Enbridge Consent Decree

Evaluation of Replacement of Portions of Line 10 within the United States

September 18, 2017

EXECUTIVE SUMMARY

This report provides the results of the evaluation for replacement of portions of Line 10 within the United States ("US Line 10") per Subsection VII.B.(23) of the Consent Decree entered in *U.S. vs. Enbridge Energy, Limited Partnership, et. Al., (Civil Action No: 1:16-cv-914)*. Enbridge is required to submit to the Environmental Protection Agency (EPA) a report evaluating replacement of US Line 10 including the segment that crosses the Niagara River near Grand Island, NY. The evaluation is also required to contain a discussion of the number, density, and severity of crack features and corrosion features found on US Line 10, as well as a comparison of these features to those found on the approximately 21-mile section of Line 10 currently undergoing replacement near Hamilton, ON. A map showing the complete route for Line 10 is provided in Appendix E.

Enbridge Liquids Pipelines administers a comprehensive Integrity Management program to maintain the safety of more than 17,000 miles of pipelines across Canada and the United States. Through this program, safety targets are established and their implementation is regularly reviewed by Enbridge to ensure that the targets are met. Safety targets are established through consideration of broad factors including regulatory requirements, corporate social responsibility, public acceptance, industry standards, and standards applicable beyond the pipeline industry, such as those in the nuclear industry. Recognizing continuous improvement in all aspects of pipeline operatorship, technology to safely manage pipelines will evolve as well as evolution of safety targets. The analysis completed considers currently-established safety targets.

The evaluation for replacement considers two key aspects; the first was the fitness-for-service analysis to assess US Line 10 pipe condition and confirm that the current integrity management programs will continue to maintain the safety of the pipeline. The second aspect is an asset-optimization review that assessed the financial impacts of continued maintenance programs versus pipe replacement to determine an optimized approach to maintaining the pipeline.

The results of the thorough fitness-for-service analysis demonstrate that all features are well within the integrity targets and none meet the criteria for excavation and repair that are specified in the Consent Decree, the Code of Federal Regulations (CFR) Title 49 conditions for remediation, Enbridge excavation criteria, or API Recommended Practice 1160 and 1176 dig selection criteria.

Analysis of the corrosion features in the Westover to Nanticoke Junction (WS-NN) segment currently being replaced in Canada confirms the density of features there is [redacted] as high as that found on US Line 10. Crack feature density is [redacted] on the WS-NN segment. Both corrosion and cracking Safety Factors for US Line 10 are [redacted] than what is found on the WS-NN segment; the severity of features on the WS-NN segment is [redacted] than that of US Line 10. The WS-NN segment has been maintained to safe integrity targets. Replacement of the WS-NN segment is driven by maintenance optimization with a secondary benefit of restoration of the original pipeline capacity.

The conclusion of this evaluation is that pipe replacement of US Line 10 is not recommended at this time because the pipeline meets current safety targets and does not require replacement to optimize maintenance. Enbridge will continue to evaluate replacement as additional pipeline condition-monitoring data becomes available. In the meantime, the recommended maintenance approach for US Line 10 is that Enbridge continue with its current annual rehabilitation programs.

The forecasted cost of the rehabilitation programs for US Line 10 compared to the total cost under a pipe replacement scenario for each segment indicates that the rehabilitation programs are much more economical as a maintenance approach over the 15-year period from 2017 to 2031. The economic benefit of the restoration of original capacity of US Line 10 is not factored in the analysis. In comparison, the replacement of the WS-NN segment is justified through maintenance optimization analysis with a secondary benefit being the restoration of the segment's original capacity.

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1. INTRODUCTION

1.1. PURPOSE

The purpose of this report is to inform EPA of the results of Enbridge's evaluation of the replacement of the portions of Line 10 within the United States ("US Line 10") as required by Subsection VII.B.(23) of the Consent Decree entered in *U.S. vs. Enbridge Energy, Limited Partnership, et. Al., (Civil Action No: 1:16-cv-914)*. This evaluation, conducted pursuant to Enbridge's established practices on assessing line replacement, includes details on the number, density, and severity of the crack and corrosion features found on US Line 10 and a financial analysis for potential pipe replacement. It also provides the number, density, and severity of the crack and corrosion features found on the approximately 21-mile section currently undergoing replacement in the Westover to Nanticoke segment in Canada, and a comparison to the features on US Line 10. Separate evaluations for the two pipeline segments that cross the Niagara River at Grand Island, NY are also provided.

1.2. DEFINITIONS

a. **Feature**: an electronic measurement reported by in-line inspection describing the condition of the pipe at any location as well as any physical objects such as anomalies, components, nearby metallic objects, welds, and appurtenances. Measurements include those related to the occurrence of potential corrosion, cracks, or dents.

b. **Corrosion Feature**: as defined in Subsection IV.10.(k) of the Consent Decree i.e. any feature on a pipeline detected by any tool, field measurement device, or other field observation that detects metal loss due to corrosion excluding metal loss that is attributable to a grinding repair.

c. **Crack Feature**: as defined in Subsection IV.10.(l) of the Consent Decree i.e. any feature on a pipeline detected by any tool, field measurement device, or other field observation that detects any crack or crack-like feature on the pipeline.

d. **Predicted Burst Pressure**: as defined in Subsection IV.10.(xx) of the Consent Decree, i.e. the lowest estimated pressure at which a feature is predicted to burst or rupture.

e. **Safety Factor**: the margin of how much stronger the pipeline is than it needs to be for the maximum design load under normal operation. Per regulation, the Safety factor shall not be less than 1.25 in Canada and not less than 1.39 in the U.S. Safety Factor is calculated as Predicted Burst Pressure divided by established Maximum Operating Pressure (MOP).

f. **Rupture Pressure Ratio (RPR)**: as defined in Subsection IV.10.(ddd) of the Consent Decree and calculated as Predicted Burst Pressure divided by 100% SMYS.

g. **Specified Minimum Yield Strength (SMYS)**: the minimum yield strength, expressed in p.s.i. (kPa), prescribed by the specification under which the material is purchased from the manufacturer.

h. **Severity**: general descriptor of an integrity feature, potentially described in terms of depth, RPR, and Safety Factor for corrosion features and in terms of depth and Safety Factor for crack features.

1.3. SCOPE

Table 1 below identifies the individual US Line 10 pipe segments that are the subject of the replacement evaluation. A map showing the complete route for Line 10 is provided in Appendix E. The pipe replacement assessment was performed according to Enbridge procedure PI-69, *Pipeline Replacement Assessment Procedure.*

Line 10 Trap-to-Trap Segment	Description of Pipe Segment Evaluated	Start Milepost	End Milepost
Westover (WS) to Nanticoke (NN)	Approximately 21-Mile segment being replaced in Canada from Westover Terminal to Nanticoke Junction Station (12 inch Diameter)	1863.23	1883.52
West Niagara River (WNR) to Grand Island (EB)	West Branch of Niagara River Crossing (12 inch Diameter)	1928.27	1928.91
Grand Island (EB) to East Niagara River (ENR)	Grand Island Segment (20 inch Diameter)	1928.91	1933.30
East Niagara River (ENR) to Kiantone Take-off (UT)	East Branch Niagara River Crossing (12 inch Diameter)	1933.30	1933.82
	East Niagara River Bank to Kiantone Take-off (12 inch Diameter)	1933.82	1951.92

Table 1: Pipeline Segments Included in Pipe Replacement Evaluation

A fitness-for-service analysis of the corrosion and crack features was performed to assess US Line 10 pipe condition and confirm that the current annual rehabilitation programs will continue to maintain the safety of the pipeline. The discussion provided on the number, density, and severity of the corrosion and crack features in this report summarizes the results and conclusions from this assessment. It should be noted that the vast majority of corrosion features (based upon extensive experience and evidence) with depths under 20% of nominal wall thickness are a result of pipe roughness and not associated with any corrosion of the pipe. Redact – 5 USC 552(b)(4) percent of all features found on US Line 10 have depths under 20% of nominal wall thickness. However, to ensure that this evaluation is extremely conservative, all such features have been assumed to be a result of corrosion. Further analysis may conclude that some or all of these features are not a result of corrosion.

The analysis also considered threats from third-party or mechanical damage and threats from geohazards and pipeline movement. The very low density of geometric anomalies identified during the evaluation evidences that mechanical damage risk is not significant on US Line 10. Also, the results of the latest geohazard inspections demonstrated no integrity concerns at this time and it was concluded this threat was not significant.

Pipe replacement assessment was performed according to Enbridge's PI-69, *Pipeline Replacement Assessment Procedure*. This involved asset management analysis to assess and compare the financial impacts under two scenarios: continuation with the current annual rehabilitation programs over the next 15 years versus pipe replacement within the same period, to determine if pipe replacement is economically optimal. The determination of whether pipe replacement was preferable relative to continuation of existing rehabilitation programs was based on the assessment of features and a comparison of the net present values of the financial impacts of each scenario.

2. EVALUATION APPROACH

2.1. EVALUATION OF CRACK AND CORROSION FEATURES

Integrity programs for Enbridge's pipelines, including Line 10, are designed to address the prevention, inspection, mitigation, and repair of defects that can occur on pipelines. Detailed information regarding a pipeline's condition is obtained through high resolution in-line inspections (ILI) to identify and monitor potential threats. Current and predicted-future characteristics of features are then calculated in order to identify features that do not meet established safety targets. Appropriate repair, mitigation measures, and rehabilitation are then planned and implemented to ensure that the identified features remain within the established safety targets over a defined period.

This process, which is considered to be a targeted rehabilitation of the pipe, ultimately entails the removal of all defects from the pipe that fail to meet (or are anticipated to not meet) Enbridge safety targets. If a targeted rehabilitation cannot be designed to ensure the safe and reliable operation of the pipeline over a defined period, then a full-line (or segment) replacement will need to occur. With the knowledge that a rehabilitation program can be designed and implemented to remove existing and potential defects so as to ensure the safe and reliable operation of a pipeline for a defined period, Enbridge will undertake a financial analysis to assess whether a replacement is financially preferable from a business perspective. Enbridge will specifically compare the costs associated with the targeted rehabilitation to the costs that would be incurred as a result of a replacement to identify whether replacement would be the preferable option.

In order to assess the existing condition of Line 10, comprehensive ILIs have been conducted to identify corrosion and crack features. The resulting information was analyzed to determine the extent of any pipeline repairs and any other mitigation measures that may be needed in order to maintain the safe and reliable operating condition of US Line 10, in accordance with the Consent Decree integrity requirements and all applicable codes and regulations. That pipeline repair and mitigation information was compiled into a targeted rehabilitation plan for Line 10, which concluded that the condition of the line could be adequately managed over a 15-year operating period.

Recognizing continuous improvement in all aspects of pipeline operatorship, the 15-year outlook considers current technology and safety targets. Evolution of technology to safely manage pipelines will evolve as well as evolution of safety targets. Safety targets progress considering broad factors such as regulatory requirements, corporate social responsibility, public acceptance, industry standards, and standards beyond the pipeline industry.

While corrosion and cracking are the predominant integrity threats for US Line 10, management of third-party or mechanical damage and geohazards or pipeline movement threats are also included in the integrity management program. Third-party damage prevention involves comprehensive right of way (ROW) monitoring and stakeholder awareness programs. Mechanical damage is monitored using caliper ILI tools that can be supplemented with data from corrosion or crack detection technology to provide additional characterization of mechanical damage features. The very low density of geometric anomalies found indicates that mechanical damage risk is not significant on this line. Geohazards are effectively managed through a combination of monitoring, inspection, assessment, and remediation. The results of the latest geohazard inspections provided assurance that no significant integrity concerns due to geotechnical and hydrotechnical hazards exist.

The following considerations were taken into account with respect to the evaluation of corrosion and crack features on US Line 10:

1. Fitness-for-service assessment was conducted on all unrepaired features based on the established MOP values for each US Line 10 segment listed in the spreadsheet referenced in the Consent Decree and located at https://www.epa.gov/enbridge-spill-michigan/enbridge-revised-maximum-operating-pressure-values. For the WS-NN segment, the assessment was based on the Canadian National Energy Board (NEB) defined MOP values for the segment.
2. Only unrepaired features are included in this report i.e. all features found that have been repaired are excluded from the analysis
3. Pressure cycling severity over the entire US Line 10 pipeline is in the light regime. This is a measure of the impact of pressure fluctuations a pipeline undergoes as part of normal operations. The potential categories of pressure cycling are classified as aggressive, moderate, or light.
4. All corrosion and crack features found in the field have been reported by ILI programs, indicating strong inspection reliability.

2.2. PIPE REPLACEMENT FINANCIAL ANALYSIS

Enbridge conducted a financial analysis in a manner consistent with its standard pipeline assessment practices to compare the costs associated with the repairs/mitigation required under the Line 10 rehabilitation plan to the costs of a pipeline replacement. For purposes of the financial analysis, Enbridge assumed that the repairs and mitigation measures anticipated under the rehabilitation plan would need to be conducted over a 15-year period.

The following considerations were taken into account for pipe replacement evaluation:

1. The criteria for economic viability are based on the net present value (NPV) comparison of the two scenarios over the 15 year period from 2017 to 2031.
2. Pipe replacement costs are based on the most recent classified and unclassified replacement estimates developed for similar evaluations.
3. The replacement of US Line 10 would be expected to restore approximately 10,000 barrels per day in annual average capacity. The economic benefit of the increased capacity is not contemplated in the financial evaluations in this report as it is not significant enough to impact the replacement decision.
4. Pipe replacement scenarios for 2025 and 2031 in-service dates were evaluated for purposes of assessing present value costs and benefits. The results of the 2031 in-service date assessment are included in this report as the conclusion remains the same for both dates
5. The fitness-for-service analysis indicates that no underwater repairs are anticipated in the two pipeline segments that cross the Niagara River in the period 2017-2031

3. REPLACEMENT EVALUATION

3.1. REPLACEMENT EVALUATION FOR THE WEST NIAGARA RIVER (WNR) - GRAND ISLAND (EB) SEGMENT

Figure 1 below shows the scope of pipe replacement evaluated for the WNR-EB segment.

CEII

Figure 1: WNR-EB Segment Pipe Replacement Scope

3.1.1. ANALYSIS OF CRACK AND CORROSION FEATURES

3.1.1.1. Corrosion Features

Table 2 below details the number, density, and severity of corrosion features found on the WNR-EB segment.

A total of [redacted] corrosion features were identified on this segment by a corrosion ILI that was conducted in 2015. The feature density is [redacted] features per mile; the severity of the features is considered to be low as all features have ILI reported depths less than [redacted] of nominal wall thickness, Safety Factors greater than [redacted] and RPRs greater than [redacted]. The average Safety Factor of [redacted] is over [redacted] times the CFR Safety Factor threshold of 1.39, confirming that established safety targets have been met.

In comparison to the corrosion density and severity found on the WS-NN segment in Canada as described in section 3.5.1, the WNR-EB segment has considerably lower corrosion density and severity ([redacted] features per mile versus [redacted] for WS-NN, and average Safety Factor of [redacted] versus [redacted] for WS-NN).

All corrosion features are below the criteria governing excavation and repair in the Consent Decree, CFR Title 49 conditions for remediation, Enbridge's excavation criteria, and API Recommended Practice 1160 dig selection criteria.

Severity (Depth, % of Wall Thickness)	Number of Features
<20	Redacted 5 USC 552(b)(4)
20-30	
30-40	
40-50	
>50	
Feature Density = [redacted] features per mile	
Severity (Safety Factor)	**Number of Features**
>2.0	Redacted 5 USC 552(b)(4)
1.75-2.0	
1.5-1.75	
1.39-1.5	
1.0-1.39	
<1.0	
Average Safety Factor = [redacted]	
Severity (RPR)	**Number of Features**
>1.1	Redacted 5 USC 552(b)(4)
1.075-1.1	
1.05-1.075	
1.025-1.05	
1.0-1.025	
<1.0	
Average RPR = [redacted]	

Table 2: Corrosion Features on the WNR-EB Segment

3.1.1.2. Crack Features

Table 3 details the number, density, and severity of crack features found on the WNR-EB segment.

A total of Re crack features were identified on this segment by a crack ILI run that was conducted in 2015. The majority of the identified crack features were determined to be manufacturing anomalies and considered to be stable at the low operating pressures of this portion of the line. In other words, it is a function of the ILI tools to report signals from benign manufacturing reflections as "crack" features and those features will be included in this assessment, despite their benign effect. The feature density is Red features per mile; the severity of the features is considered to be low as all features found have ILI reported depths less than [redacted] of nominal wall thickness and Safety Factors greater than [redacted]

The average Safety factor of [redacted] is approximately [redacted] times the CFR Safety Factor requirement of 1.39, and all features are below integrity targets.

In comparison to the crack density and severity measured in the WS-NN segment described in section 3.5.1, Redact – 5 USC 552(b)(4) [redacted] As a result, the average Safety Factor for cracks for this segment is significantly higher than the Safety Factor for WS-NN (5.21 versus 1.37 for WS-NN) Redact – 5 USC 552(b)(4)

The attributes of the crack features are below the integrity criteria for excavation and repair in the Consent Decree, CFR Title 49 conditions for remediation, Enbridge's excavation criteria, and API Recommended Practice 1176 dig selection criteria.

Severity (Depth, % of Wall Thickness)	Number of Features
<20 20-30 30-40 40-50 >50	Redacted 5 USC 552(b)(4)
Feature Density = Red features per mile	
Severity (Safety Factor)	**Number of Features**
>2.0 1.75-2.0 1.5-1.75 1.25-1.5 1.0-1.25 <1.0	Redacted 5 USC 552(b)(4)
Average Safety Factor = [redacted]	

Table 3: Crack Features in the WNR-EB Segment

3.1.2. FINANCIAL ANALYSIS FOR PIPE REPLACEMENT

Pipe replacement for this segment would involve horizontal directional drilling (HDD) under the West Branch Niagara River channel from a suitable location close to the WNR launch trap to a suitable location close to the EB receive trap.

As detailed in Appendix A, on an NPV basis the cost of the pipe replacement, which is estimated to total Red MM, is significantly higher than the cost of the rehabilitation programs, which is estimated to total Red MM over a 15-year period. Thus, the overall cost of replacement of this segment is almost three times the cost of the rehabilitation plan for this US Line 10 segment. Accordingly, the financial analysis confirms that replacement is not warranted because the safety and reliability of this US Line 10 segment can be feasibly maintained through implementation of the rehabilitation plan

3.1.3. CONCLUSION

Based on Enbridge's evaluation of the number, density, and severity of the corrosion and crack features identified on the WNR-EB segment by recent ILIs, Enbridge has determined that this pipeline segment has met integrity safety targets and pipe safety can continue to be maintained with the current annual rehabilitation programs. In addition, the results of the financial analysis for pipe replacement confirm that the Line 10 rehabilitation plan for this segment is forecasted to be more appropriate than pipe replacement for the period 2017 to 2031.

3.2. REPLACEMENT EVALUATION FOR THE GRAND ISLAND (EB) – EAST NIAGARA RIVER (ENR) SEGMENT

Figure 2 below shows the scope of pipe replacement evaluated for the EB-ENR segment.

Figure 2: EB-ENR Segment Pipe Replacement Scope

3.2.1. ANALYSIS OF CRACK AND CORROSION FEATURES

3.2.1.1. Corrosion Features

Table 4 below details the number, density, and severity of corrosion features found on the EB-ENR segment.

A total of [redacted] corrosion features were identified on this segment by a corrosion ILI that was. The feature density is [redacted] features per mile; most of these features are attributed to allowable manufacturing anomalies or possibly minor internal corrosion which is mitigated through a cleaning and inhibition program. The cleaning and inhibition program involves mechanical cleaning and batch chemical treatment performed three times per year. ILI has not reported any significant growth of these features since 2011, which is commensurate with the start of an enhanced cleaning and inhibition program. The average Safety Factor of [redacted] is approximately [redacted] times the CFR Safety Factor threshold of 1.39, and all features are above integrity targets.

In comparison to the corrosion density and severity found on the WS-NN segment in Canada as described in section 3.5.1, the EB-ENR segment has considerably lower corrosion density and severity ([redacted] features per mile versus [redacted] for WS-NN, and average Safety Factor of [redacted] versus [redacted] for WS-NN).

All corrosion features are below the criteria governing excavation and repair in the Consent Decree, CFR Title 49 conditions for remediation, Enbridge's excavation criteria, and API Recommended Practice 1160 dig selection criteria.

Severity (Depth, % of Wall Thickness)	Number of Features
<20 20-30 30-40 40-50 >50	Redacted 5 USC 552(b)(4)
Feature Density = [redacted] features per mile	
Severity (Safety Factor)	**Number of Features**
>2.0 1.75-2.0 1.5-1.75 1.39-1.5 1.0-1.39 <1.0	Redacted 5 USC 552(b)(4)
Average Safety Factor = [redacted]	
Severity (RPR)	**Number of Features**
>1.1 1.075-1.1 1.05-1.075 1.025-1.05 1.0-1.025 <1.0	Redacted 5 USC 552(b)(4)
Average RPR = [redacted]	

Table 4: Corrosion Features in the EB-ENR Segment

3.2.1.2. Crack Features

Table 5 below details the number, density, and severity of crack features found on the EB-ENR segment.

A total of Re crack features were identified on this segment by a crack ILI that was conducted in 2014. The feature density is Red eatures per mile; the severity of the features is considered to be low as all features found have ILI reported depths less than Redact – 5 of nominal wall thickness and Safety Factors greater than 1.5. The average Safety Factor of Redact – 5 is Redact times the CFR Safety Factor requirement of 1.39 and all features are above integrity targets.

In comparison to the crack density and severity measured in the WS-NN segment described in section 3.5.1, the crack density and severity measured on the EB-ENR segment is much lower Red features per mile versus Redact – 5 for WS-NN,) and average Safety Factor is higher Redact – 5 US versus Redact – 5 for WS-NN).

The attributes of the crack features are below the integrity criteria for excavation and repair in the Consent Decree, CFR Title 49 conditions for remediation, Enbridge's excavation criteria, and API Recommended Practice 1176 dig selection criteria.

Severity (Depth, % of Wall Thickness)	Number of Features
<20 20-30 30-40 40-50 >50	Redacted 5 USC 552(b) (4)
Feature Density = Red features per mile	
Severity (Safety Factor)	**Number of Features**
>2.0 1.75-2.0 1.5-1.75 1.25-1.5 1.0-1.25 <1.0	Redacted 5 USC 552(b) (4)
Average Safety Factor = Redact – 5	

Table 5: Crack Features in the EB-ENR Segment

3.2.2. FINANCIAL ANALYSIS FOR PIPE REPLACEMENT

As detailed in Appendix B, on an NPV basis the cost of the pipe replacement is estimated to total Red MM, which is significantly higher than the cost of the rehabilitation plan for this segment, which is estimated to total Red MM. Thus, the overall cost of replacement of this US Line 10 segment is almost two times the cost of the rehabilitation plan for this segment. Accordingly, the financial analysis verifies that replacement of this US Line 10 segment is not warranted because the safety and reliability of this US Line 10 segment can continue to be maintained through implementation of the rehabilitation plan.

3.2.3. CONCLUSION

Based on Enbridge's evaluation of the number, density, and severity of the corrosion and crack features found in the EB-ENR segment, Enbridge determined that this pipeline segment has met integrity safety targets and pipe safety can be maintained with the current annual rehabilitation plan for this segment. In addition, the results of the financial analysis for replacement of this US Line 10 segment confirm that pipe

replacement of this segment is therefore not a warranted maintenance option for the operating period from 2017 to 2031.

3.3. REPLACEMENT EVALUATION FOR THE EAST BRANCH NIAGARA RIVER CROSSING SEGMENT

This river crossing is part of the East Niagara River (ENR) – Kiantone Take-off (UT) trap-to-trap pipeline segment but this replacement evaluation is performed separate from the rest of the segment.

Figure 3 below shows the scope of pipe replacement evaluated for the East Branch Niagara River crossing.

Figure 3: East Branch Niagara River Crossing Pipe Replacement Scope

3.3.1. ANALYSIS OF CRACK AND CORROSION FEATURES

3.3.1.1. Corrosion Features

Table 6 below details the number, density, and severity of corrosion features detected specifically in the section of pipe under the East Branch Niagara River crossing.

A total of R corrosion features were identified on this pipeline segment by corrosion ILI that was conducted in 2015. The feature density is Reda eatures per mile; however the severity of the features is considered to be low as all features have ILI reported depths less than [redacted] of nominal wall thickness ([redacted] of the features have depths under [redacted] of wall thickness), Safety Factors greater than [redacted] and RPRs greater than [redacted] The average Safety Factor of [redacted] is over [redacted] times the CFR Safety Factor threshold of 1.39 and all features are above integrity targets.

In comparison to the corrosion density and severity found on the WS-NN segment in Canada as described in section 3.5.1, this crossing has considerably lower corrosion density and severity Red features per mile versus [redacted] for WS-NN, and average Safety Factor of [redacted] versus [redacted] for WS-NN).

All corrosion features are below the criteria governing excavation and repair in the Consent Decree, Enbridge's excavation criteria, CFR Title 49 conditions for remediation, and API Recommended Practice 1160 dig selection criteria.

Severity (Depth, % of Wall Thickness)	Number of Features
<20 20-30 30-40 40-50 >50	Redacted 5 USC 552(b)(4)
Feature Density = [redacted] features per mile	
Severity (Safety Factor)	**Number of Features**
>2.0 1.75-2.0 1.5-1.75 1.39-1.5 1.0-1.39 <1.0	Redacted 5 USC 552(b)(4)
Average Safety Factor = [redacted]	
Severity (RPR)	**Number of Features**
>1.1 1.075-1.1 1.05-1.075 1.025-1.05 1.0-1.025 <1.0	Redacted 5 USC 552(b)(4)
Average RPR = [redacted]	

Table 6: Corrosion Features in the East Branch Niagara River Crossing

3.3.1.2. Crack Features

Table 7 below details the number, density, and severity of crack features detected specifically in the section of pipe under the East Branch Niagara River crossing.

A total of [redacted] crack features were identified on this pipeline segment by a crack ILI that was conducted in 2014. The feature density is [redacted] features per mile; the severity of the features is considered to be low as all features found have ILI reported depths less than [redacted] of nominal wall thickness and Safety Factors greater than [redacted].

The average Safety Factor of [redacted] is approximately [redacted] times the CFR Safety Factor threshold of 1.39, and all features are below integrity targets.

In comparison to the crack density and severity measured in the WS-NN segment described in section 3.5.1, the crack density and severity measured in this crossing is much lower ([redacted] features per mile versus [redacted] for WS-NN, and average Safety Factor of [redacted] versus [redacted] for WS-NN).

The attributes of the crack features are below the integrity criteria for excavation and repair in the Consent Decree, CFR Title 49 conditions for remediation, Enbridge's excavation criteria, and API Recommended Practice 1176 dig selection criteria.

Severity (Depth, % of Wall Thickness)	Number of Features
<20 20-30 30-40 40-50 >50	Redacted 5 USC 552(b)(4)
Feature Density = Re features per mile	
Severity (Safety Factor)	**Number of Features**
>2.0 1.75-2.0 1.5-1.75 1.25-1.5 1.0-1.25 <1.0	Redacted 5 USC 552(b)(4)
Average Safety Factor =	

Table 7: Crack Features in the East Branch Niagara River Crossing

3.3.2. FINANCIAL ANALYSIS

The replacement of this section would involve horizontal directional drilling (HDD) under the East Branch Niagara River channel from a suitable location close the ENR launch trap to a suitable location on the East bank of the East Niagara River channel.

As detailed in Appendix C, on an NPV basis the cost of the pipe replacement is estimated to total Red MM, which is significantly higher than the cost of the rehabilitation plan for this segment that is estimated to total Red MM. Thus, the overall cost of pipe replacement is over four times the cost of the rehabilitation plan for this segment. Accordingly, the financial analysis suggests that replacement is not warranted because the safety and reliability of this US Line 10 segment can be feasibly maintained through implementation of the rehabilitation plan for the period 2017 to 2031.

3.3.3. CONCLUSION

Based on Enbridge's evaluation of the number, density, and severity of the corrosion and crack features found in the East Branch Niagara River Crossing, Enbridge determined that this pipeline segment has met integrity safety targets and pipe safety can continue to be maintained with the current annual rehabilitation plan for this segment. In addition, the results of the financial analysis for pipe replacement confirm that the rehabilitation programs for this segment are forecasted to be financially preferable over pipeline replacement.

3.4. REPLACEMENT EVALUATION FOR THE EAST NIAGARA RIVER BANK - KIANTONE (UT) SEGMENT

Figure 4 below shows the scope of pipe replacement evaluated for the East Niagara River Bank- UT segment.

Figure 4: ENR Bank - UT Segment Pipe Replacement Scope

3.4.1. ANALYSIS OF CRACK AND CORROSION FEATURES

3.4.1.1. Corrosion Features

Table 8 below details the number, density, and severity of corrosion features in the ENR Bank-UT segment.

A total of Redacted corrosion features were identified on this pipeline segment by a corrosion ILI that was conducted in 2015. The feature density is Redacted features per mile; all features have Safety Factors greater than Redacted and RPRs greater than Redacted The average Safety Factor of Redacted is over Redacted times the CFR Safety Factor threshold of 1.39, confirming integrity targets have been met.

Redacted USC 552(b)(4)

In comparison to the corrosion density and severity found on the WS-NN segment in Canada as described in section 3.5.1, this segment has lower corrosion density and severity [redacted] features per mile versus [redacted] for WS-NN, and average Safety Factor of [redacted] versus [redacted] for WS-NN).

All corrosion features are below the criteria governing excavation and repair in the Consent Decree, CFR Title 49 conditions for remediation, Enbridge's excavation criteria, and API Recommended Practice 1160 dig selection criteria.

Severity (Depth, % of Wall Thickness)	Number of Features
<20 20-30 30-40 40-50 >50	Redacted 5 USC 552(b)(4)
Feature Density = [redacted] features per mile	
Severity (Safety Factor)	**Number of Features**
>2.0 1.75-2.0 1.5-1.75 1.39-1.5 1.0-1.39 <1.0	Redacted 5 USC 552(b)(4)
Average Safety Factor = [redacted]	
Severity (RPR)	**Number of Features**
>1.1 1.075-1.1 1.05-1.075 1.025-1.05 1.0-1.025 <1.0	Redacted 5 USC 552(b)(4)
Average RPR = [redacted]	

Table 8: Corrosion Features in the ENR Bank-UT Segment

3.4.1.2. Crack Features

Table 9 below details the number, density, and severity of crack features in the ENR Bank-UT segment.

A total of [redacted] crack features were identified on this pipeline segment by a crack ILI that was conducted in 2014. The feature density is [redacted] features per mile; the severity of the features is considered to be low as all features found have ILI reported depths less than [redacted] of nominal wall thickness and Safety Factors greater than [redacted]

The average Safety Factor of [redacted] s approximately [redacted] times the CFR Safety Factor threshold of [redacted] and all features are above integrity targets.

In comparison to the crack density and severity measured in the WS-NN segment described in section 3.5.1, the crack density and severity measured in this segment is much lower ([redacted] features per mile versus [redacted] for WS-NN, and average Safety Factor of [redacted] versus [redacted] for WS-NN).

The attributes of the crack features do not currently fall within the criteria governing excavation and repair in the Consent Decree, Enbridge's excavation criteria, CFR Title 49 conditions for remediation, and API Recommended Practice 1176 dig selection criteria.

Severity (Depth, % of Wall Thickness)	Number of Features
<20 20-30 30-40 40-50 >50	Redacted 5 USC 552(b)(4)
Feature Density = [redacted] features per mile	
Severity (Safety Factor)	**Number of Features**
>2.0 1.75-2.0 1.5-1.75 1.25-1.5 1.0-1.25 <1.0	Redacted 5 USC 552(b)(4)
Average Safety Factor = [redacted]	

Table 9: Crack Features in the ENR Bank-UT Segment

3.4.2. FINANCIAL ANALYSIS FOR PIPE REPLACEMENT

The replacement of this section would also involve horizontal directional drilling (HDD) of approximately 1.6 miles starting from a suitable location close the east bank of the East Niagara River channel to a suitable location close to the Tonawanda Pump Station.

As detailed in Appendix D, on an NPV basis the cost of the pipe replacement is estimated to tota[redacted] MM, which is significantly higher than the cost of the rehabilitation plan for this segment that is estimated to total[redacted] MM. Thus, the overall cost of pipe replacement of this segment is two times the cost of the rehabilitation plan. Accordingly, the financial analysis confirms that replacement is not financially preferable because the safety and reliability of this US Line 10 segment can be feasibly maintained through implementation of the rehabilitation plan for the period from 2017 to 2031.

3.4.3. CONCLUSION

Based on Enbridge's evaluation of the number, density, and severity of the corrosion and crack features found in East Niagara River Bank to Kiantone Take-off segment, Enbridge determined that this pipeline segment has met integrity safety targets and pipe safety can continue to be maintained with the current annual rehabilitation plan for this segment. In addition, the results of the financial analysis for pipe replacement confirm that the current rehabilitation programs are forecasted to be financially preferable over pipe replacement of this segment. Pipe replacement of this segment is therefore not warranted for the period from 2017 to 2031.

3.5. COMPARISON OF THE CRACK AND CORROSION FEATURES ON US LINE 10 AND WESTOVER (WS) TO NANTICOKE (NN) SEGMENT

Figure 5 below shows the scope of pipe replacement for the WS-NN segment (~21 miles).

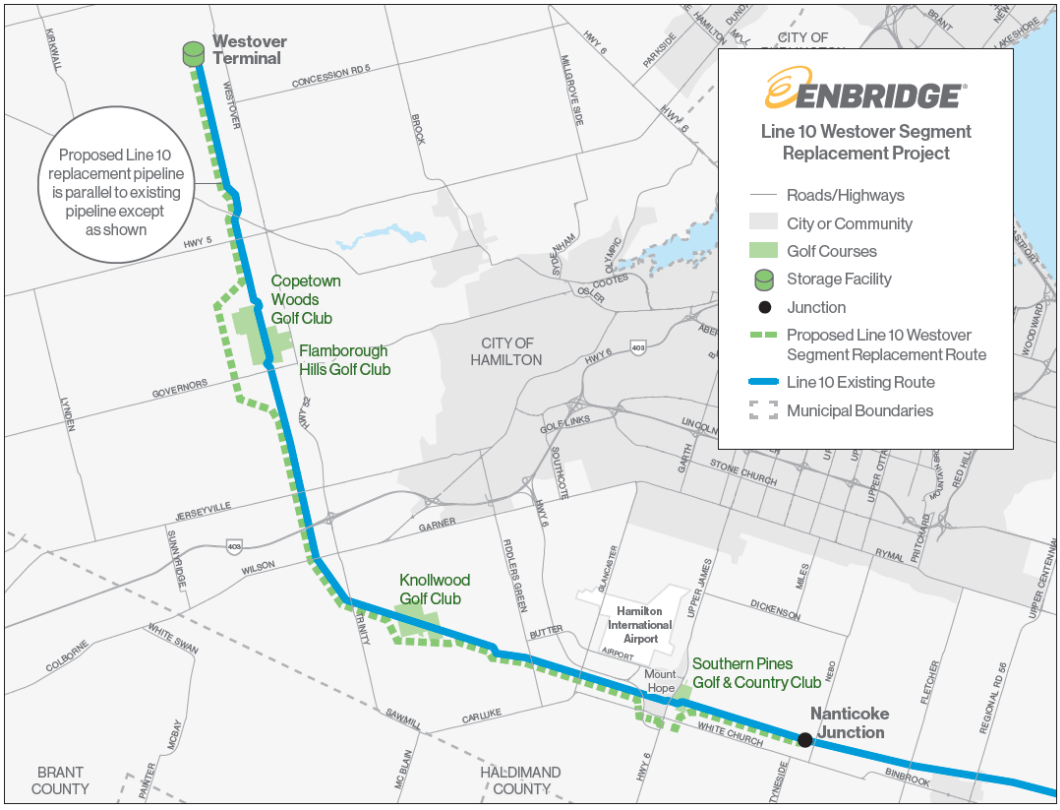

Figure 5: WS-NN Segment Pipe Replacement Scope

3.5.1. ANALYSIS OF CRACK AND CORROSION FEATURES

3.5.1.1. Corrosion Features in the WS-NN Segment

Table 10 below details the number, density, and severity of corrosion features in the WS-NN segment.

A total of Red [redacted] corrosion features were identified on this segment by an ILI that was conducted in 2012. The density of Red [redacted] features per mile is approximately Red [redacted] times higher than the overall feature density on US Line 10. The average RPR of Redact – S [redacted] is comparable to what is measured on US Line 10, however the average Safety Factor of Redact – S [redacted] s lower than the average Safety factors in US Line 10 segments ranging Redact – S [redacted] to Redact – S [redacted]

None of the features meets the excavation criteria of depth greater than 50% of nominal wall thickness, Safety Factor less than 1.39 (for Canada the threshold is 1.25), or RPR less than 1.0.

Severity (Depth, % of Wall Thickness)	Number of Features
<20 20-30 30-40 40-50 >50	Redacted - 5 USC 552(b)(4)
Feature Density = Reda features per mile	
Severity (Safety Factor)	**Number of Features**
>2.0 1.75-2.0 1.5-1.75 1.39-1.5 1.0-1.39 <1.0	Redacted - 5 USC 552(b)(4)
Average Safety Factor =	
Severity (RPR)	**Number of Features**
>1.1 1.075-1.1 1.05-1.075 1.025-1.05 1.0-1.025 <1.0	Redacted - 5 USC 552(b)(4)
Average RPR =	

Table 10: Corrosion Features in the WS-NN Segment

3.5.1.2. Crack Features in the WS-NN Segment

Table 12 below details the number, density, and severity of crack features in the WS-NN segment.

A total of Red crack features were identified on the pipeline in this segment by an ILI that was conducted in 2013. Compared to US Line 10, the density of R crack features per mile in the WS-NN segment is higher than what is measured on US Line 10 which ranges from to features per mile, Redact – 5 USC 552(b)(4)

The average Safety factor of s much lower than what is measured on all US Line 10 segments which ranges from o Redact – 5 USC 552(b)(4) WS-NN crack features are assessed to have a Safety Factor lower than the threshold for mitigation in Canada. A pressure restriction has been implemented to limit Westover discharge to restore the Safety Factor. This restriction is anticipated to remain in place until the pipeline segment is replaced.

Severity (Depth, % of Wall Thickness)	Number of Features
<20 20-30 30-40 40-50 >50	Redacted - 5 USC 552(b)(4)
Feature Density = Re features per mile	
Severity (Safety Factor)	**Number of Features**
<1 1-1.25 1.25-1.5 1.5-1.75 1.75-2 >2	Redacted - 5 USC 552(b)(4)
Average Safety Factor = Red	

Table 12: Crack Features in the WS-NN Segment

3.5.2. CONCLUSION

The corrosion feature density on the WS-NN segment is higher than that of US Line 10. The density of crack features is lower than that of the WNR-EB segment. In terms of severity, the depths of corrosion features are comparable to what is found on US Line 10 but crack features on the WS-NN segment are deeper on average. Additionally, both corrosion and crack Safety Factors are below what is found on US Line 10. Overall, this segment has a higher density of features with higher severity than what is found on US Line 10.

The evaluation of the number, density, and severity of the corrosion and crack features found in Westover to Nanticoke segment determined that this pipeline segment with the application of the pressure restriction has met integrity safety targets and pipe safety can continue to be maintained until replacement.

The replacement of the WS-NN segment is driven by maintenance optimization with a secondary benefit being the restoration of the segment's original capacity.

4. OVERALL CONCLUSIONS

Based on Enbridge's analysis of corrosion and crack features on US Line 10 segments, and Enbridge's consideration of other threats to the integrity of the pipe (e.g., third-party/mechanical damage and geohazards/pipeline movement), Enbridge has determined that the safe and reliable operation of US Line 10 can be maintained over the next 15 years with the continuation of Enbridge's rehabilitation plan for the line. In addition, the results of the financial analysis for pipe replacement verify that the rehabilitation plans for each segment are forecasted to be financially preferable over pipe replacement. It is therefore recommended that the US Line 10 rehabilitation plans continue to be the chosen maintenance approach for US Line 10 for the period from 2017 to 2031. Pipe replacement is not warranted at this time, but will continue to be evaluated periodically in accordance with Enbridge's normal practice as new inline inspection (ILI) data becomes available

APPENDICES

APPENDIX A: FINANCIAL ANALYSIS FOR PIPE REPLACEMENT

Summary Financial Analysis Results for the West Niagara River to Grand Island segment replacement

	Line 10 WNR-EB Replacement Evaluation Summary	
		2017-2031 Total
Current Annual Rehabilitation Programs	Number of Digs Forecast	Redact – 5 USC 552(b)(4)
	Number of ILI Forecast	
	Forecast Dig and ILI Costs (Undiscounted)	Redact
	Forecast Dig and ILI Costs (PV)	Redact
2031 Pipe Replacement Scenario	Number of Digs Forecast	Redact – 5 USC 552(b)(4)
	Number of ILI Forecast	
	Forecast Dig and ILI Costs (Undiscounted)	Redact
	Forecast Dig and ILI Costs (PV)	Redact
	Pipe Replacement (Undiscounted)	Redacte
	Pipe Replacement (PV)	Redact
	Replacement Total (Undiscounted)	Redacte
	Replacement Total (PV)	Redacte
Scenario Comparison	**Current Programs - Replacement (Undiscounted)**	Redacte
	Current Programs - Replacement (NPV)	Redact

APPENDIX B: FINANCIAL ANALYSIS FOR PIPE REPLACEMENT

Summary Financial Analysis Results for the Grand Island to East Niagara River to segment replacement

	Line 10 EB-ENR Replacement Evaluation Summary	
		2017-2031 Total
Current Annual Rehabilitation Programs	Number of Digs Forecast	Redact – 5 USC 552(b)(4)
	Number of ILI Forecast	
	Forecast Dig and ILI Costs (Undiscounted)	Redacte
	Forecast Dig and ILI Costs (PV)	Redacte
2031 Pipe Replacement Scenario	Number of Digs Forecast	Redact – 5 USC 552(b)(4)
	Number of ILI Forecast	
	Forecast Dig and ILI Costs (Undiscounted)	Redacte
	Forecast Dig and ILI Costs (PV)	Redacte
	Pipe Replacement (Undiscounted)	Redacte
	Pipe Replacement (PV)	Redacte
	Replacement Total (Undiscounted)	Redacte
	Replacement Total (PV)	Redacte
Scenario Comparison	**Current Programs - Replacement (Undiscounted)**	Redacte
	Current Programs - Replacement (NPV)	Redacte

APPENDIX C: FINANCIAL ANALYSIS FOR PIPE REPLACEMENT

Summary Financial Analysis Results for the East Niagara River Crossing replacement

	Line 10 East Branch Niagara River Crossing Replacement Evaluation Summary	
		2017-2031 Total
Current Annual Rehabilitation Programs	Number of Digs Forecast	Redact – 5 USC 552(b)(4)
	Number of ILI Forecast	
	Forecast Dig and ILI Costs (Undiscounted)	Redact
	Forecast Dig and ILI Costs (PV)	Redact
2031 Pipe Replacement Scenario	Number of Digs Forecast	Redact – 5 USC 552(b)(4)
	Number of ILI Forecast	
	Forecast Dig and ILI Costs (Undiscounted)	Redact
	Forecast Dig and ILI Costs (PV)	Redact
	Pipe Replacement (Undiscounted)	Redacte
	Pipe Replacement (PV)	Redact
	Replacement Total (Undiscounted)	RedactM
	Replacement Total (PV)	Redact
Scenario Comparison	**Current Programs - Replacement (Undiscounted)**	(Redacte
	Current Programs - Replacement (NPV)	(Redact)

APPENDIX D: FINANCIAL ANALYSIS FOR PIPE REPLACEMENT

Summary Financial Analysis Results for the East Niagara River Bank - Kiantone Take-off segment replacement

	Line 10 East Niagara River Bank – UT Replacement Evaluation Summary	
		2017-2031 Total
Current Annual Rehabilitation Programs	Number of Digs Forecast	Redact – 5 USC 552(b)(4)
	Number of ILI Forecast	
	Forecast Dig and ILI Costs (Undiscounted)	Redacte
	Forecast Dig and ILI Costs (PV)	Redacte
2031 Pipe Replacement Scenario	Number of Digs Forecast	Redact – 5 USC 552(b)(4)
	Number of ILI Forecast	
	Forecast Dig and ILI Costs (Undiscounted)	Redacte
	Forecast Dig and ILI Costs (PV)	Redacte
	Pipe Replacement (Undiscounted)	Redacted
	Pipe Replacement (PV)	RedactR
	Replacement Total (Undiscounted)	Redacted
	Replacement Total (PV)	Redacte
Scenario Comparison	**Current Programs - Replacement (Undiscounted)**	(Redacted)
	Current Programs - Replacement (NPV)	(Redacte

APPENDIX E: LINE 10 ROUTE MAP