NYU Core: Post-EIS Façade Improvement Acoustical Assessment

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INTRODUCTION

This report summarizes the results of an acoustical analysis for various façade improvement options and associated NYU Core construction generated interior noise levels at New York University's Washington Square Village and Silver Towers buildings. The intent of the Washington Square Village and Silver Towers façade improvement options would be to decrease the intrusion of noise associated with the anticipated construction described in Chapter 20, "Construction," of the NYU Core Final Environmental Impact Statement (FEIS). At both building complexes, the analysis included façade sound attenuation field testing, interior existing noise level measurements and prediction of interior noise levels based on the FEIS construction noise analysis.

The façade attenuation objectives, analysis methodology, test procedures, window/wall configurations considered, results and a discussion are presented below.

EXECUTIVE SUMMARY

At Washington Square Village (1 Washington Square Village, Apartment 2G) and Silver Towers (100 Bleecker Street, Apartment 2A), interior noise levels during construction of the NYU Core project with various façade improvement scenarios were predicted based on field testing of façade attenuation, existing interior noise level measurements and exterior noise levels calculated as part of the construction analysis in the 2012 NYU Core FEIS. The Apparent Outdoor-Indoor Transmission Class (AOITC) was determined for each potential improvement scenario using methods and procedures outlined in ASTM E966-10 "*Standard Guide for Field Measurement of Airborne Sound Attenuation of Building Façades and Façade Elements*." AOITC provides a single-number rating that approximates building façade attenuation in A-weighted decibels or dB(A). The field tested AOITC values were applied to exterior construction noise levels from the FEIS and the resultant levels compared to measured and calculated existing interior levels.

The Washington Square Village scenarios evaluated included some scenarios with an air conditioner cover that would preclude the use of the air conditioner while the cover is in place. For the scenarios without the air conditioner cover in place, which would allow for the use of the air conditioner, the measured attenuation improvement — compared to the existing conditions — ranged from 4 to 11 dB(A). An attenuation improvement of 5 dB(A) would be considered a readily noticeable change and an attenuation improvement of 11 dB(A) represents a sound being perceived as approximately one-half as loud. For the scenarios with the air conditioner cover in place, which would not allow for the use of the air conditioner, the measured attenuation improvement — compared to the existing conditions — ranged from 9 to 16 dB(A). An attenuation improvement of 9 dB(A) represents a sound being perceived as approximately one-half as loud and an attenuation improvement of 16 dB(A) represents a sound being perceived as approximately one-third as loud. These improvements in façade attenuation are comparable to or greater than those predicted in the 2012 NYU Core FEIS and would be sufficient to fully mitigate the construction noise impacts projected in the FEIS at Washington Square Village. One of the improvement scenarios analyzed [Test 3B(ii)] would be expected to result in no increases in noise level of 5 dB(A) or more. Three other improvement scenarios analyzed, including one with acoustical interior windows and two with replacement windows [Tests 3A(ii), 4B(ii), and 4C(ii)], would result in fewer than 10 apartments experiencing a 5 dB(A) or greater increase for an average of one year or less. **Table 6** includes a summary of results for each façade improvement option tested for Washington Square Village and further detailed discussion is provided in the **ASTM E966 Test Results and Discussion** section of this report.

For the Silver Towers scenarios evaluated, the measured attenuation improvement — compared to the existing conditions — ranged from 2 to 12 dB(A). An attenuation improvement of 2 dB(A) would be considered a barely perceptible change and an attenuation improvement of 12 dB(A) would be considered approximately half as loud. These improvements in façade attenuation are comparable to or greater than those predicted in the 2012 NYU Core FEIS and the two best-performing improvement options (tests 3C and 3D) would be sufficient to fully mitigate the construction noise impacts projected in the FEIS at Silver Towers. All of the analyzed improvement scenarios with acoustical interior windows (Test 3A, 3B, 3C, and 3D) would be expected to result in no 5 dB(A) or more increases in noise level. **Table 7** includes a summary of results for each façade improvement option tested for Silver Towers and further detailed discussion is provided in the **ASTM E966 Test Results and Discussion** section of this report.

DEFINITIONS

This report makes references to the terms "attenuation" and "façade."

ATTENUATION

Attenuation of sound refers to the reduction in the level of sound. Attenuation of airborne sound can occur over distance from the sound source or can occur when sound is transmitted through/around an obstacle. The testing described in this report examines the attenuation resulting from sound transmitting through the façade of each apartment under test. As per ASTM E966-10 and E1332-10a, attenuation in this report is quantified using the Apparent Outdoor-Indoor Transmission Class (AOITC) rating. AOITC provides a single-number rating that approximates building façade attenuation in A-weighted decibels or dB(A).

FAÇADE

Building façade refers to all exterior wall elements separating the exterior/outdoors from the building interior space. For both Washington Square Village and Silver Towers, the building façade consists of wall, windows and louvers associated with the building mechanical systems (HVAC). The overall attenuation provided by the entire façade is dependent upon the attenuation rating of each individual façade element and the relative surface area of each façade element. We note that sound takes the "path of least resistance" and the façade element that provides the least amount of attenuation will limit the overall façade attenuation achievable.

FAÇADE ATTENUATION OBJECTIVES

There are two acoustical objectives for improving the Washington Square Village and Silver Towers facades:

- Achieving the FEIS level of attenuation to fully mitigate the significant adverse noise impacts resulting from construction. According to Chapter 20 "Construction" of the FEIS, 30 dB(A) window/wall attenuation would be sufficient to fully mitigate the significant adverse impacts at both apartment complexes. Consequently, the amount of attenuation provided by each façade improvement scenario was examined and compared to this value.
- Additionally, to the extent practicable, NYU is endeavoring to minimize the number of apartments that would experience a readily noticeable change in interior noise level [i.e., increase of 5 dB(A) or more] resulting from construction. Consequently, the interior noise level increments in each apartment and the number of apartments experiencing an increase of 5 dB(A) or more during construction were determined for each façade improvement scenario.

ANALYSIS METHODOLOGY

GENERAL METHODOLOGY

The noise analysis considered the existing and future noise levels within each Washington Square Village and Silver Towers apartment. The analysis included the following steps:

- Façade attenuation was quantified via field tested for both the existing conditions and several potential façade improvement options;
- Each apartment was assigned a representative construction noise receptor location from the FEIS with predicted noise levels at the associated construction noise receptor location conservatively representing noise levels at each apartment;
- The field-tested existing conditions façade attenuation was subtracted from the calculated existing exterior noise levels at each construction noise receptor location from FEIS Appendix "E" (Construction Impacts) to calculate an existing interior noise level at each apartment;
- Interior noise level measurements were performed at various apartments within both building complexes;
- The measured interior noise levels were compared to the calculated interior noise levels at the same locations to develop adjustment factors accounting for non-traffic noise sources (i.e., pedestrians, playground users, etc.) and other "real-world" factors not accounted for in the FIES construction noise analysis of existing noise levels;
- These adjustment factors were applied to other apartments along the same building façade to determine calibrated interior noise levels at each apartment to be used as a baseline for comparison to future NYU Core construction conditions;
- Interior noise levels (as determined above), calculated construction noise at each receptor during each analyzed quarter of the construction period and the calculated façade attenuation for each potential façade improvement scenario were used to determine the anticipated interior noise level and interior noise level increment as compared to existing conditions during each quarter of the construction program; and
- The number of apartments anticipated to experience interior noise level increments during construction of 5 dB(A) or more was quantified and the duration of the 5 dB(A) or greater noise level increases was determined.

FIELD TESTING OF FAÇADE ATTENUATION

Testing locations

Field testing of façade attenuation was performed at two different apartments: 1 Washington Square Village - Apartment 2G (1 WSV, 2G) to represent the Washington Square Village buildings, and 100 Bleecker Street - Apartment 2A (ST 2, 2A) to represent the Silver Towers Buildings. The test specimen for 1 WSV, 2G is shown in **Figure 1**, and the test specimen for ST 2, 2A is shown in **Figure 2**.

Figure 1 – 1 WSV, 2G Test Specimen

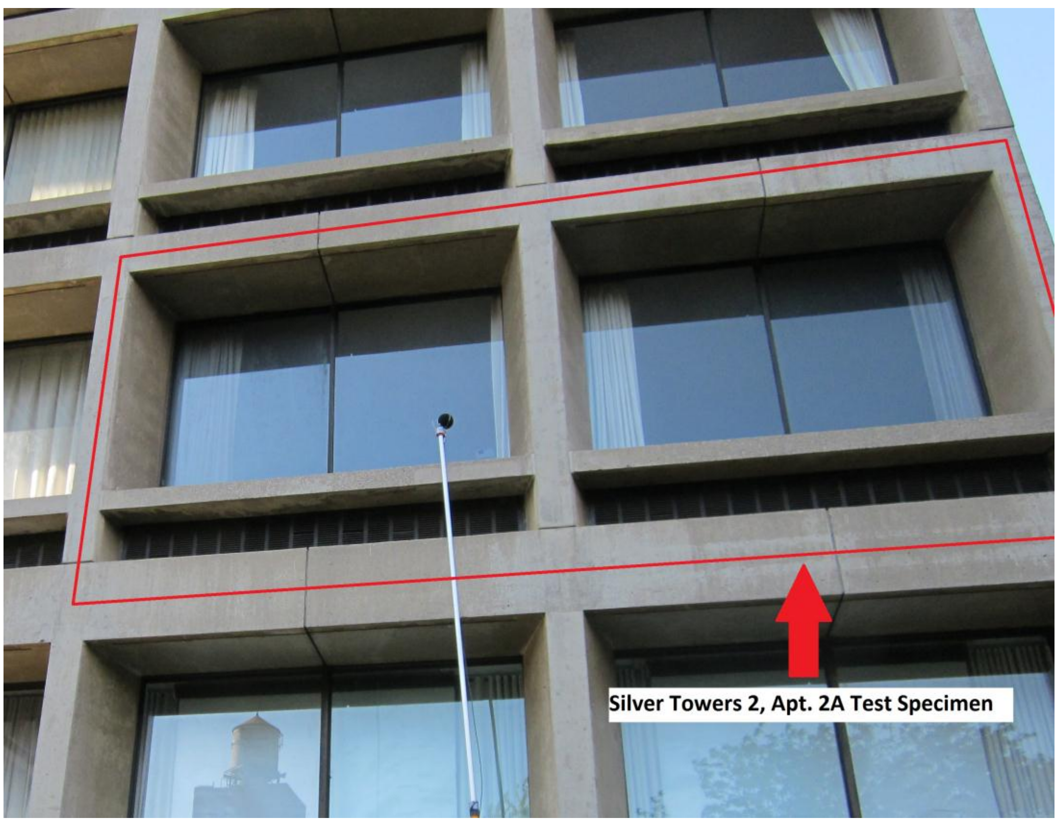

Figure 2 – ST 2, 2A Test Specimen

Equipment Used for Testing

Measurements associated with the field testing of façade attenuation were performed using Brüel & Kjær Sound Level Meters (SLMs) Type 2270 (S/N 2706757), 2250 (S/N 2717693, 2449975, 2671985), and 2260 (2384814), Brüel & Kjær Sound Level Calibrators Type 4231 (S/Ns 2412436, 1800102, 2688762, 2575543), Brüel & Kjær ½-inch microphones Type 4189 (S/Ns 2695523, 2703402, 2791735, 2953498, 2656132), and a JBL EON 515XT amplified loudspeaker. The SLMs all carried a factory calibration date within one year of their use which is standard industry practice. The calibration of each SLM was field-checked before and after readings using Brüel & Kjær Type 4231 sound level calibrators with the appropriate adaptors. The data were digitally recorded by each SLM. All measurement procedures were based on the guidelines outlined in ASTM Standard E966-10.

Façade Testing Methodology

As mentioned above, attenuation provided by a building façade can be quantified in terms of the Apparent Outdoor-Indoor Transmission Class (AOITC). The AOITC rating increases with rising façade sound attenuation performance (i.e., the greater the AOITC, the greater the sound attenuation). ASTM E90-09 "*Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements*" is used to measure the sound attenuation of an isolated wall/window/PTAC/etc. assembly in a controlled laboratory environment. ASTM E966-10 "*Standard Guide for Field Measurement of Airborne Sound Attenuation of Building Façades and Façade Elements*" is used for field measurement of airborne sound attenuation performance of a building façade. ASTM E966-10 is specifically oriented to performing field measurements to determine AOITC (referring to a field-tested value) — versus performing measurements in a laboratory (referring to an OITC value) as per ASTM E90-09 — and therefore addresses many of the issues that arise when performing field testing (such as varying angles of incidence for the sound on the façade and interior rooms that are irregularly shaped, small, or contain furniture). While ASTM E966-10 specifies the techniques and procedures for field testing of airborne sound attenuation of building facades, it also provides some latitude in the field testing procedures to address non-ideal field conditions.

As outlined in ASTM E966-10, field measurements were accomplished by creating an outdoor sound field on the façade specimen under test using a high-powered loudspeaker and a random noise generator at the following façade angles of incidence: 30, 45, and 60 degrees. (*Note: angle of incidence is the angle between a perpendicular line at the midpoint of the façade specimen to be tested and the line from that midpoint to the loudspeaker*). For each angle of incidence, two simultaneous series of sound measurements were made: one outside in close proximity to the façade specimen under test and a second in the façade specimen's associated interior room (i.e., the receiving room). The measured sound levels were then averaged, adjusted for the characteristics of the receiving room and the proximity of the outdoor microphone to the façade, subtracted, and then a field determined façade attenuation rating (i.e., AOITC) was calculated as per ASTM E1332-10.

ASSOCIATION OF APARTMENTS TO CONSTRUCTION NOISE RECPETORS

The construction noise receptor locations are shown in FEIS Figure 20-13. Receptors A1-A15 and B1-B18 represent the Washington Square Village buildings, and receptors C1-C4 and D1-D4 represent the Silver Towers Buildings. At each receptor, existing and construction noise levels were calculated at several elevations ranging from grade level to the top floor of the associated building. Each apartment in the Washington Square Village and Silver Towers complexes was associated with a specific construction noise receptor and elevation based on location. Apartments were associated with the nearest construction noise receptor provided the receptor was not at a higher elevation (i.e., further from the construction activity) than the apartment. At corner apartments with windows facing two different facades and thus represented by two different construction noise receptors, the construction noise receptor with the highest predicted construction noise levels was conservatively used.

INTERIOR NOISE LEVEL MEASUREMENTS

It was not practical to perform interior noise measurements inside every Washington Square Village and Silver Towers apartment but selecting and testing representative apartments along specific facades of each building allowed conclusions to be drawn regarding existing interior noise levels. The results for a given apartment can be applied to other apartments along that façade and along nearby comparable building facades.

The interior existing noise survey included the following types of measurements:

- Continuous measurements logged every hour from approximately 7 AM to 6 PM (i.e., the potential hours of construction), and
- Short-term "spot" measurements.

All measurements were performed on typical weekdays (i.e., Tuesday, Wednesday, or Thursday). Measurements were performed in the center of either a bedroom or living room of each apartment. Any doors or windows leading into the measurement room were closed during measurements. The apartments were unoccupied during measurements.

The continuous measurements established the existing interior noise levels in various apartments during the potential construction work hours (i.e., between 7 AM and 6 PM). The spot measurements were performed simultaneous to the continuous measurements but in an apartment on a different elevation directly above or below and facing the same direction as the apartment with the continuous measurement. These measurements were used to determine the drop-off in noise level with elevation.

Equipment for Noise Monitoring

Interior existing noise level measurements were performed using Brüel & Kjær Sound Level Meters (SLMs) Type 2270 (S/N 2706757), 2250 (S/N 2717693, 2449975, 2671985), and 2260 (2384814), Brüel & Kjær Sound Level Calibrators Type 4231 (S/Ns 2412436, 1800102, 2688762, 2575543), Brüel & Kjær ½-inch microphones Type 4189 (S/Ns 2695523, 2703402, 2791735, 2953498, 2656132). The SLMs all carried a factory calibration date within one year of their use which is standard industry practice. The calibration of each SLM was field-checked before and after readings using Brüel & Kjær Type 4231 sound level calibrators with the appropriate adaptors. The data were digitally recorded by each SLM. The time response of the SLM was set to "slow." Measured quantities included L_{eq} and L_{10} levels. All measurement procedures conformed to the guidelines listed in ANSI Standard S1.13-2005.

Measurement Locations

The interior noise measurement locations are shown in **Table 1**.

Table 1
Interior Noise Measurement Locations

Building	Facade	Apartment	Type of Measurement(s)
Silver Tower II	South	11A	Continuous 7AM to 6PM, Short Term
Silver Tower II	East	15F	Continuous 7AM to 6PM, Short Term
Silver Tower II	North	5E	Continuous 7AM to 6PM, Short Term
Silver Tower I	North	17C	Continuous 7AM to 6PM, Short Term
Silver Tower I	South	11F	Continuous 7AM to 6PM, Short Term
Silver Tower I	West	7B	Continuous 7AM to 6PM, Short Term
Silver Tower I	West	12B	Spot
1 Washington Square Village	North	6O	Continuous 7AM to 6PM, Short Term
1 Washington Square Village	West	6B	Continuous 7AM to 6PM, Short Term
2 Washington Square Village	South	4I	Continuous 7AM to 6PM, Short Term
2 Washington Square Village	South	16I	Spot
3 Washington Square Village	South	8C	Continuous 7AM to 6PM, Short Term

The measurement locations were selected based on a list provided to AKRF by NYU of vacant apartments in the Silver Tower and Washington Square Village buildings. The monitoring locations were selected to provide as much geographic coverage as possible Silver Tower and Washington Square Village building facades. These results were then extrapolated across each façade of the Silver Tower and Washington Square Village buildings based on the existing exterior noise level calculations from the FEIS and the field-tested existing façade attenuation values.

CALCULATION OF INTERIOR NOISE LEVELS

Calculation of existing interior noise levels involved subtracting the field tested existing condition façade attenuation from the FEIS's calculated existing exterior noise levels and comparing to the field tested existing interior noise levels. The FEIS construction analysis modeled existing exterior noise levels at each construction noise receptor based on existing traffic data. Subtracting the field tested existing condition façade attenuation from the modeled existing exterior noise levels provided a calculated existing interior noise level. These calculated values were adjusted based on the measured interior existing noise levels. For each existing interior noise measurement location, an adjustment factor was calculated and applied to the calculated existing interior noise levels in other apartments along the same or similar building façades.

Interior noise levels during construction were calculated for each quarter of construction analyzed in the FEIS construction analysis. The FEIS construction noise analysis predicted construction noise at each construction noise receptor location for various quarters throughout the construction period. These predictions were based on logistics diagrams, anticipated types and numbers of construction equipment, location of equipment, expected noise control measures, and other assumptions regarding the construction program. If the actual construction program were to deviate from the assumptions of the FEIS construction analysis, the resulting noise levels might differ as well.

For improvement scenario, the exterior noise level during construction at each construction noise receptor during each analyzed quarter was decreased by the field tested façade attenuation of that improvement scenario to determine an interior noise level during construction in that quarter. This level was then compared to the existing interior noise level determined as described above to calculate an interior noise level increment for each quarter. The interior noise level increments at each receptor with each scenario during each quarter made it possible to determine which apartments, if any, are anticipated to experience increments of 5 dB(A) or more, and the duration of any such increments.

ASTM E966 TEST RESULTS AND DISCUSSION

TEST 1: EXISTING CONDITIONS

The existing façade at 1 Washington Square Village, Apartment 2G included single pane double hung windows and a fixed sash with a mill finish aluminum window frame and a through the wall air conditioner that appeared to be approximately 10 years old.

The existing façade at 100 Bleecker Street, Apartment 2A included two sets of individual single pane sliding windows, as well as Packaged Terminal Air Conditioning (PTAC) units installed in a portion of each louver below the windows.

Based on the procedure outlined above, the façade attenuation of each existing condition specimen was tested. The range of field determined existing condition AOITC values for each specimen are shown in **Table 2**.

Table 2
Test 1 ASTM E966 Test Results

Test	Apartment Unit	AOITC Range[1]
1	1 Washington Square Village, Apartment 2G	25 to 26
1	100 Bleecker Street, Apartment 2A	22 to 25

Notes: [1]The range of values shown in this table may not exactly match the AOITC values for Washington Square Village and Silver Towers reported in the 2012 NYU CORE FEIS because the analysis performed for the FEIS tested some angles of incidence that were not possible to test for in this assessment due to site-specific physical constraints.

The existing single pane windows at Washington Square Village Apartment 2G were observed to have noticeable exterior-to-interior noise leakage (especially in the higher frequencies) due to aging/inadequate window seals and lightweight frames. Additionally, the through the wall air conditioner provided a relatively unimpeded path for exterior noise to enter the apartment interior. Combined with the lack of insulation/sealing in each cavity below the windows, these are the primary reasons for the relatively low existing conditions field tested AOITC values for Washington Square Village Apartment 2G.

The existing single pane windows at 100 Bleecker Street, Apartment 2A were observed to have noticeable exterior-to-interior noise leakage (especially in the higher frequencies) due to aging/inadequate window seals and lightweight frames. Additionally, the non-insulated PTAC and gap between the sheet metal blank-off panel behind the louvers and the masonry provided an unimpeded path for exterior noise to enter the apartment interior. These are the primary reasons for the relatively low existing conditions field tested AOITC values for 100 Bleecker Street, Apartment 2A.

TEST 2: EIS MINIMUM IMPROVEMENTS

Two variations of the EIS-minimum improvements at 1 Washington Square Village, Apartment 2G were tested. The first variation (Test 2A) included resealing of the existing single pane double hung windows and fixed sash, metal to metal and metal to glass components and installation of a store bought aluminum frame double hung interior storm window. The air gap between the existing glass and the interior storm was measured as 8 inches[1] and the gap was lined with homasote at its perimeter. The storm windows consisted of 1/8-inch thick single pane glass. The first variation also included the installation of a new through the wall air conditioner in the existing sleeve. The second variation (Test 2B) included all of the improvements of the first variation (Test 2A), but also included some sealing of the AC sleeve perimeter and the installation of a custom fabricated sound attenuating wood and glass AC cover. The wood cover extends around the air conditioner and has a removable glass door at the face of the air conditioner. When the AC is in use, the cover must be removed.

[1] While an 8 inch air gap is significantly larger than typical interior storm window installations, the air gap was maximized in response to NYU's request for optimum acoustical performance.

The EIS-Minimum improvements at 100 Bleecker Street, Apartment 2A included resealing of the existing single pane slider windows, metal to metal and metal to glass components and installation of a store bought aluminum frame double hung interior storm window. The air gap between the existing glass and the interior storm was measured as 3 inches[2]. The storm windows consisted of 1/8-inch thick single pane glass. Also included were replacement PTAC units with sound-attenuation materials added, including double-walled cabinets, sound-treated fan decks and additional insulation within the PTAC cavities.

Based on the procedure outlined above, the façade attenuation of each specimen with EIS-minimum improvements was tested. The range of field determined AOITC values for each specimen with EIS-minimum improvements are shown in **Table 3**.

Table 3
Test 2 ASTM E966 Test Results

Test	Apartment Unit	Improvements	AOITC Range
2A	1 Washington Square Village, Apartment 2G	Store-bought interior storm windows, new through the wall air conditioner	34 to 36
2B		Store-bought interior storm window, new through the wall air conditioner, custom air conditioner cover	37 to 39
2	100 Bleecker Street, Apartment 2A	Store-bought interior storm windows, replacement sound-attenuating PTAC	24 to 27

The Washington Square Village Apartment 2G Test 2A facade improvements resulted in greater attenuation at nearly all of the frequencies tested and provided an AOITC rating increase — as compared to the existing condition — of 8 to 10 points[3]. The maximized air gap of 8-inches (between the primary single pane window and the 1/8-inch monolithic interior storm window) provided up to an additional 16 dB of attenuation in the lower and middle frequencies as compared to the existing condition. While the interior storm windows installed for Test 2A were observed to not contain heavy duty window seals (i.e., observations noted small gaps between the individual storm window sashes/sashes and the frame), the resealing of the existing single pane windows provided attenuation improvements at the higher frequencies. It is anticipated that the replacement of the original through the wall air conditioner with a new unit also provided some attenuation improvement at higher frequencies due to the original through the wall air conditioner's anticipated degradation of seals/openings for sound to traverse.

The Washington Square Village Apartment 2G Test 2B facade improvements, which were identical to the Test 2A improvements except for the addition of a custom air conditioner cover, resulted in greater attenuation at nearly all of the frequencies tested and provided an AOITC rating increase — as compared to the existing condition — of 11 to 13 points[3]. The custom air conditioner cover provided a barrier for the sound leaking through the air conditioner and resulted in up to an additional 7 dB of attenuation in the low frequencies beyond what was provided by the Test 2A improvements.

The Test 2 improvements at 100 Bleecker Street, Apartment 2A provided an AOITC rating increase of 2 to 3 points[3] as compared to the existing condition. These façade improvements resulted in little to no additional attenuation in the lower frequencies but provided up to an additional 8 dB of attenuation in the middle frequencies and up to an additional 15 dB of attenuation in the higher frequencies as compared to the existing condition. While the interior storm windows installed for Test 2 were observed to not contain heavy duty window seals (i.e., observations noted small gaps between the individual storm window sashes/sashes and the frame), the resealing of the existing single pane windows provided attenuation improvements at the higher frequencies. The replacement PTACs with sound-attenuation packages

[2] While a 3 inch air gap is significantly larger than typical interior storm window installations, the air gap was maximized in response to NYU's request for optimum acoustical performance.

[3] Change in AOITC versus the existing condition was calculated for each individual angle of incidence.

provided little benefit since they represent a relatively small percentage of the louver surface area (and the remainder of the louvers remained unimproved for this test).

TEST 3: ACOUSTICAL INTERIOR WINDOWS AND EXTERIOR WALL IMPROVEMENTS

Two variations of the acoustical interior windows and exterior wall improvements at 1 Washington Square Village, Apartment 2G were tested. The first variation (Test 3A) included resealing of the existing single pane double hung windows and fixed sash, metal to metal and metal to glass components and installation of a horizontal sliding acoustical interior window spaced 8 inches from the existing window with homasote lining at the perimeter of the air gap. The acoustical interior windows consisted of 1/4-inch laminated glass. The second variation (Test 3B) was identical to Test 3A except the acoustical interior windows consisted of 3/8-inch laminated glass. For both variations, the new through the wall air conditioner and custom air conditioner cover installed for Test 2 remained and testing was performed both with the glass door of the air conditioner cover removed and in place. Also for both Test 3A and 3B, a pipe penetration through an interior metal blank-off panel in the radiator cavity and a gap along the bottom of this panel were sealed with non-hardening sealant.

Four variations of the acoustical interior windows and exterior wall improvements at 100 Bleecker Street, Apartment 2A were tested. The first variation (Test 3A) included resealing of the existing single pane slider windows, metal to metal and metal to glass components and the installation of a horizontal sliding acoustical interior window spaced between two and five inches from the existing window (the sashes of the primary an interior windows were installed with more or less air gap depending on their specific position in the horizontal slider frame). The acoustical interior windows consisted of 1/4-inch laminated glass. The second variation (Test 3B) was identical to Test 3A except the acoustical interior windows consisted of 3/8-inch laminated glass. Included in both Test 3A and Test 3B were the replacement PTAC units with sound-attenuation packages installed that were part of Test 2. Also for both Test 3A and 3B, the "non-PTAC" portion of the louvers was improved by:

- Sealing the existing sheet metal blank-off panel to the masonry above and below using a backer rod and non-hardening sealant
- Filling the remaining cavity (including the cavity between the PTAC sleeve and the masonry) with batt insulation and sealed with a C-Stud or similar holding in place a layer of 5/8-inch gypsum (which was caulked around its full perimeter).

Test 3C included resealing of the existing single pane slider windows, metal to metal and metal to glass components and the installation of a horizontal sliding acoustical interior window spaced between 9 and 10 inches from the existing window. The acoustical interior windows consisted of 1/4-inch laminated glass. Test 3D was identical to Test 3C except the acoustical interior windows consisted of 3/8-inch laminated glass. Included in both Test 3C and Test 3D were new PTAC units with sound-attenuation packages that achieve an OITC rating of 26 in a laboratory test. An adapter sleeve was used to install the new model PTAC in the existing PTAC sleeve. Also for both Test 3C and 3D, the louver area below the windows was improved by:

- Sealing the existing sheet metal blank-off panel to the masonry above and below using a backer rod and non-hardening sealant;
- Installing batt insulation under the existing PTAC sleeve and above the adapter sleeve in the existing sleeve;
- Installing KNM-100B loaded limp mass barrier material along the metal blank-off panel and the sides of the existing PTAC sleeve with the perimeters of the KNM material sealed using non-hardening sealant;
- Constructing a metal stud double layer 5/8-inch gypsum wall with staggered seams across the face of the existing opening between the masonry and the existing PTAC sleeve, and in the unused portion of

the existing sleeve above the adapter sleeve, with all of the perimeters sealed using non-hardening sealant;

- Constructing another double layer 5/8-inch gypsum partition parallel with the floor above the previously described double layer 5/8-inch wall connecting back into the masonry wall under the windows with all of the perimeters sealed using non-hardening sealant;
- Installing a 3/4-inch medium-density fiberboard cabinet over the gypsum walls previously described that provides structural support for the acoustical interior windows; and
- Installing 1-1/2-inch maple wood around the sides and above the acoustical interior windows, sealed to the masonry and to the acoustical interior window frames using non-hardening sealant.

Based on the procedure outlined above, the façade attenuation of each specimen with acoustical interior windows and exterior wall improvements was tested. The range of field determined AOITC values for each specimen with acoustical interior windows and exterior wall improvements are shown in **Table 4**.

Table 4
Test 3 ASTM E966 Test Results

Test	Apartment Unit	Improvements	AOITC Range
3A(i)	1 Washington Square Village, Apartment 2G	Acoustical interior window with 1/4-inch laminated glass, new through the wall air conditioner, radiator panel sealing	34 to 36
3A(ii)		Acoustical interior window with 1/4-inch laminated glass, new through the wall air conditioner, radiator panel sealing, custom air conditioner cover	38 to 42
3B(i)		Acoustical interior window with 3/8-inch laminated glass, new through the wall air conditioner, radiator panel sealing	34 to 37
3B(ii)		Acoustical interior window with 3/8-inch laminated glass, new through the wall air conditioner, radiator panel sealing, custom air conditioner cover	39 to 42
3A	100 Bleecker Street, Apartment 2A	Acoustical interior window with 1/4-inch laminated glass and approximately 3-inch air gap, replacement PTAC, below window cavity improvements	27 to 29
3B		Acoustical interior window with 3/8-inch laminated glass and approximately 3-inch air gap, replacement PTAC, below window cavity improvements	27 to 30
3C		Acoustical interior window with 1/4-inch laminated glass and approximately 9-inch air gap, new OITC 26 PTAC with adapter sleeve, double layer gypsum wall around PTAC sleeve, new PTAC cabinet	34 to 36
3D		Acoustical interior window with 3/8-inch laminated glass[1] and approximately 9-inch air gap, new OITC 26 PTAC with adapter sleeve, double layer gypsum wall around PTAC sleeve, new PTAC cabinet	33 to 35
Note: [1]One of the four 3/8-inch acoustical interior window panes had a small crack near its corner.			

The Washington Square Village, Apartment 2G Test 3A facade improvements resulted in greater attenuation — as compared to the existing condition — at nearly all of the frequencies tested and provided an AOITC rating increase of 9 to 10 points[3] with the air conditioner cover off and 13 to 16 points[3] with the air conditioner cover on. With the air conditioner cover off, the acoustical interior window's improved seals and greater mass and stiffness compared to the typical storm window resulted in only slightly more overall attenuation compared to the typical storm window in all frequencies except the highest frequencies. However, with the air conditioner cover on, the acoustical interior windows along with the radiator panel sealing resulted in improved attenuation at all tested frequencies as compared to the typical storm window with air conditioner cover. This is due to the fact that upgrades in the window system are of limited effectiveness without also eliminating the "sound flanking paths" through the air conditioner, which was done as part of Test 3.

The Washington Square Village, Apartment 2G Test 3B facade improvements, which were identical to the Test 3B improvements except for the use of 3/8-inch laminated glass rather than 1/4-inch laminated glass for the acoustical interior windows, resulted in greater attenuation — as compared to the existing condition — at nearly all of the frequencies tested and provided an AOITC rating increase of 9 to 11 points[3] with the air conditioner cover off and 14 to 16 points[3] with the air conditioner cover on. The use of 3/8-inch laminated glass rather than 1/4-inch laminated glass for the acoustical interior windows resulted in marginal attenuation improvement which is anticipated to be a result of sound flanking via the through the wall air conditioner (even with the cover on).

The 100 Bleecker Street, Apartment 2A Test 3A façade improvements provided an AOITC rating increase of 4 to 6 points[3] as compared to the existing condition. These façade improvements resulted in little to no additional attenuation in the lower frequencies but provided up to an additional 9 dB of attenuation in the middle frequencies and up to an additional 18 dB of attenuation in the higher frequencies as compared to the existing condition.

The 100 Bleecker Street, Apartment 2A Test 3B façade improvements which were identical to the Test 3B improvements except for the use of 3/8-inch laminated glass rather than 1/4-inch laminated glass for the acoustical interior windows, provided an AOITC rating increase of 5 to 6[3] points as compared to the existing condition. These façade improvements resulted in little to no additional attenuation in the lower frequencies but provided up to an additional 10 dB of attenuation in the middle frequencies and up to an additional 18 dB of attenuation in the higher frequencies as compared to the existing condition.

The acoustical interior windows installed for both Test 3A and 3B at 100 Bleecker Street, Apartment 2A were observed to have good sealing properties, provided an air gap between primary and interior windows of between 2 and 5 inches and are anticipated to be the predominant reason for the attenuation improvement in the middle and higher frequencies. However, the minimal improvement in the lower frequencies is expected to be the result of sound traversing the façade through the PTAC or PTAC louver.

The 100 Bleecker Street, Apartment 2A Test 3C façade improvements provided an AOITC rating increase of 11 to 12 points[3] as compared to the existing condition. The 100 Bleecker Street, Apartment 2A Test 3D façade improvements, which were identical to the Test 3C improvements except for the use of 3/8-inch laminated glass rather than 1/4-inch laminated glass for the acoustical interior windows, provided an AOITC rating increase of 10 to 11 points[3] as compared to the existing condition. The acoustical interior windows with 1/4-inch laminated glass performed slightly better than those with 3/8-inch laminated glass, which could be a result of the small crack in one of the 3/8-inch laminated interior window panes or may reflect small differences in installation that affected the windows' sealing properties. Both of these improvement options resulted in up to an additional 18 dB of attenuation in the lower and lower mid frequencies as compared to the existing condition which is likely attributable to sealing the large openings in the PTAC louver area and to the greater volume of air between the primary windows and acoustical interior windows.

TEST 4: WINDOW REPLACMENT AND EXTERIOR WALL IMPROVEMENTS

Three variations of the Window Replacement and Exterior Wall Improvements at 1 Washington Square Village, Apartment 2G were tested. The first variation (Test 4A) included removal of the existing window frame (except the perimeter members) as well as the existing glass and louvers. New fixed and double hung sashes — comprised of a 3/16-inch clear annealed exterior lite, a 7/8-inch air gap with argon gas, and a 1/8-inch clear annealed interior lite — replicating the existing configuration were installed. The second variation (Test 4B) was identical to Test 4A except the glass assembly consisted of a 1/4-inch clear annealed exterior lite, a 1/2-inch air gap with argon gas, and a 1/2-inch clear annealed laminated interior lite. The third variation (Test 4C) was identical to Test 4A except the glass assembly consisted of a 1/4-inch clear annealed exterior lite, a 1/2-inch warm edge anodized BB BS, and a 1/2-inch clear annealed laminated interior lite. For Tests 4A, 4B, and 4C, new insulated panels were installed over the existing panels, a new louver was installed, insulation was added in the cavity that surrounds the through the wall air conditioner sleeve and the new through wall air conditioner was re-installed. The interior sound attenuating air conditioner cover was provided for Tests 4A, 4B, and 4C and testing was performed both with the glass door of the air conditioner cover removed and in place. Also for Tests 4A, 4B, and 4C, a pipe penetration through an interior metal blank-off panel in the radiator cavity and a gap along the bottom of this panel were sealed with non-hardening sealant.

No Window Replacement option was tested for 100 Bleecker Street, Apartment 2A.

Based on the procedure outlined above, the façade attenuation of each specimen with Window Replacement and Exterior Wall Improvements was tested. The range of field determined AOITC values for each specimen with Window Replacement and Exterior Wall Improvements are shown in **Table 5**.

Table 5
Test 4 ASTM E966 Test Results

Test	Apartment Unit	Improvements	AOITC Range
4A(i)	1 Washington Square Village, Apartment 2G	Replacement window with 19/16-inch insulated glass unit, new blank-off panel, insulation in cavity around through the wall air conditioner, new through the wall air conditioner in new sleeve, radiator panel sealing	30 to 32
4A(ii)		Replacement window with 19/16-inch insulated glass unit, new blank-off panel, insulation in cavity around through the wall air conditioner, new through the wall air conditioner in new sleeve, radiator panel sealing, custom air conditioner cover	34 to 37
4B(i)		Replacement window with 1-1/4-inch insulated laminated glass unit, new blank-off panel, insulation in cavity around through the wall air conditioner, new through the wall air conditioner in new sleeve, radiator panel sealing	30 to 32
4B(ii)		Replacement window with 1-1/4-inch insulated laminated glass unit, new blank-off panel, insulation in cavity around through the wall air conditioner, new through the wall air conditioner in new sleeve, radiator panel sealing, custom air conditioner cover	37 to 40
4C(i)		Replacement window with 1-1/4-inch insulated laminated glass unit with Warm Edge Anodized BB BS, new blank-off panel, insulation in cavity around through the wall air conditioner, new through the wall air conditioner in new sleeve, radiator panel sealing	30 to 31
4C(ii)		Replacement window with 1-1/4-inch insulated laminated glass unit with Warm Edge Anodized BB BS, new blank-off panel, insulation in cavity around through the wall air conditioner, new through the wall air conditioner in new sleeve, radiator panel sealing, custom air conditioner cover	38 to 39

The Washington Square Village, Apartment 2G Test 4A facade improvements resulted in greater attenuation — as compared to the existing condition — at nearly all of the frequencies tested and provided an AOITC rating increase of 5 to 6 points[3] with the air conditioner cover off and 9 to 11 points[3] with the air conditioner cover on. With the air conditioner cover off, the insulated glass replacement windows and resealing in the panels around the radiator and air conditioner louver provided more attenuation than the existing single paned window; this option provided less attenuation than the storm window or acoustical interior window scenarios in most frequencies mainly due to the difference in air gap size (i.e., 7/8-inch vs. approximately 8 inches). With the air conditioner cover on, the Test 4A façade improvements performed almost as well as the storm window and acoustical interior window options in the middle and higher frequencies but did not provide the same acoustical performance in the low frequencies as could be achieved with an 8-inch air gap.

The Washington Square Village, Apartment 2G Test 4B facade improvements, which were identical to the Test 4A improvements except for the use of insulated laminated glass (vs. insulated glass for test 4A), resulted in greater attenuation — as compared to the existing condition — at nearly all of the frequencies tested and provided an AOITC rating increase of 5 to 6 points[3] with the air conditioner cover off and 12 to 14 points[3] with the air conditioner cover on. The use of insulated laminated glass rather than insulated glass for the replacement windows resulted in marginal attenuation improvement with the air conditioner cover off; this is anticipated to be a result of sound flanking via the through the wall air conditioner. However, with the air conditioner cover on (i.e., sound flanking via the through the wall air conditioner reduced) use of the laminated insulated glass — as compared to insulated glass — provided up to 8 dB of attenuation improvement in the lower frequencies and 3 points of AOITC rating improvement.

The Washington Square Village, Apartment 2G Test 4C facade improvements, which were identical to the Test 4B improvements except for the type of interlayer, resulted in greater attenuation — as compared to the existing condition — at nearly all of the frequencies tested and provided an AOITC rating increase of 4 to 5 points[3] with the air conditioner cover off and 13 points[3] with the air conditioner cover on. The different glazing interlayer used in Test 4C resulted in little difference as compared to Test 4B.

COMPARISON OF FAÇADE IMPROVEMENT OPTIONS AND COMMENTS

Tables 6 and **7** summarize the field-tested AOITC values for all tests performed to date and include the change in AOITC compared to the existing conditions for each of the façade improvement options at Washington Square Village and Silver Towers, respectively.

Table 6
Washington Square Village: Façade Improvements
Acoustical Comparison

Test	Conditions	Window Improvements	HVAC Improvements	Additional Improvements	AOITC[1]	Increase in AOITC vs. Existing Conditions[2]	Perceived Change with Façade Improvements vs. Existing Façade Construction	Number of Apartments Experiencing 5 dB(A) Interior L_{eq} Increase	Number of Apartment-Quarters[3] Experiencing 5 dB(A) Interior L_{eq} Increase	Maximum Interior L_{eq} Increment [in dB(A)]
2A	EIS Minimum Improvements	Typical 1/8" storm window w/ 8" air gap, resealed existing windows	New air conditioner	N/A	34 to 36	8 to 10	Approximately 1/2 as loud	67	242	8
2B			New air conditioner, custom air conditioner cover	N/A	37 to 39	11 to 13	Approximately 1/2 as loud	8	32	6
3A(i)	Acoustical Interior Window and Exterior Wall Improvements	Acoustical interior window with 1/4" laminated glass w/ 8" air gap, resealed existing windows	New air conditioner	Sealing and insulating of pipe penetrations and gaps in radiator panel	34 to 36	9 to 10	Approximately 1/2 as loud	98	387	9
3A(ii)			New air conditioner, custom air conditioner cover		38 to 42	13 to16	Approximately 1/3 as loud	2	8	5
3B(i)		Acoustical interior window with 3/8" laminated glass w/ 8" air gap, resealed existing windows	New air conditioner		34 to 37	9 to 11	Approximately 1/2 as loud	98	387	9
3B(ii)			New air conditioner, custom air conditioner cover		39 to 42	14 to 16	Approximately 1/3 as loud	0	0	4
4A(i)	Window Replacement and Exterior Wall Improvements	Replacement window with 3/16-inch clear annealed exterior lite, a 7/8-inch air gap with argon gas, and a 1/8-inch clear annealed interior lite	New air conditioner	Sealing and insulating of pipe penetrations and gaps in radiator panel, additional insulation in through the wall air conditioner cavity, new exterior blank-off panels	30 to 32	5 to 6	Readily noticeable	383	2251	13
4A(ii)			New air conditioner, custom air conditioner cover		34 to 37	9 to 11	Approximately 1/2 as loud	98	387	9
4B(i)		Replacement window with 1/4-inch clear annealed exterior lite, a 1/2-inch air gap with argon gas, and a 1/2-inch clear annealed laminated interior lite	New air conditioner		30 to 32	5 to 6	Readily noticeable	383	2251	13
4B(ii)			New air conditioner, custom air conditioner cover		37 to 40	12 to 14	Approximately 1/3 as loud	8	32	6
4C(i)		Replacement window with 1/4-inch clear annealed exterior lite, a 1/2-inch warm edge anodized BB BS, and a 1/2-inch clear annealed laminated interior lite	New air conditioner		30 to 31	4 to 5	Readily noticeable	383	2251	13
4C(ii)			New air conditioner, custom air conditioner cover		38 to 39	13	Approximately 1/3 as loud	2	8	5

Notes:
1. AOITC provides a single-number rating that approximates building façade attenuation in A-weighted decibels or dB(A).
2. Change in AOITC versus the existing condition was calculated for each individual angle of incidence.
3. Number of apartments experiencing 5 dB(A) interior noise level increase multiplied by the number of quarter-years that each apartment would experience increases greater than 5 dB(A).

Table 7
Silver Towers: Façade Improvements Acoustical Comparison

Test	Conditions	Window Improvements	HVAC Improvements	Additional Improvements	AOITC[1]	Increase in AOITC vs. Existing Conditions[2]	Perceived Change with Façade Improvements vs. Existing Façade Construction	Number of Apartments Experiencing 5 dB(A) Interior L_{eq} Increase	Number of Apartment-Quarters[3] Experiencing 5 dB(A) Interior L_{eq} Increase	Maximum Interior L_{eq} Increment [in dB(A)]
2	EIS Minimum Improvements	Typical 1/8" storm window with 3" air gap	Replacement PTAC with sound-attenuation package	N/A	24 to 27	2 to 3	Barely perceptible	158	802	7
3A	Acoustical Interior Window and Exterior Wall Improvements	Acoustical interior window with 1/4" laminated glass and approximately 2" to 5" air gap, resealed existing windows	Replacement PTAC with sound-attenuation package	Additional insulation above/around PTAC cabinet, non-PTAC louver area metal blank-off panel sealed and filled with blue foam and batt insulation and sealed with 5/8" gypsum layer held in place by C-stud and caulked full perimeter	27 to 29	4 to 6	Readily noticeable	0	0	4
3B		Acoustical interior window with 3/8" laminated glass and approximately 2" to 5" air gap, resealed existing windows			27 to 30	5 to 6	Readily noticeable	0	0	4
3C		Acoustical interior window with 1/4" laminated glass and approximately 9" air gap, resealed existing windows	New OITC 26 PTAC with adapter sleeve inside existing PTAC sleeve	Additional insulation above/around existing PTAC sleeve, non-PTAC louver area metal blank-off panel sealed, double layer gypsum wall installed across louver around PTAC sleeve, limp-mass barrier material installed on blank-off panel and PTAC sleeve sides, new PTAC cabinet installed over louver area	34 to 36	11 to 12	Approximately 1/2 as loud	0	0	-3[4]
3D		Acoustical interior window with 3/8" laminated glass and approximately 9" air gap, resealed existing windows			33 to 35	10 to 11	Approximately 1/2 as loud	0	0	-3[4]

Notes:
1. AOITC provides a single-number rating that approximates building façade attenuation in A-weighted decibels or dB(A).
2. Change in AOITC versus the existing condition was calculated for each individual angle of incidence.
3. Number of apartments experiencing 5 dB(A) interior noise level increase multiplied by the number of quarter-years that each apartment would experience increases greater than 5 dB(A).
4. Interior noise levels with these scenarios would be at least 3 dB(A) below existing noise levels throughout construction because of the additional attenuation provided.

For each façade improvement option, the "Change in AOITC vs. Existing Conditions" column in **Tables 6** and **7** represents the approximate decrease — in dB(A)[4] — of exterior noise entering the apartment's interior. An improvement of 1 to 2 dB(A) is considered to be barely perceptible and a 3 dB(A) improvement would be considered perceptible. An improvement of 5 dB(A) would be considered readily noticeable. An improvement of 10 dB(A) represents sound being a perceived as half as loud. An improvement of 15 dB(A) represents a sound being perceived as approximately one-third as loud. While responses to changes in noise level vary somewhat from individual to individual, the above relationships are used to describe the expected general perception of acoustical benefits —as compared to the existing conditions — associated with each façade improvement option.

The attenuation improvements predicted for each façade improvement scenario at Washington Square Village are comparable to or greater than the predicted levels of attenuation improvement in the 2012 NYU Core FEIS and the Test 3 and 4 scenarios exceed the FEIS upper limit of attenuation by 13 dB(A). Any of the façade improvement scenarios would be expected to provide the 30 dB(A) of attenuation that the FEIS states would fully mitigate the projected construction noise impacts at Washington Square Village.

The noise level increments during construction inside the Washington Square Village apartments would be expected to reach or exceed 5 dB(A) in some apartments for at least part of the construction period with all of the analyzed improvement scenarios, except Test 3B(ii). Three other improvement scenarios analyzed, including one with acoustical interior windows and two with replacement windows [Tests 3A(ii), 4B(ii), and 4C(ii)], would result in fewer than 10 apartments experiencing a 5 dB(A) or greater increase for an average of one year or less. The relatively low existing interior noise levels in many Washington Square Village apartments, especially apartments facing the interior courtyard, which experience existing interior noise levels as low as the mid 30s dB(A), and the close proximity of these apartments to construction activities make it relatively difficult to avoid noise level increments of 5 dB(A) or more during construction. This is the reason that, even though many of the improvement scenarios for Washington Square Village provide large improvements in attenuation, readily noticeable increases in interior noise level may still occur during construction. It is important to note that event at locations where the interior noise level increment resulting from construction would be less than 5 dB(A), the construction noise may still be audible, because it has different spectral characteristics (i.e., a different mix of frequencies) than the background noise.

The improvements in attenuation predicted for each of the façade improvement scenarios at Silver Towers are comparable to or greater than the predicted levels of attenuation improvement in the 2012 NYU Core FEIS and the Test 3C and 3D scenarios exceed the FEIS upper limit of attenuation by up to 8 dB(A). Only the Test 3C and 3D scenarios façade improvement scenarios would be expected to provide the 30 dB(A) of attenuation that the FEIS states would fully mitigate the projected construction noise impacts at Silver Towers.

The noise level increments during construction inside the Silver Towers apartments would not be expected to reach or exceed 5 dB(A) any apartments with any of the analyzed improvement scenarios, except Test 2, the EIS-minimum conditions. The relatively high existing interior noise levels in many Silver Towers apartments, especially apartments facing Houston Street, which experience existing interior noise levels as high as the low 50s dB(A), ease the burden of avoiding noise level increments of 5 dB(A) or more during construction. This is the reason that, even though only two improvement scenarios (Tests 3C and 3D) for Silver Towers provide sufficient attenuation to fully mitigate the significant adverse noise impacts, all but one result in no readily noticeable increases in interior noise level during construction. It is important to note that event at locations where the interior noise level increment resulting from

[4] Based on the ASTM E1332-10a reference spectrum.

construction would be less than 5 dB(A), the construction noise may still be audible, because it has different spectral characteristics (i.e., a different mix of frequencies) than the background noise.

To assist in putting the field determined AOITC values in perspective, it may be helpful to discuss the attenuation levels that newly constructed residential buildings in New York City are commonly designed to achieve. The amount of attenuation to be included in a New York City residential building's design is based on the development site's exterior noise levels (i.e., louder development sites require higher building attenuation levels for buildings, quieter development sites require lower building attenuation levels). Typical newly constructed residential buildings in Manhattan are designed to achieve approximately 30 dB(A) attenuation. Due to the increased level of vehicular traffic noise, approximately 35 dB(A) attenuation is common for new residential buildings that are constructed along busy avenues (ex: Second Avenue, Tenth Avenue, etc.) or elevated roadways (ex: FDR Drive, Riverside Drive, etc.). While 35 dB(A) is a somewhat more premium level of building attenuation, it is not uncommon for relatively noisy areas in New York City. For newly constructed residential buildings adjacent to elevated subway tracks or bridges with rail activity in New York City, approximately 40 dB(A) or more attenuation is often required. Attenuation levels of 40 dB(A) or more represent a particularly high-level of building attenuation generally found only in especially loud locations. ✷