

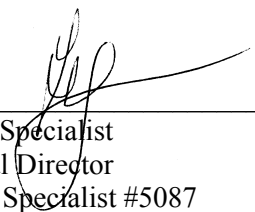
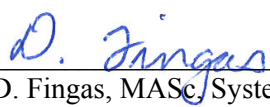
CIPS & DCVG**INSPECTION
REPORT****EXTERNAL CORROSION ASSESSMENT****NPS 20 Lakeshore Natural Gas Pipeline****DEO-10-10550-E-0**

Prepared for: Enbridge Gas Distribution Inc.
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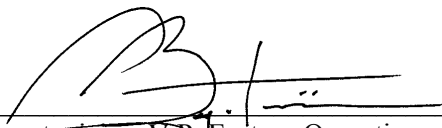
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1.0 GENERAL

Corrosion Service Company Limited (CSCL) was retained by Enbridge Gas Distribution Inc. to conduct an external corrosion assessment survey on sections of the NPS 20 Lakeshore pipeline in Toronto, Ontario. The scope of work includes conducting CIPS and DCVG surveys (i.e. indirect inspections), processing and aligning the survey data, identifying, classifying and prioritizing indications as per External Corrosion Direct Assessment (ECDA)^[1] protocol and finally recommending dig locations where the most severe corrosion attack is expected.

The actual ECDA process was not considered as an applicable risk assessment technique, due to the presence of dynamic stray currents, contaminated soil and significant changes in an adjacent cathodic protection system (i.e. Hydro One). An alternative assessment technique (i.e. bell hole examination) was recommended to assess the integrity of the line, albeit with a lower degree of confidence than in an ECDA process. The selection of the bell hole locations was done based on the results of the CIPS and DCVG surveys using the procedures defined in the ECDA process.

The integrity of each section is to be assessed independently due to significant variations in the soil conditions, protection level and dynamic stray activity.

The CIPS and DCVG surveys were performed by a Corrosion Service field crew between October 19 and November 12, 2010.

2.0 SYSTEM OVERVIEW

The NPS20 Lakeshore pipeline in Toronto runs east from the Sherway Gardens District Station #12788 in Mississauga, Ontario to the Station B District Station #10206 in Toronto, Ontario, a distance of approximately 20 km.

The line is protected by an impressed current system. The influencing rectifiers and their outputs during the survey are listed in Table 1.

Table 1. Influencing Rectifiers Parameters

No.	Gas Main	Rectifier Description & Location	Current Output (A)	Date Taken
1	20"	469700 - Courier Ln. 40M S. of Queensway - A1M01	2.01	09-Nov
2	20"	469699 - Hwy 427 & QEW w/o The East Mall - A1001	10	06-Nov
3	DM*	469432 - Kipling Ave s/o Torlake Cres - C0186	1.98	11-Dec
4	DM*	469539 - Norseman St. at Placid Rd. - D8012	1.68	15-Nov
5	20"	469566 - Lakeshore Blvd. w/o Palace Pier - A1002	1.23	08-Nov

^[1] as defined in NACE Standard SP0502-2010

2.0 SYSTEM OVERVIEW CONT'D

Table 1. Influencing Rectifiers Parameters Cont'd

No.	Gas Main	Rectifier Description & Location	Current Output (A)	Date Taken
6	20"	P469446 - 1601 Lakeshore Blvd W (Palais Royale) - A1003	3.6	02-Nov
7	DM*	469594 - Grand Ave at Beaverdale Rd - E0005	1.86	08-Nov
8	DM*	469568 - Cowan at Springhurst SW Corner - G9004	6.09	19-Nov
9	20"	469609 - Bathurst St. s/o Lakeshore Blvd - A1005	No Data	
10	DM*	469611 - Stadium Rd - I0354	No Data	
11	DM*	469452 - Front St e/o Blue Jay - I0023	1.23	18-Nov
12	20"	3294465 - Parliament Rectifier West - A1006	3.96	05-Nov
13	20"	A1007 Station B - Circuit 1	18.3	08-Nov
14	DM*	A3001 Station B - Circuit 2	0.92	09-Nov

* Distribution main branch isolated from the 20" line.

A site inspection was conducted to select four sample areas which would be representative of the pipeline condition and which would also be accessible for indirect inspection. The selected sections are listed in Table 2.

Table 2. Inspection Sections

Section Designation	Start Point	End Point	Approx. Length (m)
Islington	Islington Ave. and the Gardiner Expwy.	Royal York Rd. and the Gardiner Expwy.	938
Ontario Place	Lakeshore Blvd. at isolating flange east of British Columbia Rd.	TP at Lakeshore Blvd. west of Ontario Place Blvd.	1282
Parliament	TP at Parliament St. and Lakeshore Blvd.	TP at Lakeshore Blvd. west of Cherry St.	310
Lever	South-west corner of former Lever Plant (east of Don Roadway)	North-east corner of former Lever Plant	320

The selected sections do not coincide with previous leak sites.

3.0 INDIRECT INSPECTION MEASUREMENTS

The protection level of the pipe, and subsequently the risk of corrosion activity, was assessed using a Close Interval Potential Survey (CIPS). GPS synchronized chart recorders were installed upstream and downstream as each section was surveyed. This allowed the survey data to be partially compensated for dynamic stray currents due to TTC's DC transit system. To further reduce this impact, night surveys were conducted from November 10th to 12th, 2010 on the Lever, Parliament and Ontario Place sections of the pipeline.

On the Ontario Place, Parliament, and Lever sections, nearby Hydro One rectifiers may also influence pipeline potentials and/or cause DC interference. On the night of November 11, 2010 these rectifiers were turned off and a CIPS was conducted on each of these sections to characterize the impact on protection levels.

The DC Voltage Gradient (DCVG) method was selected as a complementary primary tool to detect and locate coating holidays.

The CIPS and DCVG were integrated into one survey for a perfect alignment of the two sets of data where possible. In some locations the ON/OFF potential shifts were too low to allow an integrated survey.

The indirect inspections were conducted using the following techniques:

- a) Influence Testing – to confirm that the line is “clean” during the CIPS, meaning that all influencing rectifiers were interrupted simultaneously and that any dynamic stray current activity (i.e. telluric currents) would be compensated in the final results.
- b) Aligned/Integrated CIPS/DCVG Survey – to assess the protection level of the lines and to detect, locate, and classify coating holidays.

3.1 Influence Testing

The influencing Enbridge rectifiers listed in Table 1 were interrupted during the surveys.

In order to confirm that all influencing rectifiers were indeed synchronously interrupted and that the line was “clean”, the pipe-to-soil potential during the OFF cycle was recorded and analyzed for any trace of rectifier activity. The test is based on the fact that a single-phase rectifier does not generate a perfect DC current (i.e. like a battery), but it introduces a significant 120 Hz ripple.

If the pipe-to-soil potential is recorded or displayed on an oscilloscope, then the magnitude of various frequencies, including 120 Hz, can be determined.

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.1 Influence Testing Cont'd

When the recording is done during the OFF cycle, and no 120 Hz ripple is found, it means that no single-phase influencing rectifier is active during the recording. Similarly, a three-phase rectifier has a 180 Hz ripple, however sometimes the signature of a three-phase rectifier cannot be accurately detected as it coincides with harmonics of the 60 Hz AC induced voltages.

A waveform was recorded during the OFF cycle (see Figure 3-1) and a frequency analysis was conducted using commercially available software^[2] to calculate the amplitude of various frequency components in order to identify signatures of influencing single-phase or three-phase rectifiers left ON or out of synchronization.

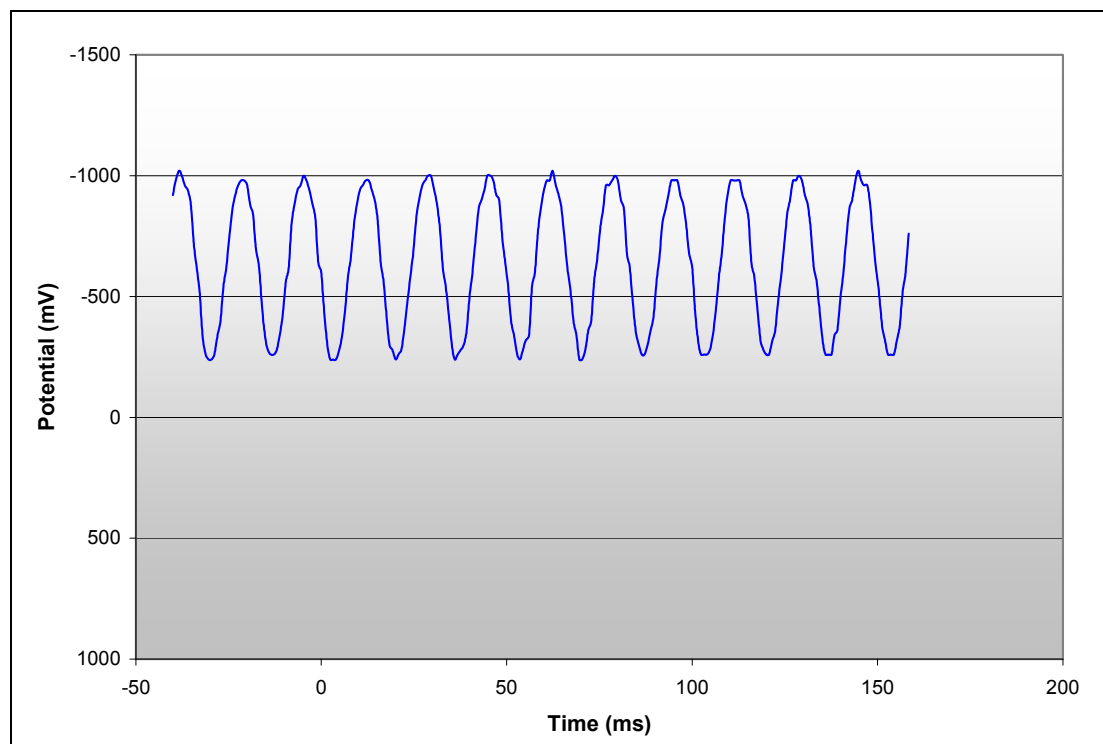


Figure 3-1 • Influence Testing. OFF Cycle Waveform. Pipe-to-Soil Potential

^[2] Software based on Fourier series mathematical model.

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.1 Influence Testing Cont'd

The frequency analysis indicated a low amount^[3] of 60 Hz AC induced voltage (i.e. 378 mV), a very low 120 Hz component (i.e. 3 mV), and a minor (i.e. 11 mV) 180 Hz component, as shown in Figure 3-2.

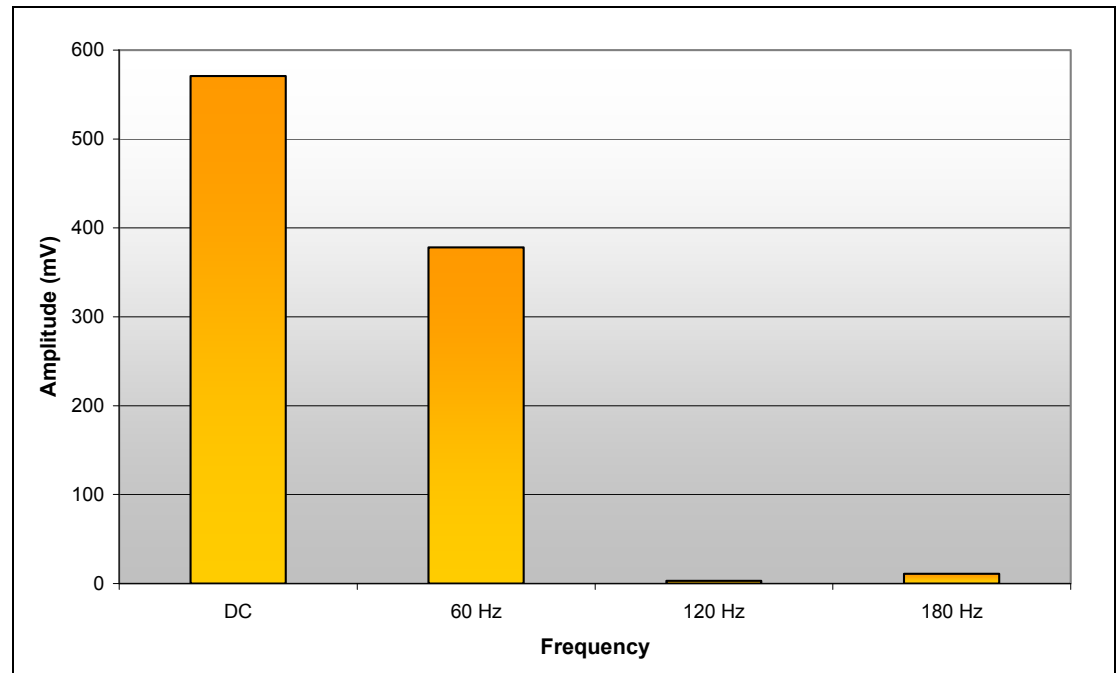


Figure 3-2 • Influence Testing. OFF Cycle Waveform. Frequency Spectrum

The absence of a 120 Hz component indicated that there was no residual DC current from single-phase rectifiers. The 180 Hz component is attributed to 60 Hz harmonics. Note that this sample was taken on the Islington section, remote from the Hydro One rectifiers.

^[3] Low in terms of risk for AC induced corrosion

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.1 Influence Testing Cont'd

Data loggers were installed at test posts to record the influence of the dynamic stray currents associated with the TTC's DC traction systems. A sample is shown in Figure 3-3. To minimize the impact of these stray currents, night surveys were conducted from November 10th to 12th, 2010 on the Lever, Parliament and Ontario Place sections of the pipeline. Long-term recorded data were also used to estimate possible stray current DC interference by comparing the protection level recorded during the day-time with the night-time records.

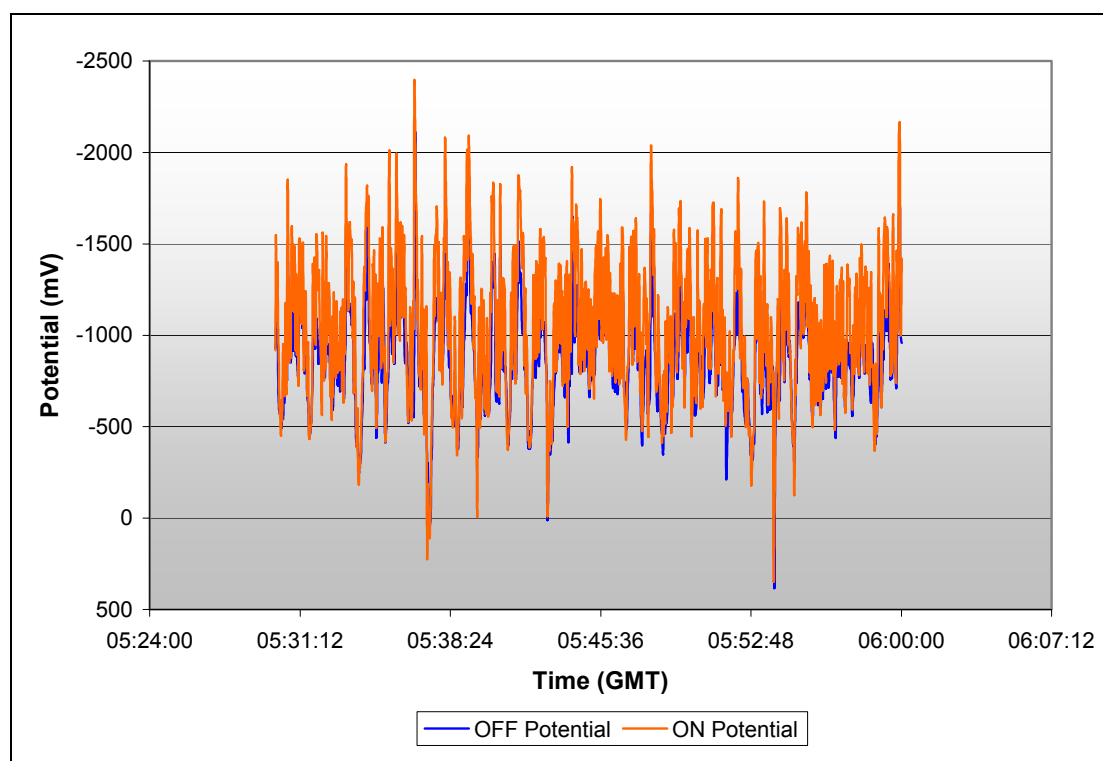


Figure 3-3 • Influence Testing. Telluric Activity (30 Minute Sample)

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.2 Aligned/Integrated CIPS/DCVG Survey

Pipe-to-soil potentials and lateral^[4] 3 m gradients were recorded every meter, including the UTM coordinates^[5] at selected locations.

The survey results are shown in the attached electronic file and are plotted in Figures 3-4 to 3-11. The line shown at -850 mV corresponds to the identification criterion for CIPS indications (locations where the line is not fully protected). Figure 3-11 shows the OFF potentials on Lever section recorded with Hydro rectifiers ON and then OFF.

The full size charts are attached in Appendix A.

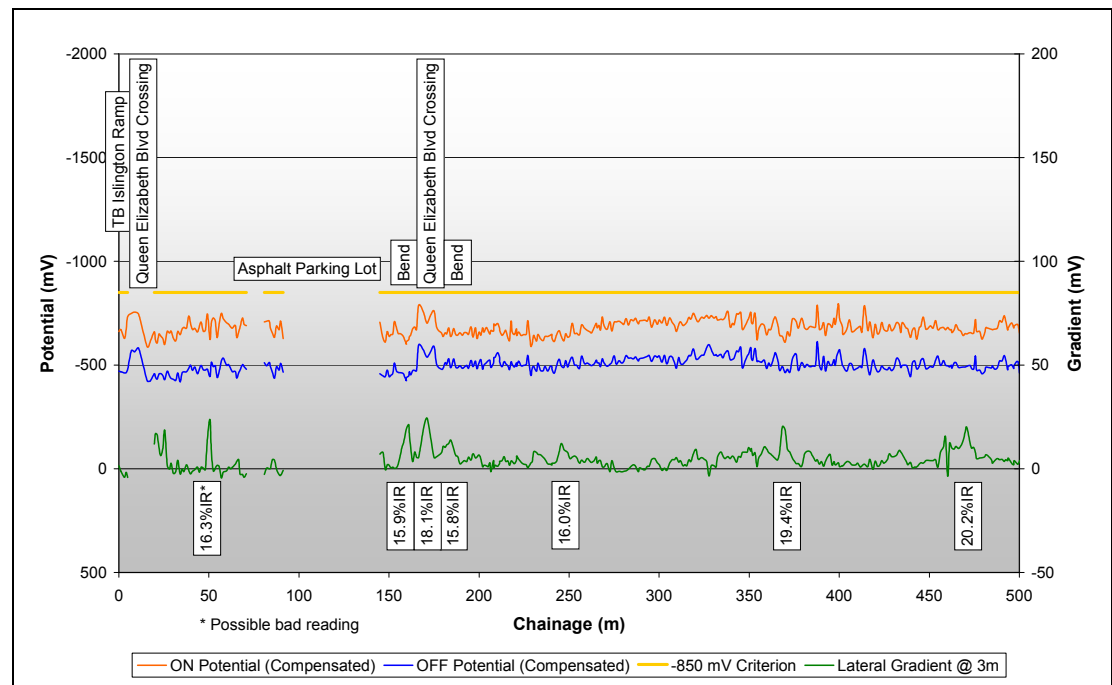


Figure 3-4 • 20" Lakeshore Line. Islington Section. Ch. 0 to 500m. Integrated CIPS/DCVG Survey

^[4] A Longitudinal DCVG survey was conducted on the Ontario Place section.

^[5] As per the Department of Defense (DOD) World Geodetic System 1984 (i.e. WGS84), which was defined as a standard by the National Imagery and Mapping Agency (NIMA) technical report 8350.2.

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.2 Aligned/Integrated CIPS/DCVG Survey Cont'd

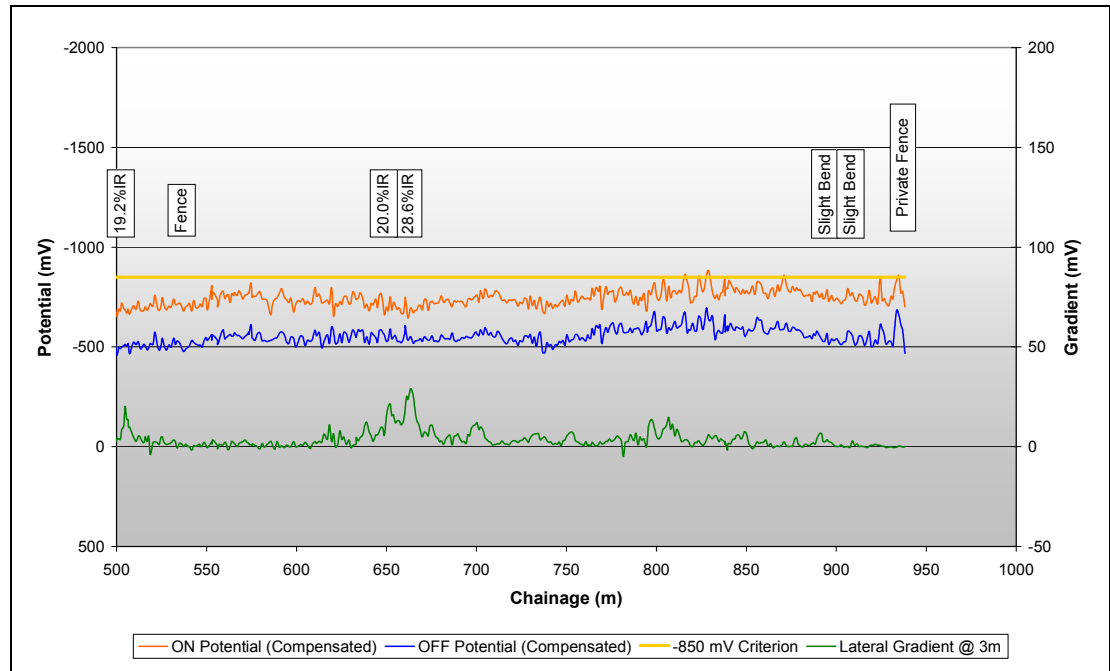


Figure 3-5 • 20" Lakeshore Line. Islington Section. Ch. 500 to 938m. Integrated CIPS/DCVG Survey

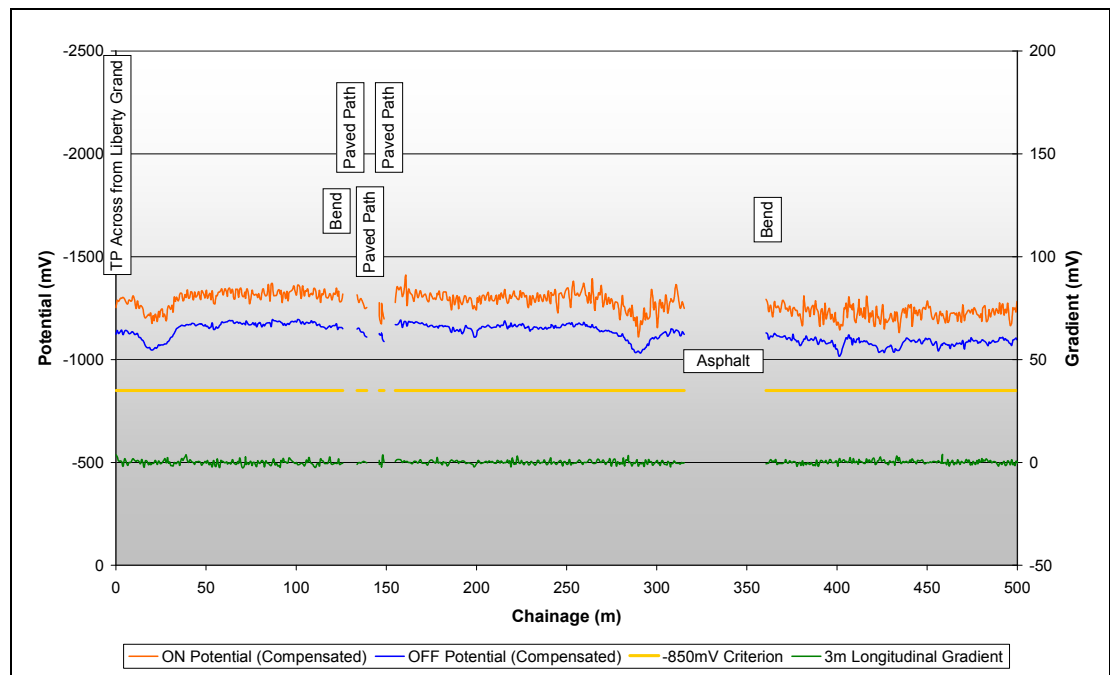


Figure 3-6 • 20" Lakeshore Line. Ontario Place Section. Ch. 0 to 500m. Integrated CIPS/DCVG Survey

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.2 Aligned/Integrated CIPS/DCVG Survey Cont'd

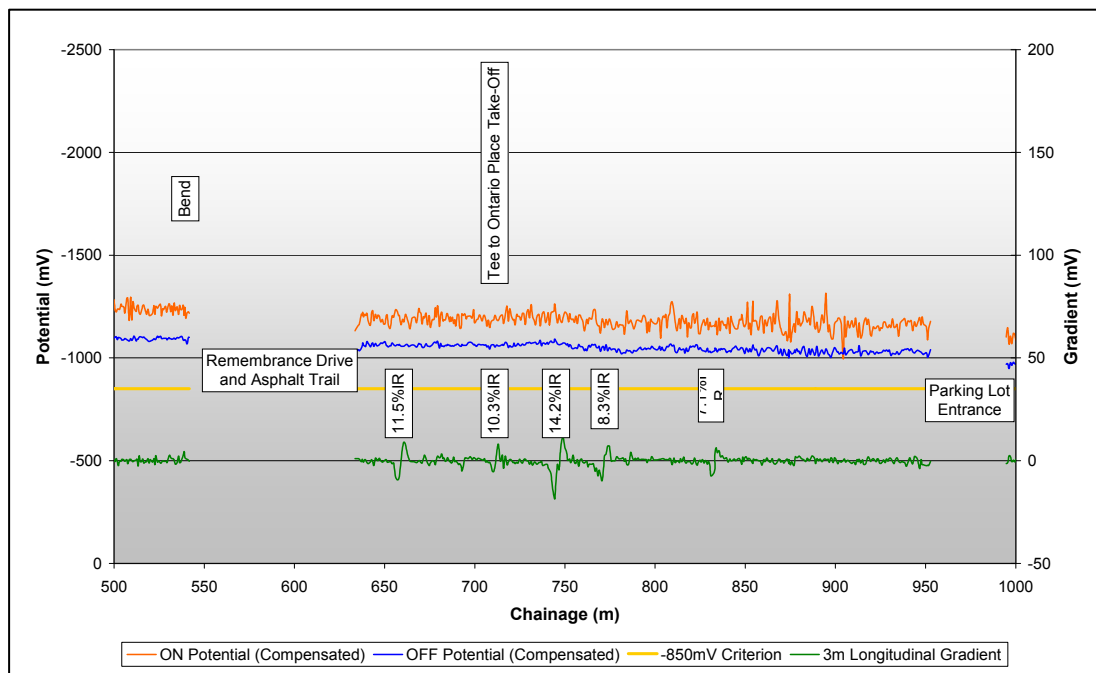


Figure 3-7 • 20" Lakeshore Line, Ontario Place Section. Ch. 500 to 1000m. Integrated CIPS/DCVG Survey

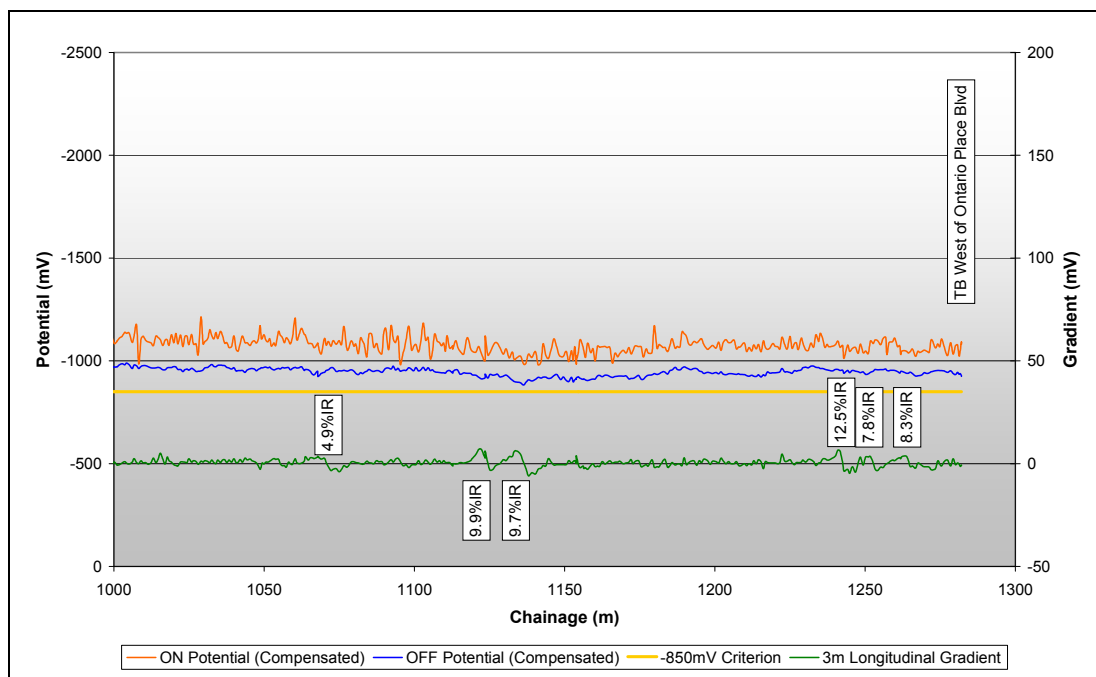


Figure 3-8 • 20" Lakeshore Line, Ontario Place Section. Ch. 1000 to 1282m. Integrated CIPS/DCVG Survey

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.2 Aligned/Integrated CIPS/DCVG Survey Cont'd

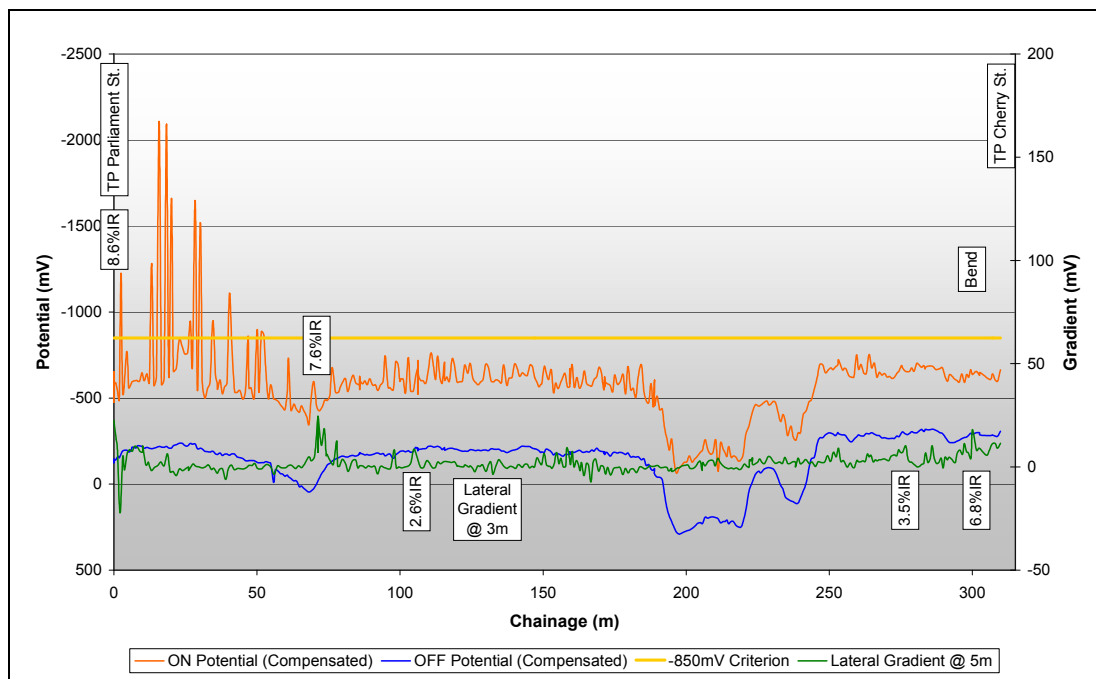


Figure 3-9 • 20" Lakeshore Line. Parliament Section. Aligned CIPS/DCVG Survey

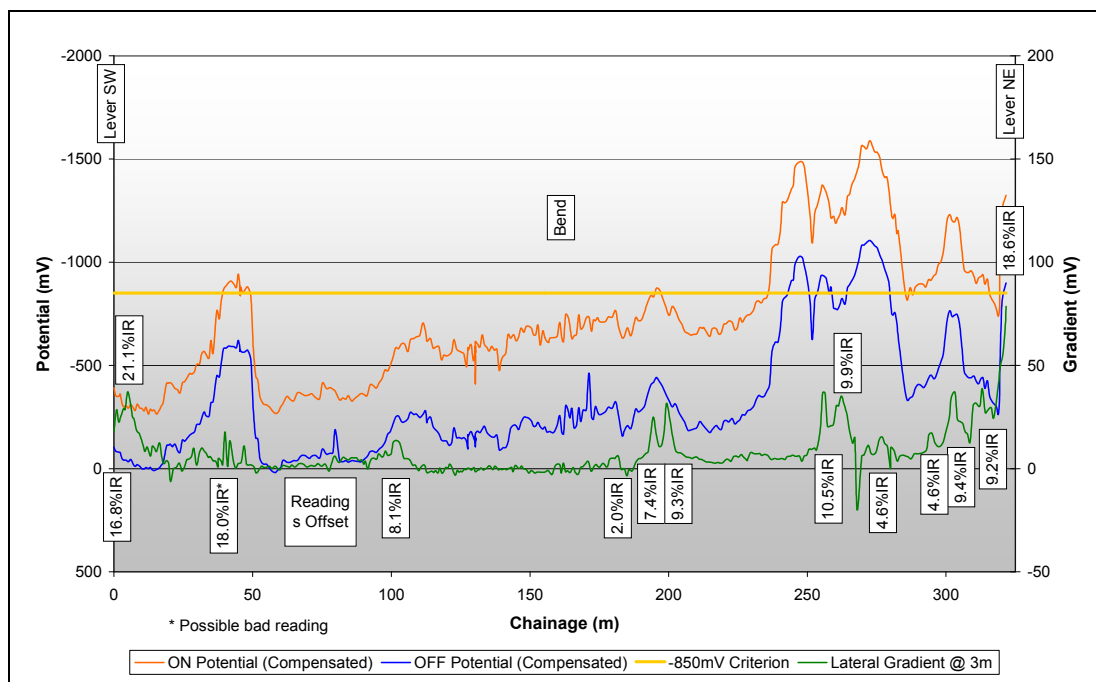


Figure 3-10 • 20" Lakeshore Line. Lever Section. Aligned CIPS/DCVG Survey

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.2 Aligned/Integrated CIPS/DCVG Survey Cont'd

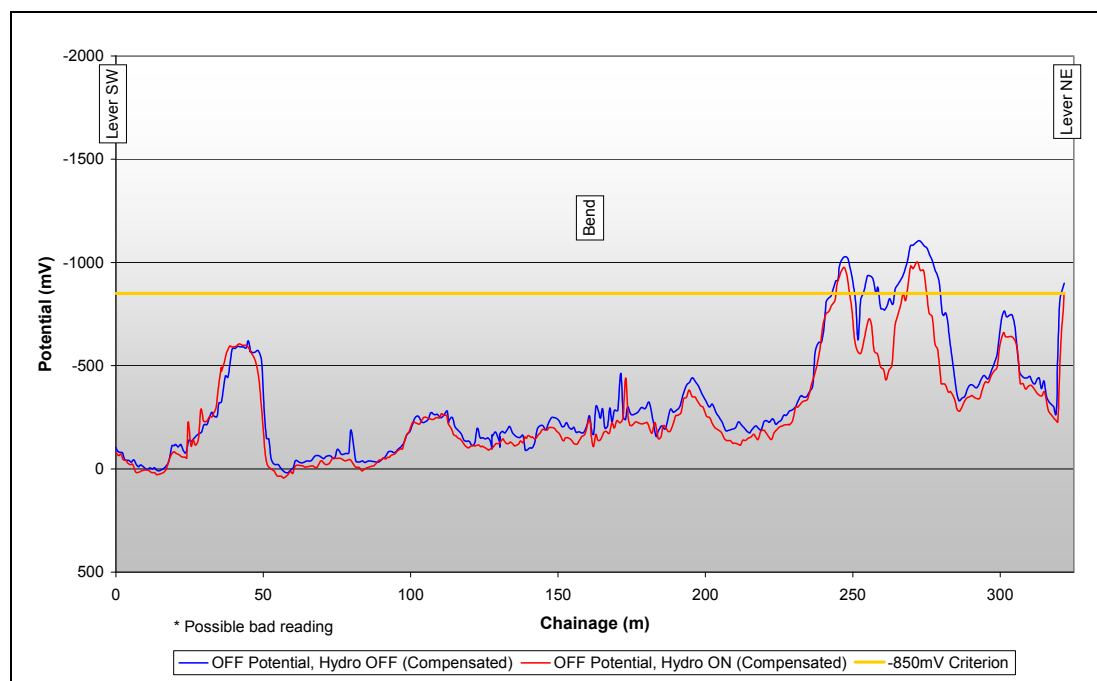


Figure 3-11 • 20" Lakeshore Line. Lever Section. OFF Potential with Hydro Rectifiers ON and OFF

3.3 Identification, Alignment & Classification of Indications

3.3.1 Identification Criteria for Indications

The following criteria were developed to identify indications in conformance with Paragraph 4.3.1 of the NACE Standard SP0502-2010:

- a) Close Interval Potential Survey: Any location displaying an OFF potential more electropositive than $-850 \text{ mV}_{\text{CSE}}$ is defined as an indication under this assessment.
- b) DC Voltage Gradient Survey: Any location displaying a severity index (i.e. %IR) higher than 15%, consistent with the characteristic shapes of the lateral or longitudinal gradient at a holiday is defined as an indication under this assessment. The calculation of the severity index from the integrated CIPS/DCVG survey data is based on the method detailed in Paper # 06193^[6] presented at the NACE 2006 Conference.

^[6] Segall M.S., Gummow R.A., Reid R.G. – Use of an Integrated CIPS/DCVG Survey in the ECDA Process, NACE Corrosion 2006, Paper No. 193, San Diego.

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

3.3.1 Identification Criteria for Indications Cont'd

- c) DC Interference: Any location displaying an electropositive shift in excess of 30 mV at an OFF potential equal to or more electronegative than $-850 \text{ mV}_{\text{CSE}}$ or any electropositive shift at an OFF potential more electropositive than $-850 \text{ mV}_{\text{CSE}}$, when the interfering rectifier is turned ON is defined as an indication under this assessment.
- d) Dynamic Stray Current Interference (DSCI): Any location displaying an electropositive shift in excess of 30 mV at an OFF potential equal to or more electronegative than $-850 \text{ mV}_{\text{CSE}}$ or any electropositive shift at an OFF potential more electropositive than $-850 \text{ mV}_{\text{CSE}}$ when comparing the average day-time and average night-time OFF potentials is defined as an indication under this assessment.

3.3.2 Alignment

The integrated CIPS/DCVG survey ensures a perfect alignment between the CIPS and DCVG data, since the two sets of data are recorded at the same location.

Sub-meter GPS coordinates were recorded at indications, as well as every 40 m and at reference points, such as bends, valves, centerlines of the roads, etc. for future reference.

3.3.3 Classification Criteria

The following criteria were developed to classify indications in conformance with Paragraph 4.3.2 of the NACE Standard SP0502-2010:

Protection Level (Close Interval Potential Survey)

- Minor: V_{OFF} between $-800 \text{ mV}_{\text{CSE}}$ and $-850 \text{ mV}_{\text{CSE}}$
- Moderate: V_{OFF} between $-750 \text{ mV}_{\text{CSE}}$ and $-799 \text{ mV}_{\text{CSE}}$
- Severe: V_{OFF} more electropositive than $-749 \text{ mV}_{\text{CSE}}$

Coating Damage (DCVG Survey)

- Minor: % I-R less than or equal to 35% and C-C (cathodic-cathodic) behaviour (Categories 1 or 2, no examination recommended)
- Moderate: % I-R higher than 35% and less than or equal to 60% and C-C or C-N (cathodic-neutral) behaviour (Category 3, major consumer of CP current)
- Severe: % I-R more than 60% or C-A (cathodic-anodic) or A-A (anodic-anodic) behaviour (Category 4, recommended for immediate repair)

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

3.3.3 Classification Criteria Cont'd

DC Interference with No CIPS Indication (DC Interference & CIPS Surveys)

- Minor: Electropositive shift greater than 30 mV, when the interfering rectifier is turned ON
- Moderate: N/A (no moderate or severe indications on fully protected lines)
- Severe: N/A (no moderate or severe indications on fully protected lines)

DC Interference with CIPS Indication (DC Interference & CIPS Surveys)

- Minor: Electropositive shift less than 30 mV, when the offending rectifier is turned ON
- Moderate: Electropositive shift from 30 mV to 60 mV, when the offending rectifier is turned ON
- Severe: Electropositive shift higher than 60 mV, when the offending rectifier is turned ON

Dynamic Stray Current Interference (Long-term recording)

- N/A. The severity of the dynamic stray current interference cannot be estimated without using coupons. The coupons are required to provide an I-R drop free potential under dynamic stray currents and to monitor the variation of this potential for at least a 24 hour period. The monitoring is required as the line may be fully protected during the night and unprotected during the day.

3.3.4 Summary and Classification of Indications

The indications found during the indirect inspection are listed and classified in Table 3.

On the Ontario Place section there were no DCVG indications satisfying the identification criterion (i.e. %IR higher than 15%). Along the Parliament and Lever sections, even small coating holidays are at risk due to a severe risk of external corrosion. As such, all along these sections the coating defects displaying the highest %IR below the identification threshold (i.e. BT) were also listed in order to be considered for digs.

Table 3 • Summary and Classification of Indications

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
-	-	Islington	From 0 to 50.5	Severe CIPS	-419mV _{CSE} @ Ch. 34.0m
43.621180	-79.512108		50.6	Minor DCVG Severe CIPS	16.3%IR C-C* -445mV _{CSE}

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

Table 3 • Summary and Classification of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
-	-	Islington Cont'd	From 50.7 to 160.9	Severe CIPS	-425mV _{CSE} @ Ch. 159.6m
43.621408	-79.510775		161.0	Minor DCVG Severe CIPS	15.9%IR C-C -462mV _{CSE}
-	-		From 161.1 to 170.9	Severe CIPS	-452mV _{CSE} @ Ch. 162.1m
43.621362	-79.510663		171.0	Minor DCVG Severe CIPS	18.1%IR C-C -538mV _{CSE}
-	-		From 171.1 to 184.0	Severe CIPS	-480mV _{CSE} @ Ch. 179.2m
43.621319	-79.510533		184.1	Minor DCVG Severe CIPS	15.8%IR C-C -488mV _{CSE}
-	-		From 184.2 to 245.6	Severe CIPS	-452mV _{CSE} @ Ch. 228.7m
43.621453	-79.509810		245.7	Minor DCVG Severe CIPS	16.0%IR C-C -496mV _{CSE}
-	-		From 245.8 to 368.3	Severe CIPS	-474mV _{CSE} @ Ch. 366.9m
43.621744	-79.508340		368.4	Minor DCVG Severe CIPS	19.4%IR C-C -492mV _{CSE}
-	-		From 368.5 to 470.7	Severe CIPS	-444mV _{CSE} @ Ch. 439.6m
43.621967	-79.507137		470.8	Minor DCVG Severe CIPS	20.2%IR C-C -493mV _{CSE}
-	-		From 470.9 to 504.6	Severe CIPS	-459mV _{CSE} @ Ch. 479.2m
43.622047	-79.506746		504.7	Minor DCVG Severe CIPS	19.2%IR C-C -512mV _{CSE}
-	-		From 504.8 to 652.0	Severe CIPS	-466mV _{CSE} @ Ch. 507.3m
-43.622426	-79.505016		652.1	Minor DCVG Severe CIPS	20.0%IR C-C -589mV _{CSE}
-	-		From 652.2 to 661.9	Severe CIPS	-521mV _{CSE} @ Ch. 658.2m
-43.622452	-79.504891		662.0	Minor DCVG Severe CIPS	28.6%IR C-C** -533mV _{CSE}
-	-		From 662.1 to 938.2	Severe CIPS	-467mV _{CSE} @ Ch. 938.2m

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

Table 3 • Summary and Classification of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
-	-	Ontario Place	From 0.0 to 660.6	DSCI***	-
43.630384	-79.419261		660.7	DSCI*** BT DCVG	11.5%IR C-C
-	-		From 660.8 to 714.1	DSCI***	-
43.630466	-79.418671		714.2	DSCI*** BT DCVG	10.3%IR C-C
-	-		From 714.3 to 748.2	DSCI***	-
43.630559	-79.418221		748.3	DSCI*** BT DCVG	14.2%IR C-C
-	-		From 748.4 to 773.6	DSCI***	-
43.630599	-79.417928		773.7	DSCI*** BT DCVG	8.3%IR C-C
-	-		From 773.8 to 833.0	DSCI***	-
43.630716	-79.417211		833.1	DSCI*** BT DCVG	7.1%IR C-C
-	-		From 833.2 to 1122.3	DSCI***	-
43.631409	-79.413821		1122.4	DSCI*** BT DCVG	9.9%IR C-C
-	-		From 1122.5 to 1133.2	DSCI***	-
43.631447	-79.413697		1133.3	DSCI*** BT DCVG	9.7%IR C-C
-	-		From 1133.4 to 1242.5	DSCI***	A preliminary moderate CIPS indication at Ch. 1153.9m was not confirmed after performing the stray current compensation
43.631819	-79.412460		1242.6	DSCI*** BT DCVG	12.5%IR C-C
-	-		From 1242.7 to 1282.1	DSCI***	-

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

Table 3 • Summary and Classification of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
43.648085	-79.361066	Parliament	0.0	BT DCVG Severe CIPS Severe DCI or DSCI ^[7]	8.6%IR C-C -146mV _{CSE}
-	-		From 0.1 to 71.2	Severe CIPS Severe DCI or DSCI ^[7]	46mV _{CSE} @ Ch. 68.2m
43.648300	-79.360251		71.3	BT DCVG Severe CIPS Severe DCI or DSCI ^[7]	7.6%IR C-C -32mV _{CSE}
-	-		From 71.4 to 104.7	Severe CIPS Severe DCI or DSCI ^[7]	-64mV _{CSE} @ Ch. 72.7m
43.648440	-79.359886		104.8	BT DCVG Severe CIPS Severe DCI or DSCI ^[7]	2.6%IR C-C -190mV _{CSE}
-	-		From 104.9 to 276.6	Severe CIPS Severe DCI or DSCI ^[7]	291mV _{CSE} @ Ch. 197.5m
43.649108	-79.357978		276.7	BT DCVG Severe CIPS	3.5%IR C-C -293mV _{CSE}
-	-		From 276.8 to 299.9	Severe CIPS	-241mV _{CSE} @ Ch. 292.9m
43.649223	-79.357727		300.0	BT DCVG Severe CIPS	6.8%IR C-C -290mV _{CSE}
-	-		From 300.1 to 309.8	Severe CIPS	-279mV _{CSE} @ Ch. 308.0m
-	-	Lever	From 0 to 0.9	Severe CIPS Minor DCI	-84mV _{CSE} 27mV Shift
43.652337	-79.345794		1.0	Minor DCVG Severe CIPS Minor DCI	16.8%IR C-C -84mV _{CSE} 18mV shift
-	-		From 1.1 to 4.8	Severe CIPS Minor DCI	-41mV _{CSE} 26mV Shift

^[7] The CIPS potential is significantly more electropositive than the pipe-to-soil potentials of unprotected steel. Therefore, this section is probably subject to severe DCI or DSCI from an unknown source.

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

Table 3 • Summary and Classification of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
43.652352	-79.345750	Lever Cont'd	4.9	Minor DCVG Severe CIPS Minor DCI	21.1%IR C-C -33mV _{CSE} 16mV shift
-	-		From 5 to 9.2	Severe CIPS Moderate DCI	-11mV _{CSE} 37mV Shift
-	-		From 9.3 to 18.3	Severe CIPS Minor DCI	9mV _{CSE} 25mV Shift
-	-		From 18.4 to 28.1	Severe CIPS Moderate DCI	-79mV _{CSE} 56mV Shift
-	-		From 28.2 to 31.6	Severe CIPS	-170mV _{CSE}
-	-		From 31.7 to 33.1	Severe CIPS Minor DCI	-275mV _{CSE} 23mV Shift
-	-		From 33.2 to 40.0	Severe CIPS	-254mV _{CSE}
43.652502	-79.345357		40.1	Minor DCVG Severe CIPS	18.0%IR C-C -581mV _{CSE}
-	-		From 40.2 to 44.2	Severe CIPS	-586mV _{CSE}
-	-		From 44.3 to 45.5	Severe CIPS Moderate DCI	-621mV _{CSE} 33mV Shift
-	-		From 45.6 to 46.5	Severe CIPS Minor DCI	-563mV _{CSE} 15mV Shift
-	-		From 46.6 to 47.3	Severe CIPS Moderate DCI	-566mV _{CSE} 45mV Shift
-	-		From 47.4 to 52.5	Severe CIPS Severe DCI	-146mV _{CSE} 225mV Shift
-	-		From 52.6 to 57.1	Severe CIPS Moderate DCI	-1mV _{CSE} 55mV Shift
-	-		From 57.2 to 66.2	Severe CIPS Minor DCI	19mV _{CSE} 28mV Shift
-	-		From 66.3 to 79	Severe CIPS Moderate DCI	-49mV _{CSE} 52mV Shift
-	-		From 79.1 to 81.3	Severe CIPS Severe DCI	-189mV _{CSE} 151mV Shift
-	-		From 81.4 to 89	Severe CIPS Moderate DCI	-31mV _{CSE} 47mV Shift

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

Table 3 • Summary and Classification of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
-	-	Lever Cont'd	From 89.1 to 90.2	Severe CIPS	-33mV _{CSE}
-	-		From 90.3 to 99.6	Severe CIPS Minor DCI	-57mV _{CSE} 27mV Shift
-	-		From 99.7 to 101.7	Severe CIPS	-180mV _{CSE}
43.652770	-79.344712		101.8	BT DCVG Severe CIPS Minor DCI	8.1%IR C-C -250mV _{CSE} 27mV Shift
-	-		From 101.9 to 103.7	Severe CIPS Moderate DCI	-255mV _{CSE} 36mV Shift
-	-		From 103.8 to 106	Severe CIPS	-226mV _{CSE}
-	-		From 106.1 to 108	Severe CIPS Moderate DCI	-272mV _{CSE} 32mV Shift
-	-		From 108.1 to 111.4	Severe CIPS Minor DCI	-248mV _{CSE} 19mV Shift
-	-		From 111.5 to 113.1	Severe CIPS Moderate DCI	-223mV _{CSE} 36mV Shift
-	-		From 113.2 to 115	Severe CIPS Severe DCI	-249mV _{CSE} 63mV Shift
-	-		From 115.1 to 118	Severe CIPS Moderate DCI	-168mV _{CSE} 40mV Shift
-	-		From 118.1 to 121.8	Severe CIPS Minor DCI	-112mV _{CSE} 29mV Shift
-	-		From 121.9 to 123.5	Severe CIPS Severe DCI	-198mV _{CSE} 83mV Shift
-	-		From 123.6 to 127.1	Severe CIPS Moderate DCI	-97mV _{CSE} 56mV Shift
-	-		From 127.2 to 127.7	Severe CIPS Severe DCI	-163mV _{CSE} 62mV Shift
-	-		From 127.8 to 129.5	Severe CIPS Moderate DCI	-159mV _{CSE} 58mV Shift
-	-		From 129.6 to 130.3	Severe CIPS Minor DCI	-107mV _{CSE} 29mV Shift
-	-		From 130.4 to 132	Severe CIPS Moderate DCI	-169mV _{CSE} 43mV Shift
-	-		From 132.1 to 134.4	Severe CIPS Severe DCI	-191mV _{CSE} 78mV Shift

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

Table 3 • Summary and Classification of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
-	-	Lever Cont'd	From 134.5 to 138.8	Severe CIPS Moderate DCI	-153mV _{CSE} 53mV Shift
-	-		From 138.9 to 142.1	Severe CIPS	-91mV _{CSE}
-	-		From 142.2 to 148.6	Severe CIPS Moderate DCI	-189mV _{CSE} 51mV Shift
-	-		From 148.7 to 156	Severe CIPS Severe DCI	-192mV _{CSE} 77mV Shift
-	-		From 156.1 to 158.5	Severe CIPS Moderate DCI	-178mV _{CSE} 56mV Shift
-	-		From 158.6 to 160.7	Severe CIPS Minor DCI	-175mV _{CSE} 16mV Shift
-	-		From 160.8 to 162.1	Severe CIPS Moderate DCI	-168mV _{CSE} 55mV Shift
-	-		From 162.2 to 165.8	Severe CIPS Severe DCI	-245mV _{CSE} 144mV Shift
-	-		From 165.9 to 166.8	Severe CIPS Minor DCI	-198mV _{CSE} 29mV Shift
-	-		From 166.9 to 172.1	Severe CIPS Severe DCI	-228mV _{CSE} 233mV Shift
-	-		From 172.2 to 172.9	Severe CIPS	-239mV _{CSE}
-	-		From 173.0 to 181.8	Severe CIPS Severe DCI	-262mV _{CSE} 118mV Shift
43.653180	-79.344212		181.9	BT DCVG Severe CIPS Severe DCI	2.0%IR C-C -259mV _{CSE} 85mV Shift
-	-		From 182.0 to 183.2	Severe CIPS	-159mV _{CSE}
-	-		From 183.3 to 186.4	Severe CIPS Moderate DCI	-183mV _{CSE} 36mV Shift
-	-		From 186.5 to 189	Severe CIPS Severe DCI	-289mV _{CSE} 105mV Shift
-	-		From 189.1 to 194.4	Severe CIPS Moderate DCI	-274mV _{CSE} 58mV Shift

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

Table 3 • Summary and Classification of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
43.653251	-79.344293	Lever Cont'd	194.5	BT DCVG Severe CIPS Moderate DCI	7.4%IR C-C -420mV _{CSE} 41mV Shift
-	-		From 194.6 to 199.1	Severe CIPS Severe DCI	-397mV _{CSE} 91mV Shift
43.653276	-79.344323		199.2	BT DCVG Severe CIPS Moderate DCI	9.3%IR C-C -360mV _{CSE} 60mV Shift
-	-		From 199.3 to 201.3	Severe CIPS Moderate DCI	-300mV _{CSE} 53mV Shift
-	-		From 201.4 to 205.7	Severe CIPS Severe DCI	-247mV _{CSE} 94mV Shift
-	-		From 205.8 to 208	Severe CIPS Moderate DCI	-186mV _{CSE} 59mV Shift
-	-		From 208.1 to 214.7	Severe CIPS Severe DCI	-192mV _{CSE} 108mV Shift
-	-		From 214.8 to 219.9	Severe CIPS Moderate DCI	-175mV _{CSE} 53mV Shift
-	-		From 220.0 to 223.8	Severe CIPS Severe DCI	-226mV _{CSE} 84mV Shift
-	-		From 223.9 to 227.5	Severe CIPS Moderate DCI	-216mV _{CSE} 49mV Shift
-	-		From 227.6 to 229.3	Severe CIPS Severe DCI	-280mV _{CSE} 66mV Shift
-	-		From 229.4 to 233.3	Severe CIPS Moderate DCI	-285mV _{CSE} 55mV Shift
-	-		From 233.4 to 235.3	Severe CIPS Minor DCI	-348mV _{CSE} 20mV Shift
-	-		From 235.4 to 236.4	Severe CIPS	-376mV _{CSE}
-	-		From 236.5 to 239.3	Severe CIPS Severe DCI	-569mV _{CSE} 95mV Shift
-	-		From 239.4 to 240.3	Severe CIPS	-613mV _{CSE}
-	-		From 240.4 to 244.1	Minor CIPS Severe DCI	-810mV _{CSE} 66mV Shift

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

Table 3 • Summary and Classification of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
-	-	Lever Cont'd	From 244.2 to 249.9	Minor DCI	174mV Shift
-	-		From 250.0 to 251	Minor CIPS Severe DCI	-804mV _{CSE} 198mV Shift
-	-		From 251.1 to 252.6	Severe CIPS Moderate DCI	-625mV _{CSE} 56mV Shift
-	-		From 252.7 to 253.5	Minor CIPS Severe DCI	-820mV _{CSE} 258mV Shift
-	-		From 253.6 to 255.5	Minor DCI	241mV Shift
43.653745	-79.344675		255.6	BT DCVG Minor DCI	10.5%IR C-C 217mV Shift
-	-		From 255.7 to 256.8	Minor DCI	281mV Shift
-	-		From 256.9 to 258.5	Minor CIPS Severe DCI	-848mV _{CSE} 327mV Shift
-	-		From 258.6 to 262.2	Moderate CIPS Severe DCI	-770mV _{CSE} 343mV Shift
43.653793	-79.344717		262.3	BT DCVG Minor CIPS Severe DCI	9.9%IR C-C -824mV _{CSE} 341mV Shift
-	-		From 262.4 to 264.3	Moderate CIPS Severe DCI	-797mV _{CSE} 240mV Shift
-	-		From 264.4 to 276.8	Minor DCI	284mV Shift
43.653897	-79.344809		276.9	BT DCVG Minor DCI	4.6%IR C-C 279mV Shift
-	-		From 277.0 to 279.4	Minor DCI	399mV Shift
-	-		From 279.5 to 285.9	Severe CIPS Severe DCI	-379mV _{CSE} 356mV Shift
-	-		From 286.0 to 291.9	Severe CIPS Moderate DCI	-331mV _{CSE} 55mV Shift
-	-		From 292.0 to 294.8	Severe CIPS Severe DCI	-407mV _{CSE} 65mV Shift

3.0 INDIRECT INSPECTION MEASUREMENTS CONT'D

3.3 Identification, Alignment & Classification of Indications Cont'd

Table 3 • Summary and Classification of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
43.654035	-79.344921	Lever Cont'd	294.9	BT DCVG Severe CIPS Moderate DCI	4.6%IR C-C -453mV _{CSE} 46mV Shift
-	-		From 295.0 to 297.2	Severe CIPS Minor DCI	-436mV _{CSE} 25mV Shift
-	-		From 297.3 to 298.2	Severe CIPS Moderate DCI	-519mV _{CSE} 40mV Shift
-	-		From 298.3 to 303.2	Severe CIPS Severe DCI	-556mV _{CSE} 112mV Shift
43.654102	-79.344973		303.3	BT DCVG Severe CIPS Severe DCI	9.4%IR C-C -743mV _{CSE} 101mV Shift
-	-		From 303.4 to 305.6	Severe CIPS Severe DCI	-696mV _{CSE} 106mV Shift
-	-		From 305.7 to 306.6	Severe CIPS Minor DCI	-469mV _{CSE} 11mV Shift
-	-		From 306.7 to 311.7	Severe CIPS Moderate DCI	-423mV _{CSE} 48mV Shift
-	-		From 311.8 to 313	Severe CIPS Severe DCI	-411mV _{CSE} 69mV Shift
43.654181	-79.345034		313.1	BT DCVG Severe CIPS Severe DCI	9.2%IR C-C -440mV _{CSE} 82mV Shift
-	-		From 313.2 to 318.9	Severe CIPS Moderate DCI	-263mV _{CSE} 57mV Shift
-	-		From 319.0 to 320	Severe CIPS Severe DCI	-359mV _{CSE} 227mV Shift
-	-		From 320.1 to 320.4	Moderate CIPS Severe DCI	-781mV _{CSE} 359mV Shift
-	-		From 320.5 to 321.6	Minor CIPS Severe DCI	-838mV _{CSE} 271mV Shift
43.654249	-79.345087		321.7	Minor DCVG Minor DCI	18.6%IR C-C 46mV Shift

* Possible bad reading

** Or galvanic anode

*** The severity of the dynamic stray current interference cannot be estimated without using coupons

4.0 DATA ANALYSIS

4.1 Islington Section

Severe CIPS indications were recorded along the entire Islington section, with pipe-to-soil potentials ranging between -400 and -600mV_{CSE}. In conjunction with this, the DCVG survey showed between 8 and 10 minor DCVG indications.

This section of the line is impacted by minor DC stray current activity.

4.2 Ontario Place Section

The Ontario Place section of the pipeline is subject to dynamic stray current interference (DSCI). The average day “OFF” potential, including IR drop produced by TTC, is more electropositive than the average night OFF potential by approximately 300mV at Liberty Grand and approximately 100mV at Ontario Place. Based on the night OFF potentials, the pipe appears to be fully protected. We recommend installing coupons at selected locations in order to determine whether the pipe remains fully protected during the day and subsequently to estimate the severity of the DSCI.

4.3 Parliament Section

The pipe-to-soil potentials recorded along the entire Parliament section correspond to severe CIPS indications, with potentials reaching +285mV_{CSE} around Ch. 200.0m. The potentials recorded between Ch. 0.0m and Ch. 250.0m are significantly more electropositive than the pipe-to-soil potentials of unprotected steel^[8] – see Figure 3-9. Part of the unusually low potentials could be the result of high circuit resistance due to possibly contaminated soil, however electropositive readings (i.e. around Ch. 200.0m) clearly indicate that this section is subject to severe DCI or DSCI from an unknown source.

4.4 Lever Section

The line displays extremely electropositive OFF potentials in conjunction with severe DC interference from Hydro One rectifiers. Due to survey restrictions,^[9] the electropositive shifts were not measured by interrupting the Hydro rectifiers. Instead, two separate surveys were conducted on two different nights (i.e. when the Hydro rectifiers were ON and OFF). As a result, even the reduced TTC activity may have impacted the results.

The DC interference from Hydro One rectifiers probably started in Spring 2009 when Hydro revamped their CP system, increasing the effective protection current by almost 400%. Although the line has only been subject to severe DCI for a very short time, given the extremely aggressive nature of DCI, we recommend prioritizing these indications as “Immediate Action Required” at all locations where the pipe is not fully protected.

^[8] The potential of unprotected steel typically ranges from -300 to -600mV_{CSE}.

^[9] Transient currents related to Hydro One steady-state DC decouplers would introduce significant errors when the rectifiers were interrupted.

4.0 DATA ANALYSIS CONT'D

4.4 Lever Section Cont'd

Two digs were already performed along this section (i.e. at Ch. 33.2m and at Ch. 157.2m) in the Spring 2009 and no significant corrosion metal loss was found. However, the major Hydro revamping also occurred in 2009 and thus is unlikely to have had enough time to impact the dig findings.

Note that the low potentials may be attributed in part to high circuit resistance in contaminated soils, however the electropositive readings and the results of the double survey (Hydro rectifiers ON and OFF) indicate severe DC interference.

5.0 SELECTION OF DIG SITES

This section covers the following activities performed in accordance with Paragraph 5.1.6 of the NACE Standard SP0502-2010.

- a) Prioritization of indications.
- b) Selection of sites recommended for examination.

The selected locations are shown in Section 5.2 of this report.

5.1 Prioritization of Indications

The following criteria were developed in conformance with Paragraph 5.2 of the NACE Standard SP0502-2010 in order to prioritize the areas displaying indications:

- Areas displaying multiple severe indications in close proximity are defined as “Immediate Action Required”.
- Areas displaying severe and moderate indications or multiple moderate indications in close proximity are defined as “Scheduled Action Required”.
- Areas with at least one severe indication, which is classified as severe by more than one indirect inspection technique, are defined as “Immediate Action Required”.
- Areas with at least one moderate indication having a prior history of severe corrosion incidents are defined as “Immediate Action Required”.
- Areas with at least one moderate indication having a prior history of moderate corrosion incidents are defined as “Scheduled Action Required”.
- Areas with minor indications having a prior severe history of corrosion incidents are defined as “Scheduled Action Required”.
- Areas displaying isolated severe indications are defined as “Scheduled Action Required”.
- All remaining areas displaying indications are defined as “Suitable for Monitoring”.

5.0 SELECTION OF DIG SITES CONT'D

5.1 Prioritization of Indications Cont'd

In order to simplify the prioritization of areas displaying multiple indications, these criteria are summarized in a matrix form, as shown in Table 4. The rationale behind the prioritization table is explained in depth in Appendix B.

Table 4 • Summary of Prioritization Criteria

DC Voltage Gradient Indication	Close Interval Potential Survey Indication		Prioritization											
			Prior History of Corrosion (PHC)				DC Interference (DCI)				AC Induced Corrosion (ACC)			
			SV	MD	MN	NI	SV	MD	MN	NI	SV	MD	MN	NI
			1	2	3	4	5	6	7	8	9	10	11	12
DCVG-SV	CIPS-SV	1	I	I	I	I	I	I	I	I	N/A	N/A	N/A	I
	CIPS-MD	2	I	I	S	S	I	S	S	S	N/A	N/A	N/A	S
	CIPS-MN	3	I	I	S	S	I	S	S	S	N/A	N/A	N/A	S
	CIPS-NI	4	I	I	S	S	I	S	S	S	N/A	N/A	N/A	S
DCVG-MD	CIPS-SV	5	I	I	I	S	I	I	I	S	N/A	N/A	N/A	S
	CIPS-MD	6	I	I	S	S	I	S	S	S	N/A	N/A	N/A	S
	CIPS-MN	7	I	S	M	M	I	S	M	M	N/A	N/A	N/A	M
	CIPS-NI	8	I	S	M	M	I	S	M	M	N/A	N/A	N/A	M
DCVG-MN	CIPS-SV	9	I	I	S	S	I	S	S	S	I	S	S	S
	CIPS-MD	10	I	S	S	S	I	S	M	M	I	S	M	M
	CIPS-MN	11	S	M	M	M	I	S	M	M	I	S	M	M
	CIPS-NI	12	M	M	M	M/N*	I	S	M	M/N*	I	S	M	M/N*
DCVG-BT	CIPS-SV	13	I	I	S	S	I	S	S	S	I	S	S	S
	CIPS-MD	14	S	S	M	M	I	S	M	M	I	S	M	M
	CIPS-MN	15	M	M	N	N	I	S	M	N	I	S	M	N
	CIPS-NI	16	N	N	N	N	I	S	M	N	I	S	M	N
DCVG-NI	CIPS-SV	17	I**	N	N	N	I**	N	N	N	I**	N	N	N
	CIPS-MD	18	I**	N	N	N	I**	N	N	N	I**	N	N	N
	CIPS-MN	19	N	N	N	N	I**	N	N	N	I**	N	N	N
	CIPS-NI	20	N	N	N	N	I**	N	N	N	I**	N	N	N

* Consider downgrading isolated minor DCVG indications suspected to be magnesium anodes to "No action required".

** Consider excavating short sections of line under severe risk of external corrosion, even if DCVG indications were not found.

Legend:

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

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

5.0 SELECTION OF DIG SITES CONT'D

5.1 Prioritization of Indications Cont'd

In order to facilitate the selection of the dig sites,^[10] the coating defects were plotted in terms of %I-R and severity limits, as shown in Figure 5-1. The full size chart is attached in Appendix A.

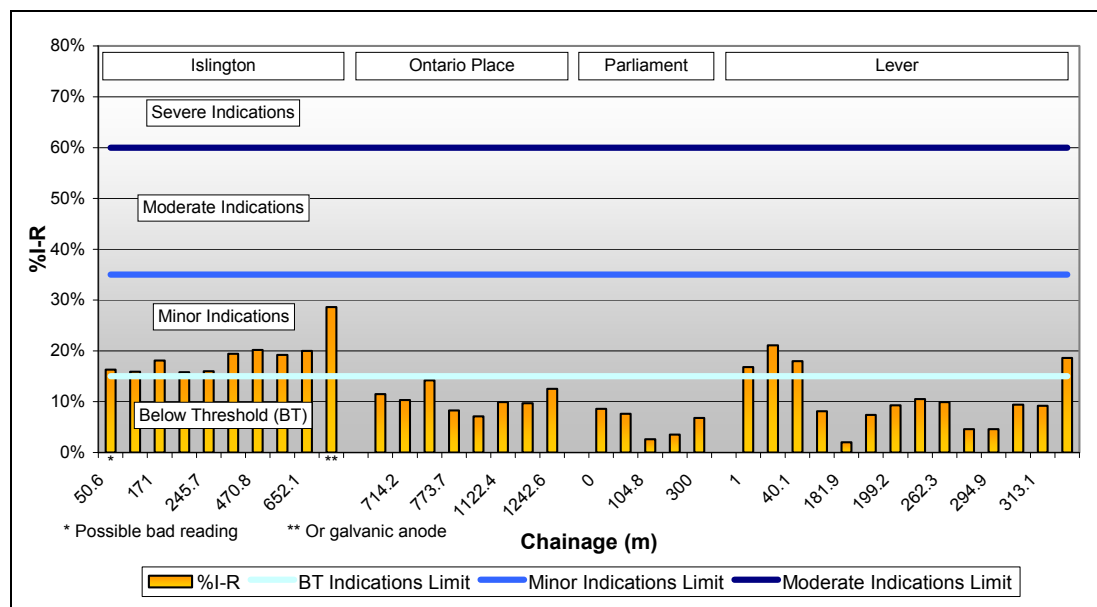


Figure 5-1 • Classification of DCVG Indications

The prioritization status for a specific area displaying multiple types of indications, with or without DCVG indications, is obtained by intersecting the relevant line and column in Table 4.

For example, from chainage 208.1m to 214.7m on the Lever section the line displays a severe CIPS indication in conjunction with a severe DCI indication. The intersection cell of the 17th line (DCVG-NI, CIPS-SV) with the 5th column (DCI-SV) indicates that a severe CIPS indication in conjunction with a severe DCI indication in a short section where no DCVG indications were found (DCVG-NI) should be considered for immediate excavation (i.e. prioritized as Immediate Action Required (I)). To assess the pipeline at this location, an excavation is proposed at the midpoint (Ch. 211.4m).

According to these criteria, the indications listed in Table 3 are prioritized as shown in Table 5, complete with GPS coordinates.

^[10] Since corrosion could only develop where the pipe is in contact with the soil (i.e. at a coating holiday), the location of the examination should coincide with a DCVG indication unless there is a risk of severe corrosion associated with DC interference.

5.0 SELECTION OF DIG SITES CONT'D

5.1 Prioritization of Indications Cont'd

Table 5 • Prioritization of Indications

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
43.621180	-79.512108	Islington	50.6	Minor DCVG (16.3%IR C-C*) Severe CIPS (-445mV _{CSE})	Scheduled Action Required
43.621408	-79.510775		161.0	Minor DCVG (15.9%IR C-C) Severe CIPS (-462mV _{CSE})	Scheduled Action Required
43.621362	-79.510663		171.0	Minor DCVG (18.1%IR C-C) Severe CIPS (-538mV _{CSE})	Scheduled Action Required
43.621319	-79.510533		184.1	Minor DCVG (15.8%IR C-C) Severe CIPS (-488mV _{CSE})	Scheduled Action Required
43.621453	-79.509810		245.7	Minor DCVG (16.0%IR C-C) Severe CIPS (-496mV _{CSE})	Scheduled Action Required
43.621744	-79.508340		368.4	Minor DCVG (19.4%IR C-C) Severe CIPS (-492mV _{CSE})	Scheduled Action Required
43.621967	-79.507137		470.8	Minor DCVG (20.2%IR C-C) Severe CIPS (-493mV _{CSE})	Scheduled Action Required
43.622047	-79.506746		504.7	Minor DCVG (19.2%IR C-C) Severe CIPS (-512mV _{CSE})	Scheduled Action Required
-43.622426	-79.505016		652.1	Minor DCVG (20.0%IR C-C) Severe CIPS (-589mV _{CSE})	Scheduled Action Required
-43.622452	-79.504891		662.0	Minor DCVG (28.6%IR C-C**) Severe CIPS (-533mV _{CSE})	Scheduled Action Required
43.630384	-79.419261	Ontario Place	660.7	DSCI*** BT DCVG (11.5%IR C-C)	TBD****
43.630466	-79.418671		714.2	DSCI*** BT DCVG (10.3%IR C-C)	TBD****
43.630559	-79.418221		748.3	DSCI*** BT DCVG (14.2%IR C-C)	TBD****
43.630599	-79.417928		773.7	DSCI*** BT DCVG (8.3%IR C-C)	TBD****
43.630716	-79.417211		833.1	DSCI*** BT DCVG (7.1%IR C-C)	TBD****
43.631409	-79.413821		1122.4	DSCI*** BT DCVG (9.9%IR C-C)	TBD****
43.631447	-79.413697		1133.3	DSCI*** BT DCVG (9.7%IR C-C)	TBD****
43.631819	-79.412460		1242.6	DSCI*** BT DCVG (12.5%IR C-C)	TBD****

5.0 SELECTION OF DIG SITES CONT'D

5.1 Prioritization of Indications Cont'd

Table 5 • Prioritization of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
43.648085	-79.361066	Parliament	0.0	BT DCVG (8.6%IR C-C) Severe CIPS (-146mV _{CSE}) Severe DCI or DSCI ^[7]	Immediate Action Required
43.648300	-79.360251		71.3	BT DCVG (7.6%IR C-C) Severe CIPS (-32mV _{CSE}) Severe DCI or DSCI ^[7]	Immediate Action Required
43.648440	-79.359886		104.8	BT DCVG (2.6%IR C-C) Severe CIPS (-190mV _{CSE}) Severe DCI or DSCI ^[7]	Immediate Action Required
43.648806	-79.358836		197.5 ^[11]	Severe CIPS (+291mV _{CSE}) Severe DCI or DSCI ^[7]	Immediate Action Required
43.648869	-79.358586		218.3 ^[11]	Severe CIPS (+249mV _{CSE}) Severe DCI or DSCI ^[7]	Immediate Action Required
43.648974	-79.358373		238.3 ^[11]	Severe CIPS (+113mV _{CSE}) Severe DCI or DSCI ^[7]	Immediate Action Required
43.649108	-79.357978		276.7	BT DCVG (3.5%IR C-C) Severe CIPS (-293mV _{CSE})	Scheduled Action Required
43.649223	-79.357727		300.0	BT DCVG (6.8%IR C-C) Severe CIPS (-290mV _{CSE})	Scheduled Action Required
43.652547	-79.345253	Lever	From 47.4 to 52.5 (50.0 ^[12])	Severe CIPS (-146mV _{CSE}) Severe DCI (225mV Shift)	Immediate Action Required
43.652817	-79.344578		From 113.2 to 115 (114.1 ^[12])	Severe CIPS (-249mV _{CSE}) Severe DCI (63mV Shift)	Immediate Action Required
43.652853	-79.344486		From 121.9 to 123.5 (122.7 ^[12])	Severe CIPS (-198mV _{CSE}) Severe DCI (83mV Shift)	Immediate Action Required
43.652874	-79.344434		From 127.2 to 127.7 (127.5 ^[12])	Severe CIPS (-163mV _{CSE}) Severe DCI (62mV Shift)	Immediate Action Required
43.652898	-79.344372		From 132.1 to 134.4 (133.3 ^[12])	Severe CIPS (-191mV _{CSE}) Severe DCI (78mV Shift)	Immediate Action Required
43.652979	-79.344167		From 148.7 to 156.0 (152.4 ^[12])	Severe CIPS (-192mV _{CSE}) Severe DCI (77mV Shift)	Immediate Action Required

^[11] The CIPS potentials reach a most severe value at this location, indicating the highest risk of corrosion resulting from the probable severe DCI or DSCI.

^[12] Center of proposed excavation.

5.0 SELECTION OF DIG SITES CONT'D

5.1 Prioritization of Indications Cont'd

Table 5 • Prioritization of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
43.653037	-79.344112	Lever Cont'd	From 162.2 to 165.8 (164.0 ^[12])	Severe CIPS (-245mV _{CSE}) Severe DCI (144mV Shift)	Immediate Action Required
43.653098	-79.344152		From 166.9 to 172.1 (171.0 ^[12])	Severe CIPS (-228mV _{CSE}) Severe DCI (233mV Shift)	Immediate Action Required
43.653180	-79.344212		181.9	BT DCVG (2.0%IR C-C) Severe CIPS (-259mV _{CSE}) Severe DCI (85mV Shift)	Immediate Action Required
43.653215	-79.344249		From 186.5 to 189 (187.8 ^[12])	Severe CIPS (-289mV _{CSE}) Severe DCI (105mV Shift)	Immediate Action Required
43.653264	-79.344308		From 194.6 to 199.1 (196.9 ^[12])	Severe CIPS (-397mV _{CSE}) Severe DCI (91mV Shift)	Immediate Action Required
43.653300	-79.344352		From 201.4 to 205.7 (203.6 ^[12])	Severe CIPS (-247mV _{CSE}) Severe DCI (94mV Shift)	Immediate Action Required
43.653341	-79.344403		From 208.1 to 214.7 (211.4 ^[12])	Severe CIPS (-192mV _{CSE}) Severe DCI (108mV Shift)	Immediate Action Required
43.653439	-79.344468		From 220.0 to 223.8 (221.9 ^[12])	Severe CIPS (-226mV _{CSE}) Severe DCI (84mV Shift)	Immediate Action Required
43.653505	-79.344508		From 227.6 to 229.3 (228.5 ^[12])	Severe CIPS (-280mV _{CSE}) Severe DCI (66mV Shift)	Immediate Action Required
43.653598	-79.344565		From 236.5 to 239.3 (237.9 ^[12])	Severe CIPS (-569mV _{CSE}) Severe DCI (95mV Shift)	Immediate Action Required
43.653641	-79.344592		From 240.4 to 244.1 (242.3 ^[12])	Minor CIPS (-810mV _{CSE}) Severe DCI (66mV Shift)	Immediate Action Required
43.653718	-79.344651		From 250.0 to 253.5 (251.8 ^[12])	Minor CIPS (-804mV _{CSE}) Severe DCI (258mV Shift)	Immediate Action Required
43.653793	-79.344717		262.3	BT DCVG (9.9%IR C-C) Minor CIPS (-824mV _{CSE}) Severe DCI (341mV Shift)	Immediate Action Required
43.653939	-79.344846		From 279.5 to 285.9 (282.7 ^[12])	Severe CIPS (-379mV _{CSE}) Severe DCI (356mV Shift)	Immediate Action Required
43.654023	-79.344912		From 292.0 to 294.8 (293.4 ^[12])	Severe CIPS (-407mV _{CSE}) Severe DCI (65mV Shift)	Immediate Action Required

5.0 SELECTION OF DIG SITES CONT'D

5.1 Prioritization of Indications Cont'd

Table 5 • Prioritization of Indications Cont'd

GPS Coordinates		Section	Chainage (m)	Classification	Notes
Latitude	Longitude				
43.654102	-79.344973	Lever Cont'd	303.3	BT DCVG (9.4%IR C-C) Severe CIPS (-743mV _{CSE}) Severe DCI (101mV Shift)	Immediate Action Required
43.654181	-79.345034		313.1	BT DCVG (9.2%IR C-C) Severe CIPS (-440mV _{CSE}) Severe DCI (82mV Shift)	Immediate Action Required
43.654238	-79.345078		From 319.0 to 321.6 (320.3 ^[12])	Severe CIPS (-359mV _{CSE}) Severe DCI (359mV Shift)	Immediate Action Required
43.652337	-79.345794		1.0	Minor DCVG (16.8%IR C-C) Severe CIPS (-84mV _{CSE}) Minor DCI (18mV shift)	Scheduled Action Required
43.652352	-79.345750		4.9	Minor DCVG (21.1%IR C-C) Severe CIPS (-33mV _{CSE}) Minor DCI (16mV shift)	Scheduled Action Required
43.652502	-79.345357		40.1	Minor DCVG (18.0%IR C-C) Severe CIPS (-581mV _{CSE})	Scheduled Action Required
43.652770	-79.344712		101.8	BT DCVG (8.1%IR C-C) Severe CIPS (-250mV _{CSE}) Minor DCI (27mV Shift)	Scheduled Action Required
43.653251	-79.344293		194.5	BT DCVG (7.4%IR C-C) Severe CIPS (-420mV _{CSE}) Moderate DCI (41mV Shift)	Scheduled Action Required
43.653276	-79.344323		199.2	BT DCVG (9.3%IR C-C) Severe CIPS (-360mV _{CSE}) Moderate DCI (60mV Shift)	Scheduled Action Required
43.654035	-79.344921		294.9	BT DCVG (4.6%IR C-C) Severe CIPS (-453mV _{CSE}) Moderate DCI (46mV Shift)	Scheduled Action Required
43.653745	-79.344675		255.6	BT DCVG (10.5%IR C-C) Minor DCI (217mV Shift)	Suitable for Monitoring
43.653897	-79.344809		276.9	BT DCVG (4.6%IR C-C) Minor DCI (279mV Shift)	Suitable for Monitoring
43.654249	-79.345087		321.7	Minor DCVG (18.6%IR C-C) Minor DCI (46mV Shift)	Suitable for Monitoring

* Possible bad reading

** Or galvanic anode

*** The severity of the dynamic stray current interference cannot be estimated without using coupons.

**** Suitable for monitoring if the DSCI indications are minor, but scheduled or immediate action required, if the DSCI indications are moderate or severe, respectively.

5.0 SELECTION OF DIG SITES CONT'D

5.2 Recommended Dig Sites

The minimum number of digs required by the ECDA protocol will be indicated for each section for future reference. The actual recommended number of digs may change depending on the site conditions, however, should all required digs be performed the level of confidence in the assessment will increase accordingly.

Note that the twenty-four indications on the Lever section and six indications on the Parliament section prioritized as “Immediate Action Required” pose an immediate threat to the pipeline under normal operating conditions.

5.2.1 Islington Section

With ten indications prioritized as “Scheduled Action Required” along the Islington section, a minimum of four digs are required on this section according to ECDA protocol:

- Two examinations at the most severe “Scheduled Action Required” indications, as per Paragraph 5.3.3.2.1 of the NACE Standard SP0502-2010.
- Two validation examinations at randomly selected locations, one at a scheduled indication and the second in an area where no indication was detected, as per Paragraph 6.7.2.1 of the NACE Standard SP0502-2010.

We recommend that the first two digs be conducted, the findings analyzed and a decision made as to whether the assessment be upgraded to an ECDA-degree of confidence by performing all the required digs.

Selected Dig Locations

- Dig #1: Islington section, chainage 161.0 m. Scheduled Action Required. GPS Coordinates: 43.621408, -79.510775. Estimated depth: 1.2 m. Severe CIPS (-462mV_{CSE}) and minor DCVG (15.9%IR C-C).
- Dig #2: Islington section, chainage 470.8 m. Scheduled Action Required. GPS Coordinates: 43.621967, -79.507137. Estimated depth: 1.7 m. Severe CIPS (-493mV_{CSE}) and minor DCVG (20.2%IR C-C).
- Dig #3 (Validation with indication): Islington section, chainage 368.4 m. Scheduled Action Required. GPS Coordinates: 43.621744, -79.508340. Estimated depth: 1.4 m. Severe CIPS (-492mV_{CSE}) and minor DCVG (19.4%IR C-C).
- Dig #4 (Validation without indication): To be randomly selected. No holidays or signs of corrosion are expected at this location.

5.0 SELECTION OF DIG SITES CONT'D

5.2 Recommended Dig Sites Cont'd

5.2.2 Ontario Place Section

With no prioritization possible along this section (i.e. all eight indications are prioritized as “TBD”), we recommend conducting two digs at the locations indicated below. Should the results of the digs indicate no metal loss due to corrosion and small holidays (i.e. as predicted by the CIPS/DCVG survey), an additional validation dig at a location with no indication would be required to bring the assessment to an ECDA-degree of confidence. The final assessment should be validated by installing coupons at the excavation sites in order to estimate the severity of the DSCI indications.

Selected Dig Locations

- Dig #1: Ontario Place section, chainage 660.7 m. TBD. GPS Coordinates: 43.630384, -79.419261. Estimated depth: 1.3 m. DSCI and below-threshold DCVG (11.5%IR C-C).
- Dig #2: Ontario Place section, chainage 1133.3 m. TBD. GPS Coordinates: 43.631447, -79.413697. Estimated depth: 1.7 m. DSCI and below-threshold DCVG (9.9%IR C-C).
- Dig #3 (Validation without indication): To be randomly selected. No holidays or signs of corrosion are expected at this location.

5.2.3 Parliament Section

With six indications prioritized as “Immediate Action Required” and two indications prioritized as “Scheduled Action Required” along the Parliament section, a minimum of eight digs plus a validation dig at a location with no indication are required on this section according to ECDA protocol:

- Six examinations at the “Immediate Action Required” indications, as per Paragraph 5.3.2.1 of the NACE Standard SP0502-2010.
- Two examinations at the most severe “Scheduled Action Required” indications, as per Paragraph 5.3.3.2.1 of the NACE Standard SP0502-2010.
- One validation examination at a randomly selected location in an area where no indication was detected, as per Paragraph 6.7.2.1 of the NACE Standard SP0502-2010.

We recommend immediately conducting the two digs at Ch. 71.3m and Ch. 197.5m to assess the pipeline condition. Based on these results a decision can be made about the remaining indications along the Parliament section. Note that this approach is not in accordance with the NACE SP0502-2010 protocol, which does not allow making the prioritization criteria less severe during the first application of the protocol.

5.0 SELECTION OF DIG SITES CONT'D

5.2 Recommended Dig Sites Cont'd

5.2.3 Parliament Section Cont'd

Selected Dig Locations

- Dig #1: Parliament section, chainage 71.3 m. Immediate Action Required. GPS Coordinates: 43.648300, -79.360251. Estimated depth: 1.8 m. Severe CIPS (-32mV_{CSE}), severe DCI and below-threshold DCVG (7.6%IR C-C).
- Dig #2: Parliament section, chainage 197.5 m. Immediate Action Required. GPS Coordinates: 43.648806, -79.358836. Estimated depth: 1.6 m. Severe CIPS (+291mV_{CSE}) and severe DCI.
- Dig #3: Parliament section, chainage 0.0 m. Immediate Action Required. GPS Coordinates: 43.648085, -79.361066. Estimated depth: 1.9 m. Severe CIPS (-146mV_{CSE}), severe DCI and below-threshold DCVG (8.6%IR C-C).
- Dig #4: Parliament section, chainage 104.8 m. Immediate Action Required. GPS Coordinates: 43.648440, -79.359886. Estimated depth: 1.3 m. Severe CIPS (-32mV_{CSE}), severe DCI and below-threshold DCVG (7.6%IR C-C).
- Dig #5: Parliament section, chainage 218.3 m. Immediate Action Required. GPS Coordinates: 43.648869, -79.358586. Estimated depth: 1.8 m. Severe CIPS (+249mV_{CSE}) and severe DCI.
- Dig #6: Parliament section, chainage 238.3 m. Immediate Action Required. GPS Coordinates: 43.648974, -79.358373. Estimated depth: 1.8 m. Severe CIPS (+113mV_{CSE}) and severe DCI.
- Dig #7: Parliament section, chainage 276.7 m. Scheduled Action Required. GPS Coordinates: 43.649108, -79.357978. Estimated depth: 1.7 m. Severe CIPS (-293mV_{CSE}) and below-threshold DCVG (3.5%IR C-C).
- Dig #8: Parliament section, chainage 300.0 m. Scheduled Action Required. GPS Coordinates: 43.649223, -79.357727. Estimated depth: 1.9 m. Severe CIPS (-290mV_{CSE}) and below-threshold DCVG (6.8%IR C-C).
- Dig #9 (Validation without indication): To be randomly selected. No holidays or signs of corrosion are expected at this location.

5.0 SELECTION OF DIG SITES CONT'D

5.2 Recommended Dig Sites Cont'd

5.2.4 Lever Section

With twenty-four indications prioritized as “Immediate Action Required”, seven indications prioritized as “Scheduled Action Required”, and three indications prioritized as “Suitable for Monitoring” along the Lever section, a minimum of twenty-eight digs are required on this section according to ECDA protocol:

- Twenty-four examinations at the “Immediate Action Required” indications, as per Paragraph 5.3.2.1 of the NACE Standard SP0502-2010.
- Two examinations at the most severe “Scheduled Action Required” indications, as per Paragraph 5.3.3.2.1 of the NACE Standard SP0502-2010.
- Two validation examinations at randomly selected locations, one at a scheduled indication and the second in an area where no indication was detected, as per Paragraph 6.7.2.1 of the NACE Standard SP0502-2010.

We recommend immediately conducting the two digs at Ch. 181.9m and Ch. 313.1m to assess the pipeline condition. Based on these results a decision can be made about reprioritizing the remaining indications along the Lever section. Note that this approach is not in accordance with the NACE SP0502-2010 protocol, which does not allow making the prioritization criteria less severe during the first application of the protocol.

Selected Dig Locations

- Dig #1: Lever section, chainage 181.9 m. Immediate Action Required. GPS Coordinates: 43.653180, -79.344212. Estimated depth: 1.1 m. Severe CIPS (-259mV_{CSE}), severe DCI (85mV shift) and below-threshold DCVG (i.e. 2.0%IR C-C).
- Dig #2: Lever section, chainage 313.1 m. Immediate Action Required. GPS Coordinates: 43.654181, -79.345034. Estimated depth: 0.7 m. Severe CIPS (-440mV_{CSE}), severe DCI (82mV shift) and below-threshold DCVG (i.e. 9.2%IR C-C).
- Dig #3: Lever section, chainage 47.4 m to 52.5 m. Immediate Action Required. GPS Coordinates: 43.652547, -79.345253 (centre of excavation). Estimated depth: 1.7 m. Severe CIPS (-146mV_{CSE}) and severe DCI (225mV shift).
- Dig #4: Lever section, chainage 113.2 m to 115.0 m. Immediate Action Required. GPS Coordinates: 43.652817, -79.344578 (centre of excavation). Estimated depth: 1.5 m. Severe CIPS (-249mV_{CSE}) and severe DCI (63mV shift).
- Dig #5: Lever section, chainage 121.9 m to 123.5 m. Immediate Action Required. GPS Coordinates: 43.652853, -79.344486 (centre of excavation). Estimated depth: 1.5 m. Severe CIPS (-198mV_{CSE}) and severe DCI (83mV shift).

5.0 SELECTION OF DIG SITES CONT'D

5.2 Recommended Dig Sites Cont'd

5.2.4 Lever Section Cont'd

Selected Dig Locations Cont'd

- Dig #6: Lever section, chainage 127.2 m to 127.7 m. Immediate Action Required. GPS Coordinates: 43.652874, -79.344434 (centre of excavation). Estimated depth: 1.5 m. Severe CIPS (-163mV_{CSE}) and severe DCI (62mV shift).
- Dig #7: Lever section, chainage 132.1 m to 134.4 m. Immediate Action Required. GPS Coordinates: 43.652898, -79.344372 (centre of excavation). Estimated depth: 1.4 m. Severe CIPS (-191mV_{CSE}) and severe DCI (78mV shift).
- Dig #8: Lever section, chainage 148.7 m to 156.0 m. Immediate Action Required. GPS Coordinates: 43.652979, -79.344167 (centre of excavation). Estimated depth: 1.3 m. Severe CIPS (-192mV_{CSE}) and severe DCI (77mV shift).
- Dig #9: Lever section, chainage 162.2 m to 165.8 m. Immediate Action Required. GPS Coordinates: 43.653037, -79.344112 (centre of excavation). Estimated depth: 1.2 m. Severe CIPS (-245mV_{CSE}) and severe DCI (144mV shift).
- Dig #10: Lever section, chainage 166.9 m to 172.1 m. Immediate Action Required. GPS Coordinates: 43.653098, -79.344152 (centre of excavation). Estimated depth: 1.1 m. Severe CIPS (-228mV_{CSE}) and severe DCI (233mV shift).
- Dig #11: Lever section, chainage 186.5 m to 189.0 m. Immediate Action Required. GPS Coordinates: 43.653215, -79.344249. (centre of excavation) Estimated depth: 1.0 m. Severe CIPS (-289mV_{CSE}) and severe DCI (105mV shift).
- Dig #12: Lever section, chainage 194.6 m to 199.1 m. Immediate Action Required. GPS Coordinates: 43.653264, -79.344308 (centre of excavation). Estimated depth: 0.9 m. Severe CIPS (-397mV_{CSE}) and severe DCI (91mV shift).
- Dig #13: Lever section, chainage 201.4 m to 205.7 m. Immediate Action Required. GPS Coordinates: 43.653300, -79.344352 (centre of excavation). Estimated depth: 0.8 m. Severe CIPS (-247mV_{CSE}) and severe DCI (94mV shift).
- Dig #14: Lever section, chainage 208.1 m to 214.7 m. Immediate Action Required. GPS Coordinates: 43.653341, -79.34440 (centre of excavation). Estimated depth: 0.8 m. Severe CIPS (-192mV_{CSE}) and severe DCI (108mV shift).
- Dig #15: Lever section, chainage 220.0 m to 223.8 m. Immediate Action Required. GPS Coordinates: 43.653439, -79.344468 (centre of excavation). Estimated depth: 0.8 m. Severe CIPS (-226mV_{CSE}) and severe DCI (84mV shift).
- Dig #16: Lever section, chainage 227.6 m to 229.3 m. Immediate Action Required. GPS Coordinates: 43.653505, -79.344508 (centre of excavation). Estimated depth: 0.8 m. Severe CIPS (-280mV_{CSE}) and severe DCI (66mV shift).

5.0 SELECTION OF DIG SITES CONT'D

5.2 Recommended Dig Sites Cont'd

5.2.4 Lever Section Cont'd

Selected Dig Locations Cont'd

- Dig #17: Lever section, chainage 236.5 m to 239.3 m. Immediate Action Required. GPS Coordinates: 43.653598, -79.344565 (centre of excavation). Estimated depth: 0.9 m. Severe CIPS ($-569\text{mV}_{\text{CSE}}$) and severe DCI (95mV shift).
- Dig #18: Lever section, chainage 240.4 m to 244.1 m. Immediate Action Required. GPS Coordinates: 43.653641, -79.344592 (centre of excavation). Estimated depth: 0.9 m. Minor CIPS ($-810\text{mV}_{\text{CSE}}$) and severe DCI (66mV shift).
- Dig #19: Lever section, chainage 250.0 m to 253.5 m. Immediate Action Required. GPS Coordinates: 43.653718, -79.344651 (centre of excavation). Estimated depth: 0.9 m. Minor CIPS ($-804\text{mV}_{\text{CSE}}$) and severe DCI (258mV shift).
- Dig #20: Lever section, chainage 262.3 m. Immediate Action Required. GPS Coordinates: 43.653793, -79.344717. Estimated depth: 0.9 m. Minor CIPS ($-824\text{mV}_{\text{CSE}}$), severe DCI (341mV shift) and below-threshold DCVG (i.e. 9.9%IR C-C).
- Dig #21: Lever section, chainage 279.5 m to 285.9 m. Immediate Action Required. GPS Coordinates: 43.653939, -79.344846 (centre of excavation). Estimated depth: 1.0 m. Severe CIPS ($-379\text{mV}_{\text{CSE}}$) and severe DCI (356mV shift).
- Dig #22: Lever section, chainage 292.0 m to 294.8 m. Immediate Action Required. GPS Coordinates: 43.654023, -79.344912 (centre of excavation). Estimated depth: 1.0 m. Severe CIPS ($-407\text{mV}_{\text{CSE}}$) and severe DCI (101mV shift).
- Dig #23: Lever section, chainage 303.3 m. Immediate Action Required. GPS Coordinates: 43.654102, -79.344973. Estimated depth: 0.8 m. Severe CIPS ($-743\text{mV}_{\text{CSE}}$), severe DCI (101mV shift) and below-threshold DCVG (i.e. 9.4%IR C-C).
- Dig #24: Lever section, chainage 319.0 m to 321.6 m. Immediate Action Required. GPS Coordinates: 43.654238, -79.345078 (centre of excavation). Estimated depth: 0.7 m. Severe CIPS ($-359\text{mV}_{\text{CSE}}$) and severe DCI (359mV shift).
- Dig #25: Lever section, chainage 4.9 m. Scheduled Action Required. GPS Coordinates: 43.652352, -79.345750. Estimated depth: 1.7 m. Severe CIPS ($-33\text{mV}_{\text{CSE}}$), minor DCI (16mV shift) and minor DCVG (21.1%IR C-C).
- Dig #26: Lever section, chainage 40.1 m. Scheduled Action Required. GPS Coordinates: 43.652502, -79.345357. Estimated depth: 1.5 m. Severe CIPS ($-581\text{mV}_{\text{CSE}}$) and minor DCVG (18.0%IR C-C).

5.0 SELECTION OF DIG SITES CONT'D

5.2 Recommended Dig Sites Cont'd

5.2.4 Lever Section Cont'd

Selected Dig Locations Cont'd

- Dig #27 (Validation with indication): Lever section, chainage 199.2 m. Scheduled Action Required. GPS Coordinates: 43.653276, -79.344323. Estimated depth: 0.8 m. Severe CIPS ($-360\text{mV}_{\text{CSE}}$), moderate DCI (41mV shift) and below-threshold DCVG (9.3%IR C-C).
- Dig #28 (Validation without indication): To be randomly selected. No holidays or signs of corrosion are expected at this location.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Although the surveys and the subsequent data analysis were performed following the ECDA protocol, the actual ECDA process cannot be considered as an applicable risk assessment technique, due to soil contamination, presence of dynamic stray currents and significant changes in an adjacent cathodic protection system (i.e. Hydro One).

We recommend using an alternative assessment technique (i.e. bell hole examination) to assess the integrity of the line, albeit with a lower degree of confidence than in an ECDA process. The selection of the bell hole locations was done based on the results of the CIPS and DCVG surveys using the procedures defined in the ECDA process.

We also recommend installing coupons at selected locations along the line in order to validate the results of the close interval survey and to facilitate future surveys by Enbridge Gas personnel.

Along the Islington section the line displays very low protection levels, under minor DC transit stray current activity. Ten locations were prioritized as “Scheduled Action Required”, requiring four digs according to the ECDA protocol. The proposed locations are shown in Paragraph 5.2.1 of the report. We recommend conducting the first two digs and then, based on the findings, deciding whether to upgrade the integrity assessment to an ECDA degree of confidence by performing all the required digs.

Along the Ontario Place section the line is subject to dynamic stray current interference (DSCI). We recommend installing coupons at selected locations in order to estimate the severity of the DSCI. We also recommend conducting two digs at the locations indicated in Paragraph 5.2.2 of the report. Should the results of the digs indicate no metal loss due to corrosion and small holidays (i.e. as predicted by the CIPS/DCVG survey), we recommend conducting a validation dig at a location with no indication^[13] to bring the assessment to an ECDA degree of confidence.

^[13] Several companies in the industry conduct this validation examination by extending the excavation at an existing dig site.

6.0 CONCLUSIONS AND RECOMMENDATIONS CONT'D

The line displays extremely electropositive values along the first 250m of the Parliament section. Part of these potentials could be the result of high circuit resistance in contaminated soil, but electropositive values clearly point to DC interference from an unknown source. Subsequently, the line displays six locations prioritized as “Immediate Action Required” and two locations prioritized as “Scheduled Action Required”. The total number of digs required by the ECDA protocol would be eight, plus a validation dig at a location with no indication, as indicated in Paragraph 5.2.3 of the report. Should all the excavations be performed, it is expected that the dig results may provide an ECDA level of confidence in the assessment of pipe integrity along this section.

We recommend immediately conducting two digs (i.e. at Ch. 71.3m and Ch. 197.5m) to assess the pipeline condition. Based on these results, a decision can be made about the remaining indications. We also recommend measuring the pipe-to-soil potential at the dig sites on grade, at half depth and at pipe level in order to assess the reliability of the CIPS in potentially contaminated soils.

Along the Lever section, the line displays extremely low (i.e. electropositive) potentials in conjunction with severe DC interference from Hydro One rectifiers. The DC interference may have only recently affected the line, following a major upgrade of the Hydro CP system in 2009. Although previous digs have not indicated any major metal loss due to corrosion, we used the most conservative ECDA criteria to temporarily prioritize the indications, resulting in 24 “Immediate Action Required” locations and 28 digs according to the ECDA protocol.

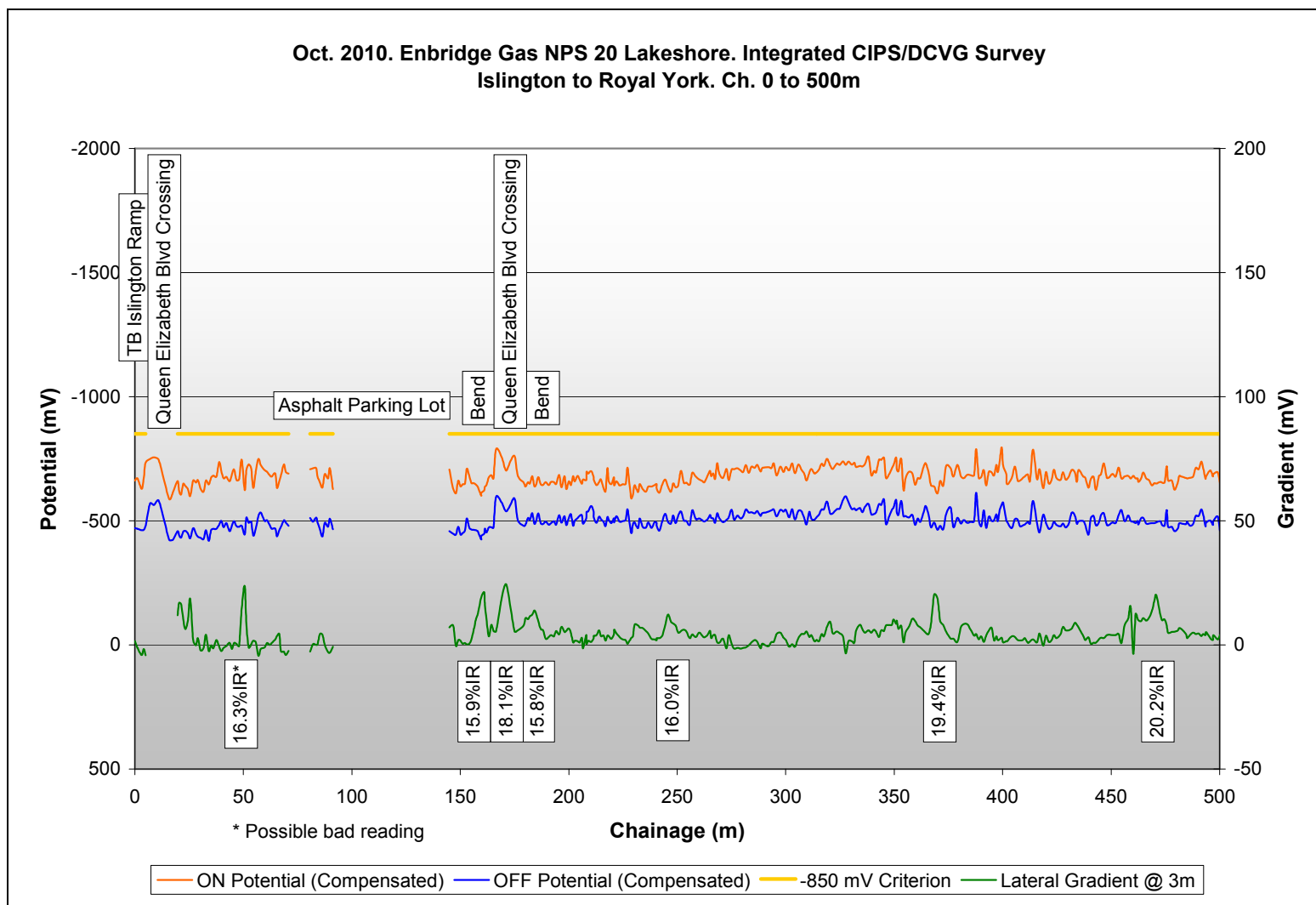
We recommend immediately conducting two digs at Ch. 181.9m and Ch. 313.1m to assess the pipeline condition. Based on these results, a decision can be made about reprioritizing the remaining indications along the Lever section. We also recommend measuring the pipe-to-soil potential at the dig sites on grade, at half depth and at pipe level, as proposed for the Parliament section.

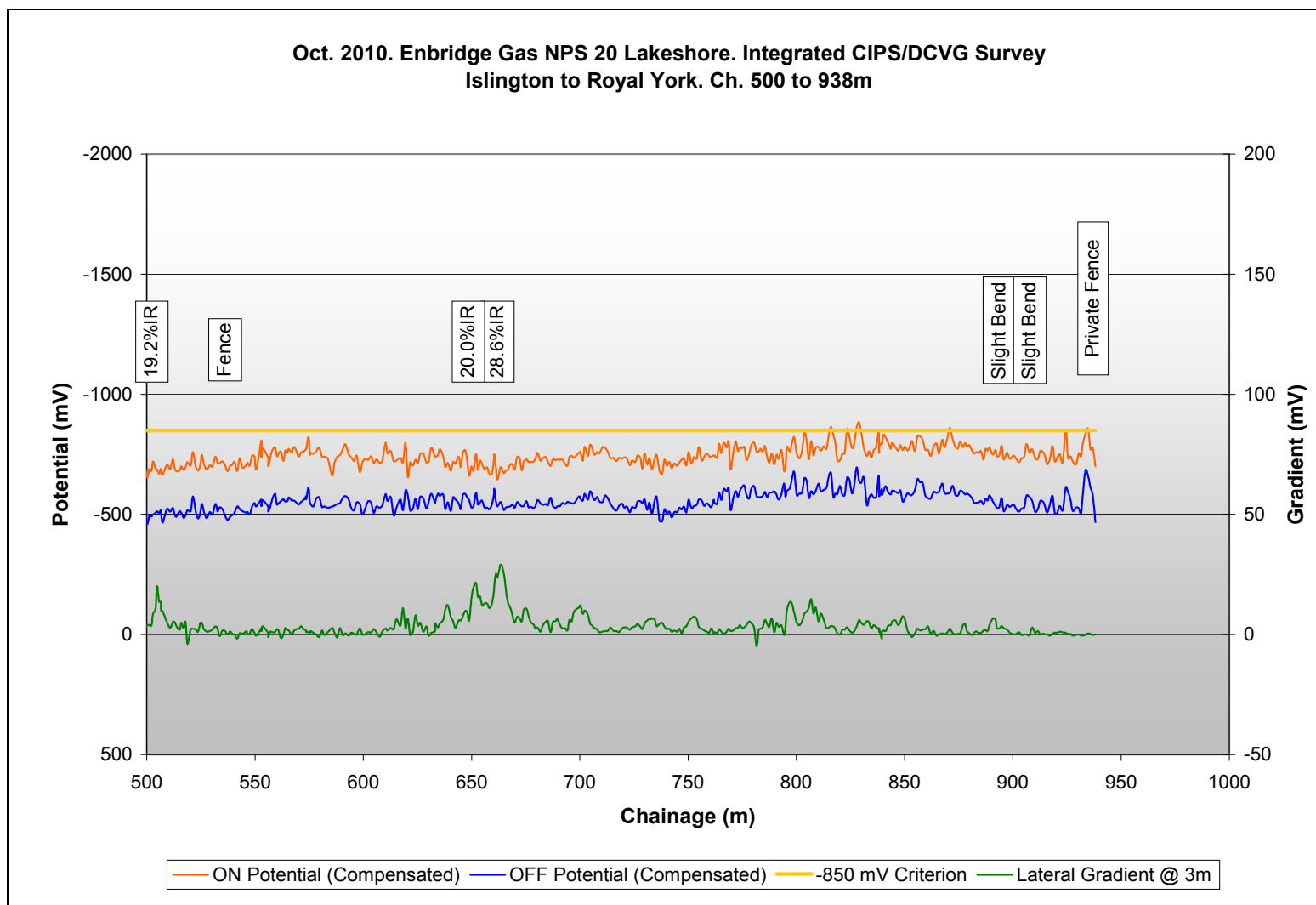
Notwithstanding the results of the digs, mitigation measures shall be coordinated with Hydro One corrosion personnel as soon as possible to nullify the DC interference along this section.

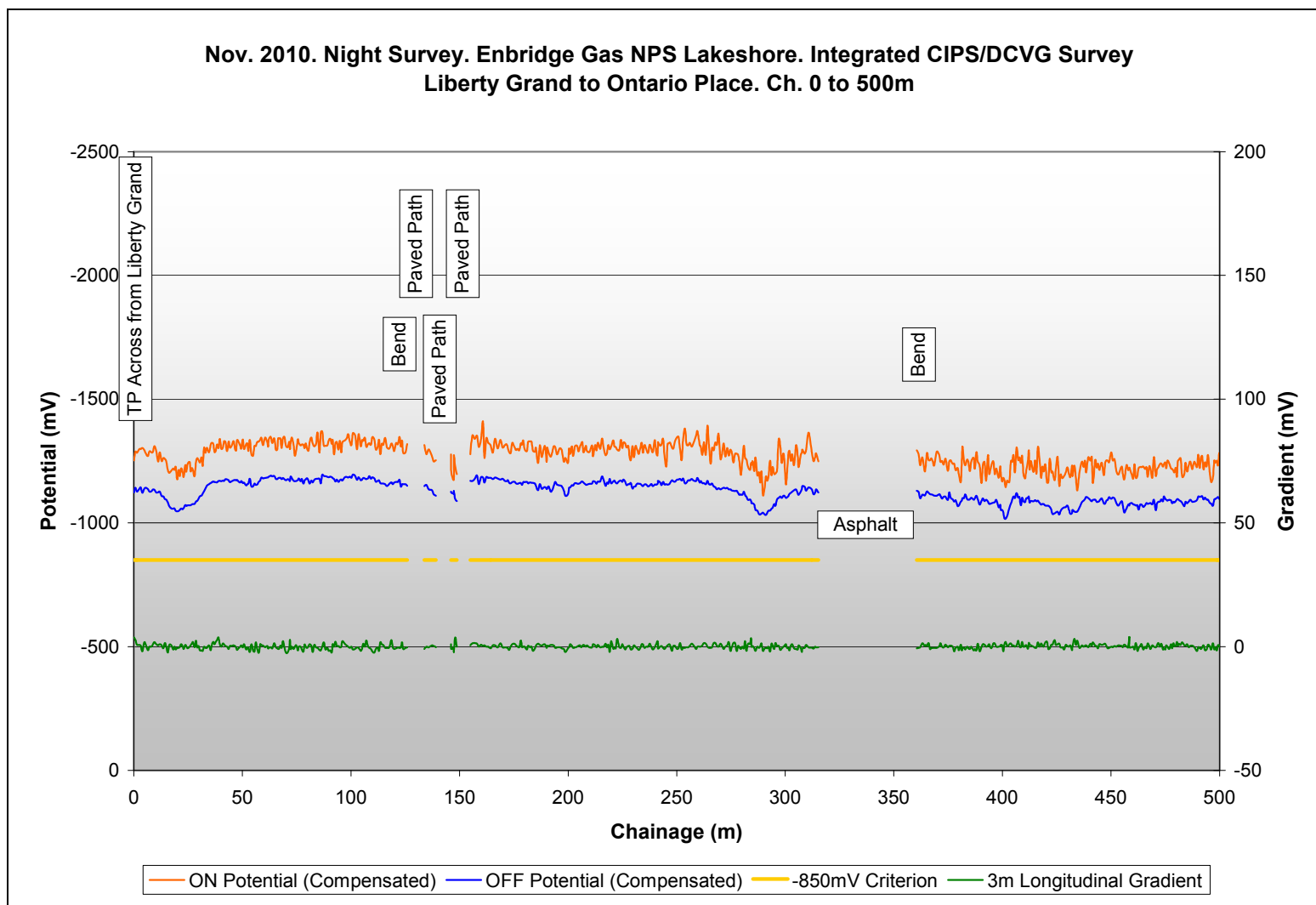


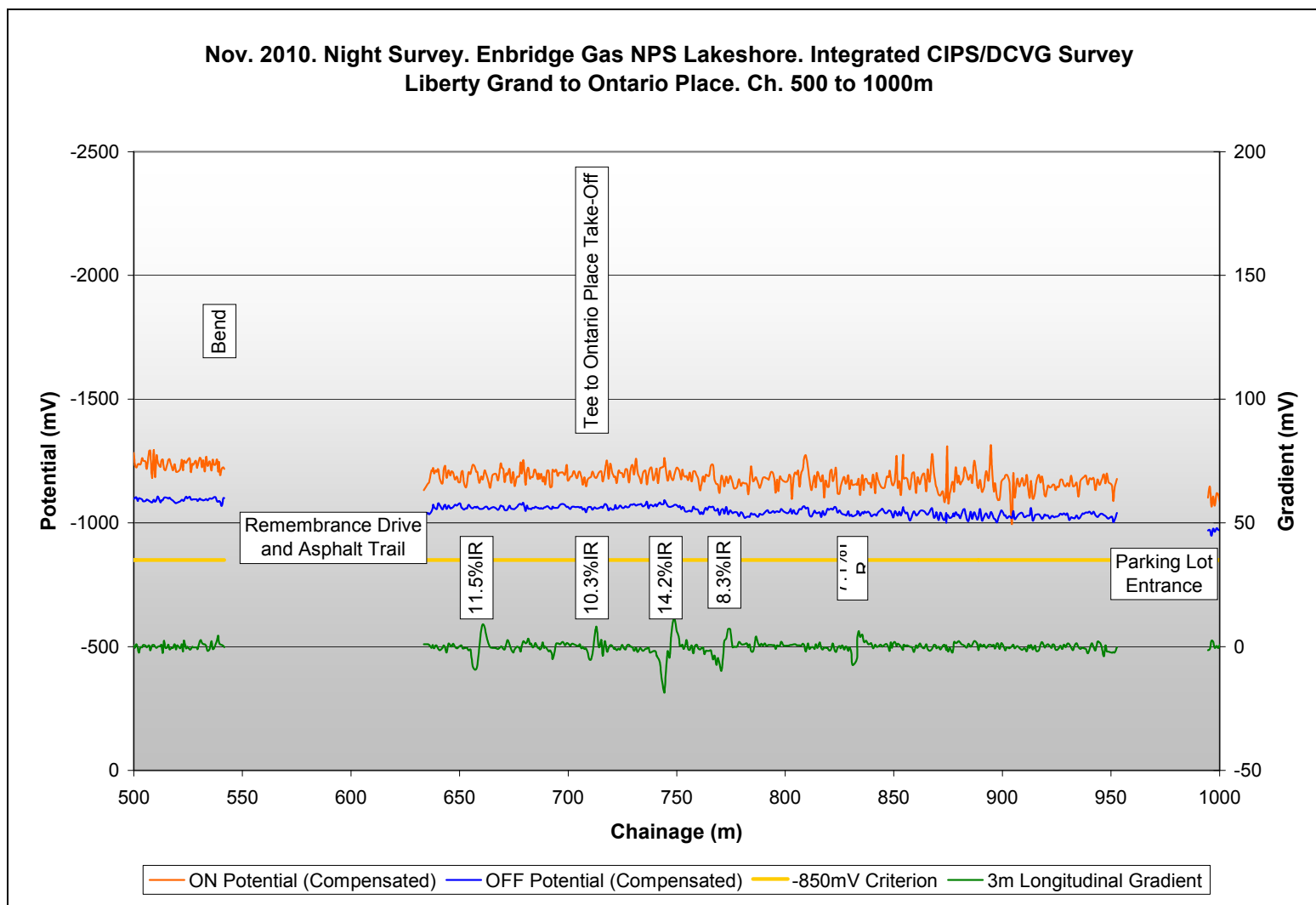
APPENDIX A

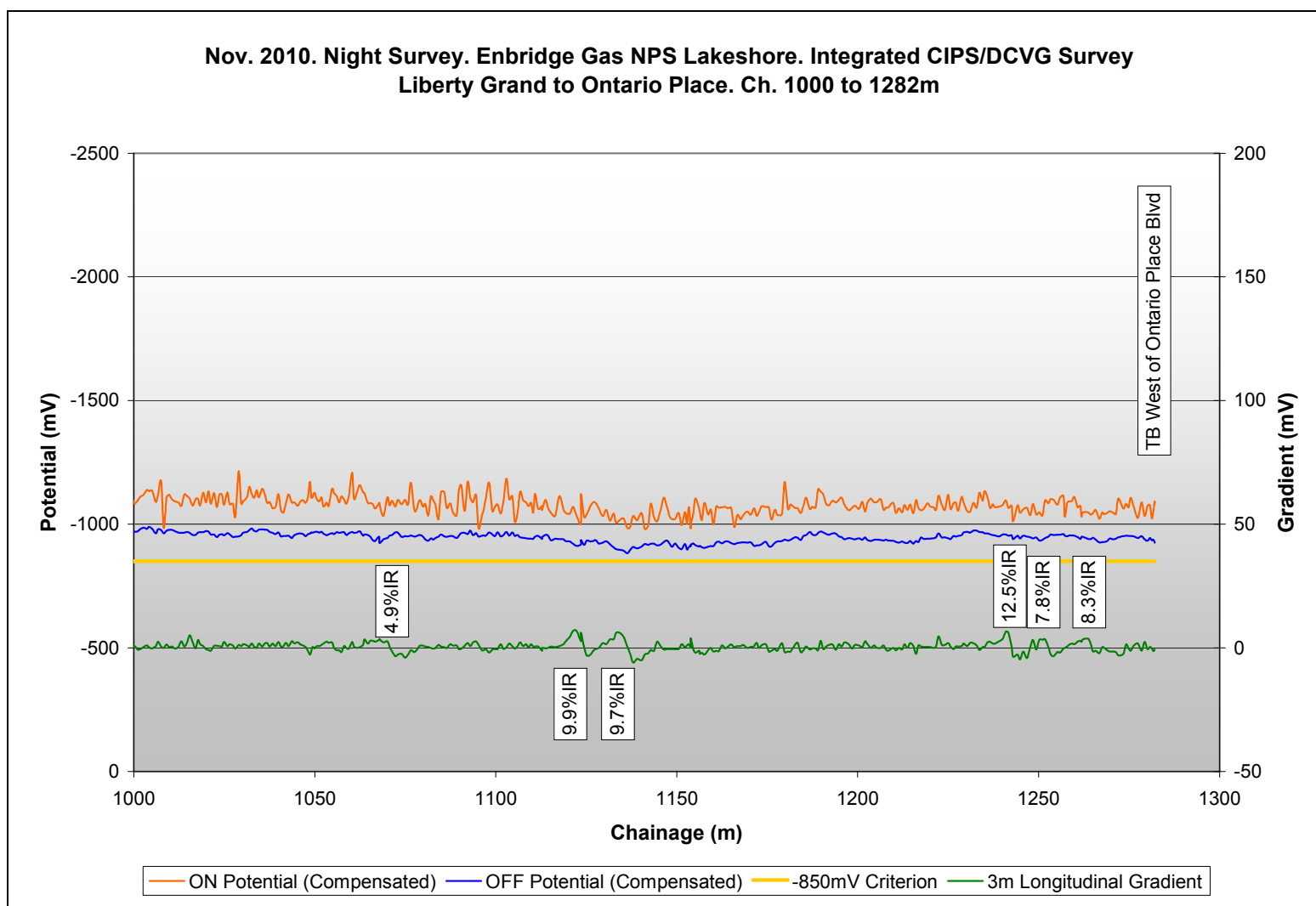
Full Size Graphs

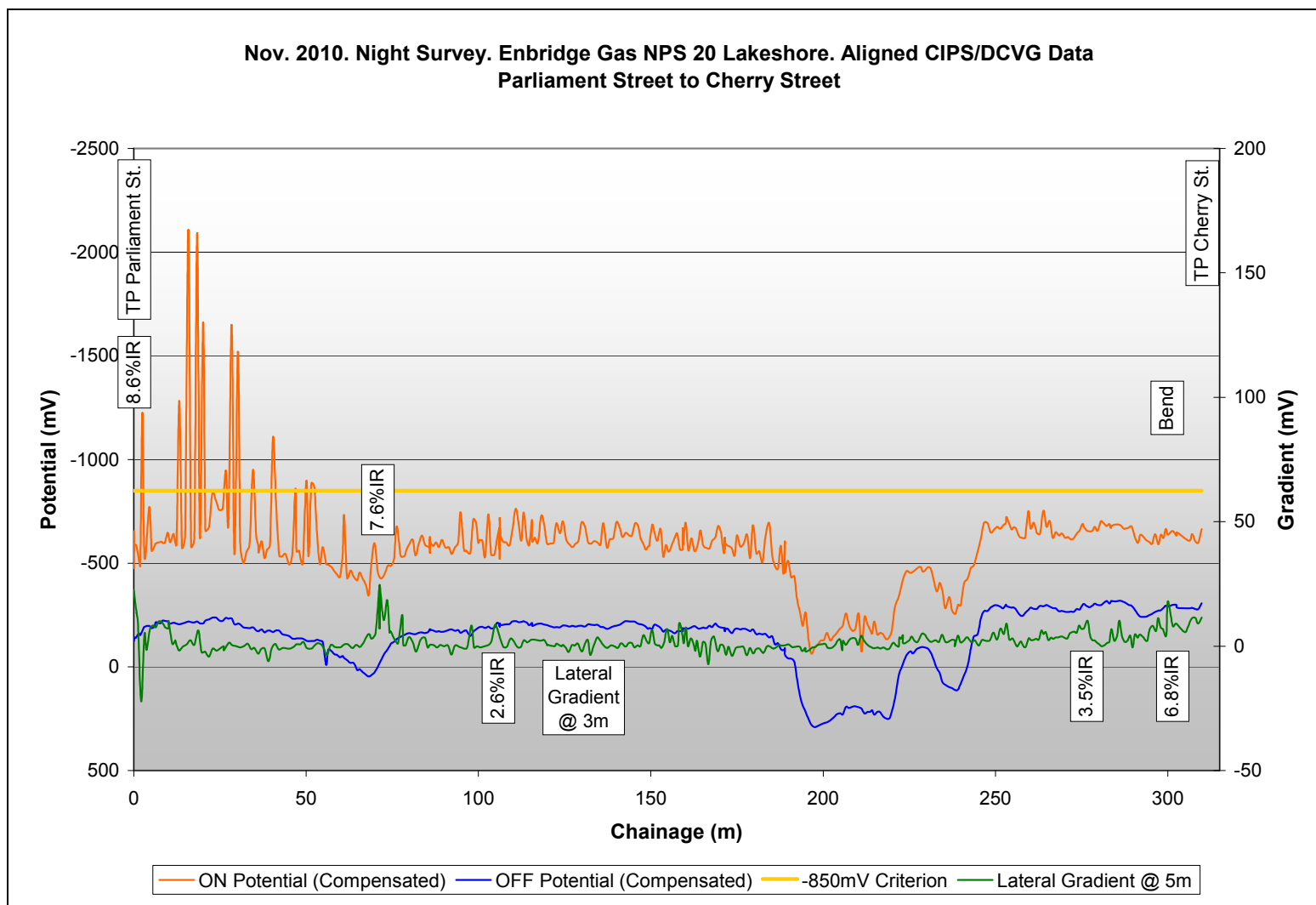


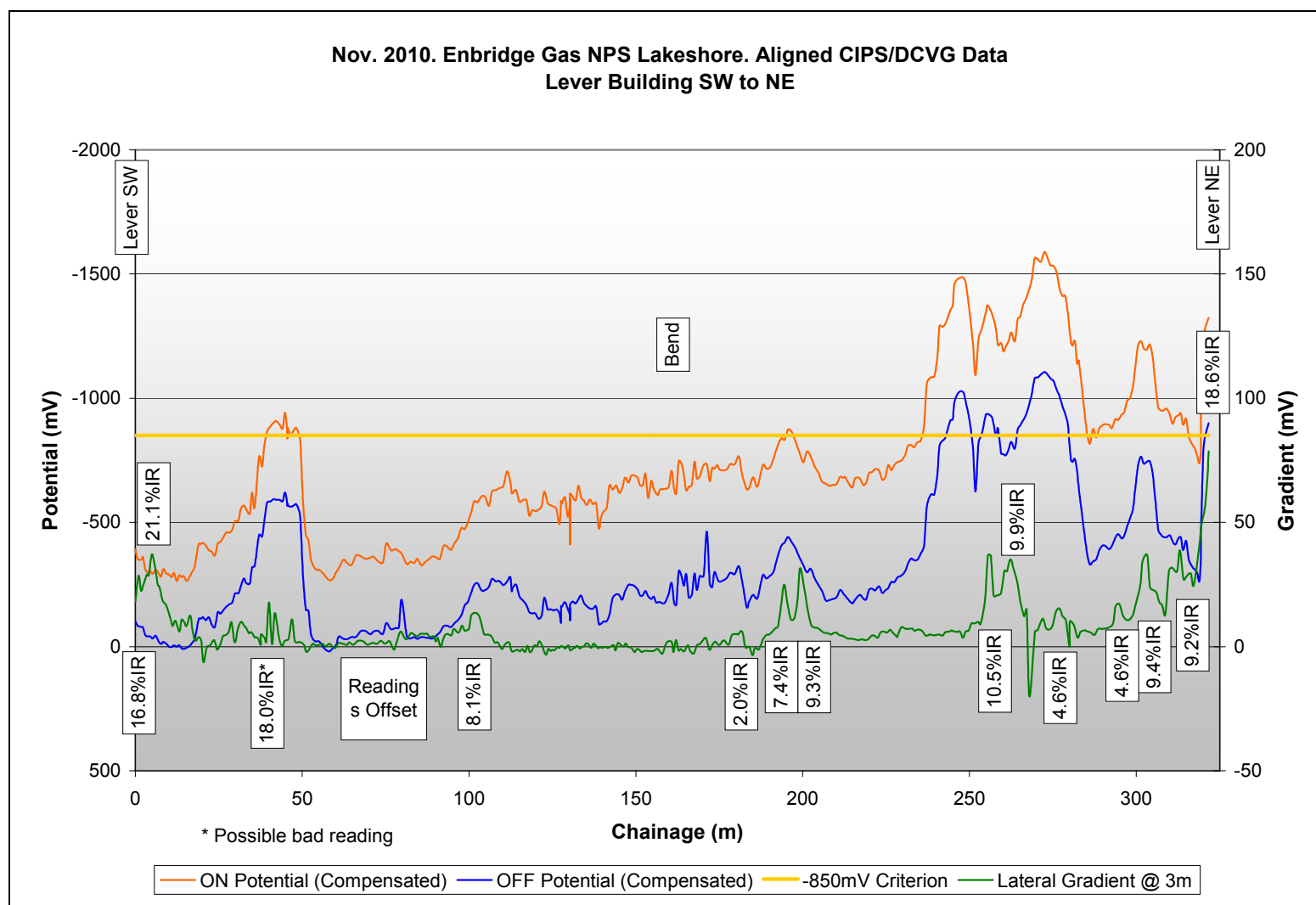


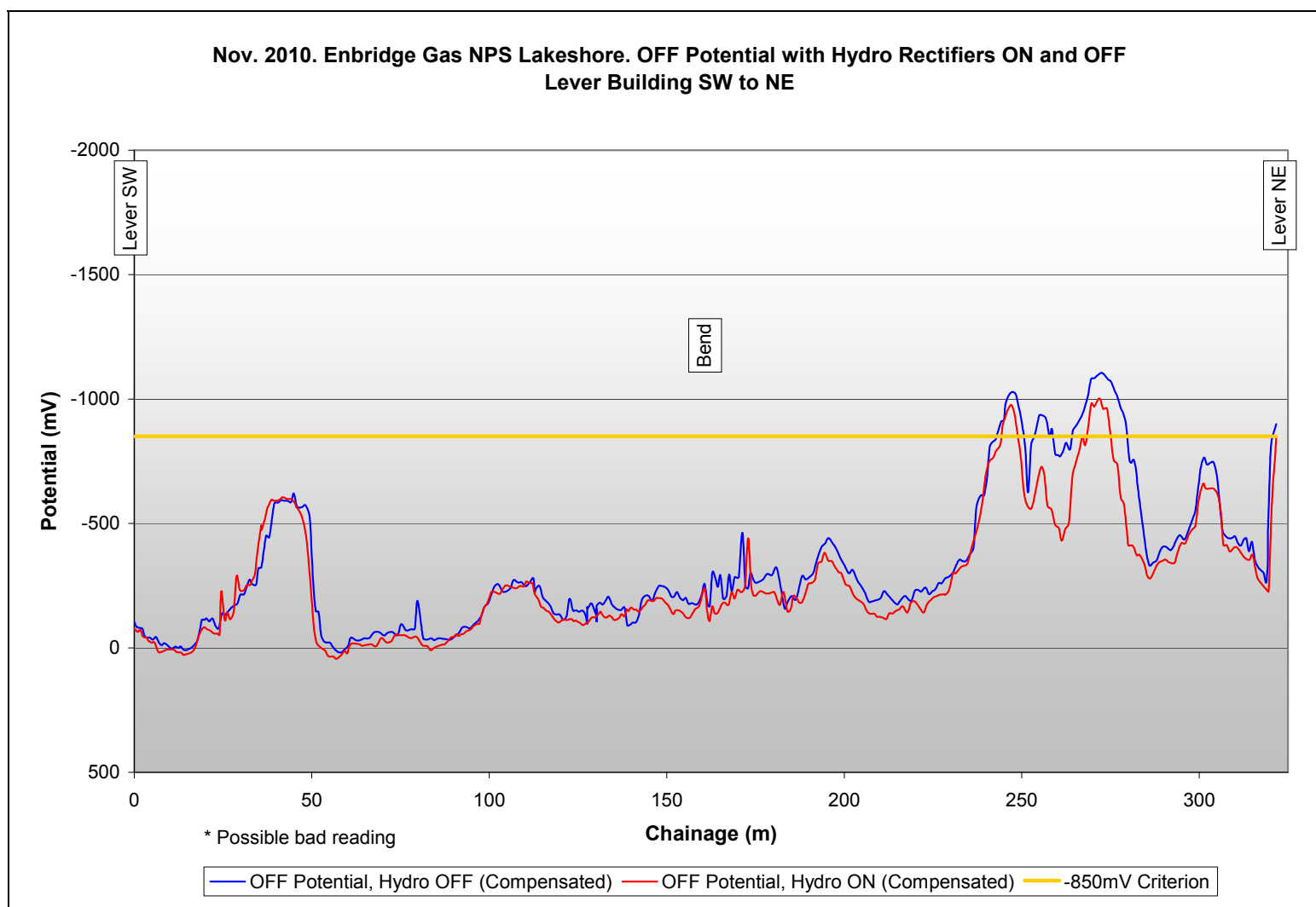




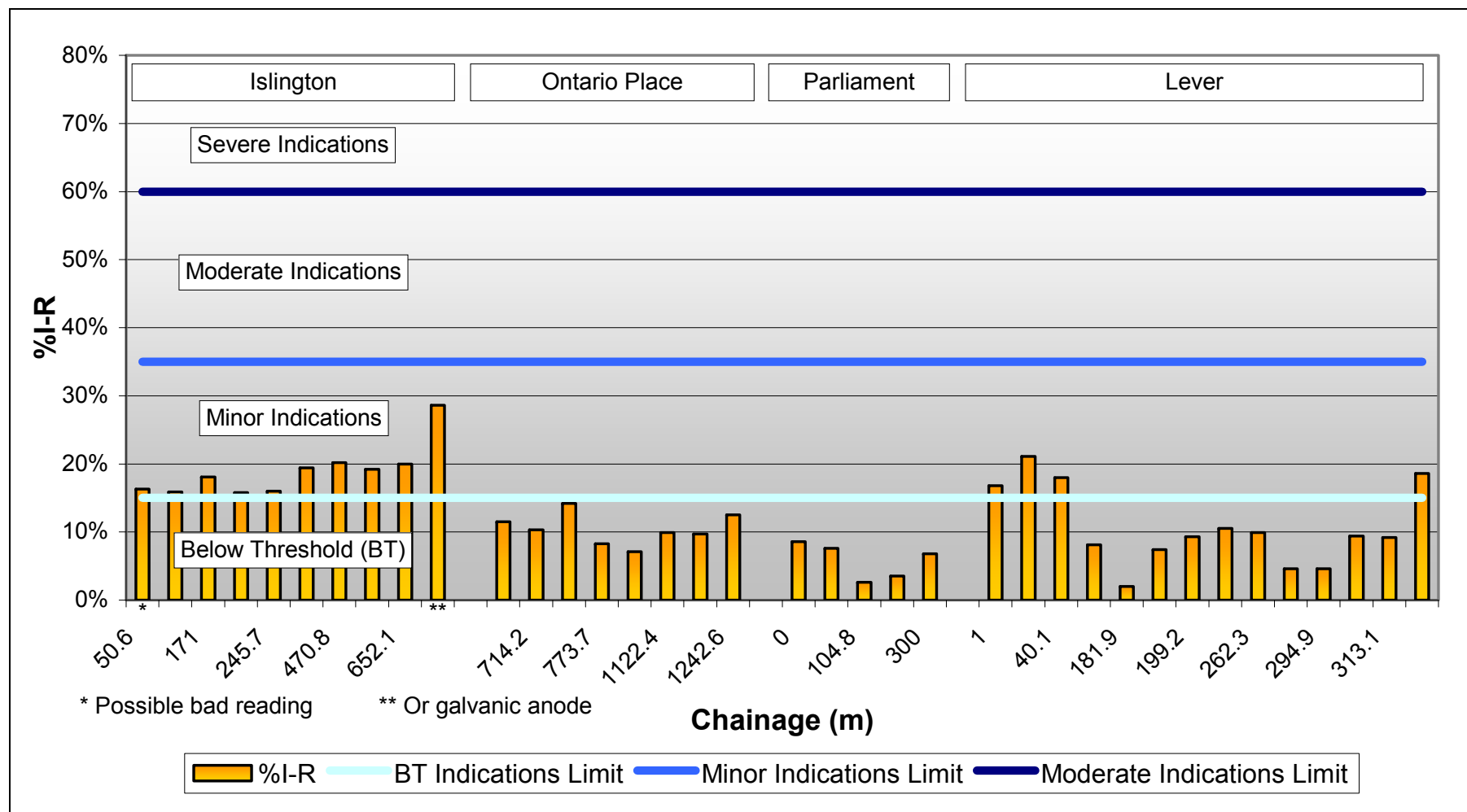








Classification of DCVG Indications



APPENDIX B

Prioritization Criteria
Rules & Explanations

PRIORITIZATION CRITERIA. RULES AND EXPLANATIONS
DATE: February 3, 2011

Revision: 0

1.0 OBJECT, SCOPE AND DEFINITIONS

1.1 Object

The object of this document is to establish a consistent approach for prioritizing ECDA indications, in conformance with the recommendations of NACE Standard SP0502-2010.

This document is not intended to provide a general protocol covering all pipelines under ECDA assessment, but rather guidelines in establishing prioritization criteria for each specific line or ECDA region, as stated in paragraph 5.2.1.2 of NACE Standard SP0502-2010.

Each rule developed in this document is associated with a paragraph explaining the intent of the rule and with a paragraph detailing the rationale behind the rule. Examples and comments will be added, as required.

1.2 Scope

This document covers all areas where the prioritization recommendations included in NACE Standard SP0502-2010 are not self-explanatory.

1.3 Definitions

The following definitions are specific to this document and come in addition to those included in Section 2 of NACE Standard SP0502-2010.

- Discrete Indication:** An indication affecting a unique location on the line, identified by GPS coordinate or flagged on site.
Examples: DCVG indications, DC interference indications at crossings, etc.
- Distributed Indication:** An indication affecting an entire section of line.
Example: In Figure 1, the section starting at chainage 9.2 m and ending at chainage 18.3 m displays a distributed severe CIPS indication, assuming that the threshold for severe indications is set at $-700 \text{ mV}_{\text{CSE}}$. The line also displays distributed DC interference indications (i.e. electropositive potential shifts when the interfering rectifier is turned on).

1.0 OBJECT, SCOPE AND DEFINITIONS CONT'D

1.3 Definitions Cont'd

- **Distributed Indication Cont'd:**

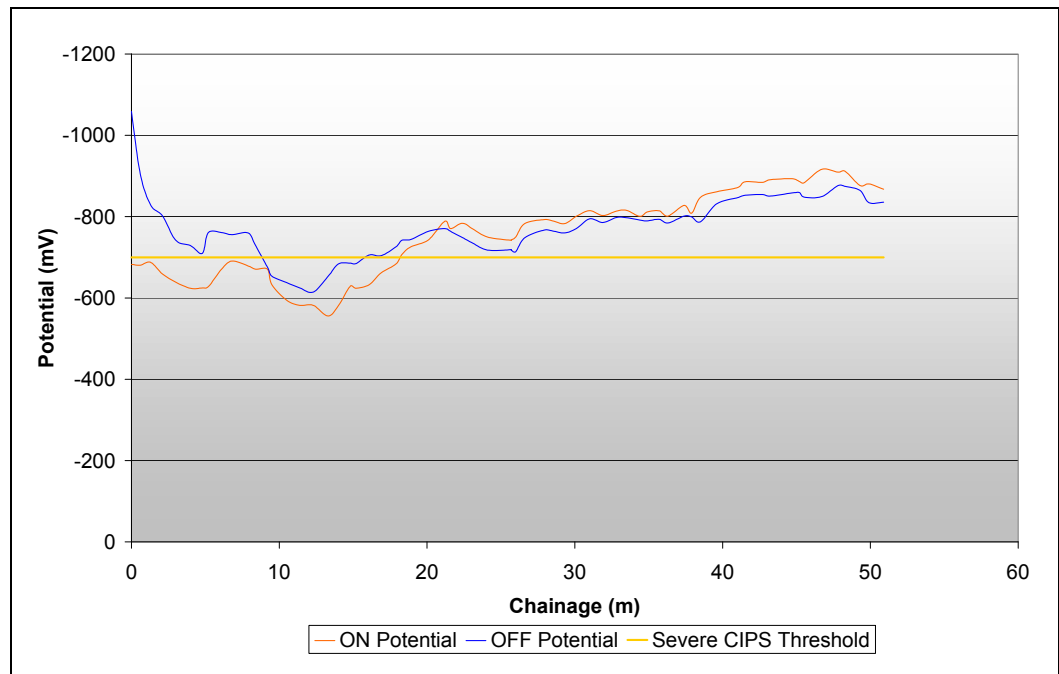


Figure 1. Distributed Severe CIPS Indication

- **Relevant Indications:** An indication or a combination of indications from different indirect inspection techniques requiring prioritization under paragraph 5.2.2 of NACE Standard SP0502-2010. By definition, only relevant indications will be prioritized under NACE Standard SP0502-2010.

Comment: The definition apparently implies that not all indications should be prioritized. The intent of this document is that distributed indications should be seen in conjunction with other discrete indications, prior to prioritization.

2.0 GENERAL RULES

2.1 Rule 2-01 Relevance and Prioritization of Distributed Indications

- Distributed indications are relevant only in conjunction with a DCVG indication, except for short sections of pipe displaying severe DC interference or AC induced corrosion indications.
- By definition, only relevant distributed indications shall be prioritized under paragraph 5.2.2 of NACE Standard SP0502-2010.

2.0 GENERAL RULES

2.1 Rule 2-01 Relevance and Prioritization of Distributed Indications Cont'd

2.1.1 Intent:

The intent of this rule is to state that indications shall be prioritized for action (i.e. immediate, scheduled, or monitoring), only when the location where this action will be performed is clearly defined. In other words, excavating kilometers of line because the section is unprotected would be unrealistic.

This rule recognizes that the actual corrosion attack may develop only at a coating holiday, where the pipe is exposed to the soil.

Localized severe indications related to accelerated corrosion, such as DC interference or AC induced corrosion, should be considered for direct examination even if no coating holidays were identified, due to the high risk of pipe failure.

2.1.2 Rationale:

CIPS, DC interference, and AC induced corrosion indications qualify the risk of external corrosion in a certain area, however this risk could result in actual corrosion attack only at a coating holiday, or in other words at a DCVG indication. As such, it would not be effective to excavate a line for direct examination, knowing that the coating will be in good condition and subsequently no corrosion would be found.

Photograph 1 shows a Canadian pipeline displaying an OFF potential of -516 mV_{CSE}, which was excavated in December 2000. The decision to excavate was taken based on the protection level, with no data regarding coating condition.



Photograph 1. Coating Condition

2.0 GENERAL RULES

2.1 Rule 2-01 Relevance and Prioritization of Distributed Indications Cont'd

2.1.2 Rationale Cont'd:

The coating was found in good condition and no corrosion was detected. The low potential was attributed to the limited effect of a remote groundbed in a soil consisting of a mixture of shot rock and gravel, having a resistivity of more than 150,000 Ω -cm. Under the approach detailed in Rule 2-01, it is expected that such unnecessary excavations would be avoided.

Furthermore, performing direct examinations along entire sections of line is unrealistic.

2.1.3 Example of Rule Application

Assume that a line displays potentials between -800 mV_{CSE} and -850 mV_{CSE}, defined as minor CIPS indications, from chainage 250.0 m to chainage 320.0 m. Two DCVG indications were identified at chainage 280.5 m and at chainage 301.0 m. The first indication displayed a %IR of 17.2% classified as minor and the second indication a %IR of 38% classified as moderate.

The CIPS and DCVG indications would be tabulated as follows under Step 2 “Indirect Inspections” of the ECDA process:

GPS Coordinates		Chainage (m)	ECDA Region	Classification	Notes
N/A	N/A	From 250.0 to 280.5	1	Minor CIPS	-xxx mV _{CSE} @ Ch. xxx
xx.xxxxxxx	xx.xxxxxxx	280.5	1	Minor CIPS Minor DCVG	-xxx mV _{CSE} 17.2%IR
N/A	N/A	From 280.5 to 301.0	1	Minor CIPS	-xxx mV _{CSE} @ Ch. xxx
xx.xxxxxxx	xx.xxxxxxx	301.0	1	Minor CIPS Moderate DCVG	-xxx mV _{CSE} 38%IR
N/A	N/A	From 301.0 to 320.0	1	Minor CIPS	-xxx mV _{CSE} @ Ch. xxx

Three indications are distributed CIPS indications and no GPS coordinates can be provided. Two combinations of indications are defined as relevant indications (i.e. chainage 280.5 and chainage 301.0). Only the relevant indications would be prioritized under Step 3 “Direct Examinations” of the ECDA process, as shown below:

GPS Coordinates		Chainage (m)	Classification	Prioritization
xx.xxxxxxx	xx.xxxxxxx	280.5	Minor CIPS Minor DCVG	To be determined
xx.xxxxxxx	xx.xxxxxxx	301.0	Minor CIPS Moderate DCVG	To be determined

2.0 GENERAL RULES

2.1 Rule 2-01 Relevance and Prioritization of Distributed Indications Cont'd

2.1.4 Comments

- a) This rule also prevents prioritizing any severe distributed indication as “Immediate Action Required”, according to paragraph 5.2.2.1.1 of NACE Standard SP0502-2010.^[1]
- b) It is possible that a line would display distributed indications (i.e. CIPS), with no DCVG indications above the identification criterion (i.e. Category 1 coating damage, less than 15%IR, C-C). Such coating defects would be defined as “below threshold” (BT) DCVG indications, with respect to prioritization.

2.2 Rule 2-02 Compounding Indications from Different Indirect Inspection Techniques

- The severity of indications from different inspection techniques at the same locations is not cumulative and shall be analyzed for each specific combination.

2.2.1 Intent:

The intent of this rule is to prevent a misinterpretation of paragraph 5.2.2.1.2^[2] of NACE Standard SP0502-2010, by automatically prioritizing a combination of two severe indications as “Immediate Action Required”.

2.2.2 Rationale:

The risk of AC induced corrosion and accelerated corrosion due to DC interference increases with the current density, and subsequently decreases with an increase in the size of the holiday. As such, a minor DCVG indication in conjunction with a DC interference and/or an AC induced corrosion indication is more dangerous than a severe DCVG indication in conjunction with the same type of indication and should be prioritized accordingly.

2.2.3 Comment

Tables have been prepared to cover the various combinations of indications.

^[1] Multiple severe indications in close proximity are prioritized in this category.

^[2] Isolated indications classified as severe by more than one indirect inspection technique at roughly the same location are prioritized in this category.

3.0 SPECIFIC PRIORITIZATION RULES

This section details prioritization rules for situations where the guidelines of NACE Standard SP0502-2010 are not self-explanatory or may be misinterpreted.

3.1 Rule 3-01 Prioritization of Relevant Distributed Severe CIPS Indications

- ▶ Relevant distributed severe indications should typically be prioritized as “Scheduled Action Required”.

3.1.1 Intent:

This rule is to prevent a misinterpretation of paragraph 5.2.2.1.1 of NACE Standard SP0502-2010 (i.e. considering a distributed indication as multiple indications in close proximity would automatically prioritize distributed severe CIPS indications as “Immediate Action Required”).

3.1.2 Rationale:

According to the General Rule 2-01, relevant distributed severe CIPS indications are coating holidays (i.e. DCVG indications) located in areas with very low protection levels. As such, they typically appear as isolated severe indications and should be prioritized according to paragraph 5.2.2.2.1 of NACE Standard SP0502-2010 (i.e. as “Scheduled Action Required”).

Note also that the best way to deal with such indications is to immediately conduct direct examinations on one or two such indications and to evaluate the severity of the corrosion attack, leaving the remaining holidays to be examined later (i.e. prior to the next ECDA). Should the examination(s) show significant corrosion attack, then all indications would be examined as soon as possible. This approach exactly matches the definition of “Scheduled Action Required” and the guidelines for determining the required number of direct examinations, as detailed in NACE Standard SP0502-2010.

3.2 Rule 3-02 Prioritization of Distributed AC Induced Corrosion Indications in conjunction with DCVG Indications

- ▶ A pipeline cannot display AC induced corrosion indications in conjunction with severe DCVG indications.
- ▶ A pipeline cannot display AC induced corrosion indications in conjunction with moderate DCVG indications.
- ▶ Severe and moderate AC induced corrosion indications in conjunction with minor DCVG indications should be prioritized as “Suitable for Monitoring”.

3.0 SPECIFIC PRIORITIZATION RULES CONT'D

3.2 Rule 3-02 Prioritization of Distributed AC Induced Corrosion Indications in conjunction with DCVG Indications Cont'd

3.2.1 Intent:

This rule is to prevent a misinterpretation of paragraph 5.2.2.1.2 of NACE Standard SP0502-2010 (see General Rule 2-02).

3.2.2 Rationale:

The AC induced corrosion indications are identified according to the magnitude of the AC current density discharged at a 1.13 cm diameter holiday (i.e. $i_{AC} > 20 \text{ A/m}^2$). Moderate and severe indications display %IR exceeding 35%, or holiday diameters of more than 60 cm. The equivalent identification criterion for AC induced corrosion in conjunction with a 60 cm holiday would be a current density of more than 1000 A/m^2 , which is unrealistic.

Minor DCVG indications display %IR exceeding 15%, or holiday diameters of more than 25 cm. The equivalent threshold for moderate ACC indications in conjunction with a 25 cm holiday would be a current density of more than 1100 A/m^2 , which is also unrealistic. Thus, the most severe level of classification for an ACC indication in conjunction with a minor DCVG indication is minor, therefore the best suited prioritization status is "Suitable for Monitoring".

3.3 Rule 3-03. Prioritization of Isolated "Below Threshold" (BT) DCVG Indications

- ▶ Isolated BT DCVG indications should be prioritized as "No Action Required" (N).
- ▶ If an ECDA region contains indications prioritized as "No Action Required", but the ECDA region did not contain any immediate, scheduled or monitored indications, one excavation is required in the ECDA region at the most severe indication. When ECDA is applied for the first time, a minimum of two direct examinations shall be performed.
- ▶ No validation direct examinations are required for indications prioritized as "No Action Required".

3.3.1 Intent:

This rule is to ensure that minor holidays, with no impact on pipeline integrity or on the efficiency of the cathodic protection system, are not excavated, except for the purpose of satisfying the minimum number of direct examinations under paragraph 5.3 of NACE Standard SP0502-2010, when no more severe indications were identified. The third sub-rule reiterates the provisions of paragraph 6.7.2.1 of NACE Standard SP0502-2010 stating that for validation, "The direct examinations shall be conducted at randomly selected locations, one of which is categorized as scheduled (or monitored if no scheduled indications exist) and one in an area where no indication was detected."

3.0 SPECIFIC PRIORITIZATION RULES CONT'D

3.3 Rule 3-03. Prioritization of Isolated “Below Threshold” (BT) DCVG Indications Cont’d

3.3.2 Rationale:

According to industry practice, Category 1 holidays (%IR less than 15%, C-C) are often considered of low importance and repair is not required. As such, the identification criterion for DCVG indications would typically be set at 15%IR and no action would be required for holidays below this threshold.

The second sub-rule specifies the required number of excavations and their location for the new “No Action Required” prioritization category, by extending the approach used for monitored indications.

The third sub-rule is based on the fact that no corrosion attack is expected at a very small holiday, on a fully protected pipeline, which is not subject to any DC or AC interference. As such, the same provisions as for areas without indications would apply.

3.4 Rule 3-04. Prioritization of “Below Threshold” (BT) DCVG Indications in Conjunction with Distributed Indications

- ▶ “Below threshold” DCVG indications in conjunction with a distributed indication shall be prioritized according to the severity of the distributed indication.

3.4.1 Intent:

This rule is to ensure the relevance and subsequently the prioritization of distributed indications, even at very small coating holidays.

3.4.2 Rationale:

As indicated in comment b) of Rule 2-01, it is possible that a line could display distributed indications (i.e. CIPS) with no DCVG indications above the identification criterion. The distributed indications will still be relevant even at small “below threshold” holidays and should be addressed accordingly.

3.5 Rule 3-05. Prioritization of Isolated Minor DCVG Indications attributable to Old Magnesium Anodes

- ▶ Isolated minor DCVG indications suspected to be old magnesium anodes may be prioritized as “No Action Required” (N).

3.5.1 Intent:

This rule allows selecting the best locations for direct examinations, by downgrading suspected isolated minor DCVG indications to the same prioritization level as isolated below threshold DCVG indications.

3.0 SPECIFIC PRIORITIZATION RULES CONT'D**3.5 Rule 3-05. Prioritization of Isolated Minor DCVG Indications attributable to Old Magnesium Anodes Cont'd****3.5.2 Rationale:**

This rule covers direct assessment where all identified DCVG indications (i.e. %IR higher than 15%) were matched by a slight increase in pipe-to-soil potentials, indicating the possible presence of an old magnesium anode. Since small holidays classified as “below threshold” (BT) indications could provide a better location for assessing the condition of the pipe, the suspected minor DCVG indications and the BT indications receive the same prioritization to allow for the best selection of the direct examination sites.

3.6 Rule 3-06. Prioritization of Isolated DCVG Indications attributable to Well Casings

- Isolated DCVG indications attributed to well casings resistor bonded to the flow-lines or gathering lines may be prioritized as “No Action Required” (N).

3.6.1 Intent:

This rule allows avoiding conducting direct examinations at locations where the DCVG indication is created by the well casings and not by a pipeline coating defect.

3.6.2 Rationale:

This rule covers direct assessment where all identified DCVG indications (i.e. %IR higher than 15%) were located at the connection to the well, indicating the presence of the well casing. Since small holidays classified as “below threshold” (BT) indications could provide a better location for assessing the condition of the pipe, the suspected minor DCVG indications and the BT indications receive the same prioritization to allow for the best selection of the direct examination sites.