APPENDIX B
GEOTECHNICAL REPORT

November 25th, 2012

City of Winkler
185 Main Street
Winkler, Manitoba
R6W 1B4
Attention: Mr. Johan Botha, P. Eng.

Dear Sir:

RE: GEOTECHNICAL INVESTIGATION FOR THE PROPOSED, NEW, ONE – STOREY, 480 M^2 AND 300 M^2 WWTP, 41 M AND 18 M DIAMETER REACTORS AND CLARIFIERS TO BE LOCATED ON THE SW QUADRANT OF SE22-3-4W IN WINKLER, MANITOBA

1.0 TERMS OF REFERENCE

On October 3rd, 2012, M. Block & Associates Ltd. (MBA) received e-mailed authorization from Mr. Johan Botha, P. Eng., representing The City of Winkler, the owner, project's developer and municipal engineer, to proceed with the geotechnical investigation for the proposed new, one–storey, 480 m^2 and 300 m^2 WWTP, 2 – 41 m and 2 – 18 m diameter reactors and clarifiers, respectively, to be located on the SW quadrant of SE22-3-4W in Winkler, Manitoba. Therefore, on November 20th and 21st, 2012, a total of five test holes were bored implementing a truck-mounted B-40 and CME drill rigs, using 5' long x 5" and 7.5" diameter interconnected continuous flight solid or hollow stem augers, respectively, all supplied by Maple Leaf Drilling Ltd. of Winnipeg, Manitoba. Representative "undisturbed" and "disturbed" soil samples were retrieved from the test holes and brought back to MBA's CSA certified materials testing laboratory in Winnipeg for unconfined compression and moisture content testing, respectively, and verification of the field soil classifications. Alternatively, during the field investigation, the fine grained soils' respective 'disturbed' undrained shear strengths were measured implementing a hand-held calibrated Pocket Geotester. Upon the completion of this investigation, the test holes' elevations and the groundwater elevations in them, if any, were measured and referenced to The City of Winkler's geodetic site survey, as illustrated on pages 18 - 25 of this report. In addition, the test holes were completely backfilled with bentonite and the soil cuttings.

2.0 SOIL LITHOLOGY AND GROUNDWATER CONDITIONS

The test holes were overlain with, approximately, 3" of black, moist, organic topsoil. Black, becoming grey in colour with increasing depth, alluvially deposited, stiff to firm, moist, silty clay was then traversed in test holes #1, #3, #4, #5 and #6 down to the 2'6", 4'6", 3'6", 3'6" and 4'6" depths, respectively. Next, brown, alluvially deposited, damp, compact, poorly-graded silty sand was observed in, only, test hole #1 down to the 5' depth. Brown, alluvially deposited, firm to soft, moist to saturated, sandy silt was then noted in test holes #1, #3, #4, #5 and #6 down to the 7', 7'6", 5'6", 7'6" and 10' depths, respectively. Finally, brown, becoming grey in colour below the 17' depth, glaciolacustrine, stiff, moist, silty clay with silt and gypsum inclusions was recorded in test holes #1, #3, #4 and #5 down to the 102', 60', 10' and 10' depths, respectively. As per MBA's quotation and its mutually agreed upon revision, the deep test holes and shallow probe holes were terminated at the aforementioned depths. Groundwater seepage and/or soil sloughing was not encountered during this investigation. The soil lithology in the test holes and their specific locations were appended to this report on pages 18 – 25.

3.0 SUMMARY OF FIELD AND LABORATORY TESTS

TH #	DEPTH	UNCONFINED COMPRESSION	BULK UNIT WEIGHT	MOISTURE CONTENT
1	11'	3145 psf	116.15 pcf	39.86 %
1	21'	3169 psf	113.04 pcf	44.16 %
1	31'	3098 psf	109.90 pcf	48.55 %
1	41'	NO RECOVERY IN SHELBY TUBE		
1	51'	3139 psf	108.58 pcf	48.67 %
1	61'	3094 psf	107.42 pcf	58.12 %
1	71'	2592 psf	105.27 pcf	54.14 %
1	81'	3143 psf	106.21 pcf	56.68 %
1	91'	3004 psf	105.00 pcf	59.38 %
1	101'	3079 psf	106.32 pcf	55.42 %

The unconfined compressive strengths are also located on test hole #1's log sheets.
The soils' measured Pocket Geotester strengths are located on test hole #3's log sheets.
Moisture content vs. Depth graphs are located on the test holes' log sheets.
A summary of the laboratory data is appended to this report on pages 31 - 32.

4.0 FOUNDATION DESIGN ALTERNATIVES

The writer was informed that the proposed two primary clarifier tanks surface areas will be 255 m^2 with an applied stress of 63 kPa. Alternatively, the proposed two donut bioreactor tanks surface areas will be 1320 m^2 with an applied stress of 71 kPa. The writer was similarly informed that these tanks must be placed 3 m – 5 m below present site grading. The soil, from the surface down to the 7' depth, generally consists primarily of alluvially deposited silty clay and sandy silt. Underlying the silt stratum, a stiff, glaciolacustrine silty clay, with an undrained shear strength of, approximately, 75 kPa, extends down to at least the 102' depth. Therefore, the net applied stress on the glaciolacustrine silty clay will be far below its undrained shear strength, making a rigidly designed and constructed reinforced concrete raft slab foundation design a feasible foundation design for these proposed tanks.

4.1 RIGIDLY REINFORCED CONCRETE RAFT FOOTING

Therefore, rigidly reinforced concrete shallow raft footings could be implemented as the foundation design for the proposed 2 – 41 m and 2 – 18 m diameter reactors and clarifiers, respectively, to be located on the SW quadrant of SE22-3-4W, Winkler, Manitoba.

Predicated upon all the aforementioned input data, the rigidly designed and constructed reinforced concrete raft footings, placed on two -150 mm deep lifts of compacted engineered granular fill overlying the in-situ clayey sub-grade soil near elevation 263.80 m, would have an allowable uniform surcharge of 125 kPa on the engineered granular base underlying this concrete raft slab. Furthermore, in order to maximize the distribution of the proposed tanks' loads, the two -150 mm deep lifts of compacted engineered granular fill overlying the in-situ silty clay sub-grade soil should extend at least 3m in all directions beyond the tanks' respective footprints. It is imperative that the reinforced concrete raft slab be rigidly engineered by a licensed professional engineer and constructed in accordance with this project's sealed structural drawings and this report's specifications.

Predicated upon the aforementioned applied loading of these tanks on the compacted "imported" granular fill's base structure and the underlying glaciolacustrine silty clay deposition's stiff undrained shear strength, the settlement analysis of this rigidly designed and constructed reinforced concrete raft slab, models maximum initial and long-term rotational settlements of less than 15 mm and 25 mm, respectively, when the aforementioned input loading data is applied onto it. Therefore, rigidly reinforced concrete raft footings are a feasible foundation system for the proposed tanks. Each rigidly reinforced concrete raft footing shall only be constructed, as specified below, on the following "imported" granular fill base structure placed on the consolidated and tested sub-grade soil near elevation 263.8 m, where its allowable bearing pressure, once every lift of the imported granular fill is compacted to the following specifications, with verification via compaction testing performed by MBA's geotechnical engineering personnel, would be 75 kPa.

First, the soil overlying the stiff silty clay shall be carefully excavated in order to expose the bearing soil with only minimal disturbance and loosening. Next, due to the possibility of surface water runoff and/or groundwater seepage into the open foundation excavation, inducing erosion, softening and/or groundwater "pumping" during the foundation installation, an approved geo-textile fabric, such as, Amoco Woven Geo-textile #2016, or another pre-approved equivalent geo-textile fabric, shall be placed directly on the inspected in-situ silty clay located at that depth. Overlying the geo-textile fabric, the rigidly reinforced concrete raft footing's minimum 150 mm deep sub-base, composed of either 50 mm or 20 mm down crushed limestone fill, C-Base gravel or another pre-approved equivalent material shall be placed in sufficient 150 mm deep layers and compacted until each lift has at least 98 % of its standard proctor density (SPD). Finally, the rigidly reinforced concrete raft footing's granular base course, composed of a 150 mm deep lift of A-Base gravel, shall then be placed and compacted until it has at least 100 % of its SPD. However, all the aforementioned soils shall only be placed and compacted in ambient air temperatures above 1° Celsius. In cooler ambient air temperatures, a lean mix concrete, or another pre-approved equivalent material, shall be placed instead. Once all the "imported" granular fill layers' degree of compaction have been verified via compaction testing by this consultant's personnel, the allowable bearing pressure on the base course would be as previously outlined. Finally, the non-air entrained minimum 600 mm deep reinforced concrete raft footing shall then be placed implementing an S-1 class of exposure.

The advantages of this floating foundation system are its moderate allowable bearing pressure, manageable modeled long-term foundation displacement, cost effectiveness and the potential use of local labour and equipment during the foundation installation. The disadvantages of this foundation type are its level of difficulty and inefficiency for proper installation during the winter months, the possibility of unexpected foundation settlement if loose and/or softened sub-grade soil are not properly compacted and/or excavated off of a foundation element, respectively, and the potential for significant foundation settlement, if constructed improperly. Therefore, prior to concreting, the geotechnical engineer's personnel shall inspect the raft slabs' respective constructions in order to verify the geo-textile's proper placement, every lift of the granular fill's density via compaction testing, actual foundation dimensions and confirm that any loose granular base and/or soft sub-grade soil have been properly compacted and/or excavated, respectively.

4.2 DRILLED CAST IN PLACE CONCRETE FRICTION PILES

Alternatively, drilled cast in place concrete friction piles could be implemented as the foundation design for the proposed new, one–storey, 480 m^2 and 300 m^2 WWTP to be located on the SW quadrant of SE22-3-4W in Winkler, Manitoba. Predicated upon the neutral plane of this pile type modeled near the 8' depth and the intentionally limited depth investigated in this test hole of 102' below present grade, the allowable effective functional friction length of glaciolacustrine silty clay at this site, from the present grade of test hole #1, is **102' – 8' = 94'**. The laboratory data indicates that the allowable average skin friction of the soil/concrete interface from the 8' to 102' depths, only, is 450 psf. Based upon these calculations, a 16" diameter friction pile drilled 102' deep, properly constructed, would safely transfer 172 kips of load down to the underlying glaciolacustrine deposition. The concrete, relative to the soil, has an additional net weight of, approximately, 35 pcf in the upper 102' of overburden. Therefore, the additional net weight of the concrete is included in the above analysis. In addition, in order to avoid reducing the piles' net efficiency, they must be spaced at least three pile diameters, on center. Furthermore, in order to resist potential soil swelling and frost jacking uplift stresses, these piles shall have minimum embedment lengths of 30' and 40' in heated and unheated areas of the site, respectively. Finally, full-length reinforcing steel shall also be installed in all the piles implemented in an unheated service condition.

It is recommended that the geotechnical engineer's personnel inspect the installation of this foundation type in order to verify that it conforms to the contents of this report, the structural drawings and project's specifications.

The foundation contractor should be fully cognizant that the alluvially deposited, soft, saturated, sandy silt could potentially slough and seep severely into a few or some of the piles' excavations during wetter seasons and/or years. Therefore, if that situation transpires, steel casing through that stratum would be required. Since soil sloughing during concreting may cause improper foundation performance, special care must be given when removing the steel sleeve not to cause sloughing soil from entering a pile's excavation from in behind it. As such, the foundation contractor should be diligent when removing the steel sleeve not to cause sloughing soil from entering the pile's excavation from in behind it. In addition, the top 7' of embedment length in every concrete pile should be mechanically vibrated.

The advantages of this piling system are its relatively fast rate of pile installation, frequency of being more economical than other piled foundation designs in this area, efficiency of installation in comparison with drilled, cast in place, spread bore concrete end-bearing piles, the many piling businesses located in the vicinity and minimal magnitude of modeled long-term foundation settlement. The disadvantages of this piling system are the limited functional depth of serviceable stiff, moist, glaciolacustrine, silty clay and, as such, frictional pile capacity on this site, the additional cost associated with the aforementioned length of steel sleeving quite possibly required to properly install this pile type, and the potential for pile settlement, if constructed improperly.

4.3 DRILLED SPREAD BORE CONCRETE END-BEARING PILES

Similarly, drilled, cast in place, spread bore concrete end-bearing piles could also be implemented as the foundation design for the proposed new, one–storey, 480 m^2 and 300 m^2 WWTP to be located on the SW quadrant of SE22-3-4W in Winkler, Manitoba. These piles shall only be constructed on the glaciolacustrine, stiff, moist, silty clay with silt inclusions at elevation 259.22 m, 7.62 m below test hole #1's current surface elevation, where the allowable bearing pressure on the soil, once mechanically-cleaned, and the piling installation supervised by qualified geotechnical personnel, would be 160 kPa. In addition, in order to avoid reducing the piles' net efficiency, they must be spaced at least two-and-a-half bell and three shaft diameters, on center, from each other.

In order to protect these short piles from frost jacking stresses in unheated applications, only, they shall have sono-tube casings installed along their upper 3.0 m of embedment length. Furthermore, the sono-tube shall be wrapped in 6 mil poly and completely greased on its inside. In addition, full-length reinforcing steel shall also be installed in all the piles implemented in an unheated service condition.

The foundation contractor should be fully cognizant that the alluvially deposited, soft, saturated, sandy silt could potentially slough and seep severely into a few or some of the piles' excavations during wetter seasons and/or years. Therefore, if that situation transpires, steel casing through that stratum would be required. Since soil sloughing during concreting may cause improper foundation performance, special care must be given when removing the steel sleeve not to cause sloughing soil from entering a pile's excavation from in behind it. As such, the foundation contractor should be diligent when removing the steel sleeve not to cause sloughing soil from entering the pile's excavation from in behind it. In addition, the top 2.4 m of embedment length in every concrete pile shall be mechanically vibrated.

The advantages of this piling system are its relatively fast rate of pile installation, moderate allowable axial compressive, tensile and frost jacking resistances, the many piling businesses located in the vicinity and minimal magnitude of modeled long-term foundation settlement. The disadvantages of this piling system are its higher cost and longer foundation installation time per pile associated with mechanically constructing the bell, the additional cost associated with the aforementioned length of steel sleeving quite possibly required to properly install this pile type, and the potential for pile settlement, if incorrectly constructed.

5.0 CONCRETE DESIGN

Due to the visibly high concentration of sulphate in the glaciolacustrine deposition at this site, Sulphate Resisting Cement shall be used in all the concrete implemented for the aforementioned concrete foundation systems. Its concrete shall have a minimum 28-Day laboratory compressive strength of 32 mPa. Furthermore, the concrete shall contain at least 550 pounds of cement per cubic yard, have a maximum water cement ratio, a plastic concrete air content and slump of 0.45, 4 to 6 percent and 60 mm to 100 mm, respectively. Alternatively, due to the higher elevation of the proposed structure relation to the elevations of these test holes and the likely low concentration of sulphate in the alluvial depositions traversed across this site, Normal Portland Cement could be used in all the concrete implemented for the WWTP's grade beams and floor slabs.

All other concrete exposed to freezing and thawing cycles shall contain an air entraining admixture that corresponds to the applicable class of exposure listed in tables 2-4 of the recent addition of CSA. Concrete poured in cold weather shall be heated and protected in accordance with CSA A23.1-04 clause 21.2.3. In addition, all concrete poured shall be tested in accordance with CSA A23.1-04 every day and at least once every 50 m^3 per day by a CSA certified concrete testing laboratory.

6.0 LIGHTLY LOADED SURFACE SLAB ON GRADE CONCRETE SLAB DESIGN

The designated working sub-grade elevation for the proposed WWTP building's concrete slab on grade shall be situated at an approved elevation. As such, all the soil located above the project's recommended working sub-grade elevation shall be excavated and then transported off of the property. In addition, all the deleterious soil encountered at or below the project's recommended working sub-grade elevation, if any, shall also be excavated and then transported off of the site. Next, prior to placing the proposed concrete floor slab's granular base structure, the in-situ, primarily fine-grained silty clay, with a high plasticity index, located at or below the working sub-grade elevation, shall then be proof-rolled using a heavy sheepsfoot roller until it has at least 95 % of its SPD. Areas failing the aforementioned proof-roll test and any other deleterious material encountered at or below the working sub-grade elevation shall be verified and documented by the geotechnical engineer's personnel. Predicated upon this consultant's recommendations, the project's slabs on grade sub-contractor shall then excavate and replace the documented failed proof-rolled soil and the other deleterious material encountered at or below the working sub-grade elevation with 100 mm or 50 mm down crushed limestone fill or another pre-approved equivalent bridging material placed in sufficient 200 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

Next, any segments of the proposed building's footprint naturally lower than the proposed sub-grade elevation, if any, shall then be brought up to the sub-grade elevation implementing either a 100 mm or 50 mm down crushed limestone fill, granular C-Base fill or another pre-approved equivalent bridging material, placed in sufficient 200 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

In order to raise the proposed slab on grade up to the underside of the granular base course elevation, the sub-base, consisting of at least one lift of C-Base, 50 mm or 20 mm down crushed limestone fill or another pre-approved equivalent material shall be placed in 150 mm deep layers and compacted until every lift has at least 98 % of its SPD. Finally, the granular base course, composed of a 150 mm deep lift of A-Base, shall be placed and compacted until it has at least 100 % of its SPD. The 150 mm deep reinforced concrete floor slab shall then be poured having a slump in the range of 70 mm to 100 mm. The concrete shall have a maximum water cement ratio of 0.45 and contain a water reducing admixture.

However, if the structural engineer or owner cannot accept the possibility of differential slab displacement of up to 25 mm and 50 mm, in heated and unheated applications, respectively, then a structurally supported concrete floor slab shall be implemented for this project.

7.0 PAVEMENT DESIGNS

All the soil depositions located above the pavements' designated working sub-grade elevation, as designated by the project's forthcoming civil engineering consultant, shall be stripped and then transported off of the site. In addition, all the deleterious soil encountered at or below the project's recommended working sub-grade elevation, if any, shall also be excavated and then transported off of the site. Next, prior to placing the proposed pavement structures' granular sub-base and base courses, the in-situ, primarily fine-grained silty clay, with a high plasticity index, located at or below the working sub-grade elevation, shall then be proof-rolled using a sheepsfoot roller until it has at least 95 % of its SPD. Areas failing the aforementioned proof-roll test and any other deleterious material encountered at or below the working sub-grade elevation shall be verified and documented by the geotechnical engineer's personnel. Predicated upon this consultant's recommendations, the project's pavement sub-contractor shall then excavate and replace the documented failed proof-rolled soil and any other deleterious material encountered at or below the working sub-grade elevation with 100 mm or 50 mm down crushed limestone fill or another pre-approved equivalent bridging material placed in sufficient 200 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

Next, any segments of the proposed pavement areas naturally lower than the proposed sub-grade elevation, if any, shall then be brought up to the working sub-grade elevation implementing either a highly plastic silty clay; 100 mm or 50 mm down crushed limestone fill; granular C-Base fill or another pre-approved equivalent bridging material, placed in sufficient 200 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

In order to provide adequate structural support in areas designated for heavy truck traffic and the sidewalk's concrete slab, their sub-bases shall consist of at least two layers of 50 mm down crushed limestone fill, C-Base fill or another pre-approved equivalent material placed in 150 mm deep lifts and compacted until each layer has at least 98 % of its SPD. However, only one lift of granular sub-base is structurally required for the light car traffic's pavement construction. Alternatively, in all traffic areas, the granular base course shall be composed of a 150 mm deep layer of A-Base, compacted until it has at least 100 % of its SPD. Finally, the light car traffic's asphalt pavement shall be laid in two layers with each lift having a minimum thickness of 38 mm. Similarly, areas with heavier truck traffic shall have 2-57 mm lifts of asphalt pavement. Each asphalt pavement area shall be consolidated until it has at least 98 % of its respective laboratory Marshall Density. An elevation drawing of the car and heavy truck traffic's pavement structures is illustrated on page 28 of this report.

The sidewalk's concrete slab shall have a design thickness of 150 mm, overlying its aforementioned granular base's structural support, and an air-entrainment, slump and water cement ratio in accordance with all the relevant CSA standards in A23.1-04.

The asphalt aggregate shall have a crushed count of >60%. The asphalt shall be placed at a temperature of 125°C to 155°C. The ambient temperature may be no less than 6°C when the asphalt is to be laid. The geotechnical engineer's personnel shall test the asphalt of the following aggregate gradation specifications and physical properties.

METRIC SIEVE SIZE (microns)	(% Passing)
16,000	100
10,000	70 – 85
5,000	55 – 70
2,500	40 – 60
1,250	25 – 50
630	15 – 40
315	5 – 20
160	4 – 11
80	3 – 7

Asphalt Cement, % total sample weight	5.0 % - 6.0 %
Voids in Mineral Aggregate	14% minimum
Air Voids	3.0% - 5.0%
Marshall Stability, N at 60° C	7 kN minimum
Flow Index, units of 250 μm	6.0 – 16.0

The pavement's slope and catch basin placement shall be designed by the project's municipal engineering consultant. Currently, the writer has not been provided the proposed municipal site plan indicating proposed cut and fill depths and, as such, it is unknown if the aforementioned soft silty deposition will be near the project's designated sub-grade elevations. However, if the sub-grade elevations are lowered substantially from the test holes' respective current elevations, then additional excavation and granular fill replacement of any soft silt should be included as a cost per unit of volume in the pavement contractors' respective base bids. Finally, the pavement shall be sufficiently sloped at a minimum grading of 2 % for expedient drainage into catch basins or towards the perimeter of the property.

8.0 LATERAL EARTH PRESSURE

Typically, new structures, such as, the one proposed for this site, have all of their below grade walls rigidly designed and constructed. Therefore, the "at-rest" earth pressures (K_o) will apply for all cases on this project. The distribution of the lateral earth pressures are dependent upon the following key factors; backfill type, compaction effort and drainage conditions. As such, the following two equations should be used for the calculation of the lateral earth pressures where sub-drainage is provided and not provided, respectively.

Sub-drainage Provided

$$P_h = K_o \gamma H$$

where:
- P_h = lateral earth pressure at any depth (psf)
- K_o = earth pressure coefficient
- γ = unit weight of the soil (pcf)
- H = height of the wall in (ft.)

Sub-drainage not Provided

$$P_h = K_o \gamma' H + \gamma_w H$$

where:
- P_h = lateral earth pressure at any depth (psf)
- K_o = earth pressure coefficient
- γ' = buoyant unit weight of the soil (pcf)
- γ_w = unit weight of water (pcf)
- H = height of the wall in (ft.)

If the sub-grade located adjacent to the tanks is utilized to support a surface concrete slab on grade or any pavement structures, 98% - 100% of its SPD (well compacted) will be required and therefore the following K_o values listed in the table below should be used.

COMPACTION SPEC. & SOIL TYPE	K_o	TOTAL UNIT WEIGHT (pcf)
98% - 100% of its SPD (Sands & Gravels)	0.43	145
98% - 100% of its SPD (Silty Clays)	0.58	110

When the sub-grade soils compaction is required to be in the range of 90% - 95% of its SPD (moderate compaction) then the following table of K_o values should be implemented.

COMPACTION SPEC. & SOIL TYPE	K_o	TOTAL UNIT WEIGHT (pcf)
90% - 95% of its SPD (Sands & Gravels)	0.55	135
90% - 95% of its SPD (Silty Clays)	0.71	100

If surcharge loadings (i.e. line loads and point loads) are to be incorporated into this projects design then the figure located on page 29, obtained from the Canadian Engineering Foundation Manual, should be used to determine their associated respective lateral pressures on the rigidly structurally designed member. For a uniformly distributed surcharge load, the lateral earth pressure is simply determined by multiplying the load by the aforementioned applicable K_o factor. In addition, for the soils that require 98% - 100% of their SPD (well compacted), the size and type of compaction equipment used to compact the backfill induces additional lateral earth pressures. Therefore, in order to calculate the lateral earth pressures caused by the compaction equipment, a design chart has been provided on page 30 of this report. In addition, it still may also be necessary to provide temporary bracing of the wall during construction in order to resist those lateral earth pressures associated with the compaction equipment.

Alternatively, if the sub-grades located adjacent to the tanks and walls are not required to support surface concrete slab on grade or pavement structures, then the standard triangular earth pressure distribution should be used for design purposes.

9.0 RECOMMENDATIONS

Predicated upon the soils' aforementioned respective strength parameters, lithology and physical properties, the current and modeled groundwater elevations, the field and laboratory test data, and the proposed project's anticipated moderate and heavy applied foundation stresses, respectively, a rigidly reinforced concrete shallow raft footing, drilled cast in place concrete friction piles or drilled spread bore concrete end-bearing piles could be implemented as the foundation design for the proposed new, one–storey, 480 m^2 and 300 m^2 WWTP, 2 – 41 m and 2 – 18 m diameter reactors and clarifiers, respectively, to be located on the SW quadrant of SE22-3-4W in Winkler, Manitoba. Based upon the aforementioned advantages and disadvantages of these foundation systems, a rigidly reinforced concrete shallow raft footing and a drilled cast in place concrete friction piled foundation designs would likely be well performing, more economical and efficient ones for the proposed heavily-loaded tanks and the moderately-loaded WWTP structures, respectively, placed on a property with the aforementioned geotechnical design parameters and constructed during non-freezing months. However, the choice of foundation type implemented for this project will ultimately depend upon their respective, previously described, advantages and disadvantages, estimated installation costs and the applied foundation loads that will be calculated by the project's structural engineering consultant.

It is recommended in the strongest of terms that the geotechnical engineer's personnel inspect the installation of all the foundation elements in order to verify that they all conform with the contents of this report, the structural drawings and the project's specifications.

Any areas of the yard naturally lower in elevation, if any, shall be brought up to its future grade implementing a highly plastic silty clay fill, 50 mm down crushed rock fill, granular C-

Base fill or another pre-approved equivalent material, placed in sufficient 200 mm deep lifts and compacted until each layer has at least 95 % of its SPD.

In order to minimize frost penetration under the WWTP building, 50 mm thick rigid horizontal insulation, or another pre-approved equivalent frost protection, shall be placed around the exterior of the entire structure. This insulation shall be placed along the face of the proposed building out to a distance 1200 mm away from it at a depth of 300 mm below future ground elevation and also along the outside faces of the structure's exterior concrete grade beams.

The backfill material around the perimeter of the proposed structure shall be brought up to its future grade implementing either a 20 mm down crushed rock fill; granular C-Base fill; or another pre-approved equivalent material, placed in sufficient 150 mm deep lifts and compacted until each layer has densities in the range of 92 % to 97 % of its SPD.

The proposed surface concrete slab on grade and all the various proposed asphalt pavement surfaces shall be constructed as per the recommendations outlined in section 6.0 and 7.0 of this report, respectively. If the owner or structural engineer cannot accept the possibility of the aforementioned differential slab on grade displacement, then a structurally supported floor slab shall be implemented for this project. Furthermore, the surface slab on grade and pavement contractors shall also take precautions to prevent the fine-grained sub-grade soils from the following conditions; freezing, excessive soil moisture loss or gain, water ponding and heavily loaded axle traffic. In addition, the granular fill placed for this project shall be free of frost, frozen material and placed at an ambient air temperature of at least 6° Celsius. In order to verify compliance with the aforementioned standard proctor and Marshall Density specifications, field compaction tests shall be taken on every lift of granular material and asphalt placed for this project, respectively. All concrete poured shall be tested in accordance with CSA A23.1-04 every day and at least once every 50 m^3 per day by a CSA Certified concrete testing laboratory. Elevation drawings of the rigidly reinforced concrete raft footing foundation's and the surface slab on grade's respective base structures are illustrated on pages 26 - 27 of this report, respectively.

The selected 50 mm down and 20 mm down crushed limestone, A-Base and C-Base gravels implemented for this project shall all meet the following gradation specifications:

METRIC SIEVE SIZE (μm)	20 mm Limestone (% Passing)	50 mm Limestone (% Passing)	A-BASE (% Passing)	C-BASE (% Passing)
50,000		100		
25,000			100	100
20,000	100		80 – 100	
5,000	40 – 70	25 – 80	40 – 70	25 – 80
2,500	25 – 60		25 – 55	
315	8 - 25		13 – 30	
80	6 - 17	5 – 18	5 – 15	5 – 18

The WWTP building's superstructure should only be supported by only one of the aforementioned approved foundation systems. In addition, in all the aforementioned feasible piled foundation designs, a void space, of at least 150 mm in thickness, should be constructed under all pile caps, grade beams and walls to allow for the potential expansive capability of the various depositions underlying this site. Lastly, the writer understands that a basement and/or a crawlspace are not intended for the proposed WWTP structure.

Since underground tanks and walls are intended underlying the parts of the proposed tanks' construction, their associated lateral earth pressures should be calculated as per section 8.0 of this report. Furthermore, the proposed tanks' and walls' excavations and shoring should, at a minimum, comply with all the Manitoba Department's Workplace Health and Safety guidelines for confined underground work and be designed by the project's structural engineering consultant, respectively. Their construction should then proceed as per those standards and the project's sealed drawings and specifications.

If any of the aforementioned design elements are modified or deleted, please contact the undersigned to determine if that course of action will be acceptable.

In addition, MBA respectfully requests an opportunity to review all the relevant finalized structural drawings and the project's foundation and materials testing specifications for this project in order to verify their conformance with the contents of this report.

The test holes drilled during the investigation represent only those specific areas tested. The soil conditions on this site may vary from that described in this report. Should that situation occur, please contact this office for further instructions.

All the geotechnical engineering design recommendations presented in this report are predicated upon the assumption that a sufficient degree of inspection will be provided during the project's construction and that a qualified and experienced foundation contractor properly installs an aforementioned pre-approved, engineered and sealed foundation type.

Any uses which a third party makes of this report, or any reliance on decisions to be made based on it, are the sole responsibility of such third parties. MBA accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based upon this report.

Yours Truly,
M. Block & Associates Ltd.

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11/25/12
S. J.
BLOCK
REGISTERED PROFESSIONAL ENGINEER

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Certificate of Authorization
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No. 1527 Expiry: April 30, 2013

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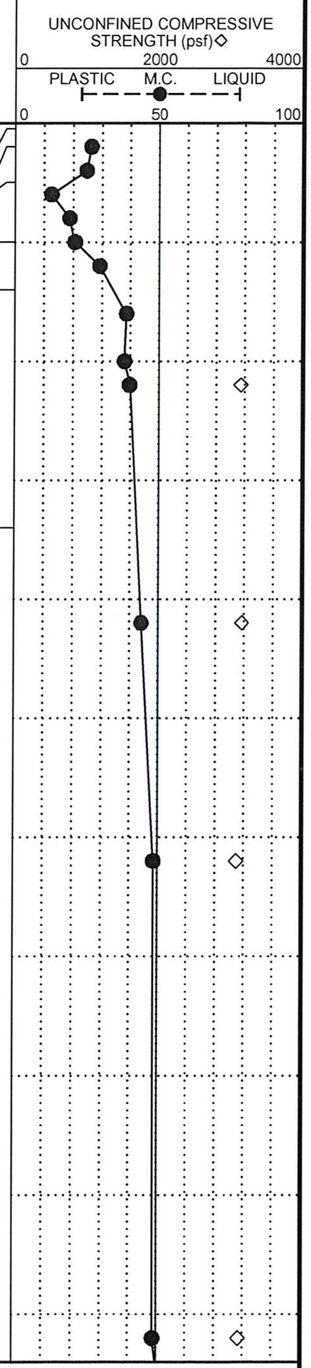
Fax: 204-339-7976

TEST HOLE NO.: 1

Client: City of Winkler	Job No.: 2012-1243	Logged By: J. Block, P. Eng.	Date: 20/11/12
Project: New WWTP, reactors and clarifiers		Reviewed By: J. Block, P. Eng.	Time: 11:30 AM
Location: SW quadrant of SE22-3-4W, Winkler, Manitoba	Elevation: 266.84m	Drawing Number: 5613	

Depth, ft	Sample Number	U S C S	MATERIAL DESCRIPTION
0	27	PT	Black, moist, organic TOPSOIL
	28	CH	Black, alluvially deposited, stiff, moist, silty CLAY
	29	CH	Grey, alluvially deposited, firm, moist, silty CLAY
	30	SM	Brown, damp, compact, poorly-graded silty SAND
5	31, 32	ML	Brown, alluvially deposited, soft, saturated, sandy SILT
	33, 34, 35	CH	Brown, glaciolacustrine, stiff, moist, silty CLAY with silt and gypsum inclusions
	36, 37, 38	CH	Grey, glaciolacustrine, stiff, moist, silty CLAY with silt inclusions



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SAMPLE TYPE SYMBOLS

- Split Spoon
- Vane Shear
- Grab Sample
- Shelby Tube
- Auger Cuttings
- Rock Core

Drill Rig:	B-40 truck mounted drill rig
Auger:	7.5" dia. hollow stem augers
Contractor:	Maple Leaf Drilling Ltd.

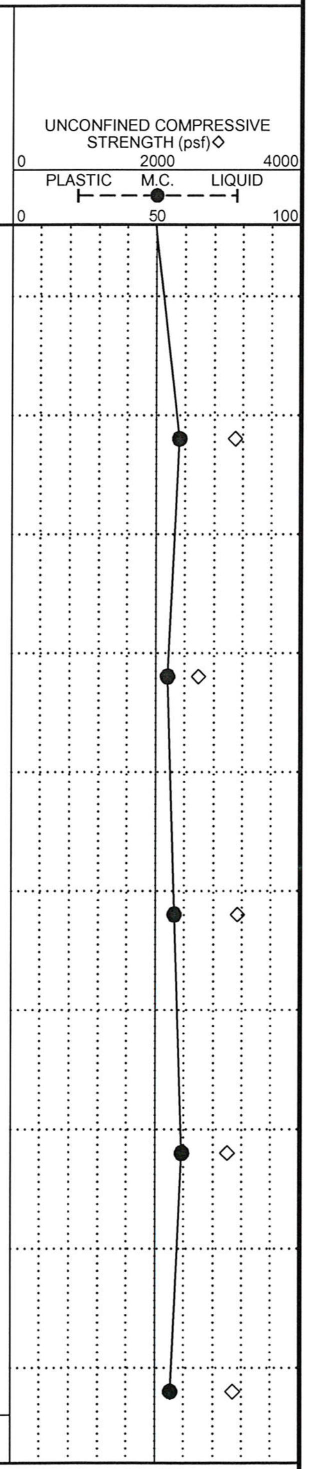
WATER LEVELS

No Ground Water Encountered

M. Block & Associates Ltd.	TEST HOLE NO.: 1
2484 Ferrier Street Winnipeg, Manitoba, R2V 4P6 Telephone: 204-334-5356 Fax: 204-339-7976	Sheet 2 of 2

Client: City of Winkler	Job No.: 2012-1243	Logged By: J. Block, P. Eng.	Date: 20/11/12
Project: New WWTP, reactors and clarifiers		Reviewed By: J. Block, P. Eng.	Time: 11:30 AM
Location: SW quadrant of SE22-3-4W, Winkler, Manitoba	Elevation: 266.84m	Drawing Number: 5613	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
52–102			CH		Grey, glaciolacustrine, stiff, moist, silty CLAY with silt inclusions *(continued)*
60	Shelby Tube	39			
70	Shelby Tube	40			
80	Shelby Tube	41			
90	Shelby Tube	42			
100	Shelby Tube	43			
102					102' - End of hollow stem test hole; - No groundwater seepage or soil sloughing in 10' deep pilot test hole



SAMPLE TYPE SYMBOLS

Split Spoon, Shelby Tube, Vane Shear, Auger Cuttings, Grab Sample, Rock Core

		WATER LEVELS
Drill Rig:	B-40 truck mounted drill rig	No Ground Water Encountered
Auger:	7.5" dia. hollow stem augers	
Contractor:	Maple Leaf Drilling Ltd.	

TEST HOLE LOG 2012-1243-CITY OF WINKLER - WWTP.GPJ M BLOCK ASSOC.GDT 25/11/12

M. Block & Associates Ltd.
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Winnipeg, Manitoba, R2V 4P6
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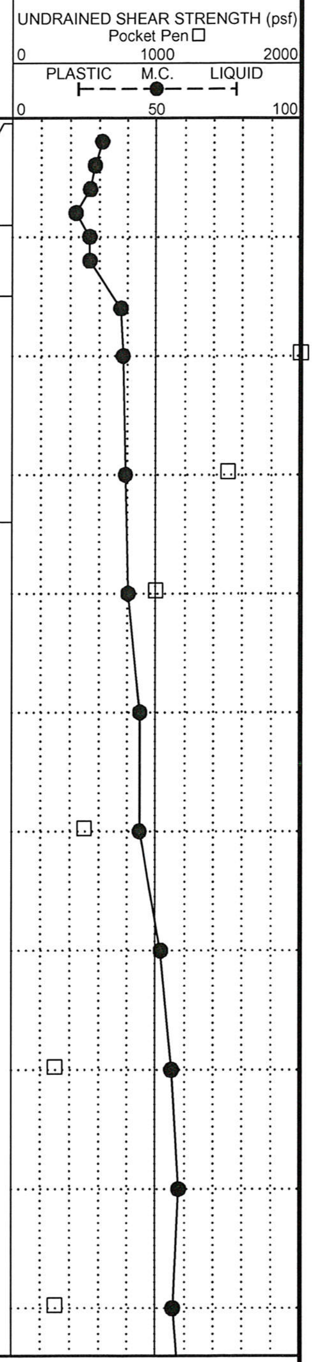
Fax: 204-339-7976

TEST HOLE NO.: 3

Client: City of Winkler	Job No.: 2012-1243	Logged By: J. Block, P. Eng.	Date: 20/11/12
Project: New WWTP, reactors and clarifiers		Reviewed By: J. Block, P. Eng.	Time: 10:00 AM
Location: SW quadrant of SE22-3-4W, Winkler, Manitoba	Elevation: 267.12m	Drawing Number: 5613	

Sample Number	USCS	MATERIAL DESCRIPTION
9	PT	Black, moist, organic TOPSOIL
10, 11, 12	CH	Black, alluvially deposited, stiff, moist, silty CLAY
13, 14	ML	Brown, alluvially deposited, soft, wet to saturated, sandy SILT
15, 16, 17	CH	Brown, glaciolacustrine, stiff, moist, silty CLAY with silt and gypsum inclusions
18, 19, 20, 21, 22, 23, 24	CH	Grey, glaciolacustrine, stiff, moist, silty CLAY with silt inclusions

Depth, ft: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50



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SAMPLE TYPE SYMBOLS

Split Spoon, Shelby Tube, Vane Shear, Auger Cuttings, Grab Sample, Rock Core

Drill Rig:	B-40 truck mounted drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

∇ Phreatic Surface #1: 5.0 ft

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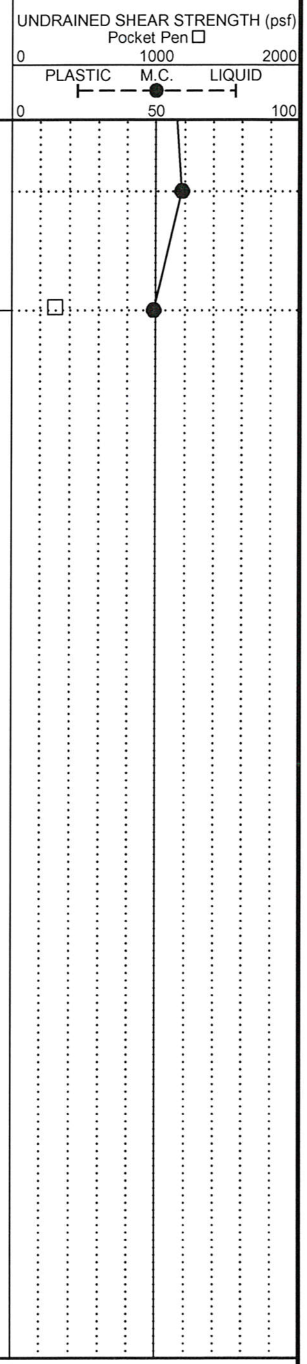
TEST HOLE NO.: 3

Client:	City of Winkler	Job No.: 2012-1243	Logged By:	J. Block, P. Eng.	Date: 20/11/12
Project:	New WWTP, reactors and clarifiers		Reviewed By:	J. Block, P. Eng.	Time: 10:00 AM
Location:	SW quadrant of SE22-3-4W, Winkler, Manitoba	Elevation: 267.12m	Drawing Number:	5613	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
			CH		Grey, glaciolacustrine, stiff, moist, silty CLAY with silt inclusions *(continued)*
55		25			
60		26			60' - End of test hole; - No groundwater seepage or soil sloughing in test hole
65					
70					
75					
80					
85					
90					
95					
100					



SAMPLE TYPE SYMBOLS

Split Spoon
Shelby Tube
Vane Shear
Auger Cuttings
Grab Sample
Rock Core

Drill Rig:	B-40 truck mounted drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

Phreatic Surface #1: 5.0 ft

M. Block & Associates Ltd.

2484 Ferrier Street
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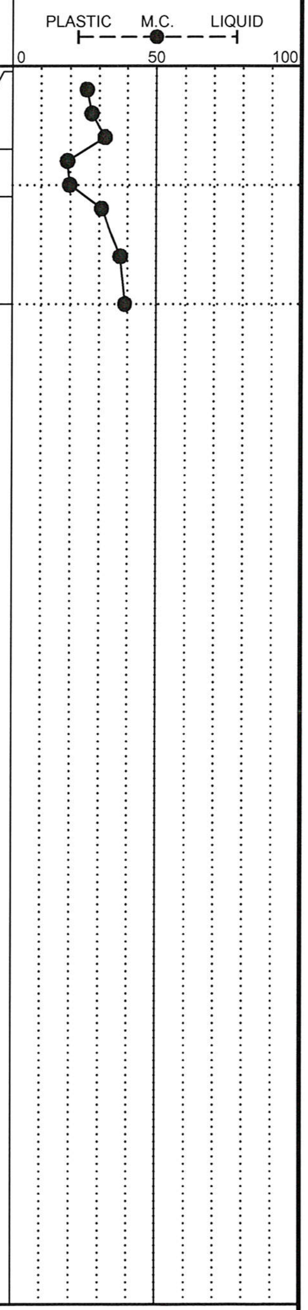
Fax: 204-339-7976

TEST HOLE NO.: 4

Sheet 1 of 1

Client: City of Winkler	Job No.: 2012-1243	Logged By: J. Block, P. Eng.	Date: 21/11/12
Project: New WWTP, reactors and clarifiers		Reviewed By: J. Block, P. Eng.	Time: 12:45 PM
Location: SW quadrant of SE22-3-4W, Winkler, Manitoba	Elevation: 267.15m	Drawing Number: 5613	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
0		52	PT		Black, moist, organic TOPSOIL
		53, 54	CH	▨	Black, alluvially deposited, stiff, moist, silty CLAY
5		55, 56	ML		Brown, alluvially deposited, firm, moist, sandy SILT
		57, 58, 59	CH	▨	Brown, glaciolacustrine, stiff, moist, silty CLAY with silt and gypsum inclusions
10					10' - End of test hole; - No groundwater seepage or soil sloughing in test hole



SAMPLE TYPE SYMBOLS

Split Spoon	Shelby Tube
Vane Shear	Auger Cuttings
Grab Sample	Rock Core

Drill Rig:	Truck mounted CME drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

No Ground Water Encountered

M. Block & Associates Ltd.
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Winnipeg, Manitoba, R2V 4P6
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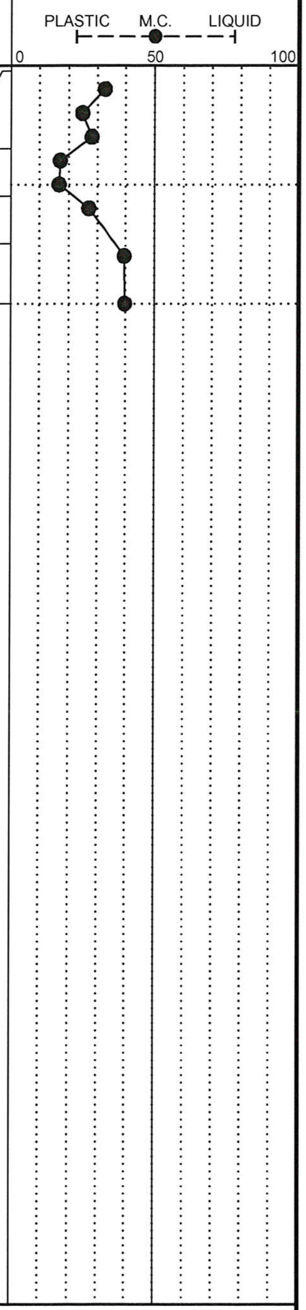
TEST HOLE NO.: 5

Client: City of Winkler	Job No.: 2012-1243	Logged By: J. Block, P. Eng.	Date: 20/11/12
Project: New WWTP, reactors and clarifiers		Reviewed By: J. Block, P. Eng.	Time: 9:30 AM
Location: SW quadrant of SE22-3-4W, Winkler, Manitoba	Elevation: 267.12m	Drawing Number: 5613	

Depth, ft	Sample Type	Sample Number	U S C S	Graphic Log	MATERIAL DESCRIPTION
0		1	PT		Black, moist, organic TOPSOIL
		2	CH		Black, alluvially deposited, stiff, moist, silty CLAY
		3			
		4	ML		Brown, alluvially deposited, firm, moist, sandy SILT
∇		5			
		6	ML		Brown, alluvially deposited, soft, saturated, sandy SILT
		7	CH		Brown, glaciolacustrine, stiff, moist, silty CLAY with silt and gypsum inclusions
10		8			
					10' - End of test hole; - No groundwater seepage or soil sloughing in test hole
15					
20					
25					
30					
35					
40					
45					
50					



SAMPLE TYPE SYMBOLS

Split Spoon | Shelby Tube
Vane Shear | Auger Cuttings
Grab Sample | Rock Core

Drill Rig:	B-40 truck mounted drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

WATER LEVELS

∇ Phreatic Surface #1: 5.5 ft

M. Block & Associates Ltd.
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Winnipeg, Manitoba, R2V 4P6
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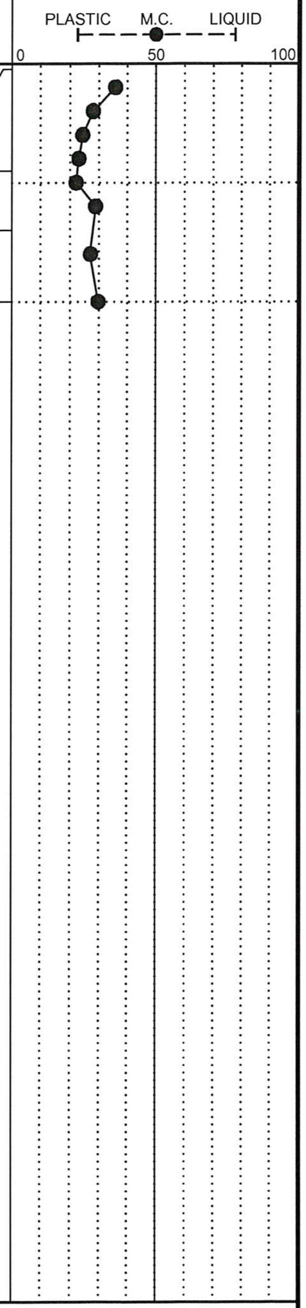
TEST HOLE NO.: 6

Sheet 1 of 1

Client: City of Winkler	Job No.: 2012-1243	Logged By: J. Block, P. Eng.	Date: 21/11/12
Project: New WWTP, reactors and clarifiers		Reviewed By: J. Block, P. Eng.	Time: 12:30 PM
Location: SW quadrant of SE22-3-4W, Winkler, Manitoba	Elevation: 267.35m	Drawing Number: 5613	

Depth, ft	Sample Number	USCS	MATERIAL DESCRIPTION
0	44	PT	Black, moist, organic TOPSOIL
	45, 46, 47	CH	Black, alluvially deposited, stiff, moist, silty CLAY
5	48, 49	ML	Brown, alluvially deposited, firm, moist, sandy SILT
▽ (7.0)	50	ML	Brown, alluvially deposited, soft, saturated, sandy SILT
10	51		10' - End of test hole; - No groundwater seepage or soil sloughing in test hole



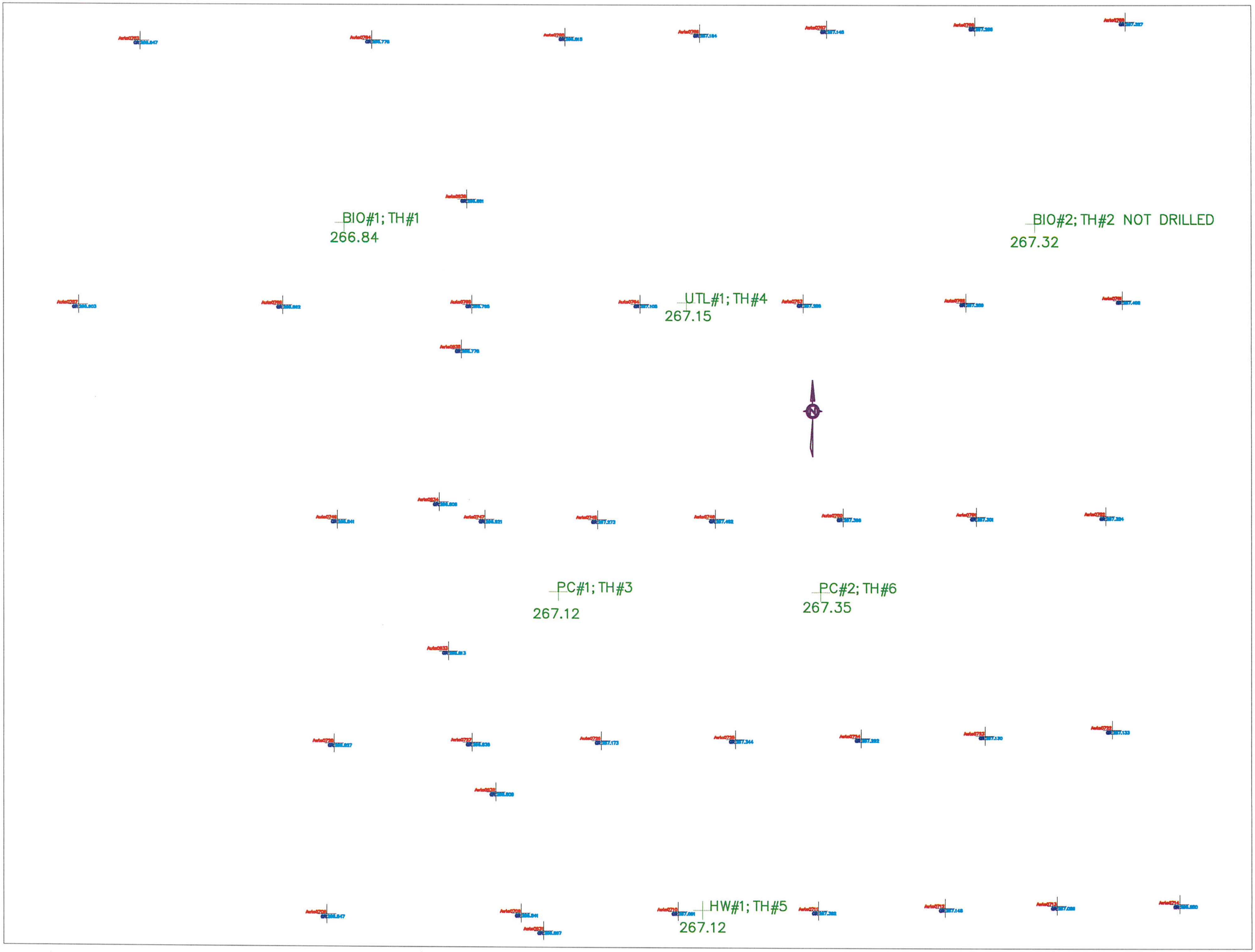
SAMPLE TYPE SYMBOLS

- Split Spoon
- Vane Shear
- Grab Sample
- Shelby Tube
- Auger Cuttings
- Rock Core

Drill Rig:	Truck mounted CME drill rig
Auger:	5" dia. continuous flight augers
Contractor:	Maple Leaf Drilling Ltd.

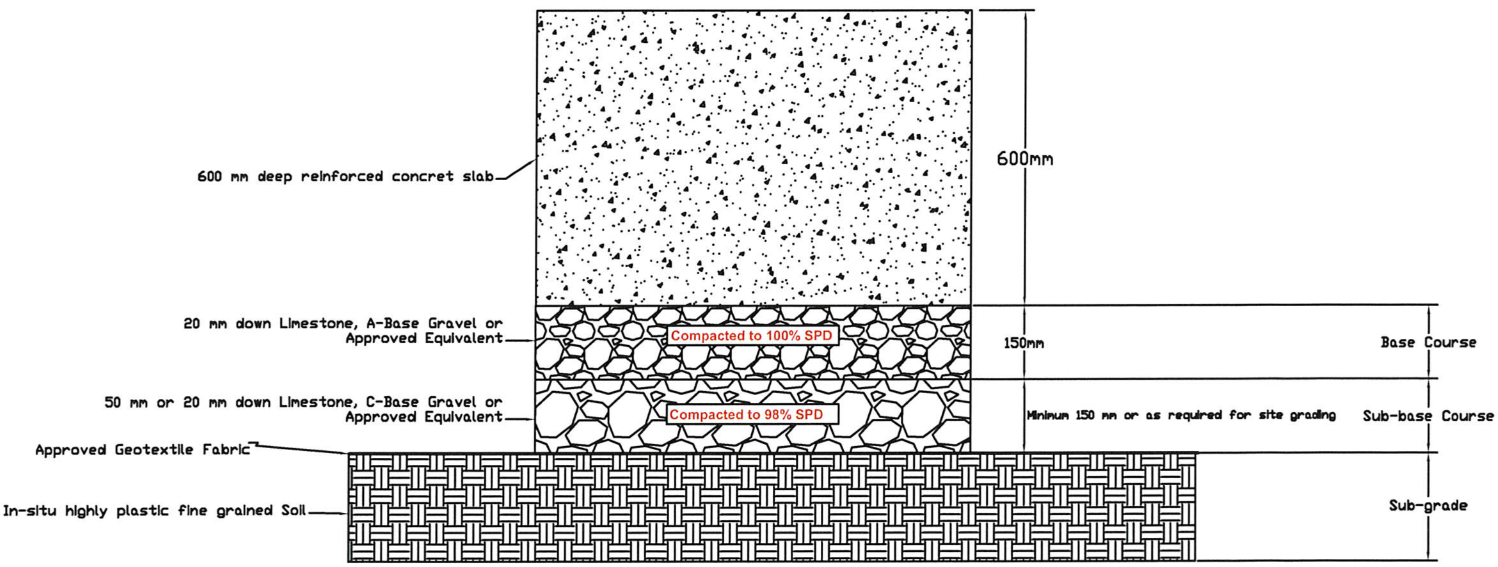
WATER LEVELS

▽ Phreatic Surface #1: 7.0 ft



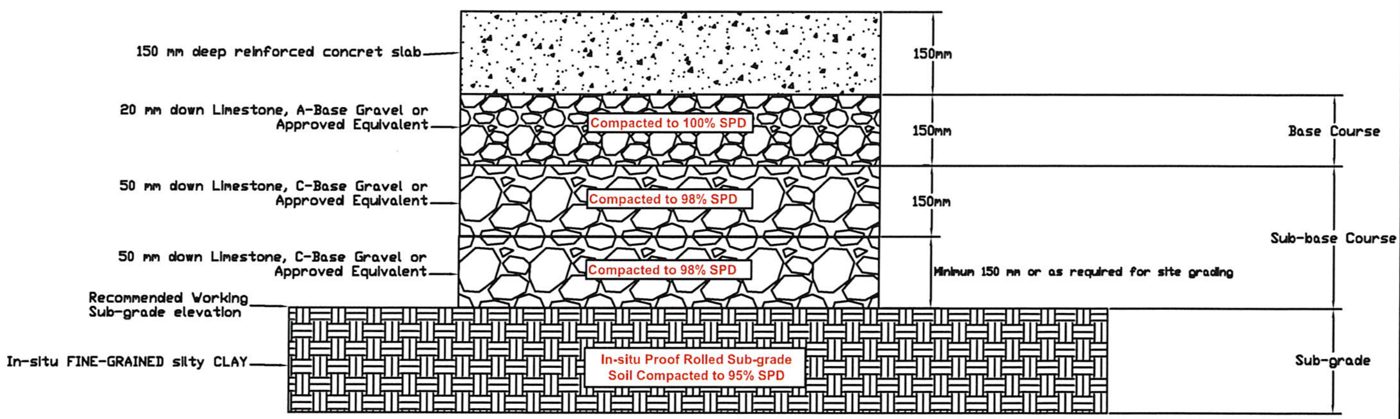
BIO#1; TH#1
266.84
BIO#2; TH#2 NOT DRILLED
267.32
UTL#1; TH#4
267.15
PC#1; TH#3
267.12
PC#2; TH#6
267.35
HW#1; TH#5
267.12

RIGIDLY REINFORCED CONCRTE RAFT FOOTING



M. Block & Associates Ltd. 2484 Ferrier Street Winnipeg, Manitoba R2V 4P6 Phone: (204)-334-5356 Fax: (204)-339-7976	Drawing: Rigidly Reinforced Concrete Footing Drawn By: J. Block, P. Eng. Reviewed By: J. Block, P. Eng.
	Project: New WWTP and tanks in Winkler Project Number: 2012-1243 Drawing Number: 5613

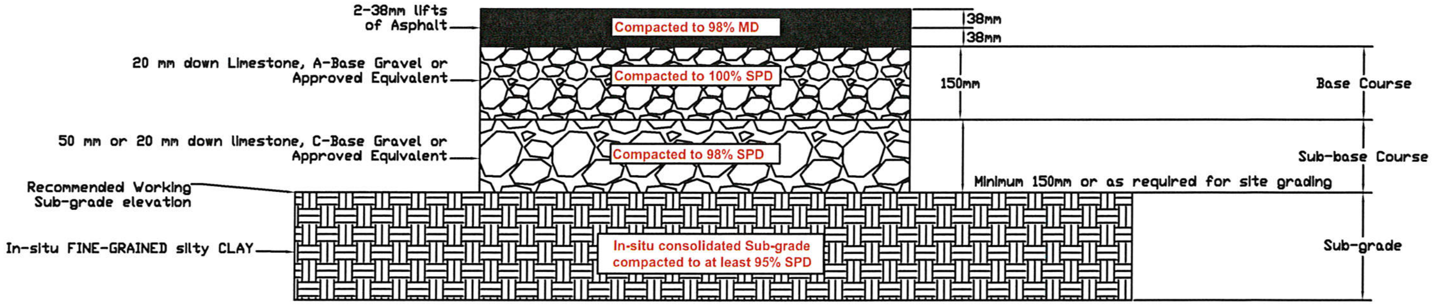
CONCRETE SLAB-ON-GRADE DESIGN



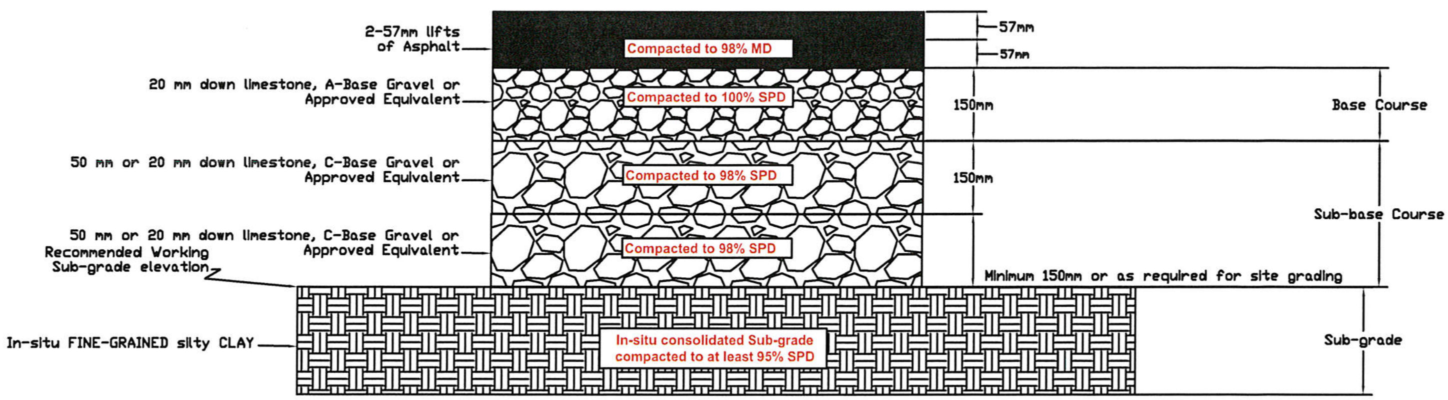
	M. Block & Associates Ltd. 2484 Ferrier Street Winnipeg, Manitoba R2V 4P6 Phone: (204)-334-5356 Fax: (204)-339-7976	Drawing: Surface Slab-on-grade Design Drawn By: J. Block, P. Eng. Reviewed By: J. Block, P. Eng. Project: New WWTP and tanks in Winkler Project Number: 2012-1243 Drawing Number: 5613

PAVEMENT DETAILS

Car Traffic Areas



Truck Traffic Areas



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Winnipeg, Manitoba
R2V 4P6
Phone: (204)-334-5356
Fax: (204)-339-7976

Drawing: PAVEMENTS' STRUCTURES
Drawn By: J. Block, P. Eng.
Reviewed By: J. Block, P. Eng.

Project: New WWTP and tanks in Winkler
Project Number: 2012-1243
Drawing Number: 5613

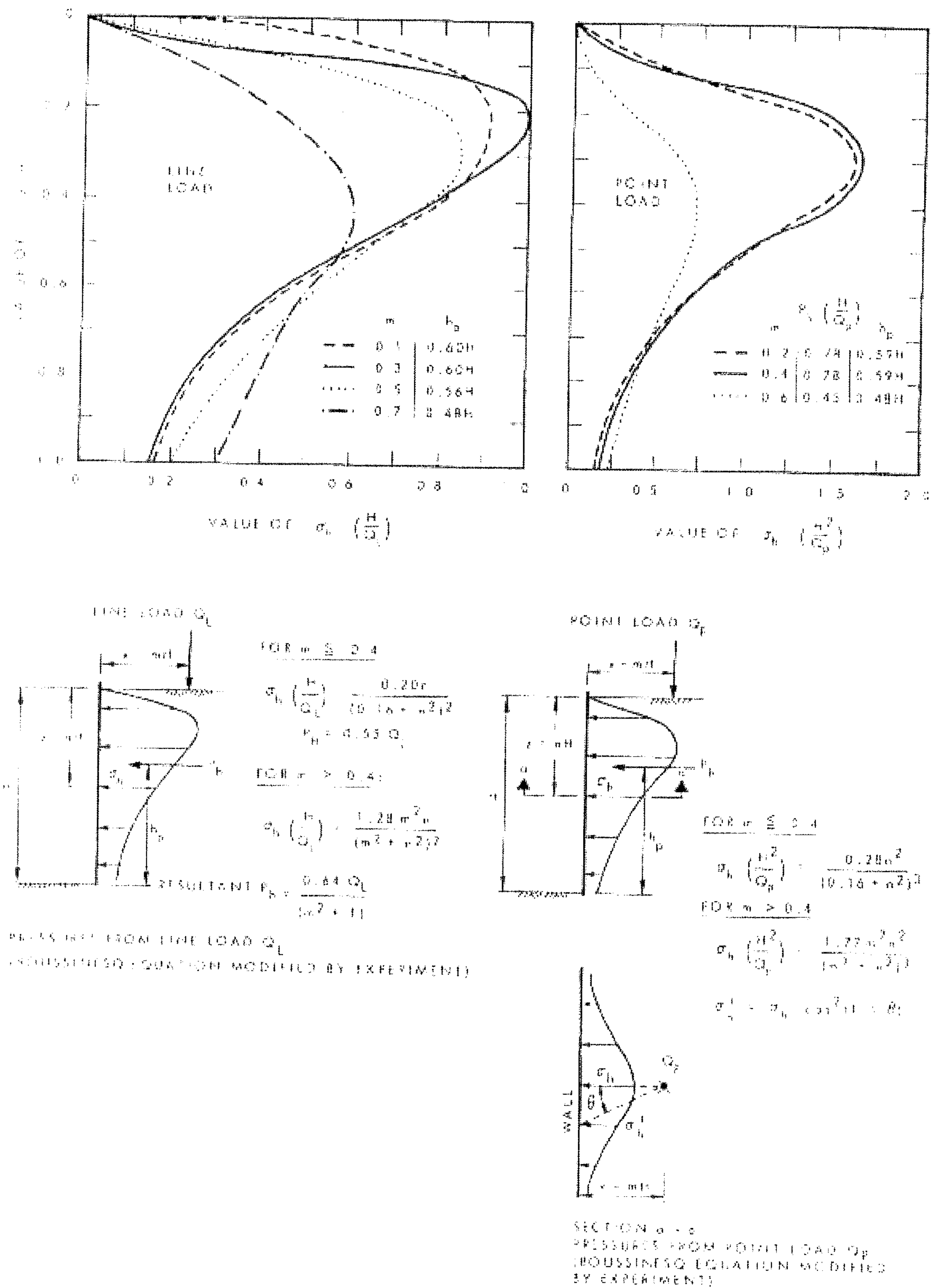
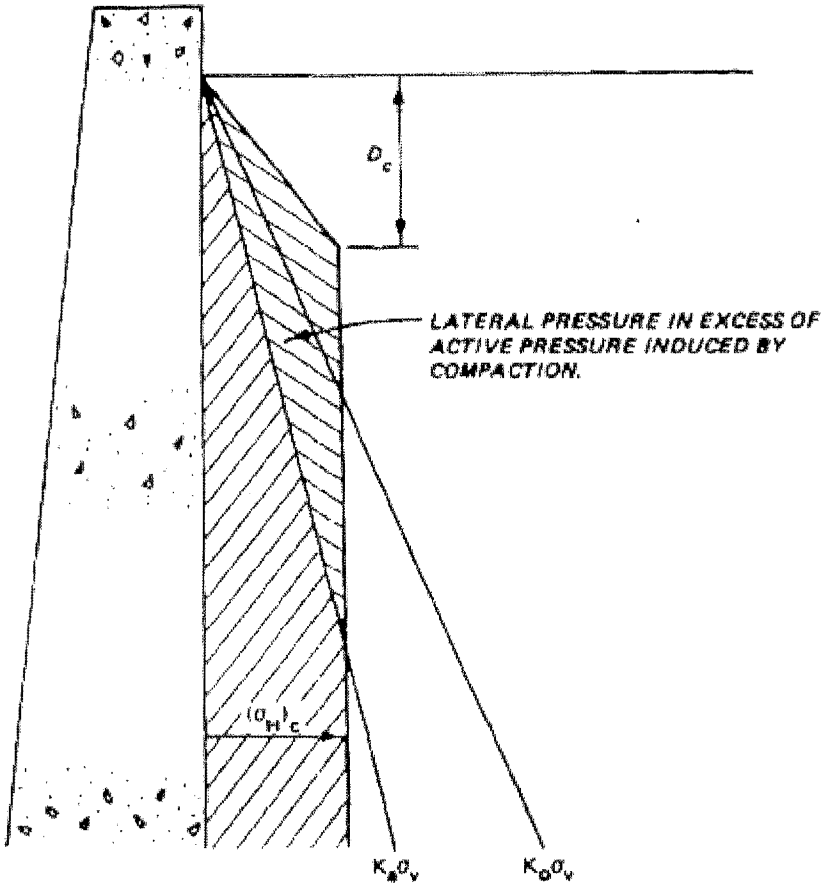


Figure 25.5: Horizontal pressures on a wall due to point and line load surcharges.



COMPACTION EQUIPMENT	CRITICAL DEPTH, D_c, ft	$(\sigma_H)_c$ psf
10-TON SMOOTH WHEEL ROLLER	1.9	420
3.2-TON VIBRATORY ROLLER	1.7	400
1.4-TON VIBRATORY ROLLER	1.2	260
400-KG VIBRATORY PLATE	1.5	340
120-KG VIBRATORY PLATE	1.0	240

Borehole	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
1	1.0							26.2			
1	2.0							24.6			
1	3.0							12.5			
1	4.0							18.7			
1	5.0							20.6			
1	6.0							29.3			
1	8.0							38.7			
1	10.0							38.0			
1	11.0							39.9			
1	21.0							44.2			
1	31.0							48.6			
1	51.0							48.7			
1	61.0							58.1			
1	71.0							54.1			
1	81.0							56.7			
1	91.0							59.4			
1	101.0							55.4			
3	1.0							31.0			
3	2.0							28.4			
3	3.0							26.9			
3	4.0							21.9			
3	5.0							26.7			
3	6.0							26.7			
3	8.0							37.6			
3	10.0							38.4			
3	15.0							39.3			
3	20.0							40.3			
3	25.0							44.5			
3	30.0							44.4			
3	35.0							51.9			
3	40.0							55.6			
3	45.0							58.0			
3	50.0							56.0			
3	55.0							59.0			
3	60.0							49.3			
4	1.0							25.7			
4	2.0							27.4			
4	3.0							32.0			
4	4.0							19.0			
4	5.0							19.8			
4	6.0							30.8			
4	8.0							37.4			
4	10.0							39.0			

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Summary of Laboratory Results

Client: City of Winkler
Project: New WWTP, reactors and clarifiers
Location: SW quadrant of SE22-3-4W, Winkler, Manitoba
Number: 2012-1243

Borehole	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
5	1.0							32.7			
5	2.0							24.8			
5	3.0							28.1			
5	4.0							17.1			
5	5.0							16.7			
5	6.0							27.1			
5	8.0							39.5			
5	10.0							39.7			
6	1.0							35.9			
6	2.0							28.0			
6	3.0							24.5			
6	4.0							23.1			
6	5.0							22.1			
6	6.0							28.9			
6	8.0							27.1			
6	10.0							29.9			

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Summary of Laboratory Results

Client: City of Winkler
Project: New WWTP, reactors and clarifiers
Location: SW quadrant of SE22-3-4W, Winkler, Manitoba
Number: 2012-1243