



THURBER ENGINEERING LTD.

July 13, 2023

File No.: 32079

Associated Engineering
#500 – 2889 East 12th Avenue
Vancouver, BC
V5M 4T5

Attention: Priscilla Tsang, P.Eng.

**HIGHWAY 1 WIDENING – 264TH STREET TO WHATCOM ROAD – SEGMENT 1
BRADNER ROAD UTILITY PRELOAD RECOMMENDATIONS**

Dear Priscilla Tsang,

We have been requested by ISL Engineering and Land Services Ltd. to provide geotechnical input for the preload design required for the Fortis gas line that is proposed to cross beneath Highway 1 west of Bradner Road. Specifically, ISL has requested how close the preload can be to the existing Bradner Overpass Structures without causing meaningful (<10 mm of settlement) settlement of the structures. ISL has also requested input for preloading the utility corridor for the BC Hydro utility and temporary City of Abbotsford watermain east of Bradner Road. It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

1. BACKGROUND

We understand that well-graded sand and gravel is a preferred material to construct the Fortis gas line preload as it can be constructed at steeper side slope angles and provide a better working pad compared to river sand for the future required crane which is anticipated for the Bradner Overpass reconstruction. Further, we understand that Fortis will install their new gas line approximately 6 months after the end of preload construction. We understand that Fortis is likely to use trenchless installation methods and will be responsible for their installation design. It is likely that the gas line will be installed in stiff to very stiff clays. While boulders were not encountered in our drilling investigations and the likelihood of encounter one is low, glacio-deposits are subject to random boulders and thus Fortis should consider means to drill or break up the boulder if encountered.

We understand that the existing BC Hydro utility, which is currently located beneath Bradner Road, will be relocated under the highway east of Bradner Road. A temporary City of Abbotsford watermain will also be relocated under the highway east of Bradner Road, close to the BC Hydro

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utility until overpass construction is complete and it can be permanently constructed beneath Bradner Road. The two utilities will be constructed near Sta. 1093+80. The median is currently near proposed final grade at Sta. 1093+80

2. SETTLEMENT ANALYSIS

We completed settlement analyses using the software Settle3D. The soil profile was based on TH21-01, TH21-04, TH22-Seg1-47 and TH22-Seg1-48. Test hole logs can be found in the FVCIP Factual Report Segment 1 dated May 19, 2023. A summary of the soil profile and the consolidation parameters used is provided below.

Table 1: Geotechnical Units and Compressibility Parameters

Soil Unit / Description	Cc	Cr	(Ca/Cc)	Cv (mm ² /s)	Cvr (mm ² /s)	Initial Void Ratio	OCD (kPa)	Young's Modulus, E (MPa)
Glaciomarine Silt / Clay (FLc) (0 m to 8 m depth)	0.21	0.04	0.035	0.3	0.8	0.8	250	-
Glaciofluvial Sand and Gravel (Sa,j) (below 8 m depth)	-	-	-	-	-	-	-	50

We considered three settlement scenarios for the west side of Bradner Road; 1) where the Fortis gas line is situated under a full median infill which is intended to replicate final highway construction, 2) a 25 m wide crest to crest preload, and 3) a 25 m wide crest to crest preload with a 1.5 m high surcharge that is left in place for 6 months. The 25 m wide crest to crest preload is representative of the preload and the conditions which the Fortis gas line will be installed. The preload is assumed to comprise sand and gravel with a unit weight of 22 kN/m³ whereas the surcharge is assumed to comprise river sand with a unit weight of 18 kN/m³.

Table 2: Total Settlement Estimates

Time	Full Median Infill	Preload (25 m wide crest to crest) Settlement Estimate	Preload (25 m wide crest to crest) Settlement Estimate – 1.5 m Surcharge for 6 Months
End of Preload Construction	-	80 mm	90 mm
3 Months After Preload Construction	-	150 mm	165 mm
6 Months After Preload Construction	160 mm	155 mm	165 mm
1 Year After Preload Construction	160 mm	160 mm	160 mm
2 Year After Preload Construction	160 mm	160 mm	160 mm
25 Year After Preload Construction	170 mm	165 mm	165 mm

The results provided above in Table 2 should be used as a relative comparison. Estimating ground settlement to an accuracy of more than 25 mm is extremely difficult given the variability of ground conditions. What we can observe from the settlement analyses is that preloading for 6 months will result in approximately 155 mm of estimated settlement, approximately 5 mm less than a full median infill over the same period. Once the median infill is completed adjacent to the preload, the long-term settlement would be approximately 170 mm. Even if the median were full infilled, there would still be minor (~10 mm), post-construction settlements between 6 months after infilling and 25 years. A 1.5 m thick surcharge could be constructed on top of the preload and left in place for 6 months so that the post-construction settlement would be negligible. A settlement plot is provided for the 25 m wide preload (Figure 1) and the differential settlement anticipate from full median infilling after the 6 month preload (Figure 2).

3. PRELOAD RECOMMENDATIONS

3.1 Fortis Gas Line

We recommend constructing the preload as wide as possible and preloading for 6 months. The preload should be constructed to underside of asphalt. The preload should be constructed with granular borrow that comprises well-graded sand and gravel containing less than 8% by mass passing the 0.075 mm sieve. Note the contractor will need to sub-excavate material to construct the pavement structure base gravels (SGSB and WGB). We do not think a surcharge is required; however, a surcharge can be used to reduce post construction settlements if desirable to the Ministry or Fortis.

We understand that the west side of the preload will be restricted due to environmentally sensitive areas. The east side of the preload toe should be setback at least 5 m from the existing Bradner Road Overpass abutment footings so that the induced settlement at the footings is negligible (estimated to be <5 mm). We recommend that the preload slopes are constructed at 1.5H:1V.

We recommend that the Bradner Road Overpass abutment footings are monitored for settlement. A settlement monitoring point on the median side of the abutment footing for each structure would be suitable. We also recommend that two settlement gauges are installed along the east and west preload crest, in the centre, where the fill is thickest. The settlement gauge must be installed on approved subgrade prior to preload construction. Settlement gauge raises must be recorded, and the Contractor must take care not to damage the settlement gauge.

Due to the contract timing, we anticipate that settlement gauge survey may be completed by the Contractor during construction but then the Ministry will likely need to have a different party complete the survey following preload construction. Survey control should be established to allow the gauges to be surveyed with an accuracy of +/- 5 mm. The top of gauge, fill elevation, extension lengths and notes on potential gauge damage and disturbance should be collected.

Settlement gauges and monitoring points should be surveyed weekly during preload construction and every two weeks following construction. The survey interval may be increased following review of the settlement data.

3.2 BC Hydro and City of Abbotsford Utilities

The grade change between existing conditions and final highway design is much less near Sta. 1093+80 where the BC Hydro and City of Abbotsford utilities are proposed. As such, we recommend preloading the ditches and portions of the median that are below design grade 10 m on each side of the proposed utility location. Similar to the west side, the preload should be constructed to underside of asphalt layer. The material should comprise granular borrow that comprises well-graded sand and gravel containing less than 8% by mass passing the 0.075 mm sieve. Where a temporary culvert is required to continue conveyance of water, we recommend overbuilding the preload by a thickness equal to the culvert diameter.

We recommend preloading for a minimum of 6 months before utility installation. It is preferable for the preload to be in place for longer. Settlement is anticipated to be much less near Sta. 1093+80 compared to the proposed Fortis utility location. As such, we recommend settlement pins be used in lieu of settlement gauges. Settlement pins comprise a 600 mm piece of rebar hammered into the finished preload grade. The settlement pins should be installed upon



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completion of preload construction to confirm settlement rates have sufficiently slowed prior to utility installation.

Survey control should be established to allow the pins to be surveyed with an accuracy of +/- 5 mm. The top of pin, pin stickup, and notes on potential damage and disturbance should be collected. Settlement pins should be surveyed weekly during preload construction and every two weeks following construction. The survey interval may be increased following review of the settlement data. We anticipate that the survey will not be required beyond 6 months, even if the preload will be in place for longer.

Yours truly,
Thurber Engineering Ltd.
Paul Evans, P.Eng.
Review Principal

Thurber Engineering Ltd.
Permit to Practice #1001319

Christopher Clarke, P.Eng.
Geotechnical Engineer

Attachment

- Statement of Limitations and Conditions
- Settlement Plots





STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client, the BC Ministry of Transportation and Infrastructure (MoTI) and Authorized Users as defined in the MoTI Special Conditions Form H0461d. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Any use which an unauthorized third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any unauthorized third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

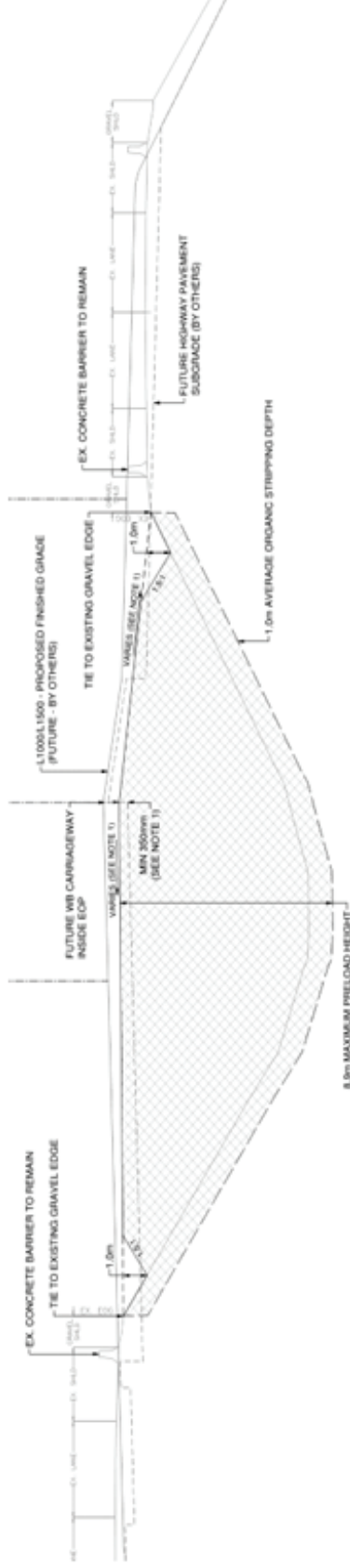
6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

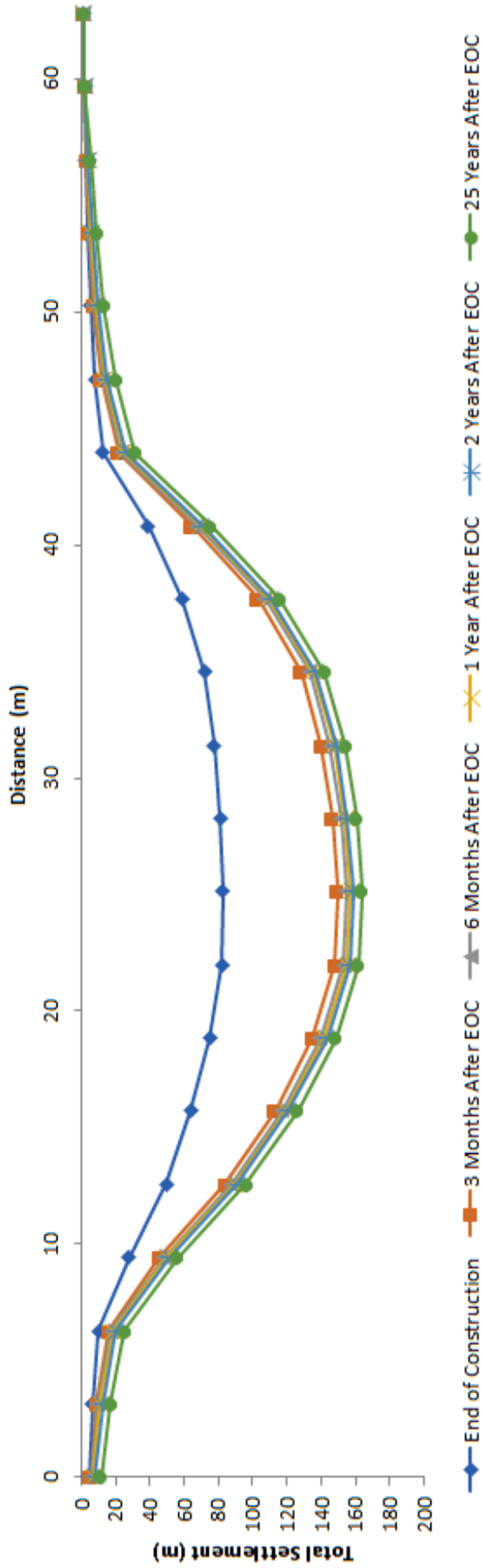
7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

Distance vs. Total Settlement of the Preload (25 m Wide Crest to Crest)

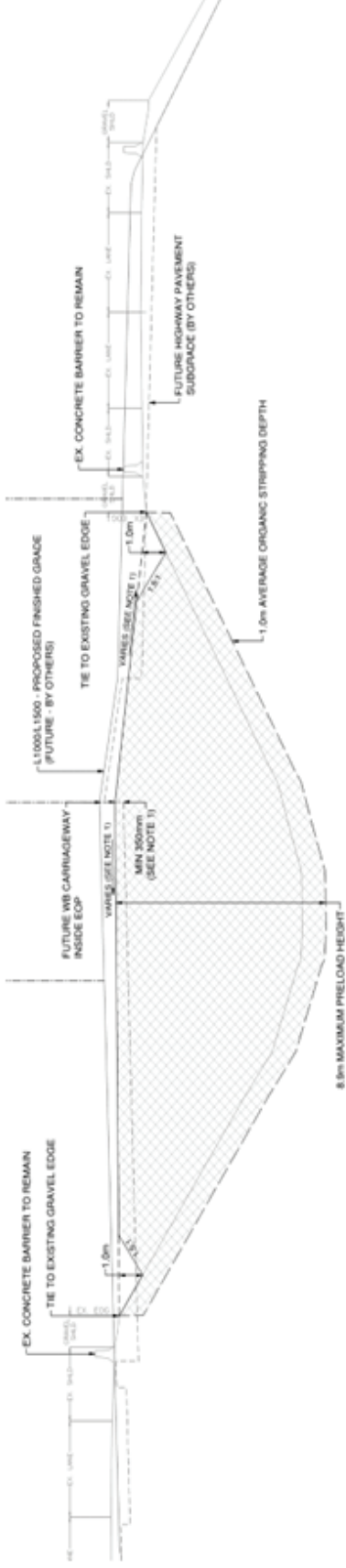


HIGHWAY 1 PRELOAD - FULL HEIGHT

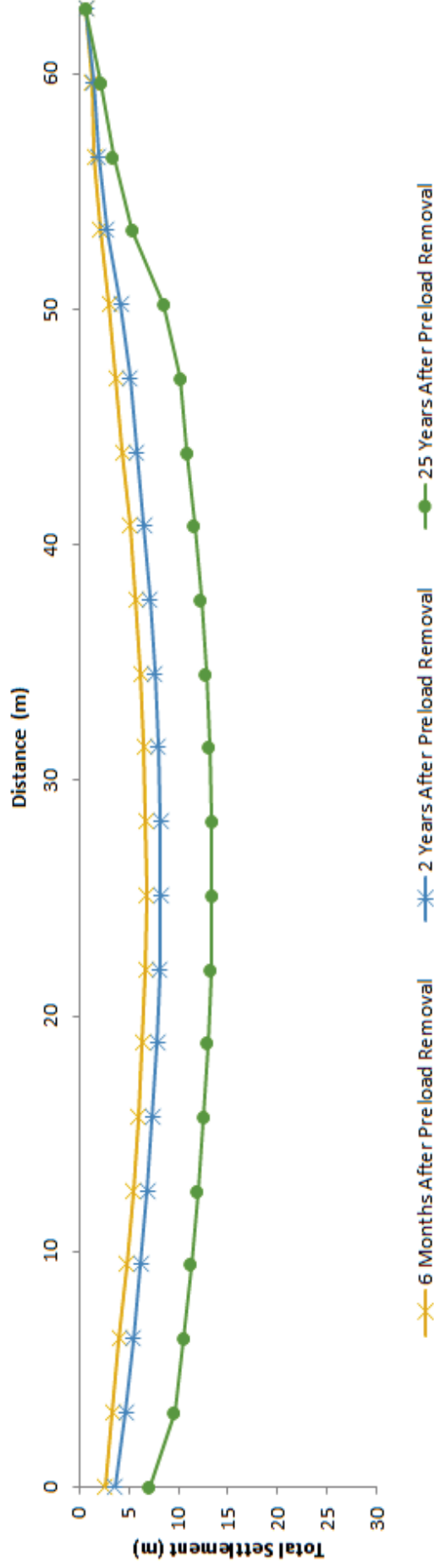


1	YYYY-MM-DD				
REV	DATE	REVISION	DRAWN BY	DATE	BY
			CJC	2023-05-05	
			DESIGNED BY	SCALE	
			CJC	NTS	
			APPROVED BY	PROJECT NO.	
				32079	
			DRAWING / FIGURE No.	REV.	
			Figure 1		
CLIENT NAME			Associated Engineering / ISL Engineering and Land Services Ltd.		
DRAWING TITLE			Absolute Settlement at Fortis Gas Line from Preload		
PROJECT NAME AND LOCATION			Highway 1 Widening - 264th Street to Whatcom Road (Segment 1) Abbotsford, BC		
SEAL			THURBER		
PERMIT TO PRACTICE					
LEGEND / NOTES					

Settlement Along Fortis Gas Line Following Full Median Infilling Assuming a 6 Month Preload



HIGHWAY 1 PRELOAD - FULL HEIGHT



✖ 6 Months After Preload Removal
 ✖ 2 Years After Preload Removal
 ● 25 Years After Preload Removal

1	YYYY-MM-DD				
REV	DATE	REVISION	DRAWN BY	DATE	BY
			CJC	2023-05-05	
CLIENT NAME			Associated Engineering / ISL Engineering and Land Services Ltd.		
DRAWING TITLE			Settlement at Fortis Gas Line After 6 Months of Preload and Full Median Infill		
PROJECT NAME AND LOCATION			Highway 1 Widening - 264th Street to Whatcom Road (Segment 1) Abbotsford, BC		
SEAL			PERMIT TO PRACTICE		
LEGEND / NOTES			DESIGNED BY: CJC APPROVED BY: - DRAWING / FIGURE NO.: Figure 2 SCALE: NTS PROJECT NO.: 32079 REV. -		