Jemena Northern Gas Pipeline Pty Ltd

Northern Gas Pipeline

Draft Environmental Impact Statement

APPENDIX P – PRIMARY ESCP

Public

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Integrated Practical Solutions

Primary Erosion and Sediment Control Plan

Proposed Northern Gas Pipeline
Tennant Creek to Mt Isa

Prepared for
EcOz 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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Acronyms

Acronym	Description
AGP	Amadeus Gas Pipeline (existing)
APA	Australian Pipeline Authority Group
APIA	Australian Pipeline Industry Association Limited
ARI	Average recurrence interval
CGP	Carpentaria Gas Pipeline (existing)
CP	Cathodic protection station
CPESC	Certified Professional in Erosion and Sediment Control
CPSS	Certified Practicing Soil Scientist
EHP	Queensland Department of Environment and Heritage Protection
EIS	Environmental Impact Statement
EOL	End-of-line
EP Act 1994	*Environmental Protection Act 1994* (Qld)
EP Reg.	*Environmental Protection Regulation 2008* (Qld)
EPP (Water)	*Environmental Protection Policy (Water) 2009* (Qld)
ESC	Erosion and Sediment Control
ESCP	Erosion and Sediment Control Plan
IECA	International Erosion Control Association
IFD	Rainfall intensity-frequency-duration
IFD	Rainfall intensity-frequency-duration data, an indication of the rainfall depth during a design storm event of a specific duration and ARI
KP	Kilometre Point (i.e. chainage), commencing at the western end of the proposed alignment
MICS	Mt Isa Compressor Station, end of line delivery station located approximately adjacent to the Mt Isa power station
MLV	Main line valve
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NGP	Northern Gas Pipeline (proposed)
NRM	Queensland Department of Natural Resources and Mines
NT	Northern Territory
NT DLRM	Northern Territory Department of Land Resource Management
NT EPA	Northern Territory Environment Protection Authority
NTU	Nephelometric Turbidity Unit
PCCS	Phillip Creek Compressor Station, start of line receipt/compressor station at Warrego, 45 km northwest of Tennant Creek, NT
PESCP	Progressive Erosion and Sediment Control Plan
Qld	Queensland
RAMSAR	Convention on Wetlands of International Importance Especially as Waterfowl Habitat
ROW	Right Of Way, narrow easement associated with the pipeline corridor
RPEQ	Registered Professional Engineer Queensland
RUSLE	Revised Universal Soil Loss Equation
SOL	Start Of Line

Glossary

Term	Definition
Camp runoff	Surface water runoff from camp disturbed areas; to be directed to sediment basins
Construction footprint	Proposed footprint for construction including construction ROW, facilities, access roads, ancillary infrastructure and camps.
Construction ROW	30 m wide corridor within which pipeline construction will occur.
Ephemeral	Watercourses or wetlands which are dry for the most of the year and flow, or fill, only immediately following rainfall.
Highly disturbed waters	Waters where 'the biological integrity of an aquatic ecosystem is measurably degraded and of lower ecological value than waters' defined above (as defined in the EPP (Water); Qld Government 2014).
Intermittent	Watercourses or wetlands which are alternatively wet and dry. They usually flow annually but cease to flow for weeks or months of each year. Intermittent streams can contain permanent pools of water which sustain life during dry periods.
Major watercourse	Watercourses with a Stream Order of three or greater, as defined in EcOz (2016a and 2016b).
Moderately disturbed water	Are waters where 'the biological integrity of an aquatic ecosystem is adversely affected by human activity to a relatively small but measurable degree' (as defined in the EPP (Water); Qld Government 2014).
Sediment basin	Basin constructed for the purposes of capturing runoff from areas disturbed as a result of construction activities. Basins are sized to hold water, allowing for the settling of suspended sediment matter. To be designed by a suitably qualified engineer and in accordance with the IECA (2008).
Slightly disturbed waters	Waters where 'the biological integrity of an aquatic ecosystem has effectively unmodified biological indicators, but slightly modified physical, chemical or other indicators' (as defined in the EPP (Water); Qld Government 2014).

Report on Primary Erosion and Sediment Control Plan
Proposed Northern Gas Pipeline
Tennant Creek to Mt Isa

1 Introduction

Douglas Partners Pty Ltd (DP) was commissioned by EcOz Pty Ltd to develop a Primary Erosion and Sediment Control Plan (ESCP) for the Proposed Northern Gas Pipeline (NGP), to be constructed from Tennant Creek to Mt Isa (the 'site').

The proposed NGP is a new underground natural gas pipeline approximately 622 km in length that connects the Amadeus Gas Pipeline (AGP) at the Warrego Compressor Station in the Northern Territory (NT) to the Carpentaria Gas Pipeline (CGP) at Mt Isa, in Queensland (Qld). It is understood that works will include civil earthworks, construction of temporary access tracks and/or track upgrades, watercourse crossings, rail/road crossings, as well as construction of ancillary developments such as temporary camps, and cathodic protection stations. This plan has been based on the proposed pipeline alignment version dated 20 July 2016.

Development of a Primary ESCP was required for obtaining relevant approvals, and for inclusion in the Environmental Impact Statement (EIS) for the project. It has been based on site information available at the time of preparation. A revised Primary ESCP based on additional site investigation data, and subsequent progressive ESCPs will be required prior to construction.

This plan has been developed in general accordance with IECA (2008: Appendix P) and the scope of services described in our proposal BNE160565 dated 2 June 2016. It must be read in conjunction with the notes attached in Appendix A and other explanatory notes, and should be kept in its entirety without separation of individual pages or sections.

1.1 Objectives

The objectives of this Primary ESCP are to provide a framework for management of erosion and control of sediments mobilised throughout construction of the pipeline, and to mitigate impacts of construction on nearby watercourses and the surrounding environments.

1.2 Scope

This Primary ESCP provides an overview of site conditions known at the time of preparation, an erosion risk assessment, and a framework for management of erosion and sediment control throughout construction of the pipeline. It is intended as a preliminary, overarching, conceptual plan for the project and does not include detailed provisions or designs for specific erosion and/or sediment controls (ESCs). Development of this plan has been constrained by limited site-specific information available at the time of preparation, and it is subject to change as further site investigations are conducted and detailed site information becomes available. This plan is not approved for construction.

A series of subsequent Progressive ESCPs (PESCPs) will be required to describe work-site specific erosion and sediment management requirements for construction works and activities in site areas considered likely to have a high erosion risk, and/or with potential to impact on sensitive environments. The PESCPs shall be consistent with the management strategies described in this report.

2 Regulatory Framework

2.1 Legislative Requirements

The NGP project falls within the legal jurisdiction of the Commonwealth, NT and Qld Governments. Approvals, permits and licences are required pursuant to the legislation within each jurisdiction. Other guidelines, standards, and best practice standards will also apply to on-site environmental management of construction works. Best Practice Erosion & Sediment Control (IECA, 2008: Appendix P) will guide the erosion and sediment control activities for the project.

Works conducted in Qld will also need to comply with the conditions of the Environmental Authority EPPG03497815 issued for the NGP under the *Environmental Protection Act 1994*.

Obtaining all legislative approvals, licencing and permits required under Commonwealth, NT and Qld legislation will be the responsibility of Jemena, the project proponent.

2.2 Staff Roles and Responsibilities

Key staff and their associated ESC-related responsibilities for this project are summarised in Table 1.

Table 1: Roles and ESC Responsibilities of Key Staff

Project Role	ESC Responsibility
Project Manager	Overall responsibility to implement ESC mitigation measures. Ensure compliance with all relevant statutory regulations, approvals and permits. Provide monthly report submissions as well as incident and non-conformance reporting.
Construction Manager/ Supervisors	On-site environmental management. Implement, inspect, monitor, and maintain ESC mitigation measures. Store soils and cleared vegetation. Monitor compliance with the ESCPs. Inspect off-site impacts and manage, as required. Monitor and record rainfall, storage volumes, water quality, treatment practices, discharge volumes. Treat, test and dispose of any captured runoff.
Environment Advisor/ Consultant	Conduct site inspections and monthly audits. Conduct water quality monitoring, coordinate analysis at a NATA-accredited laboratory, as required, and collate results and prepare reports, as required. Notify the Project Manager of any ESC non-conformances.
Site Staff	Comply and assist with the implementation and maintenance of measures described in the ESCPs. Report damage to ESCs and any potential or actual environmental harm.

Table 1: Roles and ESC Responsibilities of Key Staff (continued)

Project Role	ESC Responsibility
Erosion and Sediment Control Auditor/ Advisor/ CPESC	Conduct site inspections and audits, as required. Prepare audit reports. Provide advice regarding ESC effectiveness and improvements.

3 Project Description

3.1 Project Works

The proposed NGP project will involve the construction of a new 622 km natural gas pipeline connecting the existing AGP in the NT to the existing CGP at Mount Isa in Qld. The pipeline is to commence at a tie-in to the existing Australian Pipeline Authority Group (APA) Warrego Compressor Station on the AGP and terminates at the existing Mica Creek Meter Station on the CGP.

The following infrastructure and facilities will be constructed, and are described in order from west (NT) to east (Qld):

- A 12-inch (323.9 mm) buried gas pipeline, 622 km in length. Approximately 457 km of the pipeline will traverse the NT, and approximately 165 km will be in Qld.
- A start of line (SOL) receipt/compressor station at Warrego, 45 km northwest of Tennant Creek (NT). This facility will cover an area of 9 ha (300 m by 300 m) and is referred to as the Phillip Creek Compressor Station (PCCS).
- Main line valve (MLV) facilities at three locations along the pipeline, two covering an area of approximately 0.12 ha (30 m x 40 m) each, and one covering an area of approximately 0.24 ha (30 m x 80 m).
- Five cathodic protection (CP) stations spaced between PCCS, MICS, and the MLV sites, each covering an area of approximately 0.04 ha (20 m x 20 m). The CP sites will comprise buried anode beds, located some distance from the pipeline (generally less than 500 m), connected to the pipeline via buried cables.
- An end of line (EOL) delivery station located southwest of the Mica Creek Meter Station in Qld. This facility will cover an area of 9 ha (300 m by 300 m) and is referred to as the Mt Isa Compressor Station (MICS).

The construction footprint will comprise a 30 m wide Right of Way (ROW) to allow pipeline construction using an open trench construction methodology, and extra work spaces for temporary facilities required to support construction. Temporary facilities will include: accommodation camps for personnel; access tracks; additional works areas (turn-around points, additional space for crossings); as well as water supply bores and dams to store water for dust suppression and hydrostatic testing purposes. Only road and railway crossings will be constructed using trenchless crossing methodologies. The expected ROW cross-sectional layout is shown in Figure 1.

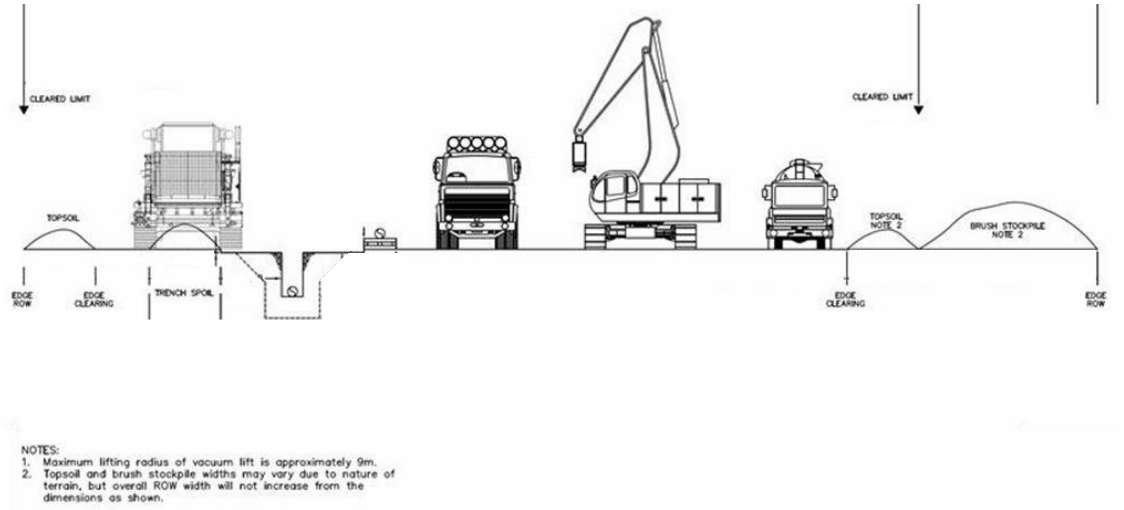

Figure 1: Typical Construction ROW Cross-Sectional Layout (EcOz 2016c: Figure 2-17)

The ROW and all temporary facilities, access tracks and extra work areas will be decommissioned and reinstated on completion of the construction phase. The only components to be retained in the long-term are access tracks to the permanent above-ground facilities (i.e. compressor stations, MLV and CP stations) and any access tracks or dams requested by the land holder(s).

Project activities that have potential to cause soil erosion and mobilisation of sediments are likely to include:

- Construction of temporary ancillary facilities, such as construction camps, access tracks, track upgrades, etc.;
- Pipeline construction works (i.e. clearing and grading along the ROW and access tracks, trenching, soil stockpiling, pipeline installation, backfilling and reinstating);
- Bulk reinstatement along the ROW, including installation of permanent diversion banks;
- Disturbance of potentially dispersive soils;
- Construction of watercourse crossings;
- Installation of permanent facilities, particularly compressor stations;
- Discharge of treated wastewater from construction camps via irrigation;
- Discharge of hydrostatic testing water to land; and
- Traffic movement and construction activities along unsealed surfaces, creating erosion and generating dust.

3.2 Construction Methods

3.2.1 Open Trenching

The majority of the pipeline, including watercourse crossings, will be constructed using an open trench construction methodology. Only road and railway crossings will be constructed using trenchless crossing methodologies. The pipeline trench will have a minimum width of approximately 624 mm, which allows for approximately 150 mm either side of the pipe.

The trench will generally follow the contours of the land by maintaining a generally constant depth from the surface, so that the pipe will also follow these contours. The minimum depth of cover over the pipe will vary along the alignment depending on the location class, as indicated in Table 2.

Table 2: Minimum Trench Cover Depths (data provided by EcOz Pty Ltd)

Location Class [(1)]	Minimum Depth of Cover (m)
Location Class R1	0.75
Location Class R2/HI	1.0
Location Class W	1.2
Black Soil Plains	1.2
Highway and Territory controlled road crossings (NT)	3.0
State controlled road crossings (Qld)	1.2
Road / track crossings	1.2
Railway crossing (below top of rail / through reserve)	3.0
Major watercourse crossing (rivers)	2.0/1.2
Minor watercourse crossing (creeks)	1.2
Pipeline section within measurement length of a dwelling / building	1.2

Notes
(1) The vast majority of the ROW is Location Class R1.
Only the export pipeline (from Mount Isa compressor station to tie-in to CGP) is designated Class R2 with a secondary location class of Heavy Industrial (HI).
Several areas along the pipeline are classed as periodically inundated (W).

3.2.2 Trenchless Construction Techniques

Both road and rail crossings will be constructed using trenchless techniques to minimise disturbance to traffic. Road crossings will be required for Warrego Road, Stuart Highway, and Diamantina Developmental Road (at KP 21, KP 39, and KP 616 respectively). A railway crossing will also be required at the Darwin to Adelaide Railway crossing (at KP 16).

Containment pits for drilling fluids and drill cuttings will be required at the drill entry and exit points (APIA, 2013). Specific sediment controls will be required at drill sites and will be described in Progressive ESCPs for each site once site-specific conditions are confirmed and additional soil and geotechnical information is available from further investigations.

3.3 Ancillary Facilities

3.3.1 General

Ancillary (supporting) facilities will be required to support construction. These will include: temporary workforce accommodation camps, access tracks (existing and new), additional works areas (turn-around points and laydown areas), as well as water supply bores and temporary dams for storing water required for dust suppression and hydrostatic testing (pressure testing) of the pipeline. The permanent ancillary developments and their locations are summarised in Table 3.

Table 3: Summary of Ancillary Developments (EcOz, 2016c)

Facility	KP Location	Jurisdiction	Latitude (degrees)	Longitude (degrees)
Phillip Creek Compressor Station (PCCS)	0	NT	-19.4494	133.8542
Cathodic Protection (CP1)	79	NT	-19.4784	134.6011
Main Line Valve 1 (MLV1)	163	NT	-19.7107	135.3573
Cathodic Protection (CP2)	211	NT	-19.8529	135.7928
Main Line Valve 2 (MLV2) and Intermediate scraper station	292	NT	-20.0930	136.5219
Cathodic Protection (CP3)	356	NT	-20.2829	137.1020
Main Line Valve 3 (MLV3)	413	NT	-20.2829	137.1020
Cathodic Protection (CP4)	489	Qld	-20.4675	137.6097
Cathodic Protection (CP5)	556	Qld	-20.6555	138.3000
Mount Isa Compressor Station (MICS)	622	Qld	-20.7311	138.9319

3.3.2 Temporary Accommodation Camps

Five temporary construction camps will be required along the ROW to accommodate construction workers (Table 4). Camps will be commissioned and decommissioned progressively with multiple camps in operation at any one time. The majority of camp infrastructure will be pre-fabricated to minimise construction requirements and aid mobilisation and demobilisation efforts.

Table 4: Summary of Camp Locations (EcOz, 2016c)

Camp	KP	Area (ha)(1)	Land Parcel Ownership	Latitude (degrees)	Longitude (degrees)
Camp 1	572	12	Pastoral Station	-20.7851	139.0830
Camp 2	440	12	Pastoral Station	-20.5633	137.8420
Camp 3	296	12	Freehold land	-20.1044	136.5630
Camp 4	169	12	Vacant Crown Land	-19.7304	135.4100
Camp 5	63	12	Pastoral Station	-19.4769	134.4490
PCCS Camp	0	12	Pastoral Station	-19.4488	133.8551

Notes
(1) Area includes 4 ha of land for irrigation of treated wastewater

3.3.3 Site Access

It is understood that site and facility access will be via a combination of existing and new tracks. Depending on the condition of existing tracks, some will be upgraded to meet project requirements and others will be used without any further modifications. New temporary tracks will be constructed, where required.

The ROW will be utilised for pipeline construction traffic and equipment to facilitate construction works (refer Figure 1) and any temporary tracks on the ROW will be removed on completion.

The majority of new tracks will be removed on completion of construction works. Only tracks for access to CP facilities, MLVs, compressor stations, and others as requested by the landholder(s) will remain as permanent features.

3.4 Proposed Construction Schedule

The construction phase of the Project is scheduled to commence in early 2017 and the pipeline system is planned to be operational in 2018. The exact timing is dependent on a number of factors, including the timeliness of the required approvals, access arrangements with relevant stakeholders, and weather conditions.

Construction of the PCCS and MICS is planned to extend through to early 2018, as access to these locations is less dependent on dry weather conditions. Commissioning of the pipeline, PCCS and MICS will follow the construction period. The construction schedule is driven by the Project objective to achieve commencement of gas transportation services (commercial operation) in 2018.

4 Existing Site Characteristics

4.1 General

The 'site' comprises a 30 m wide ROW along a 622 km linear corridor that crosses the NT and part of Qld, as well as the footprints of permanent and temporary ancillary facilities (refer Section 3.3) and associated access tracks. Existing site characteristics relevant to erosion and sediment control have been assessed based on the information available at the time this document was prepared and are summarised in the following sub-sections.

4.2 Climate and Rainfall Conditions

The proposed alignment borders two main climatic zones: the Northern Australia region with its wet summer and dry winter; and the Central Arid Zone, which is generally dry with low annual rainfall (EcOz, 2016a). Rainfall in the region occurs predominantly in the summer months, from December to March, with rainfall of 100 mm/month or greater expected during January and February (refer Table 5). Average rainfall of less than 20 mm/month could be expected during the dry season from April to October. Winter months from June to September are typically the driest months with average rainfall of less than 10 mm/month.

Table 5: Long-term Average Monthly Rainfall (BoM, 2016)

Location	Long-Term Average Monthly Rainfall Depth (mm)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tennant Creek (1)	113.5	122.6	54.2	17.0	8.5	5.0	4.6	2.4	7.4	19.5	40.5	74.6
Camooweal (2)	98.8	93.0	55.5	14.2	10.9	9.7	5.3	2.8	5.8	13.8	29.3	62.9
Mount Isa (3)	117.4	100.8	63.2	14.4	12.6	5.8	5.6	3.5	6.3	18.0	38.3	74.0
Average	109.9	105.5	57.6	15.2	10.7	6.8	5.2	2.9	6.5	17.1	36.0	70.5

Notes
(1) Tennant Creek Airport, BoM Station No 015135
(2) Camooweal Township, BoM Station No 037010
(3) Mount Isa Aero, BoM Station No 029127

Annual rainfall varies significantly from 93 mm/year to 1,093 mm/year (Mound Isa Aero station) depending on climatic conditions. Long-term annual averages range between approximately 375 mm/year (Camooweal Township) to 422 mm/year (Tennant Creek Airport).

Based on this rainfall information, construction earthworks should ideally be conducted between April and November, as currently planned. All in-stream works should be conducted when stream flows could be expected to be at a minimum. Site disturbance during the summer months, particularly in January and February, should be avoided wherever possible. If construction during the wet season is unavoidable, installation and maintenance of adequate erosion, drainage, and sediment controls would be essential.

Rainfall intensity-frequency-duration (IFD) data provides an indication of the rainfall depth during a design storm event of a specific duration and average recurrence interval (ARI). IFD data for Mount Isa Aero weather station is summarised in Table 6. Design standards recommended by IECA (2008: Tables A1 and A2) for Queensland and Northern Territory sites have been adopted for the design of temporary erosion and sediment controls.

Table 6:
Rainfall IFD Data (BoM, 2016) for the Adopted Design Standards (IECA 2008: Tables A1, A2)

Rainfall Duration	ARI (mm/hr)			
	1 Year	2 Years	10 Years (1)	50 Years
5 mins	75.5	97.9	146.0	200.0
6 mins	70.5	91.5	137.0	188.0
10 mins	59.3	76.9	115.0	157.0
20 mins	46.2	59.8	88.6	121.0
30 mins	38.7	50.1	73.9	101.0
1 hour	26.5	34.4	51.2	70.1
2 hours	16.6	21.7	33.4	46.6
3 hours	12.3	16.1	25.5	36.1
6 hours	7.2	9.5	15.9	23.2
12 hours	4.3	5.7	9.9	14.8
24 hours	2.7	3.6	6.2	9.3
48 hours	1.7	2.2	3.8	5.6
72 hours	1.2	1.6	2.7	4.0
Design Standard	Temporary culvert crossing	Temporary drainage structures with design life <12 months	Temporary sediment basin with design life <3 months.	Permanent sediment basin with design life >12 months

Notes
Data for Mount Isa Aero (BoM Station No 029127)
(1) Reference ARI for permanent drainage structures with design life >24 months

4.3 Site Topography

The majority of the proposed ROW alignment is relatively flat with only gradual changes in elevation (EcOz, 2016b). Ground elevations range between approximately 200 m AHD and 438 m AHD along the proposed alignment. Three hilly sections with steeper gradients exist near Tennant Creek (between KP 0 and approximately KP 80), between KP 260 and KP 370, and near Mount Isa (between approximately KP 565 and KP 622), as shown on the elevation profiles provided by EcOz Pty Ltd (copies attached in Appendix B as Figure 4 and Figure 5).

Slopes are generally long (>500 m to 156.6 km) with average slope gradients of less than 1%. Localised areas with greater gradients (approximately 2% to 3%) are present in the three hilly sections, and can also be expected along watercourse embankments and drainage lines. Approximate relative elevations and topography were determined by EcOz (2016b) based on topographical mapping available for the NT (50 m contour intervals), and Qld (5 m contour intervals).

The available topographical information is sufficient to provide indicative data regarding average slope gradients along the proposed ROW, however more detailed, site-specific information is required to determine topographical constraints and assessment of localised surface water flows. Contours developed from aerial photography combined with site-specific survey work will be used to inform the progressive ESCPs.

4.4 Ground Conditions

4.4.1 Regional Geology

The proposed ROW alignment transverses three distinct geological regions: the Tennant Creek Region, the Georgina Basin, and the Mount Isa Region (EcOz, 2016b). These geological formations are described in EcOz (2016b) and DP (2016), and their main characteristics are summarised in Table 7.

Table 7:
Summary of Geological Regions and Characteristics (adapted from EcOz, 2016b and DP 2016)

Geological Region	Characteristics
Tennant Creek Region	Sand plain deposits, such as silcrete and ferricrete duricrusts, colluvial and alluvial deposits, and aeolian sand dunes, flanking Palaeoproterozoic rocks of the Warramunga Province that form 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. The ridge separates the Cambrian Wiso and Georgina Basins.

Table continued on next page

Table 7:
Summary of Geological Regions and Characteristics (adapted from EcOz, 2016b and DP 2016) (continued)

Geological Region	Characteristics
Georgina Basin	A large flood plain (sedimentary basin) of low relief characterised by numerous river channels flanked by alluvium, with the intervening areas underlain by 'black soil'. It comprises a basal sequence of volcanics (Helen Springs Volcanics) and an overlying carbonate succession (Barkly Group). 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 in the vicinity of the Ranken River and in the eastern Georgina Basin. The central Georgina basin is divided by the Wonarah basement high into the Barkly Sub-basin in the west and the Undilla Sub-basin in the NT-QLD border region. The Barkly Group consists of: the Gum Ridge, Top Springs Limestone and Anthony Lagoon Beds in the Barkly Sub-basin; and the Woonarah Formation, Ranken Limestone and Camooweal Dolostone in the Undilla Sub-basin. Disconnected outcrops of Gum Ridge and Woonarah Formation occur around the proposed ROW alignment in the west and central Georgina Basin respectively. Elsewhere the Barkly Group is capped by a thin veneer of more recent Cainozoic formations including sand plains and alluvial deposits in the west of the Georgina Basin, sand dunes in the central basin and black soil plains around the NT-QLD border. Surface exposures of the Austral Downs Limestone are also recorded along drainage lines in the border region.
Mount Isa Region	The Mt Isa Inlier, that generally comprises gently sloping terrain dissected by several north-south to northeast-southwest trending ridgelines. Geology is variable with folded and faulted sedimentary rocks and dolomitised carbonates interbedded with igneous strata and with little superficial cover. Outcropping basement rocks are interspersed by Cainozoic sedimentary deposits, which include residual soils and alluvium.

4.4.2 Landforms

Six landforms have been identified within and surrounding the proposed ROW: alluvial plains, black soil plains, rocky hills, rocky plains, and swamp (EcOz, 2016b). Landform descriptions and their approximate locations along the ROW are summarised in Table 8.

Table 8: Summary of Landforms throughout the Proposed ROW Alignment (EcOz, 2016b)

KP	Landform	Description
0-53	Rocky hills	Comprises flat-topped but often steep-sided hills and ranges on sandstones, siltstones, and shales. Many rock outcrops are present. Some gently sloping areas and valleys exist.
53-352	Alluvial plains and rocky plains	Has a generally flat slope with little elevation change. A significant rise and fall in elevation is present immediately at the end of this section prior to change in landform.
352-518	Black soil plains	A large, low-lying floodplain with numerous braided streams and underlying deep grey and brown cracking clays. Also referred to as 'Channel country'.
518-584	Rocky plains	Gently undulating plains with occasional drainage depressions. Characterised by gentle slopes of less than 2%.
584-622	Rocky hills	Rocky and steep terrain at the start of the Mount Isa Inlier Bioregion. Outcrops may have a steep gradient but adjacent land may be relatively flat.

4.4.3 Acid Sulfate Soils

Site elevations are significantly greater than 20 m AHD (refer to Table 12 in Section 4.5) and excavations will not extend to depths below 5 m AHD. An acid sulfate soils (ASS) investigation is therefore not required under QASSIT (1998). However, potential may exist for ASS to be present along watercourses, alluvial plains, and black soil plains (EcOz, 2016b: Table 7-3).

If indicators of potential ASS, such as acid-tolerant plant species, oil-like slicks, and/or signs of jarosite or iron deposits are observed during future site investigations, soil sampling and testing for ASS will be required. Any ASS sampling and testing should be conducted in accordance with QASSIT (1998) recommendations.

It is considered that there is an extremely low potential for large-scale ASS management requirements on this project.

4.4.4 Site Observations and Results

DP conducted a site inspection and preliminary assessment of soil landscapes along the proposed ROW alignment where access allowed (DP 2016). Eight soil landscapes were mapped and described according to soil types, landform, and their indicative potential for erosion. The soil landscapes are summarised in Table 9 and align approximately with the various landforms described in Table 8.

Existing soil data is insufficient to identify the presence or otherwise of soil salinity, sodicity, acidity, slaking, dispersivity, or overall erosion risk. Further soil sampling and testing is required and should be conducted prior to preparation of the Progressive ESCPs.

Table 9:
Summary of Soil Landscapes identified throughout the Proposed ROW (EcOz, 2016b; DP, 2016)

Soil Code	KPs	Soil Landscape Description	Erosion Risk*	Emerson Class and pH Results
A	0-8	Red brown sandy clays and silty sands, with some gravel. Generally flat landform. Source geology is sand plain deposits flanking a north-west to south-east trending ridge of folded and faulted sedimentary greywacke, sandstone, siltstone and shale.	Low to moderate erosion risk. Clays may be dispersive. No existing erosion observed.	Silty Sand: Class 3, pH 4.9
B	8-66	Red brown fine to coarse gravelly sand, and silty sand, with localised gravel. Depths vary but soils are generally shallow and underlain by sedimentary limestone, siltstone, shale and sandstone. The landform is generally flat with undulating hills and ridges throughout. Source geology is sand plain deposits flanking a north-west to south-east trending ridge of folded and faulted sedimentary greywacke, sandstone, siltstone and shale.		Silty clay: Class 2, pH 9.8 Silty sandy gravel: Class 3, pH 4.6

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Table 9:
Summary of Soil Landscapes identified throughout the Proposed ROW (EcOz, 2016b; DP, 2016) (continued)

Soil Code	KPs	Soil Landscape Description	Erosion Risk*	Emerson Class and pH Results
C	66-212	Red brown to light brown silty sand and silty clay with some gravelly sections. Landform is generally flat, with grasses and sparse to medium density tree cover. Source geology is sand plain deposits with some outcrops of limestone, chert and breccia.	Low to moderate erosion risk. Clays may be dispersive. No existing erosion observed.	Silty Sand: Class 4, pH 5.7
D	212-350	Red-brown gravelly and silty sand soils with varying depths. Underlying rock is high strength silcrete, calcrete and conglomerate (as observed in outcrops). Landform is generally level to undulating ground with some rocky outcrops. Source geology is sand plain deposits with sand dunes, calcrete and outcrops of certified limestone, mudstone and dolostone. A sinkhole was observed during aerial surveys over this soil landscape.	Low to moderate erosion risk based on gradient and vegetation cover. Risk increases with increasing slope. Sinkholes may be present in this soil landscape. No existing erosion observed.	-
E	350-500	'Black soil plains' with light grey-brown to red-brown silty clay soil, with some local sandy patches and localised gravel. Large floodplain landform of low relief. Source geology is chertified limestone and mudstone, with some areas of dolostone.	Low to moderate erosion risk based on gradient and vegetation cover. Clay soils may be dispersive. Erosion noted along the banks of river and watercourses.	-
F	500-563	Brown silty sands and clay soils. The landform is generally flat foothills with some gullies and creeks. Soils are anticipated to be relatively deep (<1m). Source geology is characterised by alluvium and sheet wash deposits.	Moderate erosion risk based on silty and clay soils with frequent watercourses and varying slopes. Numerous washouts and eroded gullies were observed near watercourses.	-
G	563-612	Shallow silty sands over hard clay and low strength gravel and shale. The landform is generally undulating hills, with numerous creeks and gullies. Source geology is variable with folded and faulted sedimentary rocks interbedded and intruded by igneous strata.	Moderate erosion risk based on silty soils, slope and frequent watercourses. Vegetation is sparse in some areas, reducing ground cover. Clays at depth may be dispersive. No existing erosion observed.	Silty clay: Class 2 & 3, pH 5.8 & 6.1 Silty sand/gravel: Class 3 & 5, pH 4.2 & 5.4 Gypsum: Class 2, pH 6.1

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Table 9:
Summary of Soil Landscapes identified throughout the Proposed ROW (EcOz, 2016b; DP, 2016) (continued)

Soil Code	KPs	Soil Landscape Description	Erosion Risk*	Emerson Class and pH Results
H	612-621	Shallow gravelly sand and gravel soils over shallow sedimentary siltstones and sandstones. The landform is rocky and gravelly with hills of varying slope with depressions between crests. Depressions usually contain watercourses. Source geology is variable with folded and faulted sedimentary rocks interbedded and intruded by igneous strata.	Moderate to high erosion risk based on slope. Low vegetation cover and frequent watercourses. Gully erosion was observed in some depressions and along watercourses.	-

Notes
* Erosion risks are indicative based on observed conditions, such as slope and vegetation cover, and any available soil data. Dispersivity and soil structure will be investigated in pre-construction studies.
Some areas of existing erosion have been noted within the construction ROW (DP 2016).

4.4.5 Requirements for Further Assessment

More detailed soil investigations will be required prior to construction in accordance with IECA (2008) recommendations. At least one soil sample will need to be collected from each soil strata within each soil landscape to the expected depth of disturbance. Samples should also be collected near environmentally sensitive areas along the alignment to identify the requirements for any additional controls to minimise the potential for environmental harm.

Samples will need to be analysed for (as a minimum) particle size distribution, dispersion index, electrical conductivity, cation exchange potential, and exchangeable sodium percentage. Additional analyses may also be required where potential for contamination is identified during field surveys, where potential for ASS exists, and to determine whether amelioration is required for revegetation purposes.
Areas of problematic soils identified during the detailed soil survey should be mapped and specific management plans developed for problem areas. It is expected that management plans could include Dispersive Soil Management Plan(s), and/or Contaminated Soil Management Plan(s). Any management plans developed will need to include measures for handling, treatment and storage of soil, as well as the required environmental protection measures and monitoring requirements.

4.5 Surface Water Features

The proposed ROW alignment completely traverses two major river basins, as well as small sections of basins at either end (EcOz, 2016a). The ROW commences in the Wiso Basin at the western end of the pipeline, traverses the Barkly and Georgina River Basins, and terminates in the Leichhardt River Basin. The Leichhardt River Basin drains to the north towards the Gulf of Carpentaria, and all other basins drain inland towards Lake Eyre.

Each basin contains a number of watercourses, drainage lines and smaller sub-catchments. All watercourses that cross the ROW are ephemeral or intermittent and base flows are dependent on seasonal rainfall. Flooding can occur after significant rainfall. Basin features are described in detail in EcOz (2016a) and are summarised in Table 10.

A number of small, disconnected and ephemeral drainage lines are located near the western end of the ROW, whereas larger braided intermittent rivers are located near the eastern end and in the eastern portion of the NT (EcOz, 2016a). Very few drainage lines or surface water features exist in the central section of the ROW between approximately KP 100 and KP 375 where it crosses the arid zones and grasslands of the Davenport Murchison Ranges and Tanami bioregions.

The proposed ROW alignment avoids all significant wetland systems (e.g. flood-outs or waterholes), and no RAMSAR or nationally significant wetlands are within 45 km of the construction footprint (EcOz, 2016a). Some watercourses crossed by the ROW discharge into the wetlands of Lake Eyre, particularly during periods of significant rainfall which result in flooding. Minimal impacts to significant wetlands or watercourses are expected as a result of the pipeline construction if works are undertaken during the 'dry season'.

Table 10: River Basins Traversed by the Proposed ROW

Basin	KP	General Basin Description
Wiso Basin	0-15	The proposed ROW alignment does not cross any major watercourses or drainage lines in this basin.
Barkly Basin	15-308	Drainage features are generally defined, disconnected, and ephemeral to intermittent channels. The proposed ROW alignment does not cross any major watercourses or drainage lines in this basin.
Georgina River Basin	308-608	Major rivers are present and drain south toward Lake Eyre. Watercourses are highly braided and flows are dependent on rainfall. The basin contains the most significant watercourses. The Ranken River, James River and Georgina River will be traversed by the proposed ROW.
Leichhardt River Basin	608-621	The proposed ROW alignment traverses the basin near the headwaters of the Leichhardt River. The river is ephemeral and feeds Lake Moondarra, the main water source for Mount Isa township. Mica Creek will be traversed by the proposed ROW.

4.5.1 Watercourse Crossings

A number of watercourse crossings will be required within the Barkly, Georgina River, and Leichhardt River basins (Table 11). Many of the watercourses in the eastern part of NT and in Qld are braided and the ROW alignment crosses the same watercourses a number of times, as shown in EcOz Figure 2 and Figure 3 (attached in Appendix B). All watercourses within the construction footprint are seasonal, intermittent to ephemeral, and none are expected to be flowing or contain pools at the time of construction (EcOz, 2016a). All watercourses will be crossed using open trenching techniques with progressive reinstatement.

A preliminary watercourse crossing assessment was undertaken by others and describes the beds, banks, riparian condition and bed and bank profiles along the major rivers (EcOz, 2016b). Further watercourse surveys and identification of permanent water will be required prior to development of the Progressive ESCPs and commencement of construction works. Proposed watercourse crossing locations will be placed in narrow, naturally drier sections of the watercourse wherever possible to minimise potential impacts.

Table 11:
Summary of Watercourse Crossings (adapted from EcOz, 2016a: Table 3-1 & 2016b: Table 7-5)

Basin	Name	Watercourse Type	Approximate KP	Number of crossings	Bank Detail (Approximates)	Bank Condition
Barkly	Bishop Creek (NT)	Drainage line	18	1 minor drainage	-	-
	Gosse River (NT)	Flood-out	87	1	-	-
	Two additional unnamed drainage lines are crossed in the Barkly Tablelands.					
Georgina River	Ranken River (NT)	River	383	1	Bed width: 25 m-30 m Height: 2 m-3 m; Slope: varies, 20°, 45°, 70°-80°	Clay with gravel; significant erosion observed on banks where accessed by cattle
		Drainage line	383 – 396	8	-	-
	James River (NT)	River	409	1	Bed width: 10 m Height: 1 m-2 m; Slope: 10° west bank, 40°-60° east bank	Clay and mud; moderate to high severity erosion by cattle observed on banks
		Creek	411	1	-	-
		Drainage line	407-417	3	-	-
	Georgina River (NT)	River	430	1	Bed width: 16 m Height: 2.5 m-3 m; Slope: 35°-50°	Clay mud; moderate to high severity erosion by cattle observed on banks
		Drainage line	420-423	2	Bed width: 3 m-5 m Height: 0.5 m; Slope: 10%	Clay and gravel; no erosion observed
	Blue Bush Creek (NT)	Creek	443 – 451	2	Bed width: 8 m; Height: -; Slope: 20° west-40° east	Clay; no erosion observed
		Drainage line	448 – 453	4	Bed width: 1 m; Height: 0.5 m; Slope: 5%	Clay; no erosion observed
	Redbank Creek (Qld)	Creek	464	2	-	-

Table continued on next page

Table 11:
Summary of Watercourse Crossings (adapted from EcOz, 2016a: Table 3-1 & 2016b: Table 7-5) (continued)

Basin	Name	Watercourse Type	Approximate KP	Number of crossings	Bank Detail (Approximates)	Bank Condition
Georgina River (continued)	Mingera Creek (Qld)	River	472	1	Bed width: 18 m; Height: 2 m; Slope: ~60%	Mud; medium severity erosion by cattle observed on banks and bed
		Drainage line	472-498	5	-	-
	Polygonum Creek (Qld)	Creek	509	1	Bed width: -; Height: -; Slope: >60%	Sand/ rock; no erosion observed
		Drainage line	505-510	4	-	-
	One Mile Creek (Qld)	Drainage line	531	1	-	-
	Lily Hole Creek (Qld)	Creek	536	1	-	-
	Templeton River (Qld)	River	544	2	-	-
		Drainage line	525-608	13	Bed width: 2 m; Height: 0.6 m-0.8 m; Slope: 60%	Rock/ earth; no erosion observed
	Yaringa Creek (Qld)	River	590	1	Bed width: 30 m; Height: 0.6 m-0.8 m; Slope: 80%	Earth/ sand; minor gully erosion observed on banks
		Creek	585-601	4	Bed width: 5 m; Height: 0.6 m-0.8 m; Slope: >45%	Rock/ earth; mild undercut erosion observed on banks
		Drainage line	584 – 609	18	Bed width: 7 m-8 m; Height: 0.5 m-1 m; Slope: ~45%-60%	Earth/ sand; mild undercut erosion observed on banks
Leichhardt River	Mica Creek (Qld)	River	616	1	Bed width: 42 m; Height: 1.5 m; Slope: ~45%-60%	Sand; moderate gully erosion observed on banks
		Creek	611 – 619	8	Bed width: 17 m-27 m; Height: 0.4 m-1.5 m; Slope: ~45%-80%	Sand; minor bank and gully erosion by undercutting and cattle/ vehicles -
		Drainage line	609 – 621	5		
15 additional unnamed drainage lines are crossed.						

Notes
- Data not yet available

4.6 Drainage Sub-Catchments

A series of 33 indicative sub-catchments were identified along the proposed ROW by EcOz Pty Ltd, and an additional 16 sub-catchments have been assumed for ancillary developments, such as camps, CP stations, and MLV stations. Sub-catchment data is summarised in Table 12. Indicative soil conditions for each sub-catchment have been identified based on the preliminary information contained in Table 9.

Due to the extended length of the proposed ROW and the limited site-specific topographic data, ROW sub-catchments were determined on an indicative scale from hilltop to hilltop accurate to the nearest kilometre, and may need to be modified as more detailed information becomes available.

Table 12: Summary of Sub-Catchment Data

Sub-Catchment Identifier	KP Range (km)		Area (ha)	Elevation Range (m AHD)		Soil Code (1)	Predominant Soil Conditions (1)
1	0	10	30	314	357	A	Sandy clays and silty sands, with some gravel.
2	10	21	32.7	357	349	B	Gravelly sand, and silty sand, with localised gravel
3	21	29	25.5	349	375	B	
4	29	49	58.2	375	338	B	
5	49	70	65.4	338	297	B, C	Gravelly sand, and silty sand, with localised gravel. Silty clay after KP 66.
6	70	78	21.9	297	280	C	Silty sand and silty clay with some gravelly sections
7	78	236	473.4	280	237	C, D	Silty sand and silty clay with some gravelly sections. Gravelly and silty sand after KP 212.
8	236	240	14.7	237	243	D	Gravelly and silty sand.
9	240	245	14.4	243	245	D	
10	245	254	25.5	245	258	D	
11	254	262	25.5	258	268	D	
12	262	277	43.8	268	292	D	
13	277	299	65.4	292	312	D	
14	299	301	7.2	312	314	D	
15	301	306	14.7	314	317	D	
16	306	318	36.3	317	305	D	
17	318	384	196.8	305	215	E	Black soil plains: silty clay soil with some local sandy patches and localised gravel.
18	384	419	105.6	215	217	E	
19	419	432	39.9	217	206	E	
20	432	446	40.2	206	208	E	
21	446	489	130.8	208	237	E	
22	489	494	14.7	237	241	E	

Table continued on next page

Table 12: Summary of Sub-Catchment Data (continued)

Sub-Catchment Identifier	KP Range (km)		Area (ha)	Elevation Range (m AHD)		Soil Code [1]	Predominant Soil Conditions [1]
23	494	506	36.3	241	247	E, F	Black soil plains: silty clay soil with some local sandy patches and localised gravel. Silty sands and clays after KP 500.
24	506	533	80.1	247	270	F	Shallow gravelly sand and gravel soils over shallow sedimentary siltstones and sandstones.
25	533	560	80.1	270	310	F	
26	560	569	29.1	310	341	F, G	Shallow gravelly sand and gravel soils over shallow sedimentary siltstones and sandstones. Shallow silty sands over hard clay and low strength gravel and shale after KP 563.
27	569	574	14.7	341	363	G	Shallow silty sands over hard clay and low strength gravel and shale.
28	574	580	18.3	363	355	G	
29	580	595	43.5	355	396	G	
30	595	603	25.5	396	423	G	
31	603	607	11.1	423	438	G	
32	607	618	32.7	438	399	G, H	Shallow silty sands over hard clay and low strength gravel and shale. Shallow gravelly sand and gravel soils over shallow sedimentary siltstones and sandstones after KP 612.
33	618	621	9	399	370	H	Shallow gravelly sand and gravel soils over shallow sedimentary siltstones and sandstones.
Ancillary Developments							
Camp 1	572		12.0	320*		G	Shallow silty sands over hard clay and low strength gravel and shale.
Camp 2	440		12.0	205*		E	Black soil plains: silty clay soil with some local sandy patches and localised gravel.
Camp 3	296		12.0	285*		D	Gravelly and silty sand.
Camp 4	169		12.0	235*		C	Silty sand and silty clay with some gravelly sections.
Camp 5	63		12.0	290*		B	Gravelly sand, and silty sand, with localised gravel.
PCCS Camp	0		12.0	315*		A	Sandy clays and silty sands, with some gravel
PCCS	0		9.0	315*		A	
CP1	79		0.04	275*		C	Silty sand and silty clay with some gravelly sections.
CP2	211		0.04	240*		C	
CP3	356		0.04	230*		E	Black soil plains: silty clay soil with some local sandy patches and localised gravel.
CP4	489		0.04	230*		E	
CP5	556		0.04	295*		F	Shallow gravelly sand and gravel soils over shallow sedimentary siltstones and sandstones.

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Table 12: Summary of Sub-Catchment Data (continued)

Sub-Catchment Identifier	KP Range (km)	Area (ha)	Elevation Range (m AHD)	Soil Code (1)	Predominant Soil Conditions (1)
MLV1	163	0.12	235*	C	Silty sand and silty clay with some gravelly sections.
MLV2	292	0.24	280*	D	Gravelly and silty sand.
MLV3	413	0.12	210*	E	Black soil plains: silty clay soil with some local sandy patches and localised gravel.
MICS	622	9.0	385*	H	Shallow gravelly sand and gravel soils over shallow sedimentary siltstones and sandstones.

Notes for Table 12

Sub-Catchments were determined based on the proposed pipeline alignment current at 20 July 2016. ROW sub-catchments extend from hilltop to hilltop, as determined by EcOz Pty Ltd. Sub-catchment data for ancillary developments was based on information provided by EcOz Pty Ltd.

m AHD metres Australian Height Datum

(1) Based on soil codes and data presented in Table 9.

* Approximate elevation estimated from longitudinal elevation profiles along the ROW, provided by EcOz Pty Ltd.

4.7 Potential Receiving Environments

All of the watercourses and drainage lines within the proposed ROW alignment (Table 10 and Table 11) can be considered as receiving environments for this project. They are likely to be affected by site works and the potential mobilisation of sediments during rainfall and/or wind events. The majority of these watercourses drain to the south towards Lake Eyre, and only the Leichhardt River drains to the north in to the Gulf of Carpentaria. Both Lake Eyre and the Gulf contain sensitive ecosystems and will need to be protected from environmental harm.

Limited water quality information is available for the watercourses (EcOz, 2016b). Baseline data (pH and turbidity as a minimum) should be collected wherever possible up-stream and down-stream of all proposed watercourse crossings prior to, during, and after construction to monitor any potential adverse effects of construction works.

5 Potential for Erosion

5.1 Erosion Risk Assessment

Erosion risk assessment is used as an indicator tool to determine the erosion and sediment control standards that should be applied. Erosion risks from wind, raindrop impact, and flow of stormwater are dependent on a combination of soil properties, local topography, rainfall conditions, and the estimated soil loss rate. They would be expected to vary along the ROW depending on local site conditions, site activities, and the expected rainfall. Risk has been assessed based on a combination of soil properties, local topography, and rainfall conditions.

5.1.1 Erosion Risk from Soil Properties

Available preliminary soil landscape information and site observations indicate a low to moderate potential for erosion (refer Table 9). The presence of dispersive soils has not yet been comprehensively assessed, and would significantly increase the potential for erosion, if identified.

5.1.2 Erosion Risk from Topographical Information

Available topographic and sub-catchment information (refer Table 12) indicates that the general ROW alignment is likely to have a very low erosion risk from water flows using the erosion risk assessment criteria below (IECA, 2008: Table P4). However, this may vary where slope gradients are locally greater, particularly on watercourse and/or drainage line embankments, and where slopes are long (>200 m) without any intermittent slope breaks.

- Very Low risk: slope gradient less than 3%;
- Low risk: slope gradient between 3% and 5%;
- Moderate risk: slope gradient between 5% and 10%;
- High risk: slope gradient between 10% and 15%; and
- Extreme risk: slope gradient greater than 15%.

5.1.3 Erosion Risk From Rainfall Conditions

Erosion risk will vary throughout the year depending on the rainfall trends as runoff would only be generated once the topsoil becomes saturated. Average monthly rainfall ranges from <10 mm to approximately 120 mm, with the majority of rainfall expected from December to March (refer Section 4.2). Monthly erosion risk ratings have been estimated based on the long-term average monthly rainfall and are summarised in Table 13.

Table 13: Monthly Erosion Risk Ratings

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tennant Creek (1)	H	H	M	VL	VL	VL	VL	VL	VL	VL	L	M
Camooweal (2)	M	M	M	VL	VL	VL	VL	VL	VL	VL	VL	M
Mount Isa (3)	H	H	M	VL	VL	VL	VL	VL	VL	VL	L	M
Total Average	H	H	M	VL	VL	VL	VL	VL	VL	VL	L	M

Notes for Table 13

Erosion risk ratings determined based on average monthly rainfall depths (IECA, 2008: Table 4.4.2 and Table P4)

(1) Tennant Creek Airport, BoM Station No 015135

(2) Camooweal Township, BoM Station No 037010

(3) Mount Isa Aero, BoM Station No 029127

VL Very Low erosion risk (0-30 mm average monthly rainfall depth)

L Low erosion risk (>30-45 mm average monthly rainfall depth)

M Moderate risk (>45-100 mm average monthly rainfall depth)

H High erosion risk (>100-225 mm average monthly rainfall depth)

E Extreme erosion risk (>225 mm average monthly rainfall depth)

With reference to the proposed construction schedule in Section 3.4, February has a high erosion risk rating, whereas the remaining months are considered to have moderate to very low erosion risks (March to November).

5.1.4 Erosion Risk from Estimated Soil Loss

Quantitative estimates of the potential long-term average amounts of soil likely to be eroded from each sub-catchment via sheet and rill flow were calculated using the Revised Universal Soil Loss Estimation (RUSLE) method. The RUSLE method provides an estimate of annual erosion rates based on rainfall erosivity (R-Factor), soil erodibility (K-Factor), topography (i.e. slope length and gradient: LS-Factor), ground cover (C-Factor), and on-site erosion control practices (P-Factor). Soil loss has been estimated for each ROW sub-catchment and each anticipated ancillary development location. RUSLE calculations are attached in Appendix C and are summarised in Table 14 with reference to the sub-catchment identifiers.

An annual monthly rainfall erosivity value (R-Factor) of 1,219 (IECA, 2008: Table E1 for Mount Isa) was adopted as an indicative representation of the expected conditions throughout the construction areas. As site-specific information was not available, default values for soil erodibility (K-Factor) and slope length/gradient (LS-Factor) were adopted from values listed in IECA (2008: Appendix E) based on the expected soil types (refer Table 9) and the available topographic information as provided by EcOz Pty Ltd.

For estimation purposes, it was assumed that during construction works no appreciable ground cover would be present (C-Factor; IECA, 2008: Table E10). It was also assumed that the ground surface would be compacted and smooth during the construction phase (P-Factor; IECA, 2008: Table E11).

Preliminary estimates of soil loss are summarised in Table 14 and indicate that the long-term annual erosion rates would vary between approximately 4 t/ha/year and 9 t/ha/year, depending on the local sub-catchment conditions (refer to Section 0). This represents a very low erosion risk across the site, i.e. soil loss is less than 150 t/ha/year. Potential impacts of dispersive soil have not been considered in this preliminary assessment. The soil loss estimates will require refinement once additional data from further field investigations becomes available.

Table 14: Summary of Preliminary RUSLE Soil Loss Estimations

Sub-Catchment Identifier	Annual Soil Loss Rate (t/ha/year)	Sub-catchment Area (ha)	Annual Soil Loss (t/year)
1	7	30	221
2	5	33	151
3	5	26	118
4	5	58	269
5	5	65	302
6	7	22	161
7	7	473	3,484
8	5	15	68
9	5	14	67
10	5	26	118
11	5	26	118
12	5	44	202

Table continued on next page

Table 14: Summary of Preliminary RUSLE Soil Loss Estimations (continued)

Sub-Catchment Identifier	Annual Soil Loss Rate (t/ha/year)	Sub-catchment Area (ha)	Annual Soil Loss (t/year)
13	5	65	302
14	5	7	33
15	5	15	68
16	5	36	168
17	6	197	1,112
18	6	106	596
19	6	40	225
20	6	40	227
21	6	131	739
22	6	15	83
23	6	36	205
24	7	80	589
25	7	80	589
26	7	29	214
27	7	15	108
28	7	18	135
29	7	44	320
30	7	26	188
31	7	11	82
32	9	33	297
33	9	9	82
Ancillary Developments			
Camp 1	7	12	88
Camp 2	6	12	68
Camp 3	5	12	55
Camp 4	7	12	88
Camp 5	5	12	55
PCCS Camp	7	12	88
PCCS	7	9	66
CP1	5	0.04	0.2
CP2	5	0.04	0.2
CP3	4	0.04	0.1
CP4	4	0.04	0.1
CP5	5	0.04	0.2
MLV1	5	0.12	0.6
MLV2	6	0.24	1.4
MLV3	4	0.12	0.5
MICS	9	9	82

Notes for Table 14

Sub-Catchments were determined based on the proposed ROW alignment current at 20 July 2016 and locations of ancillary developments provided in EcOz (2016c).

5.1.5 Overall Erosion Risk

Based on the risk assessments described above, an overall erosion risk rating of low to very low is considered reasonable between March and November 2017. Works in sensitive areas, watercourses, and areas containing dispersive or problematic soils should be avoided in months of high erosion risk (i.e. January and February). In-stream works and watercourse crossings are only to be conducted during periods of low average rainfall and low erosion risk (i.e. April to November).

Consideration should be given to delaying commencement of construction works from February until March to minimise the likelihood of erosion from raindrop impact and water flows.

5.2 Required Erosion and Sediment Control Standards

Dust, drainage, and erosion controls would be of greatest benefit to minimise soil loss and potential downstream turbidity impacts. A minimum sediment control standard of Type 3 (or better) controls will be required for the site based on the long-term annual average soil loss rates of less than 75 t/ha/year (IECA, 2008: Table 4.5.1). Best practice techniques for forward land clearing and soil disturbance described in IECA (2008: P6.3) should be adopted.

6 Management Strategies

6.1 ESC Targets

The ESC targets for the project are to:

- Minimise the extent and duration of soil disturbance.
- Minimise erosion by wind, water and traffic.
- Drain any runoff from all disturbed site areas to sediment controls.
- Take all reasonable and practicable measures to minimise erosion and sediment discharge in storms greater than the design event.

6.2 Vegetation Clearing

The extent and duration of soil disturbance and exposed soils are to be minimised wherever reasonable and practicable. Land clearing and removal or disturbance of existing ground cover must be delayed as long as practicable and must be undertaken in conjunction with development of each stage of works. Only the minimum clearing for adequate drainage and sediment control measures shall occur until the measures are operational.

Any areas of protected vegetation and significant areas of vegetation to be retained must be clearly identified (e.g. with high-visibility tape, or fencing) prior to the commencement of clearing. All reasonable and practicable measures must be taken to minimise removal or disturbance of any trees, shrubs or ground cover that are intended to be retained. Land clearing is to be limited to the extent of the approved construction footprint. All land clearing must be in accordance with the Federal, State, Territory, and local government vegetation protection/preservation requirements and/or policies.

Disturbance to natural watercourses (including bed and banks) and their associated riparian zones must be limited to the minimum practicable. Consideration should be given to retaining minimum vegetation ground cover near watercourse crossings.

Land clearing must not extend beyond that necessary to provide for site activities during the dry season (March to November), for six weeks of works in December and January, and for four weeks if works are required in February (refer Section 5.2).

6.3 Soil and Stockpile Management

All reasonable and practicable measures must be taken to obtain the maximum benefit from existing topsoil. Topsoil (i.e. the nominal top 50 mm of soil) and sub-surface spoil from trench excavations (i.e. soil, rock) will be separated and stockpiled within the construction ROW. Topsoil will be reused as a final surface soil on reinstatement.

Stockpiles of erodible material must be appropriately protected from wind, rain, concentrated surface flow, and excessive up-slope stormwater surface flows. They should be located outside of riparian areas, more than 200 m from a wetland or spring, more than 100 m from a watercourse, up-gradient of an appropriate sediment control, and at least 2 m from any hazardous area, retained vegetation, or concentrated drainage line other than that associated with the construction of linear infrastructure. Suitable flow diversions must be established immediately up-slope of any stockpile of erodible material. Site-specific Progressive ESCPs will be required where multiple watercourse channels are located within close proximity.

6.4 Reinstatement

Excavations along the ROW and within watercourses should be reinstated as soon as practicable after installation of the pipeline and are expected to be conducted progressively. Sub-soils and any dispersive soils identified are to be returned to the base of the excavation, and the retained topsoil is to be placed on top of the trench backfill. Vegetative cover will be spread over the topsoil as soon as practicable after completion of construction works.

Reinstatement of major watercourses will be described in Progressive ESCPs, as required.

Temporary road and sediment basin areas, as well as areas to be filled and reshaped during the development should be progressively reinstated as works progress and they are removed to provide a stable landform.

6.5 Wet Weather/ Temporary Shut-Down Procedures

In the event of forecast rainfall, or an unexpected rainfall event, ensure all drainage, erosion and sediment controls are installed as per ESCP. All ESC measures in active site areas are to be inspected and any accumulated sediments removed prior to rainfall. Any water contained in sediment basins is to be monitored for water quality and discharged once the water quality objectives have been met.

Inspect all ESC measures after rainfall has ceased and repair and/or reinstate, as appropriate.

6.6 Training for Site Staff

A selection of relevant construction staff, operators and supervisors responsible for clearing, reinstatement and control works are to attend a one day soil conservation training session prior to commencement of site works. Training is to be conducted by a suitably qualified person (CPESC and/or CPSS) with relevant experience in erosion and sediment control aspects of pipeline construction and experience in the region, as recommended by the NT Department of Land Resource Management (DLRM).

7 Typical Control Measures

7.1 General

Standard ESC techniques shall be used in accordance with the recommendations of IECA (2008) and APIA (2013) to the greatest extent possible. All control structures are to be designed, installed and maintained in accordance with the management strategies identified in this plan and recommendations provided in IECA (2008), which are described in fact sheets available from NT DLRM and IECA (2008: Book 6).

Various mitigation measures will need to be implemented to mitigate the impacts of construction on nearby watercourses and the surrounding environments. Industry best practice uses a combination of control measures for drainage, erosion, and management of mobilised sediments (IECA, 2008) and these have been applied to the proposed works to minimise potential environmental risks. The trench construction layout will include drainage, erosion and sediment controls to minimise the volume of any water captured in the open trench. The majority of works will be completed during the ‘dry season’ when the chance of rainfall is low.

Typical control measures for the proposed works were selected based on the erosion risk and the design standards listed in IECA (2008: Table 4.3.1, Table 4.5.1 and Appendix E). The control measures recommended here are generic in nature and will require refinement once additional site information becomes available. Progressive ESCPs will describe site-specific controls required for nominated sections of the ROW, major watercourse crossings, any areas of problematic soil, and ancillary developments.

Typical site controls and requirements relating to the prevention of erosion and management of potentially sediment-laden runoff are outlined in the following sub-sections. Controls are to be installed as per the technical specifications in Appendix D and are to be fully operational at all times. Damaged and/or defective materials and components are to be repaired or replaced as they become ineffective for their design purpose.

7.2 Drainage Controls

Drainage controls should be designed using the rainfall IFD data provided in Table 6 and the following standards (based on IECA, 2008: Tables A1, A2). Detailed design of drainage controls will be included in the Progressive ESCPs.

- Temporary drainage structures:
  two year ARI with 150 mm freeboard (assumes design life of <12 months)
- Emergency spillways on temporary sediment basins:
  10 year ARI with 300 mm freeboard (assumes design life of <3 months)
- Emergency spillways on permanent sediment basins:
  50 year ARI with 300 mm freeboard (assumes design life of >12 months)
- Temporary culvert crossings:
  1 year ARI wherever reasonable and practicable.

7.2.1 Flow Diversions

Wherever possible, stormwater runoff from areas up-gradient of disturbed site areas must be diverted around any areas of disturbance or exposed soil. This includes diversions around active work areas, open trench areas, temporary stockpiles, and accommodation camps. Water flows through the site are to be minimised and controlled through temporary drainage structures such as catch drains, diversion banks and down-gradient mulch filter berms.

7.2.2 Drainage on Long Slopes

Long unstable slopes have potential to cause rill and/or gully erosion and must be divided into manageable drainage areas. Diversion banks should be placed along a line of constant elevation at regular intervals down the slope to collect and divert surface runoff either to stable outlets or permanent drains along the edge of the disturbance area.

Diversion banks should be constructed from site-derived material in accordance with NT DLRM recommendations (see Technical Note 8 attached in Appendix D) and should be spaced at various intervals depending on the local slope, as summarised in Table 15. Banks will also be required as permanent controls at appropriate intervals along the reinstated ROW to avoid creation of a preferential flow path along the ROW alignment, which could lead to erosion.

Table 15:
Recommended Horizontal Spacing for Diversion Banks on Non-Vegetated Slopes (NT DLRM: Technical Note 8)

Slope (%)	Spacing for Tropical Regions (m)	Spacing for Arid and Semi-Arid Regions (m)
0.5	120-130	170-180
1	90-100	120-130
2	60-70	90-100
3	50-60	70-80
4	45-50	60-70
5	40-45	55-60
6	35-40	50-55
10	28-33	40-45

7.2.3 Drainage along Access Tracks

Access tracks, both temporary and permanent, will require suitable surface drainage controls to minimise water ponding, damage and associated maintenance requirements. Drainage along access tracks should be constructed according to the NT DLRM recommendations (see Fact Sheet – Road Drainage, attached in Appendix D).

In the majority of site areas, it is expected that crowned roads with regular mitre drains and stable outlets, such as level spreaders, will be suitable. Infall and/or outfall drainage may be required where the ROW alignment is perpendicular to slopes. Alternatively, whoa-boys (or cross-banks) that drain to stable outlets can be installed along sloping tracks. Site-specific requirements will need to be assessed during subsequent field visits and be described in the Progressive ESCPs.

Where temporary access tracks are required across watercourses and/or drainage lines, installation of fords or inverts is likely to be suitable to provide a trafficable surface with minimal interference to water flow. If required, inverts should be installed so the finished surface is at or just below the stream bed level in accordance with NT DLRM recommendations (see Fact Sheet – Road Drainage, attached in Appendix D).

7.2.4 Permanent Stormwater Drainage

Permanent stormwater drainage would be required around permanent ancillary developments (CP stations, MLVs, compressor stations) and along any permanent access tracks. Permanent drainage structures must be designed by a suitably qualified Hydraulic or Civil Engineer (RPEQ qualifications required in Qld) based on a detailed assessment of site hydrology and hydraulics.

7.3 Erosion Controls

Erosion controls are to be implemented throughout construction works to minimise the mobilisation or loss of soil via wind and/or water. A range of control measures exist, including use of site-derived mulch from vegetation clearing to cover exposed areas, as well as a range of erosion control mats and blankets. A summary of various controls are summarised in Table 16.

Table 16: Summary of Erosion Control Measures for Slopes (IECA, 2008: Table 4.4.13)

Flat Land (<1V:10H)	Mild Slopes (1V:10H to 1V:4H)	Steep Slopes (>1V:4H)
Erosion Control Blankets	Bonded Fibre Matrix	Bonded Fibre Matrix
Gravelling	Compost Blankets	Cellular Confinement Systems
Mulch	Erosion Control Blankets, Mats and Mesh	Compost Blankets
Revegetation	Mulching well anchored	Erosion Control Blankets, Mats and Mesh
Rock Mulching	Revegetation	Revegetation
Soil Binder	Rock Mulching	Rock Armour
Turf	Turf	Turf

7.3.1 Dust Control

The majority of works are to be conducted during the 'dry season' when soils will be dry and potential exists for significant erosion from wind and vehicle movements that is likely to cause nuisance dust.

Application of water is expected to be sufficient to minimise dust generation on haul roads. Use of a soil binder that can generally be diluted with water and applied using a standard water truck will be investigated, if required. Depending on the duration of works at active construction areas and the intensity of traffic, reapplication may be required. Product-specific advice should be sought from the supplier.

7.3.2 Erosion within Pipe Trench

Potential exists for tunnel erosion to occur in the backfilled trench where it transects sub-surface seepage zones and the trench forms a preferential flow pathway. Erosion potential can be minimised by installing earthen trench breakers or permeable zones (sand or gravel) within the backfill where seepage zones are encountered. This will facilitate water flow across the trench, rather than along its length.

Permanent trench breakers must also be installed at regular intervals along steep slopes, and on either side of all major watercourse crossings to minimise the potential for flooding or erosion of the trench to occur. It is expected that approximately 70 trench breakers will be installed in areas of high slope gradient, the majority of which would be between KP 609 and KP 616, and near watercourse crossings between KP 383 and KP 619 (EcOz, 2016b).

7.4 Sediment Controls

Sediment controls are essentially end-of-line measures to capture any sediment mobilised through erosion via wind, traffic, or water flows. The necessity and size of sediment controls can be minimised by ensuring adequate drainage and erosion controls are in place.

A minimum sediment control standard of Type 3 (or better) controls will be required for the site based on the long-term annual average soil loss rates of less than 75 t/ha/year (IECA, 2008: Table 4.5.1). Typical Type 3 controls are summarised in Table 17. Selected sediment controls suitable for use for the project are described in the following sub-sections.

Table 17: Typical Type 3 Sediment Control Techniques (IECA, 2008: Table 4.5.3)

Sheet Flow Areas	Minor Concentrated Flow Areas (1)	Dewatering Controls	In-stream Controls
Buffer zone	Coarse sediment trap	Filter fence	Modular sediment barrier
Filter fence	Modular sediment trap	Grass filter bed	Sediment filter cage
Modular sediment trap	U-shaped sediment trap	Hydrocyclone	
Straw bale barrier	Sediment trench	Portable sediment tank	
Sediment fence (non-woven composite fabric)		Sediment fence (non-woven composite fabric)	
Mulch filter berm			

Note
(1) Includes roadside drains

7.4.1 Construction Entry/Exit Points

Site access must be restricted to the minimum number of locations practical and must be appropriately managed to minimise the risk of sediment being tracked onto sealed, public roadways. Stormwater runoff from access roads and stabilised entry/exit points must drain to an appropriate sediment control device such as a mulch filter berm or sediment fence.

The location of site access point(s) must be verified with the proponent prior to the commencement of site works. Typical installation specifications are attached in Appendix D.

7.4.2 Mulch Filter Berms

Mulch filter berms can be installed to filter sediment-laden runoff from disturbance areas. Berms should be constructed from site-derived vegetative material and installed to ensure 100% contact with the soil surface and to maximise ponding on its up-slope side, as described in the specification attached in Appendix D. They should be installed down-gradient of disturbance areas and can be installed in lieu of sediment fences.

Removal of berms is not compulsory, and they can be vegetated and left in-situ once construction and soil stabilisation works are complete.

7.4.3 Sediment Fences

Sediment fences can be installed down-gradient of disturbed site areas to allow ponding of water and settling of sediments. The base of fences need to be dug in to the ground at least 200 mm on the up-gradient side of the fence, and will require some soil disturbance to install and later remove, as described in the specification attached in Appendix D.

7.4.4 Sediment Basins

Soil loss is expected to be less than the trigger 150 t/ha/year for sediment basin requirements under IECA (2008). However in Qld, EHP (2009) requires all construction phase disturbances greater than 1 ha to take all reasonable and practicable measures to collect all runoff from disturbed areas and drain to a sediment basin.

Construction along the ROW is expected to proceed at a rate of 5 km/day (personal communication: EcOz Pty Ltd, 7 June 2016). Based on a ROW width of 30 m, this equates to an active work area of approximately 15 ha/day that would require drainage to a sediment basin for works in Qld. However, construction of sediment basins for each 5 km of ROW length is not practicable due to the low soil loss rates (refer Table 14) and intended construction during the dry season when negligible rainfall can be expected.

The requirement for sediment basin construction along the ROW in Qld will be negated through prompt reinstatement and installation of ground cover, and/or application of suitable erosion controls, such as application of a soil binder to all exposed areas and/or mulching using site-derived wastes from vegetation clearing.

Temporary construction camps in Qld are likely to require sediment basins based on the EHP (2009) criteria stated above. Preliminary design calculations for a typical construction camp sediment basin (Appendix E) indicate a required size of approximately 18.5 m by 6 m with an assumed length/width ratio of 3:1 and bank gradients of 3 H:1 V. Reducing the exposed soil areas and installation of suitable erosion controls and ground cover would reduce the required basin size. Detailed basin sizing, as well as design of emergency spillways and drainage channels must be conducted by a suitably qualified person.

Sediment basins will only contain water if rainfall occurs, and water quality monitoring will be required as outlined in EcOz (2016a: Section 6.2.3.

No sediment basins will be installed in the NT unless construction works will be conducted during the ‘wet season’ and disturbed areas cannot be stabilised.

7.5 Watercourse Crossings and Approaches

Watercourse crossings should be constructed at right angles to the stream bed in locations where the channel is straight and has well-defined banks. Cleared vegetation and other debris should be removed from the flood zone. Trafficable vehicle crossings may consist of temporary fords, inverts or bridges.

A pre-construction assessment of all proposed watercourse crossings and in-stream works will be undertaken prior to commencement of construction. It will include a hydraulic assessment of the proposed crossings, potential risks, and specific management requirements that will be outlined in Progressive ESCPs for major crossings (e.g. waterways with a stream order of 3 or more). The objective would be to minimise clearing of vegetation, disturbance of root matter in banks, and time of disturbance.

In-stream construction activities and the removal of existing watercourse crossings have the potential to generate sediment deposition within the watercourses. Sediment released from a work site into a watercourse or water body can lead to an increase in water turbidity during rainfall when water flows occur. Work areas need to be kept clean of soil deposition wherever possible. Temporary stockpiling of soil within watercourses, within flood levels, on watercourse embankments, or at the crest of embankments is to be avoided during times of flow in watercourses.

Watercourse crossings are to be scheduled so that they are constructed in the following order of preference:

1. When no water is present;
2. In times of no flow; and
3. In times of flow, but in a way that does not impede low flow.

Water flows within the channels will not need to be managed unless the construction schedule changes. Precautionary erosion and sediment controls and flow diversion systems will be installed wherever reasonable and practicable, particularly if rain is forecast.

Any potential lateral inflows of stormwater runoff from the watercourse banks will need to be diverted around disturbed site areas in a non-erosive manner. It should not be allowed to mix with sediment-laden water from work areas. Diversions such as diversion banks and/or mulch berms will be required if rainfall is expected or likely, and when lateral inflows are likely to flow through disturbed areas or cause bank erosion.

Crossing work is to be completed promptly with watercourse beds and banks reinstated and stabilised immediately following completion of works. Crossings will be reinstated to pre-disturbance condition wherever possible. No permanent aboveground structures will be installed in any watercourses.

The appointed construction Contractor will be required to prepare a Watercourse Crossing Procedure for major crossings. The procedure should describe the proposed construction methodology, sequencing and duration of works within watercourses.

Watercourse approaches and embankments are to be stabilised and protected with suitable erosion controls. Track layout and drainage measures should be designed to minimise flow of sediment-laden water directly into the watercourse. Watercourses should be protected with cross-banks (whoa boys) on either side of the watercourse immediately above the access track leading down the embankments. Typical track drainage controls are shown in the specifications attached in Appendix D. If the access cutting is longer than 15 m, it may be necessary to construct additional flow diversions.

7.6 Hydrostatic Discharge Locations

Water used for hydrostatic testing of the pipeline and any ponded water requiring dewatering from trenches will be discharged to land. Discharge should occur to specific sediment control structures to minimise the potential for erosion to occur at the discharge outlet(s) and should not allow direct discharge into a watercourse. Control measure should be located at least 100 m from the nearest watercourse.

Control sediment structures suitable for a medium to high flow rate from a concentrated discharge include: rock filter dams, either with filter cloth or aggregate used as the primary filter medium; filter tube dam; or a filter fence. Level spreaders or energy dissipaters (rock) can be used where discharge water is not sediment-laden and turbidity is <50 NTU (Nephelometric Turbidity Unit).

The control structure selected will depend on the topography and soil conditions at the discharge location and should be determined prior to commencement of dewatering and hydrostatic testing.
A Hydrostatic Test Water Management Plan will be developed prior to construction and will contain details of hydrostatic testing procedures, water quality testing, and discharge controls.

7.7 Removal of Control Measures

Control measures must be removed once stabilisation of up-gradient site areas has occurred and either a minimum of 70% ground cover has been achieved, or ground cover density matches that of the surrounding local area. Mulch filter berms and invert/ford watercourse crossings that do not impede water flows are the only controls specified that may remain after construction works and site stabilisation are complete.

7.8 Revision/ Modification of Control Measures

The selected control measures may require amendment during construction to reflect the physical site conditions and/or if the construction schedule or methodology is changed. Any amendments must be consistent with the intent of this plan.

Any amendments to major sediment control devices, such as sediment basins and channels, will require design by a suitably qualified person.

The following ESC strategies should be considered when updating this plan:

a) Minimise clearing of vegetation and removal of groundcover;

b) Minimise the extent and duration of soil exposure;

c) Protect exposed soil surfaces from erosion;

d) Divert clean water around areas of disturbance;

e) Install all control measures early in the construction cycle;

f) Capture sediment on-site; and

g) Stabilise and revegetate disturbed areas progressively and as soon as practicable.

8 Development of Progressive ESCPs

8.1 General

The Contractor shall prepare a series of progressive ESCPs (PESCPs) that detail the specific soil and water management measures for pipeline construction at each work site location. The PESCPs shall be consistent with the approach outlined in this Primary ESCP and it shall be referenced, as appropriate. The progressive ESCPs will include additional site-specific data obtained through field surveys and soil sampling and testing.

As a minimum, Progressive ESCP's will be required for the following site areas:

- Major watercourse crossings;
- Areas of dispersive soils or other problematic soils;
- High risk parts of the ROW (low lying channel country and tablelands);
- Qld construction camp (if sediment basin is required); and
- Compressor stations (with temporary and permanent ESC and drainage requirements).

8.2 ESCP Revisions/ Modifications

This is a conceptual primary ESCP for the project that will be reviewed and updated as more detailed site information comes to hand and/or in response to updated construction plans. Measures described in this plan must be implemented until a revised ESCP is available. Any ESCP revisions would need to be submitted to Jemena, as well as regulatory authorities in both NT (NT DLRM) and Qld (EHP) for approval, where required.

If the implemented controls fail to achieve the stated objectives, local government ESC standards, or the State/Territory environmental protection requirements, further revisions will be required. Where there is a high probability that serious or material environmental harm may occur as a result of sediment leaving the site, appropriate additional erosion and sediment control measures must be implemented such that all reasonable and practicable measures are being taken to prevent or minimise such harm. All necessary new or modified erosion and sediment control works must be in accordance with this plan until an amended, approved plan is available.

9 Monitoring and Maintenance

9.1 General

This ESCP has been developed with the aim of limiting sediment and turbidity transport from the site. Every effort should be made to ensure that drainage, erosion controls and sediment containment structures are well maintained and functioning correctly. If followed correctly, recommendations made in this plan should enable the development to proceed with minimal impact to the local receiving environments.

The Contractor is responsible for all inspections, monitoring, and maintenance of all ESC measures during the construction period. ESC measures may require revision if the desired control is not being achieved, or as site conditions change.

9.2 Monitoring and Inspection Requirements

Monitoring of the effectiveness of all ESC devices will be conducted regularly throughout the construction program to confirm compliance with this plan. Findings of inspections and audits will be reported to project managers and, where relevant, regulators to ensure transparency of auditing and compliance. Any issues identified during the inspections and/or audits will be corrected as described in Section 9.4.

Compliance will be monitored through:

- Daily and weekly inspections undertaken by the Contractor's representative;
- Surface water quality monitoring (where water is present);
- Monthly environmental compliance audits; and
- Biannual internal project audits by the Construction Contractor.

Additional inspections should be conducted at least daily when rain is occurring, within 24 hours prior to expected rainfall, and within 18 hours of a significant rainfall event (i.e. an event of sufficient intensity and duration to cause runoff).

Sample ESC inspection checklists are attached in Appendix F to facilitate effective inspections. Inspection records are to be kept on site by the site manager/ foreman and be made available to regulatory authorities on request. Inspections would typically include an assessment of the following items:

- Inspection of all erosion protection measures, as well as sediment control and drainage structures at least weekly during dry weather and daily during wet periods. Any damage identified should be repaired as soon as possible.
- Identification of excess sediment build-up requiring removal/ maintenance. A freeboard of at least half the design volume of sediment basins should remain at any time. No more than 0.1 m depth of sediment build-up should remain behind sediment fences at any time.
- Occurrences of excessive sediment deposition both on-site and off-site.
- Inspection of all erosion protection measures, as well as sediment control and drainage structures within 18 hours of significant rainfall events.
- Monitoring of turbidity of discharge water during significant rainfall events. Monitoring results are to be compared with the water quality objectives for the site (EcOz, 2016b).
- Inspection of any disturbed/ filled/ revegetated areas for susceptibility to erosion.
- Any areas where soil erosion is discovered should be repaired as soon as possible. If erosion is occurring, the source should be identified and additional erosion control measures should be implemented to prevent recurrence.

- Revegetated areas should be inspected weekly during dry weather to monitor progress and after significant rainfall events to determine if damage has occurred. Inspections should continue until either at least 70% ground cover has been achieved, or ground cover density matches that of the surrounding local area.
- If water is present, water quality monitoring (pH, total suspended solids, and turbidity) is to be conducted up-gradient and down-gradient of active work areas and watercourse crossings prior to, during, and post-construction and watercourse disturbance as well as immediately following significant rainfall events. Monitoring results are to be compared with the water quality objectives for the site (EcOz, 2016b).
- Weekly physical condition monitoring in watercourses as per EcOz (2016a: Section 6.2.2) requirements.
- Testing of water contained in all sediment basins/ traps prior to any discharge and immediately following significant rainfall events.
- If water quality does not comply with the water quality objectives for the site, flocculation will be required until a suitable water quality is achieved.

9.3 Maintenance

Accumulated sediment must be removed from sediment fences/mulch filter berms and either be deposited in a soil stockpile area up-gradient of a sediment control measure or buried on-site. Excessive sediment deposition at any fence/berm should be investigated to determine the source. No more than 0.1 m depth of sediment build-up should remain behind sediment fences or mulch filter berms, as described in the specifications attached in Appendix D.

Any sediment basins installed will require maintenance when sediment depths exceed a quarter of the total design sediment storage depth of the basin. The depth of sediments accumulated in the basins should not exceed the design depths of the sediment storage zones at any time.

Any blockages in drainage structures should be cleared immediately to prevent water diversion or flooding. Any deposited sediment should be removed and any damage repaired as soon as possible.

9.4 Corrective Actions

An ESC environmental incident would be any event where sediment is released from the site, whether controlled or uncontrolled, or where stormwater is released (controlled) from site which does not meet the water quality requirements. All incidents and non-conformances are to be reported as described in EcOz (2016a: Section 7) and investigated.

The severity of the non-conformance or incident will determine the reporting requirements and corrective actions. The Construction Manager should be notified of any non-conformance within 24 hours of the incident occurring. Any incident which results in an unauthorised discharge to watercourses or has the potential to result in material or serious environmental harm must be reported to the NT EPA or the Queensland Pollution Hotline (EHP) within 24 hours.

Non-compliance with the conditions of this plan will require corrective actions consistent with the nature and seriousness of the situation. The reason for the non-compliance is to be identified and appropriate corrective actions taken.

If the nominated water quality objectives are not met for sediment basins/traps, water is to be contained on-site until the objectives have been achieved.

Corrective actions could include, but not be limited to, the following:

- Re-establishment of ESC measures, as necessary.
- Implementation of additional best practice ESC measures in accordance with IECA (2008) and/or advice from a suitably qualified consultant or CPESC, if necessary.
- Issue of a 'notice to remedy', pending re-inspection of the site.
- Issue of a 'stop work notice'.

Performance indicators listed in EcOz (2016b: Section 5) provide the overarching indicators for assessment of management methods at the site. If the performance indicators are not being met, corrective actions must be implemented.

10 References

Ahern, C R, Ahern, M R, and Powell, B, (1998) *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998*, Queensland Acid Sulfate Soil Investigation Team (**QASSIT**), Department of Natural Resources, Resources Sciences Centre, Indooroopilly.

Australian and New Zealand Environment Conservation Council (ANZECC) (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1: The Guidelines*, Australian Government Publishing Service, Canberra.

Australian Pipeline Industry Association Ltd (APIA) (2013) *Code of Environmental Practice – Onshore Pipelines, Revision 3*

Bureau of Meteorology (BoM) (2016) *Climate Data Online*, available at http://www.bom.gov.au/climate/data/, accessed on 13 June 2016.

Catchments and Creeks Pty Ltd (2010) *Erosion & Sediment Control (ESC) - Fact Sheets*, available at: http://www.catchmentsandcreeks.com.au/M-fact_sheets-ESC.html

Department of State Development Infrastructure and Planning (DSDIP) (Queensland Department) (2014) *State Planning Policy—state interest guideline, Water quality*, Brisbane.

Douglas Partners Pty Ltd (DP) (2015) Letter Report on *Preliminary Geotechnical Investigation and Seismic Hazard Assessment, Proposed North East Gas Interconnector Pipeline, Tennant Creek to Mt Isa District*, dated 25 September 2015, addressed to Jemena Pty Ltd, DP Project No. 87536.00, Report 2, Brisbane.

Douglas Partners Pty Ltd (DP) (2016) *Preliminary Assessment of Geotechnical and Soil Landscape Mapping, Proposed Northern Gas Pipeline, Tennant Creek to Mt Isa*, NGP Doc No. 399-RP-GI-001, DP Project No. 87536.01, Brisbane.

EcOz Pty Ltd (2016a) *Northern Gas Pipeline, Construction Water Management Plan*, Draft Version, Document Code: EZ16232-C0301-SWS-R-0002, Darwin.

EcOz Pty Ltd (2016b) *EIS for Jemena Northern Gas Pipeline, Chapter 7-Water*, Draft Version.

EcOz Pty Ltd (2016c) *EIS for Jemena Northern Gas Pipeline, Chapter 2-Project Description*, Draft Version.

Environment and Resource Management (EHP) (Queensland Department) (2009) *Queensland Water Quality Guidelines*, Version 3. Queensland Government Publications, Brisbane.

International Erosion Control Association (IECA) (2008) *Best Practice Erosion and Sediment Control*, Picton, NSW.

11 Limitations

Douglas Partners Pty Ltd (DP) has prepared this Primary ESCP for the Proposed Northern Gas Pipeline Project from Tennant Creek to Mt Isa in accordance with DP's proposal BNE160565 dated 2 June 2016 and acceptance received from Ms Kylie Welch of EcOz Pty Ltd dated 2 June 2016. Work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of EcOz Pty Ltd 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 the 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 sub-surface conditions on the site 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. Sub-surface 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 affected by undetected variations in ground conditions across the site 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 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 / environmental / groundwater) components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A About this Report

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.

Copyright

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.

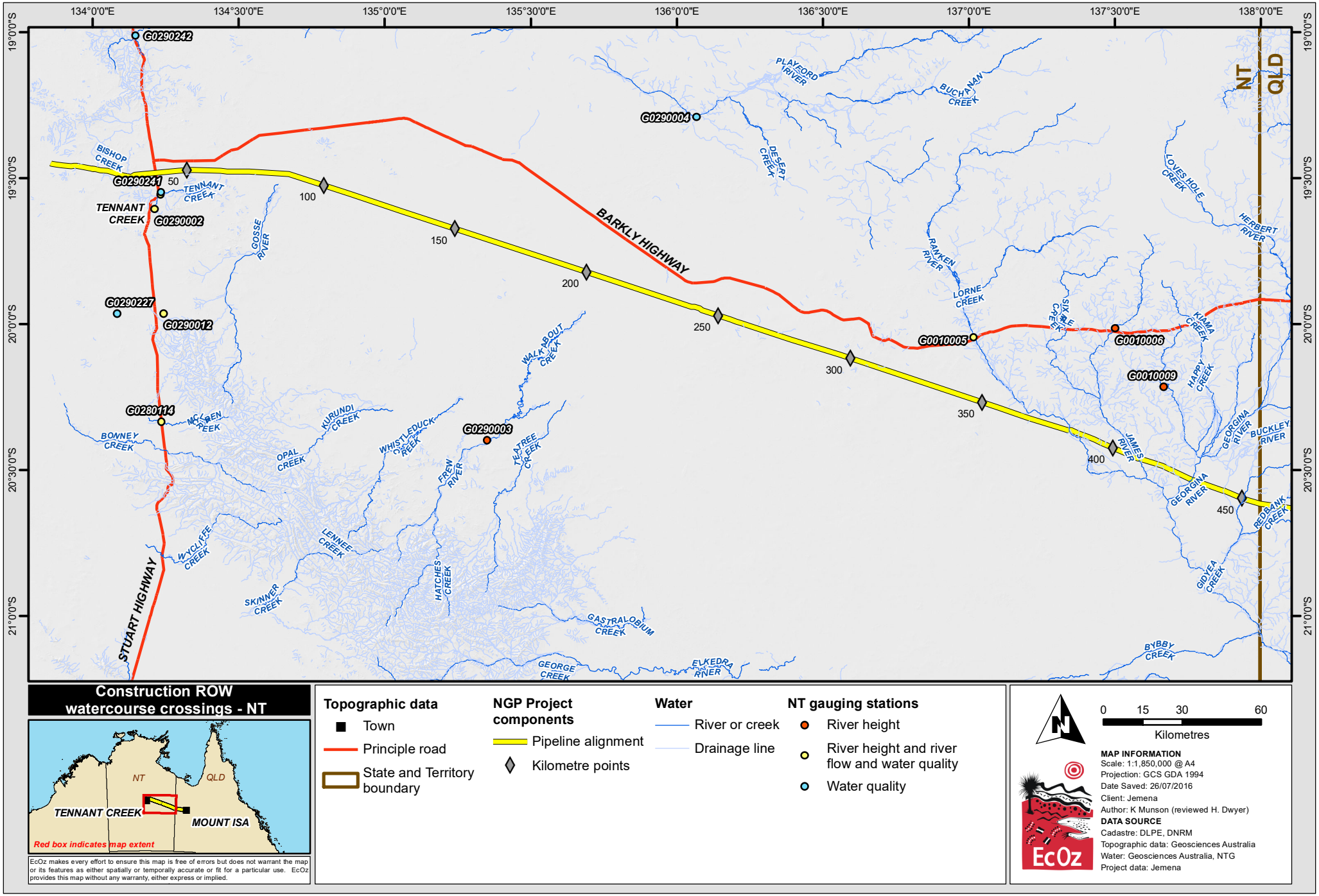
Information for Contractual Purposes

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.

Appendix B Figures, as Provided by EcOz Pty Ltd



Construction ROW watercourse crossings - NT

EcOz makes every effort to ensure this map is free of errors but does not warrant the map or its features as either spatially or temporally accurate or fit for a particular use. EcOz provides this map without any warranty, either express or implied.

Topographic data
- Town
- Principle road
- State and Territory boundary

NGP Project components
- Pipeline alignment
- Kilometre points

Water
- River or creek
- Drainage line

NT gauging stations
- River height
- River height and river flow and water quality
- Water quality

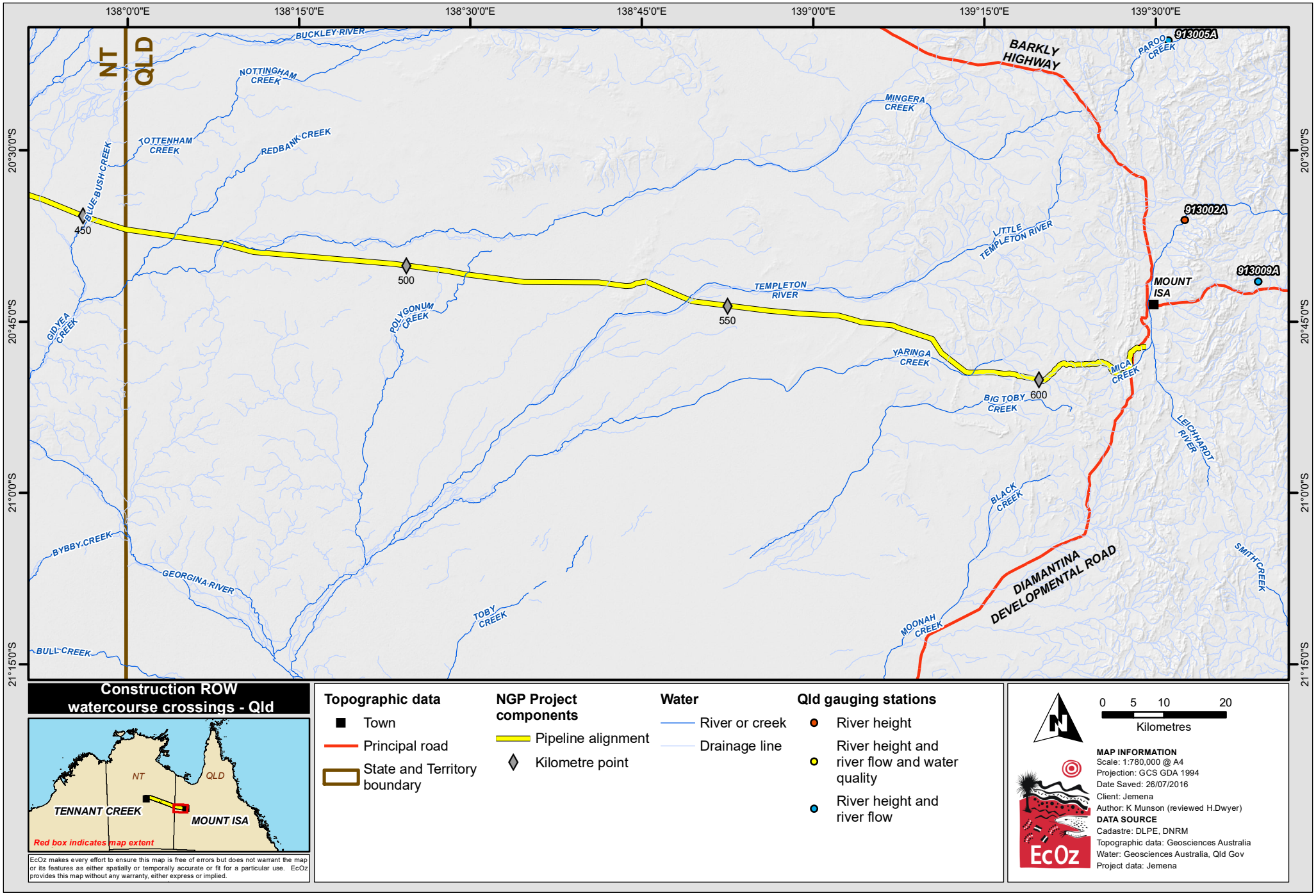
0 15 30 60
Kilometres

MAP INFORMATION
Scale: 1:1,850,000 @ A4
Projection: GCS GDA 1994
Date Saved: 26/07/2016
Client: Jemena
Author: K Munson (reviewed H. Dwyer)

DATA SOURCE
Cadastre: DLPE, DNRM
Topographic data: Geosciences Australia
Water: Geosciences Australia, NTG
Project data: Jemena

Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\JEMENA\EIS (NT)\01 Project Files\Ch7-EMP\Water\Figure 2-3 Map of construction ROW watercourse crossings NT V2.mxd

Map of watercourses and monitoring stations in relation to the construction ROW - NT



Construction ROW watercourse crossings - Qld

Topographic data
- Town
- Principal road
- State and Territory boundary

NGP Project components
- Pipeline alignment
- Kilometre point

Water
- River or creek
- Drainage line

Qld gauging stations
- River height
- River height and river flow and water quality
- River height and river flow

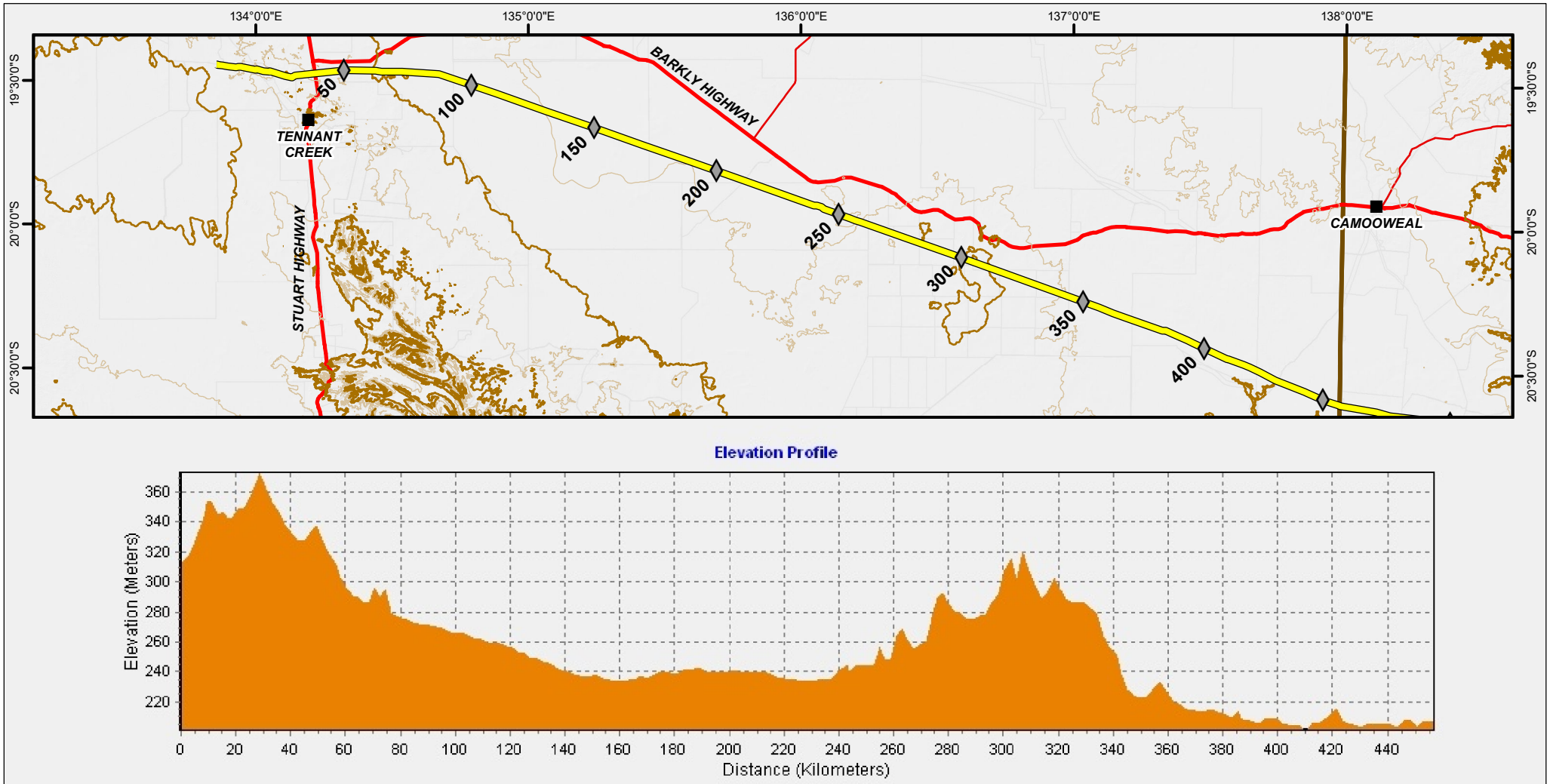
0 5 10 20
Kilometres

MAP INFORMATION
Scale: 1:780,000 @ A4
Projection: GCS GDA 1994
Date Saved: 26/07/2016
Client: Jemena
Author: K Munson (reviewed H.Dwyer)

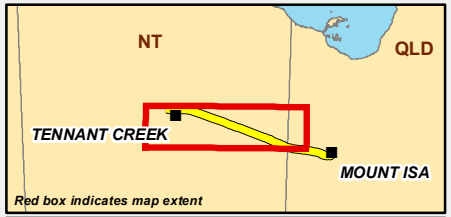
DATA SOURCE
Cadastre: DLPE, DNRM
Topographic data: Geosciences Australia
Water: Geosciences Australia, Qld Gov
Project data: Jemena

Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\JEMENA\EIS (NT)\01 Project Files\Ch7-EMP\Water\Figure 2-4 Map of construction ROW watercourse crossings QLD V1a.

Map of construction ROW and watercourse crossings - Qld



Elevation - NT



Project data
- Pipeline alignment
- Kilometre point

Topographic data
- Town
- Principal road
- Secondary road
- Property boundary
- State and Territory boundary

Elevation
- 100m contour
- 50m contour

0 15 30 60
Kilometres

MAP INFORMATION
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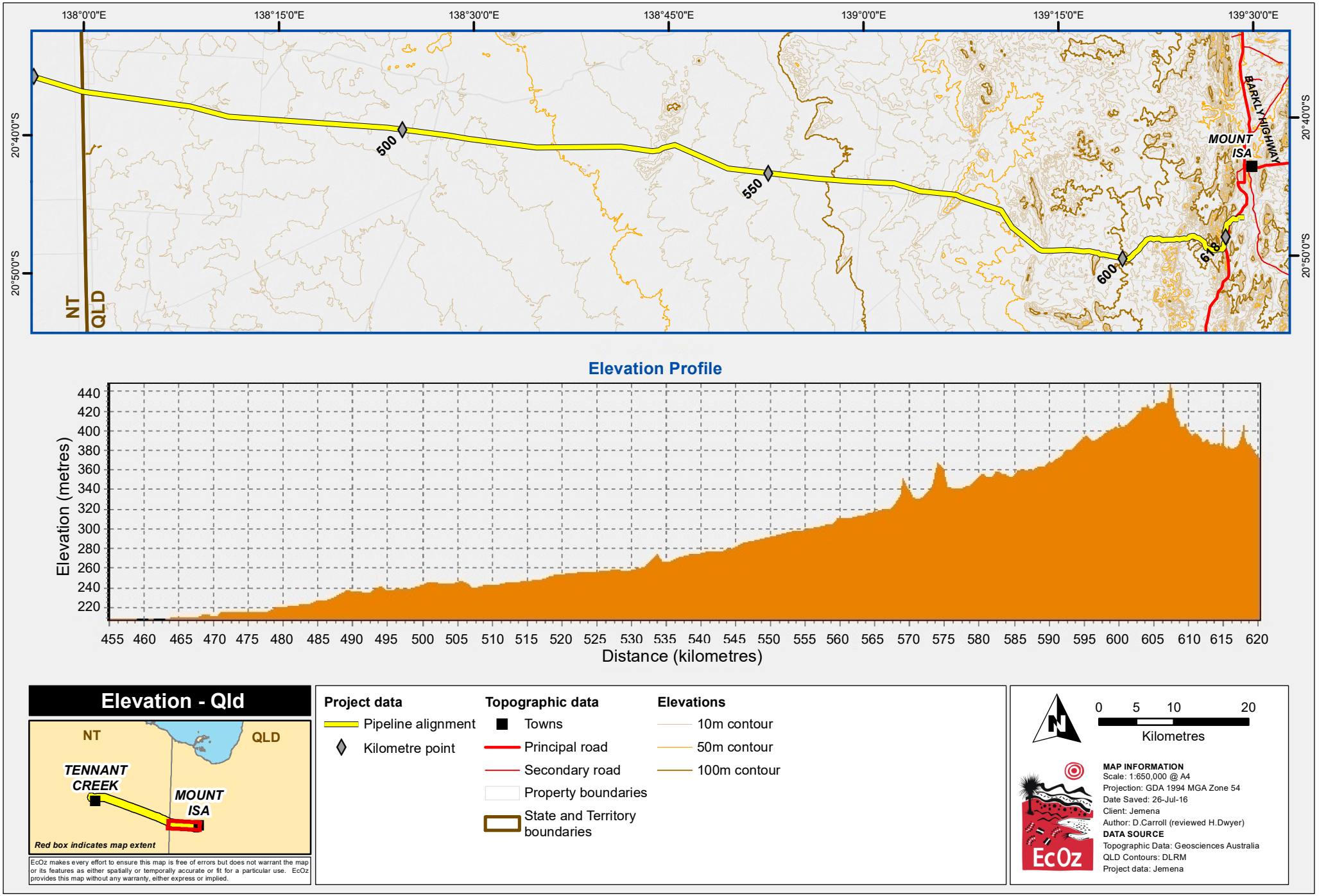
Date Saved: 26-Jul-16
Client: Jemena
Author: D.Carroll (reviewed H.Dwyer)

DATA SOURCE
Topographic Data: Geosciences Australia
Elevation Data: ArcGIS Services
Project data: Jemena

EcOz

Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\JEMENA\EIS (NT)\01 Project Files\Ch3-ExisEnv\Fig 3.7a Contours NT V1.e.mxd

Contours and elevation profile along the pipeline alignment (NT)



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\JEMENA\EIS (NT)\01 Project Files\Ch3-ExisEnv\Fig 3.7b Contours QLD V1.e.mxd

Contours and elevation profile along the pipeline alignment (Qld)

Appendix C Preliminary RUSLE Calculations

Summary of Preliminary RUSLE Soil Loss Estimations

Sub-Catchment Identifier	RUSLE Factors							Annual Soil Loss Rate (t/ha/year)	Annual Sediment Yield Estimate [6] (m^3/ha/year)	Sub-Catchment Area (ha)	Proportion of Total ROW Area [7] (%)
	R [1]	K [2]	Slope Length (m)	Slope Gradient (%)	LS [3]	C [4]	P [5]				
1	1,219	0.043	10,000	0.43	0.24	0.45	1.3	7	4	30	1.6%
2	1,219	0.027	8,500	0.31	0.24	0.45	1.3	5	3	33	1.8%
3	1,219	0.027	7,300	0.38	0.24	0.45	1.3	5	3	26	1.4%
4	1,219	0.027	14,500	0.34	0.24	0.45	1.3	5	3	58	3.1%
5	1,219	0.027	19,400	0.46	0.24	0.45	1.3	5	3	65	3.5%
6	1,219	0.043	6,100	0.30	0.24	0.45	1.3	7	4	22	1.2%
7	1,219	0.043	156,600	0.38	0.24	0.45	1.3	7	4	473	25.4%
8	1,219	0.027	3,700	0.22	0.24	0.45	1.3	5	3	15	0.8%
9	1,219	0.027	3,600	0.30	0.24	0.45	1.3	5	3	14	0.8%
10	1,219	0.027	6,100	0.64	0.24	0.45	1.3	5	3	26	1.4%
11	1,219	0.027	4,900	0.42	0.24	0.45	1.3	5	3	26	1.4%
12	1,219	0.027	9,700	0.37	0.24	0.45	1.3	5	3	44	2.3%
13	1,219	0.027	12,100	0.31	0.24	0.45	1.3	5	3	65	3.5%
14	1,219	0.027	1,200	0.43	0.24	0.45	1.3	5	3	7	0.4%
15	1,219	0.027	2,500	0.62	0.24	0.45	1.3	5	3	15	0.8%
16	1,219	0.027	7,300	0.39	0.24	0.45	1.3	5	3	36	1.9%
17	1,219	0.033	64,300	0.52	0.24	0.45	1.3	6	3	197	10.5%
18	1,219	0.033	26,700	0.18	0.24	0.45	1.3	6	3	106	5.7%
19	1,219	0.033	10,900	0.23	0.24	0.45	1.3	6	3	40	2.1%
20	1,219	0.033	8,500	0.09	0.24	0.45	1.3	6	3	40	2.2%
21	1,219	0.033	40,000	0.13	0.24	0.45	1.3	6	3	131	7.0%
22	1,219	0.033	3,700	0.45	0.24	0.45	1.3	6	3	15	0.8%
23	1,219	0.033	10,900	0.34	0.24	0.45	1.3	6	3	36	1.9%
24	1,219	0.043	25,400	0.55	0.24	0.45	1.3	7	4	80	4.3%
25	1,219	0.043	24,200	0.18	0.24	0.45	1.3	7	4	80	4.3%
26	1,219	0.043	8,400	0.38	0.24	0.45	1.3	7	4	29	1.6%
27	1,219	0.043	3,600	0.94	0.24	0.45	1.3	7	4	15	0.8%
28	1,219	0.043	3,700	0.96	0.24	0.45	1.3	7	4	18	1.0%

Table continued on next page

Summary of Preliminary RUSLE Soil Loss Estimations (continued)

Sub-Catchment Identifier	RUSLE Factors							Annual Soil Loss Rate (t/ha/year)	Annual Sediment Yield Estimate [6] (m^3/ha/year)	Sub-Catchment Area (ha)	Proportion of Total ROW Area [7] (%)
	R [1]	K [2]	Slope Length (m)	Slope Gradient (%)	LS [3]	C [4]	P [5]				
29	1,219	0.043	13,300	0.32	0.24	0.45	1.3	7	4	44	2.3%
30	1,219	0.043	7,300	0.56	0.24	0.45	1.3	7	4	26	1.4%
31	1,219	0.043	2,500	0.61	0.24	0.45	1.3	7	4	11	0.6%
32	1,219	0.053	7,300	0.73	0.24	0.45	1.3	9	5	33	1.8%
33	1,219	0.053	3,000	0.96	0.24	0.45	1.3	9	5	9	0.5%
Ancillary Developments											
Camp 1	1,219	0.043	424	1.00	0.24	0.45	1.3	7	4	12	-
Camp 2	1,219	0.033	424	1.00	0.24	0.45	1.3	6	3	12	-
Camp 3	1,219	0.027	424	1.00	0.24	0.45	1.3	5	3	12	-
Camp 4	1,219	0.043	424	1.00	0.24	0.45	1.3	7	4	12	-
Camp 5	1,219	0.027	424	1.00	0.24	0.45	1.3	5	3	12	-
PCCS Camp	1,219	0.043	424	1.00	0.24	0.45	1.3	7	4	12	-
PCCS	1,219	0.043	424	1.00	0.24	0.45	1.3	7	4	9	-
CP1	1,219	0.043	28	1.00	0.15	0.45	1.3	5	3	0.04	-
CP2	1,219	0.043	28	1.00	0.15	0.45	1.3	5	3	0.04	-
CP3	1,219	0.033	28	1.00	0.15	0.45	1.3	4	2	0.04	-
CP4	1,219	0.033	28	1.00	0.15	0.45	1.3	4	2	0.04	-
CP5	1,219	0.043	28	1.00	0.15	0.45	1.3	5	3	0.04	-
MLV1	1,219	0.043	49	1.00	0.17	0.45	1.3	5	3	0.12	-
MLV2	1,219	0.043	69	1.00	0.19	0.45	1.3	6	3	0.24	-
MLV3	1,219	0.033	49	1.00	0.17	0.45	1.3	4	2	0.12	-
MICS	1,219	0.053	424	1.00	0.24	0.45	1.3	9	5	9	-

Notes

*	Sub-Catchments were determined based on the proposed ROW alignment current at 20 July 2016 and locations of ancillary developments provided by EcOz Pty Ltd.
(1)	Annual rainfall erosivity (R-Factor) value for Mount Isa (IECA 2008: Table E1).
(2)	Default soil erodibility (K-Factor) estimated from soil description, inferred soil texture class and estimated clay content (IECA 2008: Table E5). Where multiple values apply to a sub-catchment, the highest values have been adopted. If dispersive soils are identified, K-factors will need to be increased by 20% in accordance with IECA (2008) recommendations.
(3)	Slope-length (LS-Factor) for an assumed maximum slope length of 200 m and gradients listed (IECA 2008: Table E3). Gradients have been rounded to the nearest whole number to allow determination of an LS-factor. In the absence of site-specific information for ancillary developments, a default slope gradient of 1.0% has been assumed. Maximum slope length for ancillary developments has been assumed as the diagonal length of the proposed disturbance area (e.g. 300 m by 300 m for Camps).
(4)	Soil cover (C-Factor) value for disturbed areas of the site with no appreciable ground cover (IECA 2008: Table E10).
(5)	Conservation practice (P-Factor) value for assumed compacted and smooth surface conditions during construction phase (IECA 2008: Table E11).
(6)	Bulk density assumed to be 1.8 t/m^3.
(7)	Based on total ROW area of 1,866 ha.
-	Not part of ROW

Appendix D Standard Specifications for ESC Control Devices

NT DLRM: Technical Note No. 8 – Diversion Banks
NT DLRM: Fact Sheet – Road Drainage
Typical Construction Entry/Exit Specifications
Typical Mulch Filter Berm Specifications
Typical Sediment Fence Specifications
Typical Watercourse Crossing Approaches
Preliminary Sediment Basin Design Calculations

Diversion Banks | Technical Note No. 8

Erosion and Sediment Control Guidelines

Description

A diversion bank is a compacted ridge of soil or other material used to intercept concentrated water flows and return the water back to natural overland sheet flows. Diversion banks are also referred to as rollover banks or erosion control banks.

Application and Function

Banks of different shapes and heights are used depending on the situation and the diversion requirement. Diversion banks are used on roads, tracks and fence lines to prevent or control erosion. Trafficable diversion banks are generally low and broad, whereas diversion banks used on areas being rehabilitated are higher and designed not to be trafficable.

Large and quite often very long diversion banks are generally used to divert water away from existing areas of erosion. The main purpose of diversion banks is to assist in rehabilitation by removing and/or reducing flows.

Limitations

Earth moving machinery is usually required to construct diversion banks. Depending on the type and number of banks required, construction times can be lengthy.

Advantages

Diversion banks are simple to construct, can divert small and large water flows, and are cheap to install. Material for the construction of the earth banks can be obtained on the site or imported. The construction of diversion banks is ideal in remote locations where importation of materials for erosion control is impractical.
If diversion banks are designed properly they reduce the need for table drains and other cross drainage works such as floodways and culverts.

Alternatives

Depending on the location, alternatives such as formalised drainage (culverts, mitre drains, table drains, etc) can be used on roads and tracks. Erosion control structures, such as drop structures can be used in areas of erosion, however these are more costly and time consuming to install.

Construction

It is important to place diversion banks in the right location. Diversion banks can be constructed in two ways:

•Cut and push. Lines are ripped across the area at a grade of 0.3%. A shallow channel should be cut along this line (approximately 0.6 metres deep). Excavated material is dumped on the down slope side of the channel then compacted and smoothed out to form a bank with even batters and a level top. Allow for compaction of the material, which is usually one third, with the compacted ridge not less than 0.5 metres high depending on its purpose.

•Imported Material. Use imported soil material to construct a bank with a grade of between 0.3 and 0.5%. Allow for compaction of the material, which is usually one third, with the compacted ridge not less than 0.5 metres high depending on its purpose.

To aid trafficability, an approach and departure ramp is shaped during construction of the bank. The bank should direct runoff into undisturbed vegetation or into an existing drain (care needs to taken to ensure that erosion does not occur where the water runs down into the drain).

Alternatively a level sill can be constructed at the end of the bank to enhance the spread of water back to sheet flow.
A level sill is a shallow excavation at the end of the bank, typically 5 – 7m long by 3m wide and 0.3m deep allowing water to flow out evenly along the length of the sill. There should be no disturbance to the ground surface down slope of the sill outlet.

Bank design depends on slope, catchment, soil erosion risk and expected peak flows. The below tables recommend bank spacing for various slopes. Where soils are more stable, banks can be spaced further apart.

Bank Spacing for Tropical Regions

Slope		Diversion bank spacing (metres)
%	Gradient	
0.5	1:200	120-130
1	1:100	90-100
2	1:50	60-70
3	1:33	50-60
4	1:25	45-50
5	1:20	40-45
6	1:17	35-40
10	1:10	28-33
18	1:5.5	15-20

Bank spacing for Arid and Semi-arid Regions

Slope		Diversion bank spacing (metres)
%	Gradient	
0.5	1:200	170-180
1	1:100	120-130
2	1:50	90-100
3	1:33	70-80
4	1:25	60-70
5	1:20	55-60
6	1:17	50-55
10	1:10	40-45
18	1:5.5	25-30

Trafficable diversion banks can vary in size. They can be a few metres long and 50cm high on walking tracks.
Large diversion banks have the same construction principles but their application is different. They may be large, gently sloping banks up to 30-40m long and up to 3m high on deeply eroded areas. Major gullies need a large diversion bank to divert water from the gully head and prevent further erosion. It may be necessary to build several banks.

If the diversion bank is placed on or near a road, track or fence line, it is important to remember that driving around the ends of banks often leads to erosion of the banks, so don't drive close to them.
If a number of eroded tracks are next to each other, extend banks across all tracks to be repaired.

Maintenance

Diversion banks are used in many different situations and conditions. As with any erosion control structure, banks need to be inspected to ensure that they are performing the function they were designed to do.

On roads, tracks and fence lines, diversion banks will often be eroded away due to vehicular traffic. If this is the case, the bank may either be not broad enough or too low to handle the traffic that it is experiencing.

It is generally good practice to spread wear and tear across the trafficable bank.

Additionally it is important to assess how the structure is working. The diversion bank should not pond water after rain and the outlet should not be eroding. Diversion banks aid in the maintenance of natural cross drainage, so vegetation on the down slope side of a road, track or fence line should not be starved of water.

Should any of these problems be encountered, the structure needs rectifying to ensure that its function is maintained. It is important to rectify any problems before erosion is initiated.

Contact details

For further information contact the DLRM Land Management Unit in your region. Additional Technical Notes and Erosion and Sediment Control Guidelines are available on the website: http://www.lrm.nt.gov.au/soil/management

Land Management Unit - Rangelands Division
Darwin: Phone (08) 8999 4572
Level 3, Goyder Centre,
Palmerston
Katherine: Phone (08) 8973 8838
32 Giles Street, Katherine
Alice Springs: Phone (08) 8951 9208
Tom Hare Building, Alice Springs

Road Drainage

Fact Sheet

To allow for adequate drainage, the following points need to be considered:

- **The amount of runoff expected to reach the area under consideration**
- **Potential flood areas**
- **Areas of discharge (e.g. floodways).**

The three components of adequate road or track drainage are surface, side and cross drainage.

Surface Drainage

Road Crowning

Crowning provides a low-grade fall enabling drainage from both sides of the centre of the road (See Figure 1). This method is only effective if the crown is slightly higher than the natural surface.

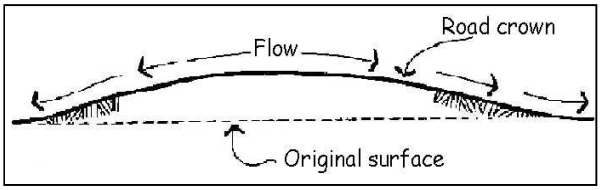


Figure 1: Crowning

Road crowning should be avoided in areas where water naturally crosses the road such as broad drainage floors. Floodways are required in these cases.

Infall and Outfall Drainage

When roads are built across the slope consideration must be given to taking water from the up slope side of the road to the down slope side of the road. When you install cross drainage you must make sure that it does not cause erosion of the road surface.

Crossfall/Outfall Drainage

The simplest method is by providing the road surface with a crossfall in the same direction as the slope (outfall drainage), thereby directing water over the road surface to disposal areas on the lower side of the road (See Figure 2).

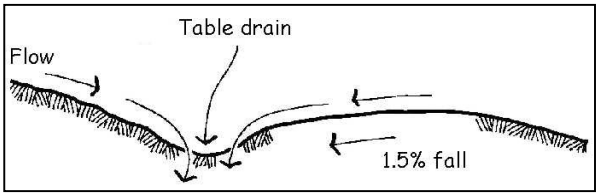


Figure 2: Crossfall/outfall drainage

The other method is by providing the road surface with infall drainage back into the slope, directing water back to the up slope side of the road (See Figure 3). If infall drainage is necessary then table drains, culverts or inverts need to be constructed. These will safely direct water to the down slope side of the road.

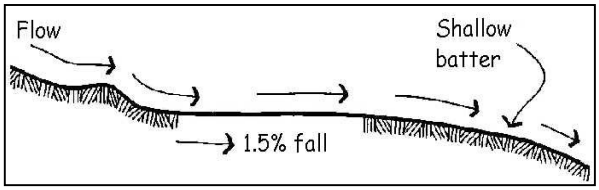


Figure 3: Infall drainage

Outfall drainage is preferred to infall drainage as there is generally no need for other drainage works such as culverts, inverts, table and mitre drains.

When installing outfall drainage on steeper slopes, batters on the downslope side of the road must not be too steep. Steep batters may erode, impacting on the road itself.

The crossfall of the road surface should be kept as flat as possible to ensure good drainage. For outfall drainage it is recommended that the maximum crossfall slope be in the order of 1.5 – 2%, whereas infall drainage slopes can be as great as 4%.

Side Drainage

Table Drains

Table drains are excavated open channels that are built parallel to roads and tracks. These drains direct runoff to disposal areas further downslope. Table drains should only be used when natural run-off is not possible.

Fill obtained from constructing table drains can be used to build up road surfaces. The design of table drains depends on a number of factors, including the size and nature of the catchment, the slope and water volumes and flow. Larger table drains may need to be designed by engineers or other suitably qualified professionals.

Table drains should be constructed with a flat bottom (trapezoid shape) (See Figure 4). In general they should be 0.5 to 1.0m wide at the

base. Avoid using V shaped drains as they may cause erosion in the channel.

Where possible table drains should be revegetated as soon as possible after construction, and regularly slashed. Table drains should not be graded.

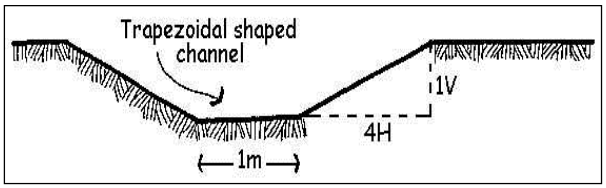


Figure 4: Table & mitre drain cross section

Mitre Drains

Water should be taken out of table drains at regular intervals using mitre (offshoot) drains. Mitre drains take runoff out of table drains or directly off road shoulders where table drains are absent. These drains dispose of water in areas away from the road (See Figure 5).

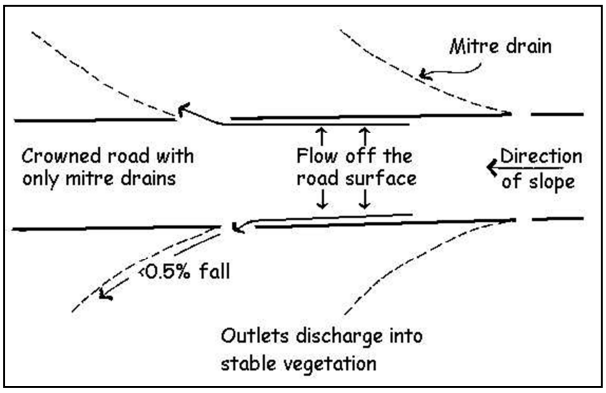


Figure 5: Crowned road with only mitre drains

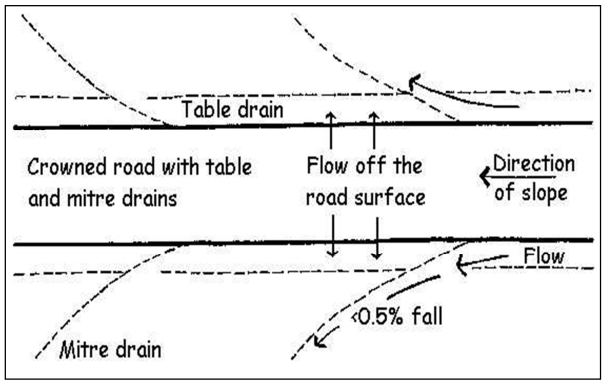


Figure 6: Crowned road with table and mitre drains

Mitre drains stop water accumulating in table drains or on the road shoulder. Ideally mitre drains should be constructed so that they have a broad flat base at least 1m wide. Mitre drains also should not be graded to produce a V.

Mitre drains should slope to direct the flow of water away from the road. To minimise erosion the slope should be no greater than 0.5% on erodible soils or 1% on stable soils. Mitre drain outlets effectively concentrate runoff, for this reason they should be located in stable undisturbed areas.

Mitre drain spacing is dependent on:

- the grade of the table drain or road
- soil type and erodibility
- rainfall

Table 1: Recommended mitre drain spacing

Slope		Mitre Drain Spacing (m)
%	Gradient	
0.5	1 : 200	170 - 180
1	1 : 100	120 - 130
2	1 : 50	90 - 100
3	1 : 33	70 - 80
4	1 : 25	60 - 70
5	1 : 20	55 - 60
6	1 : 17	50 - 55
10	1 : 10	40 - 45

Note: this table shows reccomended spacing only, and may not apply in all locations.

Cross Drainage

Engineered, stable cross drainage such as inverts, floodways or culverts can be used to collect water from upslope table drains, or drainage lines. It is generally more conomical and practical to ford drainage lines using floodways or inverts than to use major culverts or bridges. On steeper country, where creeks and drainage lines are deeper, culverts may be more practical.

Inverts and Floodways

Care must be taken in the design and construction of floodways and inverts in order to cause minimal interference to natural flows. Inverts and floodways are designed to be temporarily over topped by water flow and minimise bank and bed erosion. They should be sited at low points in the bank and at right angles to the direction of flow.

Inverts

Inverts should be constructed with the finished surface at, or just below the level of the existing stream bed. Construction of an invert is generally

based on excavating soft, erodible material. At least 300mm should be removed, geotextile may be necessary as a base. Excavated material is then replaced with compacted granular material to provide a trafficable surface (See Figure 7).

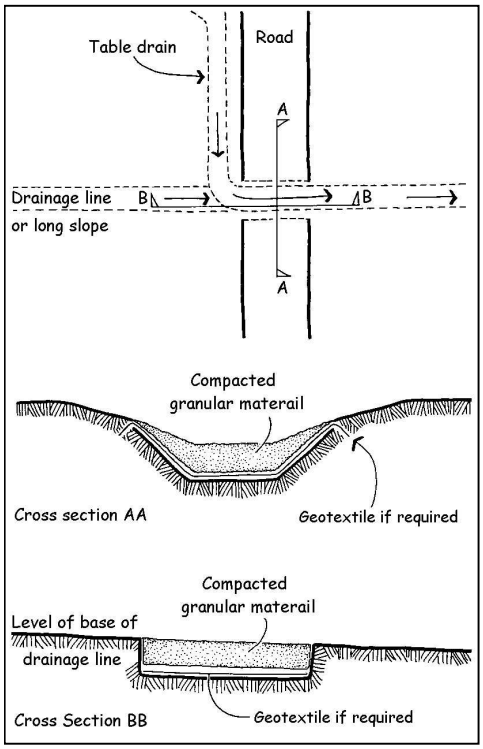


Figure 7: Inverts

Floodways

Floodways are usually elevated above the bed level of the channel and often incorporate culverts to take "normal" flows with the road only being overtopped during flood events, as illustrated in Figure 8.

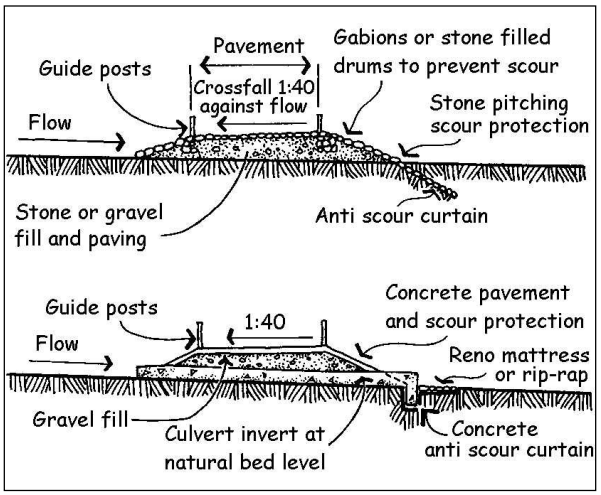


Figure 8: Floodways (Australian Road Research Board, 1993)

The design should have ends of the structure that are well anchored into the banks and obstruction to flow kept to a minimum by using gentle batter slopes on the up- and downstream faces. When it is necessary to construct an elevated floodway it is recommended that specialist advice be sought.

As floodways are generally elevated above bed level protection works are required on the downstream side of the floodway to prevent erosion.

Culverts

When culverts are used they should be angled downward at between 1 and 3%. This will minimise silting of the pipe and prevent excessive scouring at the outflow. On drainage lines the culvert should be keyed into the streambed by digging a trench and seating the culvert into it.

The area below the outlet will need protection to prevent erosion. This protection can be achieved by armouring (eg: rock mattress) the drain downstream of the outlet, or by constructing a dissipating device (see Figure 9).

Protection may also be required at the inlet. The location, spacing, size and type of culvert may vary. Advice should be sought prior to construction.

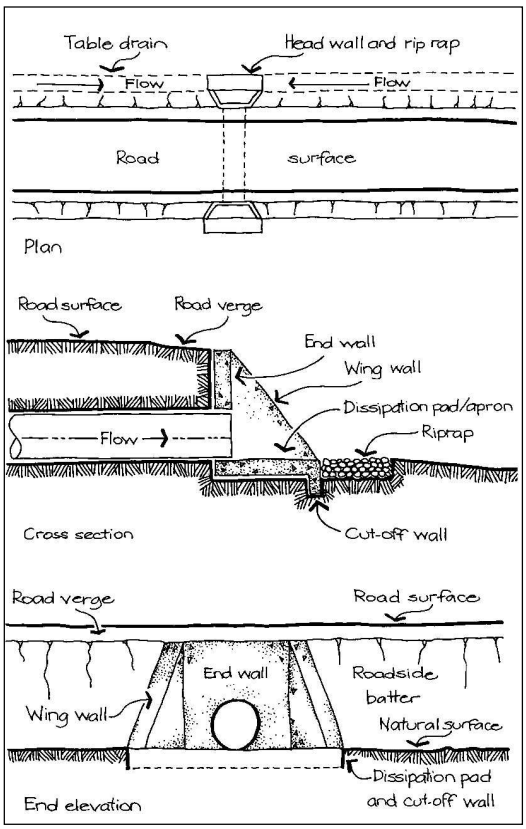


Figure 9: Culverts

Whoa Boys on Vehicle Tracks

Whoa boys can vary in size. They can be a couple of metres long and only 10–30cm high on walking tracks, or they may be large, gently sloping banks up to 30-40m and up to 3m high on deeply eroded areas.

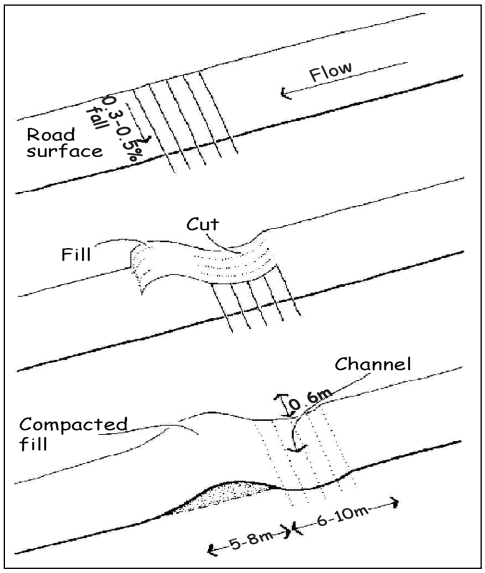
Whoa boys can be constructed in two ways:

1. By cut and fill – Lines are ripped across the area at a grade of 0.3 %. A shallow channel should be cut along this line. Excavated material is dumped on the down slope side of the channel, then compacted and smoothed out to form a bank with even batters and a level top (See Figure 10).

2. Using imported soil material to construct a bank with a grade of between 0.3 and 0.5% along the up slope edge of the bank.

To aid trafficability, an approach and departure ramp can be cut into the bank (See Figure 11). The bank should be run off into undisturbed vegetation or into an existing drain (care needs to taken to ensure that erosion does not occur where the water runs down into the drain).

Alternatively a level sill can be constructed at the



end of the bank to enhance the spread of water.

Figure 10: Whoa boy construction

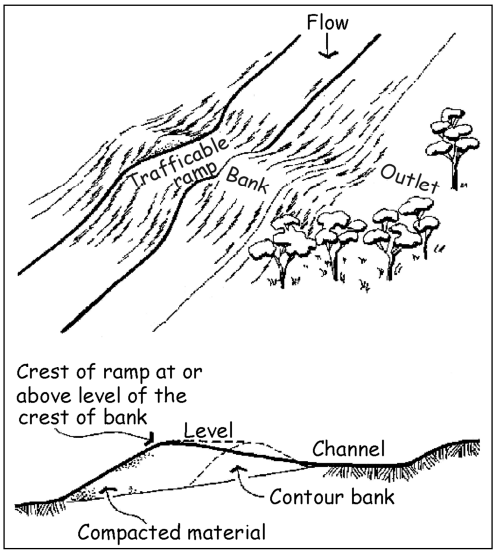


Figure 11: Whoa boy – vehicle track

Contact Details

For further information contact the DLRM Land Management Unit in your region. Additional Fact Sheets are available on the website: http://www.lrm.nt.gov.au/soil/management

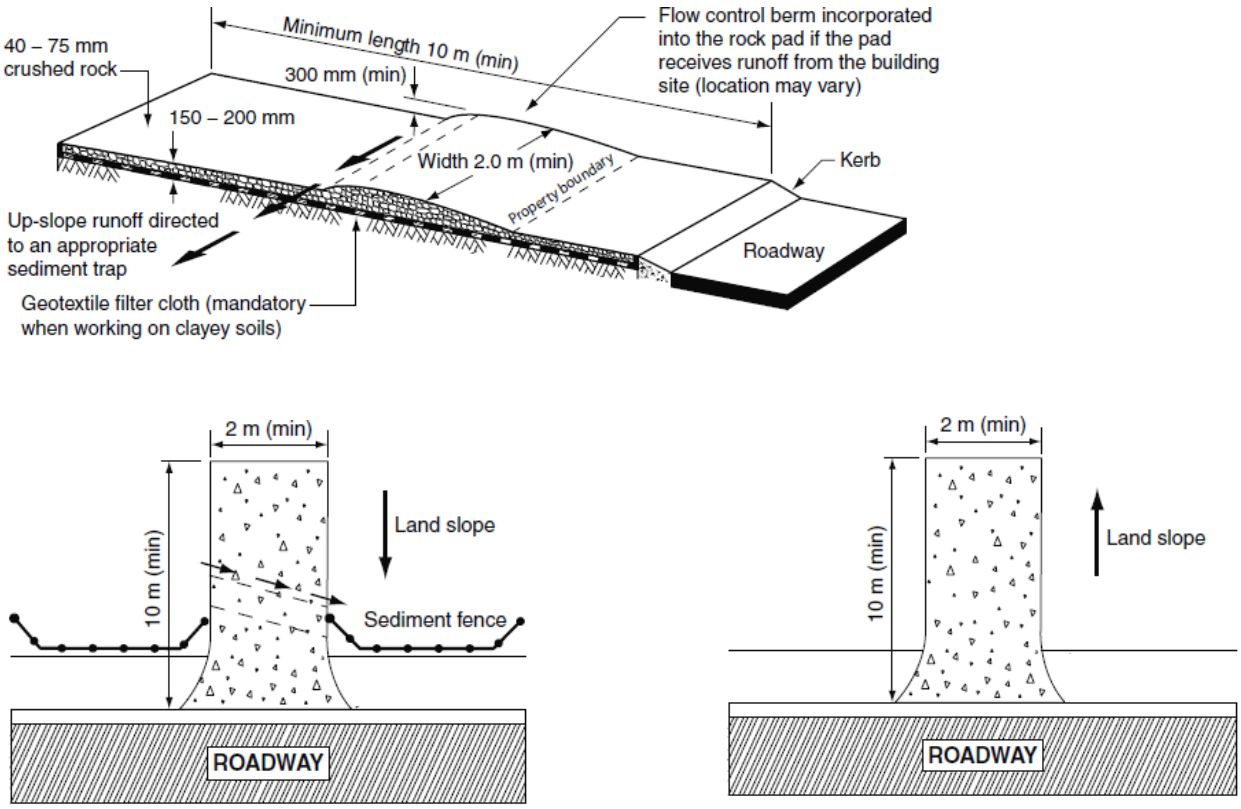
Land Management Unit - Rangelands Division

Darwin: Phone (08) 8999 4572
Level 3, Goyder Centre, Palmerston

Katherine: Phone (08) 8973 8838
32 Giles Street, Katherine

Alice Springs: Phone (08) 8951 9208
Tom Hare Building, Alice Springs

Typical Construction Entry/Exit Specifications



Typical Temporary Site Entry/Exit Rock Pad (adapted from IECA, 2008: Book 6)

Well graded, hard, angular, erosion resistant rock with a nominal diameter of 100 mm to 150 mm should be used for rock pad construction. All reasonable measures must be taken to obtain rock of near uniform size. Geotextile fabric (if used) should be a heavy-duty, needle-punched, non-woven filter cloth.

The rock pad location will need to be cleared and all stumps, roots and other vegetation removed to provide a firm foundation so that the rock is not pressed into soft ground. Clear only sufficient width to allow passage of large vehicles. Do not clear adjacent areas until the required erosion and sediment control devices are in place.

If the exposed subgrade soil is soft, plastic or clayey, installation of a sub-base layer of crushed rock or heavy-duty filter cloth will be required to provide a firm foundation.

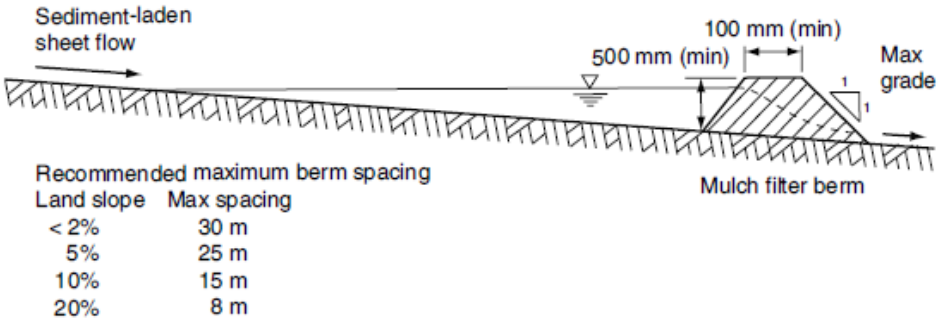
Rock should be placed to create a minimum 200 mm thick layer of clean, open-void rock. If the site is up-slope of the rock pad, a flow control berm (minimum. 300 mm high) will be required across the rock pad to divert runoff to a suitable sediment trap. The pad length should be at least 15 m, where practicable, and at least 3 m wide. It should commence at the edge of the off-site sealed road or pavement. The end of the rock pad should be flared where it meets the roadway so that wheels of turning vehicles do not travel over unprotected soil.

All site entry and exit points should be inspected prior to forecast rain, daily during extended periods of rainfall, after runoff-producing rainfall, or otherwise at fortnightly intervals. If sand, soil, sediment or mud is tracked or washed onto the adjacent sealed roadway, it must be physically removed. The roadway shall only be washed clean (if necessary for safety reasons) after all reasonable efforts have been taken to shovel and sweep the material from the roadway. Sediment is to be disposed in a suitable manner that will not cause an erosion or pollution hazard.

When the voids between the rock become filled and/or sediment is being tracked off the site, a new 100 mm layer of rock must be added and/or the rock pad must be extended. Ensure any associated drainage control measures (e.g. flow control berm) are maintained in accordance with their desired operational conditions.

The rock pad should be removed only after the site has been stabilised and it is no longer needed as a sediment trap. Remove rocks and sediment and dispose in a suitable manner that will not cause an erosion or pollution hazard. Re-grade and stabilise the disturbed ground as necessary to minimise potential erosion hazards.

Typical Mulch Filter Berm Specifications



Recommended maximum berm spacing

Land slope	Max spacing
< 2%	30 m
5%	25 m
10%	15 m
20%	8 m

Typical Installation of a Mulch Filter Berm (adapted from IECA, 2008: Book 6)

Mulch must comply with the requirements of AS 4454 with a maximum soluble salt concentration of 5 dS/m and an ideal moisture content of 30% to 50%.

Ensure berms are located along a line of constant elevation in areas away from concentrated flow, and at least 1 m, ideally 3 m, from the toe of an embankment.

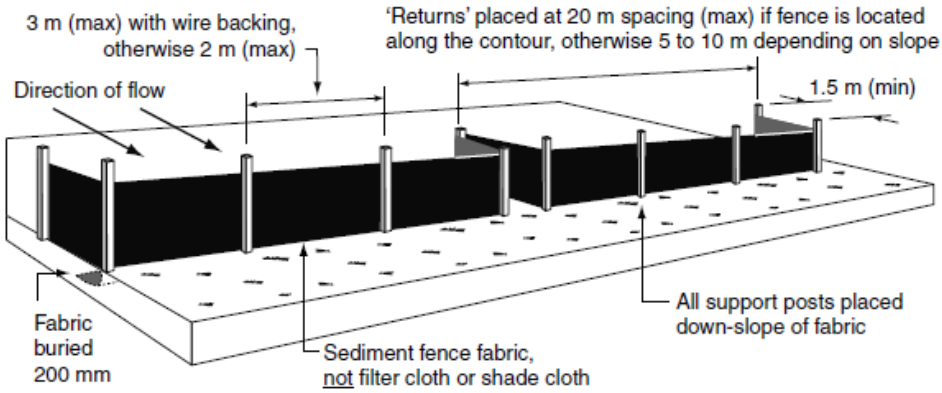
Berms are to be constructed so that they have 100% contact with the soil surface. Ponding up-slope of the berm is to be maximised, wherever possible. The concentration of flow along berms and/or the undesirable discharge of water around the end of the berms are avoided. Both ends of the berms are to be turned up the slope to prevent flow bypass prior to flowing over the top. Berms can be vegetated if they are to remain as permanent features.

All berms will require inspection at least weekly during construction works and after any significant rainfall. Repairs/maintenance are to be made immediately, if required and should be returned to its original configuration unless an amended layout is required or specified.

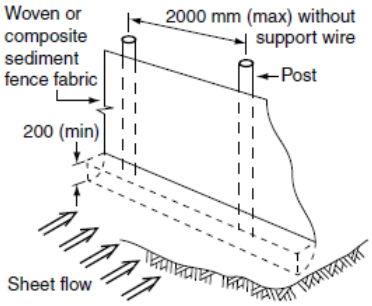
Any accumulated sediments should be removed if the sediment deposit exceeds a depth of 100 mm or one-third the berm height. Sediment is to be disposed in a suitable manner that will not cause an erosion or pollution hazard.

Berms may be removed when all up-gradient disturbed areas have been sufficiently stabilised to minimise erosion. Any accumulated sediments should be removed and be disposed in a suitable manner. Disturbed ground should be reinstated/ revegetated as necessary to minimise potential erosion hazards.

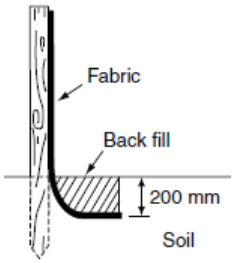
Typical Sediment Fence Specifications



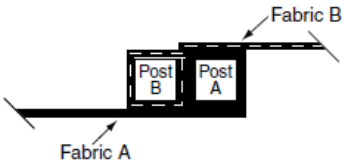
Installation Detail



Installation Detail



Fence Anchoring



Fabric Joints

Typical Sediment Fence Installation (adapted from IECA, 2008: Book 6)

Fence should be constructed using either polypropylene, polyamide, nylon, polyester, or polyethylene woven or non-woven fabric depending on soil conditions. Fabric should be at least 700 mm in width and have a minimum unit weight of 140 gsm. All fabrics are to contain ultraviolet inhibitors and stabilisers to provide a minimum of six months of useable construction life (ultraviolet stability exceeding 70%). Wire or steel mesh (min.14-gauge, max. mesh spacing 200 mm) can be used as fence reinforcement. Support posts/stakes can comprise either min. 1,500 mm^2 hardwood, min. 2,500 mm^2 softwood, or min. 1.5 kg/m steel star pickets suitable for attaching fabric.

Sediment fence is to be located along a line of constant elevation wherever practical and at least 2 m from the toe of any filling operations that may result in shifting soil/fill damaging the fence.

Returns must be installed in the fence at maximum 20 m intervals if installed along the contour, or at maximum 5 m to 10 m spacing (depending on slope) if the fence is installed at an angle to the contour. Returns shall consist of either: a V-shaped section extending at least 1.5 m up the slope; or sandbag or rock/aggregate check dam min.one third and max. half of the fence height that extends at least 1.5 m up the slope. Ends of the fence are to be turned up the slope at least 1.5 m to minimise water bypassing around the fence.

Concentration of flow along the fence and undesirable discharge of water around the ends of the fence are to be avoided.

Excavate a 200 mm wide by 200 mm deep trench along the proposed fence line, and place excavated material on the up-slope side of the trench. Secure the stakes into the ground on the lower side of the trench spaced no greater than 3 m if supported by a top support wire or weir mesh backing, otherwise at a spacing no greater than 2 m. Securely attach the support wire or mesh to the up-slope side of the stakes (if used) with the mesh extending at least 200 mm into the excavated trench. Ensure the mesh and fabric is attached to the up-slope side of the stakes. Securely attach the fabric to the support posts using either 25 mm x 12.5 mm staples, or tie wire at maximum 150 mm spacing. Securely attach the fabric to the support wire/mesh (if used) at a maximum spacing of 1 m. The completed sediment fence should be at least 450 mm, but not more than 700 mm high. If a spill-though weir is installed, ensure the crest of the weir is at least 300 mm above ground level. Backfill the trench and tamp the fill to firmly anchor the bottom of the fabric and mesh to prevent water from flowing under the fence.

If the fence is to be installed along the edge of existing trees, care must be taken to protect the trees and their root systems during fence installation. Do not attach the fabric to the trees.

Wherever possible, construct the sediment fence from a continuous roll of fabric. To join fabric, attach each end to two overlapping stakes with the fabric folding around the associated stake one turn, and with the two stakes tied together with wire.

Additional requirements for the installation of a spill-through weir:

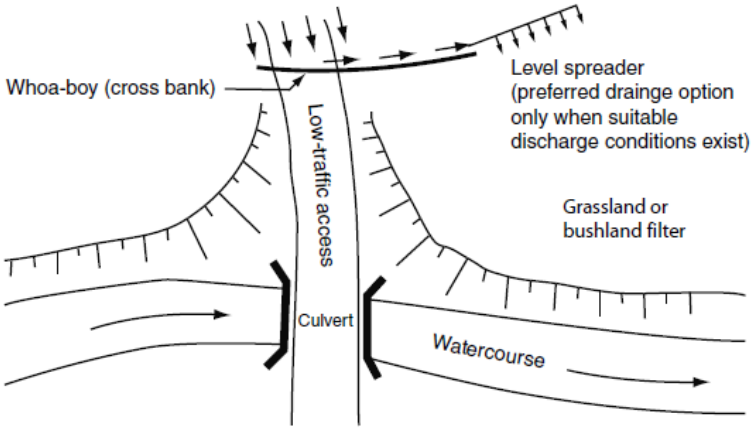
1. Locate the weir so that the weir crest will be lower than the ground level at each end of the fence.
2. Ensure the crest of the weir is at least 300 mm the ground elevation.
3. Securely tie a horizontal cross member (weir) between two support posts/stakes. Cut the fabric down the side of each post and fold the fabric over the cross member and appropriately secure the fabric.
4. Install a suitable splash pad and/or chute immediately down-slope of the weir to control soil erosion and appropriately discharge the concentrated flow passing over the weir.

Inspect sediment fences at least weekly and after any significant rain. Any necessary repairs should be made immediately. Repair any torn sections with a continuous piece of fabric from post to post. When making repairs, always restore the system to its original configuration unless an amended layout is required or specified. 4. If the fence is sagging between stakes, install additional support posts. Replace the fabric its service life exceeds six months.

Remove any accumulated sediment if the deposit exceeds a depth of one third of the height of the fence. Sediment is to be disposed in a suitable manner that will not cause an erosion or pollution hazard.

The sediment fence must be removed when disturbed areas up-slope of the sediment fence are sufficiently stabilised to minimise erosion. Remove materials and collected sediment and dispose in a suitable manner that will not cause an erosion or pollution hazard. Rehabilitate/revegetate the disturbed ground as necessary to minimise the potential erosion hazard.

Typical Watercourse Crossing Approaches



Typical Track Drainage Controls Adjacent to Watercourse Crossings (IECA, 2008)

Whoa-boy construction as per NT DLRM Fact Sheet – Road Drainage.

Appendix E Preliminary Sediment Basin Design Calculations

Typical Construction Camp

Preliminary Sediment Basin Design Calculations

Sub-Catchment

Type D — Typical Construction Camp Basin

Settling Zone Volume

V_s (m^3) = 10 x $R_{(Y\%,\ 5\text{-day})}$ x C_v x A — IECA (2008: Equation B7)

where
- 10 is a unit conversion factor
- $R_{(Y\%,\ 5\text{-day})}$ is the Y% 5-year rainfall depth; Y% is dependent on the basin life and application
- C_v is the volumetric runoff coefficient based on the nominated 5-day rainfall depth, $R_{(Y\%,\ 5\text{-day})}$
- A is the effective catchment surface area connected to the basin (ha)

Calculate $R_{(Y\%,\ 5\text{-day})}$

$R_{(Y\%,\ 5\text{-day})}$	=	K_1 x $I_{(1\ yr,\ 120hr)}$ + K_2			IECA (2008: Equation B8)
if Y%	=	75	%		IECA (2008: Table B4, for basins with design life <6 months)
K_1	=	12.90			IECA (2008: Table B4, for basins with design life <6 months)
$I_{(1\ yr,\ 120hr)}$	=	0.74	mm/hr		IECA (2008: Table B5, for Mt Isa)
K_2	=	9.90			IECA (2008: Table B4, for basins with design life <6 months)
then $R_{(Y\%,\ 5\text{-day})}$	=	19.45	mm		
C_v	=	0.14			IECA (2008: Table B7 for sandy loam and $R_{(Y\%,\ 5\text{-day})}$ nominated rainfall depth)
A	=	8.00	ha		Camp minus land application area

Therefore, settling zone volume required

V_s = 218 m^3

Sediment Storage Zone Volume

For a Type D basin, sediment storage volume is to be

at least 50% of settling volume — IECA (2008: Table B8)

= 109 m^3/yr

Estimated soil loss for the catchment from RUSLE calculation (Table 14)

Soil Loss, A	=	7	t/ha/yr
assume bulk density	=	1.8	t/m^3
Soil Loss, A	=	4.1	m^3/ha/yr

Over sub-catchment area, this equates to

Soil Loss, A = 32.7 m^3/yr

Assuming stabilisation within 1 month

Sediment storage volume required

= 9 m^3

Total Basin Volume	=	Settling Zone Volume, V_s + Sediment Storage Zone Volume		
	=	227	m^3	
Assume Basin Depth	=	1.50	m (minimum of 0.6 m)	
Basin Area	=	151	m^2	

Assuming an optimum basin length to width ratio of

3	length
1	width

Basin Dimensions

length	=	18.4	m	
width	=	6.1	m	
Bank Gradient	=	3:1	Slope (H:V)	IECA (2008: Table B9) for sandy-loam

Appendix F ESC Inspection Checklists

Weekly Site Inspection Checklist

Project _____

Location _____ **Date** _____

Inspector _____ **Signature** _____

Legend:

✓ Acceptable controls adopted

× Measures are not acceptable, or a potential problem exists

N/A not applicable

Item	Consideration	Assessment
1	Public roadways clear of sediment.	
2	Entry/exit pads clear of excessive sediment deposition.	
3	Entry/exit pads have adequate void spacing to trap sediment.	
4	The construction site is clear of litter and unconfined rubbish.	
5	Adequate stockpiles of emergency ESC materials exist on site.	
6	Site dust is being adequately controlled.	
7	Appropriate drainage and sediment controls have been installed prior to new areas being cleared or disturbed.	
8	Up-slope "clean" water is being appropriately diverted around/through the site.	
9	Drainage lines are free of soil scour and sediment deposition.	
10	No areas of exposed soil are in need of erosion control.	
11	Earth batters are free of "rill" erosion.	
12	Erosion control mulch is not being displaced by wind or water.	
13	Long-term soil stockpiles are protected from wind, rain and stormwater flow with appropriate drainage and erosion controls.	
14	Sediment fences are free from damage.	
15	Sediment-laden stormwater is not simply flowing "around" the sediment fences or other sediment traps.	
16	Sediment controls placed up-slope/around stormwater inlets are appropriate for the type of inlet structure.	
17	All sediment traps are free of excessive sediment deposition.	
18	The settled sediment layer within a sediment basin is clearly visible through the supernatant prior to discharge of such water.	
19	All reasonable and practicable measures are being taken to control sediment runoff from the site.	

Weekly Site Inspection Checklist

Item	Consideration	Assessment
20	All soil surfaces are being appropriately prepared (i.e. pH, nutrients, roughness and density) prior to revegetation.	
21	Stabilised surfaces have a minimum 70% soil coverage.	
22	The site is adequately prepared for imminent storms.	
23	All ESC measures are in proper working order.	

Monthly Site Inspection Checklist

Project _____

Location _____ **Date** _____

Inspector _____ **Signature** _____

Legend:

✓ Acceptable controls adopted

× Measures are not acceptable, or a potential problem exists

N/A not applicable

Part A: Initial site inspection

Item	Consideration	Assessment
1	Has an Erosion and Sediment Control Plan (ESCP) been approved for the site?	
2	Have all necessary development approvals been obtained?	
3	Are site conditions consistent with those assumed within the approved ESCP?	
4	Are environmental values being adequately protected?	
5	Are all ESC-related development conditions being satisfied?	
6	Was the full perimeter of the work site inspected?	
7	Are all reasonable and practicable measures being taken to minimise environmental harm?	

Part B: Site inspection and monitoring

Item	Consideration	Assessment
8	Appropriate in-house site inspections of ESC practices are being carried out such that all control measures are being maintained.	
9	Site inspections and monitoring are being carried out at appropriate times and intervals.	

Monthly Site Inspection Checklist

Part C: Site establishment

Item	Consideration	Assessment
10	Site access is controlled and the number of access points minimised.	
11	Adequate drainage and sediment controls exist at site entry/exit points.	
12	Adequate drainage, erosion and sediment controls have been placed around the site compound.	
13	Office compound area and car park gravelled/stabilised where necessary to control erosion and mud generation.	
14	Appropriate drainage and sediment controls are installed prior to new areas being cleared or disturbed.	

Part D: Site and vegetation management

Item	Consideration	Assessment
15	Vegetation Management Plan (VMP) and/or landscape plan has been prepared.	
16	VMP and/or landscape plan is being appropriately implemented.	
17	Site personnel appear to be aware of ESC requirements and have ready access to the Erosion and Sediment Control Plan.	
18	ESC measures are being installed in accordance with the approved *Installation Sequence*.	
19	Adequate supplies of ESC materials stored on-site: such as wire, stakes, sediment fence fabric, filter cloth, clean aggregate.	
20	Temporary access roads are stabilised where appropriate.	
21	Permanent roads are programed to be sealed as soon as reasonable and practicable.	
22	Sediment deposition is not observed on external roads.	
23	Adequate records are being kept regarding site inspections and site maintenance.	
24	The site is adequately prepared for the anticipated weather conditions.	
25	“Witness Points” and “Hold Points” are being appropriately managed and adhered to.	
26	Adequate protection provided for non-disturbance areas.	
27	Disturbances removed from the drip line of protected trees.	
28	Brick-, masonry-, concrete-, and tile-cutting activities not carried out within road reserves (if possible) and all liquid waste is fully contained on-site or behind bunds.	

Monthly Site Inspection Checklist

Part E: Material and waste management

Item	Consideration	Assessment
29	Chemicals and petroleum products appropriately stored on site.	
30	Emergency spill response plan has been prepared for the site.	
31	Oil/petroleum spill containment/response kits available on-site where appropriate.	
32	Adequate litter and waste receptors exist on-site.	
33	Waste receptors for concrete, paints, acid washing, litter and building waste are being maintained.	
34	Cement-laden liquid waste and wash-off is prevented from entering watercourses and stormwater systems.	
35	Waste water from construction activities such as wash water, dewatering operations, and dust control is being captured and treated.	
36	On-site mortar/cement/concrete mixing is carried out behind earth bunds, or other such measures employed to fully contain cement-laden waste and spills.	
37	Appropriate wash-down facilities provided from concrete trucks, mixing and pumping equipment.	

Part F: Soil management

Item	Consideration	Assessment
38	Long-term soil stockpiles adequately protected against wind and rain.	
39	Adequate sediment controls placed down-slope of stockpiles.	
40	Stockpile sediment control (*Filter Fence* or *Sediment Fence*) is appropriate for the soil type and site conditions.	
41	Adequate drainage controls placed up-slope of stockpiles.	
42	Soil stockpiles do not encroach upon protected vegetation.	
43	Subsoils adequately scarified prior to topsoil placement.	
44	Topsoil is being replaced at an adequate depth.	

Monthly Site Inspection Checklist

Part G: Drainage controls

Item	Consideration	Assessment
45	Construction Drainage Plans (CDPs) are consistent with actual site conditions (i.e. current stage of works).	
46	Drainage Control measures are consistent with the ESCP.	
47	Drainage Control measures are being adequately maintained in proper working order at all times.	
48	Adequate diversion/management of up-slope stormwater.	
49	Up-slope "clean" water is being appropriately diverted around/through the site in a non-erosive manner.	
50	Stormwater runoff diverted away from unstable slopes.	
51	Flow diversion channels/banks stabilised against erosion.	
52	Flow not unlawfully discharged onto an adjacent property.	
53	Spacing of cross drainage (e.g. *Catch Drains* or *Flow Diversion Banks*) down long slopes is sufficient to prevent "rill" erosion.	
54	**Catch Drains:** (a) Adequate depth/width. (b) Adequate flow capacity is being maintained. (c) Stabilised against soil scour. (d) Clear of sediment deposition. (e) Appropriate grass length is being maintained. (f) Water discharges via a stable outlet.	
55	**Check Dams:** (a) Flow is passing over the dams and not around them. (b) Check Dams are not causing excessive channel restriction. (c) Rock Check Dams are not used in shallow drains. (d) Check Dams are appropriately spaced down the drain.	
56	**Chutes (rock):** (a) Geotextile filter cloth is installed under the rock. (b) Rock placement has not reduced chute flow capacity. (c) Rock size appears adequate for expected flow velocity. (d) Water discharges via a stable outlet.	
57	**Chutes (geotextile):** (a) Lining is well anchored. (b) Mats overlap in direction of flow. (c) Lining is appropriate for flow conditions. (d) Water discharges through a stable outlet.	
58	**Level Spreaders:** (a) Outlet weir is level and undamaged. (b) No sediment deposition within *Level Spreader*. (c) Discharges "sheet" flow to a stable, well-grassed outlet.	

Monthly Site Inspection Checklist

Item	Consideration	Assessment
59	**Slope Drains:** (a) Adequate erosion/sediment controls at pipe inlet. (b) Pipes are well anchored. (c) No obvious water leaks. (d) Water discharges via a stable outlet.	
60	**Stormwater Outlets:** (a) Energy dissipation is appropriate for the conditions. (b) Rock size is greater than 200mm. (c) Soil erosion is being controlled.	

Part H: Erosion controls

Item	Consideration	Assessment
61	Erosion control standard is consistent with requirements of regulatory authority.	
62	Soil erosion is being controlled to a standard consistent with the level of environmental risk.	
63	Erosion Control measures are consistent with the approved ESCP.	
64	Raindrop impact erosion is being adequately controlled.	
65	Dust problems are being adequately controlled.	
66	Erosion Control measures are being adequately maintained in proper working order at all times.	
67	All disturbed areas are adequately stabilised given: (a) Erosion hazard risk. (b) Degree of downstream sediment control. (c) Days since earthworks were finalised. (d) Days before any soil disturbance will be re-worked.	
68	**Mulching (light):** (a) Minimum 70% coverage of soil surface. (b) Suitable tackifier used on steep slopes. (c) Drainage controls preventing mulch displacement.	
69	**Mulch (heavy):** (a) Minimum 100% coverage of soil. (b) Minimum depth adequate to control weeds. (c) Drainage controls preventing mulch displacement.	
70	**Soil Binders:** (a) No adverse environmental impacts observed. (b) No obvious over-spray. (c) Soil binders applied during appropriate weather conditions.	

Monthly Site Inspection Checklist

Part I: Sediment controls

Item	Consideration	Assessment
71	Sediment is being controlled to a standard consistent with legislative requirements and the level of environmental risk.	
72	Sediment Control is consistent with the approved ESCP.	
73	Sediment Control is appropriate for the soil type.	
74	No sub-catchment relies solely on “supplementary” sediment control traps.	
75	Sediment Control measures are being adequately maintained in proper working order at all times.	
76	Sediment control *Buffer Zones* are protected from traffic and are free of excessive sediment deposits.	
77	Straw bales are not being used for sediment control, unless justified by exceptional circumstances.	
78	Neighbouring properties are being adequately protected from sedimentation.	
79	Collected sediment is being disposed of in an appropriate manner.	
80	**Entry/Exit Points:** (a) Control measures are appropriate for the site conditions. (b) Control measures are constructed to appropriate standards. (c) Excessive sediment removed from sediment traps. (d) Excessive sedimentation is not evident on roadway. (e) Stormwater drainage is controlled such that sediment is not being washed onto the adjacent roadway.	
81	**Field (Drop) Inlet Controls:** (a) Inlet control measures allow adequate ponding around stormwater inlets to capture sediment. (b) The sediment control measures do not simply divert sediment-laden water downstream to an uncontrolled inlet. (c) Sediment control measures will not cause a safety or local flood hazard. (d) Sediment traps are appropriate for site conditions. (e) Excessive sediment deposition is removed from all traps.	
82	**Gully Inlet Controls:** (a) Sediment traps are appropriate for the type of gully inlet, either “sag” or “on-grade” inlet. (b) Sediment traps allow adequate ponding around or up-slope of stormwater inlets to capture sediment. (c) Sediment traps do not simply divert sediment-laden water downstream to an uncontrolled inlet. (d) Sediment control measures will not cause a safety, traffic or local flooding hazard. (e) Excessive sediment deposition is removed from all traps.	

Monthly Site Inspection Checklist

Item	Consideration	Assessment
83	**Table drain sediment traps:** (a) Choice of sediment trap is appropriate for flow conditions. (b) Excessive sediment is removed from all traps. (c) Spill-through weir is set to an appropriate elevation. (d) Spill-through weir has adequate width. (e) Sediment fence traps are formed in a tight U-shape that adequately prevents water bypassing the traps.	
84	**Sediment Fences:** (a) Choice of fabric is appropriate. (b) Bottom of fabric is securely buried. (c) Fabric is appropriately overlapped at joints. (d) Fabric is appropriately attached to posts. (e) Support posts are at correct spacing (2m or 3m with backing). (f) Sediment Fence does not cause flow diversion/bypass. (g) Sediment Fence has regular returns. (h) Lower end(s) of fence is/are returned up the slope. (i) Sediment Fences are free of damage. (j) All fences are free of excessive sediment deposition. (k) Fences are adequately spaced from toe of fill banks.	
85	**Sediment Controls for Non-Storm Runoff** (a) Choice of sediment trap is appropriate for the site conditions and level of environmental risk. (b) All sediment is being contained within trap.	
86	**Other Sediment Trap, Type:** (a) Choice of sediment trap is appropriate for the site conditions and level of environmental risk. (b) The sediment trap allows adequate ponding to capture coarse sediment (Type 2 and Type 3 Sediment Traps). (c) The sediment trap allows adequate filtration to capture fine sediment (Type 2 Sediment Traps). (d) The sediment trap does not simply divert sediment-laden water downstream to an uncontrolled outlet. (e) The sediment trap does not cause a safety, traffic or local flood hazard. (f) Excessive sediment deposition is removed from all traps.	

Monthly Site Inspection Checklist

Part J: In-stream works

Item	Consideration	Assessment
87	All necessary State and local government approvals have been obtained.	
88	*Temporary Watercourse Crossings* (e.g. construction access) have been reduced to the minimum practical number.	
89	In-stream disturbance is limited to the minimum necessary to complete the proposed works.	
90	Timing and staging of in-stream works will minimise exposure of the site to storm and/or stream flows.	
91	In-stream works are occurring at a time of the year that will minimise overall potential environmental harm: (a) avoiding seasonal high flows; (b) avoiding periods of likely fish migration; (c) avoiding active bird migration periods (Ramsar wetlands).	
92	In-stream structures are not located on, or adjacent to, unstable or highly mobile channel bends.	
93	Construction works are not unnecessarily disturbing in-stream or riparian vegetation.	
94	Overbank disturbances are limited to only one bank wherever reasonable and practicable.	
95	Stormwater runoff moving towards the channel from adjacent areas is being appropriately diverted around soil disturbances.	
96	Erosion is not occurring as a result of stormwater passing down channel banks.	
97	Normal channel flows are being diverted around in-bank disturbances as appropriate for the expected weather and channel flow conditions.	
98	Appropriate temporary erosion control measures are being applied to disturbed areas.	
99	Synthetic reinforced erosion control blankets/mats are not being used where there is a potential threat to wildlife.	
100	Adopted in-stream sediment control measures are appropriate for the expected site and channel conditions.	
101	*Sediment Fences* have not been placed in areas of actual or potential concentrated flow.	
102	Appropriate material (spoil) de-watering procedures have been adopted.	
103	Site stabilisation and rehabilitation is occurring as soon as practicable.	
104	Appropriate site rehabilitation measures are being adopted.	

Monthly Site Inspection Checklist

Part K: Site stabilisation/ revegetation

Item	Consideration	Assessment
105	Site stabilisation/rehabilitation plan has been prepared.	
106	Site stabilisation/revegetation is occurring in accordance with approved Plans and/or programming.	
107	Exposed areas are adequately stabilised given the site conditions, environmental risk, and construction schedule.	
108	Soil surfaces are suitably roughened prior to revegetation.	
109	Excessive soil compaction is amended prior to revegetation.	
110	Seedlings are appropriately stored prior to planting.	
111	Seedlings are not excessively mature for their pot/tube size.	
112	Drill seeding (if any) is being applied across the slope (not up and down the slope).	
113	Newly seeded areas are developing an appropriate grass cover (not just strike rate), density and grass type.	
114	No newly seeded areas require reseeding.	
115	Soil erosion within revegetated areas is being adequately controlled (i.e. mulching) during the plant establishment phase.	
116	Grass turf is not being placed directly on compacted soil.	
117	Water application is appropriate for the site conditions and water conservation requirements.	
118	Soils are being appropriately prepared (i.e. pH, nutrients, and so on) prior to revegetation.	
119	Revegetation is controlling soil erosion as required.	
120	Newly seeded areas have been lightly mulched as specified.	
121	Adequate heavy mulching placed around seedlings.	
122	Newly established plants are being adequately maintained.	
123	Weeds and grasses are being controlled around the base of newly established trees and shrubs.	
124	Plants damaged by traffic or wind-rock are adequately supported or replaced.	
125	Dead or severely damaged plants have been replaced.	

Monthly Site Inspection Checklist

Part L: Action summary

Item	Consideration	Yes or No
	Answer "Yes" if further action is required on site	
126	Do any existing control measures require modification?	
127	Are additional ESC measures required on the site?	
128	Are alternative ESC measures required on the site?	
129	Is a revised ESCP required for the site?	
130	Is further water quality monitoring required?	
131	Do any ESC measures need repairs or de-silting?	
132	Is additional erosion control (minimum 70% cover) required?	
133	Will the underlying cause of any non-compliance need further investigation?	
134	Will it be necessary for the site to adopt an alternative Code of Practice better suited to the site conditions or work activities?	
135	Will further site inspections be required?	

Notes

Monthly Site Inspection Checklist