Interstate Route H-1
Noise Study

Vicinity of Aiea Heights Drive Overpass to Kaimakani Street Overpass

Project No. HWY-L-05-06

Prepared for

State of Hawaii
Department of Transportation
Highways Division

Prepared by

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Executive Summary

This report was prepared for the Highways Division of the State of Hawaii, Department of Transportation (HDOT) by Earth Tech under Contract No. HWY-DS-EN01-2004, under Purchase Order No. 40050070. The objective of the contract was to provide the technical recommendations and requirements for the abatement of the traffic noise from the Interstate H-1 Freeway that is impacting the residential neighborhood southwest of the freeway between Aiea Heights Drive and Kaimakani Street.

The recommendations in this report are based strictly on the technical considerations for the abatement of traffic noise from the H-1 freeway. Community input was not solicited and issues such as obstruction of view and unsightly structure on the landscape are not addressed, as this type of work was not part of Earth Tech's contract. The HDOT does not have policies for the abatement of traffic noise along existing roadways where there are no proposed construction to add vehicle capacity or to change the roadway alignment. The allowable cost of the noise barriers were determined from the HDOT noise abatement policies applicable to projects which construct a new roadway, construct additional through lanes, or significantly change the horizontal or vertical alignment of an existing roadway, as noted below.

Existing noise levels for the subject study area currently exceed the U.S. Federal Highway Administration (FHWA) and Hawaii State Department of Transportation (HDOT) noise abatement criteria of 66 Leq for Activity Category B applicable to existing residences (See Appendix A, Table 1). A noise attenuating wall is recommended as the best solution to reducing noise levels since this method appears to be most reasonable solution and has been used previously in the past by HDOT. Concrete masonry units (cmu) is proposed for use as the wall material since it is historically one of the most cost effective methods of construction and commonly used by the HDOT in construction of noise attenuating walls. Two alternative alignments were evaluated as possible locations for the noise attenuating wall. The "guardrail" alignment which would replace the existing guardrail adjacent to the freeway shoulder and along the existing top of slope, or the "right-of-way" alignment which would replace the existing chain link fence at the State right-of-way adjacent to Laka Street and along the existing toe of slope.

Construction cost estimates were generated for various design criteria categories along each of the two alternative alignments. Design criteria categories for noise abatement included in this study are as follows:

Guardrail Alignment

Design Criteria Categories	Reference	Wall Height Range	Allowable Cost	Estimated Cost
5 dBA improvement for first floor receptors	Wall A	7.0 to 8.0 feet	$805,000	$738,707
5 dBA improvement to second floor receptors	Wall C	8.0 to 9.0 feet	$805,000	$795,819
Reduce noise levels below 66 Leg for first floor receptors	Wall A (66Leq)	8.0 to 12.0 feet	$945,000	$835,428

Reduce noise levels below 66 Leg for second floor receptors	Wall C (66Leq)	8.0 to 13.0 feet	$945,000	$887,037

"Allowable Cost" based upon $35,000 per benefited resident per HDOT noise abatement policies, dated June 1997, applicable to projects which construct a new roadway, construct additional through lanes, or significantly change the horizontal or vertical alignment of an existing roadway

Right-of-Way Alignment

Design Criteria Categories	Reference	Wall Height Range	Allowable Cost	Estimated Cost
5 dBA improvement for first floor receptors	Wall B	8.0 to 13.0 feet	$700,000	$901,596
5 dBA improvement to second floor receptors	Wall D	8.0 to 16.0 feet	$980,000	$961,883
Reduce noise levels below 66 Leg for first floor receptors	Wall B (66Leq)	8.0 to 16.0 feet	$840,000	$991,448
Reduce noise levels below 66 Leg for second floor receptors	Wall D (66Leq)	8.0 to 20.0 feet	$980,000	$1,105,813

"Allowable Cost" base on $35,000 per benefited resident per HDOT noise abatement policies, dated June 1997, applicable to projects which construct a new roadway, construct additional through lanes, or significantly change the horizontal or vertical alignment of an existing roadway

Construction cost estimates for all design criteria categories for the "guardrail" alignment were below the $35,000 per benefited residence State guideline. The lower construction cost estimates, as compared to the "right-of-way" alignment, are primarily due to the lower wall heights required to shield traffic noise from the study area and the use of of vertical wall footings along the top of slope. The "guardrail' alignment is within the State right-of-way and would not require any land acquisition to extend the right-of-way for wall construction. Since the lateral wall clearance from the edge of traveled way is less than 15 feet as recommended by State of California, Department of Transportation (Caltrans), design should incorporate a "safety shaped" concrete barrier at the base of the wall, the cost of which is included in the construction cost estimates for the guardrail alignment.

Except for Wall D, construction cost estimates for design criteria categories for the "right-of-way" alignment exceeded the $35,000 per benefited residence guideline. The higher construction cost estimates, as compared to the "guardrail" alignment, are primarily due to the lower ground elevation at the toe of slope, subsequent higher wall heights and proposed use of drilled cassions to prevent the wall alignment from extending beyond the existing State right-of-way. The maximum wall height for Wall D (66 Leq) of 20 feet exceeds the maximum wall height of 16 feet (for walls located greater than 15 feet from the traveled way) as recommended by Caltrans.

1.0 Project Location and Purpose

The project study area encompasses the residential neighborhood located immediately southwest of the Interstate Route H-1 freeway between the Aiea Heights Drive Overpass and the Kaimakani Street Overpass (See Figure 1). Noise measurements were taken over an area from the freeway right-of-way up to 350 feet west of the right-of-way along the streets of Laka Place, Puakala Street, Kulina Street, Poopaa Place and Eke Place which are under the jurisdiction of the City and County of Honolulu.

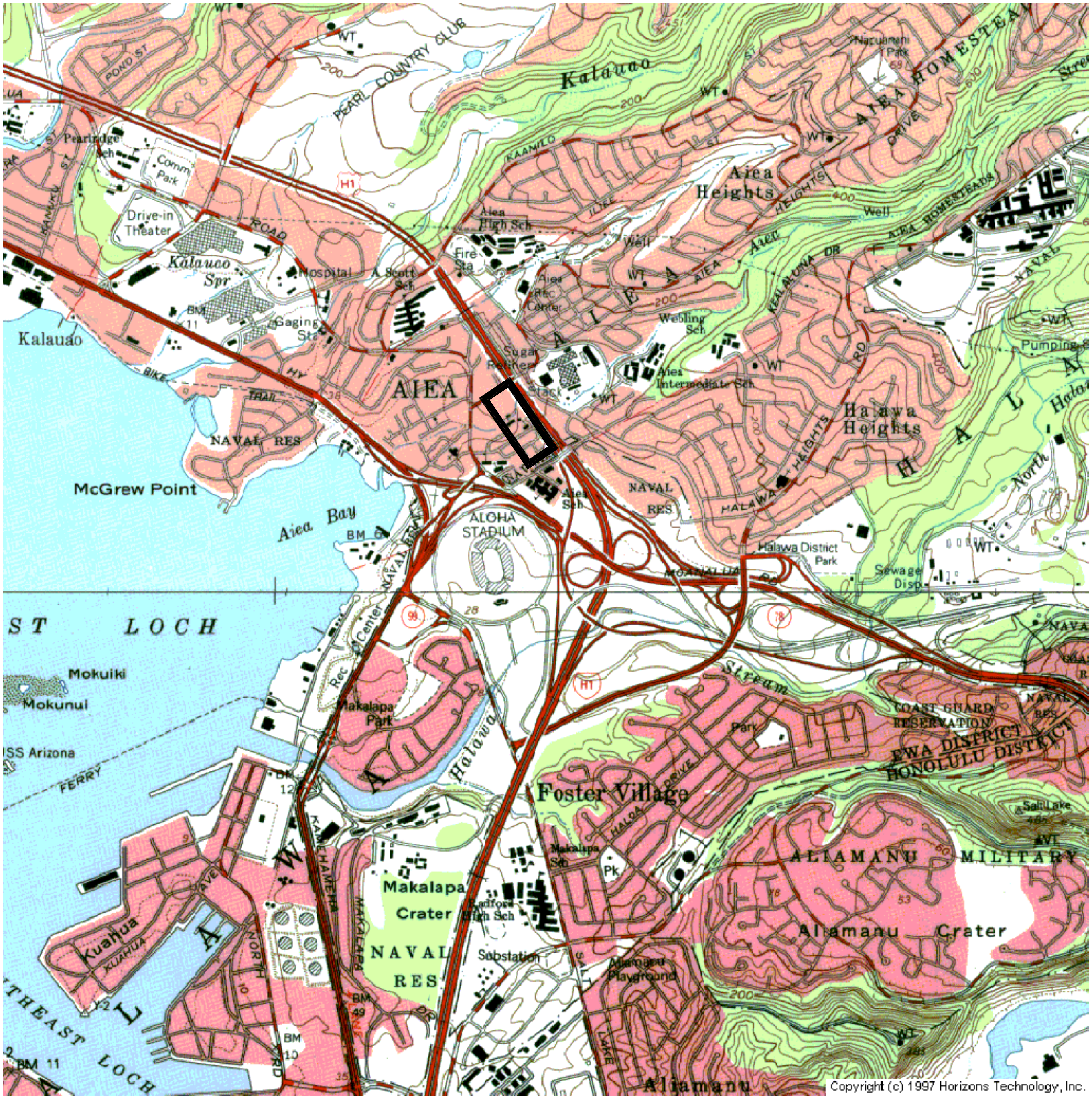
The purpose of this study is to measure the noise levels over the subject area where noise levels are suspected to exceed the State of Hawaii, Department of Transportation (HDOT) noise abatement criteria of 66 Leq and identify improvements that will reduce noise to acceptable levels. The following tasks are included in this study:

- Measure existing noise levels at various locations and times
- Model noise levels relative to terrain, ground cover, topography and shielding
- Propose noise abatement measures (noise attenuating walls)
- Propose alternative alignments for wall locations
- Determine minimum wall heights to meet 5 dBA noise reduction and 66 Leq maximum noise level criteria
- Provide construction cost estimates for the various wall heights and alternate alignments
- Evaluate construction cost estimates relative to the State's "Noise Analysis and Abatement Policy" criteria of a maximum construction cost of $35,000 per "benefited" resident
- Provide estimated design cost and time duration for design and construction

2.0 Existing Site Condition

The study area is primarily residential with one and two-story single family homes. The Aiea Shopping Center is located to the north of the study area at south side of Aiea Heights Drive. Non-residential facilities within the study area include the Aiea Hongwanji Mission Temple which also serves as facilities for the Lotus Adult Day Care Center located at the corner of Puakala Street and Laka Place. The Hongwanji Mission Preschool is located immediately west of the temple site, along Puakala Street.

The elevation along Laka Place which runs parallel to the freeway varies from between 2.5 to 12.0 feet below the freeway's west edge of pavement. The elevations increase towards the south end of the study area, to where the end of Poopaa Place is approximately 13.0 feet higher than the freeway grade.



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SCALE: 1"=2000'

FIGURE 1
LOCATION MAP

A typical cross section along the segment of Laka Place is shown on Figure 2. An existing guardrail runs along the edge of the west shoulder of the freeway. Immediately to the west of the guardrail the grade transverses down a tree lined slope to a chain link fence located along the freeway right-of-way. The chain link fence is located approximately 5 feet back of the east curb face for Laka Place.

3.0 Noise Evaluation

Noise measurements were performed by Y. Ebisu & Associates, Acoustical and Electronic Engineers on the morning of January 19, 2006, between the hours of 5:00 a.m. and 11:30 a.m. to monitor traffic noise levels during the peak morning commute. Noise levels were measured at 15 locations throughout the study area and modeled using the Federal Highway Administration (FHWA) Traffic Noise Model, Version 2.5. The resulting average noise level of 76.6 Leq was well above the 66 Leq noise abatement criteria established for Activity Category B (residences), under the State Noise Abatement Policy. See Appendix A for the complete Noise Study prepared by Y. Ebisu & Associates and Appendix B for their supplemental letter regarding wall heights relative to the 66 Leq maximum noise level criteria.

4.0 Noise Abatement

The construction of noise attenuating walls was determined to be the most feasible option to mitigate pre-existing traffic noise levels (See Appendix A, Chapter IV). Due to site constraints, only two alternatives are proposed for the alignment of the noise attenuating wall, one following the existing guard rail adjacent to the freeway shoulder and along top of slope, referred to as the "guardrail" alignment, and the second following the chain link fence along to the freeway right-of-way and toe of slope, referred to as the "right-of-way" alignment (See Figure 3). Other alignments between the top and toe of slope were not evaluated since they would require the removal and/or relocation of the existing trees and extensive excavation and embankment for wall construction.

Guardrail Alignment

The wall for the "guardrail" alignment would begin at the southwest end of the existing retaining wall for the Aiea Heights Drive Overpass along west shoulder of the freeway. From there, an existing 12-inch wide by 4-foot high concrete wall with chain link fence extends for approximately 80 linear feet (See Figure 4). The existing chain link fence would be removed and the wall height extended to meet the required wall heights for noise abatement. The wall would follow the current alignment of the guardrail along the edge of shoulder and near the top of slope. The existing guardrail would be removed and replaced with the noise attenuating

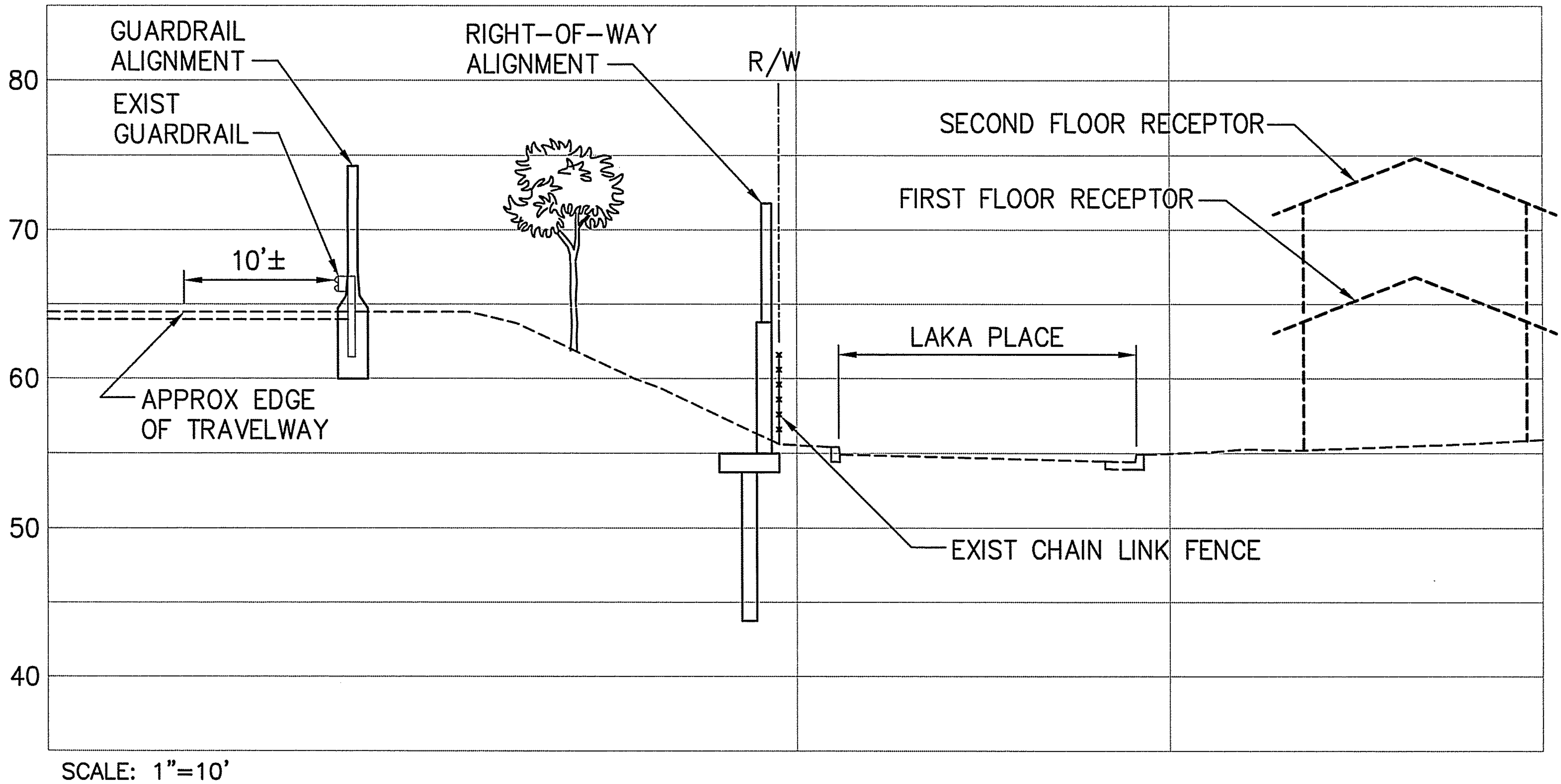


FIGURE 2
TYPICAL CROSS SECTION

Guardrail Alignment


Right-of-Way Alignment

FIGURE 3
ALTERNATIVE ALIGNMENTS

End of existing Aiea Heights Drive Overpass retaining wall

Existing concrete wall with chain link fence

FIGURE 4
NORTH END NOISE ATTENUATING WALL

wall. The wall would be approximately 10 feet from the traveled way, the minimum lateral clearance recommended by such state agencies as Caltrans. However, since the lateral clearance would be less thans15 feet, it is recommended that the wall be constructed on top of a "safety shaped" concrete barrier. The proposed alignment would continue south to beyond the existing overhead freeway sign support. From there it would transition to west up the slope bank to the existing chain link fence. The wall would then be aligned with the freeway right-of-way replacing the existing chain link fence until it terminates near the cul-de-sac at the end of Poopaa Place (See Figure 5).

The Noise Study prepared by Y. Ebisu & Associates provided the wall heights required to meet specified HDOT criteria. The range of wall heights for each criteria category along the "guardrail" alignment is as follows:

Wall	Criteria Description	Range of Wall Hts
A	5 dBA Improvement, First Floor Receptors	7.0 to 8.0 feet
C	5 dBA Improvement, Second Floor Receptors	8.0 to 9.0 feet
A (66 Leq)	Less than 66 Leq, First Floor Receptors	8.0 to 12.0 feet
C (66 Leq)	Less than 66 Leq, Second Floor Receptors	8.0 to 13.0 feet

Right-of-Way Alignment

The wall for "right-of-way" alignment, like the guardrail alignment would begin at the southwest end of the existing retaining wall and for the initial 80 linear feet would be constructed as an extension to the top of the existing 4-foot high concrete wall. From there, the "right-of-way" alignment would transition to the west following the existing chain link fence alignment along Laka Place. The existing chain link fence would be removed and replaced with the noise attenuating wall (See Figure 6).

Near the intersection of Laka Place and Kulina Drive the wall would transition up the slope bank replacing the existing chain link fence until it terminates near the cul-de-sac at the end of Poopaa Place similar to the guardrail alignment.

The range of wall heights for same criteria categories for the "right-of-way" alignment is as follows:

Wall	Criteria Description	Range of Wall Hts
B	5 dBA Improvement, First Floor Receptors	8.0 to 13.0 feet
D	5 dBA Improvement, Second Floor Receptors	8.0 to 16.0 feet
B (66 Leq)	Less than 66 Leq, First Floor Receptors	8.0 to 16.0 feet
D (66 Leq)	Less than 66 Leq, Second Floor Receptors	8.0 to 20.0 feet

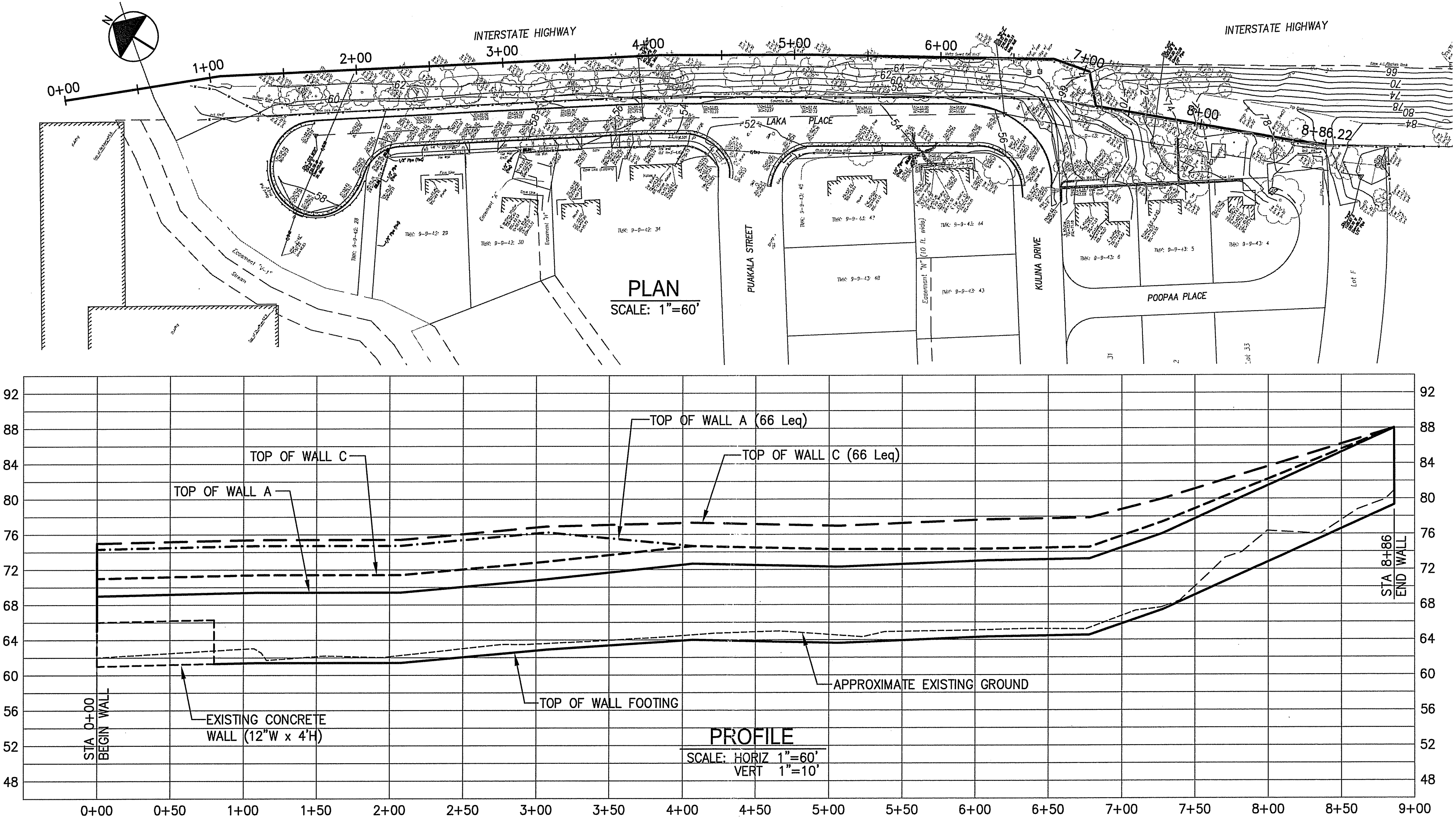


FIGURE 5
GUARDRAIL ALIGNMENT
PLAN AND PROFILE

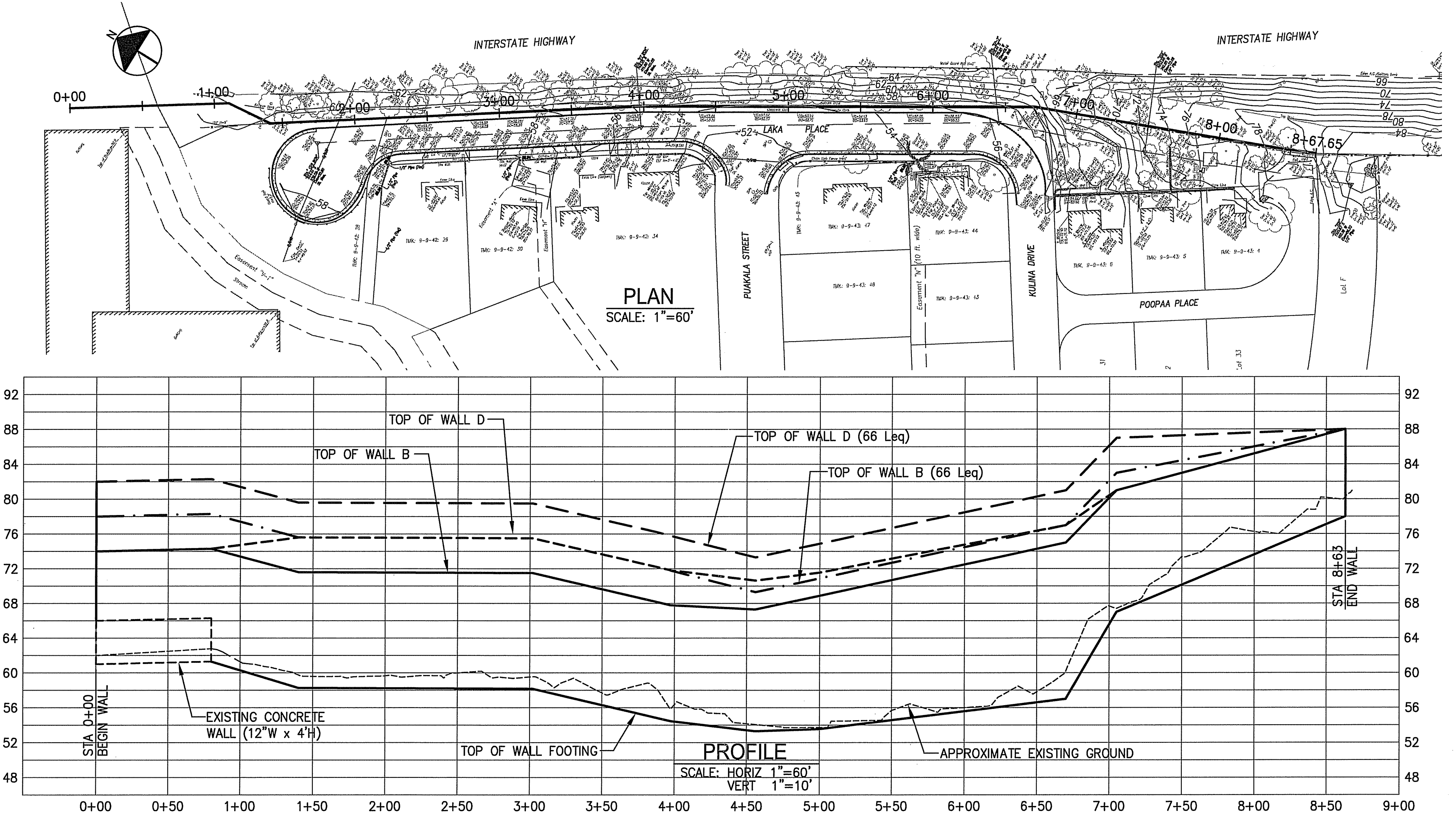


FIGURE 6
RIGHT-OF-WAY ALIGNMENT
PLAN AND PROFILE

Wall Construction

Use of concrete masonry units (cmu) for construction of the noise attenuating wall is one of the most common materials used and is proposed as the most cost effective method of construction. It is anticipated that wall heights 12 feet and under may be able to make use of vertical footings that would minimize the quantity of pavement restoration and regrading of the slope (See Figure 7). It is anticipated that wall heights greater than 12 feet may require a wider wall section (12-inch wide cmu) along the bottom section of wall and/or a deeper footing design or use of drilled cassions (See Figure 8) to support the higher lateral loads. Drilled cassions will also help in keeping the right-of-way alignment from extending beyond the State right-of-way. CMU wall construction shall be in accordance with the HDOT Standard Specification Section 513, Concrete Masonry Unit (See Appendix C).

Cast-in-place concrete walls, pre-cast concrete panels, pillar support wall designs, and pile driven footings are other methods of construction that could be used but would most likely result in higher construction costs.

Maintenance

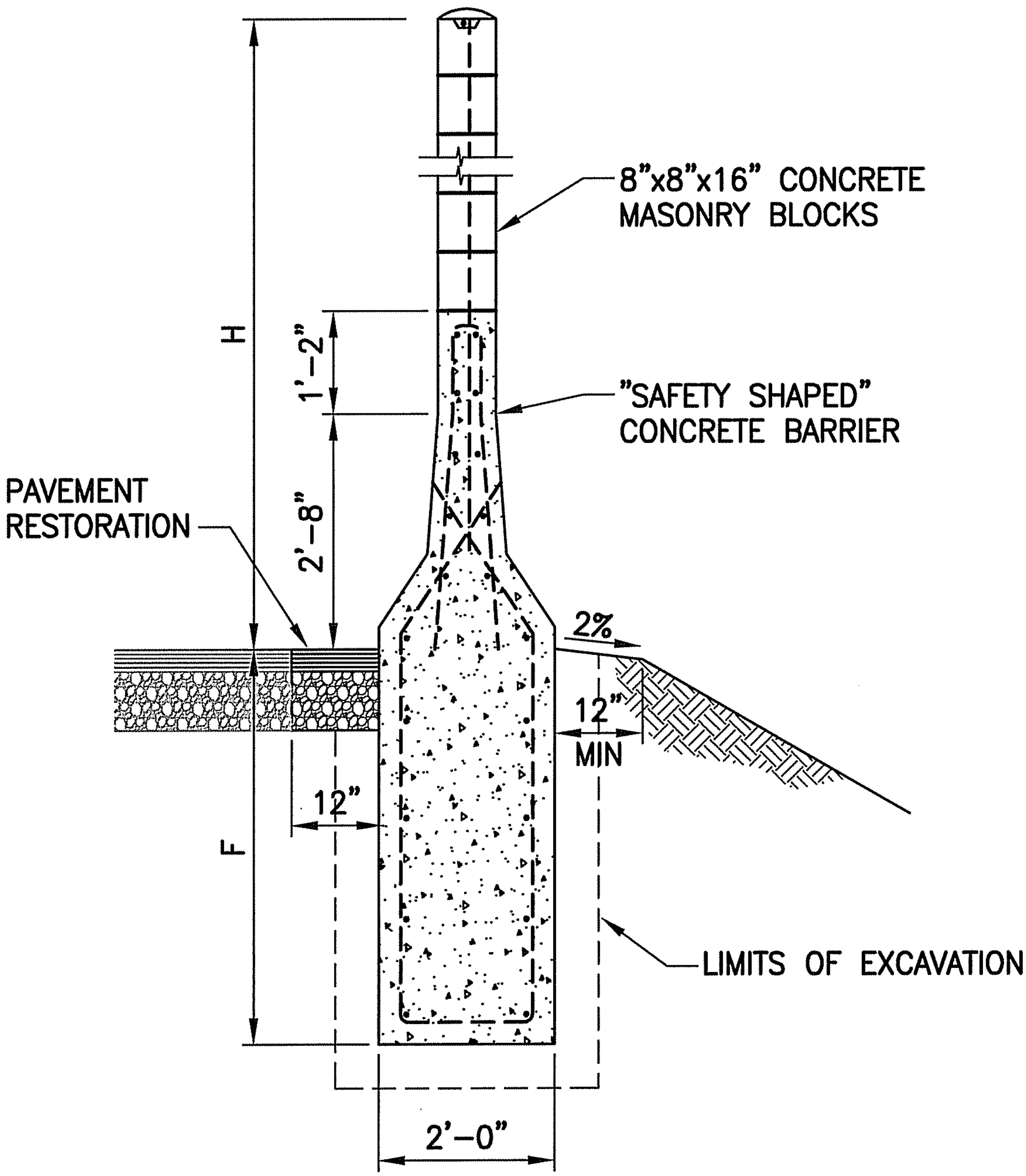
Construction of cmu or concrete attenuating walls are permanent and should not require extensive maintenance. Incidental costs to clean and remove possible graffiti can be included and performed during routine maintenance for the other walls adjacent to the freeway.

Site Constraints

Site Constraints for both alignments include utility conflicts, existing roadway improvements, and traffic control.

An existing drain inlet box located along the freeway shoulder will need to be reconstructed to accommodate the noise attenuating wall for the "guardrail" alignment. In addition, the existing 36-inch drain pipe from the inlet box that crosses the cul-de-sac at the end of Laka Place may need to be modified or concrete jacketed for wall footing construction. Near the south end of the "guardrail" alignment, final design will need to be coordinated with the overhead freeway sign support, electrical boxes, underground ductlines near the base of the support, and electrical ductlines or cables in the vicinity of any roadway lighting. The "guardrail" alignment will require extensive traffic control along the freeway however there is an estimated 10-foot shoulder that will minimize the need for lane closures and provide a clear zone for construction. Final wall alignment should be designed to minimize major tree removal. Modification or concrete jacketing of the existing 36-inch drain pipe may also be required where it crosses the wall for "right-of-way" alignment depending on the final footing

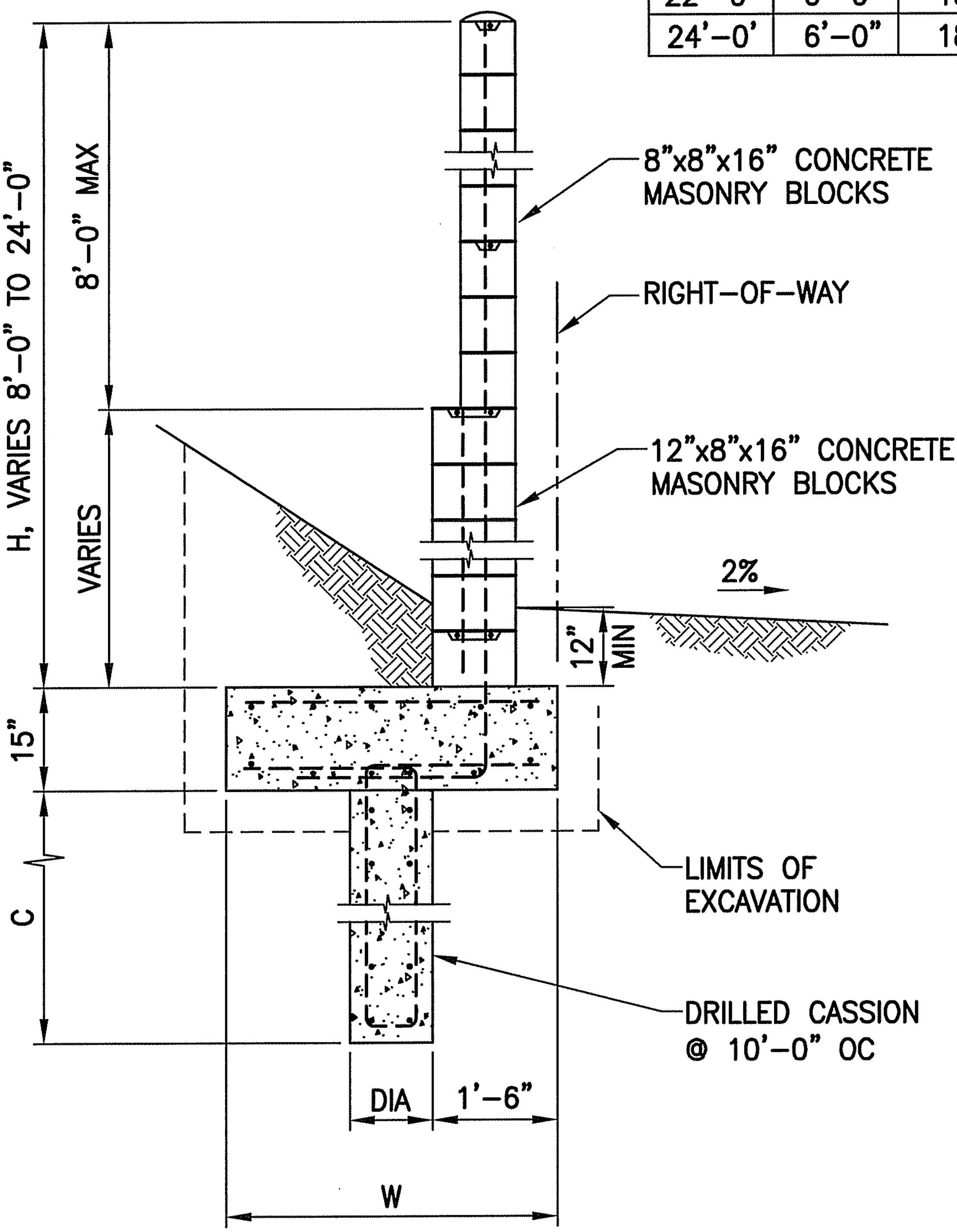
H	F
8'–0"	4'–6"
10'–0"	5'–2"
12'–0"	5'–10"



SCALE: 1/2"=1'–0"

FIGURE 7
TYPE 1 CMU WALL

H	W	DIA	C
8'–0"	4'–0"	12"	10'–0"
10'–0"	4'–0"	12"	10'–0"
12'–0"	5'–0"	15"	12'–0"
14'–0"	5'–0"	15"	12'–0"
16'–0"	5'–0"	15"	12'–0"
18'–0"	6'–0"	18"	15'–0"
20'–0"	6'–0"	18"	15'–0"
22'–0"	6'–0"	18"	15'–0"
24'–0'	6'–0"	18"	15'–0"



SCALE: 1/2"=1'–0"

FIGURE 8
TYPE 2 CMU WALL

design. Should drilled cassions be utilized, work should be coordinated to minimize disturbance to the neighboring residents and schools. Final design should be performed to ensure alignment is within the State right-of-way to prevent the State from having to acquire additional land or obtain easements that would be costly and time-consuming. Near the south end of the alignment, final design will need to be coordinated with the electrical poles, guy wires, and underground ductlines in the vicinity. Except at the north end of the "right-of-way" alignment that will also be adjacent the freeway, traffic control along Laka Place can be accomplished with single lane closures and/or detouring.

5.0 Estimated Construction Cost

Estimated construction costs are provided for each alignment alternative and relative wall heights for each criteria category. Unit costs were estimated using the "Cost Data Book", Naval Facilities Engineering Command, Pearl Harbor, Hawaii, January 2002 and adjusted at 5 percent increase per year or the RSMeans, "Heavy Construction Cost Data", 19th Annual Edition, 2005, adjusted for the 1.15 multiplier for Hawaii construction. A summary of the estimated construction costs are shown below in relation to the State's "Noise Analysis and Abatement Policy" guideline of $35,000 per "benefited" resident maximum allowable construction cost.

Wall	Alternative Alignment Design Criteria	Maximum Allowable	Estimated Const Cost
A	Guardrail, 5 dBA, First Floor Receptors	$805,000	**$738,707**
B	Right-of-Way, 5 dBA, First Floor Receptors	$700,000	$901,596
C	Guardrail, 5 dBA, Second Floor Receptors	$805,000	**$795,819**
D	Right-of-Way, 5 dBA, Second Floor Receptors	$980,000	**$961,883**
A (66 Leq)	Guardrail, 66 Leq, First Floor Receptors	$945,000	**$835,428**
B (66 Leq)	Right-of-Way, 66 Leq, First Floor Receptors	$840,000	$991,448
C66 (66 Leq)	Guardrail, 66 Leq, Second Floor Receptors	$945,000	**$887,037**
D (66 Leq)	Right-of-Way 66 Leq, Second Floor Receptors	$980,000	$1,105813

See Appendix D for estimated quantities and itemized cost breakdown.

6.0 Estimated Design Cost and Time Frame

Design of the noise attenuating wall will require the consulting services of a civil, structural, electrical, and geotechnical engineer, as well as supplemental surveying services for additional topographic survey at the north end of the wall alignment. The estimated design cost for each discipline is as follows:

- Civil Engineer $ 45,000
- Structural Engineer $ 50,000
- Electrical Engineer $ 20,000
- Geotechnical Engineer $ 20,000
- Surveying $ 15,000

Estimated Design Cost $150,000

Once funds have been allocated for the project and selection of a design consulting team in place, it is estimated that design through construction would take approximately 9 months from the notice to proceed (design 2.5 months, bidding and procurement 1.5 month, construction 5.0 months).

REFERENCES

Chapter 1100 Highway Traffic Noise Abatement, Highway Design Manual, Caltrans, November 1, 2001, Last Update 12-20-04

Cost Data Book, Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii, January 2002

Heavy Construction Cost Data, RSMeans, 19th Annual Edition, 2005

Highway Traffic Noise Barrier Construction Trends, U.S. Department of Transportation, Federal Highway Administration, Office of Natural Environment, Noise Team, Washington, D.C., April 2000

Standard Plans for Public Works Construction, "Greenbook", BNi Building News, 1997 Edition

Appendix A

Acoustic Study for the
Area Makai of H-1 Freeway
Between Aiea Heights Drive and
Kaimakani Street
Aiea, Hawaii

Y. Ebisu & Associates

ACOUSTIC STUDY FOR THE AREA MAKAI OF H-1 FREEWAY BETWEEN AIEA HEIGHTS DRIVE AND KAIMAKANI STREET; AIEA, HAWAII

Prepared for:

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Prepared by:

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MARCH 2006

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CHAPTER I. SUMMARY

The existing traffic noise levels from H-1 Freeway within the adjacent residential area makai (south) of the freeway between Aiea Heights Drive and Kaimakani Street were studied. Existing Hawaii State Department of Transportation, Highways Division (HDOT) noise abatement criteria (Reference 1) were used to determine the extent of the residential area where the HDOT traffic noise criteria level of 66 dB is currently exceeded. In addition, possible traffic noise attenuation measures were evaluated in accordance with HDOT policy (Reference 1) to identify "reasonable and feasible" means of reducing existing traffic noise levels.

This noise study was not directly associated with a highway improvement project within the study area, and is categorized as a Type II project (see Reference 1). At the present time, the HDOT does not have a program to implement Type II projects. However, this noise study was performed in accordance with current policies used for Type I projects, where improvements to new or existing highways are being planned. Noise measurements were obtained, traffic noise predictions developed, and noise abatement alternatives evaluated.

Existing traffic noise levels in the project area currently exceed the U.S. Federal Highway Administration (FHWA) and Hawaii State Department of Transportation, Highways Division (HDOT) noise abatement criteria for Activity Category B at existing residences, an adult day care center, recreation center, and at a pre-school. Therefore, traffic noise mitigation measures in the form of sound attenuating walls were recommended for implementation, providing that the costs of these mitigation measures are within the allowable limits contained in Reference 1.

Follow-on work regarding engineering and cost estimates for the recommended sound attenuating walls are required. In addition, prior to implementation and construction, consultations with the affected residents and Aiea Hongwanji Mission representatives regarding the proposed sound attenuating wall should be conducted. Issues such as obstruction of view planes, natural ventilation, and graffiti control may be of concern, and may affect the final design of the sound attenuating wall.

CHAPTER II. GENERAL STUDY METHODOLOGY

Noise Measurements. Existing traffic and background ambient noise levels at fifteen locations in the project area were measured on January 19, 2006. The traffic noise measurements were used to determine the extent of the noise study area as well as to validate the traffic noise model which was used to calculate the traffic noise levels within the study area. The traffic noise measurements were used to determine where existing traffic noise levels exceed FHWA and HDOT noise standards and criteria.

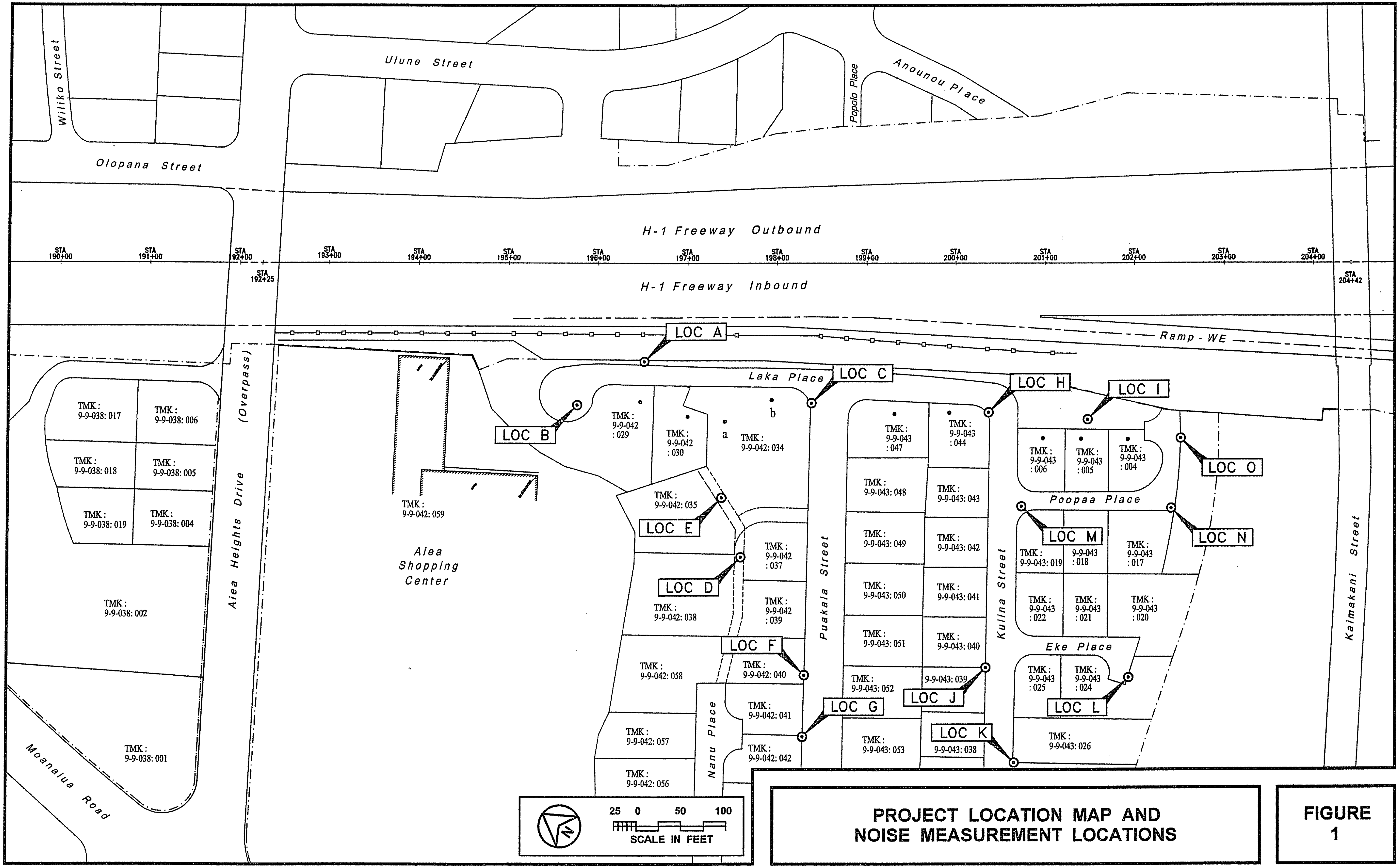
The noise measurement locations ("A" through "O") are shown in Figure 1. The results of the traffic noise measurements (which were all obtained at 5 feet above ground level) are shown in the data logs contained in Appendix C. In the data logs and throughout this report, Leq represents the average (or equivalent), A-Weighted, Sound Level. A list and description of the acoustical terminology used are contained in Appendix B.

Traffic Noise Modeling. The Federal Highway Administration (FHWA) Traffic Noise Model, Version 2.5 (or TNM, see Reference 2) was used as the primary method of calculating traffic noise levels within the study area, with model parameters adjusted to reflect terrain, ground cover, topographic data, and local shielding conditions. At the fifteen traffic noise measurement locations in the study area (Locations "A" through "O"), the measured noise levels were compared with computer modeling results to insure that measured and calculated noise levels for the existing conditions were consistent and in general agreement. Historical HDOT traffic counts on H-1 Freeway (References 3 and 4) were used to develop the traffic volumes and mixes during the am peak hour. The average vehicle speed entered into the TNM was adjusted to 44 miles per hour to achieve agreement between measured noise levels at Location "A" and those calculated by the TNM. With this input speed adjustment, the agreement between measured and predicted traffic noise levels was considered to be good and sufficiently accurate for modeling traffic noise levels in the study area.

Existing traffic noise levels were then calculated at the noise measurement locations as well as at additional noise sensitive receptor locations within the study area. Traffic mix by vehicle types and the distribution of traffic volumes among the various freeway lanes were derived from the data contained in References 3 and 4. Determinations of the periods of highest hourly traffic volumes along the project corridor were made after reviewing the hourly traffic volumes contained in Reference 4.

For this study, the following noise modeling assumptions were used:

1. Total eastbound hourly traffic volume: 13,717 vph
2. Total westbound hourly traffic volume: 5,895 vph
3. Percent of total eastbound traffic using Aiea & Moanalua Freeway Off-Ramp WE: 42.3%
4. Percent of total eastbound through traffic to Pearl Harbor: 57.7%
5. Percent of total westbound traffic from Moanalua Freeway: 51.7%



PROJECT LOCATION MAP AND NOISE MEASUREMENT LOCATIONS

FIGURE 1

6. Percent of total westbound traffic from Pearl Harbor: 48.3%
7. Traffic Mix: 95% autos; 2.5% medium trucks; and 2.5% heavy trucks and buses.
8. Average vehicle speed: 44 mph.
9. Ground propagation loss factor: Pavement

The Equivalent (or Average) Hourly Sound Level [Leq(h)] noise descriptor was used to calculate the existing traffic noise levels as required by Reference 5. Aerial photomaps, topographic survey data, and tax maps of the area were used to determine receptor locations, receptor and barrier base elevations, terrain, ground cover, and local shielding effects from building structures, which were entered into the noise prediction model.

Impact Assessments and Mitigation. Following the calculation of the existing traffic noise levels, comparisons of the traffic noise levels with FHWA and HDOT noise abatement criteria (see Table 1) were made to identify those locations within the project study area where the noise abatement criteria are presently exceeded. Within the study area, the existing traffic noise levels were compared with the 66 Leq(h) traffic noise criteria for Activity Category B (see Table 1). HDOT's 66 Leq(h) criteria was applied to all noise sensitive buildings within the study area, since, by Reference 1, HDOT has replaced the FHWA 67 Leq(h) criteria with their 66 Leq(h) criteria. Traffic noise levels are above the 66 Leq(h) criteria level over a large portion of the sudy area, so the effectiveness of sound attenuating barriers were evaluated. Minimum barrier heights required to meet HDOT's criteria of 5 dBA noise reduction along the first row of homes fronting H-1 Freeway were examined for both ground level and second floor receptors. Two alternate barrier locations were evaluated; the first located entirely along the existing chain link fence; and the second located along the chain link fence at the east end of the study area and transitioning to the existing makai guard rail between Kulina Street and the west end of the study area. Two barrier locations were evaluated since it was not intuitively obvious which alternative would meet the HDOT criteria of "reasonable" and "feasible" for noise mitigation measures; a shorter height barrier located along the makai guard rail, or a taller barrier located along the makai fence line. The noise barriers at these two locations were analyzed for acoustical performance in this study. The cost and feasibility will be analyzed by others using the results and recommendations in this study.

By Reference 1, the costs of traffic noise mitigation measures are considered to be "reasonable" if they do not exceed $35,000.00 per "benefited" residence. A benefited residence is one where at least 5 dBA of noise reduction occurs from the noise mitigation measure. The total number of benefited residences was estimated by examining the barriers' noise attenuation along the front row of homes as well as at those homes within 400 feet of the makai Right-of-Way. In addition, an adult day care center, recreation center, and pre-school building were also included as benefited residences for the purposes of this study. So, the results of this noise study were

TABLE 1

FHWA & HDOT NOISE ABATEMENT CRITERIA
[Hourly A–Weighted Sound Level– –Decibels (dBA)]

ACTIVITY CATEGORY	LEQ (h)*	DESCRIPTION OF ACTIVITY CATEGORY
A	57 (Exterior)	Lands on which serenity and quiet are of extra–ordinary significance and serve an important public need and where the preservation of those qualities is essential if the areas are to continue to serve their intended purpose.
B	67 (Exterior)	Picnic areas, recreation areas, playgrounds, activity sports areas, parks, residences, motels, hotels, churches, libraries, and hospitals.
C	72 (Exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	––––––	Undeveloped lands.
E	52 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

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* The Hawaii State Department of Transportation, Highways Division, utilizes Leq criteria levels which are 1 Leq unit less than the FHWA values shown.

transferred to those designing the sound attenuating barrier(s), who would select the barrier whose total costs are within the limits established by the $35,000.00 per "benefited" residence criteria.

CHAPTER III. EXISTING ACOUSTICAL ENVIRONMENT

The existing noise environment in the project study area was described by both measuring and calculating the Hourly Equivalent Sound Levels [Leq(h)] within the study area for the am peak traffic hour. The hourly sound levels, expressed in decibels, represent the average levels of traffic noise at the study area locations during the am peak hour as measured on January 19, 2006. The study area was defined as those developed lands makai of H-1 Freeway and within 400 feet of the makai Right-of-Way between Aiea Heights Drive and Kaimakani Street. The developed areas makai of H-1 Freeway include residences along Laka Place, Puakala Street, Kulina Street, Poopaa Place, and Eke Place.

The traffic volume, speed, and mix assumptions used to calculate the Base Year noise levels during the am peak hour along H-1 Freeway and its ramps are described in Chapter II. Comparisons of the traffic noise levels as calculated by the TNM with the noise measurement results at Locations "A" through "O" are shown in Table 2. In Table 2, the noise measurement results at Locations "B" through "O" were adjusted to am peak hour values by applying the measured variations in traffic noise levels at Location "A" with time of day to covert the measurement results at spot Locations "B" through "O" to their am peak hour values. At the majority of the measurement locations, the differences between measured noise levels and modeling results were sufficiently small such that the model was considered acceptable for describing the effectiveness of various sound attenuation barrier designs.

The estimated distance to the 66 Leq noise contour for ground level receptors was estimated to be approximately 450 feet from the highway centerline, or approximately 350 feet from the existing makai Right-of-Way. The total number of structures located within the 66 Leq noise contour was estimated to be 25 residences plus 3 facilities and a residence on the Aiea Hongwanji Mission property.

Existing traffic noise levels were calculated using the TNM at various noise-sensitive structures in the project area for both ground level and second floor receptor locations. The results of these calculations are shown in Tables 3 and 4 in the "Without Wall" columns. The receptor locations where calculations of existing traffic noise levels were made are shown in Figure 1.

From the results in Table 3, it was concluded that the HDOT noise abatement criteria for Activity Category B is being exceeded in the project area along the first row of structures fronting the makai Right-of-Way. Current traffic noise levels exceed HDOT noise abatement criteria at essentially all of the lands in Activity Category B (see Table 2) which are within 450 feet of the freeway baseline.

The typical fluctuations in instantaneous traffic noise levels during the monitoring period are shown in Figure 2, but the average traffic noise level (excluding the sirens' contributions) during the monitoring period shown was 76.6 Leq(h), and well above the 66 Leq(h) noise abatement criteria.

TABLE 2
COMPARISON OF MEASURED AND MODELING RESULTS

LOCATION	Time of Day (HRS)	Measured Leq (dB)	Adjusted Leq for AM Peak	--- MODELING RESULTS --- Ground Lvl. Leq (dB)	2nd Flr. Lvl. Leq (dB)
A At makai R/W of H-1 Freeway mauka of Lot 29, Laka Pl. (1/19/06)	0504 TO 0600	78.3	78.3	78.4	78.3
A At makai R/W of H-1 Freeway mauka of Lot 29, Laka Pl. (1/19/06)	0800 TO 0900	78.3	78.3	78.4	78.3
B West of Lot 29 at house setback line, Laka Pl. (1/19/06)	0538 TO 0553	78.2	75.7	75.3	75.1
C At northeast corner of Lot 34, Laka Pl. (1/19/06)	0724 TO 0739	72.0	73.4	72.1	75.4
D At northwest corner of Aiea Hongwanji Mission Pre-School Building (1/19/06)	0746 TO 0801	67.9	67.5	67.4	68.3
E At northeast corner of Aiea Hongwanji Mission Rec Center Building (1/19/06)	0803 TO 0818	67.4	67.2	67.9	69.2
F Near SE corner of Aiea Hongwanji Mission Pre-School Building (1/19/06)	0821 TO 0828	65.9	65.9	65.3	66.1
G At northeast corner of Lot 42, Puakala St. (1/19/06)	0830 TO 0845	63.0	63.0	64.3	65.0
H At northeast corner of Lot 44, Laka Pl. (1/19/06)	0924 TO 0939	70.4	71.8	73.2	75.1

TABLE 2 (CONTINUED)
COMPARISON OF MEASURED AND MODELING RESULTS

	LOCATION	Time of Day (HRS)	Measured Leq (dB)	Adjusted Leq for AM Peak	--- MODELING RESULTS --- Ground Lvl. Leq (dB)	2nd Flr. Lvl. Leq (dB)
I	At north property line of Lot 5, Poopaa Pl. (1/19/06)	0941 TO 0956	71.8	72.8	72.5	74.5
J	At northeast corner of Lot 39, Kulina St. (1/19/06)	1001 TO 1016	66.1	67.1	65.7	66.2
K	At southwest corner of Lot 26, Kulina St. (1/19/06)	1018 TO 1029	62.7	64.1	63.8	64.3
L	At east end of Eke Pl. fronting Lot 24. (1/19/06)	1031 TO 1046	66.0	67.0	65.0	66.0
M	At northwest corner of Lot 19, Poopaa Pl. (1/19/06)	1048 TO 1100	68.0	69.6	69.9	70.5
N	At northeast corner of Lot 17, Poopaa Pl. (1/19/06)	1102 TO 1117	65.4	68.2	67.4	69.7
O	East of Lot 4 at house setback line, Poopaa Pl. (1/19/06)	1118 TO 1133	66.4	68.8	69.7	73.7

TABLE 3
LIST OF IMPACTED AND BENEFITED RECEPTOR LOCATIONS
(GROUND FLOOR RECEPTOR ELEVATION)

RECEPTOR LOCATION	EXISTING LEQ WITHOUT WALL	EXISTING LEQ WITH WALL A	EXISTING LEQ WITH WALL B
Rec 9-9-042:029	75.4	**69.3**	**70.0**
Rec 9-9-042:030	74.6	**67.5**	**68.2**
Rec 9-9-042:034a	73.5	**66.4**	**66.7**
Rec 9-9-042:034b (Day Care)	73.1	**65.7**	**65.4**
Location D (Pre-School)	67.4	**61.7**	**61.5**
Location E (Rec. Center)	67.9	**62.0**	**61.5**
Rec 9-9-043:047	72.6	**65.2**	**64.5**
Rec 9-9-043:044	74.4	**66.5**	**65.9**
Rec 9-9-043:006	73.0	**66.6**	**67.1**
Rec 9-9-043:005	72.4	**67.1**	**67.2**
Rec 9-9-043:004	71.1	**66.0**	**66.1**
Rec 9-9-043:048	69.5	**63.3**	**62.8**
Rec 9-9-043:049	68.0	**62.3**	**62.0**
Rec 9-9-043:050	67.0	**61.8**	**61.4**
Rec 9-9-043:051	66.0	**61.0**	**60.9**
Rec 9-9-043:043	70.2	**64.0**	**63.7**
Rec 9-9-043:042	68.8	**62.8**	**63.4**
Rec 9-9-043:041	67.5	**62.0**	62.8
Rec 9-9-043:040	66.2	**61.0**	62.0
Rec 9-9-043:039	65.8	**60.8**	61.5
Rec 9-9-043:019	69.0	**63.5**	**63.8**
Rec 9-9-043:018	69.0	**63.5**	**63.9**
Rec 9-9-043:017	69.0	**63.5**	**64.0**
Rec 9-9-043:022	66.8	62.2	63.0
Rec 9-9-043:021	66.8	62.2	63.0
Rec 9-9-043:020	66.8	62.2	63.0
Rec 9-9-043:025	65.0	61.2	62.0
Rec 9-9-043:024	65.0	61.2	62.0
Total Number of "Benefited Residences":		23	20

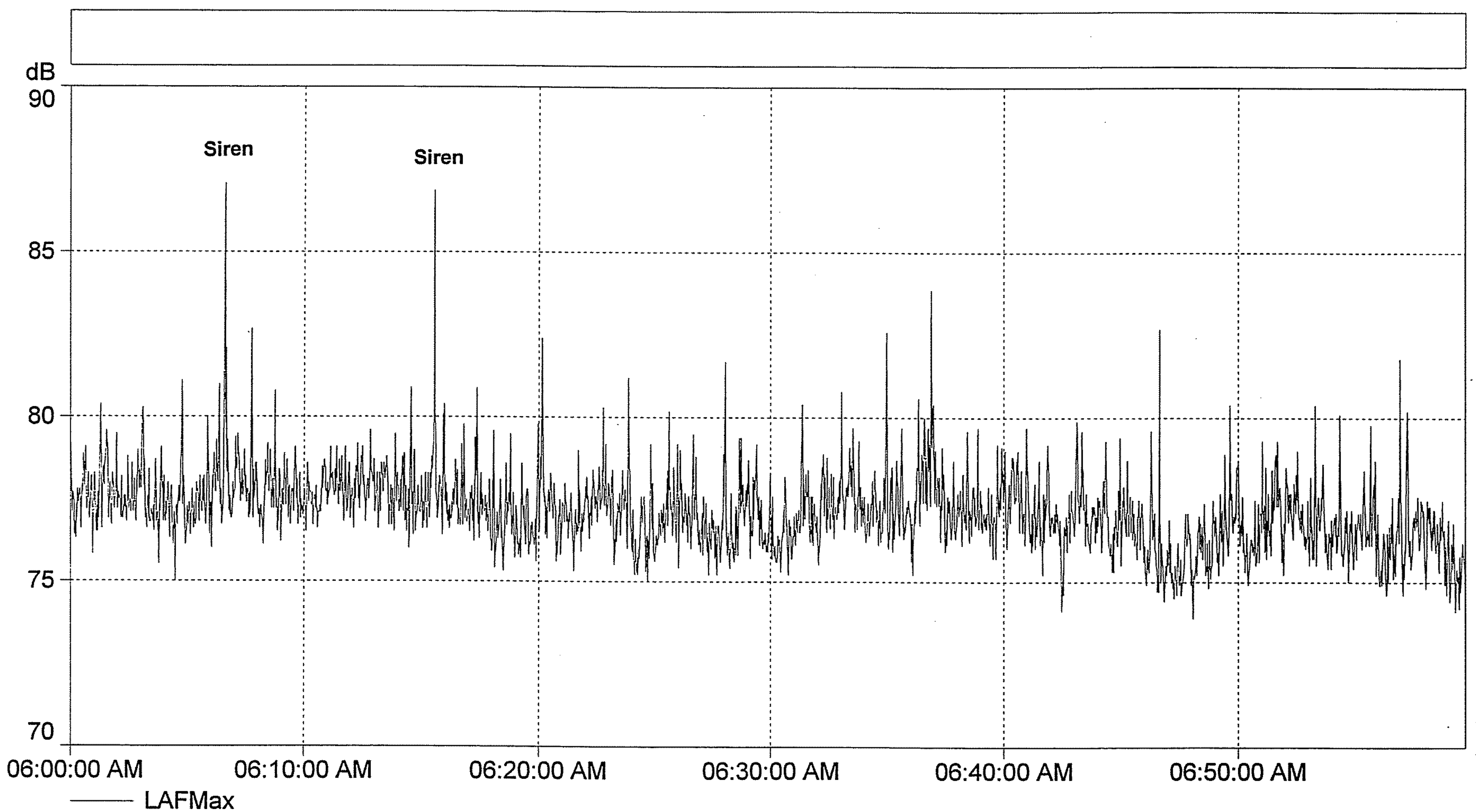
Note: Bold numbers represent "benefited residence".

TABLE 4
LIST OF IMPACTED AND BENEFITED RECEPTOR LOCATIONS (SECOND FLOOR RECEPTOR ELEVATION)

RECEPTOR LOCATION	EXISTING LEQ WITHOUT WALL	EXISTING LEQ WITH WALL C	EXISTING LEQ WITH WALL D
Rec 9-9-042:030	74.6	**68.7**	**69.5**
Rec 9-9-042:034b (Church)	75.6	**67.1**	**68.1**
Location D (Pre-School)	68.3	**62.3**	**61.6**
Rec 9-9-043:047	75.0	**66.7**	**69.6**
Rec 9-9-043:044	75.1	**68.8**	**66.8**
Rec 9-9-043:048	72.0	**64.1**	**61.3**
Rec 9-9-043:049	70.0	**63.1**	**60.6**
Rec 9-9-043:050	68.2	**62.2**	**60.0**
Rec 9-9-043:051	67.0	**61.5**	**59.5**
Rec 9-9-043:043	71.2	**65.5**	**61.9**
Rec 9-9-043:039	66.2	61.4	**59.6**
Rec 9-9-043:019	70.1	66.2	**61.8**
Rec 9-9-043:017	70.1	66.2	**62.8**
Rec 9-9-043:022	68.1	65.0	**61.8**
Rec 9-9-043:021	68.1	65.0	**61.8**
Rec 9-9-043:020	68.1	65.0	**61.8**
Rec 9-9-043:025	66.0	63.5	**61.0**
Rec 9-9-043:024	66.0	63.5	**61.0**
Total Number of Additional "Benefited Residences":		0	8 *

Notes: Bold, underlined numbers represent "benefited residence" also counted with Wall A or Wall B.

* Two additional single story structures (Lots 40 and 41) benefited by Wall D but not Wall B.



DBA VS. TIME HISTORY OF NOISE LEVELS AT LOCATION "A" (0600 TO 0700 HOURS; 1/19/06)

FIGURE 2

CHAPTER IV. POSSIBLE NOISE MITIGATION MEASURES

Possible noise mitigation measures considered included the following:

A. Restricting the Growth In the Number of Noisy Buses, Heavy Trucks, Motorcycles, and Automobiles with Defective Mufflers. The percentage contribution to the total traffic noise by heavy trucks, buses, and noisy vehicles is currently less than 50 percent, and elimination of these noise sources would reduce total traffic noise levels by less than 3 Leq(h) units. Restricting the growth rate of these vehicles (to growth rates below passenger automobile growth rates) could produce noise reductions in the order of 1 or 2 dB, which are not considered significant for the level of regulatory efforts required.

B. Alteration of the Horizontal Or Vertical Alignment of the Roadway. Major alterations of the horizontal or vertical alignment of the existing freeway was not considered appropriate due to the scope of this noise study project and due to the Right-of-Way constraints on both sides of the freeway. Vacant lands north of H-1 Freeway are not available to accommodate lateral displacements of the H-1 Freeway alignment in the order of 400 to 450 feet. Vertical realignment of the existing freeway upward would result in adverse visual impacts, and vertical realignment of the freeway via cuts would not be possible without obtaining additional Right-of-Way. For these reasons, realignment of H-1 Freeway away from the affected noise sensitive structures was not considered to be a reasonable noise mitigation measure.

C. Acquisition of Property Rights for Construction of Noise Barriers, and/or Construction of Noise Barriers Along the Right-of-Way. For single story, noise sensitive buildings, construction of a sound attenuating wall along the Right-of-Way is normally the preferred noise mitigation measure. The 5 to 7 dB of noise attenuation achievable with a 6 feet high wall may be sufficient for single story structures. Because some of the affected homes and church structures are one-story structures, construction of a sound attenuating barrier could possibly provide sufficient noise reduction benefits at the affected low-rise structures. Many of the affected noise sensitive structures are in excess of 10 feet in height, and will not benefit from 6 feet high walls. In these situations, excessive barrier heights may be required to provide sound attenuation to upper floor spaces, and height variances from local codes may be required to construct these high walls. It should also be noted that sound barriers will block the views to and from the freeway and beyond which some of the residents may enjoy and/or prefer. For these reasons, concurrence from the affected homeowners and property owners should be obtained prior to construction of sound barriers as a noise mitigation measure.

D. Acquisition of Real Property Interests To Serve As A Noise Buffer Zone. Where tall (or multistory) structures are expected to be impacted by future traffic noise, the use of sound attenuating barriers (see para. C above) will not be practical due to the excessive heights required to shield the upper levels from traffic noise. Acquisition of the real property interests to serve as noise buffer zones were considered. However, noise buffer zones extending approximately 450 feet from the freeway's baseline and at substantial cost would be required to meet the HDOT 66 Leq criteria. In general, the acquisition of property for the creation of noise buffer zones for noise mitigation has seldom been applied in Hawaii.

E. Noise Insulation of Public Use or Nonprofit Institutional Structures. Church buildings (adult day care center, recreation center, and child care enter) impacted by noise will need to be considered for noise abatement measures in conjunction with this project. Noise insulation of public use or nonprofit institutional structures in the form of closure and air conditioning is sometimes preferable over the construction of sound attenuating walls.

CHAPTER V. RECOMMENDED NOISE MITIGATION MEASURES

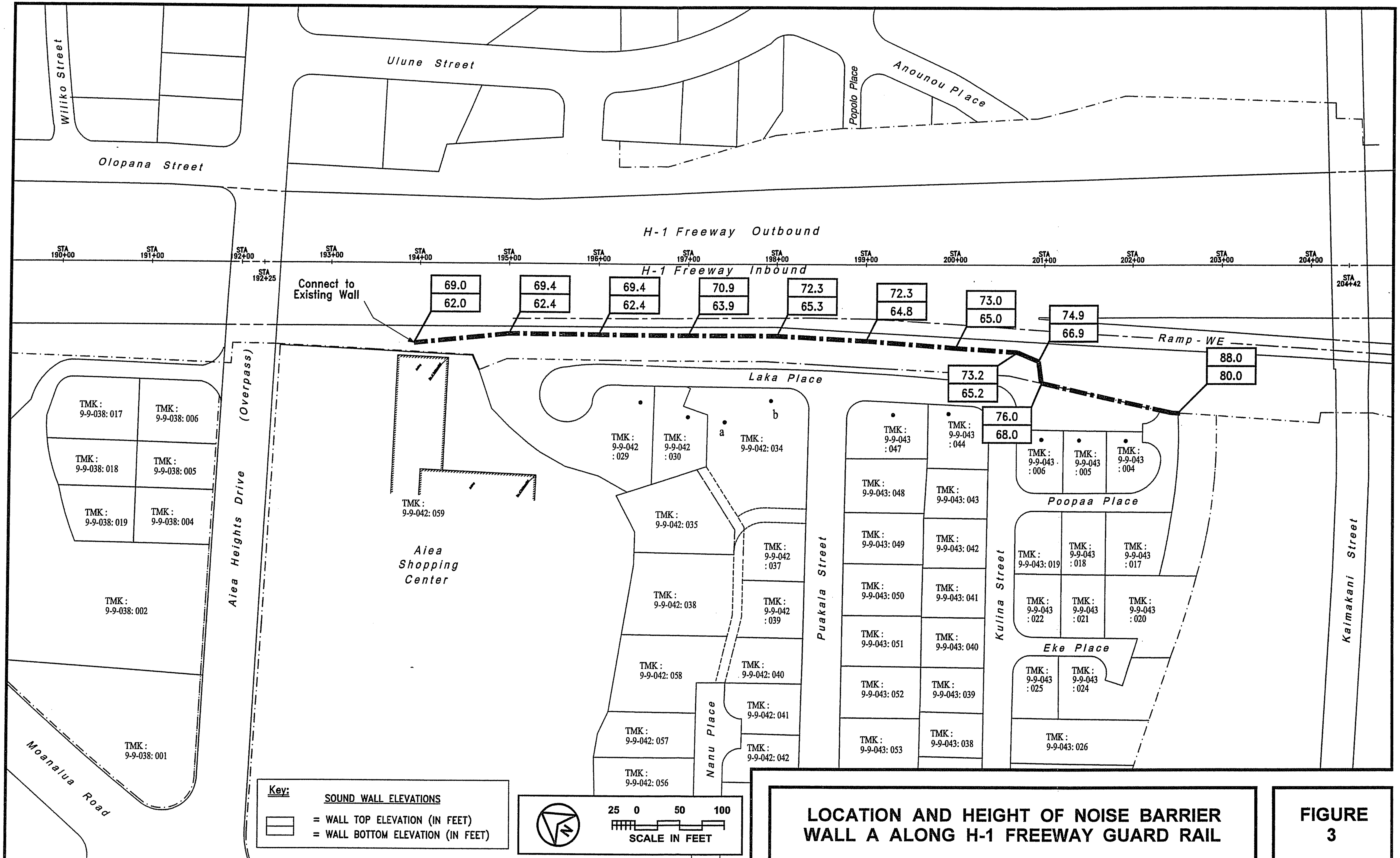
By existing HDOT policy, traffic noise mitigation measures are normally considered in conjunction with highway improvement projects, and have not been considered to remedy preexisting high traffic noise levels along State roadways. This project would represent a departure from current HDOT policy if traffic noise mitigation measures are applied within this study area. Nevertheless, the methodology used to mitigate identified traffic noise impacts in conjunction with highway improvement projects was also applied to this current noise study project.

In order to be considered for implementation, traffic noise attenuation measures (such as a wall) must provide at least 5 dB of sound attenuated at existing receptor locations where the HDOT noise abatement criteria of 66 Leq(h) is being exceeded. Those receptor locations where the 5 dB reduction can be achieved are considered to be "benefited" by the traffic noise attenuation measure. The allowable construction cost for the traffic noise attenuation measure does not exceed $35,000 per benefited residence. For the purposes of this study, all of the four structures on the Aiea Hongwanji Mission property were each considered to qualify for consideration as being a "benefited residence". Approximately 25 additional residences in the study area were also considered to qualify for consideration as being a "benefited residence".

The total number of "benefited residences" was determined for two sound attenuation walls: the first located along the chain link fence at the east end of the study area and transitioning to the existing makai guard rail between Kulina Street and the west end of the study area (Wall A); and the second located along the existing chain link fence and makai Right-of-Way (Wall B). The locations of the two sound attenuating walls are shown in Figures 3 and 4.

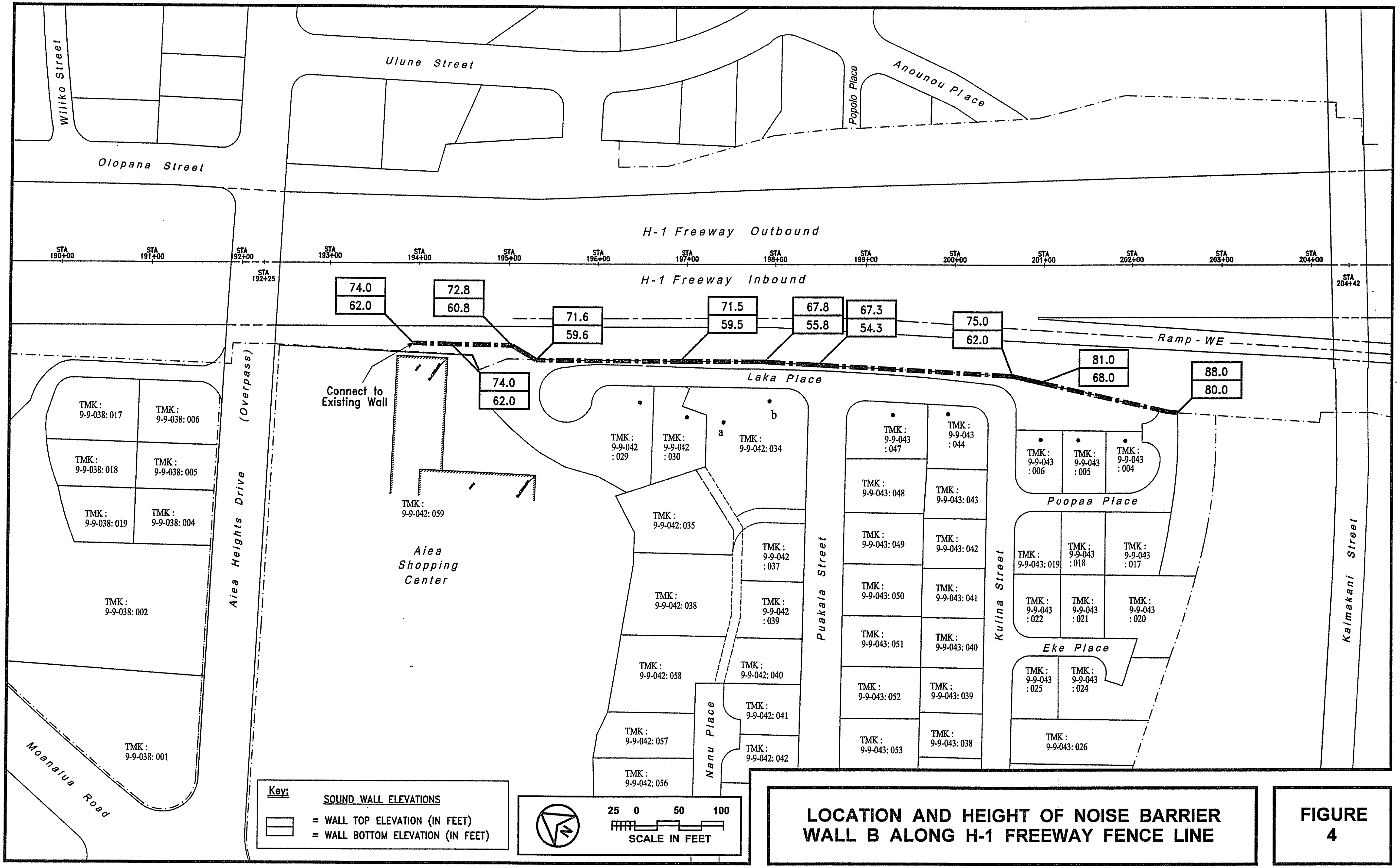
The minimum sound attenuating wall heights were determined for the two barrier configurations shown in Figures 3 and 4. Wall heights for each barrier configuration were adjusted so as to provide a minimum of 5 dB attenuation at the ground floor level of each of the structures fronting H-1 Freeway. The recommended minimum wall heights for the two barrier configurations are shown in Figures 3 and 4 for the Guard Rail and Right-Of-Way barriers, respectively. The total number of "benefited residences" at the ground floor level for each barrier configuration are shown in Table 3, with 23 residences benefited by the Guard Rail barrier shown in Figure 3, and with 20 residences benefited by the Right-Of-Way barrier shown in Figure 4.

The reason that the taller noise barriers did not produce lower noise levels in all cases (see Tables 3 and 4) is that the ground elevation at the makai fence line is lower than the highway pavement along the makai guard rail. The noise barrier's attenuation performance is controlled by the top elevation of the barrier rather than by the height of the barrier. The top elevation of the barriers was adjusted to provide a minimum of 5 dB of traffic noise attenuation at the first row of homes fronting the highway. Since the terrain, roadway, barriers, and receiver locations are not located at the same elevation



LOCATION AND HEIGHT OF NOISE BARRIER WALL A ALONG H-1 FREEWAY GUARD RAIL

FIGURE 3



LOCATION AND HEIGHT OF NOISE BARRIER WALL B ALONG H-1 FREEWAY FENCE LINE

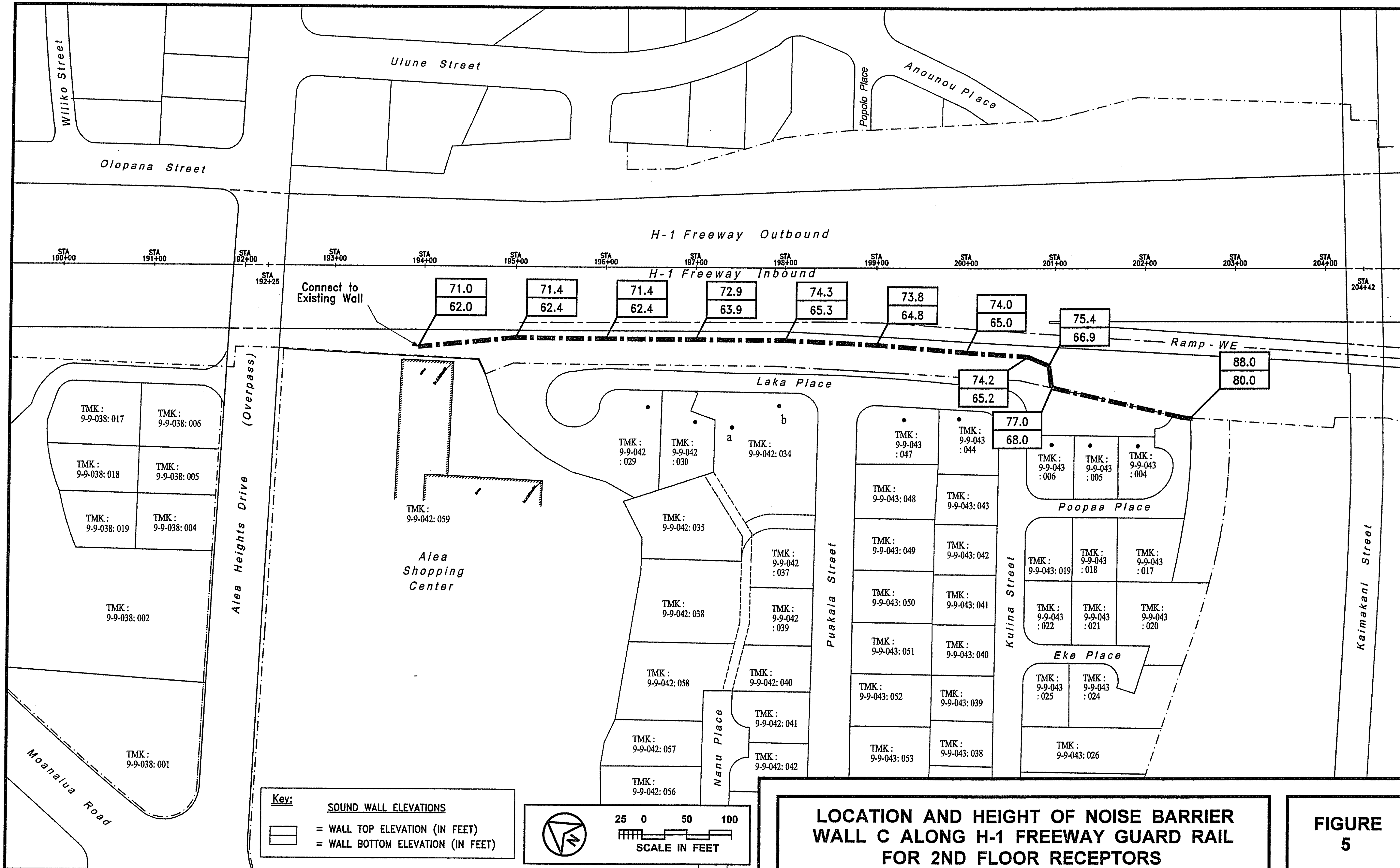
FIGURE 4

(are not located on a flat earth), it is not unreasonable to find that the sound level results at the receiver locations behind the barriers do not follow simple monotonic relationships with the noise barrier heights.

Normally, minimum sound attenuating wall heights are not based on benefiting second floor receptors because the cost of the additional wall heights required to shield the upper floor spaces tend to exceed the maximum allowable cost of $35,0000 per benefited residence. However, for this noise study, an evaluation was performed of the minimum sound attenuating wall heights required to provide a minimum of 5 dB attenuation for the second floor spaces of the structures fronting H-1 Freeway. The recommended minimum wall heights for these two barrier configurations are shown in Figures 5 and 6 for the Guard Rail and Right-Of-Way barriers, respectively. The total number of "benefited residences" at the first and second floor level for each barrier configuration are shown in Table 4, with 23 residences benefited by the Guard Rail barrier shown in Figure 5, and with 28 residences benefited by the Right-Of-Way barrier shown in Figure 6. If the costs for the Guard Rail and Right-Of-Way barriers shown in Figures 3, 4, 5, and 6 do not exceed $35,000 per benefited residence, they could be justified as being reasonable and feasible under current HDOT noise abatement policy.

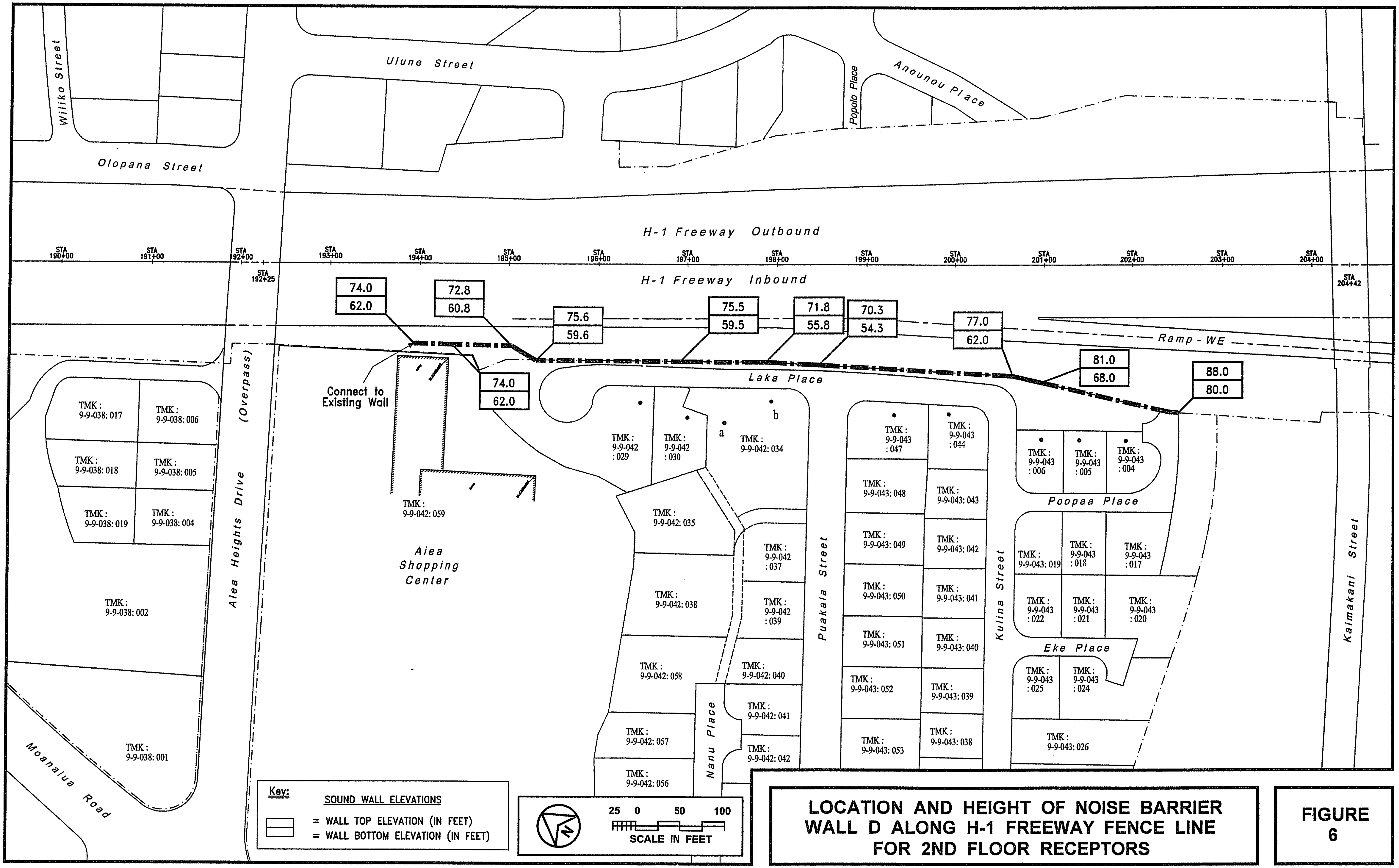
The maximum allowable cost of the Guard Rail barriers (Wall A or Wall C) is 23 x $35,000 = $805,000. The maximum allowable cost of the Right-of-Way barriers (Wall B and Wall D) are 20 x $35,000 = $700,000 and 28 x $35,000 = $980,000, respectively.

It is anticipated that potential noise impacts at any new noise sensitive or commercial establishments located in the project area may be mitigated through the inclusion of sound walls or other noise mitigation measures within the individual lot development plans. In addition, any new commercial establishments or housing units which may be planned along the freeway represent areas of potential adverse noise impacts if adequate noise mitigation measures are not incorporated into the planning of these future projects. It is anticipated that noise abatement measures such as adequate setbacks, sound attenuating walls or berms, or closure and air conditioning will be incorporated into these new developments along the freeway as required. In any event, new structures whose building permits were obtained after the date of this noise study will not be considered for noise abatement measures under existing HDOT procedures.



LOCATION AND HEIGHT OF NOISE BARRIER WALL C ALONG H-1 FREEWAY GUARD RAIL FOR 2ND FLOOR RECEPTORS

FIGURE 5



LOCATION AND HEIGHT OF NOISE BARRIER WALL D ALONG H-1 FREEWAY FENCE LINE FOR 2ND FLOOR RECEPTORS

FIGURE 6

APPENDIX A. REFERENCES

(1) "Noise Analysis and Abatement Policy;" Hawaii State Department of Transportation, Highways Division, Materials Testing and Research Branch; June 1997.

(2) "FHWA Highway Traffic Noise Model User's Guide;" FHWA-PD-96-009, Federal Highway Administration; Washington, D.C.; January 1998 and Version 2.5 Upgrade (April 14, 2004).

(3) 24-Hour Traffic Counts, Halawa Interchange; February 5-6, 2002; Hawaii State Department of Transportation.

(4) 24-Hour Traffic Counts and Vehicle-Type Classification, Station H1-11, H-1 Freeway At Kaonohi Street Grade Separation; January 15-16, 2002 and February 5-6, 2002; Hawaii State Department of Transportation.

(5) Federal Highway Administration; "Procedures for Abatement of Highway Traffic Noise and Construction Noise;" 23 CFR Chapter I, Subchapter H, Part 772; April 1, 1995.

APPENDIX B

EXCERPTS FROM EPA'S ACOUSTIC TERMINOLOGY GUIDE

Descriptor Symbol Usage

The recommended symbols for the commonly used acoustic descriptors based on A-weighting are contained in Table I. As most acoustic criteria and standards used by EPA are derived from the A-weighted sound level, almost all descriptor symbol usage guidance is contained in Table I.

Since acoustic nomenclature includes weighting networks other than "A" and measurements other than pressure, an expansion of Table I was developed (Table II). The group adopted the ANSI descriptor-symbol scheme which is structured into three stages. The first stage indicates that the descriptor is a level (i.e., based upon the logarithm of a ratio), the second stage indicates the type of quantity (power, pressure, or sound exposure), and the third stage indicates the weighting network (A, B, C, D, E.....). If no weighting network is specified, "A" weighting is understood. Exceptions are the A-weighted sound level and the A-weighted peak sound level which require that the "A" be specified. For convenience in those situations in which an A-weighted descriptor is being compared to that of another weighting, the alternative column in Table II permits the inclusion of the "A". For example, a report on blast noise might wish to contrast the LCdn with the LAdn.

Although not included in the tables, it is also recommended that "Lpn" and "LepN" be used as symbols for perceived noise levels and effective perceived noise levels, respectively.

It is recommended that in their initial use within a report, such terms be written in full, rather than abbreviated. An example of preferred usage is as follows:

The A-weighted sound level (LA) was measured before and after the installation of acoustical treatment. The measured LA values were 85 and 75 dB respectively.

Descriptor Nomenclature

With regard to energy averaging over time, the term "average" should be discouraged in favor of the term "equivalent". Hence, Leq, is designated the "equivalent sound level". For Ld, Ln, and Ldn, "equivalent" need not be stated since the concept of day, night, or day-night averaging is by definition understood. Therefore, the designations are "day sound level", "night sound level", and "day-night sound level", respectively.

The peak sound level is the logarithmic ratio of peak sound pressure to a reference pressure and not the maximum root mean square pressure. While the latter is the maximum sound pressure level, it is often incorrectly labelled peak. In that sound level meters have "peak" settings, this distinction is most important.

"Background ambient" should be used in lieu of "background", "ambient", "residual", or "indigenous" to describe the level characteristics of the general background noise due to the contribution of many unidentifiable noise sources near and far.

With regard to units, it is recommended that the unit decibel (abbreviated dB) be used without modification. Hence, DBA, PNdB, and EPNdB are not to be used. Examples of this preferred usage are: the Perceived Noise Level (Lpn was found to be 75 dB. Lpn = 75 dB). This decision was based upon the recommendation of the National Bureau of Standards, and the policies of ANSI and the Acoustical Society of America, all of which disallow any modification of bel except for prefixes indicating its multiples or submultiples (e.g., deci).

Noise Impact

In discussing noise impact, it is recommended that "Level Weighted Population" (LWP) replace "Equivalent Noise Impact" (ENI). The term "Relative Change of Impact" (RCI) shall be used for comparing the relative differences in LWP between two alternatives.

Further, when appropriate, "Noise Impact Index" (NII) and "Population Weighed Loss of Hearing" (PHL) shall be used consistent with CHABA Working Group 69 Report Guidelines for Preparing Environmental Impact Statements (1977).

APPENDIX B (CONTINUED)

TABLE I

A-WEIGHTED RECOMMENDED DESCRIPTOR LIST

	TERM	SYMBOL
1.	A-Weighted Sound Level	L_A
2.	A-Weighted Sound Power Level	L_{WA}
3.	Maximum A-Weighted Sound Level	L_{max}
4.	Peak A-Weighted Sound Level	L_{Apk}
5.	Level Exceeded x% of the Time	L_x
6.	Equivalent Sound Level	L_{eq}
7.	Equivalent Sound Level over Time (T) (1)	$L_{eq(T)}$
8.	Day Sound Level	L_d
9.	Night Sound Level	L_n
10.	Day-Night Sound Level	L_{dn}
11.	Yearly Day-Night Sound Level	$L_{dn(Y)}$
12.	Sound Exposure Level	L_{SE}

(1) Unless otherwise specified, time is in hours (e.g. the hourly equivalent level is $L_{eq(1)}$). Time may be specified in non-quantitative terms (e.g., could be specified a $L_{eq(WASH)}$ to mean the washing cycle noise for a washing machine).

SOURCE: EPA ACOUSTIC TERMINOLOGY GUIDE, BNA 8-14-78,

TABLE II

RECOMMENDED DESCRIPTOR LIST

TERM	A-WEIGHTING	ALTERNATIVE(1) A-WEIGHTING	OTHER(2) WEIGHTING	UNWEIGHTED
1. Sound (Pressure)(3) Level	L_A	L_{pA}	L_B, L_{pB}	L_p
2. Sound Power Level	L_{WA}		L_{WB}	L_W
3. Max. Sound Level	L_{max}	L_{Amax}	L_{Bmax}	L_{pmax}
4. Peak Sound (Pressure) Level	L_{Apk}		L_{Bpk}	L_{pk}
5. Level Exceeded x% of the Time	L_x	L_{Ax}	L_{Bx}	L_{px}
6. Equivalent Sound Level	L_{eq}	L_{Aeq}	L_{Beq}	L_{peq}
7. Equivalent Sound Level (4) Over Time(T)	$L_{eq(T)}$	$L_{Aeq(T)}$	$L_{Beq(T)}$	$L_{peq(T)}$
8. Day Sound Level	L_d	L_{Ad}	L_{Bd}	L_{pd}
9. Night Sound Level	L_n	L_{An}	L_{Bn}	L_{pn}
10. Day-Night Sound Level	L_{dn}	L_{Adn}	L_{Bdn}	L_{pdn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$	$L_{Adn(Y)}$	$L_{Bdn(Y)}$	$L_{pdn(Y)}$
12. Sound Exposure Level	L_S	L_{SA}	L_{SB}	L_{Sp}
13. Energy Average Value Over (Non-Time Domain) Set of Observations	$L_{eq(e)}$	$L_{Aeq(e)}$	$L_{Beq(e)}$	$L_{peq(e)}$
14. Level Exceeded x% of the Total Set of (Non-Time Domain) Observations	$L_{x(e)}$	$L_{Ax(e)}$	$L_{Bx(e)}$	$L_{px(e)}$
15. Average L_x Value	L_x	L_{Ax}	L_{Bx}	L_{px}

(1) "Alternative" symbols may be used to assure clarity or consistency.

(2) Only B-weighting shown. Applies also to C,D,E,.....weighting.

(3) The term "pressure" is used only for the unweighted level.

(4) Unless otherwise specified, time is in hours (e.g., the hourly equivalent level is Leq(1). Time may be specified in non-quantitative terms (e.g., could be specified as Leq(WASH) to mean the washing cycle noise for a washing machine.

LOCATION H-1 Freeway at Puakala (Aiea)
DATE: January 19, 2006

Start Time	End Time	Leq	Lmax	Lmin	Location	Leq @ "A"	Leq Diff.
0538	0553	75.5	82.1	72.8	B	78.2	2.7
0724	0739	72.0	82.7	69.3	C	77.6	5.6
0746	0801	67.9	75.4	64.5	D	78.5	10.6
0803	0818	67.4	73.5	63.8	E	78.4	11.0
0821	0828	65.9	71.1	60.8	F	78.3	12.4
0830	0845	63.0	68.8	58.9	G	78.3	15.3
0924	0939	70.4	80.8	64.1	H	77.6	7.2
0941	0956	71.8	78.6	66.4	I	77.8	6.0
1001	1016	66.1	74.3	61.6	J	77.8	11.7
1018	1029	62.7	71.3	59.5	K	77.6	14.9
1031	1046	66.0	74.6	60.9	L	77.8	11.8
1048	1100	68.0	81.0	62.2	M	77.5	9.5
1102	1117	65.4	74.7	61.4	N	76.9	11.5
1118	1133	66.4	78.6	61.6	O	77.1	10.7

Notes:
a. Leq = Average A-Weighted Sound Level (in dBA)
b. Lmax = Maximum A-Weighted Sound Level (in dBA)
c. Lmin = Minimum A-Weighted Sound Level (in dBA)
d. Leq Diff = Leq @ "A" minus Leq at other measurement location.

LOCATION: H-1 Freeway at Puakala (Aiea)
DATE: January 19, 2006

Start Time	End Time	Leq	Lmax	Lmin	Location
0504	0600	78.3	87.7	72.4	A
0600	0700	77.1	87.6	72.7	A
0700	0800	77.5	88.9	73.3	A
0800	0900	78.3	87.2	72.5	A
0900	1000	77.8	87.5	71.0	A
1000	1100	77.7	93.0	70.4	A
1100	1200	77.0	85.8	68.0	A

Notes:

a. Leq = Average A-Weighted Sound Level (in dBA)
b. Lmax = Maximum A-Weighted Sound Level (in dBA)
c. Lmin = Minimum A-Weighted Sound Level (in dBA)

Appendix B

Supplemental Letter
Traffic Noise Study for H-1 Freeway
At Puakala Street, Poopaa Place,
And Laka Place (Aiea Noise Study)

Y. Ebisu & Associates

Y. Ebisu & Associates
Acoustical and Electronic Engineers

1126 12th Ave., Room 305
Honolulu, Hawaii 96816
Ph. (808) 735-1634 – Fax (808) 732-0409
e-mail: ebisuyassoc@aol.com

YEA Job # 43.051
March 1, 2006

EarthTech
841 Bishop Street, Suite 500
Honolulu, Hawaii 96813

Attention: Mr. Ardalan R. Nikou, P.E.

Subject: Traffic Noise Study for H-1 Freeway At Puakala Street, Poopaa Place, and Laka Place (Aiea Noise Study)

Dear Mr. Nikou:

As requested by the client, additional sound attenuation walls were developed so as to meet the DOTH 66 Leq(h) noise abatement criteria level at all residences. Enclosed are four figures and two tables whose base numbers are keyed to their numbers in the final noise study report of March 2006. These figures and tables are identified with "66 Leq" to differentiate them from the "5 dB minimum attenuation" walls developed in accordance with current DOTH noise abatement policy.

From the enclosed figures and tables; the maximum construction costs for the four walls are as follows:

1. Wall A: 27 x $35,000 = $945,000.
2. Wall B: 24 x $35,000 = $840,000.
3. Wall C: 27 x $35,000 = $945,000.
4. Wall D: 28 x $35,000 = $980,000.

Let me know if you have any questions regarding this information

Sincerely,

Yoichi Ebisu, P.E.

encl.

TABLE 3 (66 Leq)
LIST OF IMPACTED AND BENEFITED RECEPTOR LOCATIONS
(GROUND FLOOR RECEPTOR ELEVATION)

	---------- EXISTING LEQ ----------		
RECEPTOR LOCATION	WITHOUT WALL	WITH WALL A (66Leq)	WITH WALL B (66 Leq)
Rec 9-9-042:029	75.4	**65.6**	**65.8**
Rec 9-9-042:030	74.6	**64.2**	**64.7**
Rec 9-9-042:034a	73.5	**63.4**	**63.6**
Rec 9-9-042:034b (Day Care)	73.1	**63.7**	**63.5**
Location D (Pre-School)	67.4	**59.8**	**59.8**
Location E (Rec. Center)	67.9	**59.9**	**59.8**
Rec 9-9-043:047	72.6	**63.9**	**63.1**
Rec 9-9-043:044	74.4	**65.4**	**64.3**
Rec 9-9-043:006	73.0	**65.9**	**65.2**
Rec 9-9-043:005	72.4	**65.9**	**65.7**
Rec 9-9-043:004	71.1	**65.0**	**65.1**
Rec 9-9-043:048	69.5	**61.5**	**61.4**
Rec 9-9-043:049	68.0	**60.8**	**60.8**
Rec 9-9-043:050	67.0	**60.1**	**60.0**
Rec 9-9-043:051	66.0	**59.9**	**59.8**
Rec 9-9-043:043	70.2	**63.0**	**61.4**
Rec 9-9-043:042	68.8	**62.0**	**60.9**
Rec 9-9-043:041	67.5	**61.2**	**60.2**
Rec 9-9-043:040	66.2	**60.5**	**59.8**
Rec 9-9-043:039	65.8	**60.0**	**59.8**
Rec 9-9-043:019	69.0	**62.6**	**61.9**
Rec 9-9-043:018	69.0	**62.6**	**62.4**
Rec 9-9-043:017	69.0	**62.5**	**62.8**
Rec 9-9-043:022	66.8	**61.2**	62.4
Rec 9-9-043:021	66.8	**61.2**	62.4
Rec 9-9-043:020	66.8	**61.2**	62.4
Rec 9-9-043:025	65.0	**59.9**	**59.8**
Rec 9-9-043:024	65.0	60.7	61.0
Total Number of "Benefited Residences":		27	24

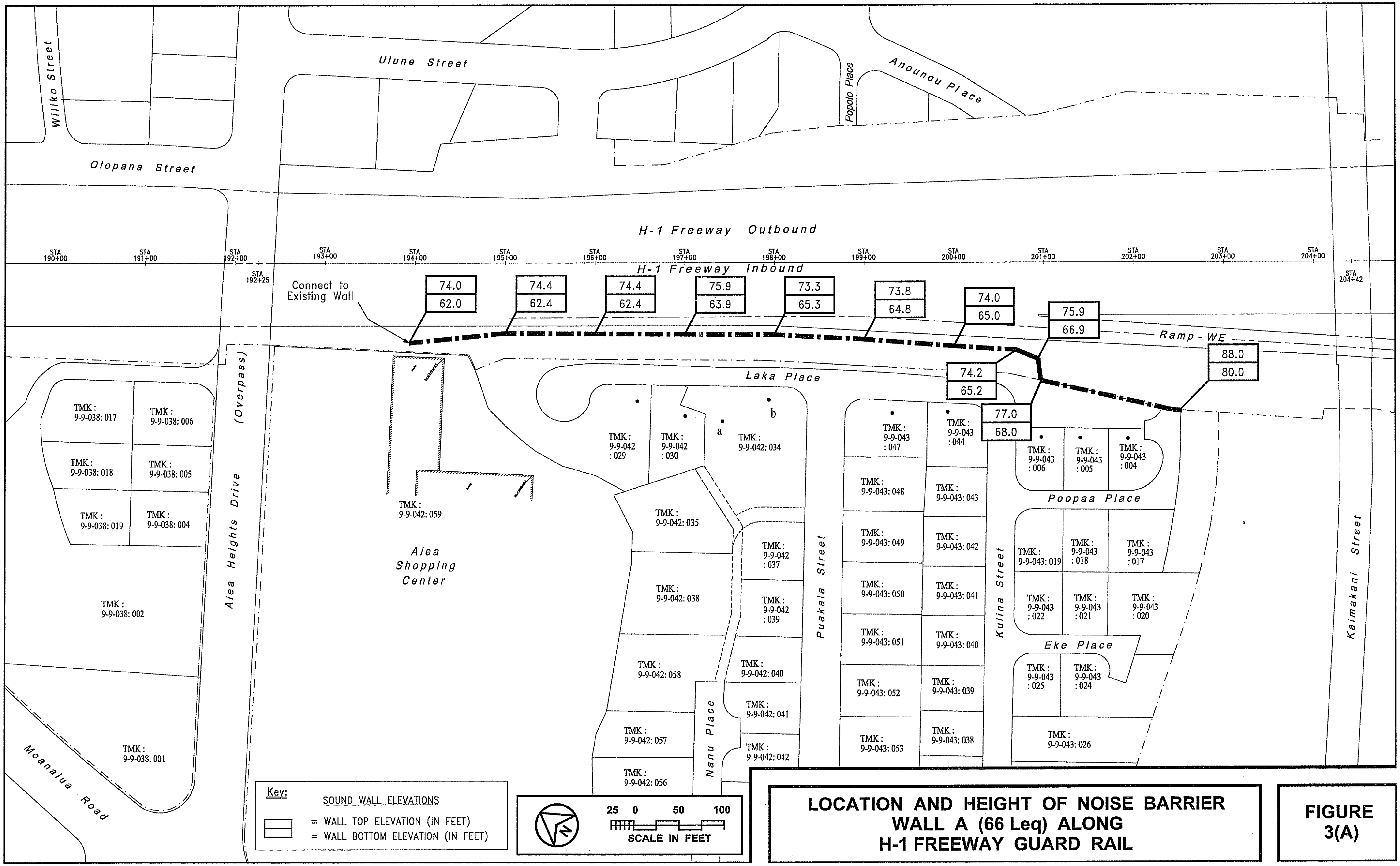
Note: Bold numbers represent "benefited residence".

TABLE 4 (66 Leq)
LIST OF IMPACTED AND BENEFITED RECEPTOR LOCATIONS
(SECOND FLOOR RECEPTOR ELEVATION)

RECEPTOR LOCATION	EXISTING LEQ WITHOUT WALL	WITH WALL C (66 Leq)	WITH WALL D (66 Leq)
Rec 9-9-042:030	74.6	**65.0**	**65.7**
Rec 9-9-042:034b (Church)	75.6	**63.9**	**64.6**
Location D (Pre-School)	68.3	**59.4**	**59.3**
Rec 9-9-043:047	75.0	**63.7**	**64.0**
Rec 9-9-043:044	75.1	**65.9**	**65.7**
Rec 9-9-043:048	72.0	**61.5**	**62.0**
Rec 9-9-043:049	70.0	**60.8**	**60.9**
Rec 9-9-043:050	68.2	**59.9**	**60.0**
Rec 9-9-043:051	67.0	**59.1**	**59.2**
Rec 9-9-043:043	71.2	**63.1**	**62.4**
Rec 9-9-043:039	66.2	**59.8**	**59.0**
Rec 9-9-043:019	70.1	**62.8**	**62.0**
Rec 9-9-043:017	70.1	65.6	65.2
Rec 9-9-043:022	68.1	**63.0**	**63.0**
Rec 9-9-043:021	68.1	**63.0**	**63.0**
Rec 9-9-043:020	68.1	**63.0**	**63.0**
Rec 9-9-043:025	66.0	**59.5**	**59.0**
Rec 9-9-043:024	66.0	62.4	62.2
Total Number of Additional "Benefited Residences":		0	4 *

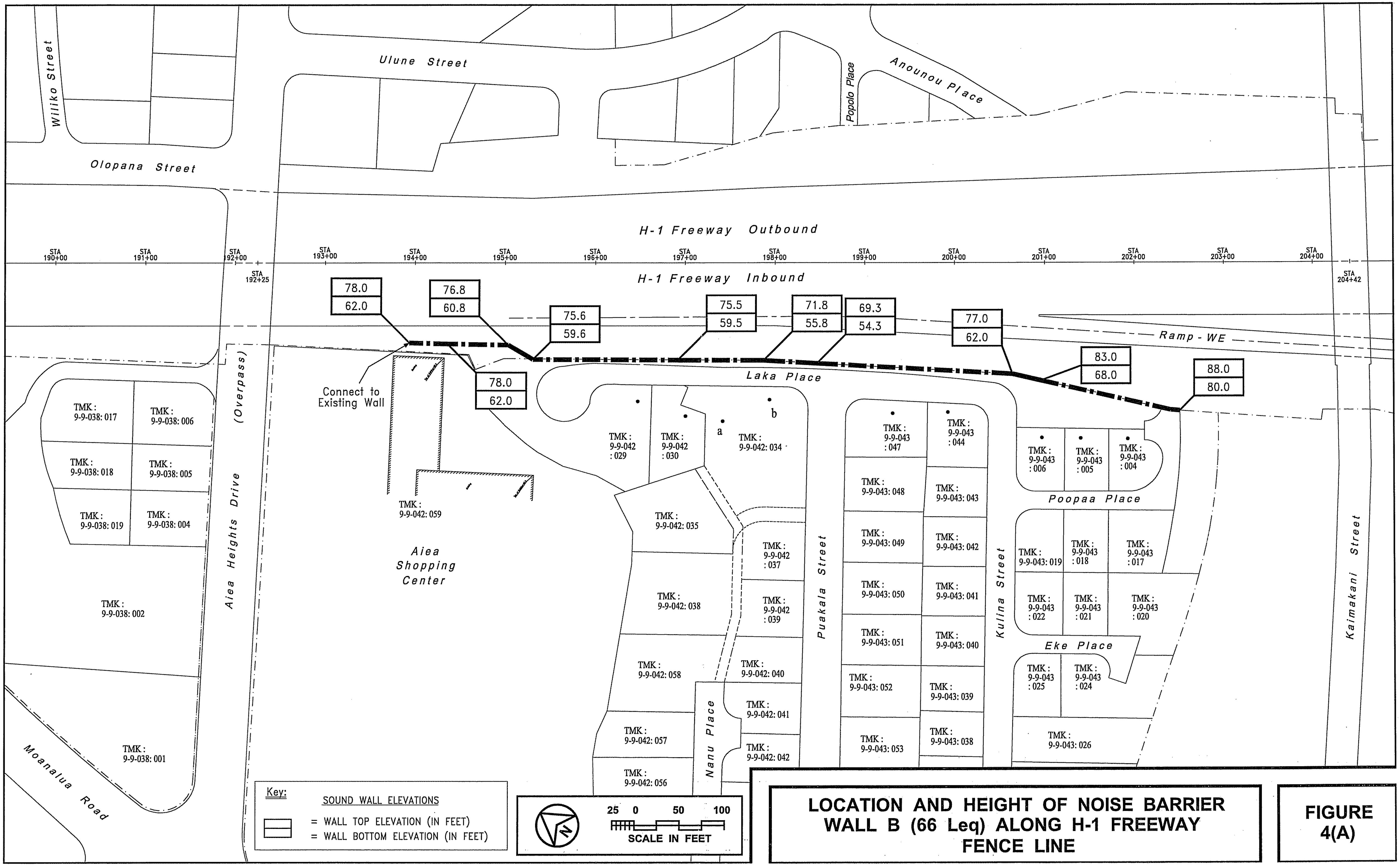
Notes: Bold, underlined numbers represent "benefited residence" also counted with Wall A or Wall B.

* One additional single story structure (Lot 24) benefited by Wall D but not Wall B.



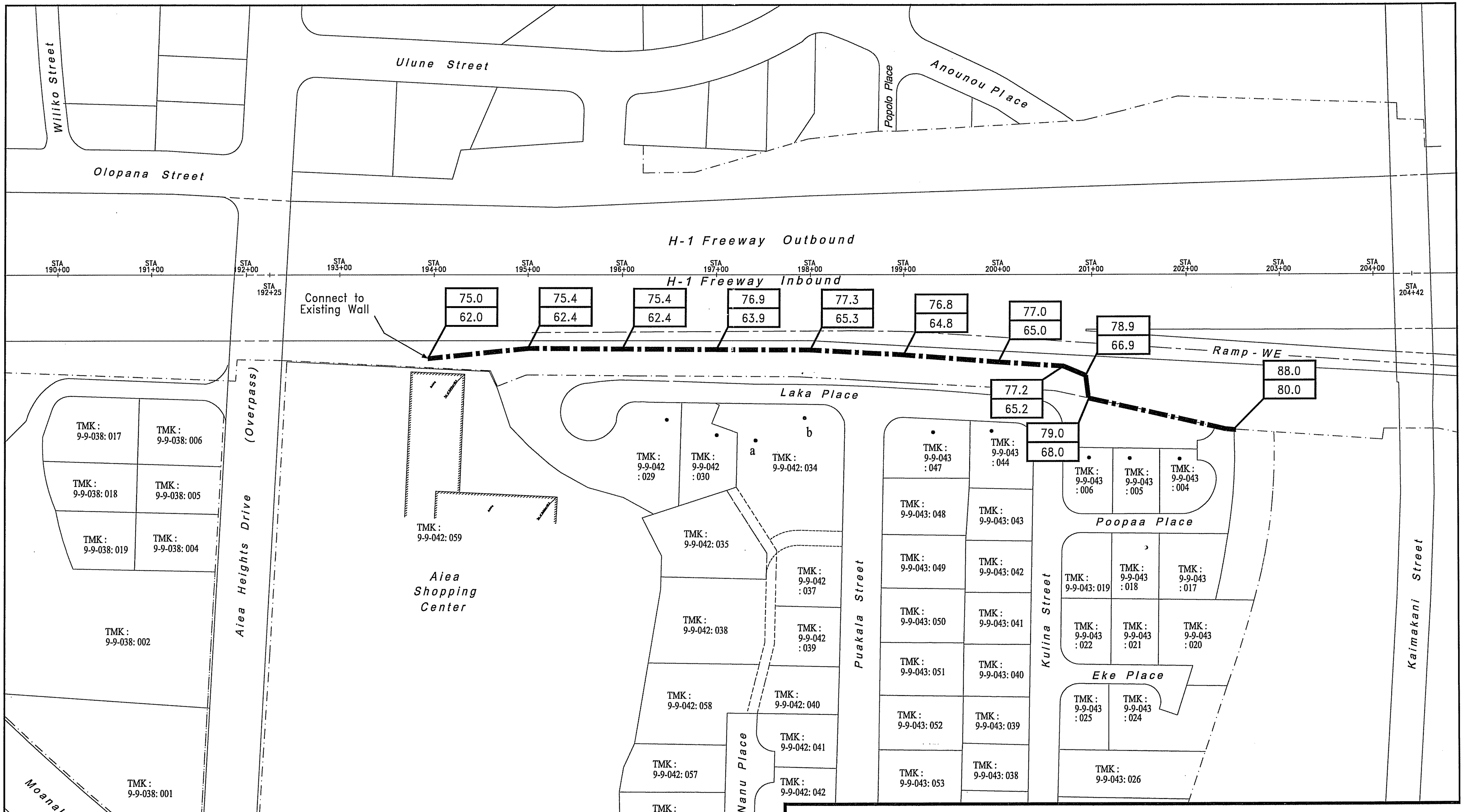
LOCATION AND HEIGHT OF NOISE BARRIER WALL A (66 Leq) ALONG H-1 FREEWAY GUARD RAIL

FIGURE 3(A)



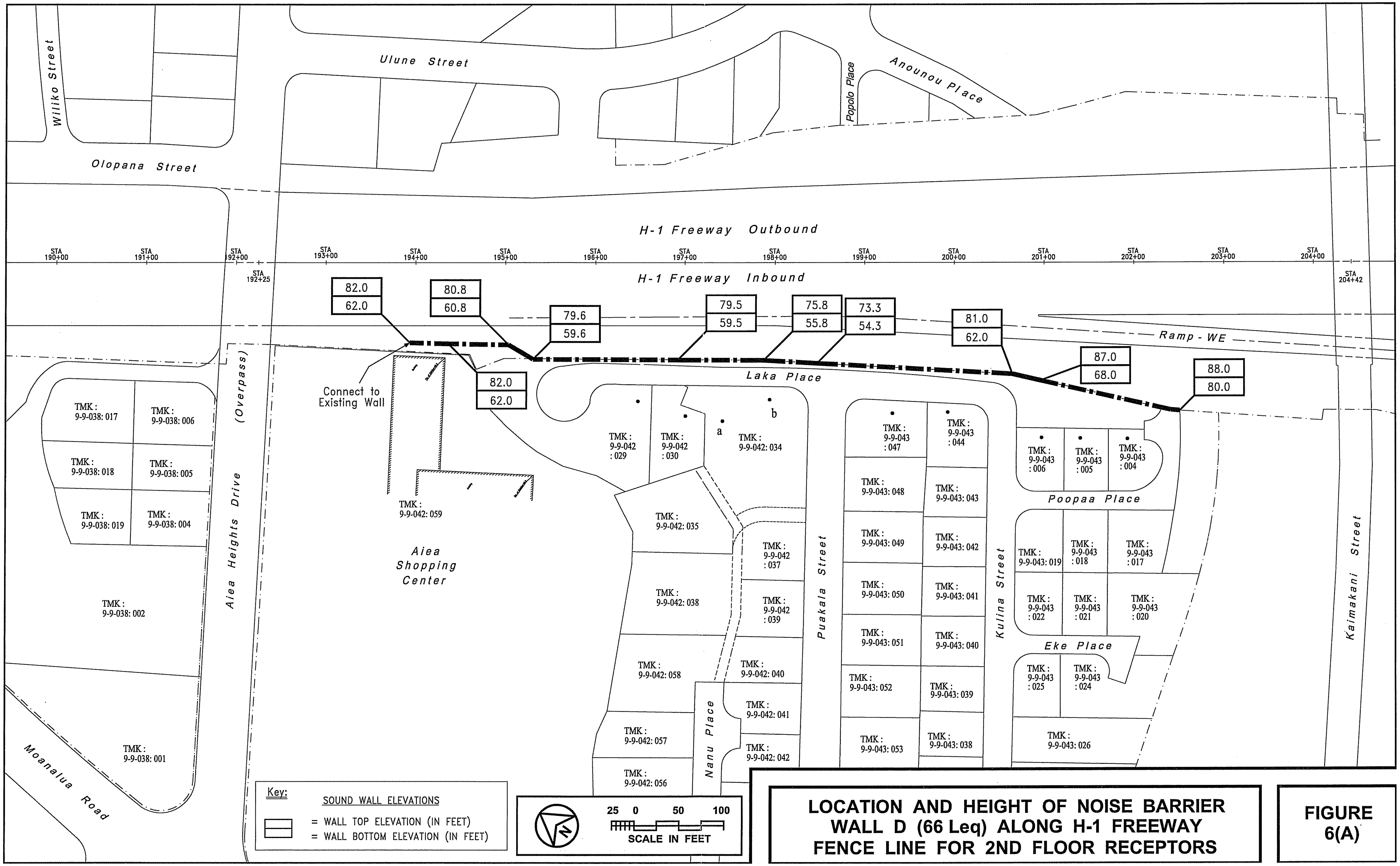
LOCATION AND HEIGHT OF NOISE BARRIER WALL B (66 Leq) ALONG H-1 FREEWAY FENCE LINE

FIGURE 4(A)



LOCATION AND HEIGHT OF NOISE BARRIER WALL C (66 Leq) ALONG H-1 FREEWAY GUARD RAIL FOR 2ND FLOOR RECEPTORS

FIGURE 5(A)



LOCATION AND HEIGHT OF NOISE BARRIER WALL D (66 Leq) ALONG H-1 FREEWAY FENCE LINE FOR 2ND FLOOR RECEPTORS

FIGURE 6(A)

Appendix C

HDOT Standard Specifications
Section 513 – Concrete Masonry Unit

Make the following a part of the Standard Specifications:

ASECTION 513 - CONCRETE MASONRY UNIT

513.01 Description. This section is for constructing concrete masonry unit walls according to the contract.

513.02 Materials. Materials shall conform to the following:

Portland Cement	701.01
Hollow Concrete Masonry Units	704.03
Reinforcing Steel	709.01
Curing Materials	711.01
Water	712.01
Hydrated Lime	712.03

Aggregates for use in mortar shall conform to ASTM C 144.

Aggregates for use in grout shall be 3/8 inch pea gravel conforming to ASTM C404 and grades according to ASTM D 448, No. 10.

Admixture, if used, shall conform to ASTM C 494, Type A or D and shall be mixed in proper amounts according to the directions of the manufacturer.

Horizontal joint reinforcement shall be trussed of ladder design with No. 9 gage, deformed side rods and welded No. 12 gage or larger cross rods, or as indicted on the plans.

Masonry cement shall be of such quality that one part masonry cement to 2-1/2 parts masonry aggregate mix tested according to ASTM C 270 shall have minimum 28 day compressive strength of 2,000 psi.

513.03 Construction Requirements.

(A) Foundation, form work, removal of forms, placing of concrete, curing and jointing shall conform to the applicable subsections of Section 503 - Concrete Structures.

(B) Fabricate concrete masonry units by adding integral pure-color concentrate number 641, manufactured by Davis Colors, at an addition rate of 1 pound per sack of cement and cured with Davis Clear (or Color Seal II in a matching Color).

Carefully stack masonry units prior to use and protect from physical damage. Handle units with reasonable care to prevent marring or damage of faces, edges and corners. Do not dump units from hand truck or wheelbarrows.

Beds on which masonry is to be laid shall be clean and truly level. Construct masonry units plumb, level and true. Masonry units in walls shall be constructed so that the exposed face is laid true and flat. All cutting and fitting as may be required for maintaining wall profiles and necessary to accommodate other trades shall be done neatly using power driven carborundum saw. The Contractor is responsible for controlling any dust pollution caused by the cutting operation. Do not wet masonry unit before use.

Lay mortar units in the first course with mortar beds not exceeding 3/4 inch in thickness. Webs adjoining cells containing reinforcements shall also be bedded in mortar to prevent escape of grout. Butter vertical head joints well for a thickness equal to face shell of block. These joints shall be shoved tightly so that mortar bonds well to both blocks. Fill joints solidly from face of block to depth of face shell.

The allowable tolerance from plumb for walls shall be 1/4 inch for every 10 foot height or a proportion thereof. The allowable tolerance from level shall be 1/4 inch for any 20 foot length or a proportion thereof.

Mortar joints shall be straight, clean and in thickness of 3/8 inch plus or minus 1/8 inch. Tool all exposed horizontal and vertical joints with 2 inch to 5/8 inch round bar at least 14 inches long to produce a dense, slightly concave surface well bonded to block at edges. Tooling shall compact mortar, pressing excess mortar out of joint rather than gouging it out.

Build all hollow masonry units to preserve unobstructed vertical continuity of cells to be filled. Walls and cross webs forming such cells shall be full-bedded in mortar to prevent leakage of grout.

Place joint reinforcement in horizontal joints so that longitudinal wires are fully embedded in face shell mortar for their entire length. Reinforce horizontal masonry unit bond beam and fill solid with grout.

Fill all cells containing vertical reinforcements with grout in lifts not exceeding 8 feet unless otherwise shown on the plans. When grouting is stopped for one hour or longer, form construction joints by stopping pour of grout 1-1/2 inches below the top of the uppermost unit. Do not place grout until mortar joints have set a minimum of 24 hours.

Care shall be taken to prevent mortar splotches. Wash off mortar spilled on wall immediately before it can set up. Protect finished walls against stains and mortar spills as work progresses. After the wall is constructed, do not saturate it with water for curing, cleaning, etc.

Point all holes or defective mortar joints in exposed masonry and where necessary, cut out defective joints and repoint. Smoothing of walls which produces >bright spots= will not be accepted. Protect adjoining work from damage.

(C) Mortar and Grout. Store Portland cement, masonry cement, lime and admixtures in such a manner as to prevent deterioration or contamination with foreign matter. Cement which has become caked, partially set or otherwise deteriorated or any material which becomes damaged or contaminated shall be rejected.

Proportion materials for mortar and grout by volume and in such manner that specified proportions can be controlled and accurately maintained. Fine aggregates shall be measured in damp loose condition. Mixing shall be by mechanical batch mixer for at least 3 minutes for mortar and 5 minutes for grout. Hand mixing shall be permitted only for small batches of 3 cubic feet or less.

(1) Mortar shall be freshly prepared and uniformly mixed in one of the following proportions:

(a) 1 part masonry cement
1 part Portland Cement
4-1/2 to 6 parts sand

(b) 1 part masonry cement
2-1/2 parts sand

Admixtures may be added in accordance with the manufacturer=s specifications. Add sufficient water to provide workable consistency.

Place mortar in final position within 1-1/2 hours after mixing. In any event, mortar shall attain not less than 2,000 psi, 28 day compressive strength.

(2) Grout shall be freshly prepared and uniformly mixed in the following proportion:

1 part Portland Cement
2 parts sand
1 part pea gravel
1/10 part lime to one part Portland Cement

Add sufficient water to produce consistency just fluid enough for pouring without segregation. Slump shall be between 9 and 11 inches. Place grout in final position within 90 minutes after mixing. Do not use grout after initial set has occurred. In any event, grout shall attain not less than 2,500 psi, 28 day compressive strength.

(D) Reinforcements. Reinforcements shall be free from scale, loose flaky rust or other coatings that will destroy the bond. Reinforcements shall be straight except for bends around corners or where bends or hooks are detailed. Size and spacing shall be accurate and shall be as indicated on the plans.

Place and tie vertical reinforcements at top and bottom and at intervals not to exceed 192 diameters of reinforcement. Lap dowels and splices as indicated but not less than 40 diameters or 24 inches, whichever is longer.

513.04 Method of Measurement. Concrete masonry units will be paid on a lump sum basis. Measurement for payment will not apply.

513.05 Basis of Payment. The Engineer will pay for the accepted concrete masonry units on a lump sum basis. Payment will be full compensation for the work prscribed in this section and the contract documents.

The Engineer will pay for the following pay item when included in the proposal schedule.

Pay Item	**Pay Unit**
Type _____ CMU Noise Barrier	Lump Sum≅

END OF SECTION 513

Appendix D

Estimated Quantities and Itemized Cost Breakdown

Interstate Route H-1 Noise Study - Guardrail Alignment, Wall A

Quantities

			CMU Wall		Footing Dimensions			Excavation		
Station	Length (ft)	Height (ft)	Height (ft)	Area (sf)	Depth (ft)	Width (ft)	Vol (cf)	Depth (ft)	Width (ft)	Vol (cf)
0+00		4.00								
0+80	80.00	4.00	4.00	320.00	0.00	0.00	0.00	0.00	0.00	0.00
1+07	27.00	8.00	4.00	108.00	4.50	2.00	243.00	5.50	3.00	445.50
2+07	100.00	8.00	4.00	400.00	4.50	2.00	900.00	5.50	3.00	1650.00
3+07	100.00	8.00	4.00	400.00	4.50	2.00	900.00	5.50	3.00	1650.00
4+07	100.00	8.67	4.67	467.00	5.17	2.00	1034.00	6.17	3.00	1851.00
5+07	100.00	8.67	4.67	467.00	5.17	2.00	1034.00	6.17	3.00	1851.00
6+08	101.00	8.67	4.67	471.67	5.17	2.00	1044.34	6.17	3.00	1869.51
6+78	70.00	8.67	4.67	326.90	5.17	2.00	723.80	6.17	3.00	1295.70
7+03	25.00	8.67	8.67	216.75	5.17	1.50	193.88	6.17	2.50	385.63
7+28	25.00	8.67	8.67	216.75	5.17	1.50	193.88	6.17	2.50	385.63
8+86	158.00	8.67	8.67	1369.86	5.17	1.50	1225.29	6.17	2.50	2437.15
	886		Sq Ft	4444			7492			13821
						Cubic Yards	277		Cubic Yards	512

Cost Estimate		Unit Cost	Quantity	Unit	Total Cost
202.1000	Remove Ex 6' High Chain Link Fence	$5.00	200	CY	$1,000
202.2000	Remove Ex Guardrail	$16.50	600	CY	$9,900
206.1000	Structural Excavation	$47.00	512	CY	$24,059
401.1000	Asphalt Pavement Restoration	$125.00	70	SY	$8,750
503.1000	Concrete Footing	$780.00	277	CY	$216,441
503.2000	Concrete Masonry Wall	$18.00	4444	SF	$79,991
503.3000	Concrete Barrier Wall	$325.00	600	LF	$195,000
601.1000	Grated Drop Inlet	$3,270.00	1	SF	$3,270
619.1000	Landscape Resotration			LS	$2,000
622.1000	Electrical Restoration			LS	$5,000
645.1000	Traffic Control			LS	$75,000
699.1000	Mobilization (not to exceed 10%)			LS	$62,041
	Subtotal				$671,552
	Contingency (10%)				$67,155
	Estimated Constuction Cost				**$738,707**

Interstate Route H-1 Noise Study - Right-of-Way Alignment, Wall B

Quantities

		Wall Dimensions						Footing Dimensions			Excavation		
Station	Length (ft)	Height (ft)	Ave Ht (ft)	8" Ht (ft)	Area (sf)	12" Ht (ft)	Area (sf)	Depth (ft)	Width (ft)	Vol (cf)	Depth (ft)	Width (ft)	Vol (cf)
0+00		9.33											
0+43	43.00	9.33	9.33	8.00	344.00	1.33	57.19	0.00	0.00	0.00	0.00	0.00	0.00
0+80	37.00	9.33	9.33	8.00	296.00	1.33	49.21	0.00	0.00	0.00	0.00	0.00	0.00
1+10	30.00	13.33	13.33	8.00	240.00	5.33	159.90	1.25	5.00	187.50	3.75	6.00	675.00
1+40	30.00	13.33	13.33	8.00	240.00	5.33	159.90	1.25	5.00	187.50	3.75	6.00	675.00
3+02	162.00	13.33	13.33	8.00	1296.00	5.33	863.46	1.25	5.00	1012.50	3.75	6.00	3645.00
3+97	95.00	13.33	13.33	8.00	760.00	5.33	506.35	1.25	5.00	593.75	3.75	6.00	2137.50
4+56	59.00	14.00	13.67	8.00	472.00	5.67	334.24	1.25	5.00	368.75	3.75	6.00	1327.50
5+00	44.00	15.33	14.67	8.00	352.00	6.67	293.26	1.25	5.00	275.00	3.75	6.00	990.00
6+70	170.00	18.00	16.67	8.00	1360.00	8.67	1473.05	1.25	5.00	1062.50	3.75	6.00	3825.00
7+05	35.00	14.00	16.00	8.00	280.00	8.00	280.00	1.25	5.00	218.75	3.75	6.00	787.50
8+63	158.00	10.00	12.00	8.00	1264.00	4.00	632.00	1.25	5.00	987.50	3.75	6.00	3555.00
	863		Sq Ft		6904		4809			4894			17618
									Cubic Yards	181		Cubic Yards	653

Cost Estimate		Unit Cost	Quantity	Unit	Total Cost
202.1000	Remove Ex 6' Chain Link Fence	$5.00	863	LF	$4,315
206.1000	Structural Excavation	$47.00	653	CY	$30,668
503.1000	Concrete Footing	$780.00	181	CY	$141,375
503.2000	Concrete Wall (8" thick)	$18.00	6904	SF	$124,272
503.2100	Concrete Wall (12" thick)	$25.00	4809	SF	$120,214
511.2000	Drilled Cassion 15" dia, 12' deep @ 10' oc	$3,200.00	61	EA	$195,200
511.3000	Drilled Cassion 18" dia, 15' deep @ 10' oc	$4,000.00	17	EA	$68,000
619.1000	Landscape Resotration			LS	$10,000
622.1000	Electrical Restoration			LS	$5,000
645.1000	Traffic Control			LS	$50,000
699.1000	Mobilization (not to exceed 10%)			LS	$74,904
	Subtotal				$819,633
	Contingency (10%)				$81,963
	Estimated Constuction Cost				**$901,596**

Interstate Route H-1 Noise Study - Guardrail Alignment, Wall C

Quantities

			CMU Wall		Footing Dimensions			Excavation		
Station	Length (ft)	Height (ft)	Height (ft)	Area (sf)	Depth (ft)	Width (ft)	Vol (cf)	Depth (ft)	Width (ft)	Vol (cf)
0+00		6.00								
0+80	80.00	6.00	6.00	480.00	0.00	0.00	0.00	0.00	0.00	0.00
1+07	27.00	10.00	6.00	162.00	5.17	2.00	279.18	6.17	3.00	499.77
2+07	100.00	10.00	6.00	600.00	5.17	2.00	1034.00	6.17	3.00	1851.00
3+07	100.00	10.00	6.00	600.00	5.17	2.00	1034.00	6.17	3.00	1851.00
4+07	100.00	10.67	6.67	667.00	5.83	2.00	1166.00	6.83	3.00	2049.00
5+07	100.00	10.67	6.67	667.00	5.83	2.00	1166.00	6.83	3.00	2049.00
6+08	101.00	10.00	6.00	606.00	5.17	2.00	1044.34	6.17	3.00	1869.51
6+78	70.00	10.00	6.00	420.00	5.17	2.00	723.80	6.17	3.00	1295.70
7+03	25.00	10.00	10.00	250.00	5.17	1.50	193.88	6.17	2.50	385.63
7+28	25.00	10.00	10.00	250.00	5.17	1.50	193.88	6.17	2.50	385.63
8+86	158.00	8.67	8.67	1369.86	5.17	1.50	1225.29	6.17	2.50	2437.15
	886			6072			8060			14673
						Cubic Yards	299		Cubic Yards	543

Cost Estimate		Unit Cost	Quantity	Unit	Total Cost
202.1000	Remove Ex 6' High Chain Link Fence	$5.00	200	CY	$1,000
202.2000	Remove Ex Guardrail	$16.50	600	CY	$9,900
206.1000	Structural Excavation	$47.00	543	CY	$25,543
401.1000	Asphalt Pavement Restoration	$125.00	70	SY	$8,750
503.1000	Concrete Footing	$780.00	299	CY	$232,855
503.2000	Concrete Masonry Wall	$18.00	6072	SF	$109,293
503.3000	Concrete Barrier Wall	$325.00	600	LF	$195,000
601.1000	Grated Drop Inlet	$3,270.00	1	SF	$3,270
619.1000	Landscape Resotration			LS	$2,000
622.1000	Electrical Restoration			LS	$5,000
645.1000	Traffic Control			LS	$75,000
699.1000	Mobilization (not to exceed 10%)			LS	$66,761
	Subtotal				$723,472
	Contingency (10%)				$72,347
	Estimated Constuction Cost				**$795,819**

Interstate Route H-1 Noise Study - Right-of-Way Alignment, 2nd Floor Receptors, Wall D

Quantities

		Wall Dimensions						Footing Dimensions			Excavation		
Station	Length (ft)	Height (ft)	Ave Ht (ft)	8" Ht (ft)	Area (sf)	12" Ht (ft)	Area (sf)	Depth (ft)	Width (ft)	Vol (cf)	Depth (ft)	Width (ft)	Vol (cf)
0+00		9.33											
0+43	43.00	9.33	9.33	8.00	344.00	1.33	57.19	0.00	0.00	0.00	0.00	0.00	0.00
0+80	37.00	9.33	9.33	8.00	296.00	1.33	49.21	0.00	0.00	0.00	0.00	0.00	0.00
1+10	30.00	13.33	13.33	8.00	240.00	5.33	159.90	1.25	5.00	187.50	3.75	5.00	562.50
1+40	30.00	17.33	15.33	8.00	240.00	7.33	219.90	1.25	5.00	187.50	3.75	6.00	675.00
3+02	162.00	17.33	17.33	8.00	1296.00	9.33	1511.46	1.25	5.00	1012.50	3.75	6.00	3645.00
3+97	95.00	17.33	17.33	8.00	760.00	9.33	886.35	1.25	5.00	593.75	3.75	6.00	2137.50
4+56	59.00	17.33	17.33	8.00	472.00	9.33	550.47	1.25	5.00	368.75	3.75	6.00	1327.50
5+00	44.00	17.33	17.33	8.00	352.00	9.33	410.52	1.25	5.00	275.00	3.75	6.00	990.00
6+70	170.00	20.00	18.67	8.00	1360.00	10.67	1813.05	1.25	6.00	1275.00	3.75	6.00	3825.00
7+05	35.00	14.00	17.00	8.00	280.00	9.00	315.00	1.25	5.00	218.75	3.75	6.00	787.50
8+63	158.00	10.00	12.00	8.00	1264.00	4.00	632.00	1.25	5.00	987.50	3.75	5.00	2962.50
	863		Sq Ft		6904		6605			5106			16913
									Cubic Yards	189		Cubic Yards	626

Cost Estimate

		Unit Cost	Quantity	Unit	Total Cost
202.1000	Remove Ex 6' Chain Link Fence	$5.00	863	LF	$4,315
206.1000	Structural Excavation	$47.00	626	CY	$29,440
503.1000	Concrete Footing	$780.00	189	CY	$147,514
503.2000	Concrete Wall (8" thick)	$18.00	6904	SF	$124,272
503.2100	Concrete Wall (12" thick)	$25.00	6605	SF	$165,126
511.2000	Drilled Cassion 15" dia, 12' deep @ 10' oc	$3,200.00	61	EA	$195,200
511.3000	Drilled Cassion 18" dia, 15' deep @ 10' oc	$4,000.00	17	EA	$68,000
619.1000	Landscape Resotration			LS	$10,000
622.1000	Electrical Restoration			LS	$5,000
645.1000	Traffic Control			LS	$50,000
699.1000	Mobilization (not to exceed 10%)			LS	$79,887
	Subtotal				$874,439
	Contingency (10%)				$87,444
	Estimated Constuction Cost				**$961,883**

Interstate Route H-1 Noise Study - Guardrail Alignment, Wall A (66Leq)

Quantities

			CMU Wall		Footing Dimensions			Excavation		
Station	Length (ft)	Height (ft)	Height (ft)	Area (sf)	Depth (ft)	Width (ft)	Vol (cf)	Depth (ft)	Width (ft)	Vol (cf)
0+00		9.33								
0+80	80.00	9.33	9.33	746.40	0.00	0.00	0.00	0.00	0.00	0.00
1+07	27.00	13.33	9.33	251.91	5.83	2.00	314.82	6.83	3.00	553.23
2+07	100.00	13.33	9.33	933.00	5.83	2.00	1166.00	6.83	3.00	2049.00
3+07	100.00	13.33	9.33	933.00	5.83	2.00	1166.00	6.83	3.00	2049.00
4+07	100.00	10.67	8.00	800.00	5.83	2.00	1166.00	6.83	3.00	2049.00
5+07	100.00	10.67	6.67	667.00	5.83	2.00	1166.00	6.83	3.00	2049.00
6+08	101.00	10.00	6.34	639.84	5.17	2.00	1044.34	6.17	3.00	1869.51
6+78	70.00	10.00	6.00	420.00	5.17	2.00	723.80	6.17	3.00	1295.70
7+03	25.00	10.00	10.00	250.00	5.17	1.50	193.88	6.17	2.50	385.63
7+28	25.00	10.00	10.00	250.00	5.17	1.50	193.88	6.17	2.50	385.63
8+86	158.00	8.67	9.34	1474.93	5.17	1.50	1225.29	6.17	2.50	2437.15
	886		Sq Ft	7366			8360			15123
						Cubic Yards	310		Cubic Yards	560

Cost Estimate		Unit Cost	Quantity	Unit	Total Cost
202.1000	Remove Ex 6' Chain Link Fence	$5.00	200	LF	$1,000
202.2000	Remove Ex Guardrail	$16.50	600	LF	$9,900
206.1000	Structural Excavation	$47.00	560	CY	$26,325
401.1000	Asphalt Concrete Pavement	$125.00	70	SY	$8,750
503.1000	Concrete Footing	$780.00	310	CY	$241,511
503.2000	Concrete Wall (8" thick)	$18.00	7366	SF	$132,589
503.3000	Concrete Barrier Wall	$325.00	600	LF	$195,000
601.1000	Grated Drop Inlet	$3,270.00	1	SF	$3,270
619.1000	Landscape Resotration			LS	$2,000
622.1000	Electrical Restoration			LS	$5,000
645.1000	Traffic Control			LS	$75,000
699.1000	Mobilization (not to exceed 10%)			LS	$70,035
	Subtotal				$759,480
	Contingency (10%)				$75,948
	Estimated Constuction Cost				**$835,428**

Interstate Route H-1 Noise Study - Right-of-Way Alignment, Wall B (66Leq)

Quantities

Station	Length (ft)	Wall Dimensions						Footing Dimensions			Excavation		
		Height (ft)	Tot Ht (ft)	8" Ht (ft)	Area (sf)	12" Ht (ft)	Area (sf)	Depth (ft)	Width (ft)	Vol (cf)	Depth (ft)	Width (ft)	Vol (cf)
0+00		13.33											
0+43	43.00	13.33	13.33	8.00	344.00	5.33	229.19	0.00	0.00	0.00	0.00	0.00	0.00
0+80	37.00	13.33	13.33	8.00	296.00	5.33	197.21	0.00	0.00	0.00	0.00	0.00	0.00
1+10	30.00	17.33	17.33	8.00	240.00	9.33	279.90	1.25	5.00	187.50	3.75	6.00	675.00
1+40	30.00	17.33	17.33	8.00	240.00	9.33	279.90	1.25	5.00	187.50	3.75	6.00	675.00
3+02	162.00	17.33	17.33	8.00	1296.00	9.33	1511.46	1.25	5.00	1012.50	3.75	6.00	3645.00
3+97	95.00	17.33	17.33	8.00	760.00	9.33	886.35	1.25	5.00	593.75	3.75	6.00	2137.50
4+56	59.00	16.00	16.67	8.00	472.00	8.67	511.24	1.25	5.00	368.75	3.75	6.00	1327.50
5+00	44.00	18.00	17.00	8.00	352.00	9.00	396.00	1.25	5.00	275.00	3.75	6.00	990.00
6+70	170.00	20.00	19.00	8.00	1360.00	11.00	1870.00	1.25	6.00	1275.00	3.75	7.00	4462.50
7+05	35.00	16.00	18.00	8.00	280.00	10.00	350.00	1.25	6.00	262.50	3.75	7.00	918.75
8+63	158.00	10.00	13.00	8.00	1264.00	5.00	790.00	1.25	5.00	987.50	3.75	6.00	3555.00
	863		Sq Ft		6904		7301			5150			18386
									Cubic Yards	191		Cubic Yards	681

Cost Estimate

		Unit Cost	Quantity	Unit	Total Cost
202.1000	Remove Ex 6' Chain Link Fence	$5.00	863	LF	$4,315
206.1000	Structural Excavation	$47.00	681	CY	$32,006
503.1000	Concrete Footing	$780.00	191	CY	$148,778
503.2000	Concrete Wall (8" thick)	$18.00	6904	SF	$124,272
503.2100	Concrete Wall (12" thick)	$25.00	7301	SF	$182,531
511.2000	Drilled Cassion 15" dia, 12' deep @ 10' oc	$3,200.00	57	EA	$182,400
511.3000	Drilled Cassion 18" dia, 15' deep @ 10' oc	$4,000.00	21	EA	$84,000
619.1000	Landscape Resotration			LS	$10,000
622.1000	Electrical Restoration			LS	$5,000
645.1000	Traffic Control			LS	$50,000
699.1000	Mobilization (not to exceed 10%)			LS	$82,330
	Subtotal				$901,317
	Contingency (10%)				$90,132
	Estimated Constuction Cost				**$991,448**

Interstate Route H-1 Noise Study - Guardrail Alignment, 2nd Floor Receptors, Wall C (66Leq)

Quantities

			CMU Wall		Footing Dimensions			Excavation		
Station	Length (ft)	Height (ft)	Height (ft)	Area (sf)	Depth (ft)	Width (ft)	Vol (cf)	Depth (ft)	Width (ft)	Vol (cf)
0+00		10.00								
0+80	80.00	10.00	10.00	800.00	0.00	0.00	0.00	0.00	0.00	0.00
1+07	27.00	14.00	10.00	270.00	5.83	2.00	314.82	6.83	3.00	553.23
2+07	100.00	14.00	10.00	1000.00	5.83	2.00	1166.00	6.83	3.00	2049.00
3+07	100.00	14.00	10.00	1000.00	5.83	2.00	1166.00	6.83	3.00	2049.00
4+07	100.00	13.33	9.67	967.00	5.83	2.00	1166.00	6.83	3.00	2049.00
5+07	100.00	13.33	9.67	967.00	5.83	2.00	1166.00	6.83	3.00	2049.00
6+08	101.00	13.33	9.67	976.67	5.83	2.00	1177.66	6.83	3.00	2069.49
6+78	70.00	13.33	9.67	676.90	5.83	2.00	816.20	6.83	3.00	1434.30
7+03	25.00	12.67	12.67	316.75	5.83	1.50	218.63	6.83	2.50	426.88
7+28	25.00	12.67	12.67	316.75	5.83	1.50	218.63	6.83	2.50	426.88
8+86	158.00	8.67	10.67	1685.86	5.83	1.50	1381.71	6.83	2.50	2697.85
	886		Sq Ft	8977			8792			15805
						Cubic Yards	326		Cubic Yards	585

Cost Estimate		Unit Cost	Quantity	Unit	Total Cost
202.1000	Remove Ex 6' Chain Link Fence	$5.00	200	LF	$1,000
202.2000	Remove Ex Guardrail	$16.50	600	LF	$9,900
206.1000	Structural Excavation	$47.00	585	CY	$27,512
401.1000	Asphalt Concrete Pavement	$125.00	70	SY	$8,750
503.1000	Concrete Footing	$780.00	326	CY	$253,981
503.2000	Concrete Wall (8" thick)	$18.00	8977	SF	$161,585
503.3000	Concrete Barrier Wall	$325.00	600	LF	$195,000
601.1000	Grated Drop Inlet	$3,270.00	1	SF	$3,270
619.1000	Landscape Resotration			LS	$2,000
622.1000	Electrical Restoration			LS	$5,000
645.1000	Traffic Control			LS	$75,000
699.1000	Mobilization (not to exceed 10%)			LS	$74,300
	Subtotal				$806,397
	Contingency (10%)				$80,640
	Estimated Constuction Cost				**$887,037**

Interstate Route H-1 Noise Study - Right-of-Way Alignment, 2nd Floor Receptors, Wall D (66Leq)

Quantities

Station	Length (ft)	Wall Dimensions						Footing Dimensions			Excavation		
		Height (ft)	Tot Ht (ft)	8" Ht (ft)	Area (sf)	12" Ht (ft)	Area (sf)	Depth (ft)	Width (ft)	Vol (cf)	Depth (ft)	Width (ft)	Vol (cf)
0+00		17.33											
0+43	43.00	17.33	17.33	8.00	344.00	9.33	401.19	0.00	0.00	0.00	0.00	0.00	0.00
0+80	37.00	17.33	17.33	8.00	296.00	9.33	345.21	0.00	0.00	0.00	0.00	0.00	0.00
1+10	30.00	21.33	21.33	8.00	240.00	13.33	399.90	1.25	6.00	225.00	3.75	7.00	787.50
1+40	30.00	21.33	21.33	8.00	240.00	13.33	399.90	1.25	6.00	225.00	3.75	7.00	787.50
3+02	162.00	21.33	21.33	8.00	1296.00	13.33	2159.46	1.25	6.00	1215.00	3.75	7.00	4252.50
3+97	95.00	21.33	21.33	8.00	760.00	13.33	1266.35	1.25	6.00	712.50	3.75	7.00	2493.75
4+56	59.00	20.00	20.67	8.00	472.00	12.67	747.24	1.25	6.00	442.50	3.75	7.00	1548.75
5+00	44.00	21.33	20.67	8.00	352.00	12.67	557.26	1.25	6.00	330.00	3.75	7.00	1155.00
6+70	170.00	24.00	22.67	8.00	1360.00	14.67	2493.05	1.25	6.00	1275.00	3.75	7.00	4462.50
7+05	35.00	20.00	22.00	8.00	280.00	14.00	490.00	1.25	6.00	262.50	3.75	7.00	918.75
8+63	158.00	10.00	15.00	8.00	1264.00	7.00	1106.00	1.25	5.00	987.50	3.75	6.00	3555.00
	863		Sq Ft		6904		10366			5675			19961
									Cubic Yards	210		Cubic Yards	739

Cost Estimate

		Unit Cost	Quantity	Unit	Total Cost
202.1000	Remove Ex 6' Chain Link Fence	$5.00	863	LF	$4,315
206.1000	Structural Excavation	$47.00	739	CY	$34,747
503.1000	Concrete Footing	$780.00	210	CY	$163,944
503.2000	Concrete Wall (8" thick)	$18.00	6904	SF	$124,272
503.2100	Concrete Wall (12" thick)	$25.00	10366	SF	$259,139
511.2000	Drilled Cassion 15" dia, 12' deep @ 10' oc	$3,200.00	57	EA	$182,400
511.3000	Drilled Cassion 18" dia, 15' deep @ 10' oc	$4,000.00	21	EA	$84,000
619.1000	Landscape Resotration			LS	$10,000
622.1000	Electrical Restoration			LS	$5,000
645.1000	Traffic Control			LS	$50,000
699.1000	Mobilization (not to exceed 10%)			LS	$91,782
	Subtotal				$1,005,284
	Contingency (10%)				$100,528
	Estimated Constuction Cost				**$1,105,813**

Appendix E

Chapter 1100
Highway Traffic Noise Abatement
Caltrans Highway Design Manual
November 1, 2001
Last Update 12-20-04

CHAPTER 1100 HIGHWAY TRAFFIC NOISE ABATEMENT

Topic 1101 - General Requirements

Index 1101.1 - Introduction

The abatement of highway traffic noise is a design consideration that is required by State and Federal Statutes and regulations and by Caltrans policy. This chapter provides design standards relating to the location, height and length of noise barriers and includes discussion on alternative designs, maintenance and emergency access considerations and aesthetics of noise barriers. Procedures and policies on minimum attenuation, design goals, assessing noise impacts, noise abatement criteria levels, priorities, reasonableness and feasibility, and cost-effectiveness are contained in the Project Development Procedures Manual and the Environmental Handbook.

1101.2 Objective

The objectives are: for new construction or reconstruction of highways, to limit the intrusion of highway noise into adjacent areas; on existing freeways to limit the noise intrusion to achievable levels within practical and financial limitations; and to limit the noise to the levels specified by statute for qualifying schools adjacent to freeways. To achieve these objectives the Department supports the following four approaches to alleviate traffic noise impacts:

(1) *Reduction at the Source.* Reduction of traffic noise at the source is the most effective control. Therefore, Caltrans encourages and supports legislation to require reduction in motor vehicle noise as advances in the state-of-the-art of motor vehicle engineering permit.

(2) *Encouraging Compatible Adjacent Land Use.* Caltrans encourages those who plan and develop land and local governments controlling development or planning land use near known highway locations to exercise their powers and responsibility to minimize the effect of highway vehicle noise through appropriate land use control. For example, cities and counties have the power to control development by the adoption of land use plans and zoning, subdivision, building and housing regulations.

(3) *Noise Abatement.* Caltrans will attempt to locate, design, construct, and operate State highways to minimize the intrusion of traffic noise into adjacent areas. When this is not possible, noise impacts may be attenuated by the construction of noise barriers.

(4) *Noise Abatement by Others.* An increasing number of requests are being made to Caltrans by owners or developers to attenuate noise reaching adjacent properties for which the State's mitigation priority is low or nonexistent. The general policy is that all feasible steps must be taken in the design of the adjacent development to attenuate noise so as not to require encroachment on the State's right of way. The State shall assume NO review authority or responsibility of any kind for the structural integrity or the effectiveness of the noise attenuation of walls constructed by others outside of the State's right of way. Where it is determined to be necessary to permit others to construct a noise barrier within the State's right of way, the general policy is that the design will meet Caltrans geometric, structural, and safety standards as established in this and other manuals and that the effects of the barrier on operation, maintenance and aesthetics of the highway will be more beneficial than detrimental.

1101.3 Terminology

The terms "noise barrier" and "soundwall" are often used interchangebly. Technically, a "noise barrier" may be any feature which blocks, prevents or diminishes the transmission of noise. An earth berm could serve this purpose. A large building could serve as a noise barrier to shield receptors further from the noise source. A dense growth of vegetation, if it were wide enough and dense enough, would be a noise barrier. A "soundwall" is a particular type of noise barrier. It is a wall, which may be constructed of concrete panels, masonry blocks, wood boards or panels, or a variety of other materials.

1101.4 Procedures for Assessing Noise Impacts

Highway traffic noise impacts are identified in the project noise study report and are listed in the environmental document. The procedures for assessing noise impacts for new highway construction or reconstruction projects, retrofit projects (Community Noise Abatement Program - HB311) along existing freeways, and School Noise Abatement Projects (HB312), are included in Title 23, United States Code of Federal Regulations Part 772, the Environmental Handbook and Project Development Procedures Manual, and Section 216 of the Streets and Highways Code.

1101.5 Prioritizing Construction of Retrofit Noise Barriers

Legal requirements and procedures for prioritizing the construction of noise attenuation barriers are provided in Section 215.5 of the Streets and Highway Code and in the Caltrans Environmental Handbook.

Topic 1102 - Design Criteria

1102.1 General

This section covers the noise barrier location, various design aspects such as height and length of noise barriers, alternative designs, maintenance considerations, and aesthetic considerations. Various types of Caltrans standard noise barrier designs are referenced. Noise barrier design procedures, from the acoustical standpoint, are included in the Caltrans Environmental Handbook. Noise level criteria and guidelines on noise reduction can be found in Caltrans Environmental Handbook and Project Development Procedures Manual.

1102.2 Noise Barrier Location

(1) *Lateral Clearances.* **Minimum lateral clearance to noise barriers shall be as provided in Topic 309.1, Horizontal Clearances, of this manual, but shall not be less than 3 m.** Lateral clearances greater than the minimums should be used whenever feasible. Where terrain permits, the most desirable location for a noise barrier from a safety perspective is just inside the right of way or, alternatively, 10 m or more from the traveled way.

When lateral clearance is 4.5 m or less, the noise barrier shall be placed on a safety shape concrete barrier. Guardrail or safety shape barrier protection should be considered when the noise barrier is located between 4.5 m and 9 m from the edge of the traveled way.

When the noise barrier is placed closer than 5 m from the traveled way, Traffic Operations should be consulted early in the design. Signs (overhead and ground mounted) and other poles and standards for lighting, Transportation Management items, call boxes, etc. should be detailed for mounting on the wall, incorporated into the wall foundation and possibly recessed into the surface of the wall.

(2) *Sight Distance Requirements.* The stopping sight distance is of prime importance for noise barriers located on the edge of shoulder along the inside of a curve. Horizontal clearances which reduce the stopping sight distance should be avoided. Noise barriers within gore areas should begin or end at least 60 m from the theoretical curb nose location.

(3) *Ultimate Location.* Noise barriers should be constructed at the ultimate location for the facility as discussed in the Project Development Procedures Manual.

1102.3 Noise Barrier Heights

(1) *Minimum Height.* Noise barriers should have a minimum height of 1.8 m (measured from the top of the barrier to the top of the foundation).

(2) *Maximum Height.* Noise barriers should not exceed 4.3 m in height (measured from the pavement surface at the face of the safety-shape barrier) when located 4.5 m or less from

the edge of the traveled way, and should not exceed 5.0 m in height above the ground line when located more than 4.5 m from the traveled way.

(3) *Truck Exhaust Intercept.* Current FHWA noise barrier design procedures result in noise barrier heights which often do not intercept noise emitted from the exhaust stack of trucks. For design purposes, the noise barrier should intercept the line of sight from the exhaust stack of a truck to the receptor. The truck stack height is assumed to be 3.5 m above the pavement. The receptor is assumed to be 1.5 m above the ground and located 1.5 m from the living unit nearest the roadway. If this location is not representative of potential outdoor activities, then another appropriate location should be justified in the noise study report.

(4) *Two-story Development.* The noise barrier should not be designed to shield the second story of two-story residences unless it provides attenuation for a substantial number of residences at a reasonable increase in cost. If the noise barrier is extended in height to provide second story attenuation, this attenuation is to be at least 5 decibels.

(5) *Parallel Noise Barriers.* Frequently, noise barriers are constructed to shield noise receivers on both sides of a highway. These are referred to as parallel barriers. If the barrier surfaces are hard, relatively smooth, and non porous, such as concrete or masonry surfaces, the barriers can reflect noise back and forth between the barriers, decreasing their effectiveness. As a result of research performed by Caltrans and others, reflective parallel barriers should have a width-to-height ratio (W:H) of at least 10:1 to avoid a risk of perceptible reduction in performance of both noise barriers. The width is the distance between the two barriers, and the height is the average height of both barriers with reference to the roadway elevation. For example, two parallel barriers, one 3 m, the other 4 m high, should be separated by at least 35 m to avoid a noticeable degradation in performance. A perceptible, or noticeable decrease in performance is defined as a reduction of 3 dBA or more in barrier attenation.

1102.4 Noise Barrier Length

(1) *General.* Careful attention should be given to the length of a noise barrier to assure that it provides adequate attenuation for the end dwelling. The Caltrans Environmental Handbook provides guidance on determining how far beyond the end dwelling a noise barrier should be extended. When appropriate, consideration should be given to terminating the noise barrier with a section of the barrier perpendicular to the freeway. This could reduce the overall barrier length, but may require an easement or acquisition from the property owner to permit construction of the noise barrier off the right of way.

(2) *Gap Closures.* In some cases, short gaps may exist between areas qualifying for a noise barrier. The closure of these gaps should be considered on a project by project basis and be justified in the Project Report.

(3) *Local Street Connections.* At on- and off-ramp connections to local streets, the Department's responsibility for noise abatement should be limited to areas where the traffic noise level from the State highway is the predominant noise source.

(4) *Barrier Overlaps.* When the noise barrier has overlapping sections, such as when concealing an access opening, the walls must be overlapped a minimum of 2.5 to 3 times the offset distance in order to maintain the integrity of the sound attenuation.

1102.5 Alternative Noise Barrier Designs

(1) *General.* Every noise barrier that is constructed as a part of new highway construction or reconstruction, or along freeways as a part of the Community and School Noise Abatement Programs, requires at least two alternative designs included in the contract plans. Selection of the most cost-effective and aesthetically pleasing designs should include an analysis of their life-cycle costs. The Project Development Procedures

Manual discusses cost analysis of noise barriers.

Standard sheets for noise barriers (sound walls) developed by the Office of Structure Design have been furnished to the Districts. These standard designs include the following materials:

- Masonry block.
- Precast concrete panel (with post or mounted on safety shaped barrier).
- Wood (post and plank or framed plywood).
- Metal (ribbed steel).
- Composite beam (Styro-foam and wire mesh core with stucco exterior).
- Other design alternatives may be considered provided they meet the structural and noise attenuation criteria. Questions regarding the approval status of various designs or products should be directed to the Chief, Office of Statewide Geometric Design Standards, in the Division of Design.

Project Files for each noise barrier project should include the justification and background for the design type or the options allowed on each project.

(2) *Design Procedures.* The plans for alternative noise barriers are to be prepared using the standard sound wall sheets and the appropriate Standard Special Provisions. As a minimum, the sound wall plans are to show the horizontal alignment, the wall profile made up of a top elevation line and a bottom elevation line, the applicable standard sound wall detail sheets, and aesthetic features sheet. The top elevation line is defined as the profile line of the minimum wall height required for the design insertion loss, and the bottom elevation line is defined as the finished grade ground line. If a concrete safety-shape barrier is involved, the top of barrier is to be designated as the bottom elevation line of the sound wall. For alternative sound walls not on a barrier, the footing design does not have to be detailed on the plans. If a barrier is required, the pile layout should be detailed for only one of the alternative designs. Although this method does not require the detailing of one complete sound wall alternative, it does not remove the necessity to solve drainage, utility, foundation, or any other problems which are unique to each project.

(3) *Pay Quantities.* The pay item for alternative sound walls without a barrier is square meter of sound wall and is measured between the top elevation line and the bottom elevation line. The square meter cost includes all types of supports (footings, piles and pile caps).

If the sound wall is on a barrier the sound wall pay item is measured from top elevation line to top of barrier, and the supporting piles or footings and barrier will be separate pay items.

The aesthetic features affect the amount of footing for the masonry block design, and these features must be shown clearly on the plans. The "Typical Sections" sheet is the recommended location to show the aesthetic treatment.

Refer to the Standard Special Provisions for more information on measurement and pay quantities.

(4) *Shop Plans.* The Special Provisions should require the successful bidder to submit two sets of shop plans of the selected alternate for approval. These shop drawings must show pile spacing, pile lengths, expansion joints location, and aesthetic treatment.

(5) *Preliminary Site Data.* In using the "Top Line/Bottom Line" concept, it is important that the preliminary site data be as complete as possible. To eliminate or minimize construction change orders the following guidelines are suggested.

- Provide accurate ground line profiles.
- Select only approved design alternative sound wall types.
- Provide adequate foundation investigation.
- Locate overhead and underground utilities.

- Review drainage and show any modifications on the plans.
- Determine and specify architectural treatment.
- Determine the need for special design, and coordinate with the Office of Structures Design during the early stages of design.

1102.6 Noise Barrier Aesthetics

(1) General. A landscaped earth berm or a combination wall and berm tend to minimize the apparent noise barrier height and are probably the most aesthetically acceptable alternative, but unfortunately these alternatives are not suitable for many sites due to limited space.

Some additional cost to enhance the noise barrier's aesthetic quality is usually warranted. However, elaborate or costly individualized designs which significantly increase the cost of the noise barrier should be avoided. Sound walls should not be designed with abrupt beginnings or ends. Generally, the ends of the sound wall should be tapered or stepped if the height of the sound wall exceeds 2 m. The District Landscape Architect should be consulted regarding the design of tapers or stepped ends, aesthetic treatment and landscaping for noise barriers.

(2) Standard Aesthetic Treatment. Only the standard aesthetic treatments for the various alternative materials developed by the Engineering Services Division of Structure Design, should be used. A description of the different types of aesthetic treatments developed are included in the "Instructions for Using the Standard Aesthetics Features Sheets" which are available from the Aesthetics and Models unit of the Division of Structures.

(3) Nonstandard Aesthetic Treatment. When a nonstandard aesthetic treatment is proposed for noise barriers, the Headquarters Traffic Liaison should be consulted.

(4) Planting of Noise Barriers. The use of plants in conjunction with noise barriers can help to combat graffiti and enhance public acceptance of the noise barrier. When landscaping is to be placed adjacent to the sound wall which will eventually screen a substantial portion of the wall, only a minimal aesthetic treatment is justified.

Index 902.3 of this manual and the Project Development Procedures Manual contain additional information on the planting of noise barriers.

1102.7 Maintenance Consideration in Noise Barrier Design

(1) General. Noise barriers placed within the area between the shoulder and right of way line complicate the ongoing maintenance operations. When there is a substantial distance behind the noise barriers and in front of the right of way line, special consideration is required. If the adjoining land is occupied with streets, roads, parks, or other large parcels, an effort should be made during the right of way negotiations to have the abutting property owners maintain the area. In this case, the chain link fence at the right of way line would not be required. Maintenance by others may not be practical if a number of small individual properties abut the noise barrier.

(2) Access Requirements. Access to the back side of the noise barrier must be provided if the area is to be maintained by Caltrans. In subdivided areas, access can be via local streets, when available. If access is not available via local streets, access gates or openings are essential at intervals along the noise barrier. Access may be provided via offsets in the barrier. Offset barriers must be overlapped a minimum of 2.5 to 3 times the offset distance in order to maintain the integrity of the sound attenuation of the main barrier. Location of the access openings must be coordinated with the District maintenance office.

(3) Noise Barrier Material. The alternative materials selected for the noise barrier should be appropriate for the environment in which it

is placed. For walls that are located at or near the edge of shoulder, the portion of the noise barrier located above the safety-shape concrete barrier should be capable of withstanding the force of an occasional vehicle which may ride up above the top of the safety barrier. At this location, concrete block, cast-in-place concrete, or precast concrete panels are the recommended alternative sound wall materials. In locations which are susceptible to fires, use of wood noise barriers should be avoided.

1102.8 Emergency Access Considerations in Noise Barrier Design

(1) General. In addition to access gates being constructed in noise barriers to satisfy the Department's maintenance needs, they may also be constructed to provide a means to access the freeway in the event of a catastrophic event which makes the freeway impassable for emergency vehicles. These gates are not intended to be used as an alternate means of emergency access to adjacent heighborhoods. Access to those areas should be planned and provided for from local streets and roads. Small openings may also be provided in the noise barrier which would allow a fire hose to be passed through it. Local emergency response agencies should be contacted early in the design process to determine the need for emergency access gates and fire hose openings.

(2) Emergency Access Gate Requirements. Access gates in noise barriers should be kept to a minimum and should be at least 300 m apart. Locations of access should be coordinated with the District Maintenance office. Only one opening should be provided at locations where there is a need for access openings to serve both the emergency response agency and Caltrans maintenance. Design of gates should comply with the soundwall details developed by the Office of Structures Design.

(3) Fire Hose Access Openings. When there is no other means of providing fire protection to the freeway, small openings for fire hoses may be provided. Fire hose access should be located as close as possible to the fire hydrants on the local street system. Where possible, fire hose access should be combined with emergency or maintenance access openings. Design of fire hose openings should be requested from the Office of Structures Design.

1102.9 Drainage Openings in Noise Barrier

Drainage through noise barriers is sometimes required for various site conditions. Depending on the size and spacing, small, unshielded openings at ground level can be provided in the barriers to allow drainage and not defeat the noise attenuation of the barrier. The following sizes of unshielded openings at ground level are allowed for this purpose:

(a) Openings of 200 mm x 200 mm or smaller, if the openings are spaced at least 3 m on center.

(b) Openings of 200 mm x 400 mm or smaller, if the openings are spaced at least 6 m on center, and the noise receiver is at least 3 m from the nearest opening.

The location and size of drainage openings need to be designed based on the hydraulics of the area. The designer should also take into consideration possible erosion problems that may occur at the drainage openings.

Where drainage requirements dictate openings that do not conform to the above limitations, shielding of the opening will be necessary to uphold the noise attenuation of the barrier. Shield design must consider the hydraulic characteristics of the site. When shields are determined to be necessary, consultation with the District Hydraulics Unit and the Division of Design Coordinator and Noise Abatement staff is recommended.