# GEOTECHNICAL INVESTIGATION REPORT
PROPOSED RESIDENTIAL DEVELOPMENT
3491 WALLACE POINT ROAD, TOWNSHIP OF OTONABEE-SOUTH MONAGHAN, ONTARIO
REDSTONE PROJECT NO. 23R107

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- TEST PIT & BOREHOLE LOGS
- LABORATORY RESULTS

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# 1.0 INTRODUCTION

This report describes the results of a geotechnical investigation performed for the design and construction of a proposed new residential subdivision to be located south of Wallace Point Road, north of Base Line, east of Matchett Line, in the Township of Otonabee South Monaghan, County of Peterborough, Ontario. Redstone Engineering Inc. (Redstone) was retained by D.M. Wills Associates Limited (DM Wills, the Client) to support their work on this project by generating this geotechnical report based on field and lab data obtained by DM Wills. The work performed by Redstone was carried out under the authorization of Mr. Ian Ames, representing DM Wills, in accordance with Redstone's proposal #P1121 dated January 13 2022. It is Redstone's understanding that DM Wills is preparing a separate report summarizing hydrogeological works performed by them.

DM Wills provided the project information to Redstone:

- by email dated January 12 2022:
  - a DM Wills drawing titled "Proposed Residential Development Preliminary Concept – 3491 Wallace Point Road – Part Lot 17, Concession 15, Township of Otonabee-South-Monaghan, County of Peterborough", dated April 21, 2021; and
  - a Peterborough County Record of Pre-Consultation for this proposed development, for a meeting dated May 11, 2021.
- by email dated March 2 2023:
  - a DM Wills drawing titled "Proposed Residential Development – 3491 Wallace Point Road, Peterborough – Draft Plan", dated February 23 2023, under DM Wills Project No. 21-85162 (herein referred to as the Draft Plan).

Based on the information provided, Redstone understands that the proponent intends to develop the property as illustrated on the Plan. Information regarding the proposed final grades, invert elevations for the new utilities, and structural loadings for the buildings were not available as of writing this report. For this report, Redstone has assumed the final grades will remain similar to existing grades, trenching for new utilities will be no deeper than 2m below existing grade, and structural loading for new buildings will be typical for 1 or 2-storey residential structures. Should any of these assumptions not align with the project's final design, Redstone must be allowed the opportunity to revisit/review the recommendations contained herein in light of such updated design parameters and details.

Appendix A contains the following documents prepared by DM Wills:

- the Draft Plan (dated February 23 2023);
- Subsurface Investigation Plan (showing the location of the test pit and boreholes performed by DM Wills, in relation to existing features);
- Test pit and Borehole logs; and
- Laboratory results (summarizing the results of particle size distribution tests).

## 2.0 PURPOSE AND SCOPE

The purpose of the geotechnical investigation is to assess the soil and groundwater conditions at the test pit and borehole locations, and based on these findings, provide geotechnical engineering opinions and recommendations relevant to supporting design and construction of the proposed development including earthworks construction (excavations and backfill), groundwater control during construction, foundations and slabs-on-grade for the buildings, open-trench utility installations, stormwater pond, and pavement structure for new roads.

This geotechnical scope does not include any pavement life cycle costing analysis, slope stability analysis, hydrogeological assessment, chemical testing, environmental assessment or opinions.

The following scope of work was performed as part of this geotechnical investigation.

1. By DM Wills:
    a. test pit and boreholes (referred to herein in combination as Test holes) were laid out onsite as identified on the Subsurface Investigation Plan (Appendix A).
    b. soil and groundwater conditions were explored by advancing, sampling and logging a total of twenty-two (22) Test holes as follows:
        i. ten (10) test pits to depths of 1.8 to 2.9m below existing grade (mbeg); and
        ii. twelve (12) boreholes to depths of 5.6 to 6.6mbeg.
    c. The test pit and borehole conditions observed were recorded, and representative samples of the soils were obtained. Groundwater observations were obtained from the open Test holes during their advancement. Test hole logs are included in Appendix A.
    d. Groundwater monitoring wells were installed in four (4) boreholes. See “MW” in the borehole identification (“MW22-01”, “MW22-02”, “MW22-03”, “MW22-04”).
    e. The ground at the Test holes was reinstated as close as possible to its original condition upon completion of the fieldwork.
    f. One (1) round of groundwater level measurements was obtained from the installed monitoring wells on July 28 2022.
    g. Laboratory analyses of representative soil samples was performed, consisting of moisture content testing of most recovered soil samples, and grain size distribution testing of seven (7) soil samples.

2. By Redstone:
    a. Geotechnical engineering analysis of field and laboratory data provided by DM Wills, and preparation of this report summarizing Redstone's geotechnical findings and recommendations.

## 3.0 FIELD AND LABORATORY PROCEDURES

DM Wills performed a field investigation under the supervision of their staff between June 20 and July 28 2022. The work consisted of subsurface exploration by means of advancing, sampling and logging ten (10) test pits to depths of 1.8 to 2.9mbeg (on June 20 2022), and twelve (12) boreholes to depths of 5.6 to 6.6mbeg (on July 11 to 13 2022), and a subsequent groundwater level reading from the monitoring wells on July 28 2022. DM Wills maintained detailed logs of the Test holes, and obtained representative samples of the materials encountered. The Test hole locations are illustrated on the "Subsurface Investigation Plan" included in Appendix A.

The test pits were advanced using an excavator. The boreholes were advanced using a track-mounted drill rig equipped with 150mm Outside Diameter (OD) solid stem augers. Representative, disturbed samples of the strata penetrated by the boreholes were obtained either directly off the augers, or using a split-barrel, 50mm OD sampler advanced by a 63.5kg hammer dropping approximately 760mm. The results of these standard penetration tests (SPT's) are reported as "N" values on the borehole logs at the corresponding depths.

DM Wills' staff supervised the test pit excavation and borehole drilling, including logging, sampling, and backfilling/reinstating them. Soil samples were recovered, retained in labeled air-tight containers, and secured for subsequent review and submission for laboratory testing. Logs of the Test holes are provided in Appendix A. The depth to groundwater was measured in the open Test holes during drilling. DM Wills reported that immediately upon completion the test pits were backfilled with the excavated soils and nominally compacted using the excavator's bucket. DM Wills also reported that the boreholes were backfilled with bentonite chips up to about 1mbeg, then soil cuttings from 1mbeg to the ground surface.

DM Wills installed groundwater monitoring wells in four (4) boreholes using 50mm OD PVC casing and slot 10 screen. The monitoring well installation details are presented graphically on the borehole log (see logs labelled MW22-01, MW22-02, MW22-03, and MW22-04). The well screen was surrounded by filter pack sand to at least 0.3m above the screen, then a bentonite seal plug to just below the ground surface, and finished with above-grade casing and protective monument. DM Wills obtained groundwater depth measurements from these monitoring wells on July 28 2022 (i.e., greater than 24 hours after their installation). Redstone understands that these wells remain in place as of writing this report.

Physical laboratory testing of soil samples consisted of moisture content testing of all recovered samples, and grain size distribution analyses of seven (7) soil samples. The borehole logs (incorporating results of the moisture content and grain size distribution testing) and the grain size distribution lab charts are included in Appendix A.

The ground surface elevation and UTM coordinates at each Test hole was obtained by DM Wills and provided to Redstone (see Test hole logs in Appendix A).

# 4.0 SITE LOCATION AND SURFACE CONDITIONS

The project site is bounded on its northerly, westerly, and southerly sides by public roads (Wallace Point Road, Matchett Line, and Base Line). To the east, and in the other directions beyond the public roads, is generally farm fields, with some residential lots located mainly to the south. Most of the site appears to be open farm field areas with vegetative cover and some trees. Based on publicly-available topographic mapping information, the site's topography generally drops from its central-southern perimeter down to lower-lying zones in its northerly area, and in its southeasterly corner. DM Wills' Draft Plan shows the site's elevation peaking at about 207.5m (along the site's central-southern perimeter), and dropping to a low of about 195.0m in its northerly area, and 198.0m in its southeasterly corner.

# 5.0 SUBSURFACE CONDITIONS

## 5.1 GENERAL

The subject property is located in the physiographic region of the "Peterborough Drumlin Field" (The Physiography of Southern Ontario, Chapman and Putnam, 1984), and straddles two Physiographic Landform areas identified as "Clay Plains" (northerly portion of the site) and "Till Plains (Drumlinized)" (southerly portion of the site).

Details of the subsurface conditions encountered at the site by DM Wills' Test holes are presented graphically on their logs (Appendix A). It should be noted that the boundaries between the strata have been inferred from Test hole observations and non-continuous samples. They generally represent a transition from one soil type to another, and should not be inferred to represent an exact plane of geological change. Further, conditions may vary between and beyond the Test holes. Following is a summarized account of the subsurface conditions encountered in the Test holes.

The subsurface conditions generally consist of topsoil over finer-grained soils typically consisting of sandy silt or silty sand, over coarser-grained soils typically consisting of sand or sandy gravel, with caving (sloughing) soils present in some boreholes as shallow as about 1.1mbeg, and groundwater present in most Test holes at depths of 5.95mbeg to 0.72m above grade (note: "above grade" indicates stabilized groundwater level located above the existing ground surface - i.e., artesian).

The following sections describe the major soil strata and groundwater conditions encountered during DM Wills' investigation in more detail, with further detail provided on their logs (Appendix A).

## 5.2 TOPSOIL

A surficial layer of topsoil was encountered in all of the Test holes, with its thickness ranging between about 0.2 and 1.1m. The topsoil was generally a brown to dark brown sandy silt with trace clay, highly organic in nature, and generally in a moist in-situ state. This soil is considered devoid of any structural properties. No testing was performed on this soil to confirm its organic/nutrient or fertility-related properties.

## 5.3 SILT / SANDY SILT / CLAYEY SILT / SANDY CLAYEY SILT / SAND & SILT

Layers of finer-grained and occasionally cohesive (clayey silt, sandy clayey silt) soils were encountered in 18 of the Test holes (nine test pits and nine boreholes). In the test pits, the top of these soils was first observed at depths ranging from about 0.2 to 0.9mbeg, and the bottom ranging from about 1.4 to at least 2.9mbeg. In the boreholes, the top of these soils was first observed at depths ranging from about 0.6 to 4.6mbeg, and the bottom ranging from about 1.5 to at least 6.6mbeg (interbedding with silty sand observed in BH22-09).

These soil layers primarily consisted of silt with varying amounts of sand and clay, occasional trace to some gravel and occasional cobbles. Occasional seams or stringers of sand appeared within these soils. The coloration of these soils is described as brown to grey/brown to grey, with occasional orange-brown colouration noted. These soils are generally described as being moist to wet to saturated, and in an occasionally loose to typically compact or dense in-situ state of relative density. Only one borehole encountered an N-count of less than 10 blows per 0.3m, that being BH22-11 between 0.6 and 1.5mbeg. The remaining N-counts within this soil were compact to dense.

Moisture content tests performed on samples of these soils yielded values ranging from about 6 to 31% moisture by weight. Grain size distribution analyses performed on samples of the silt suggest the following compositional ranges: 2 to 16% gravel, 16 to 36% sand, and 48 to 76% silt and clay (hydrometers performed on these samples indicate 5 to 20% particles smaller than 2um in size).

## 5.4 SILTY SAND

A layer of soil described as silty sand was encountered in two (2) test pits and eleven (11) boreholes. In the test pits, the top of the silty sand was first observed at depths ranging from about 1.1 to 1.4mbeg, and extended to the full depth of the two test pits. In the boreholes, the top of the silty sand was first observed at depths ranging from about 0.2 to 1.5 mbeg, and extended to depths ranging from about 1.8 mbeg (in BH22-09 where the silty sand was interbedded with layers of silt), to the full depth of the boreholes.

This soil consists primarily silty sand, with some clay and trace gravel occasionally noted. Occasional seams or stringers of coarser-grained sand appeared within this soil. The coloration of this soil is described as typically brown to grey, with occasional orange-brown mottling. The silty sand is generally described as being moist to wet. Based on N-counts ranging from 3 to 99 blows per 0.3m, the in-situ state of relative density varied from very loose to compact to dense to very dense (generally increasing with depth). Boreholes where this soil exhibited N-counts of less than 10 blows per foot (i.e., loose to very loose) included MW22-01 (above 0.5mbeg), MW22-02 (above 1.5mbeg), MW22-03 (above 2.0mbeg), BH22-06 (above 2.2mbeg), BH22-07 (above 2.2mbeg), BH22-08 (above 2.2mbeg), and BH22-11 (between 2.2mbeg and 3.1mbeg).

Moisture content tests performed on samples of the silty sand yielded values ranging from about 6 to 28% moisture by weight. Grain size distribution analyses performed on samples of the silty sand suggest the following compositional ranges: 0 to 14% gravel, 47 to 64% sand, and 36 to 39% silt and clay (hydrometers performed on these samples indicate 12 to 15% particles smaller than 2um in size).

## 5.5 SAND / SANDY GRAVEL / SAND & GRAVEL

Layers of coarser-grained and generally non-cohesive soils consisting of sand, sandy gravel, or sand and gravel were encountered in five (5) boreholes. These soils were first observed at depths ranging from about 0.6 to 6.1mbeg, and extended to the full depth of investigation in each borehole that encountered it (interbedding with sandy silt observed in BH22-10).

These soils consisted primarily of sand, or sand and gravel, with occasional trace amounts of silt and/or clay, and cobbles sometimes noted. They typically exhibited brown to grey colouration. These soils are typically described as being moist to wet to saturated. Based on N-counts of 5 to 78 blows per 0.3m, these soils exist in a loose to compact to dense in-situ state of relative density. Boreholes where these soils exhibited N-counts of less than 10 blows per foot (i.e., loose to very loose) included BH22-11 (between about 3.1 and 3.4mbeg), and BH22-12 (above 1.5mbeg).

Moisture content tests conducted on samples of these soils yielded values that ranged from approximately 3 to 15% moisture by dry weight. Grain size distribution tests performed on two (2) samples of these soils suggest the following compositional ranges: 0 to 66% gravel, 28 to 90% sand, and 6 to 10% silt and clay.

## 5.6 PRACTICAL REFUSAL

Two (2) boreholes encountered practical refusal to further borehole advancement, at depths of about 6.1mbeg (BH22-08) and 5.6mbeg (BH22-11), at which depths the presence of cobbles or boulders was inferred to have caused the refusal. The cause of this refusal at these locations was not confirmed by advancing test pits or diamond coring as part of this study.

## 5.7 GROUNDWATER & CAVING

Upon completion of advancing each Test hole, the depth to any evident groundwater and caving (of the Test hole walls) was recorded. During test pit excavations, five (5) of the test pits did not encounter groundwater seepage to their full depths (1.8 to 2.9mbeg), while the remaining five (5) open test pits encountered groundwater seepage at depths ranging between about 1.0mbeg to 2.2mbeg. During drilling, all the open boreholes encountered groundwater at depths ranging from above the ground surface (i.e., artesian, with groundwater flowing out of borehole BH22-11 at the ground surface) to 5.8mbeg. Monitoring wells installed in four of the boreholes (MW22-01 to MW22-04) were checked for groundwater levels on July 28 2022, with levels ranging from 0.72m above ground (i.e., artesian) to 5.9mbeg.

The following table summarizes the groundwater depths observed during each of these events.

Table 1: Groundwater Depth / Elevation

| Test Hole | | | Groundwater | |
|---|---|---|---|---|
| ID | Ground Surface Elevation (m) | Bottom | In Open Test hole | In Monitoring Well (July 28/22) |
| | | - - - - - - Depth (mbeg) / Elevation (m) - - - - - - | | |
| TP22-01 | 197.540 | 2.9 / 194.6 | 1.0 / 196.5 | No Monitoring Well Installed |
| TP22-02 | 201.889 | 2.9 / 199.0 | 2.2 / 199.7 | |
| TP22-03 | 206.581 | 2.7 / 203.9 | >2.7 / <203.9 | |
| TP22-04 | 201.163 | 2.9 / 198.3 | 2.1 / 199.1 | |
| TP22-05 | 195.699 | 2.7 / 193.0 | 1.4 / 194.3 | |
| TP22-06 | 194.991 | 2.7 / 192.3 | 1.1 / 193.9 | |
| TP22-07 | 195.670 | 1.8 / 193.9 | >1.8 / <193.9 | |
| TP22-08 | 196.848 | 2.7 / 194.1 | >2.7 / <194.1 | |
| TP22-09 | 196.924 | 2.4 / 194.5 | >2.4 / <194.5 | |
| TP22-10 | 197.349 | 2.9 / 194.4 | >2.9 / <194.4 | |
| MW22-01 | 205.512 | 6.55 / 198.96 | 6.10 / 199.41 | 5.93 / 199.58 |
| MW22-02 | 194.905 | 6.55 / 188.36 | 0.00 / 194.91 | -0.72 / 195.13 (2) |
| MW22-03 | 197.573 | 6.55 / 191.02 | 4.55 / 193.02 | 3.55 / 194.02 |
| MW22-04 | 197.536 | 6.55 / 190.99 | 5.80 / 191.74 | 2.77 / 194.77 |
| BH22-05 | 199.679 | 6.55 / 193.13 | 3.65 / 196.03 | No Monitoring Well Installed |
| BH22-06 | 196.176 | 6.55 / 189.63 | 3.65 / 192.53 | |
| BH22-07 | 195.240 | 6.55 / 188.69 | 2.45 / 192.79 | |
| BH22-08 | 198.316 | 6.10 / 192.22 | 5.00 / 193.32 | |
| BH22-09 | 198.543 | 6.55 / 191.99 | 2.40 / 196.14 | |
| BH22-10 | 200.694 | 6.55 / 194.14 | 2.15 / 198.54 | |
| BH22-11 | 195.565 | 5.65 / 189.92 | 0.00 / 195.56 (1) | |
| BH22-12 | 203.745 | 6.10 / 197.65 | 2.40 / 201.35 | |

(1) groundwater flowing out of open borehole at ground surface upon completion of drilling (i.e., artesian).
(2) "-0.72" depth indicates 0.72m above the ground surface (i.e., artesian).

Caving (sloughing) of the test pit walls was observed in TP22-02 and TP22-09 below depths of 2.2 and 1.1mbeg, respectively. Caving (sloughing) of the boreholes walls was observed in seven (7) boreholes, below depths ranging from about 2.4mbeg (BH22-09 and BH22-12) to 5.1mbeg (BH22-05). The rest of the Test holes remained open to their full depths during excavating and drilling.

It should be noted that the groundwater levels (and related caving) are subject to seasonal fluctuations and in response to weather events, and at any point in time may differ from those presented herein. Also, the tendency for soils to cave (or slough or otherwise collapse) is a function of multiple factors including its density or consistency, presence and/or movement of groundwater, as well as the slope, area, and duration of exposed soil faces.

# 6.0 DISCUSSION AND RECOMMENDATIONS

Supporting data upon which these recommendations are based has been presented in the foregoing sections of this report, and was obtained and provided to Redstone by DM Wills. The following recommendations are governed by the physical properties of the subsurface materials that were encountered at the site and assume that they are representative of the overall site conditions. It should be noted that these conclusions and recommendations are intended for use by the designers only. Contractors bidding on or undertaking any work at the site should examine the factual results of the assessment, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of this factual data as it affects their proposed construction techniques, equipment capabilities, costs, sequencing, and the like. Comments, techniques, or recommendations pertaining to construction must not be construed as instructions to the contractor. These recommendations are based on the project understandings outlined in Section 1 of this report. Should any of these parameters change, Redstone must be allowed to review the proposed changes and provide updated recommendations if warranted.

Details regarding our conclusions and recommendations are outlined in the following sections.

## 6.1 SAFE EXCAVATION DEPTHS

As a result of the groundwater conditions in the proposed development's northerly areas (where artesian groundwater levels were observed), it is important that the overlying confining (aquitard) soil layer's thickness, and the upwards groundwater pressure, be well understood to allow an assessment of the safe excavation depths (inferred maximum excavation depths, IMED) of subsurface construction including but not limited to excavations for utilities (trenching), house foundations, and stormwater ponds. The upwards hydraulic pressure (head) in the underlying confined aquifer creates uplift pressure on the overlying confining aquitard soil; if the uplift pressure in the underlying aquifer exceeds the overlying weight of the confining soil, failure of the confining soil layer(s) can occur in excavations in the form of groundwater upwelling such as heave, boils, fractures, etc. Also note the propensity for these confining soil layer(s) to be "leaky" based on the presence of seams/stringers of sand and/or gravel. Remediation of such uplift failures can be challenging and costly. The upwards hydraulic pressure from the underlying confined aquifer creates limits to the depths of safe excavations in this area.

Borehole MW22-02 was fitted with a monitoring well whose screened interval was from 3.0 to 6.0mbeg (about 191.9m elev to 188.9m elev), and encountered a stabilized groundwater level of 0.72m above ground (about 195.6m elev) on July 28 2022; a confining aquitard soil layer was not well identified in this borehole, therefore, for the purpose of preliminary assessment the depth to the confined aquifer in this borehole is set at the top of this well's screened interval (3.0mbeg, 191.9m elev).

Borehole BH22-11 encountered flowing groundwater at ground surface during drilling (July 11 2022) but was not fitted with a monitoring well, therefore no data is available from this location regarding the groundwater's stabilized level above the ground surface. This borehole identified what appears to be a stratigraphic complex indicative of a less-permeable confining soil layer overlying a more-permeable pressurized aquifer (clayey silt over silty sand over sand over sandy gravel); although the silty sand in this borehole does not constitute what would generally be considered a confining soil (i.e., it is more likely a gradational zone that further suggests an imperfect/leaky confining layer), for the purpose of this preliminary assessment it is included along with the clayey silt to form the overlying confining aquitard layer, extending to a depth of 3.1mbeg (about 192.5m elev).

As a preliminary assessment (pending further works as outlined herein including Section 6.10.6), a safe excavation depth has been calculated based on the information provided from MW22-02 and BH22-11 (outlined above). The safe excavation depth in this area based on this information is calculated at 0.5mbeg. Excavations extending below this depth must utilize active dewatering/depressurization of the underlying pressurized aquifer during advancement of such excavations. See Section 6.3 for recommendations regarding groundwater control. Further works including subsurface exploration with boreholes and monitoring wells will allow a more refined analysis of the safe excavation depths and development areas to which they apply (see Section 6.10.6).

## 6.2 SITE PREPARATION, EXCAVATION, AND BACKFILL

Prior to commencing earthwork construction, any and all topsoil, vegetation, existing fill, disturbed earth, organics and organic-bearing materials must be stripped and removed from all proposed new road, stormwater pond (SWP), and structural areas including buildings (foundation and floor slab areas) and from beneath any utility servicing elements such as piping and/or tanks. In all cases the subexcavated surfaces must be inspected and approved by a qualified geotechnical engineer's representative familiar with the site's ground conditions, prior to placement of any fill, formwork, or foundations.

Excavations should be carried out to conform to the manner specified in Ontario Regulation 213/91 and the Occupational Health and Safety Act and Regulations for Construction Projects (OHSA). All excavations above the water table not exceeding 1.2 m in depth may be constructed with unsupported slopes. All loose soils above the groundwater table, and all soils below the groundwater table would lose strength, could exhibit caving/sloughing upon being disturbed, and are classed by OHSA as Type 4 soil requiring unsupported walls of excavations to be sloped at 3H:1V or flatter to the base of the excavation. See Section 5.7 herein for a discussion of groundwater and caving observed in the open Test holes. The compact to dense soils above the groundwater are classed by OHSA as Type 3, requiring excavations to be sloped at 1H:1V or flatter to the excavation base. (Note that any pockets of trapped groundwater located within the soils above the groundwater table may cause these soils to collapse and temporarily behave similarly to a Type 4 soil upon being opened by excavations, in which case suitable localized excavation/shoring or other treatments will be necessary to stabilize).

If space is restricted such that the side slopes of excavations cannot be safely cut back in accordance with OHSA, and/or sloughing and cave-in are encountered in the excavations, and/or where the excavations are in close proximity to an existing structure (including a road, building or infrastructure), temporary shoring must be provided. To avoid overstressing of any shoring, the excavated materials must be placed away from the excavation perimeter at a minimum distance equalling 2 times the excavation's depth. Materials must not be stockpiled in close proximity to open excavations, and construction traffic must avoid being in proximity to open excavations. To protect against the adverse effects of erosion during construction, all ground surface drainage runoff should be directed away from the excavation area(s). Appropriate design and installation of any shoring is the responsibility of the Contractor.

Prior to soils being taken offsite for reuse and/or disposal it is recommended that appropriate chemical testing be performed on representative samples.

Based on the granular nature of some of the existing soils, it is possible that some of the more sandy and/or gravelly soils could be reused onsite as some form of backfill – possibly as pavement subgrade and/or trench backfill (pending approval at the time of construction). From a geotechnical perspective, the reuse of any excavated material onsite is conditional on it being workable, at a suitable moisture content, not overly silty or clayey, containing no organics, debris or other unsuitable / deleterious materials, and receiving final review and approval for such reuse at the time of construction. Soils that are otherwise acceptable but overly wet, will require prior processing (such as aeration) to lower their moisture content before being considered for approval as backfill material.

## 6.3 GROUNDWATER CONTROL DURING CONSTRUCTION

See Section 5.7 of this report for the depth to groundwater (and caving) encountered in the Test holes and monitoring wells. As noted, evidence of flowing artesian conditions was encountered in MW22-02 and BH22-11, with the piezometric level in monitoring well MW22-02 located at 0.72m above the ground surface on July 28 2022, and with groundwater flowing out of open borehole BH22-11 at ground surface upon extracting the augers during drilling on July 11 2022. This suggests that artesian (pressurized) groundwater exists in an aquifer located beneath a confining aquitard (i.e., less permeable layers of soil). A pressurized groundwater aquifer such as this is generally formed by hydraulically-conductive soils (eg: sand and/or gravel) being charged with water at higher elevations/grades, with the groundwater contained within the aquifer down to lower elevations/grades where it is confined by an overlying, less-permeable aquitard (eg: silt and/or clay). This combination results in the confined aquifer being pressurized (such pressure increasing in lower-lying areas of the site), with its piezometric level (i.e., level at which the pressurized groundwater level stabilizes) being above the ground surface. In BH22-02 the thickness of the confining aquitard layer and depth to the underlying pressurized aquifer is not well defined, with the stratigraphy in this borehole consisting of topsoil over silty sand with some clay extending to 2.30mbeg, over sandy silt with trace clay trace gravel and occasional cobbles (with some gravel and a sand stringer noted at depth) extending to the full depth of the borehole at 6.55mbeg. In BH22-11 there appears to be an upper confining layer(s) consisting of clayey silt grading to silty sand, over coarser-grained soils (likely the pressurized aquifer) consisting of sand over sandy gravel that starts at about 3.10mbeg.

Regarding the overlying aquitard (confining) layer: based on experience with ground conditions in the general area, and also based on the presence of sand stringers within some of the finer-grained soils (noted on DM Wills' logs), the overlying aquitard (confining) soil layer within which excavations for this construction may occur, should be expected to "leak", as it does not form an impermeable layer but rather allows upwards leakage of the underlying pressurized groundwater into excavations via hydraulically-conductive stringers, seams, or lenses of coarser-grained soils. Such upwards flow of groundwater into excavations must be avoided or appropriately managed to prevent adverse effects on excavations (including forming boils, blows, heaves, and/or shearing of the excavation base). See Section 6.1 regarding a preliminary assessment of safe excavation depths within this context.

Due to this site's existing topography consisting of higher grades in the central-southern area, and lower elevations to the north and southeast, it is possible that hydraulically-conductive soil zones (including both an upper unconfined and/or the lower confined aquifers) may be charged with groundwater in the site's elevated areas, and flow downgradient, in which case this would become evident within any downgradient excavations intersecting such soil zones. The contractor must be aware of and prepared to manage such groundwater conditions during construction.

In any case, groundwater levels (including piezometric levels driven by the underlying pressurized aquifer) are subject to seasonal fluctuations and in response to weather events, and at any point in time may differ from those presented herein. Where groundwater is present, it is cautioned that cohesionless (sand and/or gravel, some silt) soils will be easily disturbed, loosened, and may exhibit sloughing and flowing characteristics unless properly managed including lowering of the groundwater (including the piezometric level of the underlying pressurized aquifer) to at least 1m below the base of all excavations, and protection of the exposed final excavation subgrades from weather, construction traffic, and other potential sources of disturbances including groundwater upwelling.

Shallow excavations remaining above the groundwater and safe excavation depths are not expected to encounter significant groundwater infiltration, and in such shallow excavations, any groundwater encountered is expected to be controlled by pumping from collection sumps to an acceptable outlet. Excavations extending below the groundwater and/or safe excavation depths will encounter groundwater inflow that will become increasingly intensive with depth. See Section 6.1 herein for a preliminary assessment of the safe excavation depths within the context of the pressurized artesian groundwater, and note that further work is recommended to assess the related ground conditions and refine the safe excavation depths and development areas to which they apply – see Section 6.10.6 herein for recommendations regarding further works recommended in this regard.

As a preliminary recommendation (pending further assessment works regarding safe excavation depths as outlined above); where excavations extend to sufficient depth below the groundwater and/or safe excavation depths, some form of positive dewatering including well points and/or depressurization wells, possibly combined with watertight shoring systems may be required prior excavating. The need for positive dewatering of any deeper excavations may arise depending on a number of factors including the depth to the pressurized aquifer and its piezometric level at the time of construction, hydraulic conductivity of the surrounding soil and resulting rate of groundwater infiltration, the contractor's sequencing and methods, area of open excavation at any given time, and duration it remains open. In all cases the groundwater and pressurized piezometric levels should be lowered or otherwise controlled to a depth of at least 1m below the base of all excavations (or otherwise as necessary to ensure stable conditions during excavation); construction dewatering must be designed and implemented by a qualified, experienced, specialist contractor.

In general, the intensity of groundwater infiltration into excavations will depend on the depth of excavation relative to the surrounding groundwater and piezometric levels, the weather (i.e. precipitation), time of construction (i.e. snow melt), the location of excavations relative to any downgradient groundwater flows, impacts from underlying pressurized aquifers, and construction methodology employed by the Contractor. An accurate prediction of the groundwater pumping volumes cannot be made at this time, as the flow rate would be dependent on construction methods adopted by the Contractor. Care must be taken when designing excavations (including trenches, building foundations, SWP bases, and any other infrastructure) within the areas of what appears to be potentially thin and/or leaky aquitard (confining) soil cover overlying the pressurized aquifer. Sufficiently deep excavations into the upper confining aquitard soil layer can potentially destabilize that protective soil layer over the artesian aquifer causing flowing conditions (see Section 6.1 regarding safe excavation depths in this context). The need for temporary or long-term groundwater depressurizing must be examined on a specific basis at the detailed design stage once design grades and other relevant design factors become available.

If short-term pumping of groundwater at volumes greater than 50,000 L/day and less than 400,000 L/day is required during the construction stage, the Environmental Activity Sector Registry (EASR) must be completed. The EASR streamlines the process and water pumping may begin once the EASR registration is completed, the fee paid and supporting document prepared. If water taking in excess of 400,000 litres/day is required, a Permit to Take Water (PTTW) must be obtained in advance. Pumping discharges must conform to any requirements from the local municipalities, conservation agencies and any other jurisdictional agencies, as well as the MECP permitting.

The preceding comments are intended for general reference and information only. The Contractor is solely responsible for the design and implementation of any required depressurization, unwatering, and/or dewatering, including requirements for withdrawal, handling, treatment, and discharge.

Dewatering or depressurizing measures for construction have the potential to affect existing private wells in the area. It is recommended that prior to any subsurface work, a hydrogeological assessment of private wells in the vicinity of the site be identified to assess whether the wells could be affected by construction, with appropriate recommendations made to mitigate any such impacts.

## 6.4 SERVICE INSTALLATION (BEDDING AND COVER)

Proposed invert grades for service utilities were not available at the time of writing this report. These recommendations are based on an assumption the utility inverts (and associated trenching for them) will be no deeper than 2mbeg. In any case, the depth of excavations must consider the safe excavation depths outlined in Section 6.1 and related recommendations.

The materials encountered during this investigation at the assumed maximum service invert grades (2mbeg) typically consist of suitably competent native soils. It is recommended that geotechnical inspections be carried out at the time of construction to verify that the subgrade soils exposed at the trench base are consistent with the findings in this report. No pipe support issues are anticipated where the piping will be founded in the native soils provided all the recommendations contained in this report are adhered to.

To minimize impacts from the open trench on the adjacent ground and vice versa (eg: groundwater infiltration), it would be prudent for the contractor to consider construction sequencing and staging that opens the trenches in relatively short sections (eg: 2 to 4 pipe lengths maximum) to carry out the bedding, pipe laying, and backfilling expeditiously in order to reduce the length of time each section of trench remains open.

Normal compacted bedding material, placed in the Class “B” or Class “C” arrangement, is recommended for all underground services. The recommended bedding material is Granular A or 19mm crusher run (angular) limestone, as per Ontario Provincial Standard Specifications (OPSS). The minimum recommended bedding thickness for the underground services is 150mm. All bedding materials should be compacted to 98% of their Standard Proctor Maximum Dry Density (SPMDD). If trenching encounters overly wet or loose bedding subgrade (as may exist in the area of BH22-11), bedding material should consist of High Performance Bedding (HPB) or stone, wrapped in non-woven geotextile fabric equivalent to Terrafix 200R and placed in accordance with manufacture's specifications. As previously noted, it is expected that artesian (pressurized) groundwater conditions exist in the confined aquifer located below this site, and that the overlying aquitard (i.e. confining) soil layer within which excavations for this construction may occur, can be "leaky" (allowing upwards leakage of the pressurized groundwater into excavations via hydraulically-conductive stringers/seams/lenses of sand). If such conditions are encountered within the trenching subgrade, it is recommended that the bedding layer consist of HPB or HL-8 stone, wrapped in non-woven geotextile as outlined above. Note that in such conditions where trenching has extended below the safe excavation depths as outlined in Section 6.1, appropriate groundwater control including positive dewatering/depressurization (see Section 6.3) must be performed. Trenches in any areas extending below the safe excavation depth should be backfilled to include suitable reinstatement of the confining (less-permeable) soil cap/layer.

All trenches should be designed and constructed with trench plugs at appropriate locations/spacings, to minimize the migration of groundwater along the trench and bedding materials. At least one (1) trench plug should be installed between two adjacent manholes.

## 6.5 FOUNDATIONS

The recommendations provided herein are based on the Test hole information obtained during DM Wills' field and laboratory work. Updates to the commentary and recommendations can be on-going as new information of the underground conditions becomes available. For example, more specific subsurface information becomes available once excavations and foundation construction is underway. In all cases, prior to placement of any lean concrete, fill, formwork, or foundations, all excavations must be inspected and approved by a qualified geotechnical engineer's representative to ensure that the foundation bearing material has been prepared properly at the foundation subgrade level and that the founding subgrade materials exposed are similar to those encountered during this investigation. Under no circumstances should the foundations be placed directly on organic materials, loose, frozen subgrade, construction debris, or within ponded water.

Redstone is unaware whether the development plans to include basements in the residential buildings. For the purpose of minimizing excavations and resulting short-term (construction) and long-term (as-constructed) exposure to potential groundwater and related subgrade drainage issues, the designer may wish to consider minimizing or eliminating open interior building areas that extend below existing grades.

Structural loading for new residential, 1 to 2 storey buildings may be supported on reinforced strip and spread concrete footings placed on the suitably competent native soil, or on engineered fill constructed directly on such native soils. The footing (and related excavation) grades should remain as high as possible to minimize potential for impacts from the underlying pressurized aquifer. Depressurization/dewatering the underlying aquifer will be required for foundation excavations extending below the safe excavation depths (outlined in Section 6.1) to prevent heave/uplift of the excavation base and loss of bearing capacity.

The following table outlines the depths to suitably competent native soil as encountered in the boreholes.

Table 2: Competent Native Soil For Footings - Depth / Elevation

| TEST HOLE | DEPTH (mbeg) / ELEVATION (m) | TEST HOLE | DEPTH (mbeg) / ELEVATION (m) |
|---|---|---|---|
| MW22-01 | 0.8 / 204.7 | BH22-07 | 2.3 / 192.9 (2) |
| MW22-02 | 1.8 / 193.1 (1) | BH22-08 | 2.3 / 196.0 |
| MW22-03 | 2.3 / 195.3 | BH22-09 | 0.9 / 197.6 |
| MW22-04 | 0.9 / 196.6 | BH22-10 | 0.8 / 199.9 |
| BH22-05 | 0.8 / 198.9 | BH22-11 | 1.5 / 194.1 (3) |
| BH22-06 | 2.3 / 193.9 | BH22-12 | 1.1 / 202.6 |

(1) groundwater level at 0.72m *above* grade (195.6m elev) in this monitoring well on July 28, 2023
(2) groundwater level at 2.45mbeg (192.8m elev) in this open borehole on July 11, 2023
(3) footings not to go any deeper, as a zone of loose soils exists beneath (i.e., below about 2.1mbeg)

Where competent soil for footings is deeper than 1.5mbeg, to minimize the need for subexcavations below 1.5mbeg the designer may consider an alternative strategy consisting of designing the underside of footings at 1.2mbeg, placed on a 300mm thick engineered fill pad (constructed as per the engineered fill steps outlined below), with a layer of woven geotextile at the base of the engineered fill if deemed necessary by subgrade inspections during construction.

For design purposes, it is recommended that footing foundations be proportioned using the following parameters:

Table 3: Bearing Capacity Pressure / Geotechnical Resistance for Footings

| PARAMETER (kPa) | UNDISTURBED, COMPETENT NATIVE SOIL | ENGINEERED FILL (1) | | |
|---|---|---|---|---|
| | | Rock-based | Granular | Earth Borrow |
| Bearing Capacity Pressure (SLS) | 100 | 120 | 100 | 80 |
| Geotechnical Resistance (ULS), resistance factor Φ = 0.5 applied | 150 | 180 | 150 | 120 |

(1) At least 0.3m thickness

The following steps are recommended for the construction of any engineered fill:

1. Prepare the subgrade in accordance with Sections 6.2 and 6.3 of this report. This includes removing any and all existing vegetation, topsoil, fill, disturbed earth, any existing structures and/or construction debris, organics, and organic-bearing soils to the competent, undisturbed soil from within the area of the proposed engineered fill, while appropriately managing groundwater conditions.
2. The area of the engineered fill should extend horizontally 1m beyond the outside edge of the proposed foundations and then extend downward at a 1:1 slope to the suitably competent soil.
3. The base of the engineered fill area must be approved by a qualified geotechnical engineer's representative prior to placement of any fill, to ensure that all unsuitable materials have been removed, that the materials encountered are similar to those observed during this investigation, and that the subgrade is suitable for the engineered fill. It is recommended the construction contract include a provisional line-item for woven geotextile equivalent or better than Terrafix 200W to be able to apply such material on the subgrade if and where needed pending subgrade inspections during construction.
4. Engineered fill to consist of Granular B (per OPSS) or a crushed rock (50mm to 100mm minus crusher-run shot rock), or other suitable material approved at the time of construction. All engineered fill material is to be approved by a qualified geotechnical engineer's representative at the time of construction prior to its use. Any fill material placed under wet conditions should consist of an approved, rock-based fill sufficiently free of fines and surrounded by an appropriate non-woven geotextile filter fabric (to prevent migration of surrounding fines into the voids.
5. Place approved engineered fill, in maximum 200mm loose lifts, compacted to 100% of its SPMDD. Any fill placed under wet conditions should consist of an approved, rock-based fill.
6. Full time testing and inspection of the engineered fill will be required, to ensure compliance with material and compaction specifications.

Engineered fill upon which the footings are placed must be a minimum thickness of 0.3m, and the quality of any material considered for engineered fill must be approved prior to its use. Rock-based fill must be completely encapsulated with suitable filter fabric (to minimize any migration of fines from surrounding soils into the rock fill voids). Footings and foundation walls placed on engineered fill must be suitably reinforced; as a minimum, and unless specified otherwise on the structural drawings, such reinforcement should consist of 2 continuous runs of 15M rebar throughout the footings, and 2 continuous runs of 15M rebar throughout the top and bottom of the foundation walls. Self-weight settlement of engineered fill soil compacted to at least 98% SPMDD will depend on soil texture but should be anticipated to be in the range of 0.5% to 0.75% of the fill height. The rate of the settlement will also be a function of soil texture. For engineered fill consisting of Granular B material, a major portion (80% or higher) of the settlement due to the self-weight is expected to be completed during the construction stage before the placement of overlying features.

For frost protection purposes, the footings must be covered by at least 1.2m of earth (or equivalent) in all directions. Backfill to foundations should be accomplished using non-frost susceptible Granular B material.

For design purposes, a seismic Site Class D is recommended.

If any basement areas are included, to assist in managing surficial drainage water and groundwater infiltration towards the buildings, damp-proofing of the subgrade walls (including application of 'dimple board' according to manufacturer's directions) and an appropriately-outletted perimeter foundation drainage system around the building perimeters at their footing level is recommended.

## 6.6 SLAB ON GRADE

Floor slabs for the new buildings may be constructed as normal slabs-on-grade, on granular or clearstone fill over native, inorganic subsoils, prepared in accordance with Sections 6.2 and 6.3 of this report. Slabs should be formed over a base course consisting of at least 150mm of Granular A per OPSS (beneath any basement or otherwise subgrade slabs use crushed 19mm clearstone), compacted to 100% SPMDD. All grade increases or infilling below the granular or clearstone fill should be constructed in accordance with the engineered fill steps provided in Section 6.5 of this report. All fill placed as engineered fill must be inspected, approved and compaction verified by a qualified geotechnical engineer's representative.

For basement or otherwise subgrade areas, it is further recommended that:

- an underslab drainage system be utilized based on using cloth-wrapped, perforated pipe, at least 100mm in diameter, surrounded by clear, crushed stone and suitable filter protection around the stone. The underslab drains should discharge to a positive sump or other permanent frost free outlet.
- a vapour barrier be installed between the final course level of crushed clearstone and the concrete slab.

It is important to remember that the role of the building's drainage system is to protect the building from potential hydrostatic pressures and infiltrations by evacuating the water collected underneath, and around the building's periphery. The drainage system will not protect the building from the migration of humidity through the concrete - it is recommended that the slabs be waterproofed.

## 6.7 BASEMENT & EARTH RETAINING WALLS

Any subsurface structures retaining earth (including basement foundation walls and/or retaining walls) that are located above the groundwater table may be designed for lateral (horizontal) earth pressures using the following equation:

- p = k (w h + q), where:
    - p = the lateral earth pressure in kPa acting on the subsurface structure at depth h;
    - $k_a$ = the coefficient of active earth pressure;
        - = 0.3 for walls restrained from the bottom only;
        - = 0.5 for walls restrained at the top and bottom. (This value is recommended for rigid walls retaining compacted backfill);
    - $k_p$ = the coefficient of passive earth pressure, ( = 3.0);
    - w = the granular or native soil bulk density in $kN/m^3$;
        - = 21 $kN/m^3$ for well compacted, OPSS-approved Granular "B";
        - = 19 $kN/m^3$ for native soils;
    - h = the depth (in metres) below the exterior grade at which the earth pressure is being calculated; and
    - q = the equivalent value of any surcharge (in $kN/m^3$) acting on the ground surface adjacent to the structure.

The recommended value for the coefficient for sliding friction between the soil and the concrete is 0.4. In addition to the above, hydrostatic forces must be taken into account in the design where the retaining structure extends below the groundwater table. Also, any additional surcharge loading that will influence the retaining structure must be taken into account in its design.

Basement walls should be damp-proofed (including application of ‘dimple board’ according to manufacturer’s directions) and an appropriately-outletted perimeter foundation drainage system installed around the building perimeters at their footing level.

## 6.8 ROAD CONSTRUCTION & PAVEMENT

The following recommendations are provided for the design and construction of new roads and paved parking/access areas for the site's development.

1. Per Section 6.2, remove materials including all existing topsoil, fill, organics and organic-bearing materials, and any other obviously deleterious materials to their full depth, as well as frozen earth and boulders larger than 150mm in diameter encountered at subgrade elevation for the full width of construction.
2. Carefully proof-roll the subgrade in the presence of the geotechnical engineer's representative. Any overly soft or wet areas or other obviously deleterious materials must be excavated and properly replaced with suitable, approved backfill material.
3. Backfilling of sub-excavated areas and fine grading may be carried out using OPSS 1010 Granular B Type 1 or Select Subgrade Material (SSM). Organics, organic-bearing materials, and overly wet or silty/clayey soils are not suitable for reuse as backfill. All subgrade backfill materials should be placed in uniform lifts not exceeding 200 mm loose thickness and compacted to at least 95% SPMDD.
4. Adequate drainage must be achieved throughout the pavement areas. There must be positive slopes (combined with subdrains if necessary) within the pavement subgrade, to allow drainage and avoid any water accumulation.
5. Where downgradient movement of groundwater within hydraulically-conductive subgrade or otherwise near-surface soils is evident during construction, the inclusion of subdrains within the subgrade and outletted laterally may be necessary. In any areas where the subgrade exhibits excessive amounts of moisture and any groundwater accumulation, maximize the subgrade drainage by installing subdrains in the subgrade, consisting of 150mm diameter perforated subdrain pipe wrapped with knitted sock geotextile placed in a trench excavated 300 mm by 300 mm into the subgrade. The trench should be backfilled with crushed 19mm clearstone. A geotextile filter fabric wrapping surrounding the stone is required.
6. To minimize the effects of frost on differing subgrade materials, construct transitions between varying depths of granular base materials at a rate of 1:10 or flatter.
7. Granular materials should consist of Granular A and B conforming to the requirements of OPSS Form 1010 or equivalent. All granular materials should have an in-situ moisture content within 2% of their respective optimal moisture content, to assist in achieving appropriate compaction. Granular A and B materials must be in accordance with OPSS Form 1010 or equivalent. The granular courses should be compacted to a minimum 100% of their respective SPMDDs.

8. All asphaltic concrete layers should be placed, spread, and compacted confirming to OPSS Form 310 or equivalent. All asphaltic concrete should be compacted to a minimum 92.0% of their respective laboratory Maximum Relative Densities (MRDs).

The recommended pavement structures for the proposed residential development are provided below:

Table 4: Pavement Structures

| Profile | Material | Minimum Thickness (mm) | | Per OPSS |
|---|---|---|---|---|
| | | Light Duty | Heavy Duty | |
| Asphalt Surface | H.L. 3 | 50 | | 1150 |
| Asphalt Base | H.L. 8 | 50 | | |
| Granular Base | Granular A | 150 | | 1010 |
| Granular Subbase | Granular B Type 1 | 300 | 450 | |

The above-recommended pavement structures are for the end use of the project. During construction of the project, the recommended granular depths may not be sufficient to support loadings encountered including construction traffic and equipment.

The foregoing design considers that construction is carried out during dry periods, at the appropriate above-freezing temperatures, and that the subgrade is stable under construction equipment loadings. If construction is carried out during wet weather and heaving or rolling of the subgrade is experienced from the proof-rolling program, additional thickness of granular materials, geo-grids reinforcement or a combination of the two may be required.

The requirement for additional granular materials and/or utilization of geofabrics/geogrids is best determined during construction under the direction of the geotechnical engineer. However, in view of the above, it is recommended that contingency items be included into the construction contract for subgrade stabilization using either technique so that such methods are contractually available, if and when needed during construction.

## 6.9 STORMWATER MANAGEMENT POND

It is Redstone's understanding that a stormwater management pond (SWP) is proposed for this development in its northern portion (in the area of Test holes TP22-06, MW22-02 and BH22-11). Details regarding the SWP's proposed grades including its base and slopes were not available as of writing this report. The recommendations provided herein are therefore based on assumed SWP grades remaining relatively shallow (to minimize impacts from/to the groundwater including underlying pressurized aquifer). Once the final design details are available, these assumptions should be verified and these recommendations updated (if deemed necessary).

The safe excavation depths (per Section 6.1) must be considered. Due to the previously-noted presence of an underlying pressurized (artesian) aquifer and likely leaky aquitard layer in this area, it is strongly recommended that that SWP design and construction avoid excavating any deeper than is necessary (i.e., to strip surficial topsoil) so as to minimize impacts from the artesian pressure on the SWP and its construction. In any case, the construction may encounter the artesian pressure and the Contactor must be prepared to manage it appropriately.

In the proposed SWP area the native soils underlying the existing surface topsoil generally consist of sand and silt with some clay and gravel (in TP22-06) or silty sand with some clay (in MW22-02) or clayey silt with trace to some sand and trace to some gravel (in BH22-11). These soils were typically moist and described as loose to very loose. A gradation analysis performed on a sample of the sand and silt from TP22-06 (GS2 at about 0.9mbeg) suggests the following composition: 16% gravel, 36% sand, 35% silt and 13% clay-sized particles. Based on this gradation the hydraulic conductivity of such native soils is expected to be on the order of about $10^{-5}$ to $10^{-6}$cm/sec. It is noted, however, that slight variations in the soil stratigraphy may cause variations in the permeability of the soil in both vertical and horizontal orientations. Further, the soil type and gradation does vary based on the Test holes, which will cause the range of hydraulic conductivities to broaden.

Based on the soils observed, and a base grade at or just below the existing surface (to allow for topsoil stripping), it appears that construction of the SWP in this area is feasible. In general, shallow stripping of topsoil should not encounter significant groundwater provided it remains above the safe excavation depths (Section 6.1) in the context of the underlying pressurized (artesian) aquifer. Appropriate measures must be taken during construction to minimize any overland or near-surficial flow of water into the area.

Groundwater and surficial water inflow into the open SWP excavation is expected, however this is generally expected to be controlled by pumping from within the excavation, along with further measures if required including (but not necessarily limited to) well points or depressurization wells during construction. Up-gradient cutoff trenching with appropriate drainage outletting may be required during construction, and permanent drainage piping installed beneath the SWP base and suitably outletted should be considered to minimize effects from groundwater upwelling and optimize long-term performance of the SWP.

It is recommended that the SWP subgrade surfaces be proof rolled, and a geotechnical engineer's representative approve the subgrade prior to construction of the SWP berms. Construction of the berms may utilize excess site soils having a hydraulic conductivity of $10^{-5}$cm/sec or lower (i.e., generally soils consisting primarily of silt and/or clay). Such operations should place the soils in lifts no thicker than 150mm prior to compaction, and compacted to at least 95% SPMDD. It is noted that such soils can be challenging to work with due to their nature including elevated moisture contents and difficulty handling and compacting.

It is recommended that the base of the SWP be protected with an appropriate liner. The native, disturbed silty sand or sand soils in a re-compacted form would not be suitable to form the SWP's liner since the expected permeability would be too high. Conversely, the native soils having finer-grained gradation (silts and clays) would have a sufficiently low permeability and could substitute for a liner. An inspection of the excavated and exposed SWP surfaces should be performed at the time of construction, to assess where areas of increased hydraulic conductivity are present within the exposed soils, so that such areas may be lined with a more suitable (ie, less hydraulically conductive) material. It is expected that this can be accomplished using the site's silt and/or clay soils, coordinated with geotechnical inspection and approval of such materials prior to being used. It is recommended that construction of the SWP liner using such approved material be at least 600mm thick, and placed under full time geotechnical inspections.

For the purpose of the proposed SWP, the berms should be stable from slip circle failure if sloped at 3 horizontal to 1 vertical (3H:1V) or flatter in the long term both above and below the SWP's waterlevel. Between the stable water level and the expected high water level, it is recommended that the slopes be lessened to 5H:1V (or flatter) to guard against erosion by wavelet action. Slopes and berms of the SWP should be constructed so as to reduce or eliminate the effects of surficial erosion. Features to do so may include slope vegetation, installation of erosion or gabion mats, rip rap, and/or other acceptable stabilizing features.

Trench plugs should be constructed around all utilities connected to the SWP, to minimize or eliminate the possibility of piping (erosion of soils) resulting from groundwater flow around such trenched utilities.

It is recommended that a regular maintenance program for the SWP include monitoring of it for any potential slope erosion, degradation, or otherwise undesirable structural conditions. Should any such conditions become evident, immediate mitigative actions must be performed.

## 6.10 GENERAL RECOMMENDATIONS

### 6.10.1 Subsoil Sensitivity

The native subgrade soils are susceptible to strength loss or deformation if saturated or disturbed by construction traffic. Therefore, where the subgrade consists of approved soil, care must be taken to protect the exposed subgrade from excess moisture and from construction traffic. If there is site work carried out during periods of wet weather and/or elevated groundwater levels, then it can be expected that the subgrade will be disturbed unless a suitable working surface is provided to protect the integrity of the subgrade soils from construction traffic. Subgrade soil preparation work cannot be adequately accomplished during overly wet weather, and the project must be scheduled accordingly.

### 6.10.2 Test Pits During Tendering

It is recommended that the proponent consider excavating test pits at representative locations of this site during the construction tendering phase, with mandatory attendance of bidding Contractors. This will allow them to make their own assessments of the fill, soil, and groundwater conditions, and how these will affect their proposed construction methods, techniques and schedules.

### 6.10.3 Groundwater/Dewatering Professional

It is strongly recommended that the Contractor retain a qualified, experienced groundwater/ dewatering professional to make their own assessments regarding groundwater conditions, its potential impacts on construction, and strategies to appropriately control such groundwater.

### 6.10.4 Winter Construction

The subsoils encountered at the site can be frost-susceptible and freezing conditions could cause problems to preparations for foundation, sidewalks and/or pavement subgrades. As preventive measures, the following is recommended:

1. Exposed surfaces intended to support foundations must be protected against freezing by means of loose straw and tarpaulins, heating, etc.
2. Care must be exercised so that any sidewalks and/or asphalt pavements do not interfere with the opening of doors during the winter when the soils are subject to frost heave. This problem may be minimized by any one of several means including (but not necessarily limited to) keeping the doors well above outside grade, installing structural slabs at the doors, and/or by using well graded backfill and positive drainage.
3. Because of the potential for soils to experience frost heave during winter, it is recommended that exterior service trenches be excavated with shallow transition slopes to minimize the abrupt change in density and frost-susceptibility between the granular backfill (relatively non-frost susceptible) and native soils (generally more frost-susceptible).

### 6.10.5 Borehole Sealing & Well Decommissioning

Wells that exist on site (including monitoring wells installed by DM Wills as part of this investigation) are the property of the site owner. The monitoring wells can be maintained, for the time being, to facilitate groundwater monitoring that can lead up to construction, and/or in support of any EASR or PTTW applications. Should such monitoring become unnecessary and the wells become inactive and/or unmaintained, and in any case prior to or during initial stages of site construction, the wells must be decommissioned by an appropriately-licensed well contractor in compliance with O.Reg. 903.

DM Wills reported that following advancement of the boreholes drilled for this investigation, they were backfilled with bentonite chips to near surface, and cuttings were used for the final 1.0 to 1.2m to ground level. It must be noted that despite the backfilling operations including bentonite acting as a sealant, backfilled boreholes should be considered weakened columns of soil within the context of the pressurized (artesian) aquifer beneath this site, with the potential for upwards groundwater movement in and/or around such columns.

It is recommended that all wells and boreholes be suitably decommissioned and sealed to their full depth by a licensed well contractor prior to construction excavations commencing.

#### 6.10.6 Further Subsurface Exploration and Analysis

Further work for this project is recommended, as follows:

- Additional boreholes / monitoring wells: in order to suitably assess the ground conditions related to the pressurized artesian aquifer for detailed design purposes (including identifying safe excavation depths and applicable areas), it is strongly recommended that further subsurface exploration and analysis be performed. This should include advancement of additional boreholes and monitoring wells in key areas of the site including its northerly portion where artesian groundwater conditions were encountered, with a focus on assessing the thickness of the confining aquitard layer, depth to the confined aquifer, and delineating developmental areas where safe excavation depths will apply.
- Further groundwater monitoring: groundwater levels in monitoring wells (both existing wells and additional wells - see above) should be monitored at least seasonally for an annual basis to assess such groundwater level fluctuations that may impact the development's design, construction, and longer-term performance.

#### 6.10.7 Design Review and Construction Inspections

Due to the preliminary nature of the design details at the time of this report, Redstone must be allowed to review the design and proposed grading plans prior to their finalization, and provide updated recommendations if necessary at that time. In addition, it is strongly recommended that Redstone be retained to review the related earthworks specifications when they are available.

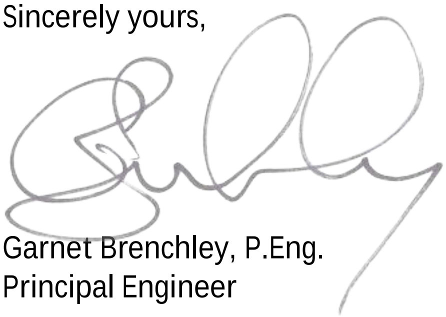
During construction, experienced geotechnical staff must observe construction activities and ensure geotechnical recommendations are carried out.

## 7.0 CLOSURE AND STATEMENT OF LIMITATIONS

The recommendations made in this report are in accordance with our present understanding of the project. The subsurface investigation was performed in accordance with current, generally accepted guidelines. However, should any conditions at the site be encountered which differ from those at the borehole locations, it is requested that Redstone be notified immediately in order to permit a reassessment of our recommendations in light of the changed conditions and exact project details. Redstone requests that they be permitted to review the recommendations of this report after the drawings and specifications are complete, or if the final project details should differ from that mentioned in this report.

The attached Statement of Limitations is an integral part of this report. Should questions arise regarding any aspect of this report, please contact our office.

Sincerely yours,




Garnet Brenchley, P.Eng.
Principal Engineer

## STATEMENT OF LIMITATIONS

This report is intended solely for D.M. Wills Associates Limited and other parties explicitly identified in the report and is prohibited for use by others without Redstone's prior written consent. This report is considered Redstone's professional work product and shall remain the sole property of Redstone. Any unauthorized reuse, redistribution of or reliance on the report shall be at the Client and recipient's sole risk, without liability to Redstone. Client shall defend, indemnify and hold Redstone harmless from any liability arising from or related to Client's unauthorized distribution of the report. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include all supporting drawings and appendices.

The recommendations made in this report are in accordance with our present understanding of the project, the current site use, ground surface elevations and conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of geotechnical engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

All details of design and construction are rarely known at the time of completion of a geotechnical study. The recommendations and comments made in the study report are based on our subsurface investigation and resulting understanding of the project, as defined at the time of the study. We should be retained to review our recommendations when the drawings and specifications are complete. Without this review, Redstone will not be liable for any misunderstanding of our recommendations or their application and adaptation into the final design.

By issuing this report, Redstone is the geotechnical engineer of record. It is recommended that Redstone be retained during construction of any and all foundations, and during earthwork operations to confirm the conditions of the subsoil are actually similar to those observed during our study. The intent of this requirement is to verify that conditions encountered during construction are consistent with the findings in the report and that inherent knowledge developed as part of our study is correctly carried forward to the construction phases.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the ten (10) test pits and twelve (12) borehole locations only (as advanced by DM Wills). Redstone Engineering is not responsible for the reinstated condition of the ground within and surrounding these 22 testholes completed by DM Wills. The subsurface conditions confirmed within these twenty-two (22) locations may vary at other locations. The subsurface conditions can also be significantly modified by construction activities on site (ex. excavation, dewatering and drainage, blasting, pile driving, etc.). These conditions can also be modified by exposure of soils or bedrock to humidity, dry periods or frost. Soil and groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction which could not be detected or anticipated at the time of our investigation. Should any conditions at the site be encountered which differ from those found at the test locations, notify Redstone Engineering immediately in order to permit a reassessment of these recommendations. If changed conditions are identified during construction, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by Redstone is completed.

# APPENDIX A

# (DM WILLS DOCUMENTS)

- Proposed Residential Development; Draft Plan … 1pg
- Subsurface Investigation Plan … 1pg
- Test Pit & Borehole Logs … 22pgs
- Laboratory Results … 7pgs


KEY PLAN

| REVISIONS | | |
|---|---|---|
| No. | Description | Date |
| | | |

| | |
|---|---|
| METRIC | Dimensions are in METRES and/or MILLIMETRES unless otherwise shown |
| LEGEND | TO BE READ IN CONJUNCTION WITH OPSD 100 SERIES |

| SUMMARY TABLE | |
|---|---|
| 85162 – WALLACE POINT ROAD, OTONABEE–SOUTH MONAGHAN | |
| REGULATIONS | PROPOSED |
| NUMBER OF LOTS | 50 RESIDENTIAL LOTS<br>1 COMMERCIAL BLOCK<br>1 SWM BLOCK<br>1 ACCESS BLOCK |
| LOT AREA (MIN.) | 0.79 ACRE (3197.0m²) |
| LOT FRONTAGE (MIN.) | 25.0m |
| AVERAGE LOT DEPTH | 72–84m |
| ROAD AREA | – |
| BUFFER AREAS | – |
| TOTAL SITE AREA | 24.79ha |


WILLS

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E. wills@dmwills.com


Project Name/Location

# PROPOSED RESIDENTIAL DEVELOPMENT

3491 WALLACE POINT ROAD, PETERBOROUGH

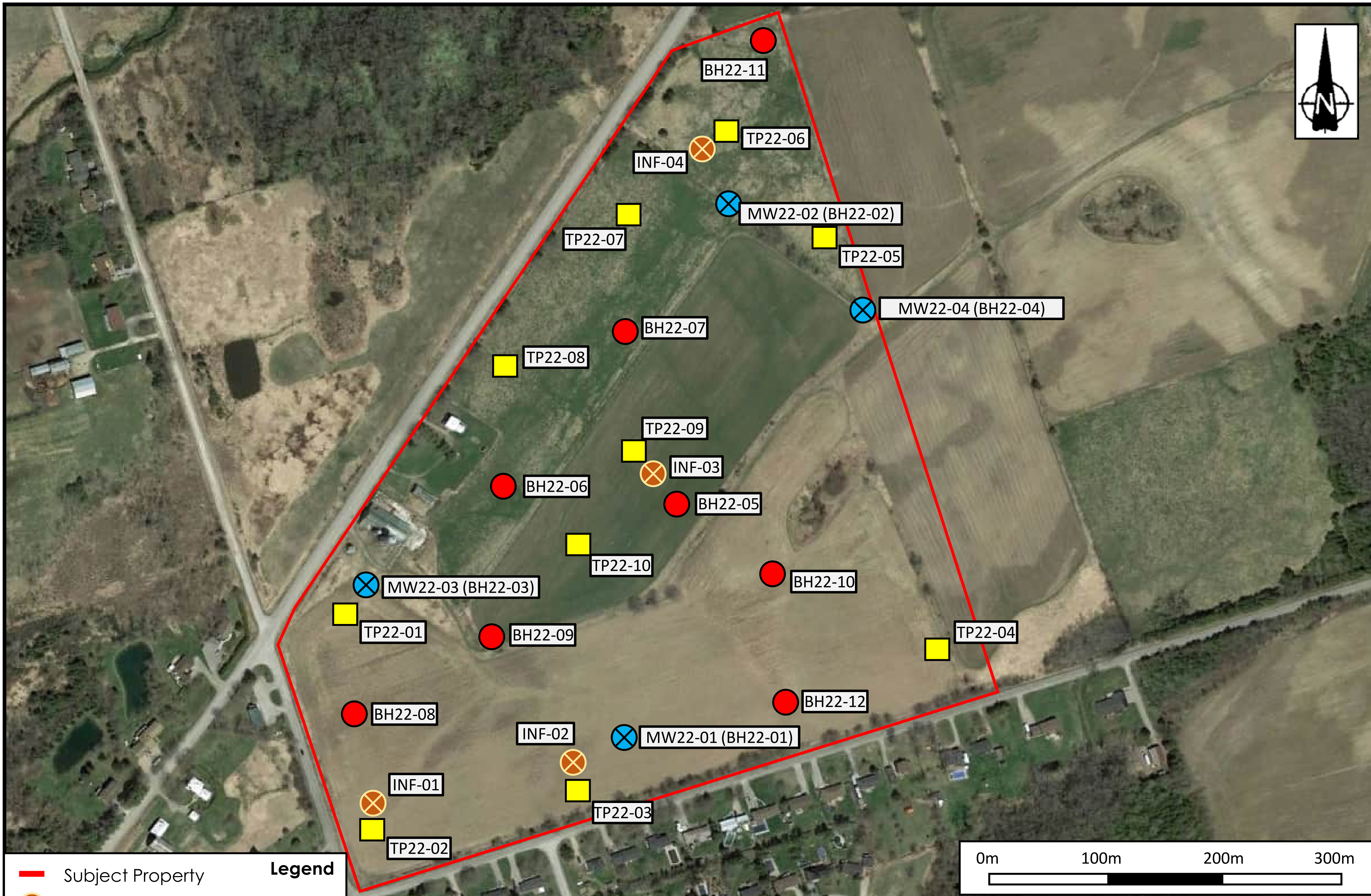
Drawing Title

## DRAFT PLAN

| | | |
|---|---|---|
| Drawn By: M.B. | SCALE: Horz. 1:1500 Vert. – | |
| Designed By: M.B. | Issue Date: February 23, 2023 | |
| Checked By: J.D.F. | Project No.: 21–85162 | Sht. No.: |
| Engineer: ––– | Dwg File No.: 85162 – DPV2 | 200 |

NOT FOR CONSTRUCTION


Printed By: mbell Printed On: February 23, 2023
q:\85000 - private\85100-85199\85162 - 3491 wallace point rd\02 drawings\02 current drawings\cad\spg\85162 - dpv2.dwg




**Legend**

- Subject Property
- Infiltration Test (INF)
- Test Pit (TP)
- Borehole (BH)
- Monitor Well (MW)

**Subsurface Investigation Plan**

3491 Wallace Point Road,
Township of Otonabee-South
Monaghan, Ontario

WILLS

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| | | | |
|---|---|---|---|
| Drawn By | LT | Scale | See scale bar |
| Checked | IA | Date | July, 2022 |
| | | | |
| Project No. | 21 - 85162 | Drawing File No. | Figure 2 |

**Project Number:** 21-85261
**Project Location:** 3491 Wallace Point Road, Otonabee-South Monaghan
**Project Name:** Wallace Point Subdivision
**Client:** Nirvana Homes

## Test Pit – TP22-01

| Excavation Date: June 20, 2022 | Elevation: 197.540 masl | UTM: 17T 713994 m E, 4800777 m N |
|---|---|---|

| Depth (mbg) | Soil Description |
|---|---|
| 0.0 – 0.9 | Brown sandy silt topsoil, trace clay, moist |
| 0.9 - 1.4 | Light brown sandy silt, some clay, moist |
| 1.4 – 2.9 | Grey to light brown silty sand, some clay, trace gravel, occasional cobble, orange-brown mottling, moist to wet below 1.0 mbg |

**Groundwater**

- Minor groundwater seepage at 1.0 mbg

**Additional Notes**

- Test pit terminated at 2.9 mbg
- 0.1 m of pooling water in test pit upon completion
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**

**Project Number:** 21-85261
**Project Location:** 3491 Wallace Point Road, Otonabee-South Monaghan
**Project Name:** Wallace Point Subdivision
**Client:** Nirvana Homes

**Test Pit – TP22-02**

| Date Completed: June 20, 2022 | Elevation: 201.889 masl | UTM: 17T 714016 m E, 4900575 m N |
|---|---|---|
| **Depth (mbg)** | **Soil Description** | |
| 0.0 – 1.1 | Brown sandy silt topsoil, trace clay, moist | |
| 1.1 – 2.9 | Light brown silty sand, some clay, trace gravel, occasional cobble below 2.3 mbg, moist to wet below 1.8 m | |
| **Grab Sample Summary** | | |
| GS-02 collected at approximately 1.2 mbg | GS2 GSA:<br>0% Gravel<br>64% Sand<br>24% Silt<br>12% Clay | |

**Groundwater**

- Groundwater seepage at 2.2 mbg

**Additional Notes**

- Test pit terminated at 2.9 mbg
- Test pit walls sloughing below 2.2 mbg
- 0.2 m of pooling water in test pit upon completion
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**

**Project Number:** 21-85261
**Project Location:** 3491 Wallace Point Road, Otonabee-South Monaghan
**Project Name:** Wallace Point Subdivision
**Client:** Nirvana Homes

**Test Pit – TP22-03**

| Date Completed: June 20, 2022 | Elevation: 206.581masl | UTM: 17T 714172 m E, 4900605 m N |
|---|---|---|

| Depth (mbg) | Soil Description |
|---|---|
| 0.0 – 0.2 | Brown sandy silt topsoil, trace clay, moist |
| 0.2 – 0.6 | Light brown sandy silt, some clay, moist |
| 0.6 – 2.7 | Light grey-brown sandy silt, some clay, trace gravel, occasional cobble/boulder, moist |
| **Grab Sample Summary** | |
| GS-03 collected at approximately 1.2 mbg | GS3 GSA:<br>2% Gravel<br>29% Sand<br>49% Silt<br>20% Clay |

**Groundwater**

- Groundwater not encountered

**Additional Notes**

- Test pit terminated at 2.7 mbg
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**

**Project Number:** 21-85261
**Project Location:** 3491 Wallace Point Road, Otonabee-South Monaghan
**Project Name:** Wallace Point Subdivision
**Client:** Nirvana Homes

**Test Pit – TP22-04**

| Date Completed: June 20, 2022 | Elevation: 201.163 masl | UTM: 17T 714478 m E, 4900745 m N |
|---|---|---|

| Depth (mbg) | Soil Description |
|---|---|
| 0.0 – 0.5 | Brown sandy silt topsoil, trace clay, moist |
| 0.5 – 2.9 | Light orange-brown to light grey-brown sandy silt, some clay, trace to some gravel, moist to wet below 2.1 mbg |

**Groundwater**

- Groundwater encountered at 2.1 mbg

**Additional Notes**

- Test pit terminated at 2.9 mbg
- 0.1 m of pooling water in test pit upon completion
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**

**Project Number:** 21-85261
**Project Location:** 3491 Wallace Point Road, Otonabee-South Monaghan
**Project Name:** Wallace Point Subdivision
**Client:** Nirvana Homes

**Test Pit – TP22-05**

| Date Completed: June 20, 2022 | Elevation: 195.699 masl | UTM: 17T 714363 m E, 4901125 m N |
|---|---|---|

| Depth (mbg) | Soil Description |
|---|---|
| 0.0 – 0.3 | Brown sandy silt topsoil, trace clay, moist |
| 0.3 - 1.4 | Light brown to grey clayey silt, trace sand, some gravel, occasional cobble, drier than plastic limit |
| 1.4 – 2.7 | Grey sandy silt, some clay, increasing cobble content with depth, wet |

**Groundwater**

- Groundwater seepage at 1.4 mbg

**Additional Notes**

- Test pit terminated at 2.7 mbg
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**

**Project Number:** 21-85261
**Project Location:** 3491 Wallace Point Road, Otonabee-South Monaghan
**Project Name:** Wallace Point Subdivision
**Client:** Nirvana Homes

**Test Pit – TP22-06**

| Date Completed: June 20, 2022 | Elevation: 194.991masl | UTM: 17T 714306 m E, 4901184 m N |
|---|---|---|

| Depth (mbg) | Soil Description |
|---|---|
| 0.0 – 0.3 | Brown sandy silt topsoil, trace clay, some gravel, moist |
| 0.3 – 2.7 | Grey to orange-brown sand and silt, some clay, some gravel, occasional cobble below 1.8 m, moist to wet below 1.1 mbg |

**Grab Sample Summary**

| | |
|---|---|
| GS-02 - collected at approximately 0.9 mbg | GS2 GSA:<br>16% Gravel<br>36% Sand<br>35% Silt<br>13% Clay |

**Groundwater**

- Groundwater seepage at 1.1 mbg

**Additional Notes**

- Test pit terminated at 2.7 mbg
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**

**Project Number:** 21-85261
**Project Location:** 3491 Wallace Point Road, Otonabee-South Monaghan
**Project Name:** Wallace Point Subdivision
**Client:** Nirvana Homes

### Test Pit – TP22-07

| Date Completed: June 20, 2022 | Elevation: 195.670 masl | UTM: 17T 714246 m E, 4901136 m N |
|---|---|---|

| Depth (mbg) | Soil Description |
|---|---|
| 0.0 – 0.5 | Brown sandy silt topsoil, trace clay, moist |
| 0.5 - 1.8 | Light brown to grey sandy silt to sand and silt, some clay, trace gravel, occasional cobble, moist |

**Groundwater**

- Groundwater not encountered

**Additional Notes**

- Test pit terminated at 1.8 mbg
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**

**Test Pit – TP22-08**

| Date Completed: June 20, 2022 | Elevation: 196.848 masl | UTM: 17T 714110 m E, 4900977 m N |
|---|---|---|

| Depth (mbg) | Soil Description |
|---|---|
| 0.0 – 0.5 | Brown sandy silt topsoil, trace clay, moist. |
| 0.5 – 2.7 | Grey to light orange-brown, sandy clayey silt, trace to some gravel, occasional cobble, moist |

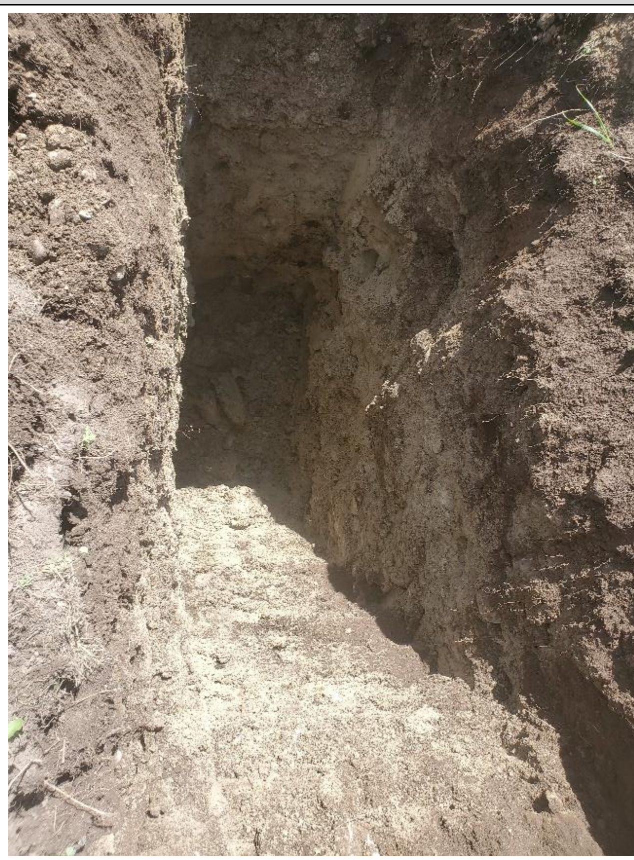
**Groundwater**

- Groundwater not encountered

**Additional Notes**

- Test pit terminated at 2.7 mbg
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**



**Project Number:** 21-85261
**Project Location:** 3491 Wallace Point Road, Otonabee-South Monaghan
**Project Name:** Wallace Point Subdivision
**Client:** Nirvana Homes

**Test Pit – TP22-09**

| Date Completed: June 20, 2022 | Elevation: 196.924 masl | UTM: 17T 714216 m E, 4900901 m N |
|---|---|---|

| Depth (mbg) | Soil Description |
|---|---|
| 0.0 – 0.3 | Brown sandy silt topsoil, trace clay, moist. |
| 0.3 – 2.4 | Light grey-brown to orange-brown sandy silt, some clay to clayey, trace gravel, occasional cobble below 1.2 mbg, moist. |

**Groundwater**

- Groundwater not encountered

**Additional Notes**

- Test pit terminated at 2.4 mbg
- Walls collapsing below 1.1 mbg upon test pit completion
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**

**Project Number:** 21-85261
**Project Location:** 3491 Wallace Point Road, Otonabee-South Monaghan
**Project Name:** Wallace Point Subdivision
**Client:** Nirvana Homes

**Test Pit – TP22-10**

| Date Completed: June 20, 2022 | Elevation: 197.349 masl | UTM: 17T 714175 m E, 4900837 m N |
|---|---|---|

| Depth (mbg) | Soil Description |
|---|---|
| 0.0 – 0.3 | Brown sandy silt topsoil, some clay, moist |
| 0.3 - 1.2 | Light brown to grey sandy silt, some clay, trace gravel, moist |
| 1.4 – 2.9 | Grey to light brown clayey silt, drier than plastic limit |

**Groundwater**

- Groundwater not encountered

**Additional Notes**

- Test pit terminated at 2.9 mbg
- Test pit backfilled and nominally compacted using excavator following completion of stratigraphic logging and sampling

**Test Pit Photos**

# WELL NUMBER MW22-01



D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

**CLIENT** Nirvana Homes

**PROJECT NAME** Geotechnical and Hydrogeological Investigation

**PROJECT NUMBER** 21-85162

**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee

**DATE STARTED** 7/13/22 **COMPLETED** 7/13/22

**UTM EASTING** 714171 **NORTHING** 4900635

**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.

**GROUND ELEVATION** 205.512 masl

**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons

**GROUNDWATER LEVELS:**

**LOGGED BY** LT **CHECKED BY** IA

**AT END OF DRILLING** No measurable groundwater

**NOTES** BH22-01

**AFTER DRILLING** 5.93 m / Elev 199.58 m

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | MATERIAL DESCRIPTION | Depth / Elev. |
|---|---|---|---|---|---|---|
| 0.20 | | | | | TOPSOIL: Brown silty sand topsoil, trace clay, moist, loose | 205.31 |
| | SS 1 | 23 | 3-3-4-7 (7) | MC: 11 % | SILTY SAND: Brown silty sand to sand and silt, trace clay, trace gravel, occasional cobble, moist, compact | |
| 1 | SS 2 | 33 | 7-7-10 (17) | MC: 9 % | | |
| 2 | SS 3 | 87 | 5-10-8 (18) | MC: 9 % | | |
| | SS 4 | 98 | 12-25-15 (40) | MC: 9 % | - dense | |
| 3 | SS 5 | 54 | 8-7-9 (16) | MC: 7 % | - compact | |
| 4.65 | | | | | -wet cm-scale sand stringer | 200.86 |
| 5 | SS 6 | 109 | 27-50-50 (100) | MC: 8 % | SILT: Light brown silt, some sand, trace clay, trace gravel, moist, very dense | |
| 6.10 | | | | WL July 28/22: 5.93 mbg | | 199.41 |
| 6.55 | SS 7 | 65 | 6-25-30 (55) | MC: 12 % | SILTY SAND: Grey silty sand, trace clay, trace gravel, wet, very dense | 198.96 |

Borehole terminated in silty sand at 6.55 mbg.

**WELL DIAGRAM**

Casing Top Elev: 0.82 (m)
Casing Type: Monument

Bentonite seal from 0 to 2.75 mbg.

Quartz sand pack filter from 2.75 to 6.10 mbg.
Point 10 slotted screen from 3.05 to 6.10 mbg.

# WELL NUMBER MW22-02



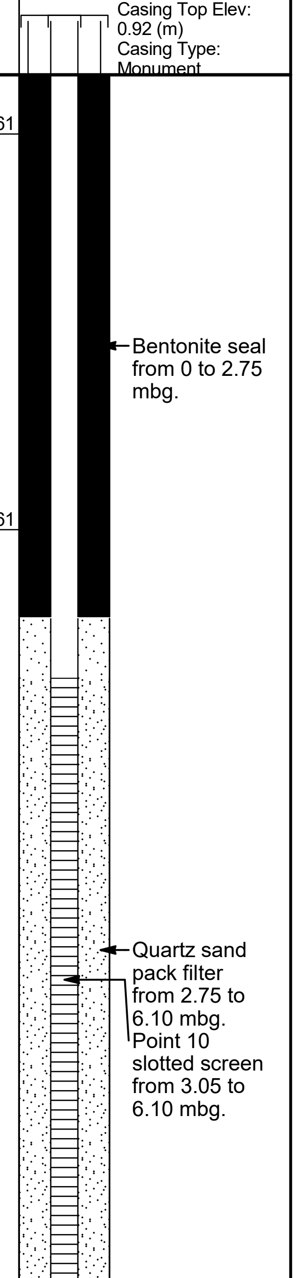
D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

**CLIENT** Nirvana Homes
**PROJECT NAME** Geotechnical and Hydrogeological Investigation
**PROJECT NUMBER** 21-85162
**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee
**DATE STARTED** 7/11/22 **COMPLETED** 7/11/22
**UTM EASTING** 714306 **NORTHING** 4901128
**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.
**GROUND ELEVATION** 194.905 masl
**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons
**GROUNDWATER LEVELS:**
**LOGGED BY** LT **CHECKED BY** IA
**AT END OF DRILLING** Groundwater at surface
**NOTES** BH22-02
**AFTER DRILLING** -0.72 m / Elev 195.63 m

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|
| 0.30 (194.61) | SS 1 | 4 | 1-1-1-2 (2) | MC: 21 % | TOPSOIL: Brown silty sand topsoil, trace clay, rootlets, moist, loose |
| | | | | | SILTY SAND: Brown-grey silty sand, some clay, moist, loose |
| 1 | SS 2 | 100 | 4-2-4 (6) | MC: 24 % | |
| 2 | SS 3 | 100 | 2-6-8 (14) | MC: 10 % | - compact |
| 2.30 (192.61) | SS 4 | 65 | 10-12-11 (23) | MC: 8 % | SANDY SILT: Grey sandy silt, trace clay, trace gravel, occasional cobble, moist, compact |
| 3 | SS 5 | 61 | 10-9-10 (19) | MC: 9 % | -wet |
| 5 | SS 6 | 65 | 8-9-13 (22) | MC: 6 % | -some gravel, saturated |
| 6.55 (188.36) | SS 7 | 65 | 10-26-22 (48) | MC: 17 % | - cm scale sand stringer, dense |

Borehole terminated in sandy silt at 6.55 mbg. Artesian conditions encounterered. Piezometric level at 0.72 meters above grade on July 28, 2022.

WELL DIAGRAM



D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

# WELL NUMBER MW22-03

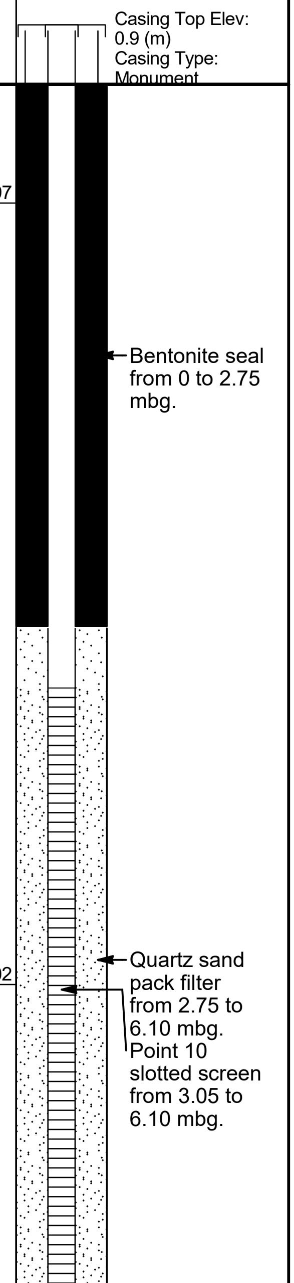


**CLIENT** Nirvana Homes
**PROJECT NAME** Geotechnical and Hydrogeological Investigation
**PROJECT NUMBER** 21-85162
**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee
**DATE STARTED** 7/11/22 **COMPLETED** 7/11/22
**UTM EASTING** 714010 **NORTHING** 4900799
**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.
**GROUND ELEVATION** 197.573 masl
**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons
**GROUNDWATER LEVELS:**
**LOGGED BY** LT **CHECKED BY** IA
**AT END OF DRILLING** 4.55 m / Elev 193.02 m
**NOTES** BH22-03
**AFTER DRILLING** 3.55 m / Elev 194.02 m

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | MATERIAL DESCRIPTION | Depth / Elev. |
|---|---|---|---|---|---|---|
| 0.00–0.60 | SS 1 | 25 | 3-4-6-8 (10) | MC: 20 % | TOPSOIL: Brown silty sand topsoil, trace clay, moist, loose | 0.60 / 196.97 |
| 1 | SS 2 | 89 | 2-3-3 (6) | MC: 19 % | SILTY SAND: Brown silty sand to sand and silt, some clay, trace gravel, moist, loose - orange-brown mottling | |
| 2 | SS 3 | 65 | 6-5-3 (8) | MC: 10 % | | |
| | SS 4 | 100 | 5-5-5 (10) | MC: 13 % | - compact | |
| 3 | SS 5 | 100 | 5-4-6 (10) | MC: 11 % WL July 28/22:3.55 mbg | | |
| 4 | | | | WL in open borehole July 11th, 2022 | | 4.55 / 193.02 |
| 5 | SS 6 | 65 | 40-18-15 (33) | MC: 18 % | SILT: Grey silt, some sand, trace clay, trace gravel, occasional cobble, saturated, dense | |
| 6 | SS 7 | 65 | 10-18-24 (42) | MC: 15 % | | 6.55 / 191.02 |

Borehole terminated in silt at 6.55 mbg.

WELL DIAGRAM



D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

# WELL NUMBER MW22-04

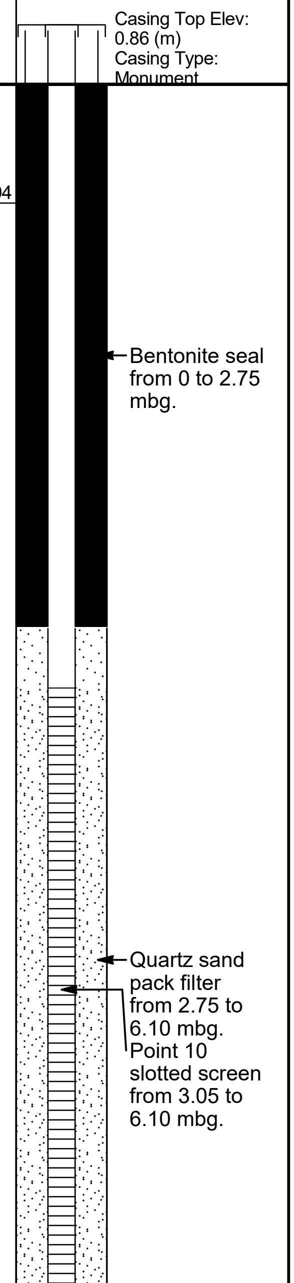


**CLIENT** Nirvana Homes
**PROJECT NAME** Geotechnical and Hydrogeological Investigation
**PROJECT NUMBER** 21-85162
**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee
**DATE STARTED** 7/12/22 **COMPLETED** 7/12/22
**UTM EASTING** 714425 **NORTHING** 4901049
**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.
**GROUND ELEVATION** 197.536 masl
**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons
**GROUNDWATER LEVELS:**
**LOGGED BY** LT **CHECKED BY** IA
**AT END OF DRILLING** 5.80 m / Elev 191.74 m
**AFTER DRILLING** 2.77 m / Elev 194.77 m
**NOTES** BH22-04

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|
| 0.00–0.60 | SS 1 | 41 | 1-3-1-4 (4) | MC: 14 % | TOPSOIL: Brown silty sand topsoil, trace clay, moist, loose (0.60 / 196.94) |
| 1 | SS 2 | 65 | 4-5-6 (11) | MCt: 10 % | SILTY SAND: Brown silty sand, trace to some clay, trace gravel, moist to wet, compact |
| 2 | SS 3 | 65 | 7-6-6 (12) | MC: 10 % | |
| | SS 4 | 91 | 4-14-7 (21) | MC: 8 % | |
| | | | | WL July 28/22: 2.77 mbg | |
| 3 | SS 5 | 100 | 6-8-12 (20) | MC: 8 %<br>GSA SS-5:<br>Gravel 14%<br>Sand 47%<br>Silt 24%<br>Clay 15% | -some clay, some gravel |
| 4 | | | | | -grey-brown |
| 5 | SS 6 | 65 | 8-13-16 (29) | MC: 7 % | |
| 6 | | | | WL in open borehole July 12th, 2022 | |
| 6.55 | SS 7 | 65 | 11-13-13 (26) | MC: 7 % | (6.55 / 190.99) |

Borehole terminated in silty sand at 6.55 mbg.

WELL DIAGRAM



D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

# BORING NUMBER BH22-05



**CLIENT** Nirvana Homes

**PROJECT NAME** Geotechnical and Hydrogeological Investigation

**PROJECT NUMBER** 21-85162

**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee

**DATE STARTED** 7/12/22 **COMPLETED** 7/12/22

**UTM EASTING** 714262 **NORTHING** 4900865

**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.

**GROUND ELEVATION** 199.679 masl

**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons

**GROUNDWATER LEVELS:**

**LOGGED BY** LT **CHECKED BY** IA

**AT END OF DRILLING** 3.65 m / Elev 196.03 m

**NOTES**

**AFTER DRILLING** ---

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| | SS 1 | 30 | 1-2-6-13 (8) | MC: 14 % | | TOPSOIL: Brown silty sand topsoil, trace clay, moist, loose |
| 0.55 | | | | | | 199.13 |
| 1 | SS 2 | 65 | 9-8-7 (15) | MC: 8 % | | SILTY SAND: Brown-grey silty sand to sandy silt, some clay, trace to some gravel, moist, compact |
| 2 | SS 3 | 100 | 5-6-7 (13) | MC: 9 % | | |
| | SS 4 | 111 | 6-5-7 (12) | MC: 9 % | | -cm-scale sand stringer, wet |
| 3 | SS 5 | 115 | 7-9-13 (22) | MC: 12 % | | |
| 4 | | | | WL in open borehole July 12th, 2022 | | |
| 4.55 | | | | | | 195.13 |
| 5 | SS 6 | 115 | 6-12-19 (31) | MC: 17 % | | SILT: Grey silt, some sand to sandy, trace silt, wet, dense<br>-cm-scale coarse sand stringer |
| 6 | SS 7 | 100 | 8-15-16 (31) | MC: 18 % | | -trace gravel |

Borehole terminated in silt at 6.55 mbg. Borehole caved to 5.1 mbg following completion.

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Peterborough, Ontario K9J 0B9

# BORING NUMBER BH22-06



**CLIENT** Nirvana Homes
**PROJECT NAME** Geotechnical and Hydrogeological Investigation
**PROJECT NUMBER** 21-85162
**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee
**DATE STARTED** 7/11/22 **COMPLETED** 7/11/22
**UTM EASTING** 714120 **NORTHING** 4900877
**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.
**GROUND ELEVATION** 196.176 masl
**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons
**GROUNDWATER LEVELS:**
**LOGGED BY** LT **CHECKED BY** IA
**AT END OF DRILLING** 3.65 m / Elev 192.53 m
**NOTES**
**AFTER DRILLING** ---

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0.00–0.60 | SS 1 | 25 | 1-1-2-5 (3) | MC: 12 % | | TOPSOIL: Brown silty sand topsoil, trace clay, moist, very loose (0.60 / 195.58) |
| 0.60–4.55 | SS 2 | 65 | 3-2-4 (6) | MC: 11 % | | SILTY SAND: Brown-grey silty sand, some clay, trace to some gravel, moist to wet, loose<br>- orange-brown mottling |
| | SS 3 | 78 | 2-1-2 (3) | MC: 11 % | | - very loose |
| | SS 4 | 100 | 5-7-13 (20) | MC: 8 % | | - moist, compact |
| | SS 5 | 72 | 10-19-25 (44) | MC: 6 %<br>WL in open borehole July 11th, 2022 | | - dense (4.55 / 191.63) |
| 4.55–6.10 | SS 6 | 78 | 8-18-32 (50) | MC: 13 %<br>GSA SS-6:<br>Gravel 8%<br>Sand 16%<br>Silt 71%<br>Clay 5% | | SILT: Grey silt, some sand, trace clay, trace gravel, occasional cobble, wet, dense (6.10 / 190.08) |
| 6.10–6.55 | SS 7 | 43 | 16-20-29 (49) | MC: 8 % | | SAND AND GRAVEL: Grey sand and gravel, some silt, wet, dense (6.55 / 189.63) |

Borehole terminated in sand and gravel at 6.55 mbg. Borehole caved to 4.9 mbg following completion.

# BORING NUMBER BH22-07



D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

**CLIENT** Nirvana Homes
**PROJECT NAME** Geotechnical and Hydrogeological Investigation
**PROJECT NUMBER** 21-85162
**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee
**DATE STARTED** 7/11/22 **COMPLETED** 7/11/22
**UTM EASTING** 714216 **NORTHING** 4901018
**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.
**GROUND ELEVATION** 195.24 masl
**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons
**GROUNDWATER LEVELS:**
**LOGGED BY** LT **CHECKED BY** IA
**AT END OF DRILLING** 2.45 m / Elev 192.79 m
**NOTES**
**AFTER DRILLING** ---

| SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS |
|---|---|---|---|
| SS 1 | 0 | 1-2-4-4 (6) | |
| SS 2 | 100 | 4-4-5 (9) | MC: 28 % |
| SS 3 | 65 | 2-3-2 (5) | MC: 14 % |
| SS 4 | 65 | 7-7-10 (17) | WL in open borehole July 11th, 2022 MC: 12 % |
| SS 5 | 65 | 5-8-10 (18) | MC: 17 % |
| SS 6 | 100 | 25-40-50 (90) | MC: 9 % |
| SS 7 | 100 | 25-49-50 (99) | MC: 12 % |

| DEPTH (m) | MATERIAL DESCRIPTION | ELEVATION |
|---|---|---|
| 0.00–0.45 | TOPSOIL: Loose, no recovery | 194.79 |
| 0.45–3.00 | SILTY SAND: Brown-grey silty sand to sand and silt, some clay, trace to some gravel, moist, loose; - wet; - compact | 192.24 |
| 3.00–4.55 | SILT: Grey silt, some sand, trace gravel, trace clay, wet, compact | 190.69 |
| 4.55–6.55 | SILTY SAND: Grey silty sand, trace gravel, trace clay, occasional cobble, wet, very dense | 188.69 |

Borehole terminated in silty sand at 6.55 mbg. Borehole caved to 4.6 mbg following completion.

BH LOGS WITH TERMINATION NOTES 85162 BOREHOLE LOGS.GPJ USETHISONEOVERBURDENBHLOGNVALUE.GDT 4/19/23

D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

# BORING NUMBER BH22-08



**CLIENT** Nirvana Homes
**PROJECT NAME** Geotechnical and Hydrogeological Investigation
**PROJECT NUMBER** 21-85162
**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee
**DATE STARTED** 7/13/22 **COMPLETED** 7/13/22
**UTM EASTING** 714005 **NORTHING** 4900686
**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.
**GROUND ELEVATION** 198.316 masl
**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons
**GROUNDWATER LEVELS:**
**LOGGED BY** LT **CHECKED BY** IA
**AT END OF DRILLING** 5.00 m / Elev 193.32 m
**NOTES**
**AFTER DRILLING** ---

| SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS |
|---|---|---|---|
| SS 1 | 23 | 1-2-3-4 (5) | MC: 20 % |
| SS 2 | 33 | 4-3-5 (8) | |
| SS 3 | 87 | 2-2-3 (5) | |
| SS 4 | 98 | 4-10-23 (33) | |
| SS 5 | 54 | 10-20-20 (40) | |
| SS 6 | 109 | 25-21-21 (42) | WL in open borehole July 13th, 2022 |

| DEPTH (m) | MATERIAL DESCRIPTION | ELEVATION |
|---|---|---|
| 0.00–0.60 | TOPSOIL: Brown sandy silt topsoil, trace clay, moist, loose | 197.72 |
| 0.60–4.55 | SILTY SAND: Brown silty sand, some clay, moist to wet, loose<br>- dense | 193.77 |
| 4.55–6.10 | SAND: Brown sand, trace silt, trace clay, trace gravel, occasional cobble, wet, dense<br>- wet | 192.22 |

Borehole terminated in sand material at 6.10 mbg due to refusal on presumed cobble/boulder.

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150 Jameson Drive
Peterborough, Ontario K9J 0B9

# BORING NUMBER BH22-09



**CLIENT** Nirvana Homes

**PROJECT NAME** Geotechnical and Hydrogeological Investigation

**PROJECT NUMBER** 21-85162

**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee

**DATE STARTED** 7/12/22 **COMPLETED** 7/12/22

**UTM EASTING** 714120 **NORTHING** 4900755

**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.

**GROUND ELEVATION** 198.543 masl

**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons

**GROUNDWATER LEVELS:**

**LOGGED BY** LT **CHECKED BY** IA

**AT END OF DRILLING** No measurable groundwater

**NOTES**

**AFTER DRILLING** ---

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| | SS 1 | 30 | 1-3-5-6 (8) | MC: 13 % | | TOPSOIL: Brown silty sand topsoil, trace clay, moist, loose |
| 0.60 | | | | | | 197.94 |
| 1 | SS 2 | 22 | 5-8-5 (13) | MC: 10 % | | SILTY SAND: Brown silty sand to sand and silt, trace clay, trace gravel, moist, compact |
| | SS 3 | 89 | 2-14-14 (28) | MC: 18 % | | |
| 1.75 | | | | | | 196.79 |
| 2 | | | | | | SILT: Grey-brown silt, some sand, trace gravel, trace clay, wet, compact |
| | SS 4 | 89 | 16-14-10 (24) | MC: 20 % | | |
| 3 | | | | | | |
| 3.20 | | | | | | 195.34 |
| | SS 5 | 72 | 15-9-16 (25) | MC: 11 % | | SILTY SAND: Grey silty sand, some clay, trace clay, wet, compact |
| 4 | | | | | | |
| 4.57 | | | | | | 193.97 |
| 5 | SS 6 | 100 | 12-15-8 (23) | MC: 15 % | | SILT: Grey silt, some sand, trace gravel, trace clay, wet, compact |
| 6 | | | | | | |
| | SS 7 | 100 | 4-4-13 (17) | MC: 14 % | | - saturated |
| 6.55 | | | | | | 191.99 |

Borehole terminated in sand and silt at 6.55 mbg. Borehole caved to 2.4 mbg following completion.

# BORING NUMBER BH22-10



D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

**CLIENT** Nirvana Homes
**PROJECT NAME** Geotechnical and Hydrogeological Investigation
**PROJECT NUMBER** 21-85162
**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee
**DATE STARTED** 7/12/22 **COMPLETED** 7/12/22
**UTM EASTING** 714334 **NORTHING** 4900807
**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.
**GROUND ELEVATION** 200.694 masl
**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons
**GROUNDWATER LEVELS:**
**LOGGED BY** LT **CHECKED BY** IA
**AT END OF DRILLING** 2.15 m / Elev 198.54 m
**NOTES**
**AFTER DRILLING** ---

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|
| 0–0.50 | SS 1 | 41 | 2-1-2-3 (3) | MC: 17 % | TOPSOIL: Brown silty sand topsoil, some clay, moist, very loose (0.50 / 200.19) |
| 0.50–2.30 | SS 2 | 65 | 6-6-7 (13) | MC: 10 % | SILTY SAND: Brown silty sand to sandy silt, trace to some clay, trace gravel, moist, compact (2.30 / 198.39) |
| | SS 3 | 65 | 14-9-12 (21) | MC: 9 % | |
| | | | | WL in open borehole July 12th, 2022 | |
| 2.30–3.00 | SS 4 | 54 | 8-21-37 (58) | MC: 6 % | SAND: brown sand, some silt, trace gravel, trace clay, moist, very dense (3.00 / 197.69) |
| 3.00–3.50 | SS 5 | 93 | 24-24-32 (56) | MC: 10 % | SANDY SILT: Grey sandy silt, trace gravel, trace clay, wet, dense (3.50 / 197.19) |
| 3.50–6.55 | | | | | SAND: Brown sand, trace silt, trace clay, wet, dense |
| | SS 6 | 43 | 3-4-17 (21) | MC: 15 % | -compact |
| | SS 7 | 65 | 18-23-20 (43) | GSA SS-7: Sand 90% Silt & Clay 10% MC: 15 % | -dense (6.55 / 194.14) |

Borehole terminated in sand at 6.55 mbg. Borehole caved to 4.6 mbg following completion.

BH LOGS WITH TERMINATION NOTES 85162 BOREHOLE LOGS.GPJ USETHISONEOVERBURDENBHLOGNVALUE.GDT 4/19/23

# BORING NUMBER BH22-11



D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

**CLIENT** Nirvana Homes
**PROJECT NAME** Geotechnical and Hydrogeological Investigation
**PROJECT NUMBER** 21-85162
**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee
**DATE STARTED** 7/11/22 **COMPLETED** 7/11/22
**UTM EASTING** 714320 **NORTHING** 4901258
**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.
**GROUND ELEVATION** 195.565 masl
**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons
**GROUNDWATER LEVELS:**
**LOGGED BY** LT **CHECKED BY** IA
**AT END OF DRILLING** 0.00 m / Elev 195.57 m
**NOTES**
**AFTER DRILLING** ---

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0.00–0.60 | SS 1 | 0 | 2-2-0-3 (2) | | | TOPSOIL: Brown silty sand topsoil, moist, very loose (0.60 / 194.97) |
| 0.60–1.50 | SS 2 | 8 | 1-1-2-4 (3) | MC: 31 % | | CLAYEY SILT: Grey-brown clayey silt, trace to some sand, trace gravel, moist, very loose (1.50 / 194.07) |
| 1.50–3.10 | SS 3 | 75 | 4-5-6-4 (11) | MC: 10 % | | SILTY SAND: Brown silty sand, some clay, trace gravel, orange brown mottling, moist, compact |
| | SS 4 | 75 | 2-3-4-4 (7) | MC: 9 % | | - grey, moist to wet, loose (3.10 / 192.47) |
| 3.10–3.35 | SS 5 | 43 | 2-2-3 (5) | MC: 11 % | | SAND: Grey sand, trace silt, trace clay, trace gravel, occasional cobble, saturated, compact (3.35 / 192.22) |
| 3.35–5.65 | | | | | | SANDY GRAVEL: Grey sandy gravel, trace silt, trace clay, occasional cobble, saturated, very dense |
| | SS 6 | 43 | 24-18-25 (43) | MC: 5 % | | - dense |
| | SS 7 | 75 | 20-30-27-19 (57) | MC: 9 %<br>GSA SS-7:<br>Gravel 66%<br>Sand 28%<br>Silt and Clay 6% | | (5.65 / 189.92) |

Borehole terminated in sand material at 5.65 mbg due to refusal on presumed cobble/boulder. Borehole caved to 4.0 mbg following completion. Artesian conditions encountered at SS-5 (groundwater flowing out of borehole) - borehole sealed with bentonite.

# BORING NUMBER BH22-12



D. M. Wills Associates Limited
150 Jameson Drive
Peterborough, Ontario K9J 0B9

**CLIENT** Nirvana Homes

**PROJECT NAME** Geotechnical and Hydrogeological Investigation

**PROJECT NUMBER** 21-85162

**PROJECT LOCATION** 3491 Wallace Point Rd, Township of Otonabee

**DATE STARTED** 7/12/22 **COMPLETED** 7/12/22

**UTM EASTING** 714364 **NORTHING** 4900698

**DRILLING CONTRACTOR** Canadian Environmental Drilling & Contractors Inc.

**GROUND ELEVATION** 203.745 masl

**DRILLING METHOD** 6" Solid Stem Auger with Split Spoons

**GROUNDWATER LEVELS:**

**LOGGED BY** LT **CHECKED BY** IA

**AT END OF DRILLING** No measurable groundwater

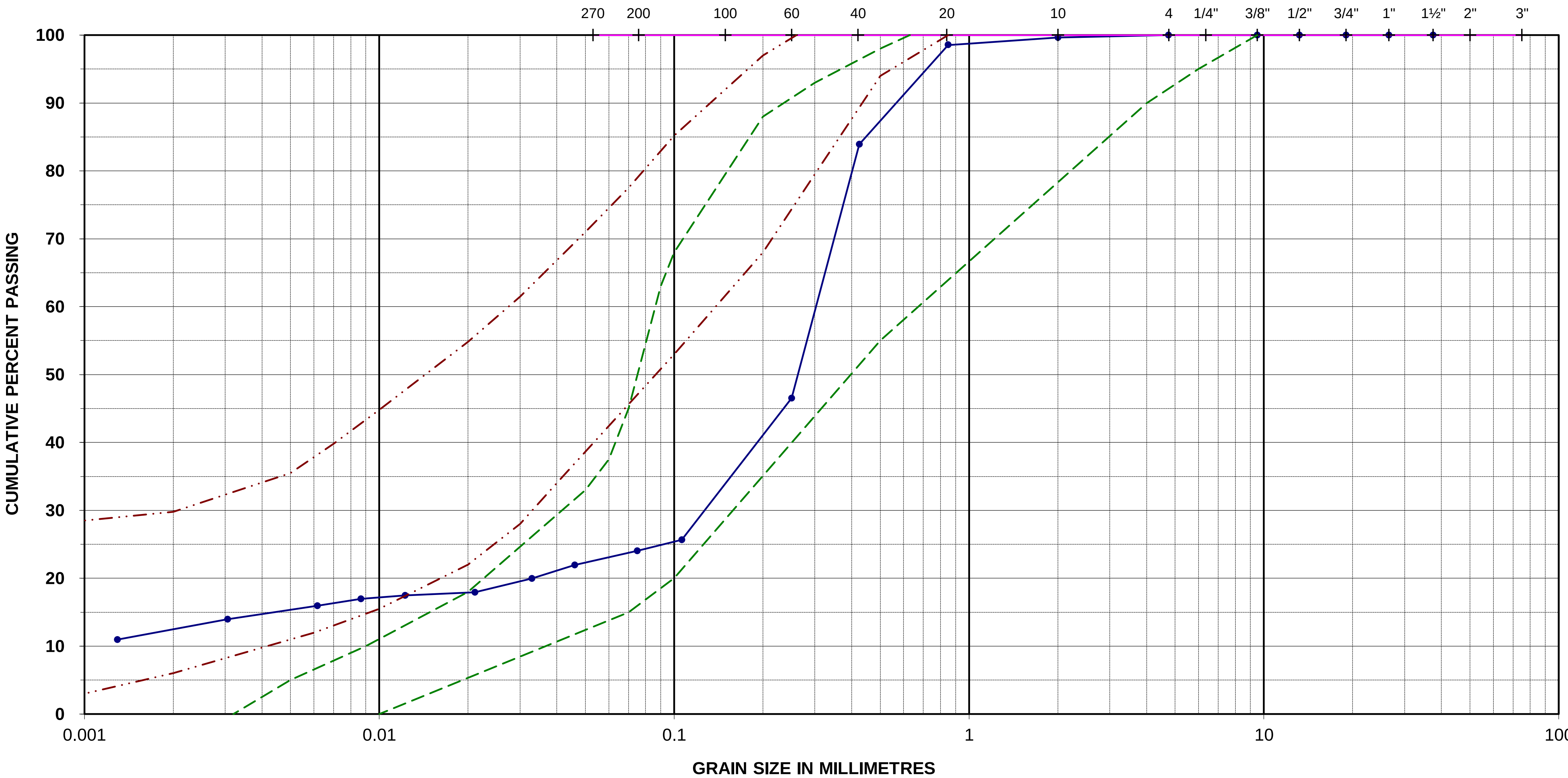
**NOTES**

**AFTER DRILLING** ---

| DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY % | BLOW COUNTS (N VALUE) | REMARKS | GRAPHIC LOG | MATERIAL DESCRIPTION |
|---|---|---|---|---|---|---|
| 0.00–0.60 | SS 1 | 49 | 1-2-3-4 (5) | MC: 17 % | | TOPSOIL: Brown silty sand topsoil, trace clay, moist, loose |
| 0.60 | | | | | | 203.15 |
| 1 | SS 2 | 0 | 2-4-5 (9) | | | SAND: Brown sand, trace silt, trace gravel, occasional cobble, moist, loose |
| | | | | | | -dense |
| 2 | SS 3 | 33 | 6-15-25 (40) | MC: 6 % | | |
| | | | | | | - very dense |
| 3 | SS 4 | 72 | 13-21-45 (66) | MC: 8 % | | |
| 4 | SS 5 | 70 | 17-36-42 (78) | MC: 3 % | | |
| 4.55 | | | | | | 199.20 |
| 5 | SS 6 | 65 | 27-25-31 (56) | MC: 9 % | | SANDY GRAVEL: Brown sandy gravel, trace silt, trace clay, occasional cobble, wet, very dense |
| 6.10 | | | | | | 197.65 |

Borehole terminated in sandy gravel material at 6.1 mbg. Borehole caved to 2.4 mbg following completion.

# PARTICLE SIZE DISTRIBUTION LS702/ASTM D422




*Unified Classification System*

| SILT AND CLAY | SAND | GRAVEL |
|---|---|---|

| | | |
|---|---|---|
| GRAVEL | 0 | % |
| SAND | 64 | % |
| SILT | 24 | % |
| CLAY | 12 | % |

------------------------ sm envelope T = 8 - 20 min/cm

— - - — - - — - — - ml envelope T = 20 - 50 min/cm

Estimated T = 20 min/cm

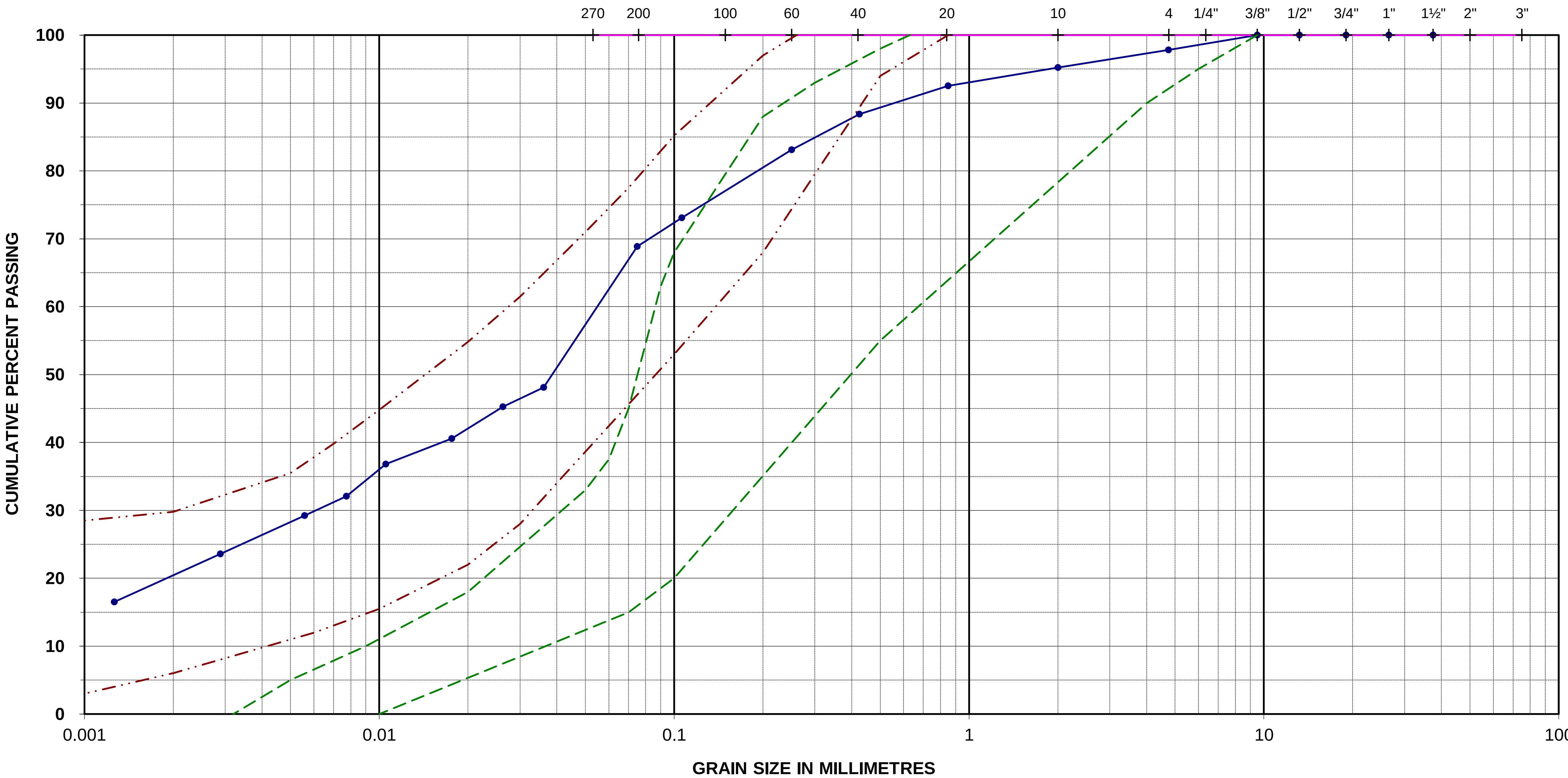
**Project Name:** DM Wills - 85162 **Project No.:** 201-07253-00

**Location ID.:** TP22-02 **Sample No./Depth:** GS2

| Sieve Size | % Passing Coarse | Sieve Size | % Passing Fine | Hydrometer (mm) | % Passing |
|---|---|---|---|---|---|
| **37.5 mm** | 100.0 | **2.00 mm** | 99.66 | **0.046** | 21.9 |
| **26.5 mm** | 100.0 | **0.850 mm** | 98.5 | **0.021** | 17.9 |
| **19.0 mm** | 100.0 | **0.425 mm** | 83.9 | **0.009** | 17.0 |
| **13.2 mm** | 100.0 | **0.250 mm** | 46.5 | **0.003** | 14.0 |
| **9.50 mm** | 100.0 | **0.106 mm** | 25.6 | **0.001** | 11.0 |
| **4.75 mm** | 100.0 | **0.075 mm** | 24.0 | | |

Note: More information is available upon request. Tested by: WGH Reviewed by: Date: 29-Jun-22

# PARTICLE SIZE DISTRIBUTION LS702/ASTM D422




*Unified Classification System*

| SILT AND CLAY | SAND | GRAVEL |
|---|---|---|

| | | |
|---|---|---|
| GRAVEL | 2 | % |
| SAND | 29 | % |
| SILT | 49 | % |
| CLAY | 20 | % |

------------------------ sm envelope T = 8 - 20 min/cm

— - - — - - — - - — - ml envelope T = 20 - 50 min/cm

Estimated T = 40 min/cm

| | | | |
|---|---|---|---|
| **Project Name:** | DM Wills - 85162 | **Project No.:** | 201-0725-00 |
| **Location ID.:** | TP22-03 | **Sample No./Depth:** | GS3 |

| Sieve Size | % Passing Coarse | Sieve Size | % Passing Fine | Hydrometer (mm) | % Passing |
|---|---|---|---|---|---|
| **37.5 mm** | 100.0 | **2.00 mm** | 95.20 | **0.036** | 48.1 |
| **26.5 mm** | 100.0 | **0.850 mm** | 92.5 | **0.018** | 40.6 |
| **19.0 mm** | 100.0 | **0.425 mm** | 88.3 | **0.008** | 32.1 |
| **13.2 mm** | 100.0 | **0.250 mm** | 83.1 | **0.003** | 23.6 |
| **9.50 mm** | 100.0 | **0.106 mm** | 73.1 | **0.001** | 16.5 |
| **4.75 mm** | 97.8 | **0.075 mm** | 68.9 | | |

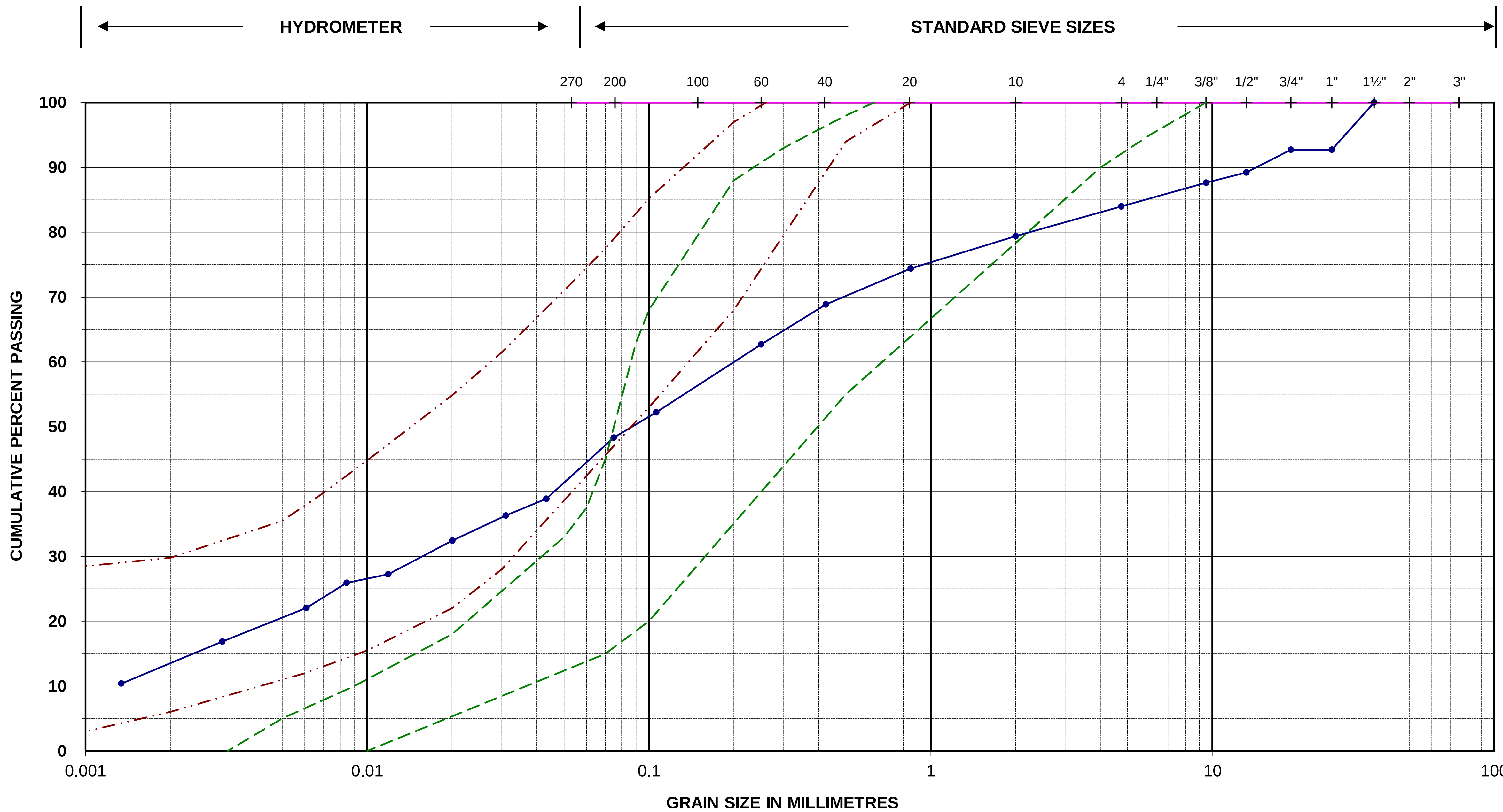
Note: More information is available upon request.

Tested by: WGH

Reviewed by:

Date: 30-Jun-22

# PARTICLE SIZE DISTRIBUTION LS702/ASTM D422




*Unified Classification System*

| SILT AND CLAY | SAND | GRAVEL |
|---|---|---|

| | | |
|---|---|---|
| GRAVEL | 16 | % |
| SAND | 36 | % |
| SILT | 35 | % |
| CLAY | 13 | % |

------------------------ sm envelope T = 8 - 20 min/cm

- - - — - - — - - — - ml envelope T = 20 - 50 min/cm

Estimated T = 30 min/cm

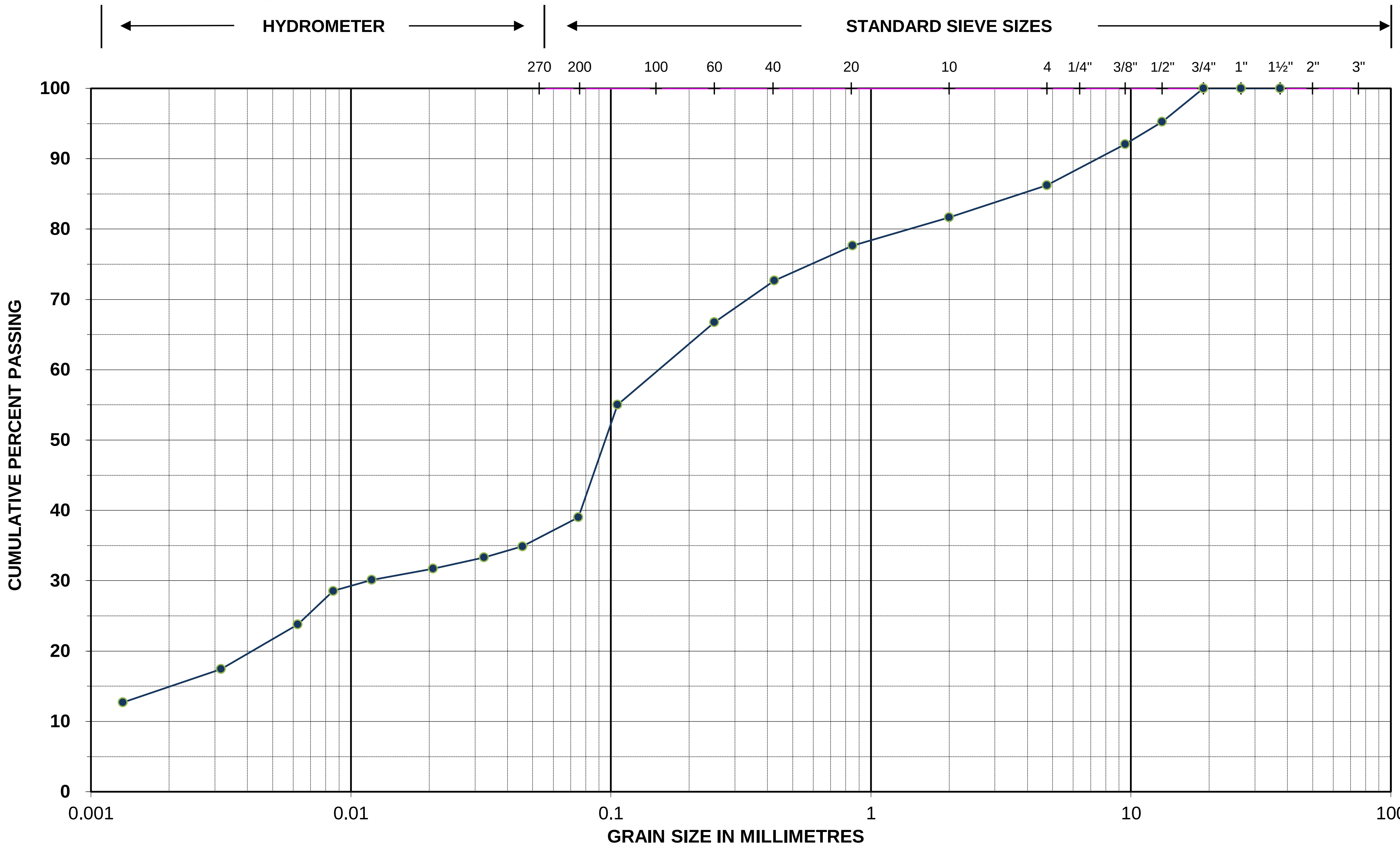
| | | | |
|---|---|---|---|
| **Project Name:** | DM Wills - 85162 | **Project No.:** | 201-07253-00 |
| **Location ID.:** | TP22-06 | **Sample No./Depth:** | GS2 |

| Sieve Size | % Passing Coarse | Sieve Size | % Passing Fine | Hydrometer (mm) | % Passing |
|---|---|---|---|---|---|
| **37.5 mm** | 100.0 | **2.00 mm** | 79.37 | **0.043** | 38.9 |
| **26.5 mm** | 92.7 | **0.850 mm** | 74.4 | **0.020** | 32.4 |
| **19.0 mm** | 92.7 | **0.425 mm** | 68.9 | **0.008** | 25.9 |
| **13.2 mm** | 89.2 | **0.250 mm** | 62.7 | **0.003** | 16.9 |
| **9.50 mm** | 87.6 | **0.106 mm** | 52.2 | **0.001** | 10.4 |
| **4.75 mm** | 84.0 | **0.075 mm** | 48.3 | | |

Note: More information is available upon request.

Tested by: WGH Reviewed by: Date: 30-Jun-22

# PARTICLE SIZE DISTRIBUTION LS702/ASTM D422




*Unified Classification System*

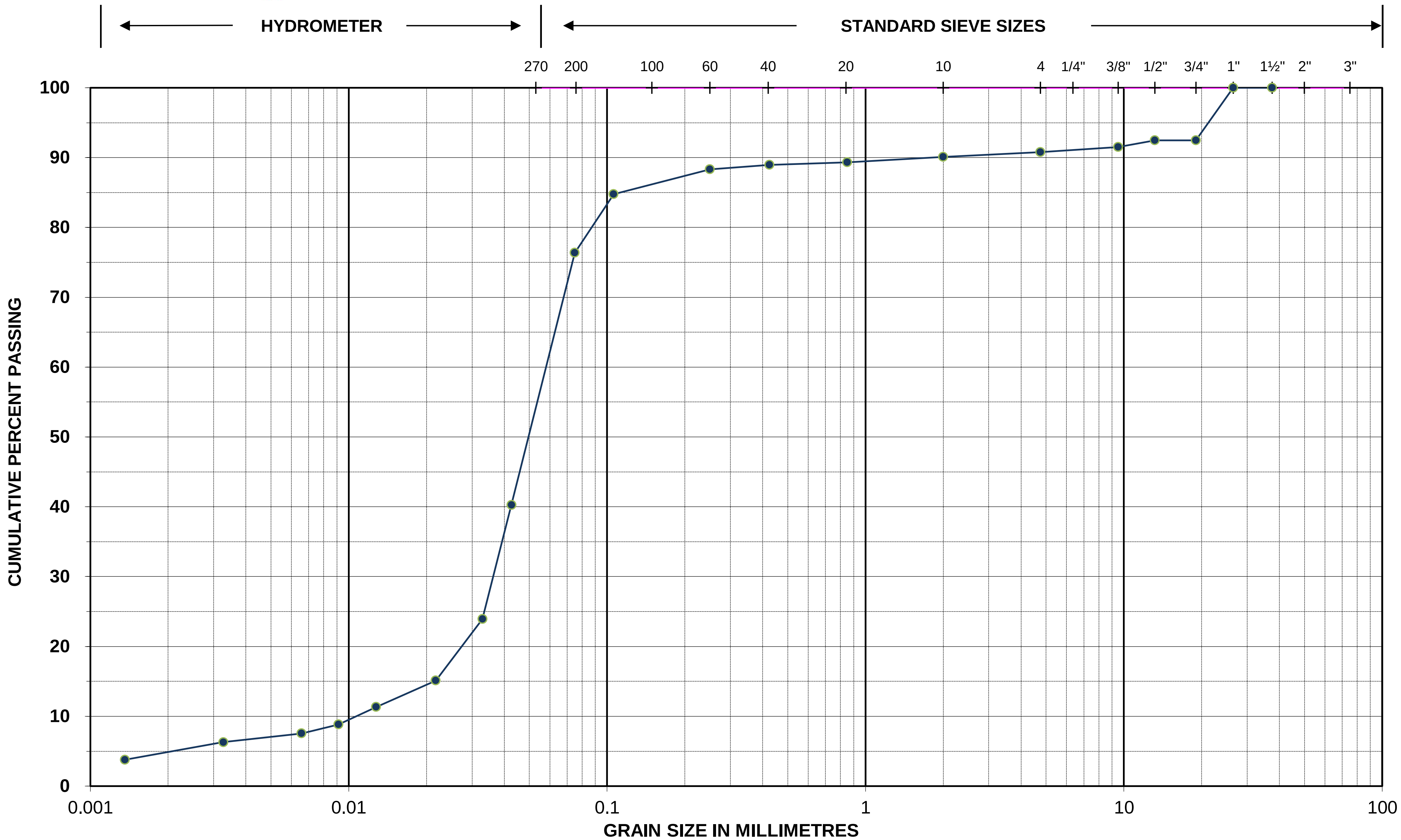
| SILT AND CLAY | SAND | GRAVEL |
|---|---|---|

| | | | |
|---|---|---|---|
| **Project Name:** | DM Wills - 85162 | **Project No.:** | 201-07253-00 |
| **Location ID.:** | BH22-04 | **Sample No./Depth:** | SS-5 |

| Sieve Size | % Passing Coarse | Sieve Size | % Passing Fine | Hydrometer (mm) | % Passing |
|---|---|---|---|---|---|
| **37.5 mm** | 100.0 | **2.00 mm** | 81.7 | **0.046** | 34.9 |
| **26.5 mm** | 100.0 | **0.850 mm** | 77.6 | **0.021** | 31.7 |
| **19.0 mm** | 100.0 | **0.425 mm** | 72.7 | **0.009** | 28.5 |
| **13.2 mm** | 95.2 | **0.250 mm** | 66.7 | **0.003** | 17.4 |
| **9.50 mm** | 92.0 | **0.106 mm** | 55.0 | **0.001** | 12.7 |
| **4.75 mm** | 86.2 | **0.075 mm** | 39.0 | | |

Note: More information is available upon request. Tested by: NLO Reviewed by: Date: 17-Aug-22

# PARTICLE SIZE DISTRIBUTION LS702/ASTM D422




*Unified Classification System*

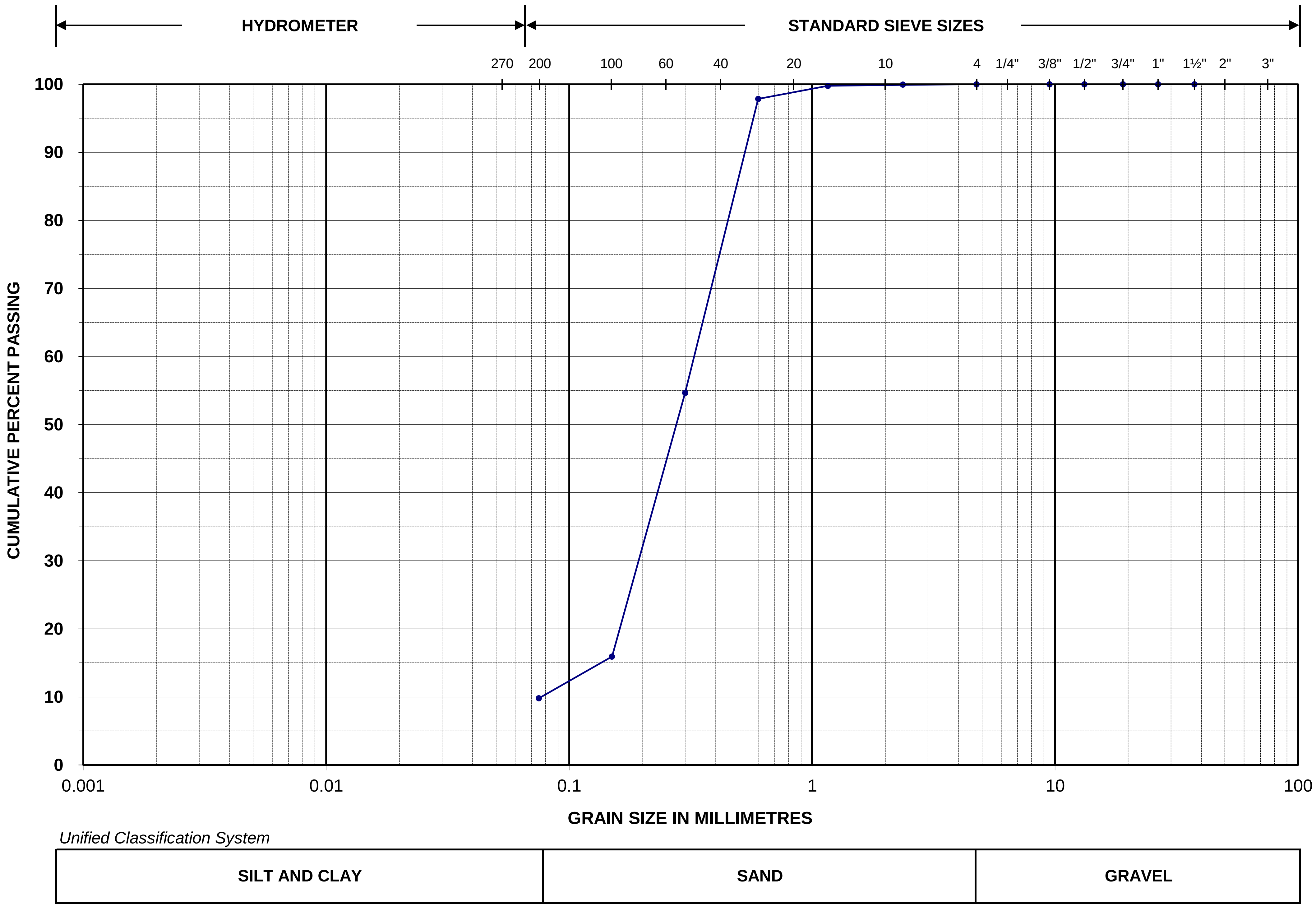
| SILT AND CLAY | SAND | GRAVEL |
|---|---|---|

| | | | |
|---|---|---|---|
| **Project Name:** | DM Wills - 85162 | **Project No.:** | 201-07253-00 |
| **Location ID.:** | BH22-06 | **Sample No./Depth:** | SS-6 |

| Sieve Size | % Passing Coarse | Sieve Size | % Passing Fine | Hydrometer (mm) | % Passing |
|---|---|---|---|---|---|
| **37.5 mm** | 100.0 | **2.00 mm** | 90.1 | **0.043** | 40.3 |
| **26.5 mm** | 100.0 | **0.850 mm** | 89.3 | **0.022** | 15.1 |
| **19.0 mm** | 92.5 | **0.425 mm** | 89.0 | **0.009** | 8.8 |
| **13.2 mm** | 92.5 | **0.250 mm** | 88.3 | **0.003** | 6.3 |
| **9.50 mm** | 91.5 | **0.106 mm** | 84.8 | **0.001** | 3.8 |
| **4.75 mm** | 90.8 | **0.075 mm** | 76.4 | | |

Note: More information is available upon request. Tested by: NLO Reviewed by: Date: 17-Aug-22

# PARTICLE SIZE DISTRIBUTION

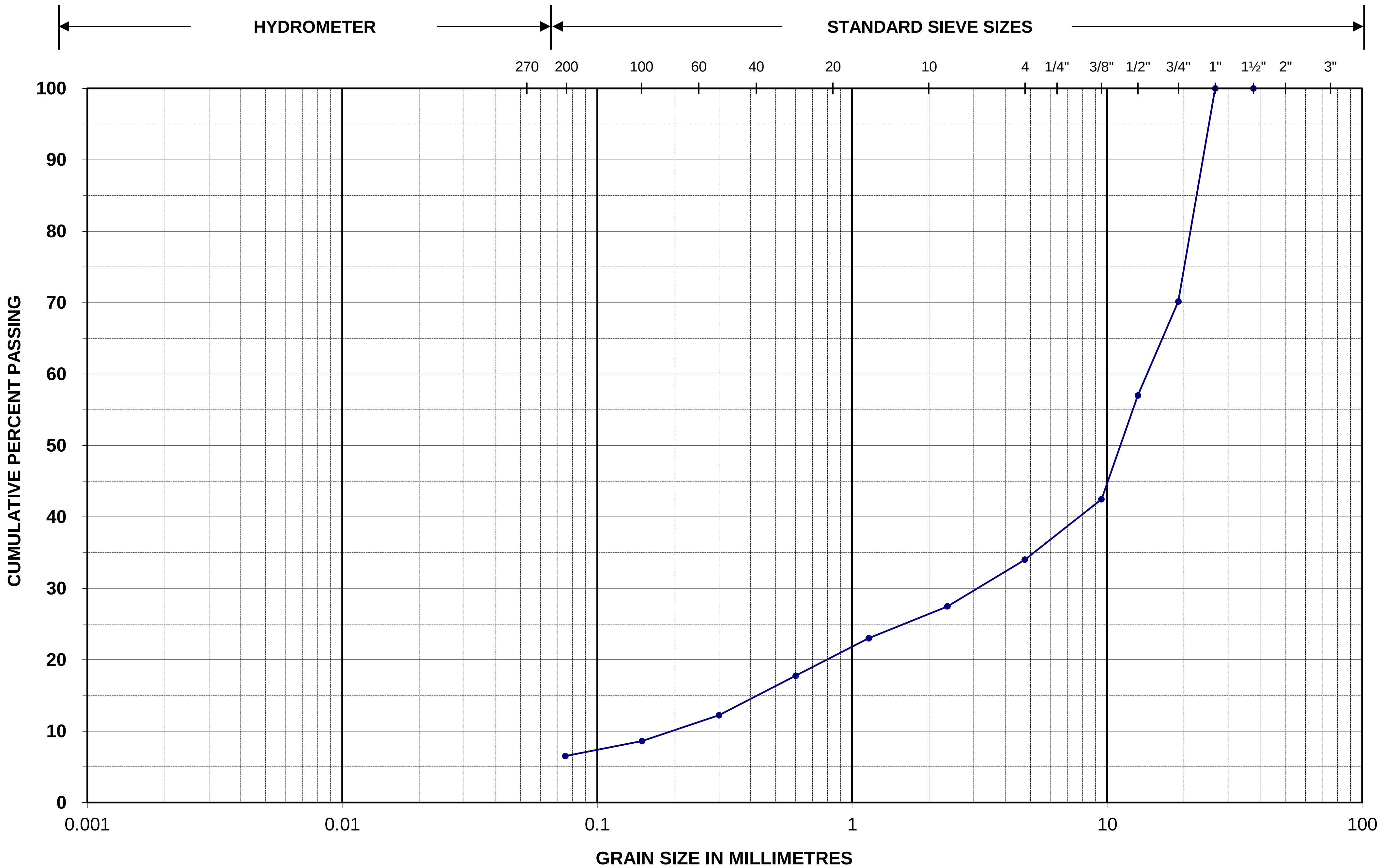



| | | | |
|---|---|---|---|
| **Project Name:** | DM Wills - 85162 | **Project No.:** | 201-07253-00 |
| **Location ID.:** | BH22-10 | **Sample No./Depth:** | SS-7 |

| Sieve Size | % Passing Coarse | Sieve Size | % Passing Fine |
|---|---|---|---|
| **37.5 mm** | 100.0 | **2.36 mm** | 99.9 |
| **26.5 mm** | 100.0 | **1.16 mm** | 99.8 |
| **19.0 mm** | 100.0 | **0.60 mm** | 97.9 |
| **13.2 mm** | 100.0 | **0.30 mm** | 54.7 |
| **9.5 mm** | 100.0 | **0.15 mm** | 15.9 |
| **4.75 mm** | 100.0 | **0.075 mm** | 9.8 |

Note: More information is available upon request.   Tested by: WGH   Reviewed by:   Date: 17-Aug-22

# PARTICLE SIZE DISTRIBUTION




*Unified Classification System*

| SILT AND CLAY | SAND | GRAVEL |
|---|---|---|

| | | | |
|---|---|---|---|
| **Project Name:** | DM Wills - 85162 | **Project No.:** | 201-07253-00 |
| **Location ID.:** | BH22-11 | **Sample No./Depth:** | SS-7 |

| Sieve Size | % Passing Coarse | Sieve Size | % Passing Fine |
|---|---|---|---|
| **37.5 mm** | 100.0 | **2.36 mm** | 27.5 |
| **26.5 mm** | 100.0 | **1.16 mm** | 23.0 |
| **19.0 mm** | 70.2 | **0.60 mm** | 17.8 |
| **13.2 mm** | 57.0 | **0.30 mm** | 12.2 |
| **9.5 mm** | 42.5 | **0.15 mm** | 8.6 |
| **4.75 mm** | 34.0 | **0.075 mm** | 6.5 |

Note: More information is available upon request. Tested by: WGH Reviewed by: Date: 17-Aug-22