ONTARIO LINE TECHNICAL ADVISOR

Memo

Date:	Tuesday, December 20, 2022
Project:	Ontario Line TA
To:	Andrea Gaus
From:	Mohamed Hosney, David Kantor, Masoud Manzari,
Subject:	Geotechnical Desktop Study for Transit Oriented Communities (TOC) North - Pape, Ontario Line

1 Introduction

This memorandum provides a summary of the currently available subsurface geotechnical condition for the TOC North Pape in conjunction with preliminary geotechnical recommendations for the design of the subject development. Furthermore, recommendations are provided for additional geotechnical and hydrogeological investigation which needs to be performed by the prospective TOC developers (DevCo). This memorandum is prepared as part of the TOC submission package to the City of Toronto for the subject development.

The preliminary geotechnical recommendations provided herein are based on our interpretation of the available subsurface data, obtained from the geotechnical investigation conducted by Metrolinx at the site, by means of a limited number of boreholes, non-continuous sampling, in-situ testing, and laboratory testing on selected soil/rock samples. The preliminary recommendations contained in this memorandum rely on the accuracy of the factual subsurface data supplied by others and the authors are not responsible for the accuracy and correctness of the subsurface data provided by others.

The data interpretations and the preliminary recommendations contained in this memorandum pertain to a specific project as described herein and are not applicable to any other project or site location. If the project is modified in concept, location, or elevation, the recommendations provided in this memorandum may not be valid.

The preliminary recommendations presented in this memorandum must not be used for detail design of the subject TOC as the recommendations are subject to confirmation/modification when the detailed final investigation is completed. The scope of the additional geotechnical investigation provided herein is the recommended minimum scope of investigation to further progress the design of the TOC for City's approval purposes. DevCo and its designers shall append this scope of investigation, as required in accordance with their design and complete the investigation before detail design of the subject TOC.

It is a condition of this document that the performance of professional services provided herein is subject to the attached Statement of Limitation and condition.

2 Project and Site Description

The proposed OL Pape Station site is located at the mid-block between Danforth Avenue and Gertrude Place and between Pape Avenue and Eaton Avenue in Toronto, Ontario. The proposed OL Pape Station will be an interchange station involving the construction of a station box crossing underneath the existing

TTC Bloor-Danforth Line 2. The station box is approximately 166 m long, 24 to 31 m wide, 36.9 m deep, aligned in the north-south direction, and located approximately 50 m east of Pape Avenue.

Based on the current general arrangement drawings (included in Appendix A for information only), two new buildings, denoted herein as TOC Pape North and South Sites, are planned to be constructed at the OL Pape Station.

The TOC North Site will consist of 3 to 7 levels building above the ground surface and 1 basement level, except for the portion south of Axis G (see Drawing No. 413T102N; Attachment A). The basement on the west side of the building will be approximately 0.3 m away from the OL station shoring wall.

The TOC South Site will consist of 4 to 29 levels building above the ground surface. The eastern portion of the building (i.e., east of Axis 7b) will include 3 basement levels. The basement on the west side of the building will be approximately 2 m to 6 m away from the station shoring wall. The portion of the TOC South Site between Axis 3 and 6 will be predominantly supported on the OL Pape Station structure. The western portion of the building (i.e., west of Axis 3) does not include any basements.

3 Sources of Geotechnical Data

The boreholes used in the preparation of this desktop report are shown on Figure B.1 of Appendix B, and the geotechnical data has been obtained from the following reports:

- Geotechnical and Geo-environmental Data Report Stage 2NT Metrolinx Ontario Line North Tunnel Westwood Avenue to Langley Avenue, Metrolinx Contract Number G85-355, Toronto, Ontario, Rev.02, prepared by Thurber Engineering Ltd, dated May 9, 2022,
- Geotechnical Engineering Data Report (Rev. 6), Proposed Ontario Line – North Tunnel, Toronto, Ontario, Contract No. G85-355A, Wood Project No. TTM19001, prepared by Wood, dated October 21, 2022,
- Geophysical Investigation, Ontario Line – Pape Segment, Toronto, Ontario, prepared by Geophysics GPR International Inc., dated June 2021,
- Downhole Seismic Survey in borehole OL-9111 at Gertrude Place, Toronto, Ontario, prepared by Geophysics GPR International Inc., dated July 4, 2022.

Reference is made to the above noted reports for the details of the currently available factual geotechnical and hydrogeological data, in conjunction with geophysical survey. The subsurface investigation for the subway project is currently ongoing and updated/new version of the above noted reports with additional data would be issued for the project, once all the planned scope of the investigation is concluded.

The following laboratory tests have been conducted in representative soil samples:

1. Moisture content
2. Bulk density
3. Specific gravity
4. Grain size and hydrometer analyses
5. Atterberg limits

6. One dimensional consolidation (Oedometer)
7. Unconfined compressive strength
8. Consolidated drained triaxial compression
9. Direct shear
10. Unconsolidated Undrained triaxial compression
11. NTNU (Norwegian University of Science and Technology) Soil Abrasion
12. Organic Content

The following laboratory tests have been conducted on representative rock samples:

1. Unconfined compressive strength (UCS)
2. Point load
3. Elastic Moduli of intact rock core in uniaxial compression
4. Swell testing suite (null swell, free swell, semi-confined swell)
5. Splitting tensile strength
6. Slake durability
7. Cerchar Abrasivity
8. Direct shear on rock joints
9. Rock thin sections and mineralogy analyzes

The following field tests have been conducted during the field investigations:

1. Standard penetration (SPT).
2. Field van shear
3. In-situ pressuremeter
4. Combined Seismic Refraction and MASW geophysical survey
5. Downhole seismic
6. Downhole acoustic and optical televiewer survey
7. Collection of subsurface gases
8. Single well response hydraulic conductivity assessment
9. Packer hydraulics conductivity assessment
10. Measurement of subsurface gas concentrations in monitoring well headspace

The following laboratory tests have been conducted on representative groundwater samples:

1. Environmental groundwater quality analyses (e.g., metals and inorganics, PHCs, VOCs, SVOCs or PAHs, PCBs, dioxins and furans, methane, and Toronto Sewer Use Bylaw parameters).

The following laboratory tests have been conducted on representative monitoring well headspace gas samples:

1. Environmental subsurface gas analyses [e.g., light hydrocarbons, VOCs, and matrix gases, which are also referred to as permanent or fixed gases (i.e., carbon dioxide, carbon monoxide, methane, nitrogen, oxygen, hydrogen, and hydrogen sulphide)].

4 Subsurface Conditions

Fourteen boreholes (i.e., OL-09108, OL-09109, OL-09110, OL-9111, G85-355-096, G85-355-096Sonic, G85-355-097D, G85-355-098, G85-355-099D, G85-355-100, G85-355-101D, G85-355-102D, G85-355-103, G85-355-119) have been drilled in vicinity of the TOC North Pape. The boreholes were advanced to

depths ranging from about 40 m to 55 m below the existing ground surface. All boreholes, except OL-9110, G85-355-096Sonic and G85-355-100, included coring of about 1.8 m to 4.7 m of bedrock. Boreholes OL 09109 and OL-09111 included coring of about 13 m of bedrock.

The existing borehole locations, the stratigraphy encountered at the borehole locations, the preliminary interpreted stratigraphy and piezometric head measurements are shown in the Interpreted Stratigraphic Profile in Appendix B. The profile is a simplification of the subsurface conditions encountered at the borehole locations. The information is inferred from generally non-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. The stratigraphic boundaries shown on the profile represent transitions between soil types rather than exact planes of geologic change. Since these boundaries have been interpolated between boreholes, the actual locations of the stratigraphic boundaries may vary from those shown on the profiles.

The subsurface soils and bedrock encountered at the TOC Sites have been consolidated into seven engineering groups according to their deposition history, anticipated engineering characteristics and behaviour. The eight groups are identified by different colours on the profiles. Due to the complex nature of the depositional environments, each engineering group represents a range of soil assemblages. The uniform colours on the profiles do not represent either uniform material characteristics or uniform soil/bedrock behaviour. Small pockets and seams of one soil group interbedded within the deposits of another soil group could not be shown on the stratigraphic profile.

The stratigraphic profile in the area of the proposed development generally consisted of approximately 45 m of overburden soils overlying Georgian Bay Formation shale bedrock. The overburden at the general area of the proposed development consists of surficial pavement structure overlying a 0.5 m to 5 m thick layer of fill materials of variable composition – silty sand (with trace clay and gravel), sand (with trace to some silt and trace clay and trace to some gravel), or sand to sandy silty (with gravel and trace clay). The native soil below the fill layer and up to the overlying bedrock is comprised of several variations of interbedded glacially deposited soils, as presented in the Interpreted Stratigraphic (Appendix B).

Intermediate and deep monitoring wells have been installed in the advanced boreholes as shown in Appendix B. Based on the shallow monitoring well, the groundwater level measured within the fill and non-plastic till layer is about 3.8 m to 5.7 m below the ground surface (i.e., at Elevation of about 112.6 m to 110. 8 m). Intermediate and deep monitoring wells screened within the sand to sandy silt till showed that the groundwater level within this layer is about 13.3 m to 17.3 m below the ground surface (i.e., at Elevation of about 102 m to 99 m). The profile presented in Appendix B can be used as a simplified preliminary groundwater pressure distribution prepared for this stage of the investigation and design.

Descriptions of subsurface conditions presented above is based upon interpolation between borings, extrapolation beyond borings and assessment of laboratory test data. The subsurface conditions might vary between and beyond the borehole locations.

5 Recommended Scope for Additional investigation

Additional geotechnical and hydrogeological investigation is required to further progress the design of the subject TOC. The minimum recommended scope of the additional investigation is presented in Table C-1 of Appendix C. The associated locations of the recommended additional boreholes are shown in Appendix B. DevCo and its designers shall append the scope of additional investigation presented herein,

as required, in accordance with their design and shall complete the investigation before detail design of the subject TOC.

The scope of the environmental testing for groundwater and for the excess soil management shall be designed by DevCo to satisfy all codes, regulations, and guidelines requirements, including, but not limited to, O-Reg 406/19.

6 Preliminary Engineering Recommendations

This section of the memorandum provides preliminary geotechnical recommendations for the subject TOC.

Where comments are made on construction, they are provided to highlight those aspects which could affect the design of the project. Therefore, construction related comments should not be regarded as suggestions or recommendations to the contractors/subcontractors given that the comments do not address all aspects of construction, such as scheduling, type of equipment, rate of production, excavation support systems, and the like. The contractors/subcontractors undertaking this work must evaluate the factual information presented in the reference reports (as outlined in Section 3) and supplement these where it appears to be needed, and then conduct their assessment and selection of the equipment based on their own interpretation of the factual data coupled with their experience with similar projects in similar geotechnical/geological environments.

The preliminary geotechnical recommendations provided herein are based on the assumption that the design and construction will be in accordance with the applicable codes and standards, and good engineering practices, and project's specifications.

6.1 Geotechnical Design Parameters

Preliminary geotechnical engineering parameters for the engineering groups encountered in the boreholes drilled at the area of TOC North Pape, that may influence the design of the TOC, are provided in the table included in Appendix D. Average values are typically listed in the table. Although in certain instances the average values may be appropriate for design purposes, if the designs are sensitive to a minimum and maximum values and/or variation of average values with depth, the range in values must be requested by the designer and considered in their design.

The average values are typically not appropriate for selection of the construction equipment. The contractors/subcontractors should consider the full range of property values when evaluating the selection of equipment and construction methods.

6.2 Temporary Shoring Walls

Temporary support to retain excavation walls will be required for the excavation of the proposed one level of basement for the North Site and three levels of basement for the South Site. The design of the temporary support must be in accordance with the 4th edition of the Canadian Engineering Foundation Manual (CFEM), and all other applicable codes and standards having jurisdiction over the development. Control of the ground movement should be a design criterion and considered by the shoring designer in order to limit the potential impact on the existing adjacent infrastructures, including the OL Pape Station structures, existing TTC box, and all adjacent utilities.

Basic soil properties for the design of the temporary shoring system are provided in Appendix D. Recommended lateral earth pressure to be used in the analytical design of the shoring are provided in Figures D.1 and D.2 of Appendix D. The preliminary design groundwater pressure should assume hydrostatic pressure for a groundwater table at elevation 113.6 m.

6.2.1 Soil Anchors

The ultimate bond strength of the anchors depends to a large extend on the contractor's means, methods, and workmanship. For preliminary design of soil anchors for Pape TOC, the ultimate unfactored bond strength provided in Table 1 below may be used. Subsequent to the final design of the shoring and commencement of the construction, the design values must be verified by the contractor through adequate number of field anchor pull out tests and the resistance factor must be applied as per applicable codes and standards. PTI DC35.1-14 recommended a minimum safety factor of 2.0 for ultimate resistance of anchors.

The ultimate unfactored bond strength provided in Table 1 is valid for 150 mm to 200 mm diameter pressure-grouted soil anchors with the grout injected under pressure of about 1.0 to 2.8 MPa. The bond length of the soil anchors typically ranges between 5 m to 12 m. The centre to centre spacing between anchors shall be more than 4 times the bond zone diameter or 20% the bond length, whichever is greater.

Table 1 Preliminary ultimate unfactored bond strength for soil anchors for Pape TOC

Soil Type in Bond Zone	Approx. Elevation (m)	Ultimate Unfactored Bond Strength (kPa)
Group 4 and/or Group 1/2 Soil[1,2]	112 - 106	300

6.3 Permanent Structures

6.3.1 Lateral Earth and Groundwater Pressures

The preliminary recommendation for the earth pressure to be used in the design of the underground basements is provided in Figure D.3 of Appendix D. An earth pressure coefficient (K) of 0.5 is recommended for the preliminary stage design. The preliminary design groundwater pressure acting on the basement walls should assume hydrostatic pressure for a groundwater table at elevation 113.6 m.

6.3.2 Foundations

Based on the available subsurface condition, the site seismic classicisation for the subject development is Site Class "C" with an average shear wave velocity (V_{s30}) of 424 m/s.

It is our understanding that the DevCo will be responsible to design the foundations of the TOC North Site and the portions of the TOC South Site which are not supported by the OL Pape Station structure. The North Site can be either supported by raft foundation or deep caissons (denoted herein as "the new foundations"). The South Site can be supported by deep caissons only, as the use of raft foundation for the portions of the TOC South Site, which are not supported by the subway station structure, may results to settlement greater than 25 mm, as discussed later. Therefore, raft foundation is not an option for the South Site.

A portion of the proposed TOC South Site building will be supported over the OL Pape Station structures, as noted in Section 2. Therefore, the Pape Station shall be designed to accommodate the anticipated

additional loads from the future TOC development. The additional loads applied to the Pape Station by the TOC South Site will results in post construction settlement and differential settlement of the OL subway structures. The TOC loads can also result in settlement and differential settlement of the existing TTC structures. The differential movement may lead to serviceability issues (e.g., track operation), and potential damage to the structures (e.g., wall covering and utility conduits that extend between the structure units, if any). The differential movement between the TTC boxes due to the construction of the OL Pape Station and the subsequent construction of the TOC development shall not exceed the allowable value as per TTC requirement (e.g., 3 mm differential settlement). Therefore, all of these aspects must be considered in design of the subway station (i.e., Pape Station) foundations and associated structures. It is our understanding that the Pape Station foundations will be designed and constructed by the Design-Build contractor.

Selection of the appropriate option for the new foundations for the South Site depends on the design of the above grade structure which dictates the required performance criteria for the new foundations such as differential settlement between the new foundations and portion of the TOC supported by the subway structure.

As noted above, there is potential for differential settlement between the portion of the new development which is supported on the subway station and the portion supported by the new foundations. A proper joint should be designed for all the building elements (e.g., slab, roof, walls) at the interface between the foundation systems, unless the building elements are designed to stand the differential settlement.

Raft Foundation:

The raft foundation for the TOC North Site can be founded on undisturbed native soils, mainly very dense non-plastic till [soil Group 4]. If fill material is encountered at the foundation elevation, then the entire fill layer below the foundation shall be excavated and backfilled with compacted engineered fill or lean concrete. The factored geotechnical resistances provided in Table 2 below can be used for the preliminary design of the raft foundation. For completeness, the geotechnical resistances of a raft option for the portions of the TOC South Site which are not supported by the OL Pape Station structure are also presented in Table 2.

Table 2. Preliminary Factored Geotechnical Resistances

Structure	Base of foundation Elevation (m)	Anticipated Founding Material	ULS Factored Geotechnical Resistance (kPa) (1)	SLS Factored Geotechnical Resistance (kPa) (1)	Vertical Modulus of Subgrade Reaction Kv (MPa/m)
TOC North Site	~111.3	Very Dense Non-Plastic Till [Soil Group 3N]	> 1200	310(2)	13
Portion of the TOC South Site which is not supported by the station foundations (i.e., east of Axis 7b)	~106.4	Very Dense Non-Plastic Till [Soil Group 3N]	> 1500	255(2)	11

(1) If engineered fill is placed below the slab, the geotechnical resistances provided in this table may need to be revised.

(2) The geotechnical resistances at SLS provided is based on an estimated settlement on the structure not exceeding 25 mm.

The preliminary anticipated loads at foundation elevations of the TOC North and South Sites due to the new developments have been provided by the structural team via email dated 12 October 2022. Based on this information, the anticipated average unfactored pressure at the foundation elevation of the North Site is approximately 170 kPa. Therefore, the raft option is a feasible option for the North Site with anticipated settlement less than 25 mm. On the other hand, the anticipated average unfactored SLS pressure at the foundation elevation of the South Site is approximately 485 kPa, which will result in a settlement exceeding 25 mm. Therefore, the raft option may not be feasible as new foundation for the South Site (portions which are not supported on the station structure).

The geotechnical resistances for the North Site raft foundation are based on a 13 m to 21 m wide slab. For the South Site raft foundation, the geotechnical resistances are based on 52 m wide slab. The geotechnical resistances presented in Table 2 are for slabs subjected to vertical concentric loading. Where eccentric or inclined loads are applied, the resistance used in the design must be reduced in accordance with the Canadian Highway Bridge Design Code (CHBDC) Clauses 6.7.3 and 6.7.4 [9].

Caissons:

As mentioned earlier, both North and South Sites can be supported by deep foundations (i.e., caissons). The caissons must be extended at least 2.5 times caisson diameter into the slightly weathered to fresh bedrock to provide adequate socket support. A minimum centre-to-centre spacing of 2.5 times caisson diameter should be maintained between caissons.

The performance of caissons in compression will depend to a large degree upon the final cleaning and verification of the condition of the subgrade (i.e., shale) at the base and condition of the shaft. The recommended factored axial geotechnical resistances at ULS, in compression and tension, for caissons of selected diameters and rock socket lengths are presented in Tables 3. Given the sensitivity of the caisson performance to the construction means and method, higher geotechnical resistances can be considered in the design if the axial resistance of the caissons will be verified by a properly designed and implemented pile load testing program prior to construction. Therefore, two factored geotechnical resistances are provided in Table 3.

The settlement of the caissons at the top of the rock socket, under the SLS load, is anticipated to be less than 10 mm.

The upper approximately 1.5 m of the shale at the site is generally found to be highly to moderately weathered and containing fragmented zones and clay seams. As such, it is recommended that the upper 1.5 m of the bedrock be discounted when calculating the required socket length of the caissons/wall to achieve the target axial resistance.

Subsequent to the completion of the additional investigation (Section 5), DevCo may analyze the option of ending the caissons within the non-plastic very dense soils above the bedrock.

Table 3 Preliminary Factored Geotechnical Resistances at ULS for Rock Socket of a Single Caisson

Caisson Rock Socket Diameter (m)	Socket Length** (m)	Factored Geotechnical Resistance in Compression at ULS (kN)*		Factored Geotechnical Resistance in Tension at ULS (kN)*	
		Without Conducting a Pile Load Test	With Conducting a Pile Load Test	Without Conducting a Pile Load Test	With Conducting a Pile Load Test
0.9	4	3,900	5,900	1,070	1,600
	6	5,000	7,400	1,600	2,400
	8	6,660	8,700	2,140	3,260
1.2	4	5,600	8,400	1,400	2,150
	6	7,700	11,500	2,140	3,260
	8	8,750	13,400	2,860	4,340

* The structural capacity of the caissons should be evaluated by the structural engineer.
** Socket Length is the embedment depth of the caisson into the slightly weathered to fresh bedrock and should not include the upper highly weathered portion of the caissons.

6.3.3 Additional Loads on the Station Walls

The use of a raft foundation to support the TOC North Site will result in additional horizontal and vertical pressures acting on the east side of the OL Pape Station wall at the interface with the subject TOC building. The additional horizontal and vertical pressures at ULS acting on the station east wall are presented in presented in Figure 1. The OL Pape station permeant structure shall be designed to accommodate these additional pressures in case the raft foundation option will be selected for the North Site.

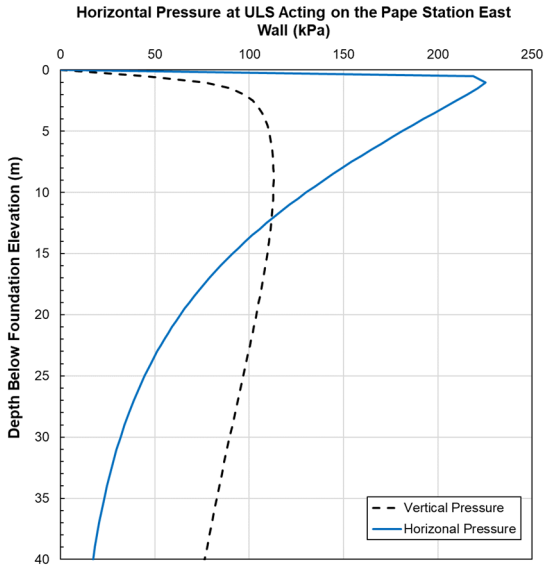

Figure 1 Additional Horizontal and Vertical Pressures acting on the OL Pape Station East Wall at the Interface with the TOC North Site Due to the TOC building Loads

The use of deep foundations for the North and South TOC buildings will still result in additional horizontal pressure acting on the OL Pape Station east walls when the caissons are moving towards the station under lateral loads acting on the TOC buildings (e.g., wind loads, seismic loads, etc.). This additional pressure should be computed subsequent to the final design of the foundations of the TOC buildings and shall be considered in the design of the station structure.

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

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a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

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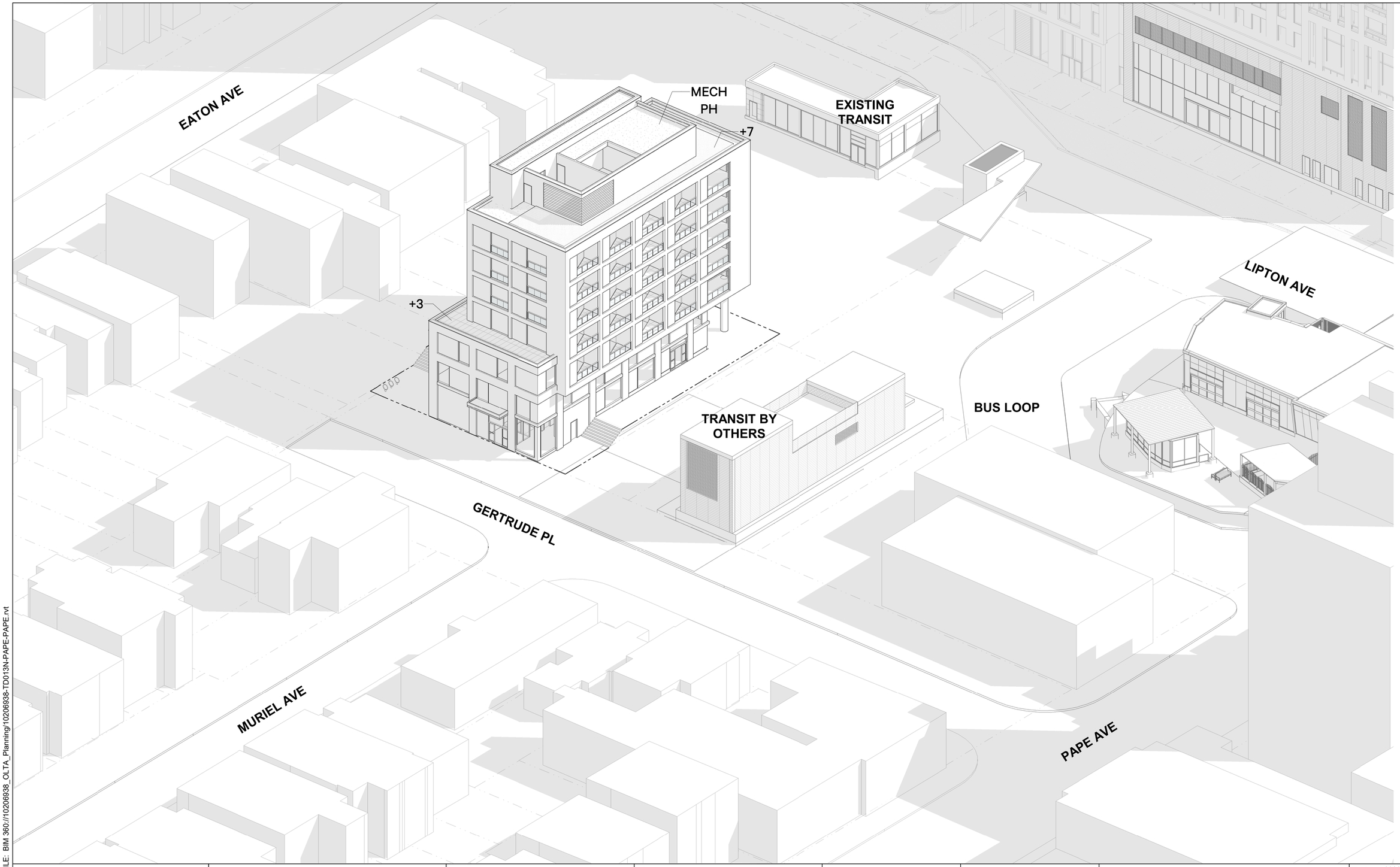
Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

ONE TEAM
ONTARIO LINE TECHNICAL ADVISOR

Appendix A: General Arrangement Drawings



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REVISIONS		
1	2022-10-24	ISSUED FOR QA/QC
2	2022-11-17	ISSUED FOR REZONING

ARCHITECTURE AND
LANDSCAPE SET - REZONING

NOT FOR ESTIMATING OR BIDDING
NOT FOR CONSTRUCTION

SvN

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ONTARIO LINE TECHNICAL ADVISOR

ONTARIO ASSOCIATION OF ARCHITECTS
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DESIGNED D.ABAD
DRAWN D.ABAD
CHECKED J.RODRIGUEZ-VILLA
APPROVED L. BRESLER

ONTARIO LINE

TITLE
TOC
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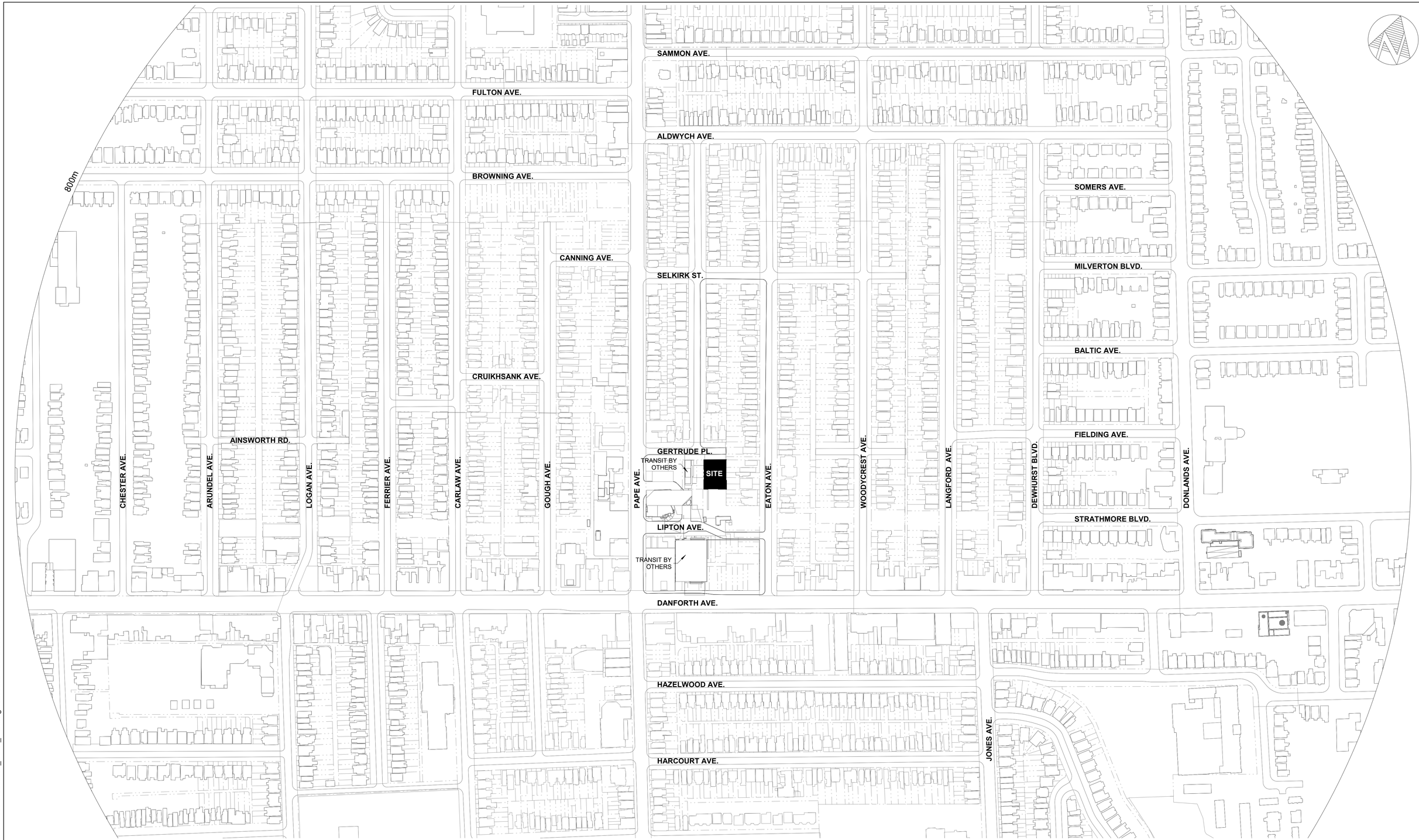
METROLINX
Infrastructure Ontario

SCALE

DRAWING NUMBER
413T001N



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REVISIONS		
1	2022-10-24	ISSUED FOR QA/QC
2	2022-11-17	ISSUED FOR REZONING

ARCHITECTURE AND LANDSCAPE SET - REZONING

NOT FOR ESTIMATING OR BIDDING
NOT FOR CONSTRUCTION

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ONETEAM
ONTARIO LINE TECHNICAL ADVISOR

ONTARIO ASSOCIATION OF ARCHITECTS
LIANA BRESLER
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DESIGNED	D.ABAD
DRAWN	D.ABAD
CHECKED	J.RODRIGUEZ-VILLA
APPROVED	L. BRESLER

ONTARIO LINE

TITLE
TOC
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CONTEXT PLAN

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METROLINX
Infrastructure Ontario

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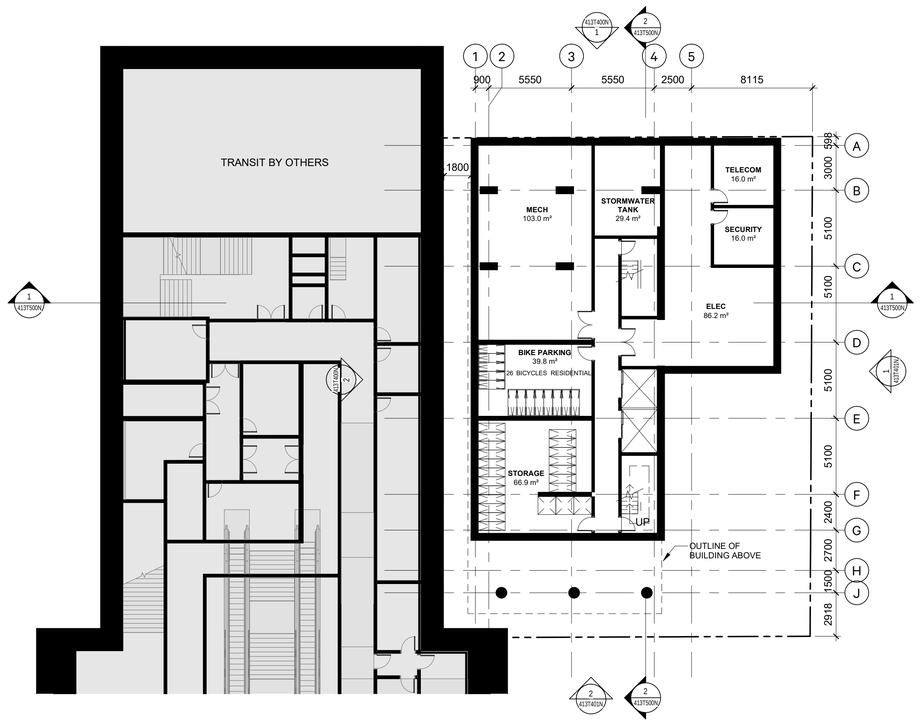

1 LEVEL B1

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REVISIONS		
1	2022-10-24	ISSUED FOR QA/QC
2	2022-11-17	ISSUED FOR REZONING

ARCHITECTURE AND LANDSCAPE SET - REZONING

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NOT FOR CONSTRUCTION

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ONTARIO ASSOCIATION OF ARCHITECTS
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LICENCE
8272

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DRAWN D.ABAD
CHECKED J.RODRIGUEZ-VILLA
APPROVED L. BRESLER

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TOC
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LEVEL B1

Plot Date: 2022-11-17 2:21:49 PM

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SCALE 1 : 200

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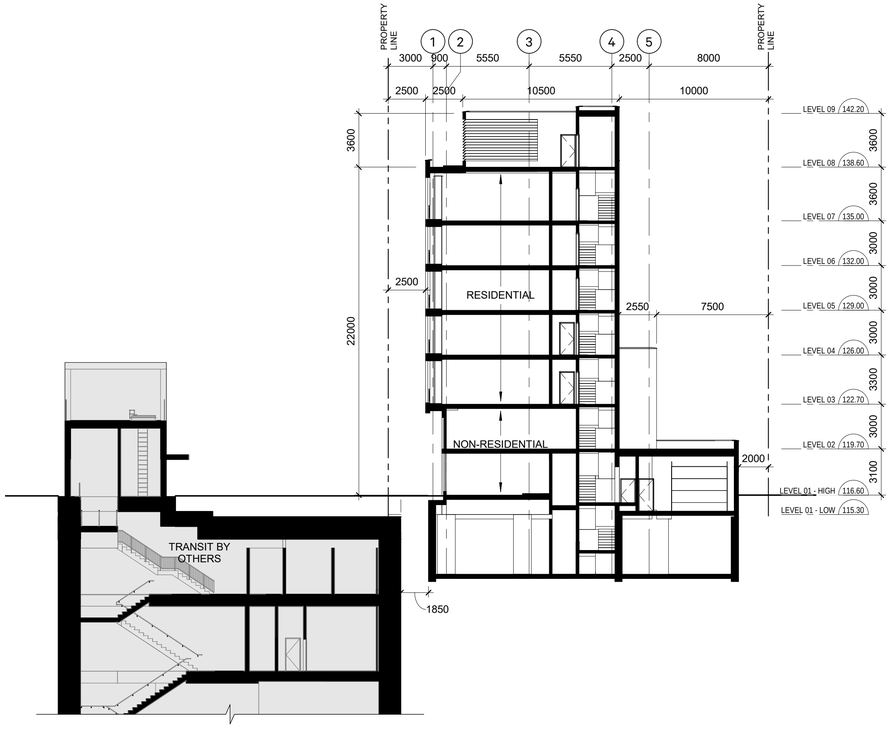

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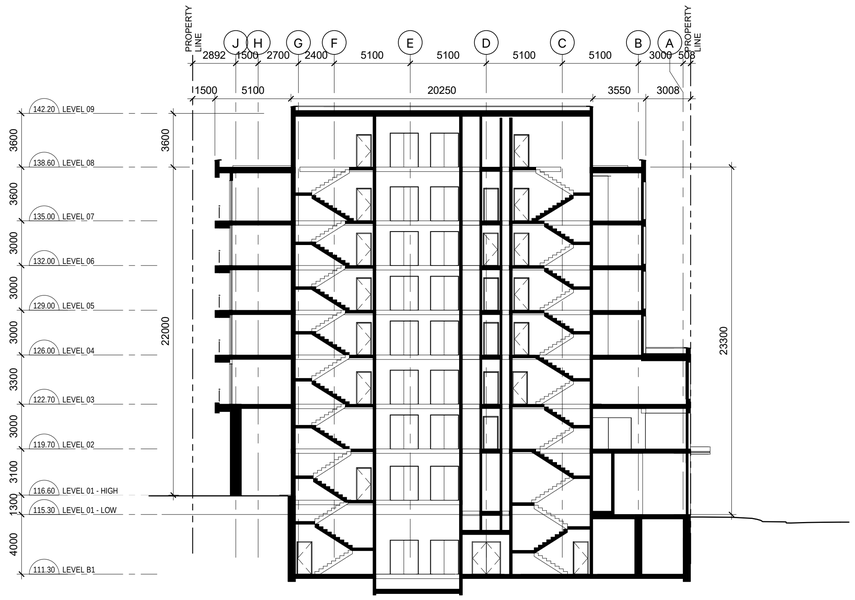

2 LONG SECTION

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REVISIONS		
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SECTIONS

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SCALE	DRAWING NUMBER
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REVISIONS		
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2	22.11.17	ISSUED FOR REZONING

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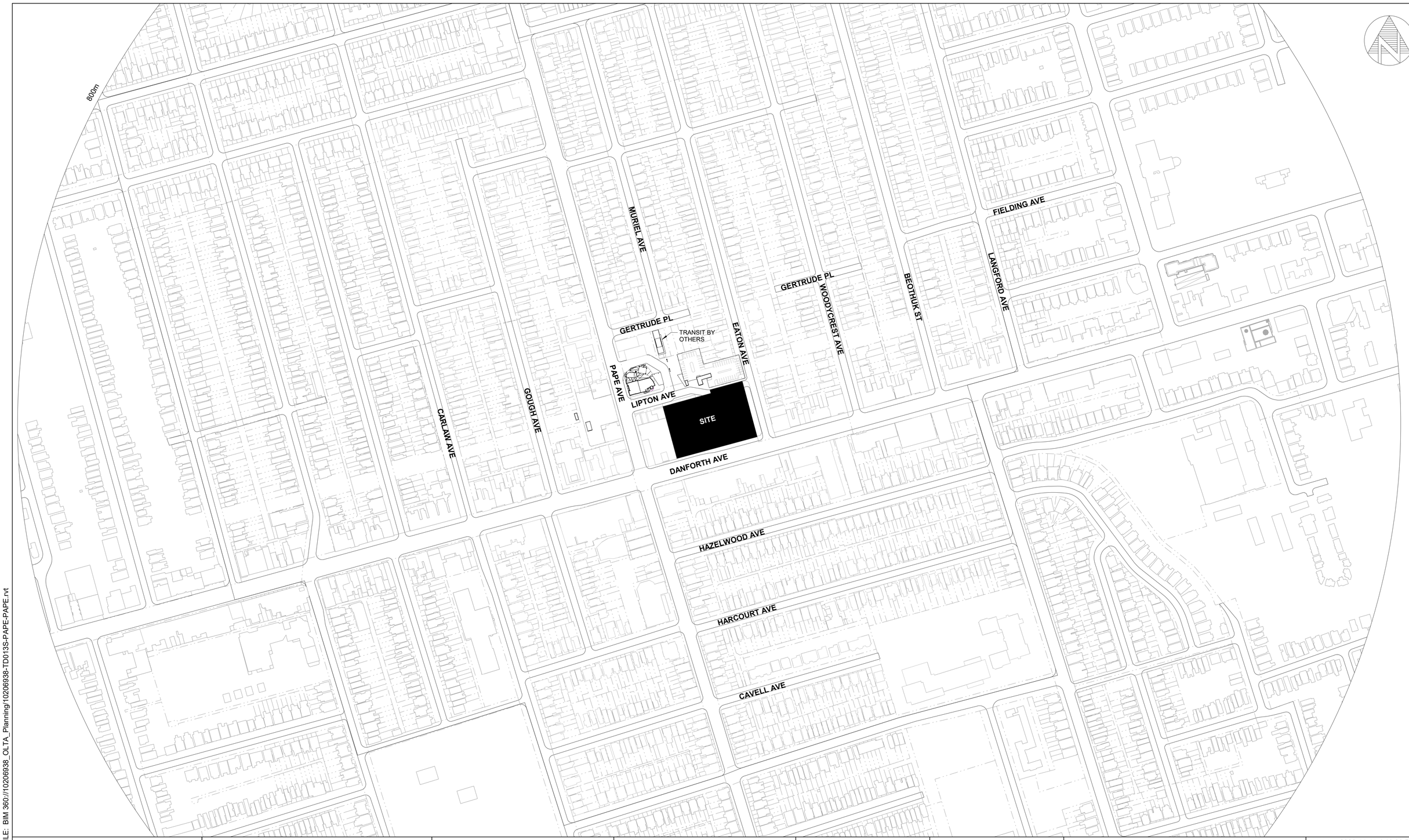
TITLE
TOC
PAPE | PAPE
CONTEXT MASSING

Plot Date: 2022-11-17 4:24:13 PM

METROLINX
Infrastructure Ontario

SCALE

DRAWING NUMBER
413T001S



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TITLE
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CONTEXT PLAN

Plot Date: 2022-11-17 4:18:08 PM

METROLINX
Infrastructure Ontario

SCALE 1 : 2000

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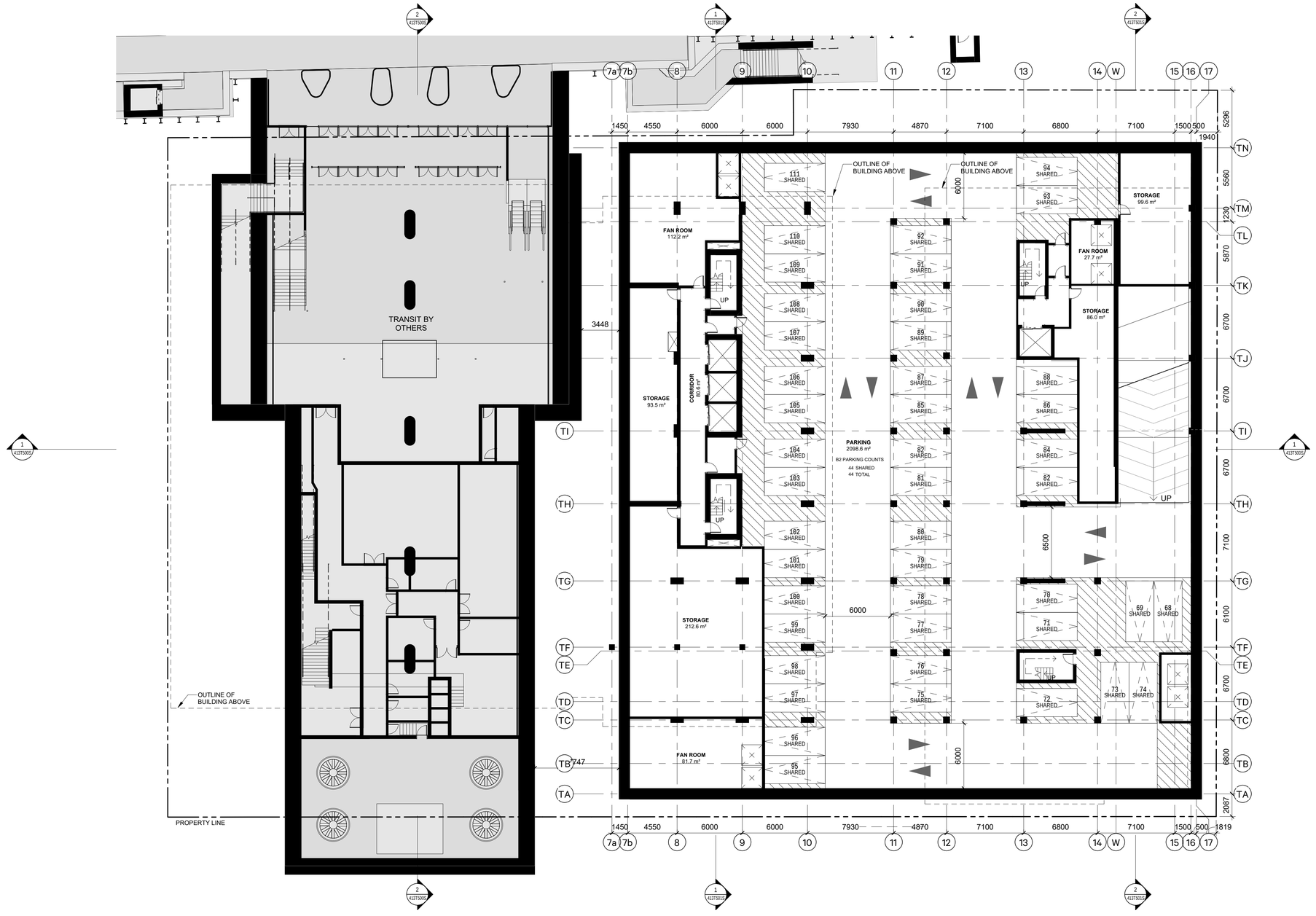

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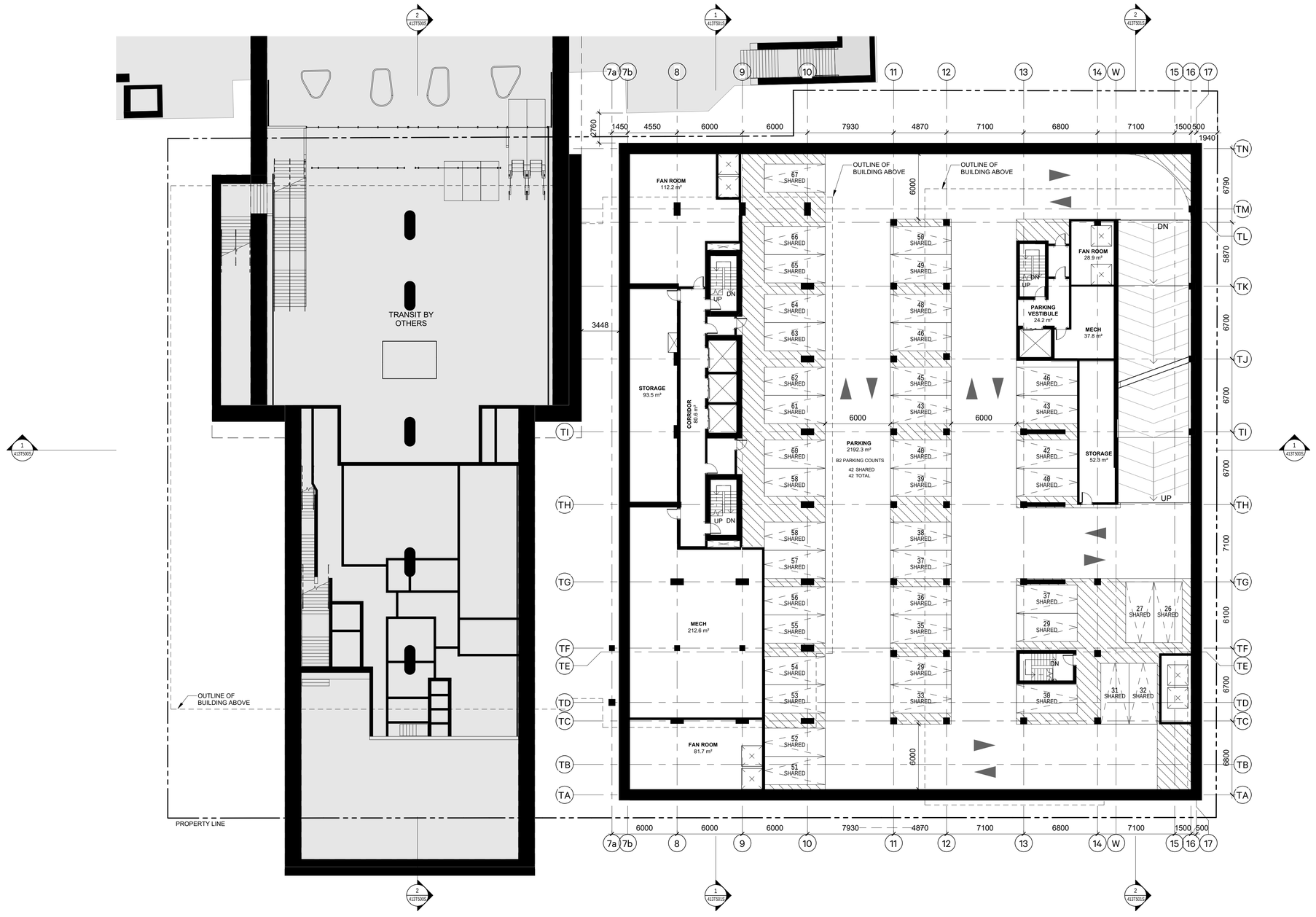
TITLE
TOC
PAPE | PAPE
LEVEL B3

Plot Date: 2022-11-17 1:59:34 PM

METROLINX
Infrastructure Ontario

SCALE 1 : 200

DRAWING NUMBER 413T101S



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2	22.11.17	ISSUED FOR REZONING

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APPROVED	L.BRESLER

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TITLE
TOC
PAPE | PAPE
LEVEL B2

Plot Date: 2022-11-17 2:00:11 PM

METROLINX
Infrastructure Ontario

SCALE	DRAWING NUMBER
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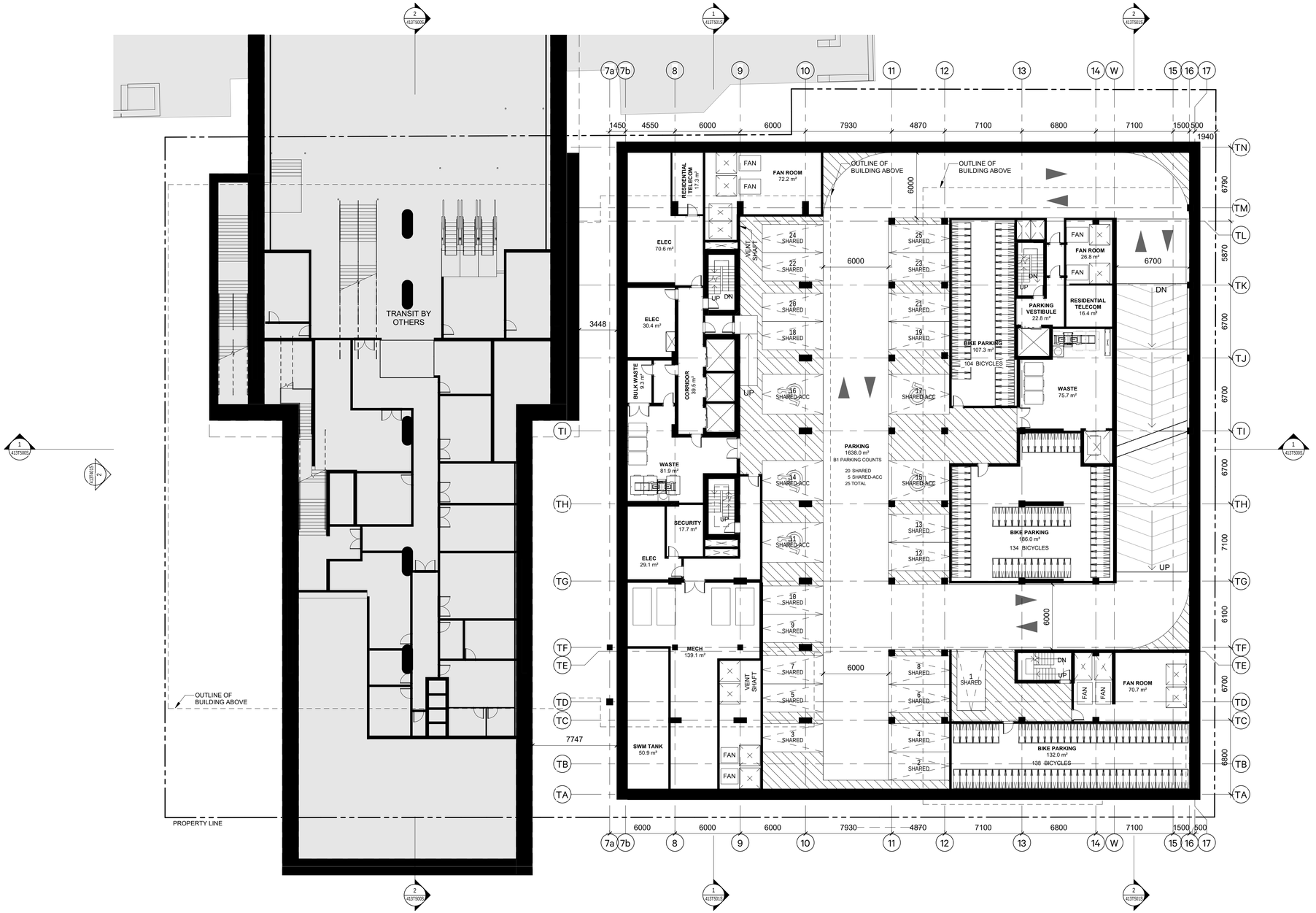

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2	22.11.17	ISSUED FOR REZONING

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TITLE
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PAPE | PAPE
LEVEL B1

Plot Date: 2022-11-17 2:01:05 PM

METROLINX
Infrastructure Ontario

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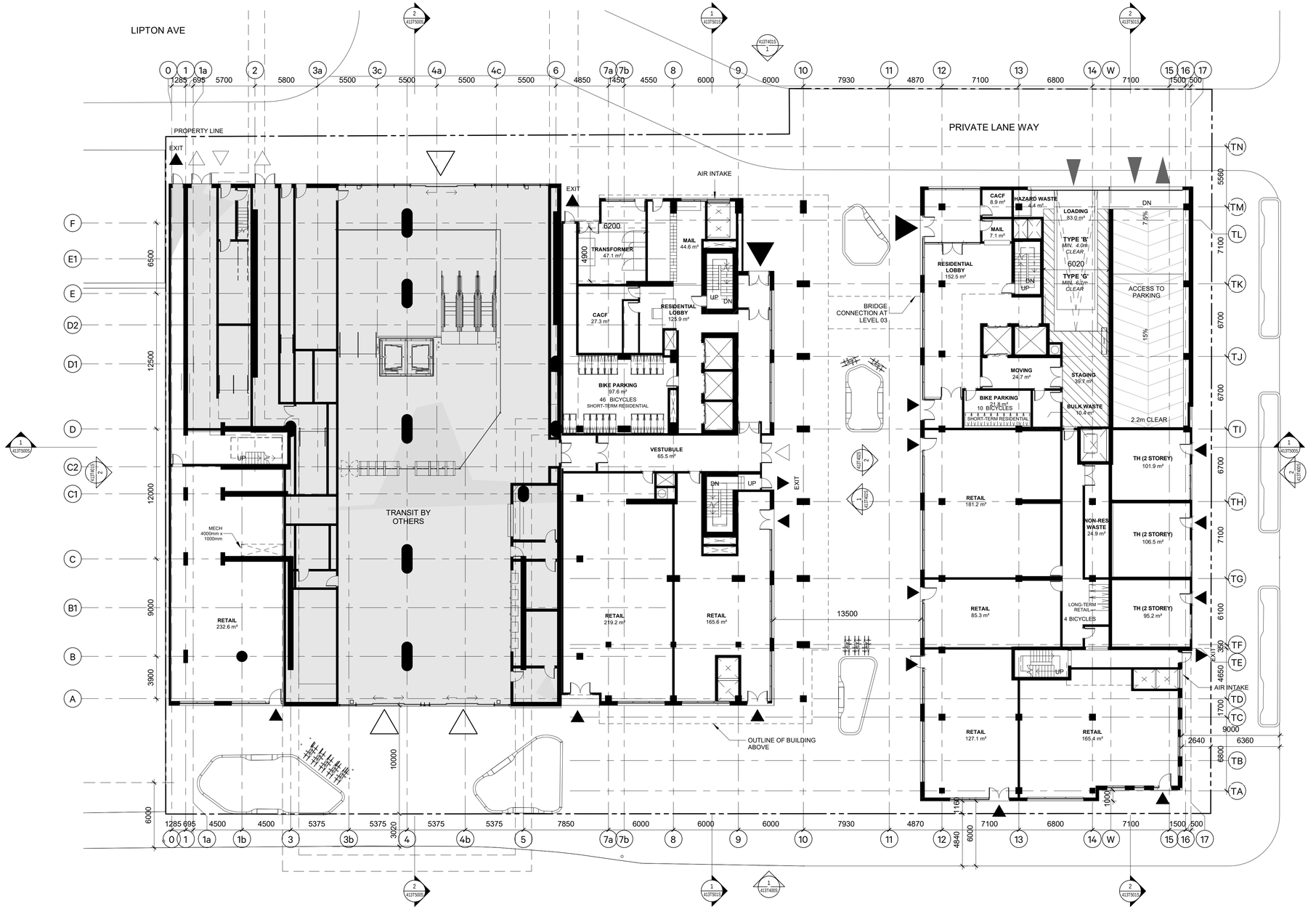

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2	22.11.17	ISSUED FOR REZONING

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TITLE
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LEVEL 1

Plot Date: 2022-11-17 2:03:01 PM

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SCALE 1 : 200
DRAWING NUMBER 413T201S

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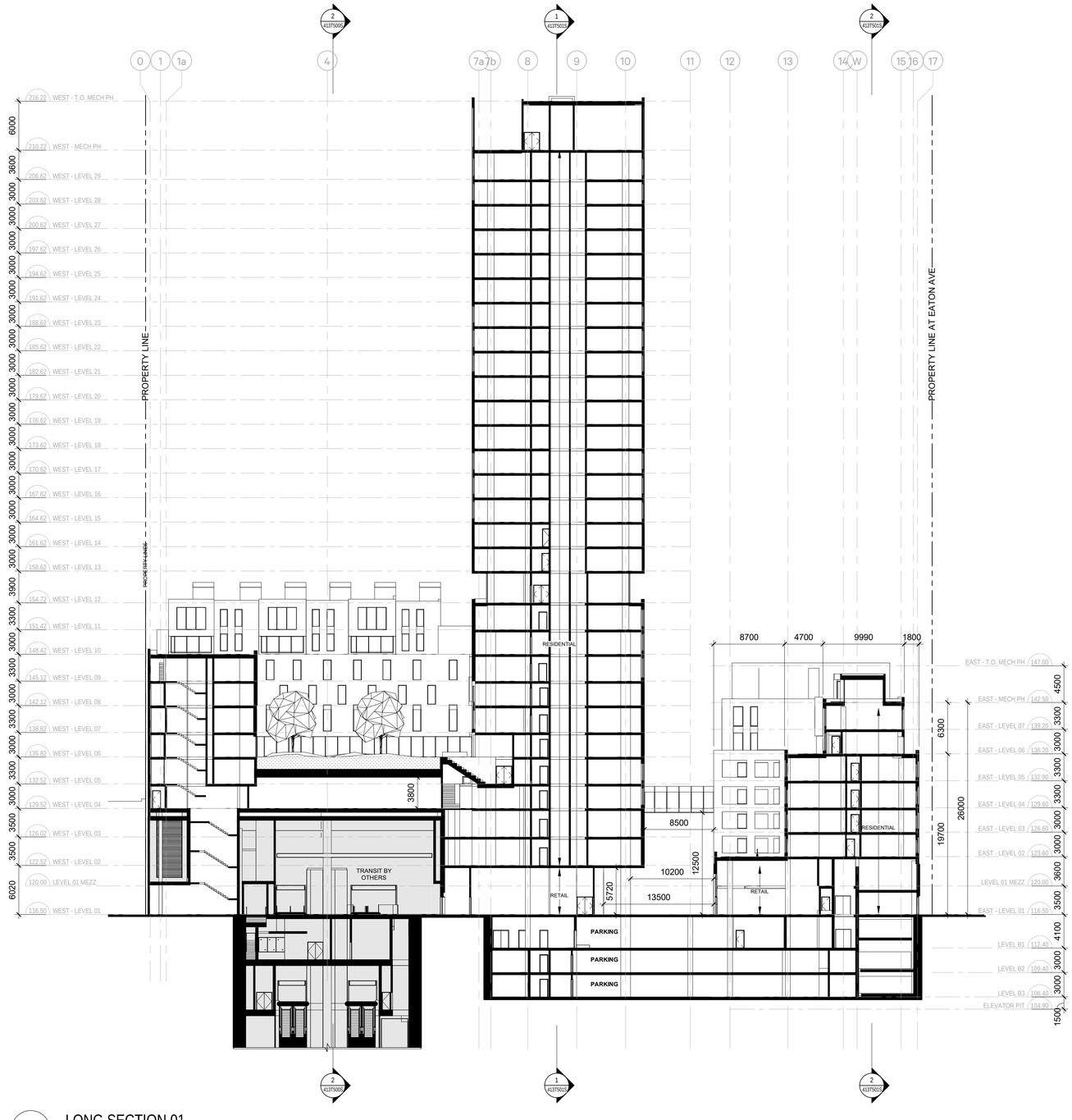

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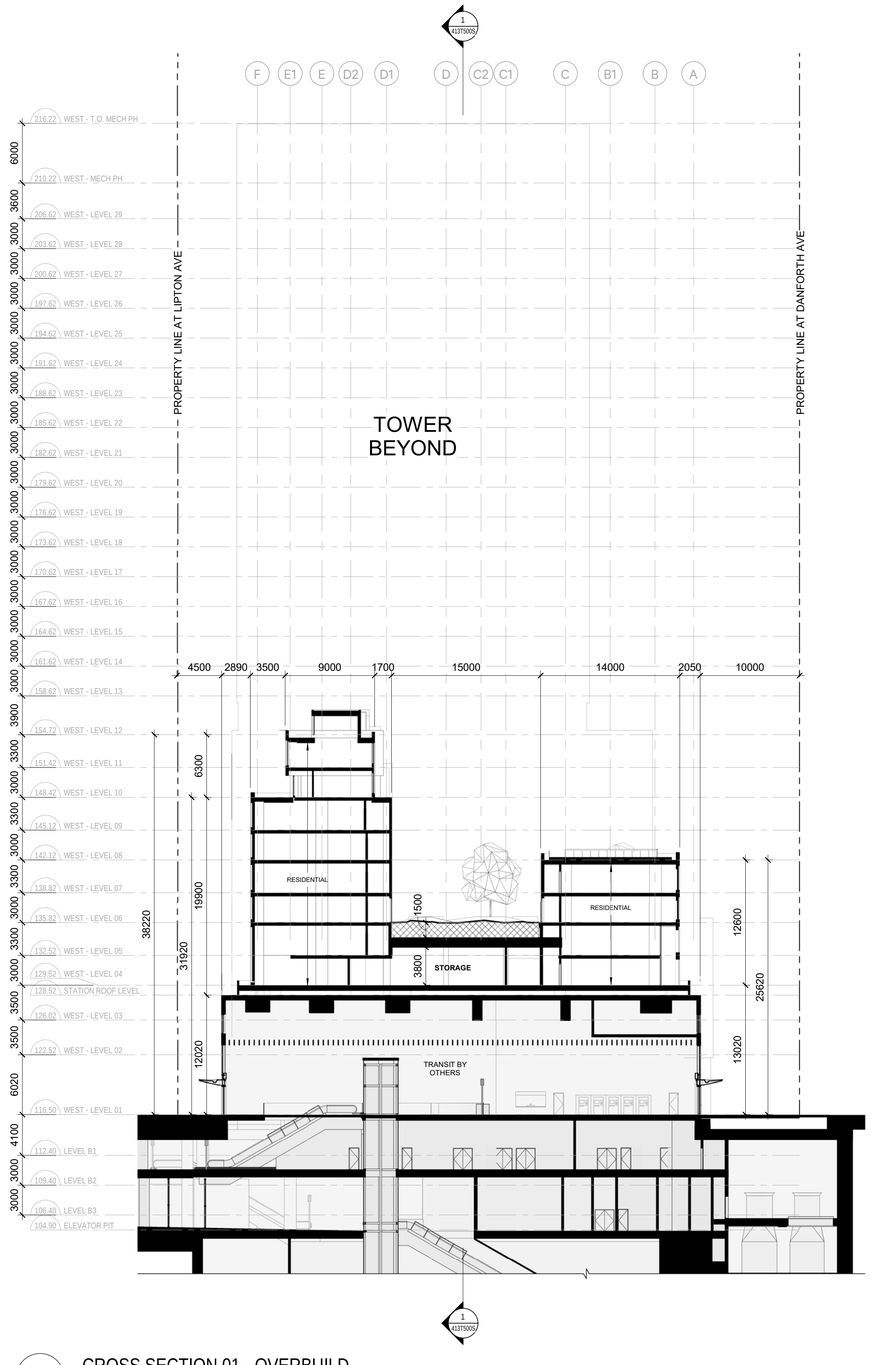

2 CROSS SECTION 01 - OVERBUILD

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SHEET No. 413T500SFILE: BIM 360://10206938_OLTA_Planning/10206938-TD013S-PAPE-PAPE.rvt

REVISIONS		
1	22.11.02	ISSUED FOR QAQC
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SECTIONS

Plot Date: 2022-11-15 5:24:12 PM

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SCALE	DRAWING NUMBER
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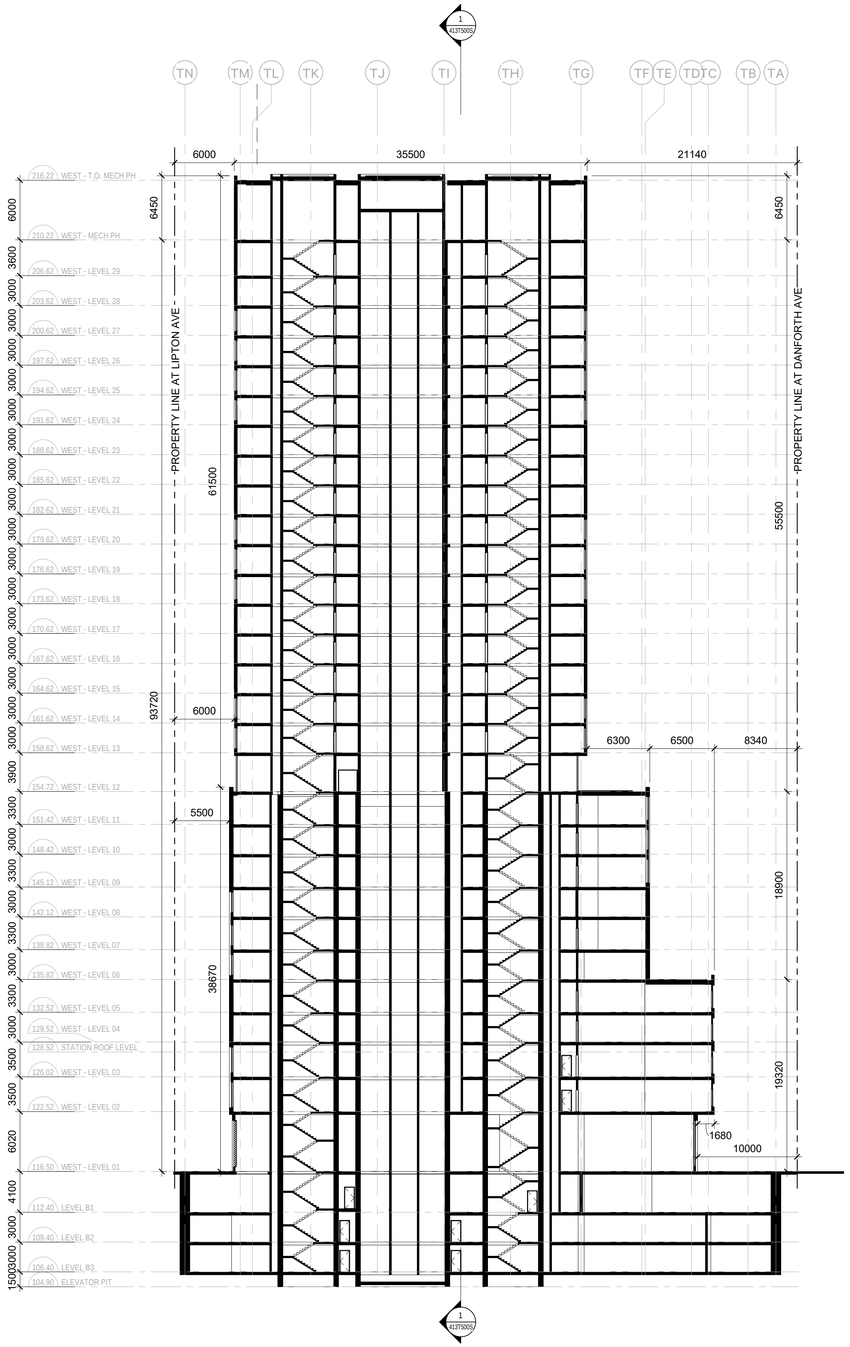
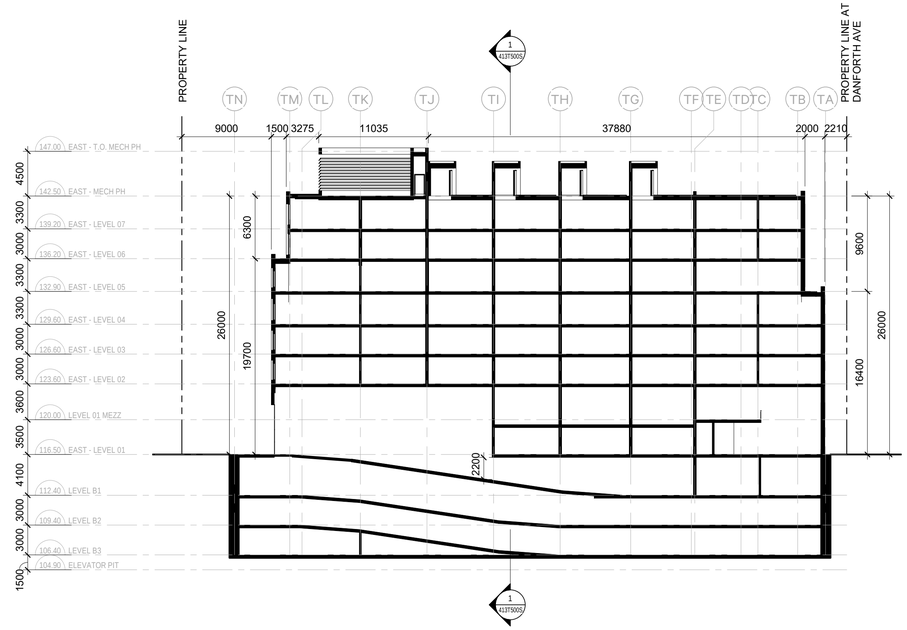


1 CROSS SECTION 03 - TOWER

1 : 300



2 CROSS SECTION 04 - MIDRISE

1 : 300

SHEET No. 413T501SFILE: BIM 360://10206938_OLTA_Planning/10206938-TD013S-PAPE-PAPE.rvt

REVISIONS		
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2	22.11.17	ISSUED FOR REZONING

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TITLE
TOC
PAPE | PAPE
SECTIONS

Plot Date: 2022-11-15 5:24:16 PM

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SCALE	DRAWING NUMBER
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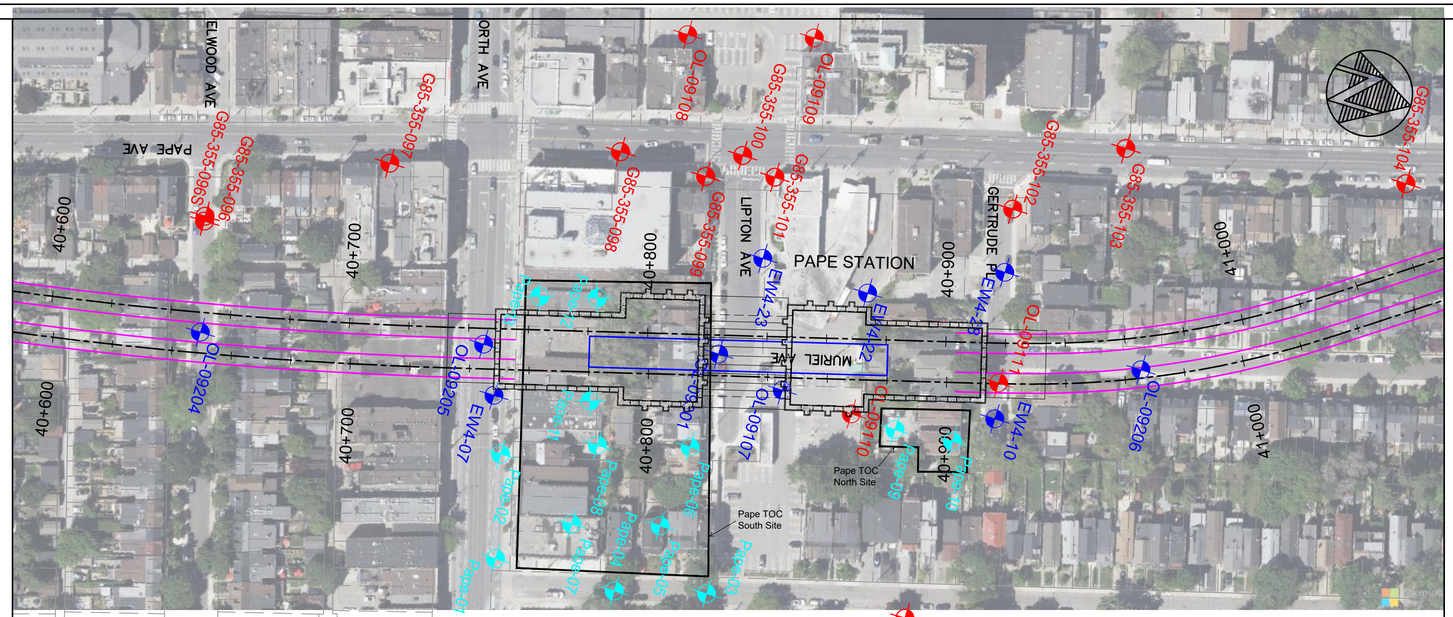
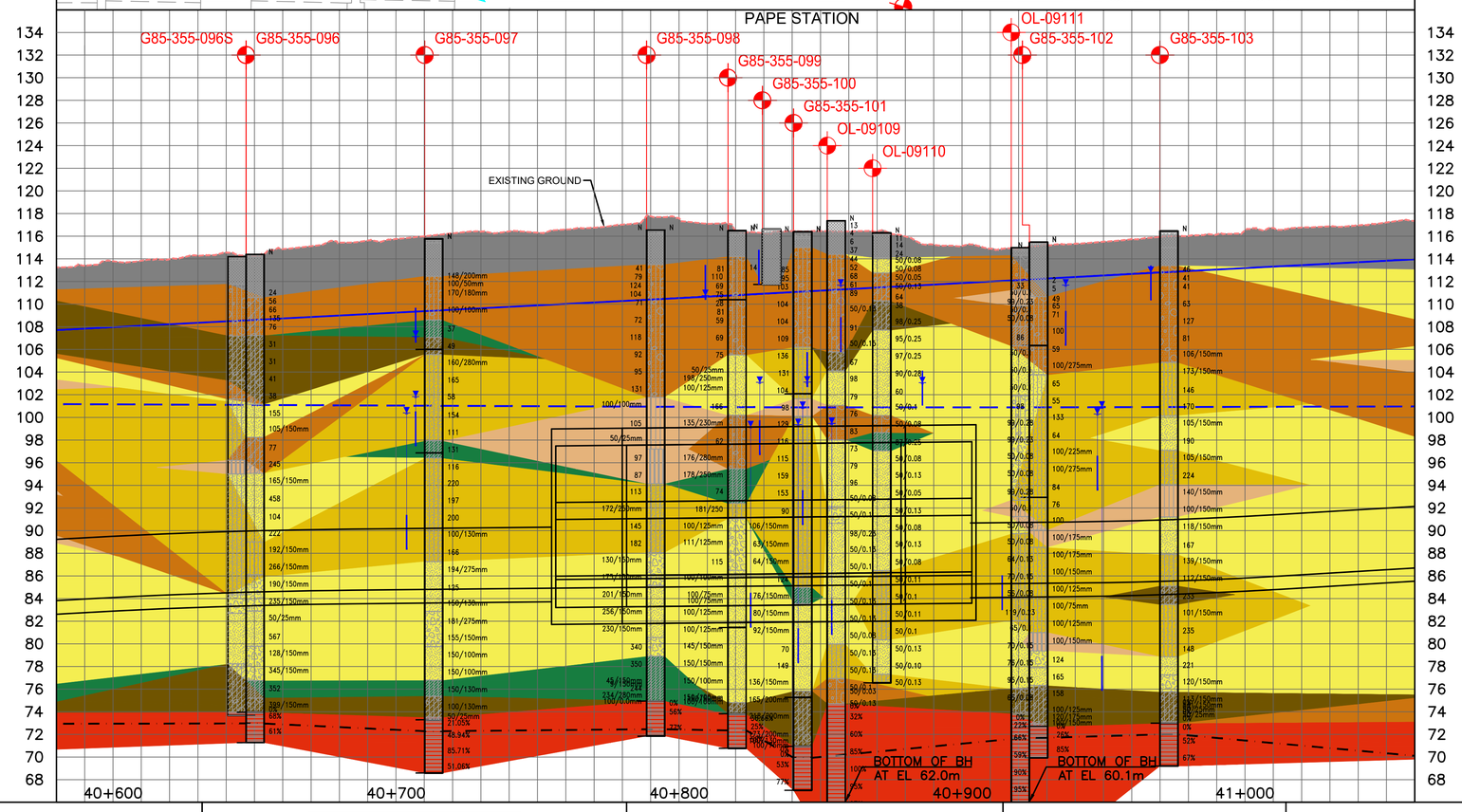
Appendix B: Interpreted Stratigraphic Profile





ENGINEERING GROUP - MAJOR SOIL DEPOSIT:

- F1 FILL
- F2 RECENT ALLUVIAL AND FLUVIAL DEPOSITS
- 1/2 INTERSTADIAL GRAVEL TO SAND
- 3N NON-PLASTIC TILL
- 3C PLASTIC TILL
- 4 INTERSTADIAL SILTY SAND TO SANDY SILT
- 5 GLACIOLACUSTRINE LOW-PLASTICITY CLAYEY SILT TO NON-PLASTIC SILT
- 6/7 GLACIOLACUSTRINE INTERMEDIATE TO HIGH PLASTICITY SILTY CLAY TO CLAY
- B BEDROCK

LITHOLOGY GRAPHIC SYMBOLS AND MATERIAL TYPES:

- 1 TOPSOIL
- 1 PEAT
- 1 ORGANIC SOIL
- 1 FILL
- 2 SANDY GRAVEL
- 3 GRAVELLY SAND
- 4 SAND
- 5 SILTY SAND
- 6 SILT
- 7 SANDY SILT
- 8 SANDY SILT TILL
- 9 SILTY SAND TILL
- 10 CLAY
- 11 SILTY CLAY
- 12 CLAYEY SILT
- 13 CLAY TILL
- 14 SILTY CLAY TILL
- 15 CLAYEY SILT TILL
- 16 COMPLETELY WEATHERED BEDROCK (RESIDUAL SOIL)
- 17 HIGHLY WEATHERED TO FRESH BEDROCK
- INTERFACE BETWEEN TYPE 16 AND 17 BEDROCK

BOREHOLE SYMBOLS:

- EXISTING ONTARIO LINE BOREHOLES
- PROPOSED BOREHOLES FOR THE TOC
- PLANNED ONTARIO LINE BOREHOLES

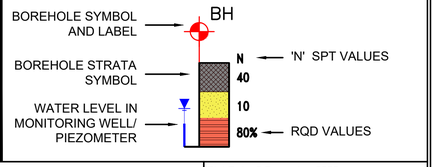
INTERPRETED PIEZOMETRIC LEVELS:

- INTERPRETED SHALLOW OVERBURDEN GROUNDWATER LEVEL
- INTERPRETED TUNNEL HORIZON GROUNDWATER LEVEL

NOTES:

1. SOIL AND GROUNDWATER CONDITIONS BETWEEN BOREHOLES ARE INTERPRETED AND MAY DIFFER FROM CONDITIONS SHOWN. BOREHOLE WIDTH IN PROFILE IS NOT TO SCALE.
2. ALL BOREHOLE LOCATIONS AND SITE FEATURES ARE APPROXIMATE.
3. SHAFT AND TUNNEL OUTLINES ARE SHOWN FOR GENERAL ILLUSTRATION PURPOSES ONLY AND DO NOT NECESSARILY INDICATE THE EXTENTS OF THE EXCAVATIONS.
4. ALL ELEVATIONS ARE IN GEODETIC METRES UNLESS OTHERWISE SHOWN.

GENERAL LEGEND:



MAY 12, 2021
RAIL ALIGNMENT
NOT FOR CONSTRUCTION

SCALE(S) 0 10 20 30 40m HOR
0 2.5 5 7.5 10m VER

STATUS

PRELIMINARY

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ONTARIO LINE SUBWAY

PAPE TOC

PLAN AND STRATIGRAPHIC PROFILE ALONG OL SUBWAY EASTBOUND TRACK

Plot Date: 2 December 2022

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Infrastructure Ontario

FIGURE B.1

FILE: 10206938-ge1000-04-bhpp.dwg
PLOTTED BY: DRAFTING01

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Appendix C: Preliminary Geotechnical and Hydrogeological Scope of Investigation

TABLE 1
TOC - North - Pape

Preliminary Scope of Work for Geotechnical and Hydrogeological Investigation

Borehole ID	Depth [Borehole Termination Criteria]	Field Investigation	Laboratory Investigation
6 boreholes (Pape-01, Pape-03, Pape-05, Pape-08, Pape-9, and Pape-12)	**55 m [10 m of rock coring]**	**Scope of Work** '- **SPT** within overburden soil at 0.75 m interval up to 6 m depth, increasing to 1.5 m interval up to borehole termination. - Photo of each recovered soil sample showing a sample, measuring tape and sample identification. - If very soft to firm plastic soil is encountered (i.e. N<10), collect Shelby Tube samples, one for every 3 m thickness of the layer, minimum one per layer (Shelby Tube, immediately followed by SPT, followed by VST). - **Pressuremeter testing (PMT) and Sonic/PQ Drilling** at BH-8, and BH-9. - **Sonic/PQ Drilling** at BH-3 **Monitoring Wells:** - Install one monitoring wells with screen tip at 5 m below ground surface at the following boreholes: Pape-03, Pape-08, Pape-10, and Pape-12. - Install one monitoring wells with screen tip at 6 m below ground surface at the following boreholes: Pape-4, Pape-07, and Pape-09. - Install one monitoring wells with screen tip at 10 m below ground surface at the following boreholes: Pape-01, Pape-05, and Pape-13. - Install one monitoring wells with screen tip at 15 m below ground surface at the following boreholes: PApe-02, and Pape-06. - Install 50 mm well with 3-m long screen in the aforementioned boreholes. Monitoring wells to be screened within the most permeable zone, with general bias towards the tip elevations mentioned above. - Groundwater level measurements to be completed during drilling and on a bi-weekly basis after installation until the water levels are stabilized, for a minimum of 3 readings. - Single well response test at the above shallow monitoring well locations (i.e., monitoring wells with tip at 4 m, 6 m, and 8 m below ground surface).	**Geotechnical Soil Testing** - Moisture content test on all soil samples - Index Properties test (Sieve, hydro, Atterberg) on 30% of the soil samples, minimum one per layer in each borehole. - Unit Weight/Density Test on 4 samples; minimum two tests at each site location. - The following advance testing should be carried out on undisturbed soil samples obtained from the sonic drilling/PQ coring at all subject BHs: i- minimum of 4 CD triaxial tests and 2 UU triaxial tests for soil samples from each borehole. The UU triaxail tests are for choesive soil only. ii- minimum of 2 Direct Shear tests for non-cohesive soil samples from each borehole, if proper samples of non-cohesive soil for triaxial tests are not obtained from PQ/sonic borheoles. iii- minimum of 3 consolidation test for cohesive soil samples from each borehole. - Rock testing: Unconfined Compressive Strength (UCS) for each run of collected rock cores. Point Load Tests as required.
7 boreholes (Pape-02, Pape-04, Pape-06, Pape-07, Pape-10, Pape-11, and Pape-13)	**40 m [auger refusal on the top of bedrock]**		

Notes:

1- The preliminary locations of the boreholes are shown in Appendix B. The preliminary borehole locations are based on the TOC development footprint obtained from the architectural drawings dated 17/11/2022. The borehole locations shall be finalized by DevCo.

2- The field investigation and laboratory testing must be completed in accordance with the best practices for geotechnical investigation and in conformance with all applicable regulations, codes, and standards.

3- The scope of investigation presented herein is the recommended minimum scope of investigation to further progress the design of TOC. Dev Co. and their designers must add to the scope of investigation presented herein, as required, for the final design of the TOC.

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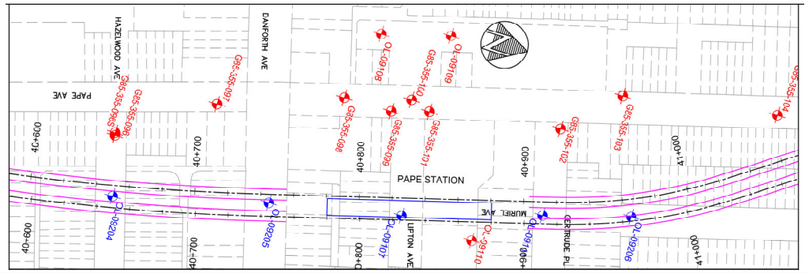
Appendix D: Preliminary Geotechnical Engineering Parameters

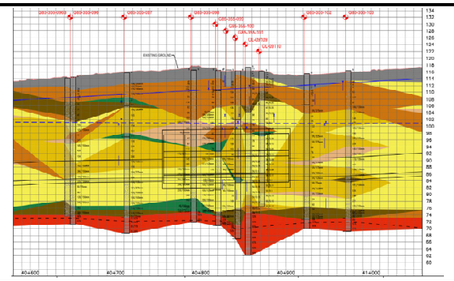
SITE



STRATIGRAPHIC PROFILE

ENGINEERING GROUP - MAJOR SOIL DEPOSIT:

- F1 FILL
- F2 RECENT ALLUVIAL AND FLUVIAL DEPOSITS
- 1/2 INTERSTADIAL GRAVEL TO SAND
- 3C PLASTIC TILL
- 3N NON-PLASTIC TILL
- 4 INTERSTADIAL SILTY SAND TO SANDY SILT
- 5 GLACIOLACUSTRINE LOW-PLASTICITY CLAYEY SILT TO NON-PLASTIC SILT
- 6/7 GLACIOLACUSTRINE INTERMEDIATE TO HIGH PLASTICITY SILTY CLAY TO CLAY
- B BEDROCK



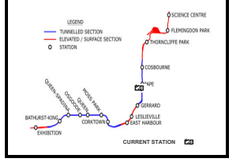
Soil Class	Soil Type Description	Zone 1 - Sta. 40+580 to Sta. 40+720				Zone 2 - Sta. 40+720 to Sta. 40+790				Zone 3 - Sta. 40+790 to Sta. 40+890				Zone 4 - Sta. 40+890 to Sta. 40+950				Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Water Content (%)	Unit Weight, γ (kN/m³) [D]	Young's Modulus, E (MPa) [A]	Young's Modulus (Unload / Reload), E_{ur} (MPa) [B]	Poisson's Ratio [C]	Undrained Shear Strength, S_u (kPa)	Effective Friction Angle, ϕ' (deg)	Effective Cohesion, c' (kPa)	Dilation Angle, Ψ (deg)	Earth Pressure Coeffiecient	
		Elevation (m)		Depth (m)		Elevation (m)		Depth (m)		Elevation (m)		Depth (m)		Elevation (m)		Depth (m)														Active (K_A)	Passive (K_P)
		From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To													
F1	Fill	115.0	112.1	0.0	2.9	116.6	113.5	0.0	3.1	116.6	112.0	0.0	4.6	116.2	112.0	0.0	4.2	-	-	-	12	21	11	55	0.2 - 0.4	-	28	-	-	0.36	2.8
3N	Non-Plastic Till	112.1	107.9	2.9	7.1	113.5	101.8	3.1	14.8	112.0	105.6	4.6	11.0	112.0	104.0	4.2	12.2	-	-	-	9	22	36	120	0.2 - 0.4	-	39	-	9	0.23	4.4
3C	Plastic Till	107.9	104.4	7.1	10.6	-	-	-	-	-	-	-	-	-	-	-	-	23	13	10	12	21.5	40	121	0.2 - 0.4	500	33	10	3	0.29	3.4
5	Glaciolacustrine Low-Plasticity Clayey Silt to Non-Plastic Silt	-	-	-	-	101.8	94.2	14.8	22.4	-	-	-	-	-	-	-	-	-	-	-	19	20.5	72	271	0.2 - 0.4	-	38	-	8	0.24	4.2
1/2 4	Interstadial Gravel to Sand to Silty Sand/Sandy Silt	-	-	-	-	-	-	-	-	105.6	100.3	11.0	16.3	104.0	95.2	12.2	21.0	-	-	-	14	21.5	73	233	0.2 - 0.4	-	42	-	12	0.20	5.0
3N	Non-Plastic Till	-	-	-	-	-	-	-	-	100.3	95.5	16.3	21.0	-	-	-	-	-	-	-	9	22	61	202	0.2 - 0.4	-	39	-	9	0.23	4.4
6/7	Glaciolacustrine Intermediate to High Plasticity Silty Clay to Clay	-	-	-	-	-	-	-	-	95.5	92.5	21.0	24.1	-	-	-	-	32	16	16	18	21	64	191	0.2 - 0.4	500	33	10	3	0.29	3.4
5	Glaciolacustrine Low-Plasticity Clayey Silt to Non-Plastic Silt	-	-	-	-	-	-	-	-	-	-	-	-	95.2	93.3	21.0	22.9	-	-	-	19	20.5	78	291	0.2 - 0.4	-	38	-	8	0.24	4.2
1/2 4	Interstadial Gravel to Sand to Silty Sand/Sandy Silt	104.4	77.5	10.6	37.5	94.2	78.9	22.4	37.6	92.5	79.0	24.1	37.6	93.3	76.1	22.9	40.1	-	-	-	14	21.5	100	318	0.2 - 0.4	-	42	-	12	0.20	5.0
3C	Plastic Till	77.5	73.6	37.5	41.4	-	-	-	-	79.0	72.2	37.6	44.4	76.1	72.2	40.1	44.0	31	18	13	11	21.5	86	257	0.2 - 0.4	700	33	10	3	0.29	3.4
6/7	Glaciolacustrine Intermediate to High Plasticity Silty Clay to Clay	-	-	-	-	78.9	73.9	37.6	42.7	-	-	-	-	-	-	-	-	36	19	17	20	20	83	249	0.2 - 0.4	700	33	10	3	0.29	3.4

[A] Secant modulus should be increased by 20% to 50% for settlement calculation

[B] Average Secant Modulus for Unload/Reload condition

[C] Long-term Effective Poisson's Ratio

[D] The unit weight values are for the intact condition and do not include bulking factor after excavation.



THURBER

ONETEAM
ONTARIO LINE TECHNICAL ADVISOR

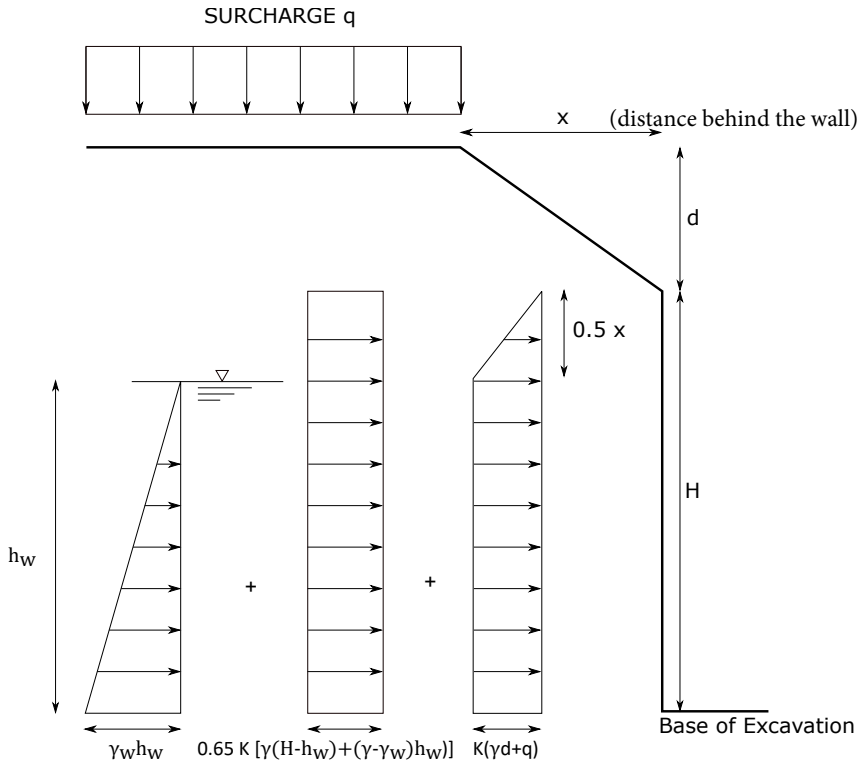
Ontario Line

TOC - NORTH - PAPE
Preliminary Interpreted Subsurface Stratigraphy and Geotechnical Parameters

Infrastructure Ontario

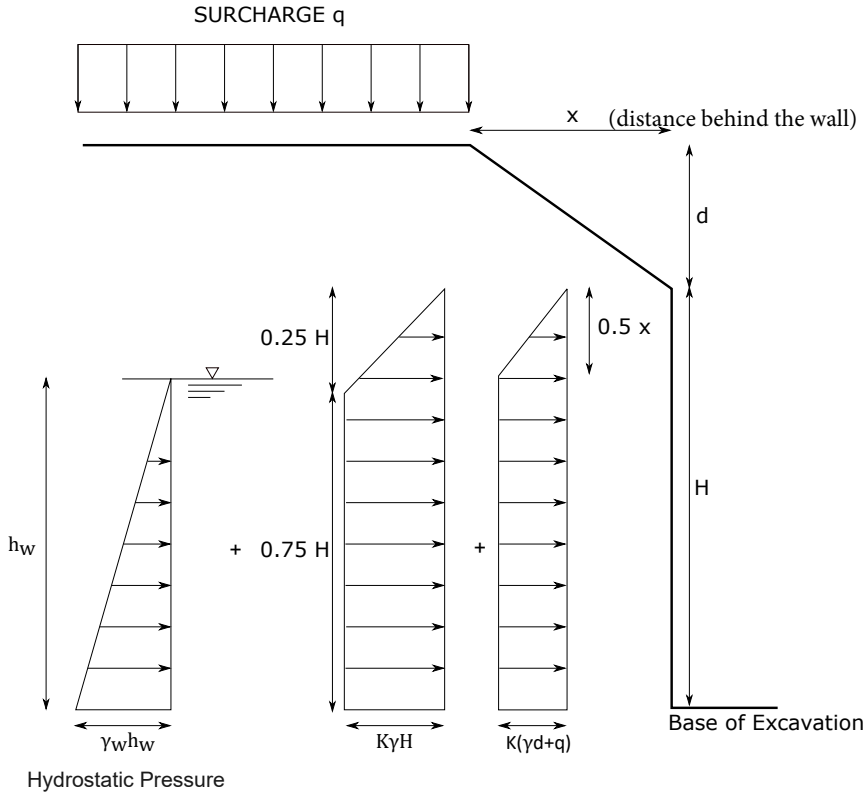
METROLINX

ENGINEER: MM	DRAWN: MH	APPROVED
DATE: 2022-11-22	SCALE: NTS	



γ = unit weight of soil
γ_w = unit weight of water
K = earth pressure coefficient
= Ka (where controlling ground deformation is not a concern) - Ka is the active coefficient of earth pressure
= 0.4 to 0.5 (to support semi-sensitive to sensitive structures)

ONE TEAM ONTARIO LINE TECHNICAL ADVISOR	SITE: TOC - North - Pape	TITLE: Lateral Earth Pressure Distribution Temporary Braced Excavation in Cohesionless Soils
PROJECT: Ontario Line	DOCUMENT OWNER: Thurber	
DATE: 2020-11-13		FIGURE: D-1



γ = unit weight of soil
γ_w = unit weight of water
s_u = undrained shear strength
K = earth pressure coefficient
= 0.2 (where controlling ground deformation is not a concern)
= 0.3 to 0.4 (to support semi-sensitive to sensitive infrastructure)

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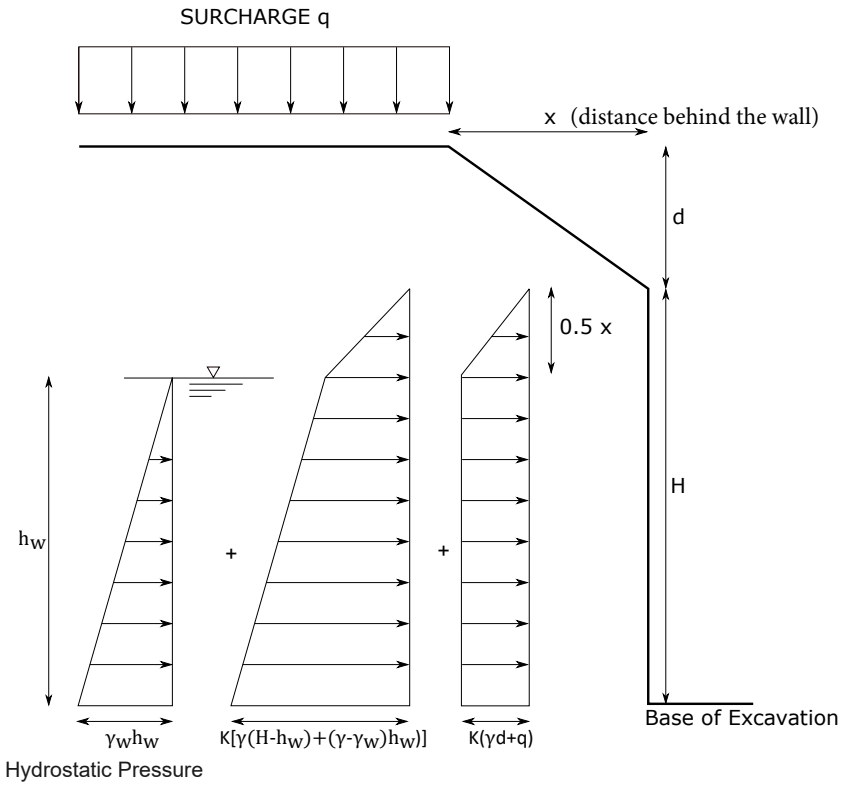
PROJECT: Ontario Line	DOCUMENT OWNER: Thurber	
DATE: 2020-11-13		FIGURE: D-2



γ = unit weight of soil
γ_w = unit weight of water
K = earth pressure coefficient as indicated in the report

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PROJECT: Ontario Line	DOCUMENT OWNER: Thurber	
DATE: 2020-11-13		FIGURE: D-3