Appendix G

Impacts on Hydrology & Water Quality from the Trans Territory Pipeline Project prepared by EWL Sciences

Impacts on Hydrology & Water Quality from the Trans-Territory Pipeline Project

Prepared for: EcOz Environmental Services

Prepared by: EWL Sciences Pty Ltd

Authors: Ian Hollingsworth, Phillipe Puig, Michael Welch

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EWL Sciences Pty Ltd
Darwin Office 482 Stuart Highway, Winnellie NT 0820
PO Box 39443, Winnellie NT 0821
Tel: (08) 8922 5200 Fax (08) 8922 5260

ABN 12 000 955 171 Registered Research Agency No 31639

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Authors:
Ian Hollingsworth, Phillipe Puig, Michael Welch

Date: October 2004

Project Manager: ________________
Ian Hollingsworth

Reviewer: ________________
Alan Puhalovich

General Manager: ________________
Dr A R Milnes

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EXECUTIVE SUMMARY

Background

A desktop survey was made to identify the potential wetland, riparian and groundwater impacts arising from construction and operation of the Trans Territory Pipeline (TTP) Project. The proposed Trans-Territory Pipeline traverses 940 km between the gas plant at Wadeye and the Alcan refinery at Gove. It crosses the Alice Springs to Darwin pipeline between Katherine and Mataranka.

Baseline Hydrology

The project infrastructure and hydrological features upon which impacts were assessed are shown in Map 1. The TTP Project traverses large sections of five surface water management areas (river basins) identified in the national catchment framework namely, Moyle, Daly, Roper, Goyder, and Buckingham River basins. Development potential has been identified in the Daly and Roper river basins. However, there are significant environmental beneficial uses associated with groundwater fed streams with significant baseflow during the dry season in the Daly, Roper, Goyder and Buckingham River basins.

The proposed TTP route intersects 426 surface water features. The location and type of each is listed in Appendix B. In most cases, the creeks dry up each year and do not flow again until the next wet season. The wet season begins approximately one month earlier in the west than in the east of the survey area. Consequently, the flow period in the western section is between November and April/May and in the eastern section between December and June. Baseline water quality is typical of that in relatively undisturbed environments in northern Australia. The surface water features include:

- 16 major rivers and streams namely: Anopheles Creek, the Moyle River, Bradshaw Creek, Daly River, Katherine River, King River, Roper Creek, Beswick Creek, Waterhouse River, Flying Fox Creek, Mainoru River, Wilton River, Goyder River, Boggy Creek, Giddy River and Latram River;
- 338 seasonal and irregular rivers and streams;
- 3 riverine floodplains approximately 10 km wide with grassland and savannah vegetation subject to seasonal flooding;
- 63 seasonal/intermittent freshwater ponds and marshes; and
- 5 freshwater springs.

Currently, groundwater extraction is concentrated in the Daly Basin. Water use is principally associated with agriculture and residential development. There is relatively minor groundwater extraction in the other drainage basins for small community supplies. Tourism associated with groundwater features down-gradient from the pipeline currently takes place at Cutta Cutta Caves in the Daly Basin and Mataranka in the Roper Basin. In the Moyle, Daly, Roper, Goyder and Buckingham basins the TTP project traverses shallow, high-yielding aquifers that have high resource value and environmental beneficial uses that would be sensitive to development impacts.

Shallow, high yielding aquifers with significant development potential based on the quality of the groundwater resource and proximity to potential development areas were identified along the following sections of the pipeline route:

1. KP0 to KP16 km (Moyle River Basin);
2. KP300 to KP350 km (Tindal-Katherine Groundwater Management Area, Daly River Basin);
3. KP780 to KP810 km (Goyder River Basin);
4. KP820 to KP910 km (Buckingham River Basin).

Water bores within the pipeline corridor with measured yields greater than 1 L/s were assessed as having potential as water supplies which pipeline construction, operation and decommissioning activities could impact upon. In the Moyle Basin 8 water bores were identified. In the Daly Basin 4 bores were identified. In the Goyder River Basin 3 water bores were identified. In the Buckingham Basin 31 water bores were identified. The locations of these bores are listed in Appendix C. These groundwater resources were considered to require a high level of protection.

Impact Assessment

Groundwater and inland drainage systems are the principal receptors of potential impacts from pipeline construction and operation. Particular activities that represent a risk of environmental impact are:

- land clearing for the right of way and topsoil stockpiling;
- trench dewatering required in areas of acid sulphate soils;
- track access and lay down area construction and maintenance;
- the source and disposal of water used in hydrostatic testing of the pipeline during commissioning;
- construction camp operation, water extraction and wastewater disposal; and
- fuel and chemical storage during pipeline operation.

Gas processing at the Blacktip Project near Wadeye to remove particulate, liquid and heavier than air fractions to meet the pipeline operating requirements will reduce the consequences of any pipeline leaks to an insignificant level. Consequently, there should be negligible risk to groundwater or surface water quality from hydrocarbon transported during pipeline operation. However, the approach taken to fuel and chemical storage during construction and operation will need to mitigate risks to the hydrological environment. Where possible, removing fuel and chemical storage facilities from sensitive groundwater areas will remove the risk of environmental impact.

There is a low to moderate risk of hydrocarbon spillage and turbidity impacts on surface water during construction and commissioning. Impacts to surface water drainage and freshwater aquatic life during the construction phase may arise in areas where sediment load into creeks is increased during the wet season as a result of land clearing and earthmoving without the necessary sediment and erosion control. Also, the geographic extent of the pipeline and the extent of each construction spread present some potential for translocation of non-endemic flora and fauna in water used for hydrostatic testing.

Groundwater extraction and trench dewatering could result in localised lowering of groundwater tables and downstream hydrological impacts. Groundwater extraction for pipeline testing, camp water supplies and vehicle wash down will lower the water table to an extent that depends on the specific properties of the aquifer. Some trench dewatering may be required where the route traverses sections of coastal wetland. In such instances, there may be risks associated with acid sulphate soil development and acid water disposal that need to be addressed in the environmental management plan.

Management Recommendations

Detailed recommendations to mitigate environmental impacts from the construction and operation of the proposed pipeline are provided in the body of this report.

A. With regard to minimising impacts from water extraction for hydrostatic pressure testing and its subsequent disposal we recommend that the proponent:

   1. consult landowners and obtain agreement regarding water extraction and disposal plans for hydrotest water;

   2. use groundwater sources rather than surface water, thus minimising the risk of transmission of non-endemic species and impacts on aquatic ecosystems;

   3. extract groundwater from shallow, high yielding aquifers to minimise groundwater lowering; and

   4. dispose of hydrotest water by land application to stable (rocky) vegetated areas to minimise direct impacts on surface water quality and wetland environments.

B. When watercourses, drainage depressions and wetlands are crossed during pipeline installation, we recommend the following actions to contain sediment, minimise erosion and stabilise the work area:

   1. use the most suitable crossing technique based on technical, environmental and cultural constraints with an environmental preference for directional drilling methods at the 16 major river and stream crossings;

   2. use trenching methods followed by reinstatement of bed and bank profiles at other wetland and stream crossings.

C. Timing pipeline construction to occur during dry season periods of low streamflow will reduce potential environmental impacts, we recommend the following actions to mitigate construction impacts on the hydrological environment:

   1. confining construction and operational activities involving land clearing to the dry season months between May and September in the western branch of the pipeline;

   2. confining these activities to the period between June and November in the eastern branch of the pipeline.

D. Measures to protect groundwater and surface water from potential impacts from wastewater disposal and fuel and chemical storage are required:

1. in the vicinity of production bores, and

2. for aquifers with high environmental values, namely the Bonaparte Gulf Basin, the Tindal-Katherine Water control area and an un-named sandstone aquifer that straddles the Buckingham and Koolatong River Basins.

E. The effect of groundwater extraction on groundwater levels and consequently groundwater dependant ecosystems will depend on the properties of the aquifer, we recommend the following action to mitigate this risk:

1. extract groundwater from bores in shallow high yielding aquifers, as opposed to deeper confined aquifers or low yielding unconfined aquifers will minimise the zone of groundwater drawdown and consequent environmental impacts.

F. Downstream water quality impacts during construction that are associated with acid sulfate soil risk may be encountered on small sections of coastal wetland identified along the route, we recommend that:

1. prior to any trench excavation or trench dewatering in these areas that an acid sulfate soil investigation is made and if some risk is identified a management program for potential acid sulfate soil areas is implemented.

1 INTRODUCTION

1.1 BACKGROUND

This report presents a desktop assessment of possible hydrology and water quality impacts associated with the infrastructure of the Trans Territory Pipeline (TTP) project. The proposed route extends for 940 km from the proposed gas processing plant at Wadeye to the Alcan refinery at Gove (Figure 1). The pipeline easement will be initiated at Wadeye and continue to a point between Katherine and Mataranka where it crosses the Alice Springs to Darwin Pipeline. The easement then continues to Beswick and on to Gove. The easement will be 30 m wide except where additional width is needed for construction access.

1.2 CLIMATE

The climate is tropical monsoonal with a dry season which extends from May to September. This is followed by a wet season that typically lasts until the end of April. The mean annual rainfall in the region is about 1,400 mm, with a majority of the rainfall occurring during the wet season. Negligible rainfall occurs during the dry season.

The wet season usually starts with localised rain storms in November and December as the monsoon trough develops followed by regular, widespread monsoonal rains in January, February and March with the pattern of localised rain storms reoccurring as the monsoon trough subsides by the end of April. The monsoon establishes earlier in the west than the east so that the wet starts in the west and moves east with approximately a month’s delay.

1.3 PROJECT OBJECTIVES

Our assessment addresses the information requirements set out in sections 4.4.1, 4.4.2 and 4.4.3 of the final EIS guidelines and listed below.

Baseline

- Provide a broad description of any waterways or other wetland habitat, natural or artificial, ephemeral or permanent, including springs and mound springs, that may be impacted by the project. Include a description of catchment systems, existing surface drainage patterns, flow, likelihood of flooding and present water uses.

- Provide a description of the relevant groundwater resources in any areas likely to be affected by the underground pipes and excavation.

- Provide details of the potential locations of pipeline waterway crossings including bed and bank profiles and describe selection criteria for determining the final crossing locations. Include information on the flow regime of the waterways in the vicinity of the pipeline, in particular the timing (and volume) of flows in relation to any construction work.

- Include information on the flow regime of the waterways in the vicinity of the pipeline, in particular the timing (and volume) of flows in relation to any construction work.

Impacts

- Describe how the pipeline might impact on the surface and groundwater features described in 4.4.1.
- Detail the extent of dewatering that may be required for installation of the pipeline and describe the potential impacts including the effects of localised lowering of groundwater tables (*ie*, zone of influence), associated disturbance to wetland and aquatic flora and fauna (if any).
- Provide details of typical waterway crossings that would be constructed and likely impacts associated with crossing at each intended location. Details including design, construction (timing), rehabilitation and maintenance should be discussed in consultation with the relevant Advisory Agency and published guidelines.
- Consider and discuss the risks associated with the proximity of the proposed condensate pipeline to borefields or aquifer recharge zones that may supply potable water.
- Detail the potential impacts from wastewater generated by construction / operational water use including translocation or introduction of non-endemic aquatic fauna and flora.

Management

- Detail safeguards and management strategies used to minimise the impacts of pipeline construction and operation on the hydrological features described above, in particular provide details on the following:
  - measures to safeguard surface and groundwater resources including options for the appropriate treatment and disposal of construction and operational wastewater, and discharge of abstracted water. Identify the preferred option and the selection criteria used;
  - measures to ensure the beds and banks of water courses remain stable and protected from the natural forces of erosion as required, incorporating preferred methodologies of relevant Advisor Agencies where practicable particularly where there has been any disturbance to the bank or to the bed; and
  - measures to safeguard downstream water quality including appropriate management of any acid sulphate soils excavated and wetland crossings.

The potential impacts from pipeline construction and operation on the surface and groundwater systems along the proposed route have been ranked using a qualitative risk ranking system. This ranking process is used to focus the recommendations on high priority issues to effectively mitigate environmental impacts from the project.

1.4 METHODS

The pipeline centre line, corridor and 10 km flag point locations were obtained in a data request to the proponent dated 30th March 2004. The location and type of intersection between the pipeline alignment and high quality groundwater resources, drainage systems and wetlands was recorded from a GIS system (ArcView 3.2). To do this, the locations of project components were overlaid on hydrogeological mapping (1:250 000), drainage (1:250

000) and raster topographic mapping (1:100 000). The types of water features were classified according to the ecosystem types used in Table 3.3.4 and Table 3.3.5 of the ANZECC water quality guidelines for environmental protection (ANZECC and ARMCANZ 2000).

The national water quality assessment framework and associated guidelines (ANZECC and ARMCANZ 2000) were applied to assess ambient water quality. The guidelines present water quality trigger values for physical and chemical stressors for different ecosystem types.

1.5 INFORMATION SOURCES

The design documentation and geographic data used in this assessment are listed in Table 1. The groundwater and surface water data for the baseline assessment were obtained from:

- the Wadeye / Nauiyu Water Study (Haig and Matsuyama 2003);
- the Environmental Water Requirements Study of the Daly River (Erskine *et al.* 2003);
- the West Arnhem Land Water Study (Zaar 2003); and
- the East Arnhem Land Water Study (Zaar *et al.* 1999).

2 BASELINE HYDROLOGY

The water resources along the route are described in the following sections in relation to the surface water management areas used in the national catchment framework used for territory wide environmental audit reporting (NLWRA 2000).

2.1 WATERWAY DESCRIPTIONS

The proposed pipeline will traverse extensive areas of five major river basins. Catchment statistics shown in Table 2 for each of these major river basins identify the size of the surface water resource and perceived development pressure. The largest surface water resource is in the Daly River basin. The next largest is in the Roper River basin. Resource use (measured by diversions) and development pressure (measured by estimated future use) identify these two catchments as recognised, economic water resources. The surface water resources in other catchments along the right of way are undeveloped and do not currently have recognised development potential. However, construction of the gas pipeline may provide development opportunities that will change the perception of low development potential.

The permanent rivers and streams along the right of way that can provide a very large water supply are listed in Table 3. The surface hydrology of the five major drainage basins that the right of way traverses is described in the following sections.

Moyle River Basin (KP000-120)

The catchment covers 7,020 km^2. The mean annual rainfall varies from 1200 mm in the south to 1500 mm in the north. There are three major Aboriginal communities namely Wadeye, Peppimenarti, and Palumpa. The basin is drained by the Moyle River and a few creeks. The Moyle River flows from the escarpment country and drains into the floodplains before flowing into the Timor Sea. There is no surface water licensing, and no surface water usage is recorded. Sections from 15 to 30 km and from 40 to 45 km traverse the headwaters of the Fitzmaurice River catchment. The catchments are described as being unaffected by development.

The average annual runoff in the Moyle River catchment is estimated to be around 600,000 ML/annum, with total diversions believed to be negligible. The numerous stream crossings that occur along the right of way are ephemeral and flow during the wet season. The few rivers and creeks that typically have measurable flow at the end of the dry season are the Fitzmaurice River, Moyle River and Tom Turners Creek. However, stream gauging stations are sparse and some unidentified creeks may support continuous streamflow.

There are limited stream flow measurements. In most cases, the creeks dry up early in the dry season each year and do not flow again until the next wet season. Some of the largest flows in the region have been measured in the Daly River near Nauiyu, Tom Turners creek near Peppimenarti and the Moyle Rover between Peppimenarti and Nganmarriyang (Palumpa). Graphs of mean monthly discharge records for Bradshaw Creek (Figure 3) indicate that flow ceases between April-May and November.

Thirty-nine intersections between the pipeline corridor and the surface drainage features in the Moyle River basin are listed in Appendix B. No field survey information is available for drainage system crossings in the Moyle River Basin.

Daly River Basin (KP120-370)

Daly River is the major river and Katherine River is one of the major tributaries. The catchment covers 52,940 km^2. The mean annual runoff is 67,400,000 ML/yr. The upper part of the catchment is moderate escarpment country and the lower part around the coastal areas is flat. There is only one major diversion, the Donkey Camp Weir on Katherine River. Pastoral Leases cover 50%, Aboriginal land covers 20%, National Park covers 9%, and the rest of the catchment is used for horticulture, agriculture and mining. The surface water usage is for urban water supply and irrigation, stock watering, mining, rural water supply and aquaculture. The mean annual rainfall varies from 700 mm in the south to 1500 mm in the north near the coast.

There is a large baseflow component to the Daly River system. The basin is largely unmodified. Total diversions have increased from 3,730 ML/yr in 1983/84 to 7,465 ML/yr in 1996/97. The majority of this increase was attributed to urban supply. However 53% of the diversions are for irrigation while 40% are for urban/industrial uses. Agricultural development has put pressure on water quality and has stimulated research into the environmental flow regimes needed to maintain groundwater dependant ecosystems (Erskine *et al.* 2003).

Graphs of mean monthly discharge records for the Daly River, the Katherine River and Bradshaw Creek (Figure 3) indicate that ephemeral stream flow ceases slightly later than areas further west, with the flow free period extending between May and November.

Seventy four intersections between the pipeline corridor and the surface drainage features in the Daly River Basin are listed in Appendix B. No field survey information is available for drainage system crossings in the Daly River Basin.

Roper River Basin (KP370-630)

There are no major infrastructure or diversions for surface water extraction within this river basin. However there is “run of river” extraction for public water supply for two communities, and irrigation. About 60% of the area is pastoral leasehold and 35% is Aboriginal land. There are twenty five pastoral leases within the SWMA and another nine partly so. Soils with few limitations for agriculture cover about 38% of the area. The Roper is the main river that drains the whole area into the Gulf of Carpentaria. Phelp, Wilton, Waterhouse and Hodgson rivers are the main tributaries of Roper River. They flow from the escarpment country through well-defined valleys and finally flow into Gulf of Carpentaria through mildly sloping low valleys. The mean annual rainfall varies from 600 mm in the south to 900 mm in the north. A surface water license has been issued for a community water supply, and three licenses for irrigation. Surface water is also used for stock watering.

Tourism, Irrigated Agriculture, Marine and Riparian uses are the likely potential developments. Forecast usage of surface water is mainly for public water supply, irrigation and stock watering. The forecast use is based on the assumption that cattle numbers in the leasehold would be 85% of its carrying capacity in 2020, and 100% in 2050. This increase in the cattle numbers represents the growth rate noted in the NT Overview Report. Cattle consumption is assumed as 50 litres per day per head. It is also assumed that 10% of the stock water consumption is from surface water. Population growth in the rural area is based on the growth rate noted in NT Overview Report. Irrigation forecast is assumed as 150% of the present usage in 2020, and 200% in 2050. The forecast use figures are only rough estimates.

One hundred and seventy nine intersections between the pipeline corridor and the surface drainage features in the Roper River Basin are listed in Appendix B. Reconnaissance survey descriptions of drainage system crossings in the Roper River Basin are given in Table 4.

Goyder River Basin (KP630-770)

There are no infrastructure or diversions within this river basin. This basin is within Aboriginal land. About 4.5% of the land area has soils with few limitations to agriculture. Goyder is the major river, and Gulbuwangay River is the major tributary. Both these rivers join in the lower part of the basin and discharge into the Arafura Sea. Both these rivers originate from the escarpment country and flow through the low valleys into low mildly sloping country. The mean annual rainfall varies from 900 mm in the south to 1100 mm in the north. There is no surface water licensing, and surface water usage is zero. No potential development issues have been identified for this catchment.

Fifty three intersections between the pipeline corridor and the surface drainage features in the Goyder River Basin are listed in Appendix B. Reconnaissance survey descriptions of drainage system crossings in the Goyder River Basin are given in Table 5.

Buckingham River Basin (KP770-930)

There are no major infrastructure or diversions for surface water extraction within this basin. This basin is within Aboriginal land. The potential for agricultural development is considered to be low. There are few rivers that flow from the escarpment country in the west and low hill country in the east to the sea. The lower part of the basin is mildly sloping to flat country. The main rivers are Woolen, Buckingham, Habgood, Cato, Peter John and Giddy. The mean annual rainfall varies from 1300 mm in the south to 1400 mm in the north. No surface water licenses have been issued, and no surface water usage has been recorded.

Graphs of mean monthly discharge records for Durabudboi River and Yirrkala Creek Figure 4 indicate that flow ceases between June and December.

Eighty two intersections between the pipeline corridor and the surface drainage features in the Buckingham River Basin are listed in Appendix B. Reconnaissance survey descriptions of pipeline crossings in the Buckingham River Basin are given in Table 6.

2.2 GROUNDWATER RESOURCES

Recharge processes in the northern areas which the TTP intersects are considered to be distributed rather than localised in particular parts of the landscape (Chin *et al.* 2000). Licensing for groundwater extraction is organised around eight Groundwater Management Units (GMUs). These represent selected major aquifer systems within gazetted "Water Control Districts" across the Northern Territory and Unincorporated Areas (UAs). Both GMUs and UAs are sub-areas of Groundwater Provinces that are the hydrogeological basins within the NT. The boundaries for these units are shown in Figure 5. The shallow high yielding aquifers in the Bonaparte Gulf Basin, the Daly River Basin (Tindal-Katherine Water Control District) and an un-named, porous sandstone aquifer in the eastern Mac Arthur Basin have identifiable conservation values in the national water quality management planning framework (EA 2001).

Water bores within the pipeline corridor with measured yields greater than 1 L/s were identified as having potential water supply value. In the Moyle River Basin, 8 water bores were identified. In the Daly River Basin, 3 bores were identified. In the Roper River Basin, 4 bores were identified. In the Buckingham River Basin, 31 water bores were identified. The locations of these bores are listed in Appendix C. The groundwater resources along the route are described in the following sections in relation to the surface water management areas.

Moyle River Basin (KP000-120)

Bores identified within the pipeline corridor in the Moyle Basin are listed in Appendix C.

Wadeye (KP000 to KP013)

A high yielding, widespread shallow aquifer system underlies the TTP corridor in the vicinity of the Wadeye community. Bore yields commonly exceed 5 L/s and less often 10 L/s. However, bore yields are very inconsistent and vary between 0.5 and 22 L/s. Higher yielding bores are associated with fracturing or a local source of recharge. The water quality is usually good.

The rock types consist of sandstone, siltstone and claystone sediments of the Upper Permian Hyland Bay Formation. An impervious claystone at a depth of 50 to 100 metres marks the base of the sandstone. This aquifer is the source of groundwater for the community of Wadeye and the outstations of Ditchi, Nangu, Kuduntiga, Ngardiniitchi, Old Mission, Kuy and Yedderr. Housing development is currently being extended along the road toward the Blacktip gas plant site.

The Wadeye community has a designated borefield for domestic water supply. The use of water from the reticulated water supply is reserved for drinking and the irrigation of lawns, community parks or football ovals. An essential service officer (ESO) with the Power Water Corporation maintains the community water supply.

Estimated daily water consumption for the Wadeye community is 1,295,000 L/day. This estimate is taken from Table 4 in the Wadeye Nauiyu water study report (Haig and Matsuyama 2003). It is based on records between 1999 – 2001, a population of 2,452 and usage of 528 L/person/day. Shallow aquifers also have environmental beneficial uses - supporting wetlands and spring-fed vegetation. The hyetograph of changing water levels in Port Keats shown in Figure 2 indicates that current consumption has not drawn the aquifer down. Water quality analyses from relevant outstation and community bores are summarised in Table 7, to which the water quality guidelines have been appended. Water quality is within Australian drinking water guidelines (ANZECC and ARMCANZ 2000) for the selected physical and chemical parameters.

The aquifer in this section of the route is a significant resource that will underpin agricultural and residential development in the Port Keats area into the future. The high quality of the groundwater resource requires a high level of protection.

Palumpa

A significant homeland supply occurs in the Southern Shallow Aquifer identified in the Wadeye/Nauiyu Water Study in the vicinity of Palumpa. The shallow aquifer occurs in sandstones extending from Table Hill in the south to the outstation of Tchindi in the north. Shallow bores have been successfully located, yielding between 1 and 5 L/s. A deep sandstone aquifer with bore yields between 4 and 20 L/s underlies the Woodycupaldiya area. Higher yielding bores in the shallow and in the deep aquifer are not necessarily associated with fracturing or faulting.

Daly River Basin (KP120-370)

Bores, dams, and springs located inside the pipeline corridor are listed in Appendix C. The Daly basin lies on a bed of Cambrian limestone and sandstone formations, but the surface formations are mostly of Cretaceous origin (Jolly 1984; Jolly *et al.* 2000). The area is characterised by three types of fractured, karstic rocks known as Tindal limestone (limestone and siltstone), Oolloo limestone dolomitic sandy limestone) and the Jinduckin Formation (a mixture of limestone, siltstone and shale). All three rock types contain extensive unconfined aquifers that serve as the primary groundwater resources in the area and, as a result, provide the base flow of the majority of the rivers and creeks in the Daly basin. Not surprisingly, groundwater has a very important role in wetland hydrology in the Daly basin (McGowan 1989; Begg *et al.* 2001).

The depth to the watertable varies from one year to another in response to rainfall amount. At sites underlain by Tindal limestone the watertable can vary during the course of a year from 3-25 m

Dorisvale (KP220-230)

Dorisvale has been provisionally selected as a site for a construction camp. Consequently, there are potential impacts from pipeline construction at the Dorisvale settlement. The hydrogeological mapping do not identify the area as having groundwater resources available for agricultural development. Consequently, ongoing risks arising from pipeline operations may be limited to impacts on the local water supply and environmental values in the Daly River.

Florina-Gum Creek (KP258-361)

A significant groundwater supply identified with land development potential extends between Florina and Gum Creek.

The limestone cave system in the dolomite aquifer down gradient from the pipeline alignment near KP350 (*Cutta Cutta Caves*) has significant heritage values that need to be protected.

Roper River Basin (KP370-630)

Bamyili-Beswick (KP390-KP420)

Water resources survey for Bamyili-Beswick indicates local weathered zone and fractured rock aquifers with yields up to 5 L/s. The Mataranka settlement on the Waterhouse River forty kilometres downstream of Beswick is well known for tourism activities focussed on groundwater fed springs.

Bulman (KP590-KP600)

A significant homeland supply occurs in fractured sandstone, siltstone and dolomite. Higher yields can occur in fault zones where the fracturing is intense or where the rocks are deeply weathered.

Goyder River Basin (KP630-770)

Community bores in the Goyder River Basin are listed in Appendix C. A shallow aquifer with large groundwater supplies occurs between KP700 and KP710. The aquifer type consists of poorly consolidated sandstone or limestone and has high porosity and permeability. The aquifer has a narrow intersection (downstream of the gas pipeline) with the headwaters of the Goyder River.

Buckingham River Basin (KP770-930)

Gove

Aquifers with large groundwater supplies occur between KP780 to KP810, KP820 to KP900 and KP910 to KP920. These sections are large regional aquifers that consist of poorly consolidated sandstone or limestone. They provide the most substantial and reliable groundwater resources in the region. This aquifer type has high porosity and permeability and can supply large volumes of water. Individual bore yields are generally more than 10 L/s and can be up to 50 L/s with efficient bore construction. This type of aquifer supplies water to the Alcan Refinery, Nhulunbuy and Yirrkala.

The volume of water that can be extracted from these aquifers may be sufficient for long term industrial or agricultural use. These aquifers naturally discharge large volumes of water throughout the year and are responsible for the baseflow of many of the large rivers. Consequently, these aquifers require a high level of protection from potential environmental impacts. Community bores are listed in Appendix C.

2.3 WATER QUALITY

Background water quality information presented in Table 7 was derived from the water quality monitoring data presented in the Wadeye/Nauiyu water study (Haig and Matsuyama 2003). Water quality data from other studies (Zaar *et al.* 1999; Erskine *et al.* 2003; Zaar 2003) were not available in a form that could be readily summarised. Typical water quality settings for northern Australia are located in Tables 3.3.4 and 3.3.5 in Chapter 3 of the Australian Water Quality Guidelines (ANZECC and ARMCANZ 2000) have been reproduced in Table 7. These values have been determined from regional data and are inherently conservative. The background ranges were within the guideline values. Consequently, background water quality is typical of relatively undisturbed ecosystems.

However, expert advice may be needed to interpret the guidelines. Dissolved oxygen values in Table 7 were derived from daytime measurements. Values may vary diurnally and with depth while pH values less than 6 are common in poorly buffered upland streams (e.g. sandstone country), where respiration from decaying organic material produces CO_2, thereby lowering pH (S. Townsend, DIPE *personal communication*). Electrical Conductivity in upland streams will vary depending on catchment geology. Values at the lower end of the range are typical of ephemeral flowing rivers in the NT. For other wetlands, values at lower end of the range are found in permanent billabongs in the NT but generally increase in the late dry season due to concentration effect of evaporation. Turbidity in NT rivers is generally low for base flow conditions while turbidity in wetlands will vary greatly, depending on general condition of catchment or river draining into the wetland, recent flow events & water levels.

Extreme water quality results can occur naturally that are well outside the ranges presented in Table 7. The ANZECC guidelines recommend that background variation in water quality is determined from a monitoring program based on at least two years of monthly monitoring data. The wet-dry tropical environment necessitates that two trigger values are derived, one for the wet season and another for the dry season.

Seasonal influences need to be defined. The extent of the available baseline water quality data does not meet this requirement of the ANZECC guidelines. However, for assessing the condition of ecosystems along the pipeline alignment, the 20 and 80 percentile values of parameter ranges are appropriate interim trigger values. Further site specific risk assessment may be required where these trigger values are exceeded to determine whether active remediation is required.

2.4 GROUNDWATER DEPTH

Dewatering will be required where the water table intersects the pipeline trench. The trench will be relatively shallow (1600 – 2500 mm) and dug during the dry season when water tables are receding and significant rainfall is unlikely.

Shallow groundwater depth is associated with wetlands, floodplains and drainage lines. Logged information on bores within the pipeline corridor was used to estimate the standing water level during the dry season when the pipeline will be constructed. Wet season groundwater levels are likely to rise closer to the surface but should not be relevant to assessing conditions during construction.

Bore logs in the pipeline corridor for the Moyle River Basin (Appendix C) indicate standing water levels between 2.9 and 23.4 m in shallow, unconfined aquifers. Groundwater variation reported in the Daly Basin (Erskine *et al.* 2003) indicates variation between 2 and 62 m during the course of the year. No bore log information or standing water level data were available for the Roper River Basin (Appendix C). However, groundwater studies describe seasonal variation in the shallow aquifer and indicate dry season standing groundwater levels below 2 m (Zaar 2003). Bore logs in the pipeline corridor in the Buckingham River Basin near Gove indicate standing water levels between 0.2 and 35.6 m in shallow, unconfined aquifers (Appendix C). The very shallow groundwater measurement was taken in the wet season (February). Shallow groundwater levels are closely linked to annual rainfall and stream flow. The shallow groundwater level rises rapidly during the wet season in response to rainfall and provides stream baseflow into the dry season, with groundwater levels falling rapidly in the subsequent dry season.

2.5 ACID SULFATE SOILS

Potential acid sulfate soils constitute a risk to downstream environmental quality. These soils occur in coastal plain landscapes at low elevations and when they are excavated and drained to produce low pH leachate containing toxic concentrations of acid, iron, aluminium and heavy metals. These may contaminate land and adjacent waterways, severely degrading the in-stream environment.

Inland occurrence of these soils is associated with stranded shorelines leaving Quaternary (or sometimes older) estuarine sediments at some distance from the coast and at elevations above sea level. In some instances in southern Australia, rising saline water tables in sand plain landscapes have formed secondary sulfides from buried estuarine sediments in combination with waterlogged pastures and lead to acid sulfate soil development (Hollingsworth *et al.* 1996). Current guidelines (ARMCANZ 1999; Dear *et al.* 2002) identify acid sulfate soils with Quaternary sediments in coastal environments below 5 m AHD, and the possibility of these soils occurring at higher elevations in near coastal sedimentary environments. The national strategy (ARMCANZ 1999) for the management of coastal acid sulfate soils recognises that elevations less than 10 m AHD represent an acid sulfate soil risk. While current land management advice in Queensland identifies coastal environments at elevations below 10 m AHD with acid sulfate soil risk. In the NT, geomorpholgical studies on the Mary River floodplain indicate Holocene sediments occur below 4 m AHD (Woodroffe and Mulrennan 1993). Advice on the distribution of acid sulfate soils along the NT coastline is based on generalised land resources mapping (1:250 000) which needs to be supported with site investigation by an accredited soil scientist. Coastal acid sulfate soil mapping is currently under review nationally and advice is likely to change. However, based on current information, acid sulfate soil risk is associated with coastal wetland and floodplain environments at elevations below 10 m AHD.

Areas where the pipeline alignment intersects low-lying coastal wetlands were identified with a risk of potential acid sulfate soils. The 20 m contour is the lowest elevation on the 1:100,000 topographic base mapping. Coastal wetlands are identified in the NT oil spill response atlas (Gecoz 2001). Consequently, areas where the pipeline alignment intersects coastal wetland mapping at elevations below 20 m AHD were identified as a risk of potential acid sulfate soils. Ten wetland areas assessed with potential acid sulfate soil risk are listed in Table 8.

3 IMPACTS FROM CONSTRUCTION AND OPERATION

The impact assessment starts with a statement of the environmental values that need protection. This is followed by description of project construction and operation activities that constitute some risk to the environmental values. Finally a qualitative risk assessment is made to focus management recommendations on likely environmental issues with significant consequences to the receiving environment.

The environmental values requiring protection are:

- water supply (drinking water, stock watering and irrigated agriculture);
- aquatic ecosystems; and
- cultural and spiritual values.

Assessing the cultural importance of water resources will require consultation with landowners having direct cultural responsibility for particular water bodies and is not addressed in our report.

3.1 PIPELINE IMPACTS

The proponent provided the following project details:

- Project Design Basis Manual, Document Ref. 138320, Revision D, 7th January 2004;
- Pipeline Design Basis, Document Ref. 138321, Revision C, 8th January 2004;
- Construction Plan, Document Ref. 77602-305-071, 19th February 2004, Revision D;
- Infrastructure Upgrade, Document Ref. 77602-305-073, 19th February 2004, Revision C; and
- Logistics Plan, Document Ref. 77602-305-072, 18th February 2004, Revision D.

The Pipeline

Where the pipeline is located in areas with recognised groundwater resources it poses some risk of hydrocarbon contamination during its operation. The principal receptors are groundwater systems, marine & coastal systems and inland waterways. Map 1 shows the project infrastructure, surface drainage, wetlands, bore locations, stream gauging locations and hydrogeological units.

While the nature of the groundwater resources and associated surface drainage systems over sections of the route from KP000 to KP016, KP780 to KP810 and KP820 to KP910 warrant a high level of protection, gas in its transported form should pose no risk of soil or groundwater contamination. The gas from Blacktip reservoir will be separated at the Blacktip Gas Plant from other reservoir fluids, namely produced water and condensate, and then compressed for available markets. The piped hydrocarbon is a volatile gas which is less dense than air and will vent from buried infrastructure to the atmosphere (Beer *et al.* 2000).

During pipeline construction, impacts to freshwater aquatic life may arise in areas where sediment load into creeks is increased during the wet season as a result of land clearing and earthmoving without the necessary sediment and erosion control. Appendix B lists the 426 surface water features that the proposed route will cross, namely:

- 16 major rivers and streams namely: Anopheles Creek, the Moyle River, Bradshaw Creek, Daly River, Katherine River, King River, Roper Creek, Beswick Creek, Waterhouse River, Flying Fox Creek, Mainoru River, Wilton River, Goyder River, Boggy Creek, Giddy River and Latram River;
- 338 seasonal and irregular rivers and streams;
- 3 riverine floodplains approximately 10 km wide with grassland and savannah vegetation subject to seasonal flooding;
- 63 seasonal/intermittent freshwater ponds and marshes approximately 10 km wide; and
- 5 freshwater springs.

Most of these surface water features occur within five river basins in the national catchment framework for surface water management, namely Moyle, Daly, Roper, Goyder and Buckingham River basins.

The following sections of the pipeline route (starting from the gas plant at Wadeye) could potentially impact on aquifers that have significant development potential or high resource value to the community:

1. 0 to 10 km (Moyle River Basin);
2. 300 to 350 km (Tindal – Katherine Groundwater Management Area, Daly River Basin)
3. 780 to 810 km (Goyder River Basin);
4. 820 to 910 km (Buckingham River Basin).

Access and Laydown Areas

Additional access will be created where the pipeline right of way departs from the existing road infrastructure. From Wadeye to the Moyle River (KP 80) and from the Daly River (KP 265) east to Gove (KP 940) the existing roads will be used for the major movements of plant and equipment. In these areas, temporary access tracks will be constructed to the right of way in several places. There is no existing road infrastructure between KP89 and KP265 and the majority of plant and equipment will need to be moved along the right of way.

Road construction and maintenance activity can direct turbid runoff into the surface drainage system. Sediment and erosion control measures will be needed to protect downstream water quality values where temporary and permanent access crosses the surface drainage system.

Ancillary Systems

Logistical plans allow for the transport of 3,500 T diesel loads during construction. The diesel and chemical storage and distribution systems have the potential to impact groundwater and surface water resources over the life of the project. The types and quantities of chemicals required for production, maintenance and operation are not yet known.

3.2 WATERWAY CROSSINGS

Directional drilling, horizontal boring and open cut methods have been proposed as the preferred construction options. Directional drilling will be appropriate to minimise impacts where permanent water bodies are intersected. Horizontal boring will be appropriate for crossings at sealed roads, highways and where embankments are to be penetrated. Open cut methods will be appropriate for the ephemeral and seasonal watercourses and wetlands that the pipeline intersects.

Sixteen significant watercourse crossings were identified, namely: Anopheles Creek, the Moyle River, Bradshaw Creek, Daly River, Katherine River, King River, Roper Creek, Beswick Creek, Waterhouse River, Flying Fox Creek, Mainoru River, Wilton River, Goyder River, Boggy Creek, Giddy River and Latram River.

We did not initially rank crossings on King Creek, Roper Creek, Flying Fox Creek, Mainoru River, Goyder River or Boggy Creek as significant because the drainage data identified these streams as seasonal rather than permanent watercourses. However, Section 2.3, Watercourse Crossings, in the Trans Territory Pipeline Construction Plan (Alcan Engineering, 19 February 2004, 77602-305-071 Rev D) identified that these watercourse crossings may require directional drilling due to environmental or construction considerations. Our analysis of significant watercourse crossings includes all the streams listed as significant in the construction document, plus the crossings on Bradshaw Creek (Table 3).

3.3 HYDROSTATIC TESTING & WASTEWATER

Integrity testing compliant with the requirements of Australian Standard AS2885.1, involves static pressure testing for strength and potential leaks by filling with water and pressurising to a pressure greater than its normal operating pressure. Design documentation indicates that water for pressure testing could be extracted from surface water, groundwater or marine sources. Each 1 km section of pipe will require 1.25 ML of water for pressure testing. The volumes to be extracted and disposed of will have potentially significant impacts on ephemeral surface water bodies. The potential impact will depend on the chemistry of the source (marine or freshwater) and whether it is disposed of to surface streams, land application or ocean outfall.

Local bores, rivers and creeks are identified in the construction plan as possible sources of water for pressure testing. Hydrotest water containing biocides and oxygen scavengers will be discharged. The most significant potential impacts of hydrostatic pressure testing are associated with the pumping of water into a wetland that originates elsewhere (either surface or groundwater). For surface water:

- aquatic biota may be physically removed from water bodies by pumping.
- substantial/complete abstraction of water from small water bodies may impact on aquatic ecosystems by removal of dry season refuges, therefore affecting species composition/abundance.

- translocation of water from one water body to another poses a risk of introducing non-endemic aquatic biota, therefore changing species composition and predator-prey relationships.
- change in physical/chemical properties (e.g. temperature, pH, salinity) of water may impact on aquatic biota by changing species composition/abundance.

For groundwaters, a change in physical/chemical properties (e.g. temperature, pH, salinity, chemical additives) of water may impact on:

- aquatic biota by changing species composition/abundance; and
- drinking water quality.

There will also be potential impacts from water supply and disposal for construction camps. Construction camps comprising up to 100 bunkhouses, mobile generators (900 to 1500 Kva) and wastewater and sewerage systems will be established for each construction spread. Camp water will be extracted from local groundwater bores, potentially lowering local water tables. Camp wastewater discharged into either septic tanks and absorption trenches, or treated by a bio-filter sewerage plant could introduce biological contamination into the groundwater.

3.4 DEWATERING

Based on the groundwater depth information presented in Section 2.4, the pipeline trench is unlikely to intersect shallow groundwater during the dry season. Directional drilling techniques will be used where significant watercourses are traversed, removing the need for trenching. Diverting surface runoff away from the trench will further reduce the need for dewatering in the event of unseasonable storms. Consequently, no significant dewatering is envisaged during pipeline trenching. However, depending on seasonal rainfall pattern and amount, some dewatering may be required in seasonal wetland areas.

Based on the limited extent of dewatering likely to be required, we do not expect that the localised lowering of water tables, or the associated impact on aquatic flora and fauna, will be significant. In the event that acid sulfate soils are identified in coastal wetlands being excavated, the wastewater will need to be treated and disposed according to guidelines for acid sulfate soil management (Dear *et al.* 2002).

3.5 CONSULTATION

Advice from the project officer in the supervising authority (Rod Johnson, NT Environment & Heritage) and expert hydrological advice (Peter Jolly, NT Department of Infrastructure, Planning & Environment) was provided. The agenda for this discussion is given in Appendix A. Our advice from this consultation focussed on the following issues:

- define the extent of disturbance associated with cathodic protection arrays (document 13832-7);
- identify possible metal contaminants (extrusion treatments/surface coatings) associated with the pipe pressure testing using water;
- identify possible contamination associated with epoxy mechanical/abrasion protection coatings;

- confirm the length of pressure testing/staging sections for calculating water volumes for hydrostatic testing (10 km sections have been assumed);
- complete outstanding project documentation (Project Design Basis Manual Doc. ref. 138320, 7th Jan 2004) - Pipeline Crossing Study, site earthworks drawings, Cathode Protection and Earthing Specification; and
- hydrocarbon pipeline, storage and processing infrastructure in the vicinity of high quality groundwater resources will require detailed fate and transport assessment consistent with investigations for contaminated site risk assessment.

The proponent responded with current information on cathodic protection (CP) arrays. Shallow ground beds will probably be used in which case a trench will be dug 3 m deep, 600 mm wide and 25 m long. Eight anodes surrounded with petroleum coke (conductor) in a bag will be placed in the trenches, which will be backfilled to bury the anodes. Riser pipes will be inserted into the trenches to allow for watering if required. Beds can be up to 500m from the pipeline and are connected by a buried cable. Beds will usually be located at scraper facilities as the CP system requires a source of power (solar).

The proponent responded with current information on potential contamination from linepipe coatings. Linepipe is not coated internally and therefore will only contaminate the hydrotest water with rust. The pipe will be heated during the coating process so that any oil used in the forming of the pipe will likely have been removed. Note that the pipe is not extruded but is continuously formed from a flat strip and an Electric Resistance Weld (ERW) used to join the edges of the strip. An oxygen scavenger such as sodium sulphite may be used in the hydrotest water to minimise corrosion of the pipe. The joint coating is on the outside of the pipe and will not come in contact with the hydrotest water.

The proponent responded with current information on water volumes required for hydrotesting for the TTP project. Assuming three construction spreads and water is used three times at each spread, then each spread would require 12,500 m3. This is based on filling and testing a 100 km section of pipe and then pushing the water along to the next section. Total requirement for pipeline is 37,500 m3. This is probably a minimum requirement. If the water is only used once the volume required would be approximately 100,000 m3.

3.6 RISK ASSESSMENT & SAFEGUARDS

The hydrological impacts that have been identified and discussed in terms of receptors and impact types are listed in Table 10. The qualitative system of risk assessment applied an assessment of consequence and likelihood to evaluate risk for each of the potential environmental impacts in Table 10. The *consequence* of environmental impacts was classified according to Table 11. The *likelihood* of a failure occurring was classified according to Table 12. Our professional judgement was used to assess the *consequence* and *likelihood* for each impact type. The likelihood and consequence allocations of issues were multiplied and the product used to rank and prioritise the issues Table 13. The results of the risk assessment associated with particular construction and operating activities are presented in Table 14

Environmental impacts with a risk ranking of 5 or more in Table 14 (shown shaded) were considered moderate to high risks to the public and/or the environment. Subsequently, mitigation measures are recommended in the following section of this report to reduce the likelihood and hence the resulting environmental risk to a low level. The residual risk rating after mitigation measures are implemented is shown in the last column of Table 14. Issues with a score of less than 5 were considered a low risk to the environment. However, further consideration in the project design may be justified based on the precautionary principle.

4 IMPACT MITIGATION RECOMMENDATIONS

Recommendations and statements of intent from the proponent may need to be changed as particular aspects of the project design are completed. During the construction phase of the project, mitigation actions are needed to address the moderate risks of environmental impact that are associated with land and waterway disturbance, fuel storage and transport and on ensuring a high level of environmental performance during the operational phase of the project. During the project operation, mitigation actions are focussed on addressing the moderate risks of environmental impact that are associated with the processing, storage and transport of hydrocarbons. Site security, maintenance and monitoring activities will be important components of the risk management system. During the decommissioning phase of the project, mitigation actions will be focussed on minimising the risk of turbidity arising from land disturbance on receiving wetland and coastal environments, and meeting stakeholder expectations of the closure process.

Specific recommendations arising from our desktop review of risk to surface and groundwater hydrology follow.

Groundwater & surface water protection

1. Implementing a water management plan with respect to hydrostatic testing, potable water supply and wastewater disposal will reduce the risk to receiving water bodies. We recommend that the proponent develops a water management plan:

   - specifying consultation with landowners is made prior to hydrotesting to develop an agreed plan for extracting and disposing of test water taking cultural as well as physical and chemical water qualities into account;
   - stipulating marine or groundwater sources are used for hydrotest water;
   - if seawater is used, then disposal of the hydrotest water to the ocean outfall is recommended;
   - if a groundwater source is used, then disposal of hydrotest water by land application to stable (rocky) vegetated areas could be considered;
   - ensuring trench dewatering (if any) is disposed of by land application; and
   - ensuring the water quality criteria for receiving surface and groundwater systems are met.

2. Design of chemical, fuel storage and waste water treatment facilities will reduce long term risks to the hydrological environment. We recommend that the proponent:

   - where possible, stores fuel and chemicals outside of sections of the route identified with groundwater sensitivity;
   - stores fuel and chemicals above ground;
   - makes regular fuel inventory measurement and record reconciliation to identify leakage loss;
   - implements leak detection systems in fuel storages and regular visual inspection for leaks;

- where above ground storage is not possible, designs underground storage tanks incorporating a double wall with an interstitial space that can be monitored, corrosion protection, overfill protection and removal or transfer connections located within a spill containment device;
- designs fuel & chemical storage facilities and handling equipment according to legislation and Australian guidelines to prevent and contain any spills; and
- in areas where groundwater sensitivities have been identified, constructs septic adsorption trenches for waste water disposal at least 400 m from any production bores otherwise septic adsorption trenches need to be at least 100 m from production bores;
- treats and disposes of sewage and putrescibles generated from the accommodation camp according to NT government codes of practice.

Water course protection

3. As a general principle, confining construction and operational activities involving land disturbance in the second and third quarters (dry season months between May and September) will reduce environmental risks associated with the project.

4. An effective sediment and erosion control program is needed to mitigate potential impacts from turbidity in runoff during construction and operation. We recommend the proponent develop and implement a sediment and erosion control plan that:

   - follows guidelines for the control of erosion and sedimentation at construction sites (Witheridge and Walker 1996) and NT soil conservation guidelines (Hadden 1993);
   - demonstrates control of all drainage onto, and leaving disturbed areas at all times;
   - includes reinstating the 'running track' along the right of way (ROW) or working width by:
     - loosening excessively compacted soil by harrowing, ripping or equivalent;
     - reinstating sub-soil and topsoil layers over the cleared area;
     - respreading cleared vegetation leaving only a 4WD track with surface drainage to control erosion and sedimentation;
   - manages access route and laydown area construction to mitigate potential impacts from turbidity on surface water and hydrocarbons on groundwater resources by:
     - specifying the precautions to be taken to minimise the potential impacts associated with land disturbance and road use in the sediment & erosion control plan;

5. The erosion and sediment control plan will need to specify the precautions taken during access track construction and pipeline installation to contain sediment, minimise erosion and stabilise the work area when watercourses, drainage depressions and wetlands are crossed. Directional drilling methods need to be considered at the 14 major river and stream crossings that we identify in Table 3. Open trenching methods followed by reinstatement of bed and bank profiles will be used at other wetland and stream crossings. The suggested design guidelines for crossings not prescriptive and are based on construction standards used in Queensland (Witheridge and Walker 1996) which form the basis of recommended sediment and erosion control measures used in the Northern Territory:

A. Pipeline crossings

- construct pipeline crossings at right angles to the direction of water flow;
- remove felled trees from the floodplain if there is the potential for this material to cause damage downstream if they are carried away in flood waters;
- minimise clearing of riparian vegetation;
- keep the width of disturbance to 6 m or less if possible;
- keep cut and fill to 0.6 m or less if possible;
- construct in a stable (straight) stream section;
- cross along the shortest possible route;
- prevent crossing from storing or diverting water;

B. Vehicle crossings

- gravel or rock cover the approaches, otherwise track layout and drainage design will be needed to prevent water from running down the approaches and into the stream;
- make service track approaches to water courses as level as practicable, otherwise gravel cover the wheel tracks on the approaches;
- protect access to a gully or water course with a diversion channel immediately above the access cut;
- avoid box cuttings in road construction as they present drainage problems, otherwise establish diversion drains to facilitate cross drainage;
- direct access down banks in the downstream direction;
- clear all fill material from the water course not used to backfill excavations.

C. Permanent crossings

- do not use fords where the stream has a deep cross-section requiring considerable excavation on the approach roads;
- consider the effects of debris blockages and erosive forces caused by overtopping flows in culvert design;
- make culverts 450 mm diameter or larger and discharge over stable surfaces (not fill);
- make the culvert flow area approximately equal to the in-bank area of the watercourse.

D. Temporary crossings

- locate crossings on sites with stable stream bed material where bank restoration will be possible;
- time construction activities to coincide with dry weather;
- restore bed and bank profiles to as near as possible to their original condition;
- drain approaches to prevent runoff flowing directly into the stream.

6. A plan for decommissioning and rehabilitation developed in consultation with relevant authorities and stakeholders will help to ensure that the area is suitably rehabilitated with acceptable levels of risk and impact remaining to surface and

groundwater beneficial uses at the end of the project. We recommend that the proponent:

- determines and agrees on decommissioning activities and implementation with stakeholders in accordance with legislation, guidelines and industry best practicable technology; and
- plans to flush residual hydrocarbons out of the onshore pipeline; and
- makes a decision in regard to best approach to the onshore component of the pipeline that will minimise potential environmental impacts and comply with legislative requirements, relevant Australian Standards and industry practice.

Downstream water quality safeguards

7. Reinstatement to the level of the surrounding natural ground surface will minimise the risk of channelled runoff causing erosion and off-site sedimentation. Otherwise where there is a risk of channelled runoff along the pipeline, drainage diversion banks will be required at approximately 50 m spacing beginning at the top of the slope in most situations. Local knowledge is the best guide to the appropriate bank spacing with optimum spacing at the distance rilling is observed for particular combinations of soil and slope. In the absence of local knowledge and where slopes exceed 9 % (15^0) and are not rocky, space diversion banks according to Table C4.1 in Institution of Engineers Australia (Witheridge and Walker 1996) reproduced in part below. Refer to the Revised USLE calculation procedure in this publication (Section B4) to estimate erosion hazard classes in the table below.

Grade	Maximum spacing of diversion banks	
	Low hazard[1]	Moderate and high hazard[2]
<9% (5^0)	60	30
9 to 27 % ($5\text{-}15^0$)	40	20
27 to 47 % ($15\text{-}25^0$)	20	10
=47 % (25^0)	10	10

[1] soil loss class 1 based on Revised USLE soil loss rate assessment of less than 300 t/ha

[2] soil loss class 2 or 3 based on Revised USLE soil loss rate assessment of above 300 t/ha

8. For sections of coastal wetland identified on the route a reconnaissance survey by an accredited soil scientist of potential acid sulfate soils is required. Where field testing identifies potential acid sulfate soils, further laboratory testing and a management program based on *ASS Soil Management Guidelines* (Dear *et al.* 2002) is warranted. Any dewatering of acid sulphate soils will need to be neutralised with lime and disposed of by land application away from drainage lines.

9. The proponent needs to implement engineering safeguards at waterway crossings to reduce the risk of pipeline failure specified in design documentation (Trans-Territory Pipeline (TTP) Engineering, Pipeline Design Basis, Document Ref. 138321), namely:

- increase the pipeline design specification for watercourse crossings to reduce the risk of pipeline exposure and damage;
- use heavy wall pipe at all crossings;
- use concrete weight coating or bolt-on weights at open cut crossings where there is significant risk of scour and/or erosion;
- increase surface cover over the pipeline at waterway crossings (at least 750 mm cover has been specified along the general pipeline route, 1200 mm at road crossings and 1500 mm at river crossings for adequate protection); and
- clearly identify the pipeline with pegs and an indicator tape placed above the pipeline at road crossings to alert people doing excavations to its location.

10. Key surface water quality parameters (Table 7) will need to be monitored in areas where water is discharged and there is a perceived risk to groundwater and surface water resources. The proponent will need to:

    - monitor groundwater and/or surface water level and quality to assess pipeline impacts on the local surface water and groundwater systems in high environmental risk areas between KP000 to KP016, KP300 to KP350, KP700 to KP710, KP780 to KP810 and KP820 to KP910.

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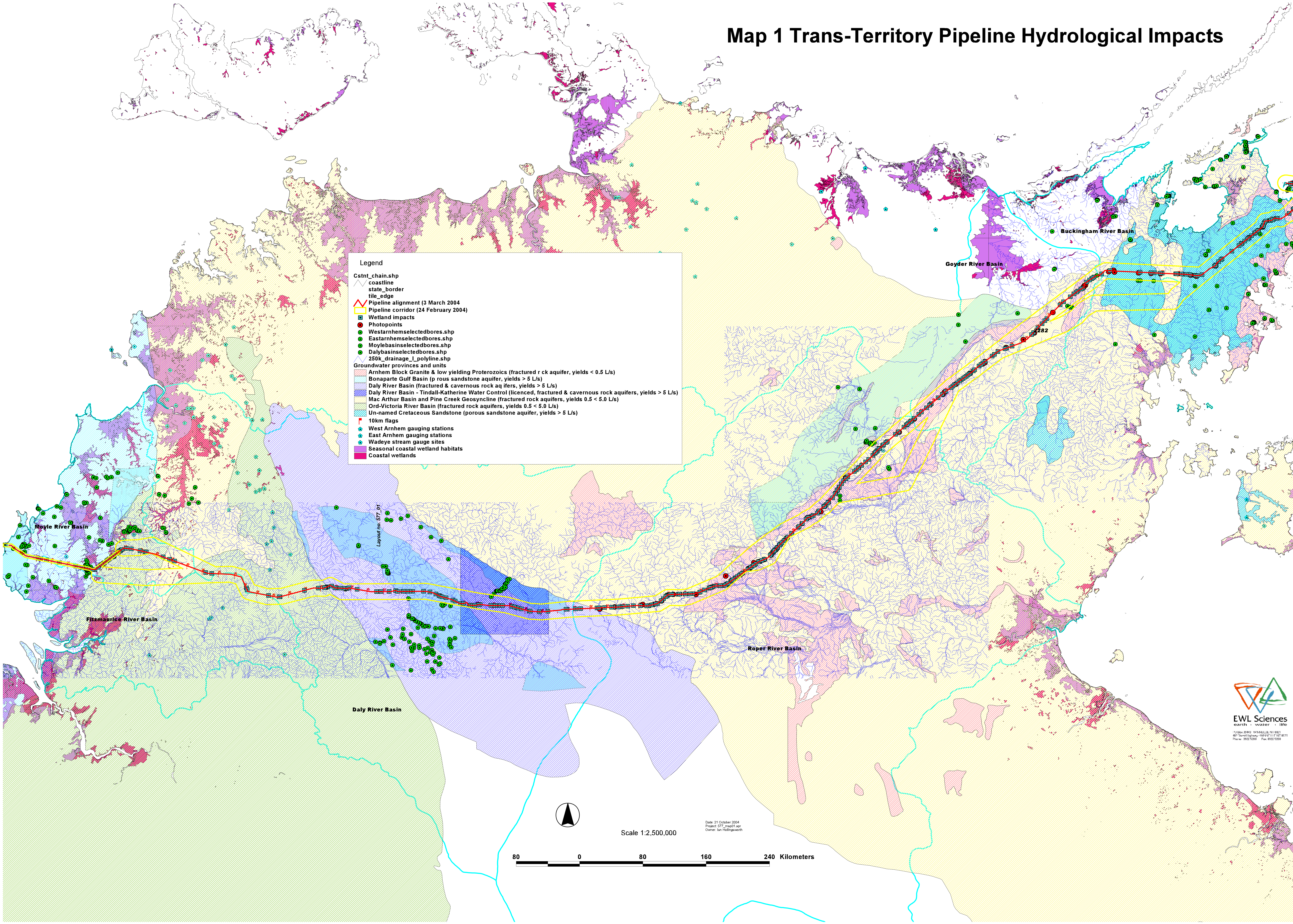
MAPS


Map 1 Trans-Territory Pipeline Hydrological Impacts
Legend
Cstnt_chain.shp
coastline
state_border
tile_edge
Pipeline alignment (3 March 2004
Pipeline corridor (24 February 2004)
Wetland impacts
Photopoints
Westarnhemselectedbores.shp
Eastarnhemselectedbores.shp
Moylebasinselectedbores.shp
Dalybasinselectedbores.shp
250k_drainage_l_polyline.shp
Groundwater provinces and units
Arnhem Block Granite & low yielding Proterozoics (fractured r ck aquifer, yields < 0.5 L/s)
Bonaparte Gulf Basin (p rous sandstone aquifer, yields > 5 L/s)
Daly River Basin (fractured & cavernous rock aq ifers, yields > 5 L/s)
Daly River Basin - Tindall-Katherine Water Control (licenced, fractured & cavernous rock aquifers, yields > 5 L/s)
Mac Arthur Basin and Pine Creek Geosyncline (fractured rock aquifers, yields 0.5 < 5.0 L/s)
Ord-Victoria River Basin (fractured rock aquifers, yields 0.5 < 5.0 L/s)
Un-named Cretaceous Sandstone (porous sandstone aquifer, yields > 5 L/s)
10km flags
West Arnhem gauging stations
East Arnhem gauging stations
Wadeye stream gauge sites
Seasonal coastal wetland habitats
Coastal wetlands
Buckingham River Basin
Goyder River Basin
Moyle River Basin
Fitzmaurice River Basin
Roper River Basin
Daly River Basin
Layout no. 577_01
2282
EWL Sciences
earth · water · life
Scale 1:2,500,000
Date: 21 October 2004
Project: 577_map01.apr
Owner: Ian Hollingsworth
80 0 80 160 240 Kilometers

FIGURES

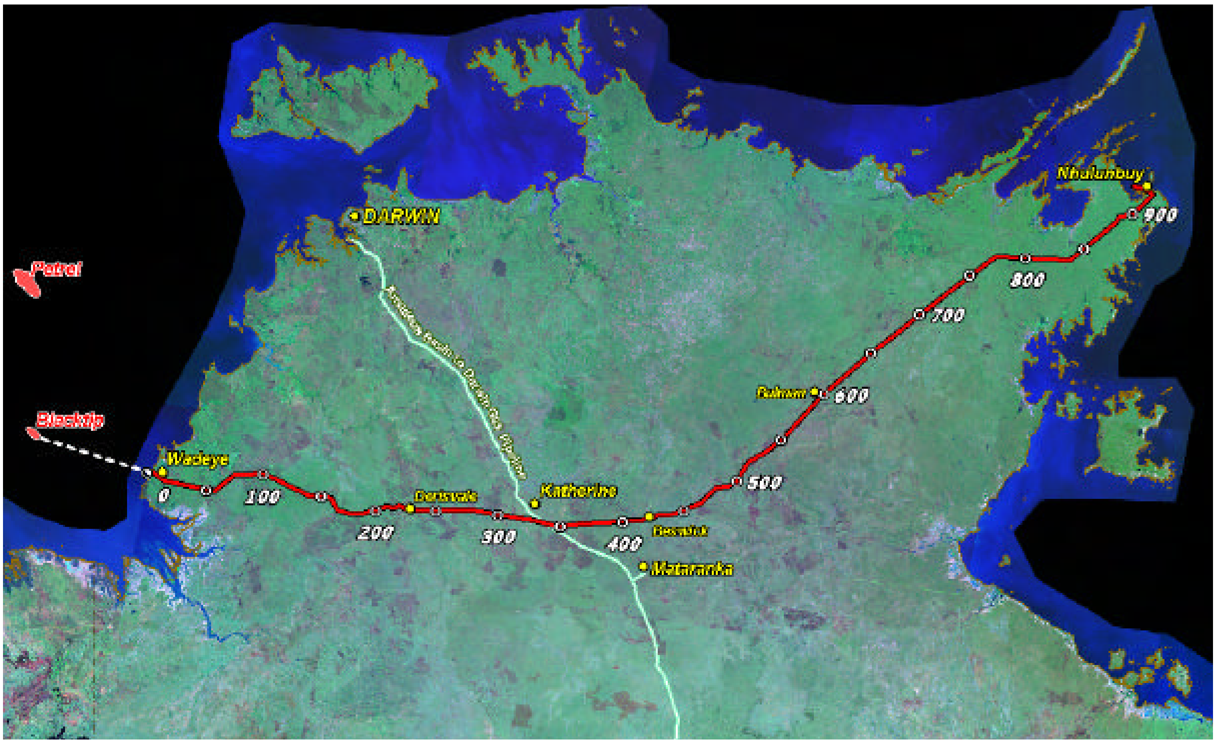


Figure 1 TTP pipeline alignment (as of February 2004)

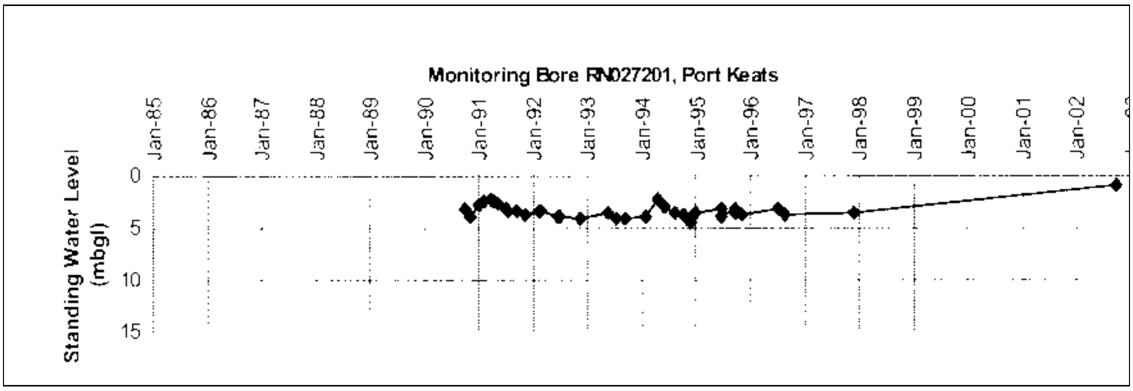


Figure 2 Monitoring bore data, Port Keats

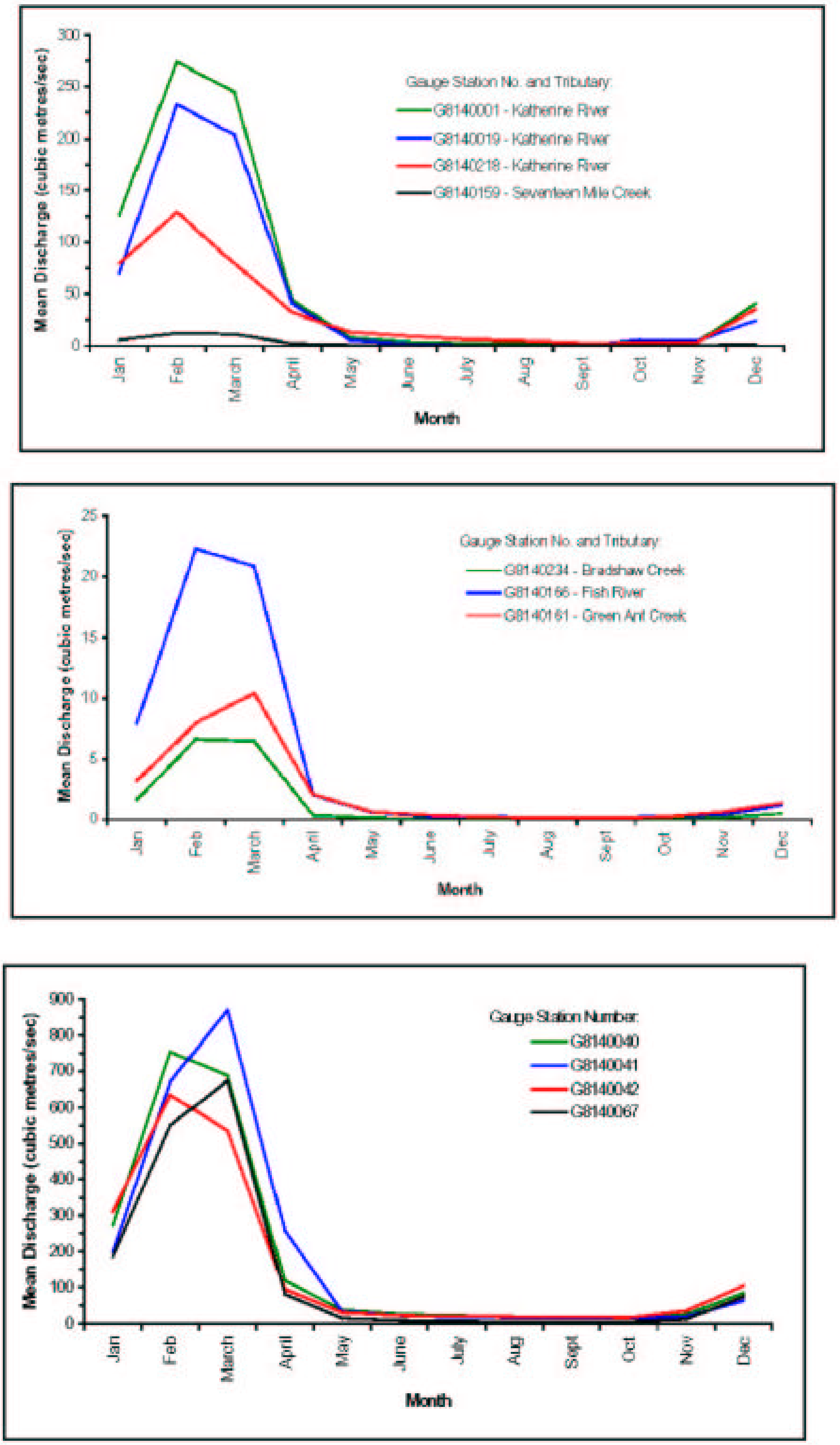


Figure 3 Mean monthly discharge indicating stream flow period (from Zaal *et al* 2003)

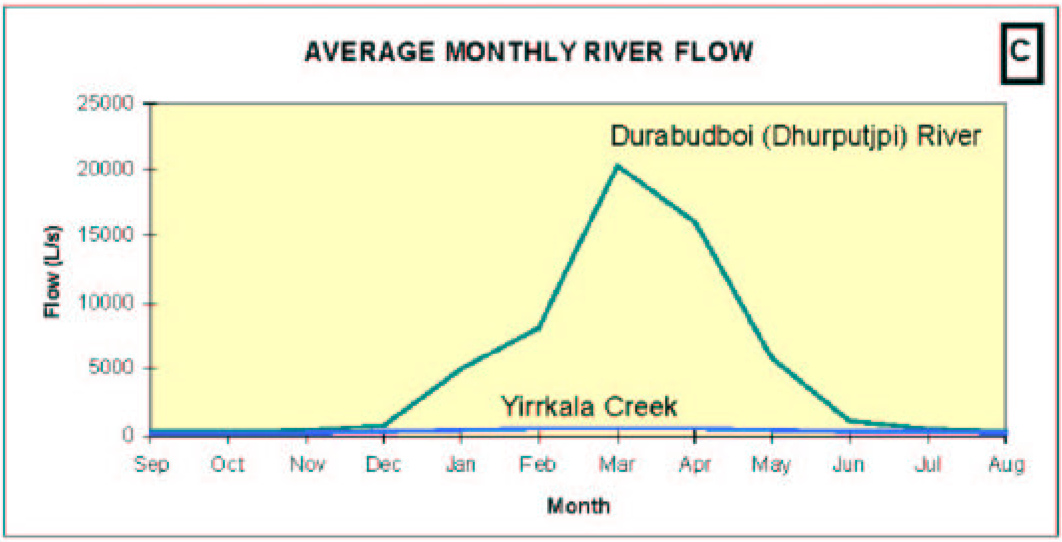


Figure 4 Stream flow period in Buckingham River catchment

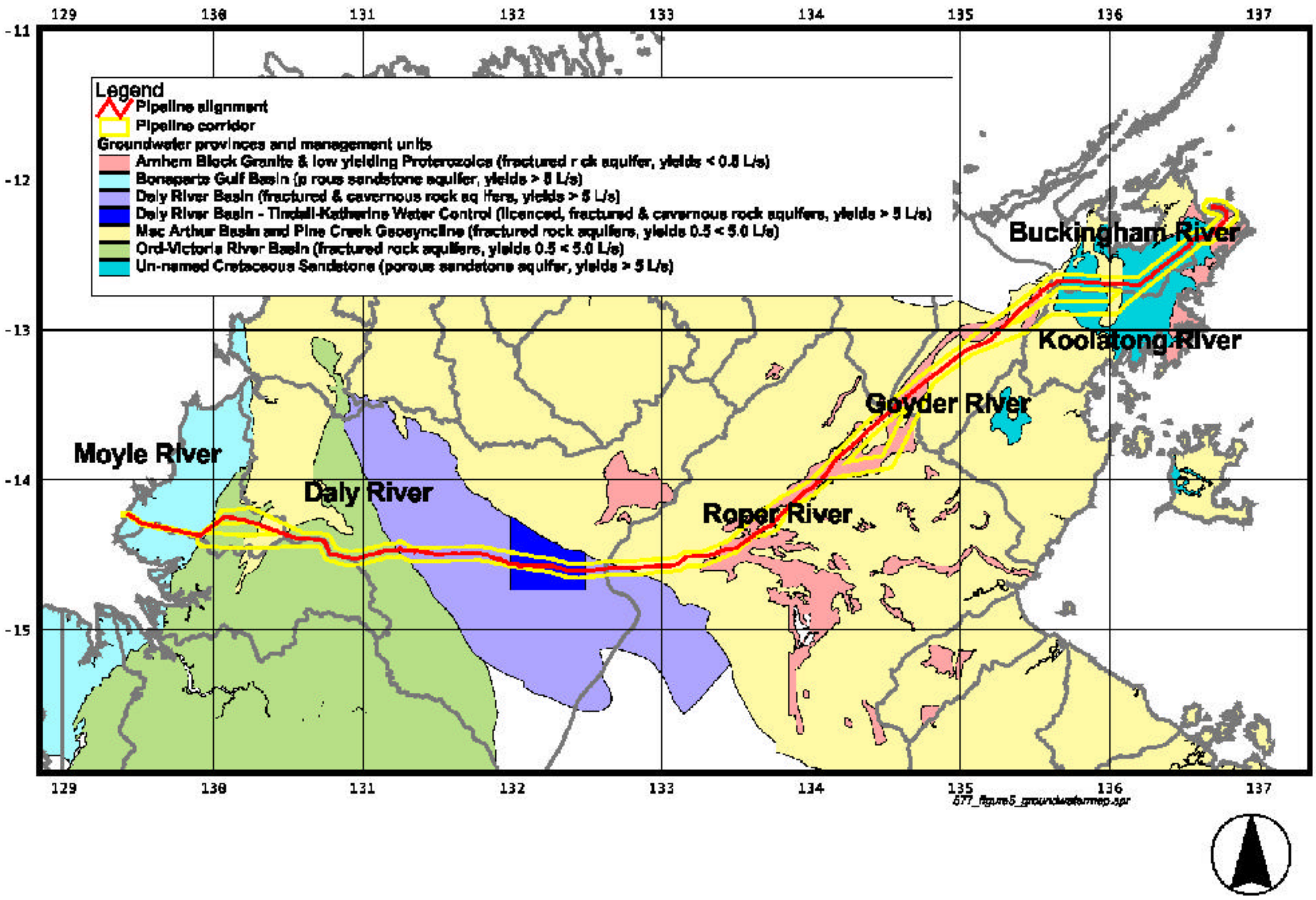


Figure 5 Groundwater resources

TABLES

Table 1 Information sources used

Theme	Document/file	Date	Company	Source
Project Description				
	R11UMP_DraftA_Ch4.doc	3/3/04	SKM	Ceri Morgan
10 km staging points	10k_Flags_5_20040303_point.shp	30/3/04	Mipela	Hayden McDonald
Pipeline alignment	Pipeline_Alignment_5_20040303_polyline.shp	30/3/04	Mipela	Hayden McDonald
Pipeline corridor	Pipeline_Corridor_5_20040224_region.shp	30/3/04	Mipela	Hayden McDonald
Drainage	Drainage_250k_polyline.shp	30/3/04	Mipela	Hayden McDonald
Roads	Roads_250k_polyline.shp	30/3/04	Mipela	Hayden McDonald
Locality	Locality_250k_point.shp	30/3/04	Mipela	Hayden McDonald
Acid Sulfate Soil Risk				
Seasonal coastal wetlands	Seasonal_wetlands	21/7/01	EcOz	GecOz (2001)
Coastal wetlands	Nt_wetlands.shp	21/7/01	EcOz	GecOz (2001)
Hydrology				
WADEYE/NAUIYU				
hydrogeology	All_hydro_final.shp	26/8/03	DIPE	Lynton Fritz
Stream gauges	all_stream_gauge_sites.shp	24/10/02	DIPE	Lynton Fritz
Bores	all_keats_bores.shp	8/11/02	DIPE	Lynton Fritz
DALY BASIN				
	Daly_bores_dams_springs	March 2003	DIPE	Erskine et al (2002)
hydrogeology	Dalyavailablegroundwater.shp	March 2003	DIPE	Erskine et al (2002)
hydrogeology	Kath94_poly_region	5/10/04	Mipela	Justin Fielke
ROPER BASIN		5/10/04	Mipela	Justin Fielke
hydrogeology	Jawoyng94_poly_region.shp			
GOYDER BASIN				
West Arnhem Land				
	groundwater.shp	1/11/02	DIPE	Lynton Fritz
	Warnhem_gauges.shp	30/10/02	DIPE	Lynton Fritz
	bores.shp	12/08/02	DIPE	Lynton Fritz
BUCKINGHAM BASIN				
East Arnhem Land				
	eastarnhemselectedbores.shp	18/02/00	DIPE	Lynton Fritz
	Earnhem_gauges.shp	17/10/99	DIPE	Lynton Fritz
	groundwater.shp	13/11/99	DIPE	Lynton Fritz
NORTHERN TERRITORY				
NT groundwater management units	gmushape.shp	24/07/01	DIPE	Lynton Fritz
National groundwater provinces	Provinceshape.shp	20/12/00	DIPE	Lynton Fritz
NT groundwater resources	Groundwaterunits.shp	20/7/04	EWLS	Ian Hollingsworth (provinceshape.shp and gmushape.shp dissolved on selected units)
1:100,000 coastline	cstnt_chain.shp	30/6/04	Ausgeo	Inernet

Table 2 Catchment statistics

		Moyle	Daly	Roper	Goyder	Buckingham
Parameter	*Units*					
Area	*km²*	7,020	52,940	79,130	10,360	8,330
Runoff	*ML/yr*	600,000	6,740,000	5,540,000	1,685,000	2,800,000
Diversions	*ML/yr*	0	7,465	526	0	0
Sustainable yield	*ML/yr*	110,000	1,110,000	950,000	302,800	440,000
Estimated use in 2020	*ML/yr*	nil	102,770	620	nil	nil
Estimated use in 2050	*ML/yr*	nil	104,530	720	nil	nil
Disturbance		<30%	<30%	<30%	<30%	<30%

Table 3 Permanent rivers and streams[1]

ID	Start distance (KP)	End distance (KP)	Name	Surface drainage feature type	Feature code[2]	Latitude	Longitude
Moyle River Basin (KP000-120)							
411	55	65	Anopheles Creek	Permanent rivers and streams	B1	-14.3811	129.912
385	75	85	Moyle River	Permanent rivers and streams	B1	-14.2771	130.065
Daly River Basin (KP120-370)							
365	225	235	Bradshaw Creek	Permanent rivers and streams	B1	-14.4897	131.355
367	225	235	Bradshaw Creek	Permanent rivers and streams	B1	-14.4901	131.355
414	255	265	Daly River	Permanent rivers and streams	B1	-14.5063	131.678
414	255	265	Daly River	Permanent rivers and streams	B1	-14.5063	131.678
307	295	305	Katherine River	Permanent rivers and streams	B1	-14.5842	132.051
Roper River (KP370-630)							
211	395	405	Beswick creek	Permanent rivers and streams	B1	-14.5947	132.896
186	415	425	Waterhouse River	Permanent rivers and streams	B1	-14.5784	133.107
272	495	505	Flying Fox Creek	Permanent rivers and streams	B1	-14.2821	133.7771
294	**545**	**555**	**Mainoru River**	Permanent rivers and streams	**B1**	**-14.0228**	**134.068**
295	**545**	**555**		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.0202**	**134.07**
296	**545**	**555**	**Mainoru River**	**Riverine floodplains, seasonally flooded grassland, savanna**	**B4**	**-14.0236**	**134.066**
149	585	595	Wilton River	Permanent rivers and streams	B1	-13.6959	134.378
151	585	595	Wilton River	Permanent rivers and streams	B1	-13.6958	134.378
Goyder River Basin (KP630-770)							
160	695	705	Goyder River	Permanent rivers and streams	B1	-13.124	135.103
Buckingham River Basin (KP770-930)							
57	835	845	Boggy Creek	Permanent rivers and streams	B1	-12.6551	136.2894
27	895	905	Giddy River	Permanent rivers and streams	B1	-12.3594	136.707
32	895	905	Giddy River	Permanent rivers and streams	B1	-12.3585	136.708
24	**905**	**915**	**Latram River**	**Permanent rivers and streams**	**B1**	**-12.3001**	**136.765**

[1]Sites photographed by Kylie Harvey (EcOz) during reconnaissance surveys are shown shaded.
[2] Feature codes used in the waterbody classification are described in Table 9.

Table 4 Roper Basin, location descriptions of pipeline crossings

Location	Description
Annie Creek (KP620-630)	Broad drainage depressions with swamps (Plate 1) on the Annie Creek system which route survey needs to avoid. Identified with sites 425 (seasonal/intermittent freshwater ponds and marshes) in Appendix B.
Maranboy Creek (KP380-390)	Headwater channels and plains of Maranboy Creek. Identified with site 205 (seasonal and irregular rivers and creeks) in Appendix B.
Beswick Creek (KP390-400)	Headwater channels and plains of Beswick Creek. Identified with site 215 (seasonal and irregular rivers and creeks) in Appendix B.
Waterhouse River (KP410-420)	Headwater channels and plains of the Waterhouse River (Plate 3). Identified with site 170 (seasonal and irregular rivers and creeks) in Appendix B.
Waterhouse River (KP420-430)	Headwater channels of the Waterhouse River. Identified with site 196 (seasonal and irregular rivers and creeks) in Appendix B.
Chambers River (KP440-450)	Headwater channels of the headwaters of Chambers River (Plate 4). Identified with site 192 (seasonal and irregular rivers and creeks) in Appendix B.
Bukalorkmi Creek (KP470-480)	Anastamotic channels and extensive floodplain (Plate 5). Identified with sites 241, 250, 255, 256, 302 (seasonal/intermittent freshwater ponds and marshes) in Appendix B.
Velkerri Creek (KP480-490)	Anastamotic channels and extensive floodplain. Identified with sites 260, 261, 262, 263, 264, 265, 297, 298, 299, 300, 303, 417 (seasonal/intermittent freshwater ponds and marshes) in Appendix B.
Maiwok Creek (KP490-500)	Numerous channels, floodplain and permanent waterholes at Dulcaruk Billabong. Identified with sites 230, 272, 273, 276, 278 (seasonal/intermittent freshwater ponds and marshes) in Appendix B.
Derim Derim Creek (KP500-510)	Floodplains and numerous channels of Derim Derim Creek (Plate 6). Identified with sites 267, 268, 274, 275, 277, (seasonal/intermittent freshwater ponds and marshes, seasonal and irregular rivers and creeks) in Appendix B.
Flying Fox Creek (KP500-510)	Floodplains and numerous channels of the headwaters of Flying Fox Creek (Plate 7). Identified with sites 230, 272, 273, 276, 278 (seasonal/intermittent freshwater ponds and marshes, seasonal and irregular rivers and creeks) in Appendix B.
Maori Creek (KP510-520)	Seasonal and intermittent stream channels. Identified with sites 269, 270, 281 (seasonal and irregular rivers and creeks) in Appendix B.
Quibobikwi Creek (KP530-540)	Extensive floodplains and seasonal channels (Plate 8). Identified with sites 231, 285, 290, 419 (seasonal and irregular rivers and creeks, seasonal/intermittent freshwater ponds and marshes) in Appendix B.
Krabakuk Creek (KP540-550)	Extensive floodplains and seasonal channels. Identified with sites 231, 285, 290, 419 (seasonal and irregular rivers and creeks) in Appendix B.
Mainoru River (KP540-550)	Anastamotic channels of Mainoru River. Identified with sites 291-293 (Riverine floodplains, seasonally flooded grassland, savanna) in Appendix B.
Horse Creek (KP560-570)	Extensive headwater swamps of Horse Creek. Identified with sites 153, 226, 225, 420 (Riverine floodplains, seasonally flooded grassland, savanna) in Appendix B.
Wilton River (KP590-600)	Route survey needs to avoid Bulman Waterhole and minimise impacts on numerous narrow intermittent streams in the headwaters of Wilton River. Identified with sites 127, 129, 149, 151 (seasonal and irregular rivers and creeks) in Appendix B.
Jasper Creek (KP610-620)	Numerous narrow intermittent streams in the headwaters of Jasper Creek. Identified with sites 125 (seasonal and irregular rivers and creeks) in Appendix B.

Table 5 Goyder Basin, location descriptions of pipeline crossings

Location	Description
Annie Creek (KP640-650)	Broad drainage depressions with swamps on the Annie Creek. Identified with sites 115 and 155 (seasonal and irregular rivers and streams) in Appendix B.
Annie Creek (KP650-660)	Monsoon vine forest patches on ridge tops on the Annie Creek system (Plate 9) and narrow valley flat crossings. Identified with sites 112-113 (seasonal and irregular rivers and streams) in Appendix B.
Annie Creek (KP660-670)	Extensive headwater swamps on the Annie Creek system (Plate 10). Identified with sites 105-107 (seasonal and irregular rivers and streams) in Appendix B.
Annie Creek (KP670-680)	Extensive headwater swamps to be avoided on the Annie Creek system (Plate 11). Identified with site 137 (seasonal and irregular rivers and streams) in Appendix B.
Annie Creek (KP680-690)	Numerous small waterholes to be avoided on the Annie Creek system (Plate 12). Identified with sites 102 and 103 (seasonal and irregular rivers and streams) in Appendix B.
Goyder River (KP690-700)	Three channels of the Goyder River with riparian vegetation and seasonally flooded grasslands and savanah (Plate 13). Identified with site 160 (riverine floodplains, seasonally flooded grassland, savanna) in Appendix B.
Goyder River (KP700-710)	Route selection will need to avoid headwater ponds and springs with associated swamps. Not identified with any site on the current route.
Goyder River (KP710-720)	Route selection will need to avoid headwater ponds and springs with associated swamps (Plate 14). Identified with site 158 (seasonal and irregular rivers and streams) in Appendix B.
Guluddy Creek (KP730-740)	Route selection will need to avoid headwater ponds and springs with associated dense Melaleuca swamps. Not identified with any site on the current route.

Table 6 Buckingham Basin, location descriptions of pipeline crossings

Location	Description
Badalngarram Creek (KP780-790)	Route selection will need to avoid headwater ponds and springs with associated monsoon vine forest patches. Identified with site 84 (seasonal and irregular rivers and streams) in Appendix B.
Buckingham River (KP780-790)	Route selection need to avoid headwater swamps and streams. Identified with site 58 (seasonal and irregular rivers and streams) in Appendix B.
Habgood River (KP790-800)	Headwater springs that the route selection process needs to avoid (Plate 15). Identified with site 95 (seasonal/intermittent freshwater ponds and marshes) in Appendix B.
Habgood River (KP800-810)	Creeks with numerous channels (Plate 16). Identified with sites 59 and 66 (seasonal/intermittent freshwater streams) in Appendix B.
	Creeks with numerous channels (Plate 17). Identified with sites 60 and 70 (seasonal/intermittent freshwater streams) in Appendix B.
Goromuru River (KP820-830)	Extensive, dense Melaleuca woodlands which should be avoided if possible, or directional drilling used. Identified with site 68 (seasonal/intermittent freshwater ponds and marshes) in Appendix B.
Goromuru River (KP830-840)	An extensive, dense Melaleuca woodland (Plate 18) where a route survey is needed to minimise the area disturbed. Identified with sites 73-79 (seasonal and irregular rivers and streams, seasonal/intermittent freshwater ponds and marshes) in Appendix B.
Goromuru River (KP840-850)	A river crossing with dense riparian vegetation and two well-defined channels that feed into extensive seasonal and coastal wetlands associated with the Goromuru River. Identified with sites 54-57 (seasonal and irregular rivers and streams, seasonal/intermittent freshwater ponds and marshes) in Appendix B.
Cato River (KP870-880)	Drainage diversion needs to be considered on rocky banks of the Cato River (seasonal and irregular river or stream). Identified with Appendix B, sites 41 and 42.
Latham River (KP910-920)	Anastomosing seasonal and irregular rivers and streams in the vicinity of Latham River (Appendix B, Locations 22-24) require careful route selection to minimise the area disturbed. Directional drilling will be required under Latham River itself (Plate 19).

Table 7 Background water quality based from Wadeye/Nauiyu water study

Analyte[1]	Units	20th percentile	80th percentile	Default Trigger Values
Chl a	µg/L			10
TP	µg P/L	7	36	10
FRP	µg P/L	1	7	5 - 25
TN	µg N/L	855	1350	350 - 1200
NO_x	µg N/L	1	4	10
NH_4^+	µg N/L	1.13	11.95	10
DO	(% saturation)			<80 - >110
pH		6.9	7.9	6.0 – 8.0
Salinity	(µS/cm)	130	530	90-900
Turbidity	(NTU)	32	127	2 - 200
Total Alkalinity	(mg/L)	2	246	

[1] Chl a=chlorophyll a, TP=total phosphorus, FRP= filterable reactive phosphate, TN=total nitrogen, NO_x=oxides of nitrogen, NH_4^+ =ammonium, DO =Dissolved Oxygen

Table 8 Coastal wetlands assessed with potential acid sulfate soil risk

ID	Longitude	Latitude	Ecosystem type
73	136.17066	-12.71102	Lowland river
74	136.17188	-12.71119	Lowland river
75	136.17231	-12.71125	Lowland river
77	136.17588	-12.71172	Wetlands
79	136.18499	-12.71294	Lowland river
408	129.94167	-14.36992	Wetlands
412	129.96372	-14.35328	Wetlands
413	129.96145	-14.35499	Wetlands
427	130.05831	-14.28203	Wetlands

Table 9 Ecosystem types[3] and wetland classes

Ecosystem Type	Wetland class[4] & description
	A- Marine and Coastal Zone Wetlands (lowland river/creek)
Marine Inshore	(A5) Sand, shingle or pebble beaches; includes sand bars, spits, sandy islets
Marine Inshore	(A7) Intertidal mud, sand or salt flats
	B- Inland wetlands (upland river/creek)
Upland river (>150 m altitude) Lowland River (<150 m altitude)	(B1) Permanent rivers and streams; includes waterfalls
Upland river (>150 m altitude) Lowland River (<150 m altitude)	(B2) Seasonal and irregular rivers and streams
Upland river (>150 m altitude) Lowland River (<150 m altitude)	(B4) Riverine floodplains; includes river flats, flooded river basins, seasonally flooded grassland, savanna and palm savanna
Wetlands	(B10)Seasonal/intermittent freshwater ponds and marshes on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes
Freshwater lakes & reservoirs	(B17) Freshwater springs, oases and rockpools

[3] Classification used in ANZECC & ARMCANZ 2000. Australian guidelines for fresh and marine water quality. Chapter 3 Aquatic Ecosystems

[4] Code used in GIS wetland coverage

Table 10 Hydrological impacts

Project Component	Receptor		Potential Impact type					
	Groundwater	Inland	Chemical	Biological & ecological	Acidity	Salinity	Turbidity	Hydrocarbons
Construction								
TTP pipeline								
working width preparation		X					X	X
topsoil stripping and grading		X					X	X
trenching & dewatering	X	X			X		X	
access & laydown areas	X	X	X				X	X
hydrostatic testing	X	X	X			X		X
backfilling		X					X	
rehabilitation and pipeline marking		X					X	
Construction camp (temporary)	X	X		X			X	X
Operational components								
Ancillary facilities								
Diesel & chemical storage	X		X					X
Pipeline	X							X
Plant access		X					X	X
Decommissioning								
Production shutdown	X	X	X					
Pipeline flushing	X					X	X	X
Removal of facilities		X					X	X

Table 11 Measures of consequence for environmental issues (AS/NZS4360 1999)

Consequence		Description
1	Insignificant	Negligible impact remediated by site personnel using standard operating procedures.
2	Minor	Minor on-site surface contamination. Short-term environmental impact remediated by site personnel. Environmental consequences for <6 months.
3	Moderate	On-site surface and phreatic zone contamination. Medium-term environmental impact remediated by site personnel. Environmental consequences for 6<12 months.
4	Major	Off-site impact to external receptors via groundwater pathways. Medium to long term environmental and community health impacts remediated by specialised non-site personnel. Environmental consequences for 1-2 years.
5	Catastrophic	Off-site major deterioration in the water resource resulting in visible and / or severe contamination resulting in permanent or long-term loss of beneficial use. Environmental consequences for >2yrs.

Table 12 Likelihood of an environmental issue occurring (AS/NZS4360 1999)

Occurrence		Description
1	Rare	Impact may occur in exceptional circumstances
2	Unlikely	Impact could occur based on design option used
3	Moderate	Impact could occur at some time in the life of the project based on the design option used
4	Likely	Impact will probably occur at some time in the life of the project based on the design option used
5	Almost certain / currently occurring	Impact expected to occur in most circumstances, including already occurring

Table 13 Qualitative risk analysis matrix (AS/NZS4360 1999)

LIKELIHOOD	CONSEQUENCE				
	1 INSIGNIFICANT	2 MINOR	3 MODERATE	4 MAJOR	5 CATASTROPHIC
1. RARE	1	2	3	4	5
2. UNLIKELY	2	4	6	8	10
3. MODERATE	3	6	9	12	15
4. LIKELY	4	8	12	16	20
5. ALMOST CERTAIN	5	10	15	20	25

Key

LOW RISK	1 to 4 points	Low risk expected, apply precautionary principle
MODERATE RISK	5 points	Moderate risk of low level, possibly chronic impacts (occur continually)
HIGH RISK	6 to 9 points	High risk expected
EXTREME RISK	10 to 25 points	Extreme risk expected

Table 14 Risk assessment results

Activity	Impact type	Likelihood	Consequence	Risk ranking	Mitigated Risk Ranking[5]
Construction &Commissioning					
TTP pipeline	Turbidity,	3	2	6	2
	Acidity	2	2	4	
Hydrostatic testing	Chemical additives	3	2	6	2
	Hydrocarbons	3	2	6	2
	Salinity	3	2	6	2
Access & laydown areas	Turbidity	3	3	9	
	Hydrocarbons	2	2	4	
Construction camps	Hydrocarbons	3	2	6	4
	Turbidity	3	2	6	4
	Biological	3	2	6	4
Operation					
TTP pipeline	Hydrocarbons	2	1	2	
Ancillary systems	Hydrocarbons	3	3	9	3
	Chemicals	3	3	9	3
	Turbidity	3	2	6	4
Decommissioning					
TTP pipeline	Hydrocarbons	3	2	6	2
	Turbidity	3	2	6	2

[5] Risk ranking where recommended mitigation measures are in place to reduce the likelihood of impact

PLATES

Plate 1 Annie Creek (Photo:122-2271)

Plate 2 Maranboy Creek (Photo:122-2245)

Plate 3 Waterhouse River (Photo:122-2246)

Plate 4 Chambers River (Photo:122-2250)

Plate 5 Bukalorkmi Creek (Photo:122-2251)

Plate 6 Derim Derim Creek (Photo:122-2256)

Plate 7 Flying Fox Creek (Photo:122-2255)

Plate 8 Quibobikwi Creek (Photo:122-2258)

Plate 9 Annie Creek (Photo:122-2274)

Plate 10 Annie Creek (Photo:122-2275)

Plate 11 Annie Creek (Photo:122-2276)

Plate 12 Annie Creek (Photo:122-2277)

Plate 13 Goyder River (Photo:122-2278)

Plate 14 Goyder River (Photo:122-2282)

Plate 15 Habgood River (Photo:122-2284)

Plate 16 Habgood River (Photo:122-2286)

Plate 17 Habgood River (Photo:122-2285)

Plate 18 Gorumuru River (Photo:122-2287)

Plate 19 Latham River (Photo: 122-2292)

APPENDICES

Appendix A
Consultation

Memo outline of consultation with DIPE – 7 April 04

EWL Sciences
earth water life

memorandum

TO : Peter Jolly & Rod Johnson
COPIES :
FROM : Ian Hollingsworth
REF : 577, 648
SUBJECT : **TTP and TTP EIS – Hydrological Impacts consultation on approach**
DATE : 7 April 2004

Information sources for hydrological resources and beneficial uses

- Wadeye / Nauiyu Water Study (NT Gov. Sept 2003)
- Environmental Water Requirements of the Daly River (NT Gov. March 2003)
- West Arnhem Land Water Study (NT Gov.)
- East Arnhem Land Water Study (NT Gov.)
- 1:250 000 vector drainage and road data

Selection criteria for pipeline crossing location and design

- Crossing selection criteria:
- straight section of stream bank
- low bank profile

Crossing design:

- perennial watercourses – directional drilling
- intermittent water courses and wetlands – open trenching

Crossing construction:

- bank profile reinstatement
- reinstatement of bed material
- dry season operation (May – September)

Impact assessment criteria

- Wetland Classification – based on Directory of Important Wetlands in Australia
- Water quality criteria – pH, EC, temperature, turbidity, dissolved oxygen
- Assessment of risk to bore fields – flow path length criteria of 100 m

Advisory guidelines for waste water impoundments

- Volume
- Distance from water courses

Advisory guidelines for bed and bank stabilisation

- Timing
- Surface treatment
- Minimising impact

Appendix B
Surface drainage features

Location and type of surface water features on the proposed route[6]

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
Moyle River Basin								
398	15	25	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3214	129.616
394	25	35	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3269	129.649
399	25	35	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3428	129.721
404	35	45	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3625	129.815
405	45	55	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3702	129.851
406	45	55	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3795	129.898
407	45	55	Lowland river		Seasonal and irregular rivers and streams	B2	-14.376	129.879
409	45	55	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3786	129.892
400	55	65	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3434	129.977
402	55	65	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3478	129.971
403	55	65	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3577	129.958
408	55	65	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3699	129.942
410	55	65	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3824	129.924
411	55	65	Lowland river	Anopheles Ck	Permanent rivers and streams	B1	-14.3811	129.912
412	55	65	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3533	129.964
413	55	65	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.355	129.961
388	65	75	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2859	130.053
389	65	75	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2904	130.047
390	65	75	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3039	130.029
393	65	75	Lowland river		Seasonal and irregular rivers and streams	B2	-14.322	130.005
395	65	75	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3121	130.018
396	65	75	Lowland river		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3278	129.998
397	65	75	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3329	129.991
379	75	85	Upland river		Seasonal and irregular rivers and streams	B2	-14.2646	130.13
380	75	85	Upland river		Seasonal and irregular rivers and streams	B2	-14.262	130.102
381	75	85	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2725	130.071
382	75	85	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2735	130.069
383	75	85	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2683	130.076
385	75	85	Lowland river	Moyle R	Permanent rivers and streams	B1	-14.2771	130.065
384	85	95	Upland river		Seasonal and irregular rivers and streams	B2	-14.275	130.179
386	85	95	Upland river		Seasonal and irregular rivers and streams	B2	-14.2814	130.208

[6] Bolding and shading indicate sites photographed in helicopter reconnaissance (Kylie Harvey, March 2004)

[7] Feature codes are described in Table 9 in the report.

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
387	85	95	Freshwater lakes & reservoirs		Freshwater springs	B17	-14.2829	130.215
391	95	105	Upland river		Seasonal and irregular rivers and streams	B2	-14.3104	130.311
392	105	115	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3237	130.347
401	105	115	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3342	130.376
Daly River Basin								
415	125	135	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3991	130.553
416	135	145	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.4041	130.587
371	155	165	Upland river		Seasonal and irregular rivers and streams	B2	-14.4868	130.784
373	155	165	Upland river		Seasonal and irregular rivers and streams	B2	-14.4968	130.788
376	175	185	Upland river		Seasonal and irregular rivers and streams	B2	-14.5295	130.909
377	175	185	Upland river		Seasonal and irregular rivers and streams	B2	-14.537	130.975
378	175	185	Upland river		Seasonal and irregular rivers and streams	B2	-14.5375	130.97
374	195	205	Upland river		Seasonal and irregular rivers and streams	B2	-14.5005	131.114
356	205	215	Lowland river		Seasonal and irregular rivers and streams	B2	-14.48	131.244
357	205	215	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4835	131.237
358	205	215	Freshwater lakes & reservoirs		Freshwater springs	B17	-14.4848	131.233
359	205	215	Freshwater lakes & reservoirs		Freshwater springs	B17	-14.4849	131.232
360	205	215	Freshwater lakes & reservoirs		Freshwater springs	B17	-14.4852	131.229
361	205	215	Freshwater lakes & reservoirs		Freshwater springs	B17	-14.4853	131.228
363	205	215	Upland river		Seasonal and irregular rivers and streams	B2	-14.4877	131.193
355	215	225	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4762	131.269
362	215	225	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4875	131.313
364	215	225	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4869	131.3
368	215	225	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4887	131.336
369	215	225	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4877	131.317
370	215	225	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.486	131.287
365	225	235	Lowland river	Bradshaw Creek	Permanent rivers and streams	B1	-14.4897	131.355
366	225	235	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4894	131.35
367	225	235	Lowland river	Bradshaw Creek	Permanent rivers and streams	B1	-14.4901	131.355
372	225	235	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4942	131.413
375	225	235	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4865	131.367
336	245	255	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5071	131.531
337	245	255	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5071	131.532
339	245	255	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5068	131.595
340	245	255	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5072	131.523

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
341	245	255	Lowland river		Seasonal and irregular rivers and streams	B2	-14.507	131.549
334	255	265	Upland river		Seasonal and irregular rivers and streams	B2	-14.5022	131.632
335	255	265	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5063	131.676
338	255	265	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5063	131.672
343	255	265	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5065	131.643
346	255	265	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5062	131.697
414	255	265	Lowland river	Daly River	Permanent rivers and streams	B1	-14.5063	131.678
342	265	275	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5056	131.79
344	265	275	Lowland river		Seasonal and irregular rivers and streams	B2	-14.506	131.728
345	265	275	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5061	131.712
347	275	285	Lowland river		Seasonal and irregular rivers and streams	B2	-14.51	131.827
348	275	285	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5215	131.86
349	275	285	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5305	131.879
350	275	285	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5332	131.884
351	285	295	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5375	131.895
352	285	295	Upland river		Seasonal and irregular rivers and streams	B2	-14.5425	131.918
353	285	295	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5551	131.957
354	285	295	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5614	131.97
305	295	305	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5743	132
307	295	305	Lowland river	Katherine River	Permanent rivers and streams	B1	-14.5842	132.051
314	295	305	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5748	132.017
320	295	305	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5847	132.057
321	305	315	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.5849	132.067
323	305	315	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5802	132.112
325	305	315	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5822	132.099
331	305	315	Lowland river		Seasonal and irregular rivers and streams	B2	-14.585	132.081
310	315	325	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5865	132.212
312	315	325	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5867	132.226
319	315	325	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5861	132.174
322	315	325	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5863	132.196
324	315	325	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5864	132.199
326	315	325	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5862	132.188
327	315	325	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5861	132.173
306	325	335	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5978	132.316
313	325	335	Upland river		Seasonal and irregular rivers and streams	B2	-14.5868	132.238
316	325	335	Upland river		Seasonal and irregular rivers and streams	B2	-14.601	132.328
329	325	335	Upland river		Seasonal and irregular rivers and streams	B2	-14.5916	132.293
330	325	335	Upland river		Seasonal and irregular rivers and streams	B2	-14.5949	132.306
315	335	345	Upland river		Seasonal and irregular rivers and streams	B2	-14.618	132.391
317	335	345	Upland river		Seasonal and irregular rivers and streams	B2	-14.6187	132.396

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
328	335	345	Upland river		Seasonal and irregular rivers and streams	B2	-14.6059	132.346
311	345	355	Upland river		Seasonal and irregular rivers and streams	B2	-14.6222	132.448
318	345	355	Upland river		Seasonal and irregular rivers and streams	B2	-14.6194	132.497
Roper River Basin								
332	355	365	Upland river		Seasonal and irregular rivers and streams	B2	-14.6082	132.599
308	365	375	Upland river	King R	Permanent rivers and streams	B1	-14.6078	132.607
309	365	375	Upland river		Seasonal and irregular rivers and streams	B2	-14.6045	132.683
333	365	375	Lowland river	Roper Ck	Permanent rivers and streams	B1	-14.6058	132.654
163	375	385	Upland river		Seasonal and irregular rivers and streams	B2	-14.6002	132.775
204	375	385	Upland river		Seasonal and irregular rivers and streams	B2	-14.5996	132.789
205	**375**	**385**	Upland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.5997**	**132.787**
179	385	395	Upland river		Seasonal and irregular rivers and streams	B2	-14.5983	132.818
215	**385**	**395**	Upland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.596**	**132.869**
216	385	395	Upland river		Seasonal and irregular rivers and streams	B2	-14.5965	132.858
173	395	405	Upland river		Seasonal and irregular rivers and streams	B2	-14.593	132.919
174	395	405	Upland river		Seasonal and irregular rivers and streams	B2	-14.5902	132.95
208	395	405	Upland river		Seasonal and irregular rivers and streams	B2	-14.5943	132.904
209	395	405	Upland river		Seasonal and irregular rivers and streams	B2	-14.5944	132.904
210	395	405	Upland river		Seasonal and irregular rivers and streams	B2	-14.5943	132.905
211	395	405	Upland river	Beswick creek	Permanent rivers and streams	B1	-14.5947	132.896
170	405	415	Upland river		Seasonal and irregular rivers and streams	B2	-14.5871	133.023
199	405	415	Upland river		Seasonal and irregular rivers and streams	B2	-14.5889	133.066
206	405	415	Upland river		Seasonal and irregular rivers and streams	B2	-14.5873	132.983
213	405	415	Upland river		Seasonal and irregular rivers and streams	B2	-14.5891	133.058
171	415	425	Upland river		Seasonal and irregular rivers and streams	B2	-14.5875	133.071
172	415	425	Upland river		Seasonal and irregular rivers and streams	B2	-14.5792	133.104
180	415	425	Upland river		Seasonal and irregular rivers and streams	B2	-14.5818	133.094
181	415	425	Upland river		Seasonal and irregular rivers and streams	B2	-14.583	133.089
186	415	425	Upland river	Waterhouse River	Permanent rivers and streams	B1	-14.5784	133.107
196	415	425	Upland river		Seasonal and irregular rivers and streams	B2	-14.5589	133.14
198	415	425	Upland river		Seasonal and irregular rivers and streams	B2	-14.5839	133.085
212	415	425	Upland river		Seasonal and irregular rivers and streams	B2	-14.5753	133.119
214	415	425	Upland river		Seasonal and irregular rivers and streams	B2	-14.5776	133.111
175	425	435	Upland river		Seasonal and irregular rivers and streams	B2	-14.5475	133.153
176	425	435	Upland river		Seasonal and irregular rivers and streams	B2	-14.5241	133.186
182	425	435	Upland river		Seasonal and irregular rivers and streams	B2	-14.5262	133.178
183	425	435	Upland river		Seasonal and irregular rivers and streams	B2	-14.5288	133.175
184	425	435	Upland river		Seasonal and irregular rivers and streams	B2	-14.5317	133.172
185	425	435	Upland river		Seasonal and irregular rivers and streams	B2	-14.5366	133.166
200	425	435	Upland river		Seasonal and irregular rivers and streams	B2	-14.5239	133.192

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
201	425	435	Upland river		Seasonal and irregular rivers and streams	B2	-14.5236	133.201
187	435	445	Upland river		Seasonal and irregular rivers and streams	B2	-14.5225	133.237
188	435	445	Upland river		Seasonal and irregular rivers and streams	B2	-14.5223	133.243
189	435	445	Upland river		Seasonal and irregular rivers and streams	B2	-14.5222	133.247
190	435	445	Upland river		Seasonal and irregular rivers and streams	B2	-14.5213	133.276
191	435	445	Upland river		Seasonal and irregular rivers and streams	B2	-14.5211	133.282
192	**435**	**445**	Upland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.5199**	**133.319**
193	435	445	Upland river		Seasonal and irregular rivers and streams	B2	-14.5203	133.305
197	435	445	Upland river		Seasonal and irregular rivers and streams	B2	-14.5223	133.244
207	435	445	Lowland river		Seasonal and irregular rivers and streams	B2	-14.5212	133.277
194	445	455	Upland river		Seasonal and irregular rivers and streams	B2	-14.4987	133.387
195	445	455	Upland river		Seasonal and irregular rivers and streams	B2	-14.5113	133.359
203	445	455	Upland river		Seasonal and irregular rivers and streams	B2	-14.5105	133.361
164	455	465	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4763	133.441
165	455	465	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4822	133.427
166	455	465	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4744	133.472
167	455	465	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4803	133.431
168	455	465	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4835	133.423
169	455	465	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4884	133.412
177	455	465	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4736	133.491
178	455	465	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4742	133.476
202	455	465	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4854	133.419
241	465	475	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.4415	133.546
242	465	475	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4287	133.565
243	465	475	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.4327	133.559
244	465	475	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.4317	133.56
245	465	475	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4224	133.574
250	465	475	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.45	133.534
251	465	475	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.4641	133.514
252	465	475	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4683	133.508
253	465	475	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.4671	133.51
254	465	475	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.4709	133.505
255	465	475	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.4459	133.54
256	465	475	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.4451	133.541
301	465	475	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4601	133.52
302	465	475	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4401	133.548
246	475	485	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4114	133.589

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
247	475	485	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4143	133.585
248	475	485	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4006	133.605
249	475	485	Lowland river		Seasonal and irregular rivers and streams	B2	-14.4051	133.598
262	**475**	**485**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.3735**	**133.644**
263	**475**	**485**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.3755**	**133.641**
264	**475**	**485**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.3765**	**133.639**
265	**475**	**485**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.3771**	**133.638**
298	**475**	**485**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.3781**	**133.637**
299	**475**	**485**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.3786**	**133.636**
300	**475**	**485**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.3808**	**133.633**
303	**475**	**485**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.3699**	**133.649**
232	**485**	**495**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.3247**	**133.725**
233	**485**	**495**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.3241**	**133.727**
234	**485**	**495**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.3354**	**133.701**
235	**485**	**495**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.3356**	**133.7**
236	485	495	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3358	133.7
237	485	495	Lowland river		Seasonal and irregular rivers and streams	B2	-14.337	133.697
238	485	495	Lowland river		Seasonal and irregular rivers and streams	B2	-14.337	133.697
239	485	495	Lowland river		Seasonal and irregular rivers and streams	B2	-14.338	133.695
240	485	495	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3385	133.694
260	**485**	**495**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.3643**	**133.657**
261	**485**	**495**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.3547**	**133.67**
297	485	495	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3496	133.678
417	485	495	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3579	133.666
418	485	495	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.3307	133.712
230	**495**	**505**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.2861**	**133.774**
272	495	505	Lowland river		Permanent rivers and streams	B1	-14.2821	133.777
273	495	505	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2958	133.765
274	**495**	**505**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.2658**	**133.792**
275	**495**	**505**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.2714**	**133.787**
276	495	505	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.2791	133.78
277	**495**	**505**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.2738**	**133.785**
278	495	505	Lowland river		Seasonal and irregular rivers and streams	B2	-14.3013	133.76
257	505	515	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2369	133.819
258	505	515	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2381	133.818
259	505	515	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2437	133.812

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
267	**505**	**515**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.256**	**133.801**
268	**505**	**515**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.2585**	**133.799**
269	505	515	Upland river		Seasonal and irregular rivers and streams	B2	-14.2075	133.85
270	505	515	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2155	133.842
271	505	515	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2188	133.838
281	**505**	**515**	Upland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.1989**	**133.859**
282	505	515	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2424	133.813
304	505	515	Lowland river		Seasonal and irregular rivers and streams	B2	-14.2306	133.826
279	515	525	Upland river		Seasonal and irregular rivers and streams	B2	-14.1774	133.882
280	515	525	Upland river		Seasonal and irregular rivers and streams	B2	-14.1779	133.881
287	515	525	Upland river		Seasonal and irregular rivers and streams	B2	-14.1425	133.918
288	515	525	Lowland river		Seasonal and irregular rivers and streams	B2	-14.1375	133.923
231	**525**	**535**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.084**	**133.982**
284	525	535	Lowland river		Seasonal and irregular rivers and streams	B2	-14.0792	133.995
285	**525**	**535**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.0848**	**133.977**
286	525	535	Lowland river		Seasonal and irregular rivers and streams	B2	-14.122	133.94
289	525	535	Lowland river		Seasonal and irregular rivers and streams	B2	-14.1197	133.942
290	**525**	**535**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.0863**	**133.974**
419	525	535	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.0959	133.963
229	**535**	**545**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.0254**	**134.064**
283	535	545	Lowland river		Seasonal and irregular rivers and streams	B2	-14.0747	134.004
291	**535**	**545**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.0537**	**134.034**
292	**535**	**545**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.0488**	**134.037**
293	**535**	**545**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.062**	**134.027**
223	545	555	Lowland river		Seasonal and irregular rivers and streams	B2	-13.9742	134.114
227	545	555	Lowland river		Seasonal and irregular rivers and streams	B2	-13.9978	134.092
228	545	555	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-14.0129	134.077
266	**545**	**555**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-14.0022**	**134.087**
294	**545**	**555**	Lowland river	**Mainoru R**	**Riverine floodplains, seasonally flooded grassland, savanna**	**B4**	**-14.0228**	**134.068**
295	**545**	**555**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-14.0202**	**134.07**
296	**545**	**555**	Lowland river	**Mainoru R**	**Permanent rivers and streams**	**B1**	**-14.0236**	**134.066**
217	555	565	Lowland river		Seasonal and irregular rivers and streams	B2	-13.9166	134.151
218	555	565	Lowland river		Seasonal and irregular rivers and streams	B2	-13.9144	134.152
219	555	565	Lowland river		Seasonal and irregular rivers and streams	B2	-13.8956	134.165
220	**555**	**565**	Upland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.9298**	**134.142**
221	555	565	Lowland river		Seasonal and irregular rivers and streams	B2	-13.9365	134.138
222	555	565	Lowland river		Seasonal and irregular rivers and streams	B2	-13.9488	134.13
224	555	565	Lowland river		Seasonal and irregular rivers and streams	B2	-13.9525	134.128

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
119	565	575	Lowland river		Seasonal and irregular rivers and streams	B2	-13.8249	134.238
153	**565**	**575**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-13.8567**	**134.2**
225	**565**	**575**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-13.8567**	**134.2**
226	**565**	**575**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-13.8768**	**134.177**
420	565	575	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-13.8654	134.19
129	575	585	Lowland river		Seasonal and irregular rivers and streams	B2	-13.8158	134.248
142	575	585	Lowland river		Seasonal and irregular rivers and streams	B2	-13.8031	134.264
143	575	585	Lowland river		Seasonal and irregular rivers and streams	B2	-13.8058	134.26
144	575	585	Lowland river		Seasonal and irregular rivers and streams	B2	-13.7906	134.279
148	575	585	Lowland river		Seasonal and irregular rivers and streams	B2	-13.7715	134.301
130	585	595	Lowland river		Seasonal and irregular rivers and streams	B2	-13.7061	134.368
131	585	595	Lowland river		Seasonal and irregular rivers and streams	B2	-13.7118	134.363
132	585	595	Lowland river		Seasonal and irregular rivers and streams	B2	-13.7327	134.343
133	585	595	Lowland river		Seasonal and irregular rivers and streams	B2	-13.7329	134.343
134	585	595	Lowland river		Seasonal and irregular rivers and streams	B2	-13.7221	134.353
135	585	595	Lowland river		Seasonal and irregular rivers and streams	B2	-13.7172	134.358
147	585	595	Lowland river		Seasonal and irregular rivers and streams	B2	-13.7563	134.319
149	585	595	Lowland river	Wilton R	Permanent rivers and streams	B1	-13.6959	134.378
151	585	595	Lowland river	Wilton R	Permanent rivers and streams	B1	-13.6958	134.378
127	595	605	Lowland river		Seasonal and irregular rivers and streams	B2	-13.6942	134.38
128	595	605	Lowland river		Seasonal and irregular rivers and streams	B2	-13.6935	134.38
139	595	605	Lowland river		Seasonal and irregular rivers and streams	B2	-13.6546	134.425
140	595	605	Lowland river		Seasonal and irregular rivers and streams	B2	-13.6609	134.418
141	595	605	Lowland river		Seasonal and irregular rivers and streams	B2	-13.6776	134.398
154	595	605	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-13.6728	134.404
125	**605**	**615**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.5997**	**134.489**
126	605	615	Lowland river		Seasonal and irregular rivers and streams	B2	-13.6145	134.471
120	615	625	Upland river		Seasonal and irregular rivers and streams	B2	-13.5733	134.519
121	615	625	Upland river		Seasonal and irregular rivers and streams	B2	-13.5374	134.561
122	615	625	Upland river		Seasonal and irregular rivers and streams	B2	-13.5434	134.554
123	615	625	Lowland river		Seasonal and irregular rivers and streams	B2	-13.5612	134.533
124	615	625	Lowland river		Seasonal and irregular rivers and streams	B2	-13.5514	134.545
136	615	625	Lowland river		Seasonal and irregular rivers and streams	B2	-13.5572	134.538
Goyder River Basin								
97	625	635	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-13.5008	134.604
98	625	635	Lowland river		Seasonal and irregular rivers and streams	B2	-13.4882	134.618
99	625	635	Lowland river		Seasonal and irregular rivers and streams	B2	-13.4631	134.648
100	635	645	Lowland river		Seasonal and irregular rivers and streams	B2	-13.44	134.674
101	635	645	Lowland river		Seasonal and irregular rivers and streams	B2	-13.446	134.668

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
114	635	645	Lowland river		Seasonal and irregular rivers and streams	B2	-13.4065	134.713
117	635	645	Lowland river		Seasonal and irregular rivers and streams	B2	-13.4486	134.664
115	**645**	**655**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.3864**	**134.737**
150	645	655	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-13.3489	134.786
155	**645**	**655**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.3701**	**134.757**
110	655	665	Lowland river		Seasonal and irregular rivers and streams	B2	-13.3051	134.844
111	655	665	Lowland river		Seasonal and irregular rivers and streams	B2	-13.3122	134.835
112	**655**	**665**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.322**	**134.822**
113	**655**	**665**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.3327**	**134.807**
116	655	665	Lowland river		Seasonal and irregular rivers and streams	B2	-13.2972	134.855
138	655	665	Lowland river		Seasonal and irregular rivers and streams	B2	-13.3401	134.797
152	655	665	Lowland river		Seasonal and irregular rivers and streams	B2	-13.2897	134.865
104	665	675	Lowland river		Seasonal and irregular rivers and streams	B2	-13.2542	134.913
105	**665**	**675**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.2654**	**134.898**
106	**665**	**675**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.2682**	**134.894**
107	**665**	**675**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.2717**	**134.889**
108	665	675	Lowland river		Seasonal and irregular rivers and streams	B2	-13.2776	134.881
109	665	675	Lowland river		Seasonal and irregular rivers and streams	B2	-13.2842	134.873
118	665	675	Lowland river		Seasonal and irregular rivers and streams	B2	-13.247	134.921
102	**675**	**685**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.1993**	**134.981**
103	**675**	**685**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.2009**	**134.979**
137	**675**	**685**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.2101**	**134.967**
145	675	685	Lowland river		Seasonal and irregular rivers and streams	B2	-13.226	134.946
146	675	685	Lowland river		Seasonal and irregular rivers and streams	B2	-13.2173	134.957
161	685	695	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-13.1443	135.053
421	685	695	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-13.1692	135.02
422	685	695	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-13.1593	135.033
156	695	705	Lowland river		Seasonal and irregular rivers and streams	B2	-13.1129	135.133
160	695	705	Lowland river	Goyder R	Permanent rivers and streams	B1	-13.124	135.103
162	695	705	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-13.1275	135.093
159	705	715	Lowland river		Seasonal and irregular rivers and streams	B2	-13.048	135.244
94	715	725	Lowland river		Seasonal and irregular rivers and streams	B2	-12.9861	135.303
157	715	725	Lowland river		Seasonal and irregular rivers and streams	B2	-13.0095	135.281
158	**715**	**725**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-13.0361**	**135.256**
92	725	735	Lowland river		Seasonal and irregular rivers and streams	B2	-12.9567	135.331
93	725	735	Lowland river		Seasonal and irregular rivers and streams	B2	-12.9687	135.32
90	735	745	Lowland river		Seasonal and irregular rivers and streams	B2	-12.8609	135.427
91	735	745	Lowland river		Seasonal and irregular rivers and streams	B2	-12.8784	135.406
86	745	755	Lowland river		Seasonal and irregular rivers and streams	B2	-12.8004	135.507

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
87	745	755	Lowland river		Seasonal and irregular rivers and streams	B2	-12.8061	135.499
88	745	755	Lowland river		Seasonal and irregular rivers and streams	B2	-12.8162	135.486
89	745	755	Lowland river		Seasonal and irregular rivers and streams	B2	-12.8328	135.464
82	755	765	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7376	135.574
83	755	765	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7492	135.557
84	**755**	**765**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.7839**	**135.535**
85	755	765	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7896	135.525
96	755	765	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7887	135.526
Buckingham River Basin								
72	765	775	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7024	135.642
76	765	775	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7205	135.599
80	765	775	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7298	135.586
81	765	775	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7254	135.592
58	**775**	**785**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.6838**	**135.69**
60	**795**	**805**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.6964**	**135.941**
70	**795**	**805**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.6955**	**135.922**
95	**795**	**805**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.6927**	**135.861**
59	**805**	**815**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.6985**	**135.986**
66	**805**	**815**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.698**	**135.975**
61	815	825	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7021	136.063
62	815	825	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-12.7027	136.075
63	815	825	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7025	136.07
64	815	825	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7025	136.07
65	815	825	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7024	136.069
67	**815**	**825**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.7047**	**136.117**
71	815	825	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7049	136.123
78	815	825	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7037	136.096
68	**825**	**835**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-12.7074**	**136.144**
69	825	835	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7073	136.212
73	**825**	**835**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.711**	**136.171**
74	825	835	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7112	136.172
75	825	835	Lowland river		Seasonal and irregular rivers and streams	B2	-12.7113	136.172
77	825	835	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-12.7117	136.176
79	**825**	**835**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.7129**	**136.185**
54	**835**	**845**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.6519**	**136.292**
55	**835**	**845**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-12.6586**	**136.283**
56	**835**	**845**	Wetlands		**Seasonal/intermittent freshwater ponds and marshes**	**B10**	**-12.6589**	**136.283**
57	**835**	**845**	Lowland river	**Boggy Ck**	**Permanent rivers and streams**	**B1**	**-12.6551**	**136.289**
51	845	855	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-12.6174	136.327

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
52	845	855	Lowland river		Seasonal and irregular rivers and streams	B2	-12.623	136.32
53	845	855	Lowland river		Seasonal and irregular rivers and streams	B2	-12.6333	136.307
49	855	865	Lowland river		Seasonal and irregular rivers and streams	B2	-12.5419	136.423
50	855	865	Lowland river		Permanent rivers and streams	B1	-12.5741	136.382
40	865	875	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4858	136.494
41	**865**	**875**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.4966**	**136.48**
42	**865**	**875**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.4991**	**136.477**
43	865	875	Lowland river		Seasonal and irregular rivers and streams	B2	-12.5043	136.47
44	865	875	Lowland river		Seasonal and irregular rivers and streams	B2	-12.5301	136.438
45	865	875	Lowland river		Seasonal and irregular rivers and streams	B2	-12.5283	136.44
46	865	875	Lowland river		Seasonal and irregular rivers and streams	B2	-12.5279	136.44
47	865	875	Wetlands		Seasonal/intermittent freshwater ponds and marshes	B10	-12.5165	136.455
48	865	875	Lowland river		Seasonal and irregular rivers and streams	B2	-12.5325	136.434
1	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4393	136.553
2	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4362	136.557
3	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4341	136.559
4	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4337	136.559
5	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4327	136.559
6	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4288	136.561
7	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4256	136.562
14	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4158	136.565
15	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4317	136.56
33	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4544	136.534
34	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4631	136.523
35	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4734	136.51
36	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4682	136.516
37	875	885	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4575	136.53
8	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4115	136.567
9	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.3997	136.597
10	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.3995	136.598
11	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.3994	136.599
12	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.399	136.602
13	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.4023	136.574
28	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.3874	136.641
29	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.3865	136.634
30	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.391	136.619
31	885	895	Lowland river		Seasonal and irregular rivers and streams	B2	-12.3961	136.612
27	895	905	Lowland river	Giddy R	Permanent rivers and streams	B1	-12.3594	136.707
32	895	905	Lowland river	Giddy R	Permanent rivers and streams	B1	-12.3585	136.708
22	**905**	**915**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.2973**	**136.768**

ID	Start (KP)	End (KP)	Ecosystem Type	Name	Surface drainage feature type	Feature code[7]	Latitude	Longitude
23	**905**	**915**	Lowland river		**Seasonal and irregular rivers and streams**	**B2**	**-12.3024**	**136.763**
24	**905**	**915**	Lowland river	**Latram R**	**Permanent rivers and streams**	**B1**	**-12.3001**	**136.765**
25	905	915	Lowland river		Seasonal and irregular rivers and streams	B2	-12.3363	136.73
26	905	915	Lowland river		Seasonal and irregular rivers and streams	B2	-12.3316	136.735
18	915	925	Lowland river		Seasonal and irregular rivers and streams	B2	-12.2021	136.767
19	915	925	Lowland river		Seasonal and irregular rivers and streams	B2	-12.2099	136.777
20	915	925	Lowland river		Seasonal and irregular rivers and streams	B2	-12.2685	136.788
21	915	925	Lowland river		Seasonal and irregular rivers and streams	B2	-12.2809	136.784
38	915	925	Lowland river		Seasonal and irregular rivers and streams	B2	-12.2336	136.788
16	925	935	Lowland river		Seasonal and irregular rivers and streams	B2	-12.1919	136.73
17	925	935	Lowland river		Seasonal and irregular rivers and streams	B2	-12.1955	136.758
39	925	935	Lowland river		Seasonal and irregular rivers and streams	B2	-12.1899	136.716

Appendix C
Groundwater bore locations

Groundwater bores located within the pipeline corridor

Bore name	Location	Const. date	Easting	Northing	Bore no	Depth (m)	Yield (L/s)	SWL (m)
Moyle River Basin								
WR 90/14 PORT KEATS	Port Keats	1/10/90	554900	8420500	RN027214	50.0	0.0	
WUDADUK O/STN.	WUDADUK	5/10/94	549550	8422990	RN029581	21.0	1.0	
PALUMPA 4/96 INVES	PALUMPA	24/08/96	594745	8410900	RN030609	32.0	7.0	
PALUMPA 10/96 INVES	PALUMPA	30/08/96	593973	8410000	RN030730	0.0	5.0	
PALUMPA 21/96	PALUMPA	18/09/96	594700	8410850	RN030771	36.8	3.3	
PALUMPA 23/96	PALUMPA	21/09/96	595110	8409820	RN030773	37.0	4.5	
PALUMPA 25/96	PALUMPA	23/09/96	594575	8409500	RN030775	27.0	3.0	
PALUMPA 28/96	PALUMPA	24/09/96	594600	8409490	RN030778	27.0	3.0	
PALUMPA 29/96	PALUMPA	24/09/96	594750	8409540	RN030779	28.0	3.0	
PALUMPA 30/96	PALUMPA	25/09/96	595090	8409820	RN030801	31.0	3.0	
Daly River Basin								
-	Daly basin	-	753132	8396361	-	-	na	
-	Daly basin	-	842205	8390518	-	-	na	
-	Daly basin	-	791424	8389968	-	-	na	
-	Daly basin	-	791424	8389968	-	-	na	
Goyder River Basin								
NO 3 MAINORU STN	Mainoru	10/9/71	408926	8456165	RN007825	91	0	-
A=135/71 MAINORU STN	Mainoru	10/9/71	408897	8453398	RN007901	91	0	-
BULMAN 4/83 BULMAN	Bulman	11/20/83	430003	8489711	RN022507	125	1	-
Buckingham River Basin								
No 1 BORE 2ND ATTEM	GOVE	6/3/65	698250	8642500	4920	89	2	33.8
PROSPECTING CAMP No 2	GOVE	8/9/69	699900	8641000	6642	66	15	35.7
PRODUCTION BORE No 5	NHULUNBUY	5/1/92	698510	8642180	7991	178	29	0.0
PRODUCTION BORE NO11	GOVE	6/8/71	700200	8642100	7997	120	29	0.0
NEW BORE NO.3	NABALCO		698300	8642550	8707	65	25	31.5
NO.4 AIRPORT	NABALCO	6/3/74	698650	8642750	8833	91	25	0.0
NO.1 AIRPORT	GOVE		699010	8641850	8834	61	25	31.1
NO. 1A	GOVE	7/1/74	699950	8641830	8835	104	25	34.9
NO. 2A	GOVE	6/19/74	699900	8641840	8836	99	25	32.9
NO.17	GOVE WELLF	5/8/80	699500	8641410	20392	90	27	26.0
3/85 (DUD)	GANYANGAR RA	2/18/85	684820	8647800	23575	19	2	0.0
WR 87/2	GOVE SPEEDWAY	10/23/87	693900	8649800	25335	69	3	5.0
WR 87/3	GOVE SPEEDWAY	10/28/87	694000	8649930	25339	21	3	4.8
WR 87/4	GOVE HOSPITAL	10/31/87	693200	8651900	25410	41	2	5.8
1/89 ROAD BORE	GOVE 6273	8/16/89	667800	8620300	26530	96	6	24.7
WR 91/1 NABALCO	GOVE	10/30/91	699670	8641180	27788	99	35	0.0
WR 91/2 NABALCO	GOVE	11/18/91	699450	8641900	27789	99	35	0.0
WR 92/1 GOVE SCHOOL	GOVE	2/18/92	694200	8652200	27966	48	2	0.2
WR 92/1 GOVE SOUTH INVEST.	GOVE	2/21/92	692400	8650700	27967	72	4	5.7
WR 92/2 GOVE SOUTH INVEST.	GOVE	2/22/92	693300	8650000	27968	54	2	8.1
WR 91/3 NABALCO	GOVE 6273	12/2/91	698600	8642200	27970	100	35	0.0
	NHULUNBUY	3/25/92	692500	8650900	27972	60	11	4.1
	NHULUNBUY	3/26/92	692100	8650600	27973	57	9	3.5
WR 92/5 GOVE SOUTH INVEST.	GOVE	2/25/92	692400	8650100	28081	36	2	2.7
	GOVE	3/11/95	700200	8641100	29092	100	30	33.0
	GOVE	3/14/95	697100	8643000	29093	76	5	33.0
	GOVE	2/8/95	699100	8642000	29799	68	5	39.7
P.14	GOVE	7/16/97	701200	8642000	31170	104	25	23.8
O/B 1	GOVE	7/9/97	701000	8643400	31171	84	10	24.0
O/B 2	MINE SITE	7/31/97	697200	8640300	31172	85	8	24.0
O/B 3	GOVE MINE	8/2/97	695600	8640500	31173	85	8	24.0

Bore name	Location	Const. date	Easting	Northing	Bore no	Depth (m)	Yield (L/s)	SWL (m)
	SITE							

REPORT FOR REVIEW

REPORT TITLE:	Trans-Territory Pipeline Project EIS
JOB NO:	Hydrology & Water Quality
SENIOR AUTHOR:	
TARGET DATE FOR SUBMISSION TO CLIENT:	

REPORT REVIEWER(s):____

PLEASE COMMENT: - IMMEDIATELY/ASAP/WITHIN A WEEK

(circle appropriate time frame),

and make specific comments as appropriate directly on the report.

	Signature
GENERAL COMMENTS	
THE DATA PRESENTED ARE ACCURATE, COMPREHENSIVE AND RELEVANT TO THE SCOPE OF WORKS	
From the viewpoint of someone **not specialising in this technical area,** the report reads well and addresses the scope of work	
The methods used to present and analyse data, results/observations (statistical methods used, graphs, tables, diagrams etc) are appropriate to the type of data gathered	
The visual aids (photos, maps, boxes, figures etc) are of a high quality and facilitate comprehension	
The references are appropriate and match those in the text	

On completion of review return report to:____