IONIK CONSULTING

N.T. GAS	CLIENT	NT GAS
	PROJECT	NT GAS 14" PIPELINE FITNESS FOR PURPOSE
	DOCUMENT	REPORT

TITLE	FFP ASSESSMENT OF 14" NATURAL GAS PIPELINE

DOCUMENT No.	OFFICE	CLIENT NO.	JOB NO.	TYPE	DOC NO.
	0 7	0 2 4 3	0 1	3	0 0 1

0	12/09	ISSUED FOR USE	SM	KB	AGL	AGL	-
B	11/09	ISSUED FOR APPROVAL	SM	KB	AGL	AGL	-
A	08/09	ISSUED FOR COMMENT	KB	SM	AGL	AGL	-
REV	DATE	REVISION	BY	CHK	ENG	PM	CLIENT

DOCUMENT REVIEW COMMENTS SHEET

TITLE: **FFP Assessment of 14" Natural Gas Pipeline**

DOCUMENT NO: **07-0243-01-3-001** REV NO: **0** CLOSED OUT

CLAUSE/SECTION	COMMENTS (Reviewer)	INITIALS	ACTION UNDERTAKEN (Originator)	Y/N
General	The report states that based on the recommended proportional corrosion growth method, only 17 defects require repair over the next ten years, yet 2689 are likely to require repair over the next 28 years. If we only repair the 17 defects in the next ten years we will be left with 2672 defects to repair in 18 years – that is almost one every two days. Whilst the repair strategy might be correct based on the modelling, it doesn't seem to be very realistic. There is no way that we will be able to repair 1040 defects within a five year period. With this in mind NT Gas would prefer to bring forward some of the repairs, to avoid having a massive block in later years. However, the report doesn't include details of any of the other 2689 defects aside from the first 17. NT Gas would like to have information on ALL of the defects requiring repair in the future, rather than only the high priority ones. Due to the amount of data expected here, we would like this data to be provided in a Excel or CSV format as well as included in the report.	AL/MC	The anomaly list beyond 10 years was excluded from the report, as it is recommended that re-inspection of this pipeline is performed in 10 years time. Engineering assessment of the new data should be performed at that time, before planning any further repair activities. The assessments have been based on 2 years of available data, plus proportional corrosion growth since installation date. It is still an average corrosion rate – accuracy will be increased with subsequent inspections and data sets. Details of all defects that will fail within 28 years are provided in excel format in APPENDIX L.	Y

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1.1	The pipeline operated by NT Gas is only 14 inches from Palm Valley to Mataranka. The pipeline then changes to 12 inch from Mataranka to Darwin City Gate and Channel Island.	MC	Agreed. Sentence amended.	Y
1.2	Typos in dot points 4 and 5 (DCVG).	MC	Agreed. Typo corrected.	Y
2.3.1 3.5	The length and width of anomalies were measured during digups. This was not included in the spreadsheet that was provided to IONIK, but can be if this will improve the accuracy of results.	MC/AL	Recommendation 2 removed. Sentence amended to "These tool tolerances are only applicable to the depth of the defect." As IC-Finesse only takes into account depth growth, the length and width of anomalies would be used for manual calculations to determine whether corrosion rates are consistent with depth calculations. This would be in addition to the agreed scope.	Y
3.3	No consideration was given to defect clustering in this report? Surely this would have a significant impact? Is there any way that clustering can be considered?	MC/AL	With clustering, the defect becomes larger and consequently the estimation of corrosion rate based on that will be too conservative. Utilizing ROSEN methodology of clustering the defects, it can be seen in the table provided with the email correspondence to NT Gas, that the total number of non-compliant defects has increased substantially, which also predicts 7 non-compliance defects	Y

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	With no consideration given to clustering, is it possible that there could be one pipeline location (for example one girth weld) that contains multiple anomalies / defects that were assessed to become non-compliant at different times? Does this make the results misleading? If you refer to table K1, there are two defects at 913.180. They have different clock positions but have reasonable width. With interaction, I would assume this would be one defect. It seems that the quantity of defects has been exaggerated based on no clustering.	MC/AL	in year 2008. This is considered too conservative and therefore not used in the assessment. It is possible for defects that were assessed to become non-compliant at different times in one area. However, by filtering those defects based on location and not by years, repair can be planned accordingly. Even though the quantity of defects is considerably less after clustering, the number of non-compliance has increased substantially.	Y
3.4.1	Rosen considered the tool rotation to be good, but what does IONIK think? Most of the sections show minimal tool rotation at the start, and none after that. Is this acceptable?	MC	Data quality can be acceptable with minimal tool tolerance. The key considerations are whether there has been sensor loss, whether magnetisation levels and tool velocity are within specification.	Y
3.5	Can you provide more detail on how the tolerances were calculated?	MC	Procedure used has been described in section 3.5. APPENDIX M is added to justify summarised figures in Table 3.2.	Y

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4.3	Some reports received by NT Gas question whether %IR is a good determination of whether a defect requires repair. Does IONIK think %IR is the best way to determine a defect's severity with regard to DCVG?	MC/JG	DCVG is a good indicator for identifying coating defects, but other factors such as depth of cover of the pipeline and resistivity must be taken into consideration to the significance of each reading. Same values of %IR could be indicative of different conditions if the above factors are different, rather than being a measure of the severity of the defect. The most accurate way is to perform dig up verification on suspected locations to confirm the condition and severity of the defect. The impact of a particular defect will also be dependent upon the CP levels at the defect location, with a large %IR defect on a well coated section of pipeline being less susceptible to corrosion than a lower %IR defect on a marginally protected pipeline.	Y
4.4	Were any of our defects found near a girth weld? If so, how were they assessed?	MC/AL	Yes, features were found near girth welds and were assessed only as parent plate anomaly. Report has been modified to include APPENDIX N. A recommendation is added to highlight that girth weld anomalies should be further reviewed in detail using applicable code such as API 579, as the assessment of girth weld anomalies as not within the agreed assessment code of ASME B31G.	Y

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	Should it be stated that an assumption was made that conditions remain exactly the same during the remaining life of the pipeline?		Agreed. Sentence added for clarity.	Y
	If RSTRENG was used instead of B31G for the FFP assessment of grown anomalies, would we end up with more or less defects to repair? How easy is it for IONIK to perform an RSTRENG assessment?		It's likely that they will have less defects to repair, based on previous project experience. IONIK can put in a CTR to carry out this assessment – estimate 2 weeks full time to re-run the analysis & revise the report.	Y
5.3.1	Measured growth rates looks at the most severe anomalies and compares growth between matched defects in 1997 and 2008. Were there any severe anomalies that were detected in 2008 but were not detected at all in 1997?	MC	Yes there were. Sensitivity analysis was performed. The most severe anomalies that could not be correlated to 97 data with confidence is attached as an Excel file in the email correspondence with NT Gas.	Y
	Last sentence of paragraph one should be 1997 not 1999.	MC	Agreed. Typographic error corrected.	Y
	Paragraph three has an extra comma (typo)	MC	Agreed. Typographic error corrected.	Y
	Newcastle Waters to Daly Waters is the only section	MC	After discussions with NT Gas, the discrepancy in surface	Y

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	for which internal corrosion rates were calculated. All the other sections had insufficient data. How much data is needed?		location is deemed acceptable for two anomalies to be matched. Therefore, note 1 is removed and calculations are performed and added to the report accordingly.	
	Should FFS be FFP? (The acronym FFS is used elsewhere though – such as section 6.5 and 6.6, however I don't know what it means)	MC	Agreed. All FFS changed to FFP throughout document.	Y
Table 6.1	The % increase in anomalies between 1997 and 2008 seems to be calculated as the difference in anomalies between years as a percentage of the total 2008 anomalies. Shouldn't this be as a percentage of the 1997 anomalies? For example, surely an increase from 99 to 141 is an increase of 42.42% not 29.79%?	MC	Agreed. Calculation re-performed and table updated.	Y
	Below the table is a comment regarding a reduction in anomalies in section 3, possibly due to inconsistent data reporting by ROSEN and/or tool tolerances. Is the anomaly comparison in Table 6.1 therefore really valid? It does not make sense for	MC/AL	Statement has been removed as it is an assumption. The anomaly comparisons stated in Table 6.1 is purely a summary of features reported by both ILI reports. Agreed, it does not make sense for anomalies to decrease and that there is a significant increase in Section 8. A	Y

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	anomalies to decrease. Is it realistic for an anomaly count to increase from 3309 in 1997 to 43511 in 2008 in section 8? Is there any way to truly determine whether what the increase in anomaly number is for a given section?		recommendation will be added to query ROSEN to review the data quality in these areas. Unfortunately, there is not any other way to truly determine the number of features, apart from those reported by the ILI contractor. The ILI contractor should be made aware of such discrepancies and may revisit the interpretation of MFL data.	
Table 6.3	Based on proportional growth, 7 internal defects are assessed to become non-compliant by 2036. Is there any way to repair these defects other than cutting out and replacing the pipe? In a dry environment with no oxygen, why would internal defects be growing anyway?	AL	Theoretically there should be no internal corrosion due to dry environment with no oxygen. However, the ILI run has identified these features. The first step would be to verify this features if practicable. Recommendation has been added into section 2.3.1 and paragraph added in section 6.3. When re-assessed, a follow-up inspection should be performed prior to predicted failure to monitor changes. The repair methods listed in Section 8.3 also apply to internal features.	Y
Table 6.3	Was any assessment performed on the percentage of defects / anomalies that were close to girth welds? This would assist in determining the number of defective heat shrink sleeves around girth welds. This is a known problem for NT Gas, but we do not know exactly the extent (photos were provided to	MC	Table for percentage of defects / anomalies that were close to girth welds is included.	Y

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	IONIK). Due to shielding by the heat shrink sleeves, CP is unlikely to be effective.			
Table 6.4	Note 1 – if there were no failures after applying corrosion rates to anomalies, shouldn't the table state 0 rather than N/A?	MC	Agreed. Amended in table.	Y
	Note 2 – I assume that corrosion rates were only calculated for sections in which rates could be determined in Table 5.1. Therefore why does note 1 apply to internal defects in sections 2 and 3? Wasn't section 7 the only section in which internal corrosion rates could be calculated?	MC	Agreed. Notes updated, as well as referencing of notes in the table.	Y
7.2	Paragraph 3 states that "the readings in section 7 show possible coating defects". I assume that this is referring to the survey not being completed in this section in 2009 due to ground bed problems. The parts that were completed showed a significant number of coating defects. Maybe this could be worded better. The DCVG survey from Renner Springs to Newcastle Waters was also not completed due to the same reason (this should also	MC	Agreed. Paragraph reworded to "The readings recorded for the 2009 survey for Section 6 (Renner Springs to Newcastle Waters) and Section 7 (Newcastle Waters to Daly Waters) of the pipeline are incomplete due to ground bed problems. Although two sections were not surveyed, the survey demonstrated an increase in the overall number of defects in the surveyed sections. Therefore, it is recommended that DCVG survey is performed on sections 6 and 7, as soon as it is practicable." Tables in Appendix C	Y

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	be reflected in table C.5).		are modified to include KP coverage.	
	Were individual DCVG defects aligned to individual areas of metal loss to determine whether metal loss anomalies were at the same location as a coating defect? Could this be used to compare %IR and corrosion growth rates?	SF/JG	Based on the analysis of data sets given, it is found that individual DCVG defects do not aligned to individual areas of metal loss and hence %IR could not be used to compare with corrosion growth rates. DCVG results may vary from IP results, depending on the accuracy of the survey, soil resistivity, the depth of buried pipeline, and whether any defects which show metal loss are shielded from cathodic protection, and hence not detected by DCVG surveys.	Y
8.3	This section lists repair options, but does not give recommendations for which repair type should be performed on specific defects / anomalies. Can this recommendation be provided?	AL	Repair options listed are industry accepted methods and can all be applied. Selection of the most appropriate repair method will depend on NT Gas strategy for repair (e.g. temporary or permanent, if repair is to be executed during operation or shut-in, etc.), orientation / location of individual or interacting anomalies, cost for repair execution, etc. The least intrusive permanent repair method is by use of structural repair clamps. Table 8.2 is added to further summarise and compare repair options.	Y
8.3.5	Typo on line 2.	MC	Agreed. Typographic error corrected.	Y
APPENDIX B	I think this appendix and the graph titles should	MC	Agreed. Titles modified with "Year 2036" at the end of each	Y

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	clearly state that this is what the defect distribution will look like in 2036 based on the growth type. At a glance, it could be confused that the graphs show the current pipeline condition, which shows a high number of non-compliant defects.		title.	
APPENDIX D	Why have different colours been used between sections? For example, the 2008 CP off readings are purple, red and green depending on the section. Is there a reason why figures D.6 and D.7 have two colours to display IP results?	MC MC	Agreed. Colours modified and made consistent. Agreed. Colours modified and made consistent.	Y Y
Figure D.5	This should be section 6 not section 5.	MC	Agreed. Typographic error corrected.	Y
Figure D.7	This legend is inconsistent with the others. The IP data should state “IP – wall thickness loss”.	MC	Agreed. Typographic error corrected.	Y
Table F.1	Note that NT Gas queried the ID anomaly with ROSEN, who confirmed it was “internal metal loss most likely caused by a milling feature (10% wall loss).	MC	Added sentence “which is confirmed by ROSEN to be a milling anomaly (see APPENDIX J).”	Y
APPENDIX H	Why is there a separate column in these tables for non-compliant external anomalies greater than 80%	MC	According to ASME B31G, if external anomaly is greater than 80% wall thickness, only the option of repair or	Y

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	wall thickness? Why would you chose to not repair an anomaly in a certain 5-year block, knowing that in the next 5-year block it will have metal loss greater than 80% wall thickness?		replace is recommended. If external anomaly is less than 80% wall thickness, but fails due to ERF>1, then options other than repair or replace, such as reducing MAOP, can be considered. Therefore, a separate column for non-compliant external anomalies greater than 80% wall thickness is included for completeness.	
APPENDIX K	I assume defect number is just a unique ID given to defects in IC Finesse?	MC	Yes. No change to document.	Y
	I am struggling to match defects stated in table J1 with the exact entry in Rosen's data. For example there are two defects listed at 913.180 in table J1. Rosen found 25 anomalies at this weld. However I can't see any at clock position 11:37 or 9:53. I also can't see any anomalies with dimensions 30 by 50 or 30 by 107 mm. I had a similar problem with I had a look at the defects at 893.702 and 893.703. Why is this?	MC	This is because in ROSOFT, under the tab "list of anomalies", these anomalies are clustered and therefore not shown. You can find individual anomalies in the tab "features".	Y
	Of the 17 defects that were recommended for repair in the next ten years, two were repaired following	MC	Recommendations modified to include only anomalies that are unrepaired to date.	Y

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	the 1997 inspection (refer to the comments field for defects 893.702 and 893.703 in table J1). As they are listed in this table, is it recommended that these defects be checked in the next ten years? Why would this be the case?			
	The acronym SWP has not been defined.	MC	Agreed. Added to Section 1.3.	Y
	The predicted growth depth of defect 893.702 is 5.049mm and defect 893.703 is 4.78mm. However, only defect 893.703 is stated to be greater than 80% wall thickness at the time of non-compliance. Wouldn't defect 893.702 also be greater than 80% wall thickness?	MC	The missing column for the predicted year of failure to occur has been added in APPENDIX K. It can be seen that defect 893.702 becomes non-compliant at an earlier date due to SWP while defect 893.703 becomes non-compliant due to 80% WT loss is reached.	Y

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SECTIONS

APPENDICES

1.0 INTRODUCTION

1.1 Background

NT Gas operates a natural gas pipeline that is 14 inches from Palm Valley to Mataranka and changes to 12 inch from Mataranka to Darwin City Gate and Channel Island [Ref.19]. The pipeline was installed in 1986 with a licence to operate for 50 years to 2036. Refer to APPENDIX A for the pipeline schematics and corresponding sections of the pipeline.

In 2008, ROSEN performed an In-line Inspection (ILI) on seven (7) sections of 14" natural gas pipeline for NT Gas. Details of these sections are shown in Table 1.1.

Table 1.1
14-inch Natural Gas Pipeline Sections

Section	Pipeline Section	Length (km)
2	Tanami Road to Ti Tree	155.05
3	Ti Tree to Wauchope	141.97
4	Wauchope to Warrego	152.70
5	Warrego to Renner Springs	122.90
6	Renner Springs to Newcastle Waters	110.49
7	Newcastle Waters to Daly Waters	137.65
8	Daly Waters to Mataranka	125.99

In addition to the 2008 ILI data the following historical data is included in this review:

- ILI results from the previous inspection in 1997 [Ref.1 - 7].
- DCVG survey results [Ref.9].
- CP data [Ref.10].
- Validation dig-up report [Ref.8].

IONIK Consulting (IONIK) has been requested by NT Gas to perform an engineering assessment of the available data to determine the pipelines fitness for purpose (FFP).

Fitness for purpose, in terms of this report, is limited to the assessment of ILI data, for ASME B31G, CP data and DCVG data.

1.2 Scope of Work

An engineering assessment was performed on 946.5 km of the 14-inch natural gas pipeline from Tanami Road to Mataranka, with sections indicated in Table 1.1.

The tasks performed as part of this engineering assessment include:

- Review of the 1997 and 2008 ILI survey data sets.
- Perform engineering assessment of 2008 ILI survey data sets to ASME B31G.
- Compare 1997 and 2008 ILI data sets; and assess corrosion growth rates.
- Interpret DCVG and CP survey data with respect to ILI survey results.
- Determine current code compliance and estimate remnant life based on ILI, DCVG and CP data.
- Select most critical anomalies for detailed assessment.
- Perform repair scenario modelling and develop anomaly repair plan.
- Comment on available repair options for various anomaly types.
- Recommend immediate repairs, where required.
- Recommend next inspection and other planned maintenance, where required.

1.3 Abbreviations

ANOM-CORR	Corrosion Anomaly
ANOM-GWAN	Girth Weld Anomaly
ANOM-MILL	Pipe Milling Anomaly
ANOM-LAMI	Number of Laminations
ANOM-LWAN	Longitudinal Weld Anomaly
ANOM-SWAN	Spiral Weld Anomaly
ASME	American Society Of Mechanical Engineers
CDP	Corrosion Detection Pig
CORR	Corrosion Feature
CP	Cathodic Protection
CUI	Corrosion Under Insulation
DCVG	Direct Current Voltage Gradient
DNV	Det Norske Veritas
ERF	Estimated Repair Factor

FBE	Fusion Bonded Epoxy
FFP	Fitness For Purpose
HAZ	Heat Affected Zone
ICCP	Impressed Current Cathodic Protection
IONIK	IONIK Consulting
ILI	In-line Inspection
IMM	Inspection, Maintenance & Monitoring
IR	Insulation Resistance
KP	Kilometre Post
MAOP	Maximum Allowable Operating Pressure
MELO-CORR	Metal Loss Corrosion Anomaly
MFL	Magnetic Flux Leakage
N/A	Not Applicable
NON-CORR	Non-Corrosion Feature
POF	Pipeline Operator Forum
ROSEN	Rosen Australia
SACP	Sacrificial Anode Cathodic Protection
SMYS	Specified Minimum Yield Strength
SWP	Safety Working Pressure
UT	Ultrasonic Testing
UTS	Ultimate Tensile Strength
WT	Wall Thickness

1.4 Definitions

"Anomalies"	Denotes a discontinuity or imperfection that indicates deviation from the design pipe condition, which shall be assessed for compliance against the relevant assessment code.
"Could"	Indicates the probability or possibility under the specified circumstances.
"Defect" or "Defects"	Denotes a discontinuity or imperfection of sufficient magnitude to warrant rejection on the basis of the requirements of the relevant pipe integrity standard (e.g. ASME B31G). As such, any reference by ROSEN in their documentation to parent metal or weld "Defects" shall be referred to as "Anomalies / Features". It is considered that irregularities detected by ROSEN should not be categorised as a "Defect(s)" until they have been assessed as being non-compliant to an appropriate assessment code.
"Estimated Repair Factor" (ERF)	The ratio of the MAOP to a specific anomaly's safe working pressure, as predicted using ASME B31G Code (or equivalent).
"Shall"	Indicates a mandatory requirement.

1.5 Standards and Codes

The following standards and codes have been applied to this analysis:

- ASME B31G, "Manual for Determining the Remaining Strength of Corroded Pipelines" [Ref.12].
- DNV-RP-F101, "Corroded Pipelines" [Ref.14].
- AS2832.1, Cathodic Protection of Metals - Pipes and Cables [Ref.16].
- NACE SP0502, Pipeline External Corrosion Direct Assessment Methodology [Ref.17].
- ISO 15589, Cathodic Protection of Pipeline Transportation Systems - Part 1: On-land Pipelines [Ref.18].

2.0 SUMMARY, CONCLUSION, RECOMMENDATIONS

2.1 Summary

A FFP assessment of the corrosion anomalies on the 14-inch NT Gas pipeline was performed in accordance with the methodology in ASME B31G [Ref.12] to the end of pipeline design life in 2036 [Ref.15, APPENDIX I].

The following corrosion rates were identified and assessed.

- Proportional anomaly growth from 1986 to 2036.
- Growth rates of matched anomalies from the ROSEN 1997 and 2008 most severe anomalies.

Descriptions of each case are given in Section 5.0, Corrosion Rate Assessment.

An engineering assessment was performed for both corrosion rates, using IC-Finesse FFP software. Refer to APPENDIX B for the IC-Finesse output graphs of the assessment.

Repair scenario modelling was performed on non-compliant anomalies for both corrosion rates. Repairs were grouped into 5 yearly blocks for the time in which the anomaly is predicted to become a defect. Refer to Section 8.0.

A review of the CP and DCVG survey data is included in Section 7.0, in accordance to AS2832.1 [Ref.16] and NACE SP0502 [Ref. 17]. Refer to APPENDIX C, APPENDIX D and APPENDIX E for a summary of survey's results.

APPENDIX K provides details of each of the non-compliant anomalies over the next 10 years, for proportional growth rates. This detail is only provided for the proportional growth rate as this is the assessment that IONIK recommend be used for the FFP of the 14" gas pipeline.

2.2 Conclusions

Based on the findings from this engineering assessment, the following conclusions are made:

1) Based on the available 2008 IP data and assessment to ASME B31G, the NT Gas 14-inch pipeline is currently Fit-For-Purpose. All anomalies are currently code compliant and there is no immediate rectification required.

2) Using IC-Finesse to grow each anomaly to the end of pipeline life (2036) based on its individual proportional growth between installation and 2008 inspection:

- The first anomaly is predicted to exceed code requirements in 2014.
- Table 2.1 highlights the number of predicted failures in the next 10 years.
- 2689 anomalies are predicted to exceed code requirements prior to the end of the pipeline design life in 2036 (1).

3) Using the average corrosion rates of the most severe anomalies (comparison growth) matched between the 1997 and 2008 inspections:

- The first anomaly is predicted to exceed code requirements by comparison growth, in 2013.
- Table 2.1 highlights the number of predicted failures in the next 10 years.
- 75074 anomalies are predicted to exceed code requirements prior to the end of the pipeline design life in 2036 (1) .

Table 2.1
First Anomalies Predicted to Exceed Code Requirements

Year Block	Number of Failures	
	Proportional Growth	Comparison Growth
0	0	0
1 - 5	0	1
6 - 10	17	1120

4) From calculated corrosion rates (see Section 5.0) it is concluded that the individual proportional growth method provides a more realistic estimate of corrosion rates. The comparison growth method could only be based on matching a select number of anomalies between 1997 and 2008 and is therefore, considered to be less reliable.

Note (1): These are anomalies predicted to exceed code requirements by end of pipeline design life in 2036. These values assume conditions remain exactly the same, which is not possible over its design life. Therefore, predicted values should be used only as indications of possible future behaviour, allowing for targeted inspection, maintenance and monitoring (IMM).

5) For each pipeline section, Table 2.2 summarises the anomalies that are predicted to be non-compliant by 2036. Refer to APPENDIX B for the defect assessment curves.

Table 2.2
Non-Compliant Defects Predicted by 2036

Pipeline Section	Number Non-Compliant Defects			2008 CP Survey
	Proportional Growth	Comparison Corrosion Rate Growth		
		EXTERNAL	INTERNAL	
Tanami Rd - TI Tree	7	0	0	65% Under-protected
TI Tree - Wauchope	9	0	0	29% Under-protected
Wauchope - Warrego	29	112	0	91% Under-protected
Warrego - Renner springs	10	5	0	12% Under-protected
Renner Springs - Newcastle Waters	449	4860	0	55% Under-protected
Newcastle Waters - Daly Waters	1497	26753	0	56% Under-protected
Daly Waters - Mataranka	688	43344	0	Protected

6) The CP surveys indicate that significant sections of the pipeline are unprotected, as indicated in Table 2.2. An over-protected potential reading at KP 316 is also reported.

7) Two (2) of the reported coating defects (KP 844.42 and KP 981.8) were reported as Category 3 defects and therefore, shall be included in a planned repair program.

8) Based on all three (3) survey results of IP, CP and DCVG, the pipeline sections that have the most anomalies are from Renner Springs to Mataranka (Section 6, 7 and 8). Sections 6 and 7 of the pipeline display inadequate CP protection for the last three (3) consecutive years, have the highest number of defects where IR is greater than 30% from the DCVG survey, and have a high number of anomalies identified by the ILI. For Section 8 (Daly Waters to Mataranka), even though there is a high number of anomalies identified by the IP run, the CP survey indicates that this section of the pipeline has been protected for the last three (3) years consecutively.

2.3 Recommendations

The following recommendations are made following the engineering assessment.

2.3.1 ILI Recommendations

1) Verify the 15 external corrosion anomalies that have currently not been verified or repair to date, [Ref. APPENDIX K] by 2013. Review corrosion rate and predicted end of life to determine whether remedial action is required prior to the next recommended ILI in 2018.

2) ROSEN to review and/or clarify data quality on the number of anomalies reported in both 1997 and 2008.

3) Verify, wherever practical, any of the reported internal corrosion anomalies to increase confidence in ROSEN feature identification.

4) Further review of girth weld anomalies and anomalies close to girth welds (±25-150mm to nearest girth weld) using applicable code such as API 579.

5) Reinspect the 14-inch pipeline by ILI by 2018. Subsequently, the following should be actioned:
   - Verification of anomalies in each section of the pipeline.
   - FFP assessment of ILI survey data.
   - Review of corrosion rates calculated in this report.
   - Review of repair scenario modelling based on updated corrosion rates.

2.3.2 CP System Recommendations

1) Carry out verification of the CP system at KP 254.1 (Section 2), KP 759.8 (Section 6) and KP 844.4 (Section 7) to determine the potential connection of the pipeline to an earthing system and/or breakdown of insulation joints. Carry out remedial action if required.

2) Verify the pipeline CP off potential reading at KP 316 (Section 2) as an over-protection reading was recorded which is not consistent with the readings in previous years.

3) Adjust the ICCP system current output accordingly to ensure adequate CP is applied whilst minimising any areas of over-protection over the entire pipeline.

4) A full pipeline off potential survey and corresponding CP review is then required in order to assess the efficiency of the CP system and highlight any remaining sporadic readings.

2.3.3 Coating Survey Recommendations

1) Immediate inspection of coating defects at KP 844.42 and KP 981.8. Following results of inspection work, coating repair may be required.

2) Survey, by DCVG of pipeline Section 6 and Section 7, as soon as it is practicable, and determine cause for high CP attenuation along Section 7.

3.0 DATA SUMMARY

3.1 Input Data

Input data to the FFP assessment is obtained from:

- Rosen Report - NT Gas 14" Gas Pipeline (Section 2) Tanami road – TI Tree. [Ref. 1].
- Rosen Report - NT Gas 14" Gas Pipeline (Section 3) TI Tree - Wauchope. [Ref.2].
- Rosen Report - NT Gas 14" Gas Pipeline (Section 4) Wauchope - Warrego. [Ref.3].
- Rosen Report - NT Gas 14" Gas Pipeline (Section 5) Warrego – Renner Springs. [Ref.4]
- Rosen Report - NT Gas 14" Gas Pipeline (Section 6) Renner Springs – Newcastle Waters. [Ref.5].
- Rosen Report - NT Gas 14" Gas Pipeline (Section 7) Newcastle Waters – Daly Waters. [Ref.6].
- Rosen Report - NT Gas 14" Gas Pipeline (Section 8) Daly Waters - Mataranka. [Ref.7].
- Metal Loss Dig Up List – EXCEL Spreadsheet supplied by NT Gas [Ref.8]
- Cumulative DCVG Inspection Result - EXCEL Spreadsheet supplied by NT Gas [Ref.9]
- Pipe To Soil Potential - EXCEL Spreadsheet supplied by NT Gas [Ref.10]

3.2 Pipeline Data

Pipeline design and operational data used in this engineering assessment is given in Table 3.1.

Table 3.1
Pipeline Data [Ref.1 - 7]

PARAMETER	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8
	Tanami Rd - Ti Tree	Ti Tree - Wauchope	Wauchope - Warrego	Warrego - Renner Springs	Renner Springs - Newcastle Waters	Newcastle Waters - Daly Waters	Daly Waters - Mataranka
Pipeline Nominal Diameter (mm)	355.60	355.60	355.60	355.60	355.60	355.60	355.60
Wall Thickness (mm)	5.80 (main) / 7.14 / 8.74	5.80(main) / 8.74	5.80(main) / 7.14 / 8.74	5.80(main) / 7.14 / 8.74	5.80(main) / 8.74	5.80(main) / 8.74	5.80(main) / 8.74
Length of Section (km)	155.05	141.97	152.70	122.90	110.49	137.65	125.99
Pipe Material	API 5L X60	API 5L X60	API 5L X60	API 5L X60	API 5L X60	API 5L X60	API 5L X60
Corrosion Coating	HDPE (1.2mm)						
CP system	Impressed current (at KP 237.6 a sacrificial anode exists)						
SMYS (MPa)	413						
Product	Dry Gas						
Year of Installation	1986						
License Expires	2036						
Design Pressure (MPa)	9.65						
MAOP (MPa)	9.65						
Current Operating Temperature (°C)	28						

3.3 Discrepancies in ROSEN Data

It should be noted that the ROSEN reports have inconsistencies regarding how the number of defects per section is calculated. In Section 2, Tanami Rd – Ti Tree, the total number of defects reported by ROSEN is the total of defects before clustering, where in the remaining sections the total number of defects reported are the total defects after clustering by ROSEN.

For the purpose of this assessment, the total number of defects before clustering are used, therefore, the numbers throughout may not match up with the ROSEN report.

3.4 IP Data Quality

The full length of the pipeline was inspected in seven (7) different sections, each section being complete in one (1) run.

ROSEN reported that all the survey data was of good quality, except for that of the Ti Tree to Wauchope section (Section 3) where some minor data loss was observed from 401,451.277m to 401,458.633m. Data from a previous inspection (1997) was utilised for these areas of data loss.

In the Wauchope to Warrego section (Section 4) all measuring channels, both primary and secondary, functioned properly and the data recorded is of good quality and complete; except for one (1) primary sensor carrier, which was observed to fail for the entire run. For the remaining sections, all measuring channels, both primary and secondary, functioned properly.

In the final section, Daly Waters to Mataranka (Section 8), two CDP runs were performed as the data quality of the first CDP run was not within ROSEN specifications. All reporting is based on the second CDP run.

3.4.1 Tool Top Position

For all sections, tool rotation was considered to be good.

3.4.2 Velocity

The velocity during all runs was within the pre-programmed ranges of the tool: Minimum velocity: 0.5 m/s; Maximum velocity: 5.0 m/s and Maximum acceleration; no greater than 3.0 m/s^2.

3.4.3 Magnetization

The magnetization during all runs was slightly above 30 kA/m. However, there is no significant effect on the sizing of the features.

3.5 MELO Corrosion IP Tool Tolerances

Site dig-ups have been carried out to validate the 1997 and 2008 IP runs. These validations are focused on the most severe anomalies. To obtain the applied tool tolerances (see Table 3.2), the percentage wall loss from the ROSEN data was compared to the field measured wall loss at the corresponding KP and clock position, for both data sets. As 2008 data set is used for proportional growth assessment, the maximum verified tool tolerance (rounded up) is used for each section. If the tolerance falls below 5%, then a tool tolerance of 5% is used for conservative purposes (see APPENDIX L for further details). The FFP assessment applies the quoted tool tolerances to individual anomalies.

For the prediction of corrosion growth in the assessment of matched anomaly, the minimum tool tolerance of the 1997 data and the maximum tool tolerance of 2008 data are used in order to obtain the worst case scenario.

Table 3.2 summarises the applicable tolerances applied to reported feature depths for worst-case assessment. These tool tolerances are only applicable to the depth of the defect.

Table 3.2
Tool Tolerances [Ref.8]

Section	Pipeline Section	1997 Data tolerance %	2008 Data tolerance %
2	Tanami Rd to Ti Tree	-18.4	5
3	Ti Tree to Wauchope	-13.8	5
4	Wauchope to Warrego	7.5	20
5	Warrego to Renner Springs	3	5
6	Renner Springs to Newcastle Waters	-8.3	5
7	Newcastle Waters to Daly Waters	-11.8	5
8	Daly Waters to Mataranka	-19.9	5

4.0 METHODOLOGY

A review of the IP data, along with the CP survey and DCVG survey obtained from NT Gas is included in Section 6.0 and Section 7.0. A side by side comparison of the results is included in APPENDIX C.

4.1 ILI Assessment

Each feature is assessed against ASME B31G to confirm safety to operate, with any anomaly failing the criteria subject to repair or rehabilitation well before critical condition is reached.

ASME B31G requires a FFP assessment to be conducted if the pipeline is shown to contain anomalies with a corroded depth greater than 10% of wall thickness. If anomalies are found with a corroded depth greater than 80%, these anomalies are considered defective and must be repaired if the pipeline is to remain in service.

If the corroded depth is greater than 10% but less than or equal to 80% then FFP of the pipeline is based on MAOP. Any anomalies determined to be defects at the pipeline's MAOP must be either repaired or the pipeline's MAOP reduced.

The ROSEN data was entered into IC Finesse and individual anomalies were grown at specified corrosion rates (see Section 5.0) for the pipelines remaining life from 2008 to 2036. IC Finesse assesses the anomalies to ASME B31G and calculates a failure pressure of each anomaly. This is then compared to the MAOP of the pipeline to determine if the defect will fail prior to the end of the design life.

A repair schedule is then created in IC Finesse for each pipeline section to reflect the time frames of the failures.

4.2 CP Survey

All CP readings provided by NT Gas were compared against the standard AS2832.1 [Ref.16] and previous surveys, to give an indication as to the level of CP the pipeline is experiencing.

The criteria for the protection of an onshore buried ferrous structure (as per AS 2832.1 [Ref.16]) is to maintain a potential on all parts of the structure equal to, or more negative than, -850mV with respect to a saturated copper/copper sulphate reference electrode. Any potential that is more positive than -850mV is classified as under-protected. However the structure should not be polarised more negative than -1200mV as any potential more negative than this value is classified as overprotected. Overprotection is to be avoided as it increases the susceptibility of pipeline coating disbondment and hydrogen embrittlement especially for the parts of the pipeline that is made of high strength materials [Ref.16].

4.3 DCVG Survey

Percentage IR readings from the DCVG surveys provided by NT Gas were compared to NACE SP0502 [Ref.17] and categorised, providing guidance for required maintenance activities. The potential difference is expressed as a fraction of the total potential shift on the pipeline, resulting in a value termed the %IR. Based on NACE SP0502 [Ref.17], the DCVG survey readings are classified into four groups as follows:

- Category 1: 1% to 15% IR – Holidays in this category are often considered of low importance, and repair is not required. A properly maintained cathodic protection system generally provides effective long-term protection to these areas of exposed steel.

- Category 2: 16% to 35% IR – Holidays in this category may be recommended for repair, based on proximity to groundbeds or other structures of importance. The holidays are generally considered of no serious threat and are likely to be adequately protected by a properly maintained CP system. This type of holiday may be slated for additional monitoring-fluctuations in the levels of protection could alter this status as the coating further degrades.

- Category 3: 36% to 60% IR - Holidays in this category are generally considered worthy of repair. The amount of exposed steel in such a holiday indicates it may be a major consumer of protective CP current and that serious coating damage may be present. These holidays would normally be recommended for programmed repair, based on proximity to groundbeds or other structures of importance. They may be considered a threat to the overall integrity of the pipeline. As in Category 2 holidays, this type of holiday may be slated for monitoring because fluctuations in the levels of CP could alter the status as the coating further degrades.

- Category 4: 61% to 100% IR - Holidays in this category are generally recommended for immediate repair. The amount of exposed steel indicates that the holiday is a major consumer of protective CP current and that massive coating damage may be present. Category 4 holidays typically indicates the potential for very serious problems with the coating and is often considered likely to pose a threat to the overall integrity of the pipeline.

Anomalies that have been left unrepaired from previous surveys are highlighted for maintenance activities.

4.4 FFP Assessment Limitations / Assumptions

The IONIK FFP assessment of MELO corrosion anomalies is limited to the following criteria:

- The pipeline was commissioned in 1986 and has a license to operate to 2036.
- It is assumed there are no residual stresses in the pipeline that might affect the assessment methodology.
- Defect repairs would be conducted at the beginning of the repair year.
- The assessment has been performed applying corrosion rates to depth and length dimensions of the anomalies.
- The assessment has been performed with the assumption that the conditions remain exactly the same during the remaining life of the pipeline.
- Metal loss anomalies are assessed to ASME B31G [Ref.12].
- The 14" pipeline was assessed to ASME B31G. Therefore, the following limitations apply to this code:
  - Girth weld corrosion features.
  - Weld heat affected zones (HAZ).
  - Defects introduced during pipe or plate manufacturing are not assessed.
  - Anomalies caused by mechanical damage are not assessed.
  - Anomalies introduced during pipe or plate manufacture are not assessed.
- The assessed anomalies were adjusted to account for the IP tool tolerances. Details can be found in Section 3.5.
- Interaction between defects has not been checked or assessed.
- Anomaly depths are conservatively taken as the maximum percentage wall loss identified by ROSEN and not the average percentage wall loss as presented in the MELO tally.

5.0 CORROSION RATE ASSESSMENT

5.1 Summary

84,274 MELO-CORR anomalies were assessed to ASME B31G. A MAOP of 9.65 MPa has been used for the FFP assessment, undertaken using IONIK's validated IC-Finesse software package [Ref. 20].

The measured depth corrosion rates of the defects were identified and assessed using two (2) methods:

- Proportional anomaly growth from 1986 to 2036.
- Growth rates of matched anomalies from the ROSEN 1997 and 2008 most severe anomalies.

The results are used to determine the extent, nature and time scale of remedial work required to maintain integrity of the pipeline throughout the required service life.

5.2 Proportional Growth Rates

The 2008 data set was assessed using corrosion rates calculated by IC Finesse. The individual anomalies are grown for the pipelines remaining life from 2008, in proportion to their individual pre-existing growth between installation and 2008.

A tool tolerance (derived from the NT gas verification work [Ref.8]) was applied to the 2008 data. Applied tolerances are provided in Table 3.2.

5.3 Matched Anomaly Growth Rates

This method assesses the anomalies using the most severe growth rates between matching the most severe anomalies from the 1997 and 2008 data.

5.3.1 Measured Corrosion Rate – ERF & Depth

The most severe external anomalies, based on ERF and depth, from the 2008 and 1997 data sets were compared against each other to calculate anomaly growth trends between the two inspections. Anomalies at matching positions, both distance and o'clock, were considered to be the same anomaly. Tool tolerances, as derived from NT Gas dig up verification (See Table 3.2) were applied to the 1997 and 2008 anomalies.

Once all anomalies were matched corrosion rates could be calculated for each anomaly by dividing the growth of the anomaly by the years it had been growing for. The average corrosion rate was then taken for that particular section. This method was used to calculate the corrosion rate for both depth and length of the anomalies.

Anomalies were matched up, tool tolerances applied and corrosion rates calculated for each section. The Internal corrosion rates for each section were again derived from the average calculated corrosion rates from the most severe anomalies.

The calculated corrosion rates for each section is summarised in Table 5.1.

Table 5.1
Corrosion Rates (mm/yr)

Section Number	Pipeline Section	EXTERNAL		INTERNAL	
		Length (mm/yr)	Depth (mm/yr)	Length (mm/yr)	Depth (mm/yr)
2	Tanami Road - TI tree	0.38	0.03	0.75	0.01
3	TI tree - Wauchope	1.22	0.03	No growth observed	0.03
4	Wauchope - Warrego	0.87	0.08	1.14	0.01
5	Warrego - Renner Springs	0.88	0.04	0.27	0.02
6	Renner Springs - Newcastle Waters	0.73	0.15	No internal anomalies recorded	No internal anomalies recorded
7	Newcastle Waters - Daly Waters	0.63	0.11	1.45	0.02
8	Daly Waters - Mataranka	0.88	0.11	0.64	0.01

It can be seen that for section 6 – 8, the estimated corrosion rates are quite high compared to other sections. These corrosion rates are conservative as they represent the corrosion rates of the most severe anomalies only, and not the pipeline as a whole. Therefore, the FFP assessment based on these corrosion rates should only be used as an indication for future inspection, maintenance and monitoring (IMM) planning.

For a less conservative and more realistic view of the pipeline status and corrosion rate over pipeline design life, the proportional growth method is recommended.

However, it is not recommended to apply these corrosion rates to projected anomaly behaviour as rates will change according to pipeline and operating conditions. Therefore, ILI surveys shall be performed within the next 10 years to re-evaluate corrosion rates.

6.0 RESULTS: ILI ASSESSMENT

6.1 Review of ROSEN Reported Features

ROSEN reported that a total of 73,372 features (after corrosion anomalies clustering) were identified during the ROSEN 2008 IP inspection of the 14” NT Gas Pipeline. A summary of these features by type, for each section, is given in APPENDIX F.

There are several girth weld anomalies listed in the results. These indications may possibly be caused by anomalies such as lack of penetration, lack of fusion or minor misalignment etc. Dimensions of metal loss anomalies reported close to the girth weld may be reduced due to the HAZ of the girth welds.

In addition to the reported metal loss anomalies, a number of very small sized signals are visible in the data but calculated below the reporting threshold of less than or equal to 5% wall loss. This occurs in the following sections: Ti Tree - Wauchope, Warrego - Renner Springs and Newcastle Waters - Daly Waters.

6.2 Review of External Corrosion Features

A total of 84,211 external metal loss anomalies were identified across all seven (7) sections of the pipeline from the 2008 IP survey [Ref.1 - 7]. Refer to APPENDIX G for the breakdown of anomalies by section. The most severe external anomaly located on the Newcastle Waters to Daly Waters section of the pipeline (log distance 893,702.413m and clock position 07:18), was found to have a maximum detected wall loss of 57%.

6.3 Review of Internal Corrosion Features

A total of 63 internal metal loss anomalies were identified across all seven (7) sections of the pipeline from the 2008 IP survey [Ref.1 - 7]. Refer to APPENDIX G for the breakdown of anomalies by section.

Due to the dry environment and the absent of oxygen in the pipeline, it is first assumed that internal corrosion will not be present. However, since the ILI run has identified these anomalies as internal corrosion features, it is recommended that a verification of these anomalies is performed, if practical. This would further increase confidence in ROSEN internal anomalies identification and allows better indications for targeted inspection, maintenance and monitoring (IMM) by modifying existing repair plan accordingly.

6.4 MELO Corrosion Anomalies

Metal loss corrosion anomalies, for both internal and external defects, are classified by the Pipeline Operator Forum (POF) specification [Ref.11] and are shown for each section, in

APPENDIX G. A summary of the corrosion anomaly totals from both the 1997 survey and the 2008 survey can be seen in Table 6.1.

Table 6.1
Number of Corrosion Anomalies Identified by ILI Surveys

Section	Pipeline Section	1997 survey	2008 survey	% Increase
2	Tanami Road - TI tree	211	415	96.68
3	TI tree - Wauchope	238	171	-28.15
4	Wauchope - Warrego	167	188	12.57
5	Warrego - Renner Springs	99	136	37.37
6	Renner Springs - Newcastle Waters	730	4866	566.58
7	Newcastle Waters - Daly Waters	1776	34982	1869.71
8	Daly Waters - Mataranka	3309	43511	1214.93

It can be seen that there are inconsistencies in the number of anomalies reported as section 3 recorded a decrease of anomalies between ILI inspections. Therefore, to truly determine the number of features present, it is recommended that a review of data quality in these areas to be revisited by ROSEN.

A summary of the location of anomalies in regards with the nearest girth weld is provided in Table 6.2.

Table 6.2
Placements of Corrosion Anomalies Identified by ILI Surveys

Section		2	3	4	5	6	7	8
Pipeline Section		Tanami Road - TI tree	TI tree - Wauchope	Wauchope - Warrego	Warrego - Renner Springs	Renner Springs - Newcastle Waters	Newcastle Waters - Daly Waters	Daly Waters - Mataranka
2008 survey		415	171	188	136	4866	34982	43511
Girth Weld Individual Corrosion Anomalies (±25mm)	Total	0	0	1	2	265	3142	4037
	Percentage	0.00%	0.00%	0.53%	1.47%	5.45%	8.98%	9.28%
Close To Girth Weld Individual Corrosion Anomalies (±25-150mm)	Total	10	1	2	15	4363	30892	38107
	Percentage	2.41%	0.58%	11.17%	11.03%	89.66%	88.31%	87.58%
Parent Plate Individual Corrosion Anomalies	Total	405	170	167	119	238	948	1367
	Percentage	97.59%	99.42%	88.83%	87.50%	4.89%	2.71%	3.14%

From Table 6.2, it is observed that in section 6 to section 8, a very high percentage of corrosion anomalies are located in or close to girth weld, as opposed to in previous sections, where corrosion anomalies are generally parent plate anomalies. Having a closer look at the POF classification, it is found that the corrosion anomalies close to girth welds are typically pitting anomalies, which indicates general external corrosion is occurring. Refer to APPENDIX N for a detail list of welds containing and/or close to corrosion anomalies.

6.5 MELO Non-Corrosion Anomalies

A total of 1176 metal loss non-corrosion anomalies were reported by ROSEN. These anomalies are classified as pipe mill anomaly and gouging anomaly.

No FFP assessment is performed on them as these features are not recognised as corrosion anomalies, and are not expected to have deteriorated since construction. Therefore, they are deemed operationally FFP, if pipeline hydro-test had been performed.

6.6 Non-Metal Loss Anomalies

A total of 139 non-metal loss anomalies were identified. Refer to APPENDIX F for the categorisation of these anomalies by type. These features are not within the scope of this FFP assessment.

6.7 FFP of 2008 ILI Survey Data

Based on the available 2008 IP data and assessment to ASME B31G, the NT Gas 14-inch pipeline is currently Fit-For-Purpose. All anomalies are currently code compliant and there is no immediate rectification required. However, it should be noted that ASME B31G has limitations to girth weld and close to girth weld anomalies (±150mm from nearest girth weld), therefore further review of these anomalies using code such as API 579 is recommended.

Using IC Finesse to grow each anomaly proportionally, the first anomaly is predicted to become non-code compliant in 2014. This feature at KP 797.748 in Section 6 (Renner Springs to Newcastle Waters) should be inspected by 2013, re-assessed and if required, repaired by 2014.

A total of 17 anomalies are predicted to become non-code compliant within the next 10 years [Ref. APPENDIX K]. These anomalies, if unrepair to date, are required to be inspected and re-assessed by 2013, followed by any repairs necessary.

There are 2689 anomalies that are predicted to fail code prior to the end of the pipeline design life in 2036.

Table 6.3 gives a summary of these anomalies by section.

Table 6.3
Number of Non-Compliant Defects by 2036 Based on Proportional Growth

Pipeline Section	Number Non-Compliant Defects (Based On Proportional Growth)	
	EXTERNAL	INTERNAL
Tanami Rd - TI Tree	3	4
TI Tree - Wauchope	7	2
Wauchope - Warrego	29	0
Warrego - Renner Springs	9	1
Renner Springs - Newcastle Waters	449	0
Newcastle Waters - Daly Waters	1497	0
Daly Waters - Mataranka	688	0

Using the average corrosion rates of the most severe anomalies matched between the 1997 and 2008 inspections, the first anomaly to become non-code compliant will do so in 2013. 75074 anomalies are predicted to fail code prior to the end of the pipeline design life in 2036. Table 6.4 gives a summary of these anomalies by section.

Table 6.4
Number of Non-Compliant Defects by 2036. Based on Average Corrosion Rate of Matched Most Severe Anomalies

Pipeline Section	Number Non-Compliant Defects (Based On Comparison Growth)	
	EXTERNAL	INTERNAL
Tanami Rd - TI Tree	0 (2)	0 (2)
TI Tree - Wauchope	0 (2)	0 (2)
Wauchope - Warrego	112	0 (2)
Warrego - Renner Springs	5	0 (2)
Renner Springs - Newcastle Waters	4860	0 (1)
Newcastle Waters - Daly Waters	26753	0 (2)
Daly Waters - Mataranka	43344	0 (2)

Note (1): No internal anomalies are recorded in this section.
Note (2): No failures after applying corrosion rate to anomaly.

All anomalies that are predicted to fail code by end of pipeline design life in 2036 are with the assumption that the conditions remain exactly the same. This is generally not possible over its design life. Therefore, predicted values should be used only as indications of possible future behaviour, allowing for targeted inspection, maintenance and monitoring (IMM).

7.0 RESULTS: EXTERNAL SURVEYS

7.1 CP survey

An Impressed Current CP (ICCP) system is in place for the pipeline from Tanami to Mataranka. A Magnesium Sacrificial Anode Cathodic Protection (SACP) system is also implemented at KP 237.6. The CP readings along the pipeline from Tanami to Mataranka have been taken at 554 locations in 2007 and 558 locations in 2008.

The test point potential survey indicates that only 55.5% and 26.9% of the pipeline in 2008 and 2007 respectively, were cathodically protected as per AS 2832.1 [Ref.16]. This standard has stated that the criteria for the protection of a buried ferrous structure is to maintain a potential on all parts of the structure equal to, or more negative than, −850 mV with respect to a saturated copper/copper sulphate reference electrode. The survey indicates that major parts of the pipeline are unprotected. The results from the survey are summarised in Table 7.1.

Table 7.1
2008 CP Off Potential Readings

Section	Pipeline Section	Total Readings Taken	Total anomalies	
			Under Protected Readings	Overprotected Readings
2	Tanami Rd to Ti Tree	83	55 (65%)	1 (1%)
3	Ti Tree to Wauchope	84	24 (29%)	0
4	Wauchope to Warrego	82	75 (91%)	0
5	Warrego to Renner Springs	69	8 (12%)	0
6	Renner Springs to Newcastle Waters	80	44 (55%)	0
7	Newcastle Waters to Daly Waters	85	48 (56%)	0
8	Daly Waters to Mataranka	75	0	0

Full details of the survey are included in APPENDIX E.

From the 2008 CP off potential survey, it was found that 3 locations were more positive than the natural or unprotected potential of steel in soil. The corresponding test point location and the off potential reading were:

- KP 254.1 = -440mV
- KP 759.8 = -400mV
- KP 844.4 = -380mV

The measured off-potential suggests that the pipeline could be connected to an earthing system, or possibly caused by a break down of insulation joints.

APPENDIX D shows 2008 CP readings against the external corrosion anomalies detected along the pipeline from Tanami to Mataranka. The readings in section 2, section 4, section 6 and section 7 of the pipeline, highlights the possibility of inadequate CP.

An over-protected potential reading had been reported in the 2008 survey, which is on the pipeline section of Tanami road to Ti-tree at KP 316 with potential reading of -1,250mV. A review of historical data indicates that this over-protected section has only become a problem in the latest survey, indicating either a fault along the pipeline or that survey results may not be reliable. Verification of the pipeline CP off potential reading at KP316 (section 2) is required.

7.2 DCVG Survey

From the available DCVG survey results from 2003 to 2009, none of the defects reported are classified as Category 4, in accordance with NACE SP0502 [Ref. 17] and so there are no immediate repair requirements.

There are seven (7) defects that are classified as Category 3, with maximum of 50% IR at KP 610.85. One (1) of these coating defects has been repaired and two (2) coating defects are left unrepaired at KP844.42 and KP981.80 [Ref.9], with 38% IR and 35.7% IR respectively. An immediate inspection of the coating at these locations is recommended.

The readings recorded for the 2009 survey for Section 6 (Renner Springs to Newcastle Waters) and Section 7 (Newcastle Waters to Daly Waters) of the pipeline are incomplete due to ground bed problems. Although there were two sections not surveyed, an increase in the overall number of defects in the surveyed sections is observed compared to previous year surveys. Therefore, it is recommended that DCVG survey is performed on Sections 6 and 7, as soon as it is practicable.

The readings, as reported by NT Gas, are summarised in Table 7.2.

Table 7.2
DCVG Survey Results

Section	Pipeline Section	Number of Readings						Comment
		<1%	1% - 15%	15% - 30%	30% - 60%	>61%	Total	
2	Tanami Rd to Ti Tree	2	423	13	2	0	440	Last survey: 2005 & 2006
3	Ti Tree to Wauchope	4	481	22	0	0	507	Last survey: 2005
4	Wauchope to Warrego	9	615	18	1	0	643	Last survey: 2004
5	Warrego to Renner Springs	1	428	30	3	0	462	Last survey: 2004 & 2005
6	Renner Springs to Newcastle Waters	2	95	20	5	0	122	Last survey: 2009 Results only available from: - KP 733.71 to KP 793.43
7	Newcastle Waters to Daly Waters	1	172	33	4	0	210	Last survey: 2009 Results only available from: - KP 844.41 to KP 855.915 - KP 959.0 to KP981.8
8	Daly Waters to Mataranka	3	140	2	0	0	145	Last survey: 2009

8.0 IMMR PLANNING

8.1 Summary

Repair scenario modelling in 5 year blocks was performed to the end of pipeline life in 2036, including the last year of the design life. The pipeline is evaluated by 'growing' existing corrosion features linearly, at the estimated rate(s) of metal loss, to the end of pipeline life date. The features were also grown using corrosion rates calculated from the worst case feature growth, of each section, between the 1997 and the 2008 ILI data. These were summarised in Table 5.1.

8.2 Estimated Repair Schedule

The repair schedule reports anomalies that are predicted to become defects in a particular year and therefore require repair. It is assumed the defects should be repaired at the beginning of the block of the years. Repair block year 0 indicates the present FFP state of the pipeline and year 28 is representative of its condition in 2036.

The repair schedules derived for each growth rate is summarised below. Details for each section can be seen in APPENDIX H.

Table 8.1
Repairs Per Year Block

Repair Block (Year)	Proportional Growth	Comparison Growth
0	0	0
1 - 5	0	1
6 - 10	17	1150
11 - 15	156	2816
16 - 20	559	11369
21 - 25	1040	37757
26 - 27	556	17764
28	361	4217

A summary of the proportional growth defects, that will become non-compliant in the next 10 years, can be seen in APPENDIX K.

8.3 Repair Options

Defects in pipelines may be repaired by a variety of methods, both temporary and permanent. Selection of the most appropriate repair method will depend on a number of factors such as feature size and location, accessibility, operating conditions, life criteria and so forth. Those that have been commonly used by pipeline operators are highlighted below.

8.3.1 Wraps

Temporary wraps can be place on the pipeline in the areas of the defects. These wraps are designed to provide additional corrosion protection and protect the existing defects.

The wrap can be applied in situ without and shutdown or depressurisation of the pipeline, however it is not a permanent repair for the existing defects. Wraps may not be able to withstand the pipeline MAOP and therefore, would require replacement, with a more permanent method, if long term fitness for service becomes an issue.

8.3.2 Composite Sleeve

In recent years, composite sleeves have been developed and used for repair of non-leaking pipeline defects. Most of the composites are fiberglass materials, but some are other types of materials, such as carbon fiber-based composites. There are two basic types of fiberglass composites being used as reinforcement sleeves: rigid material (limited to relatively straight sections of pipe) and flexible material (can be applied to bends, elbows, and tees).

The system usually consists of three (3) parts:

1) A unidirectional composite wrap material.
2) A two-part polymer adhesive between the wrap and the pipe and between layers of the wrap.
3) A high compressive strength filler compound for load transfer.

The advantages of composite reinforcements compared with steel sleeves are easier handling of the materials, lower skill requirements for installation personnel, more rapid installation, no shutdown required for installation and lower overall cost. However the composite sleeve is not yet taken as a permanent fix to the pipeline. Similar to wraps, these sleeves may require replacement in the future.

8.3.3 Welded Sleeve

The welded sleeve is designed to the same standards as the carrier pipe and therefore is capable of containing full operating pressure. The ends of the sleeve are welded to the carrier pipe making it a permanent repair for the pipeline.

As hot work is required for installation, the pipeline would have to be shut down and depressurised.

8.3.4 Clamping

Several types of mechanical clamps are available from various commercial vendors. These clamps are designed to contain full pipeline pressure, so they are generally rather thick and heavy because of the large bolts used to provide the required clamping force. The clamps normally have elastomeric seals to contain the pressure if the pipeline is leaking at the defect.

Breaking containment is not necessary for the installation of the clamps therefore; no shut down of the pipeline would be required.

8.3.5 Cut and Replace

Removal of the defective section of the pipe and replacement with a new pipe section is another permanent repair method. The defective section is cut out as a cylinder and replaced with the new pipe. The pipeline would then have to be pressure tested, as required by code.

Removal and testing of the pipe section will necessitate shutdown and depressurisation of the pipeline.

Table 8.2
COMPARISON OF REPAIR METHODS

Methods	Permanent?	Requires Shut-in?	Material Cost	Ease of Repair	Repair Timeframe	Repair Cost
Wraps	x	x	Low	Easy	Short	Low
Composite Sleeves	x	x	Low	Easy	Short	Low
Welded Sleeves	✓	✓	Medium	Medium	Medium	High
Clamping	✓	x	Medium	Easy	Medium	Medium
Cut and Replace	✓	✓	High	Difficult	Large	High

9.0 REFERENCES

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5. Rosen Final Inspection Report, June 2008. NT Gas 14” Gas Pipeline (Section 6) Renner Springs – Newcastle Waters. Project No. 9-6100-10460, Rev. C.

6. Rosen Final Inspection Report, June 2008. NT Gas 14” Gas Pipeline (Section 7) Newcastle Waters – Daly Waters. Project No. 9-6100-10460, Rev. B.

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18. ISO 15589, 2003, Cathodic Protection of Pipeline Transportation Systems - Part 1: On-land Pipelines.

19. NT Gas, November 2008, NT Gas Pipeline Schematic.

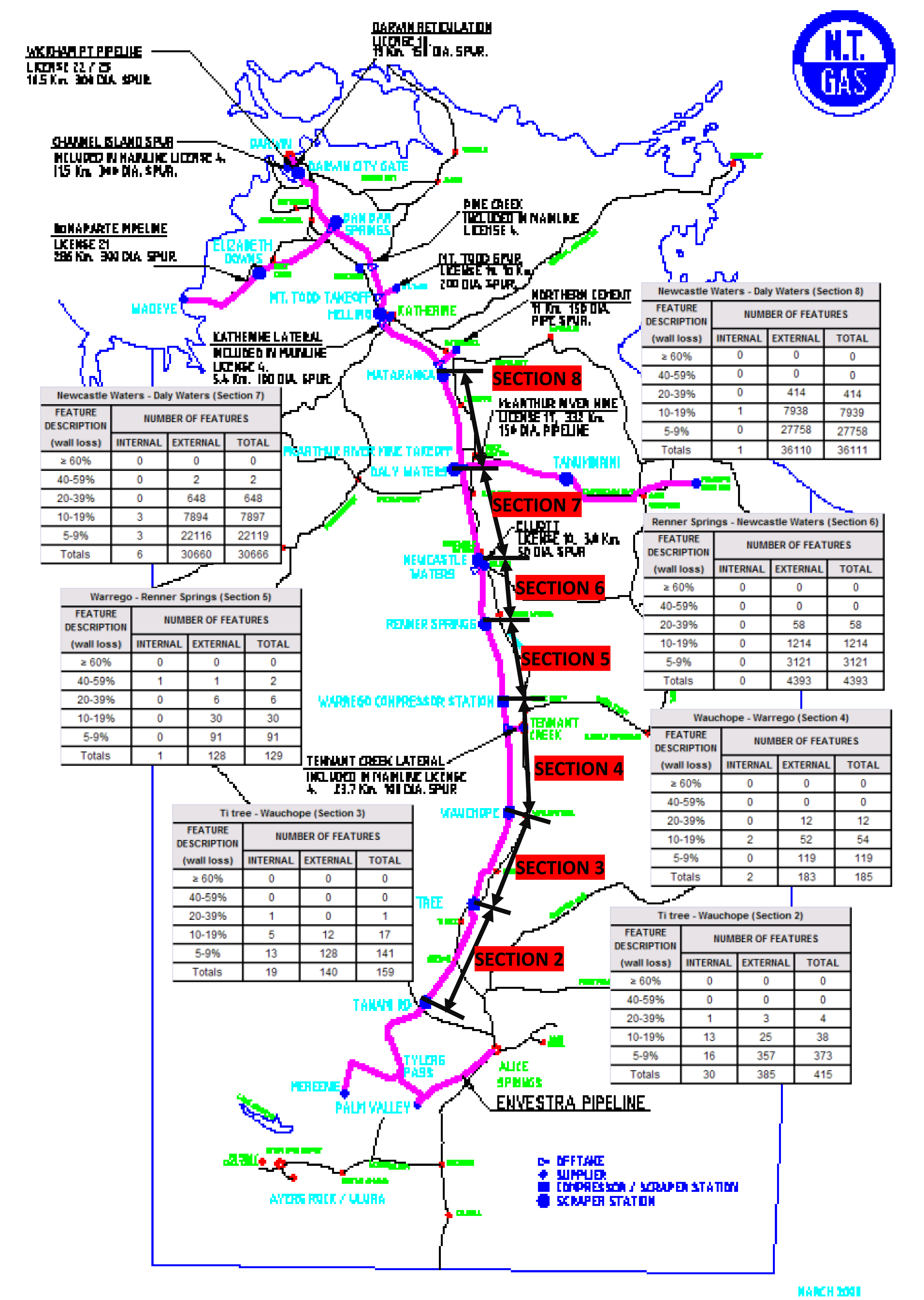
20. IC Finesse, V1.0.12, © IONIK Consulting 2005.

10.0 TABLES

APPENDIX A

PIPELINE SCHEMATICS AND ROSEN REPORTED FEATURES

NORTHERN TERRITORY PIPELINE NETWORK



Newcastle Waters - Daly Waters (Section 8)

FEATURE DESCRIPTION (wall loss)	NUMBER OF FEATURES		
	INTERNAL	EXTERNAL	TOTAL
≥ 60%	0	0	0
40-59%	0	0	0
20-39%	0	414	414
10-19%	1	7938	7939
5-9%	0	27758	27758
Totals	1	36110	36111

Newcastle Waters - Daly Waters (Section 7)

FEATURE DESCRIPTION (wall loss)	NUMBER OF FEATURES		
	INTERNAL	EXTERNAL	TOTAL
≥ 60%	0	0	0
40-59%	0	2	2
20-39%	0	648	648
10-19%	3	7894	7897
5-9%	3	22116	22119
Totals	6	30660	30666

Renner Springs - Newcastle Waters (Section 6)

FEATURE DESCRIPTION (wall loss)	NUMBER OF FEATURES		
	INTERNAL	EXTERNAL	TOTAL
≥ 60%	0	0	0
40-59%	0	0	0
20-39%	0	58	58
10-19%	0	1214	1214
5-9%	0	3121	3121
Totals	0	4393	4393

Warrego - Renner Springs (Section 5)

FEATURE DESCRIPTION (wall loss)	NUMBER OF FEATURES		
	INTERNAL	EXTERNAL	TOTAL
≥ 60%	0	0	0
40-59%	1	1	2
20-39%	0	6	6
10-19%	0	30	30
5-9%	0	91	91
Totals	1	128	129

Wauchope - Warrego (Section 4)

FEATURE DESCRIPTION (wall loss)	NUMBER OF FEATURES		
	INTERNAL	EXTERNAL	TOTAL
≥ 60%	0	0	0
40-59%	0	0	0
20-39%	0	12	12
10-19%	2	52	54
5-9%	0	119	119
Totals	2	183	185

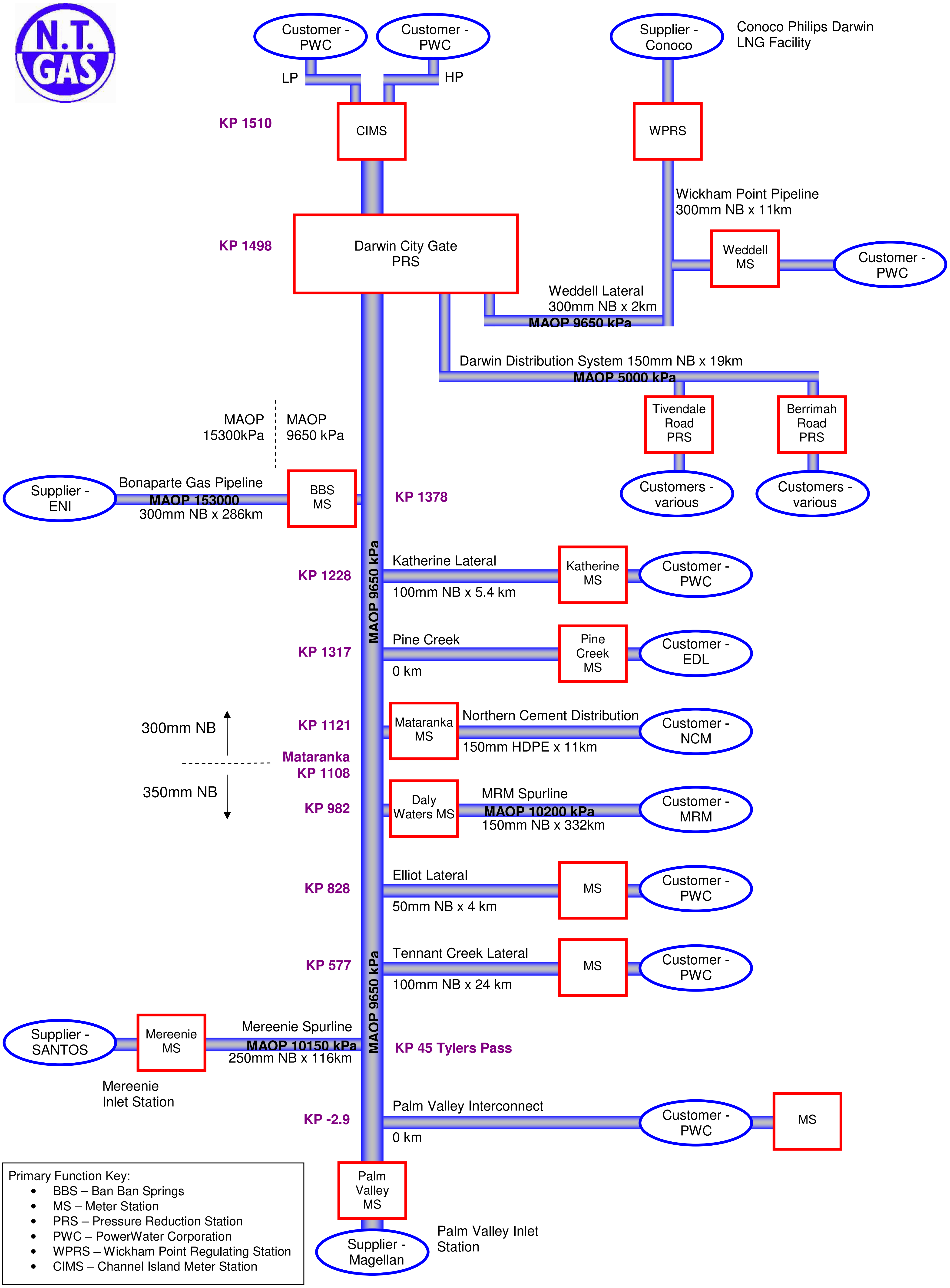
Ti tree - Wauchope (Section 3)

FEATURE DESCRIPTION (wall loss)	NUMBER OF FEATURES		
	INTERNAL	EXTERNAL	TOTAL
≥ 60%	0	0	0
40-59%	0	0	0
20-39%	1	0	1
10-19%	5	12	17
5-9%	13	128	141
Totals	19	140	159

Ti tree - Wauchope (Section 2)

FEATURE DESCRIPTION (wall loss)	NUMBER OF FEATURES		
	INTERNAL	EXTERNAL	TOTAL
≥ 60%	0	0	0
40-59%	0	0	0
20-39%	1	3	4
10-19%	13	25	38
5-9%	16	357	373
Totals	30	385	415

NT Gas Pipeline Schematic



November 2008

APPENDIX B

IC-FINESSE DEFECT ASSESSMENT CURVES

Figure B.1

Tanami Road - TI Tree - 5.8 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

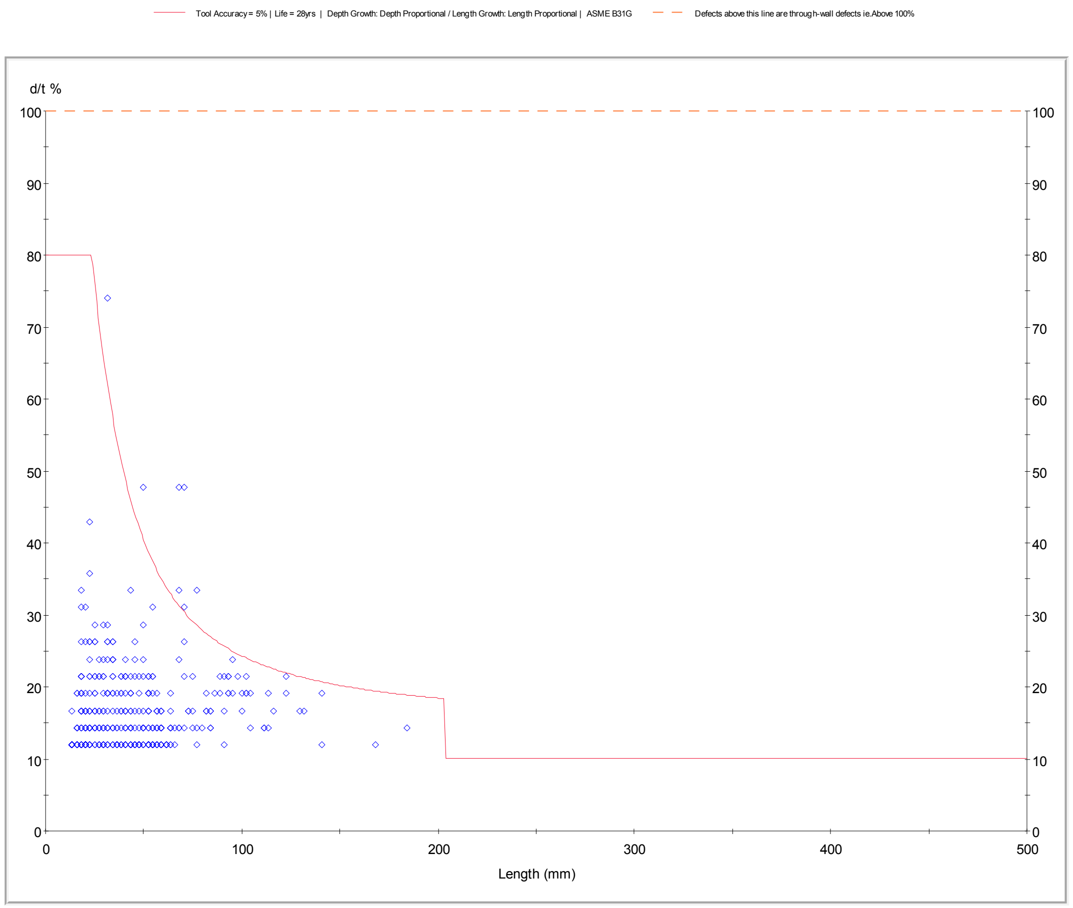


Figure B.2

Tanami Road - TI Tree – 7.14 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

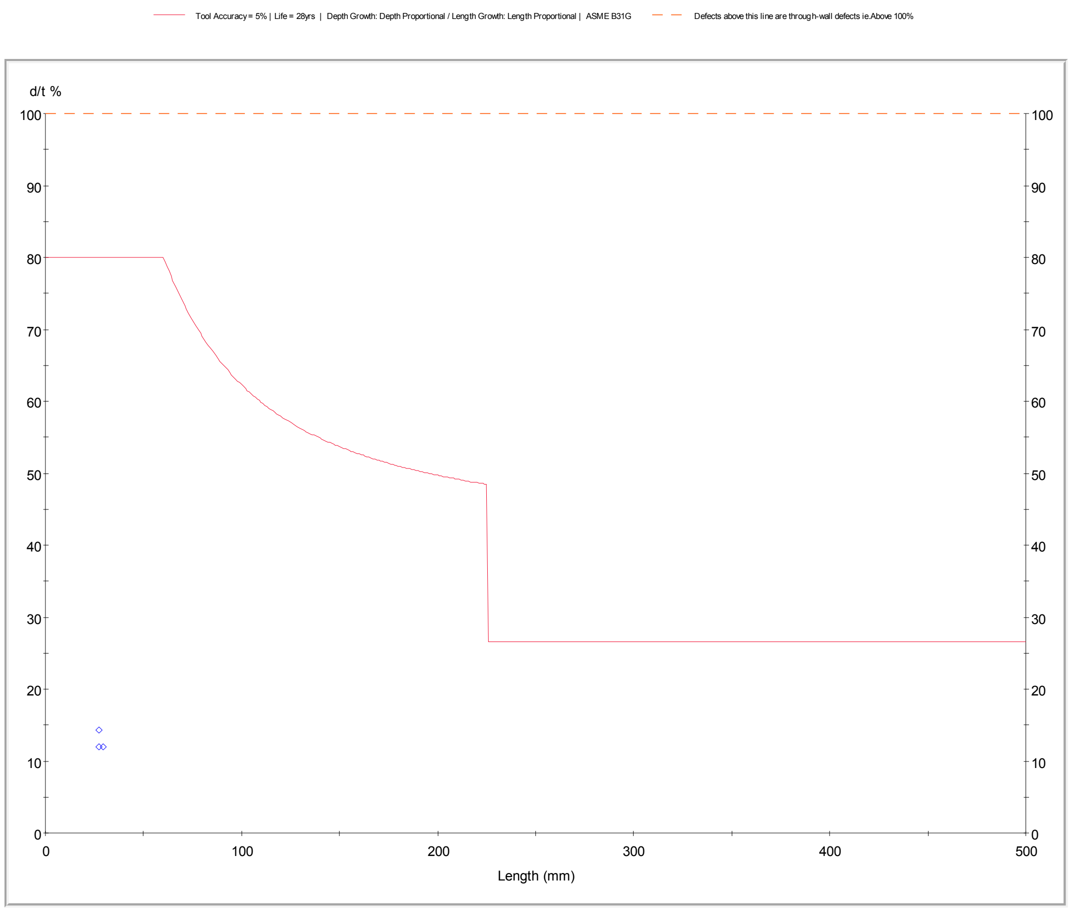


Figure B.3

Tanami Road - TI Tree – 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.0323 mm/yr, length 0.3788 mm/yr) - Year 2036

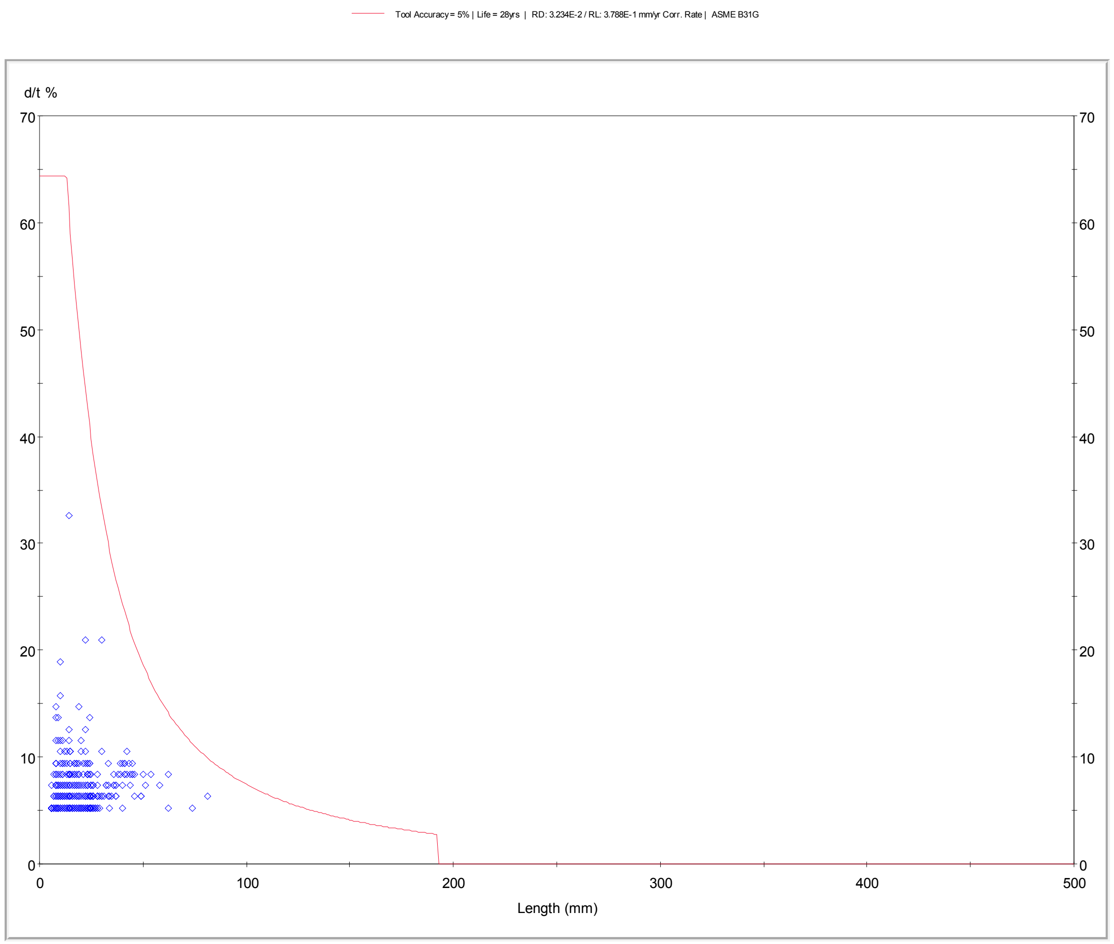


Figure B.4

Tanami Road - TI Tree – 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - INTERNAL (depth 0.0096 mm/yr, length 0.7475 mm/yr) - Year 2036

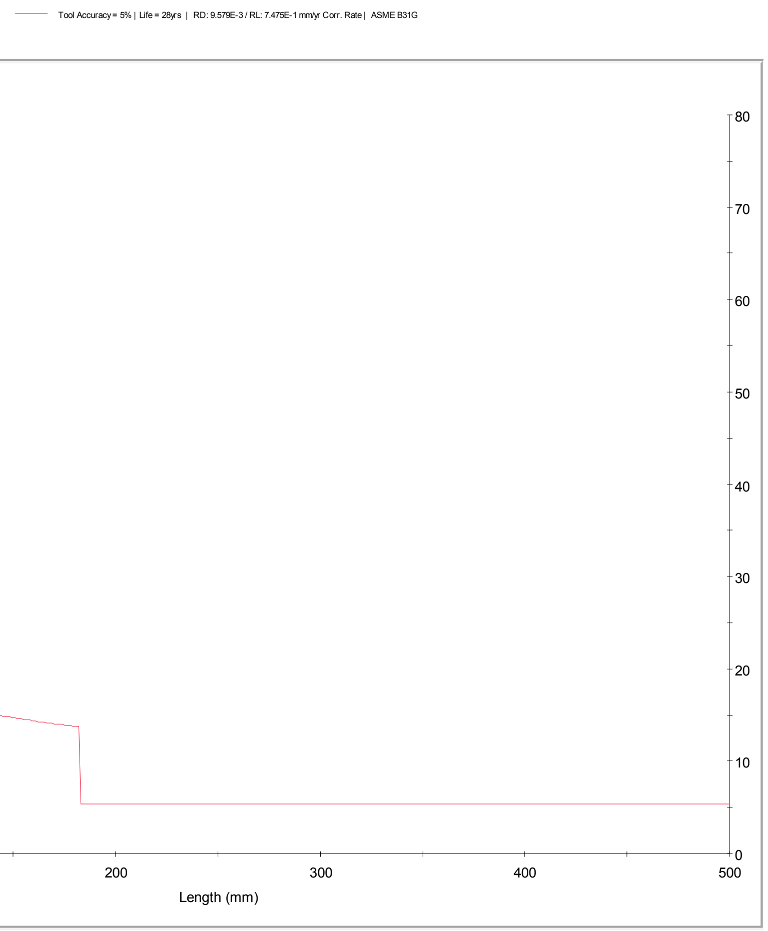


Figure B.5

Tanami Road - TI Tree – 7.14 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.0323 mm/yr, length 0.3788 mm/yr) - Year 2036

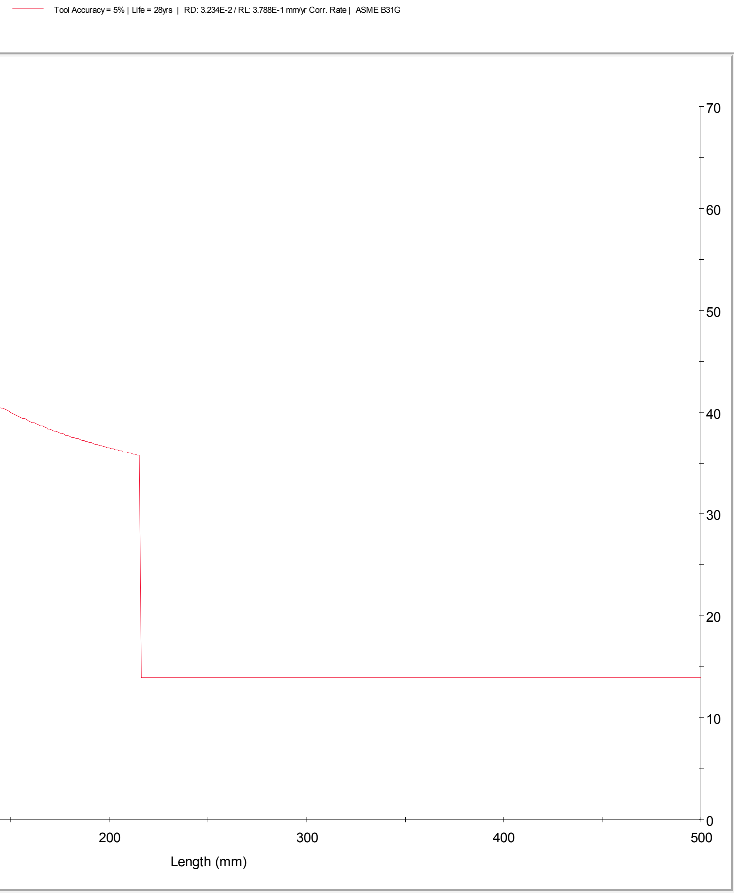


Figure B.6

TI Tree - Wauchope - 5.8 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

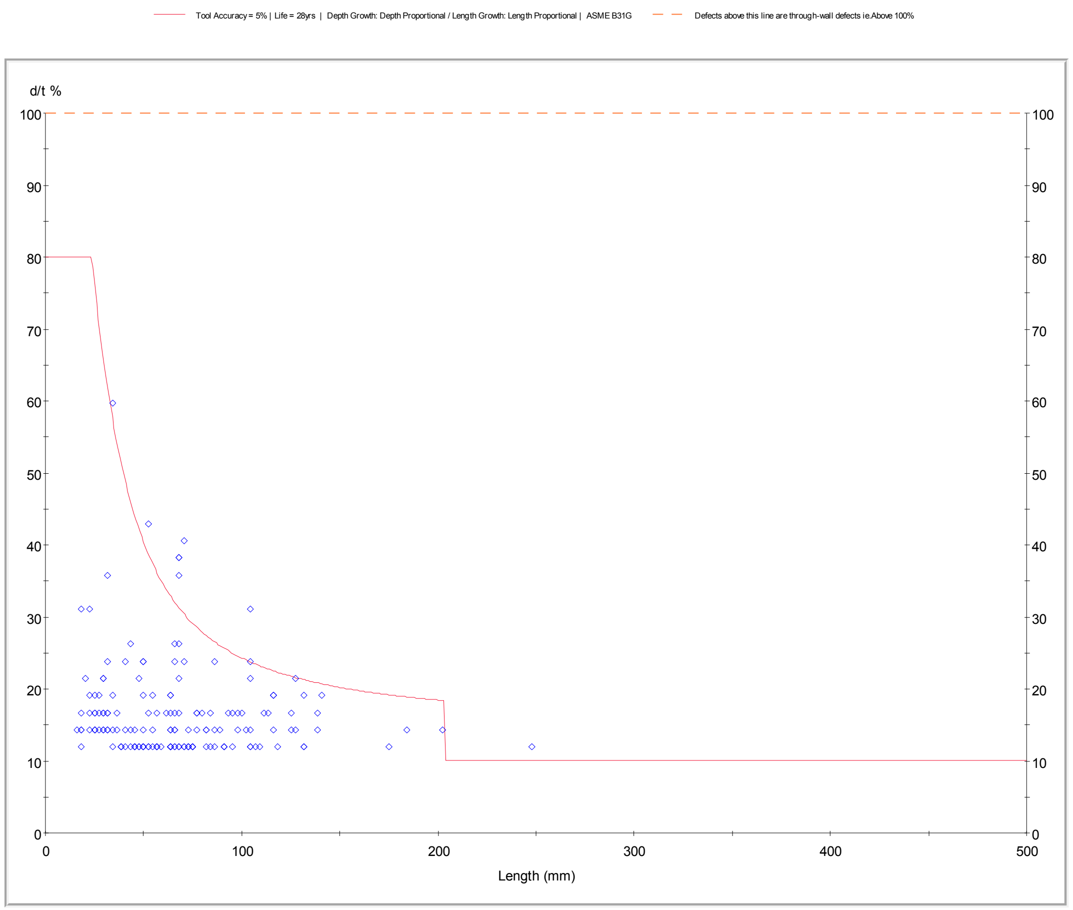


Figure B.7

TI Tree - Wauchope - 8.74 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

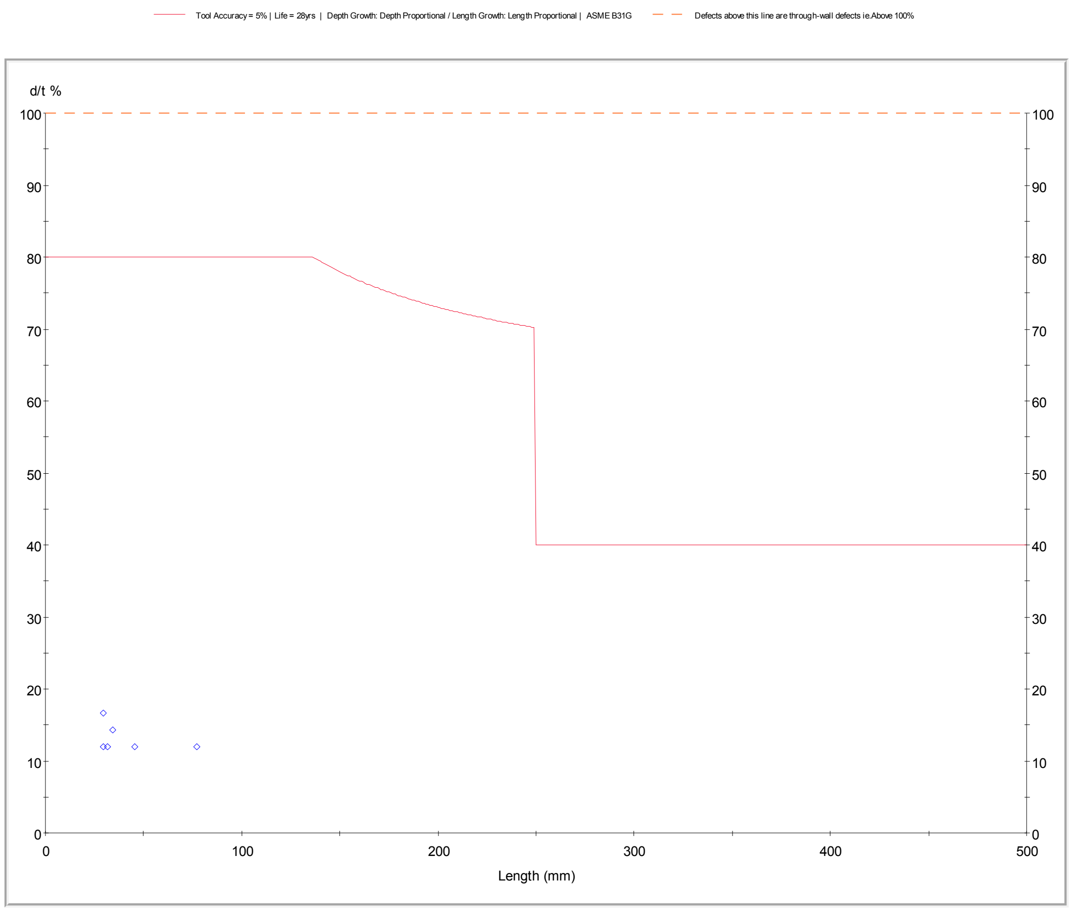


Figure B.8

Ti Tree - Wauchope - 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (Depth 0.02689 mm/yr, Length 1.22078 mm/yr) - Year 2036

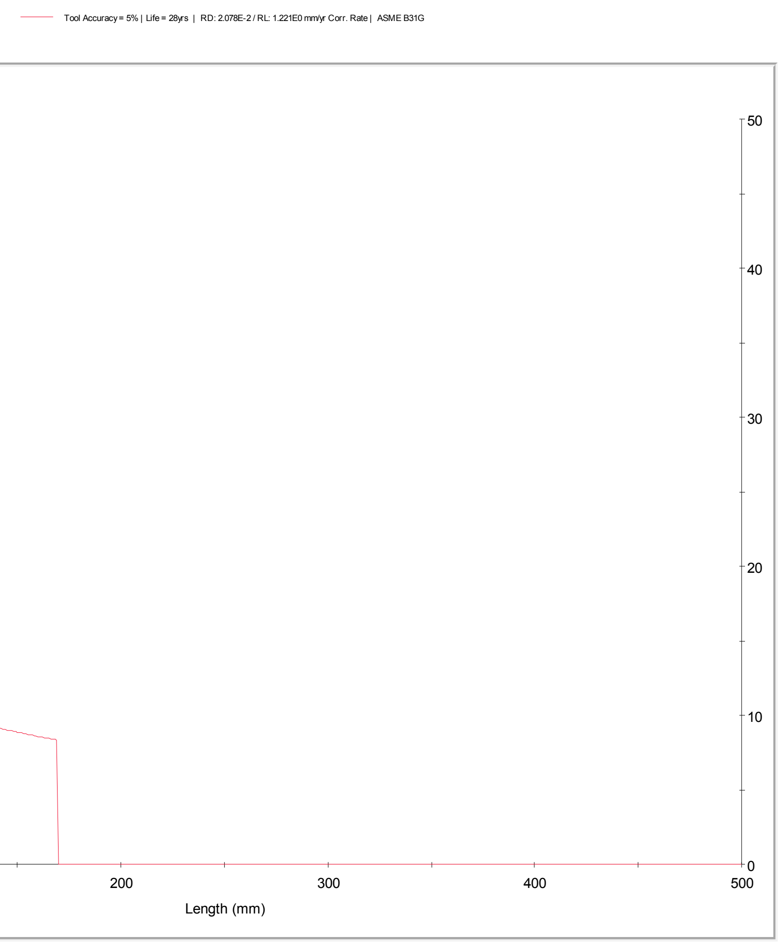


Figure B.9

Ti Tree - Wauchope - 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - INTERNAL (Depth 0.03078 mm/yr) - Year 2036

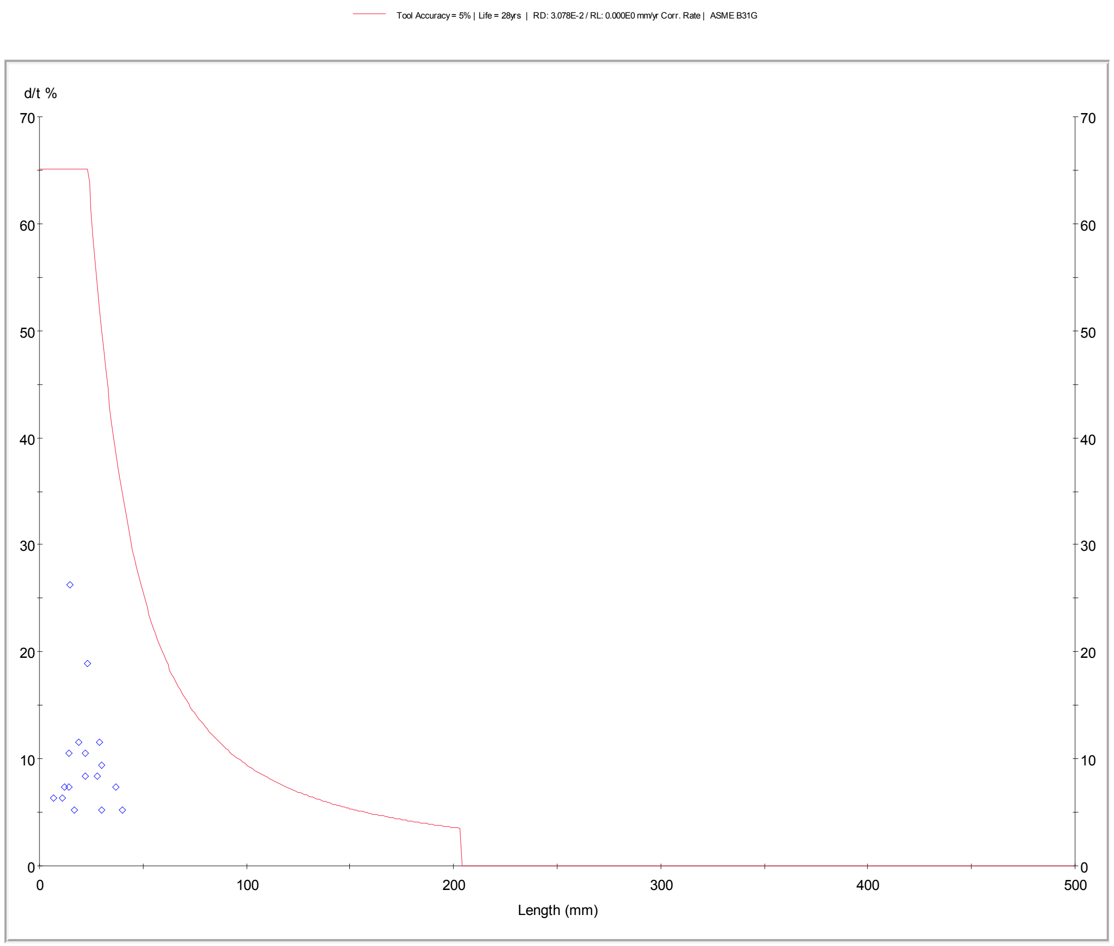


Figure B.10

Ti Tree - Wauchope – 8.74 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (Depth 0.02689 mm/yr, Length 1.22078 mm/yr) - Year 2036

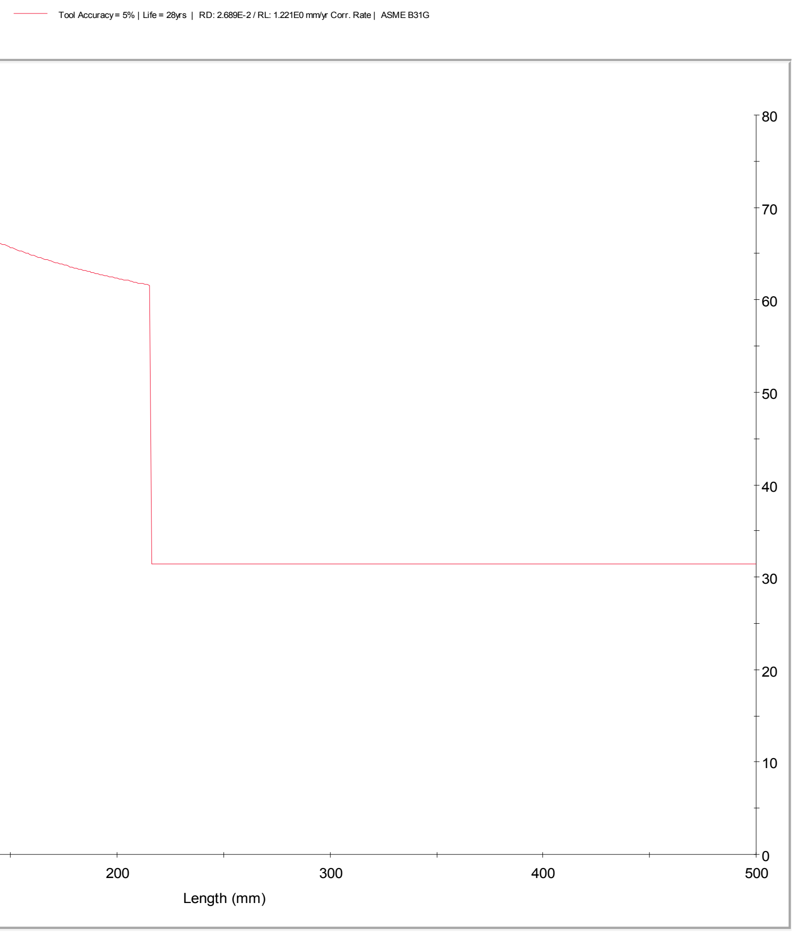


Figure B.11

Ti Tree - Wauchope – 8.74 mm WT - Anomaly Comparison Growth - ASME B31G - INTERNAL (Depth 0.03078 mm/yr) - Year 2036

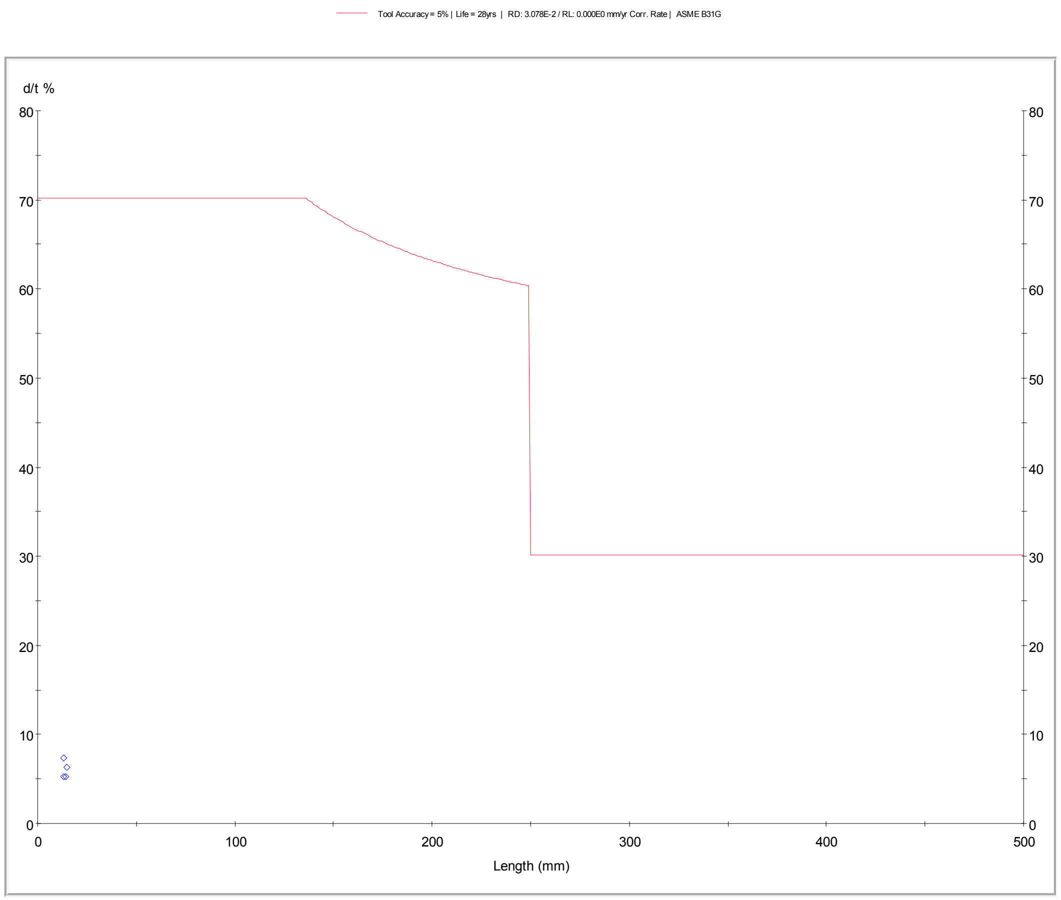


Figure B.12

Wauchope - Warrego - 5.8 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

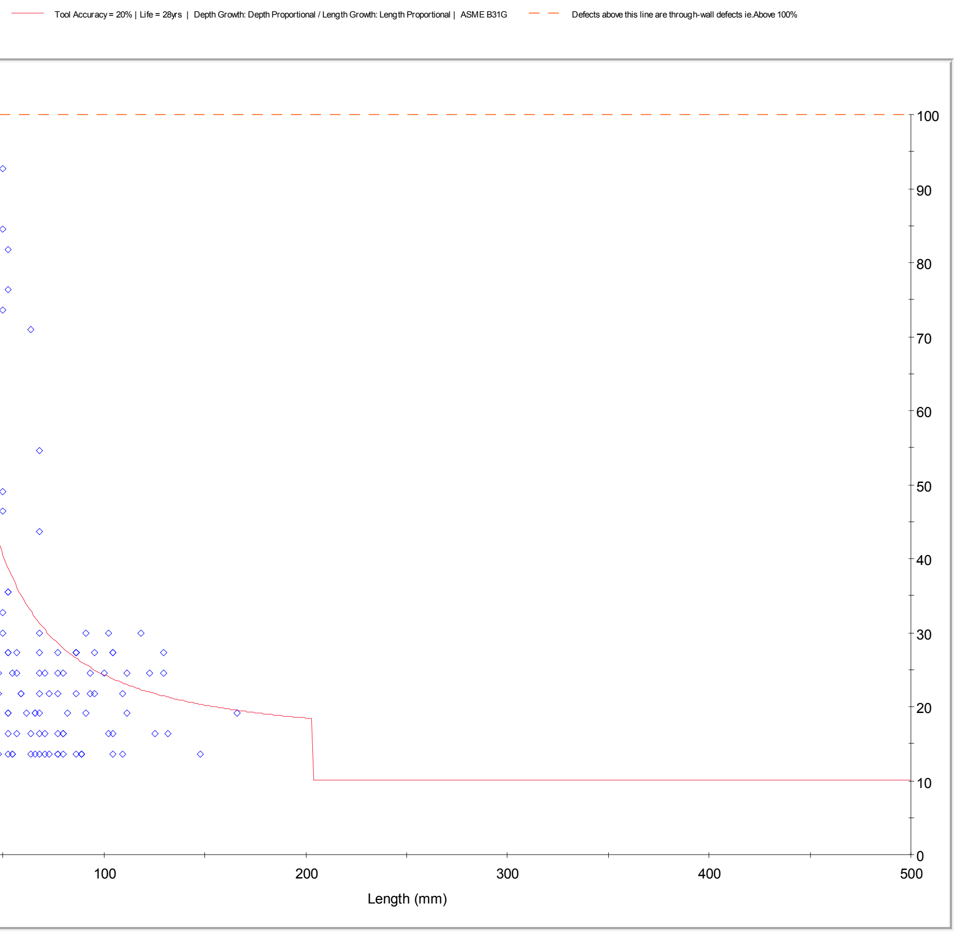


Figure B.13

Wauchope - Warrego - 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.07811 mm/yr, length 0.87013 mm/yr) - Year 2036

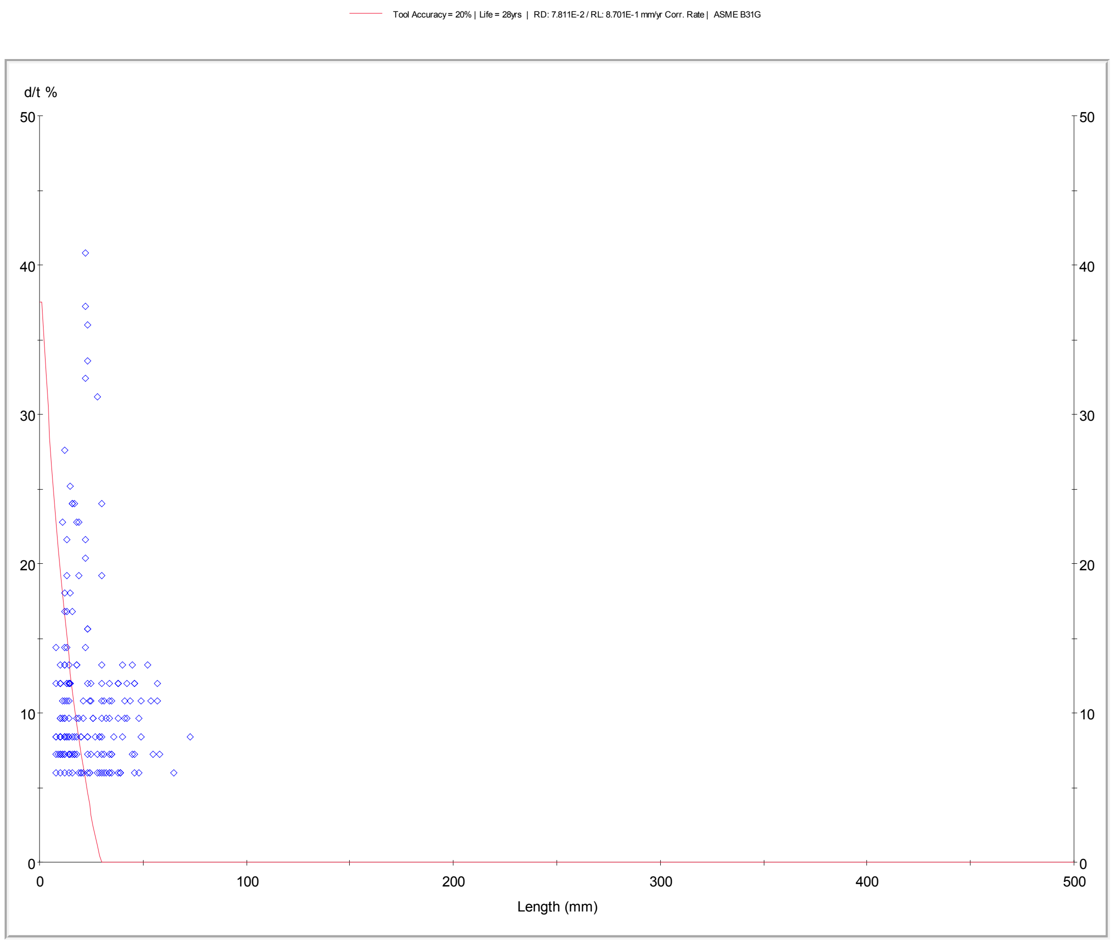


Figure B.14

Wauchope - Warrego - 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - INTERNAL (depth 0.01292 mm/yr, length 1.1364 mm/yr) - Year 2036

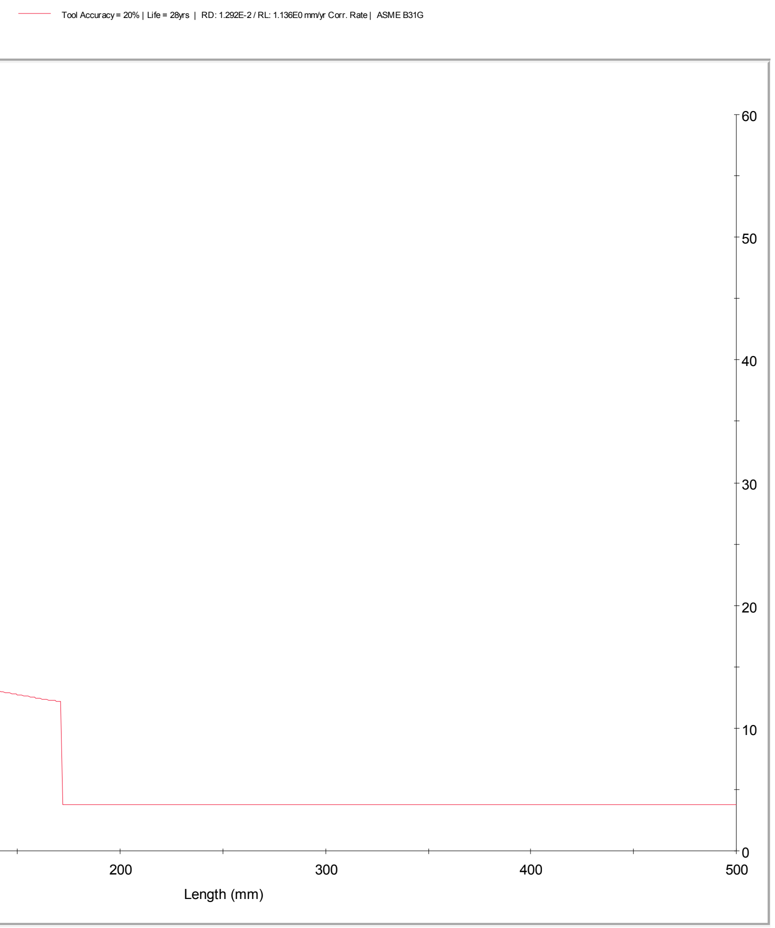


Figure B.15

Warrego – Renner Springs - 5.8 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

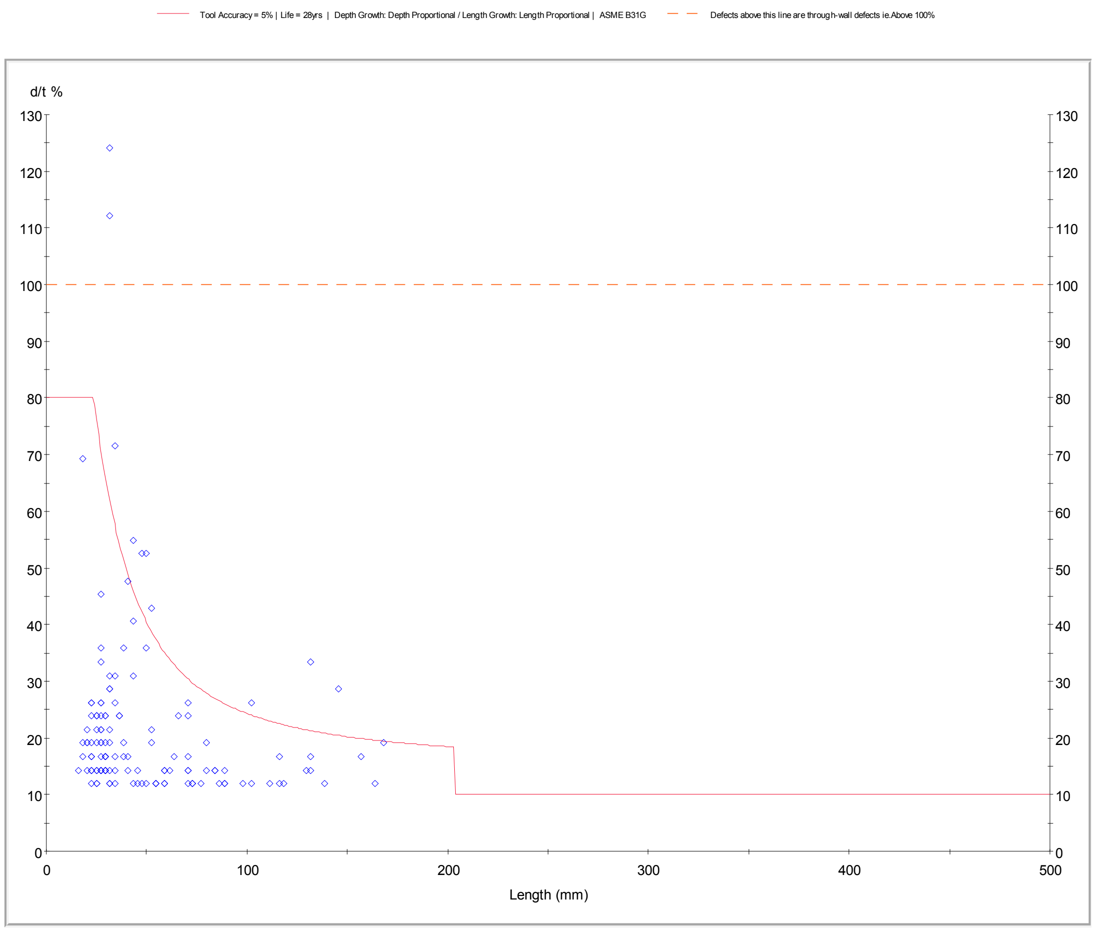


Figure B.16

Warrego – Renner Springs – 7.14 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

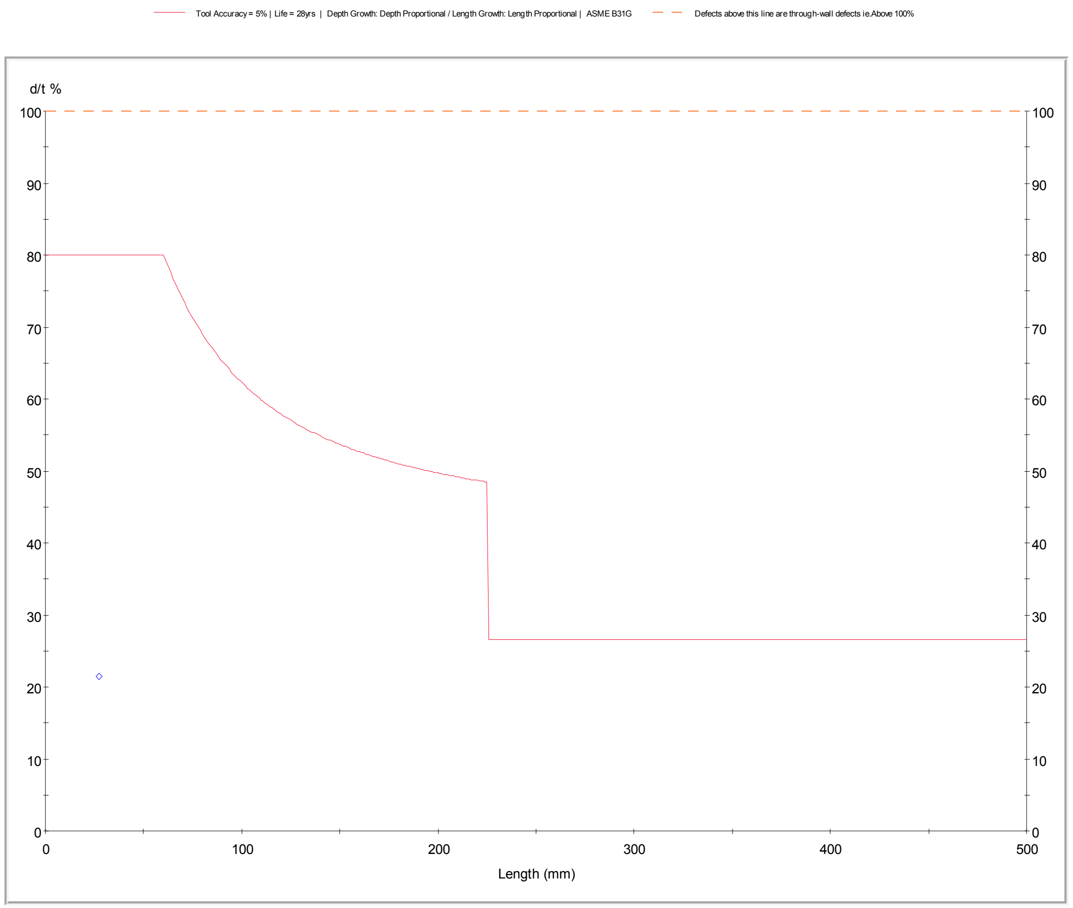


Figure B.17

Warrego – Renner Springs – 8.74 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

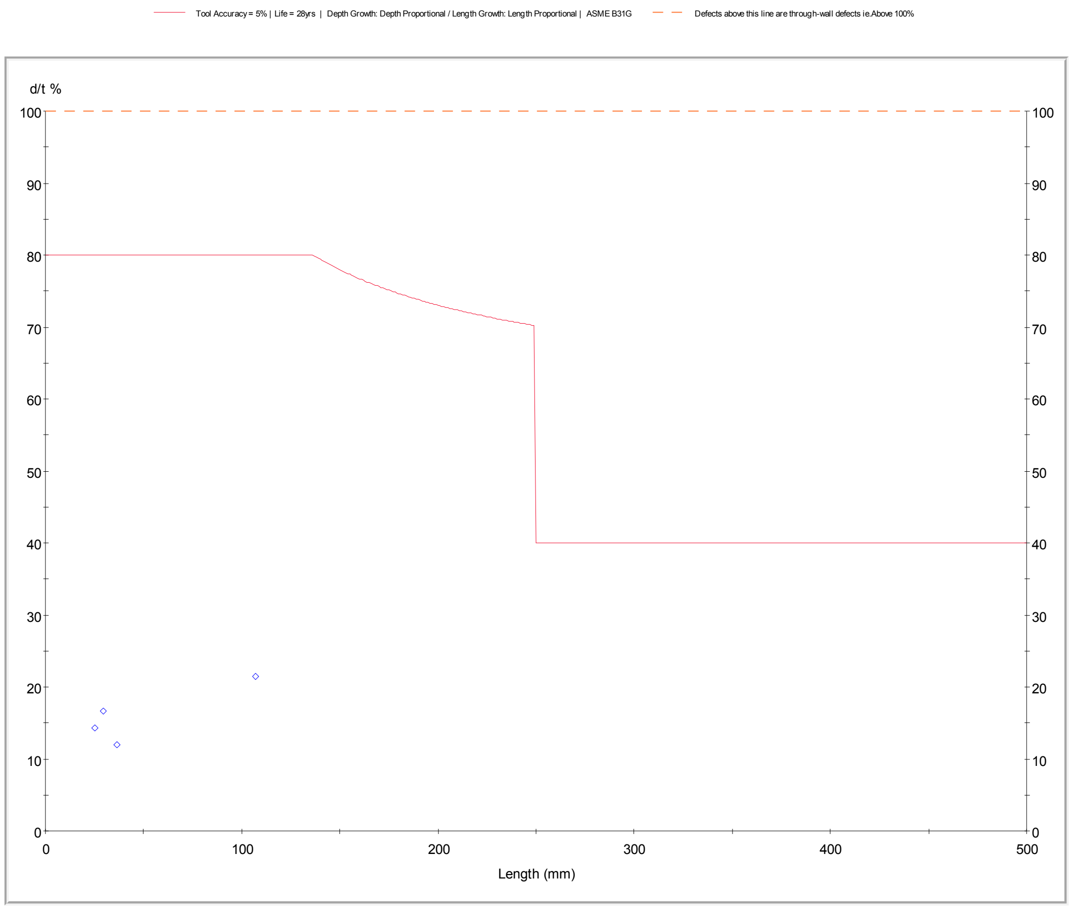


Figure B.18

Warrego – Renner Springs- 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.03716 mm/yr, length 0.87879 mm/yr) - Year 2036

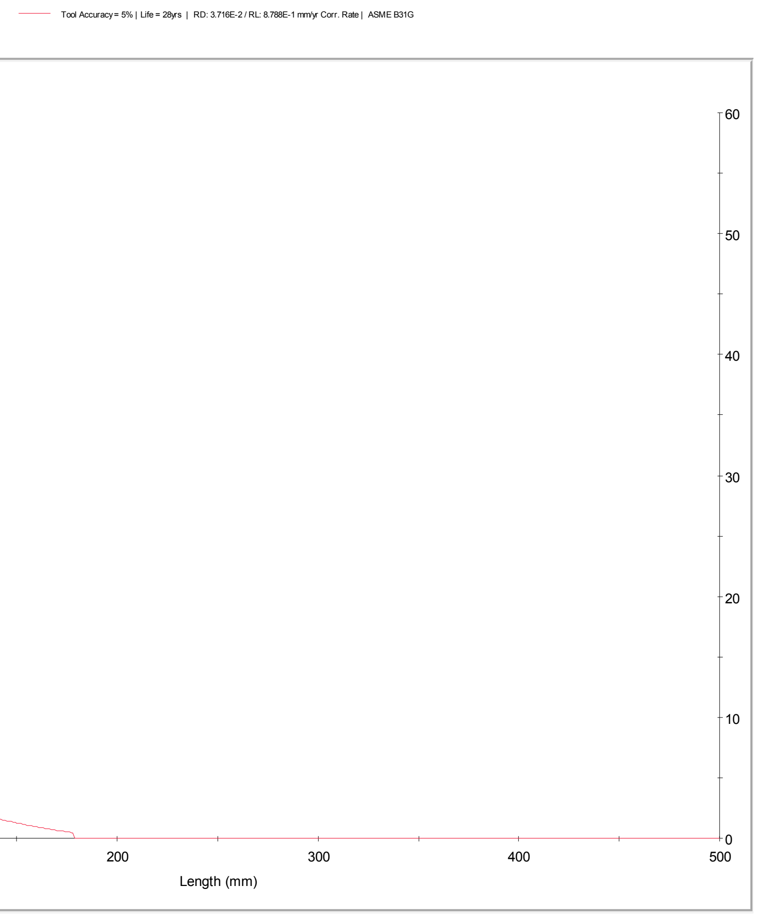


Figure B.19

Warrego – Renner Springs- 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - INTERNAL (depth 0.01635 mm/yr, length 0.27273 mm/yr) - Year 2036

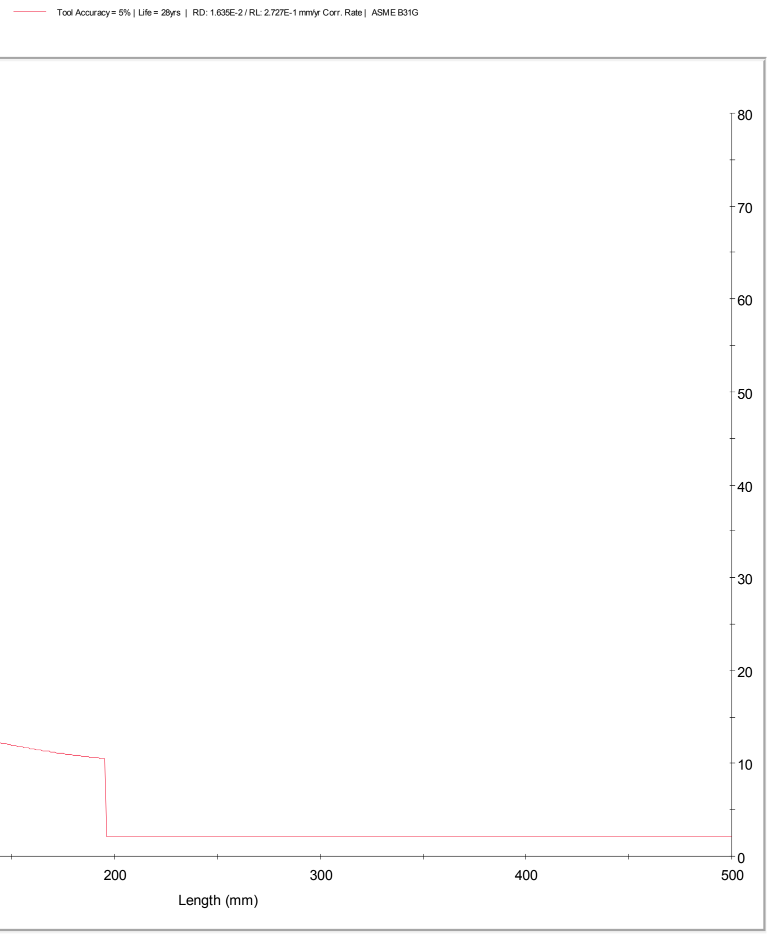


Figure B.20

Warrego – Renner Springs- 7.14 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.03716 mm/yr, length 0.87879 mm/yr**) - Year 2036**

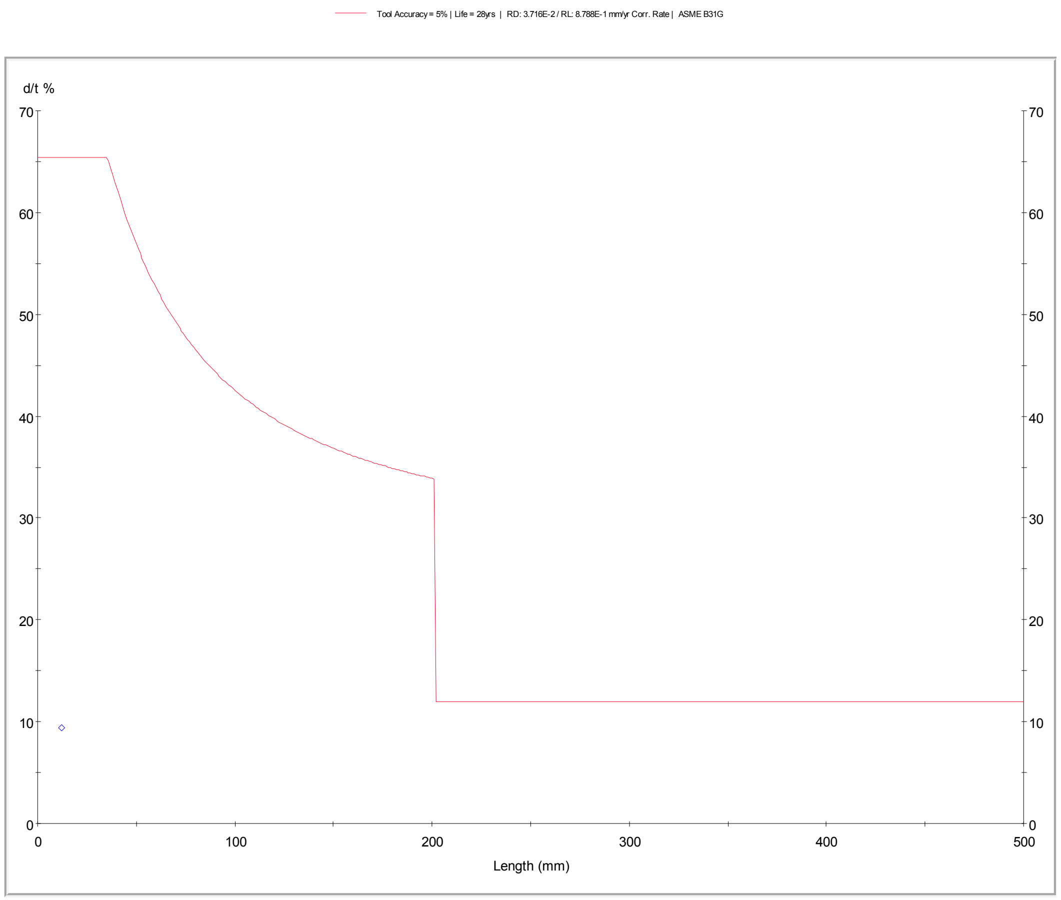


Figure B.21

Warrego – Renner Springs- 8.74 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.03716 mm/yr, length 0.87879 mm/yr) - Year 2036

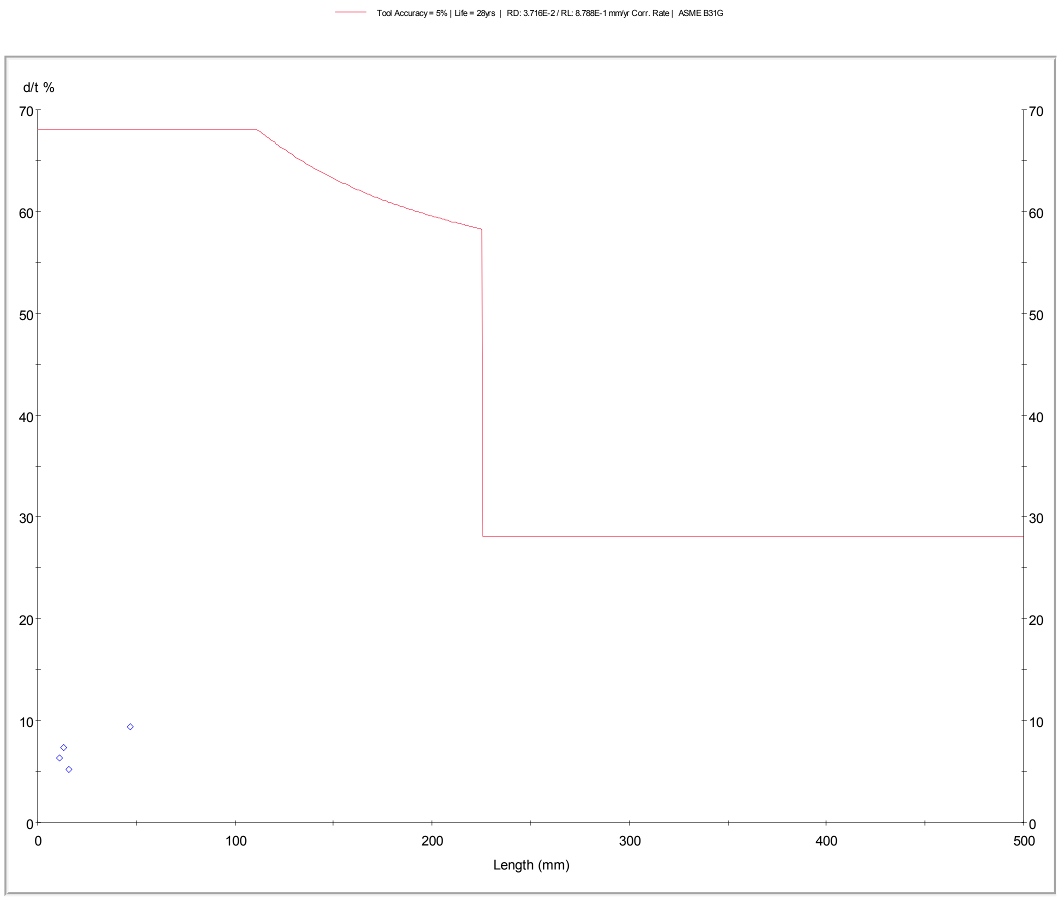


Figure B.22

Renner Springs – Newcastle Waters – 5.8 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

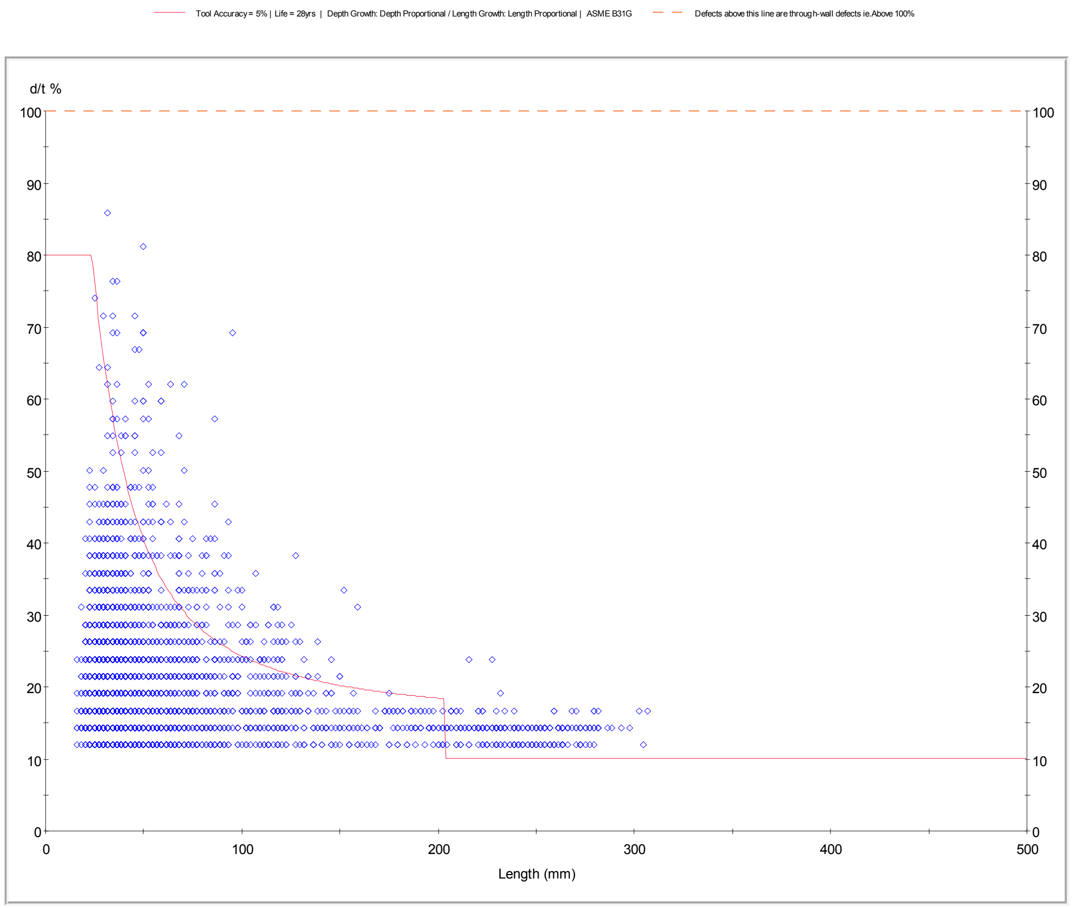


Figure B.23

Renner Springs – Newcastle Waters – 8.74 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

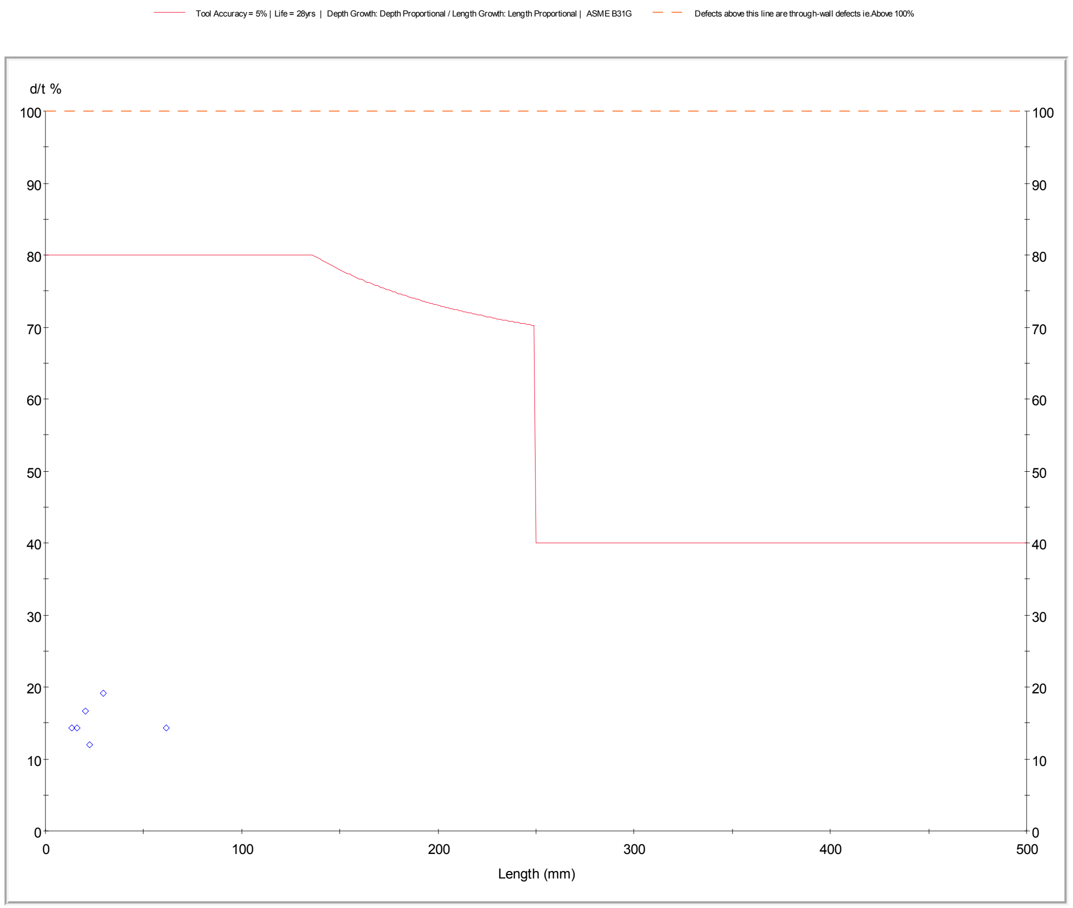


Figure B.24

Renner Springs – Newcastle Waters - 5.8 mm wt - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.14637 mm/yr, length 0.72727 mm/yr) - Year 2036

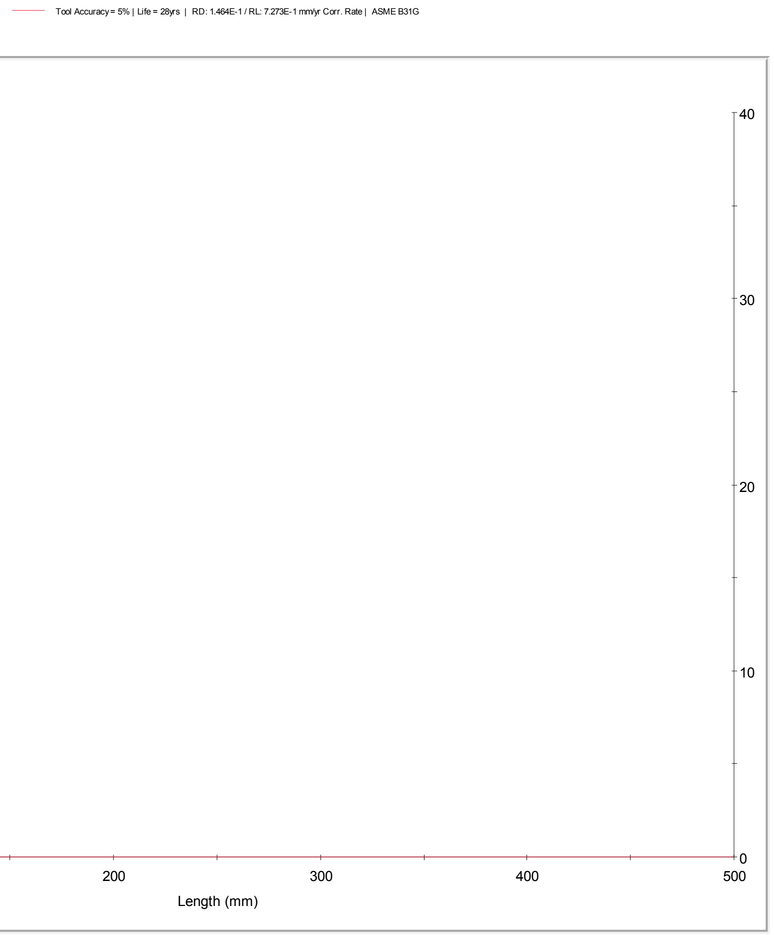


Figure B.25

Renner Springs – Newcastle Waters – 8.74 mm wt - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.14637 mm/yr, length 0.72727 mm/yr) - Year 2036

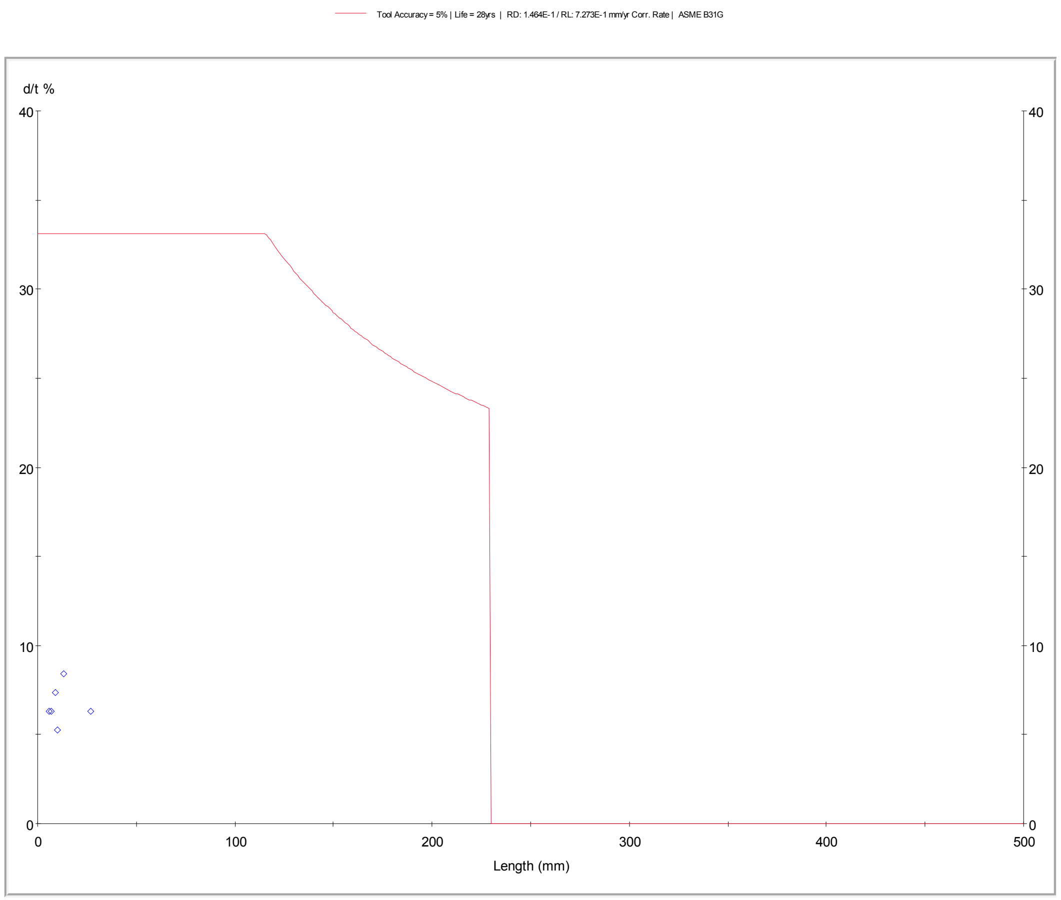


Figure B.26

Newcastle Waters – Daly Waters – 5.8 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

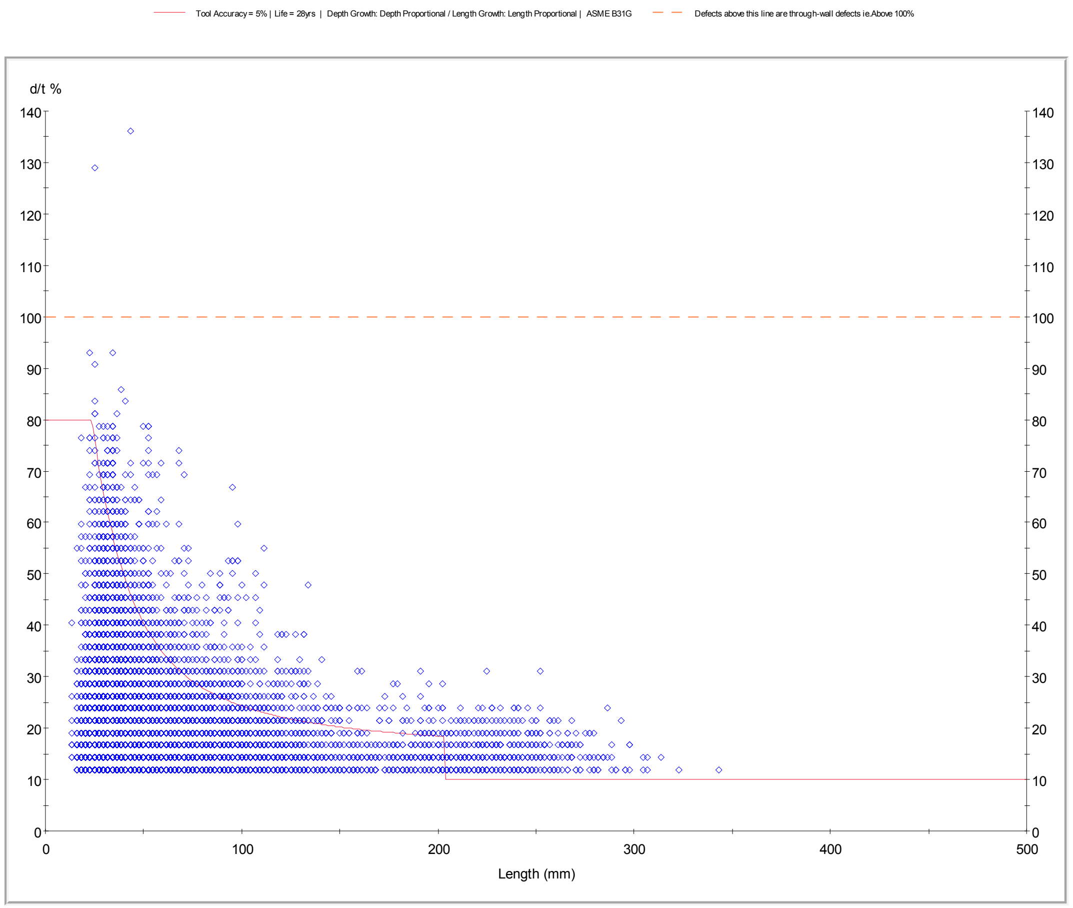


Figure B.27

Newcastle Waters – Daly Waters – 8.74 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

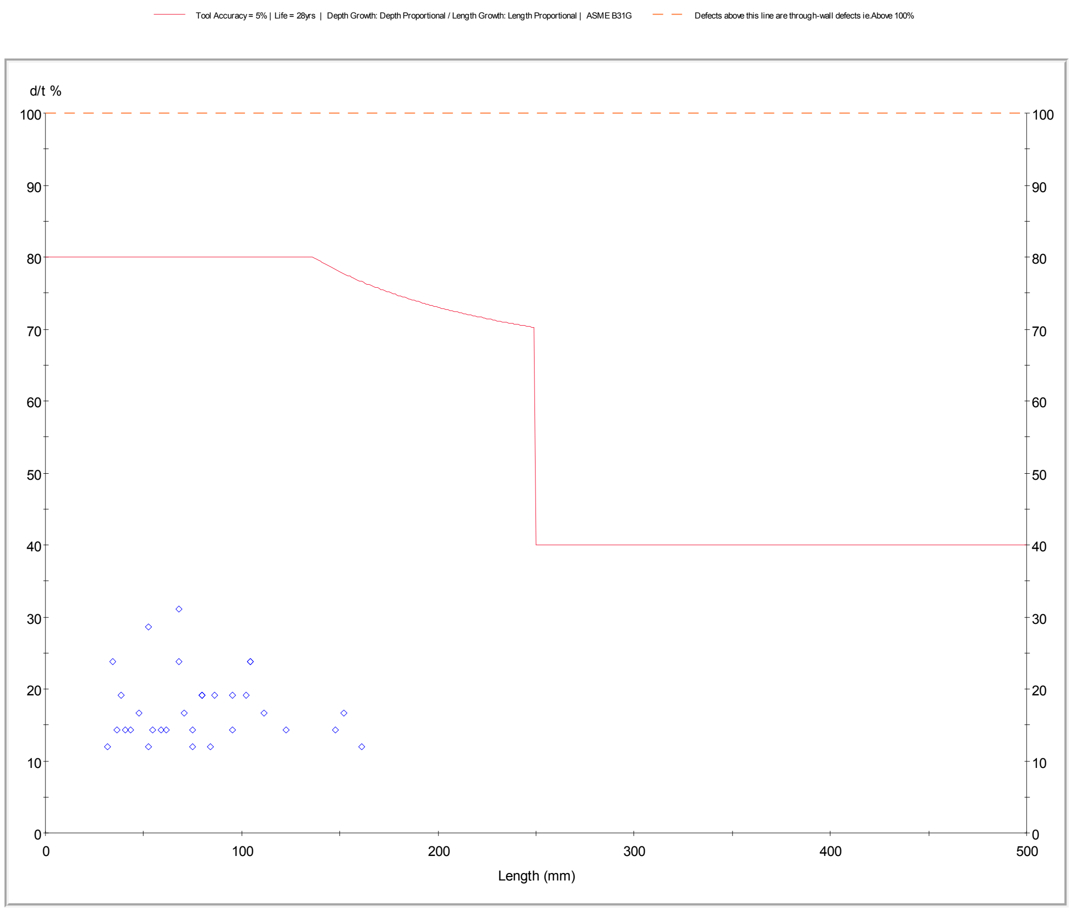


Figure B.28

Newcastle Waters – Daly Waters - 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.11177 mm/yr, length 0.62727 mm/yr) - Year 2036

Figure B.29

Newcastle Waters – Daly Waters - 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - INTERNAL (depth 0.01993 mm/yr, length 1.45455 mm/yr) - Year 2036

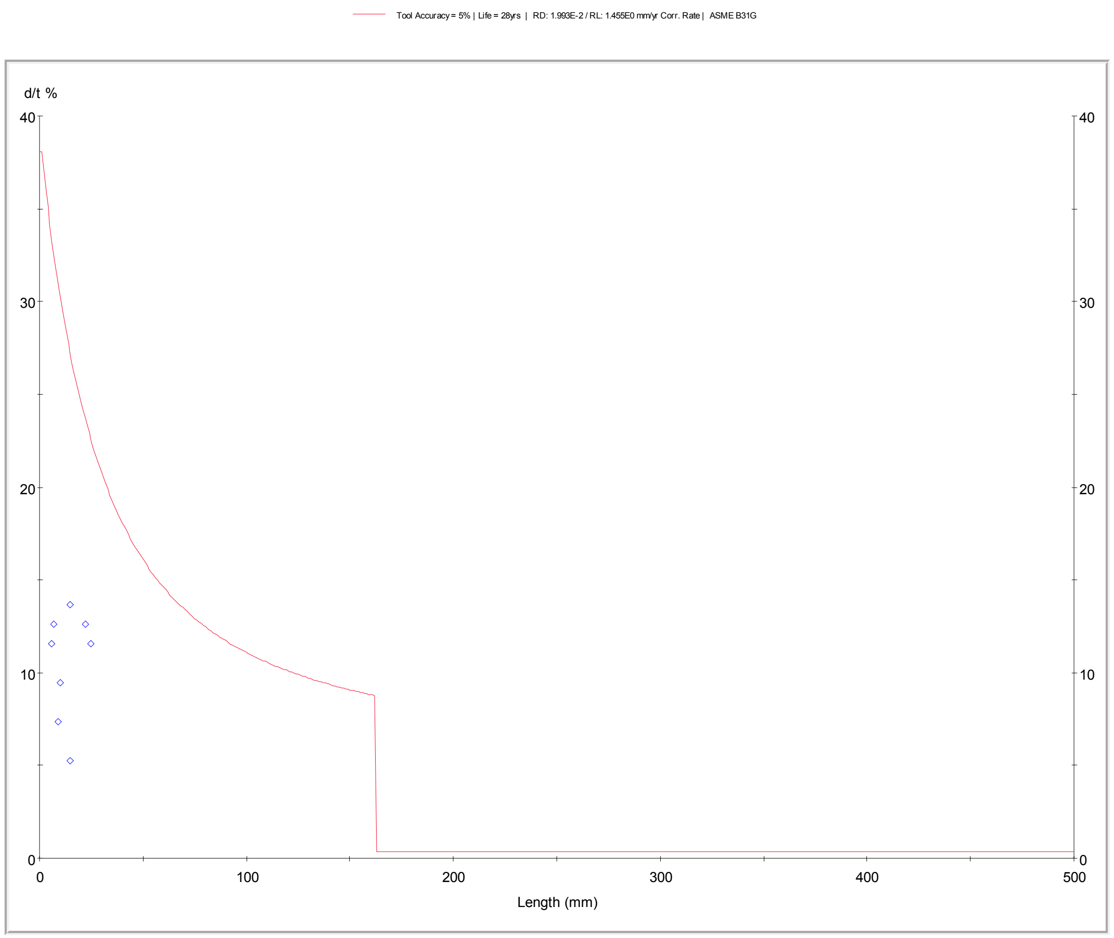


Figure B.30

Newcastle Waters – Daly Waters – 8.74 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.11177 mm/yr, length 0.62727 mm/yr) - Year 2036

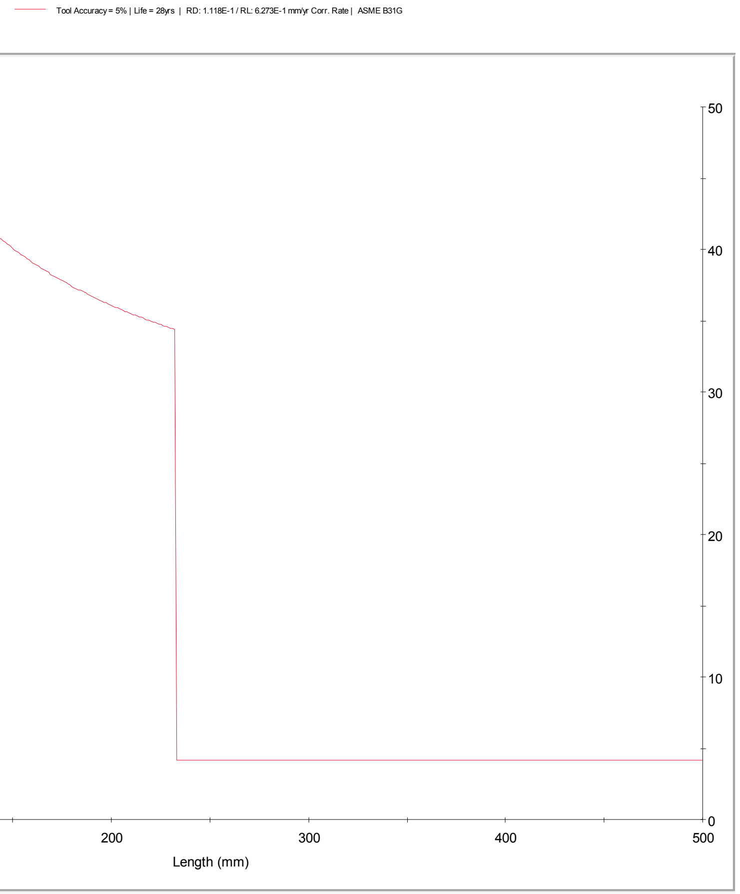


Figure B.31

Daly Waters - Mataranka – 5.8 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

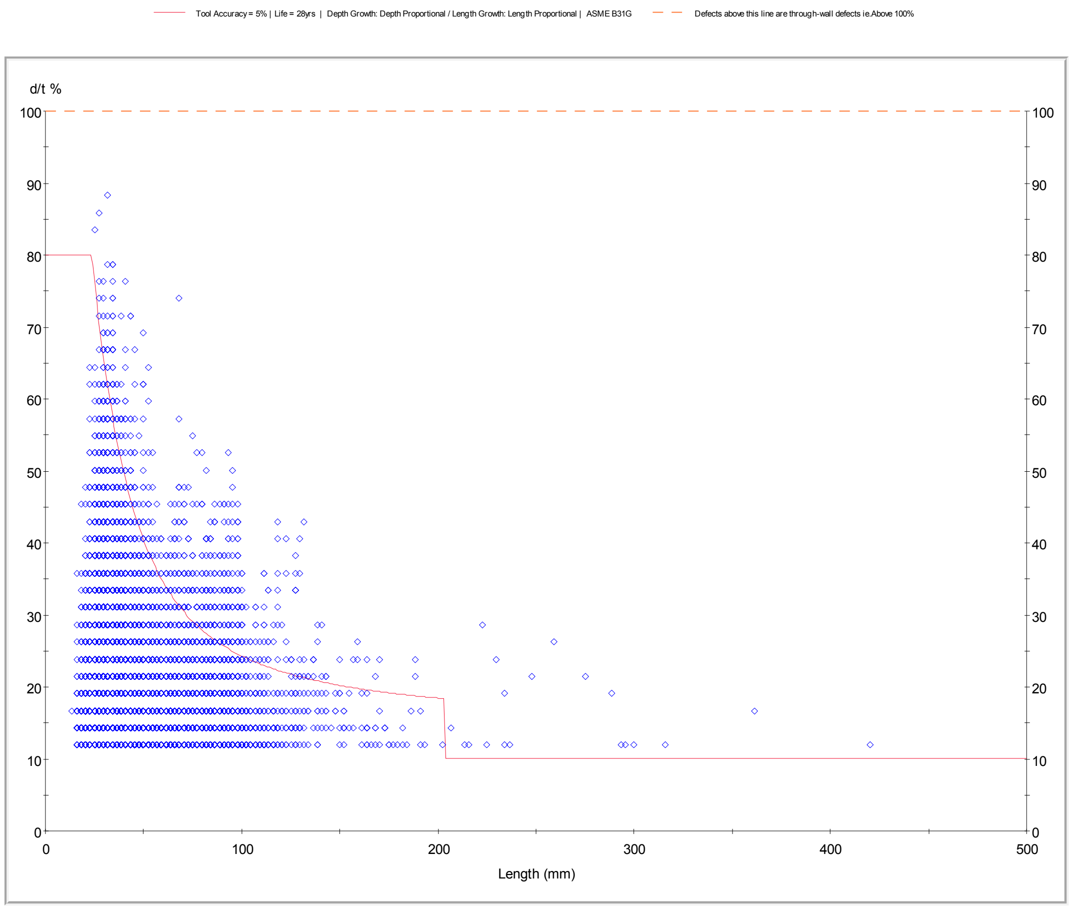


Figure B.32

Daly Waters - Mataranka – 8.74 mm WT - Anomaly Proportional Growth - ASME B31G - Year 2036

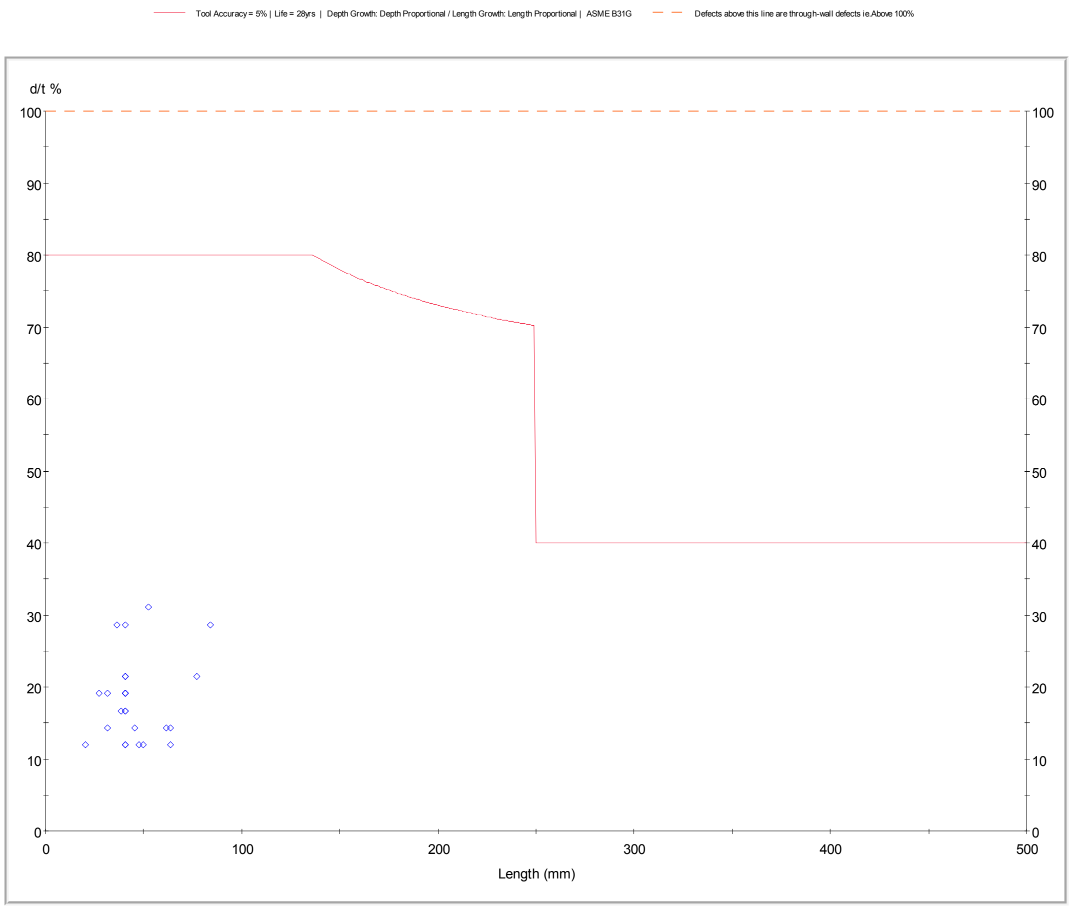


Figure B.33

Daly Waters - Mataranka - 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.11024 mm/yr, length 0.88182 mm/yr) - Year 2036

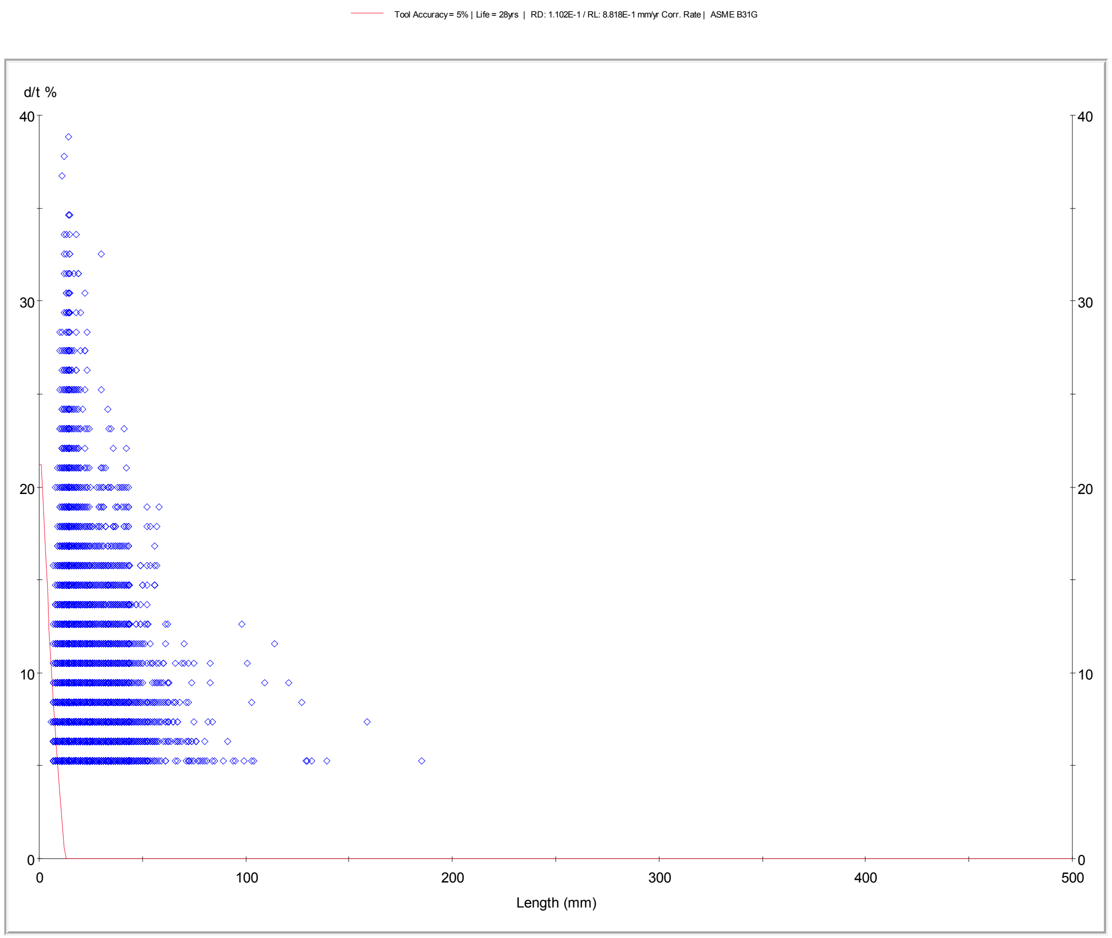


Figure B.34

Daly Waters - Mataranka - 5.8 mm WT - Anomaly Comparison Growth - ASME B31G - INTERNAL (depth 0.01313 mm/yr, length 0.63636 mm/yr) - Year 2036

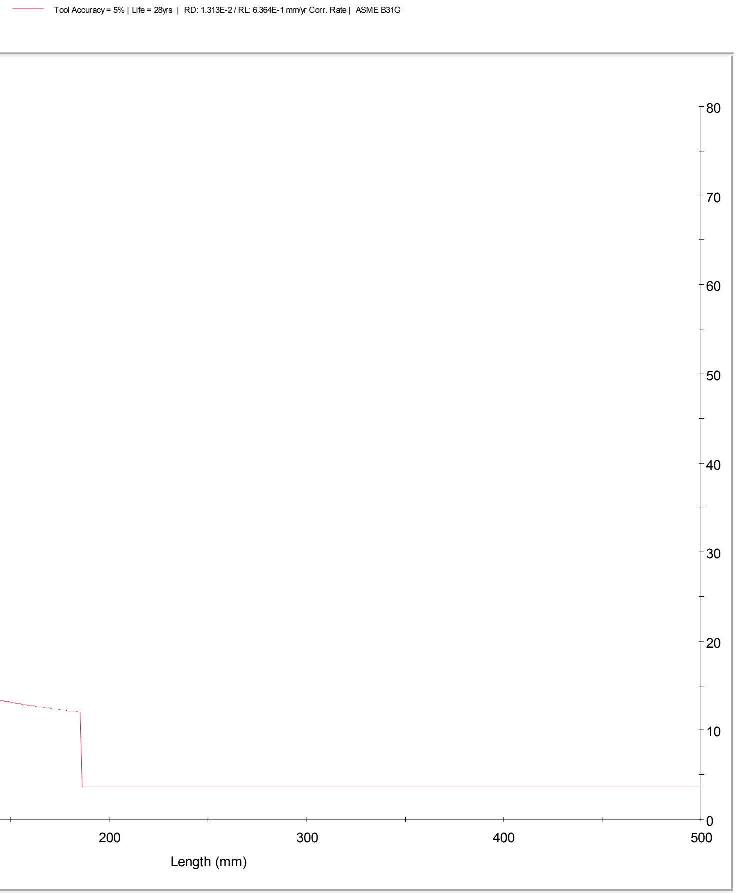
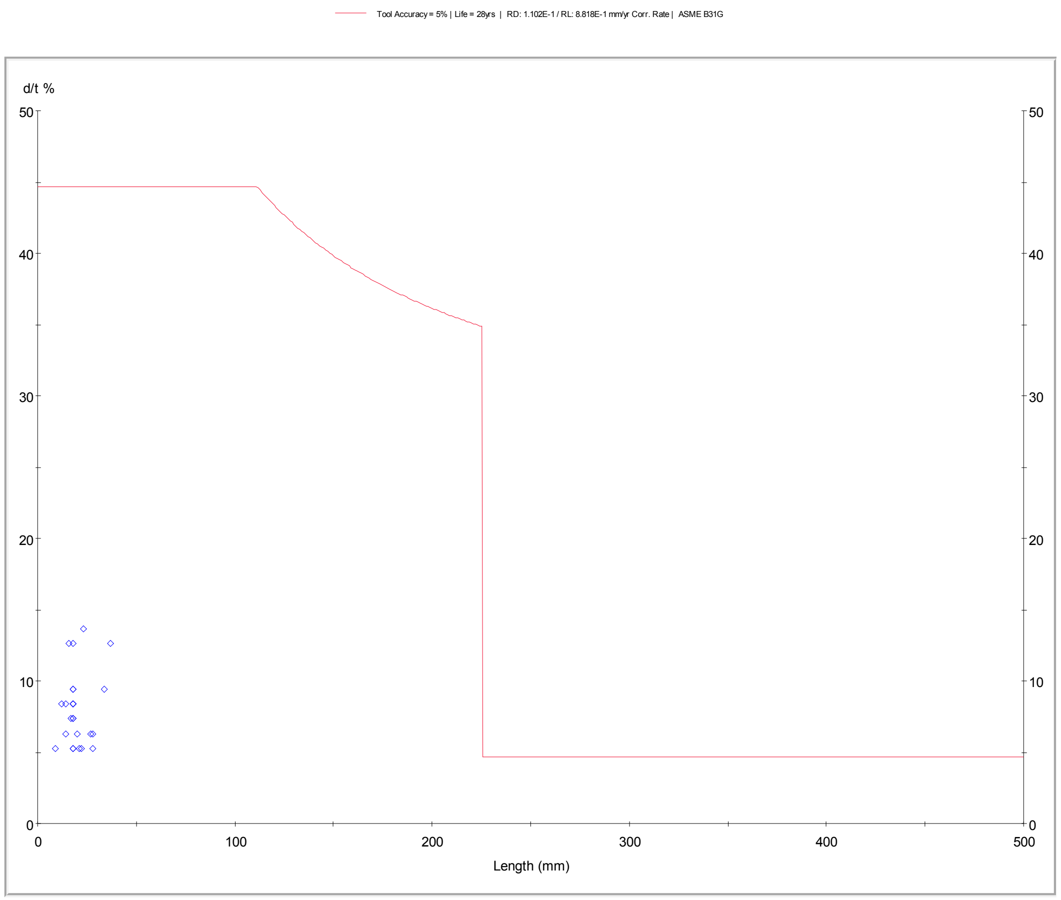


Figure B.35

Daly Waters - Mataranka – 8.74 mm WT - Anomaly Comparison Growth - ASME B31G - EXTERNAL (depth 0.11024 mm/yr, length 0.88182 mm/yr) - Year 2036



APPENDIX C

SUMMARY OF INSPECTION TECHNIQUES RESULTS

Table C.1
Findings Of The Three Inspection Techniques For Pipeline Section From Tanami Road To Ti-Tree (KP 161.0 To KP 316.1)

Inspection Techniques	Year Inspected	KP	Findings	
DCVG	2006	161 – 241.8	Total defects = 267	>30% IR = 2
				15 - 30% IR = 10
				1 - <15% IR = 255
	2005	241.8 – 316.1	Total defects = 173	>30% IR = 0
				15 - 30% IR = 3
				1 - <15% IR = 168
				< 1% IR = 2
CP	2008	161.0 – 316.1	Total Anomalies = 55 (Total readings = 83)	Under-protected = 54 (65%)
				Protected = 28 (34%)
				Overprotected = 1 (1%)
	2007	161.0 – 316.1	Total Anomalies = 67 (Total readings = 83)	Under-protected = 66 (80%)
				Protected = 16 (19%)
				Overprotected = 1 (1%)
IP	2008	161.0 – 316.1 (W.T = 5.8mm)	Total external defects =382	20 - 39% = 4
				10 - 19% = 38
				5 - 9% = 340
			Max. wall thickness loss	31% at KP 211.161884
		161.0 – 316.1 (W.T = 7.14mm)	Total external defects = 3	20 - 39% = 0
				10 - 19% = 0
				5 - 9% = 3
			Max. wall thickness loss	6% at KP 315.978014
	1997	161.0 – 316.1	Total external defects = 210	20 - 39% = 3
				10 - 19% = 50
				5 – 9% = 157
			Max. wall thickness loss	29% at KP 211.161876

Table C.2
Findings Of The Three Inspection Techniques For Pipeline Section From Ti-Tree To Wachope (KP 316.1 To KP 458.1)

Inspection Techniques	Year Inspected	KP	Findings	
DCVG	2005	316.1 – 458.1	Total defects =507	15 - 30% IR = 22
				1 - <15% IR = 481
				< 1% = 4
CP	2008	316.1 – 458.1	Total Anomalies = 24 (Total readings = 84)	Under-protected = 24 (29%)
				Protected = 60 (71%)
				Overprotected =0 (0%)
	2007	316.1 – 458.1	Total Anomalies = 76 (Total readings = 84)	Under-protected = 76 (90%)
				Protected = 8 (10%)
				Overprotected = 0 (0%)
IP	2008	316.1 – 458.1	Total external defects = 148 defects (W.T = 5.8mm)	20 - 39% = 0
				10 - 19% = 15
				5 - 9% =133
			Max. wall thickness loss	17% at KP 436.249602
			Total external defects = 2 (W.T = 8.74mm)	20 - 39% = 0
				10 - 19% = 0
				5 - 9% = 2
	1997	316.1 – 458.1	Total external defects = 222	20 - 39% = 4
				10 - 19% = 24
				5 – 9% = 194
			Max. wall thickness loss	35% at KP 379.207029

Table C.3
Findings Of The Three Inspection Techniques For Pipeline Section From Wachope To Warrego (KP 458.1 To KP 610.8)

Inspection Techniques	Year Inspected	KP	Findings	
DCVG	2004	458.1 – 610.8	Total defects = 643 defects	>30% IR = 1
				15 - 30% IR = 18
				1 - <15% IR = 615
				< 1% IR = 9
CP	2008	458.1 – 610.8	Total Anomalies =75 (Total readings = 82)	Under-protected = 75 (91%)
				Protected = 7 (9%)
				Overprotected = 0
	2007	458.1 – 610.8	Total Anomalies =82 (Total readings = 82)	Under-protected = 82 (100%)
				Protected = 0
				Overprotected = 0
IP	2008	458.1 – 610.8	Total external defects = 186 (W.T = 5.8mm)	20 - 39% = 12
				10 - 19% = 53
				5 - 9% = 121
			Max. wall thickness loss	34% at KP 523.802826
	1997	458.1 – 610.8	Total external defects = 159	20 - 39% = 3
				10 - 19% = 41
				5 – 9% = 115
			Max. wall thickness loss	24% at KP 548.979156

Table C.4
Findings Of The Three Inspection Techniques For Pipeline Section From Warrego To Renner Spring (KP 610.8 To KP 733.7)

Inspection Techniques	Year Inspected	KP	Findings	
DCVG	2005	684 – 733.7	Total defects =130	>30% IR = 2
				15 - 30% IR = 17
				1 - <15% IR = 111
	2004	610.8 - 684	Total defects = 332	>30% IR = 1
				15 - 30% IR = 13
				1 - <15% IR = 317
				< 1% IR = 1
CP	2008	610.8 - 733.7	Total Anomalies = 8 (Total readings = 69)	Under-protected = 8 (12%)
				Protected = 61 (88%)
				Overprotected = 0
	2007	610.8 - 733.7	Total Anomalies = 65 (Total readings = 69)	Under-protected = 65 (94%)
				Protected = 4 (6%)
				Overprotected = 0
IP	2008	610.8 – 733.7 (W.T = 5.8mm)	Total external defects = 130	40 – 59% = 1
				20 - 39% = 6
				10 - 19% = 31
				5 - 9% = 97
			Max. wall thickness loss	47% art KP 724.606795
		610.8 – 733.7 (W.T = 7.1mm)	Total external defects = 1	9% at KP 660.144374
		610.8 – 733.7 (W.T = 8.74mm)	Total external defects = 4	9% AT KP 610.886427
	1997	610.8 – 733.7	Total external defects = 94	40 – 59% = 1
				20 - 39% = 3
				10 - 19% = 25
				5 – 9% = 65
			Max. wall thickness loss	50% at KP 681.699153

Table C.5
Findings Of The Three Inspection Techniques For Pipeline Section From Renner Spring To Newcastle Water (KP 733.7 To KP 844)

Inspection Techniques	Year Inspected	KP	Findings	
DCVG	2009	733.7 – 793.4	Total defects = 122	>30% IR = 5
				15 - 30% IR = 20
				1 - <15% IR = 95
				< 1% IR = 2
	2003	733.7 – 844	Total defects = 179	>30% IR = 1
				15 - 30% IR = 16
				1 - <15% IR = 161
				< 1%IR = 1
CP	2008	733.7 – 844	Total Anomalies = 44 (Total readings = 80)	Under-protected = 44 (55%)
				Protected = 36 (45%)
				Overprotected = 0
	2007	733.7 – 844	Total Anomalies = 64 (Total readings = 80)	Under-protected = 64 (80%)
				Protected = 16 (20%)
				Overprotected = 0
IP	2008	733.7 – 844	Total external defects = 4,860 (W.T = 5.8mm)	20 - 39% = 70
				10 - 19% = 1,343
				5 - 9% = 3,447
			Max. wall thickness loss	36% at KP 808.959184
			Total external defects = 6 (W.T = 8.74mm)	5 - 9% =6
			Max. wall thickness loss	8% at KP 844.193693
	1997	733.7 – 844	Total external defects = 730	40 – 59% = 1
				20 - 39% = 11
				10 - 19% = 111
				5 – 9% = 607
			Max. wall thickness loss	44% at KP 742.866517

Table C.6
Findings Of The Three Inspection Techniques For Pipeline Section From Newcastle Waters To Daly Water (KP 844 To KP 981.8)

Inspection Techniques	Year Inspected	KP	Findings	
DCVG	2009	844.41 – 855.915	Total defects = 121	>30% IR = 3
				15 - 30% IR = 27
				1 - <15% IR = 90
				<1% IR = 1
		959.0 – 981.8	Total defects = 89	>30% IR = 1
				15 - 30% IR = 6
				1 - <15% IR = 82
	2003	844.4 – 981.8	Total defects = 379	>30% IR = 4
				15 - 30% IR = 19
				1 - <15% IR = 355
				< 1% IR = 1
CP	2008	844.4 – 981.8	Total Anomalies = 48 (Total readings = 85)	Under-protected = 48 (56%)
				Protected = 37 (44%)
				Overprotected = 0
	2007	844.4 – 981.8	Total Anomalies = 52 (Total readings = 80)	Under-protected = 52 (65%)
				Protected = 28 (35%)
				Overprotected = 0
IP	2008	844.4 – 981.8	Total external defects = 34,943 (W.T = 5.8mm)	40 – 59% = 2
				20 - 39% = 700
				10 - 19% = 8,728
				5 - 9% =25,513
			Max. wall thickness loss	57% at KP 893.702413
			Total external defects = 31 (W.T = 8.74mm)	10 - 19% = 6
				5 - 9% = 25
	1997		Total external defects = 1,547	40 – 59% = 3
				20 - 39% = 81
				10 - 19% = 1,107
				5 – 9% = 356
			Max. wall thickness loss	48% at KP 888.325289

Table C.7
Findings Of The Three Inspection Techniques For Pipeline Section From Daly Water To Mataranka (KP 981.8 To KP 1,107.9)

Inspection Techniques	Year Inspected	KP	Findings	
DCVG	2009	981.8 – 1107.9	Total defects = 145	>30% IR = 0
				15 - 30% IR = 2
				1 - <15% IR = 140
				< 1% IR = 3
	2003	981.8 – 1107.9	Total defects = 45	>30% IR = 1
				15 - 30% IR = 0
				1 - <15% IR = 45
CP	2008	981.8 – 1107.9	Total Anomalies = 0 (Total readings = 75)	Under-protected = 0
				Protected = 75 (100%)
				Overprotected = 0
	2007	981.8 – 1107.9	Total Anomalies = 0 (Total readings = 76)	Under-protected = 0
				Protected = 76 (100%)
				Overprotected = 0
IP	2008	981.8 – 1036.7	Total external defects = 43,485 (W.T = 5.8mm)	20 - 39% = 436
				10 - 19% = 8,927
				5 - 9% = 34,122
			Max. wall thickness loss	37% at KP 997.967614
			Total external defects = 25 (W.T = 8.74mm)	10 - 19% = 4
				5 - 9% = 21
			Max. wall thickness loss	13 % at KP 981.912133
	1997	981.8 – 1036.7	Total external defects = 3,309	40 – 59% = 1
				20 - 39% = 4
				10 - 19% = 419
				5 – 9% = 2,885
			Max. wall thickness loss	47% at KP 991.027585

APPENDIX D

WALL THICKNESS LOSS VS CP OFF POTENTIAL READINGS

Figure D.1

Section 2: Tanami Road to Ti-tree – IP % Wall Thickness Loss Vs CP Off Potential Readings

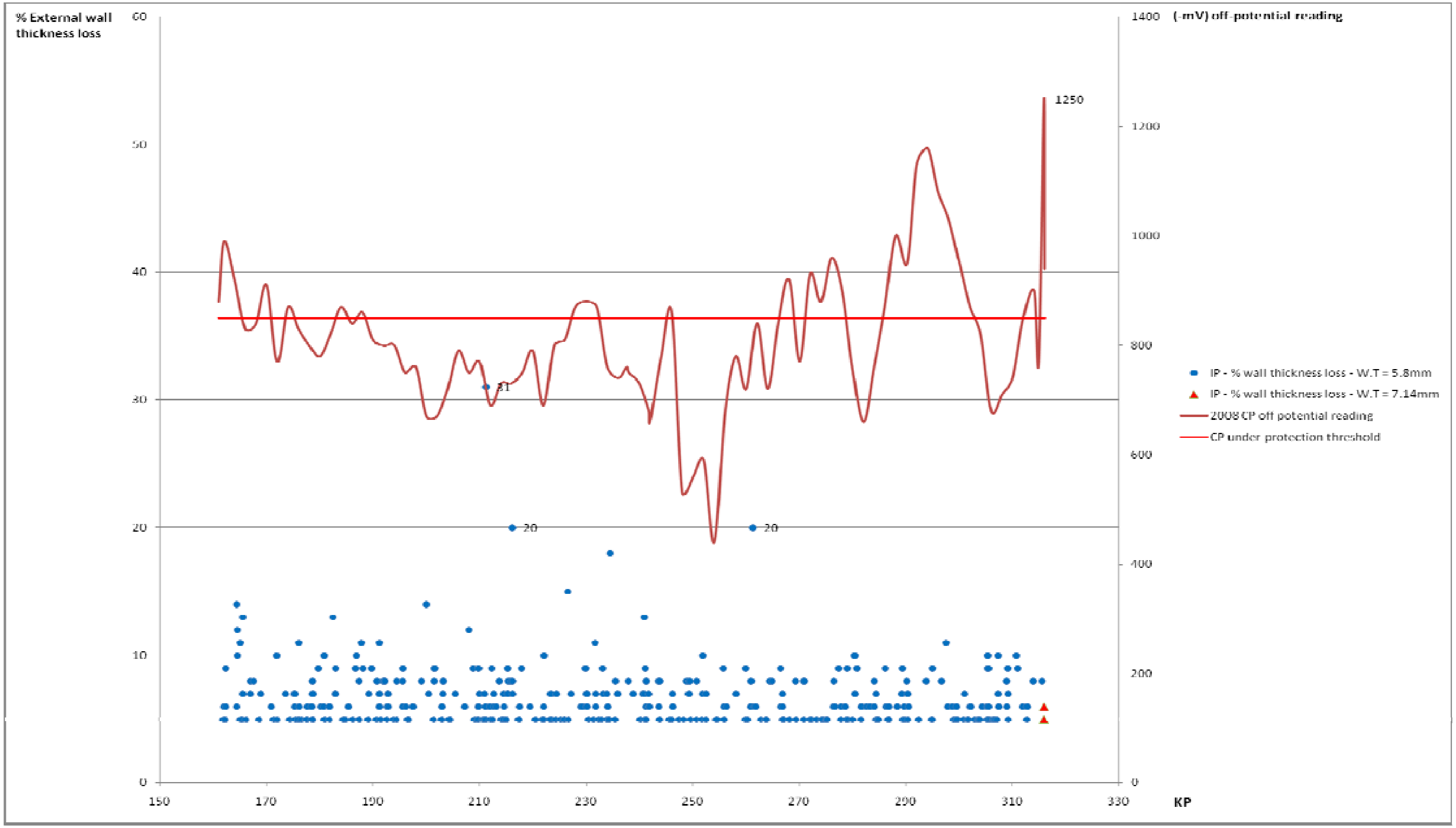


Figure D.2
Section 3: Ti-tree to Wauchope – IP % Wall Thickness Loss Vs CP Off Potential Readings

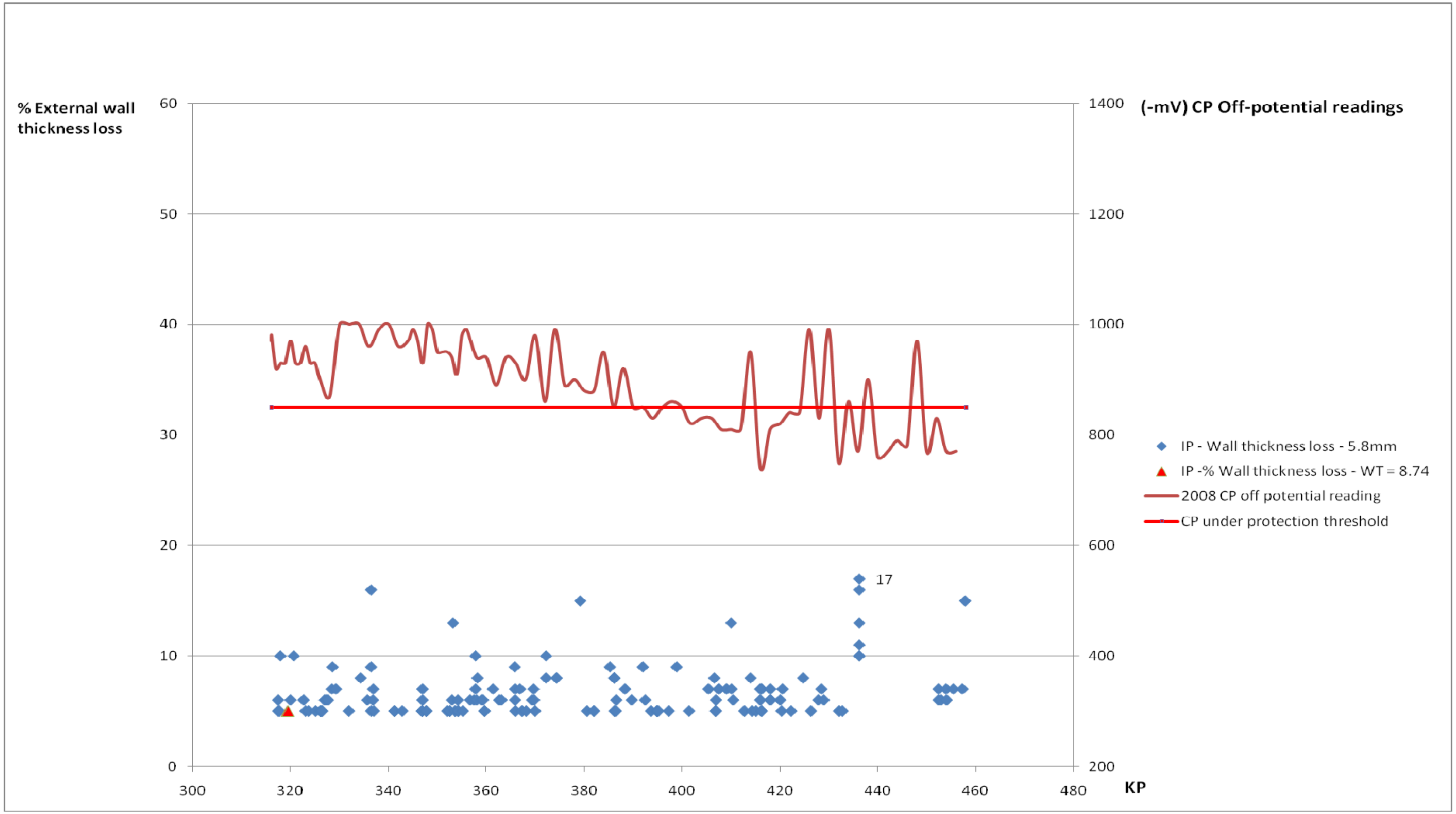


Figure D.3
Section 4: Wauchope to Warrego – IP % Wall Thickness Loss Vs CP Off Potential Readings

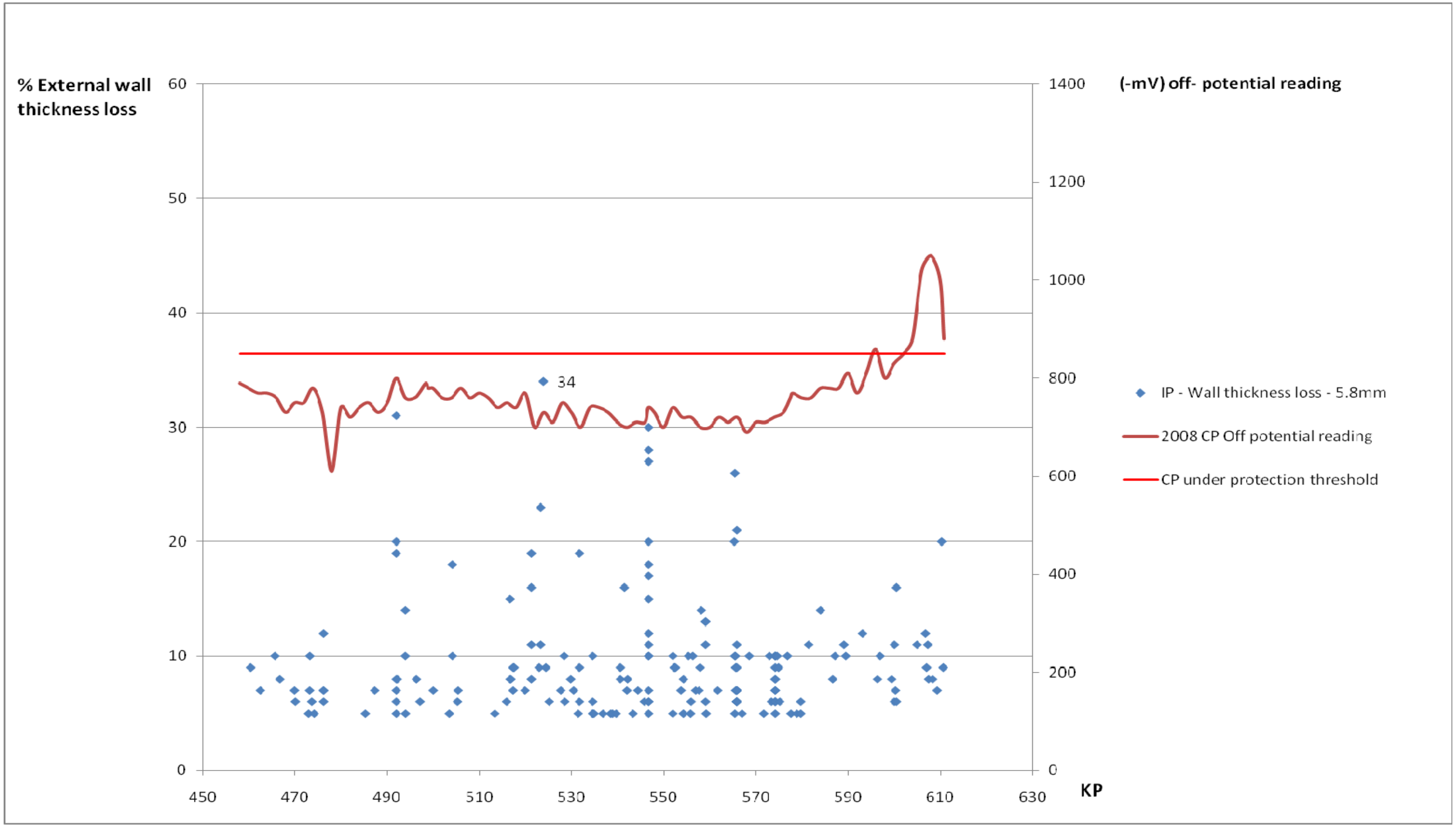


Figure D.4
Section 5: Warrego to Renner Spring – IP % Wall Thickness Loss Vs CP Off Potential Readings

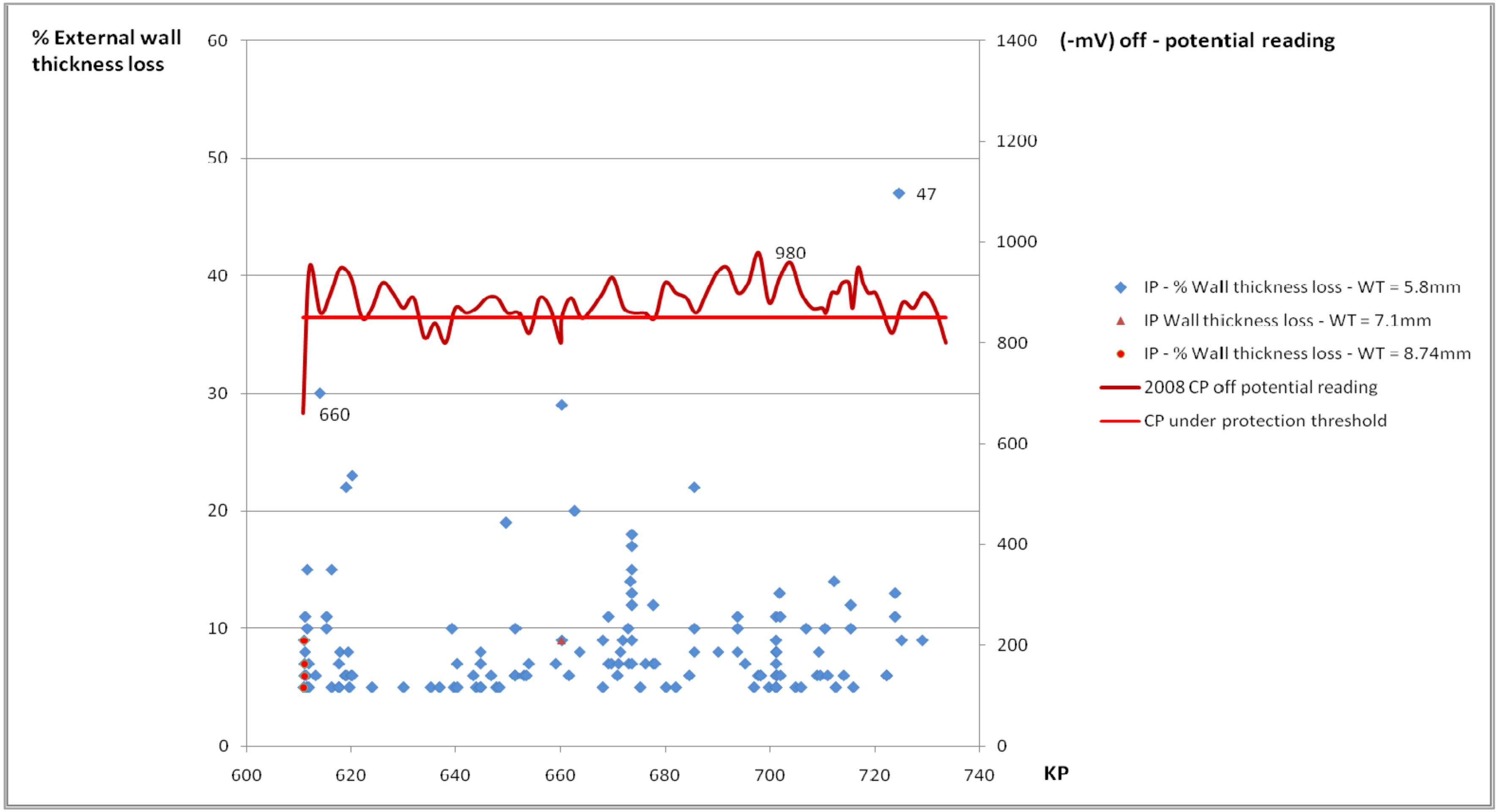


Figure D.5
Section 6: Renner Spring to Newcastle waters – IP % Wall Thickness Loss Vs CP Off Potential Readings

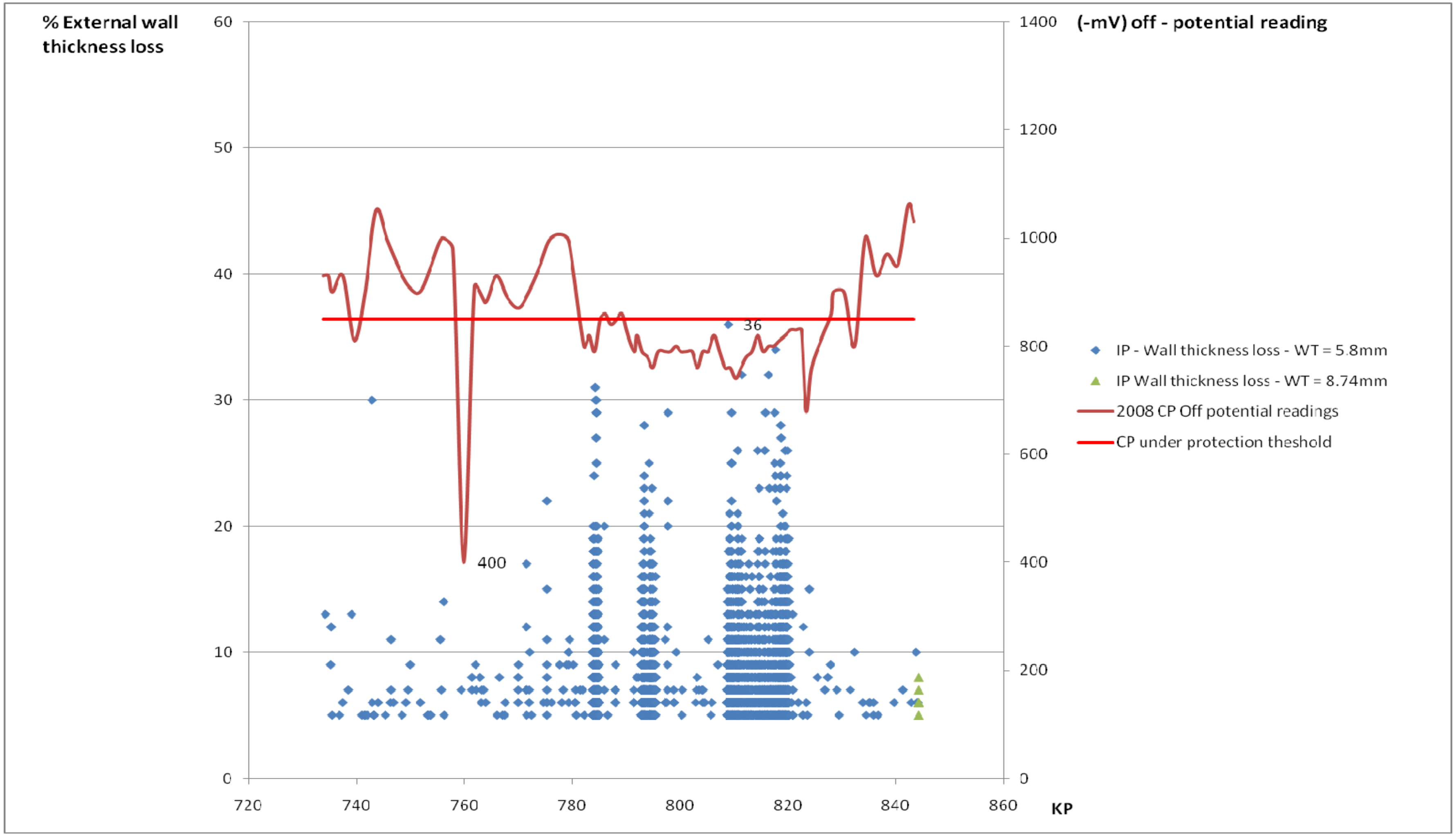


Figure D.6
Section 7: Newcastle waters to Daly waters – IP % Wall Thickness Loss Vs CP Off Potential Readings

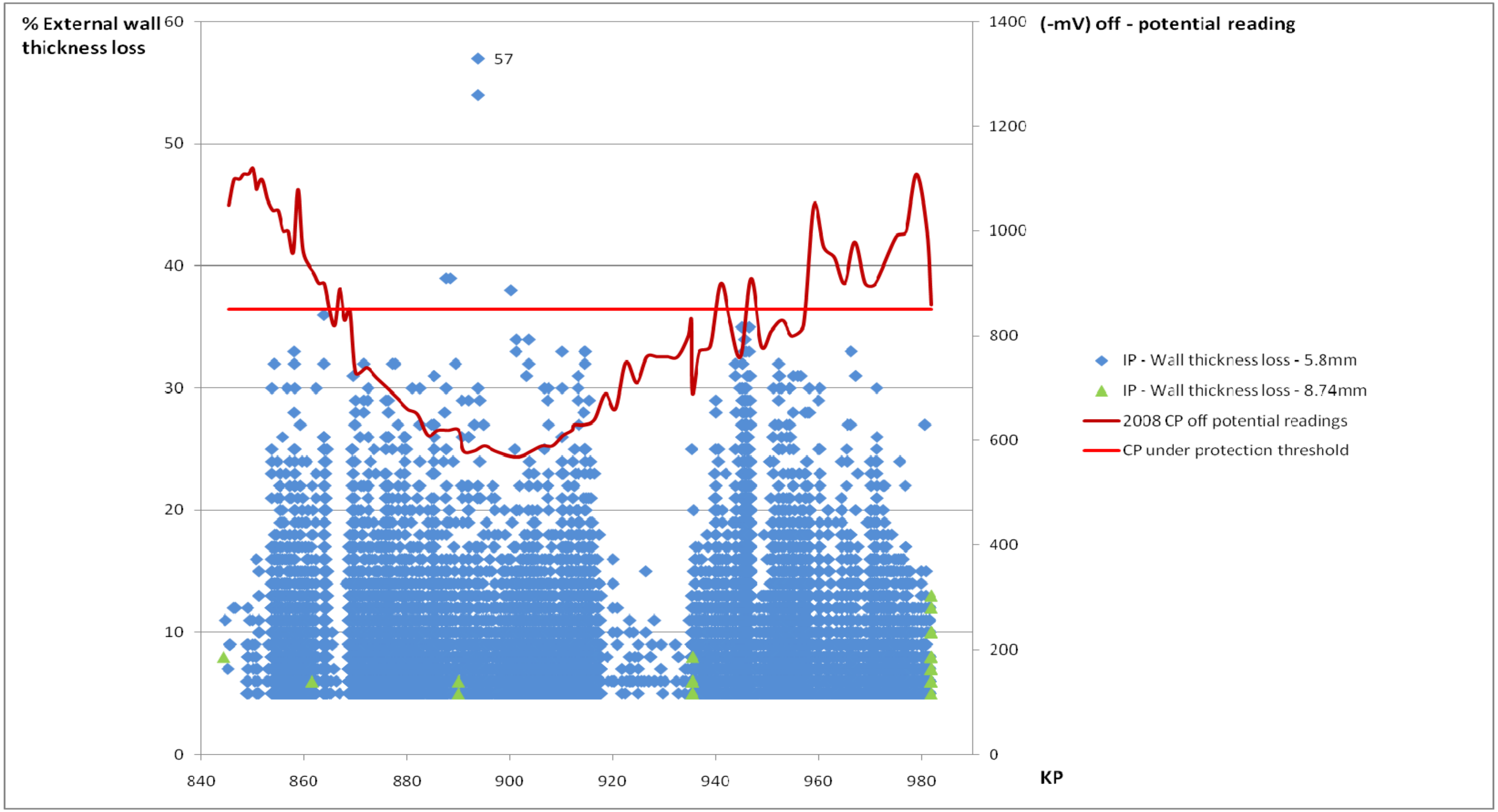
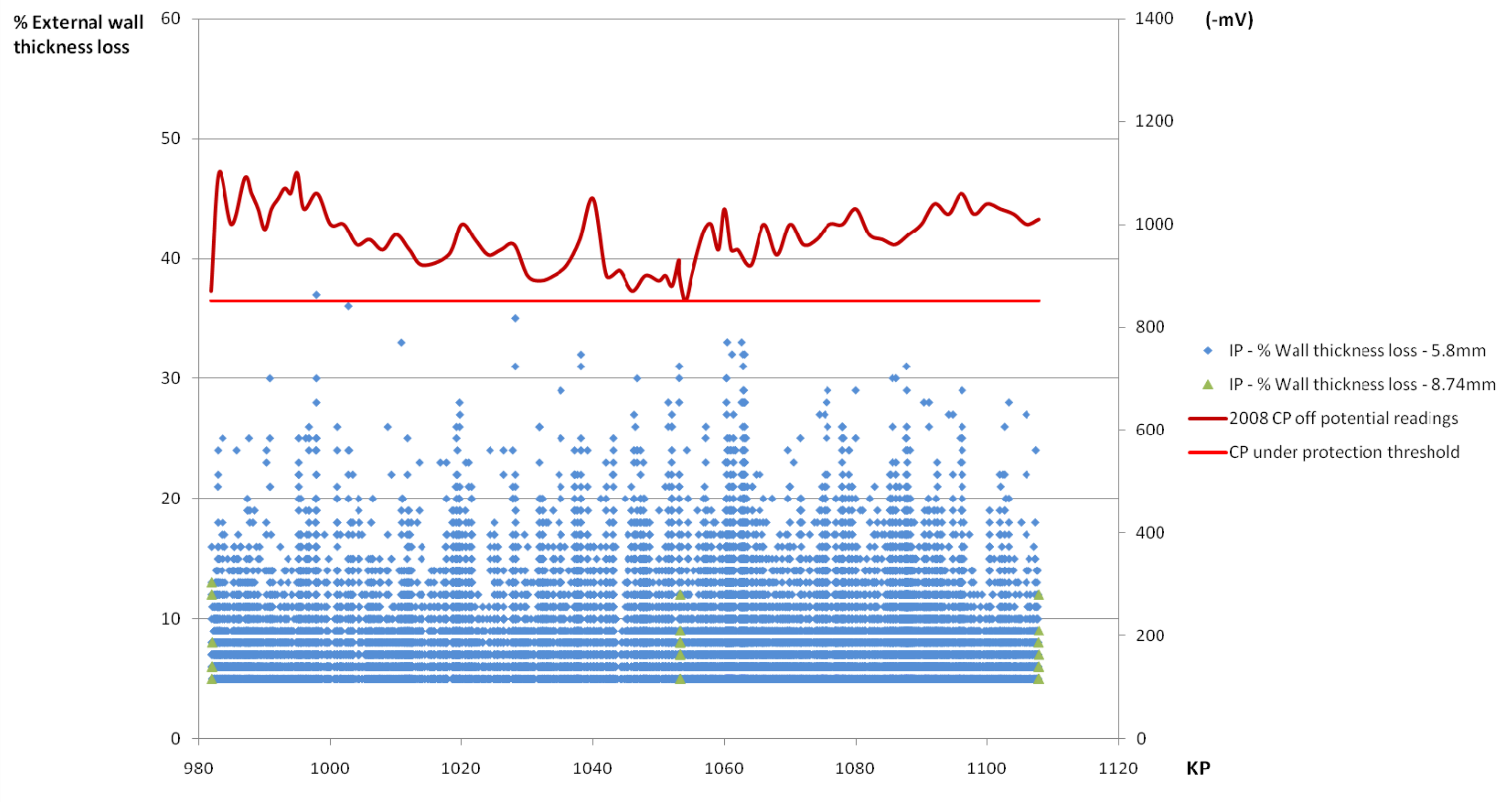


Figure D.7
Section 8: Daly waters to Mataranka – IP % Wall Thickness Loss Vs CP Off Potential Readings



APPENDIX E

2006 – 2008 CP OFF POTENTIAL READINGS

Figure E.1
Section 2: Tanami Road to Ti – Tree 2006 – 2008 CP Off Potential Readings

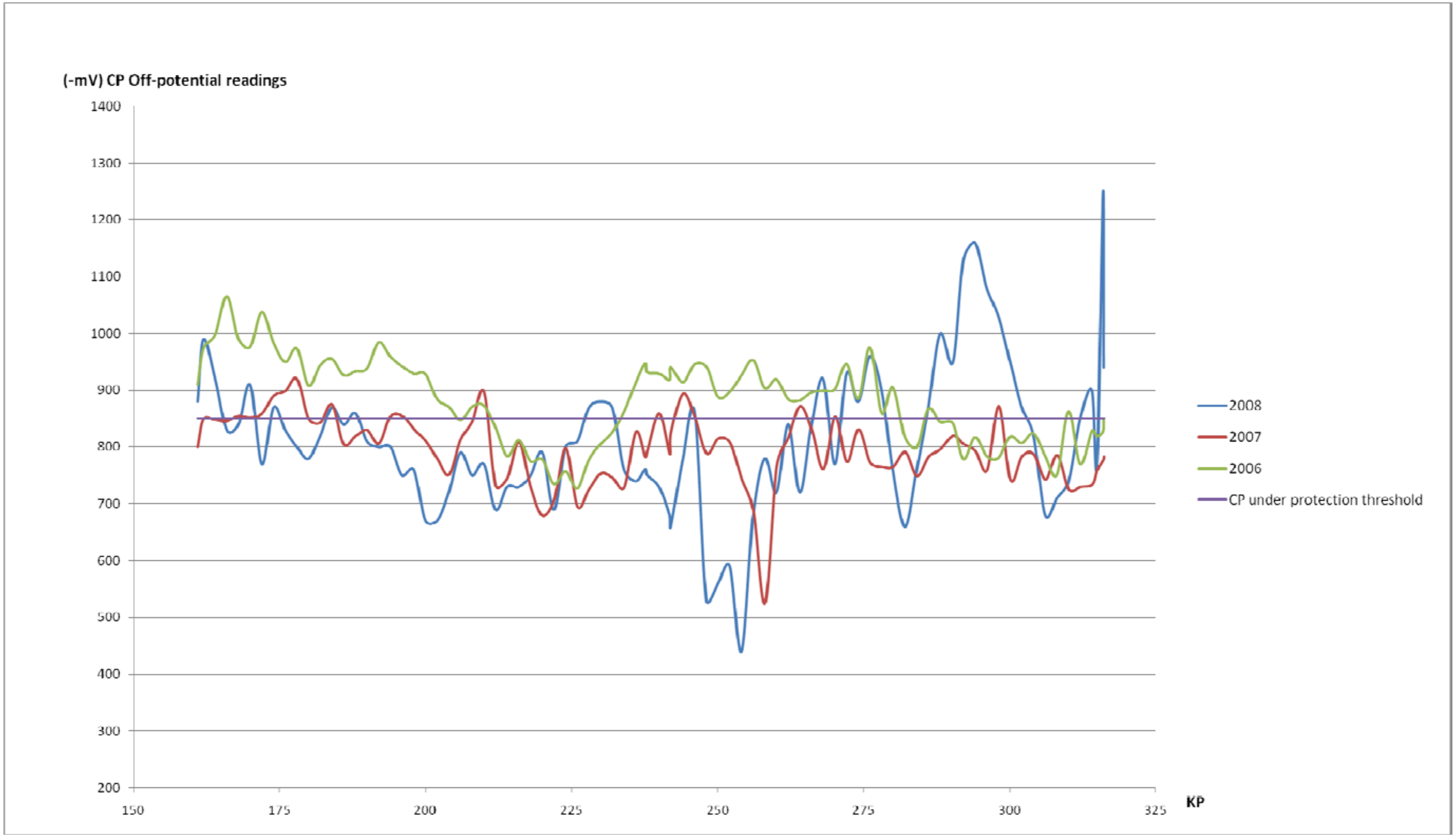


Figure E.2
Section 3: Ti – Tree to Wauchope 2006 – 2008 CP Off Potential Readings

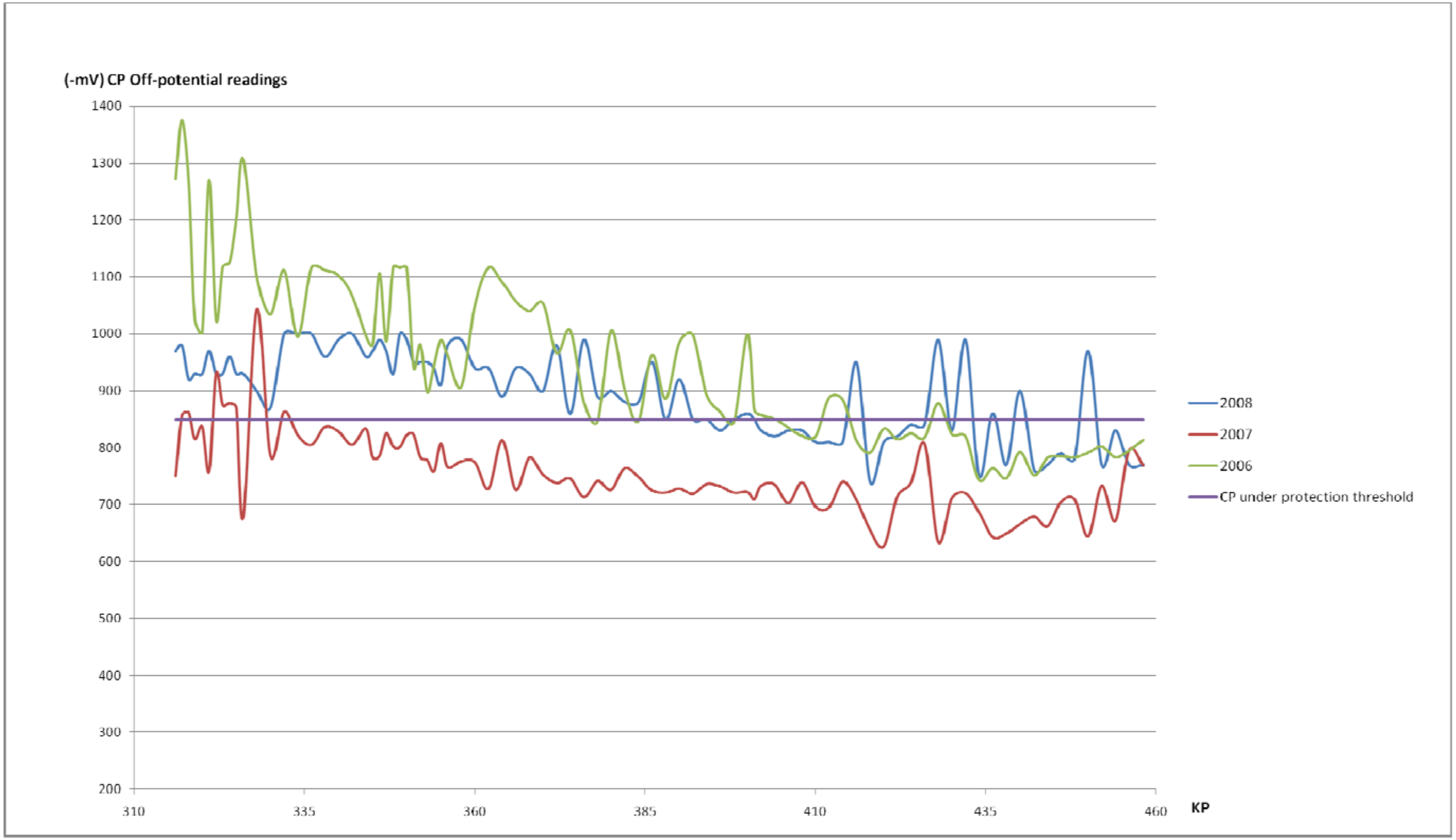


Figure E.3
Section 4: Wauchope to Warrego 2006 – 2008 CP Off Potential Readings

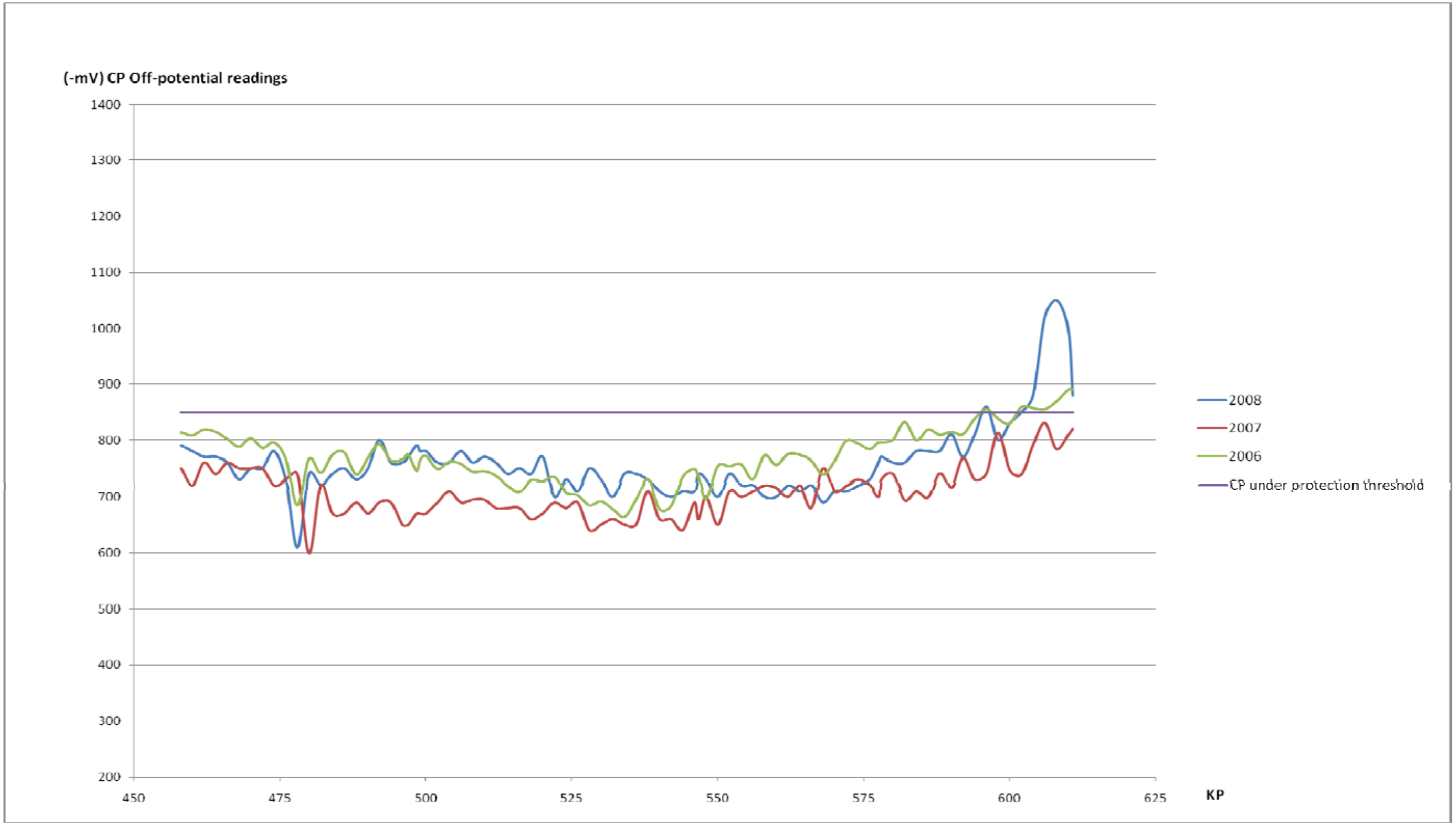


Figure E.4
Section 5: Warrego to Renner springs 2006 – 2008 CP Off Potential Readings

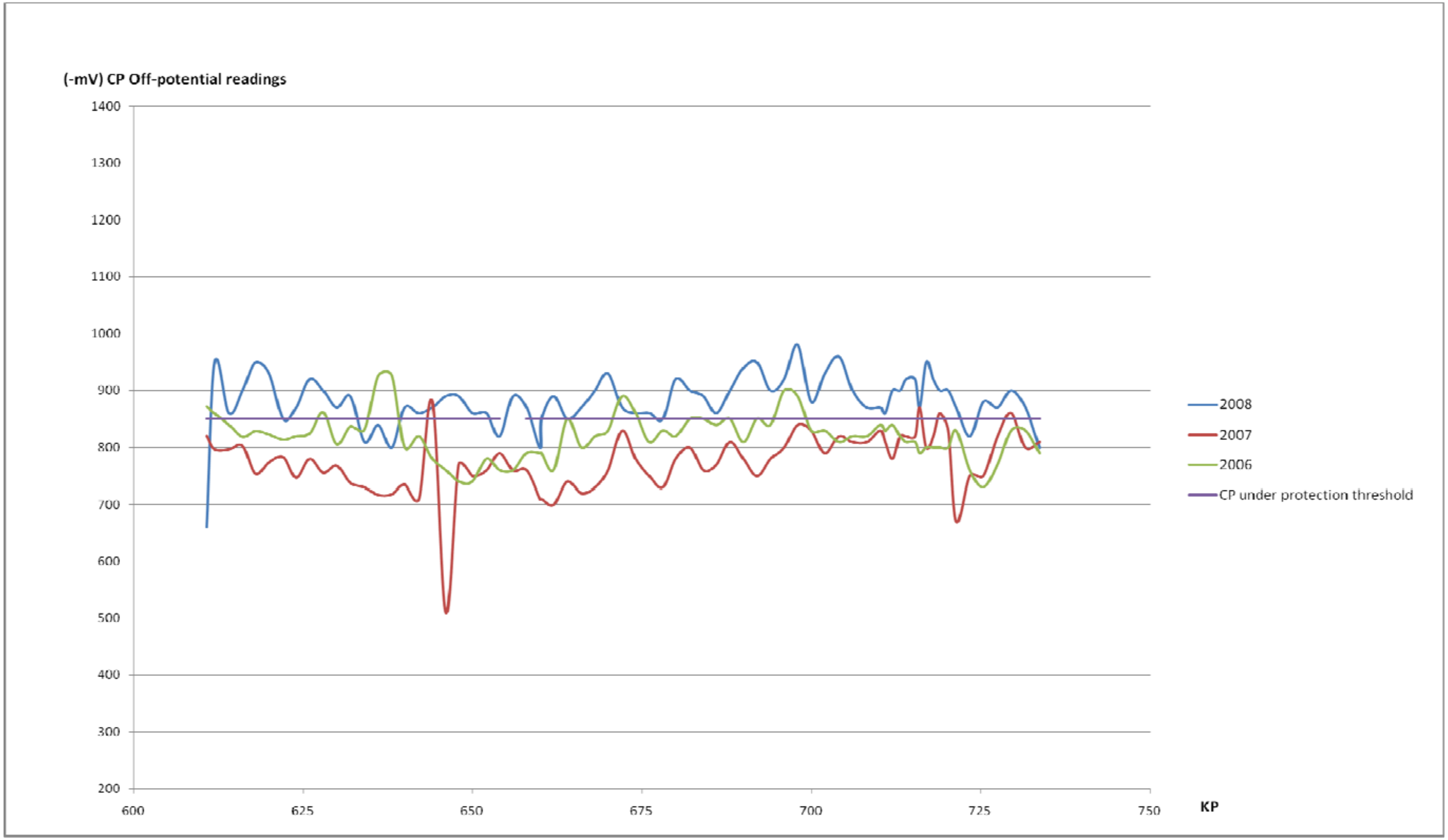
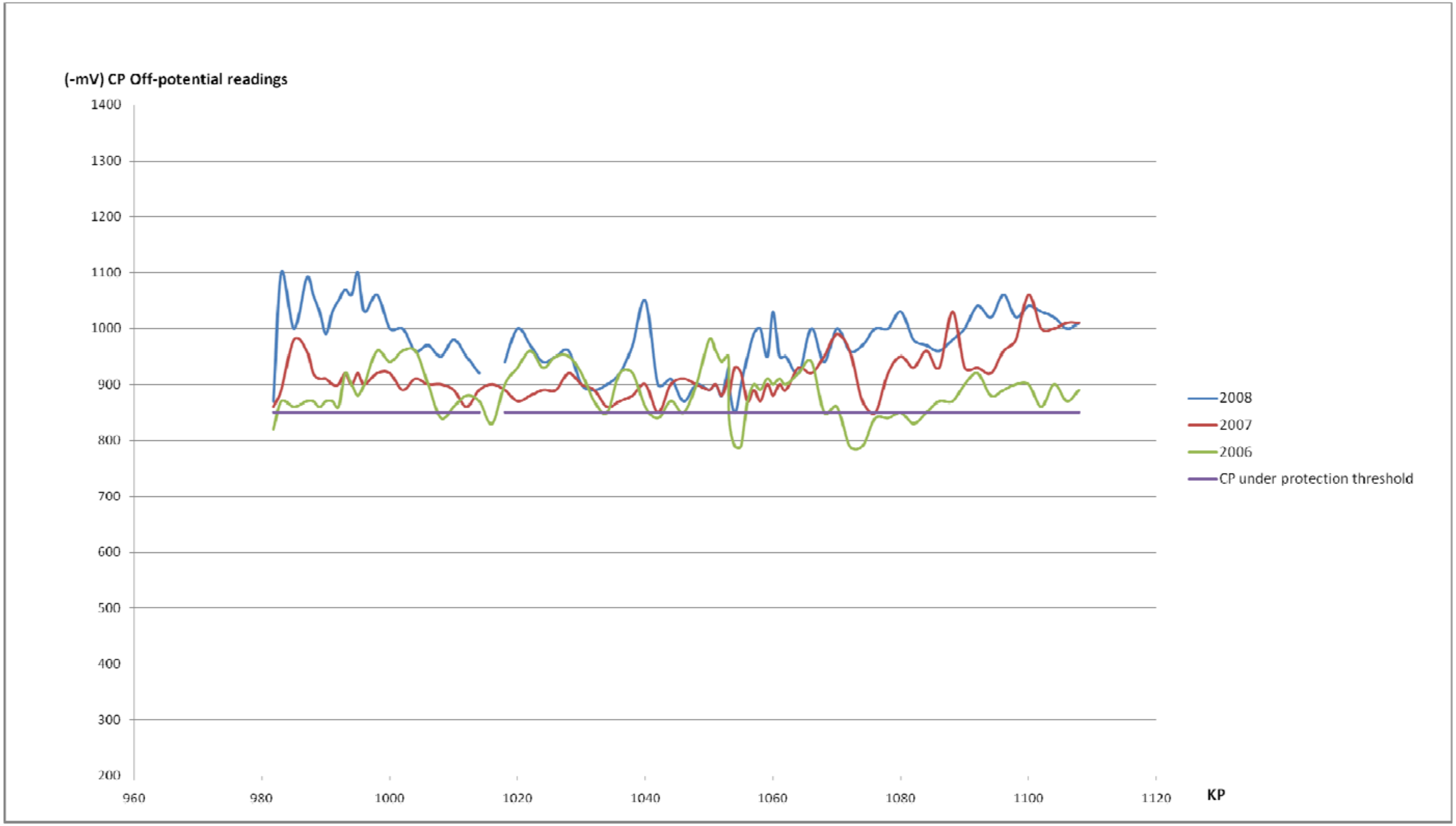


Figure E.5
Section 6: Renner springs to Newcastle waters 2006 – 2008 CP Off Potential Readings

Figure E.6
Section 7: Newcastle waters to Daly water 2006 – 2008 CP Off Potential Readings

Figure E.7
Section 8: Daly water to Mataranka 2006 – 2008 CP Off Potential Readings



APPENDIX F

SUMMARY OF ANOMALIES

Table F.1
Anomalies Reported in Section 2

	FEATURE DESCRIPTION (Type / Cause)	Tanami Rod - Ti tree NUMBER OF FEATURES INTERNAL	EXTERNAL	N/A[1]	TOTAL
Metal Loss Features	≥ 60% Wall Loss (MELO-CORR)	0	0	0	0
	40-59% Wall Loss (MELO-CORR)	0	0	0	0
	20-39% Wall Loss (MELO-CORR)	1	3	0	4
	10-19% Wall Loss (MELO-CORR)	13	25	0	38
	5-9% Wall Loss (MELO-CORR)	16	357	0	373
	Total Number of MELO-CORR				**415**
	Total Number of Metal Loss Non-Corrosion Features				**136**
	Total Number of Metal Loss Features				**551**
Other Anomalies without Depths Calculation	Number of Girth Weld Anomalies (ANOM-GWAN)				0
	Number of Laminations (ANOM-LAMI)				0
	Number of Longitudinal Weld Anomalies (ANOM-LWAN)				0
	Number of Milling Anomalies (ANOM-MILL)				17
	Number of Spiral Weld Anomalies (ANOM-SWAN)				0
	Number of Spiral Weld Irregularities (ANOM-SWAN)				0
	ID anomaly without calculation				0
	Total Number of Other Anomalies				**17**
	Total Number of Features				**568**

In addition one (1) ID anomaly (ANOM-DENT) was observed, which is confirmed by ROSEN to be a milling anomaly (see APPENDIX J).

[1] N/A – Insufficient data to classify data as internal or external.

Table F.2
Anomalies Reported in Section 3

	Ti tree - Wauchope				
	FEATURE DESCRIPTION (Type / Cause)	NUMBER OF FEATURES			
		INTERNAL	EXTERNAL	N/A[1]	TOTAL
Metal Loss Features	≥ 60% Wall Loss (MELO-CORR)	0	0	0	0
	40-59% Wall Loss (MELO-CORR)	0	0	0	0
	20-39% Wall Loss (MELO-CORR)	1	0	0	1
	10-19% Wall Loss (MELO-CORR)	5	12	0	17
	5-9% Wall Loss (MELO-CORR)	13	128	0	141
	Total Number of MELO-CORR				**159**
	Total Number of Metal Loss Non-Corrosion Features				**679**
	Total Number of Metal Loss Features				**838**
Other Anomalies without Depths Calculation	Number of Girth Weld Anomalies (ANOM-GWAN)				0
	Number of Laminations (ANOM-LAMI)				0
	Number of Longitudinal Weld Anomalies (ANOM-LWAN)				0
	Number of Milling Anomalies (ANOM-MILL)				6
	Number of Spiral Weld Anomalies (ANOM-SWAN)				0
	Number of Spiral Weld Irregularities (ANOM-SWAN)				0
	ID anomaly without calculation				0
	Total Number of Other Anomalies				**6**
	Total Number of Features				**844**

[1] N/A – Insufficient data to classify data as internal or external.

Table F.3
Anomalies Reported in Section 4

	Wauchope - Warrego				
	FEATURE DESCRIPTION (Type / Cause)	NUMBER OF FEATURES			
		INTERNAL	EXTERNAL	N/A[1]	TOTAL
Metal Loss Features	≥ 60% Wall Loss (MELO-CORR)	0	0	0	0
	40-59% Wall Loss (MELO-CORR)	0	0	0	0
	20-39% Wall Loss (MELO-CORR)	0	12	0	12
	10-19% Wall Loss (MELO-CORR)	2	52	0	54
	5-9% Wall Loss (MELO-CORR)	0	119	0	119
	Total Number of MELO-CORR				**185**
	Total Number of Metal Loss Non-Corrosion Features				**64**
	Total Number of Metal Loss Features				**249**
Other Anomalies without Depths Calculation	Number of Girth Weld Anomalies (ANOM-GWAN)				17
	Number of Laminations (ANOM-LAMI)				0
	Number of Longitudinal Weld Anomalies (ANOM-LWAN)				0
	Number of Milling Anomalies (ANOM-MILL)				9
	Number of Spiral Weld Anomalies (ANOM-SWAN)				0
	Number of Spiral Weld Irregularities (ANOM-SWAN)				0
	ID anomaly without calculation				0
	Total Number of Other Anomalies				**26**
	Total Number of Features				**275**

[1] N/A – Insufficient data to classify data as internal or external.

Table F.4
Anomalies Reported in Section 5

	Warrego - Renner Springs				
	FEATURE DESCRIPTION (Type / Cause)	**NUMBER OF FEATURES**			
		INTERNAL	**EXTERNAL**	**N/A[1]**	**TOTAL**
Metal Loss Features	≥ 60% Wall Loss (MELO-CORR)	0	0	0	0
	40-59% Wall Loss (MELO-CORR)	1	1	0	2
	20-39% Wall Loss (MELO-CORR)	0	6	0	6
	10-19% Wall Loss (MELO-CORR)	0	30	0	30
	5-9% Wall Loss (MELO-CORR)	0	91	0	91
	Total Number of MELO-CORR				**129**
	Total Number of Metal Loss Non-Corrosion Features				**92**
	Total Number of Metal Loss Features				**221**
Other Anomalies without Depths Calculation	Number of Girth Weld Anomalies (ANOM-GWAN)				19
	Number of Laminations (ANOM-LAMI)				0
	Number of Longitudinal Weld Anomalies (ANOM-LWAN)				0
	Number of Milling Anomalies (ANOM-MILL)				9
	Number of Spiral Weld Anomalies (ANOM-SWAN)				0
	Number of Spiral Weld Irregularities (ANOM-SWAN)				0
	ID anomaly without calculation				0
	Total Number of Other Anomalies				**28**
	Total Number of Features				**249**

[1] N/A – Insufficient data to classify data as internal or external.

Table F.5
Anomalies Reported in Section 6

	Renner Springs - Newcastle Waters				
	FEATURE DESCRIPTION (Type / Cause)	NUMBER OF FEATURES			
		INTERNAL	EXTERNAL	N/A[1]	TOTAL
Metal Loss Features	≥ 60% Wall Loss (MELO-CORR)	0	0	0	0
	40-59% Wall Loss (MELO-CORR)	0	0	0	0
	20-39% Wall Loss (MELO-CORR)	0	58	0	58
	10-19% Wall Loss (MELO-CORR)	0	1214	0	1,214
	5-9% Wall Loss (MELO-CORR)	0	3121	0	3,121
	Total Number of MELO-CORR				**4,393**
	Total Number of Metal Loss Non-Corrosion Features				**65**
	Total Number of Metal Loss Features				**4,458**
Other Anomalies without Depths Calculation	Number of Girth Weld Anomalies (ANOM-GWAN)				0
	Number of Laminations (ANOM-LAMI)				26
	Number of Longitudinal Weld Anomalies (ANOM-LWAN)				0
	Number of Milling Anomalies (ANOM-MILL)				4
	Number of Spiral Weld Anomalies (ANOM-SWAN)				0
	Number of Spiral Weld Irregularities (ANOM-SWAN)				0
	ID anomaly without calculation				0
	Total Number of Other Anomalies				**30**
	Total Number of Features				**4,488**

[1] N/A – Insufficient data to classify data as internal or external.

Table F.6
Anomalies Reported in Section 7

	Newcastle Waters - Daly Waters				
	FEATURE DESCRIPTION (Type / Cause)	NUMBER OF FEATURES			
		INTERNAL	EXTERNAL	N/A[1]	TOTAL
Metal Loss Features	≥ 60% Wall Loss (MELO-CORR)	0	0	0	0
	40-59% Wall Loss (MELO-CORR)	0	2	0	2
	20-39% Wall Loss (MELO-CORR)	0	648	0	648
	10-19% Wall Loss (MELO-CORR)	3	7894	0	7,897
	5-9% Wall Loss (MELO-CORR)	3	22116	0	22,119
	Total Number of MELO-CORR				**30,666**
	Total Number of Metal Loss Non-Corrosion Features				**94**
	Total Number of Metal Loss Features				**30,760**
Other Anomalies without Depths Calculation	Number of Girth Weld Anomalies (ANOM-GWAN)				14
	Number of Laminations (ANOM-LAMI)				0
	Number of Longitudinal Weld Anomalies (ANOM-LWAN)				0
	Number of Milling Anomalies (ANOM-MILL)				2
	Number of Spiral Weld Anomalies (ANOM-SWAN)				0
	Number of Spiral Weld Irregularities (ANOM-SWAN)				0
	ID anomaly without calculation				0
	Total Number of Other Anomalies				**16**
	Total Number of Features				**30,776**

[1] N/A – Insufficient data to classify data as internal or external.

Table F.7
Anomalies Reported in Section 8

	Daly Waters – Mataranka				
	FEATURE DESCRIPTION (Type / Cause)	**NUMBER OF FEATURES**			
		INTERNAL	**EXTERNAL**	**N/A[1]**	**TOTAL**
Metal Loss Features	≥ 60% Wall Loss (MELO-CORR)	0	0	0	0
	40-59% Wall Loss (MELO-CORR)	0	0	0	0
	20-39% Wall Loss (MELO-CORR)	0	414	0	414
	10-19% Wall Loss (MELO-CORR)	1	7938	0	7,939
	5-9% Wall Loss (MELO-CORR)	0	27758	0	27,758
	Total Number of MELO-CORR				**36,111**
	Total Number of Metal Loss Non-Corrosion Features				**46**
	Total Number of Metal Loss Features				**36,157**
Other Anomalies without Depths Calculation	Number of Girth Weld Anomalies (ANOM-GWAN)				7
	Number of Laminations (ANOM-LAMI)				0
	Number of Longitudinal Weld Anomalies (ANOM-LWAN)				0
	Number of Milling Anomalies (ANOM-MILL)				7
	Number of Spiral Weld Anomalies (ANOM-SWAN)				0
	Number of Spiral Weld Irregularities (ANOM-SWAN)				0
	ID anomaly without calculation				1
	Total Number of Other Anomalies				**15**
	Total Number of Features				**36,172**

[1] N/A – Insufficient data to classify data as internal or external.

APPENDIX G

POF CLASSIFICATION OF CORROSION ANOMALIES

Table G.1
POF Classifications of Section 2: Tanami Rd – TI Tree

Anomaly Classes	External	Internal
General Wall Loss	17	7
Circumferential Grooving	65	6
Axial Grooving	23	0
Pitting	176	11
Circumferential Slotting	104	6
Axial Slotting	0	0
Pinhole	0	0
Total	**385**	**30**

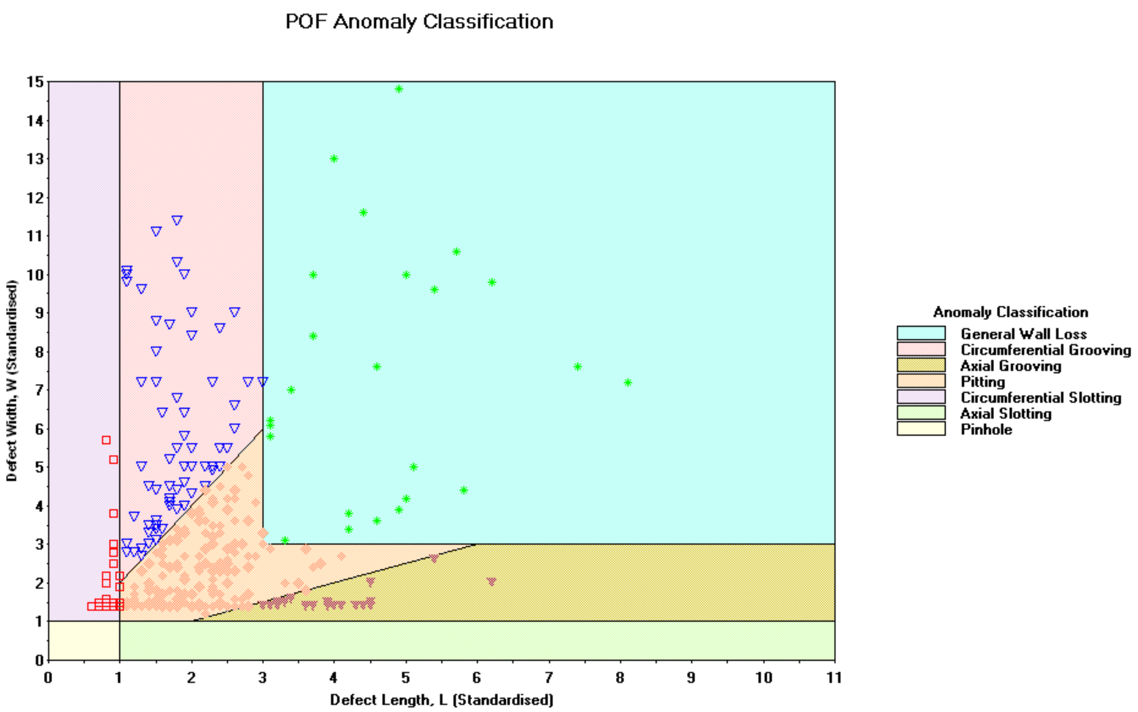


Table G.2

POF Classifications of Section 3: TI Tree – Wauchope

Anomaly Classes	External	Internal
General Wall Loss	34	2
Circumferential Grooving	13	2
Axial Grooving	22	1
Pitting	71	15
Circumferential Slotting	10	1
Axial Slotting	0	0
Pinhole	0	0
Total	**150**	**21**

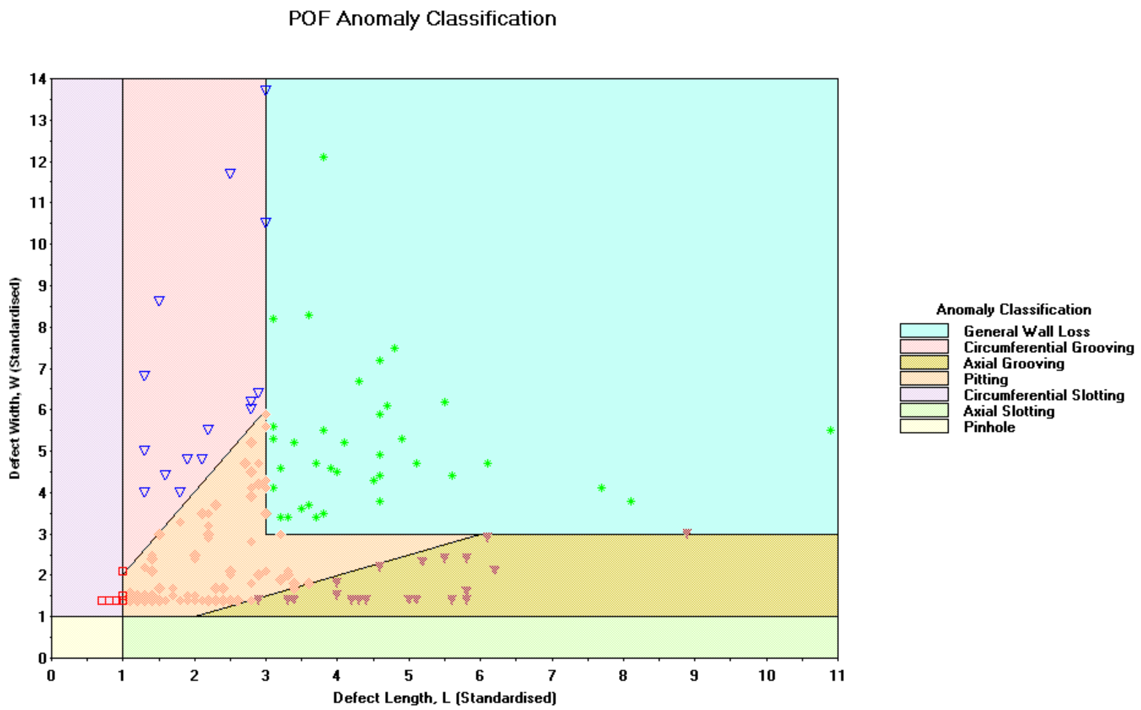


Table G.3
POF Classifications of Section 4: Wauchope – Warrego

Anomaly Classes	External	Internal
General Wall Loss	11	0
Circumferential Grooving	6	0
Axial Grooving	31	0
Pitting	116	2
Circumferential Slotting	22	0
Axial Slotting	0	0
Pinhole	0	0
Total	**186**	**2**

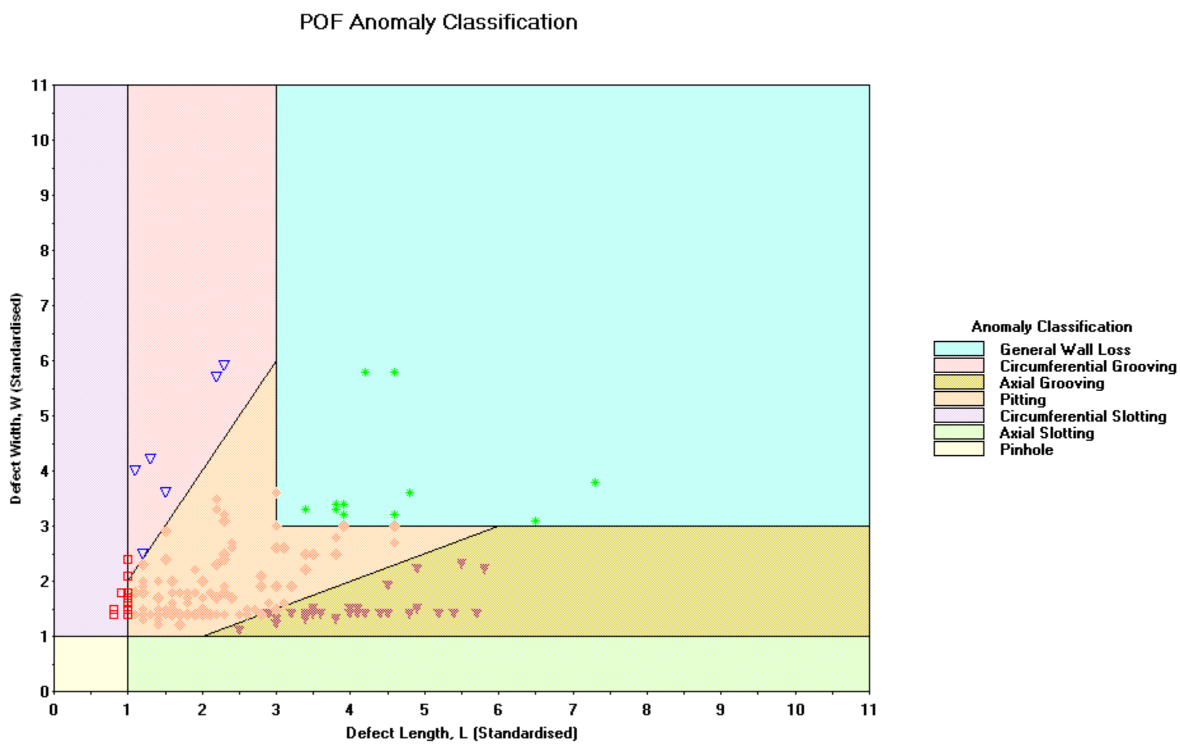


Table G.4
POF Classifications of Section 5: Warrego – Renner Springs

Anomaly Classes	External	Internal
General Wall Loss	8	0
Circumferential Grooving	7	1
Axial Grooving	19	0
Pitting	84	0
Circumferential Slotting	17	0
Axial Slotting	0	0
Pinhole	0	0
Total	**135**	**1**

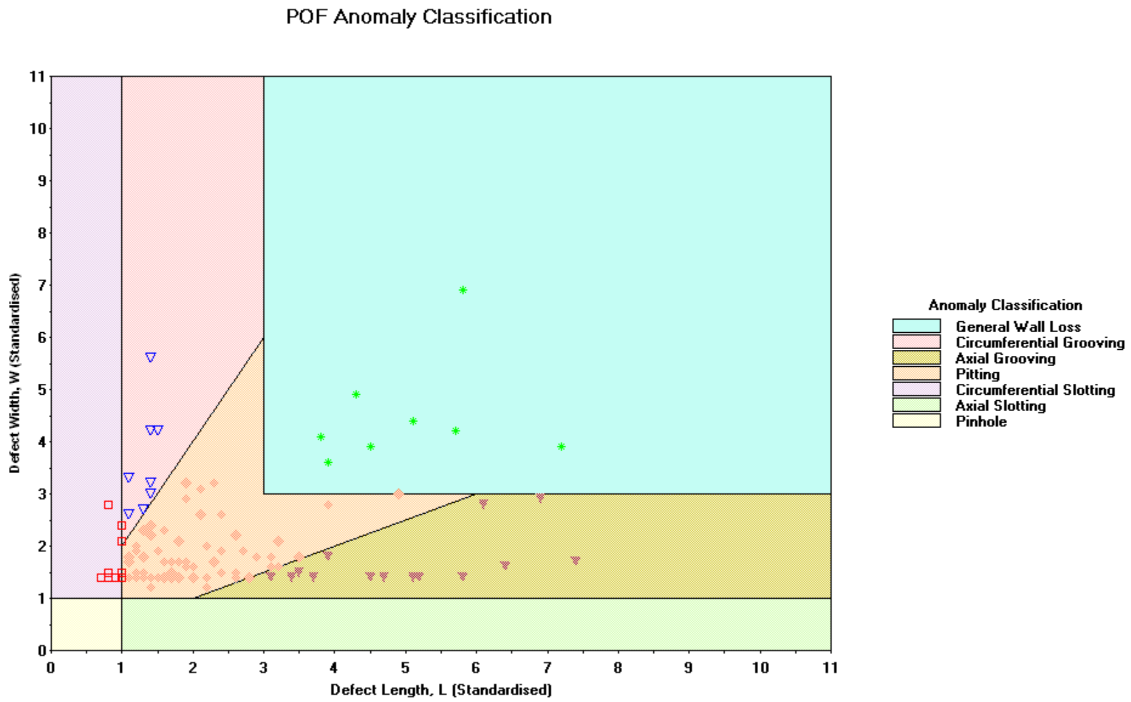


Table G.5

POF Classifications of Section 6: Renner Springs – Newcastle Waters

Anomaly Classes	External	Internal
General Wall Loss	61	0
Circumferential Grooving	550	0
Axial Grooving	920	0
Pitting	3072	0
Circumferential Slotting	263	0
Axial Slotting	0	0
Pinhole	0	0
Total	**4866**	**0**

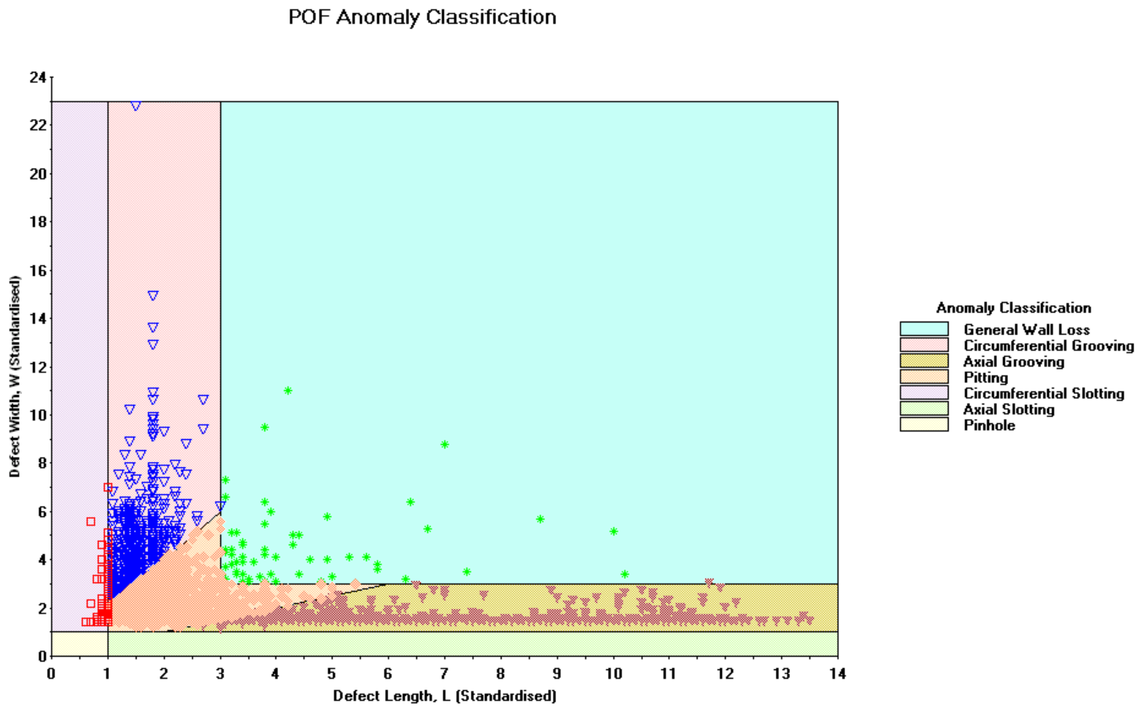


Table G.6

POF Classifications of Section 7: Newcastle Waters – Daly Waters

Anomaly Classes	External	Internal
General Wall Loss	210	0
Circumferential Grooving	3146	0
Axial Grooving	5324	0
Pitting	24269	4
Circumferential Slotting	2025	4
Axial Slotting	0	0
Pinhole	0	0
Total	**34974**	**8**

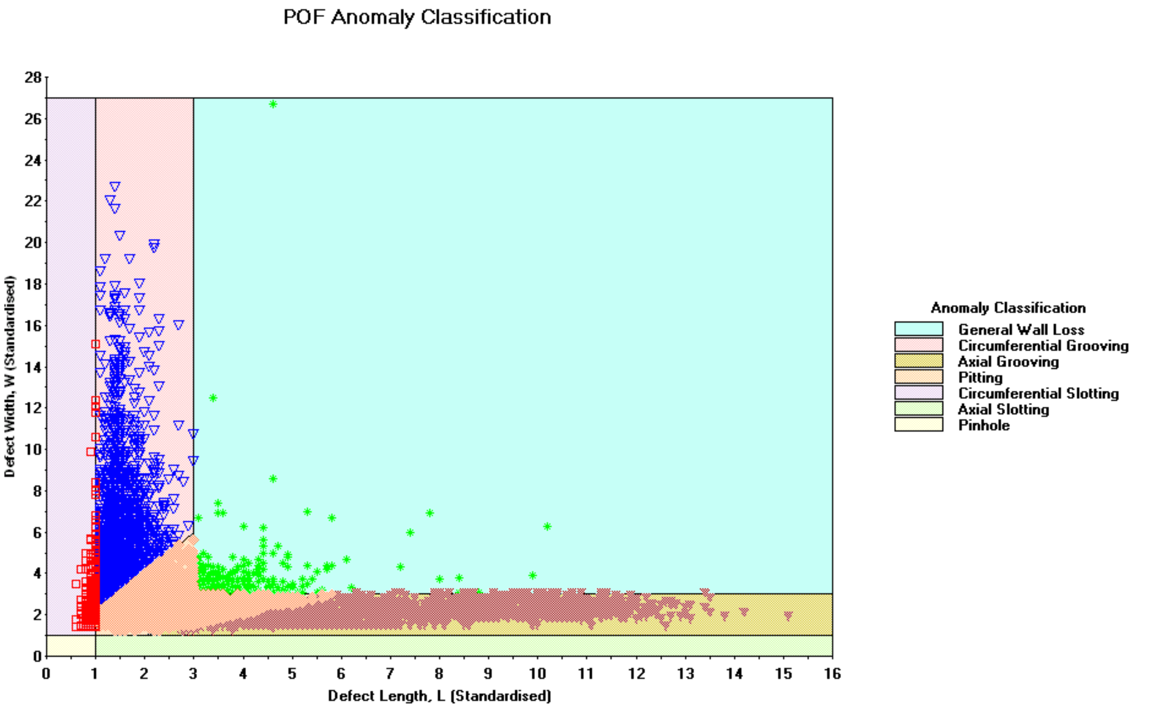
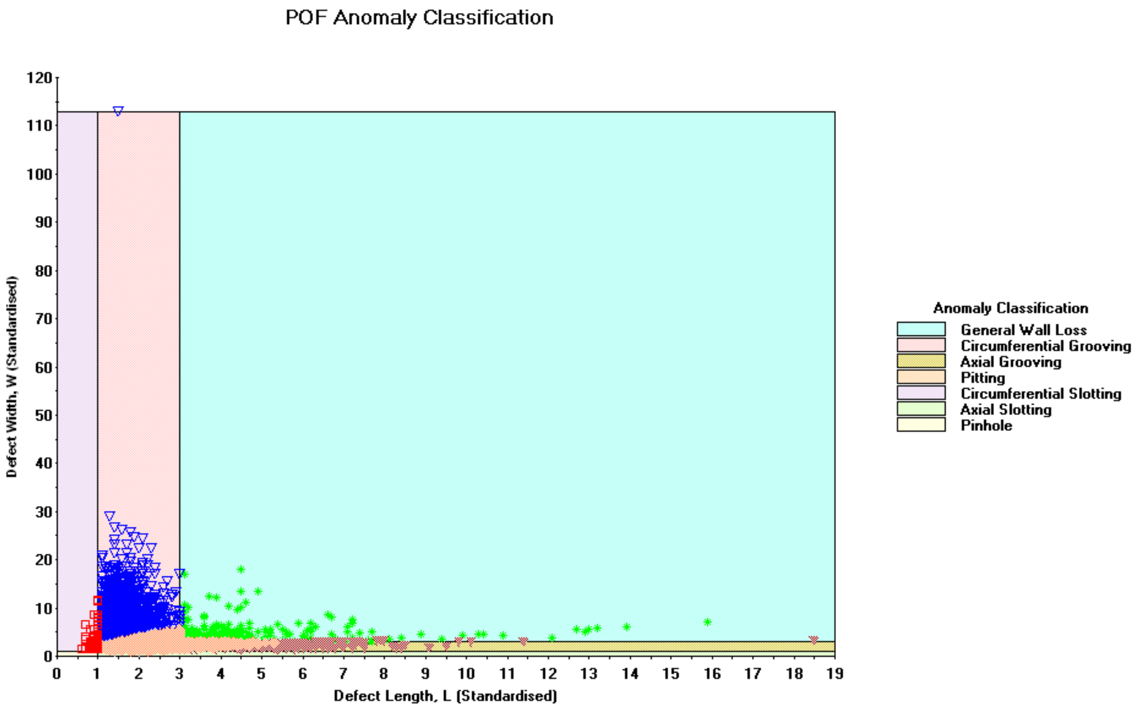


Table G.7

POF Classifications of Section 8: Daly Waters – Mataranka

Anomaly Classes	External	Internal
General Wall Loss	289	0
Circumferential Grooving	3638	0
Axial Grooving	4516	0
Pitting	32866	1
Circumferential Slotting	2201	0
Axial Slotting	0	0
Pinhole	0	0
Total	**43510**	**1**



APPENDIX H

REPAIR SCHEDULES

Table H.1
Repair Schedule Section 2: Tanami Rd – TI Tree
Proportional Growth

Proportional Growth Rate			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	0	0	0
11 - 15	0	0	0
16 - 20	2	0	2
21 - 25	3	0	3
26 - 27	1	0	1
28	1	0	1

No failures for the comparison corrosion rates - EXTERNAL / INTERNAL

Table H.2
Repair Schedule Section 3: TI Tree – Wauchope Proportional Growth

Proportional Growth Rate			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	0	0	0
11 - 15	0	0	0
16 - 20	1	0	1
21 - 25	5	0	5
26 - 27	1	0	1
28	2	0	2

No failures for the comparison corrosion rates - EXTERNAL / INTERNAL

Table H.3a

Repair Schedule Section 4: Wauchope – Warrego Proportional Growth

Proportional Growth Rate			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	0	0	0
11 - 15	7	0	7
16 - 20	2	0	2
21 - 25	9	0	9
26 - 27	5	0	5
28	6	0	6

Table H.3b

Repair Schedule Section 4: Wauchope – Warrego Comparison Growth

Comparison Corrosion Rates - EXTERNAL			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	0	0	0
11 - 15	8	0	8
16 - 20	26	0	26
21 - 25	53	0	53
26 - 27	17	0	17
28	8	0	8

INTERNAL FEATURES CALCULATED - NO FAILURES

Table H.4a

Repair Schedule Section 5: Warrego – Renner Springs Proportional Growth

Proportional Growth Rate			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	0	0	0
11 - 15	1	2	3
16 - 20	1	0	1
21 - 25	4	0	4
26 - 27	2	0	2
28	0	0	0

Table H.4b

Repair Schedule Section 5: Warrego – Renner Springs Comparison Growth

Comparison Corrosion Rates - EXTERNAL			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	0	0	0
11 - 15	0	0	0
16 - 20	1	0	1
21 - 25	2	0	2
26 - 27	1	0	1
28	1	0	1

INTERNAL FEATURES CALCULATED - NO FAILURES

Table H.5a

Repair Schedule Section 6: Renner Springs – Newcastle Waters Proportional Growth

Proportional Growth Rate			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	1	0	1
11 - 15	31	0	31
16 - 20	141	0	141
21 - 25	181	0	181
26 - 27	59	0	59
28	36	0	36

Table H.5b

Repair Schedule Section 6: Renner Springs – Newcastle Waters Comparison Growth

Comparison Corrosion Rates - EXTERNAL			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	438	0	438
11 - 15	502	0	502
16 - 20	1227	8	1235
21 - 25	2588	21	2609
26 - 27	76	0	76
28	0	0	0

INTERNAL FEATURES CALCULATED - NO FAILURES

Table H.6a

Repair Schedule Section 7: Newcastle Waters – Daly Waters Proportional Growth

Proportional Growth Rate			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	11	2	13
11 - 15	79	0	79
16 - 20	298	0	298
21 - 25	572	2	574
26 - 27	319	1	320
28	213	0	213

Table H.6b

Repair Schedule Section 7: Newcastle Waters – Daly Waters Comparison Growth

Comparison Corrosion Rates - EXTERNAL			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	1	0	1
6 - 10	663	0	663
11 - 15	1468	1	1468
16 - 20	3758	0	3758
21 - 25	8471	19	8471
26 - 27	9241	0	9241
28	3151	0	3151

INTERNAL FEATURES CALCULATED - NO FAILURES

Table H.7a

Repair Schedule Section 8: Daly Waters – Mataranka Proportional Growth

Proportional Growth Rate			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	3	0	3
11 - 15	36	0	36
16 - 20	114	0	114
21 - 25	263	1	264
26 - 27	167	1	168
28	103	0	103

Table H.7b

Repair Schedule Section 8: Daly Waters – Mataranka Comparison Growth

Comparison Corrosion Rates - EXTERNAL			
Repair Block (Year)	Non-Compliant External Anomalies <80% WT	Non-Compliant External Anomalies ≥80% WT	Total Number of Non-Compliant Defects
0	0	0	0
1 - 5	0	0	0
6 - 10	49	0	49
11 - 15	838	0	838
16 - 20	6349	0	6349
21 - 25	26622	0	26622
26 - 27	8429	0	8429
28	1057	0	1057

INTERNAL FEATURES CALCULATED - NO FAILURES

APPENDIX I

NT GAS CORRESPONDENCE

From: Ben Parkin [mailto:BParkin@ntgas.com.au]
Sent: Wednesday, 1 July 2009 12:02 PM
To: Kally Baxter
Subject: RE: 14" FFP Assessment

Kally,

The design life for the pipeline was 50 years, and it was commissioned in 1986. I do not believe this value has been renewed, but I will check with my Engineering manager when he returns later in the week.

Regards,

Ben Parkin
Pipeline Engineer
NT Gas
APA Group Northern Territory
ph: 08 8924 8129
mobile: 0427 248 132
email: bparkin@ntgas.com.au
www.ntgas.com.au

From: Kally Baxter [mailto:Kally.Baxter@ionik.net]
Sent: Tuesday, 30 June 2009 6:50 PM
To: Ben Parkin
Subject: 14" FFP Assessment

Good Afternoon Ben,

I am currently working on the 14" Pipeline FFP Assessment and I was wondering if you could provide a design life for the pipeline?
If this has been renewed since installation, then when is the design life due expire for the pipeline?

Regards,

Kally Baxter
Subsea Engineer

Direct: +61 (0)8 6314 2450
Mobile: +61 (0)4144 69223
Email: kally.baxter@ionik.net

APPENDIX J

ROSEN CORRESPONDENCE

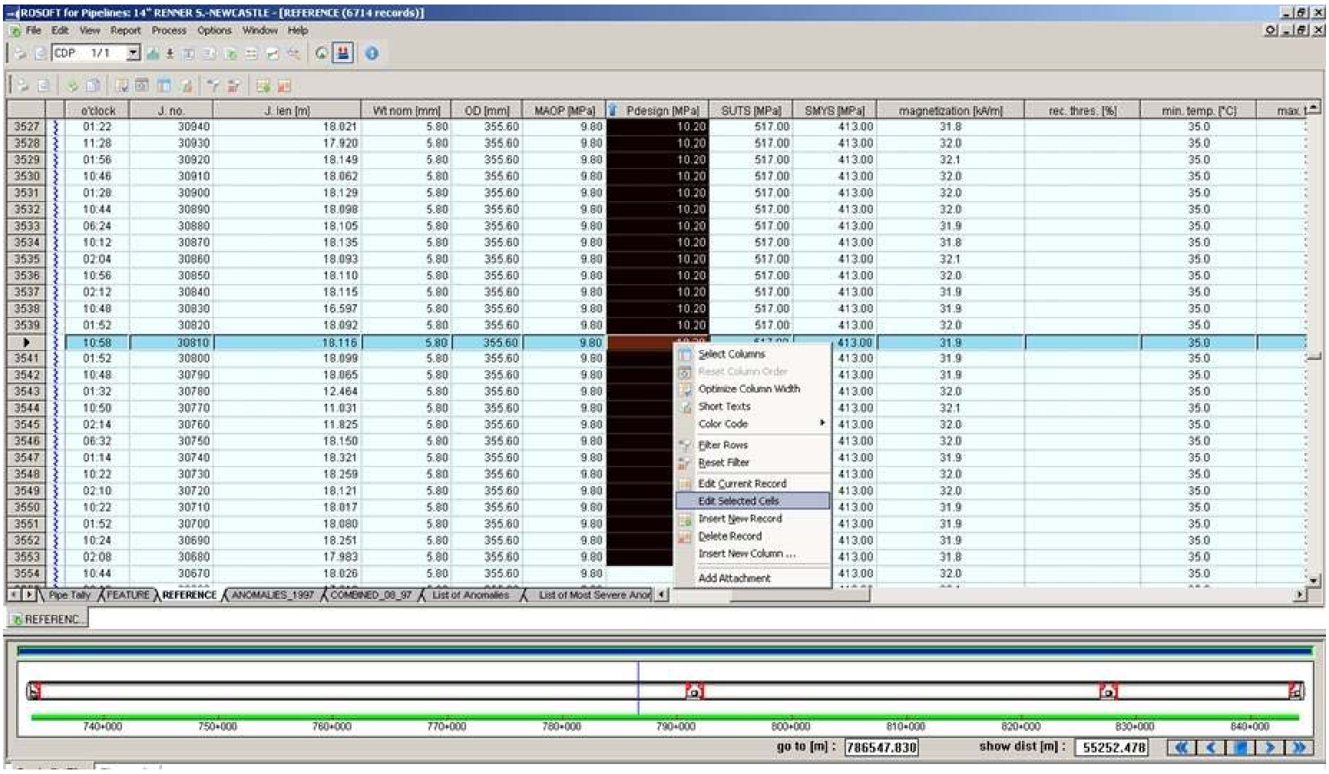
From: Parwez Akbar [mailto:PAkbar@roseninspection.net]
Sent: Monday, 12 January 2009 12:24 PM
To: Ben Parkin
Cc: Chris F. Yoxall; Roy Andrich; Harry Nomikoudis; Henry Dupal; Marius Coetzee; Mark Lackenby
Subject: RE: Final report questions

Ben,
For the reported dent no further details regarding the severity can be obtained from the MFL tool data. The severity of dents are established from the Electronic Geometry Tool (EGP) or extended geometry tool (XGP). However, further review of the detected signal shows that this reported anomaly represents an internal metal loss most likely caused by a milling feature (10% wall loss).

The ERF values for the 14RENNEW are calculated with MAOP=9.8MPa and Pdesign=10.20MPa, whereas the other sections were calculated with MAOP=Pdesign=9.65MPa, hence the difference observed. The values for the 14RENNEW section were based on onsite report and these values were not provided in the pipeline questionnaire.

A screenshot of how to change the MAOP and Pdesign values in ROSOFT is given below. Please highlight the values you want to change, right click and then select the option of “Edit Selected Cells”. The values of ERF would be recalculated when these parameters are changed.

Best Regards,
Parwez Akbar
Data Evaluation Supervisor.



From: Ben Parkin [mailto:BParkin@ntgas.com.au]
Sent: Monday, January 12, 2009 10:58 AM
To: Parwez Akbar
Cc: Chris F. Yoxall; Roy Andrich; Harry Nomikoudis; Henry Dupal; Marius Coetzee; Mark Lackenby
Subject: Final report questions

Parwez,

I have a couple of questions about some of the data in the final reports:

Section 2.4 of the TANTIT final report refers to the detection of 1 geometric anomaly w/o calculation. This is the only geometric anomaly reported for all seven sections. I assume this is the anomaly at log distance 304172.543 that is classified as a 'dent' that is 35mm long. Is there any way to determine more information about the severity of this dent?

The table below shows a comparison of the number of anomalies reported in an ERF range for all sections:

	ERF				
Section	**<0.60**	**0.60 to 0.80**	**0.80 to 0.90**	**0.90 to 1.00**	**>=1.00**
Tanami Rd to Ti Tree	0	0	0	42	0

Ti Tree to Wauchope	0	0	0	18	0
Wauchope to Warrego	0	0	0	66	0
Warrego to Renner Springs	0	0	0	38	0
Renner Springs to Newcastle Waters	0	0	1193	82	0
Newcastle Waters to Daly Waters	0	0	0	8540	7
Daly Waters to Mataranka	0	0	0	8345	8

The distribution of ERF for the Renner Springs to Newcastle Waters section seems unusual when compared to the other sections. Admittedly, many of this section's values between 0.8 and 0.9 are 0.88 and 0.89, and many values in the other sections between 0.9 and 1.0 are 0.90 and 0.91. However, does the distribution above seem correct to you?

Regards,

Ben Parkin
Pipeline Engineer
NT Gas
APA Group Northern Territory
ph: 08 8924 8129
mobile: 0427 248 132
email: bparkin@ntgas.com.au
www.ntgas.com.au

APPENDIX K

PROPORTIONAL GROWTH ANOMALIES PREDICTED TO FAIL WITHIN 10 YEARS

Table K1
PROPORTIONAL GROWTH ANOMALIES PREDICTED TO FAIL WITHIN 10 YEARS

Pipeline Section	Defect Number	KP	Orientation (Clock Position On Pipe)	Length (mm)	Width (mm)	Depth (mm)	Position	Predicted Failure Year	SWP (MPa)	ERF	Within 80% WT	Predicted Growth Depth (mm)	Predicted Growth Length (mm)	Comments
Renner Springs - Newcastle Waters	1830	797.748	3:15:00	42	110	1.682	external	2014	9.27	1.04	yes	2.569	61.09	Not verified
Newcastle Waters - Daly Waters	4520	872.436	9:01:00	49	48	1.334	external	2016	9.46	1.02	yes	2.038	71.27	Not verified
	4521	872.436	9:54:00	49	43	1.160	external	2018	9.64	1.00	yes	1.772	71.27	Not verified
	11281	893.669	8:29:00	43	14	1.276	external	2018	9.64	1.00	yes	1.949	62.55	Not verified
	11287	893.702	7:18:00	19	50	3.306	external	2015	9.58	1.01	yes	5.049	27.64	Wrapped with Denso
	11288	893.703	7:22:00	11	42	3.132	external	2018	0.00 (1)	n/a (1)	no	4.780	16.00	Wrapped with Denso
	15591	910.244	10:03:00	59	14	1.160	external	2016	9.48	1.02	yes	1.772	85.82	Not verified
	16638	913.180	11:37:00	30	50	1.798	external	2018	9.60	1.00	yes	2.746	43.64	Not verified
	16639	913.180	9:53:00	30	107	1.740	external	2018	9.65	1.00	yes	2.658	43.64	Not verified
	20423	943.926	4:56:00	42	14	1.624	external	2015	9.33	1.03	yes	2.480	61.09	Not verified
	22012	945.665	4:19:00	43	14	1.450	external	2016	9.48	1.02	yes	2.214	62.55	Not verified
	22443	945.808	7:37:00	43	14	1.276	external	2018	9.64	1.00	yes	1.949	62.55	Not verified
	23643	946.299	9:21:00	47	14	1.218	external	2018	9.62	1.00	yes	1.860	68.36	Not verified
	30307	961.908	8:42:00	111	14	0.754	external	2018	9.64	1.00	yes	1.151	161.45	Not verified
Daly Waters - Mataranka	13964	1045.893	5:15:00	58	14	1.044	external	2018	9.63	1.00	yes	1.594	84.36	Not verified
	35660	1087.704	1:40:00	30	24	1.798	external	2018	9.60	1.00	yes	2.746	43.64	Not verified
	39253	1092.043	1:17:00	159	70	0.406	external	2016	9.53	1.01	yes	0.620	231.27	Not verified

Note (1): Defect >80% WT

APPENDIX L

PROPORTIONAL GROWTH ANOMALIES PREDICTED TO FAIL WITHIN 28 YEARS

(Provided in CD1)

APPENDIX M

DERIVED TOOL TOLERANCES

Table M1
TOOL TOLERANCES

Section	Year Digup Performed	2008 Chainage	ROSEN Reported Metal Loss	Measured Wall Loss (%)	Difference (%)	Tool Tolerance Used
Tanami Rd to Ti Tree	2008	261321.892	20.00%	15.0%	-5.00%	5.00%
Tanami Rd to Ti Tree	2008	171862.059	10.00%	10.3%	0.34%	
Tanami Rd to Ti Tree	2008	307332.491	7.00%	6.9%	-0.10%	
Tanami Rd to Ti Tree	2008	307332.491	10.00%	10.3%	0.34%	
Ti Tree to Wauchope	2008	317924.591	10.00%	12.1%	2.07%	5.00%
Ti Tree to Wauchope	2008	336467.210	16.00%	15.7%	-0.31%	
Ti Tree to Wauchope	2008	336472.704	9.00%	10.3%	1.34%	
Ti Tree to Wauchope	2008	336476.113	5.00%	6.9%	1.90%	
Wauchope to Warrego	2008	523802.826	34.00%	43.1%	9.10%	20.00%
Wauchope to Warrego	2008	491913.584	31.00%	44.8%	13.83%	
Wauchope to Warrego	2008	493875.468	14.00%	19.3%	5.31%	
Wauchope to Warrego	2008	493875.689	10.00%	29.7%	19.66%	
Wauchope to Warrego	2008	565357.466	26.00%	40.0%	14.00%	
Wauchope to Warrego	2009	559001.409	13.00%	31.7%	18.72%	
Wauchope to Warrego	2009	556228.215	10.00%	10.3%	0.34%	
Wauchope to Warrego	2009	565216.218	20.00%	20.7%	0.69%	
Warrego to Renner Springs	2008	724606.795	47.00%	37.1%	-9.93%	5.00%
Warrego to Renner Springs	2008	613902.540	30.00%	29.5%	-0.52%	
Warrego to Renner Springs	2008	660112.937	29.00%	24.1%	-4.86%	
Renner Springs to Newcastle Waters	2008	808959.184	36.00%	26.7%	-9.28%	5.00%
Renner Springs to Newcastle Waters	2008	817701.950	34.00%	29.7%	-4.34%	
Renner Springs to Newcastle Waters	2008	784243.045	31.00%	28.4%	-2.55%	
Newcastle Waters to Daly Waters	2008	887520.882	39.00%	29.3%	-9.69%	5.00%
Newcastle Waters to Daly Waters	2008	903629.920	34.00%	35.3%	1.34%	
Daly Waters to Mataranka	2008	997967.604	37.00%	31.0%	-5.97%	5.00%
Daly Waters to Mataranka	2008	1002773.876	36.00%	27.6%	-8.41%	
Daly Waters to Mataranka	2008	1028225.440	35.00%	31.0%	-3.97%	

APPENDIX N

LOCATION OF WELDS WITH GIRTH WELD ANOMALIES

(Provided in CD1)