|---|
| | | | Date | Time | | Ldn (dBA) With Trains | Ldn (dBA) w/o Trains | Leq (dBA) |
| LT-1 | 15930 Jackson Street – Brighton (near unused track) | N/A | 10/18/06 | 19:00 | 24 | -- | 54 | -- |
| LT-2 | 4647 Chia Court – Dacono (near unused track) | N/A | 10/19/06 | 13:00 | 24 | -- | 59 | -- |
| LT-3 | 4871 County Road 7 – Erie (100 ft from road) | N/A | 10/19/06 | 15:00 | 24 | -- | 56 | -- |
| LT-4 | 514 Atwood Street – Longmont (track in median of street) | 80 | 10/19/06 | 17:00 | 24 | 77 | 55 | -- |
| LT-5 | 1556 Centennial Drive - Longmont | 50 | 10/23/06 | 10:00 | 24 | 73 | 51 | -- |
| LT-6 | 1375 S. County Road 15 – Berthoud (120 ft from road; track in cut) | 90 | 10/23/06 | 10:00 | 24 | 59 | 52 | -- |
| LT-7 | 208 3rd Street – Berthoud | 80 | 10/23/06 | 11:00 | 24 | 61 | 50 | -- |
| LT-8 | 1220 N. 4th Street – Berthoud (near potential maintenance facility site) | 180 | 10/23/06 | 11:00 | 24 | 63 | 50 | -- |
| LT-9 | 5105 S. Iowa Avenue – Campion | 120 | 10/24/06 | 13:00 | 24 | 63 | 53 | -- |
| LT-10 | 1246 N. Arthur Avenue – Loveland (track in cut) | 50 | 10/24/06 | 14:00 | 24 | 68 | 58 | -- |
| LT-11 | 4355 Filbert Drive – Loveland | 120 | 10/24/06 | 15:00 | 24 | 63 | 51 | -- |
| LT-12 | 328 Albion Way – Fort Collins | 150 | 10/26/06 | 15:00 | 24 | 58 | 56 | -- |
| LT-13 | 635 Mason Street – Fort Collins (track in median of street) | 80 | 10/26/06 | 16:00 | 24 | 72 | 60 | |
| LT-14 | 401 N. Timberline Road, Unit #178 – Fort Collins (near potential maintenance facility site) | N/A | 10/26/06 | 15:00 | 24 | -- | 63 | -- |
| ST-1 | SH-119 at Fairview Street – Longmont (170 feet from highway) | N/A | 10/24/06 | 17:10 | 1 | -- | 68 (est.) | 70 |
| ST-2 | Weld County Line Road 1 at Great Western Drive – Longmont (near potential station site) | N/A | 10/27/06 | 08:00 | 1 | -- | 59 (est.) | 61 |
| ST-3 | Peakview Meadows (SH 287 at Turner Avenue) – Berthoud (near potential station site) | N/A | 10/26/06 | 17:15 | 1 | -- | 59 (est.) | 61 |
| ST-4 | 2639 Cedar Drive at N. Garfield Avenue – Loveland (near potential station site) | N/A | 10/24/06 | 15:10 | 1 | -- | 59 (est.) | 61 |

- Site LT-6: 1375 S. County Road 15 – Berthoud. This site was next to a single-family home along County Road 15 that backs up to the east of the existing BNSF railroad track. The nearest grade crossing is to the north, and thus northbound trains tend to generate higher noise levels at this site due to horn use. The track behind the home is in a deep trench, which provides some noise shielding; however, because the major train noise sources (i.e. horns as well as engine exhausts and cooling fans) are at the tops of the locomotives, these sources are not shielded when closest to the home. Six daytime trains and one nighttime train passed by this site during the monitoring period, causing maximum noise levels of 84 dBA to 98 dBA for northbound trains and 84 dBA to 86 dBA for southbound trains. Without the trains, it is estimated that the Ldn from other ambient sources (primarily traffic on County Road 15) would be 52 dBA.
- Site LT-7: 208 3rd Street – Berthoud. This site was in the back yard of a single-family home that backs up to the west of the existing BNSF railroad track in the south section of Berthoud. The measured Ldn of 61 dBA at this site was dominated by freight trains and, because the nearest grade crossing is to the north at Mountain Avenue, northbound trains tend to generate higher noise levels at this site due to horn use. Six daytime trains and one nighttime train passed by this site during the monitoring period, with northbound trains generating maximum noise levels of 85 dBA to 104 dBA and southbound trains generated maximum noise levels of 77 dBA to 86 dBA. Without the trains, it is estimated that the Ldn from other ambient noise sources would be 50 dBA.
- Site LT-8: 1220 N. 4th Street – Berthoud. This site was in the back yard of a single-family home that backs up to the west of the existing BNSF railroad track in the north section of Berthoud. In addition to abutting the proposed commuter rail alignment, the rear of this property faces a proposed operation and maintenance facility site to the east of the tracks. The measured Ldn of 63 dBA at this site was dominated by freight trains that typically sound their horns approaching the grade crossings to the north and south of this location. Six daytime trains and one nighttime train passed by this site during the monitoring period, generating maximum noise levels in the range of 85 dBA to 100 dBA. Without the trains, it is estimated that the Ldn from other ambient noise sources would be only 50 dBA.
- Site LT-9: 5105 S. Iowa Avenue – Campion. This site was in the back yard of a single-family home that backs up to the east side of the existing BNSF railroad track between Berthoud and Loveland. The measured Ldn of 63 dBA at this site was dominated by freight trains; because there are no grade crossings nearby, train horns don't tend to be sounded and the major noise is caused by the locomotives themselves. Three daytime trains and one nighttime train passed by this site during the monitoring period, generating maximum noise levels in the range of 84 dBA to 88 dBA. Without the trains, it is estimated that the Ldn from other ambient noise sources (primarily from traffic on nearby US-287) would be 53 dBA.
- Site LT-10: 1246 N. Arthur Avenue – Loveland. This site was at the rear fence line of a single-family property that backs up to the west side of the existing BNSF railroad track, which is located in a deep cut in this area to the south of the Eisenhower Boulevard overpass. The measured Ldn of 68 dBA at this site was dominated by freight trains; because there are no grade crossings very close by, noise from train horns is limited at this location. Two daytime trains and one nighttime train passed by this site during the monitoring period, generating maximum noise levels in the range of 86 dBA to 97 dBA.

Without the trains, it is estimated that the Ldn from other ambient noise sources would be 58 dBA.

- Site LT-11: 4355 Filbert Drive – Loveland. This site was in the back yard of a single-family home that backs up to the east side of the existing BNSF railroad track. The measured Ldn of 63 dBA at this site was dominated by freight trains; because there are no grade crossings nearby, train horns are not typically sounded at this location. Two daytime trains and two nighttime trains passed by this site during the monitoring period, generating maximum noise levels in the range of 82 dBA to 91 dBA. Without the trains, it is estimated that the Ldn from other ambient noise sources would be 51 dBA.
- Site LT-12: 328 Albion Way – Fort Collins. This site was in the back yard of a single-family home that backs up to the west side of the existing BNSF railroad track. The measured Ldn of 58 dBA at this site resulted from a combination of noise from freight trains and other ambient sources; because there are no grade crossings nearby, train horns are not typically sounded at this location. Four daytime trains and no nighttime trains passed by this site during the monitoring period, generating maximum noise levels in the range of 79 dBA to 88 dBA. Without the trains, it is estimated that the Ldn from other ambient noise sources would be 56 dBA.
- Site LT-13: 635 S. Mason Street – Fort Collins. This site was adjacent to a residential rental property on the west side of Mason Street in Fort Collins, where the existing BNSF railroad track runs along the median of the street. The measured Ldn of 72 dBA at this site was dominated by freight trains that sound their horns near the numerous grade crossings in this area. Four daytime trains and no nighttime trains passed by this site during the monitoring period, generating maximum noise levels in the range of 101 dBA to 111 dBA. Without the trains, it is estimated that the Ldn from other ambient noise sources (primarily local street traffic) would be only 60 dBA.
- Site LT-14: 401 N. Timberline Road, Unit #178 – Fort Collins. This site was adjacent to a residence in a mobile home park located along Timberline Road, opposite a proposed commuter rail operation and maintenance facility site. The Ldn measured at this site was 63 dBA, dominated by noise from traffic on Timberline Road.
- Site ST-1: SH 119 at Fairview Street – Longmont. This site was located approximately 170 feet to the north of SH 119, and was selected to represent the residential areas along the alignment section that parallels the highway. The peak-hour Leq at this site was measured to be 70 dBA and, based on FTA methodology, the corresponding Ldn is estimated to be 68 dBA.
- Site ST-2: Weld County Line Road 1 at Great Western Drive – Longmont. This site was located approximately 100 feet to the west of County Line Road, and was selected to represent the residential area opposite the BNSF and Sugar Mill-Part B commuter rail station alternative site. The peak-hour Leq at this site was measured to be 61 dBA and, based on FTA methodology, the corresponding Ldn is estimated to be 59 dBA.
- Site ST-3: Peakview Meadows (US-287 at Turner Avenue) – Berthoud. This site was located approximately 100 feet to the east of US-287, and was selected to represent the residential area opposite the Berthoud-State Highway 56 and BNSF commuter rail station alternative site. The peak-hour Leq at this site was measured to be 61 dBA and, based on FTA methodology, the corresponding Ldn is estimated to be 59 dBA.

- Site ST-4:  2639 Cedar Drive at N. Garfield Avenue – Loveland. This site was located approximately 50 feet to the east of N. Garfield Avenue, and was selected to represent the residential area opposite the Loveland-29th Street and BNSF commuter rail station alternative site. The peak-hour Leq at this site was measured to be 61 dBA and, based on FTA methodology; the corresponding Ldn is estimated to be 59 dBA.

To provide a comprehensive baseline for the assessment of potential noise impact from the proposed introduction of commuter rail service along the portion of the alignment where the existing noise environment is dominated by freight rail operations, it is appropriate to generalize the existing noise conditions based on the noise measurement results described above. This can be accomplished by using the single-event train noise data, along with assumptions for typical daily freight schedules, to estimate the existing freight train noise exposure at each noise-sensitive receptor or receptor group based on distance from the track, and by combining the result with the noise exposure from other ambient noise sources at each site. Considering the non-scheduled nature and consequent daily variation of freight train operations, and the fact that the measurement results represent only a limited sample of current train noise exposure at a set of finite locations along the corridor, modeling of the existing freight train noise provides the most uniform approach for defining baseline noise conditions along the existing BNSF track. Furthermore, given that the FTA impact criteria are based on existing noise exposure, modeling the existing freight train noise provides a more consistent noise assessment approach along the corridor.
The train noise calculations are based on observations made during the measurement program, which suggest that there are four daytime (7:00 AM to 10:00 PM) freight train operations and one nighttime (10:00 PM to 7:00 AM) freight train operation per 24-hour day, on average. Based on the average measured train noise levels, the noise exposure (in terms of Ldn) from typical freight train operations at a distance of 100 feet from the track is estimated to be approximately 60 dBA in areas where train horns are not sounded and approximately 72 dBA in areas near grade crossings where horns are sounded for trains in both directions. Where train horns are sounded in only one direction, the Ldn at 100 feet is estimated to be 65 dBA, assuming that the horn is not sounded for the single nighttime train; this provides a conservatively low estimate of the existing noise for purposes of the impact assessment.

The total existing noise environment along the rail corridor is determined by combining the train noise (adjusted for distance) with the background ambient noise from other sources (e.g. road traffic, aircraft and general neighborhood activities). The results of the noise-monitoring program indicate that the background Ldn (i.e. without trains) generally ranges between 50 dBA and 60 dBA, depending on location along the corridor. The combination of freight train noise and background noise provides estimates for the total existing Ldn at locations along the section of the proposed commuter rail alignment between Longmont and Fort Collins with existing freight service. For all other locations, the existing noise levels are based on the measurement results for nearby or comparable areas. The resulting noise levels serve as a baseline for evaluating noise impact from the proposed commuter rail operations.

## 2.2 EXISTING VIBRATION LEVELS

To characterize the existing baseline vibration conditions at sensitive receptors along the corridor, a field measurement program was carried out during the period from October 23 through October 25, 2006. The measurement program consisted of ground vibration propagation tests as well as measurements during train operations in representative areas along the proposed commuter rail alignment. Five sites were selected to represent the range of soil conditions in areas along the corridor that include a significant number of vibration-sensitive receptors. The general locations of these sites, designated as Y-1 through V-5, are shown in **Figure 2-1** and site photographs are included in **Appendix A**. Descriptions of these sites are as follows:

- Site V-1: Dacono. This site was on vacant city-owned property adjacent to the Sweetgrass residential development, near long-term noise measurement site LT-2. The vibration measurements at this site are taken to be representative of this development, as well as other areas along the southern section of the alignment.
- Site V-2: Longmont. This site was in a park located along Atwood Street to the west of the BNSF track, just north of 6th Avenue in Longmont. The vibration measurements at this site are taken to be representative of the areas in the vicinity of Longmont.
- Site V-3: Berthoud. This site was on the west side of the BNSF track at Third Street and Capitol Avenue in Berthoud. The vibration measurements at this site are taken to be representative of the areas in the vicinity of Berthoud.
- Site V-4: Loveland. This site was on the east side of the BNSF track at Railroad Avenue and East 8th Street in Loveland. The vibration measurements at this site are taken to be representative of the areas in the vicinity of Loveland.
- Site V-5: Fort Collins. This site was in a parking lot on the east side of the BNSF track just south of Horsetooth Road in Fort Collins. The vibration measurements at this site are taken to be representative of the areas in the vicinity of Fort Collins.

The ground vibration measurements at the above sites were made with high-sensitivity accelerometers mounted in the vertical direction on either paved surfaces, or on top of steel stakes driven into soil. The acceleration signals were recorded on a TEAC Model RD-135-TE 8-channel digital audio tape recorder and subsequently analyzed in the laboratory.

The vibration propagation test procedure is shown schematically in **Figure 2-2**. As shown in the cross section view at the top, the test basically consists of dropping a 60 lb weight from a height of 3 to 4 feet onto the ground. A load cell is used to measure the force of the impact and accelerometers are used to measure the resulting vibration pulses at various distances from the ground. The relationship between the input force and the ground surface vibration, called the transfer mobility, characterizes vibration propagation at this location. It is possible to estimate the ground vibration that would be caused by another source, such as a train, by substituting the impact force with the train forces.

The bottom sketch in **Figure 2-2** shows how the dropped weight point source is used to simulate a line vibration source such as a train. Impact tests are made at regular intervals in a line along the rail alignment. For these tests, impacts were done at 11 points, spaced 15 feet apart along a line perpendicular to the line of accelerometers.

For laboratory analysis of the ground vibration propagation test data, a Larson Davis Model 2900 multi-channel spectrum analyzer was used to obtain the transfer mobility relationship for each accelerometer/impact pair. The basic steps taken to calculate 1/3 octave band transfer functions are summarized below:

1. A multi-channel spectrum analyzer was used to get narrowband transfer functions. A minimum of 20 impacts was used to obtain signal-enhanced transfer functions for each impact site-accelerometer pair. Numerical integration was used to change from acceleration to velocity.

2. The 1/3 octave band transfer mobility was calculated for each accelerometer/impact pair.

3. Each set of 1/3 octave band point-source transfer mobilities was combined using Simpson's Rule for numerical integration to estimate the equivalent line-source transfer mobility.

4. For each 1/3 octave band, a smooth curve was fit to the line source transfer mobility values. The end result is an estimate of line source transfer mobility as a function of distance from the source.

Examples of the resulting smoothed line source transfer mobilities are given in **Figure 2-3,** which provides spectra at a distance of 50 feet for the five test sites. More details on the propagation test and analysis procedures are given in the FTA guidance manual (FTA Report FTA-VA-90-1003-06, May 2006). Detailed vibration propagation data for the North I-25 Corridor are included in **Appendix C**.

**Figure 2-2 Vibration Propagation Test Procedure**

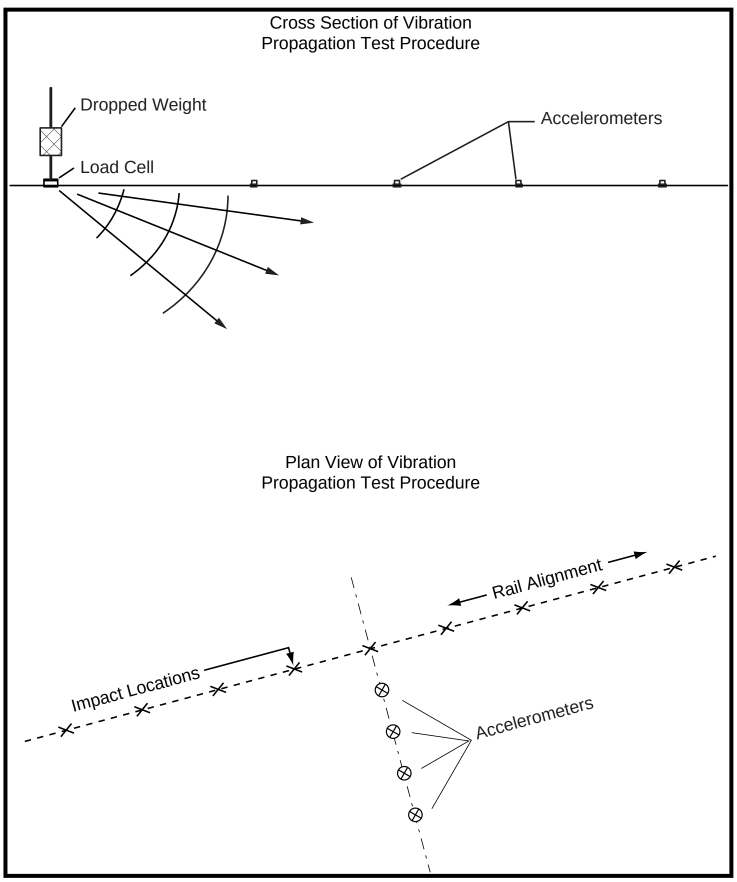
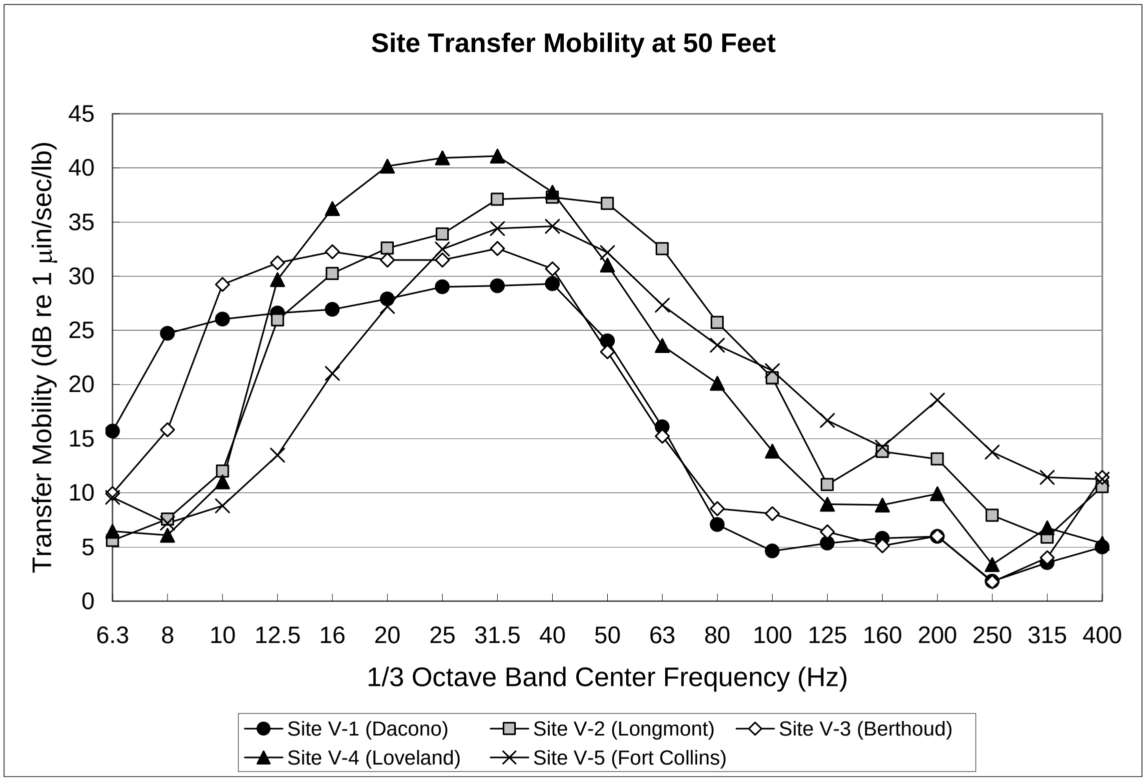


**Figure 2-3 Line Source Transfer Mobilities for the North I-25 Corridor Sites**

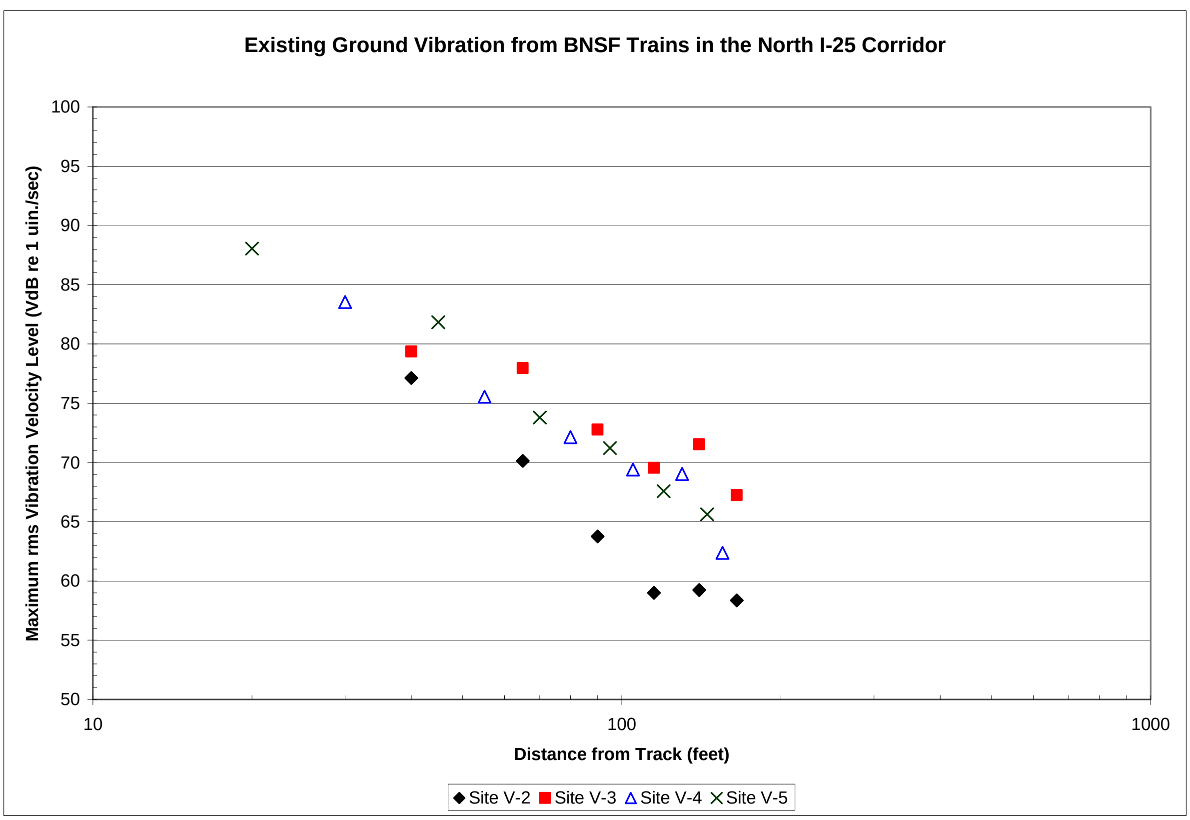



In addition to conducting propagation tests, ground vibration measurements were made at various distances from the BNSF tracks during train operations at Sites V-2 through V-5 to document existing train vibration levels along the corridor (there are currently no train operations at Site V-1). The results are summarized in **Table 2-2** and are displayed graphically in **Figure 2-4**. These results indicate that the low-speed train measured at Site V-2 in Longmont generated the lowest vibration levels and that vibration levels drop off most rapidly with distance at this site. At the remaining sites, the results exhibit similar characteristics in terms of vibration level and propagation rate. Overall, the measurements suggest that existing ground-borne vibration levels from trains operating along the BNSF track between Longmont and Fort Collins are likely to be perceptible at buildings located as far away as 100 feet to 150 feet from the track.

## Table 2-2 Summary of Ground Vibration Data for Freight Trains

| Site No. | Site Location and Description | Measurement | | # of Loc. | # of Cars | Speed (mph) | Dir | Maximum Vibration Velocity Level (VdB re 1 micro-inch/secon vs. distance from track | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Date | Time | | | | | 20 to 40 feet | 45 to 65 feet | 70 to 90 feet | 95 to 115 feet | 120 to 140 feet | 145 to 165 feet |
| V-2 | Atwood St. & 6th Ave. Longmont | 10/23/06 | 16:55 | 3 | 45 | 11 | NB | 77 | 70 | 64 | 59 | 59 | 58 |
| V-3 | Third St. & Capitol Ave. Berthoud | 10/24/06 | 11:00 | 2 | 2 | 22 | SB | 79 | 78 | 73 | 70 | 72 | 67 |
| V-4 | Railroad Ave. & E. 8th St. Loveland | 10/24/06 | 17:55 | 3 | 86 | 18 | SB | 84 | 76 | 72 | 69 | 69 | 62 |
| V-5 | So. of Horsetooth Rd. Fort Collins | 10/25/06 | 15:05 | 3 | 66 | 36 | NB | 88 | 82 | 74 | 71 | 68 | 66 |

## Figure 2-4 Existing Ground Vibration Levels from Freight Trains



# 3.0 ENVIRONMENTAL CONSEQUENCES

This section presents an evaluation of potential noise and vibration impacts along the North I-25 Corridor associated with the rail transit alternative included in the FEIS. The impact criteria, projection methods and assessment are described below.

# 3.1 NOISE AND VIBRATION IMPACT CRITERIA

## 3.1.1 Train Noise Criteria

Train noise impact for this project is based on the criteria defined in the FTA guidance manual (Report FTA-VA-90-1003-06, May 2006). The FTA noise impact criteria are founded on well-documented research on community reaction to noise and are based on change in noise exposure using a sliding scale. Although higher train noise levels are allowed in neighborhoods with higher levels of existing noise, smaller increases in total noise exposure are allowed with increasing existing noise levels. The FTA Noise Impact Criteria group noise sensitive land uses into the following three categories:

> Category 1: Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included are recording studios and concert halls.
>
> Category 2: Residences and buildings where people normally sleep. This category includes homes, hospitals and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
>
> Category 3: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

Ldn is used to characterize noise exposure for residential areas (Category 2). For other noise sensitive land uses, such as outdoor amphitheaters and school buildings (Categories 1 and 3), the maximum 1-hour Leq during the facility's operating period is used. There are two levels of impact included in the FTA criteria. The interpretation of these two levels of impact is summarized below:

> Severe Impact: Project-generated noise in the severe impact range can be expected to cause a significant percentage of people to be highly annoyed by the new noise and represents the most compelling need for mitigation. Noise mitigation will normally be specified for severe impact areas unless there are truly extenuating circumstances which prevent it.
>
> Moderate Impact: In this range of noise impact, the change in the cumulative noise level is noticeable to most people but may not be sufficient to cause strong, adverse reactions from the community. In this transitional range, other project-specific factors

must be considered to determine the magnitude of the impact and the need for mitigation. These factors include the existing level, the predicted level of increase over existing noise levels, the types and numbers of noise-sensitive land uses affected, the noise sensitivity of the properties, the effectiveness of the mitigation measures, community views and the cost of mitigating noise to more acceptable levels.

The noise impact criteria are summarized in **Table 3-1**. The first column shows the existing noise exposure and the remaining columns show the additional noise exposure from the transit project that would cause either moderate or severe impact. The future noise exposure would be the combination of the existing and project noise exposures. **Table 3-2** gives the information from **Table 3-1** in terms of the allowable increase in cumulative noise exposure (noise from existing sources plus project noise) as a function of existing noise exposure. As the existing noise exposure increases, the amount that the rail project can increase the overall noise exposure before there is impact decreases.

### 3.1.2 Train Vibration Criteria

The FTA ground-borne vibration impact criteria are based on land use and train frequency, as shown in **Table 3-3**. There are some buildings, such as concert halls, recording studios and theaters, which can be very sensitive to vibration but do not fit into any of the three categories listed in **Table 3-3**. Due to the sensitivity of these buildings, they usually warrant special attention during the environmental assessment of a transit project. **Table 3-4** gives criteria for acceptable levels of ground-borne vibration for various types of special buildings.

It should also be noted that **Tables 3-3 and 3-4** include separate FTA criteria for ground-borne noise—the "rumble" that can be radiated from vibrating room surfaces in buildings. Although expressed in dBA, the criteria are set significantly lower than for airborne noise to account for the annoying low-frequency character of ground-borne noise. However, because airborne noise tends to mask ground-borne noise for above-grade rail systems, ground-borne noise criteria are not applied for this project.

In addition to the overall vibration level criteria provided in **Tables 3-3** and **3-4** for general assessment purposes, FTA has established criteria in terms of one-third octave band frequency spectra for use in detailed analyses. For residential buildings with nighttime occupancy, the applicable criterion for a detailed analysis is a maximum vibration velocity level of 72 VdB, measured in one-third octave bands over the frequency range from 8 Hz to 80 Hz.

## Table 3-1 FTA Noise Impact Criteria

| Existing Noise Exposure (Leq or Ldn) | Project Noise Exposure Impact Thresholds, Leq or Ldn (dBA) | | | |
|---|---|---|---|---|
| | Category 1 or 2 Sites | | Category 3 Sites | |
| | Mod. Impact | Severe Impact | Mod. Impact | Severe Impact |
| <43 | Amb.+10 | Amb.+15 | Amb.+15 | Amb.+20 |
| 43 | 52 | 58 | 57 | 63 |
| 44 | 52 | 59 | 57 | 64 |
| 45 | 52 | 59 | 57 | 64 |
| 46 | 52 | 59 | 57 | 64 |
| 47 | 52 | 59 | 57 | 64 |
| 48 | 53 | 59 | 58 | 64 |
| 49 | 53 | 59 | 58 | 64 |
| 50 | 53 | 60 | 58 | 65 |
| 51 | 54 | 60 | 59 | 65 |
| 52 | 54 | 60 | 59 | 65 |
| 53 | 54 | 60 | 59 | 65 |
| 54 | 55 | 61 | 60 | 66 |
| 55 | 55 | 61 | 60 | 66 |
| 56 | 56 | 62 | 61 | 67 |
| 57 | 56 | 62 | 61 | 67 |
| 58 | 57 | 62 | 62 | 67 |
| 59 | 57 | 63 | 62 | 68 |
| 60 | 58 | 63 | 63 | 68 |
| 61 | 58 | 64 | 63 | 69 |
| 62 | 59 | 64 | 64 | 69 |
| 63 | 60 | 65 | 65 | 70 |
| 64 | 60 | 66 | 65 | 71 |
| 65 | 61 | 66 | 66 | 71 |
| 66 | 61 | 67 | 66 | 72 |
| 67 | 62 | 67 | 67 | 72 |
| 68 | 63 | 68 | 68 | 73 |
| 69 | 64 | 69 | 69 | 74 |
| 70 | 64 | 69 | 69 | 74 |
| 71 | 65 | 70 | 70 | 75 |
| 72 | 65 | 71 | 70 | 76 |
| 73 | 65 | 72 | 70 | 77 |
| 74 | 65 | 72 | 70 | 77 |
| 75 | 65 | 73 | 70 | 78 |
| 76 | 65 | 74 | 70 | 79 |
| 77 | 65 | 75 | 70 | 80 |
| >77 | 65 | 75 | 70 | 80 |

**Note:** Ldn is used for land uses where nighttime sensitivity is a factor; maximum 1-hour Leq is used for land use involving only daytime activities.

## Table 3-2 Cumulative Noise Level Increase Allowed by FTA Criteria

| Existing Noise Exposure (Leq or Ldn) | Impact Threshold for Increase in Cumulative Noise Exposure (dBA) | | | |
|---|---|---|---|---|
| | Category 1 or 2 Sites | | Category 3 Sites | |
| | Mod. Impact | Severe Impact | Mod. Impact | Severe Impact |
| 45 | 8 | 14 | 12 | 19 |
| 46 | 7 | 13 | 12 | 18 |
| 47 | 7 | 12 | 11 | 17 |
| 48 | 6 | 12 | 10 | 16 |
| 49 | 6 | 11 | 10 | 16 |
| 50 | 5 | 10 | 9 | 15 |
| 51 | 5 | 10 | 8 | 14 |
| 52 | 4 | 9 | 8 | 14 |
| 53 | 4 | 8 | 7 | 13 |
| 54 | 3 | 8 | 7 | 12 |
| 55 | 3 | 7 | 6 | 12 |
| 56 | 3 | 7 | 6 | 11 |
| 57 | 3 | 6 | 6 | 10 |
| 58 | 2 | 6 | 5 | 10 |
| 59 | 2 | 5 | 5 | 9 |
| 60 | 2 | 5 | 5 | 9 |
| 61 | 1.9 | 5 | 4 | 9 |
| 62 | 1.7 | 4 | 4 | 8 |
| 63 | 1.6 | 4 | 4 | 8 |
| 64 | 1.5 | 4 | 4 | 8 |
| 65 | 1.4 | 4 | 3 | 7 |
| 66 | 1.3 | 4 | 3 | 7 |
| 67 | 1.2 | 3 | 3 | 7 |
| 68 | 1.1 | 3 | 3 | 6 |
| 69 | 1.1 | 3 | 3 | 6 |
| 70 | 1.0 | 3 | 3 | 6 |
| 71 | 1.0 | 3 | 3 | 6 |
| 72 | 0.8 | 3 | 2 | 6 |
| 73 | 0.6 | 2 | 1.8 | 5 |
| 74 | 0.5 | 2 | 1.5 | 5 |
| 75 | 0.4 | 2 | 1.2 | 5 |

**Note:** Ldn is used for land uses where nighttime sensitivity is a factor; maximum 1-hour Leq is used for land use involving only daytime activities.

## Table 3-3 Ground-Borne Vibration and Noise Impact Criteria by Land Use Category

| Land Use Category | Ground-Borne Vibration Impact Levels (VdB re: 1 micro inch/sec) | | | Ground-Borne Noise Impact Levels (dB re: 20 micro Pascals) | | |
|---|---|---|---|---|---|---|
| | Frequent Events[1] | Occasional Events[2] | Infrequent Events[3] | Frequent Events[1] | Occasional Events[2] | Infrequent Events[3] |
| **Category 1**: Buildings where low ambient vibration is essential for interior operations. | 65 VdB[4] | 65 VdB[4] | 65 VdB[4] | N/A[5] | N/A[5] | N/A[5] |
| **Category 2**: Residences and buildings where people normally sleep. | 72 VdB | 75 VdB[3] | 80 VdB | 35 dBA | 38 dBA | 43 dBA |
| **Category 3**: Institutional land uses with primarily daytime use. | 75 VdB | 78 VdB[3] | 83 VdB | 40 dBA | 43 dBA | 48 dBA |

**Notes:**

1. “Frequent Events” is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. “Occasional Events” is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. “Infrequent Events” is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

**Table 3-4 Ground-Borne Vibration and Noise Impact Criteria for Special Buildings**

| Type of Building or Room | Ground-Borne Vibration Impact Levels (VdB re 1 micro-inch/sec) | | Ground-Borne Noise Impact Levels (dB re 20 micro Pascals) | |
|---|---|---|---|---|
| | Frequent Events[1] | Occasional or Infrequent Events[2] | Frequent Events[1] | Occasional or Infrequent Events[2] |
| Concert Halls | 65 VdB | 65 VdB | 25 dBA | 25 dBA |
| TV Studios | 65 VdB | 65 VdB | 25 dBA | 25 dBA |
| Recording Studios | 65 VdB | 65 VdB | 25 dBA | 25 dBA |
| Auditoriums | 72 VdB | 80 VdB | 30 dBA | 38 dBA |
| Theaters | 72 VdB | 80 VdB | 35 dBA | 43 dBA |

**Notes:**

1. "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.
2. "Occasional or Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.
3. If the building will rarely be occupied when the trains are operating, there is no need to consider impact. As an example consider locating a commuter rail line next to a concert hall. If no commuter trains will operate after 7 pm, it should be rare that the trains interfere with the use of the hall.

## 3.1.3 Construction Noise Criteria

Construction noise criteria are based on the guidelines provided in the FTA guidance manual. These criteria, summarized in **Table 3-5** below, are based on land use and time of day and are given in terms of Leq for an 8-hour work shift.

**Table 3-5 FTA Construction Noise Criteria**

| Land Use | Noise Limit, 8-Hour Leq (dBA) | |
|---|---|---|
| | Daytime | Nighttime |
| Residential | 80 | 70 |
| Commercial | 85 | 85 |
| Industrial | 90 | 90 |

# 3.2 NOISE AND VIBRATION PROJECTION METHODOLOGY

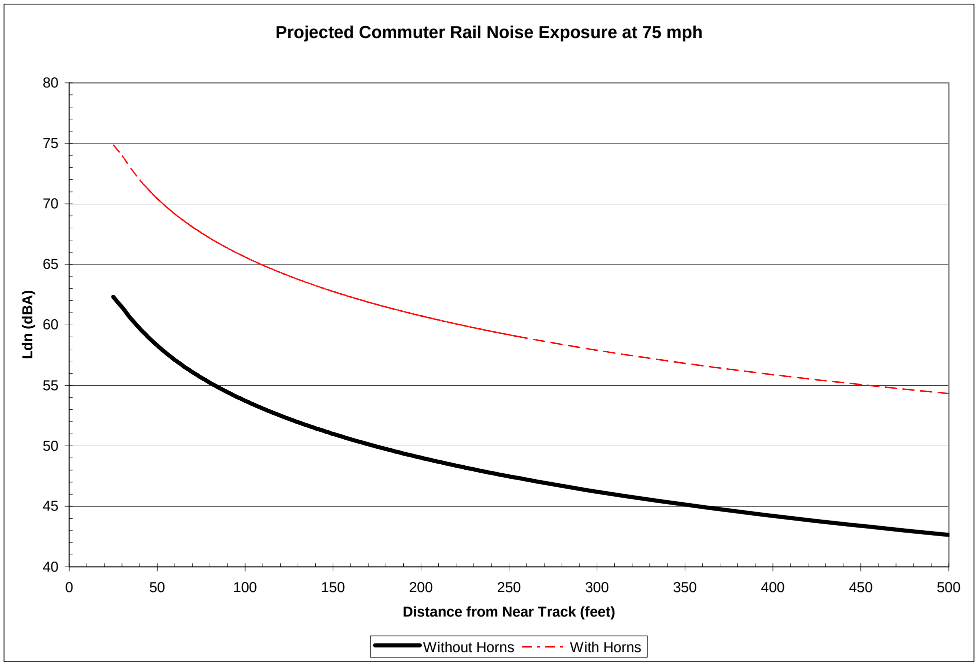
## 3.2.1 Train Noise Projections

The primary components of wayside noise from non-electrified commuter rail operations are mechanical equipment noise from the power units and wheel/rail noise from the coaches. Near grade crossings, horn noise is typically the dominant source. The projection of wayside noise from these sources was carried out using the model specified in the FTA guidance manual, based on the following assumptions:

- Commuter trains will operate on weekdays from approximately 4:30 am to 10:30 pm.
- Between Denver Union Station and Fort Collins South Transit Center (STC) Station, trains will operate with 30-minute headways during peak periods (6:00 am to 9:00 am and 4:00 pm to 7:00 pm) and with 60-minute headways at all other times. Between Fort Collins STC Station and Fort Collins Downtown Transit Center (DTC) Station, trains will operate with 60-minute headways at all times of day.
- The Diesel Multiple Unit (DMU) train consists will include two powered cars and one trailer car during peak periods and will include two powered cars at all other times.
- The maximum train operating speed will be 75 mph, with operating speeds by location based on speed profiles generated by Connetics Transportation Group dated August 4, 2010.
- The powered DMU vehicles will operate at a throttle setting of 8 where the trains are accelerating and at a throttle setting less than 6 at all other locations.
- Train horns will be sounded within ¼ mile of grade crossings at a level that meets the minimum Federal Railroad Administration (FRA) standard of 96 dBA at 100 feet.
- Noise from stationary warning bells at grade crossings was projected using FTA procedures, assuming each bell generates a maximum noise level of 73 dBA at a distance of 50 feet with a duration of 30 seconds for each train that passes through the crossing.
- Wheel impacts at crossovers and turnout locations are assumed to cause localized noise increases of 6 dBA at receptors within 200 feet from these locations and increases of 3 dBA at receptors 200-300 feet from these locations.

The projected noise exposures (in terms of Ldn) at unshielded community locations from commuter rail operations, both with and without train horns, are shown in **Figure 3-1** as a function of distance for the maximum train speed of 75 mph.

### Figure 3-1 Projected Commuter Rail Noise Exposure at 75 mph



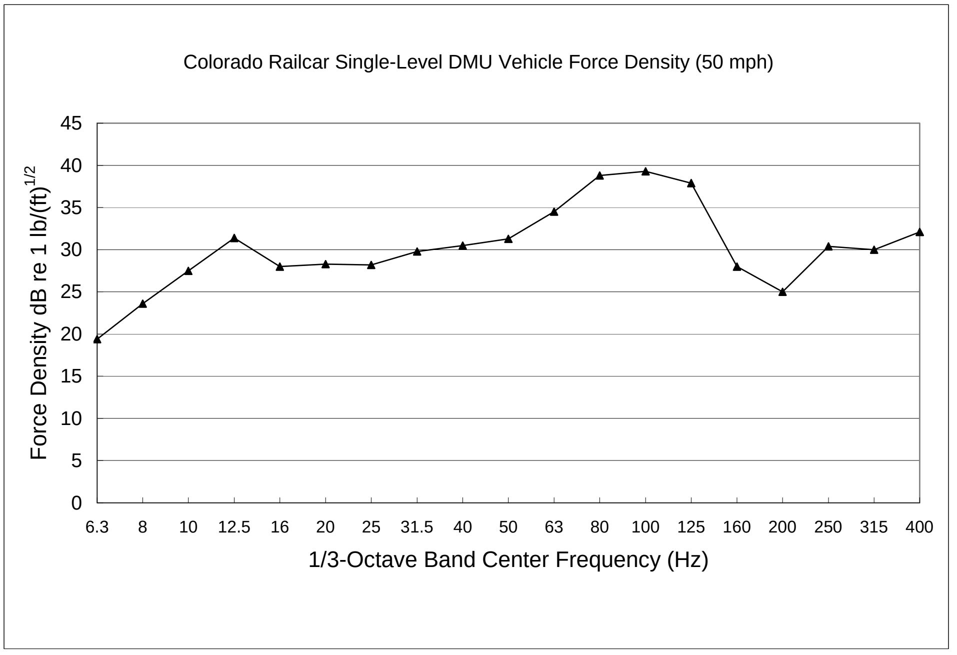

## 3.2.2 Train Vibration Projections

The following factors were used to predict train vibration levels along the project corridor:

- Vibration source levels were based on measurement data for the Colorado Railcar single-level DMU, an FRA-compliant passenger rail vehicle tested at the Transportation Test Center in Pueblo, CO.
- Vibration propagation tests were conducted at five representative sites along the corridor near sensitive receptors, as described above in **Section 2.2**. The results of these tests were combined with the vehicle vibration source level measurement data to provide projections of vibration levels from vehicles operating on the North I-25 corridor.
- The maximum train operating speed will be 75 mph, with operating speeds by location along the alignment based on speed profiles provided by Connetics Transportation Group dated August 4, 2010.
- Wheel impacts at crossovers and turnout locations are assumed to cause localized vibration increases of 10 VdB at receptors within 200 feet from these locations and increases of 5 VdB at receptors 200-300 feet from these locations.
- The vibration projections assume a ground-to-building coupling loss of 0 VdB.
- A safety factor of 3 VdB was included in the projected vibration levels along the corridor.

The assumed vehicle vibration characteristics (represented by the force density spectrum in **Figure 3-2**) were combined with the ground vibration propagation test results (represented by transfer mobility spectra such as those shown in **Figure 2-3**) to project vibration levels as a function of distance for each of the five test sites. The results of these transfer mobility tests are presented in **Appendix C**.

**Figure 3-2 DMU Vehicle Force Density Spectrum**



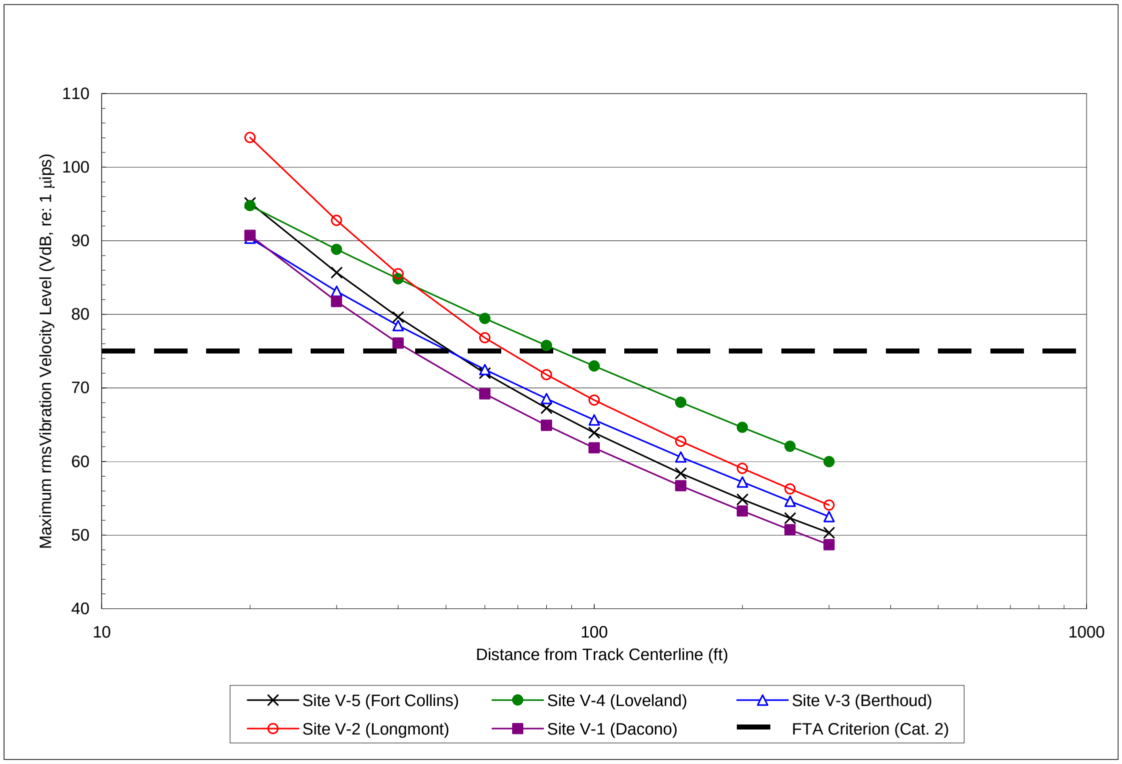

The resulting projections of maximum ground vibration levels from commuter rail operations in various areas of the corridor are shown in **Figure 3-3** as a function of distance for the maximum train speed of 75 mph. These results indicate that for maximum speed operation, there would be the potential for ground-borne vibration impact at residential buildings located within 40 feet to 80 feet from the track based on the FTA criteria for a general assessment.

### 3.2.3 Construction Noise Projections

Construction noise varies greatly depending on the construction process, type and condition of equipment used, and layout of the construction site. Many of these factors are traditionally left to the contractor's discretion, which makes it difficult to accurately estimate levels of construction noise. Overall, construction noise levels are governed primarily by the noisiest pieces of equipment. For most construction equipment, the engine, which is usually diesel, is the dominant noise source. This is particularly true of engines without sufficient muffling. For special activities such as impact pile driving and pavement breaking, noise generated by the actual process dominates.

**Table 3-6** summarizes some of the available data on noise emissions of construction equipment from the FTA guidance manual. Shown are average maximum noise level values at a distance of 50 feet. Although the noise levels in the table represent typical values, there can be wide fluctuations in the noise emissions of similar equipment. Construction noise at a given noise-sensitive location depends on the magnitude of noise during each construction phase, the duration of the noise, and the distance from the construction activities.

### Figure 3-3 Projected Commuter Rail Ground-Borne Vibration Levels at 75 mph




Projecting construction noise requires a construction scenario of the equipment likely to be used and the average utilization factors or duty cycles (i.e. the percentage of time during operating hours that the equipment operates under full power during each phase). Using the typical sound emission characteristics, as given in **Table 3-6**, it is then possible to estimate Leq or Ldn at various distances from the construction site.

The noise impact assessment for a construction site is based on:

- an estimate of the type of equipment that will be used during each phase of the construction and the average daily duty cycle for each category of equipment,
- typical noise emission levels for each category of equipment such as those in **Table 3-6**, and
- estimates of noise attenuation as a function of distance from the construction site.

Construction noise estimates are always approximate because of the lack of specific information available at the time of the environmental assessment. Decisions about the procedures and equipment to be used are made by the contractor. Project designers usually try to minimize constraints on how the construction will be performed and what equipment will be used so that contractors can perform construction in the most cost effective manner.

**Table 3-6 Construction Equipment Noise Emission Levels**

| Equipment Type | Typical Sound Level at 50 ft (dBA) |
|---|---|
| Backhoe | 80 |
| Bulldozer | 85 |
| Compactor | 82 |
| Compressor | 81 |
| Concrete Mixer | 85 |
| Concrete Pump | 82 |
| Crane, Derrick | 88 |
| Crane, Mobile | 83 |
| Loader | 85 |
| Pavement Breaker | 88 |
| Paver | 89 |
| Pile Driver, Impact | 101 |
| Pump | 76 |
| Roller | 74 |
| Truck | 88 |

**Table 3-7** is an example of the noise projections for equipment that is often used during tie-and-ballast track construction. For the calculations it is assumed that all the equipment is located at the geometric center of the construction work site. Based on this scenario, an 8-hour Leq of 88 dBA should be expected at a distance of 50 feet from the geometric center of the work site. This calculation in **Table 3-7** does not assume any noise mitigation measures or any limits on the contractor about how much noise can be made. With at-grade track construction, the duration of the activities at a specific location along the alignment will be relatively limited, usually a matter of several weeks. As a result, even when there may be noise impacts, the limited duration of the construction can mean that mitigation is not cost effective.

**Table 3-7 Typical Equipment List, At-Grade Track Construction**

| Equipment Item | Typical Maximum Sound Level at 50 ft (dBA) | Equipment Utilization Factor (%) | Leq (dBA) |
|---|---|---|---|
| Air Compressor | 83 | 50% | 80 |
| Backhoe | 80 | 40% | 76 |
| Crane, Derrick | 82 | 10% | 72 |
| Dozer | 85 | 40% | 81 |
| Generator | 81 | 80% | 80 |
| Loader | 85 | 40% | 81 |
| Pavement Breaker | 84 | 4% | 70 |
| Shovel | 80 | 40% | 76 |
| Dump Truck | 88 | 16% | 80 |
| **Total Workday Leq at 50 feet (8-hour workday)** | | | **88** |

## 3.3 Noise and Vibration Impact Assessment

The assessment of noise impact from commuter rail operations is based on a comparison of existing and projected future noise exposure for different land use categories. The assessment considered all sensitive receptors within 1,000 feet of the alignment between the Fort Collins DTC station at the north end of the line to the 162nd Avenue/SH-7 North Metro station at the south end of the line. The following steps were performed to assess train noise impact:

- A detailed land-use survey was conducted along the project corridor to identify and classify all noise-sensitive receptors according to the categories defined by FTA. The vast majority of these receptors fall under FTA Category 2, including mostly single-family residences. The remaining receptors were institutional sites falling under FTA Category 3, including schools and parks.
- The receptors were clustered based on distance to the tracks, acoustical shielding between the receptors and the tracks, and location relative to grade crossings.
- The existing noise exposure at each cluster of receptors was estimated based on the generalization of the ambient noise measurements described in **Section 2.1**, and was used to determine the thresholds for moderate and severe impact using the FTA criteria.
- Projections of future commuter train noise at each cluster of receptors were developed based on distance from the tracks, train schedule and train speed using the methods described above.
- In areas where the projections showed impact, mitigation options were evaluated.

The approach used for assessing vibration impact generally follows the approach used for assessing noise impact, except that the existing vibration levels are not considered when evaluating impact. The potential vibration impact from commuter rail operation was assessed on an absolute basis, using the FTA criteria for “detailed analysis” that are in the form of one-third octave band frequency spectra. For residential buildings with nighttime occupancy, the applicable criterion for a detailed analysis is a maximum vibration velocity level of 72 VdB, measured in one-third octave bands over the frequency range from 8 Hz to 80 Hz. Except for parks, the same sensitive receptors identified for the noise impact assessment were considered for the vibration impact assessment.

The approach used for assessing construction noise impact is based on the criteria in **Section 3.1** and the noise projection in **Table 3-7**. Assuming that construction noise is reduced by 6 decibels for each doubling of distance from the center of the site, screening distances for potential construction noise impact can be estimated. These estimates suggest that the potential for construction noise impact will be minimal for commercial and industrial land use, with impact screening distances of 70 feet and 40 feet, respectively. Even for residential land use, the potential for temporary construction noise impact would be limited to locations within about 125 feet of the corridor. However, the potential for noise impact from nighttime construction could extend to residences as far as 400 feet. Potential construction noise impacts will be evaluated during final design.

The results of the commuter rail noise and vibration impact assessment for each alignment component are described below and the projected impact locations are shown in **Appendix D**.

### 3.3.1 Noise Impacts

Detailed comparisons of the existing and future noise levels are presented in **Table 3-8** and **Appendix D** for residential locations along the alignment where noise impact is anticipated. In addition to the locations, distances to the near track and proposed train speeds, the table includes the existing noise levels, the projected noise levels from train operations, the impact criteria, the predicted total noise levels and the projected noise increases due to the introduction of commuter rail service for each receptor area. Based on a comparison of the predicted project noise level with the impact criteria, the table also includes an inventory of the number of residential and institutional receptors with impacts for each area along the corridor.

The results in **Table 3-8** indicate that without mitigation noise impact is predicted at a total of 2,192 residences along the project corridor; 1,495 with moderate impact and 697 with severe impact. Approximately half of these impacts are in Longmont. For institutional land uses, moderate noise impact is predicted at nine schools, six churches and one park and severe noise impact is predicted at six schools and one church.

### 3.3.2 Vibration Impacts

Detailed projections of future vibration levels are presented in **Table 3-9** and **Appendix D** for residential locations along the alignment where impacts are anticipated. In addition to the locations, distances to the near track and proposed train speeds, the table includes the projected vibration levels from train operations and the impact criterion for each receptor area. Based on a comparison of the predicted project vibration level with the impact criterion, the table also indicates the number of residences where vibration impact is projected for each area along the corridor. The results indicate that without mitigation vibration impact is projected at a total of 40 residences within 111 feet of the nearest track. Of these residences, 26 are in Longmont and 14 are in Loveland.

### Table 3-8 Summary of Residential Noise Impacts Without Mitigation

| Location | Dist. to Near Track (ft) | Speed (mph) | Existing Noise Level[1] | Project Noise Level[1] | | | Total Noise Level[1] | Noise Level Increase[1] | Total Number of Noise Impacts[2] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Predicted | Impact Criteria | | | | Moderate | Severe |
| | | | | | Moderate | Severe | | | | |
| **Fort Collins:** | | | | | | | | | | |
| CR44 to Fort Collins DTC | 61-594<br>*44-260*[3] | 23-35<br>*20-25*[3] | 63-75<br>*55*[3] | 60-75<br>*60-75*[3] | 60-65<br>*60*[3] | 65-73<br>*66*[3] | 65-78<br>*61-75*[3] | 2-3<br>*6-20*[3] | 81<br>*+ 6 Schools*<br>*+ 1 Church*[3] | 57<br>*+ 5 Schools*[3] |
| CR38 to CR44 | 65-459<br>*140*[3] | 35<br>*35*[3] | 58-68<br>*46*[3] | 57-71<br>*62*[3] | 57-63<br>*57*[3] | 62-68<br>*64*[3] | 61-73<br>*62*[3] | 2-4<br>*16*[3] | 205<br>*+ 1 Church*[3] | 19 |
| CR34 to CR38 | 220-660 | 30-35 | 55-60 | 55-62 | 55-58 | 61-63 | 58-64 | 3-4 | 3 | 0 |
| **Loveland:** | | | | | | | | | | |
| CR28 to CR34 | 382-462 | 60 | 56-57 | 56-57 | 56 | 62 | 59-60 | 3 | 7 | 0 |
| 29th St to CR28 | 86-543 | 35-65 | 55-65 | 56-67 | 55-60 | 61-66 | 59-69 | 2-5 | 147 | 57 |
| US34 to 29th St | 41-449<br>*316*[3] | 20-44<br>*32-35*[3] | 59-69<br>*44*[3] | 57-77<br>*57*[3] | 57-63<br>*57*[3] | 62-68<br>*64*[3] | 61-77<br>*57*[3] | 2-9<br>*13*[3] | 51<br>*+ 1 Church*[3] | 45 |
| CR18 to US34 | 42-553<br>*244-460*[3] | 20-45<br>*35*[3] | 60-78<br>*44*[3] | 58-78<br>*57-61*[3] | 57-65<br>*57*[3] | 63-75<br>*64*[3] | 62-81<br>*57-61*[3] | 2-5<br>*13-17*[3] | 88<br>*+ 2 Churches*[3] | 35 |
| CR14 to CR18 | 58-515 | 35-75 | 56-69 | 55-70 | 55-63 | 61-68 | 59-72 | 2-4 | 34 | 18 |
| **Berthoud:** | | | | | | | | | | |
| CR10 to CR14 | 80-391<br>*134-173*[3] | 48-75<br>*75*[3] | 57-65<br>*41*[3] | 56-67<br>*60-62*[3] | 56-61<br>*57*[3] | 62-66<br>*63*[3] | 60-69<br>*60-62*[3] | 2-4<br>*19-21*[3] | 15<br>*+ 2 Schools*[3] | 6 |
| Spartan Ave to CR10 | 68-387 | 20-46 | 53-67 | 55-70 | 54-62 | 60-67 | 57-71 | 2-6 | 173 | 51 |
| Wilfred Rd to Spartan Ave | 106-454 | 54-60 | 57-65 | 56-66 | 56-60 | 62-66 | 59-69 | 3-4 | 5 | 1 |
| CR2 to Wilfred Rd | 163-453 | 61-65 | 57-62 | 56-63 | 56-59 | 62-64 | 59-65 | 3 | 3 | 0 |
| **Longmont:** | | | | | | | | | | |
| SR66 to CR2 | 170-835 | 20-65 | 54-62 | 56-64 | 55-58 | 61-64 | 58-66 | 3-6 | 5 | 1 |
| Mountain View Ave to SR66 | 36-623<br>*175-248*[3] | 32-35<br>*35*[3] | 54-75<br>*44*[3] | 55-76<br>*61-63*[3] | 55-65<br>*57*[3] | 61-73<br>*64*[3] | 58-78<br>*61-63*[3] | 3-8<br>*17-19*[3] | 395<br>*+ 1 Church*[3]<br>*+ 1 School*[3] | 238 |

| Location | Dist. to Near Track (ft) | Speed (mph) | Existing Noise Level[1] | Project Noise Level[1] | | | Total Noise Level[1] | Noise Level Increase[1] | Total Number of Noise Impacts[2] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Predicted | Impact Criteria | | | | Moderate | Severe |
| | | | | | Moderate | Severe | | | | |
| Martin St to Mountain View | 30-698 *88-262*[3] | 33-35 *35*[3] | 54-80 *44-48*[3] | 55-79 *64-71*[3] | 54-65 *57-58*[3] | 60-75 *64*[3] | 57-82 *64-71*[3] | 2-7 *16-23*[3] | 242 + *1 Park*[3] | 151 + *1 School* + *1 Church*[3] |
| CR1 to Martin St | 276 | 59-65 | 62 | 60 | 59 | 64 | 64 | 2 | 1 | 0 |
| CR7/SR119 to CR1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CR18 to CR7/SR119 | 133-382 | 67-75 | 56 | 56-64 | 56 | 62 | 59-64 | 3-8 | 15 | 2 |
| **Erie:** | | | | | | | | | | |
| SR52 to CR18 | 55-318 | 75 | *56* | 56-63 | 56 | 62 | 59-63 | 3-7 | 10 | 1 |
| CR10 to SR52 | 201-451 | 50-75 | 56 | 56-61 | 56 | 62 | 59-62 | 3-6 | 7 | 0 |
| **Brighton:** | | | | | | | | | | |
| CR6 to CR10 | 104-317 | 40-60 | 59-63 | 59-67 | 57-59 | 63-64 | 62-67 | 3-8 | 7 | 15 |
| CR2 to CR6 | 488 | 50 | 54 | 56 | 55 | 61 | 58 | 4 | 1 | 0 |
| **Total:** | | | | | | | | | **1,495 + 9 Schools + 6 Churches + 1 Park** | **697 + 6 Schools + 1 Church** |

[1] Noise levels are based on Ldn and measured in dBA, except for land use category 3 which are based on peak-hour Leq.
[2] All impacts are residential unless otherwise noted.
[3]Values are for land use category 3 receptors. Noise levels are based on Leq and measured in dBA.

### Table 3-9 Summary of Residential Vibration Impacts Without Mitigation

| Receptor Location | Dist. to Near Track (ft) | Speed, (mph) | Maximum 1/3 Octave Band Vibration Level (VdB re 1 µin./sec) | | Total Number of Vibration Impacts |
|---|---|---|---|---|---|
| | | | Predicted | Impact Criterion | |
| **Fort Collins:** | | | | | |
| CR44 to Fort Collins DTC | 0 | 0 | 0 | 0 | 0 |
| CR38 to CR44 | 0 | 0 | 0 | 0 | 0 |
| CR34 to CR38 | 0 | 0 | 0 | 0 | 0 |
| **Loveland:** | | | | | |
| CR28 to CR34 | 0 | 0 | 0 | 0 | 0 |
| 29th St to CR28 | 111 | 45 | 72 | 80 | 8 |
| US34 to 29th St | 39 | 35 | 75 | 80 | 4 |
| CR18 to US34 | 80 | 35 | 74 | 80 | 2 |
| CR14 to CR18 | 0 | 0 | 0 | 0 | 0 |
| **Berthoud:** | | | | | |
| CR10 to CR14 | 0 | 0 | 0 | 0 | 0 |
| Spartan Ave to CR10 | 0 | 0 | 0 | 0 | 0 |
| Wilfred Rd to Spartan Ave | 0 | 0 | 0 | 0 | 0 |
| CR2 to Wilfred Rd | 0 | 0 | 0 | 0 | 0 |
| **Longmont:** | | | | | |
| SR66 to CR2 | 0 | 0 | 0 | 0 | 0 |
| Mountain View Ave to SR66 | 36 | 35 | 78 | 72 | 21 |
| Martin St to Mountain View | 30 | 35 | 82 | 72 | 5 |
| CR1 to Martin St | 0 | 0 | 0 | 0 | 0 |
| CR7/SR119 to CR1 | 0 | 0 | 0 | 0 | 0 |
| CR18 to CR7/SR119 | 0 | 0 | 0 | 0 | 0 |
| **Erie:** | | | | | |
| SR52 to CR18 | 0 | 0 | 0 | 0 | 0 |
| CR10 to SR52 | 0 | 0 | 0 | 0 | 0 |
| **Brighton:** | | | | | |
| CR6 to CR10 | 0 | 0 | 0 | 0 | 0 |
| CR2 to CR6 | 0 | 0 | 0 | 0 | 0 |
| **Total:** | | | | | **40** |

# 4.0 MITIGATION

## 4.1 TRAIN NOISE MITIGATION

Potential mitigation measures for reducing commuter rail noise impacts are described below:

- Limiting Use of Train Horns. The FRA has issued regulations (24 June 2005) regarding safety at grade crossings that would apply to the portion of the North I-25 alignment with shared BNSF freight operations and that may result in noise impacts to sensitive receptors near grade crossings. An option for reducing such impacts under the FRA regulation would be to establish “quiet zones” at grade crossings. In a quiet zone, train operators would sound warning devices (e.g. horns) only in emergency situations rather than as a standard operational procedure because of safety improvements made to the at-grade crossings. Establishing a quiet zone requires cooperative action among the municipalities along the rail right-of-way, BNSF and appropriate federal, state and local agencies. The municipalities are key participants as they must initiate the request to establish the quiet zone through application to FRA. In addition, to meet safety criteria, improvements are required at grade crossings; these may include modifications to the streets, raised medians, warning lights, four-quadrant gates and other devices. The FRA regulation also authorizes the use of automated wayside horns at crossings with flashing lights and gates as a substitute for the train horn. While activated by the approach of trains, these devices are pole-mounted at the grade crossings, thereby limit the horn noise exposure area to the immediate vicinity of the grade crossing. Although the establishment of quiet zones or the use of wayside horns would be very effective noise mitigation measures, considerable design analysis and coordination efforts will be required to determine if these measures are feasible. In the event that it is not possible to eliminate the sounding of train horns, horns or other warning devices with reduced sound emission can be considered.

- Noise Barriers. This is a common approach to reducing noise impacts from surface transportation sources. The primary requirements for an effective noise barrier are that (1) the barrier must be high enough and long enough to break the line-of-sight between the sound source and the receiver, (2) the barrier must be of an impervious material with a minimum surface density of 4 lb/sq. ft. and (3) the barrier must not have any gaps or holes between the panels or at the bottom. Because many materials meet these requirements, the barrier type is usually dictated by aesthetics, durability, cost and maintenance considerations. Noise barriers for commuter rail systems typically range in height from eight to twelve feet.

- Building Sound Insulation. Sound insulation of residences and institutional buildings has been widely applied around airports and has seen limited application for transit projects. Although this approach has no effect on noise in exterior areas, it may be the best choice for sites where noise barriers are not feasible or desirable, and for buildings where indoor sensitivity is of most concern. Substantial improvements in building sound insulation (on the order of 5 to 10 dBA) can often be achieved by adding an extra layer of glazing to the windows, sealing any holes in exterior surfaces that act as sound leaks, and providing forced ventilation and air-conditioning so that windows do not need to be opened.

- Special Trackwork. The clanging of rail wheels over rail gaps at track turnout locations increases airborne noise by about six dBA, so turnouts can be a major source of noise impact. If turnouts cannot be relocated away from sensitive areas, another approach is to use spring-rail, flange-bearing or moveable-point frogs in place of standard rigid frogs. These devices allow the flangeway gap to remain closed in the main traffic direction.
- Property Acquisitions or Easements. Additional options for avoiding noise impacts are for the transit agency to purchase affected properties or to acquire easements by paying the homeowners to accept the future train noise conditions. These approaches are usually taken only in isolated cases where other mitigation options are infeasible, impractical, or too costly.

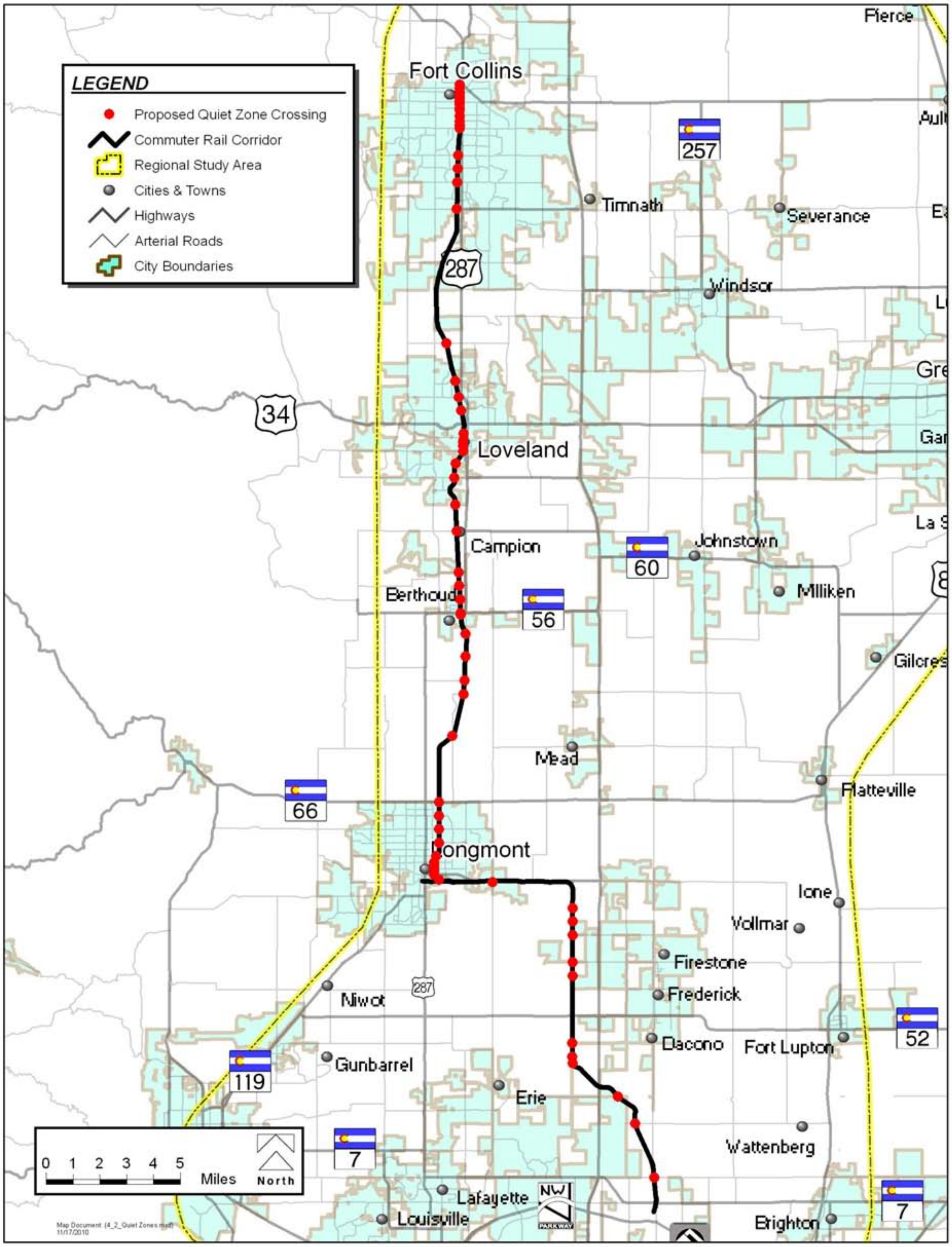
As discussed in **Section 3.1.1**, FTA states that in implementing noise impact criteria, severe impacts should be mitigated if at all practical. At the moderate impact level, more discretion should be used, and other project-specific factors should be included in considering mitigation. These factors can include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-to-indoor sound insulation and the cost-effectiveness of mitigating the noise. However, FTA also states that there is a stronger need for mitigation if a project is proposed in an area currently experiencing high noise levels (e.g. with Ldn above 65 dBA) from surface transportation sources.

High noise levels are clearly the case in the areas along the project corridor from Fort Collins to Longmont that are near the BNSF tracks where most of the impacts are predicted. In these areas, the existing noise exposure is dominated by existing freight train and horn noise, with Ldn levels typically ranging from 65 dBA to 75 dBA. In such cases, FTA indicates that impacts predicted in the moderate range should be treated as if they were severe in terms of mitigation.

In view of the above considerations, the approach for this project is to try to mitigate most, if not all, of the predicted noise impacts. The results of the noise analysis suggest that the most effective mitigation measure would be to eliminate train horn noise near all affected residential areas by establishing quiet zones at 64 grade crossings (**Figure 4-1** and **Table 4-1**). It is estimated that this mitigation measure could eliminate noise impacts at all but 21 residences, where moderate impacts would remain. Although the establishment of quiet zones is the recommended noise mitigation measure, it is dependent on actions by local governments and therefore alternative measures may also need to be considered.

Other beneficial, though less effective, mitigation approaches include the use of wayside horns and minimizing train horn noise emission. It should be noted that at locations where the noise impact is dominated by train horns near the numerous grade crossings, noise barriers are not likely to be reasonable and feasible and are not considered to be an appropriate noise mitigation approach. In addition to the large barrier heights that would be required to shield noise from the horns at the top of the DMU vehicles, barrier effectiveness would be limited due to the necessary breaks at each grade crossing. In addition, noise barriers would generate secondary (e.g. visual) impacts and would not likely be acceptable to the community and local governments. However, noise barriers would be practical and effective for mitigating the residual impacts after the implementation of quiet zones.

## Figure 4-1 Proposed Quiet Zone Locations for Commuter Rail



### Table 4-1 Proposed Railroad Quiet Zone Crossings

| Number | Railroad Crossing |
|---|---|
| 1 | Maple Street, Fort Collins |
| 2 | LaPorte Avenue, Fort Collins |
| 3 | Mountain Avenue, Fort Collins |
| 4 | Oak Street, Fort Collins |
| 5 | Olive Street, Fort Collins |
| 6 | Magnolia Street, Fort Collins |
| 7 | Mulberry Street, Fort Collins |
| 8 | Myrtle Street, Fort Collins |
| 9 | Laurel Street, Fort Collins |
| 10 | Old Main Drive, Fort Collins |
| 11 | University Avenue, Fort Collins |
| 12 | Pitkin Street, Fort Collins |
| 13 | Lake Street, Fort Collins |
| 14 | Prospect Road, Fort Collins |
| 15 | Drake Road, Fort Collins |
| 16 | Swallow Road, Fort Collins |
| 17 | Horsetooth Road, Fort Collins |
| 18 | Harmony Road, Fort Collins |
| 19 | 57th Street, Loveland |
| 20 | 37th Street, Loveland |
| 21 | 29th Street, Loveland |
| 22 | Garfield Avenue, Loveland |
| 23 | 10th Street, Loveland |
| 24 | 7th Street, Loveland |
| 25 | 6th Street, Loveland |
| 26 | 4th Street, Loveland |
| 27 | 1st Street, Loveland |
| 28 | Railroad Avenue, Loveland |
| 29 | 14 Street SW, Loveland |
| 30 | LCR16, Loveland |
| 31 | 42nd Street SW, Campion |
| 32 | LCR10E, Berthoud |
| 33 | LCR10, Berthoud |

| Number | Railroad Crossing |
|---|---|
| 34 | Bunyan Avenue, Berthoud |
| 35 | SH56/Mountain Avenue, Berthoud |
| 36 | Welch Avenue, Berthoud |
| 37 | Private crossing, Berthoud |
| 38 | Private crossing, Berthoud |
| 39 | LCR2e, Berthoud |
| 40 | County Line Road, Berthoud |
| 41 | 115th Street, Longmont |
| 42 | SH66, Longmont |
| 43 | 21st Avenue, Longmont |
| 44 | 17th Avenue, Longmont |
| 45 | Mountain View Avenue, Longmont |
| 46 | 9th Avenue, Longmont |
| 47 | Longs Peak Avenue, Longmont |
| 48 | 6th Avenue, Longmont |
| 49 | 5th Avenue, Longmont |
| 50 | 4th Avenue, Longmont |
| 51 | 3rd Avenue, Longmont |
| 52 | Martin Street, Longmont |
| 53 | WCR1, Longmont |
| 54 | Harbor Drive, Longmont |
| 55 | WCR20.5, Frederick |
| 56 | WCR20, Frederick |
| 57 | Godding Hollow Parkway, Frederick |
| 58 | Private crossing, Frederick |
| 59 | WCR12, Erie |
| 60 | Private crossing, Erie |
| 61 | Private crossing, Erie |
| 62 | WCR8, Broomfield |
| 63 | WCR6, Thornton |
| 64 | 168th Avenue, Thornton |

As shown in **Table 4-2**, it is estimated that a total of 2,400 lineal feet of 12-ft high noise walls could eliminate noise impacts at all such locations. Potential noise mitigation measures will need to be further evaluated during project design to determine feasible and reasonable approaches.

**Table 4-2 Potential Noise Barrier Mitigation Locations**

| Location along Alignment | | Side of Track | Civil Station Location | Barrier Length (ft) | Number of Residences Protected |
|---|---|---|---|---|---|
| 29th Street – LCR 28 | (Loveland) | East | 2009-2022 | 1,300 | 14 |
| LCR 14 – LCR 18 | (Campion) | East | 1684-1689 | 500 | 2 |
| SH 52 – WCR-18 | (Frederick) | West | 221-236 | 600 | 5 |
| **TOTAL:** | | | | **2,400** | **21** |

# 4.2 TRAIN VIBRATION MITIGATION

Beyond ensuring that the vehicle wheels and track are well maintained, there are some approaches that can be considered to reduce ground-borne vibration from commuter rail operation, as follows:

- Ballast Mats. A ballast mat consists of a pad made of rubber or rubber-like material placed on an asphalt or concrete base with the normal ballast, ties and rail on top. The reduction in ground-borne vibration provided by a ballast mat is strongly dependent on the frequency content of the vibration and design and support of the mat.
- Tire Derived Aggregate (TDA). Also known as shredded tires, a typical TDA installation consists of an underlayment of 12 inches of nominally 3-inch size tire shreds or chips wrapped with filter fabric, covered with 12 inches of sub-ballast and 12 inches of ballast above that to the base of the ties. Tests suggest that the vibration attenuation properties of this treatment are midway between that of ballast mats and floating slab track. While this is a low-cost option, it has only recently been installed on two U.S. light rail transit systems (San Jose and Denver) and its long-term performance is unknown.
- Under-Tie Pads. This treatment consists of resilient rubber pads placed underneath the ties. Although tests using the Amtrak Acela high-speed trainset indicated that inserting such pads under the concrete ties provided significant vibration attenuation over a wide frequency range, experience with this treatment is limited.
- Floating Slabs. Floating slabs consist of thick concrete slabs supported by resilient pads on a concrete foundation; the tracks are mounted on top of the floating slab. Most successful floating slab installations are in subways, and their use for at-grade track is rare. Although floating slabs are designed to provide vibration reduction at lower frequencies than ballast mats, they are extremely expensive.
- Special Trackwork. Because the impacts of vehicle wheels over rail gaps at track turnout locations increases ground-borne vibration by about 10 VdB, turnouts are a major source of vibration impact when they are located in sensitive areas. If turnouts cannot be relocated away from sensitive areas, another approach is to use spring-rail, flange-bearing or moveable-point frogs in place of standard rigid frogs at turnouts. These

devices allow the flangeway gap to remain closed in the main traffic direction for revenue service trains.

- Property Acquisitions or Easements. Additional options for avoiding vibration impacts are for the transit agency to purchase the affected properties or to acquire easements by paying the homeowners to accept the future train vibrations. These approaches are usually taken only in isolated cases where other mitigation options are infeasible, impractical, or too costly.

Vibration impacts that exceed FTA criteria are considered to be significant and to warrant mitigation, if reasonable and feasible. To evaluate the effectiveness of mitigation, typical vibration reductions for potential measures were applied, on a one-third octave frequency basis, to the projected ground vibration spectra at locations where vibration impact is anticipated. The results indicate that using special trackwork at the turnout locations listed in **Table 4-3** could eliminate 13 of the 40 projected vibration impacts. Beyond that treatment, the installation of 4,100 lineal feet of TDA (shredded tires) beneath each of the tracks at the locations listed in **Table 4-4** could eliminate all of the remaining vibration impacts. While TDA would be the most effective mitigation measure, it is estimated that ballast mats could eliminate all but four of the remaining impacts. However, these measures will need to be further investigated during project design to evaluate their feasibility.

**Table 4-3 Potential Special Trackwork Vibration Mitigation Locations**

| Location along Alignment | | Civil Station Location |
|---|---|---|
| 29th Street – CR 28 | (Loveland) | 1969 |
| CR 18 – US 34 | (Loveland) | 1851 |
| Wilfred Rd. – Spartan Ave. | (Berthoud) | 1445 |
| Martin St. – Mountain View Ave. | (Longmont) | 1074 |

**Table 4-4 Potential Track Vibration Isolation Mitigation Locations**

| Location along Alignment | | Civil Station Location | Length (feet) |
|---|---|---|---|
| US 34 to 29th Street | (Loveland) | 1918 – 1922 | 400 |
| US 34 to 29th Street | (Loveland) | 1889 – 1894 | 500 |
| CR 18 to US 34 | (Loveland) | 1832 – 1836 | 400 |
| Mountain View Av. To SH 66 | (Longmont) | 1097 – 1101 | 400 |
| Mountain View Av. To SH 66 | (Longmont) | 1057 – 1069 | 1,200 |
| Mountain View Av. To SH 66 | (Longmont) | 1007 – 1015 | 800 |
| Mountain View Av. To SH 66 | (Longmont) | 999 – 1003 | 400 |
| **TOTAL:** | | | **4,100** |

## 4.3 CONSTRUCTION NOISE MITIGATION

Construction activities will be carried out in compliance with all applicable local noise regulations. If warranted, specific residential property line noise limits could be developed during final design and included in the construction specifications for the project, and noise monitoring could be performed during construction to verify compliance with the limits. This approach allows the contractor flexibility to meet the noise limits in the most efficient and cost-effective manner. Noise control measures that can be applied as needed to meet the noise limits include the following:

- Avoiding nighttime construction in residential neighborhoods.
- Using specially quieted equipment with enclosed engines and/or high-performance mufflers.
- Locating stationary construction equipment as far as possible from noise-sensitive sites.
- Constructing noise barriers, such as temporary walls or piles of excavated material, between noisy activities and noise-sensitive receivers.
- Re-routing construction-related truck traffic along roadways that will cause the least disturbance to residents.
- Avoiding impact pile driving near noise-sensitive areas, where possible. Drilled piles or the use of a sonic or vibratory pile driver are quieter alternatives where the geological conditions permit their use. If impact pile drivers must be used, their use will be limited to the periods between 8 AM and 5 PM on weekdays.

With the incorporation of the appropriate noise mitigation measures, impacts from construction-generated noise should not be significant. To provide added assurance, a complaint resolution procedure could also be put in place as appropriate to rapidly address any noise problems that may develop during construction.

## 4.4 MITIGATION SUMMARY

A summary of noise and vibration mitigation options is provided in **Table 4-5**. For noise, the recommended mitigation measures are the establishment of quiet zones and installation of noise barriers. It is estimated that quiet zones at 64 at-grade crossings could eliminate noise impacts at all but 21 residences along the project corridor. All of the residual moderate noise impacts could then be eliminated by construction of a total of 2,400 lineal feet of noise walls in three segments.

For vibration, it is estimated that that applying special trackwork at four turnout locations could eliminate 13 of the vibration impacts. Installation of 4,100 lineal feet of TDA at appropriate locations beneath each of the tracks could eliminate the remaining 27 projected vibration impacts. It is also estimated that the installation of ballast mats at these locations could eliminate all but four of the vibration impacts.

These potential noise and vibration mitigation options will need to be further investigated during project design to evaluate their feasibility.

### Table 4-5 Summary of Noise and Vibration Mitigation Options

| Potential Mitigation Option | | | Number of Residual Impacts |
|---|---|---|---|
| **Type** | **Description** | **Amount** | |
| Noise | FRA Quiet Zones | 64 Grade Crossings | 21 |
| | FRA Quiet Zones and Noise Barriers | 64 Grade Crossings and 2,400 lineal feet | 0 |
| Vibration | Special Trackwork | 4 Turnouts | 27 |
| | Special Trackwork and TDA | 4 Turnouts and 4,100 Track Feet | 0 |
| | Special Trackwork and Ballast Mats | 4 Turnouts and 4,100 Track Feet | 4 |

# Appendix A
# Site Photographs

NORTH I-25 EIS

information. cooperation. transportation.

**THIS PAGE INTENTIONALLY LEFT BLANK.**

Figure A-1. Site LT-1, 15930 Jackson Street - Brighton, CO

Figure A-2. Site LT-2, 4647 Chia Court - Dacono, CO

Figure A-3. Site LT-3, 4871 County Road 7 - Erie, CO

Figure A-4. Site LT-4, 514 Atwood Street - Longmont, CO

Figure A-5. Site LT-5, 1556 Centennial Drive - Longmont, CO

Figure A-6. Site LT-6, 1375 S. County Road 15 - Berthoud, CO

Figure A-7. Site LT-7, 208 3rd Street - Berthoud, CO

Figure A-8. Site LT-8, 1220 N. 4th Street - Berthoud, CO

NORTH I-25 EIS

information. cooperation. transportation.

**Figure A-9. Site LT-9, 5105 S. Iowa Avenue - Campion, CO**

**Figure A-10. Site LT-10, 1246 N. Arthur Avenue - Loveland, CO**

NORTH I-25 EIS

information. cooperation. transportation.

**Figure A-11. Site LT-11, 4355 Filbert Drive - Loveland, CO**

**Figure A-12. Site LT-12, 328 Albion Way – Fort Collins, CO**

**Figure A-13. Site LT-13, 635 Mason Street – Fort Collins, CO**

**Figure A-14. Site LT-14, 401 Timberline Road (Unit #178) – Fort Collins, CO**

**Figure A-15. Site ST-1, SH119 at Fairveiw Street - Longmont, CO**


**Figure A-16. Site ST-2, County Line Road 1 at Great Western Drive - Longmont, CO**

**Figure A-17. Site ST-3, Peakview Meadows (US287 at Turner Avenue) - Berthoud, CO**

**Figure A-18. Site ST-4, 2639 Cedar Drive at N. Garfield Avenue - Loveland, CO**

**Figure A-19. Site V-1, Sweetgrass Development - Dacono, CO**

**Figure A-20. Site V-2, Collyer Park - Longmont, CO**

**Figure A-21. Site V-3, Third Street and Capitol Avenue - Berthoud, CO**

**Figure A-22. Site V-4, Railroad Avenue and East 8th Street - Loveland, CO**

NORTH I-25 EIS

information. cooperation. transportation.

**Figure A-23. Site V-5, South of Horsetooth Road – Fort Collins, CO**

NORTH I-25 EIS

information. cooperation. transportation.

# Appendix B
# Noise Measurement Data

THIS PAGE INTENTIONALLY LEFT BLANK.

North I-25 EIS

information. cooperation. transportation.

Site LT-1: 15930 Jackson Street - Brighton, CO

Ldn: 55.4 dBA (10/18/06 – 10/19/06)

**Table B-1. Noise Survey Results, Site LT-1**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 19:00 | 49.6 | 57.8 | 42.2 | 55.0 | 52.1 | 49.8 | 48.7 | 45.8 | 43.9 |
| 20:00 | 49.5 | 59.3 | 41.9 | 55.3 | 51.7 | 49.6 | 48.7 | 46.3 | 44.1 |
| 21:00 | 48.8 | 65.1 | 39.2 | 58.6 | 50.9 | 48.3 | 46.9 | 43.2 | 40.5 |
| 22:00 | 44.0 | 53.7 | 34.9 | 51.3 | 46.9 | 43.8 | 42.4 | 39.1 | 37.0 |
| 23:00 | 42.6 | 54.1 | 35.7 | 50.1 | 44.7 | 42.5 | 41.5 | 38.9 | 37.1 |
| 0:00 | 42.6 | 55.2 | 32.6 | 51.4 | 45.4 | 41.9 | 40.6 | 36.6 | 33.5 |
| 1:00 | 44.4 | 63.1 | 32.0 | 56.9 | 45.6 | 39.6 | 37.9 | 35.0 | 33.1 |
| 2:00 | 39.7 | 55.2 | 32.2 | 50.3 | 42.4 | 38.0 | 36.7 | 33.9 | 32.7 |
| 3:00 | 42.4 | 58.4 | 32.2 | 53.2 | 44.4 | 41.1 | 39.6 | 34.7 | 32.8 |
| 4:00 | 45.7 | 57.5 | 35.6 | 53.3 | 48.7 | 45.8 | 44.1 | 39.6 | 37.0 |
| 5:00 | 48.8 | 57.7 | 42.1 | 55.0 | 51.0 | 48.9 | 48.1 | 45.1 | 43.0 |
| 6:00 | 50.7 | 58.4 | 45.9 | 54.3 | 52.1 | 50.9 | 50.4 | 48.8 | 47.3 |
| 7:00 | 50.1 | 56.9 | 46.6 | 53.8 | 51.5 | 50.3 | 49.7 | 48.4 | 47.3 |
| 8:00 | 62.6 | 91.2 | 45.4 | 61.9 | 60.2 | 55.1 | 52.3 | 47.9 | 46.2 |
| 9:00 | 49.2 | 60.9 | 44.6 | 54.4 | 50.8 | 49.1 | 48.5 | 47.0 | 45.7 |
| 10:00 | 49.1 | 62.7 | 45.0 | 55.2 | 50.6 | 48.9 | 48.3 | 46.7 | 45.6 |
| 11:00 | 48.7 | 64.4 | 41.2 | 55.6 | 51.1 | 48.5 | 47.5 | 44.9 | 43.1 |
| 12:00 | 48.6 | 67.2 | 39.6 | 57.2 | 50.7 | 47.9 | 46.8 | 43.7 | 41.2 |
| 13:00 | 52.9 | 66.5 | 45.0 | 59.3 | 55.5 | 53.0 | 51.8 | 48.7 | 46.4 |
| 14:00 | 57.3 | 66.6 | 47.4 | 62.8 | 60.3 | 57.7 | 56.4 | 52.0 | 49.1 |
| 15:00 | 58.9 | 81.8 | 47.6 | 69.7 | 59.6 | 57.1 | 55.7 | 51.6 | 49.1 |
| 16:00 | 55.5 | 72.1 | 45.1 | 63.8 | 57.8 | 55.2 | 53.7 | 48.5 | 46.2 |
| 17:00 | 54.4 | 69.0 | 45.3 | 59.4 | 56.5 | 55.2 | 54.3 | 48.9 | 46.5 |
| 18:00 | 53.4 | 77.4 | 43.2 | 58.6 | 56.4 | 51.8 | 50.4 | 46.9 | 44.5 |

NORTH I-25 EIS

information. cooperation. transportation.

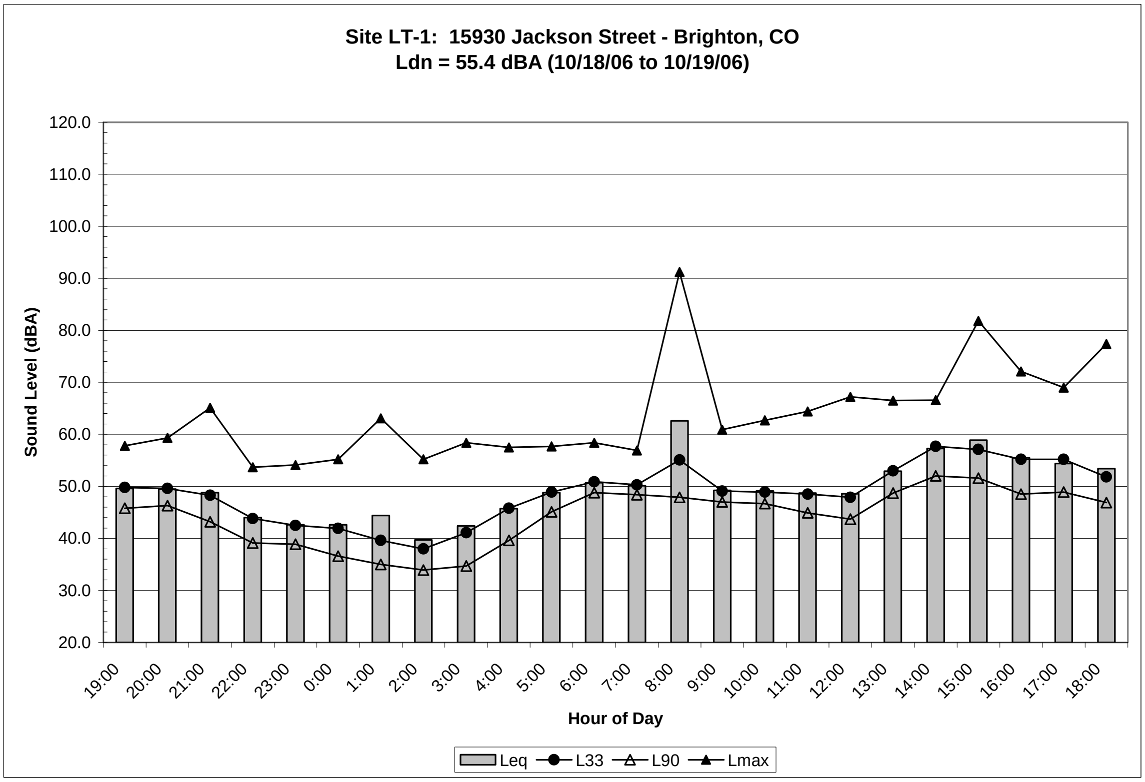



**Figure B-1. Noise Survey Results, Site LT-1**

Site LT-2: 4647 Chia Court - Dacono, CO

Ldn: 58.5 dBA (10/19/06 – 10/20/06)

**Table B-2. Noise Survey Results, Site LT-2**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 13:00 | 51.1 | 66.1 | 45.4 | 58.7 | 52.7 | 50.7 | 50.0 | 48.1 | 46.8 |
| 14:00 | 55.6 | 77.8 | 46.0 | 60.1 | 52.9 | 51.0 | 50.4 | 48.7 | 47.3 |
| 15:00 | 51.6 | 72.6 | 45.0 | 59.7 | 51.9 | 50.2 | 49.5 | 47.4 | 46.0 |
| 16:00 | 51.8 | 64.6 | 48.1 | 55.5 | 53.3 | 52.0 | 51.4 | 49.9 | 48.8 |
| 17:00 | 54.2 | 66.6 | 49.0 | 59.4 | 55.7 | 54.3 | 53.7 | 52.1 | 50.4 |
| 18:00 | 53.3 | 59.7 | 49.4 | 56.9 | 54.8 | 53.6 | 53.0 | 51.5 | 50.2 |
| 19:00 | 52.0 | 59.2 | 47.1 | 56.0 | 54.0 | 52.3 | 51.6 | 49.5 | 48.2 |
| 20:00 | 50.9 | 65.3 | 43.9 | 56.4 | 53.0 | 50.9 | 50.0 | 47.3 | 45.3 |
| 21:00 | 49.8 | 59.6 | 40.8 | 56.4 | 52.7 | 49.9 | 48.7 | 44.5 | 41.5 |
| 22:00 | 50.0 | 60.4 | 42.6 | 55.4 | 52.6 | 50.1 | 49.1 | 45.7 | 43.5 |
| 23:00 | 50.3 | 61.4 | 44.2 | 56.1 | 52.5 | 50.6 | 49.6 | 47.1 | 45.3 |
| 0:00 | 47.7 | 58.9 | 40.3 | 54.1 | 50.5 | 47.7 | 46.6 | 43.4 | 41.2 |
| 1:00 | 47.6 | 56.2 | 40.0 | 52.7 | 50.0 | 48.0 | 47.1 | 43.7 | 41.3 |
| 2:00 | 47.6 | 58.4 | 39.2 | 53.8 | 50.6 | 47.8 | 46.2 | 42.9 | 40.3 |
| 3:00 | 50.6 | 60.5 | 41.7 | 56.8 | 53.4 | 50.8 | 49.6 | 46.0 | 43.0 |
| 4:00 | 50.8 | 60.5 | 41.0 | 57.2 | 53.8 | 51.0 | 49.7 | 45.6 | 41.7 |
| 5:00 | 55.5 | 65.4 | 47.9 | 62.1 | 57.8 | 55.7 | 54.7 | 51.7 | 49.8 |
| 6:00 | 56.2 | 72.8 | 49.8 | 60.7 | 58.0 | 56.5 | 55.6 | 53.0 | 50.8 |
| 7:00 | 54.9 | 65.5 | 48.2 | 62.4 | 57.0 | 54.8 | 53.9 | 51.0 | 49.2 |
| 8:00 | 58.6 | 67.2 | 51.6 | 64.5 | 61.9 | 58.3 | 57.2 | 54.9 | 52.5 |
| 9:00 | 53.2 | 63.5 | 45.4 | 60.5 | 57.0 | 53.0 | 50.8 | 47.3 | 46.0 |
| 10:00 | 51.2 | 64.8 | 43.3 | 59.3 | 53.4 | 51.1 | 50.0 | 46.2 | 44.7 |
| 11:00 | 51.7 | 66.3 | 45.8 | 57.8 | 53.7 | 51.6 | 50.7 | 48.1 | 46.5 |
| 12:00 | 51.3 | 61.1 | 46.4 | 55.5 | 53.2 | 51.6 | 50.8 | 49.0 | 47.2 |

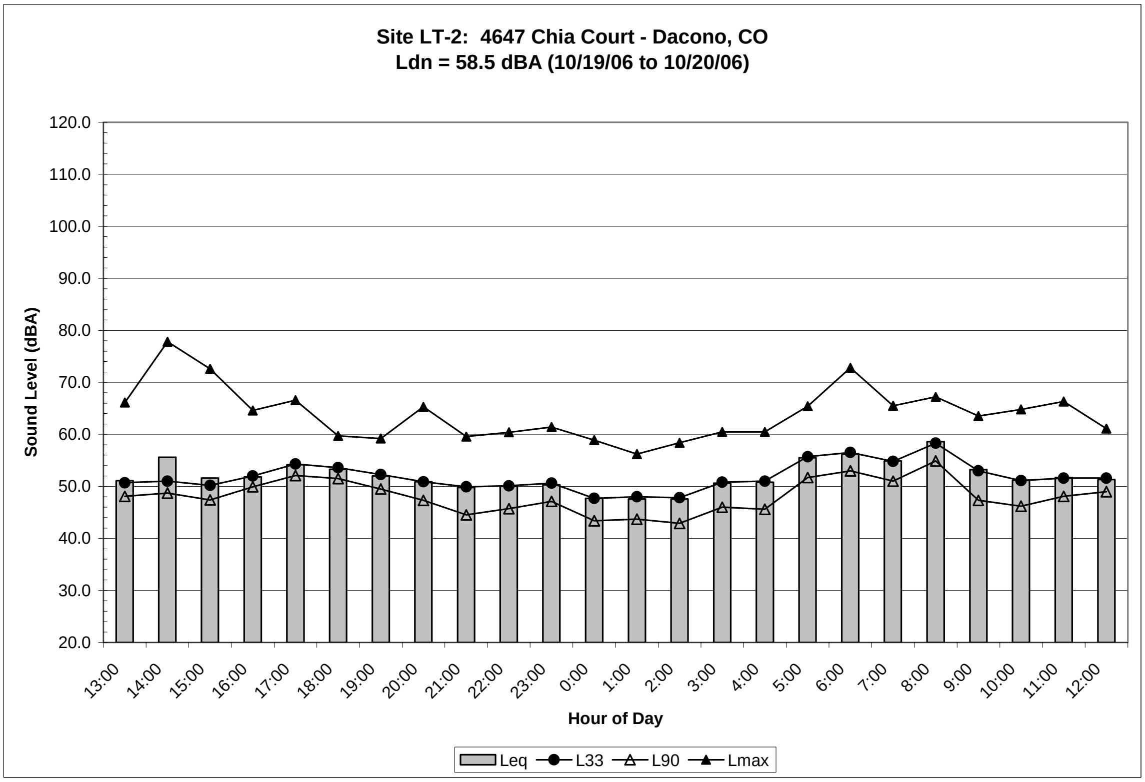



**Figure B-2. Noise Survey Results, Site LT-2**

NORTH I-25 EIS

information. cooperation. transportation.

Site LT-3: 4871 County Road 7 - Erie, CO

Ldn: 56.2 dBA (10/19/06 – 10/20/06)

**Table B-3. Noise Survey Results, Site LT-3**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 15:00 | 54.5 | 74.0 | 41.1 | 63.6 | 57.5 | 53.3 | 51.3 | 45.7 | 42.3 |
| 16:00 | 55.9 | 75.7 | 45.7 | 63.6 | 58.6 | 55.4 | 53.9 | 50.0 | 47.3 |
| 17:00 | 58.3 | 70.4 | 44.7 | 67.0 | 61.8 | 57.7 | 55.5 | 49.8 | 46.7 |
| 18:00 | 57.9 | 82.0 | 43.9 | 65.0 | 60.7 | 56.7 | 54.9 | 49.8 | 47.0 |
| 19:00 | 49.1 | 63.4 | 35.1 | 58.9 | 53.2 | 46.6 | 44.0 | 38.8 | 36.3 |
| 20:00 | 48.3 | 65.2 | 32.9 | 60.6 | 50.7 | 43.7 | 41.5 | 37.3 | 33.8 |
| 21:00 | 46.9 | 64.4 | 32.2 | 60.0 | 47.4 | 42.9 | 40.5 | 35.4 | 33.2 |
| 22:00 | 42.2 | 63.8 | 31.3 | 51.6 | 43.6 | 40.0 | 38.5 | 34.8 | 32.4 |
| 23:00 | 44.4 | 64.1 | 32.3 | 51.4 | 46.3 | 43.5 | 41.6 | 37.1 | 34.3 |
| 0:00 | 43.0 | 59.0 | 30.0 | 55.1 | 44.6 | 41.7 | 40.4 | 35.4 | 31.1 |
| 1:00 | 41.7 | 64.9 | 25.9 | 48.6 | 42.7 | 38.0 | 34.0 | 28.3 | 26.3 |
| 2:00 | 35.6 | 43.2 | 27.0 | 41.4 | 38.4 | 36.5 | 35.2 | 29.5 | 28.0 |
| 3:00 | 40.9 | 62.2 | 30.1 | 50.0 | 41.5 | 39.0 | 36.6 | 32.8 | 31.0 |
| 4:00 | 41.6 | 66.9 | 28.0 | 48.2 | 42.4 | 39.9 | 37.8 | 30.1 | 28.5 |
| 5:00 | 45.9 | 68.7 | 34.4 | 57.9 | 45.5 | 43.0 | 41.9 | 38.9 | 36.3 |
| 6:00 | 52.0 | 69.9 | 43.2 | 63.6 | 53.8 | 48.6 | 47.6 | 44.7 | 44.0 |
| 7:00 | 56.1 | 73.2 | 43.5 | 65.8 | 58.9 | 54.9 | 52.7 | 46.7 | 44.1 |
| 8:00 | 53.0 | 65.5 | 41.1 | 61.8 | 56.0 | 53.2 | 50.6 | 44.2 | 42.1 |
| 9:00 | 49.1 | 66.2 | 35.2 | 60.8 | 51.6 | 45.7 | 43.1 | 37.7 | 36.1 |
| 10:00 | 56.6 | 73.2 | 38.3 | 70.2 | 58.5 | 50.4 | 48.0 | 41.2 | 39.2 |
| 11:00 | 60.7 | 76.3 | 41.1 | 71.8 | 63.1 | 58.9 | 56.7 | 48.1 | 43.3 |
| 12:00 | 59.6 | 73.9 | 48.4 | 67.2 | 62.6 | 59.5 | 58.1 | 53.2 | 49.6 |
| 13:00 | 57.4 | 74.3 | 45.7 | 64.7 | 60.9 | 57.2 | 55.1 | 50.7 | 47.2 |
| 14:00 | 60.4 | 76.7 | 45.2 | 68.9 | 64.1 | 59.7 | 57.5 | 51.3 | 47.8 |

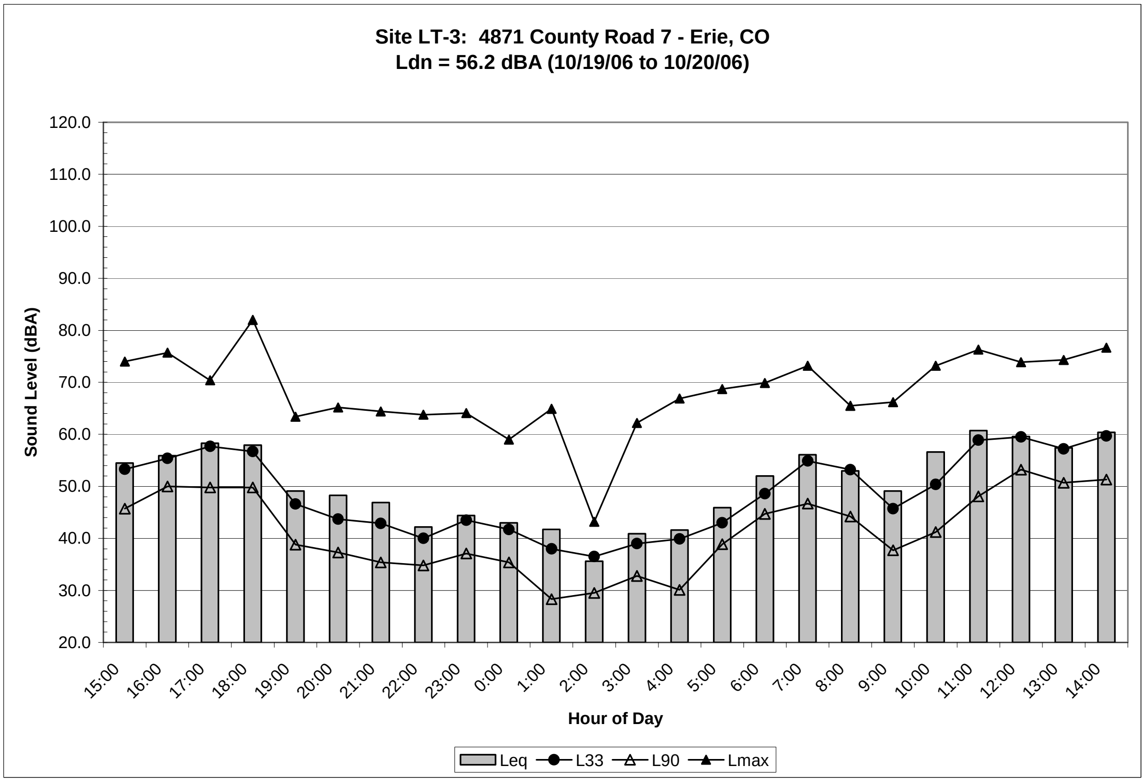



**Figure B-3. Noise Survey Results, Site LT-3**

information. cooperation. transportation.

Site LT-4: 514 Atwood Street - Longmont, CO

Ldn: 76.6 dBA (10/19/06 – 10/20/06)

**Table B-4. Noise Survey Results, Site LT-4**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 17:00 | 53.3 | 76.8 | 45.8 | 63.4 | 54.3 | 50.5 | 49.4 | 47.2 | 46.2 |
| 18:00 | 54.9 | 76.3 | 45.5 | 67.9 | 53.7 | 50.3 | 49.4 | 47.2 | 46.0 |
| 19:00 | 81.4 | 108.2 | 44.0 | 92.7 | 62.3 | 49.5 | 48.1 | 45.8 | 44.5 |
| 20:00 | 47.5 | 65.8 | 39.3 | 57.9 | 48.8 | 45.9 | 44.9 | 42.5 | 40.3 |
| 21:00 | 46.3 | 67.6 | 40.1 | 54.8 | 47.1 | 45.1 | 44.4 | 42.6 | 41.1 |
| 22:00 | 46.7 | 61.5 | 39.8 | 56.8 | 48.0 | 45.8 | 45.0 | 42.7 | 41.1 |
| 23:00 | 47.5 | 64.3 | 41.1 | 57.1 | 48.0 | 46.5 | 45.8 | 43.9 | 42.3 |
| 0:00 | 51.9 | 66.7 | 38.6 | 63.2 | 55.4 | 47.5 | 46.0 | 41.2 | 39.3 |
| 1:00 | 46.6 | 64.5 | 38.2 | 58.6 | 48.2 | 45.1 | 43.5 | 40.2 | 39.0 |
| 2:00 | 46.3 | 57.8 | 39.1 | 51.7 | 48.8 | 46.6 | 45.6 | 42.4 | 40.5 |
| 3:00 | 44.2 | 55.9 | 36.8 | 49.7 | 46.8 | 45.3 | 43.4 | 39.1 | 37.3 |
| 4:00 | 77.6 | 107.5 | 36.8 | 77.5 | 49.3 | 45.0 | 43.6 | 40.4 | 38.1 |
| 5:00 | 46.6 | 59.0 | 40.4 | 51.3 | 48.7 | 46.8 | 45.9 | 43.3 | 41.3 |
| 6:00 | 49.7 | 65.9 | 44.2 | 55.4 | 51.0 | 49.7 | 49.1 | 46.6 | 45.0 |
| 7:00 | 73.8 | 105.0 | 47.4 | 77.9 | 59.3 | 53.5 | 52.5 | 49.9 | 48.1 |
| 8:00 | 54.5 | 66.4 | 48.3 | 63.9 | 56.2 | 53.2 | 52.5 | 50.2 | 49.0 |
| 9:00 | 49.9 | 73.5 | 40.0 | 58.0 | 50.8 | 48.3 | 47.4 | 43.8 | 41.5 |
| 10:00 | 82.4 | 111.1 | 42.0 | 89.4 | 60.2 | 50.6 | 49.5 | 45.7 | 43.4 |
| 11:00 | 48.0 | 60.3 | 40.9 | 55.0 | 51.2 | 47.8 | 46.1 | 43.2 | 41.4 |
| 12:00 | 55.8 | 70.3 | 41.2 | 64.1 | 59.1 | 55.1 | 53.7 | 48.8 | 44.1 |
| 13:00 | 52.3 | 70.3 | 42.6 | 60.9 | 54.6 | 51.6 | 50.2 | 46.3 | 44.0 |
| 14:00 | 82.6 | 110.0 | 41.7 | 77.9 | 63.3 | 54.8 | 53.0 | 45.4 | 43.0 |
| 15:00 | 51.1 | 70.2 | 38.4 | 60.9 | 53.6 | 50.0 | 48.0 | 42.8 | 40.3 |
| 16:00 | 49.3 | 71.7 | 39.6 | 57.5 | 51.4 | 48.3 | 47.0 | 43.2 | 41.2 |

North I-25 EIS

information. cooperation. transportation.

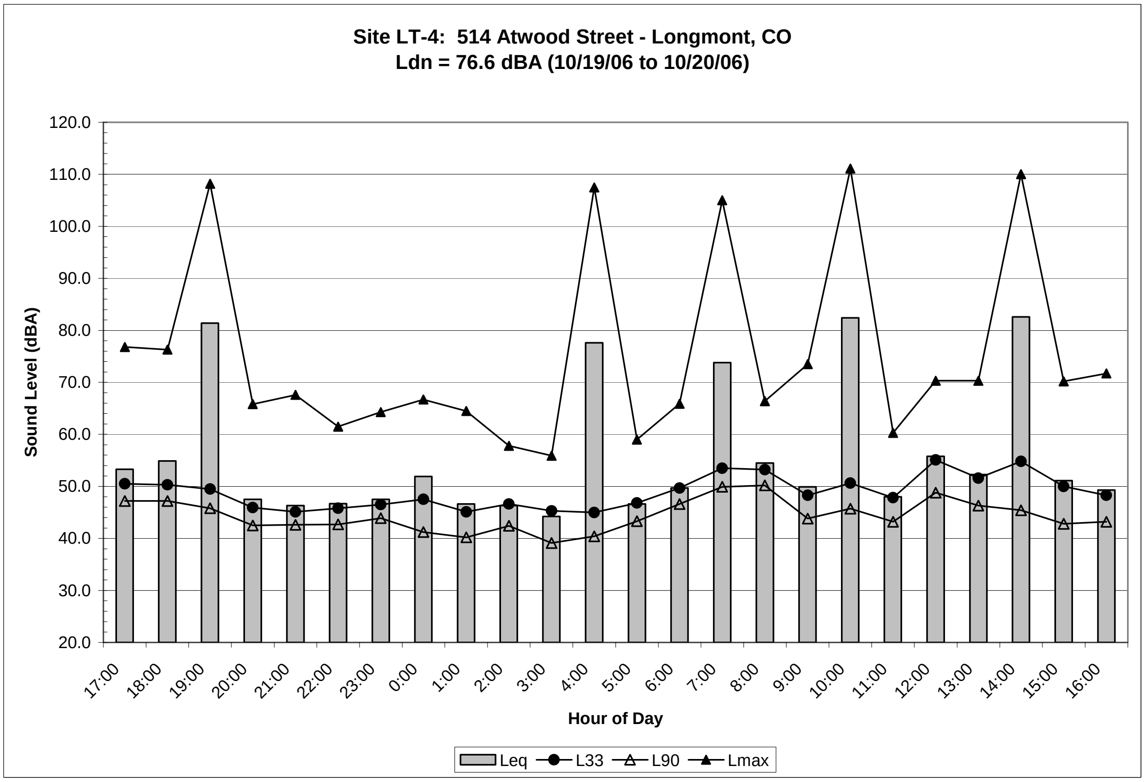



**Figure B-4. Noise Survey Results, Site LT-4**

NORTH I-25 EIS
information. cooperation. transportation.

Site LT-5: 1556 Centennial Drive - Longmont, CO

Ldn: 72.5 dBA (10/23/06 – 10/24/06)

**Table B-5. Noise Survey Results, Site LT-5**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 10:00 | 51.3 | 66.0 | 37.9 | 58.2 | 53.7 | 52.2 | 49.8 | 43.9 | 39.3 |
| 11:00 | 80.4 | 110.6 | 36.4 | 77.4 | 55.2 | 53.0 | 50.8 | 42.5 | 38.4 |
| 12:00 | 65.7 | 89.8 | 34.8 | 78.3 | 63.8 | 49.2 | 47.0 | 39.3 | 36.6 |
| 13:00 | 47.8 | 62.9 | 35.5 | 59.0 | 51.0 | 43.6 | 42.0 | 38.8 | 36.5 |
| 14:00 | 44.0 | 63.6 | 34.0 | 56.2 | 44.8 | 40.9 | 39.3 | 36.2 | 34.7 |
| 15:00 | 43.7 | 63.5 | 34.0 | 56.2 | 45.1 | 40.8 | 39.6 | 36.8 | 35.1 |
| 16:00 | 45.6 | 72.9 | 33.9 | 56.8 | 46.8 | 41.5 | 40.0 | 37.2 | 35.4 |
| 17:00 | 83.1 | 112.5 | 36.8 | 80.8 | 51.2 | 45.9 | 44.4 | 41.0 | 39.1 |
| 18:00 | 48.2 | 63.5 | 42.0 | 57.8 | 49.5 | 47.4 | 46.5 | 44.3 | 43.1 |
| 19:00 | 47.0 | 64.3 | 41.1 | 56.3 | 48.1 | 45.9 | 45.0 | 43.3 | 42.0 |
| 20:00 | 45.2 | 53.9 | 40.6 | 49.5 | 46.9 | 45.5 | 44.8 | 42.8 | 41.4 |
| 21:00 | 45.7 | 59.1 | 38.2 | 50.9 | 47.8 | 45.8 | 44.9 | 42.7 | 40.8 |
| 22:00 | 64.6 | 91.1 | 36.2 | 76.9 | 50.1 | 44.8 | 43.3 | 40.4 | 38.2 |
| 23:00 | 41.2 | 56.2 | 33.6 | 48.2 | 43.9 | 41.0 | 39.8 | 37.1 | 35.1 |
| 0:00 | 38.7 | 54.7 | 31.0 | 46.5 | 41.3 | 38.2 | 36.9 | 34.2 | 31.9 |
| 1:00 | 37.1 | 53.2 | 31.3 | 43.5 | 39.0 | 37.2 | 36.3 | 33.9 | 32.0 |
| 2:00 | 38.6 | 61.9 | 31.4 | 44.9 | 40.0 | 37.6 | 36.6 | 34.3 | 32.7 |
| 3:00 | 38.1 | 58.3 | 31.7 | 45.5 | 40.0 | 37.5 | 36.4 | 34.2 | 32.5 |
| 4:00 | 41.2 | 55.4 | 34.9 | 48.6 | 43.7 | 40.8 | 39.5 | 37.1 | 35.7 |
| 5:00 | 44.9 | 55.7 | 38.6 | 50.9 | 47.7 | 44.8 | 43.6 | 40.9 | 39.2 |
| 6:00 | 60.7 | 85.5 | 42.0 | 70.8 | 51.2 | 49.0 | 48.1 | 45.1 | 43.2 |
| 7:00 | 50.1 | 63.8 | 43.5 | 55.8 | 51.8 | 50.3 | 49.5 | 47.5 | 46.0 |
| 8:00 | 47.6 | 63.5 | 41.1 | 55.9 | 48.9 | 47.2 | 46.4 | 44.0 | 42.3 |
| 9:00 | 78.2 | 109.9 | 36.4 | 65.6 | 49.4 | 45.3 | 43.6 | 38.3 | 37.1 |

NORTH I-25 EIS

information. cooperation. transportation.

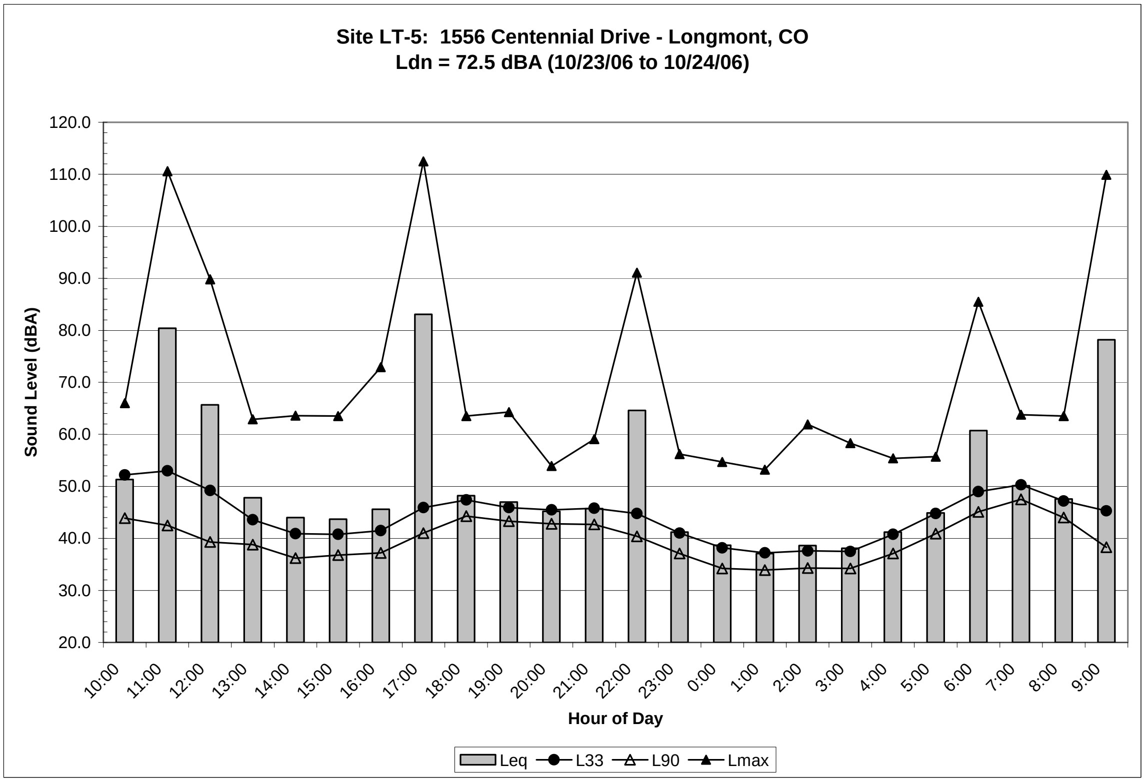



**Figure B-5. Noise Survey Results, Site LT-5**

Site LT-6: 1375 S. County Road 15 - Berthoud, CO

Ldn: 59.2 dBA (10/23/06 – 10/24/06)

**Table B-6. Noise Survey Results, Site LT-6**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 10:00 | 52.8 | 79.0 | 34.2 | 63.8 | 50.1 | 40.2 | 38.2 | 35.6 | 34.4 |
| 11:00 | 48.1 | 73.5 | 32.7 | 58.5 | 49.5 | 42.0 | 39.1 | 35.0 | 33.4 |
| 12:00 | 65.0 | 94.2 | 30.9 | 76.1 | 56.7 | 44.0 | 39.8 | 33.3 | 31.3 |
| 13:00 | 49.5 | 75.4 | 28.6 | 62.3 | 49.6 | 39.2 | 35.6 | 31.1 | 29.3 |
| 14:00 | 49.2 | 71.0 | 27.8 | 61.1 | 52.5 | 41.6 | 36.7 | 30.0 | 28.3 |
| 15:00 | 49.7 | 69.1 | 26.6 | 61.6 | 53.0 | 43.2 | 39.2 | 29.6 | 27.2 |
| 16:00 | 50.7 | 74.2 | 26.4 | 62.0 | 53.1 | 43.9 | 40.3 | 31.5 | 27.9 |
| 17:00 | 49.6 | 74.2 | 26.5 | 60.6 | 53.1 | 42.5 | 37.9 | 31.2 | 27.6 |
| 18:00 | 62.3 | 92.4 | 29.0 | 62.6 | 51.5 | 42.5 | 39.0 | 33.1 | 30.1 |
| 19:00 | 68.0 | 98.4 | 28.3 | 67.8 | 50.4 | 38.9 | 35.4 | 30.5 | 28.8 |
| 20:00 | 40.8 | 59.6 | 27.9 | 54.3 | 40.7 | 35.6 | 34.1 | 30.8 | 28.7 |
| 21:00 | 58.9 | 86.1 | 27.3 | 67.3 | 50.3 | 39.0 | 35.6 | 30.1 | 28.1 |
| 22:00 | 41.9 | 65.3 | 24.8 | 54.6 | 40.1 | 33.8 | 31.8 | 27.8 | 25.8 |
| 23:00 | 43.5 | 70.4 | 22.7 | 55.7 | 36.7 | 29.6 | 27.3 | 24.4 | 23.1 |
| 0:00 | 38.0 | 62.8 | 21.9 | 49.6 | 35.8 | 28.2 | 26.6 | 23.5 | 22.2 |
| 1:00 | 36.6 | 62.0 | 22.3 | 44.0 | 39.5 | 33.9 | 30.6 | 24.4 | 23.1 |
| 2:00 | 36.8 | 66.8 | 20.6 | 40.3 | 27.2 | 25.0 | 24.4 | 22.3 | 21.0 |
| 3:00 | 30.9 | 57.9 | 21.0 | 38.0 | 31.1 | 27.6 | 25.7 | 22.3 | 21.1 |
| 4:00 | 38.3 | 63.7 | 23.1 | 49.8 | 35.8 | 30.6 | 28.6 | 25.2 | 23.5 |
| 5:00 | 43.6 | 65.6 | 30.3 | 56.4 | 44.7 | 37.0 | 35.4 | 31.8 | 30.4 |
| 6:00 | 57.7 | 84.7 | 32.1 | 68.1 | 52.3 | 42.8 | 39.5 | 35.5 | 33.8 |
| 7:00 | 52.2 | 77.0 | 34.2 | 62.5 | 54.8 | 48.0 | 44.2 | 37.5 | 34.8 |
| 8:00 | 48.3 | 70.3 | 33.3 | 59.7 | 51.2 | 43.4 | 40.8 | 36.5 | 33.8 |
| 9:00 | 56.7 | 83.8 | 35.4 | 67.6 | 50.8 | 43.9 | 41.7 | 38.1 | 36.4 |

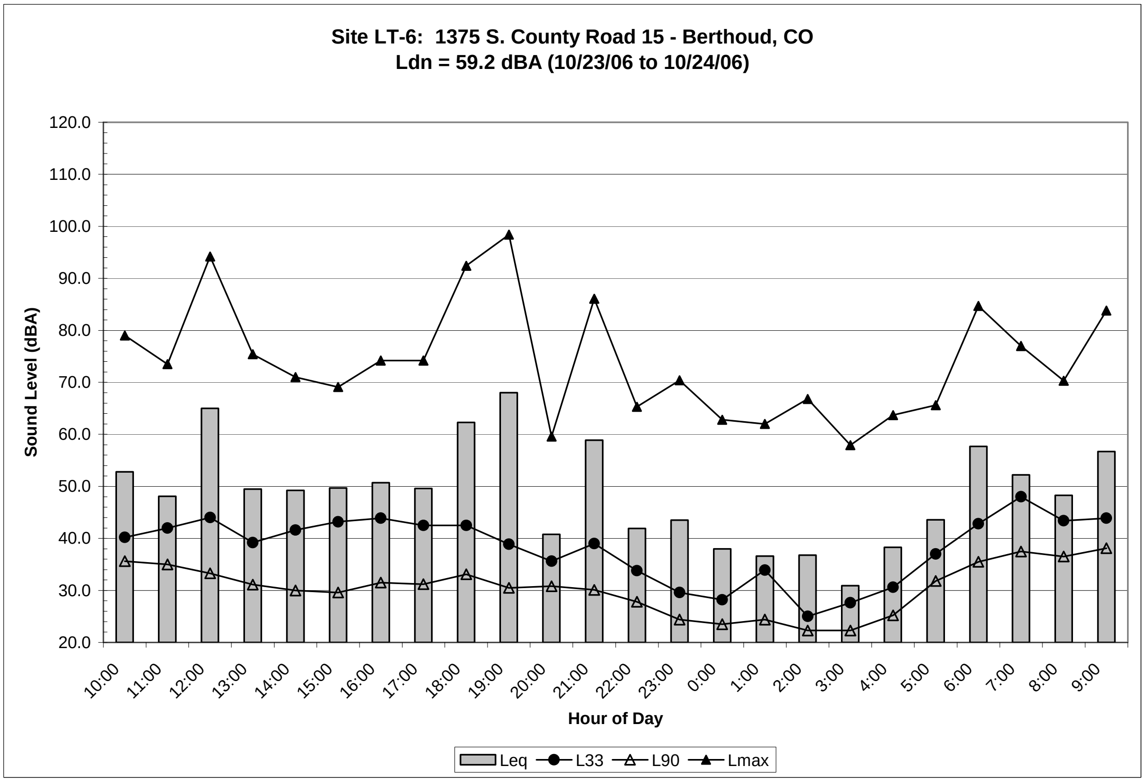



**Figure B-6. Noise Survey Results, Site LT-6**

NORTH I-25 EIS

information. cooperation. transportation.

Site LT-7: 208 3rd Street - Berthoud, CO

Ldn: 61.4 dBA (10/23/06 – 10/24/06)

### Table B-7. Noise Survey Results, Site LT-7

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 11:00 | 45.4 | 65.4 | 33.5 | 56.1 | 49.2 | 40.9 | 38.5 | 35.5 | 34.3 |
| 12:00 | 73.4 | 103.5 | 31.3 | 69.6 | 52.8 | 41.8 | 38.3 | 33.2 | 31.7 |
| 13:00 | 41.5 | 64.6 | 30.5 | 53.5 | 42.7 | 37.0 | 35.1 | 32.1 | 30.9 |
| 14:00 | 45.2 | 68.6 | 29.8 | 57.6 | 46.0 | 36.8 | 34.6 | 31.6 | 30.3 |
| 15:00 | 48.5 | 66.3 | 29.6 | 60.8 | 51.0 | 43.7 | 40.3 | 33.8 | 31.3 |
| 16:00 | 41.9 | 57.3 | 31.1 | 52.5 | 46.2 | 38.6 | 36.6 | 33.4 | 31.6 |
| 17:00 | 42.4 | 62.6 | 32.1 | 51.4 | 45.1 | 41.1 | 39.5 | 36.1 | 33.5 |
| 18:00 | 65.6 | 96.2 | 38.7 | 68.2 | 50.8 | 46.8 | 45.1 | 41.5 | 39.7 |
| 19:00 | 60.0 | 85.3 | 38.6 | 73.8 | 52.4 | 48.2 | 46.7 | 43.3 | 41.0 |
| 20:00 | 44.0 | 58.5 | 36.9 | 51.8 | 46.5 | 43.8 | 42.4 | 39.2 | 37.5 |
| 21:00 | 59.5 | 86.6 | 32.6 | 73.5 | 46.9 | 42.2 | 40.9 | 37.2 | 33.8 |
| 22:00 | 39.7 | 53.5 | 30.2 | 48.0 | 42.2 | 39.5 | 38.2 | 34.5 | 31.2 |
| 23:00 | 37.3 | 56.2 | 28.6 | 45.7 | 39.3 | 36.1 | 34.8 | 31.2 | 29.4 |
| 0:00 | 34.3 | 54.4 | 28.1 | 43.8 | 35.8 | 32.8 | 31.5 | 29.4 | 28.6 |
| 1:00 | 31.9 | 46.6 | 27.4 | 39.1 | 33.9 | 31.4 | 30.5 | 28.8 | 28.1 |
| 2:00 | 33.5 | 49.5 | 27.9 | 41.6 | 35.9 | 33.0 | 31.8 | 29.0 | 28.1 |
| 3:00 | 33.8 | 50.7 | 27.8 | 42.8 | 36.2 | 32.7 | 31.6 | 29.2 | 28.2 |
| 4:00 | 37.7 | 54.5 | 28.3 | 46.8 | 40.2 | 36.6 | 34.7 | 31.6 | 29.2 |
| 5:00 | 42.0 | 54.2 | 33.7 | 49.5 | 44.7 | 41.9 | 40.4 | 36.7 | 34.9 |
| 6:00 | 54.7 | 77.4 | 39.5 | 70.3 | 48.6 | 46.5 | 45.6 | 43.0 | 40.6 |
| 7:00 | 49.6 | 65.2 | 41.5 | 58.8 | 51.5 | 48.7 | 47.7 | 45.2 | 43.3 |
| 8:00 | 48.2 | 69.1 | 41.3 | 56.7 | 49.3 | 46.8 | 45.8 | 43.2 | 42.0 |
| 9:00 | 63.4 | 95.1 | 35.6 | 61.2 | 49.2 | 45.8 | 44.0 | 38.6 | 36.7 |
| 10:00 | 47.7 | 69.5 | 33.0 | 61.3 | 45.1 | 38.1 | 36.9 | 34.7 | 33.3 |

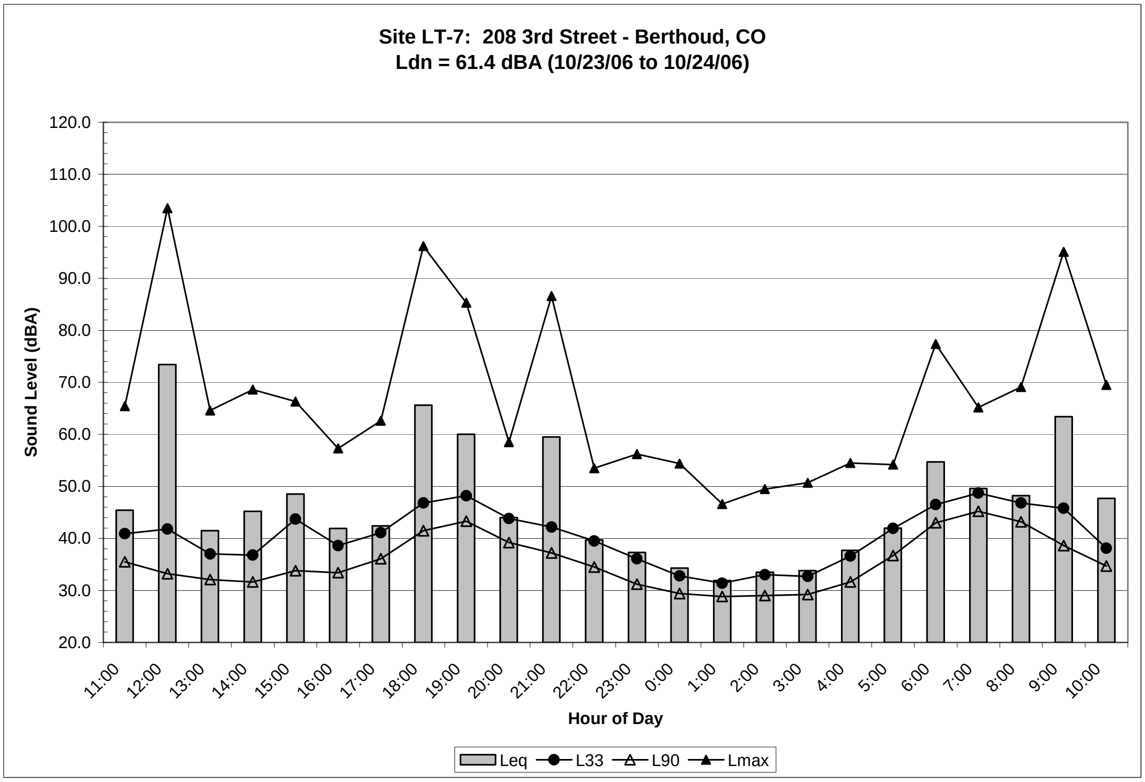



**Figure B-7. Noise Survey Results, Site LT-7**

NORTH I-25 EIS

information. cooperation. transportation.

Site LT-8: 1220 N. 4th Street - Berthoud, CO

Ldn: 63.2 dBA (10/23/06 – 10/24/06)

**Table B-8. Noise Survey Results, Site LT-8**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 11:00 | 44.2 | 59.4 | 35.0 | 54.7 | 47.0 | 42.2 | 40.4 | 37.3 | 36.1 |
| 12:00 | 73.4 | 100.2 | 31.9 | 81.1 | 52.3 | 42.2 | 39.8 | 35.6 | 33.4 |
| 13:00 | 40.6 | 53.3 | 32.9 | 49.4 | 43.4 | 39.9 | 38.4 | 35.3 | 34.0 |
| 14:00 | 43.6 | 63.6 | 31.8 | 54.5 | 44.9 | 40.4 | 39.1 | 35.9 | 34.1 |
| 15:00 | 43.6 | 63.5 | 32.5 | 55.0 | 45.3 | 40.9 | 39.0 | 35.4 | 33.5 |
| 16:00 | 43.0 | 61.3 | 33.1 | 53.8 | 44.7 | 41.2 | 39.7 | 36.7 | 34.9 |
| 17:00 | 43.2 | 53.6 | 34.4 | 49.9 | 46.0 | 43.5 | 42.1 | 38.4 | 36.4 |
| 18:00 | 60.8 | 90.5 | 35.3 | 67.9 | 49.5 | 44.8 | 43.4 | 39.2 | 36.5 |
| 19:00 | 65.4 | 93.9 | 33.5 | 78.0 | 48.3 | 43.4 | 41.5 | 36.9 | 34.4 |
| 20:00 | 42.0 | 54.8 | 31.5 | 48.5 | 44.8 | 42.1 | 40.8 | 37.3 | 33.2 |
| 21:00 | 70.3 | 99.5 | 33.4 | 78.2 | 46.8 | 42.4 | 40.9 | 37.0 | 34.4 |
| 22:00 | 38.2 | 57.6 | 26.9 | 47.0 | 40.7 | 37.6 | 35.9 | 31.1 | 28.0 |
| 23:00 | 34.9 | 52.9 | 24.8 | 43.7 | 37.0 | 33.7 | 31.6 | 27.6 | 25.5 |
| 0:00 | 34.1 | 48.1 | 26.0 | 43.4 | 37.6 | 32.6 | 30.9 | 28.0 | 26.5 |
| 1:00 | 33.8 | 48.0 | 26.7 | 43.8 | 36.6 | 31.4 | 30.2 | 28.3 | 27.2 |
| 2:00 | 34.7 | 51.1 | 25.6 | 44.6 | 38.3 | 32.4 | 30.0 | 27.1 | 26.0 |
| 3:00 | 35.4 | 51.6 | 24.9 | 47.1 | 38.2 | 32.9 | 30.9 | 26.8 | 25.5 |
| 4:00 | 38.3 | 53.1 | 26.2 | 48.2 | 41.8 | 36.7 | 34.5 | 30.1 | 28.0 |
| 5:00 | 40.5 | 51.2 | 28.4 | 48.1 | 43.9 | 40.6 | 38.8 | 31.6 | 29.2 |
| 6:00 | 60.6 | 86.0 | 35.9 | 74.1 | 48.3 | 45.7 | 44.5 | 40.5 | 37.3 |
| 7:00 | 47.9 | 57.9 | 40.2 | 54.0 | 50.4 | 48.1 | 47.0 | 44.2 | 42.0 |
| 8:00 | 45.6 | 55.5 | 40.0 | 51.3 | 47.9 | 45.7 | 44.8 | 42.4 | 40.7 |
| 9:00 | 55.2 | 84.8 | 36.1 | 61.7 | 48.4 | 44.2 | 42.6 | 38.8 | 37.1 |
| 10:00 | 41.9 | 56.6 | 35.8 | 50.7 | 44.5 | 40.7 | 39.6 | 37.5 | 36.4 |

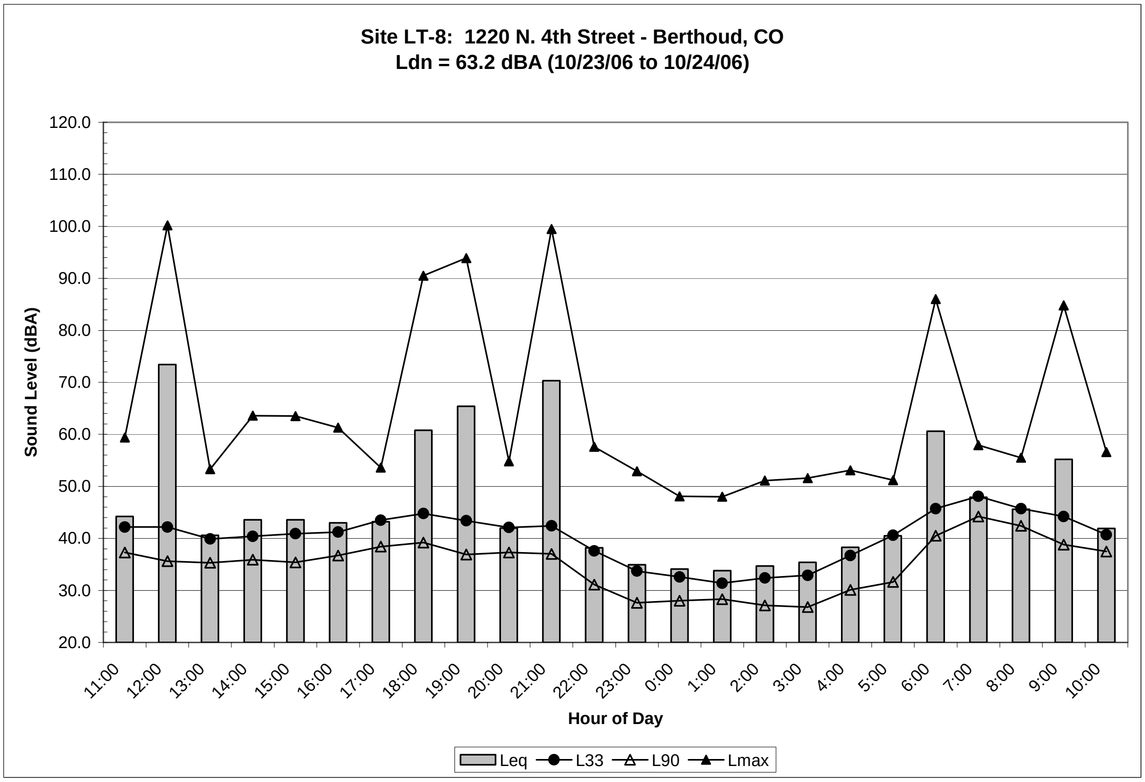



**Figure B-8. Noise Survey Results, Site LT-8**

Site LT-9: 5105 S. Iowa Avenue - Campion, CO

Ldn: 62.8 dBA (10/24/06 – 10/25/06)

**Table B-9. Noise Survey Results, Site LT-9**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 13:00 | 59.1 | 83.5 | 30.6 | 73.2 | 52.9 | 46.4 | 44.2 | 38.6 | 33.2 |
| 14:00 | 49.2 | 66.6 | 31.0 | 58.8 | 54.8 | 45.1 | 41.0 | 36.8 | 33.0 |
| 15:00 | 47.4 | 69.3 | 30.2 | 60.6 | 47.5 | 41.7 | 39.9 | 35.6 | 32.1 |
| 16:00 | 45.0 | 63.4 | 32.6 | 54.7 | 47.1 | 43.9 | 42.4 | 37.4 | 34.0 |
| 17:00 | 48.4 | 68.6 | 36.6 | 55.4 | 50.5 | 48.1 | 46.6 | 42.0 | 39.1 |
| 18:00 | 63.3 | 87.3 | 36.0 | 74.5 | 54.2 | 48.6 | 46.8 | 41.5 | 37.9 |
| 19:00 | 45.7 | 61.0 | 33.5 | 53.9 | 47.9 | 45.6 | 44.2 | 40.1 | 36.1 |
| 20:00 | 45.0 | 61.8 | 33.4 | 55.2 | 47.3 | 43.7 | 42.3 | 37.6 | 35.0 |
| 21:00 | 42.6 | 54.9 | 32.6 | 49.4 | 45.2 | 42.6 | 41.3 | 37.5 | 34.5 |
| 22:00 | 41.8 | 58.4 | 30.4 | 50.4 | 44.7 | 41.0 | 39.4 | 34.9 | 31.8 |
| 23:00 | 38.5 | 52.0 | 28.2 | 46.3 | 41.7 | 38.2 | 36.7 | 32.2 | 29.8 |
| 0:00 | 34.6 | 51.7 | 24.2 | 43.0 | 37.5 | 33.7 | 31.9 | 27.5 | 25.4 |
| 1:00 | 33.2 | 48.5 | 22.7 | 43.6 | 36.6 | 30.4 | 28.6 | 24.2 | 23.0 |
| 2:00 | 60.3 | 84.3 | 22.2 | 75.7 | 41.6 | 32.8 | 28.9 | 24.1 | 22.3 |
| 3:00 | 64.6 | 87.6 | 22.9 | 76.4 | 43.8 | 32.1 | 29.6 | 24.6 | 23.1 |
| 4:00 | 41.1 | 61.0 | 24.1 | 52.6 | 43.9 | 37.2 | 33.6 | 27.2 | 25.1 |
| 5:00 | 45.3 | 59.1 | 26.9 | 54.7 | 49.0 | 43.6 | 41.3 | 32.9 | 27.6 |
| 6:00 | 49.9 | 60.7 | 40.3 | 55.9 | 53.0 | 50.1 | 48.6 | 45.2 | 42.3 |
| 7:00 | 52.5 | 62.7 | 41.0 | 59.2 | 55.2 | 52.8 | 51.6 | 47.3 | 44.0 |
| 8:00 | 53.2 | 72.4 | 41.8 | 61.8 | 55.8 | 52.4 | 50.6 | 46.1 | 43.4 |
| 9:00 | 46.5 | 59.2 | 33.7 | 55.8 | 50.3 | 45.0 | 42.7 | 38.4 | 35.8 |
| 10:00 | 57.6 | 82.5 | 31.2 | 57.8 | 45.7 | 41.0 | 39.4 | 35.2 | 33.1 |
| 11:00 | 40.8 | 57.8 | 32.2 | 51.2 | 43.0 | 39.1 | 37.7 | 34.5 | 33.1 |
| 12:00 | 41.6 | 58.4 | 31.4 | 52.2 | 44.4 | 39.5 | 37.9 | 34.4 | 32.6 |

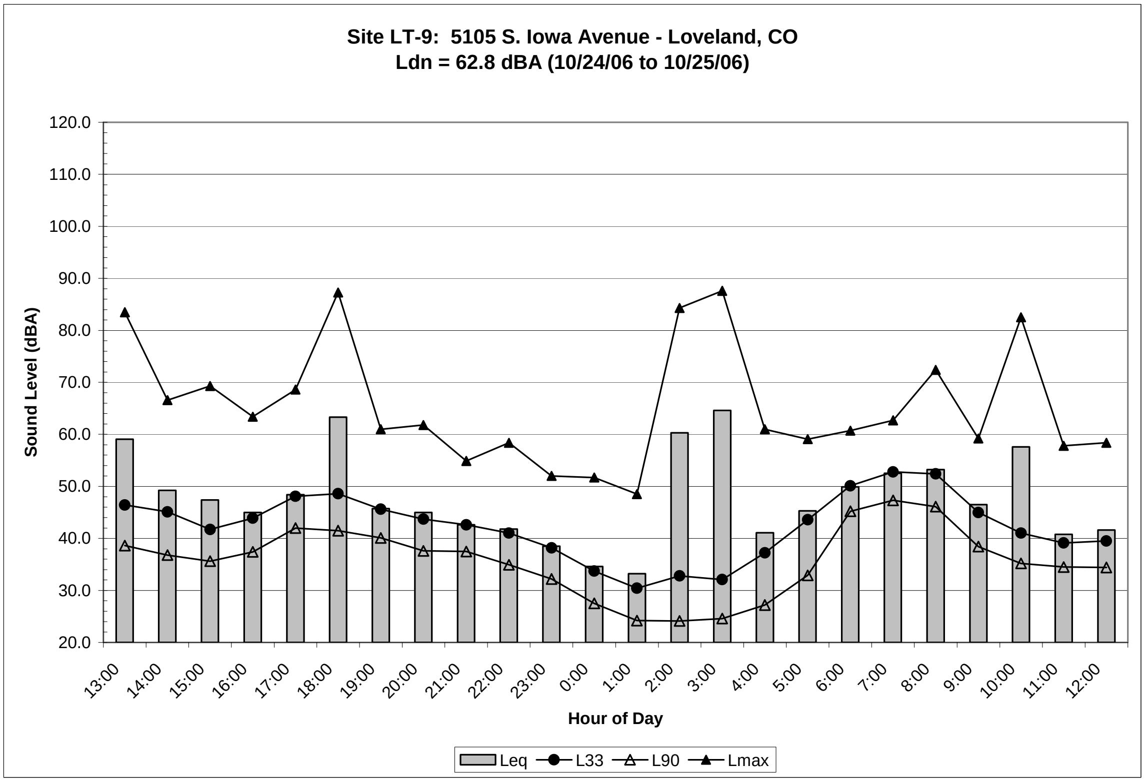



**Figure B-9. Noise Survey Results, Site LT-9**

North I-25 EIS

information. cooperation. transportation.

Site LT-10: 1246 N. Arthur Avenue - Loveland, CO

Ldn: 67.9 dBA (10/24/06 – 10/25/06)

**Table B-10. Noise Survey Results, Site LT-10**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 14:00 | 43.8 | 63.7 | 36.3 | 51.8 | 45.5 | 43.3 | 42.4 | 40.1 | 38.4 |
| 15:00 | 44.7 | 58.9 | 38.3 | 51.5 | 46.6 | 44.5 | 43.7 | 41.6 | 40.1 |
| 16:00 | 48.4 | 69.7 | 40.6 | 57.1 | 49.9 | 47.1 | 46.2 | 43.4 | 41.7 |
| 17:00 | 64.7 | 91.9 | 42.0 | 76.9 | 51.9 | 48.3 | 47.0 | 45.0 | 43.4 |
| 18:00 | 50.9 | 68.5 | 42.8 | 57.9 | 53.6 | 50.5 | 49.0 | 46.3 | 44.3 |
| 19:00 | 49.6 | 72.8 | 43.1 | 57.2 | 50.5 | 48.7 | 47.8 | 45.7 | 44.2 |
| 20:00 | 48.1 | 61.9 | 42.4 | 53.2 | 49.9 | 48.4 | 47.6 | 45.4 | 44.1 |
| 21:00 | 49.7 | 61.2 | 42.9 | 54.4 | 52.0 | 50.2 | 49.1 | 46.2 | 44.2 |
| 22:00 | 47.0 | 67.6 | 39.4 | 51.7 | 48.9 | 47.1 | 46.2 | 43.1 | 41.1 |
| 23:00 | 43.3 | 56.4 | 37.5 | 49.5 | 45.5 | 43.4 | 42.5 | 40.2 | 38.4 |
| 0:00 | 41.8 | 55.1 | 32.0 | 50.3 | 44.0 | 41.4 | 40.4 | 37.7 | 33.4 |
| 1:00 | 39.1 | 49.6 | 34.5 | 44.2 | 41.0 | 39.2 | 38.4 | 36.2 | 35.0 |
| 2:00 | 62.6 | 86.4 | 32.8 | 78.4 | 43.0 | 38.7 | 37.7 | 35.3 | 33.6 |
| 3:00 | 70.8 | 97.0 | 33.5 | 75.8 | 61.8 | 40.7 | 39.1 | 36.0 | 34.2 |
| 4:00 | 56.1 | 85.4 | 35.8 | 58.8 | 43.8 | 41.4 | 40.3 | 37.6 | 36.2 |
| 5:00 | 44.6 | 59.1 | 38.2 | 49.5 | 46.7 | 44.8 | 43.9 | 41.2 | 39.2 |
| 6:00 | 48.2 | 54.7 | 43.2 | 51.8 | 49.9 | 48.6 | 47.8 | 45.6 | 44.0 |
| 7:00 | 51.0 | 70.2 | 46.3 | 59.2 | 51.3 | 50.0 | 49.5 | 48.2 | 47.1 |
| 8:00 | 59.6 | 78.5 | 45.9 | 72.3 | 59.5 | 53.3 | 52.2 | 48.6 | 46.7 |
| 9:00 | 53.3 | 72.8 | 49.4 | 59.9 | 54.4 | 51.9 | 51.4 | 50.3 | 49.7 |
| 10:00 | 49.9 | 67.7 | 38.9 | 58.8 | 51.9 | 50.0 | 45.5 | 41.8 | 39.7 |
| 11:00 | 48.4 | 75.2 | 38.5 | 55.5 | 49.7 | 45.0 | 43.7 | 41.4 | 39.4 |
| 12:00 | 44.5 | 56.4 | 38.4 | 50.8 | 46.5 | 44.5 | 43.7 | 41.4 | 39.6 |
| 13:00 | 44.3 | 58.1 | 38.5 | 51.3 | 46.1 | 44.0 | 43.2 | 41.1 | 39.7 |

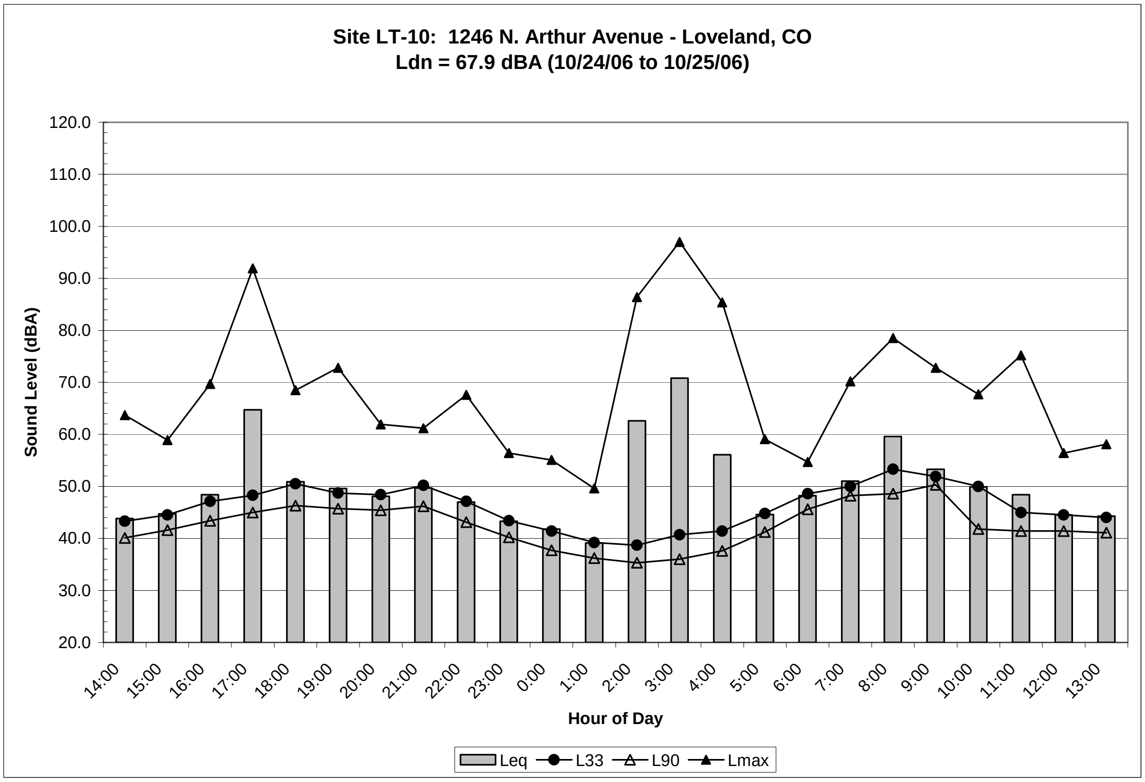



**Figure B-10. Noise Survey Results, Site LT-10**

NORTH I-25 EIS

information. cooperation. transportation.

Site LT-11: 4355 Filbert Drive - Loveland, CO

Ldn: 63.0 dBA (10/24/06 – 10/25/06)

**Table B-11. Noise Survey Results, Site LT-11**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 15:00 | 42.7 | 60.7 | 32.6 | 53.0 | 44.9 | 41.3 | 39.7 | 36.2 | 34.2 |
| 16:00 | 46.7 | 63.0 | 34.5 | 55.8 | 50.4 | 45.3 | 40.9 | 36.7 | 35.1 |
| 17:00 | 62.4 | 81.7 | 37.4 | 76.4 | 56.5 | 50.1 | 48.3 | 41.3 | 38.8 |
| 18:00 | 45.4 | 62.2 | 39.1 | 52.4 | 47.7 | 45.2 | 44.0 | 41.1 | 39.8 |
| 19:00 | 44.0 | 59.8 | 35.7 | 50.5 | 46.5 | 43.8 | 42.6 | 39.0 | 36.8 |
| 20:00 | 46.0 | 59.7 | 38.4 | 52.9 | 48.3 | 45.9 | 44.8 | 41.3 | 39.3 |
| 21:00 | 44.1 | 51.8 | 37.8 | 48.3 | 46.1 | 44.5 | 43.7 | 41.2 | 39.2 |
| 22:00 | 40.1 | 49.2 | 32.8 | 45.8 | 42.8 | 40.3 | 39.3 | 36.3 | 34.2 |
| 23:00 | 37.8 | 53.2 | 29.9 | 46.5 | 39.9 | 37.3 | 36.2 | 33.2 | 31.0 |
| 0:00 | 35.1 | 43.2 | 28.0 | 40.4 | 37.6 | 35.6 | 34.5 | 31.0 | 28.7 |
| 1:00 | 34.7 | 47.7 | 26.7 | 41.8 | 37.6 | 34.7 | 33.3 | 29.7 | 27.4 |
| 2:00 | 59.9 | 82.8 | 28.0 | 74.4 | 39.5 | 36.2 | 34.7 | 31.1 | 28.6 |
| 3:00 | 38.4 | 57.5 | 29.7 | 48.8 | 40.3 | 36.8 | 35.5 | 32.5 | 30.5 |
| 4:00 | 65.0 | 90.8 | 31.8 | 78.8 | 44.8 | 39.2 | 38.0 | 35.1 | 33.2 |
| 5:00 | 43.6 | 58.5 | 35.8 | 50.2 | 46.0 | 43.8 | 42.7 | 38.4 | 36.4 |
| 6:00 | 46.7 | 55.4 | 42.0 | 50.5 | 48.6 | 47.2 | 46.4 | 44.1 | 42.6 |
| 7:00 | 49.2 | 59.6 | 45.8 | 54.4 | 50.7 | 49.3 | 48.7 | 47.2 | 46.2 |
| 8:00 | 48.8 | 63.0 | 44.6 | 56.2 | 50.4 | 48.6 | 47.8 | 46.1 | 45.1 |
| 9:00 | 47.5 | 70.5 | 36.6 | 58.1 | 48.7 | 45.6 | 43.7 | 38.8 | 37.4 |
| 10:00 | 46.3 | 63.5 | 37.6 | 56.5 | 48.8 | 44.6 | 43.0 | 40.2 | 38.6 |
| 11:00 | 42.9 | 63.1 | 33.6 | 51.6 | 45.8 | 42.2 | 40.6 | 36.8 | 34.5 |
| 12:00 | 42.3 | 63.8 | 30.9 | 53.8 | 42.7 | 38.6 | 37.1 | 33.8 | 31.8 |
| 13:00 | 44.3 | 64.8 | 29.8 | 57.5 | 43.7 | 39.1 | 37.5 | 34.3 | 31.3 |
| 14:00 | 65.1 | 89.6 | 29.9 | 79.3 | 47.5 | 38.9 | 36.8 | 32.6 | 31.0 |

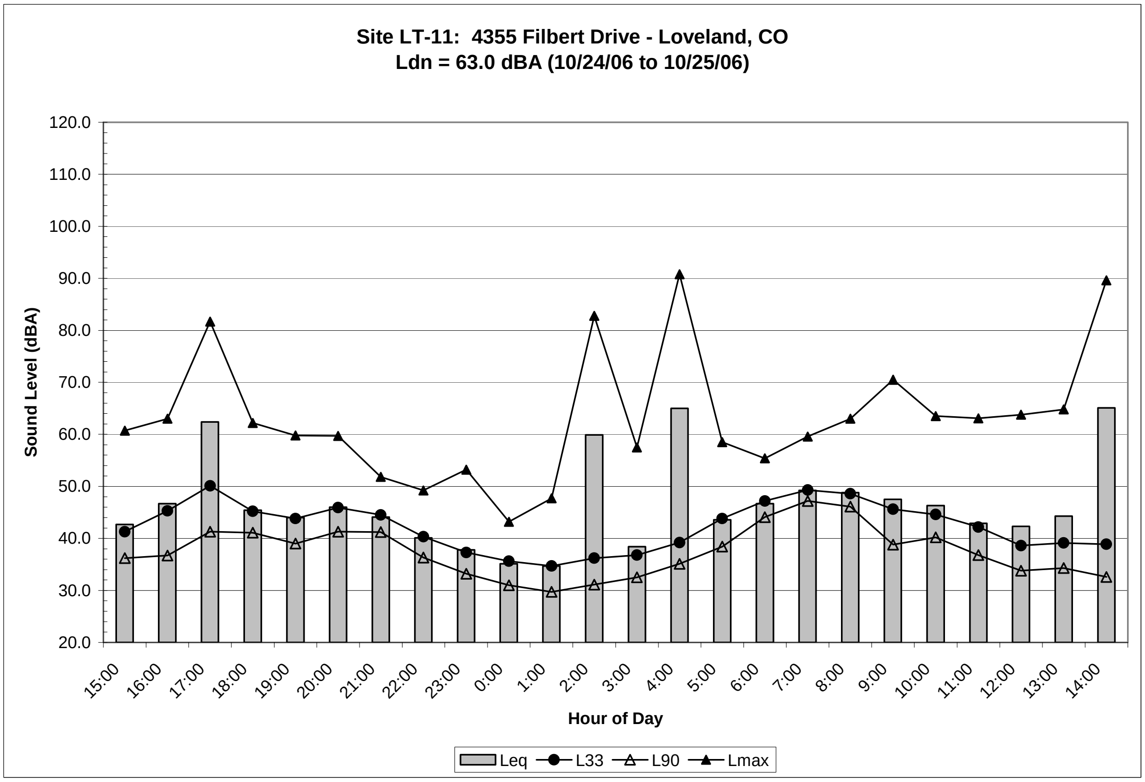



**Figure B-11. Noise Survey Results, Site LT-11**

NORTH I-25 EIS

information. cooperation. transportation.

Site LT-12: 328 Albion Way – Fort Collins, CO

Ldn: 58.0 dBA (10/26/06 – 10/27/06)

### Table B-12. Noise Survey Results, Site LT-12

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 15:00 | 53.2 | 72.9 | 49.4 | 55.9 | 54.5 | 53.4 | 52.8 | 51.4 | 50.2 |
| 16:00 | 53.2 | 68.1 | 48.1 | 56.3 | 54.6 | 53.5 | 53.0 | 51.3 | 49.9 |
| 17:00 | 58.1 | 79.3 | 50.3 | 70.4 | 55.9 | 54.7 | 54.2 | 52.7 | 51.5 |
| 18:00 | 54.1 | 79.0 | 49.7 | 57.2 | 54.6 | 53.6 | 53.1 | 51.8 | 50.5 |
| 19:00 | 65.6 | 93.9 | 49.4 | 79.3 | 54.8 | 53.4 | 52.8 | 51.2 | 50.1 |
| 20:00 | 50.9 | 58.0 | 45.9 | 54.4 | 52.7 | 51.3 | 50.6 | 48.7 | 47.1 |
| 21:00 | 52.5 | 65.1 | 47.4 | 56.4 | 54.2 | 52.8 | 52.2 | 50.3 | 48.7 |
| 22:00 | 51.7 | 57.8 | 44.9 | 55.7 | 53.8 | 52.2 | 51.2 | 48.6 | 46.4 |
| 23:00 | 49.6 | 57.2 | 43.9 | 53.9 | 51.7 | 50.0 | 49.0 | 46.6 | 45.0 |
| 0:00 | 46.6 | 54.6 | 41.7 | 50.8 | 48.7 | 47.0 | 46.2 | 43.7 | 42.3 |
| 1:00 | 45.4 | 56.3 | 39.8 | 51.7 | 47.4 | 45.5 | 44.6 | 42.3 | 40.6 |
| 2:00 | 46.9 | 59.5 | 38.6 | 53.0 | 49.4 | 47.0 | 45.9 | 43.2 | 39.9 |
| 3:00 | 45.3 | 54.5 | 38.6 | 51.3 | 48.1 | 45.4 | 44.1 | 41.1 | 39.3 |
| 4:00 | 46.3 | 58.8 | 38.4 | 52.4 | 48.9 | 46.6 | 45.2 | 41.5 | 39.5 |
| 5:00 | 46.8 | 54.8 | 41.6 | 51.6 | 49.0 | 47.1 | 46.2 | 44.0 | 42.6 |
| 6:00 | 51.7 | 76.2 | 42.3 | 58.8 | 52.8 | 50.2 | 49.2 | 45.8 | 43.5 |
| 7:00 | 62.0 | 87.8 | 46.8 | 71.8 | 54.8 | 52.6 | 51.7 | 49.3 | 47.8 |
| 8:00 | 57.5 | 79.5 | 44.1 | 72.9 | 52.7 | 50.8 | 49.8 | 47.6 | 45.7 |
| 9:00 | 49.4 | 64.8 | 43.0 | 58.6 | 51.8 | 47.9 | 46.9 | 45.0 | 43.6 |
| 10:00 | 47.8 | 69.9 | 41.4 | 54.5 | 49.3 | 46.7 | 45.7 | 43.7 | 42.4 |
| 11:00 | 60.5 | 82.7 | 41.2 | 74.0 | 52.7 | 47.8 | 46.5 | 43.9 | 42.3 |
| 12:00 | 46.1 | 61.1 | 40.6 | 54.2 | 47.3 | 45.4 | 44.7 | 43.0 | 41.4 |
| 13:00 | 47.7 | 67.7 | 40.6 | 58.6 | 48.5 | 45.4 | 44.6 | 42.9 | 41.5 |
| 14:00 | 51.4 | 69.1 | 40.4 | 62.4 | 54.7 | 48.5 | 46.1 | 42.7 | 41.3 |

NORTH I-25 EIS

information. cooperation. transportation.

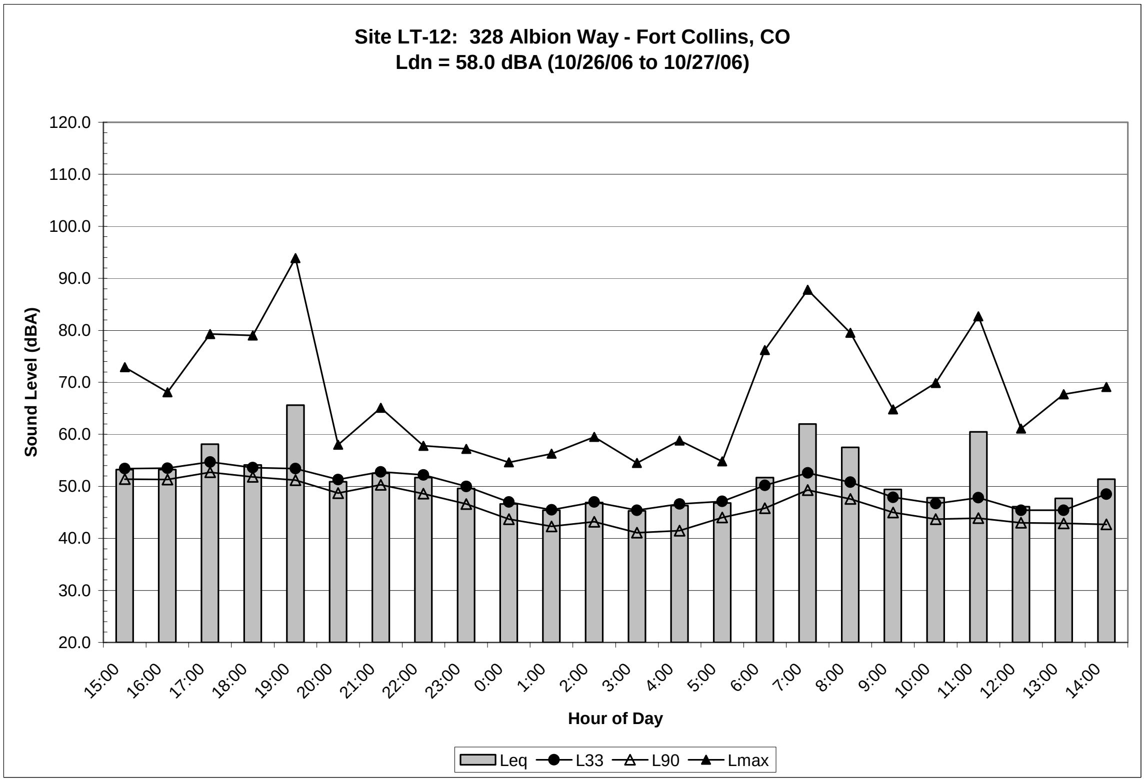



**Figure B-12. Noise Survey Results, Site LT-12**

NORTH I-25 EIS

information. cooperation. transportation.

Site LT-13: 635 Mason Street – Fort Collins, CO

Ldn: 71.6 dBA (10/26/06 – 10/27/06)

### Table B-13. Noise Survey Results, Site LT-13

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 16:00 | 59.0 | 77.4 | 48.5 | 68.0 | 62.3 | 57.5 | 55.1 | 51.7 | 49.7 |
| 17:00 | 76.5 | 106.9 | 48.6 | 79.4 | 65.9 | 59.3 | 56.4 | 51.7 | 50.1 |
| 18:00 | 58.1 | 78.1 | 47.6 | 66.7 | 61.2 | 57.0 | 54.7 | 50.3 | 48.3 |
| 19:00 | 69.8 | 100.8 | 46.8 | 78.2 | 64.6 | 55.7 | 53.0 | 49.4 | 47.7 |
| 20:00 | 55.1 | 71.8 | 45.6 | 64.5 | 58.5 | 53.2 | 51.4 | 48.2 | 46.5 |
| 21:00 | 54.5 | 67.2 | 46.4 | 63.3 | 58.0 | 53.1 | 51.7 | 49.1 | 47.2 |
| 22:00 | 54.6 | 74.1 | 46.2 | 64.7 | 57.1 | 52.3 | 50.8 | 48.3 | 47.1 |
| 23:00 | 51.6 | 68.6 | 44.7 | 61.8 | 53.5 | 49.7 | 48.7 | 46.3 | 45.2 |
| 0:00 | 51.6 | 69.0 | 44.6 | 62.4 | 54.0 | 49.2 | 48.1 | 46.3 | 45.2 |
| 1:00 | 49.5 | 71.2 | 40.5 | 59.4 | 51.0 | 47.6 | 46.7 | 44.3 | 42.2 |
| 2:00 | 48.6 | 69.2 | 41.2 | 58.4 | 49.9 | 46.9 | 45.9 | 43.7 | 42.2 |
| 3:00 | 58.3 | 79.3 | 39.3 | 72.2 | 58.8 | 46.4 | 45.1 | 42.2 | 40.2 |
| 4:00 | 46.1 | 66.2 | 40.5 | 56.1 | 46.7 | 45.0 | 44.4 | 42.4 | 41.1 |
| 5:00 | 47.6 | 63.4 | 40.8 | 57.8 | 48.6 | 46.4 | 45.6 | 43.5 | 41.6 |
| 6:00 | 52.1 | 66.5 | 42.8 | 62.5 | 54.4 | 51.3 | 48.7 | 45.5 | 44.1 |
| 7:00 | 80.7 | 111.2 | 47.6 | 80.7 | 65.9 | 56.3 | 54.2 | 50.1 | 48.7 |
| 8:00 | 60.5 | 78.2 | 48.9 | 68.4 | 64.9 | 59.4 | 55.7 | 51.0 | 49.4 |
| 9:00 | 55.3 | 69.3 | 45.7 | 64.6 | 59.5 | 53.1 | 50.6 | 47.7 | 46.3 |
| 10:00 | 81.8 | 109.3 | 45.6 | 79.8 | 65.2 | 56.1 | 52.8 | 48.3 | 46.3 |
| 11:00 | 56.7 | 70.5 | 46.6 | 64.7 | 60.8 | 56.1 | 53.5 | 49.1 | 47.4 |
| 12:00 | 57.6 | 71.3 | 44.9 | 66.3 | 61.4 | 56.9 | 54.5 | 48.6 | 46.2 |
| 13:00 | 57.3 | 73.2 | 45.3 | 66.8 | 60.9 | 56.2 | 53.3 | 48.2 | 46.2 |
| 14:00 | 56.5 | 76.5 | 44.0 | 66.4 | 59.9 | 55.0 | 52.2 | 47.5 | 45.2 |
| 15:00 | 59.2 | 81.6 | 45.5 | 69.9 | 61.9 | 56.7 | 53.8 | 48.6 | 46.5 |

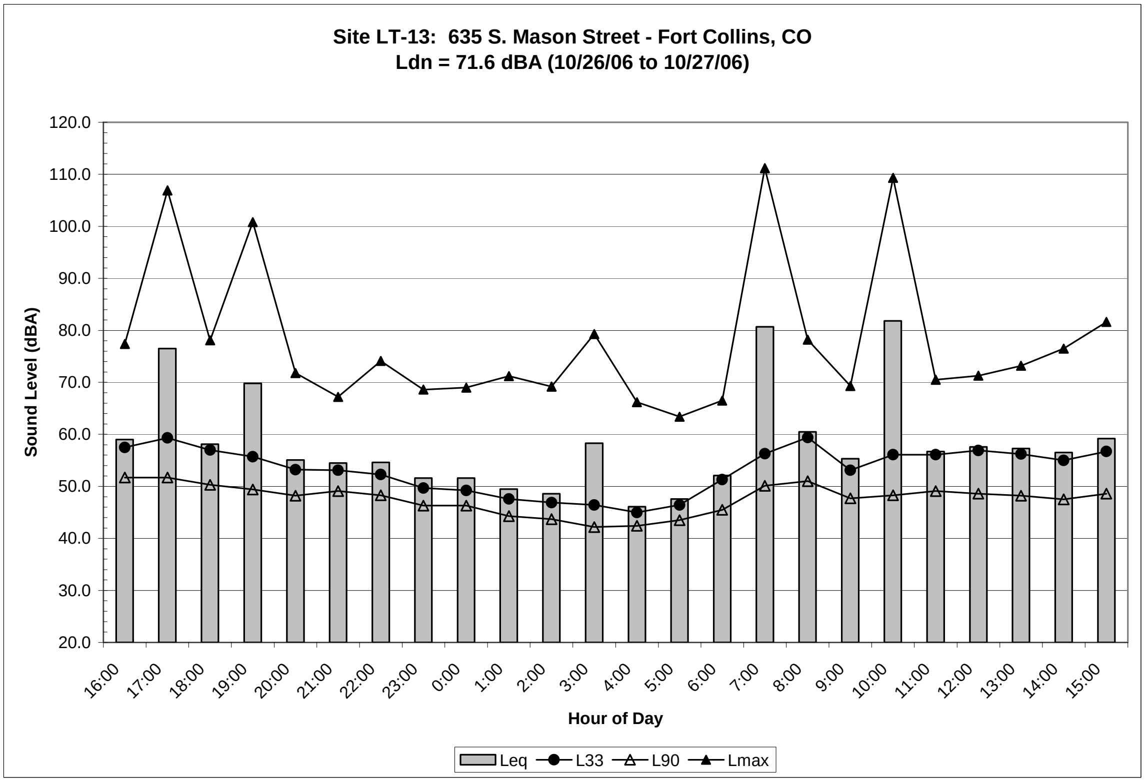



**Figure B-13. Noise Survey Results, Site LT-13**

NORTH I-25 EIS

information. cooperation. transportation.

Site LT-14: 401 N. Timberline Road, Unit #178 – Fort Collins, CO

Ldn: 63.1 dBA (10/26/06 – 10/27/06)

**Table B-14. Noise Survey Results, Site LT-14**

| Start Hour | LEQ | LMAX | LMIN | L1 | L10 | L33 | L50 | L90 | L99 |
|---|---|---|---|---|---|---|---|---|---|
| 15:00 | 61.9 | 76.8 | 43.2 | 69.8 | 65.4 | 62.3 | 60.0 | 51.0 | 45.5 |
| 16:00 | 62.6 | 78.9 | 45.4 | 69.5 | 65.7 | 62.8 | 61.0 | 53.5 | 47.7 |
| 17:00 | 63.8 | 87.1 | 46.0 | 71.7 | 65.5 | 62.6 | 60.5 | 53.0 | 48.7 |
| 18:00 | 60.7 | 69.9 | 44.8 | 67.6 | 64.5 | 61.4 | 58.5 | 50.1 | 46.8 |
| 19:00 | 58.8 | 81.3 | 40.7 | 66.7 | 62.7 | 57.6 | 53.2 | 44.7 | 42.2 |
| 20:00 | 60.3 | 85.3 | 39.7 | 70.4 | 62.5 | 56.3 | 52.3 | 44.1 | 41.0 |
| 21:00 | 56.7 | 70.1 | 38.4 | 66.5 | 61.9 | 53.2 | 47.3 | 41.5 | 39.1 |
| 22:00 | 55.0 | 72.4 | 37.0 | 66.3 | 59.4 | 47.4 | 44.0 | 39.4 | 38.0 |
| 23:00 | 52.4 | 70.8 | 34.5 | 64.3 | 55.6 | 44.0 | 41.8 | 37.3 | 35.2 |
| 0:00 | 51.4 | 73.5 | 34.3 | 63.4 | 52.5 | 43.4 | 41.3 | 37.3 | 35.2 |
| 1:00 | 49.2 | 69.0 | 33.6 | 62.8 | 48.3 | 41.2 | 39.5 | 36.0 | 34.2 |
| 2:00 | 49.2 | 68.5 | 33.4 | 62.3 | 48.4 | 40.3 | 38.6 | 35.5 | 34.1 |
| 3:00 | 49.9 | 70.6 | 30.3 | 64.4 | 47.5 | 38.8 | 36.7 | 33.0 | 31.1 |
| 4:00 | 51.5 | 70.1 | 33.7 | 64.2 | 53.9 | 43.5 | 40.8 | 36.5 | 34.5 |
| 5:00 | 56.4 | 72.6 | 34.8 | 66.5 | 61.4 | 51.8 | 47.9 | 40.3 | 36.2 |
| 6:00 | 61.4 | 83.3 | 45.4 | 69.5 | 64.7 | 60.7 | 57.3 | 49.2 | 46.4 |
| 7:00 | 63.9 | 82.2 | 49.2 | 71.4 | 66.8 | 64.0 | 62.1 | 53.9 | 50.7 |
| 8:00 | 63.2 | 74.9 | 47.3 | 71.2 | 66.6 | 63.5 | 61.4 | 52.9 | 48.9 |
| 9:00 | 61.6 | 75.5 | 41.3 | 70.2 | 65.3 | 61.4 | 58.6 | 48.2 | 42.9 |
| 10:00 | 61.0 | 78.2 | 40.2 | 70.6 | 64.8 | 60.3 | 56.5 | 43.8 | 41.2 |
| 11:00 | 60.9 | 73.9 | 38.2 | 69.9 | 64.8 | 60.6 | 57.9 | 45.0 | 41.0 |
| 12:00 | 60.3 | 74.8 | 38.8 | 69.2 | 63.8 | 60.2 | 57.7 | 45.2 | 40.3 |
| 13:00 | 60.5 | 73.7 | 37.5 | 69.4 | 64.3 | 60.3 | 57.6 | 44.5 | 39.6 |
| 14:00 | 60.1 | 73.0 | 35.6 | 68.9 | 63.8 | 60.2 | 57.6 | 44.4 | 37.4 |

NORTH I-25 EIS

information. cooperation. transportation.

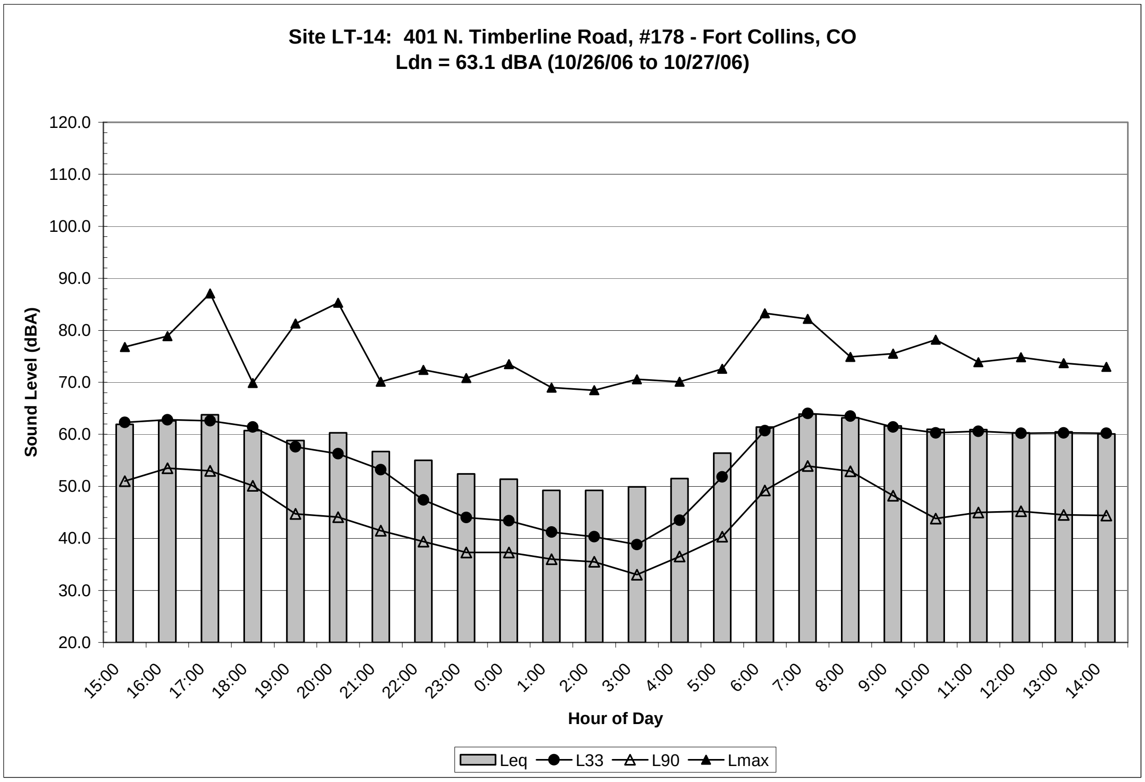



**Figure B-14. Noise Survey Results, Site LT-14**

NORTH I-25 EIS

information. cooperation. transportation.

# Appendix C
# Vibration Measurement Data

NORTH I-25 EIS

information. cooperation. transportation.

**THIS PAGE INTENTIONALLY LEFT BLANK.**

## Site V-1: Dacono

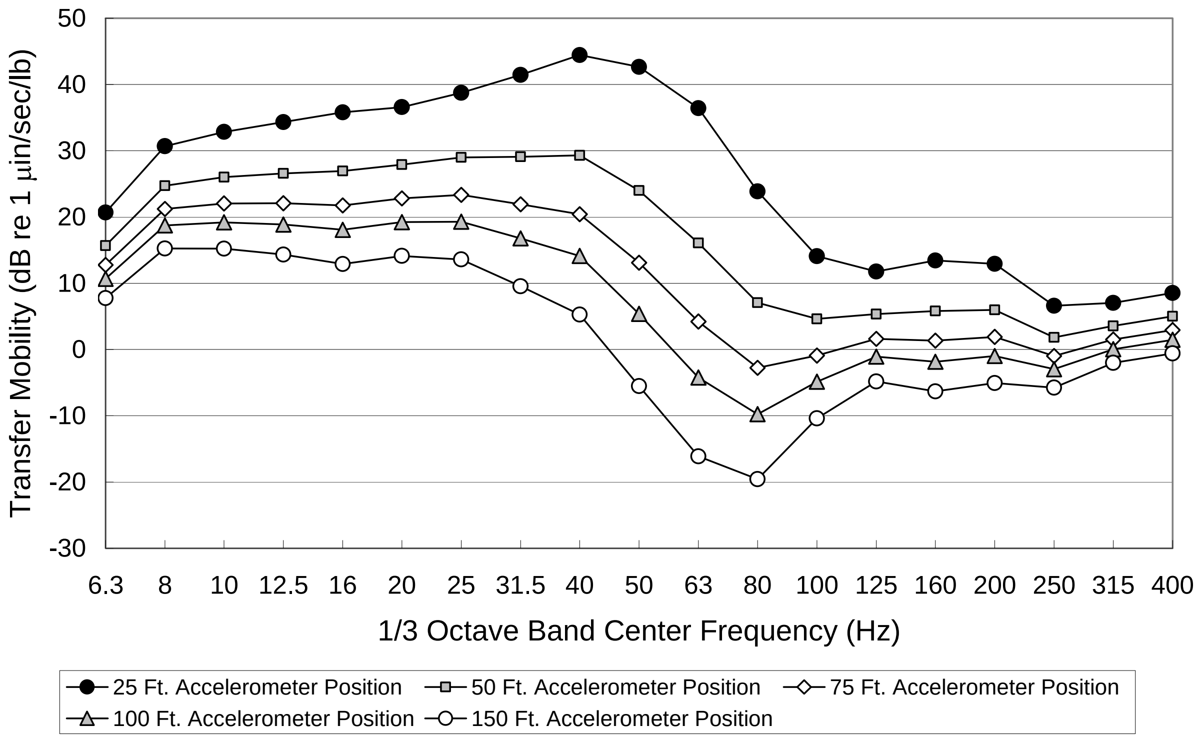



**Figure C-1. Representative Transfer Mobility Functions, Site V-1**

NORTH I-25 EIS

information. cooperation. transportation.

## Table C-1. Line Source Transfer Mobility Coefficients, Site V-1

| Frequency (Hz) | A | B | C |
|---|---|---|---|
| 6.3 | 43.9 | -16.6 | 0.0 |
| 8 | 58.4 | -19.9 | 0.0 |
| 10 | 64.5 | -22.7 | 0.0 |
| 12.5 | 70.3 | -25.7 | 0.0 |
| 16 | 76.9 | -29.4 | 0.0 |
| 20 | 76.9 | -28.8 | 0.0 |
| 25 | 83.9 | -32.3 | 0.0 |
| 31.5 | 98.7 | -41.0 | 0.0 |
| 40 | 114.8 | -50.3 | 0.0 |
| 50 | 129.2 | -61.9 | 0.0 |
| 63 | 130.7 | -67.5 | 0.0 |
| 80 | 101.9 | -55.8 | 0.0 |
| 100 | 58.1 | -31.5 | 0.0 |
| 125 | 41.6 | -21.3 | 0.0 |
| 160 | 48.9 | -25.4 | 0.0 |
| 200 | 45.3 | -23.1 | 0.0 |
| 250 | 28.8 | -15.9 | 0.0 |
| 315 | 23.3 | -11.6 | 0.0 |
| 400 | 24.9 | -11.7 | 0.0 |

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2

d = Distance in feet

**Site V-2: Longmont**

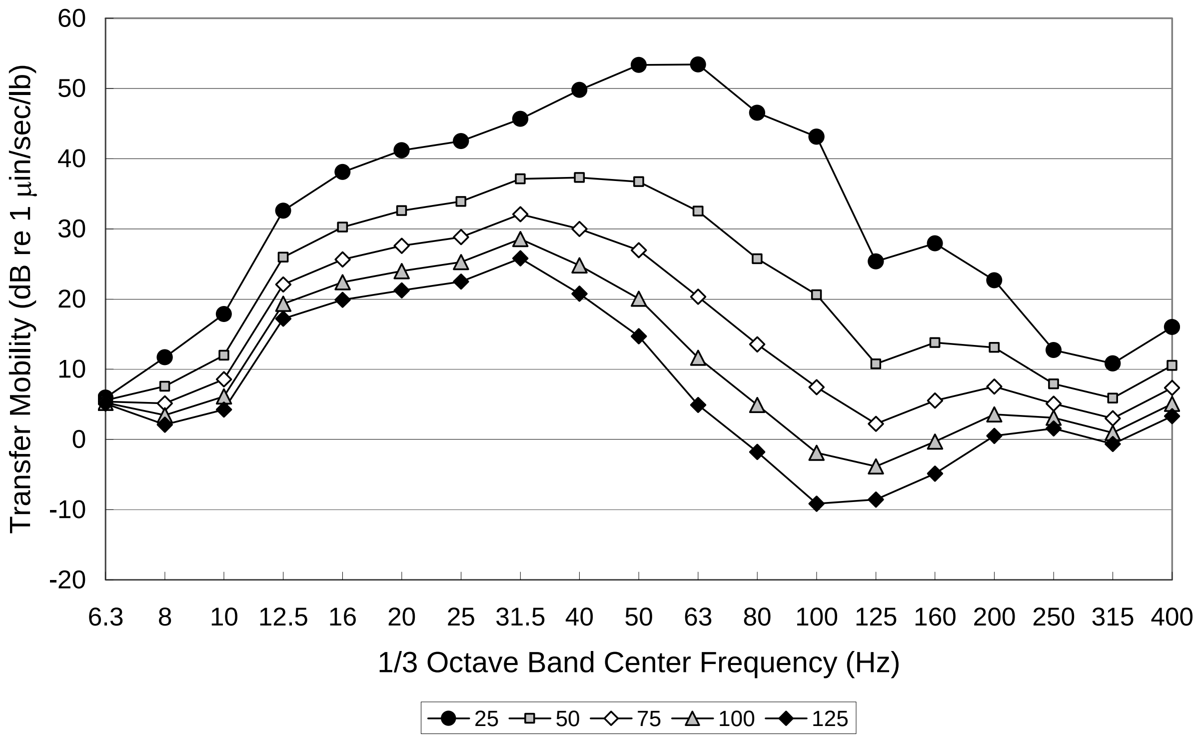



**Figure C-2. Representative Transfer Mobility Functions, Site V-2**

NORTH I-25 EIS
information. cooperation. transportation.

**Table C-2. Line Source Transfer Mobility Coefficients, Site V-2**

| Frequency (Hz) | A | B | C |
|---|---|---|---|
| 6.3 | 7.6 | -1.2 | 0.0 |
| 8 | 30.9 | -13.7 | 0.0 |
| 10 | 45.0 | -19.4 | 0.0 |
| 12.5 | 63.3 | -22.0 | 0.0 |
| 16 | 74.5 | -26.1 | 0.0 |
| 20 | 81.1 | -28.6 | 0.0 |
| 25 | 82.5 | -28.6 | 0.0 |
| 31.5 | 85.4 | -28.4 | 0.0 |
| 40 | 107.8 | -41.5 | 0.0 |
| 50 | 130.7 | -55.3 | 0.0 |
| 63 | 150.4 | -69.4 | 0.0 |
| 80 | 143.1 | -69.1 | 0.0 |
| 100 | 147.6 | -74.8 | 0.0 |
| 125 | 93.2 | -48.5 | 0.0 |
| 160 | 93.4 | -46.9 | 0.0 |
| 200 | 67.0 | -31.7 | 0.0 |
| 250 | 35.1 | -16.0 | 0.0 |
| 315 | 33.8 | -16.4 | 0.0 |
| 400 | 41.4 | -18.2 | 0.0 |

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2

d = Distance in feet

NORTH I-25 EIS

information. cooperation. transportation.

**Site V-3: Berthoud**

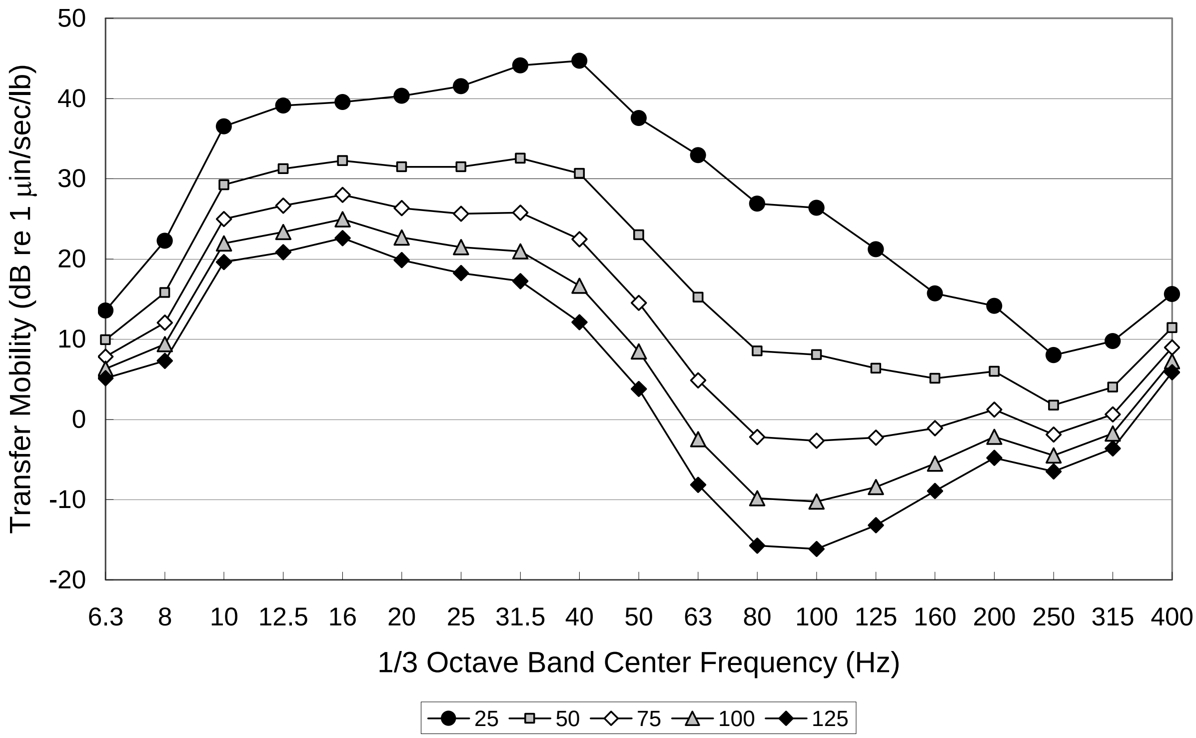



**Figure C-3. Representative Transfer Mobility Functions, Site V-3**

**Table C-3. Line Source Transfer Mobility Coefficients, Site V-3**

| Frequency (Hz) | A | B | C |
|---|---|---|---|
| 6.3 | 30.4 | -12.1 | 0.0 |
| 8 | 52.1 | -21.4 | 0.0 |
| 10 | 70.3 | -24.2 | 0.0 |
| 12.5 | 75.6 | -26.1 | 0.0 |
| 16 | 73.5 | -24.3 | 0.0 |
| 20 | 81.2 | -29.3 | 0.0 |
| 25 | 88.1 | -33.3 | 0.0 |
| 31.5 | 97.9 | -38.5 | 0.0 |
| 40 | 109.9 | -46.6 | 0.0 |
| 50 | 105.1 | -48.3 | 0.0 |
| 63 | 115.1 | -58.8 | 0.0 |
| 80 | 112.1 | -60.9 | 0.0 |
| 100 | 111.4 | -60.8 | 0.0 |
| 125 | 89.9 | -49.2 | 0.0 |
| 160 | 65.0 | -35.2 | 0.0 |
| 200 | 52.0 | -27.1 | 0.0 |
| 250 | 37.0 | -20.7 | 0.0 |
| 315 | 36.5 | -19.1 | 0.0 |
| 400 | 35.1 | -13.9 | 0.0 |

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2

d = Distance in feet

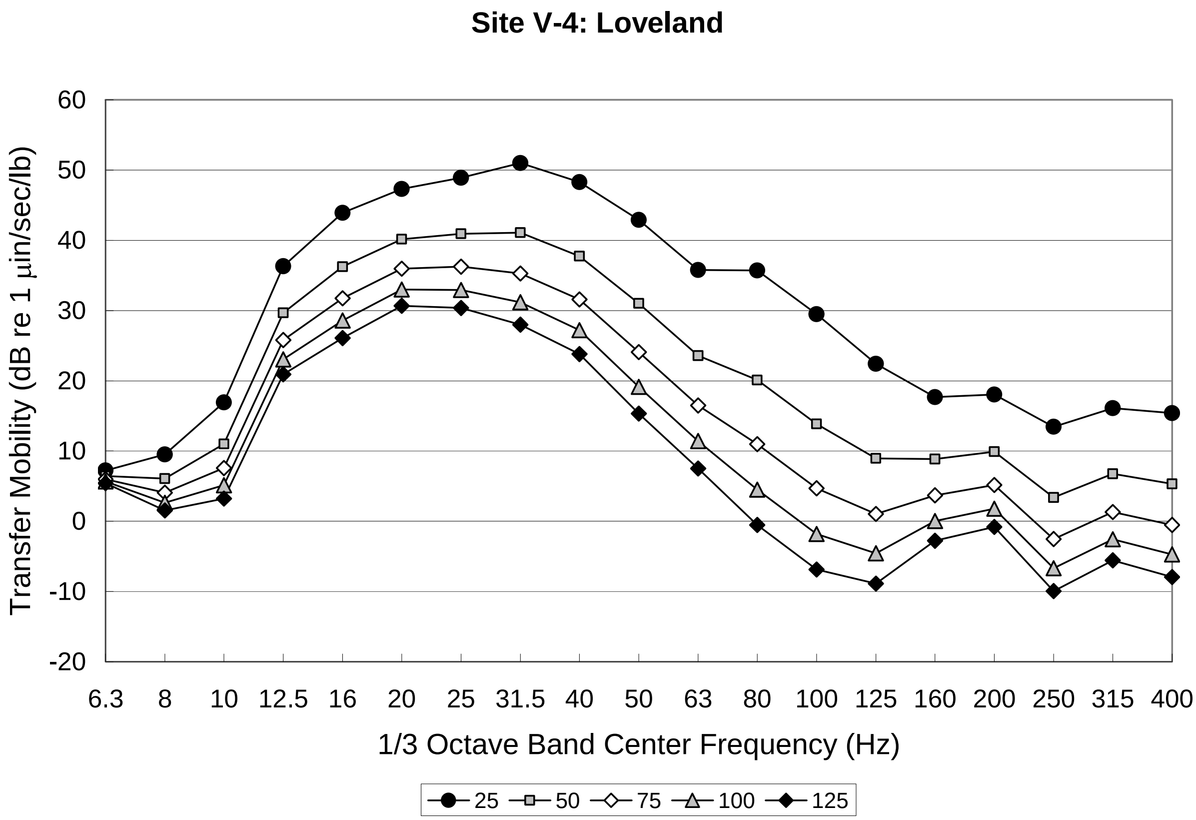



**Figure C-4. Representative Transfer Mobility Functions, Site V-4**

**Table C-4. Line Source Transfer Mobility Coefficients, Site V-4**

| Frequency (Hz) | A | B | C |
|---|---|---|---|
| 6.3 | 10.8 | -2.6 | 0.0 |
| 8 | 25.5 | -11.4 | 0.0 |
| 10 | 44.3 | -19.6 | 0.0 |
| 12.5 | 67.1 | -22.0 | 0.0 |
| 16 | 79.6 | -25.5 | 0.0 |
| 20 | 80.6 | -23.8 | 0.0 |
| 25 | 85.9 | -26.5 | 0.0 |
| 31.5 | 97.1 | -33.0 | 0.0 |
| 40 | 97.3 | -35.0 | 0.0 |
| 50 | 98.0 | -39.4 | 0.0 |
| 63 | 92.3 | -40.4 | 0.0 |
| 80 | 108.2 | -51.9 | 0.0 |
| 100 | 102.2 | -52.0 | 0.0 |
| 125 | 85.0 | -44.8 | 0.0 |
| 160 | 58.6 | -29.3 | 0.0 |
| 200 | 55.7 | -27.0 | 0.0 |
| 250 | 60.2 | -33.5 | 0.0 |
| 315 | 59.4 | -31.0 | 0.0 |
| 400 | 62.0 | -33.4 | 0.0 |

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1μin/sec/lb/(ft)^1/2

d = Distance in feet

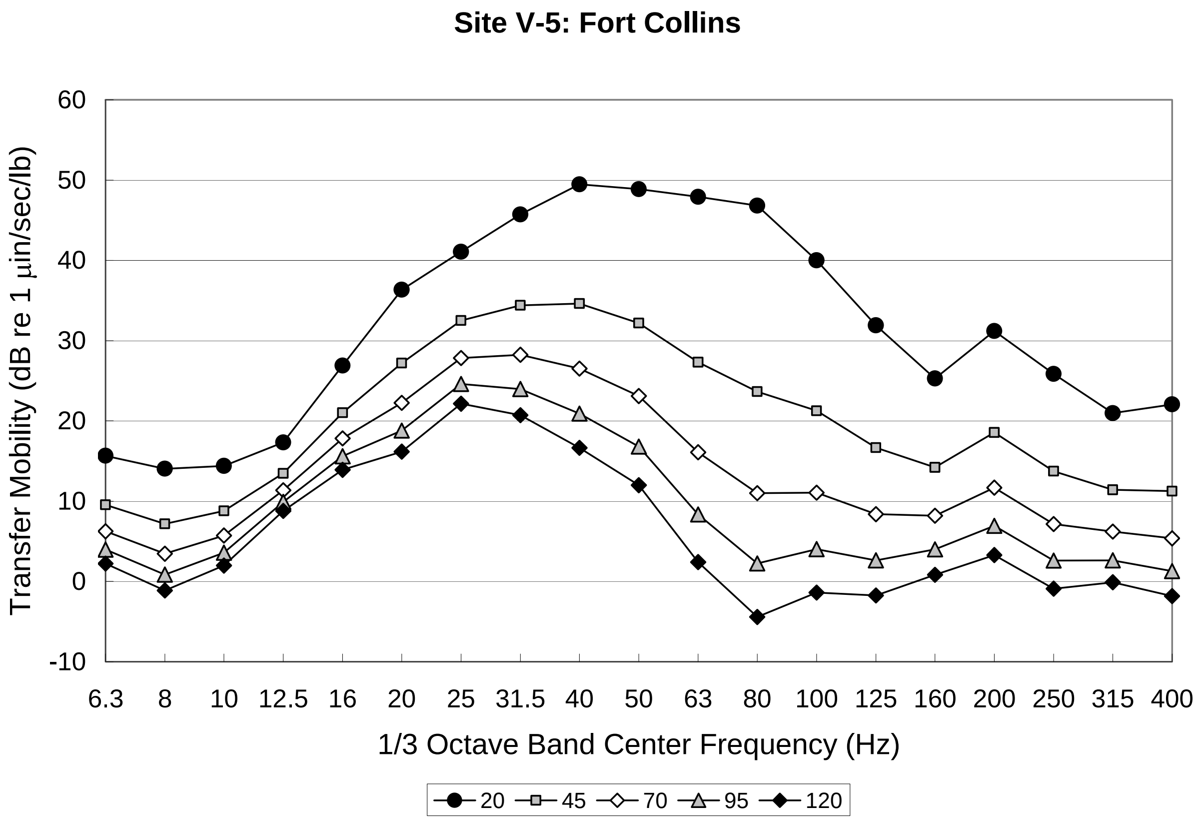



**Figure C-5. Representative Transfer Mobility Functions, Site V-5**

## Table C-5. Line Source Transfer Mobility Coefficients, Site V-5

| Frequency (Hz) | A | B | C |
|---|---|---|---|
| 6.3 | 38.1 | -17.3 | 0.0 |
| 8 | 39.4 | -19.5 | 0.0 |
| 10 | 35.2 | -16.0 | 0.0 |
| 12.5 | 31.6 | -11.0 | 0.0 |
| 16 | 48.6 | -16.7 | 0.0 |
| 20 | 70.1 | -25.9 | 0.0 |
| 25 | 72.7 | -24.3 | 0.0 |
| 31.5 | 87.5 | -32.1 | 0.0 |
| 40 | 104.4 | -42.2 | 0.0 |
| 50 | 110.5 | -47.4 | 0.0 |
| 63 | 124.0 | -58.5 | 0.0 |
| 80 | 132.5 | -65.8 | 0.0 |
| 100 | 109.2 | -53.2 | 0.0 |
| 125 | 88.2 | -43.3 | 0.0 |
| 160 | 66.2 | -31.5 | 0.0 |
| 200 | 77.8 | -35.8 | 0.0 |
| 250 | 70.6 | -34.4 | 0.0 |
| 315 | 56.2 | -27.1 | 0.0 |
| 400 | 62.0 | -30.7 | 0.0 |

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1μin/sec/lb/(ft)^1/2

d = Distance in feet

NORTH I-25 EIS

information. cooperation. transportation.

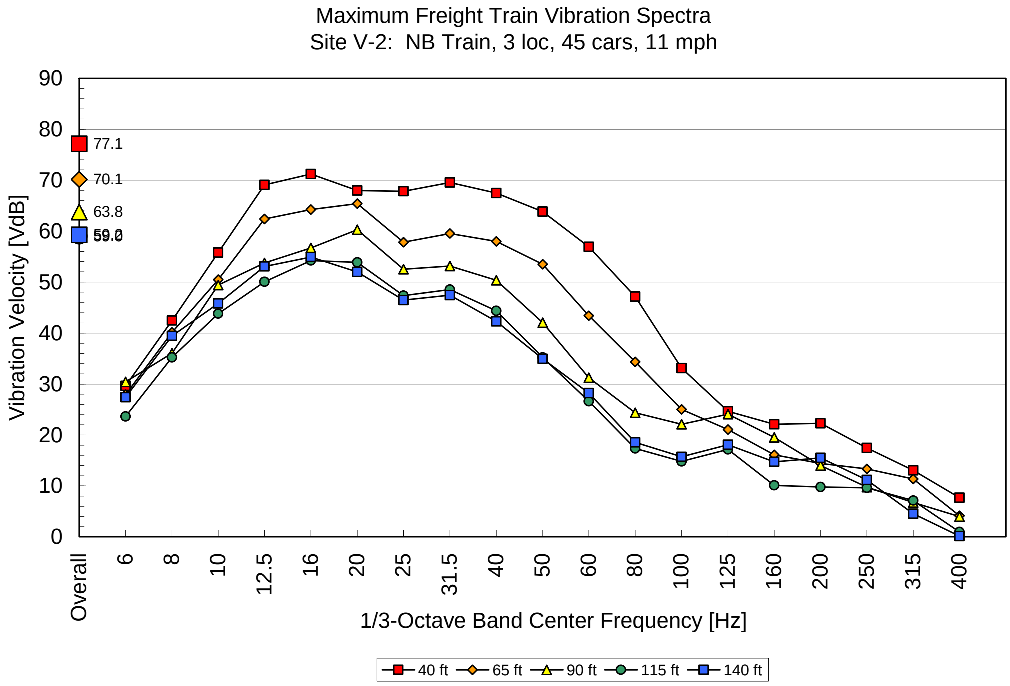



**Figure C-6. Existing Freight Train Ground Vibration Spectra at Site V-2 (Longmont)**

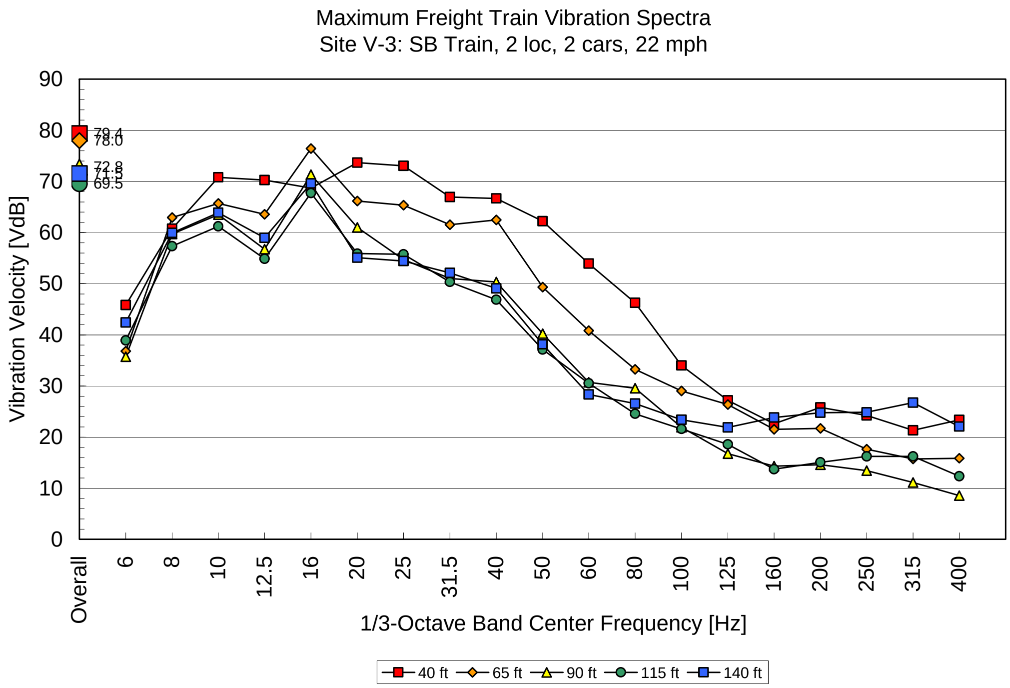



**Figure C-7. Existing Freight Train Ground Vibration Spectra at Site V-3 (Berthoud)**

NORTH I-25 EIS

information. cooperation. transportation.

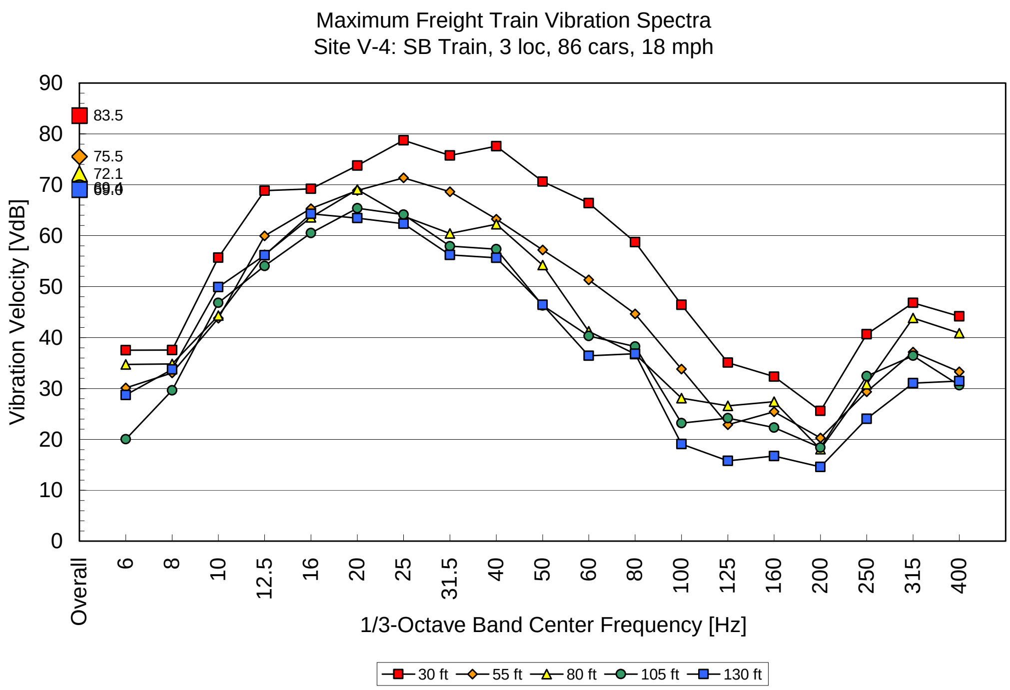



**Figure C-8. Existing Freight Train Ground Vibration Spectra at Site V-4 (Loveland)**

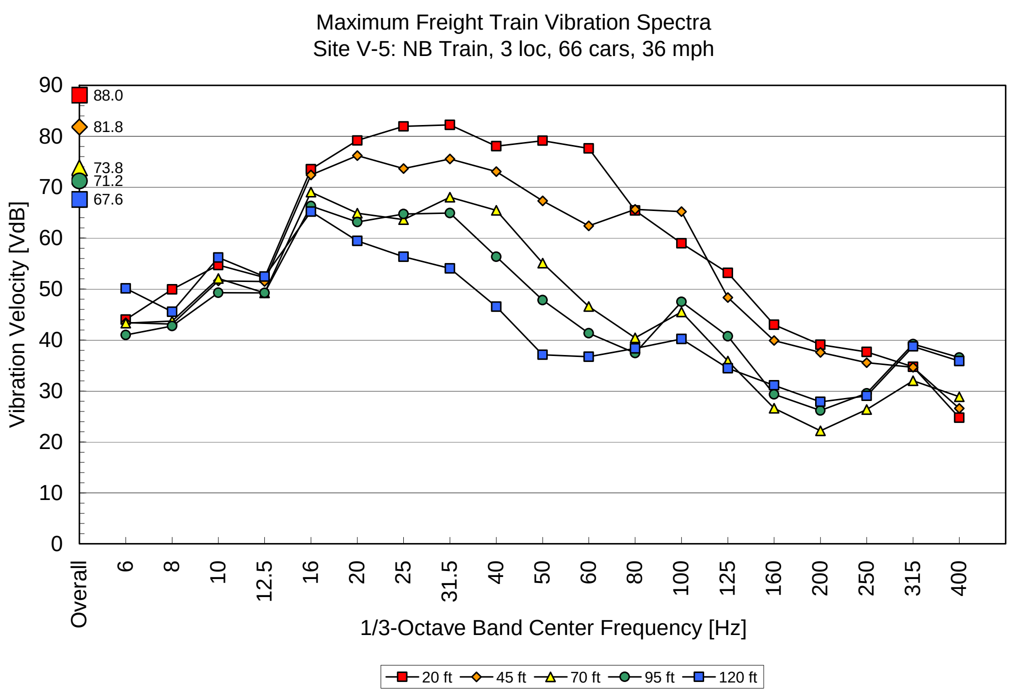



**Figure C-9. Existing Freight Train Ground Vibration Spectra at Site V-5 (Fort Collins)**

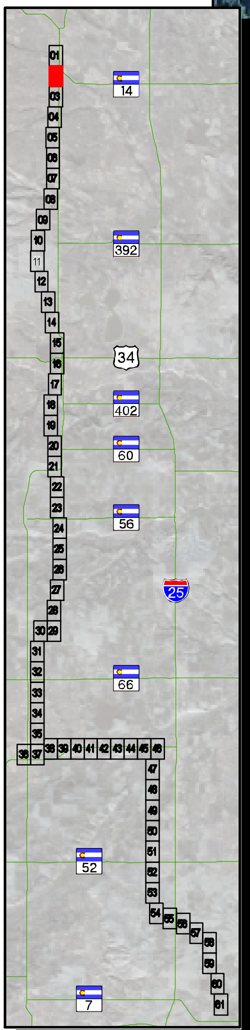
NORTH I-25 EIS

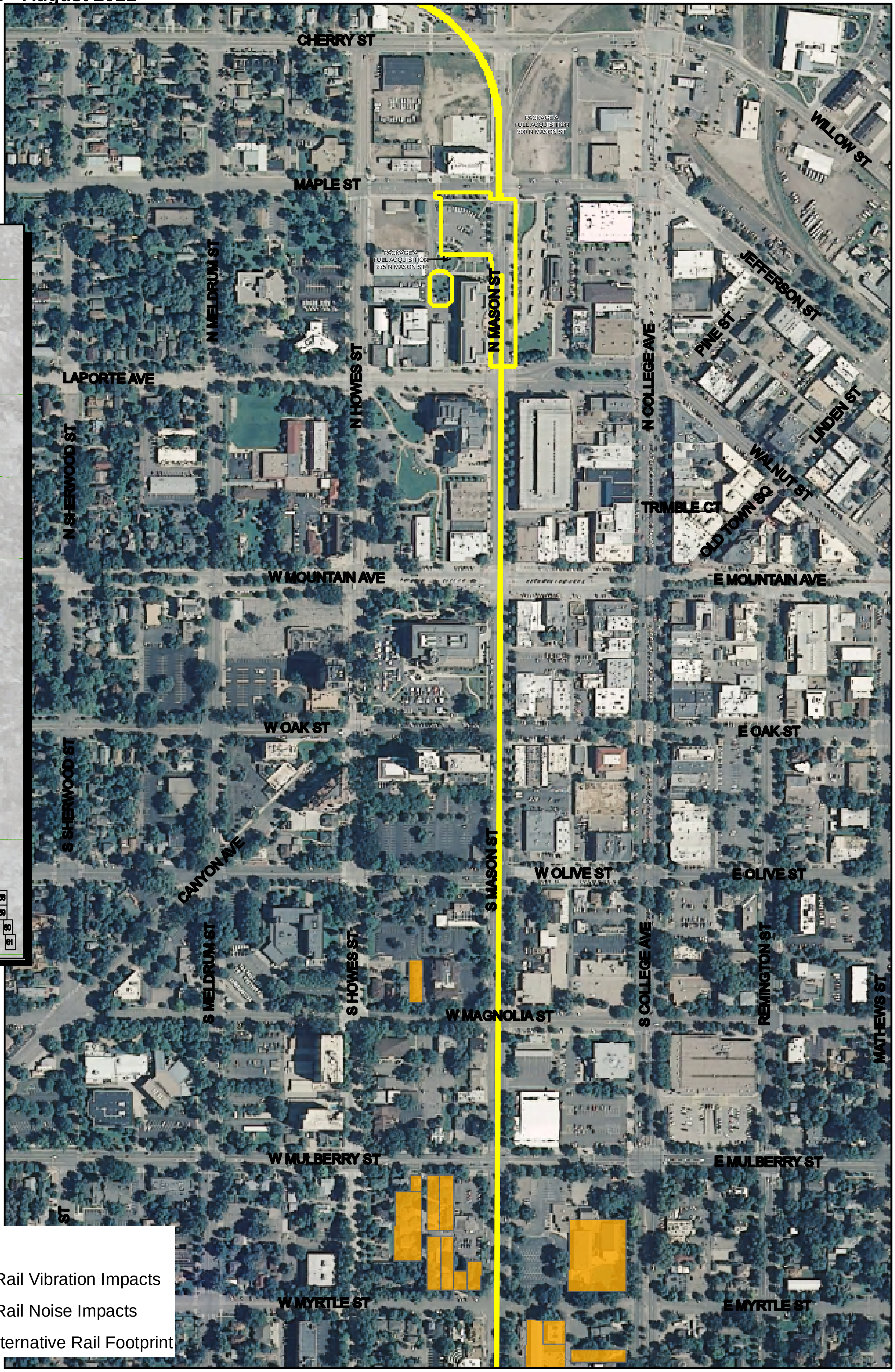
information. cooperation. transportation.

# Appendix D
# Noise and Vibration Impact Locations

**THIS PAGE INTENTIONALLY LEFT BLANK.**

Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

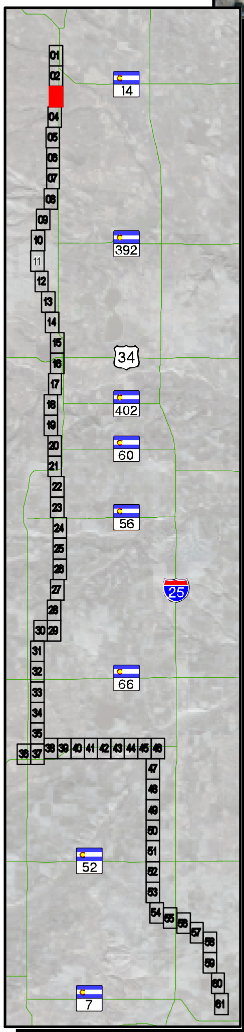
Map Document: (Appendix D.mxd)
10/22/2010

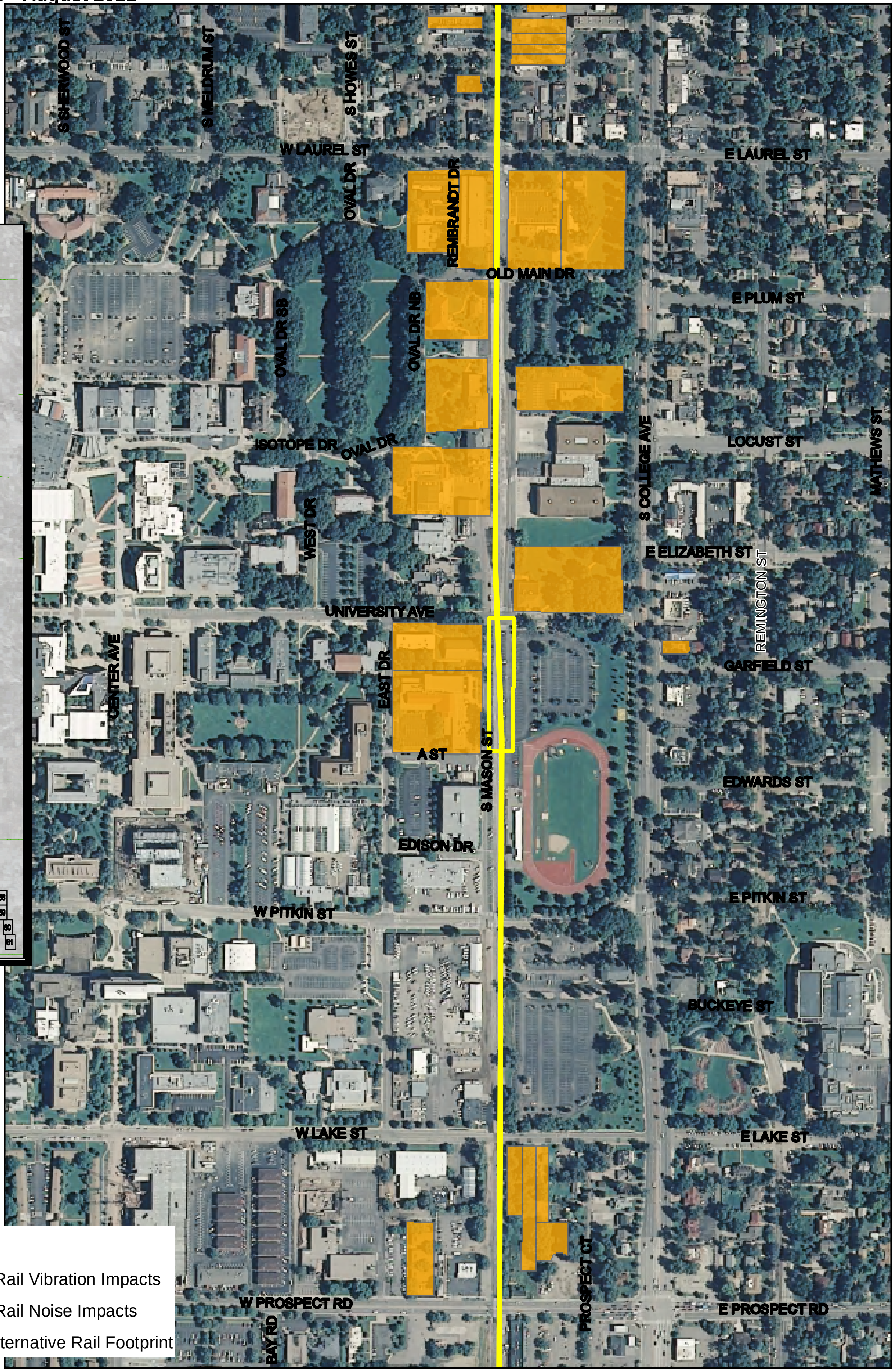
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

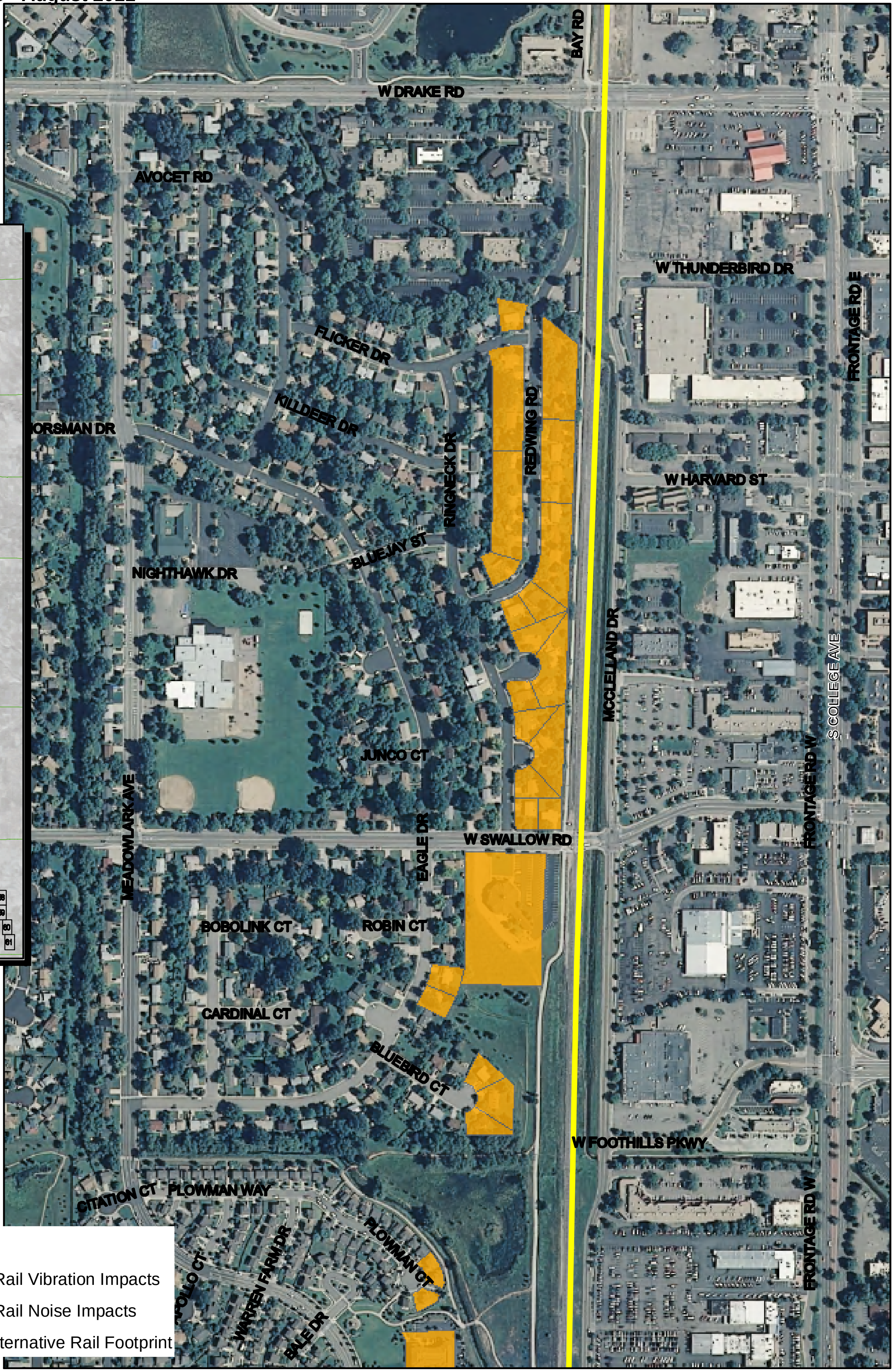
- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

Map Document: (Appendix D.mxd)
10/22/2010

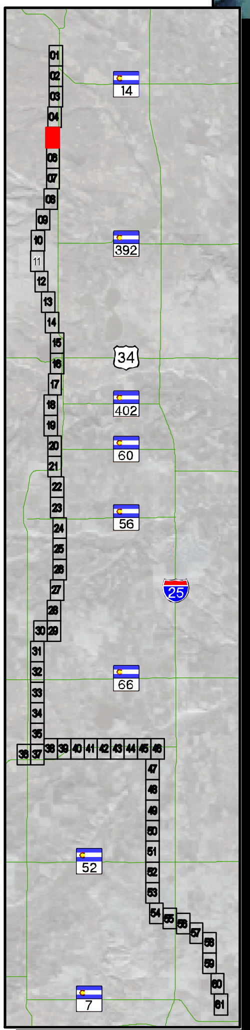
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative




Map Index



## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

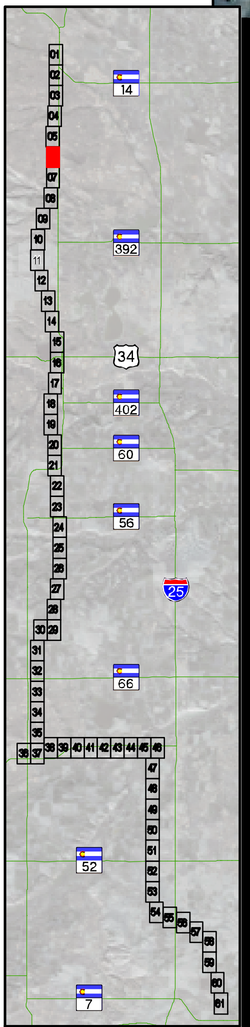
Map Document: (Appendix D.mxd)
10/22/2010

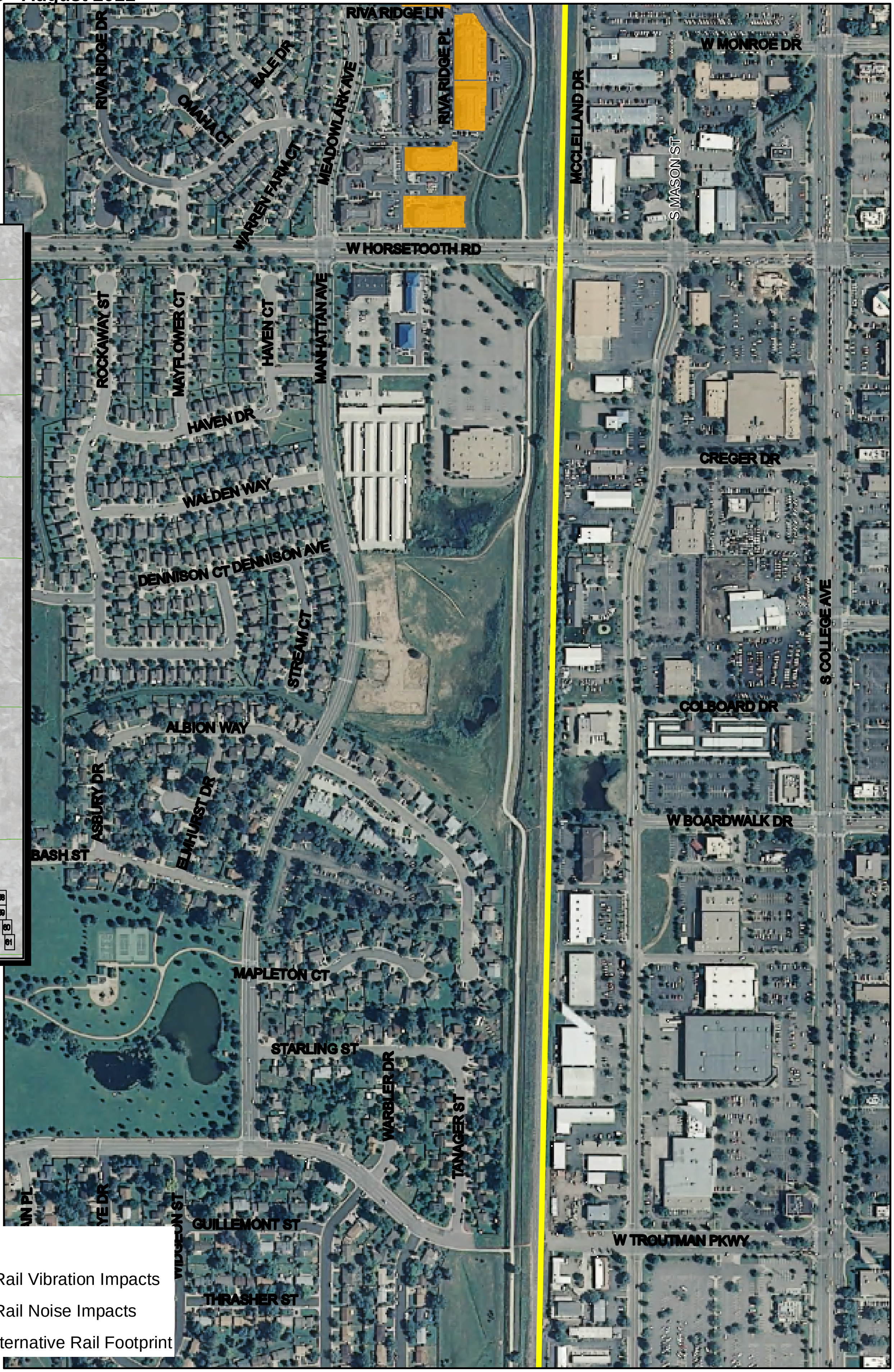
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

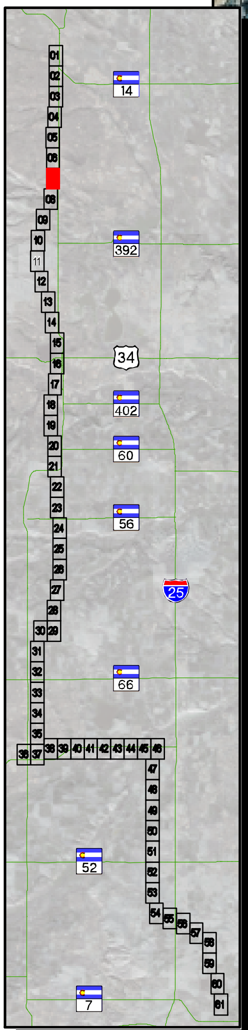
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index





## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

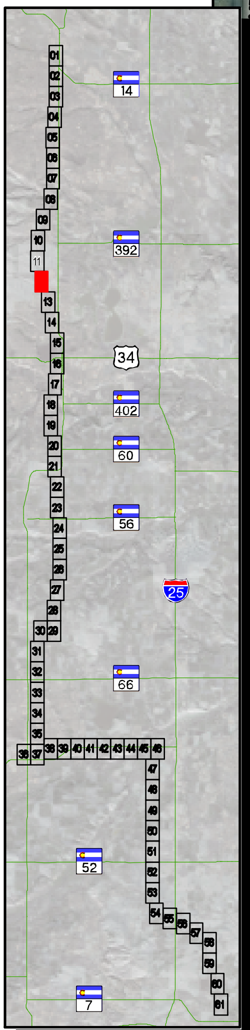
Map Document: (Appendix D.mxd)
10/22/2010

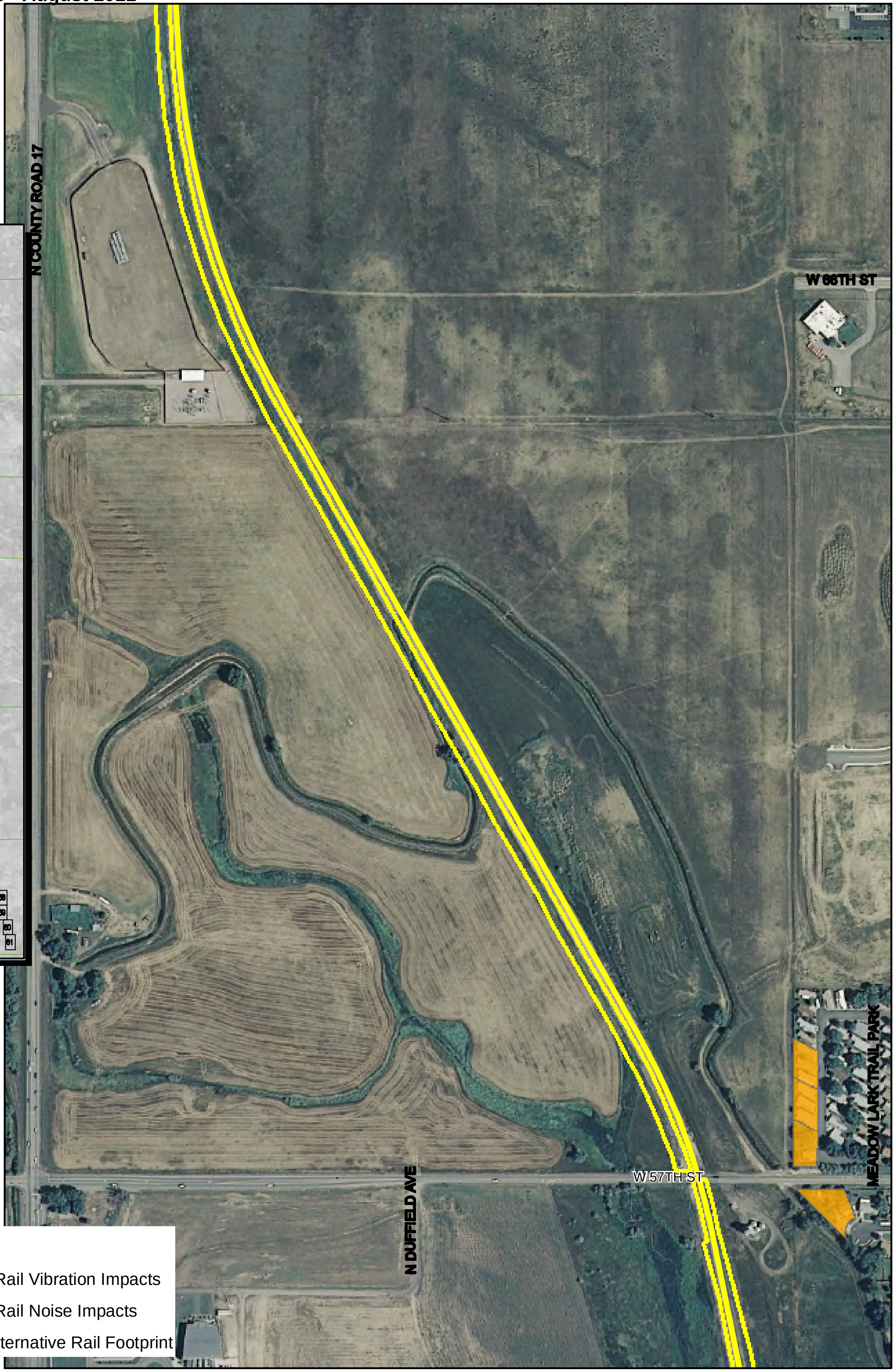
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

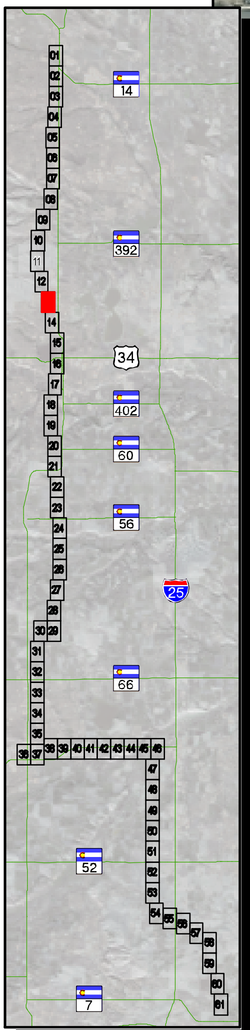
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index





## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative


## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

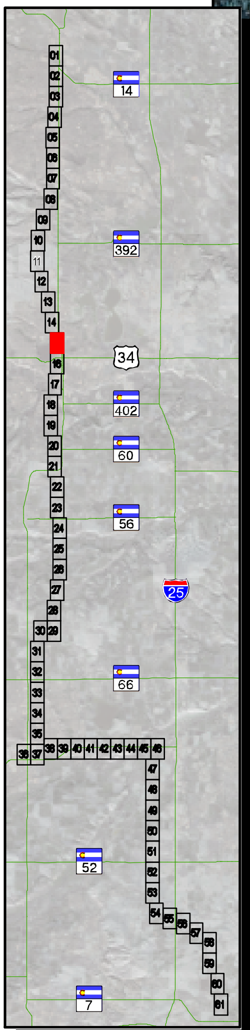
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index





## Legend

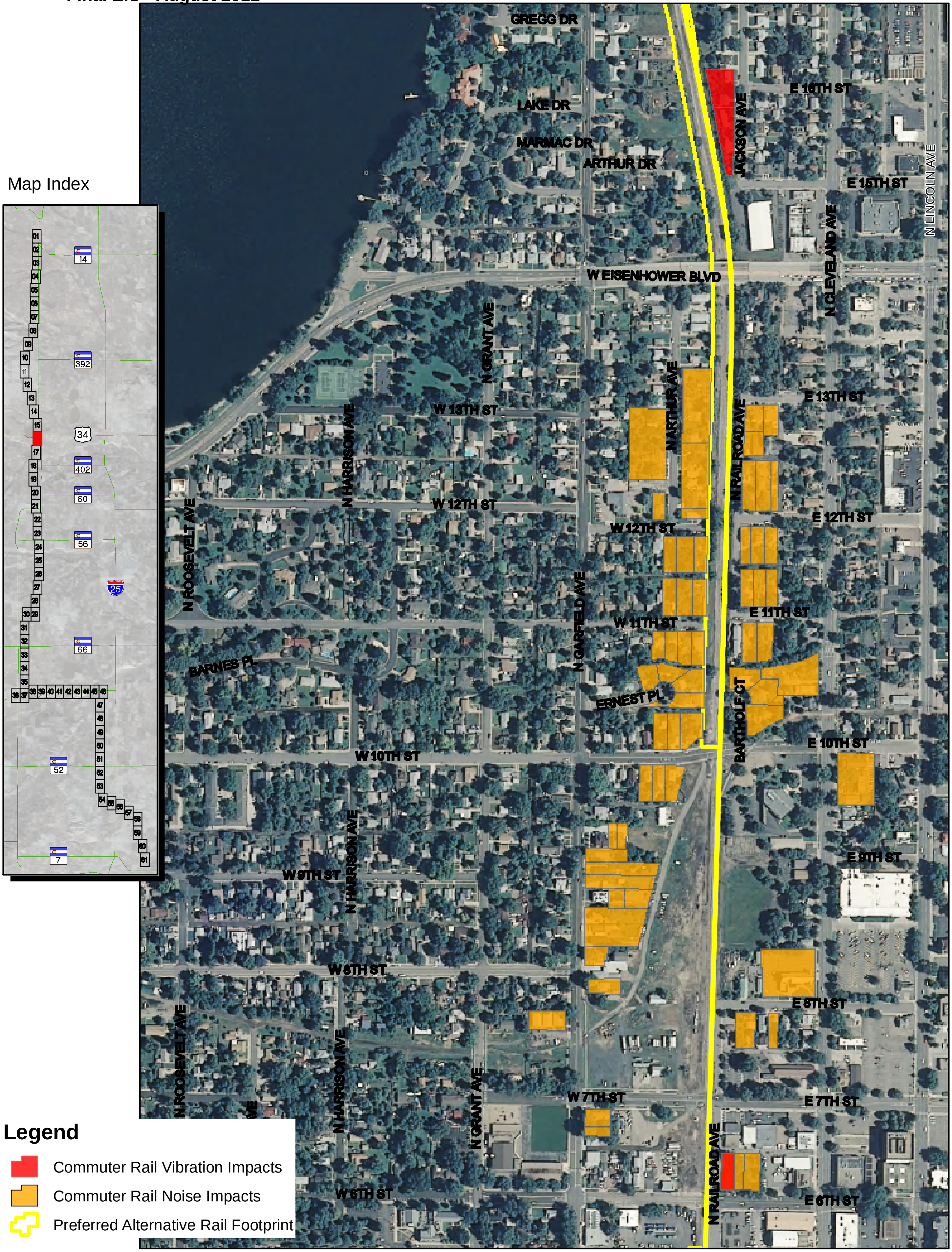
- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

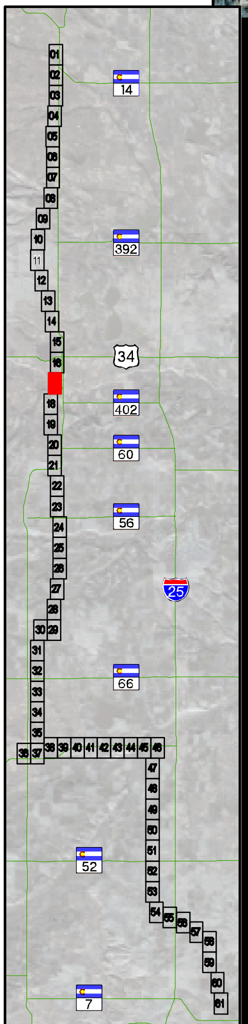
Map Document: (Appendix D.mxd)
10/22/2010

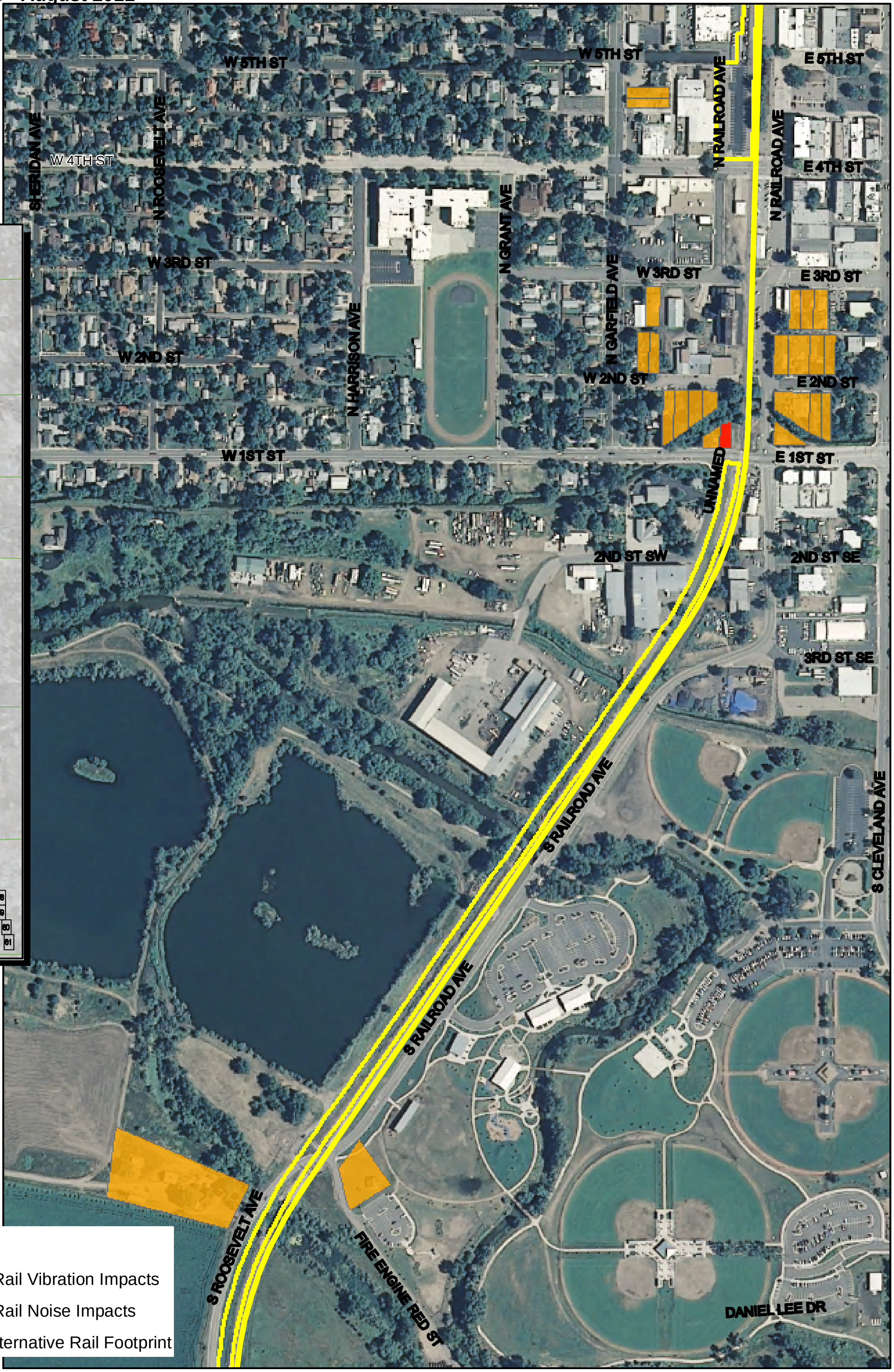
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index


## Legend

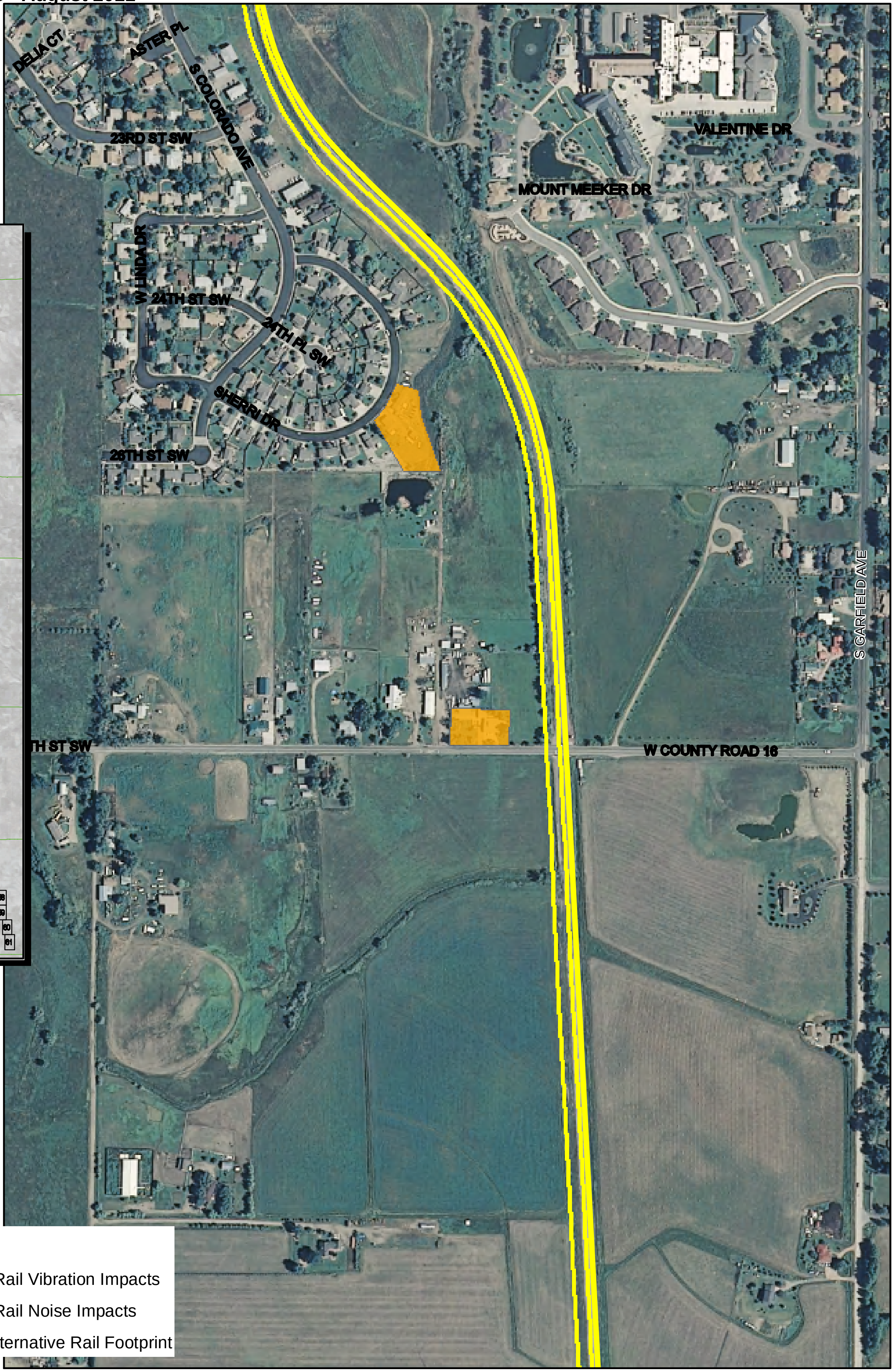
- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

Map Document: (Appendix D.mxd)
10/22/2010

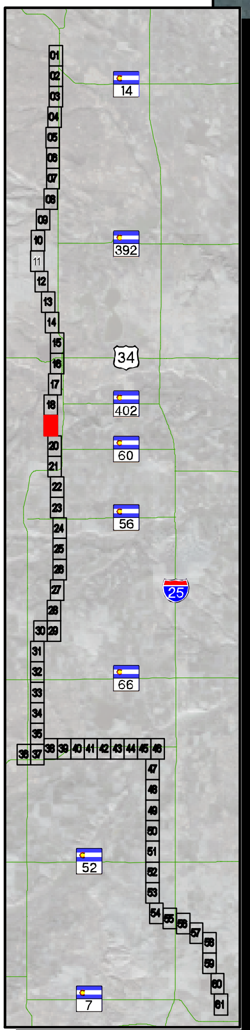
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative




Map Index



## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

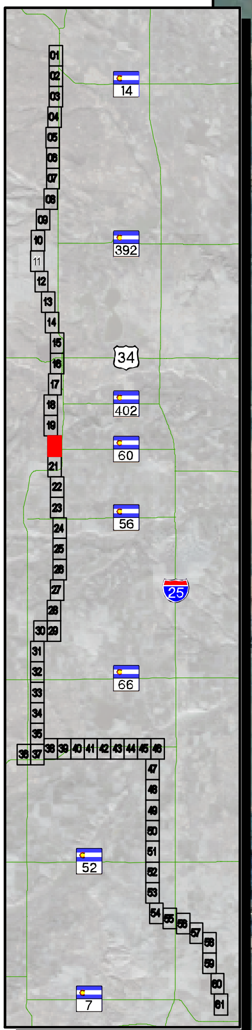
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

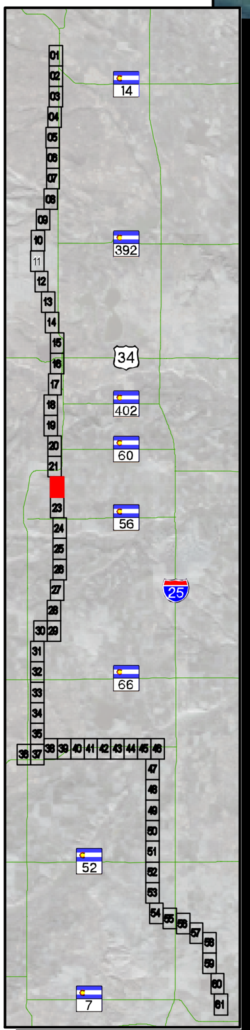
Map Document: (Appendix D.mxd)
10/22/2010

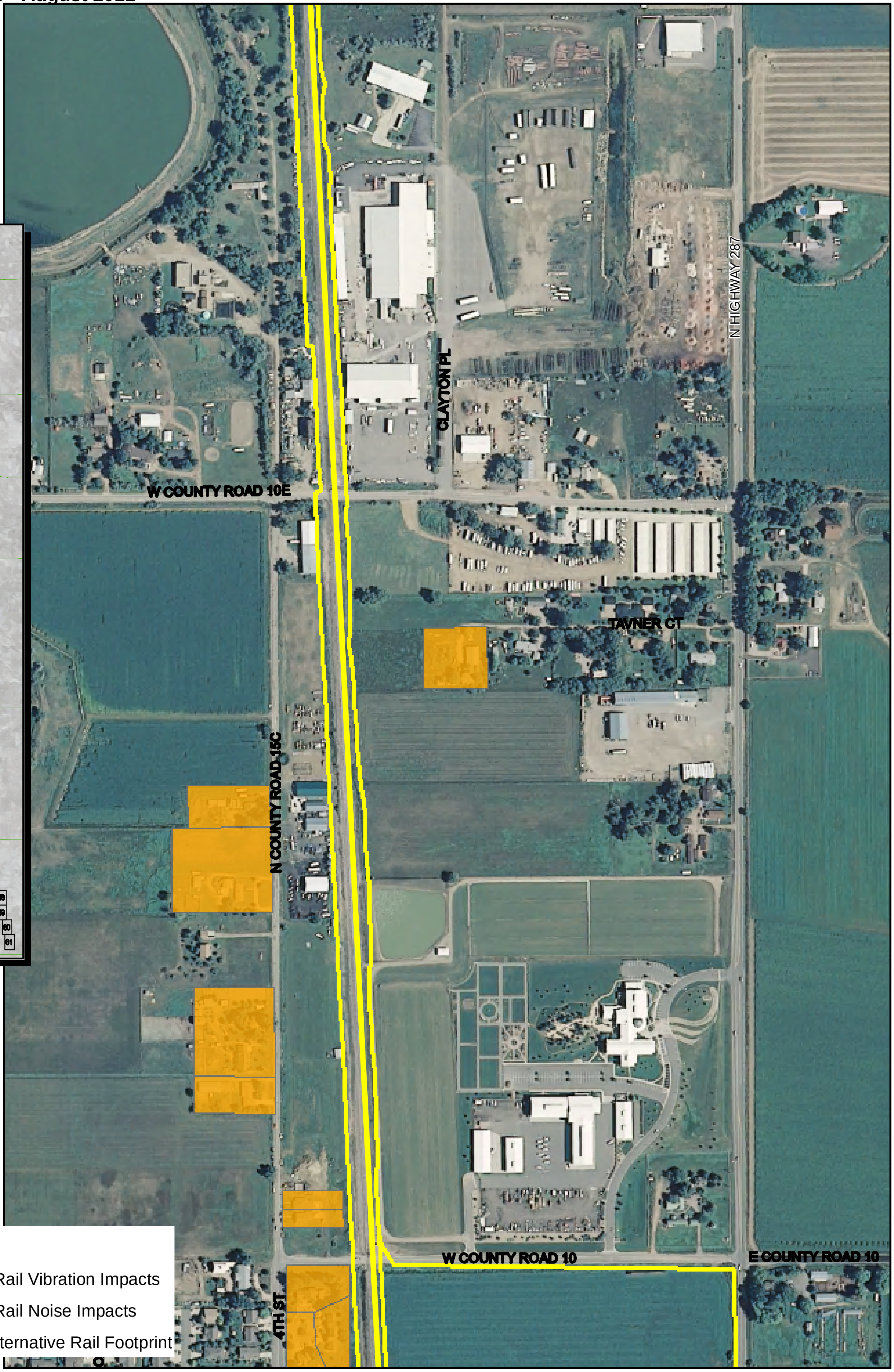
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

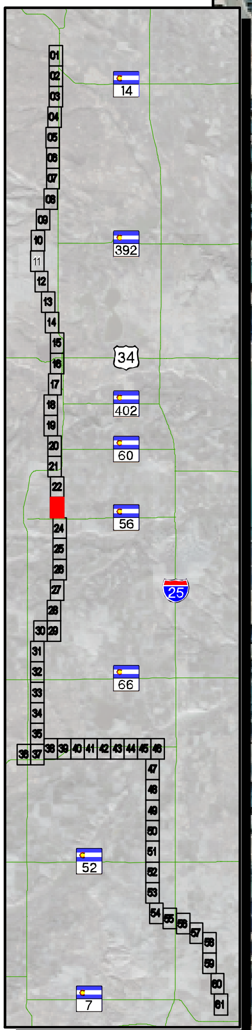
Map Document: (Appendix D.mxd)
10/22/2010

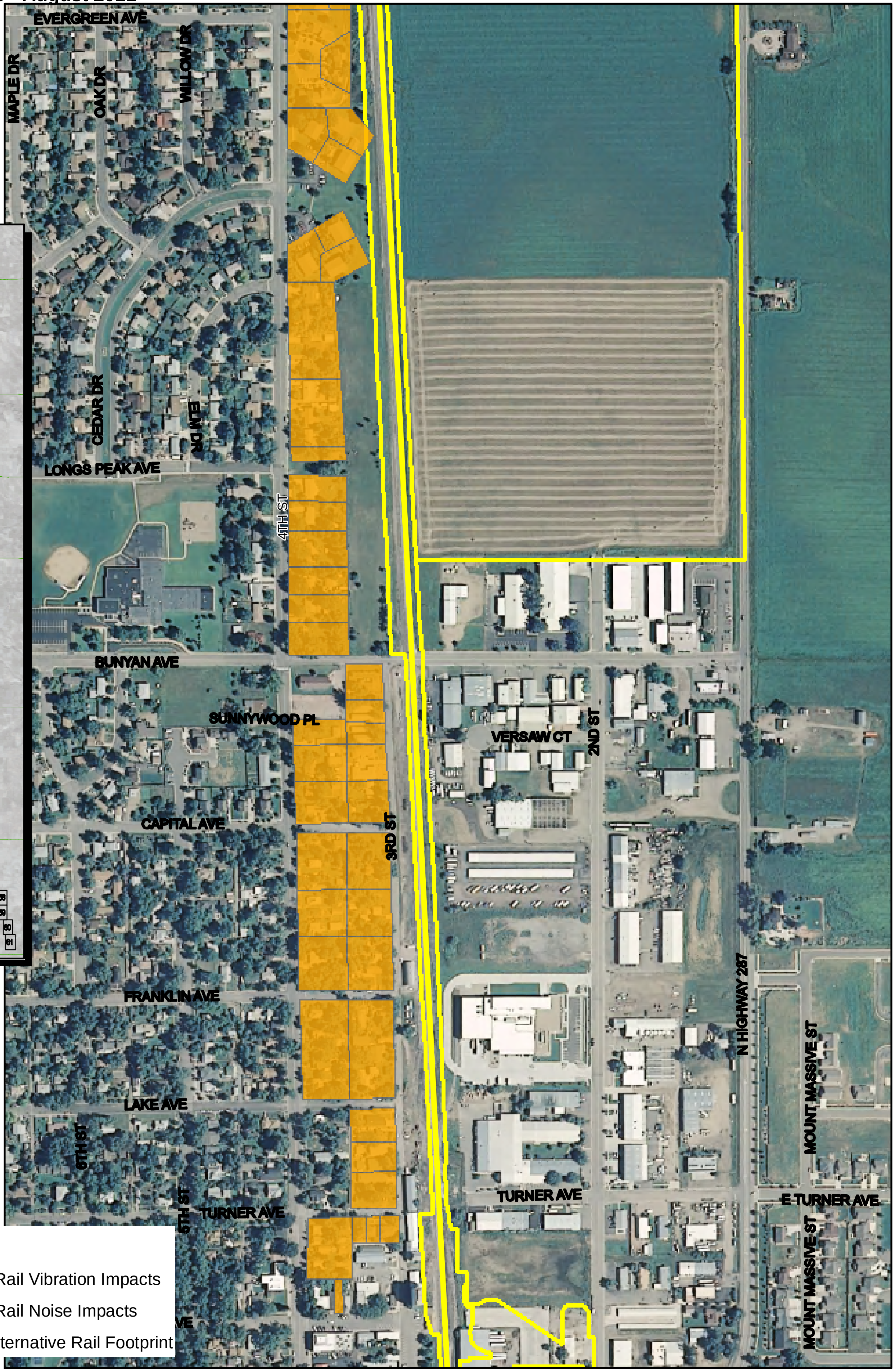
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

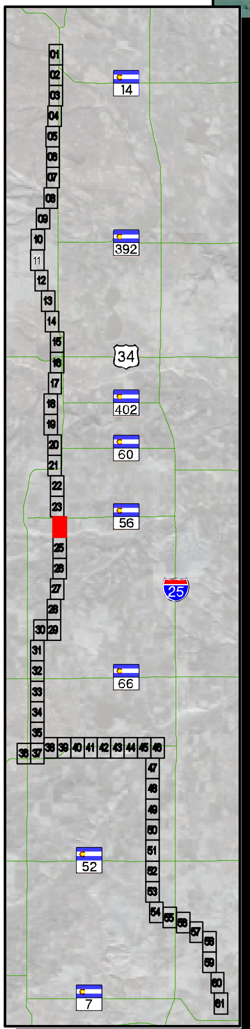
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index





## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

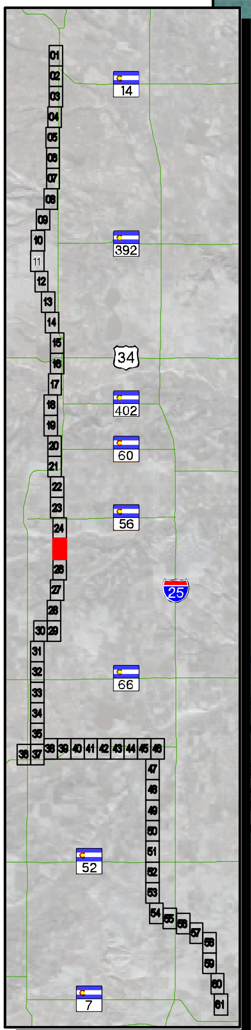
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index





## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

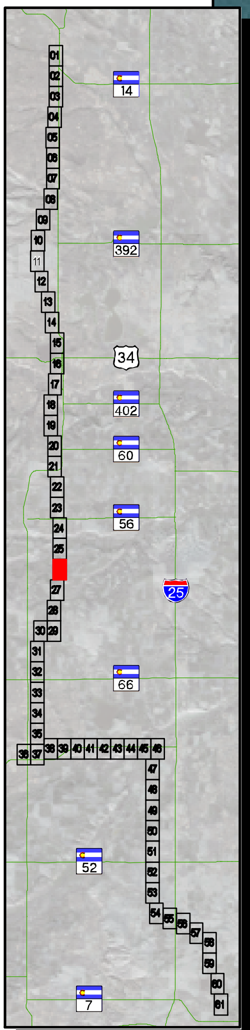
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index





## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

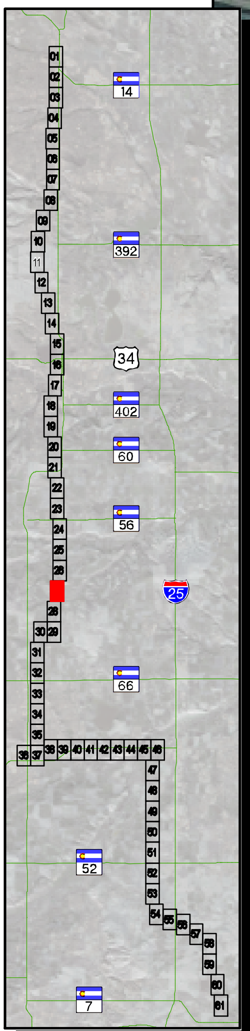
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative


Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

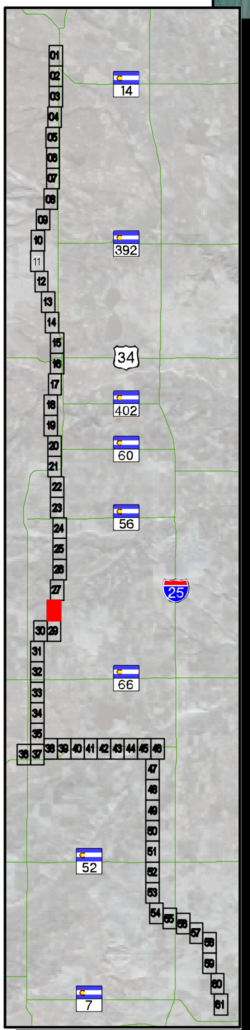
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index





## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

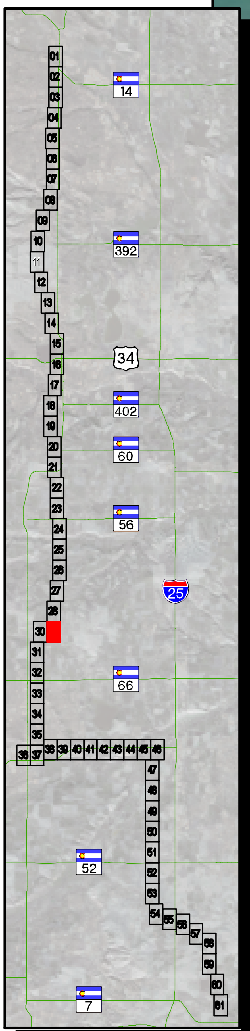
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative


Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

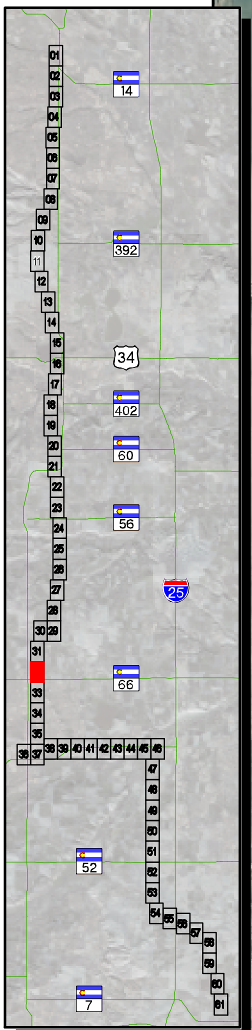
Map Document: (Appendix D.mxd)
10/22/2010

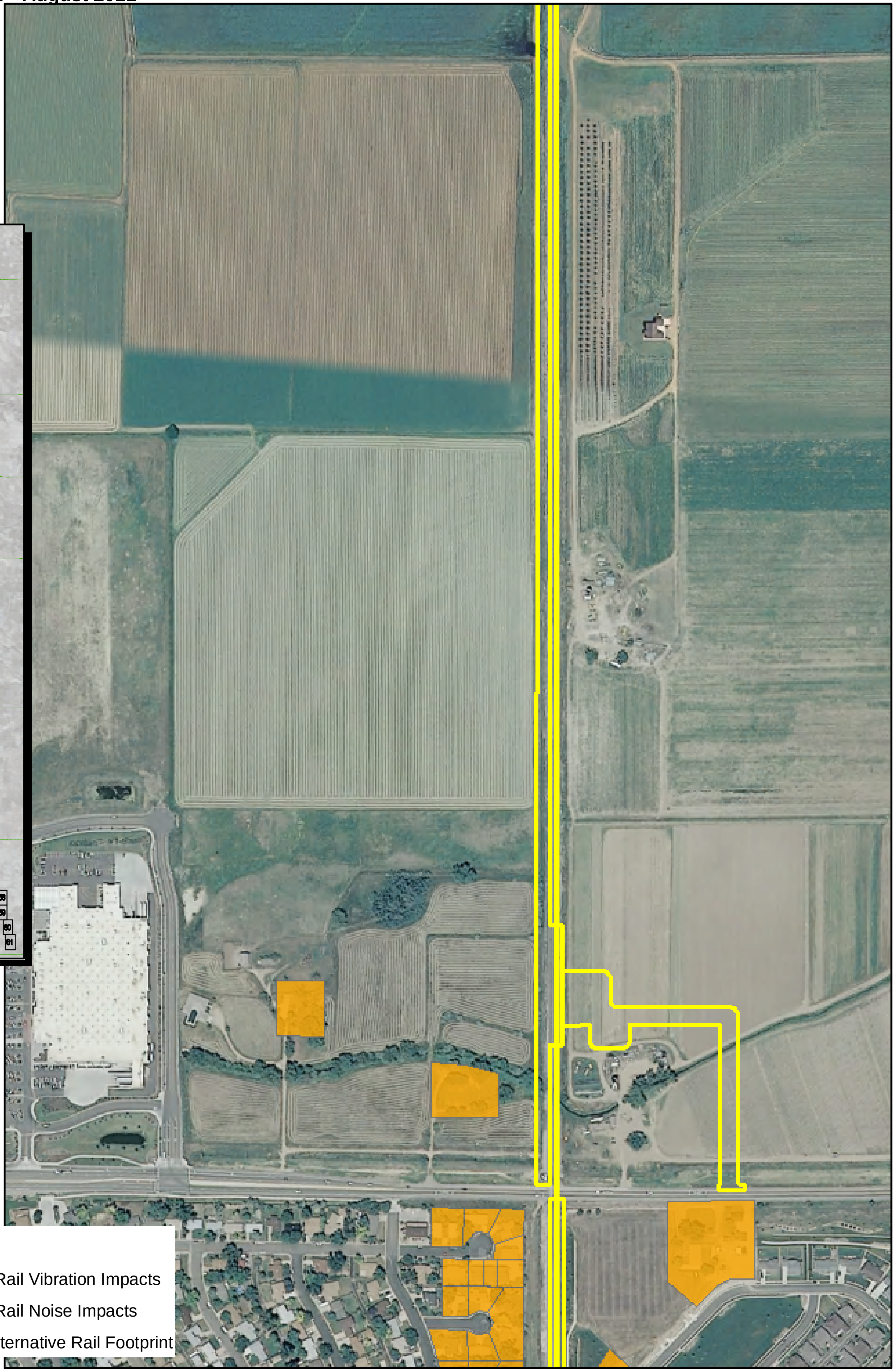
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index



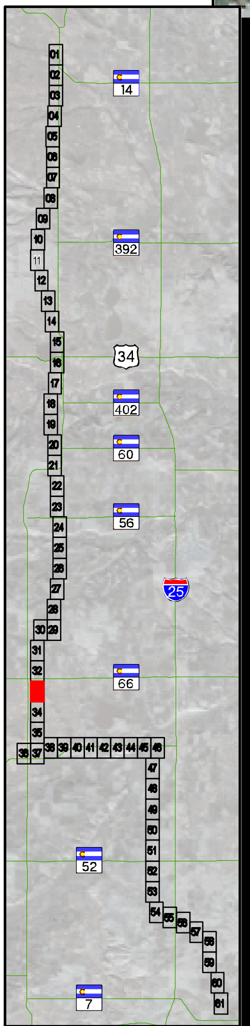

Map Document: (Appendix D.mxd)
10/22/2010

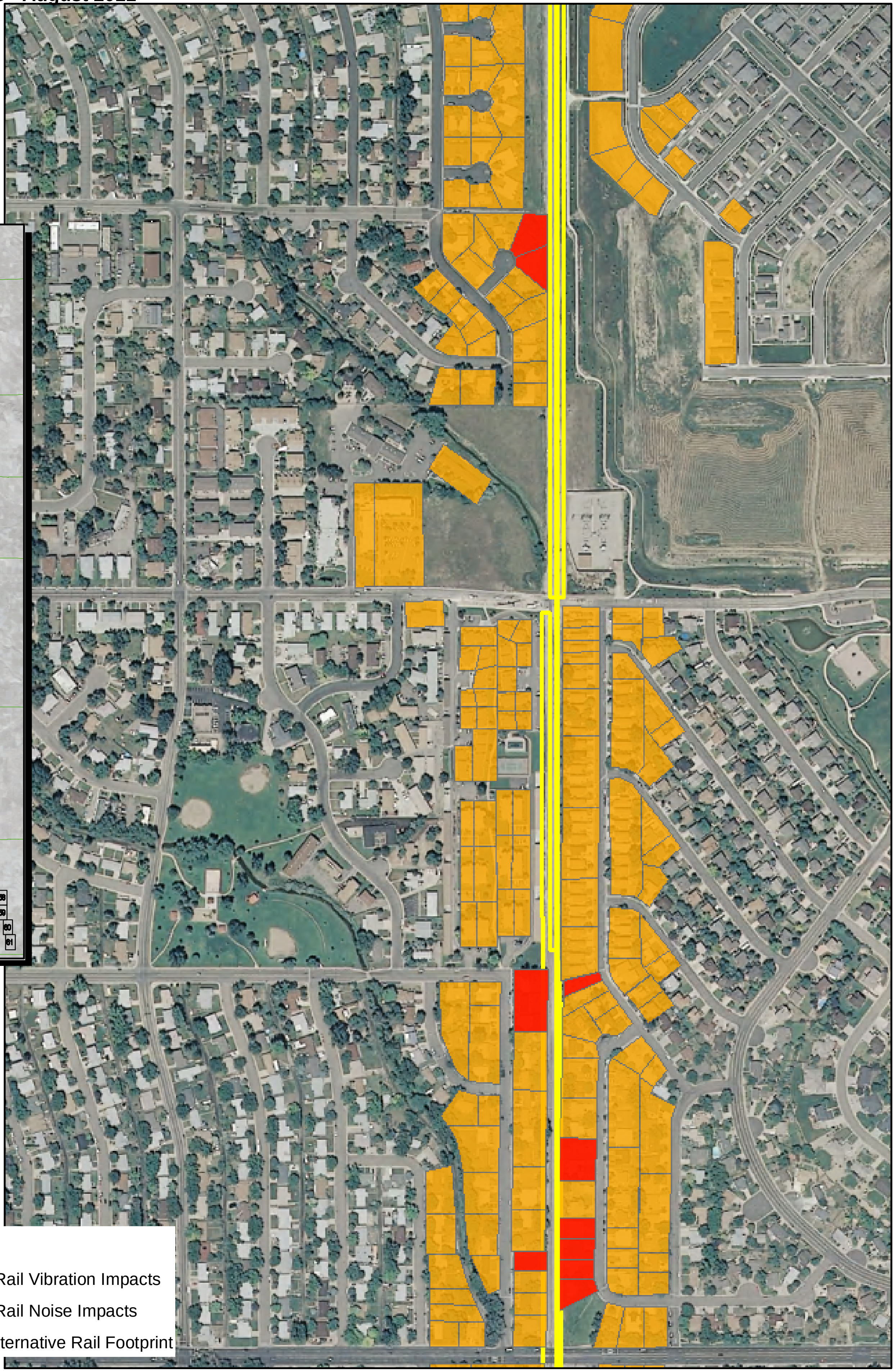
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index



## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

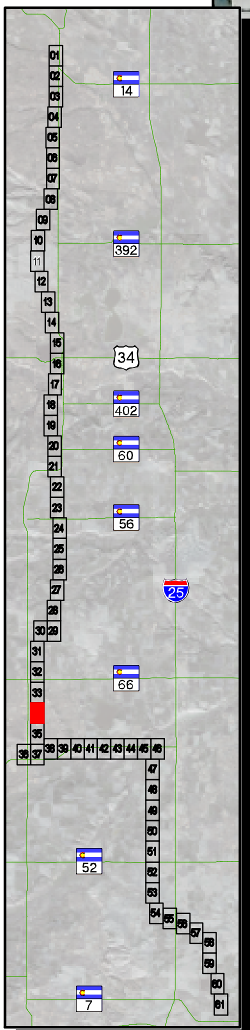
Map Document: (Appendix D.mxd)
10/22/2010

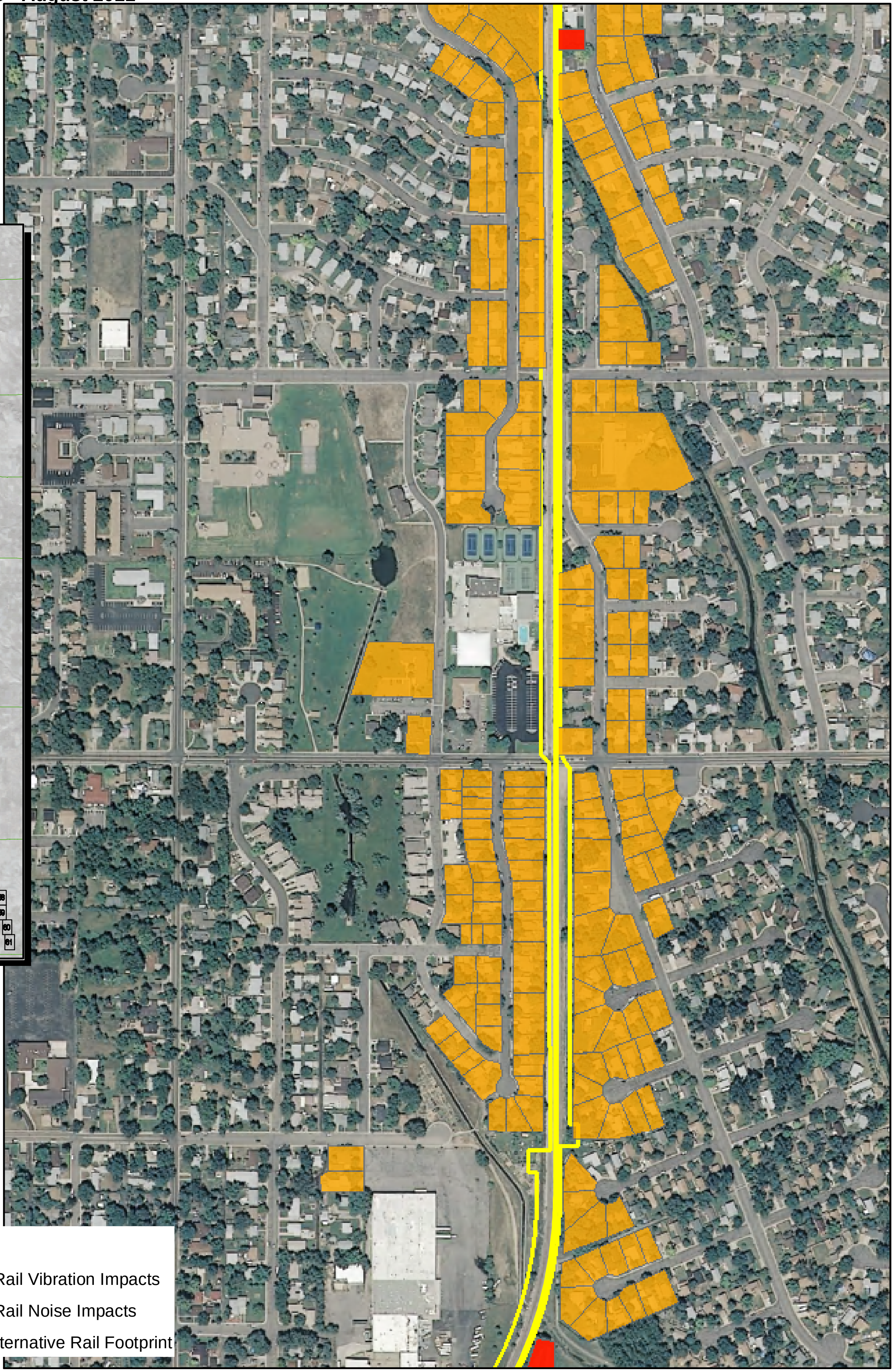
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index



## Legend

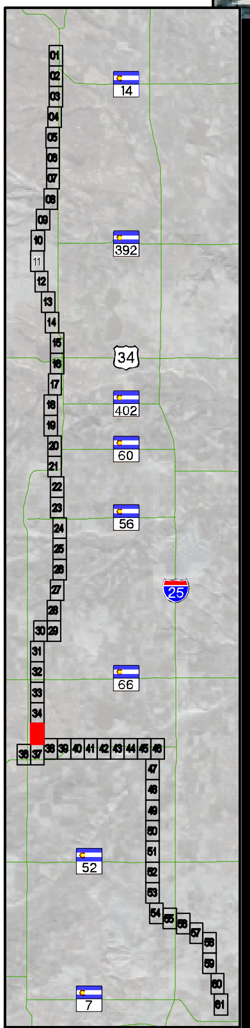
- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

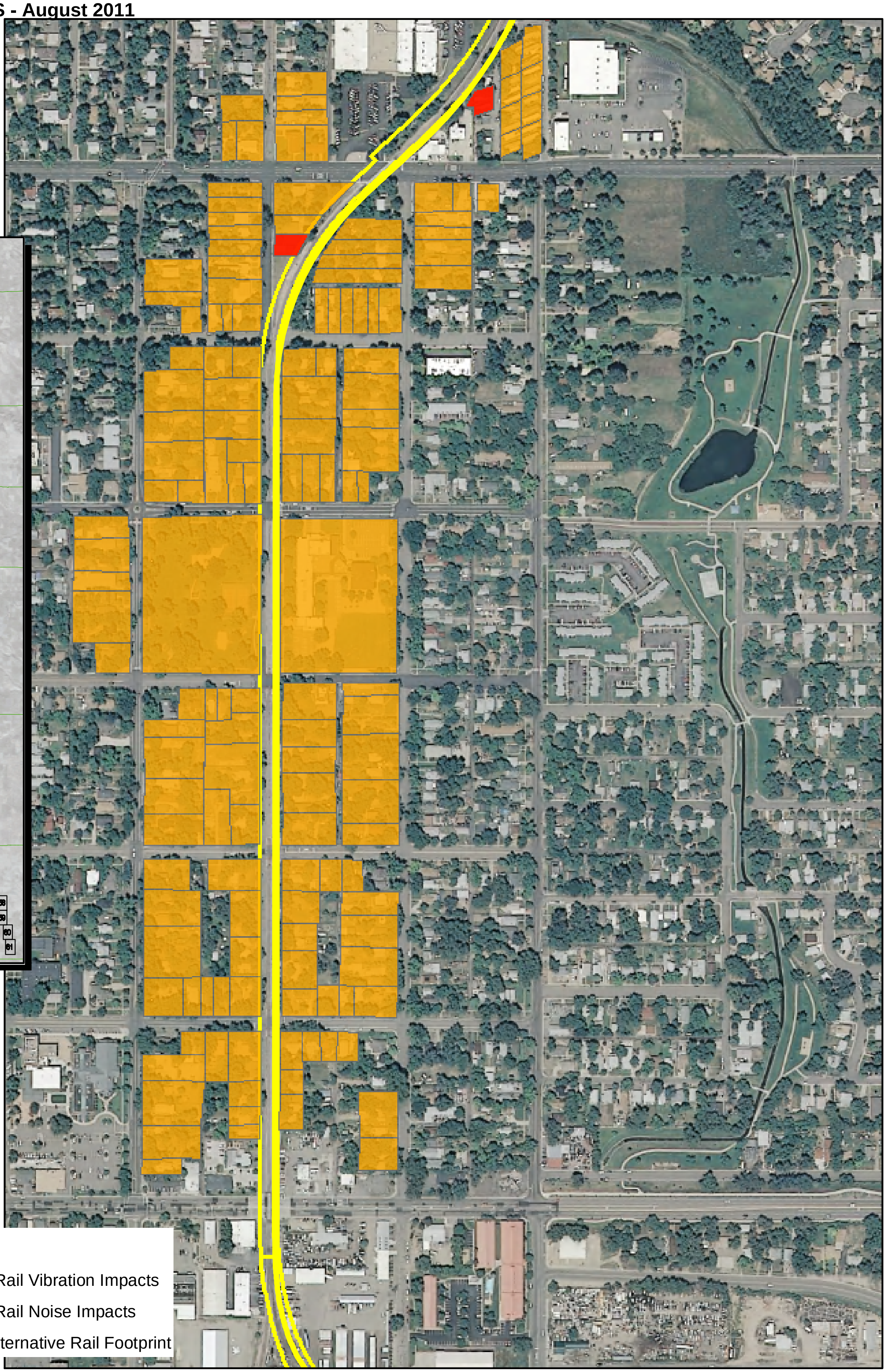


0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative



## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

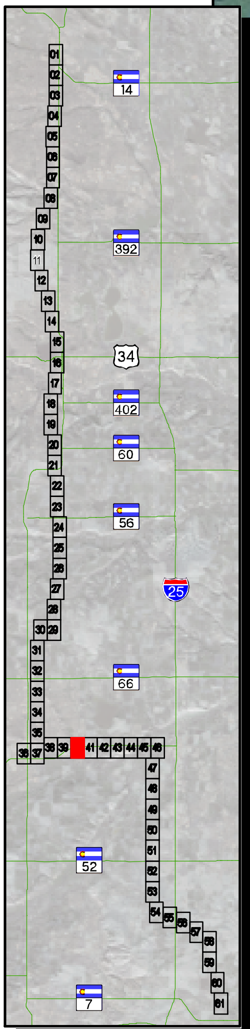
Map Document: (Appendix D.mxd)
10/22/2010

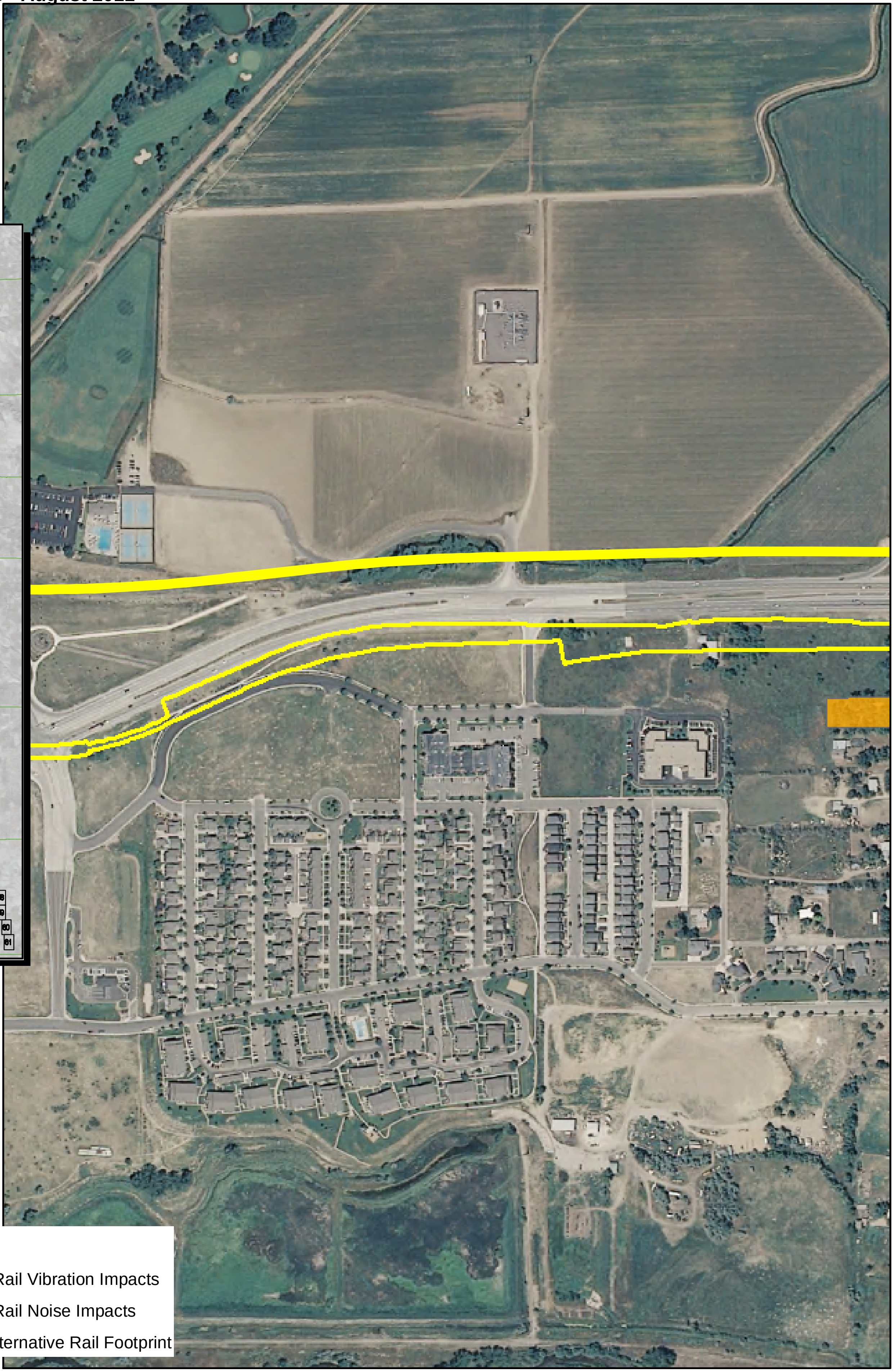
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index



## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

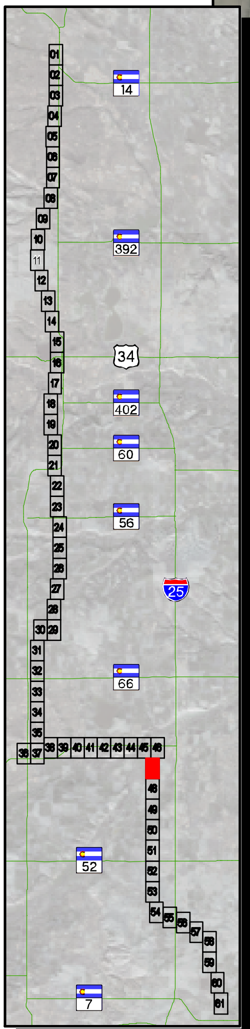
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

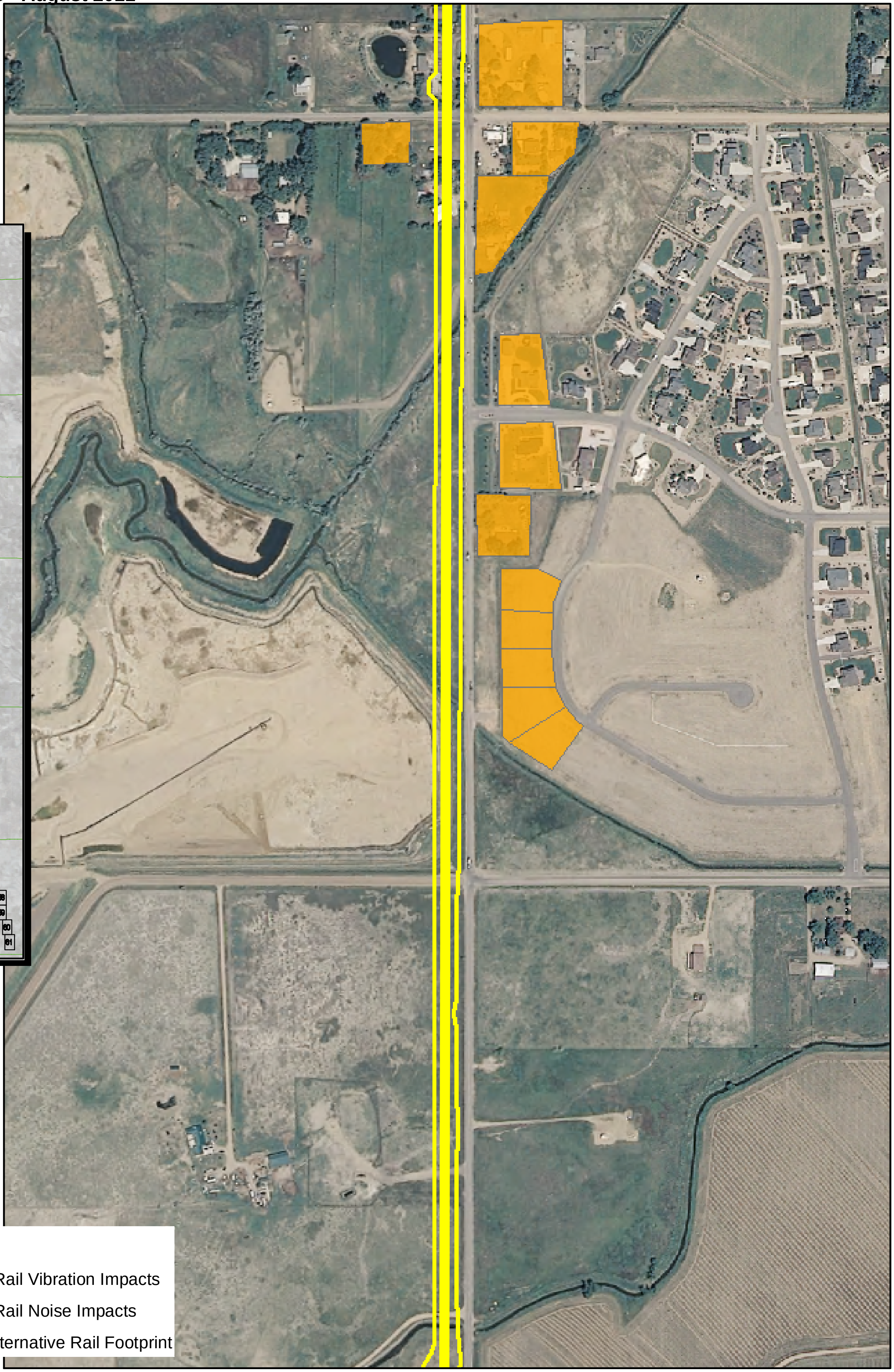
- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

Map Document: (Appendix D.mxd)
10/22/2010

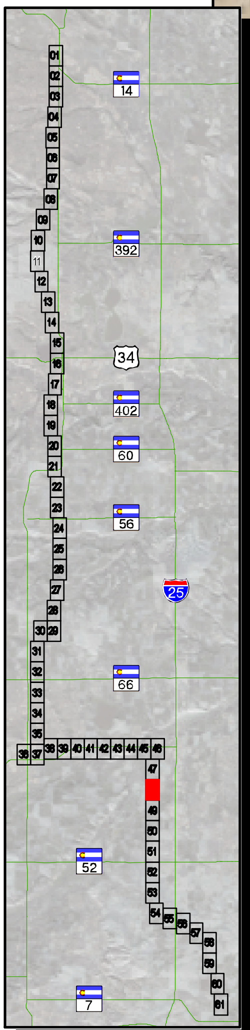
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative



Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

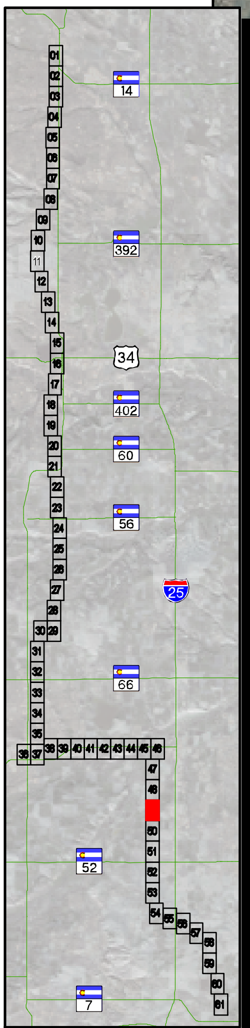
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

Commuter Rail Vibration Impacts

Commuter Rail Noise Impacts

Preferred Alternative Rail Footprint

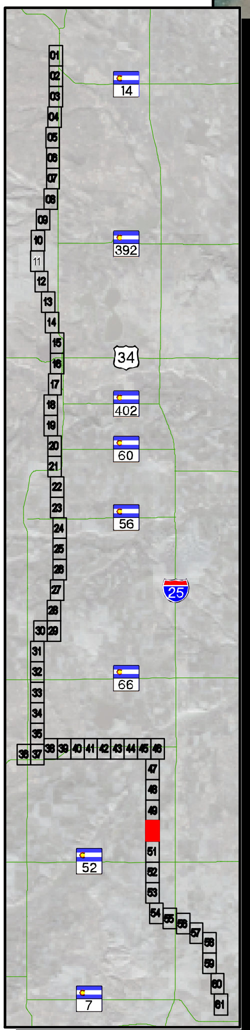
Map Document: (Appendix D.mxd)
10/22/2010

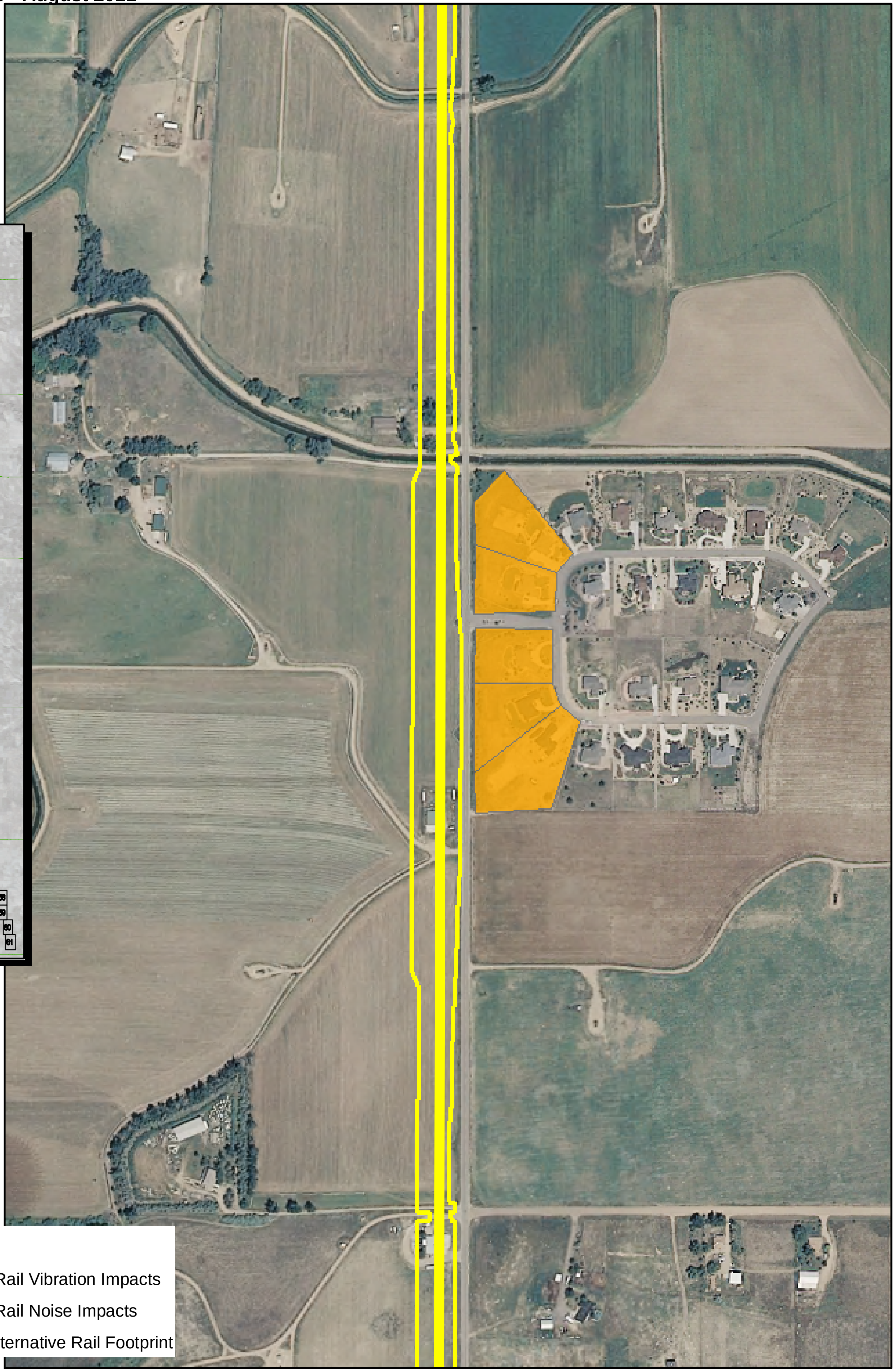
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index



## Legend

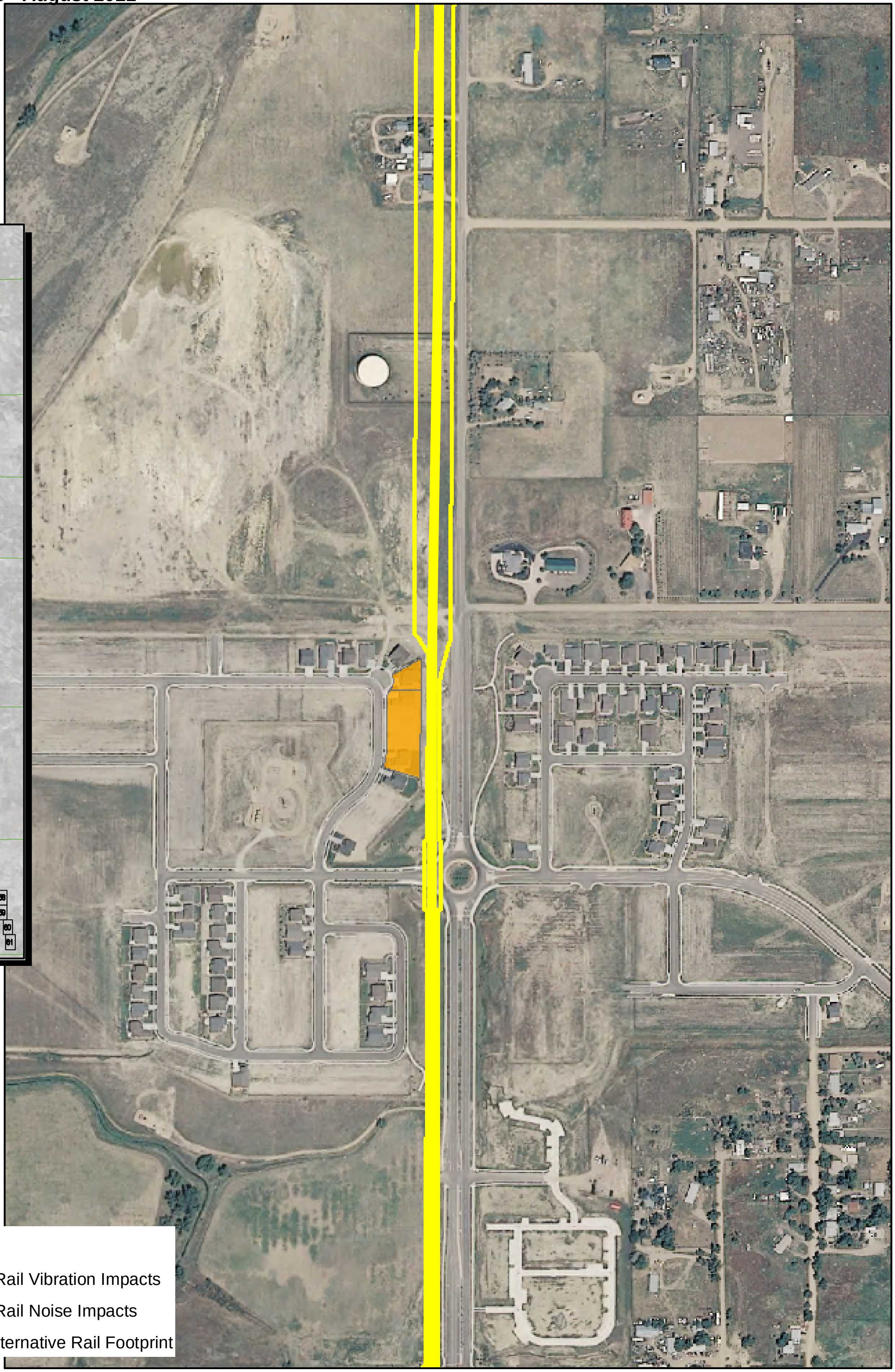
- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

Map Document: (Appendix D.mxd)
10/22/2010

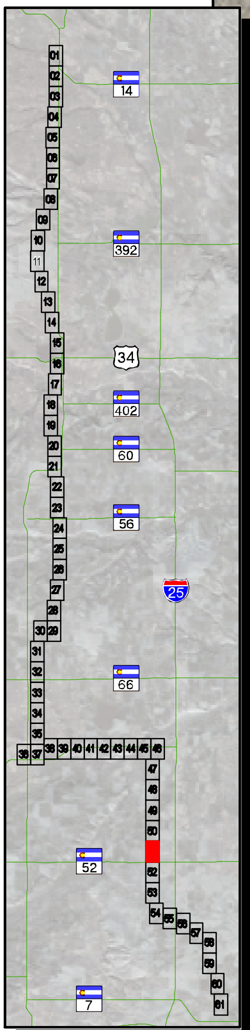
0 300 600
Feet

NORTH

Rail Noise Impacts
Preferred Alternative



Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

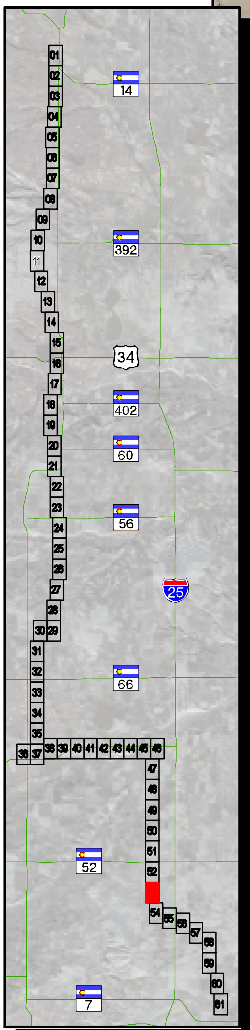
Map Document: (Appendix D.mxd)
10/22/2010

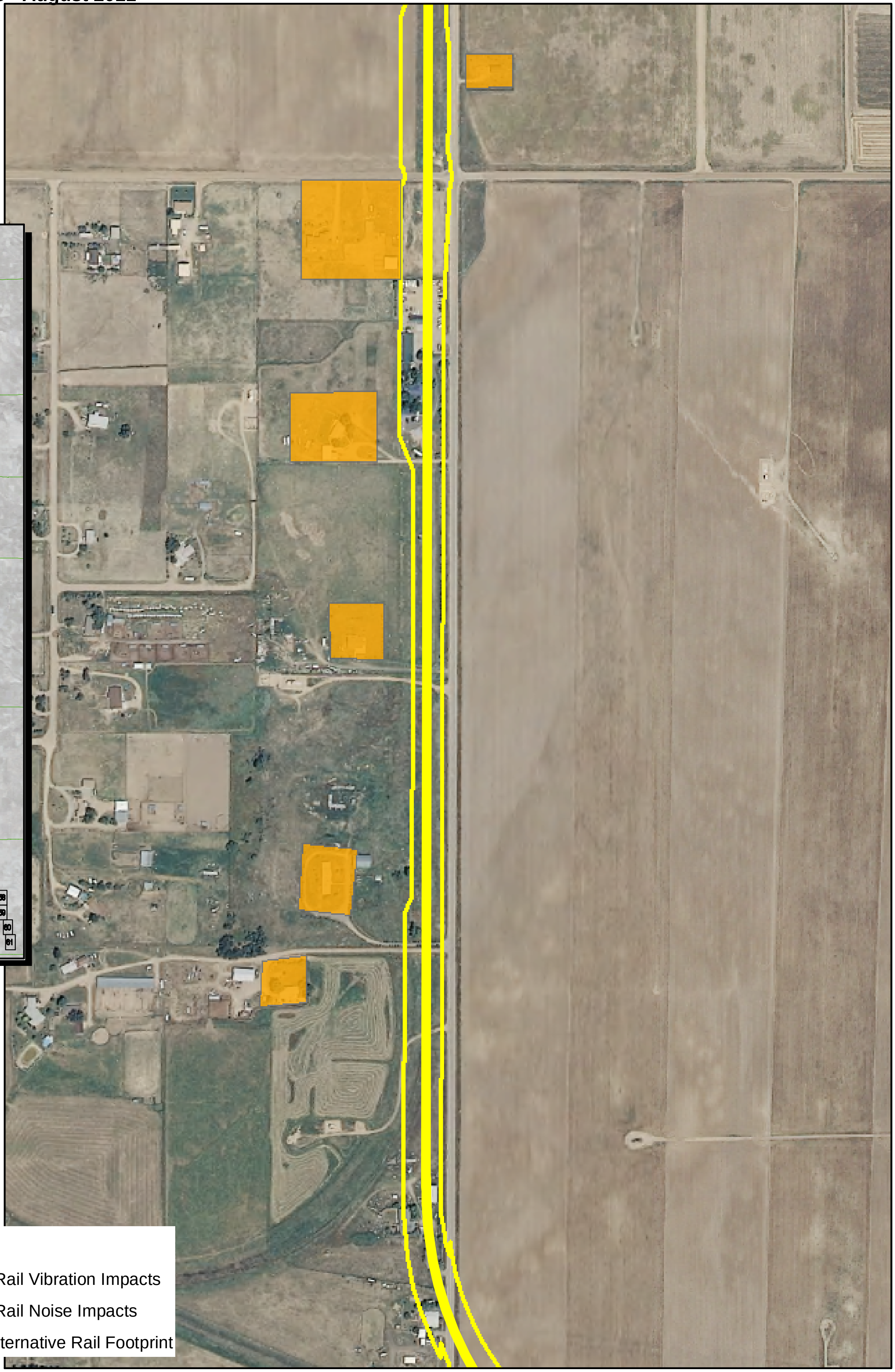
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index



## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

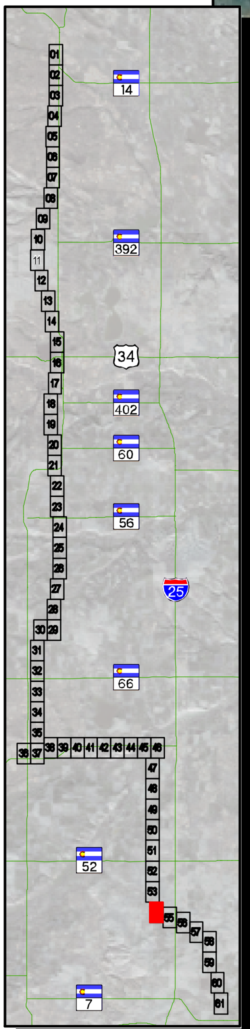
Map Document: (Appendix D.mxd)
10/22/2010

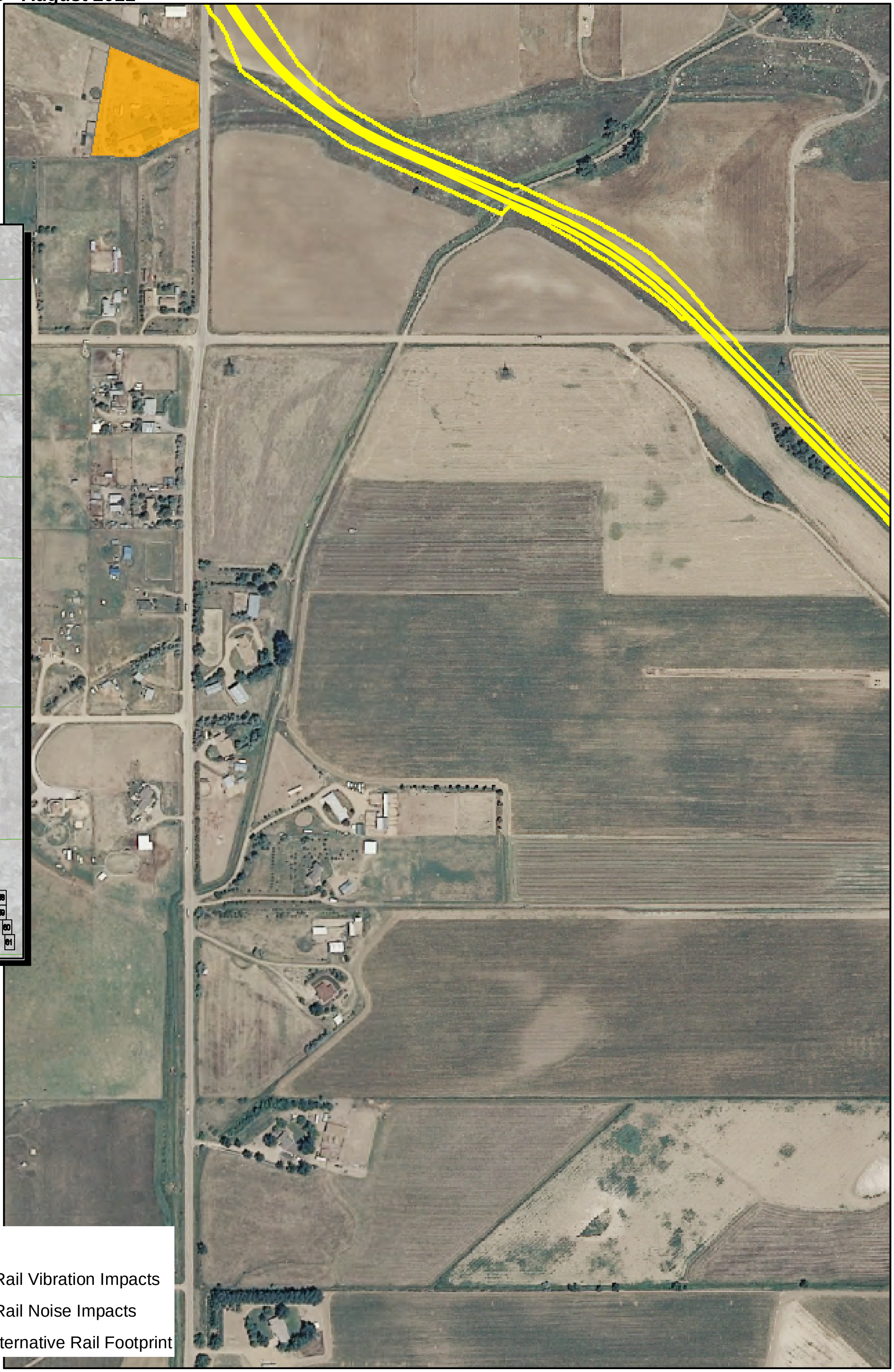
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index



## Legend

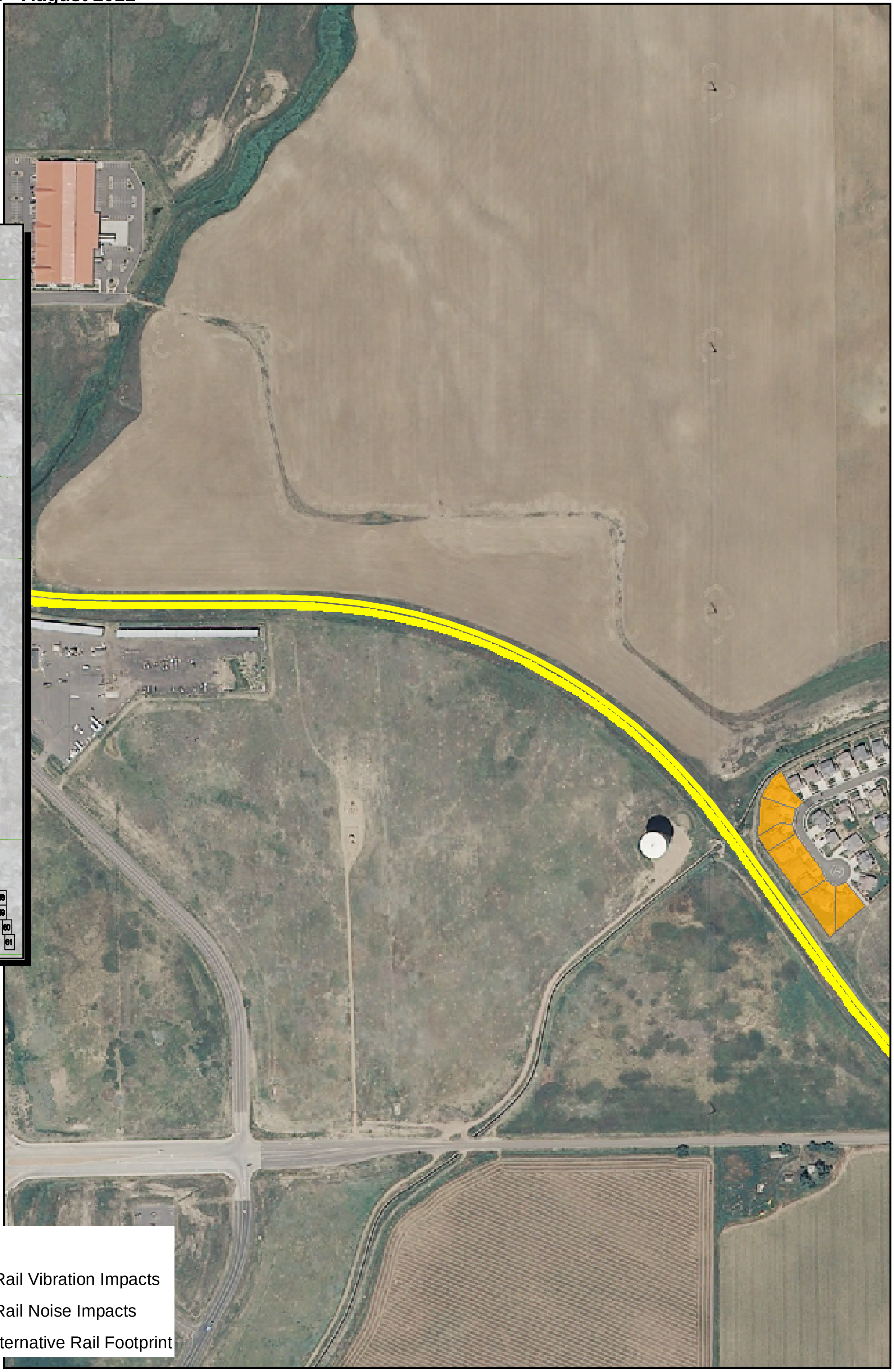
- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

Map Document: (Appendix D.mxd)
10/22/2010

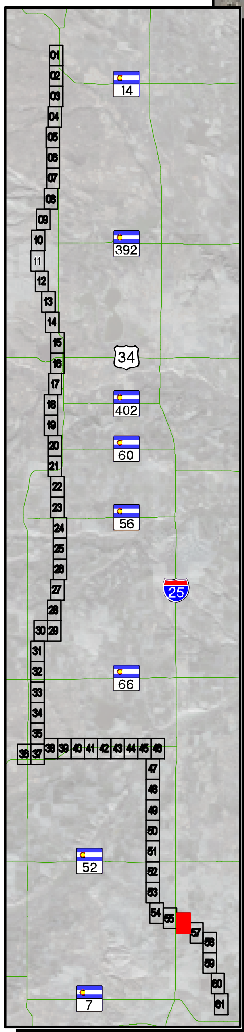
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative



Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

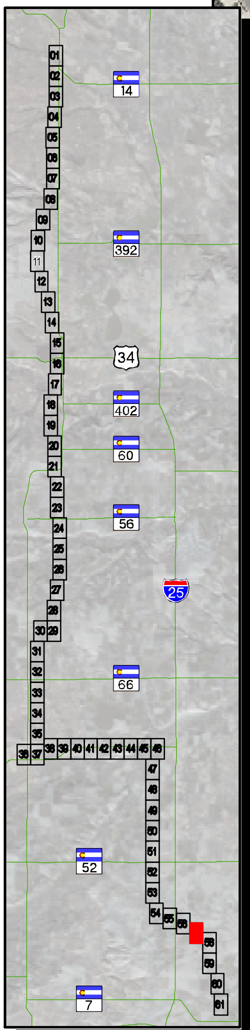
Map Document: (Appendix D.mxd)
10/22/2010

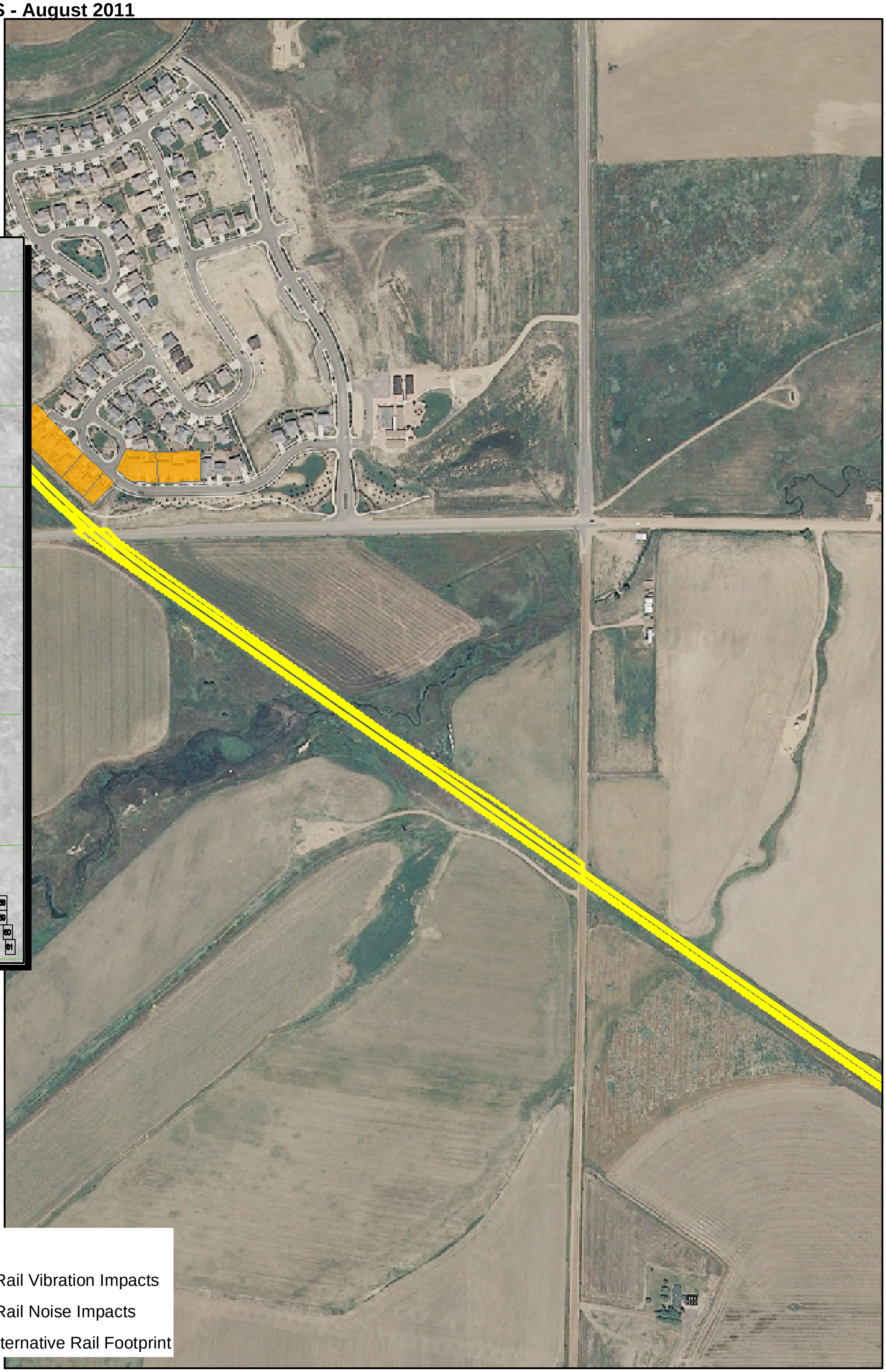
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index



## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

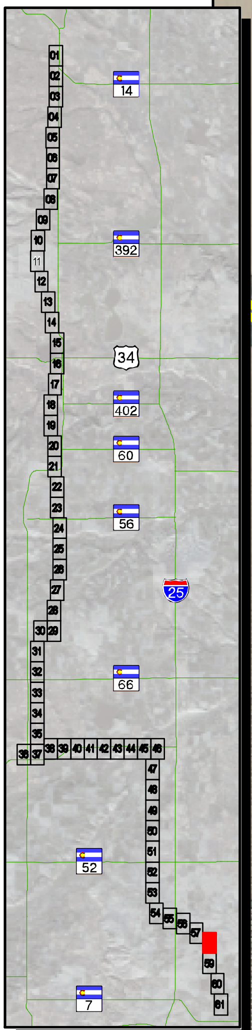
Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index




## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

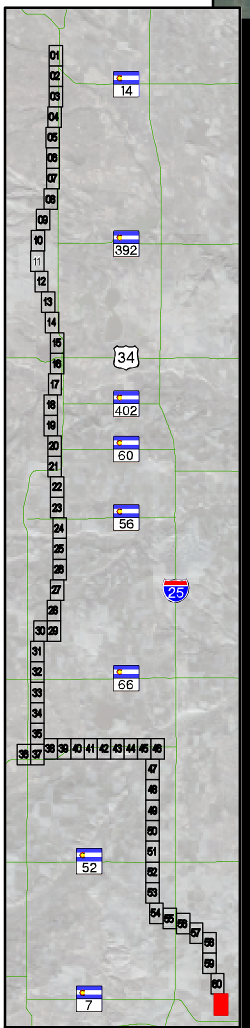
Map Document: (Appendix D.mxd)
10/22/2010

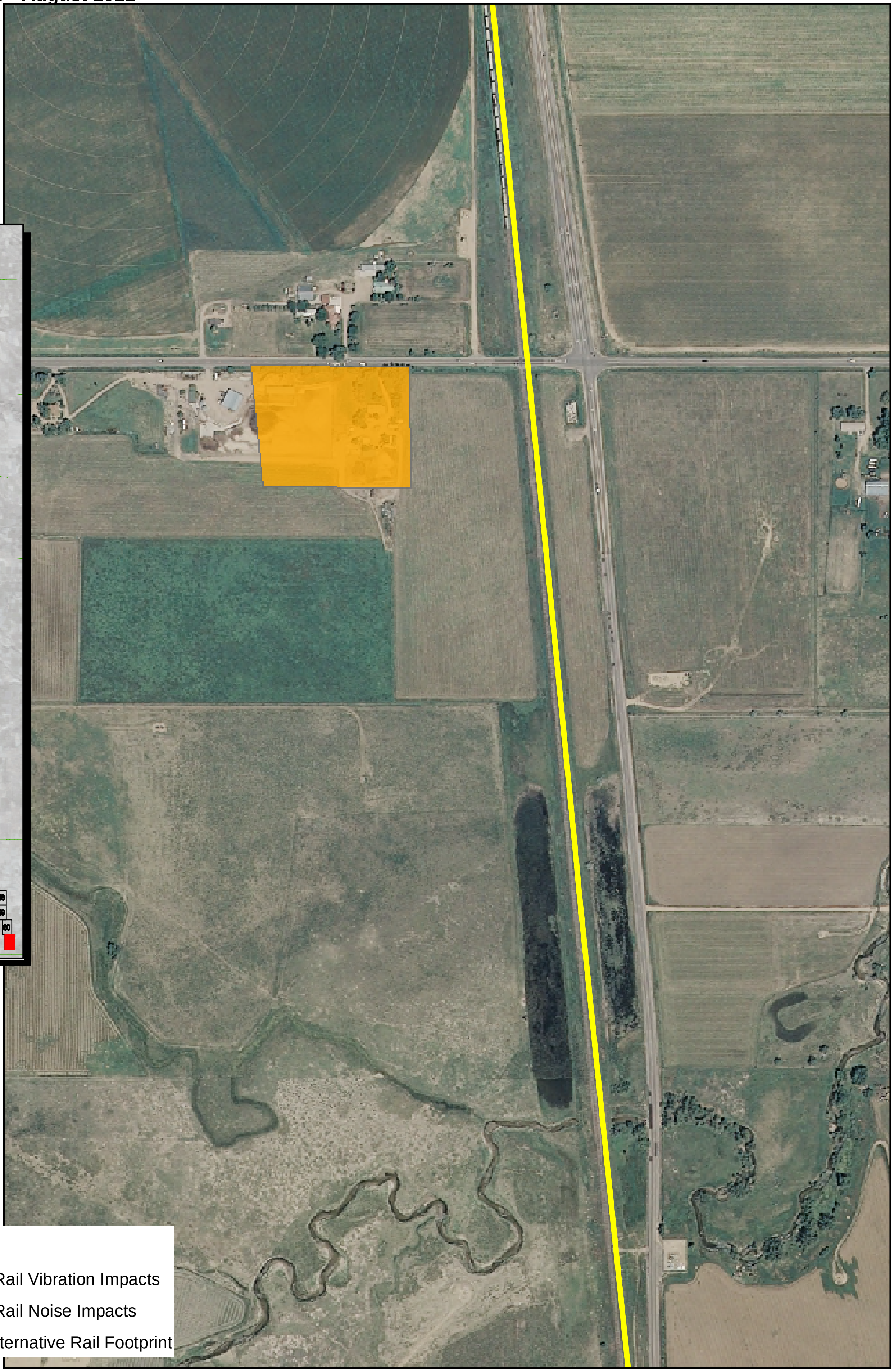
0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative

Map Index





## Legend

- Commuter Rail Vibration Impacts
- Commuter Rail Noise Impacts
- Preferred Alternative Rail Footprint

Map Document: (Appendix D.mxd)
10/22/2010

0 300 600 Feet

NORTH

Rail Noise Impacts
Preferred Alternative