March 2013

GEOTECHNICAL REPORT

TCPL Leming Lake Sales Lateral Loop Pipeline Project

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REPORT

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by TransCanada Pipeline Ltd. (TCPL) to complete geotechnical investigations at locations selected by TCPL for the proposed Leming Lake Sales Lateral Loop Pipeline, located near the City of Cold Lake, Alberta. This report summarizes the methodology used, the findings of the investigations, and provides comments and recommendations regarding the geotechnical aspects of the design and construction of the site for the proposed pipeline.

The proposed scope of work was outlined in Golder's proposal to TCPL, dated December 14, 2012 (Proposal # 12-1321-0108). The scope of work for this assignment includes:

- a geotechnical investigation to obtain information on the subsurface soil and groundwater conditions at Water Course No.3, three valve sites and five pipe line bend locations;
- laboratory testing on selected soil samples obtained during the geotechnical investigation; and
- preparation of this geotechnical report, with the results of the investigation and comments on the stability of the slopes at Water Course # 3 (WC3).

Authorization to proceed with the work was granted in TCPL's Work Authorization dated December 17, 2012 (TCPL Project # P2180970-TD320).

Golder conducted a desk study and a muskeg probing program for the same project previously. Report "Geotechnical Site Conditions, Desk Study of Water Course No.3" dated January 2, 2013 and technical memorandum "Muskeg Probing - TransCanada Leming Lake Sales Lateral Loop Pipeline Project" dated February 25, 2013 were issued to TCPL.

The professional services retained for this project include only the specified geotechnical aspects of the subsurface conditions at the site. The presence or implications of possible surface or subsurface contaminants from any source are outside the terms of reference for this study and have not been investigated or addressed. Use of this report is subject to the *Important Information and Limitations of this Report*, which follows the text of this report and forms an integral part of this document.

1.1 Site Description and Proposed Development

The Leming Lake Sales Lateral Loop proposed pipeline route is 36.6 km in length and extends from the SW corner of 21-65-4-W4 to the SW corner of 21-65-7-W4.

The project is located in east central Alberta near the Saskatchewan border and comprises hilly, dissected terrain with areas of flat to low relief. The topography near WC3 is rolling to flat and incised by waterways.

The South Slope of WC3 crossing is about 27 m high with an average slope angle of about 15 degrees. The North Slope is about 28 m high with an average slope angle of about 9 degrees (1V:6H). The area is generally densely forested with a cleared existing Right of Way (ROW).

At the time of the investigation, at the investigation sites the snow cover was approximately 300 to 500 mm depending on the surrounding tree cover.

2.0 GEOTECHNICAL INVESTIGATION

2.1 Desk Study

2.1.1 Surficial and Bedrock Geology

Golder previously conducted a desk study that was submitted under separate cover (Geotechnical Site Conditions Desk Study of Water Course No. 3, dated January 2, 2013). This report included review of water well records, selected aerial photos, and surficial and bedrock geology maps. Based on the published surficial geology of the area in which Leming Lake Sales Lateral Loop Pipeline is proposed, the subsurface soils are generally described as undivided moraine plain, consisting of unsorted mixtures of sand, silt, clay and minor pebbles, cobbles and boulders (Surficial Geology of the Sand River Area).

2.2 Site Preparation

The borehole locations were surveyed and staked by Universal Geomatics Solution (UGS) who was subcontracted by TCPL. UGS also trimmed trees and removed snow as necessary to clear the work area. The snow removal at helicopter staging area was done by Double D Bobcat Services & Contracting Ltd. who was subcontracted by Golder.

2.3 Field Investigation

The field investigation was carried out from January 6 to 24, 2013 and consisted of two boreholes located at WC3 on the south slope, three boreholes located at the valve sites, and five hand-augered holes located at bend locations. Borehole and hand auger locations are illustrated on Figures 1 through 12. At the proposal stage, it was planned to potentially putdown four boreholes at WC3 (two on the south slope and two on the north slope). Based on the results of the desktop study, supplemented by Golder traversing the north slope on foot and the resulting observations, Golder recommended that TCPL consider removing the two proposed borings on the north slope. TCPL accepted this recommendation and these two borings were not attempted during the field program.

Drilling and sampling operations were supervised by a member of Golder's geotechnical engineering staff, who visually observed and logged the soil and groundwater conditions encountered during drilling in accordance with the Golder Soil Classification System, which is included in Appendix A with a list of abbreviations and symbols.

2.3.1 Boreholes at Water Course No. 3

Boreholes WC3-BH-03 and WC3-BH-04 (on the WC3 south slope) were drilled and sampled to a depth of 4.7 mbgs (meters below ground surface) and 27.9 mbgs respectively. Borehole WC3-BH-03 was drilled close to the toe of the slope and WC3-BH-04 was drilled at the top of the slope, about 10 to 15 m south of the crest. The boreholes were drilled at the locations staked by TCPL. Drilling was completed using a heli-portable drill rig owned and operated by Geotech Drilling Services Ltd (subcontracted to Golder) with 150 mm diameter solid and hollow stem augers. Helicopter was provided by DELTA Helicopter Ltd., subcontracted by TCPL.

In-situ Standard Penetration Tests (SPTs) were carried out at 1.5 m vertical intervals to about 20 m depth and at about 3 m intervals below that depth to refine the estimated soil stratigraphy. Soil samples were obtained from the SPTs and directly from the auger flights. All collected soil samples were field-inspected, stored in moisture proof bags and transported to Golder's geotechnical laboratory.

Detailed description of the conditions encountered in each borehole are provided in the Record of Borehole Sheets in Appendix A. Based on information gathered during the geotechnical investigation, inferred geotechnical conditions (i.e. fence diagram) are presented on Figure 13.

2.3.2 Boreholes at Valve Stations

Three boreholes (BH13-01 to BH13-03) were drilled at proposed valve sites (i.e. Stn. 0+000 m, 19+000 m, and 25+775 m). All boreholes were drilled and sampled to a depth of 5.8 mbgs at the locations staked by TCPL. Drilling was completed using a track mounted drill rig owned and operated by Mobile Augers and Research Ltd. (subcontracted to Golder) with 150 mm diameter solid stem augers. SPTs were carried out at 1.5 m intervals in addition to logging and sampling of auger cuttings every 1.5 m or as needed to estimate soil stratigraphy. Thin walled, open samplers (Shelby tubes) were obtained at selected depths within the cohesive soil layer(s). All collected soil samples were field-inspected, stored in moisture proof bags and transported to Golder's geotechnical laboratory.

Detailed descriptions of the conditions encountered in each borehole are provided in the Record of Borehole Sheets in Appendix A.

2.3.3 Hand Augered Holes at Bend Locations

Five holes (HA13-01 to HA13-05) were hand augered at the bend locations (i.e. Stn. 12+830 m, 12+975 m, 16+225 m, 17+320 m, 31+375 m) to depths of 0.6 to 2.5 mbgs. The holes were augered at the locations selected by TCPL. Hand augering was completed by a member of Golder's geotechnical engineering staff, who visually logged the peat and mineral soil conditions encountered. Note that hand auger methods are limited to relatively small grab samples and cannot penetrate as deep as mechanised auger methods. All collected soil samples were field-inspected, stored in moisture proof bags and transported to Golder's geotechnical laboratory.

Detailed descriptions of the conditions encountered in each borehole are provided in the Record of Borehole Sheets in Appendix A.

2.4 Laboratory Testing

Upon completion of the field program, soil samples were taken to Golder's Calgary Laboratory for further examination, classification and testing. The testing program included measurement of water content, Atterberg Limits (plasticity), and grain-size analyses on selected soil specimens. The results of the laboratory tests are included on the Record of Borehole Sheets (Appendix A) with detailed results in Appendix B.

2.5 Subsurface Conditions

Detailed descriptions of the subsurface conditions encountered in each borehole are presented in the Record of Borehole Sheets provided in Appendix A. Classification and identification of soils have been based on commonly accepted methods employed in the practice of geotechnical engineering. In some cases, the stratigraphic boundaries shown on the Record of Borehole Sheets represent transitions between soil types rather than distinct lithologic boundaries. It should be recognized that subsurface conditions often vary both with depth and laterally between individual borehole locations. The following is a generalized summary of the subsurface conditions encountered at the borehole locations.

2.6 Generalized Stratigraphy and Groundwater

2.6.1 Water Course No. 3

Subsurface soils encountered near the top of the slope comprised stiff to very stiff, brown, silty clay to 1.7 mbgs; underlain by compact brown sand to 10.4 mbgs; underlain by very stiff to hard silty clay and sand to 28 mbgs. Near the toe of the slope, soft to firm clayey sand was encountered to 2.7 mbgs underlain by compact sand to the termination depth of borehole (4.7 mbgs). Borehole WC3-BH-03, near the toe, was terminated at 4.7 mbgs due to auger refusal on suspected cobles or boulders.

Inferred water seepage was observed during drilling at 1.5 mbgs in Borehole WC3-BH-03 and 8.8 mbgs in Borehole WC3-BH-04. Standpipe installations were not attempted. The groundwater table is expected to fluctuate seasonally in response to variations in precipitation, runoff and water levels in nearby watercourses. The seepage observations made in the boreholes during drilling may not reflect the range of groundwater level fluctuations that occur at the site or the groundwater conditions that will be encountered during construction, which should be confirmed at the time of construction.

2.6.2 Valve Stations

In Borehole BH13-01, organic silt was encountered to 0.5 mbgs; underlain by firm to very stiff silty clay and sand to 5.8 mbgs.

In Borehole BH13-02, a 0.3 m thick organic silt layer was encountered at ground surface; underlain by firm to stiff clayey silt to 0.8 mbgs; underlain by compact silty sand and clayey sand to 3.0 mbgs; underlain by very stiff silty clay and sand to 5.8 mbgs.

In Borehole BH13-03, fibrous peat was encountered to 0.9 mbgs; underlain by sand to 1.5 mbgs; underlain by stiff silty clay and sand to 5.8 mbgs.

2.6.3 Bend Locations

Fibrous peat was encountered to 1.3 mbgs in Hand Auger Hole HA13-01; underlain by amorphous peat to 2.5 mbgs.

In Hand Auger Hole HA13-02, fibrous peat was encountered to 1.8 mbgs; underlain by amorphous peat to 2.4 mbgs. Hand Auger Holes, HA13-01 and HA13-02, did not penetrated into mineral soils, and had to be terminated at 2.5 m depth since samples could not be retrieved.

In Hand Auger Hole HA13-03, silty peat was encountered to 0.4 mbgs; underlain by clayey silt/silty sand to 0.8 mbgs; underlain by clayey sand/silty sand to 1.3 mbgs.

In Hand Auger Hole HA13-04, fibrous peat was encountered to 0.15 mbgs; underlain by clayey sand/silty sand to 0.6 mbgs. This hand auger hole was terminated at 0.6 m due to practical auger refusal.

In Hand Auger Hole HA13-05, fibrous peat was encountered to 0.15 mbgs; underlain by firm to stiff silty clay and sand to 1.3 mbgs. Hand Auger Hole HA13-05 was terminated at 1.3 mbgs due to practical auger refusal.

3.0 STABILITY ASSESSMENT OF WATER COURSE NO. 3 SOUTH SLOPE

The ground topography of the cross section is based on UGS survey data presented in the Profile and Cross-Section Drawing 120380F01, provided in Appendix C. The estimated soil stratigraphy is based on the findings of the geotechnical investigation.

3.1.1 Geotechnical Parameters

The inferred geotechnical parameters were developed based on borehole drilling information, correlations using laboratory test results and our experience with similar soils. Table 1 summarizes the parameters used in this assessment.

Table 1: Soil Parameters Used for Slope Stability Analysis, Water Course No. 3

Soil Type	Unit Weight, γ (kN/m^3)	Effective Cohesion, c' (kPa)	Effective Friction Angle, ϕ' (degrees)
Stiff Silty Clay	19	0	28
Compact Sand	19	0	32
Very Stiff to Hard Silty Clay	22	0	30
Soft to Firm Clayey Sand	17	0	27

The groundwater table elevation was assumed to be at 7 mbgs at the location of Borehole WC3-BH-04, and 1 mbgs at Borehole WC3-BH-04.

3.1.2 Methodology

The stability assessment incorporated the results of two dimensional limit equilibrium methods of analysis using the effective stress approach. The commercial software SlopeW (GEO-SLOPE) was used. The analysis was used to assess circular and non-circular trial failure surfaces using the Morgenstern-Price method of analysis. The factor of safety is defined as the ratio of the actions tending to resist failure to the driving actions tending to cause failure. The factor of safety of numerous potential failure surfaces was computed in order to establish the minimum factor of safety. For temporary construction, a minimum calculated factor of safety not less than 1.3 is typically used. For permanent construction, a minimum calculated factor of safety not less than 1.5 is typically used.

Typical results are shown on Figures 14 to 16 in Appendix C. As shown on Figure 14, the minimum calculated factor of safety for trial failure surfaces is about 1.0 for the upper portion of the slope (from about elevation 636 masl (meters above sea level, NAD83 datum) to elevation 629 masl). This trial failure surface is relatively shallow (about 1.3 m deep, measured perpendicular to the slope) but the assessment results indicate that this potential failure surface is marginally stable. Trial failure surfaces in the upper slope with calculated factors of safety less than 1.3, which extend approximately 3.0 m deep measured perpendicular to the slope, are shown on Figure 15. Calculated factors of safety between 1.0 and 1.3 suggest that the upper portion of the slope is marginally stable for potential failure surfaces located between the ground surface and a depth of about 3 m, measured perpendicular to the slope. The minimum calculated factor of safety for relatively deeper-seated failure surfaces (i.e. excluding trial failure surfaces between ground surface and a depth of about 3 m) is about 1.5, as shown on Figure 16.

3.2 Comments and Recommendations

Based on the results of the slope stability assessment, the calculated minimum factor of safety for the upper portion of the south slope is between 1.0 and 1.3, which indicates marginal stability for trial failure surfaces that extend to a depth of about 3 m (measured perpendicular to the slope) in this area.

It is recommended that TCPL consider re-grading (flattening) the upper portion of the slope to increase slope stability. To achieve a calculated minimum factor of safety of 1.5 for the upper slope (from elevation 636 masl to elevation 629 masl), analysis results indicate that the slope would need to be flattened to about 1V:2.4H (23 degrees below horizontal). To achieve a calculated minimum factor of safety of 1.3 for the upper slope, this section of the slope would need to be flattened to about 1V:2H (26 degrees below horizontal).

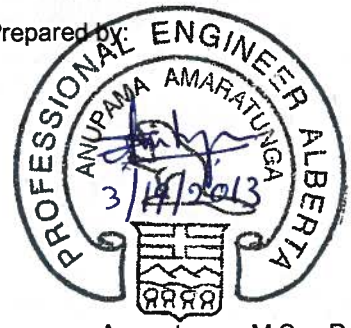
4.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

Yours truly,

GOLDER ASSOCIATES LTD.
APEGA PERMIT TO PRACTICE #05122

Prepared by:



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IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

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The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines.

Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. A qualified professional should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, a qualified professional should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for a qualified professional to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that a qualified professional be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.