

Jemena Northern Gas Pipeline Pty Ltd

Northern Gas Pipeline

Draft Environmental Impact Statement

APPENDIX L – PRELIMINARY ASSESSMENT OF GEOTECHNICAL AND SOIL LANDSCAPE MAPPING (JUNE 2016)

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Douglas Partners

Geotechnics | Environment | Groundwater

Preliminary Assessment of
Geotechnical and Soil Landscape Mapping

Proposed Northern Gas Pipeline
Tennant Creek to Mt Isa

Prepared for
Jemena Northern Gas Pipeline Pty Ltd

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.



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Table of Contents

	Page
1. Introduction	1
2. Previous Work.....	1
3. Regional Geology.....	2
4. Site Inspection.....	2
5. Field Work Results	3
6. Laboratory Testing	3
7. Assessment of Alignment Conditions	3
8. Comments	6
8.1 Erosion and Dispersion	6
8.2 Acid Sulfate Soils	6
8.3 Solution Features	7
9. Phase II Investigation.....	8
10. Limitations	8
11. References.....	9
Appendix A: About This Report Soil Descriptions Rock Descriptions	
Appendix B: Drawings 1 to 6 – Site and Test Location Plans	
Appendix C: Results of Field Work, Table 1 and Plates 1 to 30	
Appendix D: Results of Laboratory Testing	

Report on Geotechnical and Soil Landscape Mapping

Proposed Northern Gas Pipeline

Tennant Creek to Mt Isa

1. Introduction

This report presents the results of geotechnical and soil landscape mapping of the proposed northern gas pipeline alignment between Tennant Creek to Mt Isa. The inspection was commissioned by Jemena Northern Gas Pipeline Pty Ltd, email dated 15 April 2016 and was undertaken in general accordance with Douglas Partners Pty Ltd (DP) proposal BNE160337.Rev1 dated 1 April 2016.

It is understood that proposed pipeline extends between Warrego near Tennant Creek and Mt Isa, linking the Amadeus and Carpentaria Pipelines, respectively. The approximately 625 km gas pipeline will be of steel construction and placed in a trench at about 1.25 m depth.

Additional structures with buildings footprints of up to approximately 300 m square are also proposed and include:

- Compressor Stations (CP1 to CP4);
- MLVs (1 to 4); and
- EOL Delivery Stations.

The inspection comprised broad mapping of the alignment followed by a preliminary hazard assessment, the results of which were used to position test locations for the proposed Phase II intrusive works. The details of the field work and assessment are presented in this report.

This report must be read in conjunction with the notes entitled 'About This Report' in Appendix A, and any other notes attached and should be kept in its entirety without separation of individual pages or sections.

2. Previous Work

DP has previously undertaken a desktop study of the alignment and preliminary investigation at its eastern and western extents. The findings were reported in the following documents:

- Desktop Geotechnical Study, Proposed North East Gas Interconnector Pipeline, Tennant Creek to Mt Isa, (Project Ref: 87536.00, issued July 2015); and
- Preliminary Geotechnical Investigation and Seismic Hazard Assessment, Proposed North East Gas Interconnector Pipeline, Tennant Creek to Mt Isa, (Project Ref: 87536.00, issued September 2015).

The findings of the above reports were used in this assessment and as such the reports should be read in conjunction with the current report.

3. Regional Geology

Based on the information presented on published maps and accompanying notes by the Department of Mines, the proposed alignment will generally cross the following geological units and topography between Warego and Mount Isa (Points 1 to 5 are referenced in the attached electronic KMZ file):

- Warrego to E:449723 N:7843574 (Point 1) – sand plain deposits flanking a north-west to south-east trending ridge of folded and faulted sedimentary greywacke, sandstone, siltstone and shale intruded and interbedded with acid igneous strata.
- E:449723 N:7843574 (Point 1) to E:606643 N: 7795808 (Point 2) – sand plain deposits with some outcrops of limestone, chert and breccia (Barkly Tablelands).
- E:606643 N: 7795808 (Point 2) to E:715780 N:7756895 (Point 3) – hill of relatively low relief characterised by sand plains deposits with some sand dunes, calcrete and outcrops of chertified limestone and mudstone, dolostone around its lower reaches. The later 'solid' geology is also predominant across the top of the hill.
- E:715780 N:7756895 (Point 3) to E:249505 N:7705012 (Point 4) – large flood plain of low relief characterised by numerous river channels flanked by alluvium with the intervening areas underlain by 'black soil'. Chertified limestone and mudstone, and dolostone in the west, and limestone in the centre and east underlie the superficial soils and are depicted locally outcropping along river channels.
- E:249505 N:7705012 (Point 4) to E:2991775 N:7704540 (Point 5) – gently falling foothills of the Selwyn Range, characterised by alluvium and sheet wash deposits.
- E:2991775 N:7704540 (Point 5) to Mt Isa – gently sloping terrain, dissected by several north-south to northeast-southwest trending ridgelines. Geology is variable with folded and faulted sedimentary rocks intruded and interbedded with igneous strata with little superficial cover.

Digital versions of the maps were presented in the desktop study report.

4. Site Inspection

The site inspection was undertaken between 3 and 9 May 2016, and comprised mapping the alignment where access tracks permitted and land owner permission was given. During the site inspection, the soil scientist and engineering geologist mapped/noted and photographed the following:

- rock outcrops, creek beds and slopes (i.e. lithology, strength, dip/strike, gradient etc.);
- landforms in accordance with Australian Soil and Land Survey Field Handbook (descriptions for tree cover and landform herein are based on this publication);
- vegetation types and changes;
- potential for acid sulfate soils (i.e. indicators such as acid, salt or waterlogged tolerant plant species, presence of Jarosite, water clarity or the corrosion of infrastructure); and
- any other information relevant to the project.

The route taken and the observation points (waypoints) are detailed on the attached KMZ file, and are summarised on the site inspection plans (Drawings 1 to 6) in Appendix B.

5. Field Work Results

The results of the field work, including comments and photographs of the conditions encountered during the site inspection and those in the preliminary investigation are given in Table 1 and Plates 1 to 30, in Appendix C. These should be read in conjunction with the notes 'About this Report' and other explanatory notes in Appendix A.

6. Laboratory Testing

Emerson class number and pH tests were performed on selected disturbed samples taken from the test pits excavated at either end of the alignment during the previous preliminary investigation. Detailed test report sheets are given in Appendix D and the results are summarised in Table 2 below.

Table 2: Summary of Dispersion and pH Testing

Bore	Depth (m)	Description	Emerson Class No.	pH	Potential for Erosion*
TC01	0.00 – 0.30	Silty sand	3	4.9	High
TC05A	0.00 – 0.20	Silty sand	3	4.5	High
TC06	0.60 – 0.80	Silty clay	2	9.8	Very high
TC07	0.00 – 0.30	Silty sandy gravel	3	4.6	High
TC08	1.00 – 1.30	Silty sand	4	5.7	Medium
M102	0.40 – 0.50	Silty clay	3	5.8	High
M103	0.00 – 0.30	Silty sand	3	4.2	High
M104	0.40 – 0.60	Silty sandy gravel	4	5.4	Medium
M105B	0.20 – 0.50	Silty clay	2	6.1	Very high
M108	1.00 – 1.50	Gypsum?	2	6.1	Very high

* Ref. 1

7. Assessment of Alignment Conditions

Based on the findings of the site inspection, preliminary investigation and the above testing (which are detailed in the Table 1, Appendix C) the alignment was divided into Zones A to H, based on landform, soil type and the potential for erosion. A descriptive summary of the zones is given in Table 3 on the following page, with the lateral extents depicted on the drawings in Appendix B and the attached KMZ file. It should be noted that following completion of the inspection, the geotechnical components of the scope were not required and have been reported separately.

Table 3: Summary of Site Inspection, Mapping and Assessment

Zone	Chainage (KP)		Photo ID	Emerson Class & pH Testing	Zone Overview and Erosion/Dispersion Potential based on testing and Conditions Observed
	Start	End			
A	0	8	1 & 2	Silty Sand - Class 3, pH 4.9	Generally level with 50% to 60% grass cover and sparse to dense tree cover. Subsurface conditions comprise silt and sandy clay soils with low to moderate erosion potential.
B	8	66	3 to 7	Silty clay - Class 2, pH 9.8 Silty sandy gravel – Class 3, pH 4.6	Generally level with undulating ridges, 50% to 60% grass cover with sparse to mid dense tree cover. Subsurface conditions comprise locally gravelly silty sand soils, which are underlain by sedimentary limestone, siltstone, shale and sandstone of generally low strength. High strength sandstone and very high strength hematite were also noted in the section. Low to moderate erosion potential, increasing to moderate where at the toe of slopes.
C	66	212	8 to 15	Silty Sand - Class 4, pH 5.7	Generally level with 50% grass and sparse to mid dense cover of trees. Subsurface conditions comprise silty sand soils locally gravelly and clayey. Depth to rock not proven. Low to moderate erosion potential, clay soils may be dispersive.
D	212	350	16 to 19	-	Generally level to undulating ground with some hills and outcrops up to 20m in height. Ground cover is 30% to 60% grass with sparse to mid dense tree cover. Subsurface conditions comprise gravelly and silty sand soils. Depth to rock variable with very high strength silcrete/calcrete, conglomerate observed in exposures and locally at the surface. Low to moderate erosion potential, increasing to moderate where at the toe of slopes.
E	350	500	20 to 31	-	Generally characterised by level ground with 50% to 90% grass cover and sparse grading to very sparse trees. Subsurface conditions comprise silty locally sandy clay soils with the depth to rock not directly assessed. Very high strength silcrete was locally exposed at the surface in the east and high to very high strength limestone exposed in the river and creek in the west. Low to moderate erosion potential, clay soils may be dispersive.

Table 3 (Cont): Summary of Site Inspection, Mapping and Assessment

Zone	Chainage (KP)		Photo ID	Emerson Class & pH Testing	Zone Overview and Erosion/Dispersion Potential based on testing and Conditions Observed
	Start	End			
F	500	563	32 to 38	-	Generally characterised by level ground with 50% grass cover (locally approximately 10%) with sparse to isolated, dwarf to miniature trees. Subsurface conditions comprise silty sandy and clayey soils. Depth to rock not assessed, but anticipated at >1m depth. Low to moderate (locally moderate where little ground cover) erosion potential, clayey soils may be dispersive.
			38 to 54		Generally characterised in the west by level ground with 50% grass cover and sparse to isolated dwarf to miniature trees. In the east, near or adjacent to the creek, conditions comprise gently southward falling ground with 10% grass cover and very sparse Acacia. Frequent washouts noted and gully erosion around creek tributaries. Subsurface conditions comprise silty sandy and clayey soils. Depth to rock not assessed, but anticipated at >1m depth. Moderate erosion potential locally evident by washouts. Clay soils may be dispersive.
G	563	612	Refer Test Pit Logs MI01 & MI02	Silty clay – Class 2 & 3, pH 5.8 & 6.1	Generally characterised by level ground with little grass cover and sparse dwarf to medium trees with some south-westerly draining ephemeral creeks. Subsurface conditions comprise silty sand over hard clays and low grading medium strength shale. Moderate erosion potential and clay may be dispersive.
			Refer Test Pit Logs MI03 to MI08	Silty sand/gravel – Class 3 & 5, pH 4.2 & 5.4 Gypsum? – Class 2, pH 6.1	Generally characterised by level to undulating ground with occasional small hills with approximately 50% grass and sparse dwarf to medium trees. Numerous ephemeral creeks cross the area and are locally up to 1m deep. Subsurface conditions comprise shallow silty sand and gravelly soils over shallow (<1m depth) granite of very low strength grading to low strength with depth. Moderate erosion potential and clay soils may be dispersive.

Table 3 (Cont): Summary of Site Inspection, Mapping and Assessment

Zone	Chainage (KP)		Photo ID	Emerson Class & pH Testing	Zone Overview and Erosion/Dispersion Potential based on testing and Conditions Observed
	Start	End			
H	612	621	55 to 60	-	<p>Generally characterised by hilly terrain of gently to moderately sloping ground and simple slopes in depressions between steep crest slopes.</p> <p>Depressions between slopes are generally characterised by ephemeral creeks. Less than 30% grass cover with sparse dwarf to medium trees. Subsurface conditions comprise shallow silty sand and gravelly soils over shallow granite and locally metamorphose sedimentary siltstone and sandstone of variable strength. Moderate to high erosion potential.</p>

8. Comments

8.1 Erosion and Dispersion

In general, with the exception of the eastern end of the alignment at Mt Isa, most of the alignment is of low relief, with localised areas of low to moderate relief around Tennant Creek; approximately 50% grass cover, with some localised areas of 10% grass cover; and sparse to mid dense, dwarf to miniature tree cover. The surface soils encountered were largely silty and sandy (sand plains deposits) in the central and western portions of the alignment and more clayey in the eastern portion (alluvial floodplain). Based on the observations made and the laboratory testing undertaken it is preliminarily assessed that there is a low to moderate risk of erosion and that the clayey soils may be dispersive.

At the eastern end of the alignment the relief graded from undulating with occasional small hills, 50% grass cover and sparse dwarf to medium trees to hilly terrain at Mt Isa, with steep crest slopes and simple toe slopes, 30% grass cover and sparse dwarf to medium trees. The area was generally characterised by ephemeral creeks and silty sandy and gravelly soils over shallow rock, and it is preliminarily assessed that there is a moderate to high risk of erosion.

The above erosion assessments are preliminary only and will need to be confirmed by intrusive investigation, subsequent laboratory testing and assessment against the proposed construction practices.

8.2 Acid Sulfate Soils

No evidence of acid sulfate soils (ASS) such as the presence of acid, salt or waterlogged tolerant plant species, the presence of jarosite, water clarity or the corrosion of infrastructure was noted within the sections of the alignment inspected.

A review of the broad scale National Acid Sulfate Soils risk map generally indicates an extremely low (locally low in the east) probability for ASS occurrence along the alignment. The map depicts some small localised and isolated high probability zones which appear to coincide with the limestone in the centre of the alignment and in the clayey floodplain soils of Zone E. The map further indicates that the high probability zones relate to inland lakes, waterways, wetlands and riparian zones, and with the exception of shallow ephemeral creeks and the two rivers (where the risk is indicated as low), were not identified along the sections of the alignment inspected.

Based on the above, it is anticipated that an ASS investigation will not be required. However, it is recommended that when undertaking the Phase II works that the field operatives are informed of the potential for ASS, the field indicators and the correct sampling procedures. In the field, if ASS are suspected, following agreement with Jemena and DP, they should be investigated, sampled and the area displaying ASS indicators mapped.

With regard to the project Environmental Management Plan, assuming no evidence of ASS are encountered during the Phase II investigation, it is recommended that a brief ASS Management Plan is included providing information on what to do if suspected ASS are encountered.

8.3 Solution Features

It is understood that during a flyover of the alignment, a potential sink hole was observed at chainage KP 257.2 [(E:625892.00 N:7789050.00), location noted in attached KMZ file and photograph provided below in Figure 1]. It is further understood that the crew landed and confirmed that the alignment passed through the feature, and that no evidence of a 'cave in' was observed. However, in transit to the location other indications of some small 'cave-ins' in outcrops were noted.



Figure 1: Photo of Sink Hole at Chainage KP257.2

Research of information published by the Northern Territory Geological Survey indicates that shallow solution features (sink holes) are widespread within the calcrete. This rock unit is depicted on the geological maps as a 17 km section extending south-eastwards some 20 km south-east of the Barkly Homestead (extents noted on attached KMZ file).

The alignment largely avoids the depicted outcrops of calcrete. However, where the alignment crosses the aforementioned 17 km section, sand plain deposits are shown which could indicate that they are either: a veneer say <1m thick over the calcrete; the calcrete is not present; or that a 'trough' like feature is present between the two outcrops which would potentially increase the potential for solution features due to channelling of any groundwater.

The calcrete generally comprises calcareous cemented materials. It can be pisolithic to nodular or massive, and where of a coarser nature with less cohesiveness and silicification and exposed to an erosive environment (i.e. water), would be more susceptible to solution. It should be noted that calcrete is also locally mapped in the centre of the alignment (refer attached KMZ file).

No solution features were mapped in the Wornarah Formation to the east of the calcrete (refer attached KMZ file), however, the predominantly calcareous nature of this formation would make it susceptible to solution features, but the potential would be reduced due to its chertification.

9. Phase II Investigation

Based on the results and subsequent assessment of the site inspection, a Sediment Sampling Plan has been devised to target the erosion and dispersion characteristics of the soils, landforms and erosion features assessed where possible along the alignment. The proposed test pit locations (refer plans in Appendix B and the attached KMZ file) were positioned by the soil scientist and in accordance with the IECA 2008, Best Practice Erosion and Sediment Control, document (Ref: 2).

The test pits will be excavated using a backhoe (or similar) to 2 m depth or prior refusal/collapse. The test pits will be logged and each layer sampled by a geotechnical engineer and the records will include salient features such as increased soil pore concentration which may indicate potential collapsing soils, face stability, ingress of groundwater, machine type, bucket width, ease of excavation and live root depth. In-situ testing will comprise pocket penetrometer tests and vane shear testing (where possible) in cohesive soils and dynamic cone penetrometer (DCP) testing to 2 m depth or prior refusal adjacent to each test location.

Upon completion of excavation, logging and photographing of the test pits, the pits would be backfilled with the excavated spoil and tamped by the backhoe/excavator bucket. Any excess material would be mounded above the surface at the test locations and wheel/track rolled.

With regard to assessing the likelihood and/or investigation of solution features along the alignment, DP should be contacted for further information.

10. Limitations

DP has prepared this Phase I report for the proposed Northern Gas Pipeline from Tennant Creek to Mt Isa in general accordance with DP's Proposal BNE160337 Rev1 dated 1 April 2016 and acceptance received from Jemena Northern Gas Pipeline Pty Ltd dated 22 March 2016. The work was carried out under the agreed Consultancy Agreement between Douglas Partners Pty Ltd and Jemena Northern Gas Pipeline Pty Ltd – Contract 4600004785 dated 31 May 2016. This report is provided for the

exclusive use of Jemena Northern Gas Pipeline Pty Ltd and their consulting engineers for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report, DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the subsurface conditions only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Subsurface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the notes attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report. This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required by the Health and Safety Legislation and Regulations, to be included in a safety report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

11. References

1. Erosion Hazard Assessment Supporting Technical Notes–October 2010, Brisbane City Council.
2. International Erosion Control Association (Australasia), 2008, Best Practice Erosion and Sediment Control.

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Appendix A

About This Report
Soil Descriptions
Rock Descriptions

About this Report

Douglas Partners



Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;

- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.



Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 - 5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.



Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approx Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and longer sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq 100 \text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Appendix B

Drawings 1 to 6 – Site and Test Location Plans



TP1
TP2

TP3

TP4

TP5

TP6

DRAWING 1

DRAWING 2

DRAWING 3

TP7

TP8

TP9

TP10

TP11

TP12

TP14

TP16

TP20

TP19

TP21

TP22

DRAWING 5

DRAWING 4

TP24

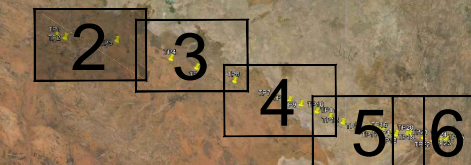
TP25

TP23





LOCALITY PLAN:-



LEGEND:

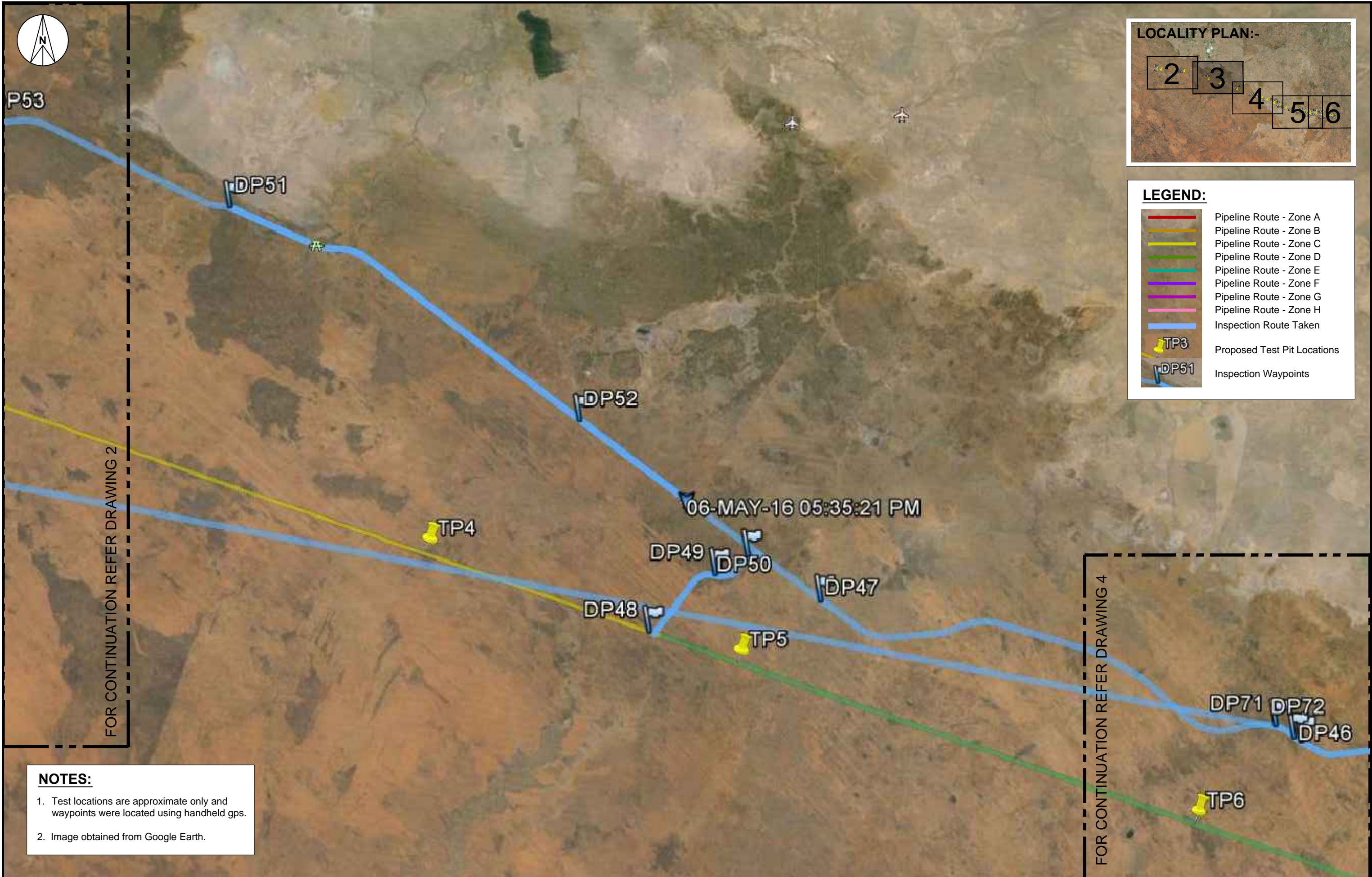
- Pipeline Route - Zone A
- Pipeline Route - Zone B
- Pipeline Route - Zone C
- Pipeline Route - Zone D
- Pipeline Route - Zone E
- Pipeline Route - Zone F
- Pipeline Route - Zone G
- Pipeline Route - Zone H
- Inspection Route Taken
- TP3 Proposed Test Pit Locations
- DP51 Inspection Waypoints

NOTES:

- Test locations are approximate only and waypoints were located using handheld gps.
- Image obtained from Google Earth.

FOR CONTINUATION REFER DRAWING 3





NOTES:

1. Test locations are approximate only and waypoints were located using handheld gps.
2. Image obtained from Google Earth.





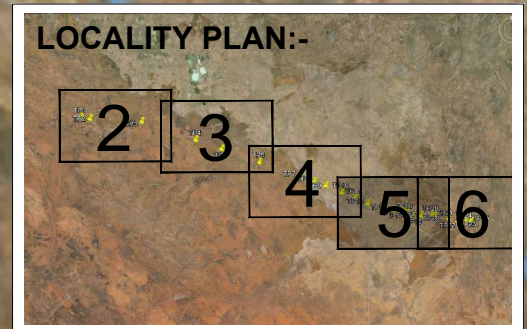
LEGEND:

- Pipeline Route - Zone A
- Pipeline Route - Zone B
- Pipeline Route - Zone C
- Pipeline Route - Zone D
- Pipeline Route - Zone E
- Pipeline Route - Zone F
- Pipeline Route - Zone G
- Pipeline Route - Zone H
- Inspection Route Taken
- Proposed Test Pit Locations
- Inspection Waypoints

NOTES:

- Test locations are approximate only and waypoints were located using handheld gps.
- Image obtained from Google Earth.



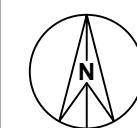


LEGEND:

- Pipeline Route - Zone A
- Pipeline Route - Zone B
- Pipeline Route - Zone C
- Pipeline Route - Zone D
- Pipeline Route - Zone E
- Pipeline Route - Zone F
- Pipeline Route - Zone G
- Pipeline Route - Zone H
- Inspection Route Taken
- TP3 Proposed Test Pit Locations
- DP51 Inspection Waypoints

NOTES:

- Test locations are approximate only and waypoints were located using handheld gps.
- Image obtained from Google Earth.





FOR CONTINUATION REFER DRAWING 5

LOCALITY PLAN:-



LEGEND:

	Pipeline Route - Zone A
	Pipeline Route - Zone B
	Pipeline Route - Zone C
	Pipeline Route - Zone D
	Pipeline Route - Zone E
	Pipeline Route - Zone F
	Pipeline Route - Zone G
	Pipeline Route - Zone H
	Inspection Route Taken
	Proposed Test Pit Locations
	Inspection Waypoints

DP22

04-MAY-16 08:22:58 AM

DP20 DP19 TP20 TP21 DP9 DP10

TP22

08-MAY-16 07:34:17 PM 09-MAY-16 02:00:58 PM

DP1 DP2

TP25 TP27 TP26

NOTES:

1. Test locations are approximate only and waypoints were located using handheld gps.
2. Image obtained from Google Earth.



Appendix C

Field Work Results – Table 1 & Plates 1 to 30

Table 1 - Alignment Conditions and Assessment

Zone	Chainage		Summary of Geological Conditions Anticipated from Desk Study	Waypoint ID	Photo ID	Landform, Topography and Vegetation	Surface Soil Type	Soil/Strata Description	Emerson Class and pH	Observed Erosion Characteristics	Overview	Investigation/Testing Proposed				
	Start	End														
A	KP 0	KP 8	Sand plain deposits flanking a north-west to south-east trending ridge of folded and faulted sedimentary greywacke, sandstone, siltstone and shale intruded and interbedded with acid igneous strata. Refer Warego to Point 1	DP64	1	Level with 60% grass, sparse to dense miniature to medium Grevillea, Acacia and Eucalyptus	Sandy clay (CL)	Red brown sandy silty clay with some gravel. Gravel is fine to medium and angular-sub angular, sand is fine to medium.	None	No erosion features	Generally level with 50% to 60% grass cover and sparse to dense tree cover. Subsurface conditions comprise silt and sand clay soils with low to moderate erosion potential.	Propose one test pit TP1 and additional testing from TC01 if required.				
				DP65	2											
					See Pit Log	Level with 50% grass with sparse trees	Silty sand (SM)	0.3 m medium silty sand over hard medium plasticity silty clay with trace of sand to 1.5m depth	Silty sand Class 3 pH 4.9							
B	KP 8	KP 66		DP66		Undulating with hills between 10m to 20m in height with 50% grass and sparse to mid dense miniature to medium Grevillea, Acacia and Eucalyptus	Gravelly Sand with some Silt (SP)	Red brown fine to coarse angular to sub-rounded gravelly fine to coarse sand with some silt	None	None Observed	Generally level with undulating ridges, 50% to 60% grass cover with sparse to mid dense tree cover. Subsurface conditions comprise locally gravelly silty sand soils, which are underlain by sedimentary limestone, siltstone, shale and sandstone of generally low strength. High strength sandstone and very high strength Hematite were also noted in the section. Low to moderate erosion potential, increasing to moderate where at the toe of slopes.	Propose one test pit TP2 and additional testing from TC04 to TC07 if required.				
				DP67												
				DP68	3											
				TC04		Level with 60% grass, sparse to dense miniature to medium Grevillea, Acacia and Eucalyptus	Silty sand (SM)	Medium dense grading very dense, red brown silty fine sand to 1. 5m depth								
				DP63	4			Red brown silty fine to medium sand with some clay								
				TC05A & B	See Pit Log			0.2m of medium dense red brown silty fine sand with some gravel over extremely low to low strength grading low/low to medium strength, weathered siltstone								
				DP69				Observation Only								
				DP70												
				TC06	See Pit Log	Level with 60% grass with sparse trees	Silty sand (SM)	0.1m medium dense silty fine sand over hard medium plasticity silty clay with trace of sand to 1.4m depth	Clay Class 2 pH 9.8							
				DP62	5	Level with 50% grass, isolated to mid dense miniature to medium Eucalyptus and Acacia		Red brown silty fine to medium sand	None							
				TC07	See Pit Log	Level with 50% grass with sparse trees	Silty sandy gravel (GP)	1.2m dense red brown silty sandy gravel with some cobbles over low strength moderately weathered limestone	Silty sandy gravel Class 3 pH 4.6							
				DP59	6	Level with <5% grass, sparse to mid dense dwarf to low Grevillea, Acacia and Eucalyptus	Silty sand (SM)	Red brown silty fine to medium sand	None							
				DP60	7	Level with 50% grass, sparse to dense miniature to low Acacia and Eucalyptus		Red brown silty fine to medium sand								
			DP61		Pull over bay on side of highway	Gravel Filling (information only)		N/A		Information only						

Table 1 - Alignment Conditions and Assessment

Zone	Chainage		Summary of Geological Conditions Anticipated from Desk Study	Waypoint ID	Photo ID	Landform, Topography and Vegetation	Surface Soil Type	Soil/Strata Description	Emerson Class and pH	Observed Erosion Characteristics	Overview	Investigation/Testing Proposed	
	Start	End											
C	KP 66	KP 212	Sand plain deposits with some outcrops of limestone, chert and breccia (Barkly Tablelands). Refer Point 1 to Point 2	TC08	See Pit Log	Level with 50% grass, sparse to mid dense trees	Silty sand (SM)	Medium dense grading dense, red brown silty fine sand to 1.5m depth	Silty Sand Class 4 pH 5.7	None Observed	Generally level with 50% grass and sparse to mid dense cover of trees. Subsurface conditions comprise silty sand soils locally gravelly and clayey. Depth to rock not proven. Low to moderate erosion potential, clay soils maybe dispersive.	Propose two test pits TP3 and TP4, and additional testing from TC08 and TC09 if required.	
				DP58	8	Level with 60% grass, very sparse to sparse miniature to low Eucalyptus and Grevillea		Red brown silty fine to medium sand with a trace of clay	None				
				DP57	9	Level with 50% grass, very sparse to mid dense micro to low Acacia, Grevillea, Eucalyptus		Red brown silty fine to medium sand					
				DP56	10	Level with <5% grass, sparse to dense low to medium Eucalyptus and Acacia	Silty Clay (CL)	Light brown silty clay with some fine to medium sand					
				TC09	See Pit Log	Level with 50% grass, sparse to mid dense trees	Silty sand (SM)	Medium dense grading dense, red brown silty fine sand to 1.5m depth					
				DP55	11	Level with 40% grass, very sparse to sparse miniature to low Eucalyptus, Acacia, Grevillea		Red brown silty fine to medium sand with a trace of coarse sand					
				DP54		Level to slightly undulating with 10% grass, sparse to dense micro to low Acacia and Grevillea	Sandy Gravel (GP)	Red brown sandy, sub angular to rounded fine to medium gravel with some silt					
				DP53	12	Level to slightly undulating 40% grass, very sparse to dense micro to low Acacia							
				DP51	13	Level with 10% grass, miniature to medium Acacia, Eucalyptus and Grevillea							
				DP52	14	Level with 20% grass, sparse to dense dwarf to low Grevillea, Acacia	Silty sand (SM)	Red brown silty fine to medium sand with some subrounded to rounded gravel					
				DP48	15	Level with 50% grass, very dense to dense micro to low Acacia, Grevillea, Eucalyptus and Gossypium australe							
D	KP 212	KP 350	Hill of relatively low relief characterised by sand plain deposits with some sand dunes, calcrete and outcrops of certified limestone and mudstone, dolostone around its lower reaches. The later 'solid' geology is also predominant across the top of the hill. Refer Point 2 to Point 3	DP49		Level with 50% grass, very dense to closed or dense micro to low Acacia, Grevillea, Eucalyptus and Gossypium australe	Silty sand (SM)	Veneer of red brown silty fine to medium sand with some subrounded to rounded gravel over silcrete/calcrete	None	None Observed	Generally level to undulating ground with some hills and outcrops up to 20m in height. Ground cover is 30% to 60% grass with sparse to mid dense tree cover. Subsurface conditions comprise gravelly and silty sand soils. Depth to rock variable with very high strength silcrete/calcrete, conglomerate observed in exposures and locally at the surface. Low to moderate erosion potential, increasing to moderate where at the toe of slopes.	Propose three test pits TP5 to TP7, spread along the alignment	
				DP50				Location of Sink Hole observed during aerial reconnaissance approximately estimated size 20m to 30m wide by 4m to 5m deep. Silty sand appears to overlie rock of limestone nature					
				SINK HOLE				Red brown silty fine to medium sand with some rounded gravel of silicified sandstone					
				DP47	16								
				DP71		Road cutting - 1 m high. Surrounding area is gently undulating	Gravelly Sand (GM)	Red brown angular to subangular fine to coarse gravelly fine to medium sand					
				DP46	17	Level to gentle undulating slope to the west and 60% grass, very sparse to dense, micro to low Acacia and Eucalyptus							
				DP72									
				DP73		Hill to south of highway maybe 10m to 20m high	Observations only			Observation only			
				DP45		Slight crest and land dips to west							

Table 1 - Alignment Conditions and Assessment

Zone	Chainage		Summary of Geological Conditions Anticipated from Desk Study	Waypoint ID	Photo ID	Landform, Topography and Vegetation	Surface Soil Type	Soil/Strata Description	Emerson Class and pH	Observed Erosion Characteristics	Overview	Investigation/Testing Proposed
	Start	End										
				DP44	18	Level locally slightly undulating, with 2.5m-3.0m high road cutting and approx 10m high hill to the south. Ground cover is 30% grass, very sparse to sparse, micro to low Acacia, Eucalyptus and Grevillea	Gravelly Sand (GM)	Red brown angular to subangular fine to coarse gravelly fine to medium sand		None Observed		
				DP43	19	Level with 10% grass, mid dense to dense miniature to low Acacia and Grevillea		Red brown subangular fine to medium gravelly, fine to medium sand with a trace of clay				
E	KP 350	KP 500	large floodplain of low relief characterised by numerous river channels flanked by alluvium with the intervening areas underlain by 'black soil'. Chertified limestone and mudstone, Dolostone in the west, and limestone in the centre and east underlie the superficial soils and are depicted locally outcropping along river channel. Refer Point 3 to Point 4	DP74	20	Very gently inclined up to northwest. River surrounded by grassland 90% cover, generally very sparse to mid dense, medium Eucalyptus on river banks	Sandy Clay (CL)	Light grey brown fine to medium sandy silty clay	None	Erosion of the clay soils and limestone in river bank noted	Generally characterised by level ground with 50% to 90% grass cover and sparse grading to very sparse trees. Subsurface conditions comprise silty locally sandy clay soils with the depth to rock not directly assessed. Very high strength silcrete was locally exposed at the surface in the east and high to very high strength limestone exposed in the river and creek in the west. Low to moderate erosion potential, clay soils maybe dispersive.	Propose seven test pits TP8 to TP14, targeting creeks, erosion features and soils types.
				DP42	21	Level with 60% grass and succulents, very sparse to sparse or open dwarf to low Acacia and Grevillea	Gravelly Sand (GM)	Red brown silty fine to medium sand with some coarse sand and subangular fine to coarse gravel		None Observed		
				DP75	22	Level locally undulating with 80% to 90% grass	Sandy Gravel (GP)	Red brown fine to medium sandy angular to subangular fine to coarse gravel with some clay/silt				
				DP41	23	Very gently to the north with 60% grass and mid dense to closed or dense low to tall Eucalyptus on banks	Sandy Clay (CL)	Grey brown fine to coarse sandy silty clay with a trace of angular to subangular gravel		Erosion noted in sides of Georgina River, dissolution of limestone noted		
				DP40	24	Level with 60% grass, isolated miniature possible Eucalyptus	Silty Clay (CH-CI)	Brown silty clay with a trace of fine sand. Limestone gravel and cobbles on surface		None Observed		
				DP39	25	Gently sloping creek banks with 60% to 70% grass and very sparse to sparse, low to medium Acacia and Eucalyptus		Brown silty clay with a trace of fine sand.				
				DP38	26	Level to very gently to north, with 60% grass	Silty Clay (CI - CH)	Brown silty clay with a trace of fine sand				
				DP37	27			Brown silty clay with a trace of fine sand some silcrete cobbles and boulders				
				DP36	28	Increased grass and Eucalyptus on creek banks		Brown silty clay with a trace of fine sand				
				DP35	29	Level 50% grass		Red brown silty clay with a trace of fine sand. Angular to subrounded gravel on surface				
				DP34	30	Level <5% grass		Brown silty clay, cobbles and boulders on surface				
				DP33	31	Level to very gently southwards with 40 to 50% dry grass		Brown fine to medium sandy silty clay				
				DP32	32	Level 10% grass, isolated low to medium Eucalyptus and Acacia	Clayey Sand (SC)	Red brown clayey fine to medium sand with some silt. Boulders and cobbles noted on side of road.				
				DP31	33	Level with 40% grass, isolated miniature to low Acacia and Eucalyptus						

Table 1 - Alignment Conditions and Assessment

Zone	Chainage		Summary of Geological Conditions Anticipated from Desk Study	Waypoint ID	Photo ID	Landform, Topography and Vegetation	Surface Soil Type	Soil/Strata Description	Emerson Class and pH	Observed Erosion Characteristics	Overview	Investigation/Testing Proposed		
	Start	End												
F	KP 500	KP 563	Gently falling foothills of the Selwyn Range, characterised by alluvium and sheet wash deposits. Refer Point 4 to Point 5	DP30	34	Level to very gently falling towards creek, generally low Eucalyptus	Sandy Clay (CL)	Red brown fine to medium sandy, silty clay. Cobbles and boulders noted on surface at DP31	None	None Observed	Generally characterised by level ground with 50% grass cover (locally approximately 10%) with sparse to isolated, dwarf to miniature trees. Subsurface conditions comprise silty sandy and clayey soils. Depth to rock not assessed, but anticipated at >1m depth. Low to moderate (locally moderate where little ground cover) erosion potential, clayey soils maybe dispersive.	Propose three test pits, TP15 and TP17 to target variation in soil type and landform.		
				DP29	35	Level with 80% grass		Brown fine to medium sandy, silty clay.						
				DP28	36	Level with <5% grass, isolated miniature to dwarf Acacia	Clayey Sand (SC)	Red brown clayey fine to medium sand with some silt.						
				DP27	37	Level with 40% grass, isolated miniature to low Acacia and Eucalyptus		Red brown clayey fine to medium sand with some silt.						
				DP26	38	Level with 10% grass, isolated miniature to dwarf Acacia	Sandy Clay (CL)	Light grey brown fine to coarse sandy silty clay with a trace of subrounded to rounded gravel		None Observed				
				DP25	39	Level with 5% grass, very sparse to sparse low to medium Eucalyptus	Clayey Gravel (GC)	Brown/red brown clayey angular to subrounded gravel with some fine to medium sand and silt						
				DP24	40	Level with 60% grass and isolated miniature Acacia	Sandy Clay (CL)	Light grey brown fine to coarse sandy silty clay with a trace of subrounded to rounded gravel						
				DP23	41	Level with 60% grass and very sparse low to medium Eucalyptus	Sandy Silt (ML/CL)	Brown fine to medium sandy silt with a trace of clay and some subrounded to rounded gravel						
				DP22	42	Level to very gently falling to the southeast, with 50% grass, isolated to very sparse miniature to dwarf Acacia	Sandy Clay (CL)	Brown fine to medium sandy silty clay with a trace of subrounded fine gravel						
				DP20	43	Level with 50% grass, isolated to sparse or open dwarf to medium Grevillea and Eucalyptus	Clayey Sand (SC)	Red brown clayey fine to medium sand with some silt.						
				DP21										
				DP19	44	Level with 50% to 60% grass	Sandy Clay (CL)	Grey brown silty fine to coarse sandy clay with a trace of fine rounded gravel		None Observed	Generally characterised in the west by level ground with 50% grass cover and sparse to isolated dwarf to miniature trees. In the east near or adjacent to the creek, conditions comprise gently southward falling ground with 10% grass cover and very sparse Acacia. Frequent washouts noted and gully erosion around creek tributaries Subsurface conditions comprise silty sandy and clayey soils. Depth to rock not assessed, but anticipated at >1m depth. Moderate erosion potential locally evident by washouts. Clay soils maybe dispersive.	Propose four tests pits, TP18 to TP21, targeting creeks, erosion features and soils types.		
				DP18	45	Ground falls gently to southeast, 10% to 20% grass cover with isolated to very sparse dwarf to low Acacia	Sandy Clay (CL)	Red brown fine to coarse sandy silty clay with some subangular to subrounded gravel		Large washouts observed				
				DP17	46	Very gently to east with 10-20% grass, isolated to very sparse dwarf to low prickly acacia				Gully erosion observed				
				DP16	47	Gently to the south with 5% to 10% grass		Brown fine to coarse sandy silty clay with some fine to coarse gravel		Washouts observed				
				DP15										
				DP14	48	Level with 50% grass		Brown silty fine to coarse sandy silty clay with a trace of subangular to subrounded gravel						
				DP13	49	Level with Approx 10-20% grass, and isolated dwarf to low prickly acacia	Silty Sand (SM)	Red brown silty fine to coarse sand with some subangular to subrounded gravel						

Table 1 - Alignment Conditions and Assessment

Zone	Chainage		Summary of Geological Conditions Anticipated from Desk Study	Waypoint ID	Photo ID	Landform, Topography and Vegetation	Surface Soil Type	Soil/Strata Description	Emerson Class and pH	Observed Erosion Characteristics	Overview	Investigation/Testing Proposed
	Start	End										
				DP12	50	Level with approx 90% grass, isolated dwarf to low prickly Acacia	Sandy Clay (CL)	Brown fine to coarse sandy clay with some silt and a trace of subangular to subrounded gravel		None Observed		
				DP11	51	Level with approx 90% grass.	Clayey Gravelly Sand (GC)	Brown clayey silty, fine to coarse gravelly fine to coarse sand				
				DP10	52	Level to falling very gently to the east with approx 80-90% - grass tussocks, isolated dwarf to low Acacia	Silty Clay (CL)	Light grey brown silty clay with some fine to medium sand and a trace of subrounded to rounded fine to medium gravel				
				DP9	53	Level to falling very gently to the east with approx 80-90% - grass tussocks, and isolated to very sparse low Eucalyptus and Acacia						
				DP8	54	Level with approx 60% - grass tussocks, Eucalyptus and Acacia - very sparse to mid-dense, dwarf to medium	Silty Sand (SM)	Light brown silty fine to coarse sand with a trace of subrounded to rounded gravel				
Section between DP8 and M01 not mapped due to weather conditions											Mapping and test pit investigation between DP8 and MI01	
G	KP 563	KP 612	Gently sloping terrain, dissected by several north-south to northeast-southwest trending ridgelines. Geology is variable with folded and faulted sedimentary rocks intruded and interbedded with igneous strata with little superficial cover. Refer Point 5 to Mt Isa	MI01	See Pit Log	Level with 5% to 10% grass and sparse dwarf to medium trees	Silty Sand (SM)	0.1m of medium dense silty sand over low strength grading medium strength, highly fractured below 0.8m depth, moderately weathered shale	None	None Observed	Generally characterised by level ground with little grass cover and sparse dwarf to medium trees with some south-westerly draining ephemeral creeks. Subsurface conditions comprise silty sand over hard clays and low grading medium strength shale. Moderate erosion potential and clay maybe dispersive.	Propose four test pits TP22 to TP25 with additional testing from MI01 to MI08 if required. Pits to target creeks, changes in relief and soil types
				MI02	See Pit Log			0.4m depth of medium dense silty sand over hard medium plasticity silty clay	Silty clay Class 3, pH 5.8			
				MI03	See Pit Log	Level with approx 60% grass and very sparse to mid-dense, dwarf to medium trees		0.3m depth of medium dense silty sand with some gravel over low, grading low to medium strength at 0.6m depth granite	Silty sand Class 3, pH 4.2			
				MI04	See Pit Log		Silty sandy gravel (GP)	dense, grading very dense at 0.4m depth silty sandy gravel over low strength granite at 1m depth	Silty sandy gravel Class 5, pH 5.4			
				MI05A	See Pit Log	Level with 40% to 50% grass		0.3m of dense silty sandy gravel over hard medium plasticity silty clay with some sand and a trace of gravel to 0.7m depth. Low strength grading low to medium strength with depth granite.	None			
				MI05B	See Pit Log	Level with approx 50% grass and sparse, dwarf to medium trees	Sandy Gravelly Clay (GL)	0.1m depth of hard, red brown low plasticity sandy gravelly clay over hard medium plasticity silty clay to 0.8m depth, then very low strength granite grading very low to low strength at 1.3m depth	Clay Class 2, pH 6.1			
				MI06	See Pit Log	Level to undulating with approx 50% grass and sparse to mid-dense, dwarf to medium trees		0.4m depth of hard, red brown low plasticity sandy gravelly clay over very low to low strength granite. Grading low strength below 1m depth				

Table 1 - Alignment Conditions and Assessment

Zone	Chainage		Summary of Geological Conditions Anticipated from Desk Study	Waypoint ID	Photo ID	Landform, Topography and Vegetation	Surface Soil Type	Soil/Strata Description	Emerson Class and pH	Observed Erosion Characteristics	Overview	Investigation/Testing Proposed		
	Start	End												
				MI07	See Pit Log	Level with some small hills with simple slopes and approx 60% - grass and sparse, dwarf to medium trees	Silty Sand (SM)	0.1m of dense silty sand over hard medium plasticity clay with some sand and fine gravel to 0.6m depth then very low strength granite. Grading low strength below 1.2m depth.	None					
				MI08	See Pit Log	Level with approx 60% grass and very sparse to mid-dense, dwarf to medium trees		0.2m of dense silty sand over hard medium plasticity clay with some sand and fine gravel to 0.6m depth then hard/lightly cemented gypsum	Gypsum Class 2, pH 6.1	Possible gypsum encountered in test pit - potentially highly dispersive				
Section between MI08 and DP78 not mapped due to weather conditions														
H	KP 612	KP 621	Gently sloping terrain, dissected by several north-south to northeast-southwest trending ridgelines. Geology is variable with folded and faulted sedimentary rocks intruded and interbedded with igneous strata with little superficial cover. Refer Point 5 to Mt Isa	DP78	55	Gently undulating with 20-30% grass, very sparse to mid dense low to medium Acacia and Eucalyptus	Gravelly Sand (GM)	Red brown angular to subrounded fine to coarse gravelly fine to coarse sand with a trace of silt and clay	None	None Observed	Generally characterised by hilly terrain of gently to moderately sloping ground and simple slopes in depressions between steep crest slopes. Depressions between slopes are generally characterised by ephemeral creeks. Ground cover is less than 30% grass with sparse dwarf to medium trees. Subsurface conditions comprise shallow silty sand and gravelly soils over shallow locally metamorphose sedimentary siltstones and sandstone of variable strength. Moderate to high erosion potential.	Propose four test pits TP26 to TP29 with additional testing from MI09 to MI12 if required. Pits to target changes in relief and soil types		
				DP77			Silty Sand (SM)	Red brown silty fine to coarse sand over siltstone						
				DP76		In base of approximately 50m wide creek bed at toe of moderate steep slope to north. Ground level falls gently to west.	Sand (SW)	medium to coarse sand and fine to coarse gravel in creek bed. No fines (silt or clay), colluvial wedge on hillsides above insitu rock						
				DP7	56	Hilly/ridge lines with simple lower slopes grading to steep to very steep slopes towards the crest to the north, east and west. Open depressions observed between crests. Approx 30% - grass tuccocks, spinifex, Acacia, Eucalyptus - very sparse to mid dense, dwarf to medium	Silty Sand (SM)	Red brown silty fine to medium sand with some angular to sub-rounded gravel						
				DP6	57	Alignment comprises gently undulating ground with 10% to 50% grass and sparse miniature to medium Acacia and Eucalyptus. Looking west beyond alignment 10m to 20m high hill with simple lower slopes grading to steep to very steep at crest. DP3 located at toe of simple slope ground level inclined at approx 5 degrees.	Gravel and Cobbles	Red brown angular fine to coarse gravel with some silt, fine to coarse and trace boulders, some rock outcrops						
				DP5	58		Silty Sandy Gravel (GP)	Red brown silty fine to coarse sandy fine to coarse angular gravel, rock outcrops visible		Some gully erosion observed adjacent to road				
				DP4										
				DP3										
				MI-12	See Pit Log		Silty Clay (CL-CI)	0.4m depth of very stiff medium plasticity silty clay with some sand and gravel over extremely low strength grading very low strength siltstone		None Observed				
				DP2	59	Gently sloping to northeast with approx 40% ground cover - grass tuccocks, Acacia, Eucalyptus - sparse to very	Gravel and Cobbles	Red brown silty fine to coarse sandy fine to coarse angular gravel with some angular cobbles, rock outcrops visible						

Table 1 - Alignment Conditions and Assessment

Zone	Chainage		Summary of Geological Conditions Anticipated from Desk Study	Waypoint ID	Photo ID	Landform, Topography and Vegetation	Surface Soil Type	Soil/Strata Description	Emerson Class and pH	Observed Erosion Characteristics	Overview	Investigation/Testing Proposed
	Start	End										
				DP1	60	Acacia, Eucalyptus - sparse to very sparse, dwarf to medium	Silty Sand with Gravel (GP)	Red brown silty fine to medium sand with some angular fine to coarse gravel and cobbles				

Table Key

Comments		Landforms			
Observation points are not on or near alignment	Land forms etc assessed from Test Pit photos		40 - 50% grass and trees etc predominately sandy soils	Approx 50% or more grass with sparse to no trees	level to gently undulating less than 30% grass with sparse to isolated trees

Appendix D

Laboratory Report Sheets

Determination of Emerson Class Number and pH Value of Soil

Client: Jemena Northern Gas Pipeline Pty Ltd		Project No: 87536.01	
Project: Northern Gas Pipeline		Report No: BO16-0833	
Location: Mt Isa to Tennant Creek		Report Date: 12.05.2016	
		Date Sampled: 25.08.2015	
		Date of Test: 11.05.2016	
		Page: 1 of 1	

SAMPLE NO	DEPTH (m)	DESCRIPTION	WATER TYPE	WATER TEMP	CLASS NO.	pH VALUE
TC01	0.00 - 0.30	Silty sand	De-ionised	22°C	3	4.9
TC05A	0.00 - 0.20	Silty sand	De-ionised	22°C	3	4.5
TC06	0.60 - 0.80	Silty clay	De-ionised	22°C	2	9.8
TC07	0.00 - 0.30	Silty sandy gravel	De-ionised	22°C	3	4.6
TC08	1.00 - 1.30	Silty sand	De-ionised	22°C	4	5.7
M102	0.40 - 0.50	Silty clay	De-ionised	22°C	3	5.8
M103	0.00 - 0.30	Silty sand	De-ionised	22°C	3	4.2
M104	0.40 - 0.60	Silty sandy gravel	De-ionised	22°C	4	5.4
M108	1.00 - 1.50	Gypsum	De-ionised	22°C	2	6.1
M105B	0.20 - 0.50	Silty clay	De-ionised	22°C	2	6.1

Test Method(s): AS 1289 3.8.1, AS 1289 4.3.1

Sampling Method(s): Sampled by Brisbane Engineering Department


Remarks:



NATA Accredited Laboratory
 Number: 828

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

Tested: AC
 Checked: SJ


 Srdjan Jajcanin
 Laboratory Manager