ATTACHMENT E

7 December 2018

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Strathmore Square
Phase I Noise Analysis

Montgomery County, Maryland

Report #181207
Project #FSD1801

For: Fivesquare Development @ Grosvenor Metro, LLC

By: Jeff Ford
Kody Snow

Acoustical Engineering Solutions.

1 EXECUTIVE SUMMARY

Phoenix Noise & Vibration has conducted an analysis of transportation noise impact upon the proposed Strathmore Square development in Montgomery County, Maryland. Upon completion, the development will consist of multiple multifamily buildings. This study, limited to noise impact from the Metro and surrounding roadways, primarily Rockville Pike, and Tuckerman Lane, included:

- On-site 24-hour noise level measurements.
- Computer modeling.
- Determination of future transportation noise levels.
- Preliminary mitigation recommendations to meet Montgomery County's residential noise regulations.

Noise impact at Strathmore Square will vary with height; therefore, impact has been presented at the ground level and across all building elevations to show how the noise level changes with height throughout the site. Impact is presented in varying levels of noise indicating the future transportation noise level. All calculated noise levels account for the presence of existing buildings, significant structures, and surrounding topography, as well as all future site buildings. Structures along roadways/railways act as noise barriers, providing protection from noise exposure and reducing the impact and extent of any potential mitigation required, if any, to comply with Montgomery County's noise regulations.

Once future topography for the site is available and all proposed outdoor activity areas are shown on the site plan, the analysis can be completed to determine more accurately the ground level noise impact upon the site and if any outdoor activity areas will be impacted. Future transportation noise levels will be above 65 dBA Ldn at the ground level throughout a small portion of the site closest to the Metro and Tuckerman Lane; however, the proposed park will not be exposed to noise levels above 65 dBA Ldn. While the park will not be impacted by noise levels above 65 dBA Ldn, it is unclear if there will be additional outdoor activity areas at the site. Any outdoor activity areas that will be within the 65 dBA Ldn noise contour will require additional mitigation to maintain noise levels within the County's outdoor noise limit.

A portion of the residential buildings located closest to the Metro and Tuckerman Lane will be impacted by transportation noise levels greater than 65 dBA Ldn. Future transportation noise levels will be greatest for those buildings nearest the Metro and Rockville Pike, with impact up to 72 dBA Ldn upon the lower levels of Building 6. Residences impacted by noise levels above 65 dBA Ldn will require further analysis to determine if proposed building architecture will be capable of maintaining indoor noise levels at the required 45 dBA Ldn indoor limit. This analysis can only be conducted once well-developed architectural plans for the residential buildings throughout the site are available. Final mitigation designs will be detailed following the availability of architectural plans.

2 NOISE TERMINOLOGY

2.1 dB vs. dBA

While the standard unit of measurement for sound is the decibel (dB), discussions of noise impacting the human ear use "dBA." The "A" refers to a frequency weighting network used to simulate the human ear's unequal sensitivity to different frequencies. The A-weighted noise level is therefore more representative of a human's perception of a noise environment than the unweighted overall noise level in dB and is currently used in most all environmental noise studies.

2.2 Ldn

The day-night average noise level, or Ldn, is the equivalent sound pressure level averaged over a 24-hour period, obtained by adding 10 dB to sound pressure levels measured from 10:00 p.m. to 7:00 a.m. This 10 dB "penalty" accounts for the added sensitivity caused by noise generated during the nighttime hours.

The Ldn is NOT a measurement of the instantaneous noise level. It is very possible to have several short term events (tractor trailer, emergency vehicle siren, car horn, etc.) which generate a relatively high noise level (e.g. 85 dBA) during a given time period, yet have a more moderate overall Ldn value (e.g. 65 dBA Ldn).

2.3 Summing Noise Levels

Noise levels from multiple sources do not add arithmetically; i.e. when two noise sources generate 60 dB individually, they do not produce 120 dB when combined. Noise levels are measured using a logarithmic scale; therefore they must be summed logarithmically. In the decibel scale, two identical, non-coherent noise sources having the same noise level produce a 3 dB increase above the condition of one source alone (i.e. two 80 dB lawnmowers running at the same time generates 83 dB).

Similarly, two different noise sources with a difference of 10 dB in their individual levels results in no measureable increase in noise when they are combined. Put another way, the quieter noise source does not increase the overall noise generated by the louder source; i.e. adding an 80 dB lawnmower into a noise environment where a 90 dB lawnmower is already running does not increase the noise level above 90 dB.

3 NOISE REGULATION

Traffic noise impact for proposed residential developments in Montgomery County is governed by Table 2-1 (reprinted in Table 1) on page 8 of the *Staff Guidelines for the Consideration of Transportation Noise Impacts In Land Use Planning and Development* (June 1983). Accompanying this table is Map 2-1 (see Figure 1), indicating outdoor noise level requirements not to be exceeded throughout the County.

Table 1: Maximum Levels for Exterior Noise & Building Line[1] For Noise Sensitive Land Uses (Table 2-1).

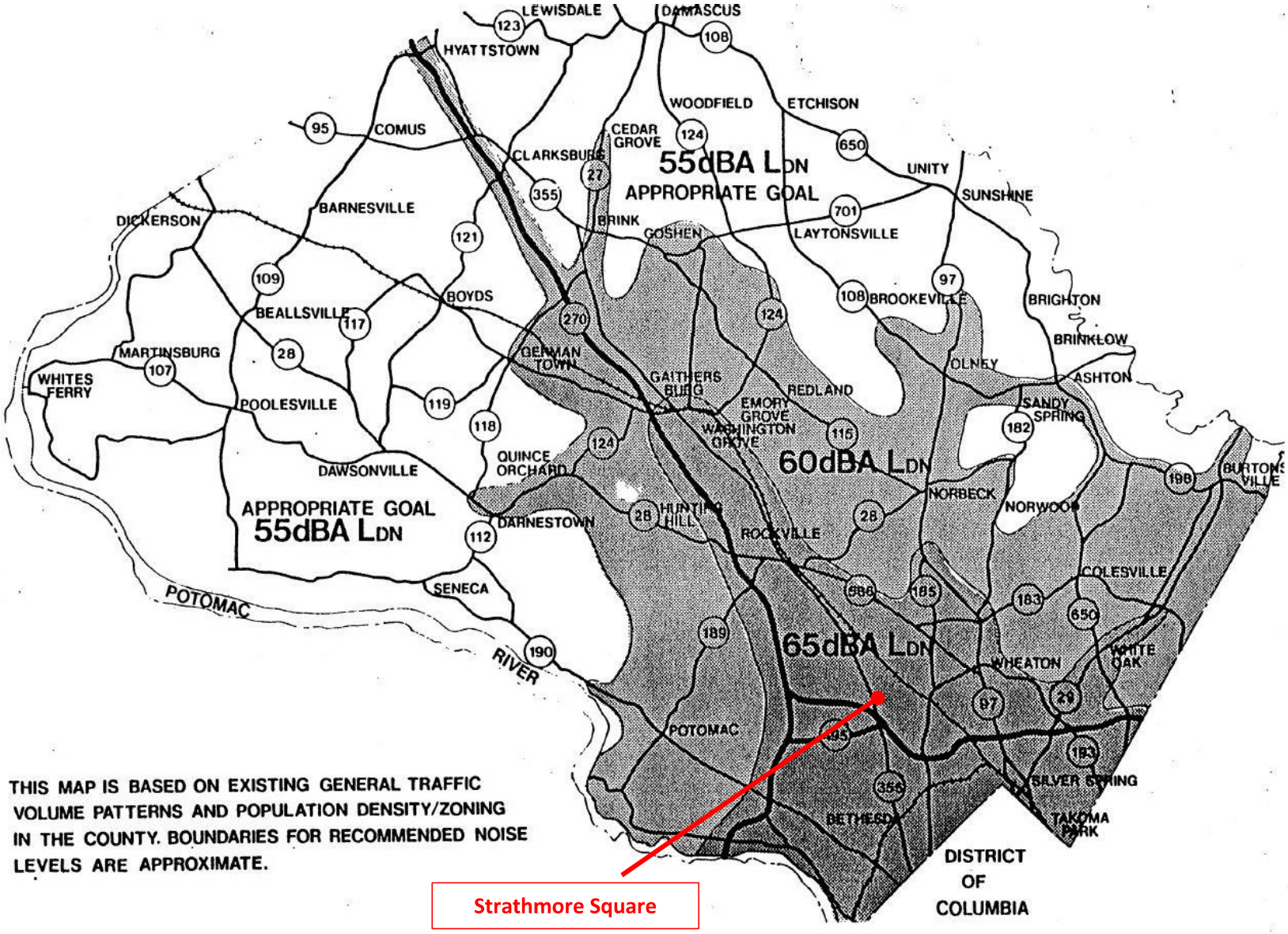
Guideline Value	Area of Application
Ldn = 55 dBA	This guideline is suggested as an appropriate goal in permanent rural areas of the County where residential zoning is for five or more acres per dwelling unit and background levels are low enough to allow maintenance of a 55 dBA Level. This guideline is consistent with Federal, State, and County goals for residential areas.
Ldn = 60 dBA	This is the basic residential noise guideline which will be applied in most areas of the County where suburban densities predominate. Maintenance of this level will protect health and substantially prevent activity interference both indoors and outdoors. Noise attenuation measures will be recommended to allow attainment of this level.
Ldn = 65 dBA	This guideline will generally be applied in the urban ring, freeway, and major highway corridor areas, where ambient levels are such that application of a stricter guideline would be infeasible or inequitable. Significant activity interference will occur outdoors and indoors if windows are partially opened, but available evidence indicates hearing is adequately protected. Noise attenuation measures will be strongly recommended to attain this level.

[1] Building line as used here refers to habitable structures only. It does not include garages, sheds, or recreational accessory buildings.

According to Map 2-1, Strathmore Square is located within the 65 dBA Ldn noise zone, indicating that noise levels in outdoor activity areas throughout the site should be maintained at or below 65 dBA Ldn. Any outdoor area exposed to future transportation noise levels above 65 dBA Ldn typically requires further analysis to determine the mitigation designs necessary to comply with this requirement.

When outdoor noise levels exceed the recommended guideline value, Montgomery County also requires an analysis of indoor noise levels in residential buildings. According to Sections 2.2.2 and 2.2.3 of the *Staff Guidelines*, any residential building impacted by noise levels above 65 dBA Ldn must be evaluated to certify that the building structure will be capable of maintaining indoor noise levels at 45 dBA Ldn.

Figure 1: Map 2-1 from *Staff Guidelines for the Consideration of Transportation Noise Impacts In Land Use Planning and Development* (June 1983).



4 SITE DESCRIPTION

Strathmore Square (approximate development outline shown in red in Figure 2) is located to the east of Rockville Pike. Tuckerman Lane runs to the north and curves to the east of the site as well. The Metro Red Line is also located to the west of the site, between Rockville Pike and the site. The Grosvenor-Strathmore Metro station is located directly adjacent to the property line of the site. The Metro enters a tunnel approximately 50 feet south of Tuckerman Lane.

In the vicinity of the site, Rockville Pike is composed of three northbound and three southbound lanes, while Tuckerman Lane is generally composed of two westbound and two eastbound lanes to the north of the site and one northbound and one southbound lane to the east of the site. The Metro is composed of one northbound track and one southbound track.

Figure 2: Existing site plan (outlined in red) and surroundings. Aerial image dated April 30, 2018, courtesy of Google Earth.

5 NOISE MEASUREMENTS

On November 29 – 30, 2018, Phoenix Noise & Vibration conducted an on-site noise measurement survey to determine existing transportation noise levels throughout the site. This involved continuous noise level measurements and monitoring for one 24-hour period. Measurements were made using two Norsonic Type 118 and three Norsonic Type 140 Precision Integrating Sound Level Meters. All meters were calibrated prior to the survey traceable to National Institute of Standards and Technology (NIST). Each meter meets the ANSI S1.4 standard for Type 1 sound level meters.

During the 24-hour measurement, noise levels were recorded and averaged over five-minute time intervals. Noise measurements were then used to calculate the site's 24-hour average day-night noise level (Ldn), which includes the 10 dBA penalty for noise levels measured during nighttime hours.

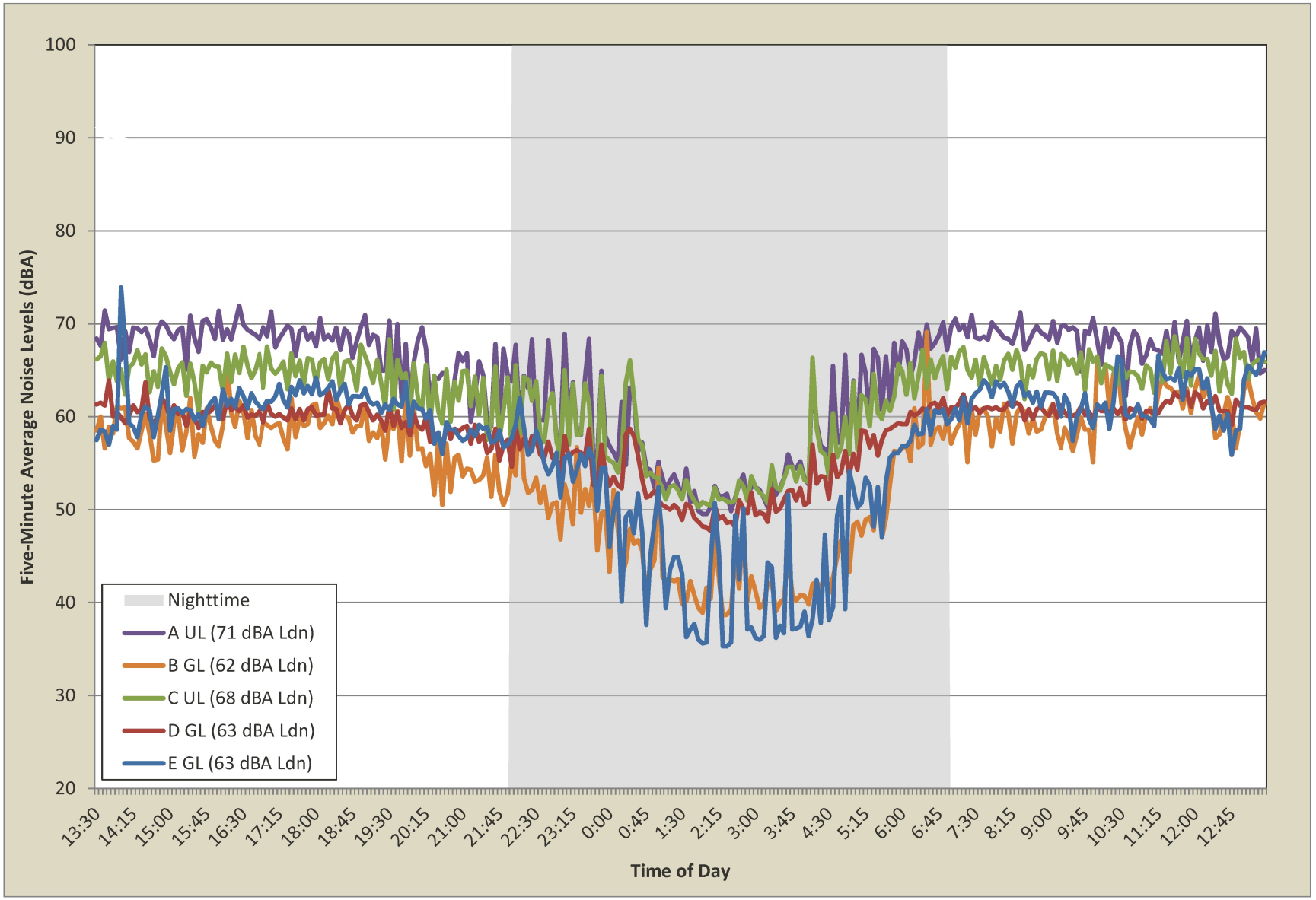
Noise level measurements were made at the locations shown on Drawing 1 of the Appendix. Measurements were made at 5 feet, 25 feet, and 45 feet above existing grade to account for the transportation noise level as it varies with height above the ground. Measurement D was on top of the existing parking garage in order to obtain noise measurements very high in elevation. Measurement results are presented in Table 2.

Table 2: 24-hour noise measurement results.

Measurement Location	Height Above Adjacent Grade (feet)	Measured Noise Level (dBA Ldn)	Primary Noise Source
A	25	71	Metro and Rockville Pike
B	5	62	Tuckerman Lane
C	25	68	Metro and Rockville Pike
D	45	63	Metro and Rockville Pike
E	5	63	Tuckerman Lane

Figure 3 presents the survey results graphically, showing the noise level as measured in five-minute increments throughout the survey. Figure 3 indicates the actual measured values over the 24-hour period. While the 10 dBA nighttime penalty is not shown graphically, it was included in the Ldn calculations.

Figure 3: Five-minute average noise levels recorded during 24-hour noise survey.



6 COMPUTER MODELING

The existing and future sites were computer modeled using the CadnaA software program, a three-dimensional noise propagation model capable of determining the noise level impact from multiple noise sources across vertical and horizontal surfaces while accounting for factors such as topography, significant structures, surface reflections, railway data, and roadway data (traffic volumes, speeds, and vehicle classifications, etc.). Noise levels can be presented either in spot locations or as noise contours of equal value throughout a defined surface area.

6.1 Current Model

A current model was developed to simulate the existing site and its surroundings using information provided on the site's existing site plan,[1] the Montgomery County GIS, and data collected during the 24-hour measurement survey, inputting existing topography, roadway/railway alignments, and buildings. Roadway/railway noise levels were calibrated using the on-site noise measurements by adjusting the modeled input until the modeled noise level output matched the measured values.

6.2 Future Model

A future model was developed by altering the calibrated current model to include projected roadway data, and the future information for the Strathmore Square development (building layout and established heights). While the Metro was included in the future model, railway noise output was not adjusted (from the current model) due to the unavailability of projected railway data.

Future topography was not available at the time of the analysis. Once available, future topography can be incorporated into the future model and the noise level throughout the site can be recalculated. It should also be noted that not all building details were provided in the civil drawings; therefore, the exact footprints and heights are not exact. Once final building heights and footprints are available, the model should be revised to reflect the proposed buildings more accurately.

The future model calculated the site's projected noise level contours at 5 feet above grade, as presented on Drawing 2 of the Appendix, which represent the noise impact in outdoor spaces throughout the site.

The future noise impact was also calculated across all future building facades (shown on Drawing 3 of the Appendix). The varying colors on the building elevations on Drawing 3 represent the future noise impact at that location. Notice how the noise level changes with respect to height and orientation to the roadways/railways.

All noise levels presented on Drawings 2 and 3 are calculated in the presence of all future buildings, as well as all existing surrounding buildings, topography, and significant structures. These noise levels account for the effect of buildings and other significant structures in reducing

[1] Provided by Vika on November 19, 2018.

and reflecting roadway/railway noise propagation and are more representative of the noise level actually experienced at a specific location following the full build-out of the site.

6.3 Roadway Data

Existing average annual weekday traffic (AAWDT) volumes, vehicle percentages, and nighttime percentages for the roadways were based upon the most recent data published by the Maryland State Highway Administration (MDSHA). MDSHA does not typically provide future traffic data; therefore, a conservative, 2% increase in traffic compounded annually until 2038 was assumed.[2]

Table 3: Roadway traffic data.

Traffic Data	Rockville Pike	Tuckerman Lane (west of Rockville Pike)	Tuckerman Lane (east of Rockville Pike)	Bus Lane[A]
2017 AAWDT	60,391	20,065	11,715	320
2038 AAWDT	91,533	30,412	17,756	476
Truck %	4%	5%[A]	5%[A]	100% Buses
Nighttime %	13%	8%	12%	7%
Speed Limit	45 mph	30 mph	30 mph	5 mph

A. The Metro bus lane traffic data is estimated based on observations made during the noise measurements.
B. MDSHA does not provide automobile and truck percentages for Tuckerman Lane; therefore, the typically used industry assumption in absence of this data was used.

6.4 Future Noise Impact

Drawing 2 of the Appendix (noise level contours at 5 feet above adjacent grade) indicates that the proposed park between Buildings 4 and 5 will not be impacted by noise levels above 65 dBA Ldn. It is unclear if there are any other proposed outdoor activity areas throughout the site. If any other outdoor activity areas are to be proposed for the site, further analysis will be necessary to determine if they will be impacted by noise levels above 65 dBA Ldn.

Drawing 3 of the Appendix indicates the future transportation noise levels upon all levels of the future residences at Strathmore Square. Future transportation noise impact will be greatest for those residences nearest the Metro and Rockville Pike. More specifically, Building 6 will be exposed to noise levels of up to 72 dBA Ldn at the lower levels of the west elevation. Noise impact is summarized below in Table 4.

[2] Montgomery County typically requires that roadway noise impact studies be conducted using the projected traffic volumes 20 years from the date of the study.

Table 4: Noise impact upon the proposed multifamily buildings of Strathmore Square.

Building	Building Elevation	Maximum Future Noise Impact (dBA Ldn)
1	North	<65
	East	65
	South	<65
	West	<65
2	North	<65
	East	65
	South	<65
	West	<65
3A	North	<65
	East	65
	South	<65
	West	<65
3B	North	<65
	East	65
	South	<65
	West	<65
4	North	65
	East	<65
	South	68
	West	69
5	North	<65
	East	<65
	South	65
	West	67
6	North	67
	East	<65
	South	69
	West	72

Residences exposed to noise levels above 65 dBA Ldn require further analysis (see Section 7.2 below) to determine the mitigation measures necessary to comply with Montgomery County's indoor noise regulation.

7 MITIGATION

According to Montgomery County's noise regulations for residential development, residential sites and buildings impacted by noise levels above 65 dBA Ldn require further analysis to determine the mitigation measures necessary to maintain noise levels in outdoor activity areas and indoor living spaces at 65 and 45 dBA Ldn, respectively.

7.1 Outdoor Noise Levels

Drawing 2 indicates that the proposed park between Buildings 4 and 5 will not be exposed to noise levels above 65 dBA Ldn. If any other outdoor activity areas will be proposed at locations on the site that are impacted by noise levels above 65 dBA Ldn, additional analysis will be required to determine whether mitigation will be required.

7.2 Indoor Noise Levels

7.2.1 Building Shell Analysis

According to the future noise levels shown on Drawing 3, some of the future residences will be exposed to noise levels above 65 dBA Ldn. Residential buildings exposed to noise levels above 65 dBA Ldn (at any height) require further analysis to determine whether the proposed building construction will be capable of maintaining indoor noise levels below 45 dBA Ldn. This evaluation, or "building shell analysis," calculates a room's indoor noise level based upon its exterior noise level, the Sound Transmission Class (STC) ratings[3] of its various building components, the amount of exposed exterior wall area, and the room's size and finish.

Modifications to standard building construction may not be necessary for all units impacted by future noise levels above 65 dBA Ldn. It is possible that the proposed standard building construction will provide sufficient noise reduction to maintain the required 45 dBA Ldn indoor noise level for outdoor noise levels above 65 dBA Ldn; however, the proposed building construction must be evaluated to determine the need for modifications.

A detailed evaluation of the proposed architecture for the Strathmore Square future buildings cannot be conducted at this time, as well-developed architectural drawings (floor plans, unit plans, building elevations, window/door schedule) are not yet available; therefore, the specific mitigation designs (i.e. wall, window, and door STC ratings) required for residential units to comply with Montgomery County's indoor noise level limit, if necessary, cannot yet be accurately determined. Additionally, the site should be re-analyzed once future topography is available and the final building footprints and heights are known.

When architectural drawings are available, noise impact will be analyzed for each residence impacted by transportation noise levels above 65 dBA Ldn. Likewise, mitigation requirements will also be provided for each residence individually where necessary. Calculating minimum STC ratings specific to each residence reduces "overbuilding" (i.e. installing windows/doors with unnecessarily high STC ratings).

[3] The STC rating is a single number value which describes a building element's (wall, window, door, roof, etc.) ability to reduce noise transmission from one side of the partition to the other.

To aid in the early phases of the design process and provide information on the factors that influence noise reduction in residential buildings, general mitigation design guidelines and explanations are provided in Section 7.2.22.

7.2.2 STC Rating Requirements

The noise reduction provided by a building structure, and the resulting indoor noise level, are primarily dependent upon the percentage of the exterior wall surface area occupied by "non-wall" items and the STC ratings of these items. These items, typically windows and doors, act as "holes" in what would otherwise be a relatively effective exterior wall, significantly reducing its ability to prevent noise transmission. Consequently the exterior surface area occupied by windows and doors is a significant issue. This information is recorded and tracked so that the STC ratings of exterior elements can be adjusted accordingly until the required indoor noise level is achieved.

While the wall construction is also an important factor, the "holes" in the wall (i.e. the windows and doors) must be addressed first if the noise reduction of the overall building shell is to be significantly increased and the indoor noise level decreased. This can be accomplished by reducing the size of existing windows/doors and/or increasing the STC ratings of windows/doors.

Table 5 and Table 6 illustrate this concept, indicating window/door STC rating requirements based upon the window/door (or glass) area when using either cementitious/Hardi panel or brick/masonry exterior walls.[4] The STC ratings shown are those necessary to maintain indoor noise levels at 45 dBA Ldn when using that specific exterior wall construction.

The values included in Table 5 and Table 6 were calculated using one generic room (15 feet x 15 feet, carpeted room with two walls exposed to noise) to demonstrate the concept of varying window/door percentages and the resulting effect on required STC ratings. Values in Table 5 and Table 6 **should not** be universally applied to outdoor noise impact upon Strathmore Square residences; however they can be used to gain a general idea of the window/door STC ratings to be expected based upon the level of noise impact upon a building elevation. Actual STC ratings will depend upon interior room finishes and characteristics, room/building orientation with respect to the noise source, building geometry, etc.

[4] STC ratings were calculated assuming exterior walls constructed of one layer of 5/8" interior gypsum board, 2" x 4" wood studs with 3.5" fiberglass batt insulation, one layer of ½" exterior plywood, and the specified exterior wall finish.

Table 5: Hypothetical window/door STC ratings with cementitious or Hardi panel exterior walls.

	Percentage of Exterior Wall Area Occupied by Windows/Doors			
	20%	40%	60%	80%
Outdoor Noise Impact (dBA Ldn)	**Required Window/Door STC Rating Necessary to Maintain Indoor Noise Levels Below 45 dBA Ldn (When Using Cementitious or Hardi Panel Exterior Walls)**			
≤ 65	25	25	27	28
70	28	30	32	33
75	35	37	38	39

Note:
A. Due to the limited STC rating achievable by the exterior construction, the window/door STC ratings will be significantly high (>50 STC), which means that the construction of the exterior will need to be modified to increase the wall's STC rating.

Table 6: Hypothetical window/door STC ratings with brick/masonry exterior walls.

	Percentage of Exterior Wall Area Occupied by Windows/Doors			
	20%	40%	60%	80%
Outdoor Noise Impact (dBA Ldn)	**Required Window/Door STC Rating Necessary to Maintain Indoor Noise Levels Below 45 dBA Ldn (When Using Brick/Masonry Exterior Walls)**			
≤ 65	25	25	27	28
70	27	30	32	33
75	32	35	37	38

STC ratings apply to one individual element. The composite STC rating is the overall STC rating of a partition with multiple elements (e.g. a wall with a window) and is always controlled by the building element with the lowest individual STC rating. In residential construction, this is almost always the glass (windows and doors); therefore the percentage of the exterior wall occupied by glass becomes critical. This also means the amount of outdoor noise heard inside a unit is primarily dependent on the glass percentage and STC rating, not the wall STC rating.

In other words, when the glass occupies such a significant portion of the exterior wall, increasing the wall STC rating even drastically will not decrease the indoor noise level. Increasing the composite STC rating of the partition must be accomplished by first addressing the "weakest link" in the partition (the glass).

Note that when windows and/or doors occupy a high percentage of the impacted façade, substantially higher window/door STC ratings than those typically used in standard construction (usually around 25 STC) may be required depending upon the noise level impact. For reference, STC ratings greater than approximately 33 STC require either laminated glass, increased airspace between glass panes, or varying glass pane thicknesses.

8 CONCLUSION

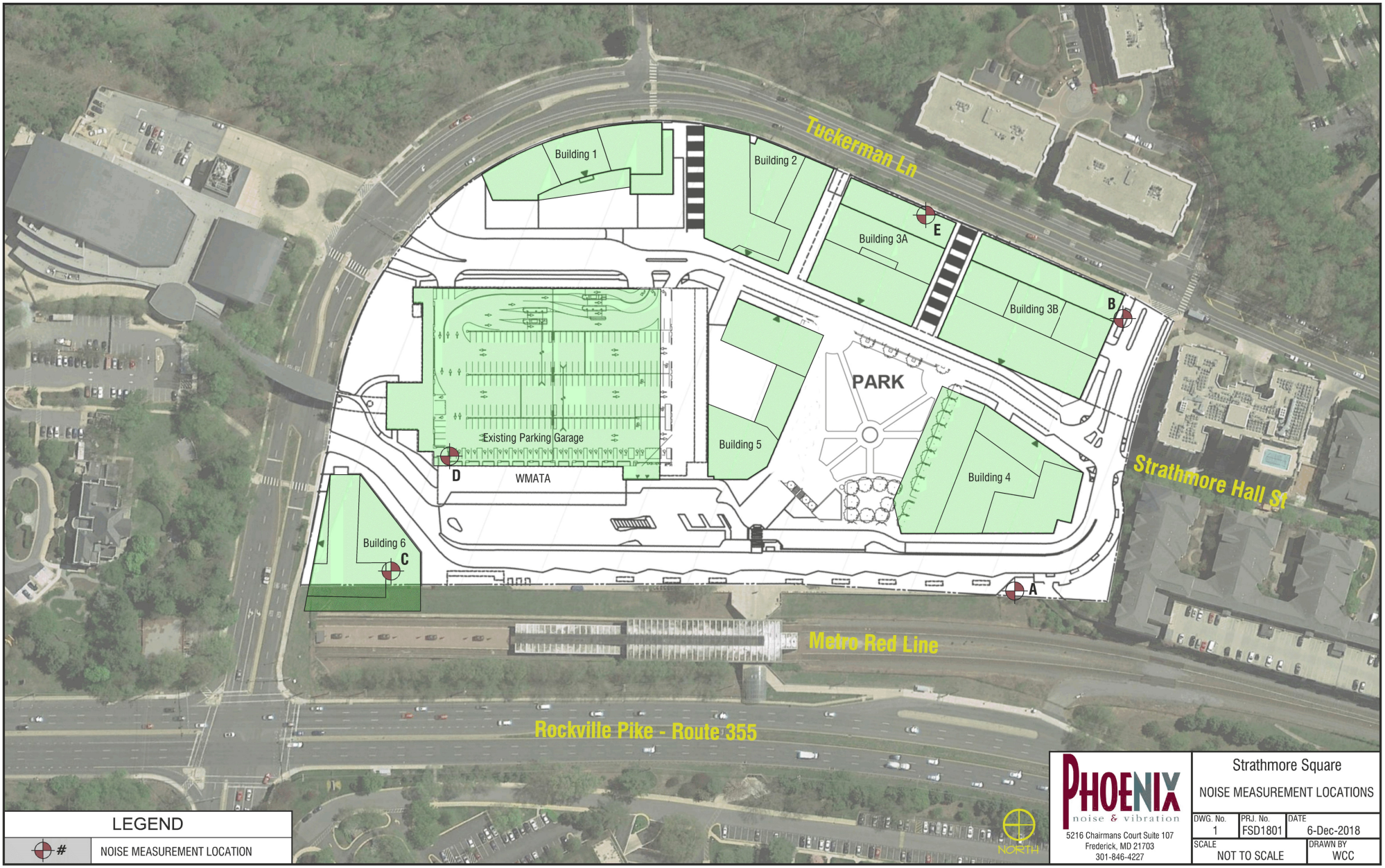
Strathmore Square residences will be exposed to future roadway noise levels above 65 dBA Ldn and up to 72 dBA Ldn. While this represents a moderate level of noise impact, compliance with Montgomery County's residential noise regulations can be achieved through reasonable modifications to proposed building plans.

Due to the close proximity to the Metro and several roadways, transportation noise levels within areas closest to these noise sources will be above 65 dBA Ldn at the ground level. While the proposed park will not be exposed to noise levels above 65 dBA Ldn, it is unclear if there will be additional outdoor activity areas proposed for the site. Once future topography is available and all proposed outdoor activity areas are shown on the site plan, the site will be re-analyzed to determine the exact extent of future noise impact upon the outdoor activity areas.

Some of the residences at Strathmore Square will be exposed to future transportation noise levels above 65 dBA Ldn. While noise impact upon these residences will be above the recommended outdoor noise level of 65 dBA Ldn, compliance with Montgomery County's residential 45 dBA Ldn indoor noise level requirement can be achieved through modifications to proposed building construction. Depending upon the noise level specific to each residence, modifications may include only increased window/door STC ratings or slight adjustments to exterior wall construction and upgraded windows/doors. Further analysis is required to determine the exact mitigation designs necessary, which will be established once a builder has been selected and architectural plans (building elevations, window/door schedule, unit plans) for the future residential buildings are available.

Please Note: The results of this Phase I Noise Analysis have been based upon the site information made available at the time of this study, including existing topography, projected roadway traffic volumes, and the currently proposed ultimate building layout and building heights. When any of this information be altered, additional analysis will be required to determine if the results and recommendations presented herein are capable of reducing outdoor and indoor noise levels to comply with Montgomery County's noise level requirements for residential development.

APPENDIX



LEGEND

#	NOISE MEASUREMENT LOCATION

PHOENIX noise & vibration
5216 Chairmans Court Suite 107
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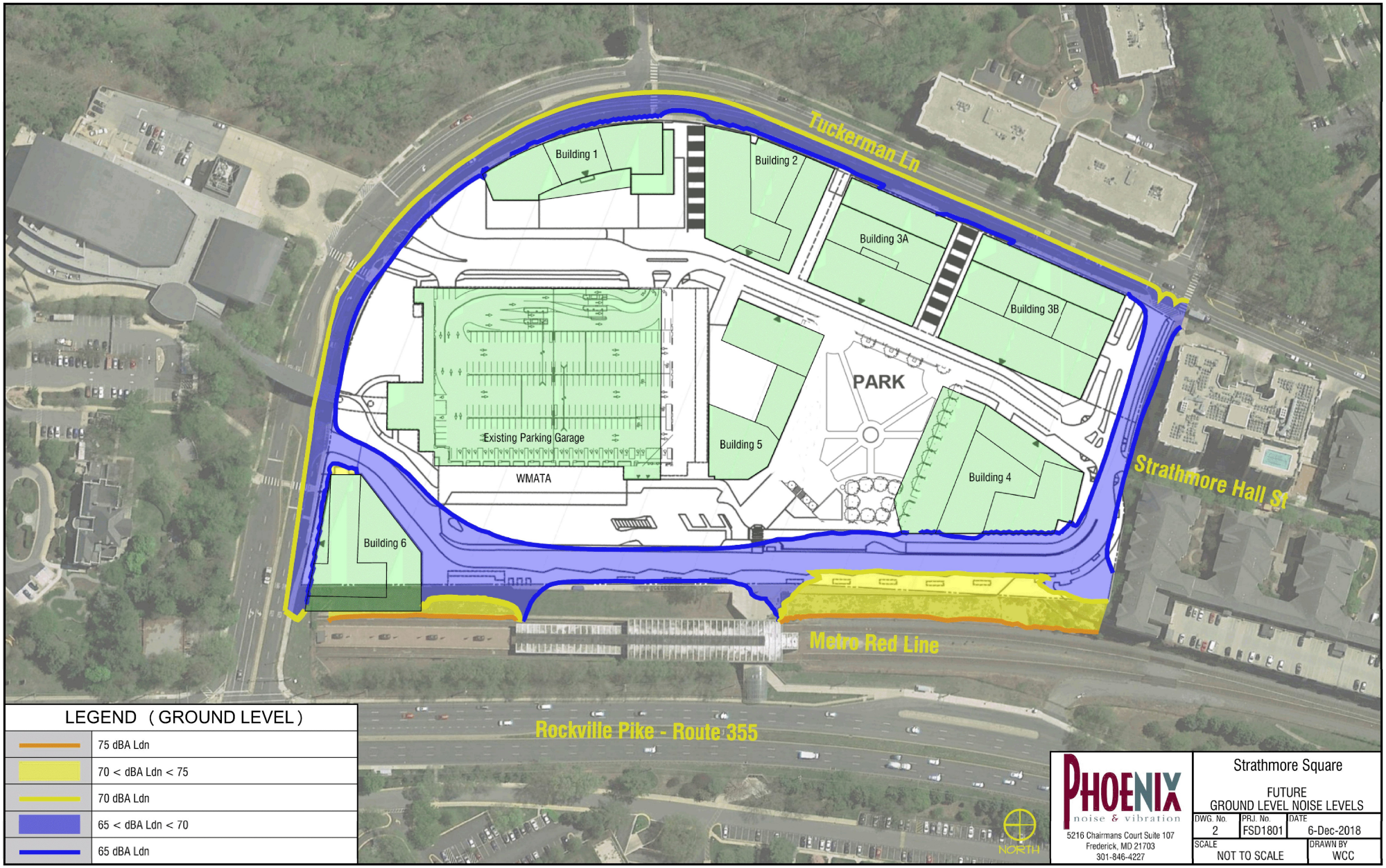
301-846-4227

Strathmore Square

NOISE MEASUREMENT LOCATIONS

DWG. No.	PRJ. No.	DATE
1	FSD1801	6-Dec-2018

SCALE	DRAWN BY
NOT TO SCALE	WCC



LEGEND (GROUND LEVEL)	
	75 dBA Ldn
	70 < dBA Ldn < 75
	70 dBA Ldn
	65 < dBA Ldn < 70
	65 dBA Ldn

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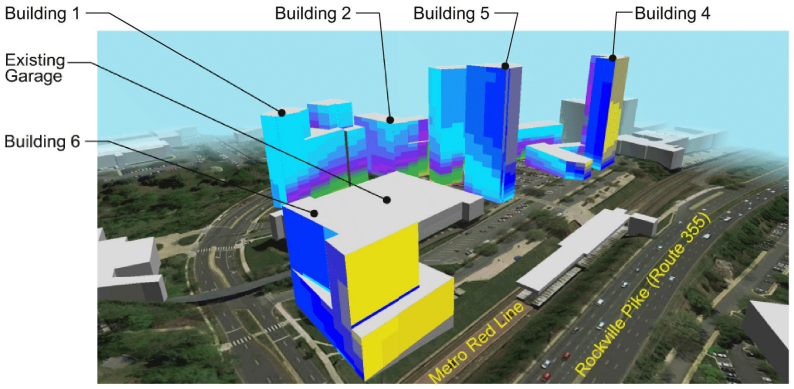
Strathmore Square

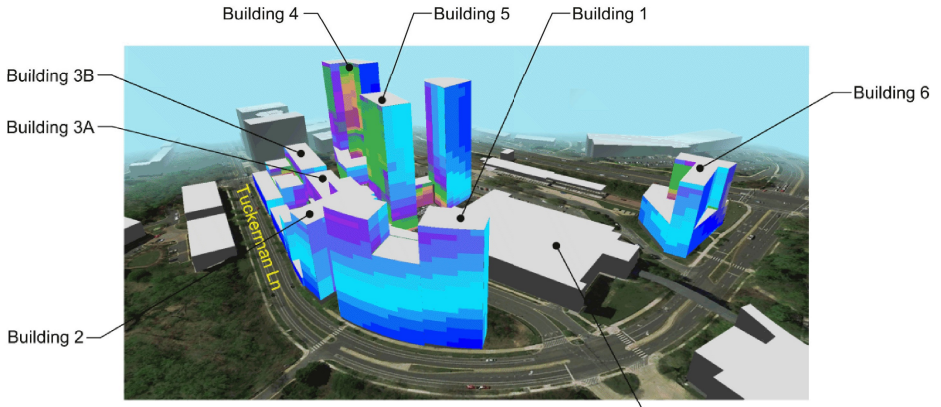
FUTURE
GROUND LEVEL NOISE LEVELS

DWG. No.	PRJ. No.	DATE
2	FSD1801	6-Dec-2018

SCALE	DRAWN BY
NOT TO SCALE	WCC



1 Looking Southeast



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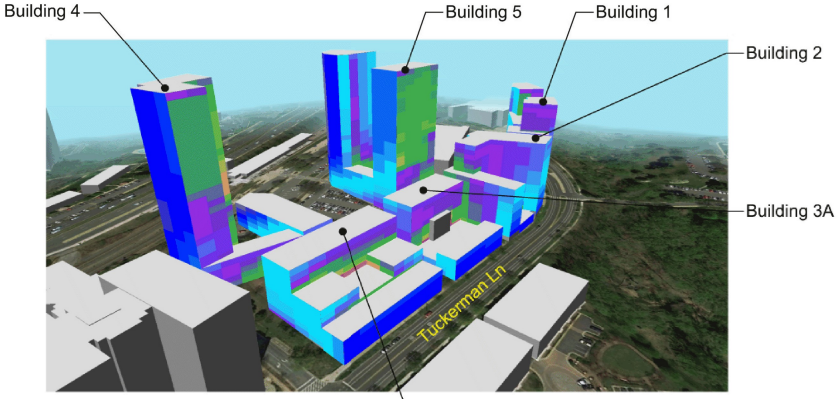
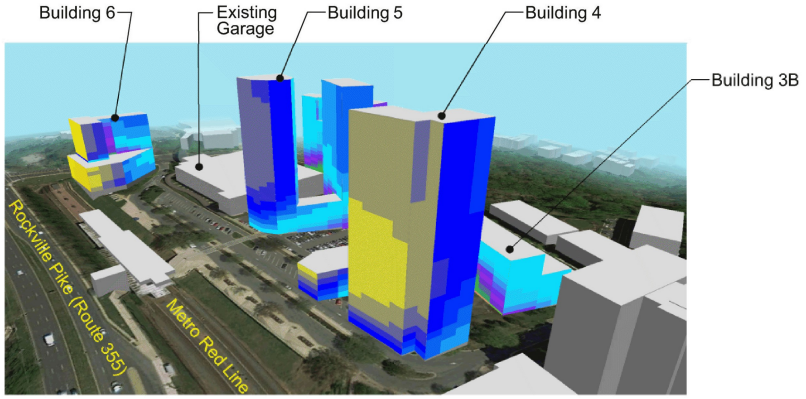
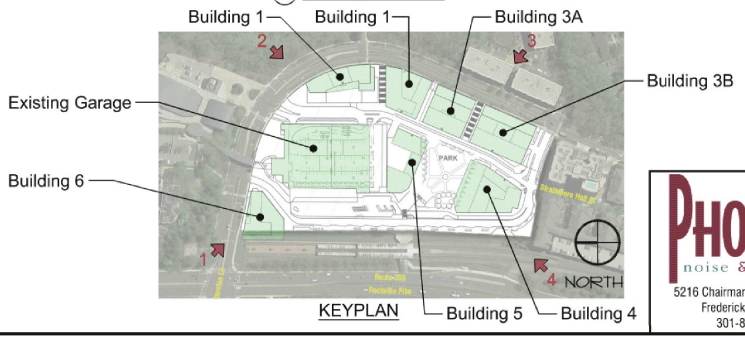


3 Looking Northwest



4 Looking Northeast



KEYPLAN

Future Transportation Noise Levels (dBA Ldn)

72 71 70 69 68 67 66 65 64 63 62 61 60 59 58 57 56 55 54 53 52 51 50 49 48 47 46 45

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Strathmore Square

FUTURE TRANSPORTATION NOISE IMPACT

DWG. No.	PRJ. No.	DATE
3	FSD1801	6-Dec-2018

SCALE	DRAWN BY
NOT TO SCALE	WCC