REPORT NO: 6048-21

GEOTECHNICAL INVESTIGATION
PROPOSED RAMPART INDUSTRIAL SUBDIVISION
PART OF SECTION 35-53-25 W4M
FUTURE 142nd STREET AND 153rd AVENUE
EDMONTON, ALBERTA

April 2010

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GEOTECHNICAL INVESTIGATION

PROJECT: Proposed Rampart Industrial Subdivision

LOCATION: Part of Section 35-53-25 W4M
Future 142nd Street and 153rd Avenue
Edmonton, Alberta

CLIENT: Al-Terra Engineering Ltd.
4010 – 76th Avenue
Edmonton, Alberta
T6B 2P1

ATTENTION: **Mr. Corry Broks, P. Eng.**

1.0 INTRODUCTION

This report presents the results of the geotechnical analysis made on the site of the proposed Rampart Industrial Subdivision in Edmonton, Alberta. Three subsurface investigations were completed in the subject area:

- Hoggan Engineering and Testing (1980) Ltd. in 2009.
- AECOM in 2008.
- Shelby Engineering Ltd in 1997.

Testhole logs from these investigations were utilized to complete geotechnical planning and design aspects of the industrial development project. Authorization to proceed was received from Mr. Corry Broks of Al-Terra Engineering Ltd. in March 2010.

2.0 SITE DESCRIPTION

The proposed industrial development is located part of Section 35-53-25 W4M in northwest Edmonton. It is located southeast of Campbell Road and northwest of the intersection of 142nd Street and future 153rd Avenue. The area is typically empty farmland with some low spots and small treed areas. The site is bordered by agricultural land and residential development.

Once complete, the project is understood to be a fully serviced industrial subdivision. The project will likely be completed in 5 or 6 stages.

3.0 GEOLOGICAL REVIEW

The project area generally consists of glaciolacustrine deposits overlaying glacial till, overlaying either disturbed Saskatchewan sands and gravels or bedrock. The glaciolacustrine deposits consist of bedded sands, silts and clays deposited in large preglacial lake called Glacial Lake Edmonton. The bedrock is mainly found between 15 and 35 meters below ground surface (BGS) but can be found at 10 to 15 meters as rafted or ice shoved bedrock (Kathol McPherson, 1975).

A review of the Atlas: Coal-mine Workings of the Edmonton Area by Richard Spence Taylor indicated that coal mines were not an issue in the Rampart Industrial Subdivision.

4.0 SOIL CONDITIONS

A detailed description of the soils encountered is found on the attached testhole logs in Appendixes A, B and C. It should be noted that the soils encountered in 1997 by Shelby Engineering Ltd. (Shelby), in 2008 by AECOM, and in 2009 by Hoggan Engineering and Testing (1980) Ltd. (Hoggan) were typically consistent throughout. In general, the soil conditions at this site consisted of surficial topsoil, underlain by glaciolacustrine clay overlaying clay till and/or sand, overlaying clay shale. Clay fill was encountered in Testhole 09-1 at the surface and deposits of silt were noted in some testholes within the clay layer.

Topsoil

Surficial topsoil was encountered in all of the testholes except Testhole 09-1. The topsoil depths encountered ranged from 150 to 300 millimeters with the exception of Testhole 09-6 where approximately 760 millimeters of topsoil was encountered. The topsoil depths are known at testhole locations only and may vary in between testholes.

Clay Fill

Clay fill was encountered in at the surface of Testhole 09-1 to a depth of approximately 900 millimeters BGS. The clay fill was noted to be silty, moist, grey in colour and high plastic.

Clay

Glaciolacustrine clay was the next soil encountered below the surficial topsoil or fill in all of the testholes. This material was generally medium or high plastic, and typically had a variable

consistency. Moistures and consistency ranged from moist and very stiff near the surface and very moist to wet and soft to firm with increased depth. The clay material was typically mottled grey and brown and high plastic in the upper zones of the layer and grey and low to medium plastic in the lower zones. The clay featured traces of silt and sand lenses throughout. The clay material was encountered to depths in the range of 5.3 to 8.8 meters BGS in most testholes.

Silt

Silt was encountered in three testholes within the clay layer between depths of 1.55 and 4.3 meters BGS with thicknesses ranging between 0.5 and 1.2 meters. The silt was typically medium plastic, firm to stiff and contained trace to some clay, clay lenses, trace sand and was brown to light brown in color.

Clay Till

A medium plastic clay till was encountered in the deep testholes below the clay to depths in the range of 5.5 and 8.9 meters BGS. The clay till was typically silty, sandy, moist and stiff to very stiff in nature with Standard Penetration Test "N" values between 13 to 90 blows per 300 millimeters. Occasional sand lenses, typically associated with water seepage, were noted in this layer at variable locations throughout the site.

Sand

Sand was encountered below the clay and clay till in some testholes. The sand layers varied in thickness between 0.2 and 2.0 meters and was encountered at variable depths, typically below 5.4 meters BGS. The sand was predominately silty, medium dense, with trace to some clay, trace gravel and brown to grey ion color. The sand material was typically wet and saturated.

Bedrock

Clay shale and sandstone bedrock soils were encountered in four testholes at depths below 8.4 to 10 meters BGS. The bedrock material was typically moist, grey and very stiff to hard with Standard Penetration Test "N" values between 23 to 100 blows per 300 millimeters.

At the completion of drilling, approximately 1 to 6.5 meters of slough and 2 to 7.3 meters of water were noted in all the deeper Shelby testholes while no accumulations of water or sloughing was noted in any of the other testholes.

5.0 GROUNDWATER CONDITIONS

The groundwater table within the study area varied from low to high. The watertable was observed to be between approximately 0.40 and deeper than 8.95 meters below the ground surface. Watertable readings were taken at various times of the year with the results as follows:

Groundwater Table Readings
Proposed Rampart Industrial Subdivision
(Meters Below Ground Surface)

Testhole Number	Testhole Elevation	Depth to Watertable		Watertable Elevation
		22/18/2009	04/01/2010	01/01/2010
09-1	685.52	Dry	Dry	<679.73
09-2	684.11	Dry	Dry	<678.32
09-3	683.66	Dry	Dry	<677.87
09-4	683.75	2.92	3.04	680.71
09-5	684.23	2.52	2.64	681.59
09-6	683.13	1.79	1.84	681.29
09-7	684.19	2.20	2.51	681.68
Testhole Number	Testhole Elevation	Depth to Watertable		Watertable Elevation
		06/09/2008	21/09/2008	21/09/2008
TH08-01	684.97	4.91	5.02	679.95
TH08-02	684.11	7.31	7.23	676.88
TH08-05	683.29	1.67	1.71	681.58
TH08-07	687.93	Dry	7.57	680.36
TH08-09	688.06	Dry	Dry	N/A
TH08-11	684.65	3.97	4.03	680.62
TH08-13	687.09	5.89	5.96	681.13
Testhole Number	Testhole Elevation	Depth to Watertable 15/07/1997		Watertable Elevation 15/07/1997
TH-1	N/A	2.10		N/A
TH-6	N/A	0.70		N/A
TH-15	N/A	0.40		N/A

It should be noted that water table levels may fluctuate on a seasonal or yearly basis with the highest readings obtained in the spring or after periods of heavy rainfall or extended dry weather. These readings would be near or slightly below the seasonal average levels.

6.0 RECOMMENDATIONS

6.1 Site Preparation and Grading

1. This site appears to have low areas containing water. These areas should be drained prior to stripping. Conventional clearing and stripping should be possible for the rest of the site. The topsoil layer was mostly 150 to 300 millimeters thick, although Testholes 09-6 had 760 millimeters of topsoil. The topsoil depth is known only at the testhole locations, and may vary between testholes.

   Clay fill was also encountered in Testhole 09-1 to a depth of approximately 900 millimeters BGS. The clay fill appeared to have trace organics and should be assessed further at the time of construction by a qualified geotechnical engineer in order to confirm its suitability as site grading material.

2. It is understood that the fill material will mainly be the silty clay, clayey silt and clay till from cut areas, borrow areas, and storm ponds. The clay and silt will be mostly above optimum moisture content, and will likely require drying. Most of the near surface clay material encountered throughout this site were medium to high plastic in nature and is highly susceptible to swelling and shrinkage. The clay material should be placed at slightly above optimum moisture content, typically in the range of 1 to 3 percent. This will significantly reduce the swelling and shrinkage effects on future building and surface utility areas. If at all possible, high plastic clay should not be used below future building slab-on-grades.

   The silt material encountered in some testholes is highly frost susceptible and should be limited to areas below the top 1.0 to 1.5 meters below final grade. This will significantly reduce any frost heave concerns of the silt material. The clay till is near to slightly above optimum and will require minor amount of drying.

3. It is understood from Al-Terra that all fill in the industrial lots and road areas will be placed and compacted to a minimum 97 percent of the Standard Proctor Density (SPD). The fill should be placed in maximum 150 millimeter thick lifts at or slightly above

optimum moisture content. Any topsoil or non-engineered fill must first be stripped from the fill area.

Fill placement to 97 of SPD may be difficult in some situations. One of these situations occurs when soft, very moist, underlying soils are exposed once stripping has been completed, which may be seen in the low areas areas. Compacting the first lift of fill material over these soft underlying soils to the 97 percent of SPD standard may be impossible. Construction of a clay pad up to 500 millimeters maximum thickness can be utilized to obtain an adequate working platform to start from. This pad should be compacted to a minimum of 95 percent of SPD where possible. The normal fill lift thickness and compaction criteria mentioned above should be applied to successive lifts. The pad should be comprised of near optimum clay that does not require drying.

6.2 Preliminary Building Foundations and Slab on Grade

1. The following foundation recommendations are preliminary in nature. The foundation requirements of industrial buildings vary greatly depending on individual building design. A detailed geotechnical investigation is necessary for each lot once the actual building locations and site usage have been determined in order to determine detailed foundation parameters and construction recommendations specific to the proposed structures.
2. Construction of commercial and industrial units on the native soils encountered throughout this site is feasible, as long as appropriate construction measures are utilized. In general, observed conditions which require attention include potential ingressing groundwater within deep excavations due to the high watertable, particularly at Testholes 09-4, 09-5, 09-6, 09-7, TH08-05, TH-1, TH-6 and TH-15 where the levels stabilized above 3.0 meters from existing grade; surficial high plastic soils which are highly susceptible to swelling and shrinkage; deep topsoil at Testholes 09-6; fill encountered at Testholes 09-1; and the very moist to wet clay encountered in some testholes below 2.0 meters. The proposed industrial units may be supported by continuous or spread footings bearing on undisturbed native inorganic soils, although bearing capacities in the very moist or wet clay will be relatively low. Also, shrinkage and swelling potential movement must be accepted for footings bearing on the high plastic clay.

3. Surficial topsoil was observed in all testholes except Testhole 09-1 where fill was the surficial soil encountered. The topsoil typically ranged from 150 to 300 millimeters except for Testhole 09-6 where the topsoil extended to 0.76 meters. Also, fill was encountered to 0.9 meters at Testhole 09-1. The footing elevation of any structures should be set below the topsoil and fill zones. No footings or slabs should be permitted to bear on or above the topsoil and organic clay soils.
4. Suitable clay till and bedrock end bearing soils for bored cast-in-place piles were encountered at the depth in some of the testholes drilled. Skin friction cast in place piles within the clay, clay till and bedrock soils are also feasible. Some ingressing ground water may be encountered due to the high watertable in portions of this site and the sand encountered in some of the testholes. Casing for cast in place piles would likely be required, and should be available on site during piling operations. In the event casing is not required, slowly ingressing groundwater could be encountered, therefore the pile concrete should be on-site during the pile drilling allowing for quick concrete placement after the pile is inspected.
5. Temporary and long-term dewatering may be required for basement excavations advanced below the watertable.
6. The native near surface clays encountered appear to be adequate for slab-on-grade support for typical commercial floor loads. However, as noted, some of the clays encountered in the testholes are high plastic and are a concern for shrinkage and swelling.

6.3 <u>Groundwater and Drainage Issues</u>

1. The groundwater readings in the proposed subdivision were generally low to high, and are a concern in design and construction of underground and surface utilities, and building construction.
2. Typically the groundwater seepage rates into utility trenches from the moist native clays should be relatively low with increased amounts occurring in trenches where very moist or wet clays are encountered. Areas where sand is encountered, water seepage can be expected to be moderate to high. Trace to high amounts of slough and water were noted in the Shelby Testholes while no water or slough was encountered in all other testholes at the completion of drilling. It is expected that some trench dewatering may be necessary in areas where ingressing water is noted in the trenches. Construction delays can be expected.

3. In high watertable areas, subgrade softening below surface utilities is a concern. In these areas, attempts should be made to lower the watertable. This may be accomplished by using sub-drains, usually consisting of perforated pipe and manhole inlets, to collect groundwater below the road area. Other options which may be utilized are hydraulically connecting the bedding materials to the manholes, or leaving the rings off the storm sewers during construction, allowing groundwater to seep into the sewer. When employing this method, it is important to wrap the joints in filter cloth to prevent silting. The exact configuration and need for the sub-drains should be determined during construction.
4. Water dispersed on the property from the roof leaders must not be allowed to accumulate against foundation walls. To ensure positive drainage, the soil surface of all lots should be made sloping away from all buildings. This will require a positive lot grading of at least five percent away from the foundation walls for a minimum of 1.5 meters.
5. In order to ensure no flow paths for water from the roof leaders occur adjacent to the foundation walls, the following two alternatives are proposed:
   i) A concrete splash pad, placed beneath the downspouts, a minimum of 1.2 meters long and firmly anchored to the house foundation can be used.

   or

   ii) A permanent downspout extension could be used to carry water away from the foundation wall.

6.4 <u>Underground Utilities</u>

1. The subsurface soil conditions encountered in the testholes are considered generally poor to good for the installation of underground utilities incorporating the City of Edmonton backfilling and compaction requirements. The lower portions of the clay, where it became very moist to wet at depth would be considered fair to poor. The upper clay and clay till soils were near or slightly above optimum moisture content and would be considered good.
2. Topsoil and other organic materials are not considered suitable for backfill material. This topsoil should be separated from the non-organic soils, and should not be re-used as trench backfill. The clay fill encountered in Testhole 09-1 featured trace organics and should be assessed onsite during construction by a qualified geotechnical engineer for its suitability as trench backfill.

3. The watertable was located between 0.4 and lower than 8.95 meters below ground surface in the testholes, indicating that saturated conditions will likely be encountered in the trenches in these areas, depending on the design elevations and nature of the subsoil. Ingressing water and sloughing was noticed in the Shelby Testholes, shallower cut trenches may be necessary to ensure trench stability. Temporary dewatering and delays may be required in any area where ingressing water and sloughing is encountered during trenching.

4. The surficial medium and high plastic clay material was typically stiff to very stiff and moist near the surface, and very moist to wet and softer with increased depth. Moisture conditioning of the trench backfill will be required. The amount of moisture conditioning will vary depending on the nature moisture content of the soils. In areas where the dryer surficial layer of clay is deep enough, it may be possible to mix the overlying dryer layer of clay with the underlying wetter layer to obtain satisfactory moisture content for trench backfill. The very moist to wet silty clay and clayey silt soils encountered at depth will require considerable drying if they are to be used as trench backfill material. The clay till was generally moist with the moisture content near optimum. The following chart illustrates moisture content criteria for the soil where Atterberg Limit Series tests were performed. The moisture contents of the AECOM Testholes and the Atterberg Liquid and Plastic Limits along with the moisture contents of the Shelby Testholes were estimated from the testhole logs.

Trench Backfill Maximum Moisture Content Criteria
Proposed Rampart Industrial

Testhole Number	Sample Depth	Liquid Limit	Plastic Limit	Field Moisture Content	Plasticity Index (PI)	Maximum Moisture Content Criteria: Uniform Backfill			Conventional Backfill			PL+10 Criteria	
						PI/2	PL+PI/2	+/- Criteria	PI/3	PL+PI/3	+/- Criteria	PL+10	+/- Criteria
09-1	2.3 m	53.5	20.8	31.9	32.7	16.4	37.2	-5.3	10.9	31.7	0.2	**30.8**	1.1
09-3	0.6 m	66.3	20.7	21.3	45.6	22.8	43.5	-22.2	15.2	35.9	-14.6	**30.7**	-9.4
09-4	5.3 m	41.8	17.2	39.3	24.6	12.3	29.5	9.8	8.2	25.4	13.9	27.2	12.1
09-6	3.8 m	53.4	21.5	39.8	31.9	16.0	37.5	2.3	10.6	32.1	7.7	**31.5**	8.3
08-01	0.8 m	57.2	20.7	37.0	36.5	18.3	39.0	-2.0	12.2	32.9	4.1	**30.7**	6.3
08-02	7.0 m	19.4	12.4	18.0	7.0	3.5	15.9	2.1	2.3	14.7	3.3	22.4	-4.4
08-02	8.5 m	18.2	18.0	10.0	0.2	0.1	18.1	-8.1	0.1	18.1	-8.1	28.0	-18.0
08-03	3.8 m	44.1	20.0	38.0	24.1	12.1	32.1	6.0	8.0	28.0	10.0	30.0	8.0
08-04	0.8 m	65.8	19.2	25.0	46.6	23.3	42.5	-17.5	15.5	34.7	-9.7	**29.2**	-4.2
08-05	0.8 m	90.2	25.1	38.0	65.1	32.6	57.7	-19.7	21.7	46.8	-8.8	**35.1**	2.9
08-05	7.0 m	38.7	16.6	36.0	22.1	11.1	27.7	8.4	7.4	24.0	12.0	26.6	9.4
08-05	8.5 m	26.1	13.8	29.0	12.3	6.2	20.0	9.1	4.1	17.9	11.1	23.8	5.2
08-06	0.8 m	54.0	20.3	24.0	33.7	16.9	37.2	-13.2	11.2	31.5	-7.5	**30.3**	-6.3
08-06	3.8 m	33.1	21.0	36.0	12.1	6.1	27.1	9.0	4.0	25.0	11.0	31.0	5.0
08-06	7.0 m	15.9	14.5	19.0	1.4	0.7	15.2	3.8	0.5	15.0	4.0	24.5	-5.5
08-07	2.3 m	49.3	19.4	35.0	29.9	15.0	34.4	0.7	10.0	29.4	5.6	29.4	5.6
08-09	8.5 m	23.7	13.8	14.0	9.9	5.0	18.8	-4.8	3.3	17.1	-3.1	23.8	-9.8
08-10	8.5 m	35.9	15.3	22.0	20.6	10.3	25.6	-3.6	6.9	22.2	-0.2	25.3	-3.3
08-12	3.8 m	50.0	20.2	40.0	29.8	14.9	35.1	4.9	9.9	30.1	9.9	30.2	9.8
08-12	7.0 m	35.0	19.9	37.0	15.1	7.6	27.5	9.6	5.0	24.9	12.1	29.9	7.1
08-14	0.8 m	49.8	20.4	25.0	29.4	14.7	35.1	-10.1	9.8	30.2	-5.2	30.4	-5.4
08-14	5.3 m	39.1	18.0	37.0	21.1	10.6	28.6	8.5	7.0	25.0	12.0	28.0	9.0
08-14	8.5 m	14.6	15.7	15.0	-1.1	-0.6	15.2	-0.1	-0.4	15.3	-0.3	25.7	-10.7
08-15	2.3 m	45.5	19.9	23.0	25.6	12.8	32.7	-9.7	8.5	28.4	-5.4	29.9	-6.9
TH-1	1.4 m	60.0	18.0	23.0	42.0	21.0	39.0	-16.0	14.0	32.0	-9.0	**28.0**	-5.0
TH-4	5.3 m	45.0	24.0	39.0	21.0	10.5	34.5	4.5	7.0	31.0	8.0	34.0	5.0
TH-9	0.5 m	60.0	32.0	36.0	28.0	14.0	46.0	-10.0	9.3	41.3	-5.3	42.0	-6.0

Notes: - City specifications state that when the plasticity index criteria for maximum moisture content exceeds 10 percent over plastic limit, the plasic limit plus 10 percent shall govern. Also, the top 1.5 metres in convetional trenching has a maximum moisture content of PL+8 or the formula, whichever is less.
- All values are percentages.
- Bold values of PL+10 are governing criteria.
- Chart shows only the samples which were tested for Atterberg Limits. See testhole logs for all moisture content data.

5. Standard trenching cutback angles of approximately 30 degrees from the vertical are anticipated for mcst areas of the site, although some portions of the moister clays and silts may require increased cutback angles of 45 degrees or more in order to remain stable, due to their low strength and elevated moisture contents. Actual cutback angles should be determined in the field during construction. Exact stable slope values cannot be pinpointed without detailed and extensive analysis. For this reason, this information should be used as a guideline only and that the optimum cutback angles for utility trenches be determined in the field during construction. The Occupational Health and

Safety Act, Part 32 Excavations and Tunneling should be strictly followed, except were superseded by this report.

6. To minimize pipe loading, trench widths should be minimal but compatible with safe construction operations. The trench width must be wide enough to accommodate pipe bedding and compaction equipment.

7. Temporary surcharge loads, such as spill piles, should not be allowed to within 3.0 meters of an unsupported excavation face, while mobile vehicles should be kept back at least 1.0 meter. All excavations should be checked regularly for signs of sloughing or failures, especially after rainfall periods.

8. Pipe bedding and trench backfill procedures should adhere to the City of Edmonton specifications as outlined in The Servicing Standards manual. The backfill material beneath and above the pipe should be an approved bedding sand material where conditions allow. This material should be hand placed and hand tamped, with care taken to fill the underside of the pipe. The City of Edmonton Type B pipe bedding configuration is considered suitable. Ingressing groundwater may be encountered in the trenches below the water table. To overcome the installation difficulties which may be encountered where ingressing groundwater and/or poor bearing conditions may be a problem, it is recommended that a washed rock and geotextile separator be utilized for pipe bedding in these areas. The washed rock and geotextile configuration should be determined in the field during construction.

9. The moisture content of the upper clay in the testholes was variable, but was generally moist above approximately 2.0 meter and typically moist to very moist below that. The variable condition of the soils will cause a corresponding variability in the utility trench pipe bedding and backfill conditions. As a minimum, drying of the very moist soils prior to placement in the trench will be required when adequate compaction cannot be achieved at the natural moisture content.

10. Trench compaction requirements of the City of Edmonton are 100 percent of the One-Point Proctor Density above a depth of 1.5 meters, and 97 percent of the One-Point Proctor Density below this level. The maximum lift thickness is 300 millimeters. This degree of compaction should be achievable with a considerable amount of mixing and/or drying of the trench backfill in portions of the trench.

Aggressive drying of the trench backfill may be performed in order to improve road subgrade conditions, and should be considered for this site. It is suggested that a maximum moisture content of 5 percent above the plastic limit be set for the top 1.5 meters of the trench, in order to improve conditions for the construction of surface utilities.

11. It should be noted that the ultimate performance of the trench backfill is directly related to the consistency and uniformity of the backfill compaction, as well as the underground contractors construction procedures. In order to achieve this uniformity, the lift thickness and compaction criteria should be strictly enforced. The amount of drying performed during trench backfill compaction will directly affect the subgrade performance during roadway construction.
12. The upper high plastic clays should be separated from the lower silt and very silty clays during trenching, and replaced in the top 1.5 meters of the trench to help reduce the frost heave potential for the above roads.

6.5 Surface Utilities

1. The subsurface soil conditions encountered throughout this site are considered generally good to poor for the construction of roads, curbs, and sidewalks in undisturbed areas. Difficulty will likely be encountered in utility areas due to mixing of materials during trench backfilling as well as low areas and areas where cuts are planned during site grading. The existing topsoil, clay fill and other deleterious materials should be removed prior to construction of roads, sidewalks and other surface utilities.
2. The main concern for surface utility construction at this site is the high moisture content of the underlying clay and silt material. The near surface clay materials were near or slightly above optimum moisture content, but mixing and disturbance during underground utility installation will degrade the soil conditions. Extra subgrade work beyond standard scarification and re-compaction may be required in order to construct an adequate working platform for the pavement structure placement and long term support. It is noted that the degree of trench backfill drying and separation during underground utility installation affects the soil conditions for road and sidewalk construction, with increased drying and separation improving the soil conditions.

At the time of drilling the moisture content was near or slightly above optimum in

the near surface clays. Very moist to wet soils were generally noted below approximately 1.0 to 2.0 meters. In undisturbed areas where final subgrade elevation will be at or above the existing elevation, a minimum 10 kg/m² cement stabilized subgrade preparation should be adequate. However, in areas where shallow cuts are planned or areas where very moist clays are encountered, 20 to 30 kg/m² of cement mixed to a minimum 300 millimeters may be required. Also, extensive drying should be considered. If at all possible, cuts should be avoided at this site during site grading.

Where the final subgrade is near the very moist to wet clay, and in disturbed underground utility areas, extra subgrade measures will be required. These measures may include aggressively drying the very moist materials to obtain a more stable and stronger subgrade. An estimated 1.5 meters of material would be required to bridge the in-situ soft clay soils (See also Item 4 for frost heave concern). This method can be accomplished during underground utility construction using uniform backfill methods, as described in the previous section. If the upper high plastic clays are to be used for this purpose, they should be compacted at a minimum of 2 percent over optimum, to avoid future swelling concerns. Deep cement stabilization may work in limited areas at 25 to 30 kg/m², provided some backfill drying is performed.

Another option would be the use of a pit-run gravel subbase. The estimated thickness of subbase to support the roadway is 450 to 600 millimeters. A medium duty woven geotextile, Amoco 2006 or equivalent, should initially be placed below the gravel for separation and reinforcement. The placement of the wic drain at the bottom of granular subbase is recommended. We estimate that a small portion of the site may require a pit-run subbase.

It is recommended that the subgrade be inspected by qualified personnel during construction to determine the recommended subgrade treatment. The subgrade should be proof rolled after final compaction, and any areas showing visible deflections should be inspected and repaired.

3. The near surface inorganic clays are generally medium to high plastic in nature and are susceptible to swelling. Experience has shown that cement stabilization is effective in reducing the swelling potential of high plastic clays. Application rates would best be determined in the field during construction. The addition of 10 kilograms of cement per

square meter of subgrade mixed to a depth of 150 millimeters is estimated for the purpose of reducing the swelling potential.

Care must be taken not to allow any excess moisture into these soils. It is recommended that all areas beyond the back of curb/sidewalk be landscaped as soon as possible to avoid water permeating into the subgrade from free standing puddles. The near surface soils encountered throughout this area exhibit a moderate to high swelling potential, and it is important that subgrade soils not be allowed to dry excessively when exposed. Moisture contents should be kept slightly over optimum for high plastic clay areas.

4. The observed watertable depths are low to high at this site, between approximately 0.4 and below 8.95 meters below ground surface, and varying around the site. The near surface plastic clays are of moderate frost susceptibility. A watertable within approximately 3.0 meters of the road surface is required for significant frost heaving to occur. The closer the watertable is to the surface, the higher is the frost heave potential. Some standpipes in the testholes at this project have stabilized well above this level, and the potential for frost heave will be moderate to high in these areas. Therefore, the design grade should be set as high as possible. No cuts are recommended for these areas. No other frost heave considerations are considered necessary.

   An attempt should be made to lower the watertable in high watertable areas. This may be accomplished by using sub-drains, usually consisting of perforated pipe at manholes. Other options which may be utilized are hydraulically connecting the bedding materials to the manholes, or leaving the rings off the storm sewers during construction, allowing groundwater to seep into the sewer. When employing this method, it is important to wrap the joints in filter cloth to prevent silting. The exact configuration and need for sub-drains should be determined during construction.

5. It is assumed that all the subdivision roads, apart from the arterials, are classified as light industrial. The following pavement design may be applied to the proposed industrial roadways. An estimated California Bearing Ratio of 3.0 percent and a design life of 20 years is used in the designs. The previous items have discussed the possible difficulty and recommended options for attaining this CBR at this site, and need to be referenced. The stated ESAL values were obtained from City of Edmonton guidelines or estimated based on the Rampart Neighbourhood Traffic Impact Study prepared by AECOM in October 8, 2009

utilizing truck traffic of 10 percent and an aggregate truck factor of 1.0. The pavement structure can be modified if alternate traffic loading is forwarded to our firm.

Recommended Staged Roadway Structures
Proposed Rampart Industrial

Structure Options	Light Industrial Local ($1.8x10^6$ ESALs)	Future 153 Avenue ($5.9x10^6$ ESALs)
Stage 1		
Asphaltic Concrete (ACO)	40 mm	50 mm
Asphaltic Concrete (ACB)	70 mm	100 mm
Crushed Gravel (20 mm)	300 mm	350 mm
Stage 2 (Future)		
Asphaltic Concrete (ACO)	40 mm	50 mm

Note: 98 % Compaction required on Stage 2 overlay.
ACB = City of Edmonton Designation Asphaltic Concrete Base Course.
ACO = City of Edmonton Designation Asphaltic Concrete Overlay.

6.6 Cement

Tests on selected soil samples indicated negligible to very severe concentrations of water soluble soil sulphates in the near surface clay deposits. The following alternatives are advised:

1. Underground Concrete Pipe

   Concrete used for all underground pipes must be constructed of C.S.A. Type HS, sulphate resistant Portland cement.

2. Curbs and Sidewalks

   All concrete for surface improvements such as sidewalks and curbs should be constructed using CSA Type GU, normal Portland cement.

3. Foundation Construction

   All concrete used for construction and coming into direct contact with the soil must be made with CSA Type S1, sulphate resistant Portland cement. A minimum 56-day compressive strength of 35 megapascals is recommended for house foundation construction due to the sulphate content. The water-to-cementing ratio should be a maximum of 0.4. In addition, all

concrete subject to freeze thaw must be air entrained with 5 to 7 percent air. Individual locations may show higher or lower concentrations of soluble soil sulphates, and thus additional soil testing on particular sites may prove valuable.

6.7 Stormwater Management Facility

1. It is understood that a stormwater management facilities will be located in the southeast portion of the site near Shelby Testholes TH-9 to TH-14, AECOM Testhole TH08-05 and Hoggan Testholes 09-5 to 09-7. In these testholes the subsurface soils encountered were comprised of medium to medium to high plastic clay soils, which should yield sufficiently low permeability characteristics for water retention purposes. No liner is considered necessary. The near surface clay was generally stiff to firm with a moist consistency and should be excavated by scrappers. The clay soils became very moist to wet with a firm to soft consistency with increased depth. The soft to firm clays may require a backhoes and trucks in order to excavate. Excavation methods are best determined by the contractor during construction.

   Maximum excavation side slopes of 3:1 should be geotechnically stable in the upper clay materials while the very moist, vey silty clay and silt materials will likely require gentler slopes of 5:1 for adequate stability. Gentler slopes may be desirable for land use, maintenance, or recreational activities. Below the water level, a maximum slope of 4:1 is recommended for stability purposes in the clay till. The very silty clay and silt should have 7:1 sideslopes below the normal water level. Stabilized water level measurements indicate a water level of approximately 1.7 to 2.6 meters below the ground surface in the area of the proposed pond, at elevations of 681 to 683 meters. Excavation and grading below this level will likely experience some ingressing groundwater, and may be more difficult.
2. Dry pond construction below the watertable may produce constant water seepage into the outlets, and a soft, saturated pond bottom. Therefore, a dry pond would not be recommended below the above noted elevations.
3. All containment areas of a dry pond and the above waterline portion of wet ponds should be protected to minimize erosion. The sideslopes of wet ponds should be protected from wave and ice erosion near the waterline.

The material being excavated from the stormwater pond is suitable for engineered lot fill, although some drying will be required to make use of the very moist to wet material encountered in the testholes. All topsoil, must be separated from the non-organic soil and not used as backfill material.

7.0 CLOSURE

This report has been prepared for the exclusive and confidential use of City of Edmonton, Al-Terra Engineering Ltd., and authorized agents. Use of this report is limited to the subject proposed Rampart Industrial Subdivision. The recommendations given are based on the subsurface soil conditions encountered during test boring, current construction techniques and generally accepted engineering practices. No other warranty, expressed or implied, is made. Due to geological randomness of many soils formations, no interpolation of soil conditions between or away from the testholes has been made or implied. Soil conditions are known only at the test boring location. Should other soils be encountered during construction or other information pertinent become available, the undersigned should be contacted as the recommendations may be altered or modified.

We trust this information is satisfactory. If you should have any further questions, please contact our office.

Respectfully Submitted:

Hoggan Engineering & Testing (1980) Ltd.

PERMIT TO PRACTICE
HOGGAN ENGINEERING & TESTING (1980) LTD.
Signature
Date May 6/10
PERMIT NUMBER: P 3691
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

Abe Rahime, P. Eng.

Reviewed By: Rick Evans, P. Eng.
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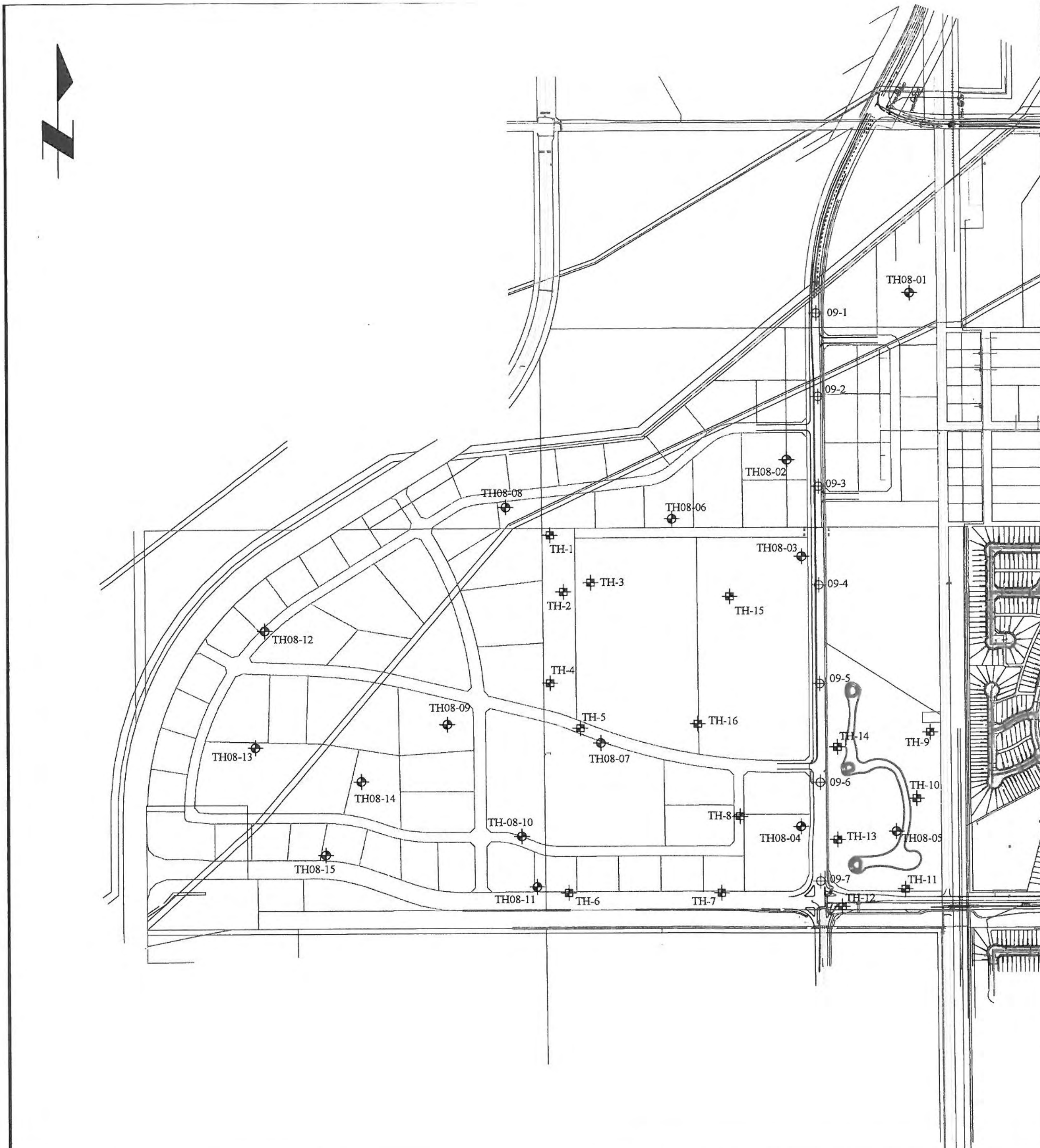
APPENDIX A - SITE PLAN AND HOGGAN TESTHOLES



LEGEND

- 2009 Hoggan Testholes
- 2008 AECOM Testholes
- 1997 Shelby Testholes

HOGGAN ENGINEERING & TESTING (1980) LTD.

Approximate Testhole Location
Proposed Rampart Industrial Subdivision
142 Street and 153 Avenue
Edmonton, Alberta

SCALE: NTS	DATE: April 2010
FILE #: 6048-21	FIGURE #: 1