GEMINI™ Metal Loss Inspection Report prepared for:

Enbridge Energy, Limited Partnership
20" GEMINI™ Metal Loss Inspection Report
NPS20 Line 5 North Straits East – Mackinaw
Total Distance: 4.13 miles

GEMINI™ Inspection Date: April 12, 2017
Tool Pulled Date: April 12, 2017

Baker Hughes Pipeline Inspection 4839 – 90th Ave S.E. Calgary, Alberta, Canada, T2C 2S8

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Issue Number	Release Date	Issue Date	Client Data Verified	Description of Changes
2008-243 Issue #1	June 8, 2017			Initial Issue
2008-243 Issue #2	November 22,2017	Nov 24, 2017		- Anomaly type classification. - Revised some Wall thickness transition.

Note:

This report has been specifically prepared for Enbridge Energy, Limited Partnership (herein after called "Enbridge"). Any use which a third party makes of this report, or any sole reliance on or decisions to be made based on the information contained herein, are the sole responsibility of such third parties. Baker Hughes Pipeline Inspection accepts no responsibility for the damages, if any, suffered by any third party as a result of decisions made or actions based on the information contained in this report.

Information provided herein represents the best efforts of Baker Hughes Pipeline Inspection to evaluate the described lines. Judgements concerning pipe condition are left entirely to Enbridge Energy, Limited Partnership. All information herein represents only Baker Hughes Pipeline Inspection's interpretation of the pipeline inspection information and shall not be construed as a warranty or guarantee of the structural condition of the pipeline, its fitness for use, or any other condition.

Executive Summary

Baker Hughes Pipeline Inspection has completed a high resolution GEMINI™ inspection of Enbridge Energy, Limited Partnership 4.13miles NPS20 Line 5 oil pipeline from North Straits East to Mackinaw, Michigan on April 12, 2017.

This MFL report re-issue was triggered upon review of previous ILI data made available by Enbridge. After review of this data and re-visiting anomaly classification by Baker Hughes it was determined that reclassification of anomalies is necessary to maintain the consistency of analysis processes and adherence to expected Baker Hughes anomaly classification guidelines.

The GEMINI™ magnetic metal loss inspection was performed to identify and assess the severity of anomalies contained in this pipeline. A comprehensive analysis of the magnetic flux leakage data collected by BHI's GEMINI™ tool on this pipeline has identified no individual or clustering metal loss anomaly. Appendix 15 has the list of manufacturing related anomalies which are the main findings of our current analysis and re-issue of this report.

The analysis of the caliper data has identified no dents greater than 2% O.D., and no ovalities greater than 5% O.D. in the line.

Enbridge provided updated GPS coordinates in 2016 for 2 locations along the entire line, consisting of the launch and receive valves. Since the 2005 and 2013 GEOPIG™ inspections, both the launch and receive areas of the pipeline have been replaced. This information was integrated with the pipe centerline coordinates obtained from the inertial survey, providing a means for locating pipeline anomalies and a foundation for a Geographic Information System (GIS). A listing of the UTM coordinates based on the NAD83 datum is listed in Appendix 5.

We would like to thank Enbridge Energy, Limited Partnership for their assistance and cooperation during this inspection, and we look forward to working together in the near future.

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1.1 Inspection Summary

1.1.1 Operational Details

Baker Hughes Pipeline Inspection has mobilized equipment and a qualified crew to perform in-line inspections of the following system:

BHI Job Number	2008-243
Pipeline Operator	Enbridge Energy, Limited Partnership
Segment Name	NPS20 Line 5 North Straits East – Mackinaw
Launch Site	North Straits, Michigan
Receive Site	Mackinaw, Michigan
Pipeline Nominal Diameter	20”
Product	Oil
Predominant Pipeline Grade(API)	GRADE A
Predominant Weld Type	Seamless
Section Length	4.13miles
Date of VECTRA™ Inspection	April 12,2017
Duration of VECTRA™ Inspection	47 minutes
Field Project Manager	Dale Simpson

Table 1. Operational Details

Pre-launch inspections of the GEMINI™ tool were performed at Enbridge’s work shop in North Straits, Michigan. After passing all of the Baker Hughes pre-run inspection procedures at the North Straits Station, the tool was launched at 17:34 on April 12, 2017. The tool entered the receive trap and was removed at 18:21 on April 12, 2017 at the Mackinaw Station. The GEMINI™ tool was received relatively clean with no apparent damage.

Field analysis indicated that a complete set of MFL data was collected for the run. All other systems including the odometers and inertial system functioned normally for the entire run.

1.1.2 Tool Specifications

Baker Hughes Pipeline Inspection utilized a high resolution 20" VECTRA™ tool for this particular in-line inspection. This tool was specifically tailored at BHI's tool assembly shop in Calgary, Alberta, Canada for the inspection and the general specifications are detailed as follows:

VECTRA™ MFL	
Corrosion Detection Threshold	10% of wall thickness
Depth Sizing Accuracy	± 10% of wall thickness
Length Sizing Accuracy	± 0.4" or ± 10 mm
Width Sizing Accuracy	± 0.4" or ± 10 mm

Table 2. VECTRA™ Tool Specifications. Accuracies are based on general corrosion features in seam-welded pipe not interacting with welds, using a confidence interval of 80%. (A more comprehensive list of sizing performance specifications can be found in Appendix 3.)

Inertial / Location	
Inertial Accuracy	1:2000
Weld to Weld Distance Accuracy	± 0.5" or ± 13mm
Bending Strain Accuracy	± 0.02%
Bend Angle Accuracy	± 0.1°

Table 4. Inertial / Location Specifications.

1.1.3 Data Analysis Parameters

Baker Hughes Pipeline Inspection used the following data analysis parameters for this particular analysis.

GEMINI™ MFL	
Severity Method	Effective Area RPR (SMYS)
Severity Ratio	RPR
Interaction Criteria for Clustering	3t x 3t (expanding box)
Chainage Reference	Absolute
Clock Position Reference	Centre

Table 5. VECTRA™ Data Analysis Parameters.

1.2 Metal Loss Summary

1.2.1 The most significant metal loss anomalies by Effective Area RPR (SMYS)

Baker Hughes Pipeline Inspection has identified 0 individual metal loss features. After applying 3t x 3t interaction for clustering rules to these detected magnetic anomalies, 0 clusters or individual anomalies were created.

BHI chainage (ft)	BHI Identifier	U/S BHI GWD (#)	Wall Surface	Clock Position (hh:mm)	Peak Depth (%)	Length (in)	Width (in)	RPR Eff. Area (SMYS)	Eff. Area Burst (psi)	Comment
-	-	-	-	-	-	-	-	-	-	-

Table 6. The most significant anomalies by Effective Area RPR (SMYS)

Company Name	Segment	MAOP (psi)	Pipe Grade (psi)	Product	Date of Run
Enbridge Energy, Limited Partnership	NPS20 Line 5 North Straits East – Mackinaw	1754/1872/2160/3508/3800	A, X52, X60,X65	Oil	April 12,2017

Table 7. Pipeline Information

1.2.2 The most significant metal loss anomalies by depth

Baker Hughes Pipeline Inspection has identified 0 individual metal loss features. After applying 3t x 3t interaction for clustering rules to these detected magnetic anomalies and 0 clusters or individual anomalies were created.

BHI chainage (ft)	BHI Identifier	U/S BHI GWD (#)	Wall Surface	Clock Position (hh:mm)	Peak Depth (%)	Length (in)	Width (in)	RPR Eff. Area (SMYS)	Eff. Area Burst (psi)	Comment
-	-	-	-	-	-	-	-	-	-	-

Table 8. The most significant anomalies by depth

Company Name	Segment	MAOP (psi)	Pipe Grade (psi)	Product	Date of Run
Enbridge Energy, Limited Partnership	NPS20 Line 5 North Straits East – Mackinaw	1754/1872/2160/3508/3800	A, X52, X60,X65	Oil	April 12,2017

Table 9. Pipeline Information

1.2.3 Tabulation of Detected Magnetic Anomalies by wall location / depth

The quantity and classification of identified metal loss features are listed below:

Depth	Internal Features	External Features	Total Number of Features
0% - 10%	0	0	0
10% - 20%	0	0	0
20% - 30%	0	0	0
30% - 40%	0	0	0
40% - 50%	0	0	0
50% - 60%	0	0	0
60% - 70%	0	0	0
70% - 80%	0	0	0

Table 10. Depth distribution of internal and external features.

1.2.4 Corrosion Severity

Feature	Value	GW	Orientation (°)	Radial Position (Int/Ext)
Worst Depth	-	-	-	-
Worst Eff. Area RPR	-	-	-	-
Number of Features with Eff. Area RPR <= 0.90	0	n/a	n/a	n/a
Number of Features with Depth >= 65.00%	0	n/a	n/a	n/a

Table 11. Corrosion Severity Note: only unsleeved corrosion severity features were included in this table.

1.2.5 Detected Magnetic Anomalies Histogram by Depth

No Data to Report

1.2.6 Pressure Sentence Plot

No Data to Report

1.2.7 Metal Loss Anomaly Orientation Plot by Wall Surface

No Data to Report

1.3 Other Significant Features

Baker Hughes Pipeline Inspection is capable of finding more than just metal loss features with its GEMINI™ tool. The following features have been located and classified:

Feature	Number of Features
Bend	23
Flange	1
Girth Weld	882
Internal Diameter Restriction	1
Seam Weld	15
Support	3
Tee	18
Valve	2

Table 12. List of identified pipeline features

1.3.1 Manufactured / Pipe Mill Anomalies

During the manufacturing process of creating a piece of pipe, numerous material flaws can occur during the fabrication and/or welding of the pipe. These abnormalities can include laminations, inclusions, hard spots, slivers, blisters, laps, weld trim, internal coating imperfections, or other features that have altered the magnetic permeability of the pipe line. If analysis identifies an indication consistent with that of one of these features, it is characterized as a Pipe Mill Anomaly (PMA).

BHI's sizing algorithms are based on the assumption that the flux leakage measured is associated with pure metal loss. As manufacturing anomalies can be the result of other physical properties the actual depths and dimensions may differ significantly to those estimated during analysis. It is for this reason that the predicted dimensions of a PMA are often provided as a general extent of an anomaly, though location will be precise (Chainage and Clock Position). The depth measurement reported for the PMA is the equivalent metal loss that would be calculated from the flux leakage signal response were it pure metal loss resulting, as an example from corrosion. Where a manufacturing anomaly contains multiple signals the dimensions will correspond to the overall extent of the anomaly and the depth measurement to the deepest equivalent metal loss calculated within the PMA.

BHI has identified 41 pipe mill anomalies within this pipeline. A complete listing can be found in Appendix 15.

1.3.2 Weld Anomalies (GWA/SWA)

There are various circumstances that can create an MFL signal on a circumferential weld. For example, if there is metal loss in the vicinity of the weld then Baker Hughes will conservatively assume that the signal was due to associated metal loss and characterize it accordingly. Besides metal loss due to corrosion, there could be an isolated flaw caused during the welding process. These flaws are difficult to discern as an air gap in the weld and metal loss due to corrosion have very similar signals. For consistency, BHI employs a defined decision process to characterize such anomalies.

Once an anomaly is identified on a circumferential weld, it is determined if the signals are possible metal loss. After that, it is determined if the signals are restricted to the weld. If the signal is not restricted to the weld, then it is automatically assumed to be metal loss and characterized as a DMA (on GWD/SWD). If the signal is indeed restricted to the weld (i.e. the signal does not extend to either side of the weld), has related metal loss in the vicinity, the anomaly is deemed to be a DMA that is a possible GWA (Girth Weld Anomaly) / SWA (Seam Weld Anomaly). BHI has identified no Seam Weld Anomalies and no Girth Weld Anomalies in this pipeline. A complete listing can be found in Appendix 15.

1.3.3 Girth Weld Anomaly Severity

Feature Type	No. of features	GW	Orientation (°)	Circumferential Length (in)
GW Anomaly	n/a	n/a	n/a	n/a
Longest GW Anomaly	n/a	n/a	n/a	n/a

Table 13. Girth Weld Anomaly Severity

1.3.4 Magnet

Any anomalies identified that do not have indications consistent with those exhibited in testing and verification by features such as metal loss, dents or other standard pipeline features are classified these feature as 'Magnet'.
In this particular line, BHI has classified total of 28 anomalies as 'Magnet'. Commented as 'Possible Magnet or CP'.

1.3.5.1 Additional Information – Estimated Wall Thickness

During the process of incorporating information provided by Enbridge, BHI can identify areas with unidentified wall thickness properties. By using relative axial bias levels, BHI can estimate the wall thickness of a pipe based on the provided and already correlated data. Table 12 provides a summary of these estimated areas.

Estimated Wall Thickness (in)	Estimated MAOP (psi)	Estimated Pipe Grade (ksi)	Pipe Description	Total Section Length (ft)
-	-	-	-	-

Table 14. List of estimated wall thickness areas

1.4 Deformation and Mechanical Damage Summary

1.4.1 Dent Overview

A thorough review of the GEMINI™ caliper survey data has identified no individual dents. The plot below summarizes all of the dents identified in the line as a function of chainage and clock position. A complete list of the identified dents can be found in Appendix 16.

No Data To Report

1.4.2 MFL Deformation Analysis

Baker Hughes Pipeline Inspection has recently improved the analysis techniques of tri-axial MFL signals. By closely analyzing the radial and circumferential components of MFL data, certain inferences can be drawn about the length, width, and depth of pipe wall deformations. High sampling frequency, tight sensor spacing, and sensor arm pivot design help us closely examine the surface of a deformation as the tool traverses the dent. When an atypical MFL signal appears on the surface of a deformation, BHI classifies these deformations as "stress concentrators on a dent". These features have further been classified as a crack, a wrinkle, an individual anomaly, or a gouge. For this particular inspection, caliper data was used to identify & size deformations.

1.4.2.1 Cracks

Tri-axial hi-resolution MFL tools are able to detect cracks if the crack is large enough and the crack is orthogonal to the magnetic saturation axis. As long as there is a physical volumetric gap, an MFL signal will respond by reporting a narrow metal loss type of signal. When this signal occurs directly in the center of a dent, and the signals circumferential width to axial length ratio is larger than 3:1, the feature is typically predicted to be a circumferential crack.

BHI has not identified any possible cracks in dents in this particular line.

1.4.2.2 Wrinkle / Buckle

Baker Hughes Pipeline Inspection has the ability to identify wrinkled or buckled pipe. Buckles and wrinkles are characteristically different than a typical dent in that the circumferential width of the deformation is greater than the length. BHI's MFL tool has the ability to analyze bending strain at these locations and by overlaying this data on the MFL data.

BHI caliper data has identified no wrinkles larger than or equal to 2% O.D. The table below shows the deepest wrinkles that BHI has identified.

BHI Identifier	BHI Absolute Distance (ft)	U/S BHI GWD #	Dist. to U/S GWD (ft)	Depth (% O.D.)	Length (in)	Width (in)
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Table 15. Wrinkle/Buckle listing

1.4.2.3 Mechanical Damage/Gouges

Mechanical damage/gouges have a unique set of properties when viewed with a tri-axial MFL tool. Gouges are typically characterized by an elongated groove or cavity caused by physical mechanical removal of metal. By closely examining the tri-axial MFL signal, as well as accounting for the geographical position and the feature orientation, no gouges have been identified.

1.4.3 Mechanical Damage which interacts with other anomalies

The table below shows the deformations that BHI has identified to be interacting with other anomalies or features.

Deformations	Total	Deepest Deformation					
		BHI Identifier	Depth (%O.D.)	BHI Absolute Distance (ft)	U/S BHI GWD (#)	Dist. to U/S GWD (ft)	Comments
On DMA	-	-	-	-	-	-	-
On DMA| On GWD	-	-	-	-	-	-	-
On DMA| On SWD	-	-	-	-	-	-	-
On DMA| On SWD| On GWD	-	-		-	-	-	-
On GWD	-	-	-	-	-	-	-
On SWD	-	-	-	-	-	-	-
On SWD| On GWD	-	-	-	-	-	-	-
Under SLV	-	-	-	-	-	-	-
Under SLV|On GWD	-	-	-	-	-	-	-
Under SLV|On SWD	-	-	-	-	-	-	-

Table 16. Deformation interaction listing

Note: Sizing and characterization of metal loss or other stress raisers on dents is provided on a best endeavors basis to assist the pipeline operator by providing, in some cases, additional insight as to the potential severity of the metal loss. Due to inconsistent sensor ride, material properties, wall thickness and potential sensor lift-off in the vicinity of the deformation, sizing cannot be guaranteed to be within our normal specification.

1.5 Inertial and Tool Performance

1.5.1 Inertial Data

The inertial survey provides pipeline plan, profile and bending strain, allowing one to locate the pipeline in the UTM mapping projection, and to detect pipeline movement between inspection runs. The positional information is derived from the onboard strap down inertial unit, the odometer readings and the UTM coordinates of selected tie points obtained from a GPS survey.

1.5.1.1 GPS Tie Points

Enbridge provided updated GPS coordinates in 2016 for 2 locations along the entire line, consisting of the launch and receive valves. Since the 2005 and 2013 GEOPIG™ inspections, both the launch and receive areas of the pipeline have been replaced. This information was integrated with the pipe centerline coordinates obtained from the inertial survey, providing a means for locating pipeline anomalies and a foundation for a Geographic Information System (GIS). A listing of the UTM coordinates based on the NAD83 datum is listed in Appendix 5.

1.5.2 Tool Performance

1.5.2.1 Velocity

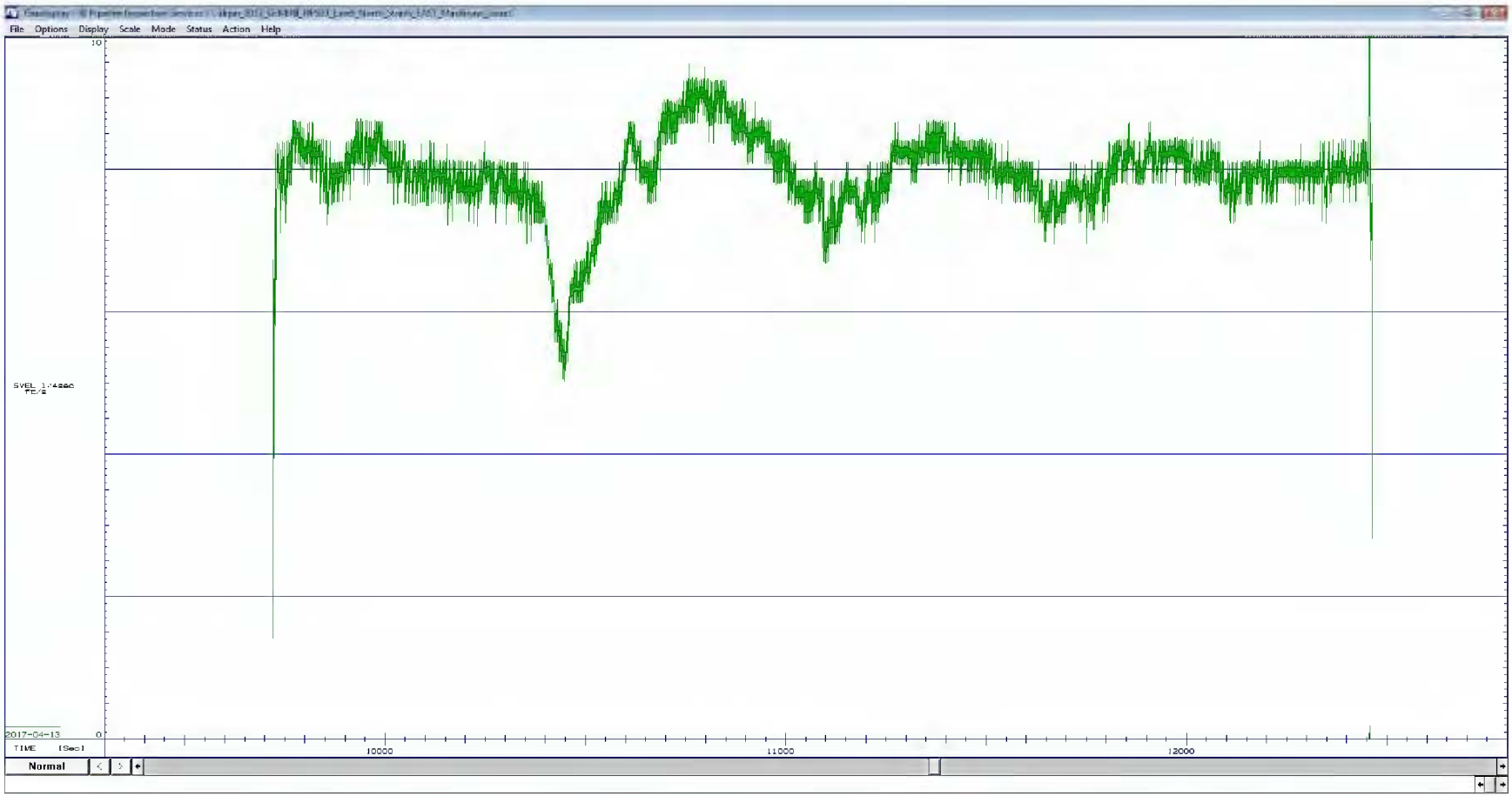


Figure 1. This graph shows the velocity of the tool as it progresses through this particular pipeline segment. The axis on the left indicates velocity in ft/s, while the bottom axis has 2 different scales. One scale represents distance in meters, while the other contains time in seconds. The tool's average velocity was 7.87ft/s. The maximum velocity attained by the tool was 10.17ft/s. 0% of the line was over 14.76ft/s, the highest acceptable velocity of this tool.

1.5.2.2 Plan and Profile

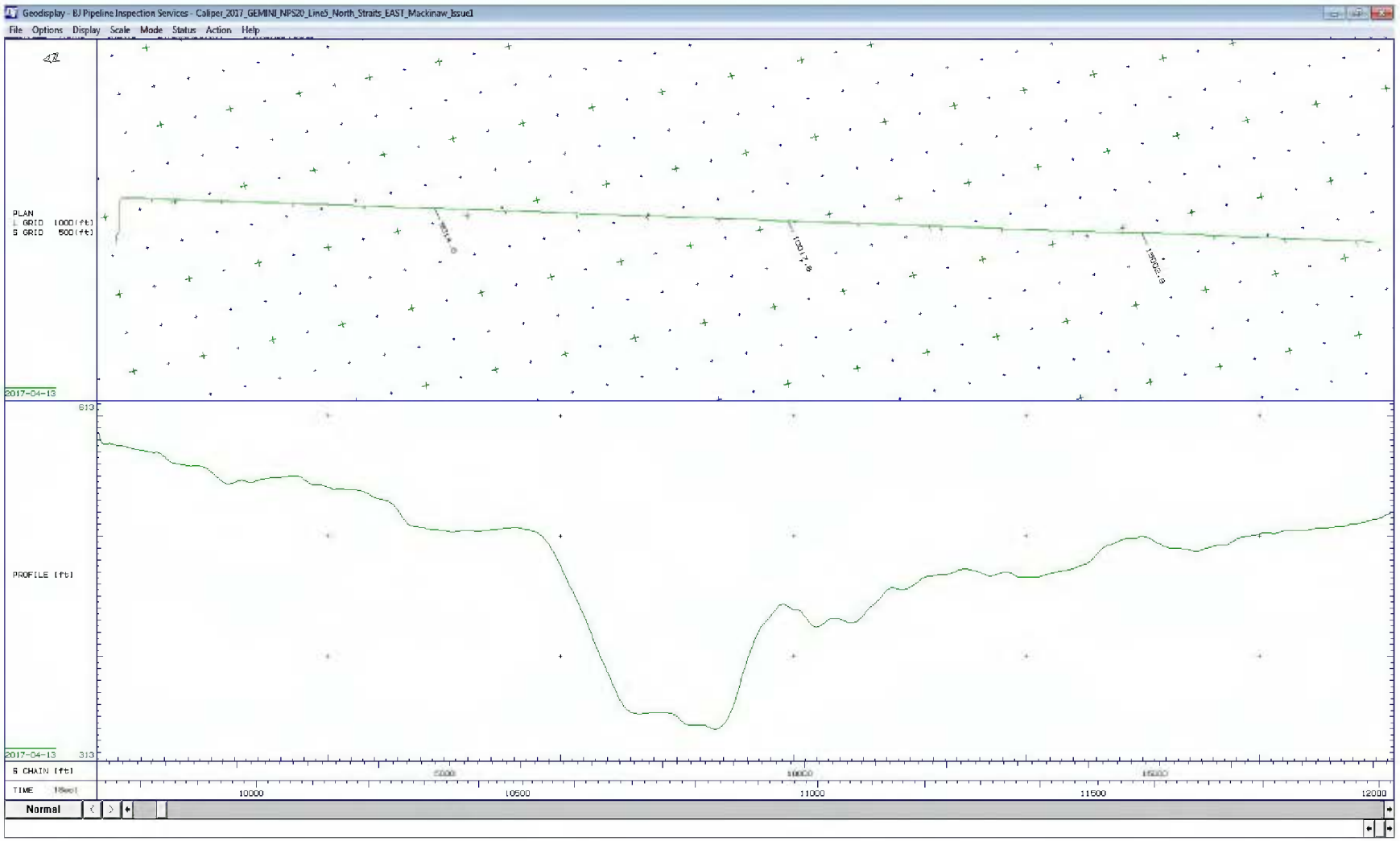


Figure 2. This display shows the plan and profile of the entire pipe-line segment as recorded during the inspection runs. The pipeline position is provided in terms of Northing, Easting and Height as a function of chainage. This data was processed by rotating and scaling the inertial data to known tie-points. Accurate positional information has been provided in the NAD83 datum.