Draft Report

OR 217: Sunset Hwy - Tualatin Valley Hwy

ODOT Key Number 06025

Traffic Noise Impacts Analysis

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Prepared for

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1. Introduction

This Technical Noise Analysis for the Oregon Highway 217 (OR 217) Sunset Highway (US 26) to Tualatin Valley Highway corridor was prepared as requested by the Oregon Department of Transportation (ODOT). The purpose of this analysis is to review noise levels for this project, and to determine if noise mitigation meets ODOT reasonable and feasible criteria. Where noise impacts are identified, noise abatement will be considered and analyzed in accordance with the policy and procedures given in the ODOT *Traffic Noise Manual*, June, 1996.

2. Project Description

A $36.5 million project will add a third northbound lane on OR 217 between the Tualatin-Valley Highway (OR 8) and US 26. This third northbound lane will begin just north of OR 8 and continue north to the Barnes Road off-ramp. Other modernization features include improving the Wilshire Street off-ramp, building retaining walls and improving drainage. This report covers only the additional third northbound lane between Walker Road and the Sunset Highway.

2.1. No-Build Project Description

There is no formal No-Build Alternative. A No-Action Alternative was used for the Noise Analysis and assumes the same future traffic volumes, speed and mixture as the future Build Alternative.

3. Analysis Requirements

This report was prepared as required by ODOT. A Traffic Noise Analysis is required whenever a project includes a new highway, an increase in the number of traffic lanes, or a substantial realignment (horizontal or vertical) of an existing highway. The addition of the third northbound lane between Walker Road and the Sunset Highway and community concern is the justification for this Noise Analysis.

The methodology used is defined in the ODOT *Traffic Noise Manual*, 1996, and the United States Department of Transportation (USDOT) Federal Highway Traffic Noise Standards (Title 23 of the Code of Federal Regulations (CFR) Part 772, *Procedures for Abatement of Highway Traffic Noise and Construction Noise*). A complete description of the procedures and methodology used in the analysis is given in the Methodology section. A bibliography of the technical support documents used for this report is in Appendix A.

4. Project Study Area and Land Use

Traffic noise studies are only required when a project includes a new highway, an increase in the number of traffic lanes, or a substantial realignment (horizontal or vertical) of an existing highway. Therefore, this Traffic Noise Analysis only covers the auxiliary lane between Walker Road and the Sunset Highway, on the east side of OR 217. Normally, the noise analysis would cover both sides of the highway, however there is a noise wall along the west side of OR 217 through this area and therefore, no noise analysis was required for the west side of OR 217.

The project study area is the residential area north of Walker Road, along the east side of OR 217. There is a group of single-family homes located uphill from OR 217 along SW 103rd, 106th and 107th Avenues between SW Porter Street and SW Arborcrest Way. Figure 1 provides an overview of the study area with the residential land uses identified.

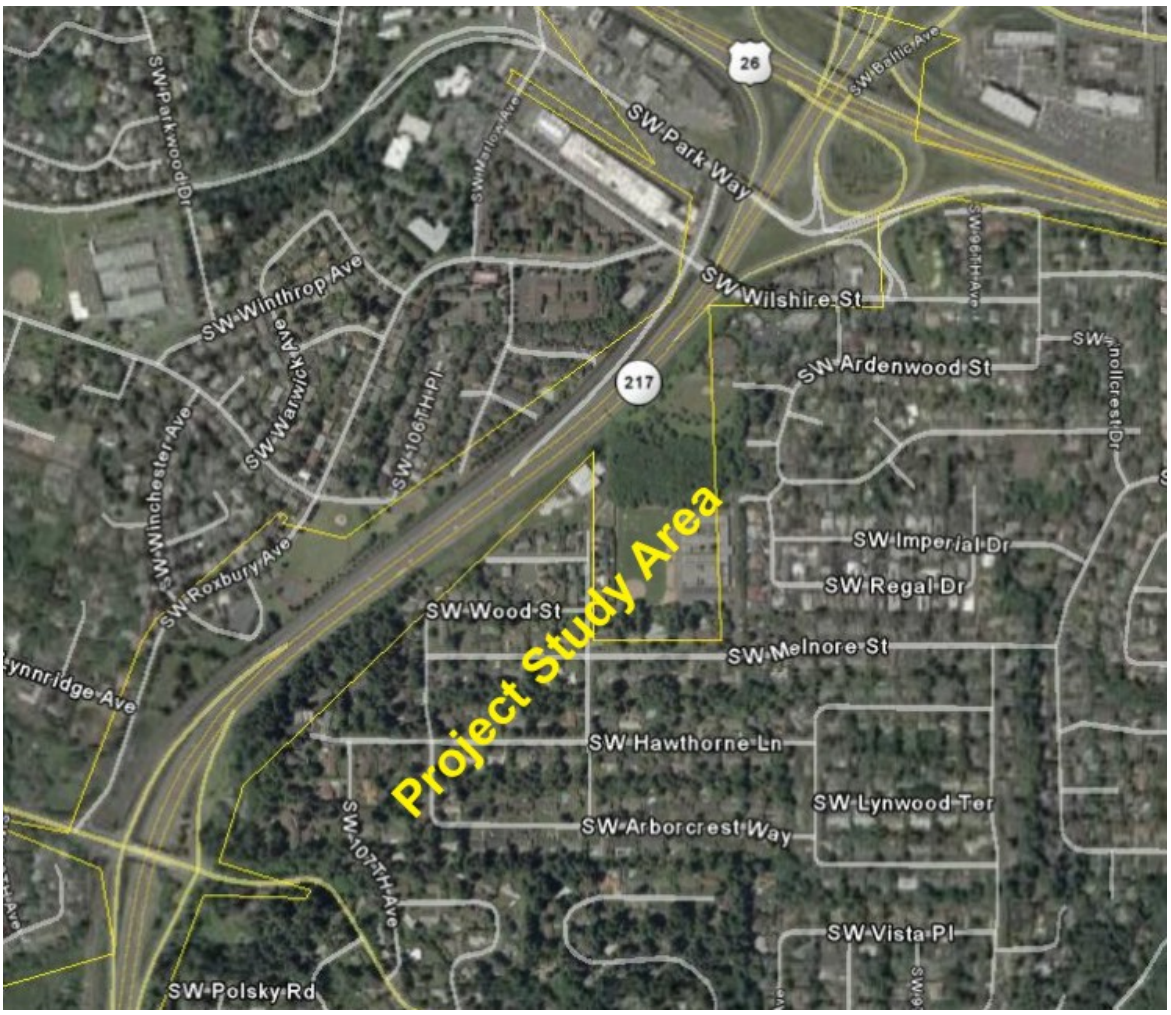


Figure 1: Study Area and Land Use

4.1. Zoning and Comprehensive Land Use Plan Design

There are no zoning or comprehensive land use plan designs that affect the noise analysis for this project.

4.2. Displacements Due to Project Construction

There are no displacements planned as part of this project.

5. Methodology

This section provides details on the methods used for the Traffic Noise Analysis.

5.1. Acoustic Terminology

Noise is generally defined as unwanted sound. Noise is measured in terms of sound pressure level. It is expressed in decibels (dB), which are defined as 10 log P^2/P^2ref, where P is the root-mean-square (RMS) sound pressure and P_{ref} is the reference RMS sound pressure of 2 x 10^{-5} Newtons per square meter.

The number of fluctuation cycles, or pressure waves per second, of a particular sound is the frequency of the sound. The human ear is less sensitive to higher and lower frequencies than to mid-range frequencies. Therefore, sound level meters used to measure environmental noise generally incorporate a weighting system that filters out higher and lower frequencies in a manner similar to the human ear. This system produces noise measurements that approximate the normal human perception of noise. Measurements made with this weighting system are termed "A-weighted" and are specified as "dBA" readings.

Several noise descriptors are used that take into account the variability of noise over time. The equivalent sound level (L_{eq}) is the level of a constant sound for a specified period of time that has the same sound energy as an actual fluctuating noise over the same period of time. It is an energy average sound level. Another descriptor, the statistical sound level, is the sound level that is equaled or exceeded for a specified percentage of a given measurement period. For example, L_{90} is the notation for the noise level within a measurement interval that is equaled or exceeded 90 percent of the time.

The maximum noise levels (L_{max}) that occur during an event, such as the passing of a heavy truck or the flyover of an airplane, can be useful indicators of interference with speech or sleep. In summary, the noise level descriptors are defined as follows:

Symbol	Description
L_{eq}	The average noise level (energy basis)
L_{max}	The maximum noise level
L_x	The noise level that is equaled or exceeded for "x" percent of the time

5.1.1. Noise Reduction with Distance

Noise levels decrease with distance from a noise source. For each doubling of the distance from a point source (such as an engine), noise levels decrease by 6 dBA due to the geometric divergence of the sound waves. Excess noise reduction (attenuation) can be provided by vegetation, terrain, and atmospheric effects that block or absorb noise. The L_{eq} noise level from a line source (such as a road) will decrease by 3 dBA for each doubling of distance (3 dB/DD) because of geometric divergence alone. However, the L_{max} from individual vehicles on the road will decrease by 6 dBA/DD. Therefore, the maximum noise levels (L_{max}) decrease more rapidly with distance from the road than do the average noise levels (L_{eq}).

Subjectively, a 10-dBA change in noise level is judged by most people to be approximately a twofold change in loudness (e.g., an increase from 50 dBA to 60 dBA causes the loudness to double). A 3-dBA increase is a barely perceptible increase.

5.1.2. Report Noise Level Descriptors

All noise levels referred to in this report that are for the purpose of evaluating potential impacts are stated as hourly equivalent sound pressure levels (L_{eq}) in terms of decibels on the A-scale (dBA). Noise levels stated in terms of dBA approximate the response of the human ear by filtering out some of the noise in the low and high frequency ranges that the ear does not detect well. The A-scale is used in most ordinances and standards. The equivalent sound pressure level is defined as the average noise level, on an energy basis, for a stated period of time (e.g., hourly). For more information, a detailed introduction to acoustics is given in Appendix B.

5.2. Method of Analysis

Projected traffic noise level conditions were calculated using the *FHWA Traffic Noise Model* (TNM version 2.5 - USDOT, 2004), developed for FHWA. Input to the model included traffic volume and speed information from roadway traffic counts and data generated by the Oregon Department of Transportation. Noise emission levels used in the model were nationwide averages for automobiles, medium trucks, and heavy trucks. The noise reducing effects of front-line[1] residences, roadway depressions and topography were included in the calculations where appropriate.

[1] For the Purpose of this report, "front-line" refers to noise sensitive receivers located directly adjacent to the project roadway.

5.3. Impact Criteria

The traffic noise impact criteria, against which the project traffic noise levels are evaluated, are taken from Title 23 of the Code of Federal Regulations (CFR) Part 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise. The criterion applicable for residences, churches, schools, recreational uses, and similar areas is an exterior hourly equivalent sound level (L_{eq}) that approaches or exceeds 67 dBA. The criterion applicable for other developed lands, such as commercial and industrial uses, is an exterior L_{eq} that approaches or exceeds 72 dBA. There are no criteria for underdeveloped lands or construction noise. A summary of the FHWA noise regulations is contained in Table 1.

Table 1: FHWA Roadway Noise Abatement Criteria

Land Use Category and Description		Hourly Leq (dBA)
Type A	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose	57 (exterior)
Type B	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, (exterior) motels, hotels, schools, churches, libraries and hospitals	67 (exterior)
Type C	Developed lands, properties or activities not included in the above categories	72 (exterior)
Type D	Undeveloped land	--
Type E	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums	52 (interior)

5.3.1. Oregon State Traffic Noise Criteria

ODOT considers a traffic noise impact to occur when predicted project-related traffic noise levels approach, within 2 dBA, the criteria level in Table 1, or substantially exceed existing levels. Therefore, residential impacts (Type B property) occur at 65 dBA, and commercial impacts (Type C property) occur at 70 dBA. In addition, ODOT considers a 10 dBA increase over the existing noise levels a substantial increase, and therefore an impact.

There are no Type A land uses identified in the project corridor. Residential land use, schools, parks and playgrounds, churches and hospitals are all considered Type B land uses, and therefore noise impacts would occur if projected related noise levels meet or exceed 65 dBA L_{eq}.

6. Existing Environment and Noise Levels

The existing noise environment is composed primarily of traffic noise from OR 217, the light rail system, and noise from arterial roads such as Walker Road. Other noise sources in the project area include general commercial activities, residential and commercial construction,

and other general residential activities, such as children playing and household maintenance and upkeep.

6.1. Noise Measurements

On-site noise monitoring was performed and is used to establish the existing noise environment and calibrate the FHWA traffic noise model (TNM). Project staff monitored noise levels at 3 locations in the project study area and performed concurrent traffic counts when possible during the noise monitoring periods. The sound level meters used for the measurements were Bruel & Kjaer Type 2238. The sound level meters meet or exceed American National Standards Institute (ANSI) S1.4-1983 for Type 1 Sound Measurement Devices. All measurement procedures complied with ANSI S1.13-1971. System calibration was performed before and after each measurement session with a Bruel & Kjaer Type 4231 sound level calibrator. Table 2 provides a summary of the noise measurement sites and results of the on-site monitoring. The noise measurement sites are shown on Figure 2.

Table 2: OR 217 Project On-Site Measured Noise Levels

M#	Description[1]	Date & Time[2]	Noise Level
M1	SW Hawthorne Ln at SW 107th Ave	1/24/06 @ 3:40 pm	59.5 dBA L_{eq}
M2	10587 Wood Street	1/24/06 @ 4:20 pm	77.5 dBA L_{eq}
M3	SW Porter St Cul-de-sac behind berm	1/24/06 @ 5:05 pm	60.6 dBA L_{eq}

1. Noise monitoring sites shown on Figure 2
2. All monitoring sessions were 20 minutes long

Figure 2: Project Area Noise Monitoring Locations

6.1.1. Non-Transportation Related Noise Sources

Non-transportation noise sources would include commercial activities, outdoor activities at schools and parks, nearby construction projects and other noise sources not resulting from traffic on public roadways. There were no notable non-transportation related noise sources identified during the on-site visit and noise monitoring sessions.

6.2. Comparison with FHWA Traffic Noise Model

Existing traffic noise levels were also modeled, as previously described, to test the agreement of calculated and measured noise levels. Traffic volumes from the on-site traffic counts were

used for model calibration. Comparisons of the measured and calculated noise levels for the three noise monitoring locations are given in Table 3.

Table 3: Model Calibration Levels

Monitoring Location Number and Description[1]		Noise Level Comparison (dBA L_{eq})[2] Measured	Modeled	Difference
M1	SW Hawthorne Ln at SW 107th Ave	59.5	58.4	1.1
M2	10587 Wood Street	77.5	75.9	1.6
M3	SW Porter St Cul-de-sac behind berm	60.6	59.3	1.3

1. Noise monitoring sites shown on Figures 5 and 6
2. Comparison of hourly L_{eq} noise levels – measured versus modeled and difference

The modeled and measured noise results given in Table 3 agree within 2 dBA. Because a 2 dBA change in noise levels is barely perceptible to the average human ear, an agreement of +/- 2 dBA or less is considered acceptable for modeled and measured noise level deviations.

7. Traffic Noise Analysis

Determination of existing and future noise levels was established using noise modeling. The modeling was performed for 15 representative receiver locations throughout the project corridor. Figure 3 is a vicinity map showing the noise modeling receiver locations.

7.1. Traffic Data

The data used in this analysis was provided by traffic engineers at ODOT. The data included the traffic speeds, volumes and mixture for the peak-vehicle hour and peak-truck hour. Complete plots of the traffic data along with a link map are given in Appendix C.

Prior to performing the impact analysis, a comparison of the peak-truck and peak-vehicle hours was performed. Because trucks are louder than cars, the peak-truck hour is often the loudest hour of the day, and therefore often used in the noise analysis. The existing peak-truck hour noise levels were projected to be higher than the peak-traffic hour noise levels, and therefore peak-truck hour volumes were used for this analysis.

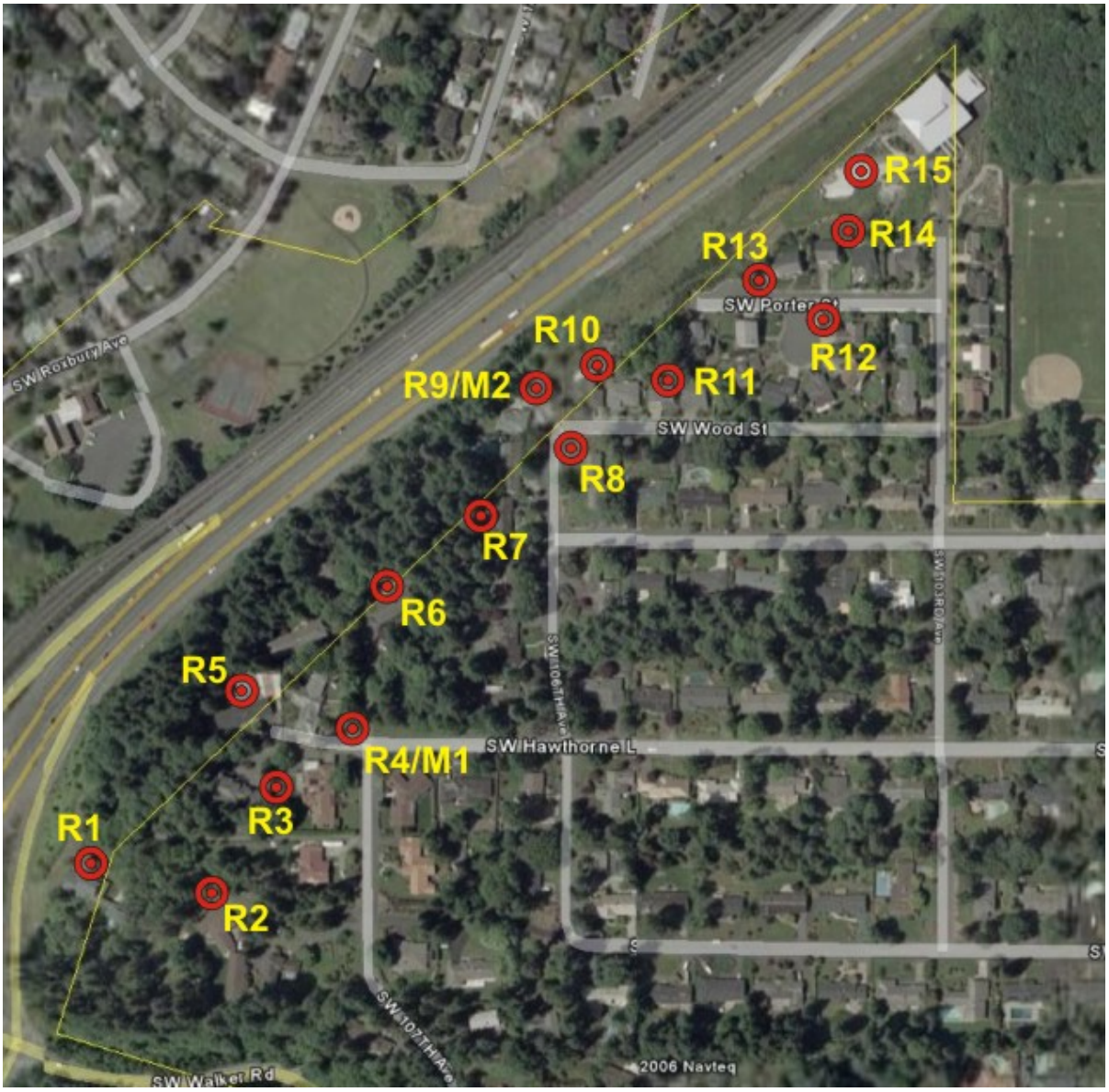


Figure 3: Project Area Noise Modeling Locations

7.2. Existing Modeled Noise Levels

Existing noise levels were modeled, as described, using year 2005 traffic volumes and speeds provided by ODOT traffic engineers. Overall, noise levels in the project area ranged from 51 to 76 dBA L_{eq}. The highest noise levels were modeled near receiver R1 and receivers R7 through R10, where noise levels exceed 70 dBA, with receiver R9 having modeled noise levels of 76 dBA L_{eq}. Receivers 12 through 15 are protected by an existing berm that was constructed by the resident represented by R15. Table 4 provides a summary of the modeled noise levels for the current conditions

Table 4: Existing Conditions Noise Levels

Receiver[1]	Number of Structures[2]	Land Use Description[3]	Noise Level (hourly Leq dBA)[4]
R-1	1	Residential	**72**
R-2	2	Residential	**68**
R-3	2	Residential	63
R-4/M-1	1	Residential	58
R-5	2	Residential	**68**
R-6	1	Residential	**70**
R-7	3	Residential	**73**
R-8	2	Residential	**70**
R-9/M2	2	Residential	**76**
R-10	2	Residential	**72**
R-11	2	Residential	**65**
R-12	3	Residential	61
R-13/M3	2	Residential	59
R-14	2	Residential	62
R-15	1	Residential	51

1. Receiver locations are shown on Figures 7 and 8
2. Number of structures in the immediate area predicted to have the same noise level
3. Receiver Land Use
4. Year 2005 peak-truck noise hourly noise levels in L_{eq} dBA.

7.3. Future No-Build Noise Levels

Under the No-Build Alternative, year 2030 traffic noise levels are projected to range from 53 to 77 dBA L_{eq}. Noise levels are projected to increase by 1 to 2 dBA L_{eq} at all receivers in the study area. Again, the highest noise levels were in the center of the study area (R6 to R10) and near the Walker Road ramps (R1). A summary of the No-Build modeled noise levels are provided in Table 5.

7.4. Build Future Modeled Noise Levels

Under the Build Alternative, year 2025 traffic noise levels are projected to range from 54 to 78 dBA L_{eq}. Increases of 1 to 3 dBA are projected throughout the project study area. Receivers R1 and R5 through R10 are projected to have noise levels above 70 dBA L_{eq} with receiver R9 projected to have noise levels as high as 78 dBA L_{eq}. A summary of the Future Build modeled noise levels are provided in Table 6.

Table 5: Future No-Build Noise Levels

Receiver[1]	Number of Structures[2]	Land Use Description[3]	Noise Level (hourly Leq dBA)[4]
R-1	1	Residential	73
R-2	2	Residential	69
R-3	2	Residential	65
R-4/M-1	1	Residential	59
R-5	2	Residential	70
R-6	1	Residential	71
R-7	3	Residential	74
R-8	2	Residential	71
R-9/M2	2	Residential	77
R-10	2	Residential	73
R-11	2	Residential	67
R-12	3	Residential	62
R-13/M3	2	Residential	60
R-14	2	Residential	63
R-15	1	Residential	53

1. Receiver locations are shown on Figures 7 and 8
2. Number of structures in the immediate area predicted to have the same noise level
3. Receiver Land Use
4. Year 2005 peak-truck noise hourly noise levels in L_{eq} dBA

Table 6: Future Build Noise Levels

Receiver[1]	Number of Structures[2]	Land Use Description[3]	Noise Level (hourly Leq dBA)[4]
R-1	1	Residential	73
R-2	2	Residential	69
R-3	2	Residential	65
R-4/M-1	1	Residential	60
R-5	2	Residential	70
R-6	1	Residential	72
R-7	3	Residential	75
R-8	2	Residential	72
R-9/M2	2	Residential	78
R-10	2	Residential	73
R-11	2	Residential	67
R-12	3	Residential	63
R-13/M3	2	Residential	60
R-14	2	Residential	63
R-15	1	Residential	54

1. Receiver locations are shown on Figures 7 and 8
2. Number of structures in the immediate area predicted to have the same noise level
3. Receiver Land Use
4. Year 2005 peak-truck noise hourly noise levels in L_{eq} dBA

8. Traffic Noise Impact Analysis

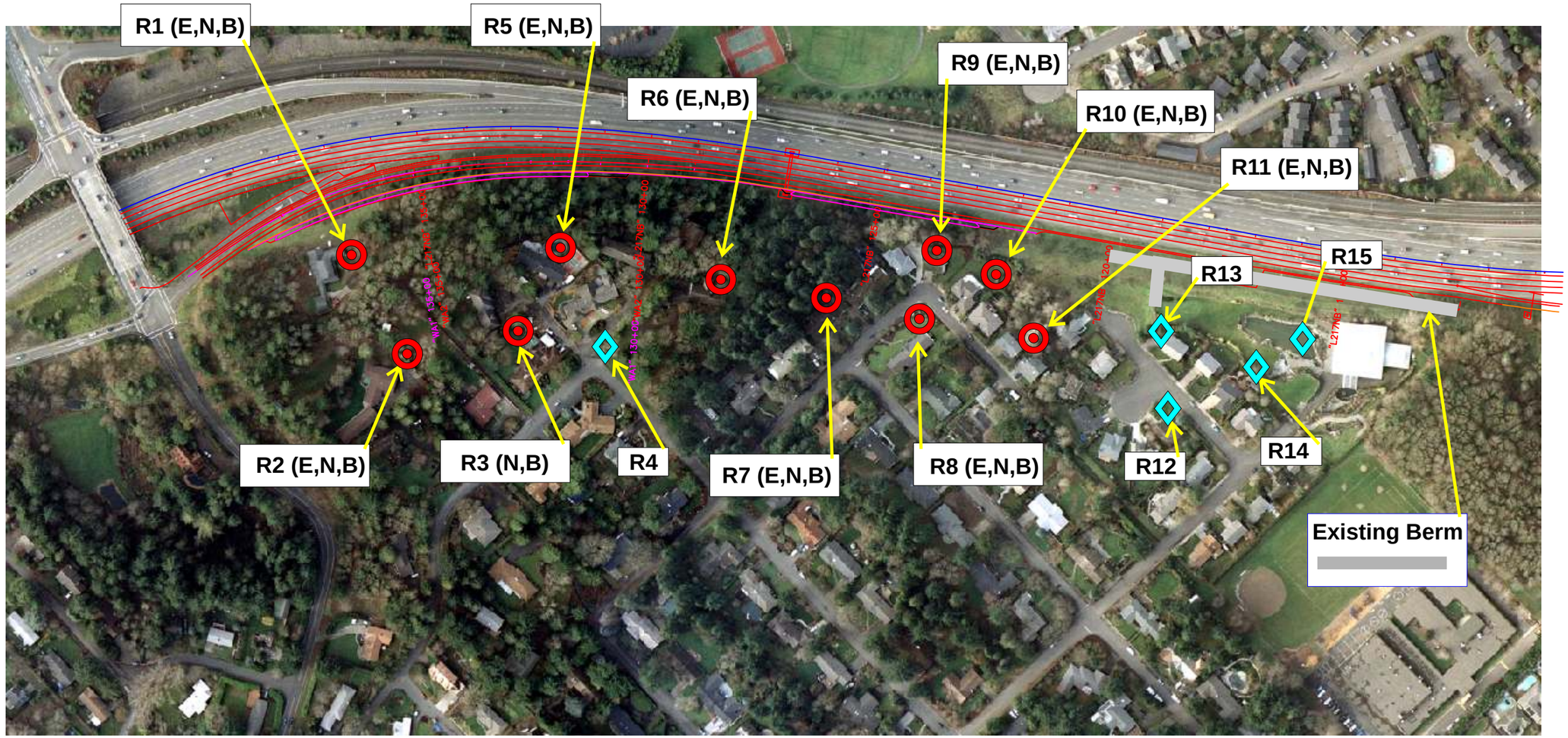
The modeled noise level data was used to determine which noise sensitive land use along the project corridor exceeds the ODOT criteria under the Existing, No-Build, and Build Alternatives. Under the existing conditions, there are 17 residential structures that are projected to exceed the ODOT traffic noise impact criteria. The number of traffic noise impacts increases to 19 under the No-Build and Build Alternatives. No noise impacts were identified for receivers R12 through R15 due to the berm along the west property line of Receiver R15. Receiver R4 also has noise levels below the criteria because of the distance from the highway and shielding of other residences in the area.

Table 7 provides a comparison of the Existing, No-Build, and Build noise levels with noise levels that exceed the criteria identified. Figure 4 provides an aerial view of the project corridor, proposed widening, and receivers with impacts identified.

Table 7: Noise Level Impact Summary and Comparison

Receiver Information[1]		Traffic Noise Criteria	Noise Levels in dBA L_{eq}			Change: *Existing to*	
			Existing[2]	No-Build[3]	Build[4]	No- Build[5]	Build[6]
R-1	Residential	65	**72**	**73**	**73**	1	1
R-2	Residential	65	**68**	**69**	**69**	1	1
R-3	Residential	65	63	**65**	**65**	2	2
R-4/M-1	Residential	65	58	59	60	1	2
R-5	Residential	65	**68**	**70**	**70**	2	2
R-6	Residential	65	**70**	**71**	**72**	1	2
R-7	Residential	65	**73**	**74**	**75**	1	2
R-8	Residential	65	**70**	**71**	**72**	1	2
R-9/M2	Residential	65	**76**	**77**	**78**	1	2
R-10	Residential	65	**72**	**73**	**73**	1	1
R-11	Residential	65	**65**	**67**	**67**	2	2
R-12	Residential	65	61	62	63	1	2
R-13/M3	Residential	65	59	60	60	1	1
R-14	Residential	65	62	63	63	1	1
R-15	Residential	65	51	53	54	2	3

Notes: Noise impacts are in **Bold-Red** typeface
1. Receivers shown on Figure 4
2. Existing peak-truck noise hourly noise levels in L_{eq} dBA
3. Future No-Build peak-truck noise hourly noise levels in L_{eq} dBA
4. Future Build Year 2025 peak-truck noise hourly noise levels in L_{eq} dBA
5. Change in noise level: Existing to No-Build
6. Change in noise level: Existing to Build



Noise Modeling Locations without Traffic Noise Impact

Noise Modeling Locations with Traffic Noise Impacts
(E = Existing Impact; N = No-Build Impact; B = Build Impact)

Michael Minor & Associates
Sound.Vibration.Air
Portland Oregon

0 125 250 500
1.00 in
Figured Scale 1 inch to 250 Feet @ 11x17

N

Figure 4
Project Area Noise Impacts
OR217: Sunset Hwy - Tualatin Valley Hwy

9. Evaluation of Noise Abatement Measures

In accordance with the ODOT Traffic Noise Manual, when traffic noise impacts are identified, noise abatement measures must be considered for those developments that existed prior to the date of public knowledge of the project. This includes identifying:

- Noise abatement measures which are reasonable and feasible and which are likely to be incorporated in the project.
- Noise impacts for which no apparent solution is available and an explanation of why noise abatement was not recommended.

9.1. Mitigation Options

Several different traffic noise abatement measures are evaluated whenever noise impacts are expected. These include traffic management measures, highway design measures, and noise barriers, including earthen berms. Any specific mitigation measure recommended as part of the project must be feasible and reasonable. Possible mitigation measures are given below.

Traffic Management Measures*:* Traffic management measures include modification of speed limits and restricting or prohibiting truck traffic. Restricting truck use on the project roadways would reduce noise levels at nearby receivers since trucks are louder than cars. However, displacing truck traffic from one roadway to another would only shift noise impacts from one area to another, and conflicts with the project objective.

Highway Design Measures*:* Highway design measures include altering the roadway alignment and depressing roadway cut sections. Alteration of roadway alignment could decrease noise levels by moving the noise source farther away from the affected receivers.

Noise Barriers: Construction of noise barriers between the roadways and the affected receivers would reduce noise levels by physically blocking the transmission of traffic-generated noise. Barriers can be constructed as walls or earthen berms. Earthen berms require more right-of-way than walls, and are usually constructed with a 3-to-1 slope.

9.1.1. Noise Barrier Basics

Several aspects of noise barrier design can help to assure that sufficient noise reduction characteristics (referred to as insertion loss) are achieved and that ODOT criteria are met. Noise barriers or berms should do more than break the line-of-sight between the noise source and the receiver. Noise barriers should be long enough to prevent significant flanking of noise around the ends of the walls. Openings in noise walls, such as for driveways and pedestrian access, can significantly reduce a barrier's insertion loss, making it ineffective at reducing noise.

Other items that can impact the overall effectiveness of noise barriers include the horizontal placement, topography between the receiver and the project corridor, and the elevation relationship between the receiver, noise barrier, and roadway. In general, noise barriers are most effective if placed close to the noise source, or close to the receiver location. In addition, if the sensitive receivers are located above the roadway grade, the overall effectiveness of the noise barrier can be significantly reduced unless it is placed at the same elevation as the receptor. Finally, noise barriers are normally most effective for receivers located close to the project corridor. For distances greater than 300 to 500 feet, the relative reduction of noise barriers will usually become negligible.

9.2. Cost of Noise Mitigation

For residential areas, all benefited residences must be considered in determining a noise barrier cost per residence. A benefited residence is any impacted or non-impacted residence that gets a reduction of 5 dBA or more. A reasonable cost will be a typical maximum of $25,000 per benefited residence. The typical maximum of $25,000 can be exceeded, but shall not be higher than $35,000 per residence. To exceed the $25,000 limit, one or more of the following conditions must occur:

1. Equity and fairness, if other noise abatement measures are present or proposed in the area
2. Logical termini for walls, close a gap between walls
3. Strong public support for mitigation
4. A noise increase of 10 dBA or more
5. High noise levels, Leq 70 dBA or higher
6. The residence was constructed prior to 1976

Due to the high noise levels modeled in this project corridor, this report assumes the ODOT maximum cost for noise abatement of $35,000 per receiver. Project noise mitigation measures evaluated are given in Section 9.3.

9.3. Project Noise Abatement Measures

Several different noise walls were considered for the impacted receivers along the project corridor. The one main limiting factor in designing noise walls for this area is the poorly constructed berm located along the eastern side of the highway in the northern end of the project study area. The location of the berm was noted on Figure 4. This berm was constructed by the resident represented by receiver R15. The berm is not considered stable, and disturbing the berm may cause a slide. In addition, project engineers would not consider constructing a noise barrier on, or near the berm due to the berms instability.

Therefore, with the limitations of the berm, three different noise walls were considered. Two different noise walls that run parallel to OR 217 were considered. Noise Wall One runs along the property line of the residences from the southern end of the berm to the Walker

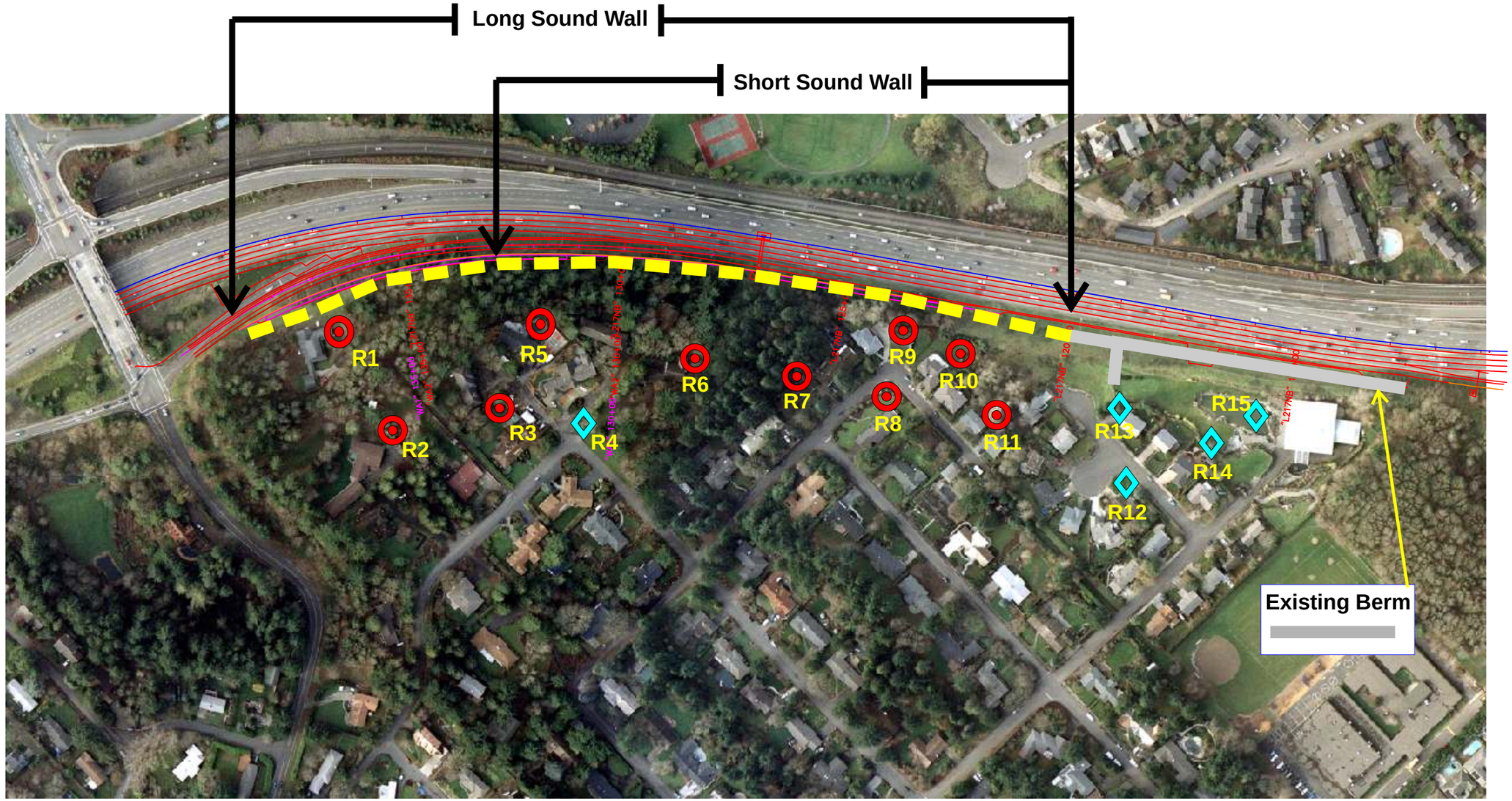
Road overpass. A second wall from the southern end of the berm to just south of receiver R5 was also considered. The noise walls are shown on Figure 5.

The full length noise wall was effective at reducing noise levels by 2 to 10 dBA L_{eq}. The noise wall also reduced the number of noise impacts from 19 to 12. The wall ranges from 10 to 22 feet in height and has a length of 1560 feet. At an estimated cost of $25.00 per square foot, the cost of the wall is estimated at $604,307. The noise wall provides a benefit of 5 dBA L_{eq} or greater for nine residences, and therefore has a cost per residence of $67,145, which exceeds the maximum cost criteria of $35,000 per receiver. Therefore, this wall was not recommended for construction.

By reducing the length of the wall and ending it near receiver R5, an attempt was made to provide a more cost effective solution to the noise impacts. The noise wall with the reduced length still required heights of 10 to 22 feet to provide sufficient noise reductions. The walls cost was estimated at $423,490. This wall benefited 8 residences at a cost of $52,936, which also exceeded the cost criteria.

Finally a curved wall was designed that wrapped around receivers R7 through R11. The location of this wall is shown on Figure 6. The height of this wall ranged from 14 to 22 feet and provided noise reductions of 2 to 11 dBA L_{eq} for the affected properties, benefiting 5 residences with 5 dBA noise reductions. The walls length was 500 feet and the estimated cost was $238,625. The cost per receiver was $47,725 or $12,725 per receiver over the maximum allowable expenditure for noise mitigation.

It should also be noted that none of the noise walls were effective at eliminating noise impacts at receivers R7 through R10. These four receivers represent 9 residences that, with any of the mitigation measures, would still have noise levels above the 65 dBA criteria. Future noise levels at these locations are projected to range from 66 to 71 dBA if noise walls were constructed. The high noise levels are due to the clear line-of-sight these residences have over the berm to the northern segment of OR 217.



Noise Modeling Locations without Traffic Noise Impact

Noise Modeling Locations with Traffic Noise Impacts

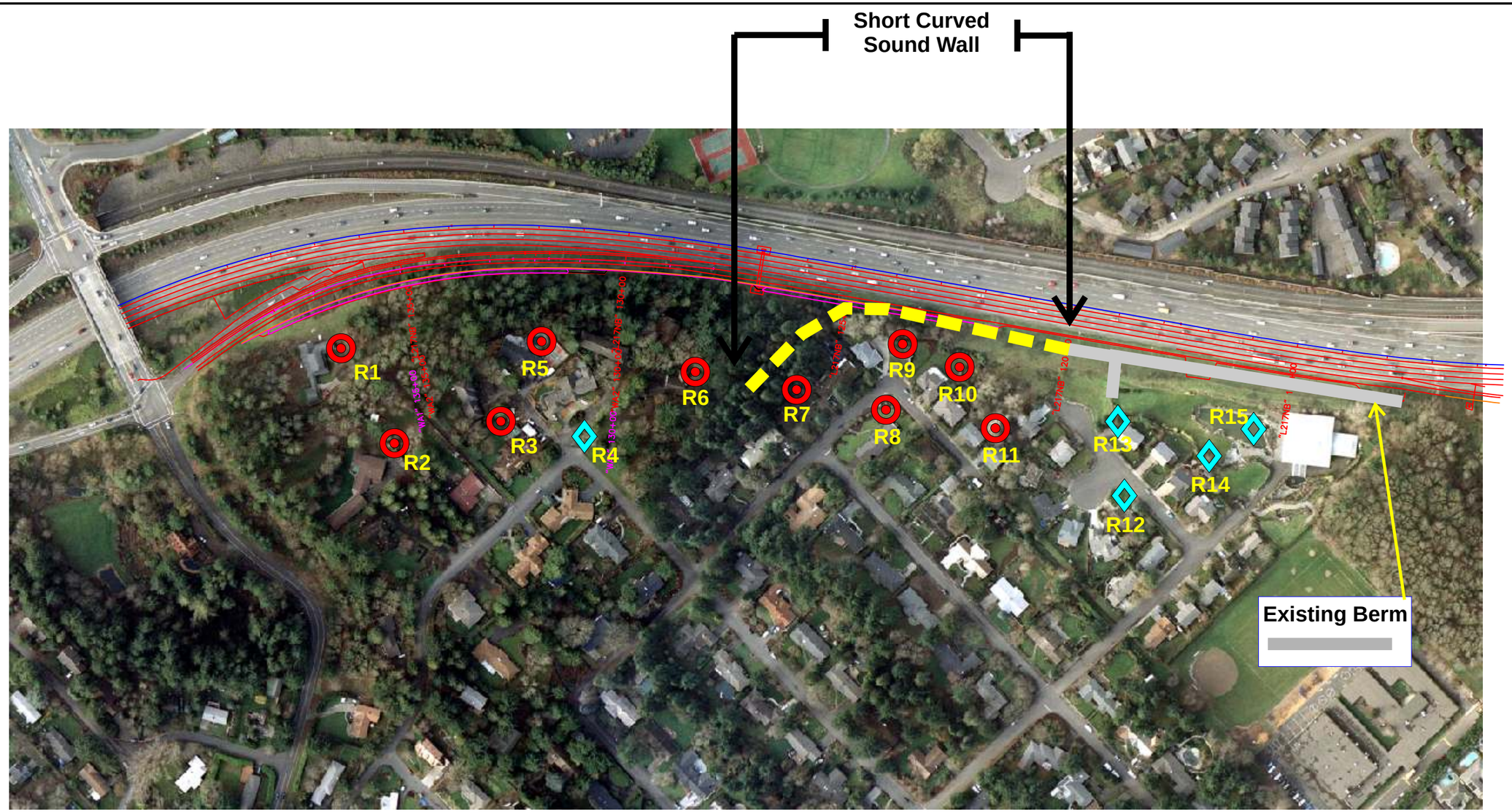
Michael Minor & Associates
Sound.Vibration.Air
Portland Oregon

0 125 250 500
1.00 in

Figured Scale 1 inch to 250 Feet @ 11x17

N

Figure 5
Parallel Noise Wall Alternatives
OR217: Sunset Hwy - Tualatin Valley Hwy



Noise Modeling Locations without Traffic Noise Impact

Noise Modeling Locations with Traffic Noise Impacts

Michael Minor & Associates
Sound.Vibration.Air
Portland Oregon

0 125 250 500
1.00 in

Figured Scale 1 inch to 250 Feet @ 11x17

N

Figure 6
Short Noise Wall Alternative
OR217: Sunset Hwy - Tualatin Valley Hwy

9.3.1. Residual Noise Impacts

Under the Build Alternative there are an estimated 19 residential locations in the project study are that are projected to exceed the traffic noise criteria. This is an increase of 2 over the current number of residences exceeding the criteria. Noise levels under the Build Alternative are projected to increase by 1 to 3 dBA L_{eq} over the current levels, with several homes projected to have noise levels in excess of 70 dBA L_{eq}.

Several attempts were made to design a noise wall that would be effective at reducing noise and also meet the maximum ODOT cost of $35,000 per receiver. All noise mitigation considered was rejected due to the low insertion loss of noise walls and / or due to cost of the mitigation significantly exceeding the ODOT maximum allowable cost for noise mitigation.

The existing berm along the western property line of R15 is too low to reduce noise at receivers R7 through R11, and due to its construction, it is not possible to construct a wall on top of the berm. Therefore, noise continues to flank over the berm, making all noise walls considered either ineffective or too expensive.

No noise mitigation was available that meets the criteria. Therefore, this report can not recommend that any mitigation measures be constructed as part of the project.

10. Construction Noise Analysis

This section provides general information on project construction and potential construction noise impacts.

10.1. Construction Noise Levels

Noise would be generated by heavy equipment used during major construction periods under the Build Alternative. Major noise producing equipment used at this construction site could include, concrete pumps, cranes, excavator, haul trucks, loader, tractor trailers and general supporting equipment. Maximum noise levels could reach up to 80 dBA at the nearest receivers along the project work area. Other noise producing equipment expected during this phase include backhoe, air compressors, fork lifts, pumps, power plants, service trucks and utility trucks. Potential worst case noise levels are given in Table 8.

Paving of the highway would be a major noise source. Noise levels during paving are projected at 80 to 86 dBA at 100 feet from the activity. Noise from haul trucks is projected to range from 78 to 82 dBA at 100 feet during normal pass-bys while removing debris from the site and during paving operations.

Following the heavy construction, general construction such as installation of bridge railing, signage, roadway striping and other general activities would still need to occur. These less

intensive activities are not expected to produce noise levels above 80 dBA except during rare occasions, and even then, only for short periods.

Table 8: Construction Noise Levels
(Combined worst-case noise levels for all equipment at 50 feet from work site)

Scenario[1]	Equipment[2]	Lm[3]	L_{eq}[4]
Preparation for construction and initial staging	Air compressors, backhoe, fork lifts, haul trucks, loader, pumps, power plants, service trucks, tractor trailers, utility trucks	93	86
Roadway grinding, paving and general structural improvements	Air compressors, backhoe, cement mixers, concrete pumps, crane, fork lifts, haul trucks, jack hammers, loader, pavement grinder and paver, pumps, power plants, service trucks, tractor trailers, utility trucks, vibratory equipment, welders	95	89
Miscellaneous activities, including striping, lighting and signs	Air compressors, backhoe, crane, fork lifts, haul trucks, loader, pumps, service trucks, tractor trailers, utility trucks, welders	91	83

1. Operational conditions under which the noise levels are projected
2. Normal equipment in operation under the given scenario
3. Lm (dBA) is an average maximum noise emission for the construction equipment under the given scenario. For this type of equipment and activities, the Lm is approximately equal to the L_{01}
4. L_{eq} (dBA) is an energy average noise emission for construction equipment operating under the given scenario. For this type of equipment, the L_{eq} is approximately equal to the L_{50}

10.2. Construction Mitigation Measures

Several construction noise abatement methods can be implemented to limit the noise levels at the nearby noise sensitive land uses. The following is a list of mitigation measures that could be used to reduce construction related noise levels.

Several construction noise abatement methods, including operational methods, equipment choice or acoustical treatments, can be implemented to limit the impacts. Operation of construction equipment can be limited within 500 ft. of any occupied dwelling unit at night (10 P.M. to 7 A.M.) or on Sundays or legal holidays, when noise and vibration would have the most severe effect. All engine-powered equipment would be required to have mufflers installed according to the manufacturer's specifications and all equipment would be required to comply with pertinent equipment noise standards of the U.S. Environmental Protection Agency.

The State of Oregon could limit construction activities that produce the highest noise levels, such as concrete breaking, hauling, loading spoils, jack hammering and the use of other noisy demolition equipment to daytime hours of 7:00 A.M. to 7:00 P.M.

The following is a list of recommended noise mitigation measures that should be contained in the contract specifications:

- All engine-powered equipment should be required to have mufflers installed according to the manufacturer's specifications.
- All equipment should be required to comply with pertinent equipment noise standards of the U.S. Environmental Protection Agency.
- Limit jackhammers, concrete breakers, saws, and other forms of demolition to daytime hours.
- Noise may be minimized by regular inspection and replacement of defective mufflers and parts that do not meet the manufacturer’s specifications.
- Install temporary or portable acoustic barriers around stationary construction noise sources.
- Locate stationary construction equipment as far from nearby noise-sensitive properties as possible.
- Shut off idling equipment.
- Notify nearby residents whenever extremely noisy work will be occurring.
- Restrict the use of back-up beepers during evening and nighttime hours.

Appendix A

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Appendix B

Introduction to Acoustics

Sound is defined as any pressure variation that the human ear can detect, from barely perceptible sounds to sound levels that can cause hearing damage. The magnitude of the variations of the air pressure from the static—or normal—air pressure is a measure of the sound level. The number of cyclic pressure variations per second is the frequency of sound. When sounds are unpleasant, unwanted, or disturbingly loud, we tend to classify them as noise.

Compared with the static air pressure, the audible sound pressure variations range from the threshold of hearing—a very small 20 μPa (20 x 10^{-6} Pascal)—to 100 Pa, a level so loud it is referred to as the threshold of pain. Because the ratio between these numbers is more than a million to one, using Pascal to describe sound levels can be awkward. The "dB" measurement is a logarithmic conversion of air pressure level variations from Pascal to a unit of measure with a more convenient numbering system. This conversion not only allows for a more convenient scale, but is also a more accurate representation of how the human ear reacts to variations in air pressure. Measurements made using the decibel scale will be denoted dB.

The smallest noise level change that can be detected by the human ear is approximately 3 dB. A doubling in the static air pressure amounts to a change of 6 dB, and an increase of 10 dB is roughly equivalent to a doubling in the perceived sound level. Under free-field conditions, where there are no reflections or additional attenuation, sound is known to decrease at a rate of 6 dB for each doubling of distance. This is commonly known as the inverse square law. For example, a sound level of 70 dB at a distance of 100 feet would decrease to 64 dB at 200 feet, or 58 dB at 400 feet. The mathematical definition of sound pressure level in dB is listed below.

- **L_p (sound pressure level).** The sound pressure in dB is 20 times the log of the ratio of the measured pressure, p, to the static pressure, p_o, where p_o is 20 μPa.

$$L_{pa} = 20Log_{10}\left(\frac{p}{p_o}\right)dB \quad (re\ 20\mu Pa)$$

In acoustic measurements where the primary concern is the effect on humans, the sound readings are sometimes compensated by an "A"-weighted filter. The A-weighted filter accounts for people's limited hearing response in the upper and lower frequency bands. Sound pressure level measurements made using the A-weighted filter are denoted dBA. For short-term and impulsive noises, such as surface blasting, a C-weighted filter is normally used. The C-weighted filter helps to account for the short time period and frequency of impulsive noises.

General Measurement Descriptors

- **L_{eq} (equivalent continuous sound level).** The constant sound level in dBA that, lasting for a time "T," would have produced the same energy in the same time period "T" as an actual A-weighted noise event.

$$L_{eq} = 20Log_{10}\frac{1}{T}\int_{T}^{0}\left(\frac{p(t)}{p_o}\right)^2 dt$$

- **MaxPeak (maximum A-weighted sound level).** The greatest continuous sound level, in dBA, measured during the preset measurement period.

- **L_{max} (maximum A-weighted RMS sound level).** The greatest RMS (root-mean square) sound level, in dBA, measured during the preset measurement period.

- **L_{min} (minimum A-weighted RMS sound level).** The lowest RMS (root-mean square) sound level, in dBA, measured during the preset measurement period.

Community Noise Level Descriptors

The following sound level descriptors are commonly used in community noise measurements:

- **L_{dn} (day-night average sound level).** A 24-hour equivalent continuous level in dBA where 10 dB is added to nighttime noise levels from the hours of 10:00 p.m. to 7:00 a.m.

- **CNEL (community noise equivalent level)**. A 24-hour equivalent continuous level in dBA where 5 dBA is added to evening noise levels from 7:00 p.m. to 10:00 p.m. and 10 dBA is added to nighttime noise levels from 10:00 p.m. to 7:00 a.m.

- **SEL (sound exposure level)**. That constant level in dBA that, lasting for 1 second, has the same amount of acoustic energy as a given A-weighted noise event lasting for a period of time T. This measurement is most commonly used for airport noise.

Statistical Noise Level Descriptors

Public response to sound depends greatly upon the range that the sound varies in a given environment. For example, people generally find a moderately high, constant sound level more tolerable than a quiet background level interrupted by high-level noise intrusions. In light of this subjective response, it is often useful to look at a statistical distribution of sound levels over a given time period. Such distributions identify the sound level exceeded and the percentage of time exceeded; therefore, it allows for a more complete description of the range of sound levels during the given measurement period.

The sound level descriptor L_{xx} is defined as the sound level exceeded XX percent of the time. Some of the more common versions of this descriptor and their corresponding definitions are listed below:

- L_{01} The sound level is exceeded 1 percent of the time. This is a measure of the loudest sound levels during the measurement period. Example: During a 1-hour measurement, an L_{01} of 95 dBA means the sound level was at or above 95 dBA for 36 seconds.

- L_{10} The sound level is exceeded 10 percent of the time. This is a measure of the louder sound levels during the measurement period. Example: During a 1-hour measurement, an L_{10} of 85 dBA means the sound level was at or above 85 dBA for 6 minutes.

- L_{50} The sound level is exceeded 50 percent of the time. This level corresponds to the median sound level. Example: During a 1-hour measurement, an L_{50} of 67 dBA means the sound level was at or above 67 dBA for 30 minutes.

- L_{90} The sound level is exceeded 90 percent of the time. This is a measure of the nominal background level. Example: During a 1-hour measurement, an L_{90} of 50 dBA means the sound level was at or above 50 dBA for 54 minutes.

- L_{99} The sound level is exceeded 99 percent of the time. This is the quietest or minimum level during the measurement period. Example: During a 1-hour measurement, an L_{99} of 42 dBA means the sound level was at or above 42 dBA for 59 minutes and 24 seconds.

Other commonly used L_{XX} values include $L_{2.5}$, $L_{8.3}$, and L_{25}. These correspond to the 5-, 10-, and 15-minute time levels for a 1-hour measurement period, respectively.

Sound Propagation Characteristics

Several factors determine how sound levels reduce over distance. Under ideal conditions, a point noise source in free space will attenuate at a rate of 6 dB each time the distance from the source doubles (using the inverse square law). An ideal line source (such as constant flowing traffic on a busy highway) reduces at a rate of approximately 3 dB each time the distance doubles. Under real-life conditions however, interactions of the sound waves with the ground often results in attenuation that is slightly higher than the *ideal* reduction factors given above. Other factors that affect the attenuation of sound with distance include existing structures, topography, foliage, ground cover, and atmospheric conditions such as wind, temperature, and relative humidity. The following list provides some general information on the potential affects each of these factors may have on sound propagation.

- **Existing Structures.** Existing structures can have a substantial effect on noise levels in any given area. Structures can reduce noise by physically blocking the sound transmission and, under special circumstances, may cause an increase in noise levels if the sound is reflected off the structure and transmitted to a nearby receiver location. Measurements have shown that a single-story house has the potential, through shielding, to reduce noise levels by as much as 10 dB or greater. The actual noise reduction will depend greatly on the geometry of the noise source, receiver, and location of the structure. Increases in noise caused by reflection are normally 3 dB or less, which is the minimum change in noise levels that can be noticed by the human ear.

- **Topography**. Topography includes existing hills, berms, and other surface features between the noise source and receiver location. As with structures, topography has the potential to reduce or increase sound depending on the geometry of the area. Hills and berms when placed between the noise source and receiver can have a significant effect on noise levels. In many situations, berms are used as noise mitigation by physically blocking the noise source from the receiver location. In some locations, however, the topography can result in an overall increase in sound levels by either reflecting or channeling the noise towards a sensitive receiver location.

- **Foliage.** Foliage, if dense, can provide slight reductions in noise levels. FHWA provides for up to a 5 dBA reduction in traffic noise for locations with at least 30 feet of dense evergreen foliage. Because foliage varies in the project area, no reduction for foliage will be used in the analysis.

- **Ground Cover.** The ground cover between the receiver and the noise source can have a significant effect on noise transmission. For example, sound will travel very well across reflective surfaces such as water and pavement, but can be attenuated when the ground cover is field grass, lawns, or even loose soil. During the environmental impact statement (EIS) phase of the project, detailed information related to sound transmission

in the project area will be compiled through a combination of on-site monitoring, noise modeling, and published information. This information will be used during the final noise modeling to account for the varying ground conditions in the project area.

- **Atmospheric Conditions**. Atmospheric conditions that can have an effect on the transmission of noise include wind, temperature, humidity and precipitation. Wind can increase sound levels if it is blowing from the noise source to the receiver; conversely, it can reduce noise levels if blowing in the opposite direction. Noise propagation can also be significantly affected when the temperature gradient is such that an inversion is formed. Other atmospheric conditions, such as humidity and precipitation are rarely severe enough to result in significant changes in noise level propagation.

Typical Sound Levels

Two figures are included as sound level reference material. Figure B-1 contains some common noise sources, their nominal maximum sound level in dBA, and the usual public response. The levels in this graph are comparable to the L_{max} noise level descriptor. This graph would be useful when comparing the loudest noise produced with other familiar noise sources a person may have experienced.

Figure B-1: Typical Maximum Sound Levels

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (human judgment of different sound levels)
Jet aircraft takeoff from carrier (50 feet)	140	Threshold of pain	64 times as loud
50-horse power siren (100 feet)	130		32 times as loud
Loud rock concert near stage, Jet takeoff (200 feet)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 feet)	110		8 times as loud
Jet takeoff (2,000 feet)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 feet)	90		2 times as loud
Garbage disposal, food blender (2 feet), Pneumatic drill (50 feet)	80	Moderately loud	Reference loudness
Vacuum cleaner (10 feet), Passenger car at 65 mph (25 feet)	70		1/2 as loud
Large store air-conditioning unit (20 feet)	60		1/4 as loud
Light auto traffic (100 feet)	50	Quiet	1/8 as loud
Bedroom or quiet living room Bird calls	40		1/16 as loud
Quiet library, soft whisper (15 feet)	30	Very quiet	
High quality recording studio	20		
Acoustic Test Chamber	10	Just audible	
	0	Threshold of hearing	

Sources: Beranek (1988) and U.S. EPA (1971).

Appendix C

Traffic Data for Noise Analysis

Figure C-1 and the following two tables provide the traffic volumes, speed and vehicle mixture used for this analysis.

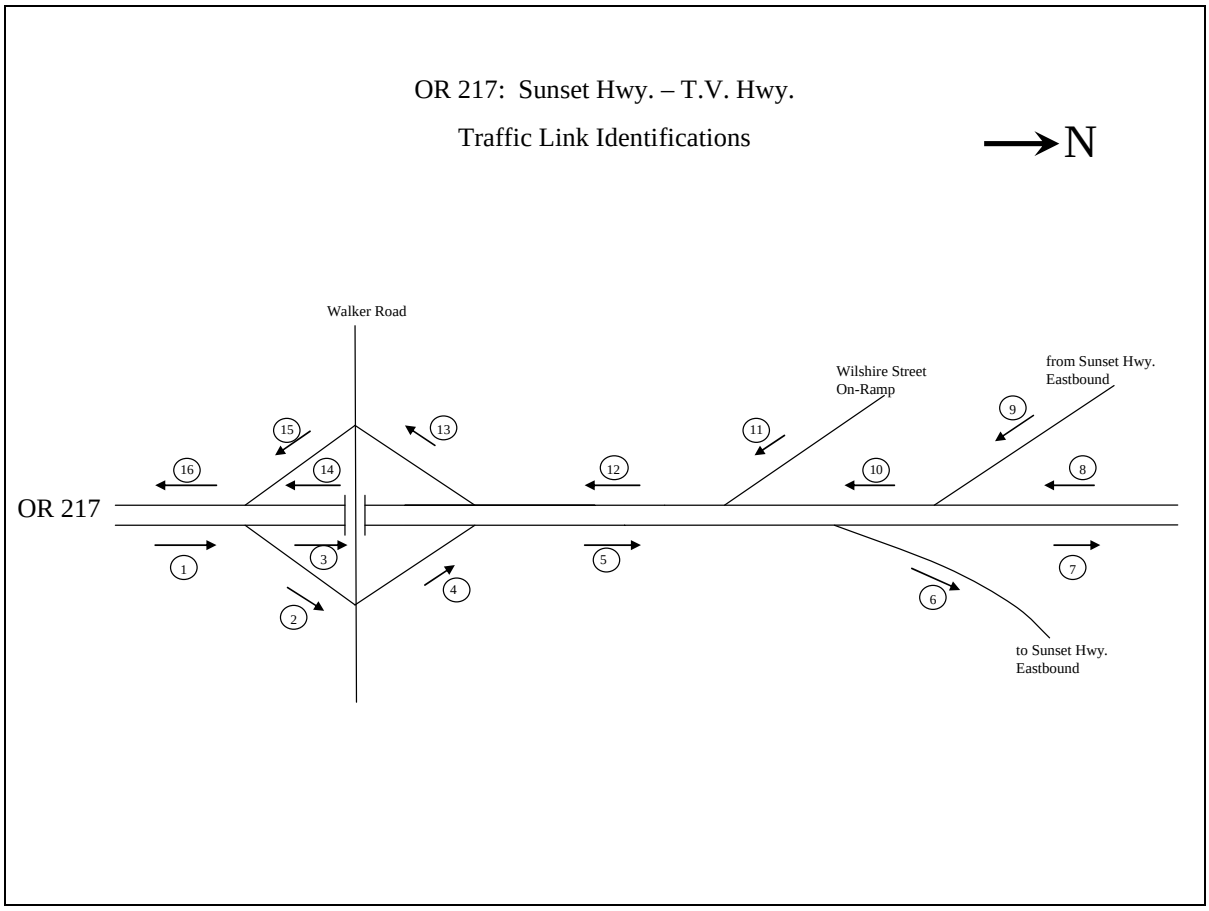

Figure C-1

REGION 1 TRAFFIC ANALYSIS UNIT
EIS TRAFFIC DATA

PROJECT: OR 217: Sunset Hwy. - T.V. Hwy.
LOCATION: Beaverton
ALTERNATIVE: 2005 and 2025 No-Build

PRINTING DATE: February 17, 2006
UNIT: English

SECT	DIST (mile)	YEAR	POSTED SPEED	VOL	AUTO	MTR	HTR	SP	PEAK TRUCK HOUR VOL	AUTO	MTR	HTR	SP
OR 217 NB (North of TV Hwy On-ramp)													
1	0.16	2005	55	4050	3985	20	45	55	4050	3751	121	178	55
1	0.16	2025	55	5630	5540	28	62	44	5620	5204	169	247	44
Walker Road NB Off-ramp													
2	0.16	2005	45	780	767	4	9	44	780	723	23	34	44
2	0.16	2025	45	1160	1141	6	13	35	1160	1074	35	51	35
OR 217 NB (Walker Off - Walker On)													
3	0.41	2005	55	3270	3218	16	36	52	3270	3028	98	144	52
3	0.41	2025	55	4470	4399	22	49	25	4470	4139	134	197	25
Walker Road NB On-ramp													
4	0.22	2005	55	330	324	2	4	55	330	305	10	15	55
4	0.22	2025	55	630	620	3	7	54	630	583	19	28	54
OR 217 NB (Walker On - Sunset EB Off)													
5	0.38	2005	55	3600	3542	18	40	55	3600	3334	108	158	55
5	0.38	2025	55	5100	5018	26	56	52	5090	4713	153	224	52
Off-ramp (OR 217 NB - Sunset EB)													
6	0.18	2005	55	950	935	5	10	55	950	880	28	42	55
6	0.18	2025	55	950	935	5	10	55	950	880	28	42	55
OR 217 NB (Sunset EB Off - Barnes Off)													
7	0.35	2005	55	2650	2608	13	29	55	2650	2454	79	117	55
7	0.35	2025	55	4150	4083	21	46	30	4150	3843	124	183	30
OR 217 SB (Sunset WB On - Sunset EB On)													
8	0.35	2005	55	2460	2418	22	20	55	1900	1785	48	67	55
8	0.35	2025	55	3400	3342	31	27	52	2630	2472	66	92	55

ABBREVIATION: SECT = SECTION NUMBER
VOL = TOTAL VOLUME
MTR = MEDIUM TRUCK VOLUME
SP = SPEED OF VEHICLE
AUTO = AUTOMOBILE VOLUME
HTR = HEAVY TRUCK VOLUME

ANALYST: CHI MAI
CHECKED BY: SIMON ENG
FILE: OR217 Sunset to TV EIS.xls

REGION 1 TRAFFIC ANALYSIS UNIT
EIS TRAFFIC DATA

PROJECT: OR 217: Sunset Hwy. - T.V. Hwy.
LOCATION: Beaverton
ALTERNATIVE: 2005 and 2025 No-Build

PRINTING DATE: February 17, 2006
UNIT: English

	DIST		POSTED	PEAK HOUR					PEAK TRUCK HOUR				
SECT	(mile)	YEAR	SPEED	VOL	AUTO	MTR	HTR	SP	VOL	AUTO	MTR	HTR	SP
On-ramp (Sunset EB - OR 217 SB)													
9	0.23	2005	55	1350	1327	12	11	55	1040	978	26	36	55
9	0.23	2025	55	1560	1534	14	12	55	1210	1138	30	42	55
OR 217 SB (Sunset EB On - Wilshire On)													
10	0.24	2005	55	3810	3746	34	30	55	2950	2773	74	103	55
10	0.24	2025	55	4960	4875	45	40	52	3830	3600	96	134	55
Wilshire SB On-ramp													
11	0.23	2005	55	240	236	2	2	55	190	178	5	7	55
11	0.23	2025	55	400	393	4	3	55	310	291	8	11	55
OR 217 SB (Wilshire On - Walker Off)													
12	0.3	2005	55	4050	3982	36	32	55	3130	2942	78	110	55
12	0.3	2025	55	5360	5269	48	43	51	4140	3891	104	145	55
Walker SB Off-ramp													
13	0.18	2005	45	450	442	4	4	45	350	329	9	12	45
13	0.18	2025	45	630	619	6	5	45	490	461	12	17	45
OR 217 SB (Walker Off - Walker On)													
14	0.36	2005	55	3600	3539	32	29	55	2780	2613	70	97	55
14	0.36	2025	55	4730	4649	43	38	53	3660	3440	92	128	55
Walker SB On-ramp													
15	0.17	2005	55	710	698	6	6	53	550	517	14	19	55
15	0.17	2025	55	1400	1376	13	11	30	1080	1015	27	38	35
OR 217 SB (Walker On - TV Hwy Off)													
16	0.24	2005	55	4310	4237	39	34	54	3330	3130	83	117	55
16	0.24	2025	55	6130	6026	55	49	35	4740	4455	119	166	53

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3	0.41	2005	55	3270	3218	16	36	55	3270	3028	98	144	55
3	0.41	2025	55	4470	4399	22	49	54	4470	4139	134	197	54
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4	0.22	2005	55	330	324	2	4	55	330	305	10	15	55
4	0.22	2025	55	630	620	3	7	54	630	583	19	28	54
OR 217 NB (Walker On - Sunset EB Off)													
5	0.38	2005	55	3600	3542	18	40	55	3600	3334	108	158	55
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Off-ramp (OR 217 NB - Sunset EB)													
6	0.18	2005	55	950	935	5	10	55	950	880	28	42	55
6	0.18	2025	55	950	935	5	10	55	950	880	28	42	55
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8	0.35	2005	55	2460	2418	22	20	55	1900	1785	48	67	55
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PRINTING DATE: February 17, 2006
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	DIST		POSTED	PEAK HOUR					PEAK TRUCK HOUR				
SECT	(mile)	YEAR	SPEED	VOL	AUTO	MTR	HTR	SP	VOL	AUTO	MTR	HTR	SP
On-ramp (Sunset EB - OR 217 SB)													
9	0.23	2005	55	1350	1327	12	11	55	1040	978	26	36	55
9	0.23	2025	55	1560	1534	14	12	55	1210	1138	30	42	55
OR 217 SB (Sunset EB On - Wilshire On)													
10	0.24	2005	55	3810	3746	34	30	55	2950	2773	74	103	55
10	0.24	2025	55	4960	4875	45	40	52	3830	3600	96	134	55
Wilshire SB On-ramp													
11	0.23	2005	55	240	236	2	2	55	190	178	5	7	55
11	0.23	2025	55	400	393	4	3	55	310	291	8	11	55
OR 217 SB (Wilshire On - Walker Off)													
12	0.3	2005	55	4050	3982	36	32	55	3130	2942	78	110	55
12	0.3	2025	55	5360	5269	48	43	51	4140	3891	104	145	55
Walker SB Off-ramp													
13	0.18	2005	45	450	442	4	4	45	350	329	9	12	45
13	0.18	2025	45	630	619	6	5	45	490	461	12	17	45
OR 217 SB (Walker Off - Walker On)													
14	0.36	2005	55	3600	3539	32	29	55	2780	2613	70	97	55
14	0.36	2025	55	4730	4649	43	38	53	3660	3440	92	128	55
Walker SB On-ramp													
15	0.17	2005	55	710	698	6	6	53	550	517	14	19	55
15	0.17	2025	55	1400	1376	13	11	30	1080	1015	27	38	35
OR 217 SB (Walker On - TV Hwy Off)													
16	0.24	2005	55	4310	4237	39	34	54	3330	3130	83	117	55
16	0.24	2025	55	6130	6026	55	49	35	4740	4455	119	166	53

ABBREVIATION:
SECT = SECTION NUMBER
VOL = TOTAL VOLUME
MTR = MEDIUM TRUCK VOLUME
SP = SPEED OF VEHICLE
AUTO = AUTOMOBILE VOLUME
HTR = HEAVY TRUCK VOLUME

ANALYST: CHI MAI
CHECKED BY: SIMON ENG
FILE: OR217 Sunset to TV EIS.xls