FINAL REPORT

929 RICHMOND ROAD

OTTAWA, ONTARIO

LAND USE PLANNING
NOISE AND VIBRATION FEASIBILITY STUDY

RWDI #1800803

May 22, 2018

SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI was retained by Roderick Lahey Architect Inc. to conduct an environmental noise and vibration feasibility study for the proposed 20-storey development to be located at 929 Richmond Road in Ottawa, Ontario. The purpose of this assessment was to predict noise and vibration levels affecting the proposed development using the applicable guidelines and determine the overall feasibility of the project.

This assessment considers the impacts of road traffic noise from Richmond Road and Woodroffe Avenue and vibration from the future Confederation Line Light Rail Transit (LRT) expansion. At the time of this report, the alignment of the LRT expansion had not been finalized with two proposed alignments being considered (Richmond Street and Byron Park alignments). As such, the vibrations impacts of both alignments are presented. As the future LRT expansion is proposed to be underground at this location, it is not expected that airborne noise impacts at the façade of the development will be significant. No other existing sources of environmental noise or vibration are anticipated to significantly impact the development.

Sound due to road-traffic sources exceed the City of Ottawa and Publication NPC-300 sound level limits at the proposed development. This report outlines requirements for addressing the excess sound and which Warning Clauses must apply to purchase or rental agreements. The proposed development can meet the requirements of the City of Ottawa and NPC-300 with the following:

- Implementation of Warning Clause “D” on all units. The warning clause would be included in agreements of Offers of Purchase and Sale, and lease/rental agreements.
- All units must include the installation of central air conditioning.
- A safety barrier installed along edges of the penthouse amenity OLA_1. The safety barrier, which is typically 1 to 1.2 m in height, must be solid in construction and free of gaps and cracks

Vibration effects from the proposed Confederation Line LRT Expansion were predicted in accordance with the methods of the United States Department of Transportation - Federal Transit Administration. The predicted limits of both considered track alignments were assessed and found that the Richmond Road alignment is at the 0.1 mm/s limit, and the Byron Park alignment was below the 0.1 mm/s limit. The screening assessment included assumptions regarding soil type that should be verified through a detailed vibration propagation study if the Richmond Road alignment is selected. If the Byron Park alignment is selected, no further study is required, and no mitigation measures are needed.

The feasibility study was based on assumptions regarding building configurations and construction and therefore the resulting recommendations are broad. Therefore, prior to the construction of the development, a detailed design study is required to ensure that appropriate noise control measures have been incorporated into the design.

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1 INTRODUCTION

RWDI was retained to conduct a noise and vibration feasibility study for the proposed development to be located at 929 Richmond Road in Ottawa, Ontario. The purpose of this assessment was to assess the impact of all noise and vibration sources affecting the development using the applicable guidelines, and determine the overall feasibility of the project. This noise feasibility study was based on the site plan drawings dated April 30, 2018 and elevations dated March 29th, 2018.

As part of the Site Plan and Zoning By-Law Amendment, the City of Ottawa requested a noise and vibration study be completed to determine the compatibility of the new residential development and the existing and future sources of environmental noise and vibration.

The purpose of the feasibility study was to assess the impact of all noise sources affecting the proposed development. This assessment considered the impacts of road traffic noise from Richmond Road and Woodroffe Avenue, and vibration levels due to the proposed Confederation Line LRT expansion. As the future LRT expansion is proposed to be underground, it is not anticipated that noise impacts at the façade of the development will be significant. No other significant roadways are near the proposed development and no other existing sources of environmental noise or vibration are anticipated to significantly impact the development.

The scope of this study did not include evaluation of noise from stationary sources proposed as part of the development of 929 Richmond Road. The mechanical equipment will be designed to achieve compliance with the City of Ottawa and MOECC guidelines.

2 DESCRIPTION OF PROJECT AND SITE

The proposed development site is located at 929 Richmond Road on the corner of Richmond Road and Woodroffe Avenue in Ottawa, Ontario. The 20-storey development will consist of a mixed commercial and residential ground level with the remaining storeys consisting of residential units. The building includes a common outdoor amenity rooftop area on the 20th floor. The floorplan drawings of the proposed development is attached in **Appendix A**.

3 SOUND ON PROPOSED DEVELOPMENT

The detailed evaluation of transportation-related noise affecting the proposed development was assessed using the City of Ottawa Environmental Noise Control Guidelines (Ottawa, 2016) and the MOECC guidelines, as defined in Publication NPC-300 (MOECC, 2013).

3.1 Road-Traffic Noise Assessment

3.1.1 Road-Traffic Source Assessment Criteria

For assessing sound originating from road-traffic sources, the City of Ottawa Guidelines and Publication NPC-300 define sound level criteria for two types of locations: outdoor living areas (OLAs), and indoor areas of sensitive uses.

An OLA is defined as an outdoor area easily accessible from the building and designed for the quiet enjoyment of the outdoor environment. Courtyards, terraces and balconies (with a depth of more than 4 m) are considered noise-sensitive OLAs. The daytime sound level limit for an OLAs is an equivalent sound level of 55 dBA averaged over the daytime hours (07:00 to 23:00h). City of Ottawa Guidelines and Publication NPC-300 does not define a nighttime sound level limit for OLAs.

Indoor spaces have daytime and nighttime sound level limits relating to the type of usage, such as living/dining rooms or bedrooms. Indoor living areas within the proposed developments include dining/living rooms and bedrooms.

The City of Ottawa and NPC-300 sound level criteria for transportation-related sources are summarized in **Table 1**.

Table 1: City of Ottawa and NPC-300 Road-Traffic Source Sound Level Criteria for Sensitive Land Uses

Assessment Location	Time of Day	Time Period	Sound Level Limit[1]
Outdoor Living Area	Daytime	07:00-23:00h	55 dBA
Indoor Living Area	Daytime	07:00-23:00h	45 dBA
	Nighttime	23:00-07:00h	45 dBA
Sleeping Quarters	Daytime	07:00-23:00h	45 dBA
	Nighttime	23:00-07:00h	40 dBA

1. The average sound level over the time period at the assessment location must not exceed the sound level limit.

3.1.2 Traffic Data

Richmond Road and Woodroffe Avenue are the only roadways whose road-traffic emissions are anticipated to significantly impact the development. Other roads in the area are minor (Byron Avenue) or distant and are not expected to have a significant impact on the development. The location of the proposed development in relation to Richmond Road and Woodroffe Avenue is shown below in **Figure 1**.

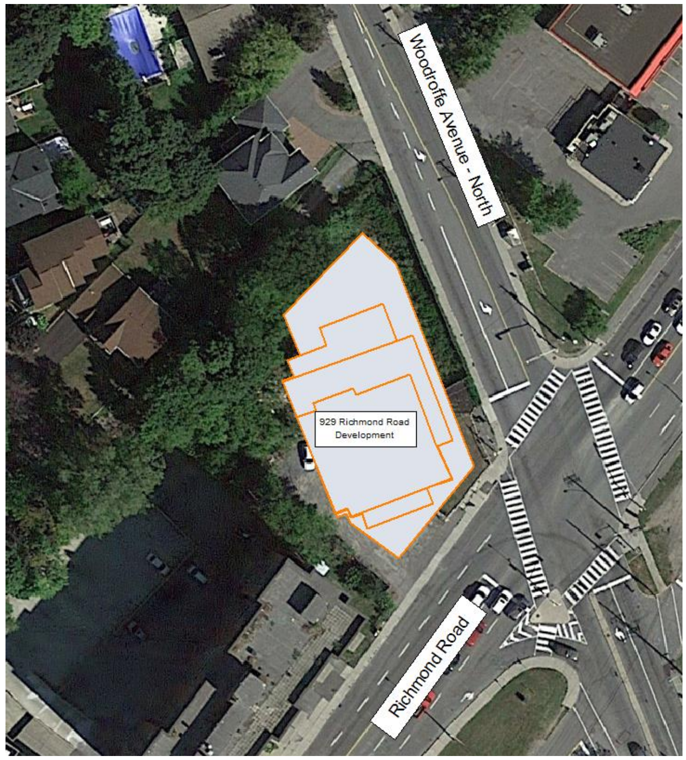

Figure 1: Proposed Development in Relation to Significant Road Noise Sources

The AADT traffic volumes and light, medium, and heavy vehicle classification breakdown used within this assessment were taken from Table B1 in the City of Ottawa Environmental Noise Control Guidelines. This volume was split in half to account for both the eastbound and westbound traffic for Richmond Road. A summary of the traffic data is provided in **Table 2**. See **Appendix B** for copies of the traffic data and sample calculations.

Table 2: Road Traffic Data for Transportation-related Source Assessment

Roadway Link	AADT[1]	Daytime / Nighttime Split (%Day / %Night)	%Light	%Medium	%Heavy	Speed (km/hr)
Woodroffe Avenue	15000	92 / 8	88	7	5	50
Richmond Road (Eastbound)	7500					
Richmond Road (Westbound)	7500					

1. AADT – Annual Average Daily Traffic.

3.1.3 Representative Receptors for Transportation Sources

The selection of receptors is based on the site plan drawing dated April 30, 2018. The locations of the receptors in relation to the development site plan are shown in **Figure 2**.

Those façade receptors located on the podium levels (NR1, NR2, NR4, NR5 and NR6) were modelled at the second storey windows while receptor NR3 was modelled at the third storey. Sound levels at higher storeys will be lower. Receptor NR2 is located at the corner of the development, whose exposure to road traffic is greatest. One outdoor living area, OLA1, was assessed at the 20th floor shared amenity patio. None of the private balconies have a depth of more than four meters, and thus these locations did not need to be considered as outdoor living areas.

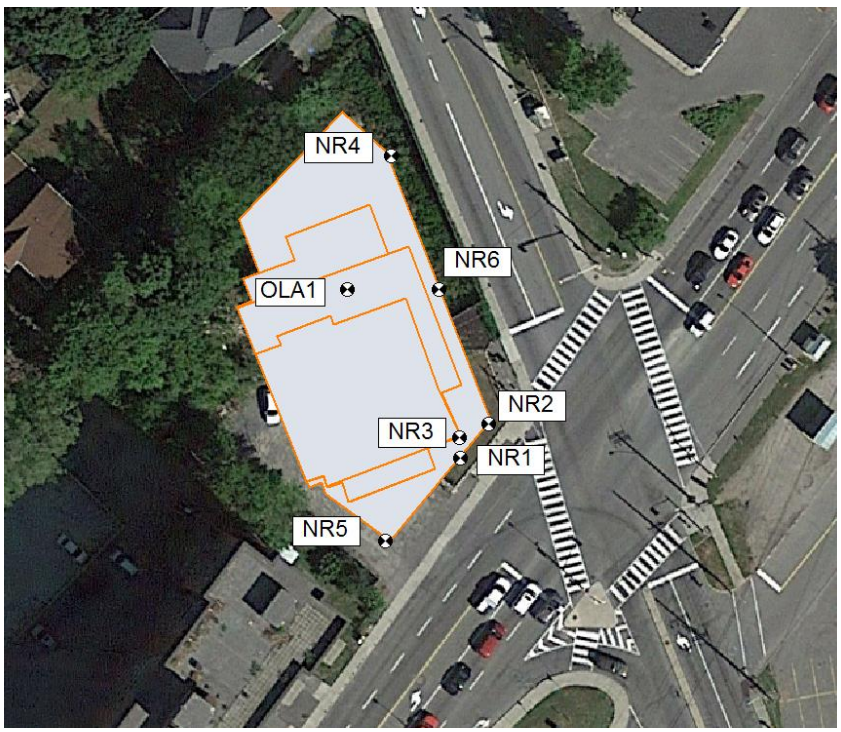

Figure 2: Locations of Noise Sensitive Receptors in relation to the 929 Richmond Road Development

3.1.4 Noise Modelling Results

Sound levels from road traffic along Richmond Road and Woodroffe Avenue were estimated using a spreadsheet implementation of the Ontario Road Noise Analysis Method for Environment and Transportation (ORNAMENT) algorithms (MOECC, 1989). The detailed inputs and outputs from the ORNAMENT modelling are provided in **Appendix C.**

3.1.5 Indoor Sensitive Areas

The indoor sound level is calculated from the sound level at the corresponding façade location. The indoor sound level is derived from the façade level by a reduction of 28 dB, which estimates the loss through a minimum OBC window construction. The calculated worst-case indoor sound levels compared to the applicable limits for road traffic noise are presented in **Table 3**.

Table 3: Results of Façade ORNAMENT Modelling for Traffic-Noise Assessment

Receptor	Predicted Facade Road-Traffic Sound Exposures (dBA)		Predicted Indoor Road-Traffic Sound Exposures (dBA) [1]		Indoor Sound Level Limit (dBA)		Compliance with Limit? (Yes/No)	
	Daytime L_{EQ}, 16hr	Nighttime L_{EQ}, 8hr	Daytime L_{EQ}, 16hr	Nighttime L_{EQ}, 8hr	Daytime L_{EQ}, 16hr	Nighttime L_{EQ}, 8hr	Daytime	Nighttime
NR1	71	63	43	35	45	40	**Yes With Conditions**	**Yes With Conditions**
NR2	72	64	44	36	45	40	**Yes With Conditions**	**Yes With Conditions**
NR3	70	62	42	34	45	40	**Yes With Conditions**	**Yes With Conditions**
NR4	71	63	43	35	45	40	**Yes With Conditions**	**Yes With Conditions**
NR5	67	59	39	31	45	40	**Yes With Conditions**	**Yes With Conditions**
NR6	70	63	42	35	45	40	**Yes With Conditions**	**Yes With Conditions**

1. Predicted indoor sound levels include a 28 dB reduction in sound level due to loss through a minimum standard Ontario Building code window.

Indoor Sensitive Areas – Addressing Excess Sound

The road traffic sound levels at the façade are higher than 65 dBA during the daytime and 60 dBA during the nighttime. These sound levels at the façade may be acceptable, provided that all residential units include the installation of central air conditioning. As well, future tenants must be warned through the appropriate NPC-300 Warning Clause “Type D”. Warning Clause “Type D” requires the dwelling to be designed to allow for the future installation of air conditioning at the occupant’s discretion. The wording of the “Type D” warning clause is presented in **Section 5**.

In addition to the required warning clauses, building components including walls and doors need to be designed to ensure the indoor sound levels comply with the limits detailed in **Table 3**. The south and east facades of the development will require building components with more significant transmission losses in comparison to the remaining façades. As the design of the proposed development progresses, including window and room dimensions, a detailed design study of suitable building components is required.

3.1.6 Outdoor Living Areas

Table 4 summarizes the predicted road traffic sound levels at the OLA.

Table 4: Results of OLA ORNAMENT Modelling for Traffic-Noise Assessment

Receptor	Predicted OLA Road-Traffic Sound Exposures Without Barrier (dBA)	Predicted OLA Road-Traffic Sound Exposures With 1.2 m Barrier (dBA) [1]	Outdoor Sound Level Limit (dBA)	Compliance with Limit? (Yes/No)
	Daytime L_{EQ}, 16hr	Daytime L_{EQ}, 16hr	Daytime L_{EQ}, 16hr	
OLA1	65	50	55	**Yes with conditions**

1. Assessment assumes a 1.2 m high safety barrier around the edges of the building perimeter.

As shown in **Table 4**, the sound level at OLA1 is lower than the 55 dBA limit. To achieve 55 dBA, a safety barrier which is typically 1 to 1.2 m in height must be solid in construction and free of gaps and cracks. The locations which require the solid safety barrier for sound reductions are illustrated in red in **Figure 3**.

Figure 3: The locations of the required solid parapet

4 VIBRATION ON THE PROPOSED DEVELOPMENT

The Confederation Line Light Rail Transit project is proposed to be less than 100 m away from the proposed development. Due to the close proximity of the rail line, vibration impacts from the LRT were considered. The rail line is planned to start running parallel to the development in in the year 2024. The trains will consist of two separate cars and will be electric, with no locomotives. In the area surrounding the development, the rails will be situated in an underground tunnel. Thus, airborne noise emissions with the passing of trains on the façade of the development were assumed to be insignificant.

At the time of this report, the alignment of the LRT expansion had not been finalized, with two proposed locations being considered: Richmond Road and Byron Park. The locations of these alignments, in relation to the proposed development, are shown below in **Figure 4**. In discussions with the Transportation Services Department for the City of Ottawa, it was indicated that the Byron Park alignment is currently the preferred option, but the final selection of alignment will be selected in the first quarter of 2018. As such, vibration impacts of both alignments are presented.

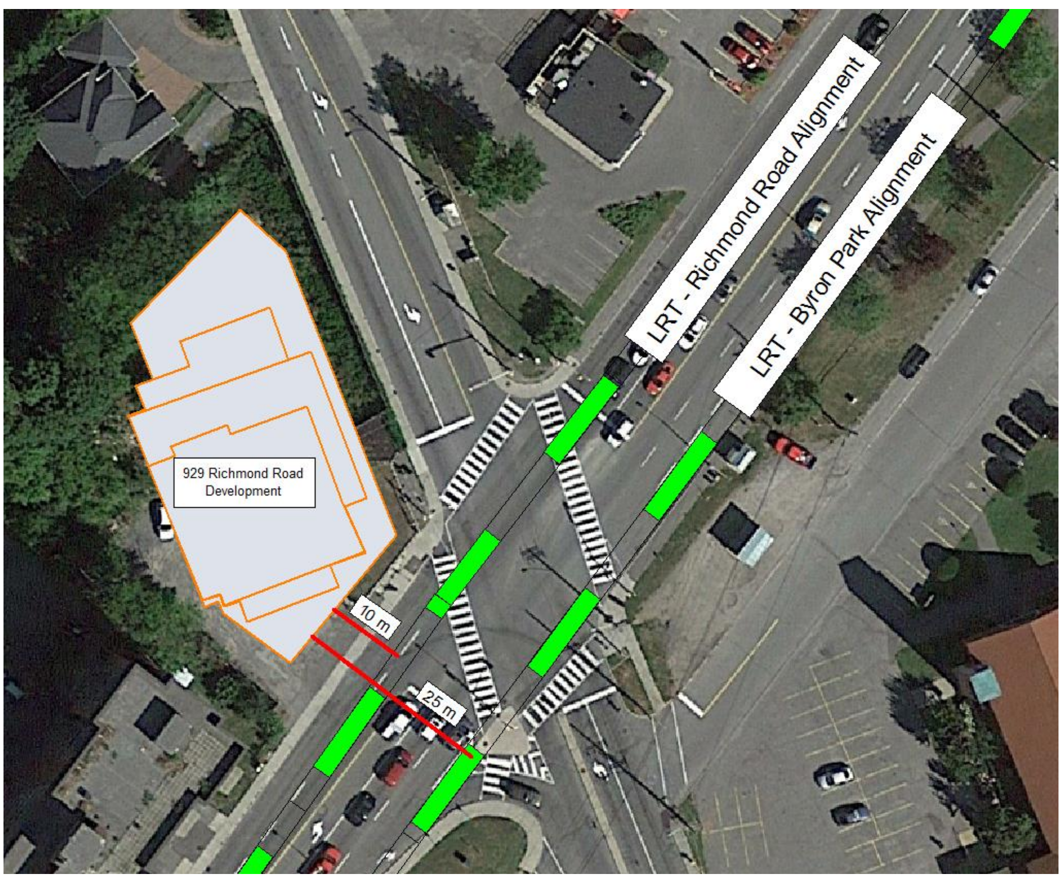

Figure 4: Locations of the Two Proposed Alignments in relation to the 929 Richmond Road Development

4.1 Vibration Source Assessment Criteria and Modelling Results

Vibration effects from the proposed Confederation Line LRT Expansion were predicted in accordance with the methods of the United States Department of Transportation - Federal Transit Administration (FTA, 2006). Vibration levels were expressed in terms of root-mean-square (RMS) velocity in the vertical direction, which is the dominant axis for vibration generated from mobile sources such as trains and most closely correlated with human annoyance and perceptibility. In the absence of specific guidelines for the City of Ottawa, the predicted vibration levels were assessed against the MOECC/TTC Protocol for Noise and Vibration Assessment 0.1 mm/s limit (MOECC/TTC, 1993). This limit represents the threshold of perception for humans. Predicted vibration levels from both alignments are detailed in **Table 5**. Example FTA calculations of the predicted vibration levels are included in **Appendix D**.

Table 5: Predicted Vibration Levels Associated with Two Proposed LRT Expansion Alignments

LRT Expansion Alignment	Closest Distance Between Track and Development (m)	RMS Vibration Level		Mitigation Required?
		Predicted Vibration Level (mm/s)	Limit (mm/s) [1]	
Richmond Road	10	0.098	0.10	No
Byron Park	25	0.055	0.10	No

1. RMS vertical vibration velocity limit as defined in the MOE-TTC Protocol for Noise and Vibration Assessment.

A shown in Table 5, the vibration levels due to the Confederation Line LRT Expansion Richmond Road alignment is predicted to be at the 0.1 mm/s perceptibility limit. The above screening assessment incorporates assumptions about the maintenance of the LRT system and the soil type surrounding the building. These calculations assume a well-maintained system (i.e., no worn wheels or track) of the proposed Confederation Line LRT and a soil type with typical propagation. It is reasonable to expect that the LRT will be kept in good working order with regular maintenance on the wheels and rail lines. However, the actual geological conditions may influence the vibration levels at the proposed development. For the Byron Park alignment, it is not expected that the soil type will affect the vibration levels in such a way that they would exceed the 0.1 mm/s limit. However, for the Richmond Road alignment, the actual geological conditions could result in perceptible vibration levels above the 0.1 mm/s limit. Therefore, if the Richmond Road alignment is selected in the first quarter of 2018, a detailed study on the vibration characteristics of the soil surrounding the proposed development would be required to ensure no mitigation measures are required. If the Byron Park alignment is selected, no mitigation measures would be required.

5 WARNING CLAUSES

Type D: *"This dwelling unit has been supplied with a central air conditioning system which will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the Municipality and the Ministry of the Environment."*

6 CONCLUSION

RWDI completed a noise and vibration feasibility study to assess the noise and vibration impacts affecting the proposed development at 929 Richmond Road. Road traffic noise from Richmond Road and Woodroffe Avenue were identified as the dominant sources of sound that could affect the proposed development.

Sound due to road-traffic sources exceed the City of Ottawa and Publication NPC-300 sound level limits at the proposed development. This report outlines requirements for addressing the excess sound and which Warning Clauses must apply to purchase or rental agreements. The proposed development can meet the requirements with the following:

- Implementation of Warning Clause "D" on all units. The warning clause would be included in agreements of Offers of Purchase and Sale, and lease/rental agreements.
- All units must include the installation of central air conditioning.
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Vibration effects from the proposed Confederation Line LRT Expansion were predicted in accordance with the methods of the United States Department of Transportation - Federal Transit Administration. The predicted limits for two proposed track alignments were assessed and found that the Richmond Road alignment is at the 0.1 mm/s limit, with the Byron Park alignment below this limit. The screening assessment included assumptions regarding soil type which should be verified through a detailed vibration propagation study if the Richmond Road alignment is selected. If the Byron Park alignment is selected, no further study is required, and no mitigation measures are required.

The feasibility study was based on assumptions regarding building configurations and construction and therefore the resulting recommendations are broad. As such, prior to the construction of the development, a detailed design study is required to ensure that appropriate noise control measures have been incorporated into the design.

7 REFERENCES

1. Ontario Ministry of the Environment and Climate Change (MOECC), 1989, ORNAMENT Ontario Road Noise Analysis Method for Environment and Transportation, Technical Publication

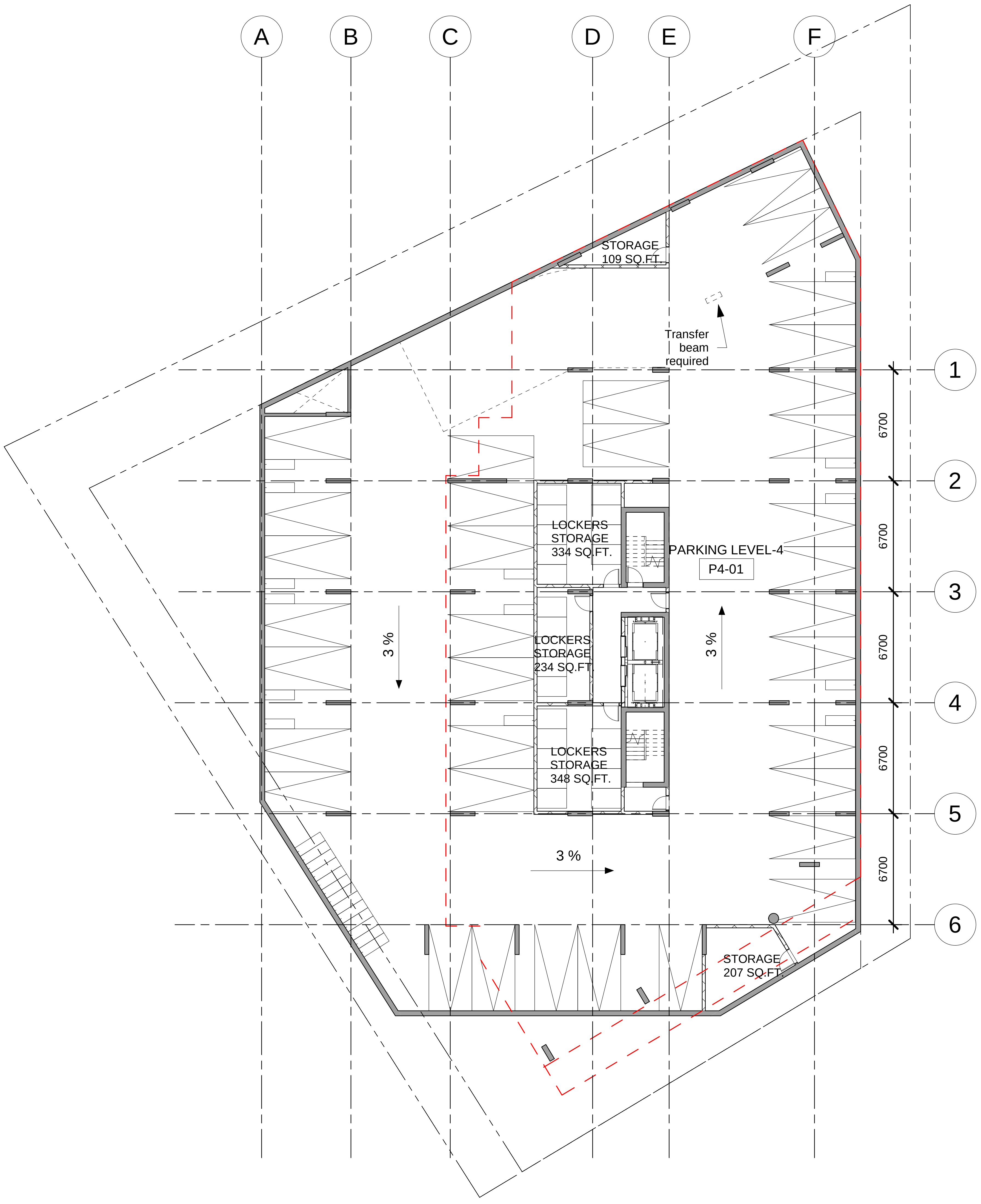
2. MOECC/TTC, June 1993, Publication MOEE/TTC Protocol for Noise and Vibration Assessment

3. Federal Transit Administration, U.S. Department of Transportation (FTA), 2006, *Transit Noise and Vibration Impact Assessment.*

4. Ontario Ministry of the Environment and Climate Change (MOECC), August 2013, Publication NPC-300, *Environmental Noise Guideline Stationary and Transportation Sources – Approval and Planning*

5. City of Ottawa (Ottawa), 2016, Environmental Noise Control Guidelines

APPENDIX A



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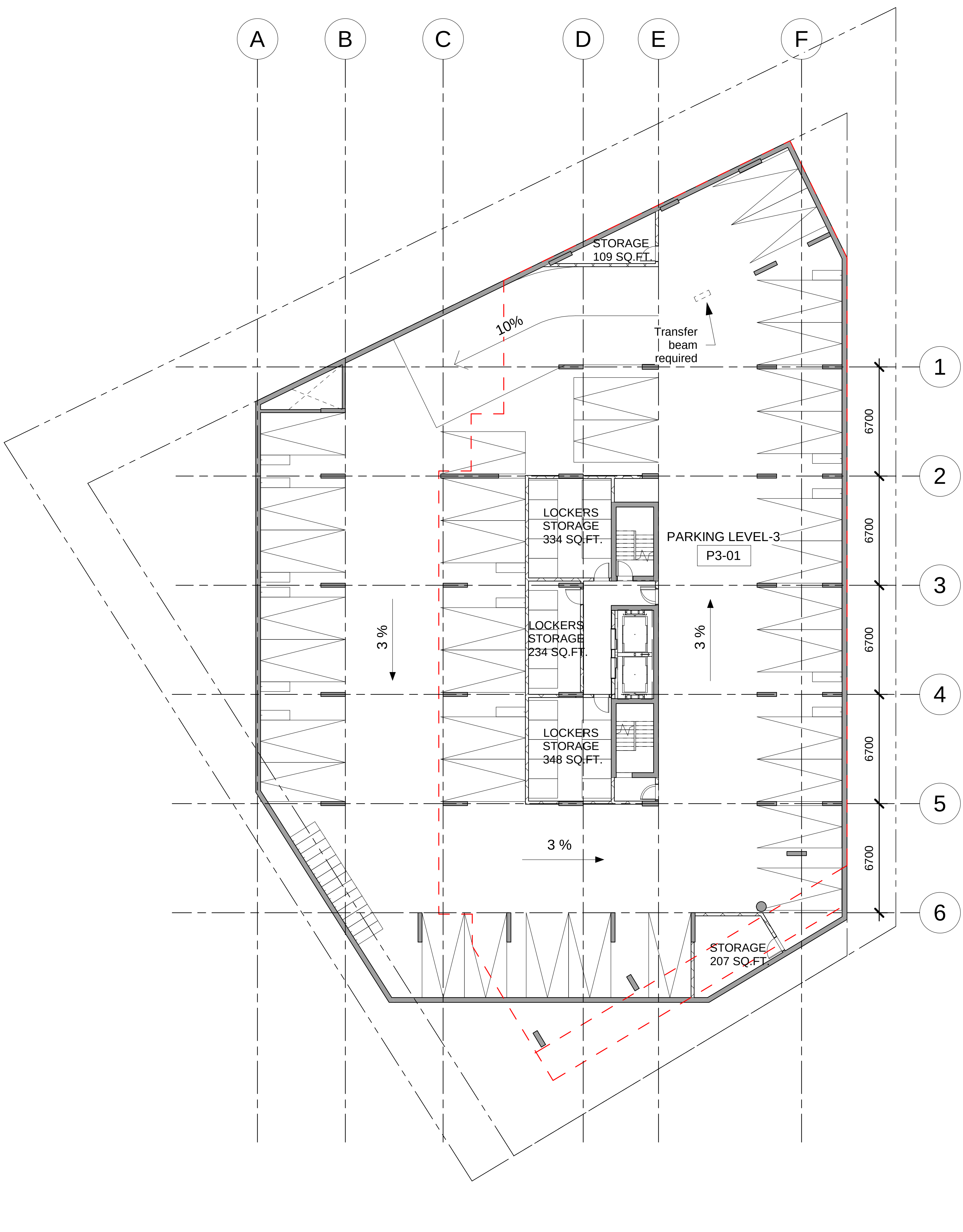

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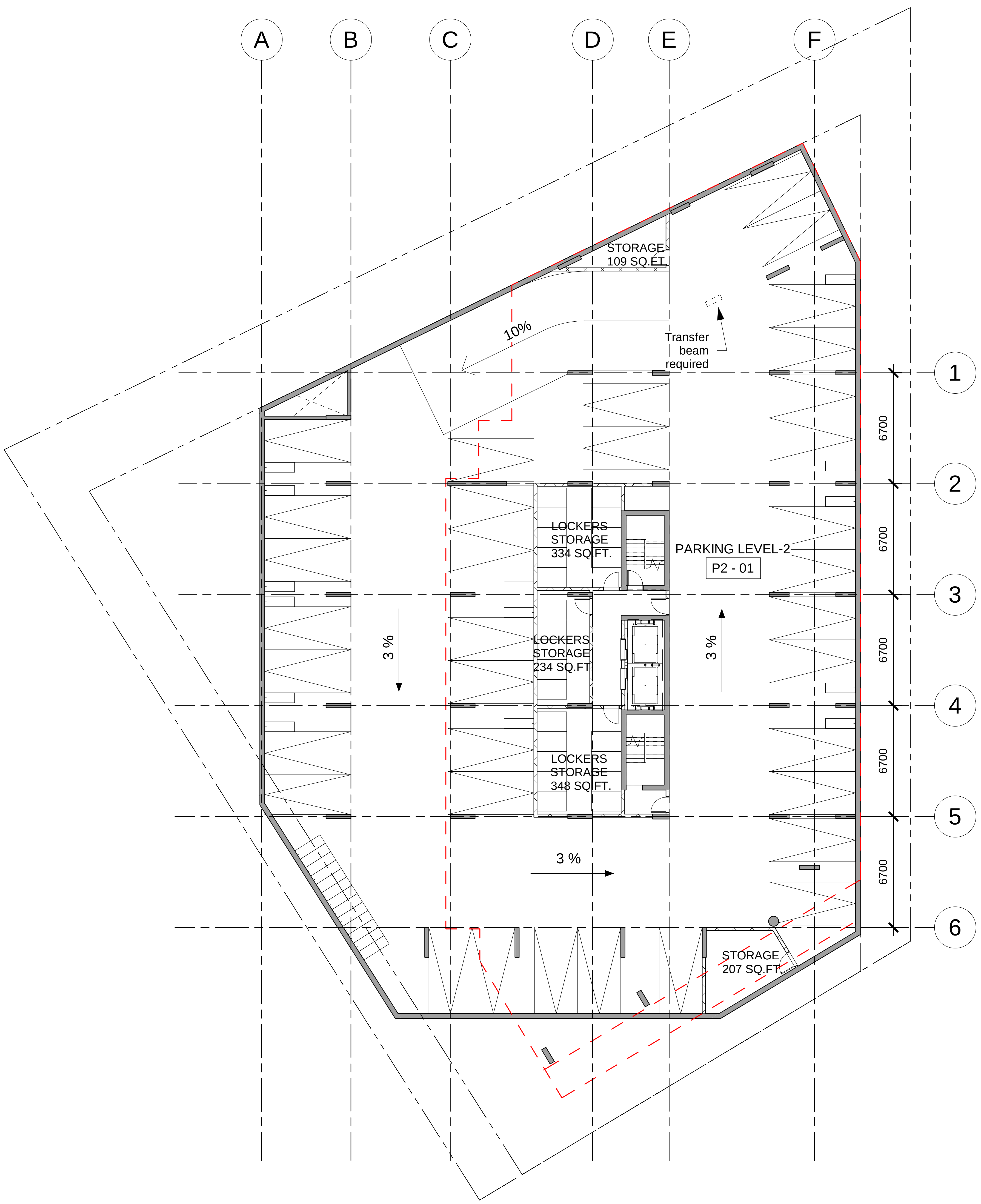

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THE AZURE - OTTAWA

929 RICHMOND RD.

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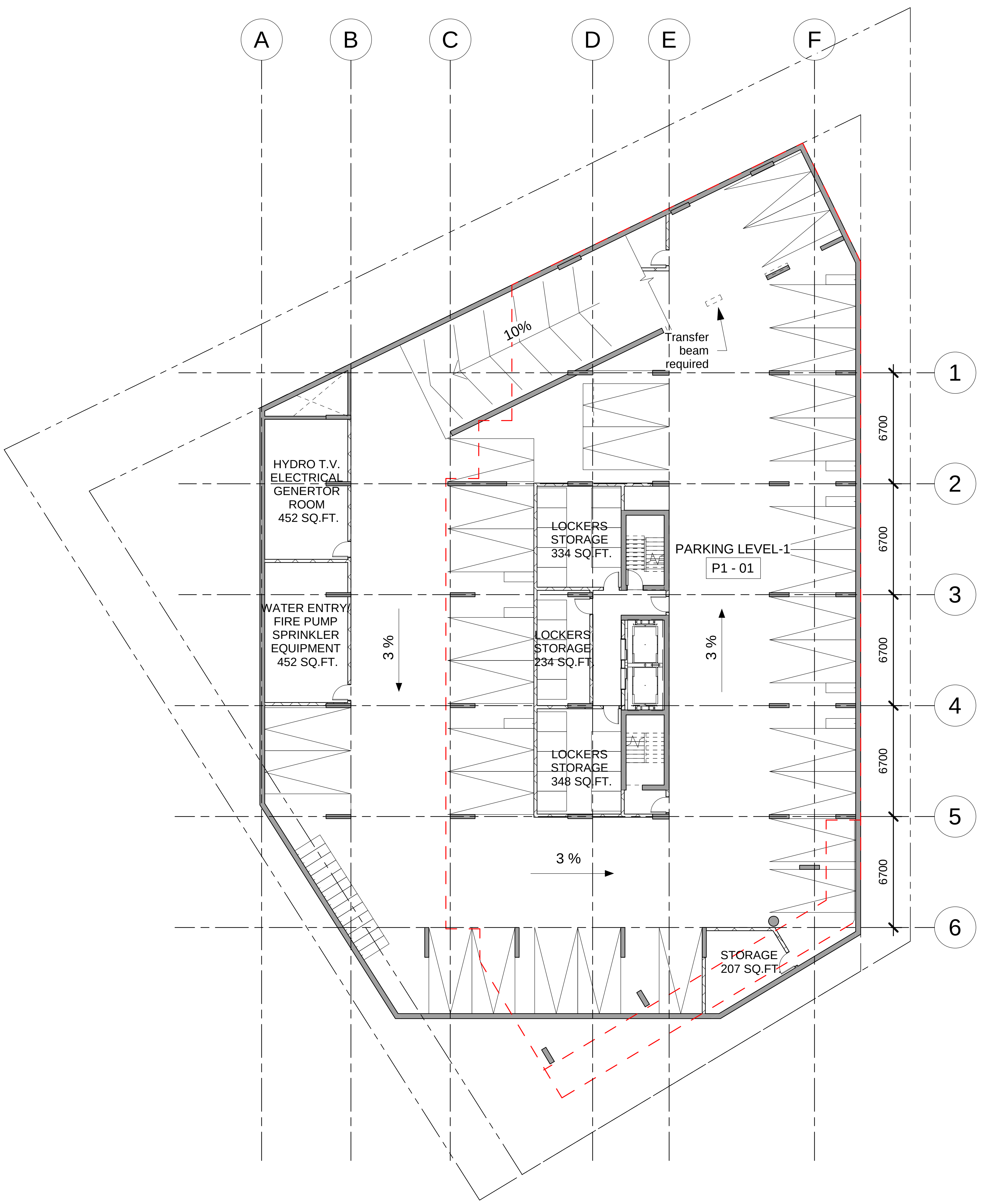

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THE AZURE - OTTAWA

929 RICHMOND RD.

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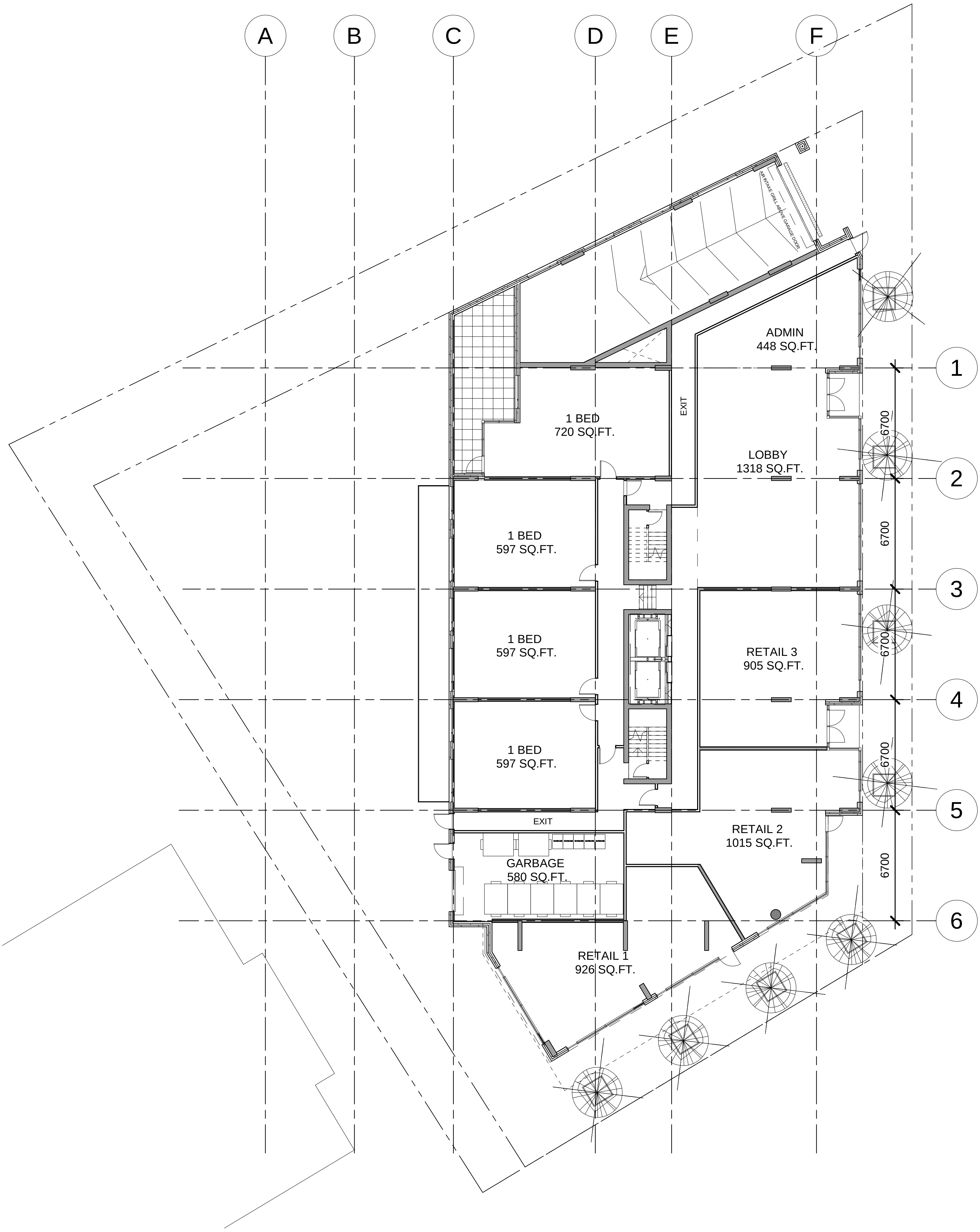

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GROUND FLOOR PLAN

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929 RICHMOND RD.

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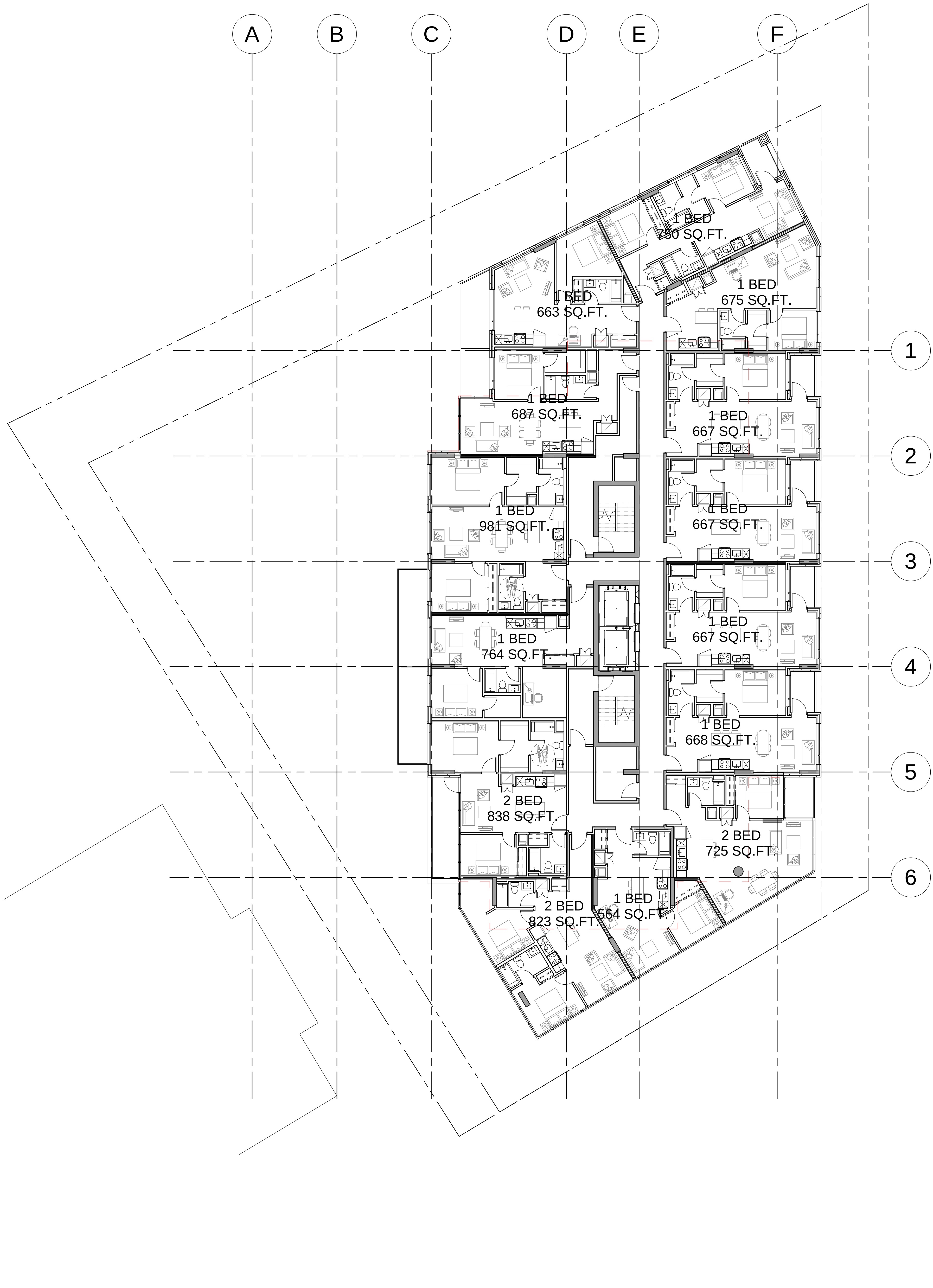

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2nd to 4th PODIUM FLOOR PLAN
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THE AZURE - OTTAWA

929 RICHMOND RD.

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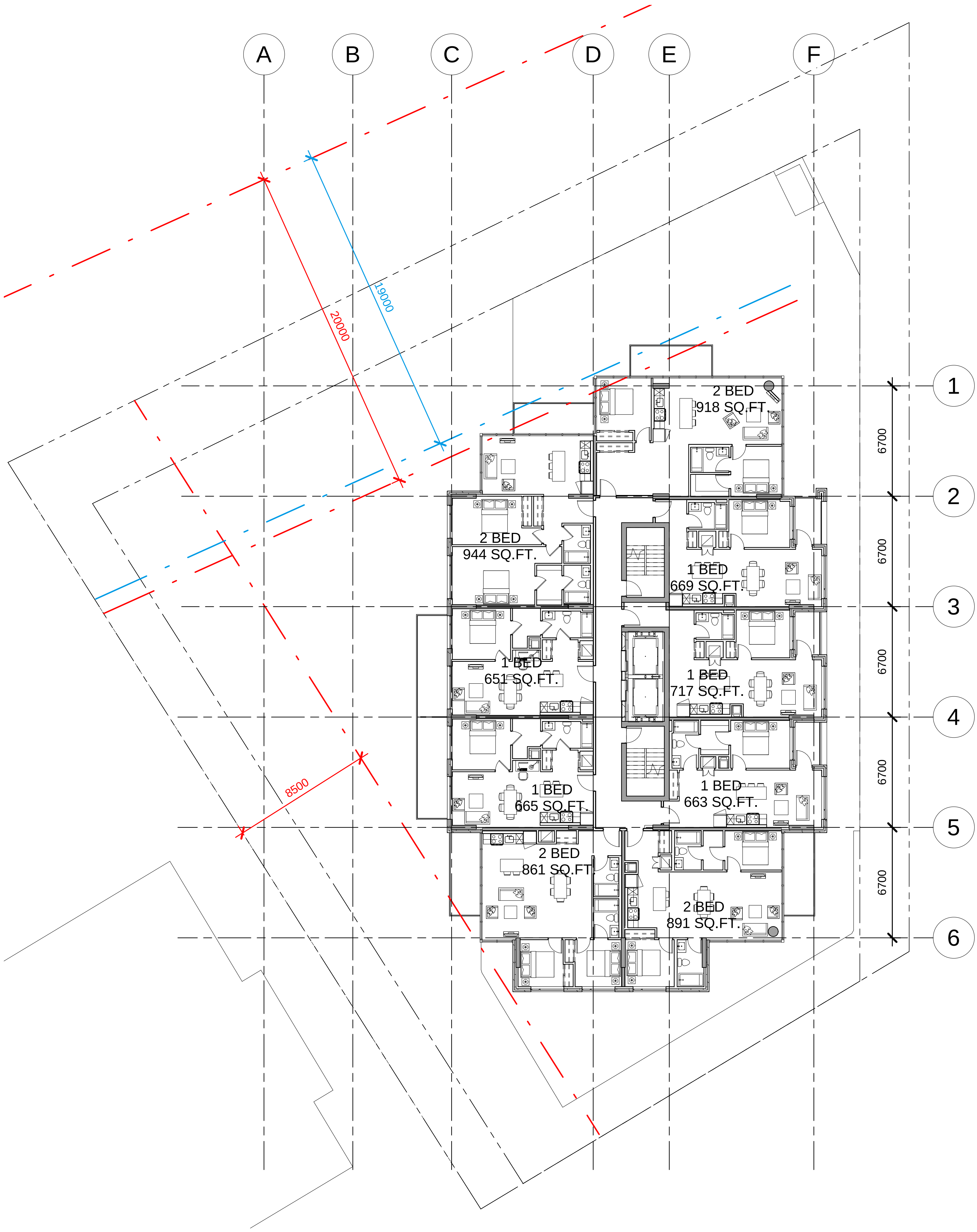

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5th to 14th TYPICAL FLOOR PLAN

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THE AZURE - OTTAWA

929 RICHMOND RD.

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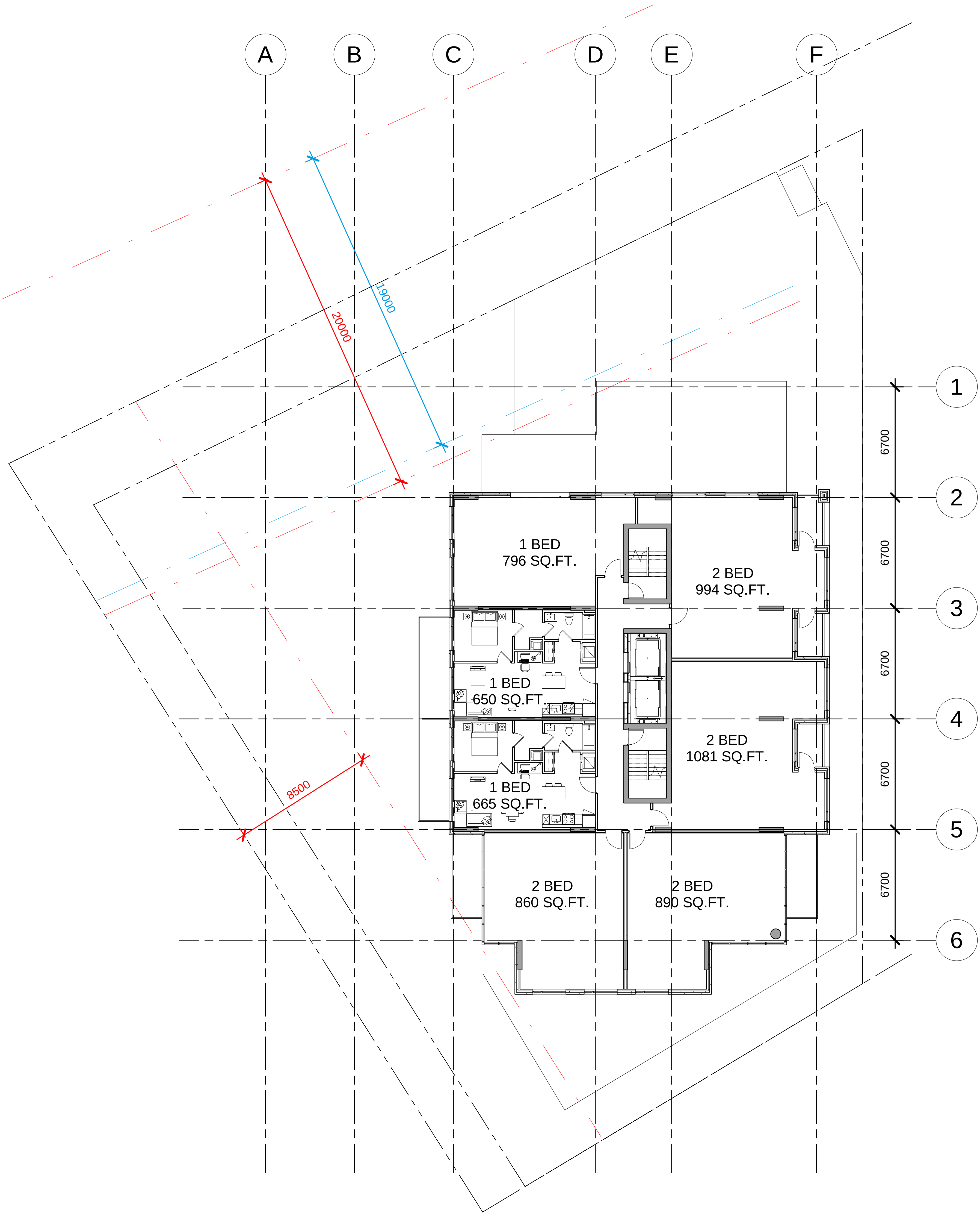

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15 to 18th PENTHOUSE FLOOR PLAN

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THE AZURE - OTTAWA

929 RICHMOND RD.

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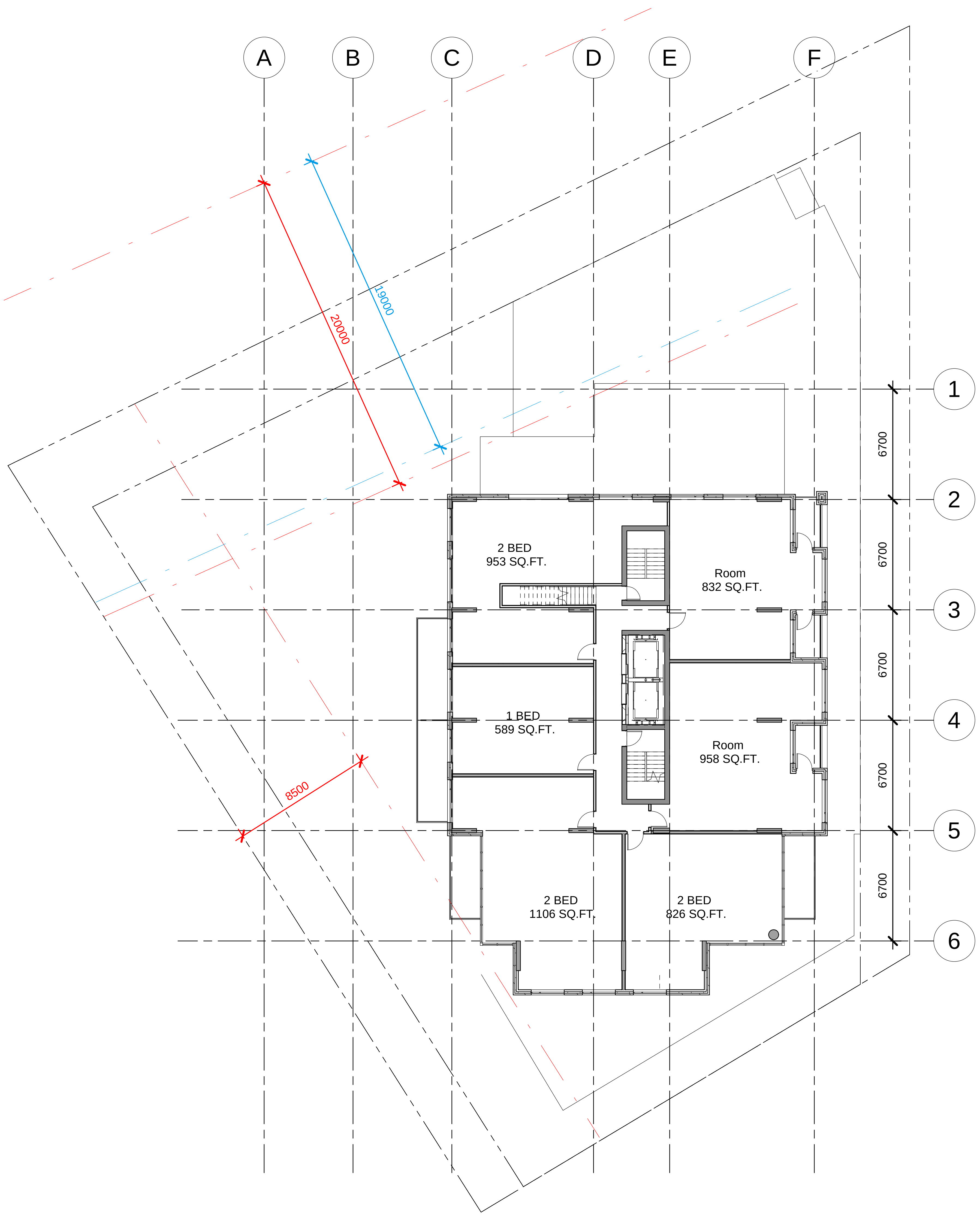

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19th PENTHOUSE FLOOR PLAN
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THE AZURE - OTTAWA

929 RICHMOND RD.

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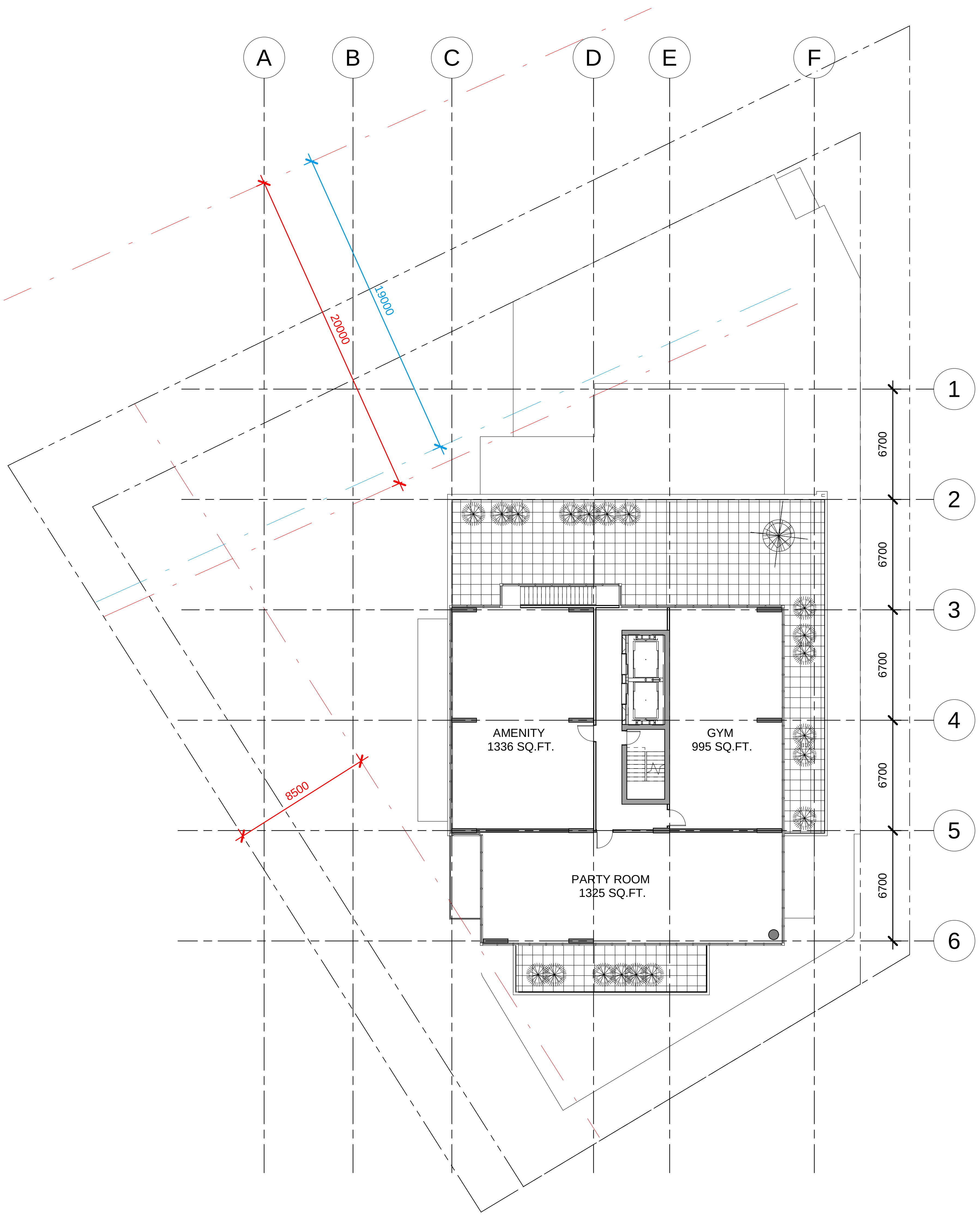

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AMENITY FLOOR PLAN

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THE AZURE - OTTAWA

929 RICHMOND RD.

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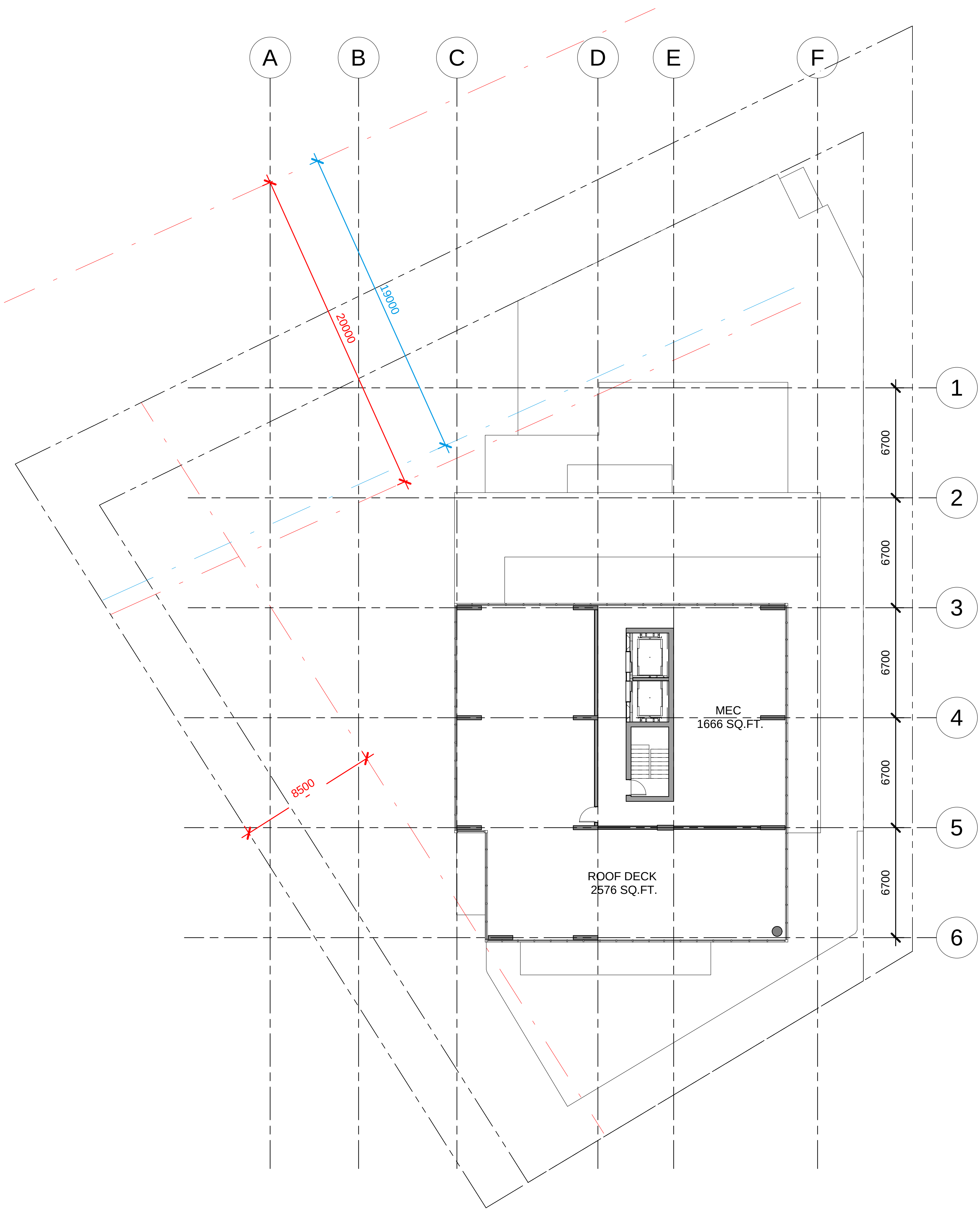

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MECHANICAL FLOOR PLAN

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929 RICHMOND RD.

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APPENDIX B

Appendix B: Table of Traffic and Road Parameters To Be Used For Sound Level Predictions

Table B1 Traffic And Road Parameters To Be Used For Sound Level Predictions

Row Width (m)	Implied Roadway Class	AADT Vehicles/Day	Posted Speed Km/Hr	Day/Night Split %	Medium Trucks %	Heavy Trucks % [1]
NA [2]	Freeway, Queensway, Highway	18,333 per lane	100	92/8	7	5
37.5-44.5	6-Lane Urban Arterial-Divided (6 UAD)	50,000	50-80	92/8	7	5
34-37.5	4-Lane Urban Arterial-Divided (4-UAD)	35,000	50-80	92/8	7	5
23-34	4-Lane Urban Arterial-Undivided (4-UAU)	30,000	50-80	92/8	7	5
23-34	4-Lane Major Collector (4-UMCU)	24,000	40-60	92/8	7	5
[illegible]	2-Lane Rural Arterial (2-RAU)	15,000	50-80	92/8	7	5
20-30	2-Lane Urban Arterial (2-UAU)	15,000	50-80	92/8	7	5
20-30	2-Lane Major Collector (2-UMCU)	12,000	40-60	92/8	7	5
30-35.5	2-Lane Outer Rural Arterial (near the extremities of the City) (2-RAU)	10,000	50-80	92/8	7	5
20-30	2-Lane Urban Collector (2-UCU)	8,000	40-50	92/8	7	5

Traffic Data used for Woodroffe Avenue and Richmond Road

[1] The MOE Vehicle Classification definitions should be used to estimate automobiles, medium trucks and heavy trucks.

[2] The number of lanes is determined by the future mature state of the roadway.

APPENDIX C

ORNAMENT

Ontario Road Noise Analysis Method for ENvironment and Transportation

version 2.07

Job No. 1800803 Scenario Daytime - 2027

Job Name 929 Richmond Road

ROAD CHARACTERISTICS | **SOURCE-RECEIVER-BARRIER-TOPOGRAPHY CHARACTERISTICS**

ID	Description	Time Period	Number of Vehicles: Autos	Medium	Heavy	Speed (km/h)	Road Gradient (%)	Two Way? (y/n)	Pavement Type	Road Viewable Angle Θ_1	Θ_2	Source-Receiver Distance (m)	Ground Type (Hard/Soft)	Topo-graphy Type	Source Height (m)	Road Elevation (m asl)	Receptor Height (m)	Receptor Elevation (m asl)	Ground Elevation Change (m): Elevation Change e (m)	Hor. Dist a (m)	Hor. Dist b (m)	Barrier Height (m)	Barrier Elevation (m asl)	Barrier-Reciever Distance (m)	Barrier Viewable Angle Θ_1	Θ_2	No. of Rows of Houses	Density of Houses (% Houses)	Depth of Woods	Adjustment (dB)	Reason For Adjustment	**Total Segment L_{eq} (dBA)**
NR1 - 2nd Floor South Façade	Woodroffe Avenue	16	12144	966	690	50		y	1	-30	90	19.0	Hard	A	1.5	0.0	4.5	0.0														66
	Richmond Eastbound	16	6072	483	345	50		y	1	-90	90	16.5	Hard	A	1.5	0.0	4.5	0.0														65
	Richmond Westbound	16	6072	483	345	50		y	1	-90	90	9.5	Hard	A	1.5	0.0	4.5	0.0														68
Total															-																	**71**
															-																	
NR2 - 2nd Floor Southeast Façade	Woodroffe Avenue	16	12144	966	690	50		y	1	-30	90	13.5	Hard	A	1.5	0.0	4.5	0.0														67
	Richmond Eastbound	16	6072	483	345	50		y	1	-90	90	16.5	Hard	A	1.5	0.0	4.5	0.0														65
	Richmond Westbound	16	6072	483	345	50		y	1	-90	90	9.5	Hard	A	1.5	0.0	4.5	0.0														68
Total															-																	**72**
															-																	
NR3 - 3rd Floor South Façade	Woodroffe Avenue	16	12144	966	690	50		y	1	0	90	17.8	Hard	A	1.5	0.0	8.5	0.0														65
	Richmond Eastbound	16	6072	483	345	50		y	1	-60	90	18.1	Hard	A	1.5	0.0	8.5	0.0														64
	Richmond Westbound	16	6072	483	345	50		y	1	-60	90	11.0	Hard	A	1.5	0.0	8.5	0.0														66
Total															-																	**70**
															-																	
OLA - Amenity Floor	Woodroffe Avenue	16	12144	966	690	50		y	1	-90	90	57.2	Hard	A	1.5	0.0	1.5	50.6				1.2	50.6	10.0	-90	90						47
	Richmond Eastbound	16	6072	483	345	50		y	1	-90	90	63.1	Hard	A	1.5	0.0	1.5	50.6				1.2	50.6	11.0	-90	90						44
	Richmond Westbound	16	6072	483	345	50		y	1	-90	90	67.2	Hard	A	1.5	0.0	1.5	50.6				1.2	50.6	11.0	-90	90						44
Total															-																	**50**
															-																	
NR4 - 2nd Floor North Façade	Woodroffe Avenue	16	12144	966	690	50		y	1	-90	90	11.2	Hard	A	1.5	0.0	4.5	0.0														70
	Richmond Eastbound	16	6072	483	345	50		y	1	-90	35	48.2	Hard	A	1.5	0.0	4.5	0.0														59
	Richmond Westbound	16	6072	483	345	50		y	1	-90	35	41.2	Hard	A	1.5	0.0	4.5	0.0														60
Total															-																	**71**
															-																	
NR5 - 2nd Floor West Façade	Woodroffe Avenue	16	12144	966	690	50		y	1	60	90	33.0	Hard	A	1.5	0.0	4.5	0.0														58
	Richmond Eastbound	16	6072	483	345	50		y	1	0	90	18.1	Hard	A	1.5	0.0	4.5	0.0														62
	Richmond Westbound	16	6072	483	345	50		y	1	0	90	10.7	Hard	A	1.5	0.0	4.5	0.0														64
Total															-																	**67**
															-																	
NR6 - 2nd Floor East Façade	Woodroffe South Link	16	12144	966	690	50		y	1	-90	90	12.6	Hard	A	1.5	0.0	4.5	0.0														69
	Richmond Eastbound	16	6072	483	345	50		y	1	-90	35	32.0	Hard	A	1.5	0.0	4.5	0.0														61
	Richmond Westbound	16	6072	483	345	50		y	1	-90	35	25.4	Hard	A	1.5	0.0	4.5	0.0														62
Total															-																	**70**

Pavement 1 = Normal AL Asphalt

Topography A = Flat/gently sloping ground

ORNAMENT

Ontario Road Noise Analysis Method for ENvironment and Transportation

version 2.07

Job No. 1800803 Scenario Nighttime - 2027

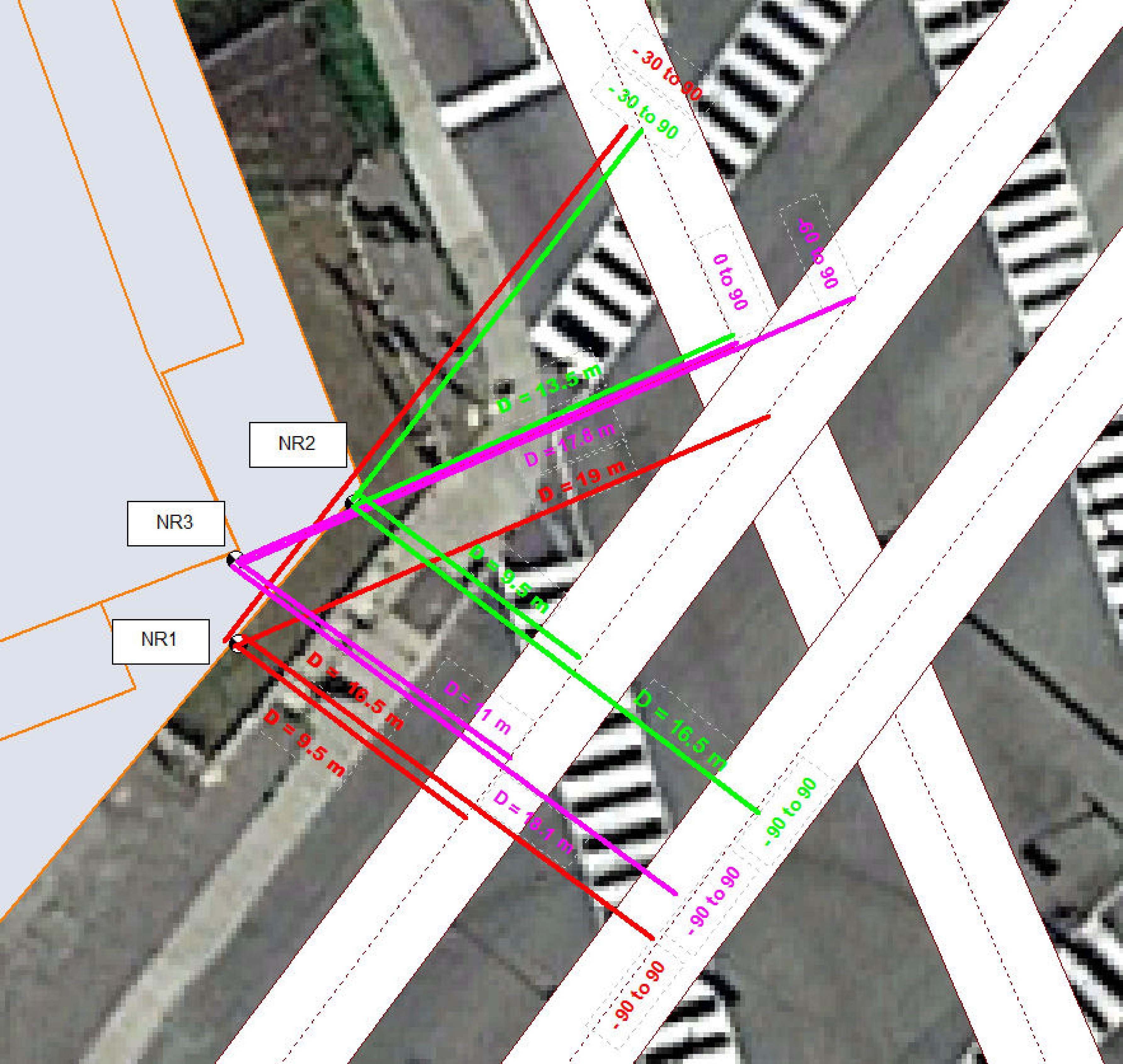
Job Name 929 Richmond Road

ROAD CHARACTERISTICS / **SOURCE-RECEIVER-BARRIER-TOPOGRAPHY CHARACTERISTICS**

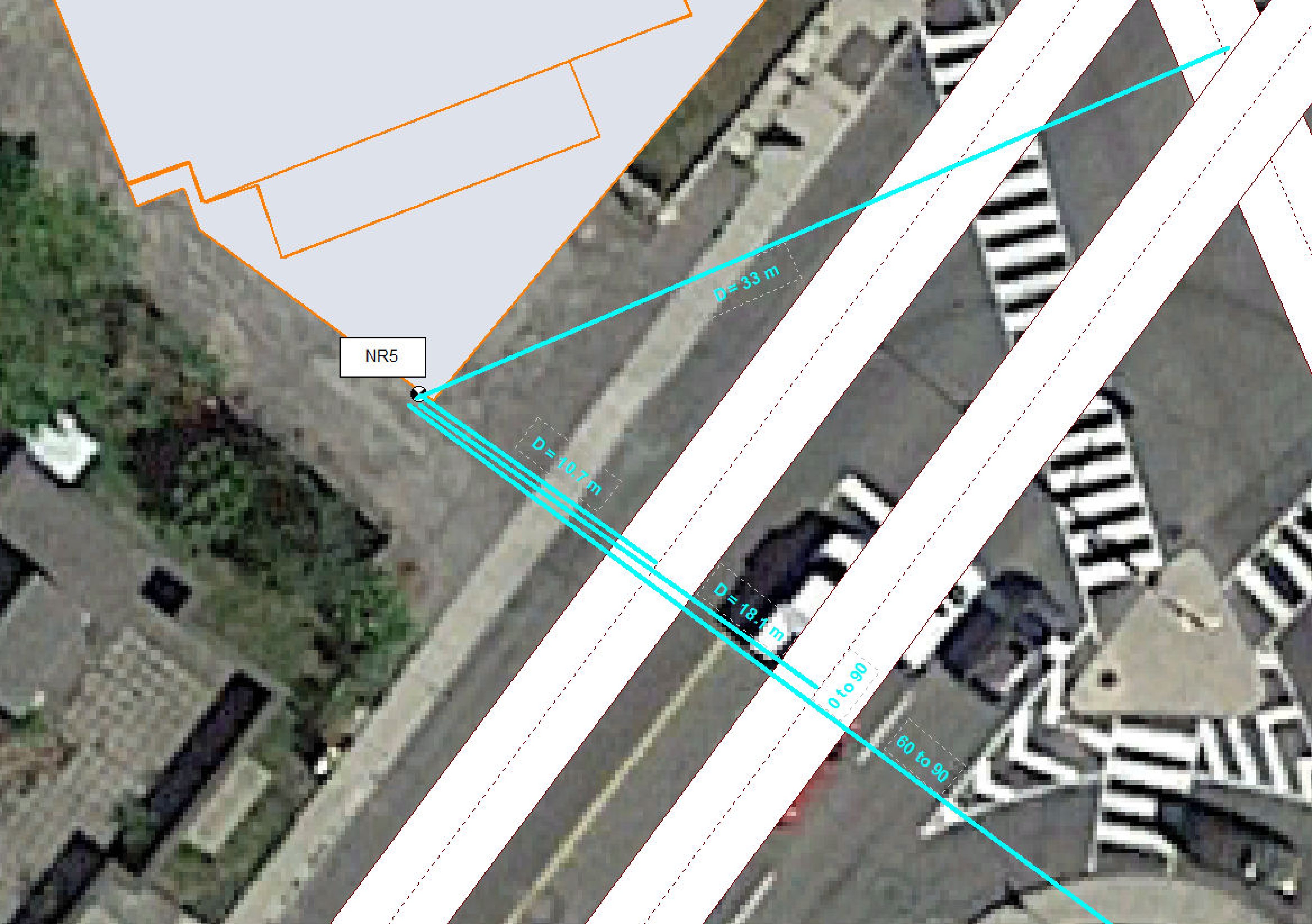
ID	Description	Time Period	Number of Vehicles			Speed (km/h)	Road Gradient (%)	Two Way? (y/n)	Pavement Type	Road Viewable Angle		Source-Receiver Distance (m)	Ground Type (Hard/Soft)	Topo-graphy Type	Source Height (m)	Road Elevation (m asl)	Receptor Height (m)	Receptor Elevation (m asl)	Ground Elevation Change (m)			Barrier Height (m)	Barrier Elevation (m asl)	Barrier-Reciever Distance (m)	Barrier Viewable Angle		No. of Rows of Houses	Density of Houses (% Houses)	Depth of Woods	Adjustment (dB)	Reason For Adjustment	Total Segment L_{eq} (dBA)
			Autos	Medium	Heavy					Θ_1	Θ_2								Elevation Change e (m)	Hor. Dist a (m)	Hor. Dist b (m)				Θ_1	Θ_2						
NR1 - 2nd Floor South Façade	Woodroffe Avenue	8	1056	84	60	50		y	1	-30	90	19.0	Hard	A	1.5	0.0	4.5	0.0														58
	Richmond Eastbound	8	528	42	30	50		y	1	-90	90	16.5	Hard	A	1.5	0.0	4.5	0.0														58
	Richmond Westbound	8	528	42	30	50		y	1	-90	90	9.5	Hard	A	1.5	0.0	4.5	0.0														60
Total															-																	**63**
															-																	
NR2 - 2nd Floor Southeast Façade	Woodroffe Avenue	8	1056	84	60	50		y	1	-30	90	13.5	Hard	A	1.5	0.0	4.5	0.0														60
	Richmond Eastbound	8	528	42	30	50		y	1	-90	90	16.5	Hard	A	1.5	0.0	4.5	0.0														58
	Richmond Westbound	8	528	42	30	50		y	1	-90	90	9.5	Hard	A	1.5	0.0	4.5	0.0														60
Total															-																	**64**
															-																	
NR3 - 3rd Floor South Façade	Woodroffe Avenue	8	1056	84	60	50		y	1	0	90	17.8	Hard	A	1.5	0.0	8.5	0.0														57
	Richmond Eastbound	8	528	42	30	50		y	1	-60	90	18.1	Hard	A	1.5	0.0	8.5	0.0														56
	Richmond Westbound	8	528	42	30	50		y	1	-60	90	11.0	Hard	A	1.5	0.0	8.5	0.0														59
Total															-																	**62**
															-																	
NR4 - 2nd Floor North Façade	Woodroffe Avenue	8	1056	84	60	50		y	1	-90	90	11.2	Hard	A	1.5	0.0	4.5	0.0														62
	Richmond Eastbound	8	528	42	30	50		y	1	-90	35	48.2	Hard	A	1.5	0.0	4.5	0.0														51
	Richmond Westbound	8	528	42	30	50		y	1	-90	35	41.2	Hard	A	1.5	0.0	4.5	0.0														52
Total															-																	**63**
															-																	
NR5 - 2nd Floor West Façade	Woodroffe Avenue	8	1056	84	60	50		y	1	60	90	33.0	Hard	A	1.5	0.0	4.5	0.0														50
	Richmond Eastbound	8	528	42	30	50		y	1	0	90	18.1	Hard	A	1.5	0.0	4.5	0.0														54
	Richmond Westbound	8	528	42	30	50		y	1	0	90	10.7	Hard	A	1.5	0.0	4.5	0.0														56
Total															-																	**59**
															-																	
NR6 - 2nd Floor East Façade	Woodroffe South Link	8	1056	84	60	50		y	1	-90	90	12.6	Hard	A	1.5	0.0	4.5	0.0														62
	Richmond Eastbound	8	528	42	30	50		y	1	-90	35	32.0	Hard	A	1.5	0.0	4.5	0.0														53
	Richmond Westbound	8	528	42	30	50		y	1	-90	35	25.4	Hard	A	1.5	0.0	4.5	0.0														54
Total															-																	**63**

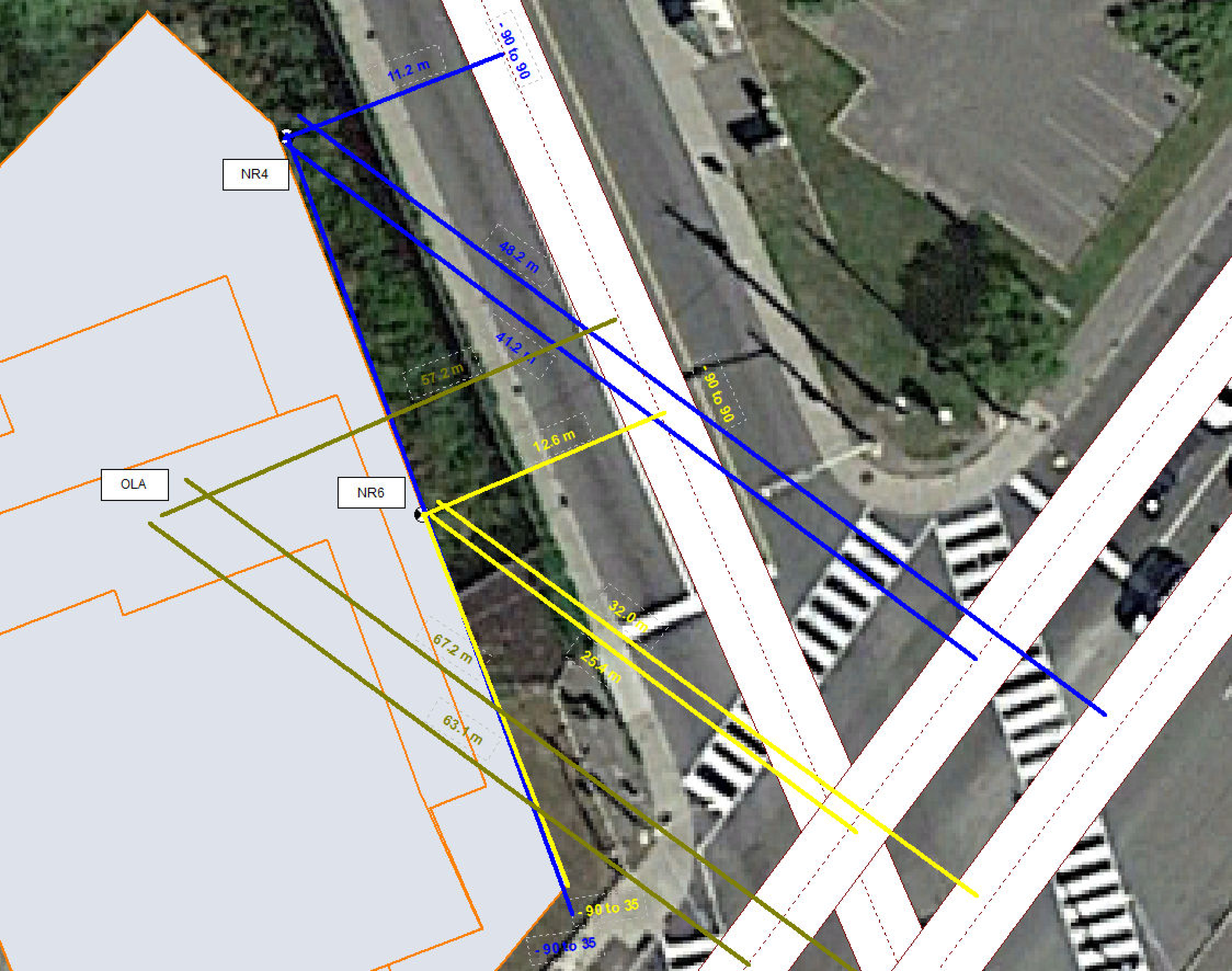
Pavement 1 = Normal AL Asphalt

Topography A = Flat/gently sloping ground



NR2
NR3
NR1
- 30 to 90
- 30 to 90
0 to 90
-60 to 90
D = 13.5 m
D = 17.8 m
D = 19 m
D = 9.5 m
D = 16.5 m
D = 11 m
D = 16.5 m
D = 9.5 m
D = 18.1 m
-90 to 90
-90 to 90
-90 to 90


NR5
D= 33 m
D = 10.7 m
D = 18.1 m
0 to 90
60 to 90



NR4
NR6
OLA
11.2 m
- 90 to 90
48.2 m
41.2 m
57.2 m
12.6 m
- 90 to 90
32.0 m
25.4 m
67.2 m
63.1 m
- 90 to 35
- 90 to 35

APPENDIX D

U.S. DoT Federal Transit Administration - "Transit Noise and Vibration Impact Assessment"

"FTA Vibration Screening Model"

Job No.	1800803
Job Name	929 Richmond Road
Scenario	Richmond Road Alignment - Closer to Development

Note: All vibration levels in dB are VdB re: 1 μin/s

1a. Define Train

	Input	Description	Resulting Adjustments
Train Type	L	(F) reight, (L)RT/Rapid Transit, (B)us	-2.6
Train Speed	60	km/h	0
Stiff Suspension?	n	Vertical resonance frequency greater than 15 Hz (y/n, usually n)	0
Resilient Wheels?	n	No effect on vibration, included to match standard (y/n)	0
Worn wheels?	n	Worn wheels or wheels with flats (y/n, usually no for new or well maintained system)	

1b. Define Track Type

	Input	Description	Resulting Adjustments
Rail Type	CWR	Jointed Track (J) or Continuous Welded Rail (CWR)	0
Worn or Corrugated track?	n	Worn track (y/n, usually n for new or well maintained system)	0
Special Trackwork?	n	Crossovers, diamonds, frogs, etc. (y/n)	0

Mitigation Features

	Input	Description	Individual	Resulting Adjustments
Floating slab trackwork?	n	Concrete floating slab on spring isolators (y/n)	0	
High Resilience Fasterners?	n	Used with concrete track slabs (y/n)	0	0
Resiliently Supported Ties?	n	Concrete ties on rubber blocks, with resilient fasteners (y/n)	0	
Ballast mats?	n	Rubber mat placed over concrete, under the ballast (y/n)	0	

TTC Streetcar System Only (Based on RWDI Measurements W07-5120C)

	Input	Description	Note	Resulting Adjustments
New Track Tech. Max vibration	n	For maximum vibration from TTC new track tech (apply no other mit feature)	Mutually exclusive choices	0
New Track Tech., Avg Vibration	n	For average vibration from TTC new track tech (apply no other mit feature)	May also both be "n"	0

Other Path Features

	Input	Description	Resulting Adjustments
Elevated Structure?	n	On berm or bridge (y/n)	0
In open cut?	y	No effect on vibration, included to match standard (y/n)	0

Subway Systems Only

Relative to bored tunnel:

	Input	Resulting Adjustments
Station	n	0
Cut and Cover	y	-3
Rock-Based	n	0

Base Vibration Level at 3 m	81.5	VdB, FTA base curve levels at 3 m from track
Total Train and Track Type Adjustments	-5.6	VdB
Adjusted Vibration Level at 3 m	**75.9**	VdB, including train type and track type adjustements above.

2. Define Path

	Input	Description	Note	Resulting Adjustments
Efficient propagation in soil	n	Accounts for clay soils or other mediums with efficient propagation (y/n)	Mutually exclusive choices	0
Propagation in rock layer	y	Accounts for lower attenuation with distance in rock versus soil (y/n)	May also both be "n"	1.0
Total Path Type Adjustments	1.0	VdB		

3a. Vibration Level at Given Receptor

				Resulting Adjustments
Source-Receiver distance	**10**	m, from track to receptor (DISTANCE should be less than 100 m)		-5.2
Total distance and path adjustments	-4.2	VdB		
Vibration Level at distance	**71.7**	VdB	**0.098** mm/s r.m.s.	

Notes:
The above value can be used in general for rail vibration assessment, and represents the "free field" value of vibration at the foundation.
Vibration levels within the structure will depend on ground coupling to the building foundation, and effects within the structure (resonances, etc.).
For typical residential houses (woodframe buildings), these generally cancel out. (-5 VdB for coupling, -2 dB for 2nd storey, +6 dB for resonances = -1 VdB for typical bedroom)
For commercial buildings, hotels, hospitals, etc., these effects can be significant.

U.S. DoT Federal Transit Administration - "Transit Noise and Vibration Impact Assessment"

"FTA Vibration Screening Model"

Job No. 1800803
Job Name 929 Richmond Road

Scenario Byron Park Alignment - Further Away

Note: All vibration levels in dB are VdB re: 1 μin/s

1a. Define Train

			Resulting Adjustments
Train Type	L	(F) reight, (L)RT/Rapid Transit, (B)us	-2.6
Train Speed	60	km/h	0
Stiff Suspension?	n	Vertical resonance frequency greater than 15 Hz (y/n, usually n)	0
Resilient Wheels?	n	No effect on vibration, included to match standard (y/n)	0
Worn wheels?	n	Worn wheels or wheels with flats (y/n, usually no for new or well maintained system)	0

1b. Define Track Type

Rail Type	CWR	Jointed Track (J) or Continuous Welded Rail (CWR)	0
Worn or Corrugated track?	n	Worn track (y/n, usually n for new or well maintained system)	0
Special Trackwork?	n	Crossovers, diamonds, frogs, etc. (y/n)	0

Mitigation Features

Floating slab trackwork?	n	Concrete floating slab on spring isolators (y/n)	0	0
High Resilience Fasterners?	n	Used with concrete track slabs (y/n)	0	
Resiliently Supported Ties?	n	Concrete ties on rubber blocks, with resilient fasteners (y/n)	0	
Ballast mats?	n	Rubber mat placed over concrete, under the ballast (y/n)	0	

TTC Streetcar System Only (Based on RWDI Measurements W07-5120C)

New Track Tech. Max vibration	n	For maximum vibration from TTC new track tech (apply no other mit feature)	Mutually exclusive choices	0
New Track Tech., Avg Vibration	n	For average vibration from TTC new track tech (apply no other mit feature)	May also both be "n"	0

Other Path Features

Elevated Structure?	n	On berm or bridge (y/n)	0
In open cut?	y	No effect on vibration, included to match standard (y/n)	0

Subway Systems Only

Relative to bored tunnel:

Station	n	0
Cut and Cover	y	-3
Rock-Based	n	0

Base Vibration Level at 3 m	81.5	VdB, FTA base curve levels at 3 m from track
Total Train and Track Type Adjustments	-5.6	VdB
Adjusted Vibration Level at 3 m	**75.9**	VdB, including train type and track type adjustements above.

2. Define Path

Efficient propagation in soil	n	Accounts for clay soils or other mediums with efficient propagation (y/n)	Mutually exclusive choices	0
Propagation in rock layer	y	Accounts for lower attenuation with distance in rock versus soil (y/n)	May also both be "n"	3.3
Total Path Type Adjustments	3.3	VdB		

3a. Vibration Level at Given Receptor

Source-Receiver distance	**25**	m, from track to receptor (DISTANCE should be less than 100 m)		-12.5
Total distance and path adjustments	-9.2	VdB		
Vibration Level at distance	**66.8**	VdB	**0.055** mm/s r.m.s.	

Notes:
The above value can be used in general for rail vibration assessment, and represents the "free field" value of vibration at the foundation.
Vibration levels within the structure will depend on ground coupling to the building foundation, and effects within the structure (resonances, etc.).
For typical residential houses (woodframe buildings), these generally cancel out. (-5 VdB for coupling, -2 dB for 2nd storey, +6 dB for resonances = -1 VdB for typical bedroom)
For commercial buildings, hotels, hospitals, etc., these effects can be significant.