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TECHNICAL MEMORANDUM

Title: Acoustical Design Assessment

Project: Equinix SV-10/SV-11 Data Centers
Prepared For: Sheehan Partners
Prepared By: David M. Hessler, P.E.
Revision: A
Issue Date: December 10, 2015
Reference No: TM-2020-100215-A

Attachments: Table T-2020-100115-A Input Calculations

1.0 Introduction

A noise model of the Equinix SV-10 and SV-11 data centers in San Jose, CA has been developed in order to determine if any design changes might be necessary to maintain compliance with the local noise ordinance limits of 55 dBA at the boundaries of abutting residentially zoned land parcels and 60 dBA at commercial zonings. The lower limit of 55 dBA would apply at the southern property line immediately outside the SV-10 generator yard and at the property line just west of SV-10. All other boundaries around SV-10 and SV-11 would be subject to the higher 60 dBA noise limit.

The basic design of the both projects is the DC Flex prototype. SV-11 is essentially a direct application whereas the generator yard of SV-10 is slightly modified to fit the property.

1.1 Executive Summary

In general, based on the available sound data from the mechanical equipment suppliers, the current design for both SV-10 and SV-11 using ACS generator packages and an acoustically lined 25 ft. metal screen wall appears to satisfy the noise requirements at all site boundaries. This result is predicated on the ACS packages meeting the guaranteed acoustical performance of 75 dBA at 23 ft. and enhancing the acoustical performance of the SV-10 generator yard barrier by adding a backing layer of 16 ga. (as previously recommended and now incorporated into the construction plans).

No information on the noise emissions from the Pritchard-Brown generator enclosures is currently available; however, a review of the package plans indicates that the units are likely to produce fairly high sound levels. For example, the cooling air inlet louvers along the sides of the package and the radiator

discharge involve no acoustical treatment whatsoever, so it appears doubtful that the enclosure would reduce engine noise by 30 dBA (relative to an unenclosed unit) as currently stated. Because there is insufficient information available to model these units *and* they don't appear to be feasible, only the Caterpillar units have been analyzed.

Apart from the diesels and the generator yards there is a potential issue with compliance at the property line to the WNW of SV-10 near the future traffic circle. A level of 55 dBA is technically required at the property line but the predictions suggest that the actual level may be right at the limit due to exhaust air noise from the SV-10 cooling units. It is unclear if this is an actual issue, however, because the sound emissions from the Venmar exhausts are not known with any certainty or reliability. In other words, the difference between the predicted and required level at this property boundary is well within the uncertainty inherent in the model calculations, so it would be hard to justify a recommendation to add noise mitigation to the exhaust air path. Field testing of an existing Venmar unit is recommended to eliminate this uncertainty prior to construction because of the sheer number of units (48) and the difficulty and costs that would be associated with the installation of retrofit mitigation.

While the current conceptual Phase 1 design for SV-10 calls for the generator yard barrier to be erected in separate sections, it would be advisable to initially build it so that it is continuous from Col. Line A to M on the south side. Otherwise the open gap between Col. Line F and J will result in non-compliant property line sound levels with 2 or 3 diesels operating.

2.0 Assumptions and Inputs

The principal external noise sources associated with the DC Flex design are the back-up diesel generators in the outdoor generator yard and the numerous air conditioning units in the 2 story mechanical yard on the opposite side of the building. Sound power level inputs to the noise model for these sources were developed from supplier sound information/guarantees. It is important to note that in all cases the manufacturer's acoustical performance information is either lacking entirely, vague or gives no details on where the noise is specifically coming from or what the sound emissions from different parts of the units actually are. A number of assumptions, estimates and calculations, detailed in in **Table T-2020-100115-A** (attached) and briefly described below, were necessary to make the best use of the available information. However, the accuracy of the derived inputs and, by extension, the model predictions are consequently somewhat uncertain. Field measurements of the actual noise emissions from these or similar components at comparable operational facilities would be needed to remove this uncertainty.

2.1 Generator Yard

The current design of the screen wall for the SV-10 and SV-11 generator yards consists of a 25 ft. high barrier formed from 16 ga. horizontally corrugated steel over a supporting framework and lined with fiberglass insulation. In accordance with the latest plans, a second layer of 16 ga. steel has been added to provide additional mass and improve the acoustical performance of the barrier so that no significant noise bleeds through the wall.

The noise model assumes Caterpillar 3516C diesels packaged in ACS enclosures that are guaranteed to produce an overall sound pressure level of no more than 75 dBA at 23 feet. In an effort to represent these units in a reasonably realistic way in the 3-dimensional noise model, the noise emissions from each package

are divided into three sources: the combustion exhaust stack just above the center of the enclosure, the cooling air intake on the end wall of each unit and the radiator/cooling air exhaust out the top of each unit at the opposite end. The frequency content and magnitude (sound power level) of each of these sources was derived from field measurements of a roughly comparable diesel generator package with the values normalized to add up to 75 dBA at the guarantee distance of 23 ft. Most of the noise is assumed to emanate from the exhaust stack at a height of 17.4 ft. above ground level. 8 of the 9 units in each generator yard are assumed to be in operation as a worst-case scenario in the model. Since the principal directions of concern for SV-10 are to the south and west, for design purposes the eastern-most unit is the only one off line in the model. In the SV-11 generator yard one of the 7 units in the ground level bay is assumed to be off while both of the elevated units over the loading dock are on.

The plans and noise information for an alternative (-30 dBA) diesel package by Pritchard-Brown have been reviewed. Although this alternative appears to be regarded as a low noise option, the 30 dBA reduction refers only to the near field sound pressure level immediately around the unit relative to an unenclosed diesel - and does not describe the total far field noise reduction relative to some standard design. In fact, because the cooling air intakes along the sides of the package are not acoustically treated and because there is virtually no silencing in the radiator exhaust path, it seems quite likely that this unit would be substantially, if not dramatically, louder than the ACS package. Because there is insufficient information available to model these units and they don't appear to be feasible, only the Caterpillar units have been analyzed.

2.2 Mechanical Yard

The screen wall for the cooling units is made up primarily of solid metal panels but the exhaust air discharge from each Venmar cooling unit is ducted to a perforated panel and essentially ejected through the wall. In terms of noise, the sound from the six exhaust/scavenger air fans is radiated from each discharge with very little loss through the perforated plate. The sound power level of the fans was used to estimate the total sound power at each discharge. A total of 18 units are assumed to be operating on each level (with 6 units serving as standbys). The sound from all 18 discharges on each level is simplified into a long narrow noise source in the model. Another source on the sides of each upper level unit for the outside air intakes is also estimated from the exhaust air fan sound power level with estimated allowances for the sound path through the unit internals (distribution wheel) to the intake louvers. Again, no specific noise information, apart from the basic fan sound power level spectra, was available for these units, so the model inputs are best-estimates based on a set of rather meager facts.

The snapshots of the model below show how the mechanical and generator yards are generally represented.

Figure 2.2.1 Noise Model Looking S

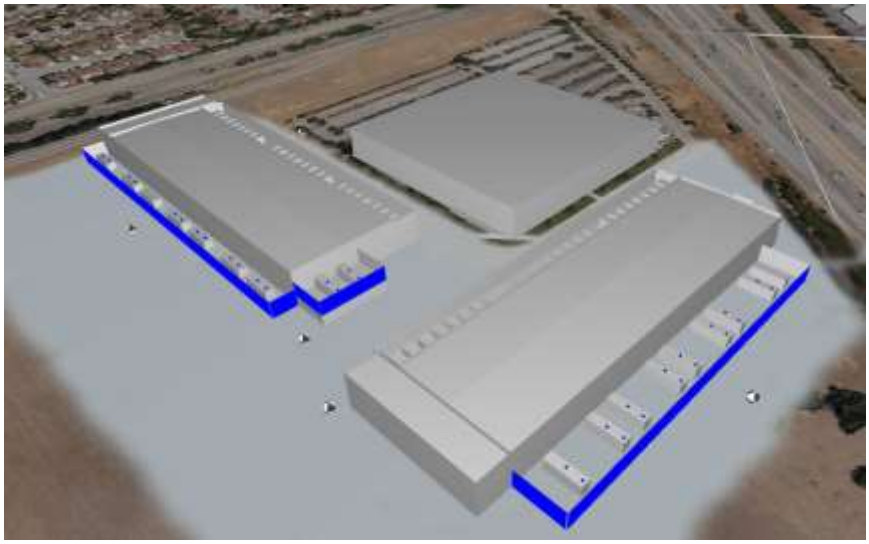


Figure 2.2.2 Noise Model Looking N

3.0 Analysis Results

Three scenarios have been modeled:

Table 3.0.1 Modeling Scenarios

Plot	Diesel Enclosure Supplier SV-10	Diesel Enclosure Supplier SV-11	Scenario
1	ACS/Caterpillar	ACS/Caterpillar	Full Build-out
2	ACS/Caterpillar	ACS/Caterpillar	SV-10 Phase 1 – Existing Design
3	ACS/Caterpillar	ACS/Caterpillar	SV-10 Phase 1 – Reommended Design

Plot 1 shows the sound emissions from the full build-out of SV-10 and SV-11, per the latest plans based on the use of ACS packages for the diesels. This design assumes that the generator barrier walls for both installations are relocated to be 50 ft. out from the buildings and that the SV-10 barrier is acoustically enhanced with a backing layer of 16 ga. steel. Under this scenario compliance with the 55 dBA residential noise limit is expected to the south and west of SV-10; however, it should be noted that there is a potential issue with compliance at the property line to the WNW of SV-10 near the future traffic circle. A level of 55 dBA is technically required at the property line but the predictions suggest that the actual level may be right at the limit due to exhaust air noise from the SV-10 cooling units. It is unclear if this is an actual issue, however, because the sound emissions from the Venmar exhausts are not known with any certainty or reliability. In other words, the difference between the predicted and required level at this property boundary is well within the uncertainty inherent in the model calculations, so it would be hard to justify a recommendation to add noise mitigation to the exhaust air path.

Plot 2 shows the sound contours associated with only Phase 1 of SV-10 (assuming SV-11 is also present and operational as a worst-case). During this stage of construction there will only be three diesels, 1, 2 and R1 and the current concept is to build the generator yard barrier only where it is adjacent to these three units leaving a gap between Col. Lines F and J. The plot shows that noise from this gap is likely to exceed 55 dBA at the southern property line with all three units on - and roughly the same situation would still occur if one of the units (R1, for instance) were off as a reserve. Consequently, it would be prudent to erect the generator barrier in one continuous run from Col. Line A to M during Phase 1, rather than filling in the gap during a later phase.

Plot 3 shows the Phase 1 sound levels with a continuous barrier. In this case, the 55 dBA noise limit is met along the southern site boundary except in a small, largely irrelevant area near the highway.

4.0 Recommendations

The current design for both projects appears to be generally satisfactory with respect to meeting the applicable noise limits at full build-out, however, the following actions are recommended to better ensure compliance.

4.1 SV-10 Phase 1 Generator Yard Barrier

If the generator yard barrier is built in a piecemeal/sectional fashion during Phase 1, leaving a gap between Col. Lines F and J, then it is unlikely that that SV-10 will meet the 55 dBA residential limit at the southern boundary during diesel operation. The barrier should be built in a continuous manner between column lines A and M during Phase 1.

4.2 Verification of ACS Generator Sound Levels

The sound power level of the exhaust stack exit on each ACS diesel is currently estimated at 100 dBA re 1 pW because this performance leads to an overall sound pressure level of 75 dBA at 23 ft., which is the guaranteed performance of each package. No specific exhaust sound level has been provided by ACS. It is important to note that this assumed baseline performance (100 dBA) is already considerably quieter than the performance of a “typical” diesel exhaust with a respectable silencer. Consequently, it would be advisable to verify that this is, in fact, the exhaust sound level prior to the fabrication of the 18 units required

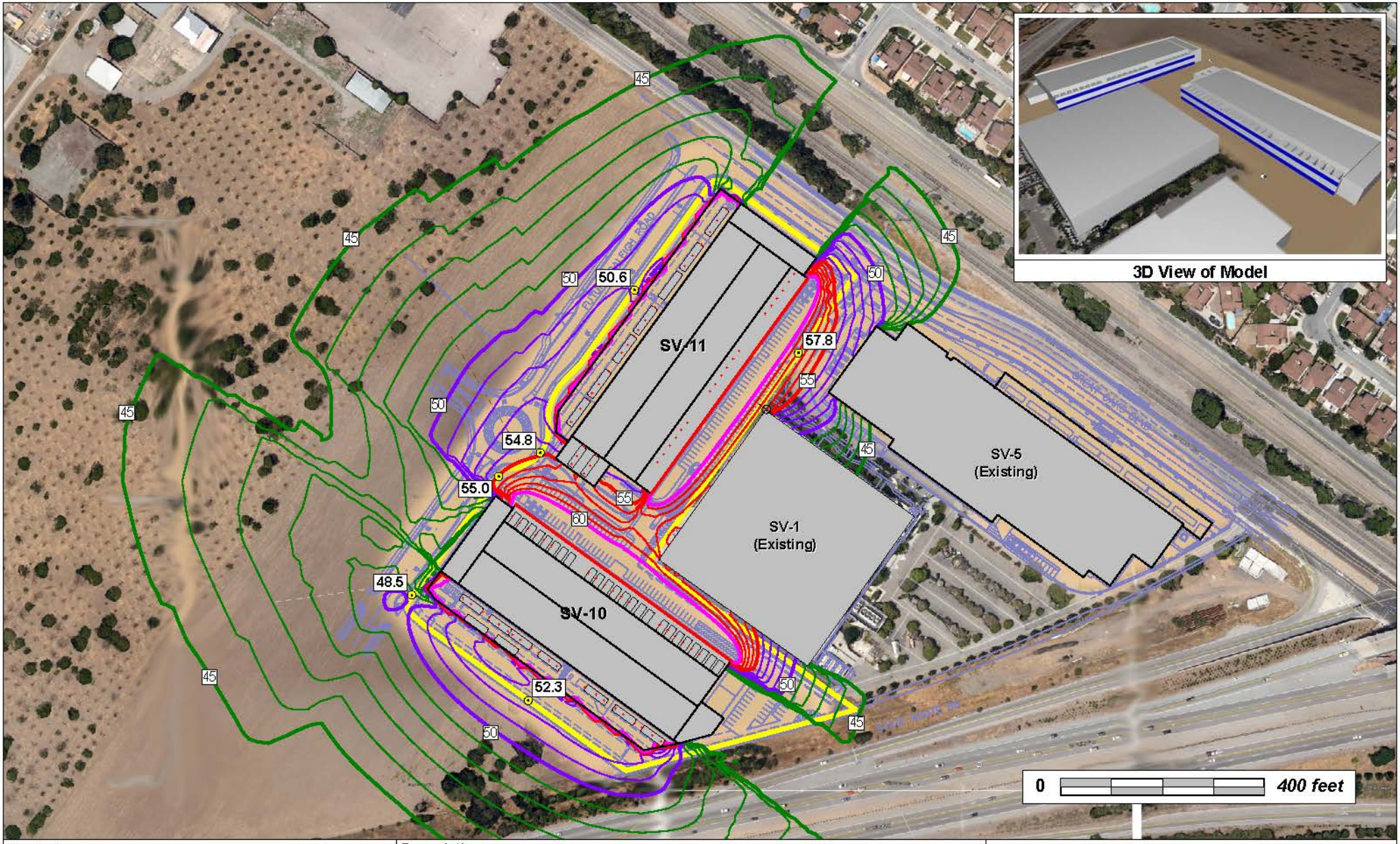
for these two projects by measuring a comparable existing diesel package with a generally similar exhaust silencer. Exhaust stack noise is particularly important at these projects because compliance with the property line sound levels is almost entirely dependent on the exhaust stack sound emissions from the diesels. If the exhaust silencing is deficient it would be much more difficult and costly to replace or augment the silencing on a retrofit basis than to fit an appropriate silencer into the initial design.

4.3 Verification of Pritchard-Brown Generator Sound Levels

If there is a cost-advantage or other reason to use Pritchard-Brown diesel engine enclosures the sound emissions from a generally similar package design should be verified through a brief field survey of an existing unit - even if not an exact match with the SV-10 design.

4.4 Verification of Venmar Exhaust Air Sound Levels

As is evident from Plot 1 there may be an issue with regulatory compliance at the property line WNW of the SV-10 because of noise from the exhaust air discharges from the Venmar cooling units. The model input for this source is based on a crude estimate derived from the scavenger fan sound power level and is considered an approximation. It would be highly advantageous to have a better understanding what this sound level is actually going to be before all 48 units are installed at SV-10. As with the diesel packages above, a brief field measurement survey of a comparable existing unit would remove all uncertainty from the model and determine if noise mitigation is required or not. Moreover, the magnitude of the required reduction, if one is needed, would dictate what form of mitigation is best suited to this particular situation – and would inform the design of all future DC Flex applications.



Project: SV-10 Data Center	*Description:* **Plot 1**	*Legend:* Property Line; Design Point
Prepared for: Sheehan Partners	Estimated Sound Contours (dBA) with Latest Site Revision (12/08/15).	
Date: December 8, 2015 — *Drawing #:* SV11-Rev-F-1-1		

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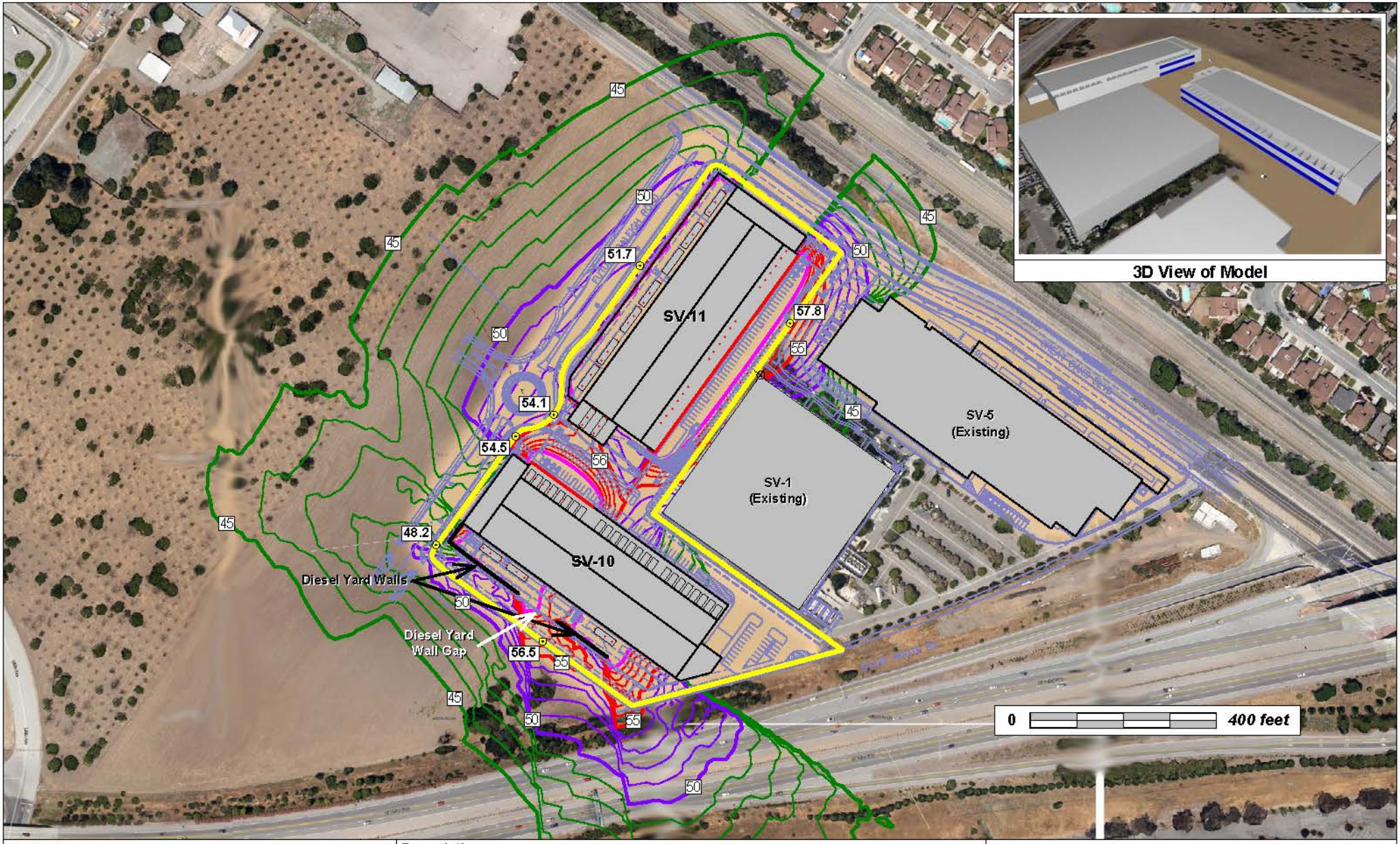

Project: SV-10 Data Center	*Description:* **Plot 2**	*Legend:*
Prepared for: Sheehan Partners	Estimated Sound Contours (dBA) of SV-10 Phase 1 Operating with Incomplete (Gap & Open Ended) Diesel Yard Noise Screen	Property Line
Date: December 9, 2015 / *Drawing #:* SV11-Rev-F-1-2		Design Point

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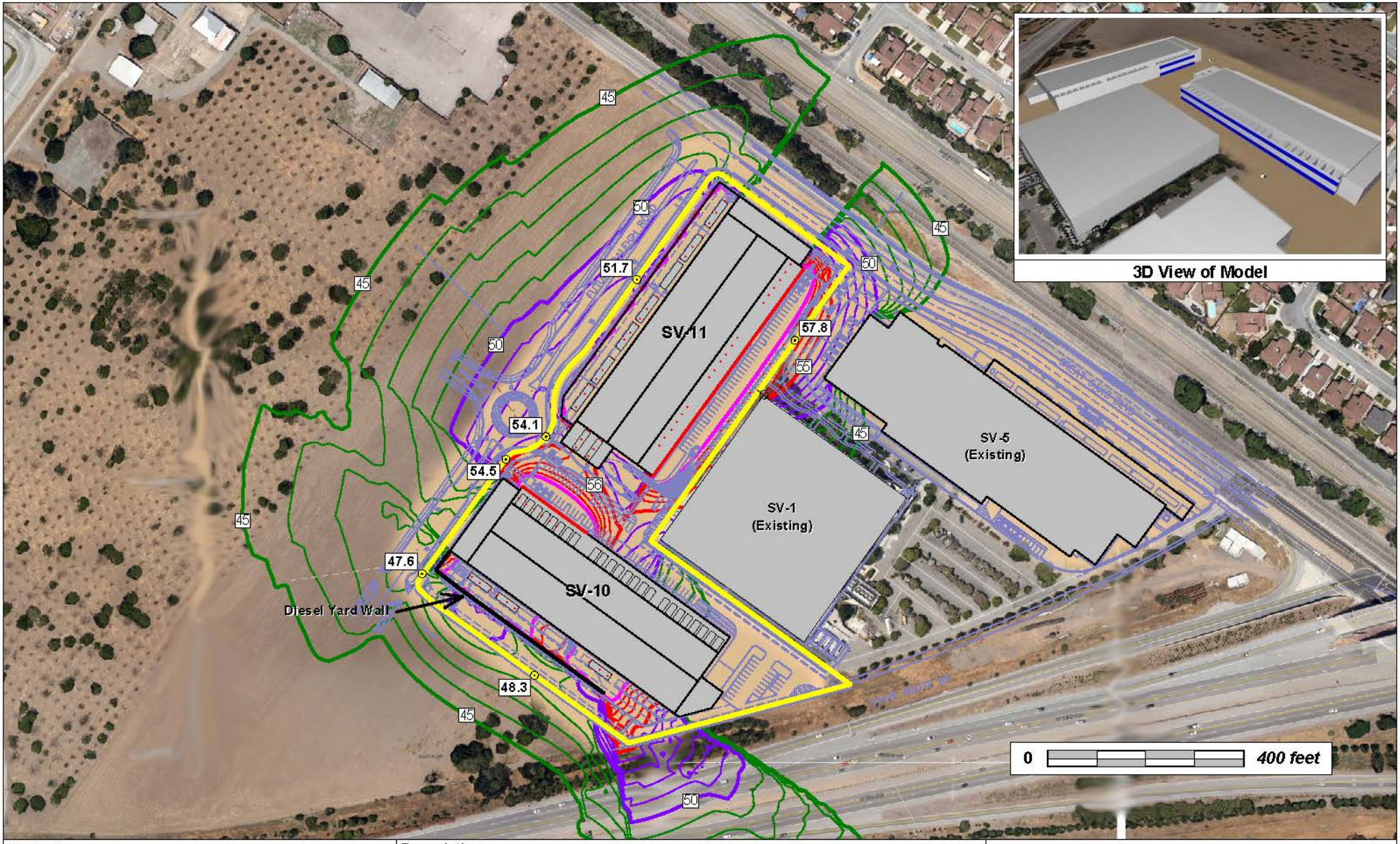

Project: SV-10 Data Center	*Description:* **Plot 3**	*Legend:*
Prepared for: Sheehan Partners	Estimated Sound Contours (dBA) of SV-10 Phase 1 Operating with Incomplete (Open Ended) Diesel Yard Noise Screen	Property Line
Date: December 9, 2015 / *Drawing #:* SV11-Rev-F-1-2-1		Design Point

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Table: **T-2020-100115-A** **Page:** **1**
Title: **Calculation of Source Sound Power Levels**
Project: **Equinix SV-10**
Revision: A
Date: 10/6/2015

Descriptor		31.5	63	125	250	500	1000	2000	4000	8000	dB(A)	dB(C)
		Octave Band Center Frequency, Hz										
Diesel Generators - ACS Packages												
D1 ACS. Diesel Generator Combustion Exhausts												
Measured Lp(2 m) Flush (Noble)	70	86.1	89.4	97.3	94.5	95.4	88.7	83.2	70.6	60.7	**95.0**	
Distance	2	m										
Radiating Area (Assume 3/4 Hemisphere)	37.7	m^2										
Apparent Lw		101.9	105.2	113.1	110.3	111.2	104.4	99.0	86.4	76.5	**110.9**	117.1
Measured Lp(5 m) Flush	71	79.8	85.5	86.4	88.1	90.1	82.0	76.6	63.4	53.4	88.7	
Distance	5	m										
Radiating Area (Assume Hemispherical)	157.1	m^2										
Apparent Lw		101.8	107.5	108.3	110.1	112.1	104.0	98.6	85.3	75.3	**111.1**	116.2
Measured Lp(5 m) Flush	72	74.8	82.6	87.7	81.2	82.7	76.8	71.8	58.0	48.1	82.8	
Distance	10	m										
Radiating Area (Assume Hemispherical)	628.3	m^2										
Apparent Lw		102.8	110.6	115.6	109.2	110.7	104.8	99.8	86.0	76.1	**110.8**	118.5
Use Average of All Three Derivations												
Engine Exhaust Lw (Baseline)		**102.1**	**107.7**	**112.3**	**109.8**	**111.3**	**104.4**	**99.1**	**85.9**	**76.0**	**110.9**	116.9
Scaling to 75 dBA at 23 ft. Performance		-1	-3	-8	-9	-11	-12	-14	-16	-15		
Adjusted Lw Exhaust Stack		**101**	**105**	**104**	**101**	**100**	**92**	**85**	**70**	**61**	**100**	109
Path Attenuation:												
Source Receiver Distance	**7**	m										
Hemispherical Distance Loss, m	7	-25	-25	-25	-25	-25	-25	-25	-25	-25		
Air Absorption (10°C / 70%RH), m	7	0	0	0	0	0	0	0	0	0		
Stack Directivity, deg.	90											
Number of Sources	1	0	0	0	0	0	0	0	0	0		
Other Loss		0	0	0	0	0	0	0	0	0		
Sum of Path Attenuation:		-25	-25	-25	-25	-25	-25	-25	-25	-25		
Far Field Lp (Based on 75 dBA Perf.)		**76**	**80**	**79**	**76**	**75**	**68**	**60**	**45**	**36**	**75.0**	**84.3**
D2 ACS. Diesel Generator Radiator Exhaust (Top of Package)												
(With Small Silencer)												
Measured Lp(150 mm) (Noble)	120	82.9	91.0	97.4	88.0	82.6	76.0	70.6	65.5	59.2	85.3	
Opening Dimensions	2.3 x 3.8 m											
Radiating Area	8.7	m^2										
Apparent Lw		92.3	100.4	106.8	97.5	92.0	85.4	80.1	74.9	68.6	**95.1**	108.1
Est. Near Field Correction		-4	-3	-3	-2	-2	-1	-1	-1	0		
Baseline Radiator Louver Lw		**88.3**	**97.4**	**103.8**	**95.5**	**90.0**	**84.4**	**79.1**	**73.9**	**68.6**	**93.0**	105.3
Scaling to 75 dBA at 23 ft. Performance		0	0	0	0	0	0	0	0	0		
Adjusted Lw - Radiator Exhaust		**88.3**	**97.4**	**103.8**	**95.5**	**90.0**	**84.4**	**79.1**	**73.9**	**68.6**	**93.0**	105.3
Path Attenuation:												
Source Receiver Distance	**7**	m										
Hemispherical Distance Loss, m	7	-25	-25	-25	-25	-25	-25	-25	-25	-25		
Air Absorption (10°C / 70%RH), m	7	0	0	0	0	0	0	0	0	0		
Directivity	90	-1	-2	-3	-5	-8	-10	-11	-11	-11		
Number of Sources	1	0	0	0	0	0	0	0	0	0		
Other Loss		0	0	0	0	0	0	0	0	0		
Sum of Path Attenuation:		-26	-27	-28	-30	-33	-35	-36	-36	-36		
Far Field Lp (Based on 78 dBA Perf.)		**62**	**71**	**76**	**65**	**57**	**49**	**43**	**38**	**33**	**62.6**	**77.2**

Notes:
Lp = Sound Pressure Level, dB re 20 μPa
Lw = Sound Power Level, dB re 1 pW

Table: **T-2020-100115-A** **Page:** **2**
Title: **Calculation of Source Sound Power Levels**
Project: **Equinix SV-10**
Revision: A
Date: 10/6/2015

Descriptor			31.5	63	125	250	500	1000	2000	4000	8000	dB(A)	dB(C)
			Octave Band Center Frequency, Hz										
D3 ACS. Diesel Generator Air Inlet Louver Face (End of Package)													
(With Silencing)													
Measured Lp(150 mm)	123		79.1	83.5	89.6	76.3	67.0	65.3	62.0	58.6	55.2	75.2	
Opening Dimensions	3.8 x 3.6 m												
Radiating Area	13.7	m^2											
Apparent Lw			90.5	94.9	100.9	87.6	78.4	76.6	73.4	70.0	66.6	**87.1**	102.1
Est. Near Field Correction			-4	-3	-3	-2	-2	-1	-1	-1	0		
Baseline Inlet Louver Lw			**86.5**	**91.9**	**97.9**	**85.6**	**76.4**	**75.6**	**72.4**	**69.0**	**66.6**	**84.8**	99.1
Scaling to 75 dBA at 23 ft. Performance			0	0	0	0	0	0	0	0	0		
Adjusted Lw - Radiator Exhaust			**86.5**	**91.9**	**97.9**	**85.6**	**76.4**	**75.6**	**72.4**	**69.0**	**66.6**	**84.8**	99.1
Path Attenuation:													
Source Receiver Distance	**7**	m											
Hemispherical Distance Loss, m	7		-25	-25	-25	-25	-25	-25	-25	-25	-25		
Air Absorption (10°C / 70%RH), m	7		0	0	0	0	0	0	0	0	0		
Stack Directivity, deg.	90												
Number of Sources	1		0	0	0	0	0	0	0	0	0		
Other Loss			0	0	0	0	0	0	0	0	0		
Sum of Path Attenuation:			-25	-25	-25	-25	-25	-25	-25	-25	-25		
Far Field Lp (Based on 75 dBA Perf.)			**62**	**67**	**73**	**61**	**51**	**51**	**47**	**44**	**42**	**59.9**	**74.2**
Nominal Total Lp at 7 m													
Based on Guaranteed 75 dBA Performance			**77**	**81**	**82**	**76**	**76**	**68**	**61**	**48**	**43**	**75**	**85**
10-1 ACS. Noise Radiation Thru Metal Gen Yard Barrier (South Side)													
Estimated Lp at 10 ft. from Exhaust End of Packages													
Meas. Lp at 23 ft. from Exh End (WE, Paris)			82	78	78	67	63	58	53	50	43	66	
Rough Adjust to 10 ft.			7	7	7	7	7	7	7	7	7		
Est. Lp Incident on Wall at 10 ft.			**89**	**85**	**85**	**74**	**70**	**65**	**61**	**57**	**50**	**74**	
TL 16 ga. Sheet	2.5		4	10	16	22	28	34	40	47	35	8000	fc
NR=TL+3			7	13	19	25	31	37	43	50	38		
Est. Lp Radiated from Ext. of Wall			81	71	66	49	38	28	17	7	13	**52**	
Height of Barrier	7.6	m											
Length of Barrier	175	m											
Radiating Area of Barrier, S	1330	m^2											
Nom. Lw = Lp + 10 log (S)			**113**	**103**	**97**	**80**	**70**	**59**	**48**	**39**	**44**	**83**	
10-2 ACS. Noise Radiation Thru Metal Gen Yard Barrier (West End)													
Meas. Lp at 23 ft. from Side (WE, Paris)			81	76	80	71	70	66	64	58	51	72	
Rough Adjust to 20 ft.			1	1	1	1	1	1	1	1	1		
Est. Lp Incident on Wall at 20 ft.			**82**	**77**	**81**	**72**	**71**	**67**	**65**	**59**	**52**	**73**	
TL 16 ga. Sheet	2.5		4	10	16	22	28	34	40	47	35	8000	fc
NR=TL+3			7	13	19	25	31	37	43	50	38		
Est. Lp Radiated from Ext. of Wall			74	64	62	47	40	30	21	9	14	**48**	
Height of Barrier	7.6	m											
Length of Barrier	10.7	m											
Radiating Area of Barrier, S	81	m^2											
Nom. Lw = Lp + 10 log (S)			**93**	**83**	**81**	**66**	**59**	**49**	**40**	**29**	**33**	**67**	