Appendix M.3 – Pavement Investigations Report

Kennedy Road Environmental Assessment between Steeles Avenue and Major Mackenzie Drive

REPORT

PAVEMENT DESIGN REPORT

P-16-167, Schedule C Class EA Study for Improvements to Kennedy Road (Y.R. 3) from Steeles Avenue to Major Mackenzie Drive, Markham, Ontario

Submitted to:

Michelle Mascarenhas, P.Eng.
HDR Inc.
100 York Boulevard, Suite 300
Richmond Hill, Ontario
L4B 1J8

Submitted by:

Golder Associates Ltd.
#1, 215 Shields Court, Markham, Ontario, L3R 8V2, Canada

+1 905 475 5591

Project No. 1664178

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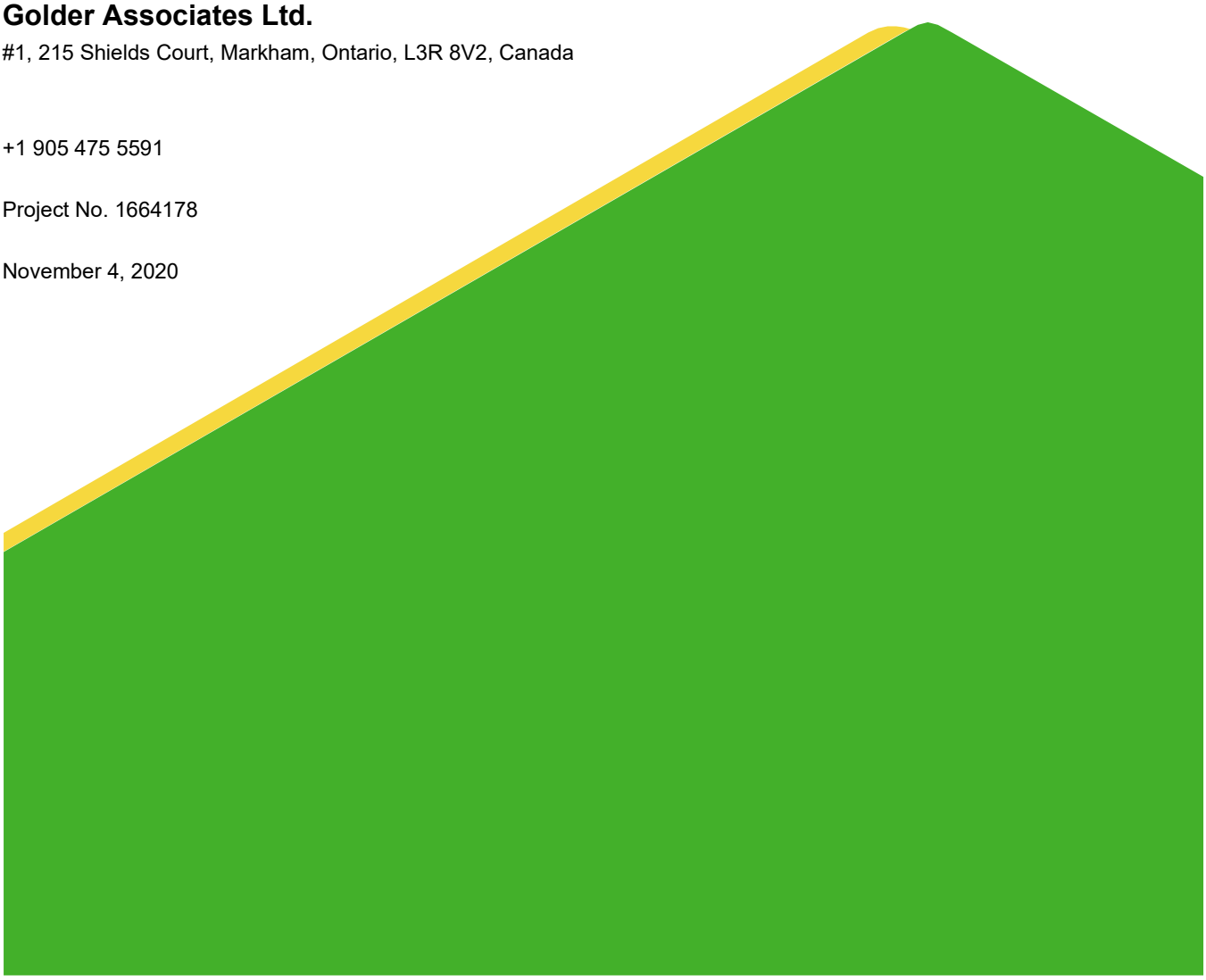

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by HDR Inc. (HDR) to carry out a geotechnical/pavement investigation for the design of Kennedy Road (Y.R. 3) from Steeles Avenue (Y.R. 95) to Major Mackenzie Drive (Y.R. 25) in the City of Markham, Ontario, as shown on the key plan, Figure 1.

The pavement investigation is part of the overall Municipal Class Environmental Assessment Study (Class EA) for improvements to Kennedy Road. This technical report (Report) presents the results of the geotechnical investigation carried out within the project limits and provides pavement design recommendations for the proposed road widening and rehabilitation. The terms of reference and scope of work for the investigation and design services were outlined in Section 6.3.7.3 of the Request for Proposal number P-16-167 (RFP), and Golder's proposal dated November 21, 2016.

The factual data, interpretations and preliminary recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not constructed within eighteen months of the date of the field investigation, Golder should be given an opportunity to confirm that the recommendations are still valid.

2.0 PROJECT UNDERSTANDING

It is our understanding that the Regional Municipality of York (the Region) has proposed to rehabilitate and widen Kennedy Road, with the objective of increasing north-south capacity, to accommodate growth, and improve overall network connectivity. The study area includes approximately nine (9) kilometres of Kennedy Road from Steeles Avenue to Major Mackenzie Drive.

The existing pavements consists of a 4-lane north-south urban arterial road with an intermittent centre shared left turn lane, occasional right turn lanes, and frequent bus inlets; lane widths range from 3.5 m to 4 m. The proposed widening will include a 6-lane cross section accommodating a Transit High Occupancy Vehicle lane and an on-street bicycle lane in each direction. In accordance with the Region's 2016 10 Year Roads and Transit Capital Construction Program, Kennedy Road will be rehabilitated in the following phases:

- Steeles Avenue to Denison Street – beyond the 10 years horizon;
- Denison Street to Highway 7 – proposed in 6-10 years horizon; and
- Highway 7 to Major Mackenzie Drive – beyond the 10 years horizon.

It should be noted that this study began in 2016 and the construction schedule is anticipated to change based on York Region's updated program.

The purpose of the investigation was to evaluate the existing pavement structure, subgrade soils and ground water conditions along Kennedy Road, and to provide preliminary pavement design recommendations for the proposed roadway improvements. This report addresses the pavement design for the widening and rehabilitation of Kennedy Road.

Golder has prepared reports for the foundation engineering aspects of the project under separate covers. The boreholes included in this report were for the purposes of obtaining information for the pavement designs and were generally advanced to a depth of 1.5 m. However, selected boreholes advanced as part of the foundation investigation were also used to provide information for this pavement design report.

3.0 PROJECT WORK PROGRAM

The pavement engineering investigation of Kennedy Road consisted of the following:

- A visual condition survey to evaluate the existing condition of the pavement within the project limits;
- Preparation of a Borehole Location Plan approved by York Region prior to carrying out the field investigation;
- Marking/staking all proposed borehole location and arranging for the clearances of underground utilities at the proposed borehole locations;
- Obtaining applicable road permits from York Region;
- A geotechnical/pavement field investigation which consisted of seventy-nine (79) boreholes advanced to a depth of approximately 1.5 m below ground surface on the existing lanes and boulevards; and
- Laboratory testing of selected representative samples of the granular base, subbase, and subgrade soils to assess the material characteristics including grain size distribution and water content.

4.0 INVESTIGATION PROCEDURE

Golder prepared a plan showing the proposed borehole locations and depths for approval by representatives of HDR and the Region. The site was marked/staked at all the proposed borehole locations and the utility locations of underground utilities were identified through Ontario One Call. Using a Trimble Geox7 GPS unit, the as-drilled borehole locations and ground surface elevations were surveyed and referenced to geodetic datum.

The field work for the investigation was carried out in November 2018, when seventy-nine (79) boreholes were advanced at the locations shown on the Borehole Location Plan (Figure 2). The boreholes were drilled using solid stem augers advanced by a truck mounted drill rig supplied and operated by specialist drilling contractors, subcontracted to Golder, as well as by manual gas-powered hand augering operated by Golder. The shallow groundwater/drainage conditions were noted in the open boreholes during drilling. The soil samples obtained during the site investigation were brought to Golder's Whitby laboratory where further examination and classification testing (i.e. water contents, grain size distributions and Atterberg limits) were carried out on select samples.

The work for this investigation was monitored on a full-time basis by members of Golder's engineering and technical staff, who logged the boreholes and cared for the recovered samples. The boreholes were advanced to identify and measure the individual pavement layers (asphalt, granular base/subbase, etc.), assess the type of subgrade soils and groundwater conditions, and obtain material samples from selected boreholes for laboratory testing.

It should be noted that the boundaries between the strata have been inferred from drilling observation and non-continuous sampling. They generally represent a transition from one soil to another and should not be inferred to represent and exact plane of geologic change. Furthermore, conditions may vary between and beyond the boreholes.

Borehole logs and laboratory results are presented in the Record of Boreholes found in Appendix B.

5.0 SOIL AND PAVEMENT DATA

The following sections present the condition of the existing pavements based on a visual survey, as well as the existing pavement structure and subgrade soil conditions encountered in the boreholes. The geotechnical/ pavement investigation was carried out in November 2018.

5.1 Visual Condition Survey

Golder carried out a visual pavement condition inspection of Kennedy Road between Steeles Avenue and Major Mackenzie Drive. The pavements encountered were generally in fair to good condition, with localized areas with moderate to severe distresses (i.e. pavement distress areas). Kennedy Road within the project limits has an urban cross-section with curbs, gutters and catch basins for drainage.

Based on a visual examination of the pavement surface, it appears that the pavement surface along Kennedy Road was constructed at different times. Further, Kennedy Road appears to have undergone various maintenance treatments such as localized machine patching, micro-surfacing, routing and sealing of cracks, and pothole repairs. As such, for visual evaluation purposes we have separated the pavements in four general segments; the types, severities, and densities of surface distresses within each segment are documented in the subsections below.

Photographs of typical surface conditions were taken throughout all sections and are presented on Figures 3-1 to 3-8 following the text of this report. The findings of the visual condition survey are presented in Appendix A and are summarized below, separately for each of the four sections.

5.1.1 Steeles Avenue to 300 m North of Denison Street

The first segment of Kennedy Road had a Pavement Condition Rating (PCR) of 75 and a Riding Condition Rating (RCR) of 7.5, indicating the pavement is generally in good condition. The following surface distresses were documented:

- Intermittent, slight severity transverse cracking at catch basins;
- Intermittent, slight to moderate map cracking;
- Intermittent, slight to moderate transverse single and multiple cracking;
- Frequent, slight to moderate longitudinal single and multiple cracking;
- Severe map cracking at localized pavement change at CN Rail; and
- Severe longitudinal and transverse cracking and slight rutting at intersections.

5.1.2 300 m North of Denison Street to 14th Avenue

The second segment of Kennedy Road had a PCR of 65 and an RCR of 6.0, indicating the pavement is generally in fair condition. The following surface distresses were documented:

- Intermittent, slight severity wheel track rutting;
- Intermittent, moderate severity transverse cracking at catch basins;
- Intermittent, moderate alligator cracking and potholes.
- Intermittent, moderate to severe pavement edge cracking;

- Frequent, slight ravelling;
- Frequent, moderate to severe longitudinal and transverse single and multiple cracking; and
- Frequent, moderate map cracking;

5.1.3 14th Avenue to Highway 7

The third segment of Kennedy Road had a PCR of 75 and an RCR of 7.5, indicating the pavement is generally in good condition. The following surface distresses were documented:

- Intermittent, slight to moderate severity cracking at catch basins;
- Intermittent, slight to moderate severity longitudinal and transverse single cracking;
- Intermittent, slight to moderate severity pavement edge cracking;
- Intermittent, slight severity pavement edge cracking; and
- Intermittent, slight severity map cracking.

The pavement appears to be micro-surfaced from north of the 407 Express Toll Route (ETR) to 250 m north of Helen Boulevard, and just south of Highway 7 in the northbound lanes.

5.1.4 Highway 7 to Major Mackenzie Drive

The fourth segment of Kennedy Road had a PCR of 70 and an RCR of 7.0, indicating the pavement is generally in good condition. The following surface distresses were documented:

- Intermittent, slight ravelling;
- Intermittent, severe potholes;
- Intermittent, moderate severity cracking at catch basins;
- Frequent, slight severity wheel track rutting;
- Frequent, slight to severe longitudinal cracking;
- Intermittent, slight to moderate transverse cracking;
- Intermittent, moderate severity pavement edge cracking; and
- Intermittent, moderate to severe alligator and map cracking;

The pavement appears to be micro-surfaced north of 16th Avenue; reflective cracks have been sealed and the repairs are performing well. Pavement distress areas were identified at Highway 7 and at most intersections.

5.2 Pavement Structure – Borehole Data

The existing pavement structures encountered in the boreholes advanced within the project limits are summarized in Table 1 below. Based on the variability of the pavement structures throughout the Kennedy Road corridor, the pavement was divided into six (6) different sections as noted below.

Table 1: Summary of Existing Pavement Structure

Section	Direction	Layer Thicknesses (mm)			Subgrade(s) Encountered
		Hot Mix Asphalt	Granular Base	Granular Subbase	
Section 1: Steeles Avenue to 300 m north of Denison Street	NB	100 – 175 (140)	260 – 350 (295)	320 – 430 (380)	Clayey Silt Silty Sand
	SB	100 – 170 (140)	290 – 500 (365)	310 – 530 (405)	
Section 2: 300 m north of Denison Street to 14th Avenue	*NB	340 – 350 (345)	420 – 470 (430)	-	Clayey Silt Silty Clay
	SB	90	220	290	
Section 3: 14th Avenue to 407 ETR	NB	150	190	1010	Silty Clay
	*SB	330 – 345 (340)	270 – 385 (330)	-	
Section 4: 407 ETR to Highway 7	*NB	100 – 170 (130)	190 – 300 (220)	350 – 550 (425)	Sandy Silt Silty Sand Clayey Silt Silty Clay
	SB	80 – 160 (130)	160 – 440 (270)	220 – 620 (395)	
Section 5: Highway 7 to 16th Avenue	NB	100 – 130 (125)	150 – 340 (195)	290 – 580 (435)	Clayey Silt Silty Clay
	SB	90 – 130 (110)	140 – 585 (275)	330 – 510 (445)	
Section 6: 16th Avenue to Major Mackenzie Drive	NB	160 – 190 (165)	150 – 300 (205)	430 – 700 (520)	Silty Sand Silty Clay
	SB	140 – 180 (165)	280 – 350 (305)	320 – 760 (495)	

Note: The thicknesses shown present the range and the (average). The 95th percentile of the full pavement structure thickness was used to estimate the depth of excavation in the widening to facilitate lateral drainage.
*Localized variable pavement structure was encountered.

Flexible pavements were encountered along the northbound and southbound lanes of Kennedy Road. Generally, the pavement structure consists of asphalt underlain by granular base and subbase. The predominate subgrade soils types include Silty Clay, Clayey Silt, Silty Sand, or Sandy Silt.

It is important to note that numerous asphalt patches and pavement changes were documented throughout the site, and as such, localized variances in the pavement structure were encountered within some sections. Based on the field investigation, we have generally delineated the major variances in the pavement structure into the approximate sub-sections shown in Table 2.

Table 2: Limits of Subsections

Section	Sub-section / Limits	Layer Thicknesses (mm)			Variance
		Hot Mix Asphalt	Granular A	Granular B	
Section 2	**Sub-section A:** NB LTL from 300 m north of Denison Street to 50 m south of High Glen Avenue	350	-	-	HMA layer directly on top of subgrade.
Section 3	**Sub-section B:** SB L1 from the CN Rail to 407 ETR	130	360	1010	Thinner HMA layer.
Section 4	**Sub-section C:** NB L2 from Helen Avenue to Driveway of 8111 Kennedy Road	320	-	390	Thicker HMA layer

Note: The limits of each sub-section were estimated based on the available information from the pavement investigation.

Sub-section A does not have a granular base layer (HMA underlain by subgrade) and been approximately delineated to the left-turn-lane from 300 m north of Denison Street to 50 m south of High Glen Avenue. The pavement structure encountered consists of 350 mm of HMA placed directly on top of subgrade, while the adjacent northbound lane 2 consists of 350 mm of HMA underlain by 400 mm of granular base.

Sub-section B has a comparably **thinner** HMA layer than the remainder of Section 3 and is approximately in the southbound lane 1 from the CN rail to 407 ETR (at the pavement change). The pavement structure encountered consists 130 mm of HMA underlain by 360 mm of granular base and 1,010 mm of granular subbase. The pavement structure south of Sub-section B (i.e. the pavement change at the CN rail) has an average HMA thickness of 340 mm, an average granular base thickness of 330 mm, and an average granular subbase thickness of 685 mm.

Sub-section C has relatively **thicker** HMA layer when compared to the remainder of Section 4 and is located approximately within the northbound lane 2 from Helen Avenue to the driveway of 8111 Kennedy Road. The pavement structure encountered consists of 320 mm of HMA underlain by 390 mm of granular subbase. The pavement structure encountered to the north and south of the delineated area consists of an average HMA thickness of 130 mm, an average granular base thickness of 220 mm, and an average of granular subbase thickness of 425 mm.

During the detailed design of Kennedy Road, it is recommended that the subsections noted above should be investigated in greater detail and localized pavement recommendations developed.

5.3 Topsoil Thicknesses

Based on the boreholes advanced in the boulevards within the project limits, the existing topsoil thicknesses are summarized in Table 3 below.

Table 3: Summary of Existing Topsoil Thicknesses

Section	Direction	Topsoil Thicknesses (mm)	Subgrade(s) Encountered
Section 1: Steeles Avenue to 300 m north of Denison Street	NB	130 – 170 (150)	Clayey Silt Silty Sand
	SB	130	
Section 2: 300 m north of Denison Street to 14th Avenue	NB	110 – 200 (155)	Clayey Silt
	SB	150	
Section 3: 14th Avenue to 407 ETR	NB	180	Silty Clay Clayey Silt
	SB	130	
Section 4: 407 ETR to Highway 7	NB	30	Sand and Gravel Silty Sand Sand Silty Clay Clayey Silt
	SB	130 – 180 (160)	
Section 5: Highway 7 to 16th Avenue	NB	110 – 210 (160)	Silty Clay Sandy Silt Silty Sand
	SB	130 – 170 (150)	
Section 6: 16th Avenue to Major Mackenzie Drive	NB	90 – 100 (95)	Silty Sand Silty Clay Silty Sand
	SB	130	

The boulevards within the project limits generally consists of Clayey Silt, Silty Clay, Silty Sand, Sandy Silt, Sand and Gravel, and Sand. Granular fill was encountered in two boreholes in the southbound direction, extending to depths of 650 mm and 1,150 mm below ground surface.

5.4 Groundwater

The majority of the subgrade samples recovered were in moist condition. Free water was not encountered in any of the boreholes drilled within the project limits. Locations where moist to wet conditions were encountered are shown in Table 4.

Table 4: Locations where Wet Subgrade Soils were Encountered

Borehole	Location	Depth (mm/m)	Soil Type	Soil Condition
BH 309	East boulevard	910	Sand	Moist to Wet
BH 605	Southbound lane 2	680 – 1.5	Clayey Silt	Moist to Wet
BH 214	Southbound lane 2	790 – 1.5	Sandy Silt	Wet
BH ENV9/404	West boulevard	440 – 1.1	Silty Sand	Wet

It should be noted that the groundwater levels are expected to fluctuate, being higher during wet periods (i.e. spring thaw, after rainfall, etc.) and lower during the drier summer months. Further, it is important to note that this geotechnical investigation was carried out before and after periods of heavy precipitation.

5.5 Bedrock

Bedrock was not encountered in any of the boreholes advanced for this investigation within the project limits.

6.0 LABORATORY TESTING

The soil samples obtained from the boreholes were brought to Golder's laboratory in Whitby (CCIL certified, including regular participation in MTO's Soils and Aggregate Correlation Program) for further examination and testing. Testing of selected granular base, subbase, and subgrade samples included in-situ water content determination and grain size distribution (sieve analysis and hydrometer).

In addition, chemical testing was carried out on five subgrade soil samples obtained at locations identified in the Contamination Overview Study (COS) report to have potential for soil contamination (i.e. in the vicinity of properties of 'moderate' environmental concern). The samples collected were analyzed for metals and inorganics, and for petroleum hydrocarbons fraction 1 to fraction 4 ("PHCs F1-F4") parameters.

6.1 Grain Size Distribution and Water Content

6.1.1 Granular Base

Grain size distribution tests were carried out on nine (9) samples of the crushed granular base material obtained from the northbound and southbound lanes directly beneath the asphalt. The results of the gradation tests are shown in Figures C1 to C2 of Appendix C and indicate that seven (7) out of nine (9) samples did not satisfy the gradation requirements listed in OPSS.MUNI 1010 for Granular A material, generally due to excessive material passing one or more sieves. The remaining two (2) out of nine (9) samples had marginal exceedances and generally satisfied the gradation requirements. The water contents of the granular samples tested ranged from 1.5 to 7.0 percent indicating dry to moist condition.

6.1.2 Granular Subbase

Grain size distribution tests were carried out on nine (9) samples of granular subbase material obtained from the northbound and southbound lanes. The results of the gradation tests are shown on Figures C3 to C4 of Appendix C and indicate that three (3) out of nine (9) samples did not satisfy the gradation requirements listed in OPSS.MUNI 1010 for Granular B, Type I material, generally due to excessive fines (material passing the 75 µm sieve). The remaining six (6) samples either satisfied or generally satisfied (three samples had marginal

exceedances) the gradation requirements. The water contents of the granular subbase samples tested ranged from 2.7 to 6.4 percent indicating dry to moist condition.

6.1.3 Subgrade Soil

Grain size distribution tests were carried out on ten (10) samples of the subgrade soil material obtained from the northbound and southbound lanes, and the east and west boulevards. The results of the gradation tests are shown on Figures C5 to C8 of Appendix C and indicate that the predominate subgrade soil types included sandy silty clay / silty clay; sandy clayey silt / clayey silt; clayey silt and sand; as well as silty sand / clayey silty sand.

The water contents of the sandy silty clay / silty clay subgrades ranged from 21.4 to 25.4 percent, indicating moist to wet condition. The water contents of the sandy clayey silt / clayey silt subgrade ranged from 16.4 to 20.8 percent, indicating moist to wet condition. The water contents of the clayey silt and sand subgrade ranged from 9.9 to 14.2 percent, indicating moist condition. The water contents of the silty sand / clayey silty sand subgrade ranged from 6.9 to 13.1 percent, indicating moist condition.

6.2 Environmental Analysis

In conjunction with the geotechnical/pavement investigation, a limited number of the geotechnical boreholes were advanced at locations where there is the potential for soil contamination and selected soil samples were collected and submitted for environmental testing. The purpose of this limited subsurface environmental investigation (“Investigation”) was to identify and assess the environmental quality of soil and potential risk of worker exposure during construction of the proposed future roadway upgrades. The focus was on shallow soil quality as the proposed construction activities are anticipated to be shallow.

Golder previously completed a Contamination Overview Study (“COS") of the Kennedy Road Right-of-Way from Steeles Avenue to Major Mackenzie Drive, Markham, Ontario (dated November 2017, reference 1664178 (5000)).

The findings of the COS identified several Areas of Potential Environmental Concern (“APECs”) in the study area. The APECs were categorized based on a risk ranking approach (i.e., a ranking of low, moderate or high potential for subsurface environmental impact). The following outlines the APECs identified via the COS:

- Seven gas stations (moderate risk) and four dry cleaners (low risk) were observed within the study area;
- Several properties within the study area were identified as having former and current private and retail fuel tanks on site (low to moderate risk). The condition and operation period of these tanks was unknown;
- Nine autobody repair and service shops (low risk) were identified within the study area; and,
- Multiple environmental spills (low risk) including diesel fuel, gasoline, transformer oil and fuel oil were listed on or adjacent to the Kennedy Road ROW, some of which were associated with retail gas stations. The spills ranged in size from 38 L to 1,800 L and environmental impacts were unknown or not confirmed in many cases.

In addition to the above, it is anticipated that fill material and salt-related impacts as a result of roadway de-icing activities may be present along the Kennedy Road ROW.

Based on the above findings, it was recommended that a subsurface investigation be carried out in the vicinity of each APEC identified as having a moderate risk in order to assess the potential presence of subsurface contamination and the potential for impacts, if any, to affect the proposed ROW improvements.

During the geotechnical/pavement investigation, boreholes located near APECs of moderate risk were chosen to assess the environmental soil quality. The following sections provide a summary of the methodology and findings of the Investigation.

6.2.1 Approach

The geotechnical/pavement field investigation was carried out in November 2018. A total of seventy-nine (79) boreholes were advanced along Kennedy Road at the locations shown on the Borehole Location Plans (Figures 2-1 to 2-31). Soil samples for environmental testing were collected from five boreholes (ENV1, ENV3, ENV4, ENV5, ENV10) located in the vicinity of areas of 'moderate' environmental concern identified in the COS report. The soil samples were collected from 0.13 to 0.65 mbgs (ENV1 SA1), 0.76 to 1.50 mbgs (ENV3 SA2), 0.71 to 1.20 mbgs (ENV4 SA1) and 0.71 to 1.50 mbgs (ENV5 SA1 and ENV10 SA2). Soil conditions at each borehole are provided in the Record of Borehole sheet in Appendix B.

At each borehole mentioned above, soil samples were collected for textural classification and field screening (for selected soil samples), using a RKI Eagle II instrument which includes a dual gas photoionization detector ("PID") and combustible gas meter, calibrated with isobutylene gas and hexane gas, respectively. Soil samples, based on soil screening and field observations (i.e., staining), if any, were selected and placed in pre-cleaned laboratory-supplied sample containers.

One soil sample was collected at each borehole location and submitted to AGAT Laboratories Ltd ("AGAT") in Mississauga for laboratory analysis. The samples collected were analysed for metals, inorganics, petroleum hydrocarbon fractions 1 to 4 ("PHCs F1-F4") and benzene, toluene, ethylbenzene and xylenes ("BTEX").

The analytical results of the soil samples were compared to the Table 2 and 3 Site Condition Standards in a potable and non-potable groundwater condition (considered to be applicable for the Site), respectively, for Industrial, Commercial and Community property use (coarse textured soil) in the Ministry of Environment, Conservation and Parks ("MECP") document "*Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act*", dated April 15, 2011 ("Table 2 standards" and "Table 3 standards").

6.2.2 Results

Boreholes ENV1, ENV3, ENV4, ENV5 and ENV10 were advanced to a maximum depth of 1.5 mbgs. The surface at ENV1, ENV4 and ENV10 consisted of topsoil underlain by silty sand and gravel, clayey silt, and silty clay respectively, followed by silty sand or sandy silt and silty clay to the end of the boreholes (ENV4 and ENV 10). ENV1 was advanced to 0.65 mbgs (silty sand). The surface at ENV3 and ENV5 consisted of asphalt, underlain by granular (ENV3) and sand (ENV5) and in turn by silty clay (ENV3) and silty sand (ENV5).

No visual evidence of environmental contamination (i.e. staining) was observed in the soil samples during drilling. RKI Eagle II instrument readings associated with the soil samples collected from the boreholes ranged from 0 parts per million ("ppm") to 55 ppm for combustible vapours and ranged from 0 ppm to 3 ppm for organic vapours. These values are generally not considered indicative of environmental impact.

The laboratory certificates of analyses are provided in Appendix D. Based on a review of the analytical results for the confirmation soil samples collected on November 18 and 19, 2018, it was determined that the soil samples met the Table 2 standards and Table 3 standards, except for the following parameters:

- Sample ENV5 SA1, - sodium adsorption ratio ("SAR") (13.2) was above the Table 2 and 3 Standard of 12.

6.2.3 Summary and Discussion of Findings

The following were noted during the Investigation:

- In general, the material from each location consists either of topsoil underlain by silty sand, clayey silt and silty clay followed by silty sand and gravel or sandy silt and silty clay (ENV1, ENV4 and ENV10) or of asphalt underlain by granular (ENV3) and sand (ENV5) and in turn by silty clay (ENV3) and silty sand (ENV5) to the end of the borehole;
- No staining was noted within the material;
- RKI Eagle II instrument readings associated with the soil samples collected from the boreholes ranged from 0 ppm to 55 ppm for combustible vapours and ranged from 0 ppm to 3 ppm for organic vapours. These values are generally not considered indicative of environmental impact;
- Soil samples were submitted from five test locations to AGAT for analysis of the following parameters: metals and inorganics, PHCs F1-F4 and BTEX;
- Analytical results were compared to Table 2 standards and Table 3 standards;
- Analytical results did not exceed Table 2 or Table 3 standards with the following exceptions:
  - Sample ENV5 SA1 - SAR (13.2) was above the Table 2 and 3 Standard of 12;

Based on the findings of the Investigation, the potential risk of worker exposure to contaminants is low. In addition, elevated concentrations of SAR are commonly found in shallow soils in the urban environment due to routine salting practices for the purposes of public safety and are not considered to represent a risk to human health where present in an urban transportation corridor.

The material may be suitable for reuse on- or off-site, however given the elevated SAR, site specific evaluation of the potential receiving site would be recommended prior to exportation.

In terms of waste management options available for excess soil, the analytical results indicate that the soil may be suitable for re-use on the road allowance either below the pavement structure or at depths of greater than 1.2 mbgs if reused within the non-paved portion of the road allowance (i.e., boulevard). For off-site reuse, site specific evaluation of the potential receiving site would be recommended prior to exportation.

It should be noted that movement of soil to a site that is the subject of a Record of Site Condition requires that specific testing protocols are followed and that the material must satisfy the applicable standards. Please note that the level of testing outlined herein is meant to provide a broad indication of general soil quality based on the soil samples tested. It is not intended to be fully compliant with the excess soil characterization provisions contained in O.Reg 153/04. If full compliance with O.Reg. 153/04 is desired, a much higher sampling and testing frequency and other site assessment work will be required. Further, prospective receiving sites for any excess soils generated from the site may have specific sampling and analysis requirements which go beyond the screening-level analyses described herein. Acceptance of soils for import is ultimately at the discretion of the receiving facility.

If excess soil materials generated during construction vary in composition from the samples tested by Golder, additional testing is recommended to determine their suitability for disposal/reuse. Note that the excess soil reuse options as discussed herein are limited to the environmental quality of the soil.

7.0 PAVEMENT DESIGN AND ANALYSIS

This section of the report provides engineering information for the geotechnical/pavement design aspects of the project, based on our interpretation of the information obtained during this investigation, and our understanding of the project requirements. The information in this portion of the report is provided for the guidance of the design engineers. Where comments are made on construction, they are provided only in order to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking any work at the site should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing and the like.

7.1 Traffic Data and Road Classification

The traffic data provided by HDR in an email dated February 22, 2019, were used to estimate Equivalent Single Axle Loads (ESALs) and carry out the pavement design analyses. Based on the varying levels of traffic and pavement structures along Kennedy Road, the traffic data has been split into six (6) sections.

A summary of the traffic data along Kennedy Road is presented in Table 5 below.

Table 5: Summary of Traffic Data

Section	Design Parameters			
	AADT (and Year)	% Commercial, % Heavy Trucks	Traffic Growth	Estimated ESALs for the Design Period (20 Years)
Section 1: Steeles Avenue to 300 m north of Denison Street	39,148 (2015) 46,840 (2024) 61,371 (2041)	1.76%	2.0% (2015 to 2024) 1.6% (2024 to 2041)	3.7 x 10^6
Section 2: 300 m north of Denison Street to 14th Avenue	43,913 (2015) 50,912 (2024) 64,131 (2041)	7.47%	1.7% (2015 to 2024) 1.4% (2024 to 2041)	16.7 x 10^6
Section 3: 14th Avenue to 407 ETR	42,943 (2015) 49,612 (2023) 64,616 (2041)	7.45%	1.8% (2015 to 2023) 1.5% (2023 to 2041)	16.4 x 10^6
Section 4: 407 ETR to Highway 7	43,971 (2015) 56,493 (2024) 80,145 (2041)	6.83%	2.8% (2015 to 2024) 2.1% (2024 to 2041)	18.1 x 10^6
Section 5: Highway 7 to 16th Avenue	32,438 (2015) 46,571 (2028) 60,705 (2041)	5.23%	2.8% (2015 to 2028) 2.1% (2028 to 2041)	11.4 x 10^6
Section 6: 16th Avenue to Major Mackenzie Drive	25,096 (2015) 38,515 (2028) 51,933 (2041)	3.73%	3.4% (2015 to 2028) 2.3% (2028 to 2041)	6.9 x 10^6

Based on the Region's road classification system, and the AADT data above, this section of Kennedy Road is classified as an Arterial Road.

7.2 AASHTO Design Analysis

The estimation of the ESALs for each section of Kennedy Road, as shown in Table 5 above, has been carried out over a design period of 20 years. The design analyses were carried out using the "AASHTO Guide for Design of Pavement Structures 1993" and MTO's "Adaption and Verification of AASHTO Pavement Design Guide for Ontario Conditions, MI-183", dated March 2008.

To develop an appropriate strategy, Golder has also reviewed the York Region Road Design Guidelines (October 2018). The Region's minimum design requirements have been compared to the minimum design requirements required by AASHTO, and the more conservative design option was selected.

We understand that the minimum standard design used for Arterial Roads in the Region is as follows:

- 50 mm SP 12.5 FC1
- 100 mm SP 19.0
- 150 mm Granular A
- 450 mm Granular B

Total pavement thickness = 750 mm.

The results of the borehole investigation, and the laboratory testing on subgrade soil samples, were used to develop the pavement designs and rehabilitation strategies. In accordance with MI-183, the design parameters used for the pavement design analysis are summarized in Table 6 below.

Table 6: Pavement Design Parameters

Design Criteria	Parameters Selected	
	Rehabilitation	Widening
Initial Serviceability	4.4	4.5
Terminal Serviceability	2.5	
Reliability Level (%)	90	
Overall Standard Deviation	0.47	
Roadbed Soil Resilient Modulus	27 – 35 MPa (Silty Sand / Sandy Silt / Clayey Silt / Silty Clay)	

7.3 Pavement Design Alternatives

Based on the design analysis and the existing pavement condition, three alternative strategies were developed for the rehabilitation of Kennedy Road. The rehabilitation options considered are as follows (note – the thicknesses of milling, excavating, granular placement, and paving varies for each section of Kennedy Road):

Option 1 – Partial Depth Milling

- Mill the existing asphalt (multiple lifts) leaving a minimum of 50 mm of existing asphalt; and
- Pave with new Hot Mix Asphalt (HMA).

Option 2 – Full Depth Asphalt Removal

- Full depth removal of asphalt, partial excavation of granular material (if necessary); and
- Pave with new HMA.

Option 3 – Full Depth Reconstruction

- Full depth removal of existing asphalt and granular materials, and subgrade soils to the depth of the proposed new pavement structure;
- Place and compact Granular B, Type I, subbase as required;
- Place and compact 150 mm of Granular A base; and
- Pave with new HMA.

For the purpose of the LCCA, we have selected Section 6 southbound to illustrate the potential pavement design alternatives proposed. The three options result in differing grade raises as described below.

7.3.1 Option A – Mill and Overlay

This option consists of milling at least two lifts of the existing HMA and overlaying with at least 3 lifts of new HMA. Crack repairs should be carried out on the existing HMA base after milling.

Partially mill the existing HMA to a depth of 90 mm, and place 145 mm of new HMA as follows:

- 40 mm SP 12.5 FC1, Surface Course
- 50 mm SP 19.0, Binder Course
- 55 mm SP 19.0, Binder Course

This option will result in a grade raise of 55 mm and the resulting total asphalt thickness will be 220 mm.

7.3.2 Option B – Full Depth Asphalt Removal

This option consists of removing the entire asphalt layers, adding new Granular A material if necessary, and paving with 3 lifts of new HMA. The same strategy can be applied across all sections of Kennedy; however, the grade raises will vary across sections.

Remove the existing HMA full depth (approximately 150 mm), add new Granular A for fine grading, and place 180 mm of new HMA as follows:

- 40 mm SP 12.5 FC1, Surface Course
- 50 mm SP 19.0, Upper Binder Course
- 90 mm SP 25.0, Lower Binder Course

This option will result in a grade raise of 15 mm.

7.3.3 Option C – Full Depth Reconstruction

The full depth reconstruction option for Section 6 southbound is presented below.

Remove the existing HMA, granular materials and subgrade soils to 870 mm below proposed finished grade and place the following:

- 40 mm SP 12.5 FC1, Surface Course
- 50 mm SP 19.0, Upper Binder Course
- 80 mm SP 25.0, Lower Binder Course
- 150 mm new Granular 'A' Base
- 550 mm new Granular 'B Type I' Subbase

This option will not result in a grade raise.

7.4 Life Cycle Cost Analysis

A 50-year Life Cycle Cost Analysis (LCCA) was carried out for three pavement rehabilitation options considered for Section 6 southbound of Kennedy Road in accordance with MTO's "Guidelines for the Use of Life Cycle Cost Analysis on MTO Freeways" dated March 17, 2003. The initial construction and the life cycle cost were calculated based on unit costs from MTO's 2016 Hi-Co database. In accordance with the current MTO policy, a five percent (5%) discount rate was assumed in the LCCA.

The details of the proposed rehabilitation strategies and the associated initial construction and life cycle costs are provided in Tables F-1 to F-4 (Appendix F) and are summarized in Table 7 below.

Table 7: Alternative Pavement Design Analysis – Section 6

Design & Analysis Parameters	Option A	Option B	Option C
	Mill and Overlay	Full Depth Asphalt Removal	Reconstruction
Milling/Excavation (mm)	90	165	870
New HMA (mm)	145	180	170
Existing HMA (mm)	75	-	-
Existing Granular Base (mm)	305	305	-
Existing Granular Subbase (mm)	495	495	-
New Granular Base (mm)	-	-	150
New Granular Subbase (mm)	-	-	550
Structural Number (mm)	151	145	142
Grade Raise (mm)	55	15	None
Initial Construction Cost per lane per km ($)*	180,000	220,000	340,000
Initial Construction Cost Ranking	**1**	**2**	**3**
50 Years Life Cycle Cost per lane per km ($)	308,000	335,000	442,000
Life Cycle Cost Rating	**1**	2	3

* The initial construction cost does not include the additional cost for crack repairs in Option 1 or the cost of staging.

Based on the Life Cycle Cost Analysis, Option A – Mill and Overlay, is the recommended strategy.

7.5 Pavement Design Recommendations

Based on the traffic volume, the existing pavement condition, a comparison of the pros and cons for the three options, and considering the initial and life cycle costs, Option A – Mill and Overlay is considered to be the most suitable and cost-effective design for the rehabilitation of Kennedy Road within the project limits.

For ease of construction, we have recommended the same grade raise in each of the sections. The designs should be verified during the detailed design as property acquirements and crown shifts are not known at this time. The excavation depth in the widening areas are at a minimum based on the 95th percentile of the total pavement structure encountered in the boreholes and grade raises have been considered in the sections noted below. If the designs presented in this report are modified during the detailed design, the designers should adjust the depth of excavation in the widening accordingly.

7.5.1 Section 1 – Kennedy Road from Steeles Avenue to 300 m north of Denison Street

The 20-year pavement design recommendations for the rehabilitation of the Section 1 components are provided in Table 8.

Table 8: Recommended Widening/Rehabilitation Strategies for Section 1

Direction	Design	Recommendation	Lift Thicknesses (mm)	Grade Raise
Southbound	Widening	Excavate 1,080 mm below the **proposed** grade and reconstruct with: ■ 770 mm of Granular B, Type I ■ 150 mm of Granular A ■ 160 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 70 mm SP 19	+60 mm
	Rehabilitation	Mill 100 mm / Pave 160 mm	40 mm SP 12.5 FC1 50 mm SP 19 70 mm SP 19	
Northbound	Rehabilitation	Mill 100 mm / Pave 160 mm	40 mm SP 12.5 FC1 50 mm SP 19 70 mm SP 19	
	Widening	Excavate 910 mm below the **proposed** grade and reconstruct with: ■ 600 mm of Granular B, Type I ■ 150 mm of Granular A ■ 160 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 70 mm SP 19	

7.5.2 Section 2 – Kennedy Road from 300 m north of Denison Street to 14th Avenue

The 20-year pavement design recommendations for the rehabilitation of the Section 2 components are provided in Table 9.

Table 9: Recommended Widening/Rehabilitation Strategies for Section 2

Direction	Design	Recommendation	Lift Thicknesses (mm)	Grade Raise
Southbound	Widening	Excavate 920 mm below the **proposed** grade and reconstruct with: ■ 490 mm of Granular B, Type I ■ 150 mm of Granular A ■ 280 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 90 mm SP 25 100 mm SP 25	+120 mm
	Rehabilitation	Remove/excavate 160 mm existing asphalt and granular materials / Pave 280 mm	40 mm SP 12.5 FC1 50 mm SP 19 90 mm SP 25 100 mm SP 25	
Northbound	Rehabilitation	Mill 90 mm / Pave 210 mm	40 mm SP 12.5 FC1 50 mm SP 19 60 mm SP 19 60 mm SP 19	
	Widening	Excavate 920 mm below the **proposed** grade and reconstruct with: ■ 560 mm of Granular B, Type I ■ 150 mm of Granular A ■ 210 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 60 mm SP 19 60 mm SP 19	

7.5.3 Section 3 – Kennedy Road from 14th Avenue to 407 ETR

The 20-year pavement design recommendations for the rehabilitation of the Section 3 components are provided in Table 10.

Table 10: Recommended Widening/Rehabilitation Strategies for Section 3

Direction	Design	Recommendation	Lift Thicknesses (mm)	Grade Raise
Southbound	Widening	Excavate 840 mm below the **proposed** grade and reconstruct with: ■ 450 mm of Granular B, Type I ■ 150 mm of Granular A ■ 240 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 100 mm SP 25	N/A
	Rehabilitation	Mill 140 mm / Pave 140 mm	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19	
Northbound	Rehabilitation	Mill 100 mm / Pave 100 mm	40 mm SP 12.5 FC1 60 mm SP 19	
	Widening	Excavate 1,200 mm below the **proposed** grade and reconstruct with: ■ 870 mm of Granular B, Type I ■ 150 mm of Granular A ■ 180 mm of HMA	40 mm SP 12.5 FC1 60 mm SP 19 80 mm SP 25	

7.5.4 Section 4 – Kennedy Road from 407 ETR to Highway 7

The 20-year pavement design recommendations for the rehabilitation of the Section 4 components are provided in Table 11.

Table 11: Recommended Widening/Rehabilitation Strategies for Section 4

Direction	Design	Recommendation	Lift Thicknesses (mm)	Grade Raise
Southbound	Widening	Excavate 1,020 mm below the **proposed** grade and reconstruct with: ■ 630 mm of Granular B, Type I ■ 150 mm of Granular A ■ 240 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 100 mm SP 25	+110 mm
	Rehabilitation	Mill 130 mm / Pave 240 mm	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 100 mm SP 25	
Northbound	Rehabilitation	Mill 130 mm / Pave 240 mm	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 100 mm SP 25	
	Widening	Excavate 930 mm below the **proposed** grade and reconstruct with: ■ 540 mm of Granular B, Type I ■ 150 mm of Granular A ■ 240 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 100 mm SP 25	

7.5.5 Section 5 – Kennedy Road from Highway 7 to 16th Avenue

The 20-year pavement design recommendations for the rehabilitation of the Section 5 components are provided in Table 12

Table 12: Recommended Widening/Rehabilitation Strategies for Section 5

Direction	Design	Recommendation	Lift Thicknesses (mm)	Grade Raise
Southbound	Widening	Excavate 1,200 mm below the **proposed** grade and reconstruct with: ■ 850 mm of Granular B, Type I ■ 150 mm of Granular A ■ 200 mm of HMA	40 mm SP 12.5 FC1 60 mm SP 19 100 mm SP 25	+125 mm
	Rehabilitation	Mill 75 mm / Pave 200 mm	40 mm SP 12.5 FC1 60 mm SP 19 100 mm SP 25	
Northbound	Rehabilitation	Mill 75 mm / Pave 200 mm	40 mm SP 12.5 FC1 60 mm SP 19 100 mm SP 25	
	Widening	Excavate 1,025 mm below the **proposed** grade and reconstruct with: ■ 675 mm of Granular B, Type I ■ 150 mm of Granular A ■ 200 mm of HMA	40 mm SP 12.5 FC1 60 mm SP 19 100 mm SP 25	

*Moderate frost susceptible soil was encountered in the southbound lane 2, north of Highway 7. As such, consideration should be made to remove the frost susceptible materials and increase the granular subbase depth to 1.2 m below the proposed grade (i.e. the frost depth).

7.5.6 Section 6 – Kennedy Road from 16th Avenue to Major Mackenzie Drive

The 20-year pavement design recommendations for the rehabilitation of the Section 6 components are provided in Table 13.

Table 13: Recommended Widening/Rehabilitation Strategies for Section 6

Direction	Design	Recommendation	Lift Thicknesses (mm)	Grade Raise
Southbound	Widening	Excavate 1,020 mm below the **proposed** grade and reconstruct with: ■ 700 mm of Granular B, Type I ■ 150 mm of Granular A ■ 170 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25	+55 mm
	Rehabilitation	Mill 115 mm / Pave 170 mm	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25	
Northbound	Rehabilitation	Mill 115 mm / Pave 170 mm	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25	
	Widening	Excavate 1,050 mm below the **proposed** grade and reconstruct with: ■ 730 mm of Granular B, Type I ■ 150 mm of Granular A ■ 170 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25	

7.5.7 Transitions

To prevent construction joints reflecting through the new pavement within a short period of time, proper transverse and longitudinal transitions should be provided at the section limits as detailed in MTO SP103-F01.

7.6 Pavement Design Alternative – No Grade Raise

Based on discussions with HDR and the Region on similar projects, an alternative pavement design was requested assuming a grade raise cannot be accommodated in the future throughout the Kennedy Road corridor. Generally, this pavement design alternative will require full depth asphalt removal and partial excavation of the underlying granular material, resulting in thicker asphalt layers throughout the project to satisfy the required structural number. Where complete asphalt removal is required, construction staging will need to be considered such that traffic does not travel on the exposed granular base.

7.6.1 Section 1 – Kennedy Road from Steeles Avenue to 300 m north of Denison Street

The 20-year pavement design alternatives for the rehabilitation of the Section 1 with no grade raise are provided in Table 14.

Table 14: Alternative Widening/Rehabilitation Strategies for Section 1

Direction	Design	Recommendation	Lift Thicknesses (mm)
Southbound	Widening	Excavate 1,020 mm below the **proposed** grade and reconstruct with: ■ 700 mm of Granular B, Type I ■ 150 mm of Granular A ■ 170 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25
	Rehabilitation	Excavate 170 mm below the **proposed** grade and pave with 170 mm HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25
Northbound	Rehabilitation	Excavate 170 mm below the **proposed** grade and pave with 170 mm HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25
	Widening	Excavate 850 mm below the **proposed** grade and reconstruct with: ■ 530 mm of Granular B, Type I ■ 150 mm of Granular A ■ 170 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25

7.6.2 Section 2 – Kennedy Road from 300 m north of Denison Street to 14th Avenue

The 20-year pavement design alternatives for the rehabilitation of the Section 2 with no grade raise are provided in Table 15.

Table 15: Alternative Widening/Rehabilitation Strategies for Section 2

Direction	Design	Recommendation	Lift Thicknesses (mm)
Southbound	Widening	Excavate 850 mm below the **proposed** grade and reconstruct with: ■ 480 mm of Granular B, Type I ■ 150 mm of Granular A ■ 220 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25
	Rehabilitation	Excavate 850 mm below the **proposed** grade and reconstruct with: ■ 480 mm of Granular B, Type I ■ 150 mm of Granular A ■ 220 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25
Northbound	Rehabilitation	Mill 90 mm / Pave 90 mm	40 mm SP 12.5 FC1 50 mm SP 19
	Widening	Excavate 860 mm below the **proposed** grade and reconstruct with: ■ 480 mm of Granular B, Type I ■ 150 mm of Granular A ■ 220 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25

7.6.3 Section 3 – Kennedy Road from 14th Avenue to 407 ETR

The 20-year pavement design alternatives for the rehabilitation of the Section 3 with no grade raise are the same as that provided in Table 10.

7.6.4 Section 4 – Kennedy Road from 407 ETR to Highway 7

The 20-year pavement design alternatives for the rehabilitation of the Section 4 with no grade raise are provided in Table 16.

Table 16: Alternative Widening/Rehabilitation Strategies for Section 4

Direction	Design	Recommendation	Lift Thicknesses (mm)
Southbound	Widening	Excavate 910 mm below the **proposed** grade and reconstruct with: ■ 500 mm of Granular B, Type I ■ 150 mm of Granular A ■ 260 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25 90 mm SP 25
	Rehabilitation	Excavate 410 mm below the **proposed** grade and reconstruct with: ■ 150 mm of Granular A ■ 260 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25 90 mm SP 25
Northbound	Rehabilitation	Excavate 410 mm below the **proposed** grade and reconstruct with: ■ 150 mm of Granular A ■ 260 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25 90 mm SP 25
	Widening	Excavate 850 mm below the **proposed** grade and reconstruct with: ■ 440 mm of Granular B, Type I ■ 150 mm of Granular A ■ 260 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 80 mm SP 25 90 mm SP 25

7.6.5 Section 5 – Kennedy Road from Highway 7 to 16th Avenue

The 20-year pavement design alternatives for the rehabilitation of the Section 5 with no grade raise are provided in Table 17.

Table 17: Alternative Widening/Rehabilitation Strategies for Section 5

Direction	Design	Recommendation	Lift Thicknesses (mm)
Southbound	Widening	Excavate 1,150 mm below the **proposed** grade and reconstruct with: ■ *780 mm of Granular B, Type I ■ 150 mm of Granular A ■ 220 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25
	Rehabilitation	Excavate 370 mm below the **proposed** grade and reconstruct with: ■ 150 mm of Granular A ■ 220 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25
Northbound	Rehabilitation	Excavate 370 mm below the **proposed** grade and reconstruct with: ■ 150 mm of Granular A ■ 220 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25
	Widening	Excavate 900 mm below the **proposed** grade and reconstruct with: ■ 530 mm of Granular B, Type I ■ 150 mm of Granular A ■ 220 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25

*Moderate frost susceptible soil was encountered in the southbound lane 2, north of Highway 7. As such, consideration should be made to remove the frost susceptible materials and increase the granular subbase depth to 1.2 m below the proposed grade (i.e. the frost depth).

7.6.6 Section 6 – Kennedy Road from 16th Avenue to Major Mackenzie Drive

The 20-year pavement design alternatives for the rehabilitation of the Section 6 with no grade raise are provided in Table 18.

Table 18: Alternative Widening/Rehabilitation Strategies for Section 6

Direction	Design	Recommendation	Lift Thicknesses (mm)
Southbound	Widening	Excavate 900 mm below the **proposed** grade and reconstruct with: ■ 530 mm of Granular B, Type I ■ 150 mm of Granular A ■ 220 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25
	Rehabilitation	Excavate 220 mm below the **proposed** grade and pave with 220 mm HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25
Northbound	Rehabilitation	Excavate 220 mm below the **proposed** grade and pave with 220 mm HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25
	Widening	Excavate 1,050 mm below the **proposed** grade and reconstruct with: ■ 680 mm of Granular B, Type I ■ 150 mm of Granular A ■ 220 mm of HMA	40 mm SP 12.5 FC1 50 mm SP 19 50 mm SP 19 80 mm SP 25

8.0 PADDING

Padding due to lanes and/or crown shifts is not accounted for in the design recommendations and may/will cause additional grade raises in some sections.

Where required, padding to correct crossfall or the profile of existing pavements, should be carried out using Superpave 12.5 to a maximum depth of 40 mm and Superpave 19 for thicknesses greater than 40 mm. The Superpave 19 mix placed as padding should be in lifts of 50 mm to 70 mm in thickness.

Padding should be placed on top of the Superpave 25 or Superpave 19 Lower Binder Course.

9.0 THIN OR POOR BASE ASPHALT SECTIONS

As the above noted designs are based on an average HMA thickness, if there are instances where the existing asphalt is milled to the required depth and granular materials are encountered, or in instances where the existing asphalt is in poor condition and cannot be paved over; it is recommended that the contractor partially remove the granular base materials to allow for a single 50 mm lift of SP 19 lower binder course HMA.

10.0 FROST PENETRATION DEPTH

Based on OPSD 3090.101 (November 2010), a frost penetration depth of 1.2 m can be assumed for design purposes.

11.0 FROST SUSCEPTIBILITY AND PROPOSED MITIGATIONS

The frost susceptibility of the subgrade soils has been assessed using the Ministry of Transportation of Ontario's ("MTO") guidelines, which are based on the percentage of silt sized particles, as outlined below:

Table 19: MTO Frost Susceptibility Guidelines

Grain Size (75-5 µm)	Susceptibility to Frost Heaving
0 – 40 %	Low
40 – 55 %	Moderate
55 – 100 %	High

Based on the laboratory test results, majority of the soils encountered within the project limits exhibit low susceptibility to frost heaving. Generally, the pavement designs recommended above are adequate to provide frost protection under these conditions, provided the roadway is positively sloped towards catch basins, and subdrains/ditches are present to drain the pavement.

Moderate susceptibility to frost heaving was encountered in one borehole, north of Highway 7 in southbound lane 2. During the detailed design investigation, it is recommended that the moderately frost susceptible soil is further assessed, delineated, and considered for removal.

Further, the subbase thickness may have to be increased if highly frost susceptible soils, soft/wet soils, or organics are encountered during construction. As such, the exposed subgrade soils in the widening areas should be proofrolled and inspected by a qualified geotechnical engineer before placing the granular materials.

12.0 SOILS ERODIBILITY "K" FACTOR

Based on the laboratory test results, the estimated soil erodibility "K" factors for nine (9) out of the ten (10) subgrade soils encountered in this investigation ranged from 0.11 to 0.25, and as such, the erodibility can generally be described as low.

One subgrade sample encountered north of Highway 7 in southbound lane 2 (i.e. the location of moderately frost susceptible subgrade soil) could be classified as moderate erodibility (estimated K factor is 0.38).

13.0 ASPHALT CEMENT

Superpave mixes should be used for all HMA. It is recommended that PG 70-28 asphalt cement be used for Superpave 12.5 FC1 surface course lifts, and PG 64-28 used for Superpave 12.5, Superpave 19, and Superpave 25 binder course or padding lifts. It is also recommended that the upper two lifts of the asphalt (including the surface course) be polymer modified asphalt cement ("XJ") of the same PGAC grade.

The asphalt cement quality should satisfy the requirements of the Region's technical specifications, where applicable.

14.0 TRAFFIC CATEGORY

The traffic category and PGAC recommendations are listed in Table 20.

Table 20: Traffic Category and PGAC Requirement

Hot Mix	Location	Traffic Category	PGAC
SP 12.5 FC1	All Roads	D	70-28
SP 19	All Roads	D	64-28
SP 25	All Roads	D	64-28

15.0 TACK COAT

It is recommended that tack coat be applied to all existing or milled asphalt surfaces and between all new HMA lifts. Tack coat should conform to the requirements of Ontario Provincial Standard Specifications OPSS.PROV 308 (April 2012).

16.0 COMPACTION

The granular materials (granular base and subbase; existing and new) should be compacted to 100 percent of the material's SPMDD. The HMA should be compacted to a minimum of 92 percent of the material's Maximum Relative Density (MRD) with the exception of SP 19 which should be compacted to a minimum of 91 percent of the MRD.

17.0 INSPECTION AND TESTING

During construction, in-situ density tests and materials testing should be carried out to confirm that the conditions exposed are consistent with those encountered in the boreholes and to monitor conformance to the pertinent project specifications. Asphalt testing should be carried out in a CCIL certified laboratory.

18.0 CLOSURE

This Report was authored under a Subconsultant Agreement between HDR and Golder for the Regional Municipality of York's ("Owner") projects. The Report is provided to HDR and Regional Municipality of York for their use, utilizing their judgment, in fulfilling a portion of HDR's particular scope of work. No other party may rely upon this report, or any portion thereof, without Golder's express written consent and any reliance of the reports by others will be at that user's sole risk and liability, notwithstanding that they may have received this Report through an appropriate user. In addition, Golder shall not be liable for any use of the Report for any purpose other than that for which the same was originally prepared or provided by Golder, or any improper use of this Report, or to any party other than HDR.

We trust that this report provides sufficient pavement design information to proceed with the design of this project. If you have any questions regarding the contents of this report or require additional information, please do not hesitate to contact this office.

Signature Page

Golder Associates Ltd

Original signed by:

Gordon Goode, B.A.Sc., EIT
Pavement and Materials Engineer in Training

Original signed by:

Steven Jagdat, M.A.Sc., P.Eng.
Associate, Pavement and Materials Engineer

GBG/SYJ/gbg;ljv;mes

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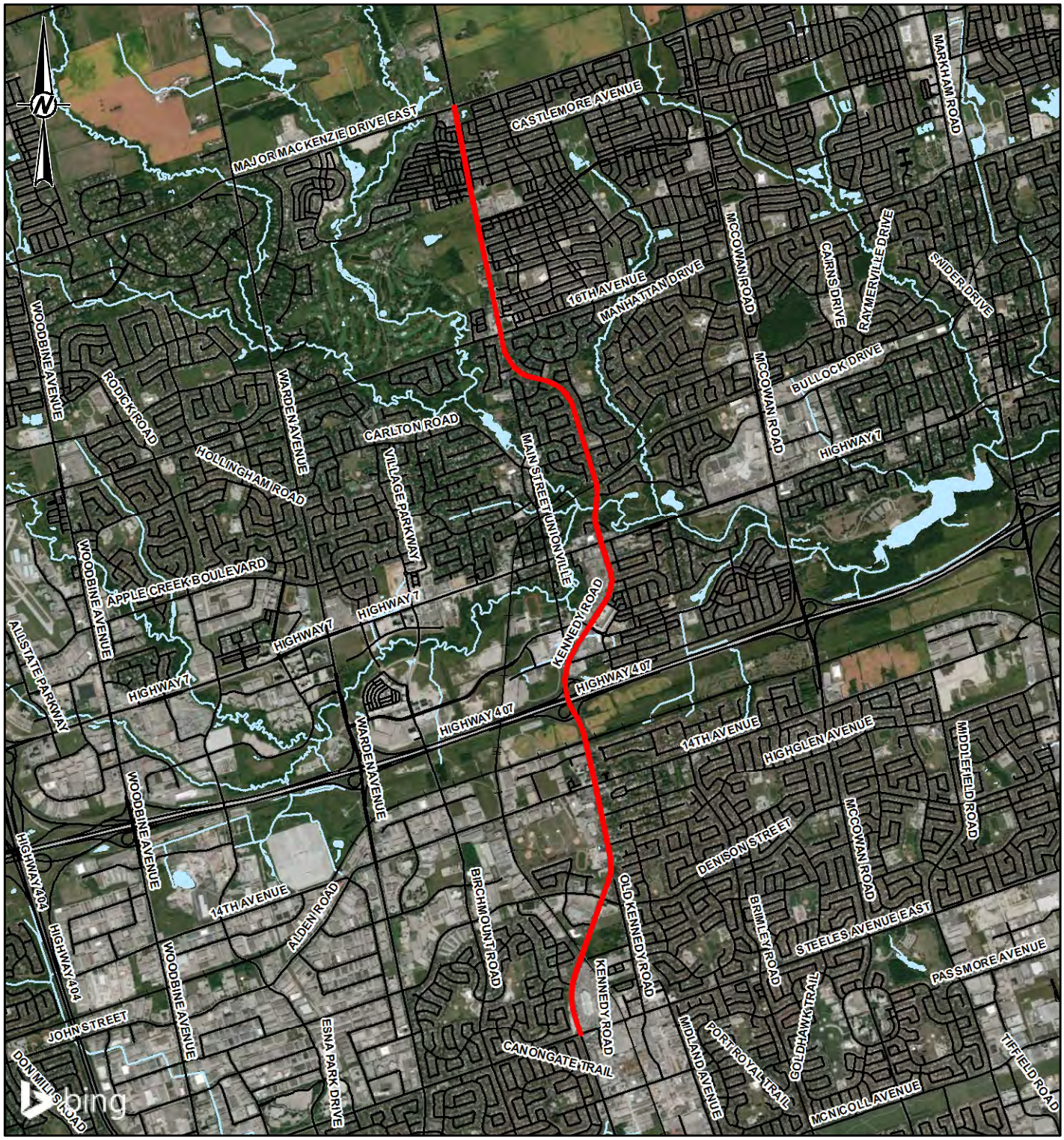

LEGEND

- ROAD
- RAILWAY
- WATERCOURSE
- WATERBODY
- STUDY CORRIDOR

0 1,000 2,000

1:50,000 METERS

REFERENCE(S)

1. IMAGERY: © 2019 MICROSOFT CORPORATION © 2018 DIGITALGLOBE ©CNES (2018) DISTRIBUTION AIRBUS DS
2. BASE DATA: LIO MNRF 2017
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
SCHEDULE C CLASS EA STUDY FOR IMPROVEMENTS TO KENNEDY ROAD

TITLE
SITE PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2019-01-11
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0007		1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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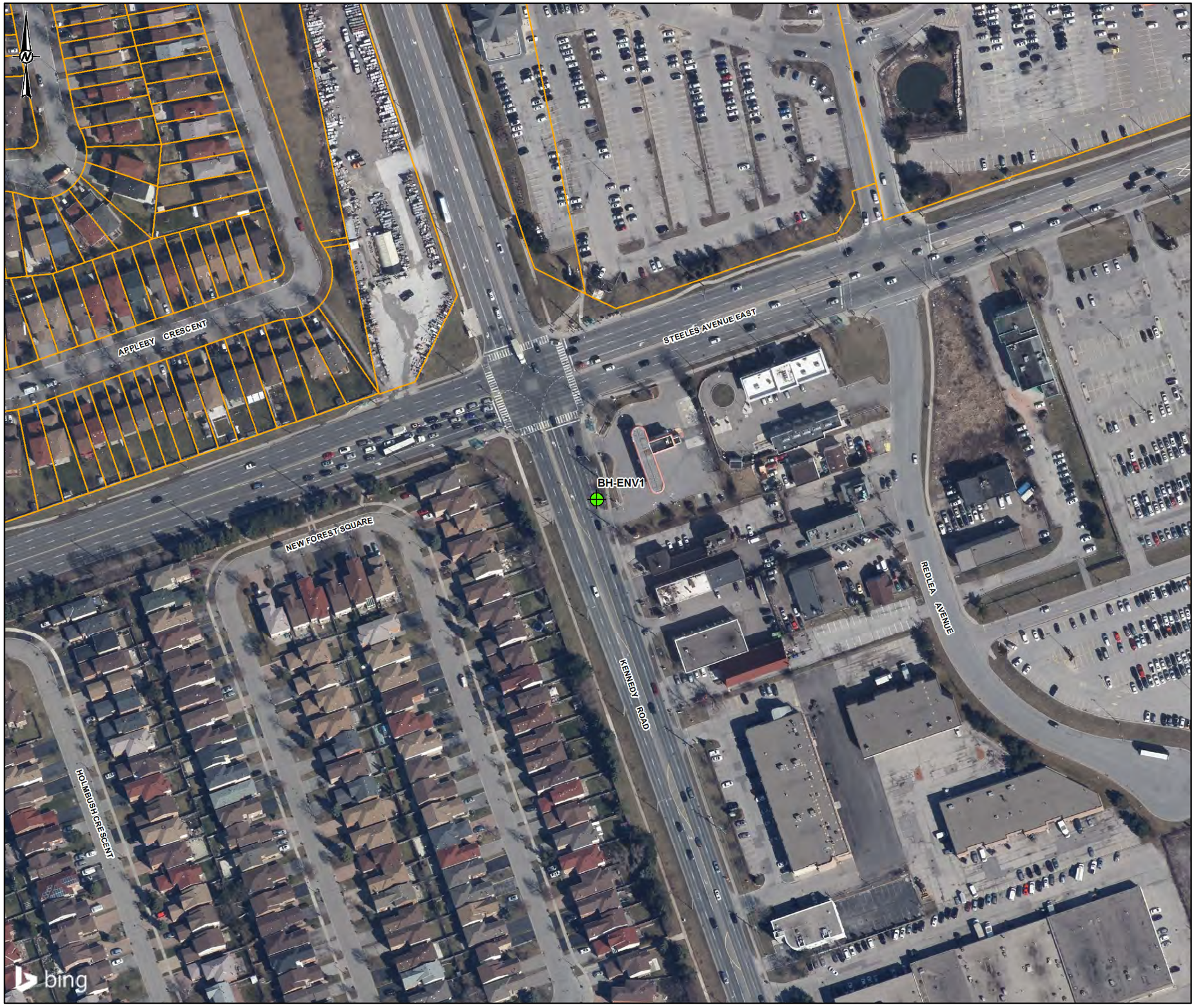

LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100

1:1,700 Meters

REFERENCE(S)

1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT

HDR CORPORATION

PROJECT

KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE

BOREHOLE LOCATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

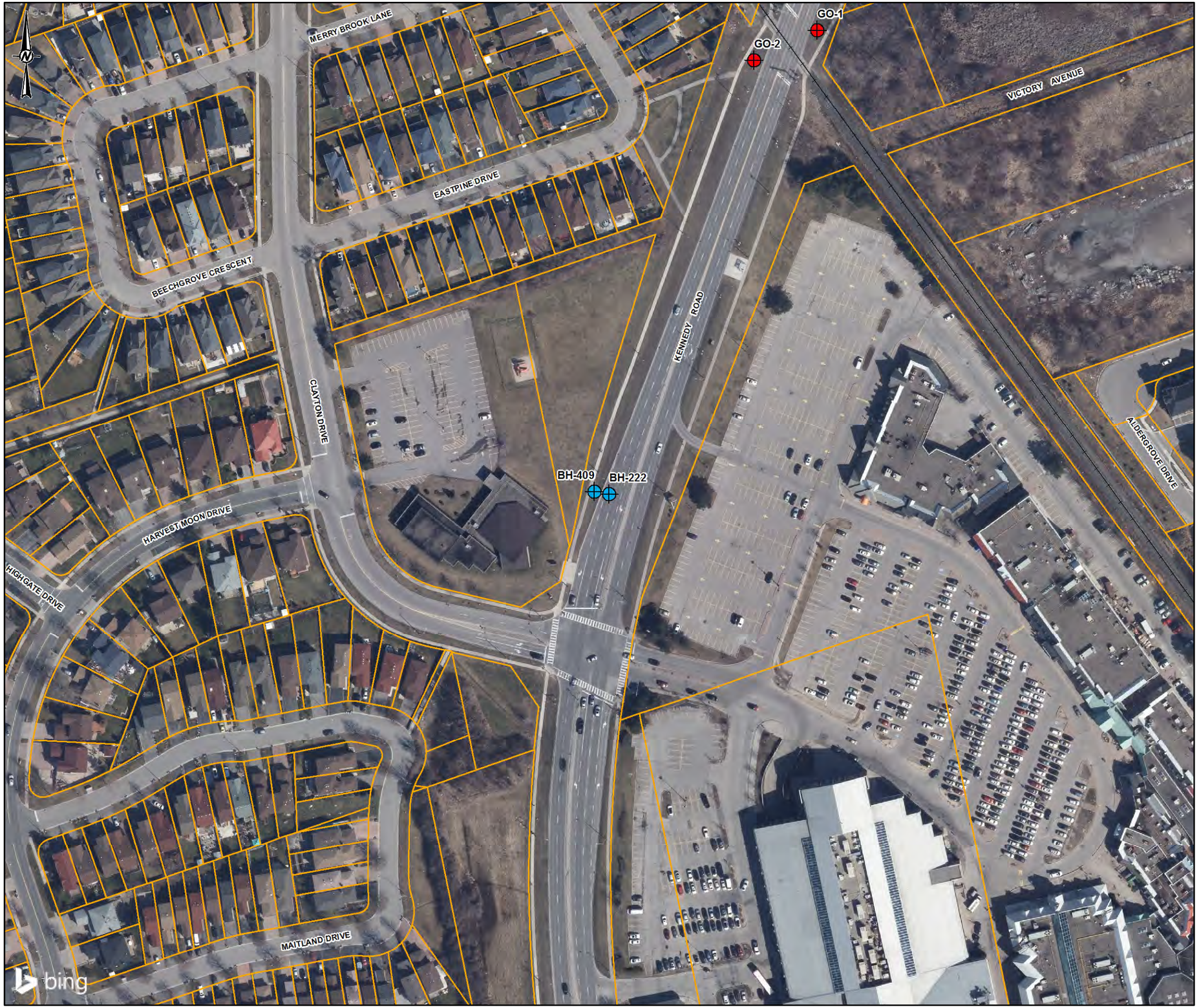
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-2**

25mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

S:\Clients\Region_of_York\Kennedy_Ros499_PROJ\1664178_HDR\40_PROD\0005_Geotechnical_Works\1664178-0005-BG-0001.mxd



LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)

1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-3**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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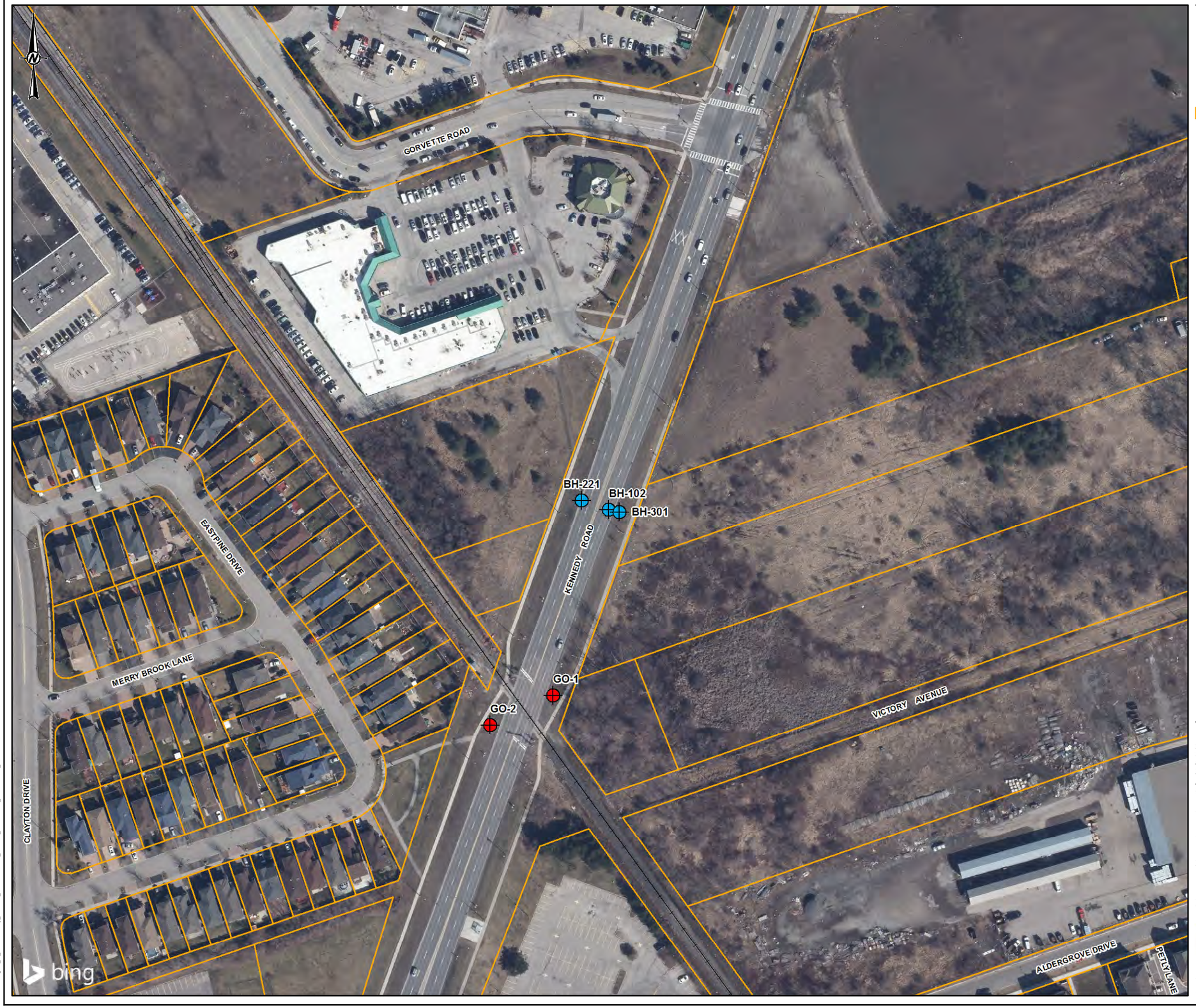

LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-4**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm
0

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LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-5**

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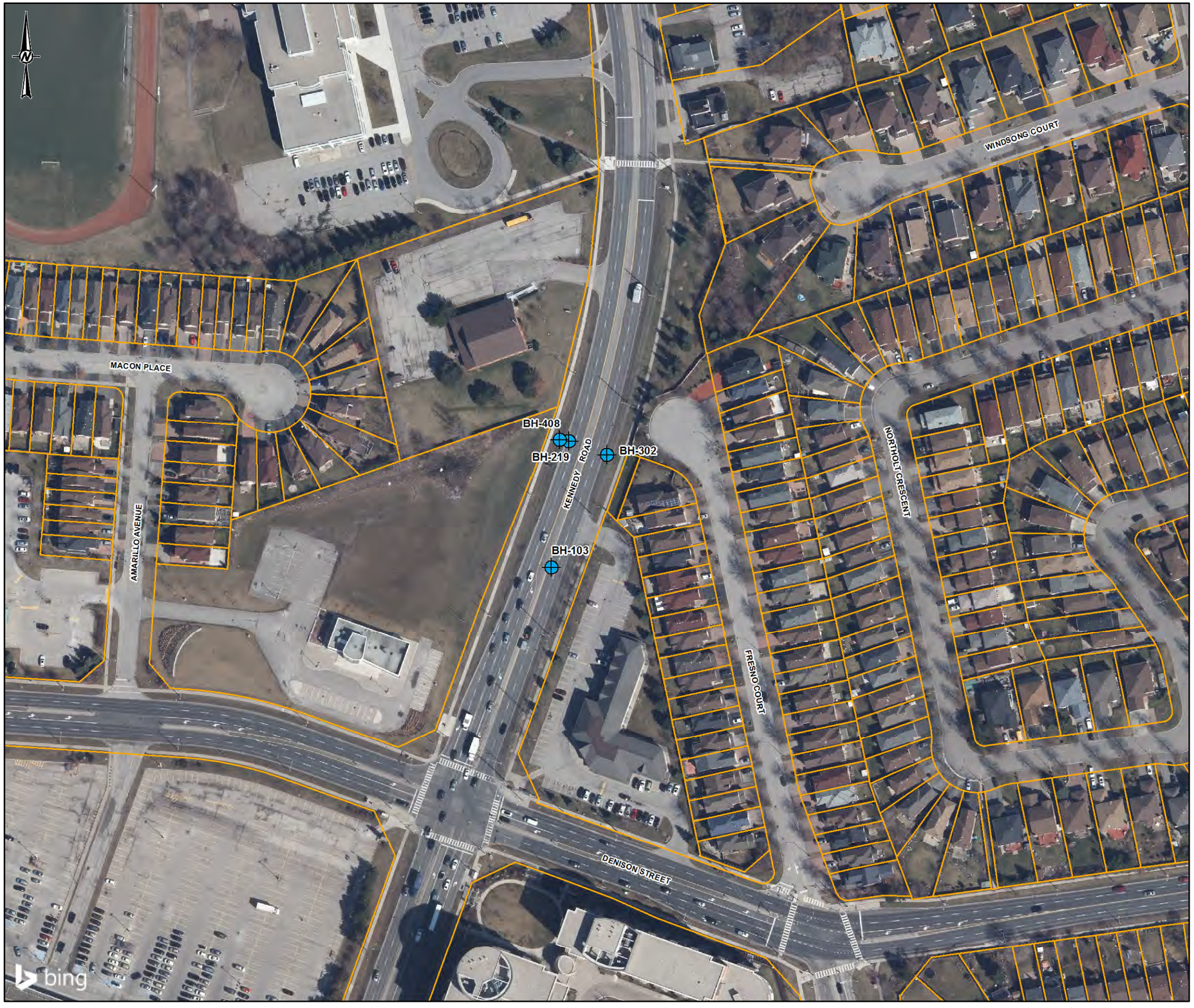
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm



LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-7**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-8**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100

1:1,700 Meters

REFERENCE(S)

1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT

HDR CORPORATION

PROJECT

KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE

BOREHOLE LOCATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-9**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-10**

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100

1:1,700 Meters

REFERENCE(S)

1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT

HDR CORPORATION

PROJECT

KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE

BOREHOLE LOCATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-11**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm
0

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LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100

1:1,700 Meters

REFERENCE(S)

1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT

HDR CORPORATION

PROJECT

KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE

BOREHOLE LOCATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-12**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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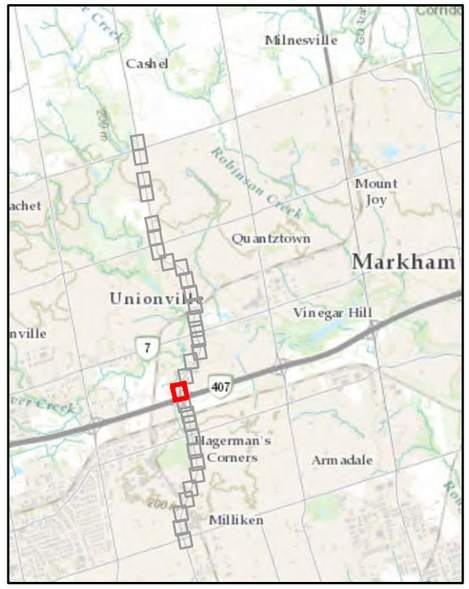
LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary



0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-13**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-14**

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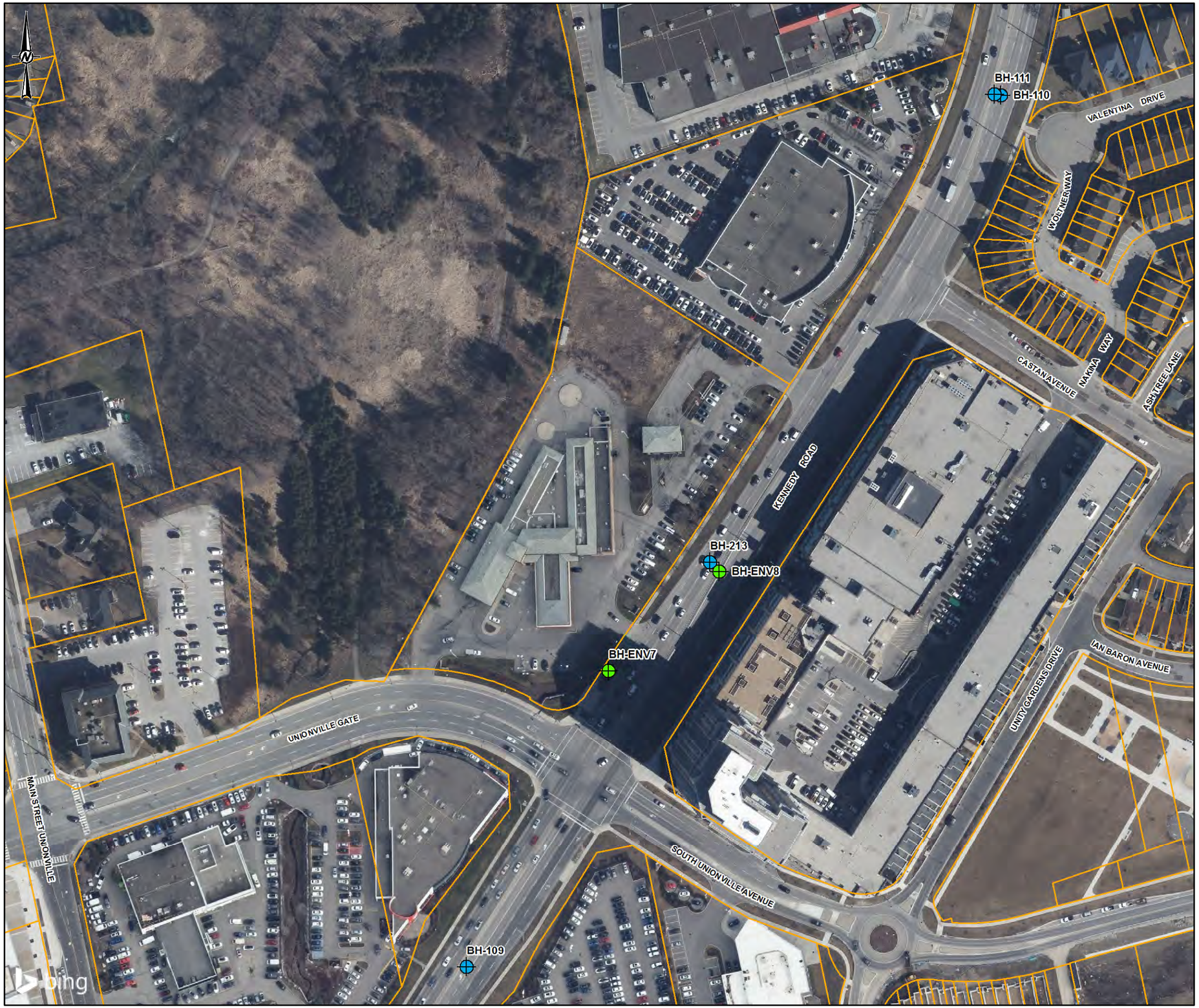
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm



LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-15**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm
0

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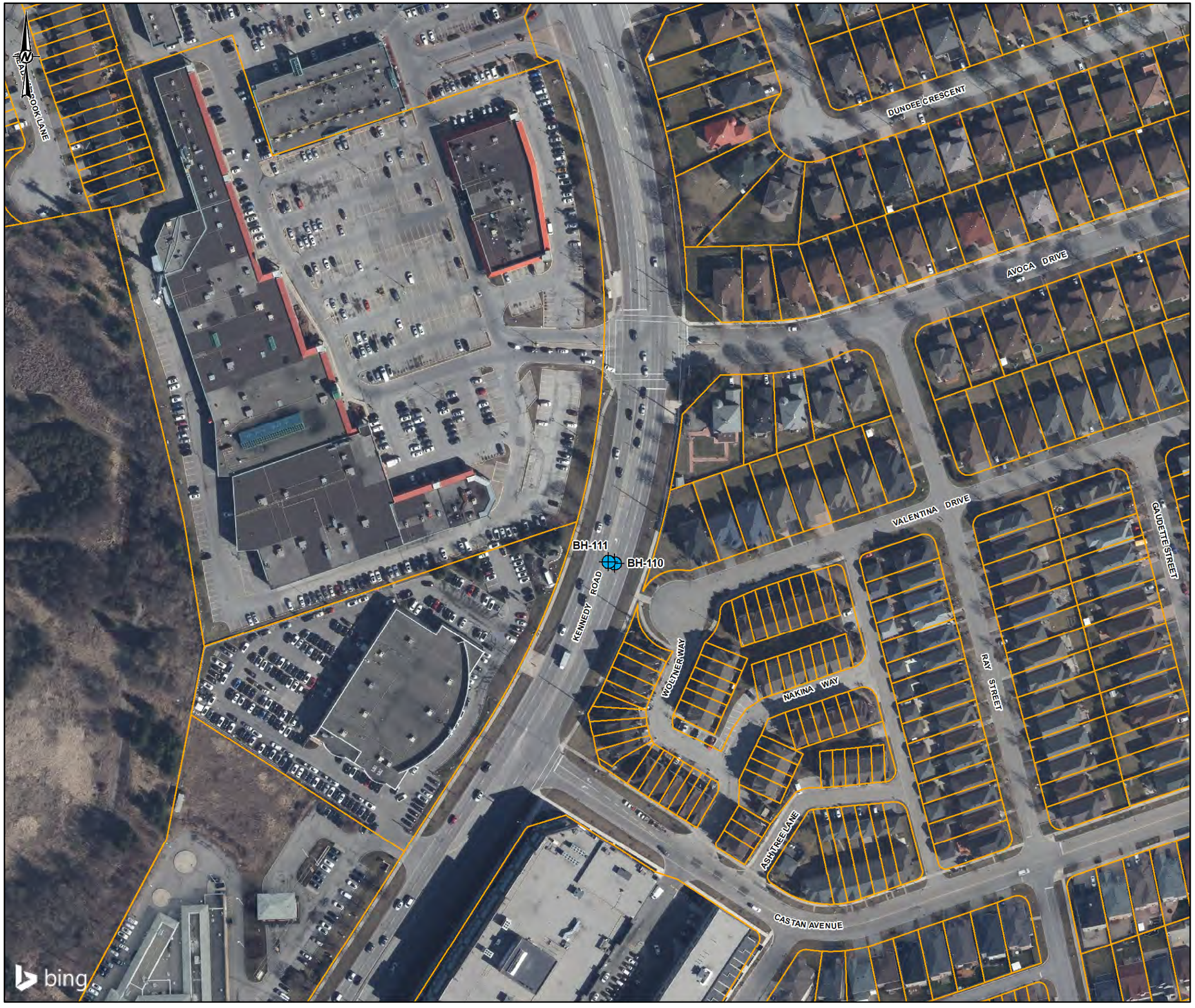
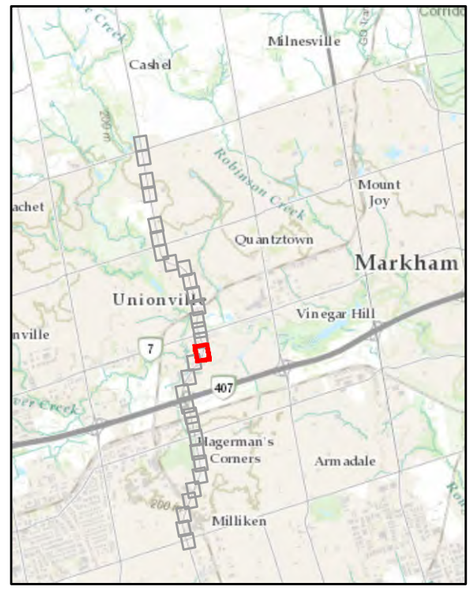


LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary



0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-16**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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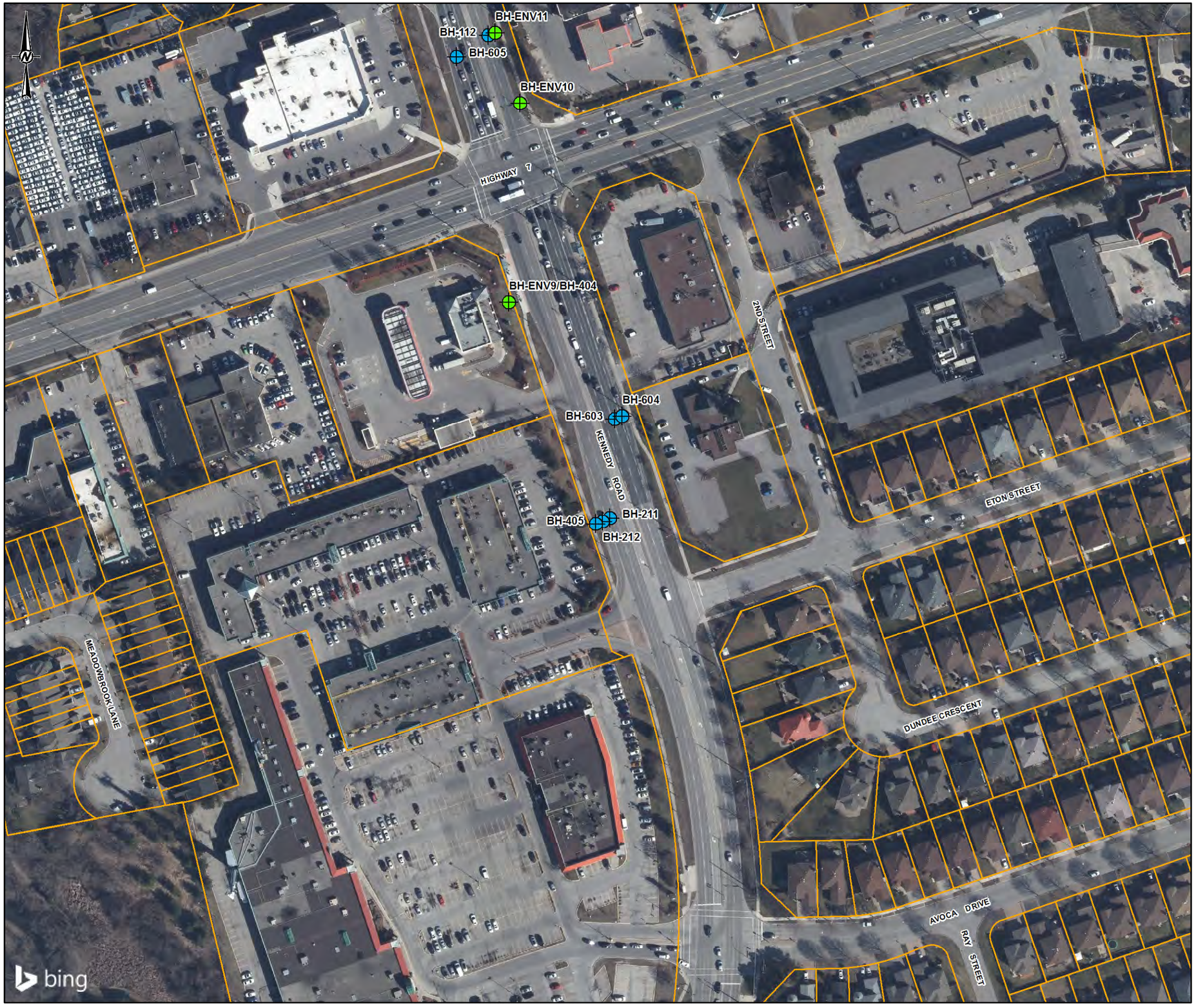

LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-17**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-18**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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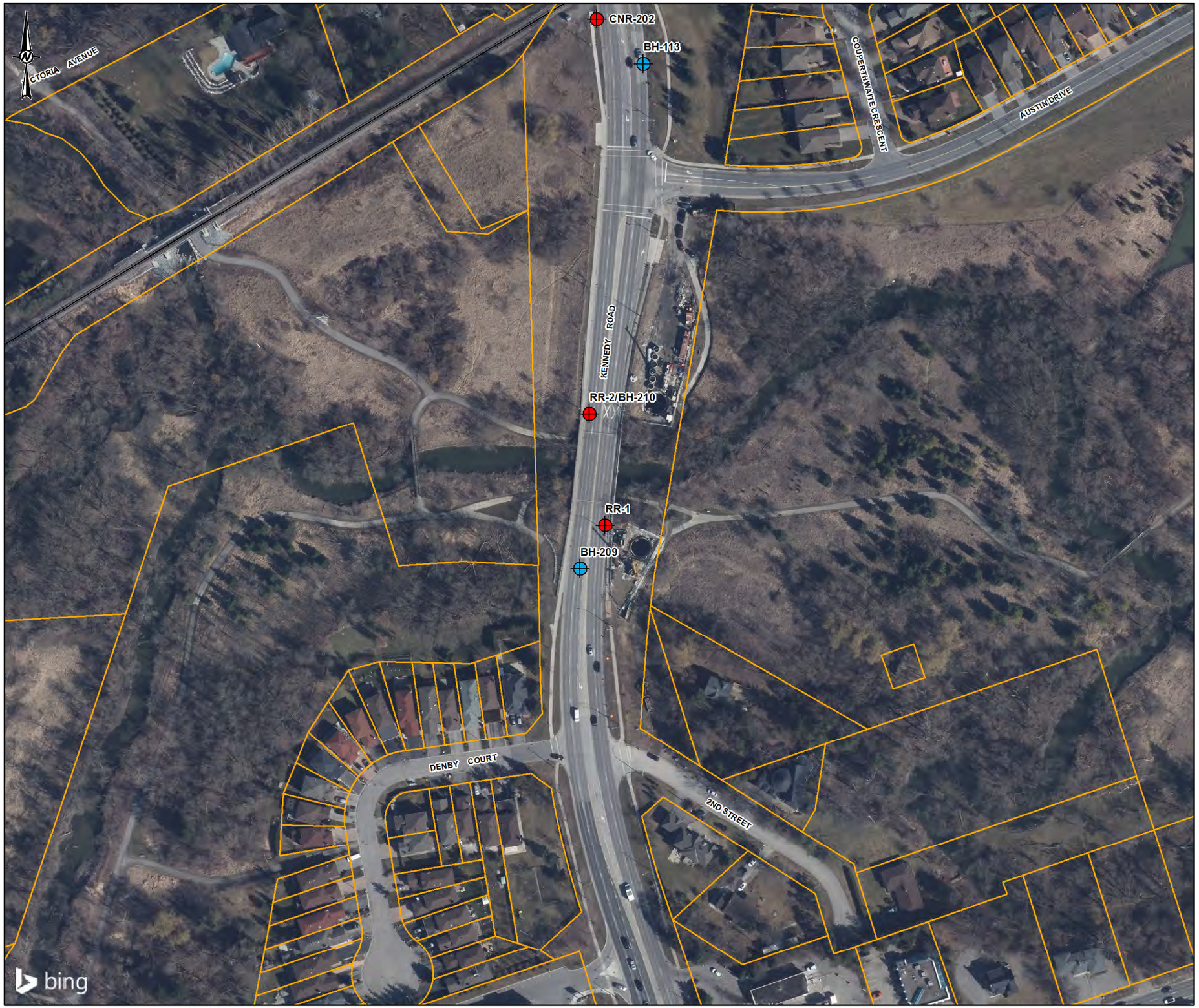

LEGEND

- Foundation Borehole
- Pavement Borehole
- Environmental Borehole
- Property Boundary

0 25 50 75 100
1:1,700 Meters

REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2016
2. IMAGERY PROVIDED BY THE REGION OF YORK, 2017
3. PARCELS PROVIDED BY THE REGION OF YORK (MARCH 2017)
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
HDR CORPORATION

PROJECT
KENNEDY ROAD (Y.R. 67)
STEELES AVENUE (Y.R. 95) TO MAJOR MACKENZIE DRIVE (Y.R. 25), CITY OF MARKHAM, REGION OF YORK

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-13
DESIGNED	MM
PREPARED	MM
REVIEWED	GG
APPROVED	SJ

PROJECT NO.	CONTROL	REV.	FIGURE
1664178	0001	0	**2-19**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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