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Use of ECDA Approach in Prioritization of ILI Anomalies

S.M. Segall, P. Eng.
R.A. Gummow, P. Eng.
D. Fingas
Corrosion Service Company Limited
2-498 Markland St.
Markham, ON L6C 1Z6 Canada

John Shore, P. Eng.
Union Gas Limited
A Spectra Energy Company
50 Keil Drive North
Chatham, ON N7M 5M1 Canada

ABSTRACT

An effective In-line Inspection (ILI) program must provide a prioritized excavation response plan to address anomalies identified as being of particular concern.

Locations that show potential for imminent or short term failure are prioritized under Phase 1 and Phase 2 responses respectively. Anomalies that could grow to become a severe risk for pipeline integrity prior to the next ILI are prioritized as Phase 3 excavations.

This paper describes the use of External Corrosion Direct Assessment (ECDA) principles in prioritizing Phase 3 anomalies on a gas pipeline in northern Ontario, resulting in a more effective excavation program.

A type of ECDA prioritization criterion, based on the results of an integrated Close Interval Potential Survey/Direct Current Voltage Gradient (CIPS/DCVG) survey in conjunction with the results of Phase 1 and Phase 2 digs, is proposed.

Keywords: ILI, ECDA, CIPS, DCVG, Prior History of Corrosion, Digs

INTRODUCTION

In-line inspections were conducted in 2002 and 2006 on a NPS10 gas line in northern Ontario. Based on the prioritized excavation response plan, 49 digs were performed under the Phase 1 and Phase 2 responses[(1)] and a total of 62 digs remained to be performed under Phase 3 response. Prioritizing these Phase 3 digs and re-evaluating the statistically predicted growth of the anomalies has become extremely important both in terms of allocating pipeline owner resources and ensuring the pipe integrity.

This paper describes the use of ECDA principles in prioritizing Phase 3 anomalies on this pipeline.

[(1)] The purpose of Phase 1 and Phase 2 ILI responses is to identify and excavate any locations that show potential for imminent (Phase 1) or short term (Phase 2) failure.

TECHNICAL APPROACH

The following information was provided by the pipeline owner or was available in archives:

a) Background pipeline data, as required in the pre-assessment phase of a typical ECDA process
b) ILI data, complete with GPS coordinates for the reference points
c) Dig reports
d) Results of a 2010 integrated CIPS/DCVG survey.

As a first step, the data collected along the line during the 2010 CIPS/DCVG survey were aligned with the 2006 ILI data. The existing and the future digs were added for reference. One example of the resulting aligned data is shown in Figure 1.

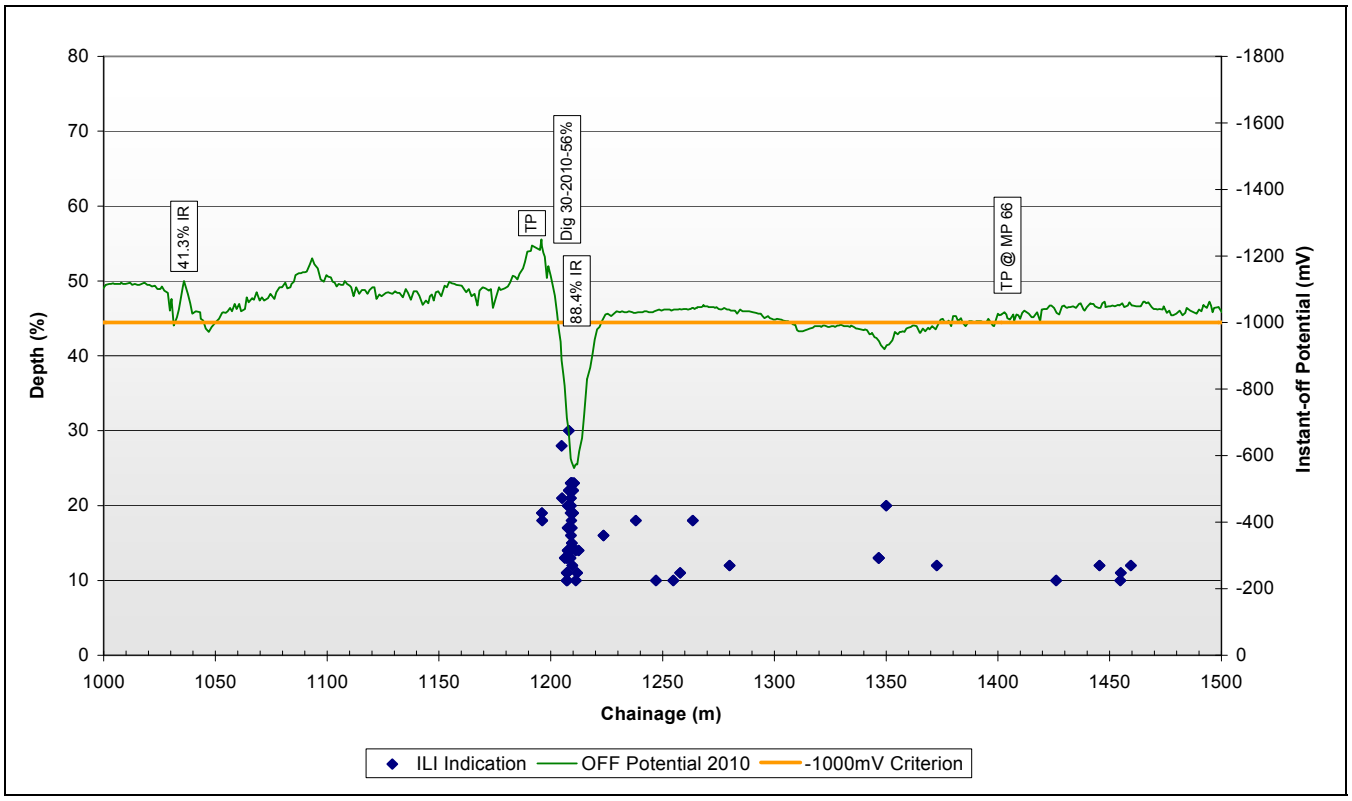


Figure 1: NPS10 Line. Ch. 1000m to 1500m. ILI/CIPS/DCVG Aligned Data

The findings of each existing ILI dig were then analyzed in conjunction with the CIPS/DCVG data in order to develop an adequate prioritization protocol. For example, Figure 1 indicates that dig 30-2010 was performed in this section at chainage 1209.3. A 56% through wall pit was found, which correlated well with a CIPS indication (-560mV$_{CSE}$) and a DCVG indication (88.4%IR). No prior history of corrosion was reported in this area.

The next step was to classify the various types of indications. The depth of the pits found at the ILI digs was used to identify and classify any prior history of corrosion (PHC).

The following classification criteria were used in this project:

a) Protection Level (Close Interval Potential Survey)
   - Minor: V_{OFF} between -800 mV$_{CSE}$ and -1000 mV$_{CSE}$
   - Moderate: V_{OFF} between -600 mV$_{CSE}$ and -799 mV$_{CSE}$
   - Severe: V_{OFF} more electropositive than -600 mV$_{CSE}$

b) Coating Damage(DCVG Survey)
- Minor: % I-R less than or equal to 35%
- Moderate: % I-R greater than 35% and less than 60%
- Severe: % I-R equal to or more than 60%

c) Prior History of Corrosion (Adjacent ILI Dig Data)
- Minor: 25%[(2)] to 44% pit depth, within 100m of the ILI dig
- Moderate: 45% to 59% pit depth, within 100m of the ILI dig
- Severe: 60% and greater pit depth, within 100m of the ILI dig

A very conservative prioritization protocol was then developed based on an ECDA approach, in conformance with NACE Standard SP0502-2010.

Finally, the proposed protocol was applied to the remaining 62 digs. The locations prioritized as Immediate Action Required (I) and Scheduled Action Required (S) were expected to display severe or moderate corrosion, and were conservatively designated as Group A. The remaining lower risk digs were designated as Group B.

An excerpt from the prioritization table for the remaining digs is shown in Table 1.

Table 1
Prioritization of Remaining Digs (Excerpt)

Group	Upcoming Digs	Average Chainage	CIPS	DCVG	PHC	Prioritization
A	35	3277.0	SV	SV	MN	I
	36	3320.4	SV	MD	MN	I
	37	3378.2	SV	SV	MD	I
	38	3393.4	SV	MD	MD	I
	39	3401.8	SV	MN	MD	I
	41	3470.3	SV	SV	MD	I
	42	3498.1	SV	MD	MD	I
	43	3520.9	MD	SV	MD	I
	44	3568.3	MD	SV	UNK	S
B	31	2833.6	NI	MD	NI	M
	32	2896.8	NI	MN	MD	M
	33	3016.6	MN	MN	MD	M
	34	3057.7	NI	NI	MN	N
	49	4158.7	MN	NI	SV	M
	50	4468.0	NI	NI	UNK	N

Legend:

SV = Severe indication
MD = Moderate indication
MN = Minor indication
BT = Below threshold
NI = No indication
UNK = Unknown

I = Immediate action required
S = Scheduled action required
M = Suitable for monitoring
N = No action required
N/A = Not Applicable

[(2)] Even well protected pipes displaying average rates of corrosion less than 1mpy, may result in up to 25% pit depth after more than 44 years.

The prioritized future digs are shown in conjunction with the CIPS, DCVG and ILI indications in Figure 2. Historical digs,[3] from group A, were added for reference.

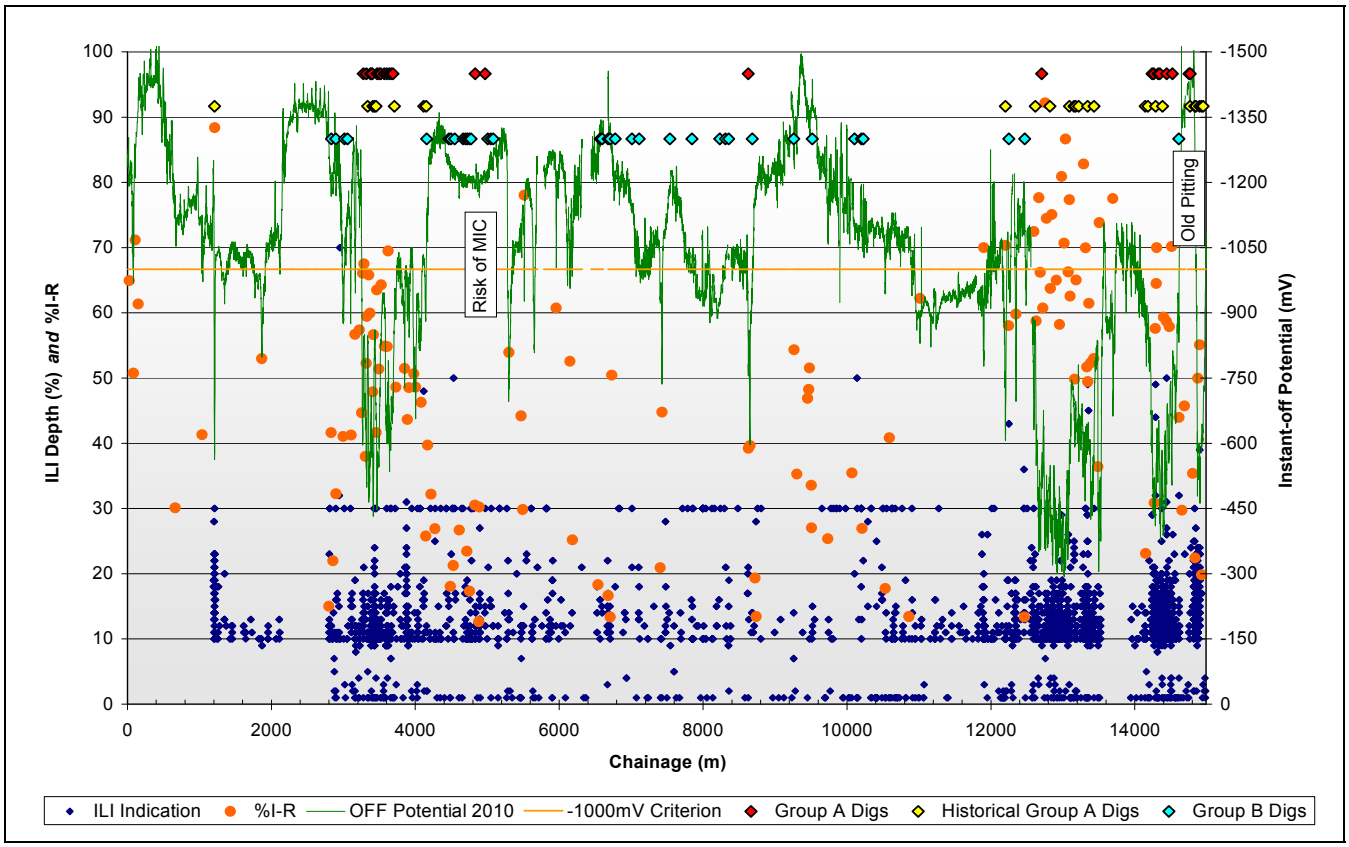


Figure 2: Overview of Proposed Digs vs. ILI/CIPS/DCVG Data

[3] Historical group A digs are defined as 2002 – 2010 digs which would have been included under group A using the proposed prioritization protocol.

The two areas displaying severe sub-criterion potentials, where the majority of the digs in group A were located, are shown in Figures 3 and 4.

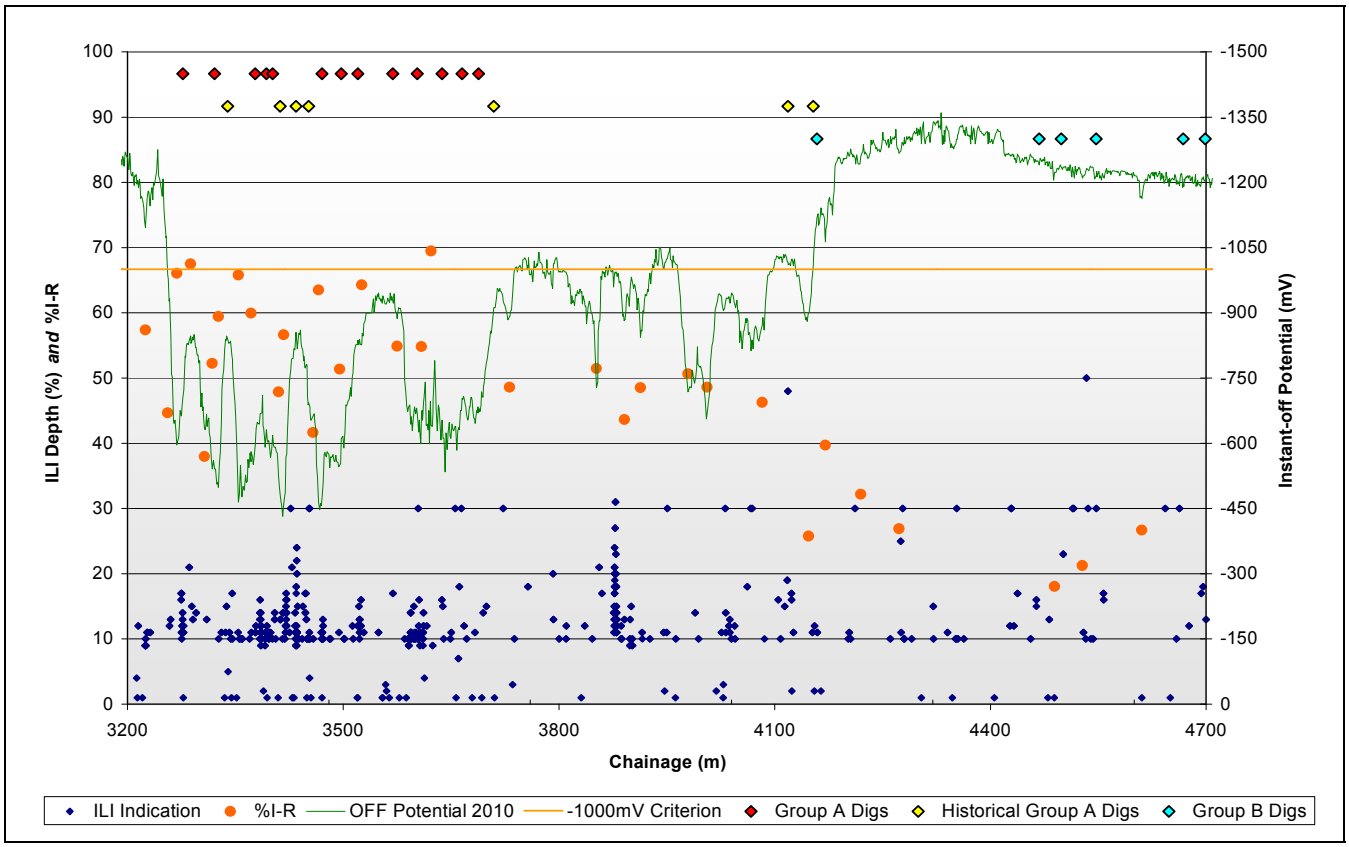


Figure 3: Ch. 3200 to 4700. Overview of Proposed Digs vs. ILI/CIPS/DCVG Data

The digs in group A shown in Figure 3, are concentrated in the area between chainages 3250 and 4200, with protection levels as low as -450mV$_{CSE}$ and calculated %I-R exceeding 60%. The remaining digs, prioritized as group B, are located in an area where the pipe is fully protected.

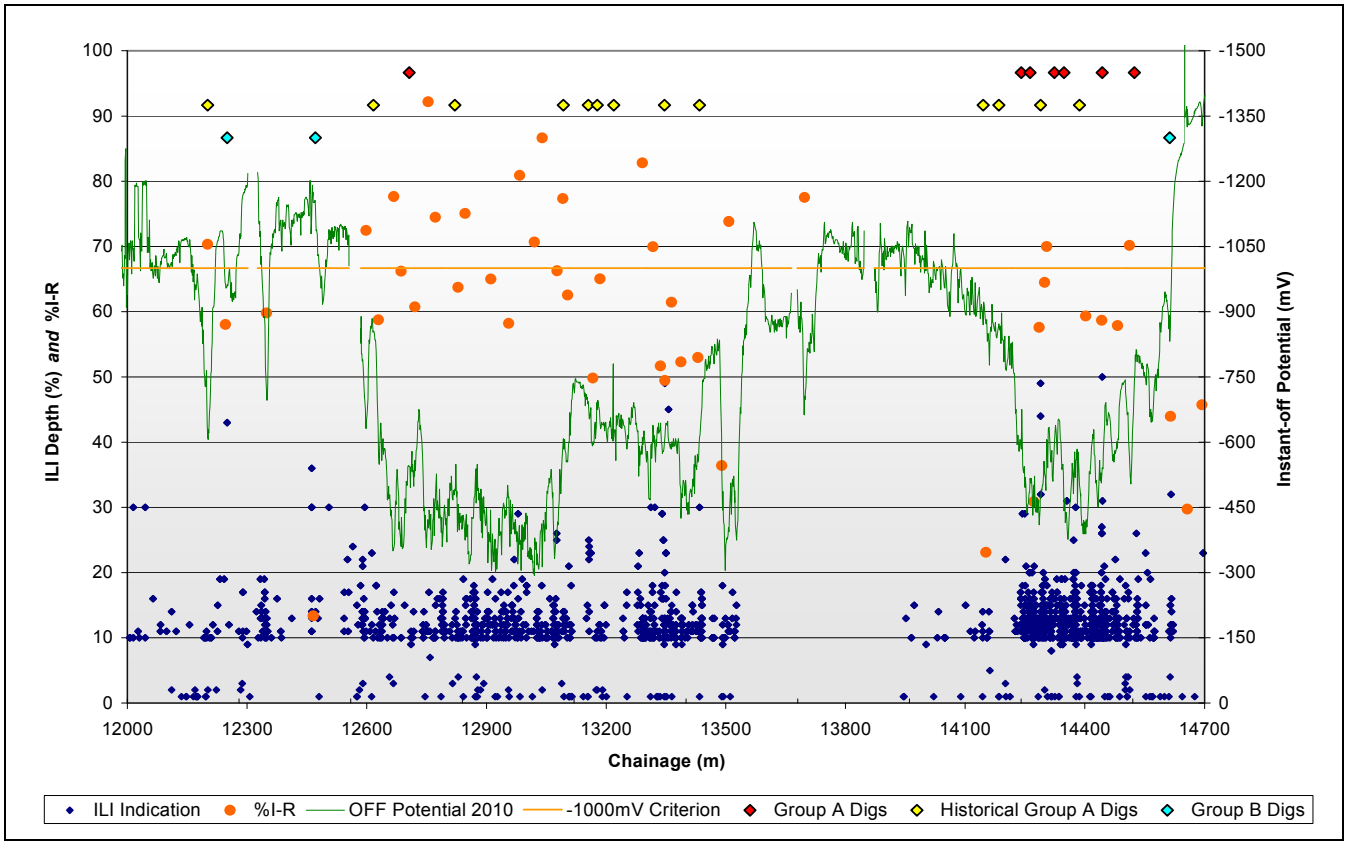


Figure 4: Ch. 12000 to 14700. Overview of Proposed Digs vs. ILI/CIPS/DCVG Data

Figure 4 shows the second section with extended sub-criterion potentials. Note that digs chosen as 'most-at-risk' (group A), using the ECDA type analysis, also typically coincide with higher concentrations of ILI anomalies. This trend can also be observed over the whole line in Figure 2.

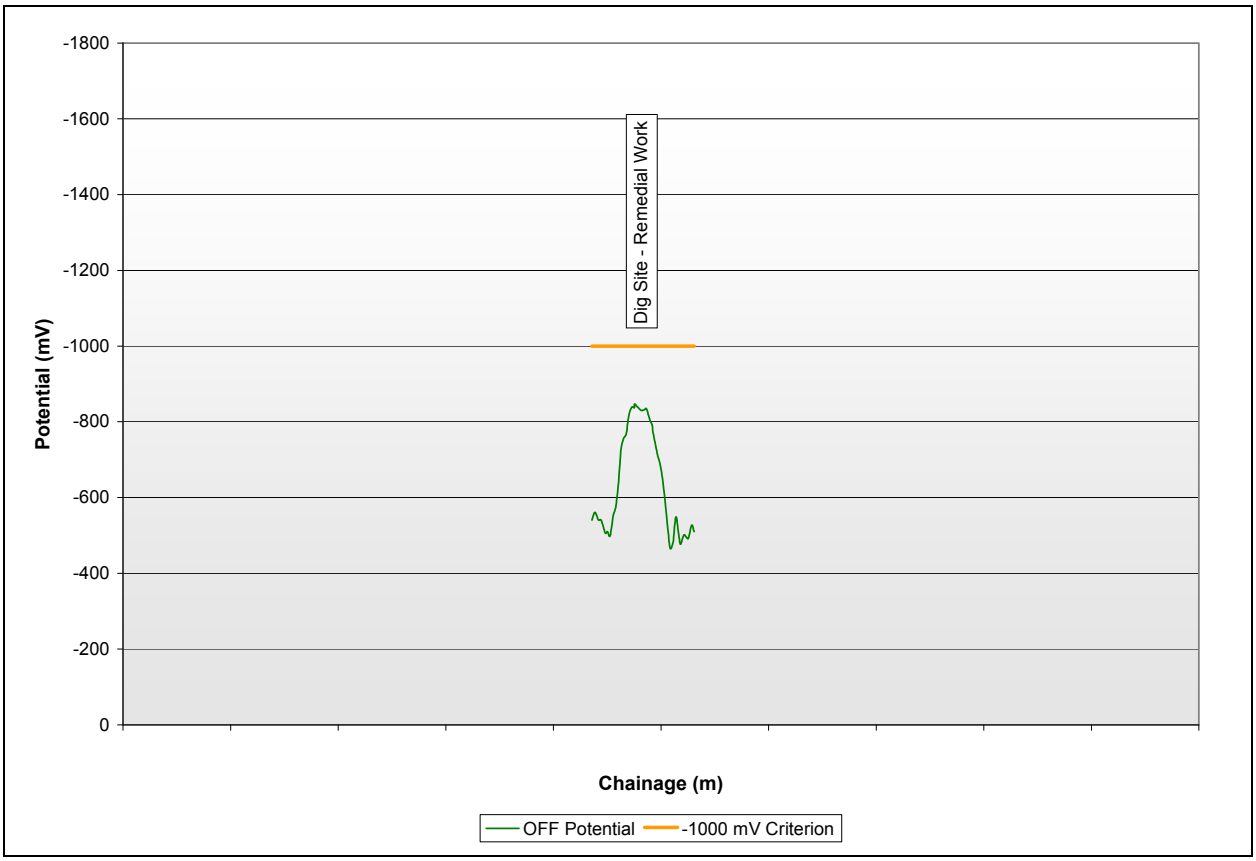
A total of 37 digs, prioritized as "No Action Required" or "Suitable for Monitoring", were included in group B and subsequently removed from the immediate priority list. The remaining 25 digs, including their ECDA prioritization, were to be ranked based on the ILI data and the risk factor for the specific location.

VALIDATION

The proposed prioritization protocol was validated using the findings of the existing digs. The CIPS and DCVG indications were identified from the 2010 CIPS/DCVG survey data. The prior history of corrosion was determined based on the findings at the adjacent digs (i.e. excluding the dig itself). The results were then compared with the actual dig findings to determine the reliability of the ECDA approach.

As the majority of the digs were performed before the 2010 survey, rules and procedures were established to estimate the coating quality and the protection level of the line prior to the remedial work associated with the digs. An example of such rules, complete with rationale, is shown in Figure 5. Note that the remedial work could influence only the validation process and does not affect the prioritization of the remaining ILI digs.

Rule: For prioritization purposes, a dig located in an area displaying improved potentials at the dig site and sub-criterion potentials on both sides (see graph) is considered as displaying a CIPS indication classified as the most severe CIPS indication when located within 50m of the dig.



Rationale: It would be unrealistic to assume that a dig location displaying ILI anomalies attributed to corrosion would be the only well protected area. As such, the local improvement was attributed to remedial work following the dig.

Note: The degree of confidence in this estimation is very high.

Figure 5: Example of Rule Covering the Effect of Remedial Work

The results of the validation process are shown in Table 2.

Table 2
Results of the Validation Process

Group	Severe Corrosion	Moderate Corrosion	Minor or No Corrosion
A	100%	63%	41%
B	0%	37%	59%

As indicated in Table 2, **all** locations displaying severe corrosion and 63% of the locations displaying moderate corrosion were identified. However, 41% of the digs displaying minor or no corrosion were overrated and included in Group A.

Since the validation process was applied to existing digs, the 2010 CIPS/DCVG measured the pipe condition as remediated at these locations. Subsequently, the accuracy of the prioritization protocol as applied to the remaining digs is expected to be significantly higher.

CONCLUSIONS

The results of CIPS and DCVG surveys may be successfully integrated with ILI data and ILI dig findings to prioritize remaining ILI digs, as seen in Figures 2 to 4.

A very conservative ECDA-based protocol was proposed to prioritize 62 remaining digs on a pipeline in northern Ontario. The prioritization protocol resulted in the removal of 37 digs from the immediate priority list with a very high level of confidence. Furthermore, useful information in terms of prioritization status was added to the remaining 25 digs, for consideration in the final ranking.

The proposed protocol was validated using the findings of the already performed digs. Although the accuracy of the validation process was affected by remedial work following the digs, all locations displaying severe corrosion and 63% of the locations displaying moderate corrosion, were identified.

It is expected that when applied only to remaining digs, with no influence from remedial work, the accuracy of the proposed prioritization protocol would be even higher.