Chapter 6
Landform and Soils

PACIFIC **ALUMINIUM**

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6.1 DESCRIPTION

6.1.1 Topography

The pipeline route traverses relatively flat topography and largely skirts areas of greater topographic range such as the Mitchell Ranges (Figure 4-1). The route commences to the east of Katherine within the eastern margins of the Sturt Plateau (KP0-KP88), an area typically characterised as flat to gently undulating plains with little local relief before passing through the High Black Range. The alignment then continues in a north-easterly direction and follows the base of the Arnhem Land Plateau through relatively flat land with some portions of hilly to rugged terrain. The central portion of the pipeline route crosses the Gulf Fall (KP120-KP202), a region with gorges, water holes and dissected sandstone plateaux, as well as the ranges of the Arnhem Ridges region (KP420-KP426 and KP429-KP446). The north-eastern section of the pipeline route transects the northern portion of the Mitchell Ranges (KP400-KP440), before reaching the Gove Peninsula, a region of dissected lowlands with alluvial and estuarine plains. A summary of the topographical features along the proposed pipeline route is presented in Table 6-1.

Table 6-1: Topographical features in the project area (adapted from EcOz 2004)

PIPELINE KP	TOPOGRAPHY
0-88	Generally limited topographic variation. Some stream crossings and undulations may be encountered. The estimated average elevation is 200 m AHD with nearby spot heights ranging from 220 m AHD to 270 m AHD.
78-120	Large topographic variations as valleys and ridges associated with a mountain/hills system. No specific height contour information is available on the maps provided. The closest spot heights to the alignment range from 240 m AHD to 280 m AHD.
120-400	Flood plain area with flats and seasonal streamlines associated with drainage from the Arnhem Plateau to the north-west of the area.
400-440	Large topographic variations as valleys and ridges associated with the northern portion of the Mitchell Ranges.
440–535	Flood plain area with flats and seasonal streamlines associated with monsoonal drainage lines. The estimated average elevation of this area is 100 m AHD.
535-560	Large topographic variations as valleys and ridges associated with a mountain/hill system.
560–600	Flat topography with a slope towards the coast. Some tidal-influenced streams may be encountered.

6.1.2 Geology

The Northern Territory is divided into a series of geological regions which are defined based on structural and stratigraphic evolution and deformation, together with characteristic mineralisation styles (NTG 2013). The geology of the region traversed by the KGGP is variable and comprises rock dated between the Mesozoic and Proterozoic eras (Figure 6-1). The pipeline route extends over four major geological regions which are summarised in Table 6-2.

Table 6-2: Summary of geological regions along pipeline route

GEOLOGICAL REGIONS	LENGTH (KP)	DESCRIPTION
Daly Basin	0-15	Sedimentary and volcanic comprising limestone, dolostone, sandstone, siltstone
Carpentaria Basin	15-56 113-117 441-474 487-560 568-587	Sedimentary comprising sandstone, mudstone, limestone
McArthur Basin	56-113 117-414 425-441 474-487	Sedimentary and minor volcanic comprising dolostone, sandstone, shale, felsic and mafic volcanic rocks, minor microgranite
Arnhem Province	414-425 560-568 587-604	Sedimentary, metamorphic, igneous and volcanic comprising dolostone: greywacke, shale, granulite, amphibolite, felsic volcanic rock and granite

The published geology shows the surficial deposits overlying solid geology along the pipeline alignment typically comprise unconsolidated alluvium, colluvium, regolith/residual soils, channel and flood plain alluvium, estuarine and delta deposits, coastal sand dunes and ferruginous duricrust (laterite). Figure 6-1 provides the surface geology of the pipeline route.

Faults and seismic activity

The intraplate tectonic environment of the Australian continent is generally one of low seismic activity with no known active faults. Notwithstanding, records held by Geoscience Australia show a number of earthquakes have occurred within the Northern Territory since records commenced in 1960. The published geology indicates that 11 known faults cross the current pipeline alignment. Four of these faults are concealed while the remaining seven faults are identified as exposed. Examination of the earthquake data relative to the identified faults shows that there is no apparent correlation within the area of interest.

A Risk Assessment Report completed for the design phase of the project identified that the pipeline would pass through areas which have the potential to be impacted by forces associated with an earthquake (Appendix N). A pipeline at Tennant Creek (approximately 700 km south of Katherine) was buckled by an earthquake in 1988, and although no loss of containment occurred, the pipeline needed to be shutdown to undertake repairs on a buckled section. It was identified that material properties of the pipeline can be selected to ensure ductility of the pipe (i.e. plastic deformation rather than brittle fracture). This will be investigated further in the design phase of the KGGP Project.

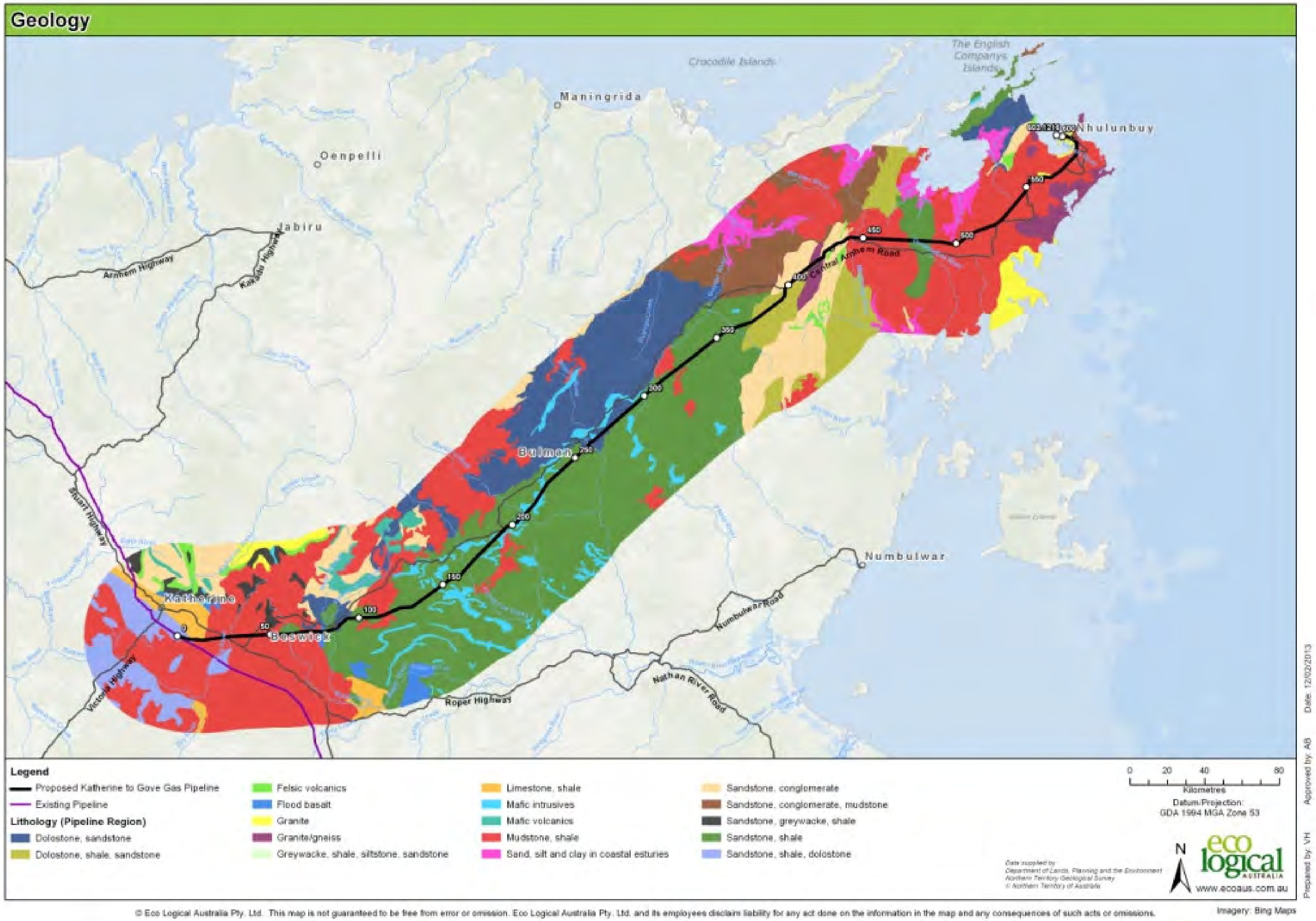


Figure 6-1: Geology

Karst formations

The proposed pipeline route commences and extends east across a karst landscape formed by the weathering/dissolution of soluble carbonate rocks such as limestone and dolomite of the Daly River Group. The Daly River group comprises Oolloo Dolostone over the Jinduckin Formation which in turn gives way to the Tindall Limestone. The latter is a highly soluble rock exposed, or close to the surface, within the Katherine area and is known to possess a thickness of up to 709 m. Karp (2002) notes that a significant thickness of soluble rock is necessary for development of karst. For this reason, karst terrain is extensively developed in the Tindall Limestone and to a lesser extent on the Oolloo Dolostone but is typically absent in the Jinduckin Formation.

Karp (2002) advises that dissolution leads to the formation of caves and other subsurface drainage conduits which in turn occasionally propagate to surface forming sinkholes. Sinkholes are typically circular or elliptical closed surface depressions with localised internal drainage which subsequently collapse into voids formed by solution of the carbonate rock below. Sinkhole development within the Katherine area is typically limited to:

- Collapse sinkholes—formed by the collapse of the roof of a cavern.
- Solution sinkholes—dished surface features formed by appreciable surface solution of the carbonate rock without fracture.
- Suffosion sinkholes—accumulation of overburden materials into widening joints and pipes within the underlying soluble carbonate rock.

A technical study undertaken in 2002 by Northern Territory Government assessed the land degradation associated with sinkhole development in the Katherine region focusing on the Tindall Limestone underlying the township of Katherine (Karp, 2002). A total of 283 sinkholes were identified within the study area. The study indicated that there these sinkholes were randomly distributed features with no relationship to geology, depth to bedrock, topography or morphology.

While geological mapping in the area does not show limestone to be present, Golder (2004) identified a sinkhole in the area east of Boggy Creek (at approximately KP511.6). Review of the current geological information shows that in the area from KP486 to KP560 the solid geology comprises Cretaceous to Jurassic age sedimentary deposits comprising sandstone, mudstone and limestone. It appears that these rocks are extensively masked by a regolith unit comprising alluvial, colluvial, residual and other undifferentiated unconsolidated deposits. Further evaluation is therefore warranted in this area to initially establish the nature and origin of this feature and subsequently determine the nature and extent of further investigations.

6.1.3 Land systems and soils

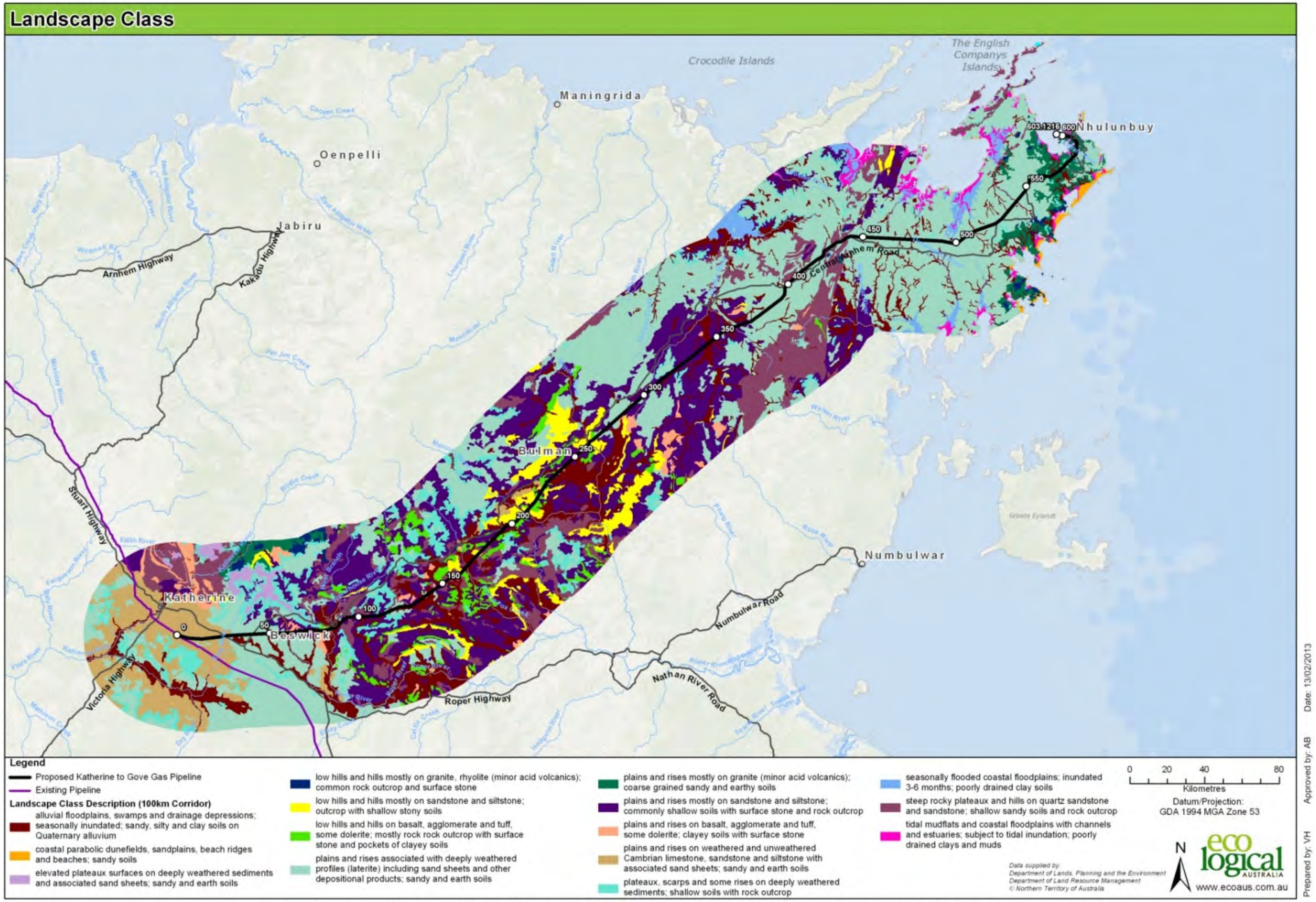
The NT Department of Land Resource Management has mapped and provided descriptions of land systems across various regions of the NT (Lynch et al. 2012). A total of 15 landscape classes occur within the 100 km wide corridor containing the pipeline route. The distribution of the landscape classes across the project area and surrounds, and descriptions of each, are summarised in Table 6-3 and shown on Figure 6-2.

Table 6-3: Landscape classes in the project area and surrounds (from Lynch et al. 2012)

LANDSCAPE CLASS	KP RANGE*	DESCRIPTION
1	25 – 360	Alluvial floodplains, swamps and drainage depressions; seasonally inundated; sandy, silty and clay soils on Quaternary alluvium
2	East of 500 – 580**	Coastal parabolic dunefields, sandplains, beach ridges and beaches; sandy soils
3	North of 0 – 60**	Elevated plateaux surfaces on deeply weathered sediments and associated sand sheets; sandy and earth soils
4	North of 40 – 100**	Low hills and hills mostly on granite, rhyolite (minor acid volcanics); common rock outcrop and surface stone
5	100 – 280	Low hills and hills mostly on sandstone and siltstone; outcrop with shallow stony soils
6	80 – 260	Low hills and hills on basalt, agglomerate and tuff, some dolerite; mostly rock outcrop with surface stone and pockets of clayey soils
7	360 – 550	Plains and rises associated with deeply weathered profiles (laterite) including sand sheets and other depositional products; sandy and earth soils
8	550 - 600	Plains and rises mostly on granite (minor acid volcanics); coarse grained sandy and earthy soils
9	50 – 360	Plains and rises mostly on sandstone and siltstone; commonly shallow soils with some surface stone and rock outcrop
10	50 – 80 and 270 - 280	Plains and rises on basalt, agglomerate and tuff, some dolerite; clayey soils with surface stone
11	0 – 25	Plains and rises on weathered and unweathered Cambrian limestone, sandstone and siltstone with associated sand sheets; sandy and earthy soils
12	0 - 200	Plateaux, scarps and some rises on deeply weathered sediments; shallow soils with rock outcrop
13	north and south of pipeline 400 – 550**	Seasonally flooded coastal floodplains; inundated 3-6 months; poorly drained clay soils
14	60 – 450	Steep rocky plateaux and hills on quartz sandstone and sandstone; shallow sandy soils and rock outcrop
15	450 - 600	Tidal mudflats and coastal floodplains with channels and estuaries; subject to tidal inundation; poorly drained clays and muds

*As depicted in Figure 6-2, the distribution of landscape classes in the project area and surrounds is uneven and patchy. Therefore the KP ranges indicate an estimation of the general distribution of these classes in the project area.

** Does not intersect pipeline corridor directly.



Imagery: Bing Maps

Figure 6-2: Landscape class

Dominant soil mapping by CSIRO (Isbell 1996) identifies the soils crossed by the pipeline alignment as mainly Kandosols and Tenosols with less frequent and less extensive areas of Vertosols, Rudosols and Hydrosols. The linear extent of the various soil orders is presented in Table 6-4 below:

Table 6-4: Approximate KP range of soil orders encountered along the pipeline route (from Isbell 2002)

SOIL ORDER	LINEAR LENGTH (KM)	APPROXIMATE KP RANGE*
Kandosol	302	Most prevalent 0-300
Vertosol	6	47-49 58-60 83-85
Tenosol	257	93-119 214-224 240-253 273-340 345-361 363-377 384-431 586-603
Rudosol	33	262-267 430-441 559- 559 574-582
Hydrosol	6	340-345 361-363

*As depicted in Figure 6-3, the distribution of soil types within these general soil orders is uneven and patchy.

Maps showing the pipeline route and associated dominant soil units are presented in Figure 6-3. A description of the main soil types encountered along the pipeline route is provided below.

Kandosols

Kandosols are the most common and extensive soil unit crossed by the pipeline route (approximately half of its length) but appears to be more prevalent within the initial 300 km section. Commonly known as red earths, this order comprises soils with weak or massive subsoil structure, a clay content of greater than 15% in the B horizon, no strong texture contrast and no carbonate throughout the profile. These soils are often very deep (three metres or more), mostly well drained and possess low levels of nitrogen and phosphorus. Surface soils are often subject to crusting and hard setting and erosion hazard is severe on slopes in areas of high intensity rainfall (NLWRA 2001).

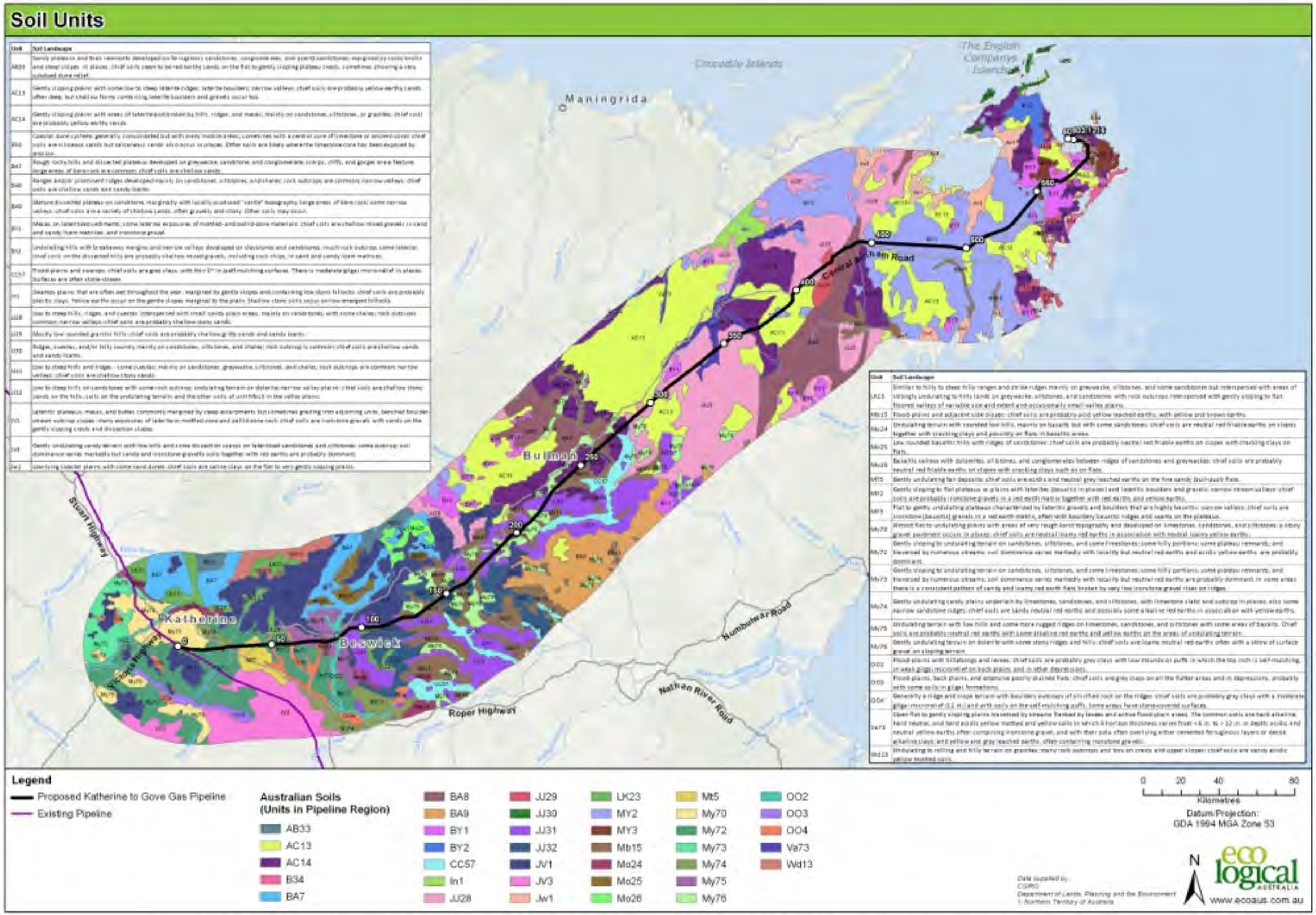


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Figure 6-3: Soil units

Vertosols

Vertosols are only encountered in three short sections within the initial 100 km of the alignment (KP47-KP49, KP58-KP60 and KP83-KP85). Also known as black earths and black cracking clays, these soils are usually associated with arid lands and generally described as clay soils (>35% clay) that swell, shrink and crack as soil moisture varies. Lenticular structure and slicken sides are diagnostic features. Vertosol soils often contain high sodium levels near the surface and are commonly deficient in sulphur and zinc. Erosion hazard is serious on slopes in areas of high intensity rainfall (NLWRA 2001). This soil is also subject to the development of hard pans if subject to sustained heavy machinery use under wet conditions.

Tenosols

Tenosols (commonly known as earthy sands) are the second most prevalent soils order crossed by the pipeline route. These soils may be considered as intermediate between Rudosols (characterised by having only a minimal development of soil features such as horizons) and Kandosols in which B horizon development is clearly expressed with more than 15% of clay. Tenosols therefore encompass a fairly wide range of soils which, apart from some A horizons, do not have a strong degree of horizon development. These soils have very low inherent fertility, are typically highly permeable material with a free draining structure and are susceptible to wind erosion if poorly vegetated (NLWRA 2001).

Rudosols

Rudosols are crossed by the pipeline in four areas KP262-KP267, KP430-KP441, KP559- KP559 and KP574-KP582. These soils are generally encountered on steep or mountainous terrain. The soils are often thin and poorly developed and as such vulnerable to erosion. These soils are mostly encountered within desert regions.

Hydrosols

Hydrosols are shown to be present in two short sections in the central section of the pipeline between KP340-345 and KP361-363. These soils can be saturated for two to three months or more due to local influence. Distribution is often limited to wet drainage depressions, low lying narrow coastal plains and seepage areas on lower slopes.

Drainage of potentially acid sulphate hydrosols can pose engineering and environmental problems and lead to acidification.

6.1.4 Potential acid sulphate soils (PASS)

Acid sulphate soils commonly occur in coastal marine environments such as estuarine systems, mangrove swamps and backswamps. They occur less commonly inland, but have been documented to form in waterlogged (anaerobic) and / or drained fresh water conditions where there has been a build-up of sulphidic material, e.g. rivers and stream channels, lakes, wetlands, billabongs, groundwater systems (Fitzpatrick and Shand, 2008). Where these sulphidic materials remain submerged there is little chance of oxidation; however when these materials are disturbed and exposed (i.e. pipeline construction), the sulphides, namely pyrite (FeS_2), react with oxygen to form sulphuric acid (H_2SO_4). If these sulphuric materials are subsequently covered with water, significant amounts of acidity and heavy metals can be released into the water (Fitzpatrick and Shand, 2008).

A detailed desktop review and assessment strategy was undertaken by Worley Parsons to ascertain the potential occurrence of ASS in the project area. This was undertaken in accordance with guidelines developed by the Queensland Acid Sulphate Soil Investigation Team (QASSIT) and used land systems reporting to identify potential ASS environments in the project area (Lynch and Wilson, 1998; Aldrick and Wilson, 1992).

Based on the dominant soil types, landform and vegetation, the land systems identified as potential ASS environments in the broader region containing the project area include the Littoral (L), Pinwinkle (Pw) and Effington (Ef) land systems. These land systems are characterised by the following:

- L - tidal mud flats and coastal floodplains with channels and estuaries.
- Pw - low swampy coastal floodplains and depressions.
- Ef - planar to gently undulating alluvial floodplains comprised of stream channels and closed swamps that are very poorly to poorly drained landforms with prolonged seasonal inundation.

The pipeline ROW does not traverse the L and Pw land systems but intersects the Ef land system at approximately KP581, KP589 and KP594.

Figure 6-4 shows the location of potential ASS environments.

6.2 POTENTIAL IMPACTS OF CONSTRUCTION AND OPERATION

The project has the potential to directly impact landforms and soils through vegetation clearing, excavation, potential spills and leaks of hazardous material and poor rehabilitation practices. Each of these environmental aspects is defined for this project in Chapter 5. These aspects may potentially result in a number of direct and indirect impacts including:

- Soil erosion.
- Landslides and slope instability.
- Exposure of acid sulphate soils.
- Soil contamination.
- Karst formation impacts.

6.3 MITIGATION RESPONSES AND ASSESSMENT OF POTENTIAL IMPACTS

An assessment of the potential impacts on landforms and soils as a result of the project, and key proposed mitigation responses to minimise these impacts are presented in the following sections and summarised in Table 6-5. A full outline of the management and mitigation measures to be implemented as part of the project is provided in the EMP (Appendix O).

6.3.1 Soil erosion

Soil loss via wind or water erosion has many direct and indirect impacts, including:

- Removal of valuable top soil and possibly sub soils with associated impacts on plant growth.
- Long term instability of disturbed areas, leading to reduced rehabilitation success.
- Damage to roads, fence lines and other infrastructure.
- Siltation of watercourses.
- Reduction in water quality in creeks, rivers and coastal areas with associated impacts on aquatic life.

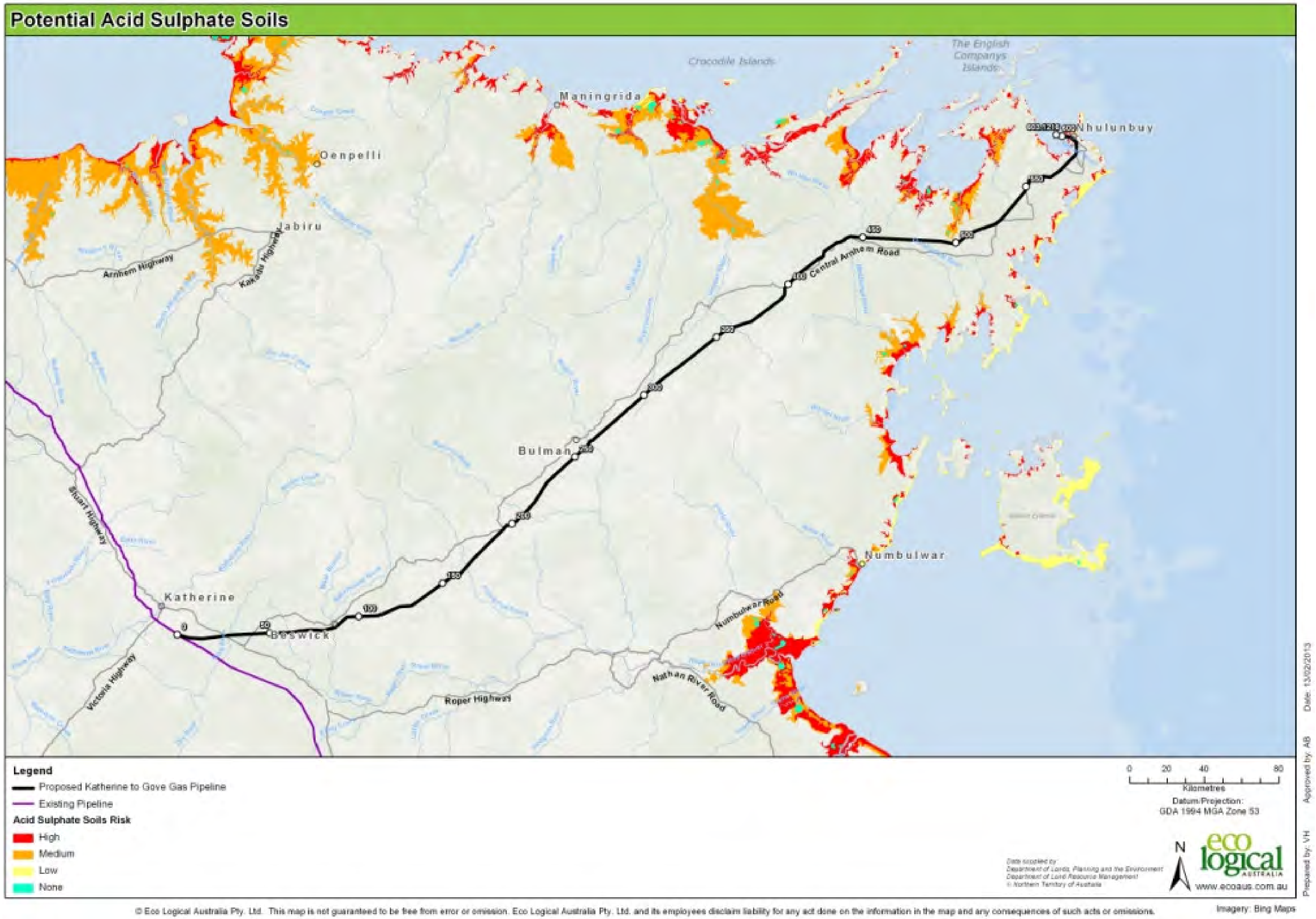

Figure 6-4: Potential acid sulphate soils

Erosion risk across most Northern Territory landscapes is considered to be at least moderate due to the occurrence of high intensity rainfall. Slopes of one per cent or greater are considered to be an erosion risk (NRETAS 2010). Given the incidence of high intensity rainfall across the region encompassing the project area, the potential for erosion on cleared and disturbed soils is significant. Exposure of soils due to vegetation clearing and earthworks increases the risk of erosion; the extent of which will be dependent on a range of factors including soil type, landform, slope angle and position, rainfall and management. Particularly sensitive areas include drainage areas, steep slopes with shallow soils, and areas with fragile soil types including sandy and sodic or dispersive soils.

The pipeline alignment was modified in early design stages to avoid wherever possible vegetation communities sensitive to disturbance and at risk of significant soil erosion (i.e. ecologically sensitive habitats such as riparian corridors). The proposed method to be used at each watercourse crossing has been determined based on environmental factors, geotechnical constraints and landholder views in regards to the significance of the watercourse. Horizontal Directional Drilling (HDD) and open-trenching are the preferred construction methods. Nine watercourses have already been identified as potentially requiring HDD for ecological and engineering reasons (Table 2-6). HDD would also be used at any watercourse that is determined to be in flow by the construction contractor at the time of constructing the crossing. The use of HDD construction techniques minimises surface disturbance and substantially reduces any potential impacts to riparian vegetation (see Section 2.6.5 for more detail).

Poor rehabilitation practice can allow, and in some cases exacerbate, rill and gully erosion, lead to sedimentation of waterways, threaten the integrity of infrastructure, and facilitate the colonisation of aggressive weed species which alter habitats and adversely affect fire regimes. Avoidance of poor rehabilitation practices is of particular concern for linear developments (where length of slope exacerbates risk) and for those involving riparian and in-stream developments in which rehabilitation must be sufficiently progressed to withstand significant wet season stream flows.

Measures to avoid, mitigate and manage soil erosion are considered necessary (Table 6-5). Impacts to landforms and soils from vegetation clearing would be managed through implementation of measures described in the Soils and Landforms Management Plan contained in Appendix O.

Mitigation and management measures prescribed in this plan would be implemented during construction and operation to reduce the potential for soil erosion in the project area with the result that the risks are minimised and effective management measures are applied to control erosion if detected.

6.3.2 Slope instability and landslides

The pipeline route traverses relatively flat topography but in some areas does encounter moderate to steeply sloping topography. Construction of the pipeline in these areas could, under certain conditions initiate landslides or lead to slope instability and erosion.

Where the pipeline route skirts areas such as the Mitchell Ranges and other similar topographical features, it typically passes through valleys where colluvium (which is characterised as landslide debris) is present.

No previous assessments have been undertaken to identify the potential for landslides and slope instability along the proposed pipeline alignment. Potential hazards would be confirmed through aerial photograph and LIDAR interpretation, field mapping and where appropriate direct investigation prior to construction.

Impacts associated with slope instability and landslide during construction of the pipeline would be managed through implementation of measures summarised in Table 6-5.

6.3.3 Exposure of potential acid sulphate soils

Excavation of the pipeline ROW is the key construction activity to be undertaken that may potentially disturb or expose ASS. If ASS were disturbed or exposed as a result of excavation during construction of the pipeline ROW, the following potential impacts may result:

- Adverse changes to the water quality of the soil, groundwater, surface water, wetlands, watercourses and estuaries.
- Degradation of ecosystems and ecosystem services dependant on water.
- Loss of habitat and biodiversity (specifically fish kills).
- Corrosion of metallic and concrete structures such as roads, bridges, pumps, pipes and foundations.
- Invasion of and dominance of wetlands and waterways by acid tolerant water plants, plankton and pathogens.
- Poor rehabilitation outcomes.
- Increased human health risks associated with contamination of soil or, groundwater and acid dust.

The desktop assessment undertaken by Worley Parsons indicated that the pipeline ROW intersects the Ef land system (which has the potential for inland ASS) at approximately KP581, 589 and 594. As a result, field-based assessment would be undertaken ahead of construction to clarify whether areas of potential ASS are present and likely to be disturbed for pipeline construction. An Acid Sulphate Soils Management Plan will be developed prior to construction describing the proposed construction methods and management measures to be implemented during construction and operation including: general ASS management requirements; techniques commonly used to treat ASS during and post construction; validation testing; and dewatering and storage requirements.

Potential impacts from excavation would also be managed through implementation of measures described in the Soils and Landforms Management Plan contained in Appendix O and summarised in Table 6-5. Mitigation and management measures prescribed in this plan would be implemented during construction and operation to reduce the potential for exposure of ASS in the project area with the result that residual environmental impacts of ASS following mitigation will be negligible.

6.3.4 Soil contamination

Vehicle and plant refuelling activities would be undertaken during construction. Fuel and other small chemical or hydrocarbon spills could occur during refuelling operations, potentially impacting the surrounding soils. Hazardous materials storage facilities and handling equipment would be segregated and bunded, kept in good order and designed in such a way as to prevent and contain spills.

Impacts to soils from potential spills and leaks would be managed through implementation of measures described in the Soils and Landforms Management Plan, (Appendix O) and summarised in Table 6-5. Mitigation and management measures prescribed in this plan would be implemented during construction and operation to reduce the potential for soil contamination in the project area. With the implementation of mitigation and management measures, it is considered unlikely that contamination of soils from spills would occur as a result of implementation of the project.

6.3.5 Karst formation impacts

Desktop and field studies have indicated the potential for karst formations to be present in geological formations between KP0-KP60 (the Daly River Group) and KP486-KP560; with an existing sinkhole identified east of Boggy Creek (KP511.6).

An assessment of the potential for karst formations within these areas is proposed and would be completed during the 2013 dry season.

6.3.6 Environmental Management Plans (EMPs)

All potential impacts to soils and landforms would be mitigated through the implementation of measures summarised in Table 6-5 and described in the following Provisional EMPs for the project (Appendix O):

- Soils and Landforms Management Plan.
- Hydrology and Water Quality Management Plan.
- Waste Management Plan.
- Rehabilitation Management Plan.

6.4 SUMMARY

After mitigation is applied, construction and operation of the project is expected to result in the following outcomes in relation to landforms and soils:

- The risk of soil erosion is minimised and effective management measures are applied to control erosion if detected.
- The potential for landslides and mass movement is minimised.
- Potential soil losses along water crossings are minimised and there is no significant long term impact on water quality and the adjacent aquatic, riparian or ephemeral habitats.
- No environmental impacts occur due to the exposure of ASS.
- The risk of accidental spills and degradation of soil quality is minimised.
- Impacts on karst formations will be avoided.

Table 6-5: Mitigation for landform and soil impacts during construction

<table>
<tr><th rowspan="2">POTENTIAL IMPACT</th><th colspan="2">PROPOSED MITIGATION (ACTION)</th><th rowspan="2">ANTICIPATED EFFECT OF MITIGATION</th></tr>
<tr><th>AVOIDANCE</th><th>MINIMISATION</th></tr>
<tr><td>Soil erosion</td><td>• The total area to be disturbed would be restricted to the minimum area required to construct the pipeline and above ground facilities.
• Construction activities involving significant land disturbance would be confined to the Dry season, wherever possible.</td><td>• Under the Soils and Landforms Management Plan and the Rehabilitation Management Plan, a risk assessment will be undertaken to determine sections of the pipeline requiring a higher level of soil conservation planning, works, and rehabilitation.
• Site-specific soil conservation and rehabilitation measures to minimise erosion will then be determined according to level of identified risk.
• Water crossings to use HDD, sediment controls and/or be constructed to minimise erosion
• Progressive vegetation clearing and rehabilitation to minimise period of bare soil exposed to erosion</td><td>The risk of soil erosion is minimised and effective management measures are applied to control erosion if detected.</td></tr>
<tr><td>Slope instability and landslides</td><td>• The project has been designed to avoid significant topographical features where practicable.</td><td>• Under the Soils and Landforms Management Plan and the Rehabilitation Management Plan, appropriate soil conservation works would be installed to prevent mass movement and safely control runoff.</td><td>Minimise the potential for landslides or mass movements.</td></tr>
<tr><td>Exposure of ASS</td><td>• A field-based assessment would be undertaken prior to construction to identify and confirm areas of potential ASS identified in the desktop assessment. If areas of potential ASS are confirmed an Acid Sulphate Soils Management Plan would be</td><td>• Should ASS be encountered, the Acid Sulphate Soils Management Plan will describe proposed construction methods and management measures.
• Potential impacts from excavation will also be managed through the implementation of measures described in the Soils and Landforms</td><td>All ASS to be disturbed by the project are identified and managed appropriately to ensure no environmental impacts occur due to their exposure.</td></tr>
</table>

POTENTIAL IMPACT	PROPOSED MITIGATION (ACTION)		ANTICIPATED EFFECT OF MITIGATION
	AVOIDANCE	MINIMISATION	
	developed prior to construction and implemented during construction and operation.	Management Plan.	
Soil contamination	• Fuel and chemical storage would be above ground and will be located an appropriate distance from surface water resources. • Construction crew will be trained in fuel handling and how to effectively contain and clean up spills • Each construction site will have an approved emergency plan and spill kits to deal with accidental spills • All fuel and hazardous materials will be handled and stored in bunded areas in accordance with the corresponding Materials Safety Data Sheets (MSDS) and Australian Standards	• Fuel and chemical storage, handling and distribution systems will be designed and constructed in accordance with Australian Standards, and will be fitted with leak detection systems and spill kits. • Other procedures as per the Hydrology and Water Quality Management Plan and the Waste Management Plan.	The risk of accidental spills is minimised and effective management measures are deployed in the event of a spill. Degradation of existing soil quality.is minimised.
Karst formation impacts	• An assessment of the potential for karst formations within these areas is proposed and would be completed during the 2013 dry season.		Impacts on karst formations will be avoided.