Chapter 7

Water Resources

PACIFIC **ALUMINIUM**

Contents

Figures

Tables

7 Water Resources

This section describes the existing surface water and groundwater resources in the project area and potential impacts on these water resources from construction of the KGGP Project, in particular the following key activities:

- Extraction of surface water or groundwater for water supply purposes.
- Disposal of water used for project activities.
- Disturbance of surface water or groundwater systems during the construction phases of the KGGP Project.

A water resources assessment for the KGGP Project has been conducted. This assessment is provided in Appendix B and the key findings are provided in this Chapter.

7.1 DESCRIPTION

The existing surface water and groundwater resources in the project area are described in Sections 7.1.1 and 7.1.2.

7.1.1 Existing surface water resources

The KGGP is proposed to pass through the upper section of the Daly River Basin, the northern part of the Roper River Basin, the central portion of the Goyder River Basin and the upper Buckingham River Basin between Katherine and Gove. The Daly River Basin drains westwards to the Timor Sea, while the Roper River drains eastwards to the Gulf of Carpentaria, and the Goyder River and Buckingham River Basins drain northwards to the Arafura Sea. The surface water management areas are presented in Figure 7-1.

The upper Daly River Basin and Roper River Basin are located south of the Arnhem Land Plateau and receive significantly lower annual rainfall (approx. 800-1,100 mm p.a.) than the northern basins draining to the Arafura Sea (approximately 1,500-1,800 mm p.a.) (BoM, 2013), with the bulk of the rainfall occurring between October and April. Potential evaporation is approximately 2,200-2,500 mm/year over the region and is significantly greater than annual rainfall. Table 7-1 provides the streamflow characteristics of the watercourses proposed to be traversed by the KGGP Project, obtained from streamflow records at the Department of Land Resource Management (DLRM) gauging stations.

Table 7-1: Streamflow data summary

GAUGE ID	STREAM	PERIOD OF RECORD	MEAN ANNUAL DISCHARGE (ML/year)	AREA (km^2)	RUNOFF (mm/year)	MAX. FLOW (m^3/s)	MIN. FLOW (L/s)
G8250002	Goyder River	1/9/67 – 1/9/02	788,940	5,440	136	1,413	1830
G8260053	Latram River	1/11/63 – 1/11/85	25,230	85	293	142	65
G8260219	Giddy River	1/9/71 – 1/11/86	44,150	111	552	617	18
G9030003	Wilton River	1/9/67 – 1/6/78	505,000	4,480	112	2,253	14
G9030088/9	Waterhouse River	1/12/60 – 1/8/04	239,760	3,110	73	1,771	<10

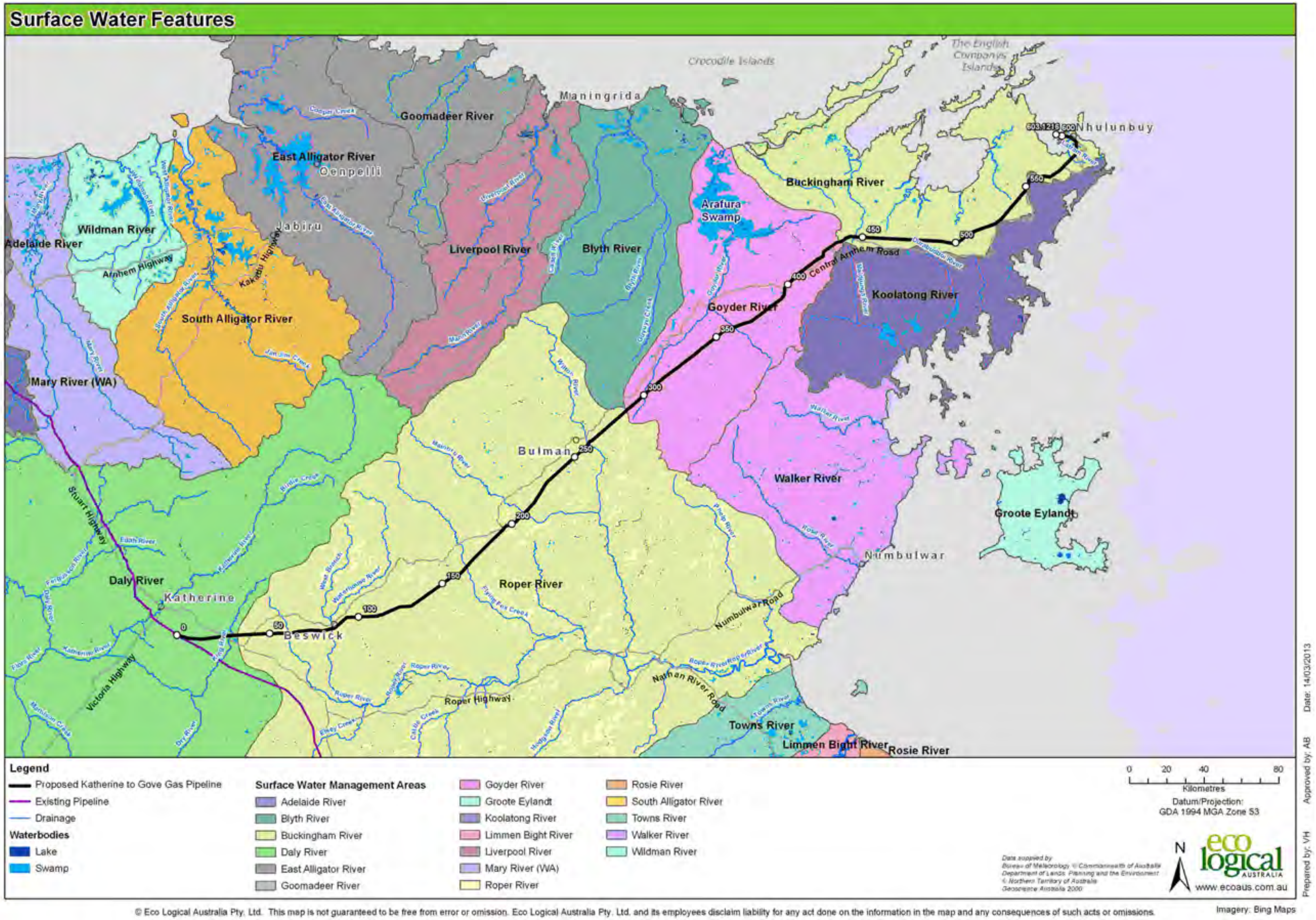

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Figure 7-1: Surface water management areas

Surface runoff is generally limited to the wet, summer monsoon season (December to March), with most watercourses ceasing to flow during the mid to late dry season. Perennial flow is mainly restricted to the larger rivers where baseflow is supplied from groundwater.

The average monthly runoff depths for the gauging stations are shown on Figure 7-2. Records indicate that 70-85% of the annual runoff from the rivers that drain to the northern coast occurs over the December to April period, while approximately 95% of the annual runoff from the rivers that drain to the east and west, the Daly, Roper and McArthur Rivers, occurs over the same period.

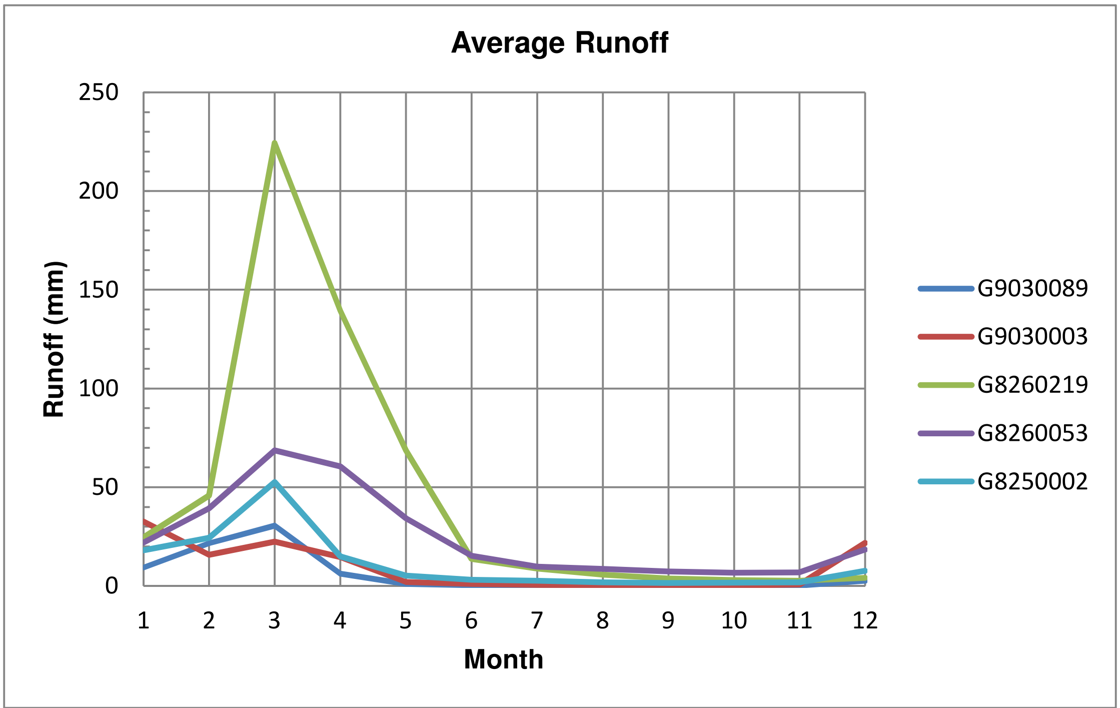

Figure 7-2: Average monthly runoff

The average runoff at station *G9030003* for January is dominated by the January 1976 flood period that contributed approximately 80% of the total January runoff over the period of records. Similarly, the average runoff at *G260219* for March is dominated by the March 1980 flood period that yielded 50% of the total March runoff over the period of records. Although this may be a statistical anomaly due to the relatively short period of record, it does indicate the extreme intra-annual variability of these systems.

The lag between the onset of the wet season rainfall in November and the rise in streamflow in December is due to the build-up of soil moisture prior to catchment saturation and resultant surface runoff. Similarly, the recession of streamflow through May and June reflects the baseflow from groundwater as the soils drain.

The eastern river basins are underlain by porous sandstone aquifers that have a much higher yield than the fractured rock aquifers underlying the central and western sections of the route. The higher yielding aquifers and slightly higher winter rainfall around Gove provide relatively higher dry season flows in the coastal rivers.

7.1.2 Existing groundwater resources

The Northern Territory obtains about 128 gigalitres (GL) of groundwater per annum from 55 Groundwater Management Units (GMUs). The NT *Water Act* enables the declaration of Water Control

Districts (WCD) within the Northern Territory, providing an increased level of water management and protection.

The proposed pipeline corridor traverses the following six GMUs (Figure 7-3):

- Daly River Basin – Tindall Limestone.
- Daly River Basin – Jinduckin Formation.
- Proterozoic Sedimentary Rock (North East Northern territory).
- Proterozoic Rocks low yielding (Bulman).
- Proterozoic Sedimentary (Adelaide River).
- McArthur Basin including Gove Water Control District (WCD).

These GMUs are largely contained in the McArthur River and Daly River groundwater provinces, and are described below.

Daly River Basin – Tindall Limestone

The first approximately 50 km of the proposed pipeline corridor is within the Daly River Basin. Three aquifers are present in the Lower Palaeozoic Daly Basin, a sequence of gently dipping carbonate rocks. The major aquifer is the Tindall Limestone, the basal formation. Individual bores can produce water up to 60 L/s and average 80 m deep. Water quality is generally good and suitable for most purposes. The aquifer is fractured and cavernous and is hydraulically connected to the Katherine River. Springs in the river bed and bank at Katherine discharge groundwater when river levels are low; however, during flood events, river water flows back into the aquifer. Distributed recharge also occurs, averaging approximately 40-140 mm/year dependent upon whether the aquifer is confined by the overlaying cretaceous sediments or unconfined and open to direct recharge.

A borefield three kilometres east of the town of Katherine supplements the river water. Up to 40% of the annual supply of 4,039 million litres is from these groundwater bores. Groundwater is blended with the river water to increase pH, making it less corrosive to metal pipes. High hardness (a measure of the amount of calcium (Ca^{2+}) and magnesium (Mg^{2+})) limits the proportion of groundwater used. The aquifer also supports a small horticultural and cropping industry.

Limestone inter-fingers with the overlying Jinduckin Formation to form less extensive aquifers. Evaporite deposits in the shales locally impart high sulphate (SO_4^{2-}) concentrations to groundwater. Total Dissolved Solids (TDS) reach a maximum of 4,000 milligrams per litre (mg/L) and elevated radium (Ra) contents have also been reported.

The uppermost formation in the basin, the Oolloo Limestone, forms a major aquifer similar in properties to the Tindall Limestone. The depth to groundwater level varies during the year, in response to rainfall recharge, from 3 – 25 m.

Daly River Basin – Jinduckin Formation

The Jinduckin Formation is located within the Daly River Basin. This comprises gently dipping Palaeozoic Jinduckin Formation of the Daly River Basin sequence. The aquifers are present in fractured and karstic limestone interbeds, within a section consisting mainly of siltstone. Bores in the limestone are capable of producing moderate yields. Water quality is generally moderate and may be locally brackish due to the presence of interbedded evaporite deposits. Such groundwaters are high in sulphate (SO_4^{2-}), calcium (Ca^{2+}), sodium (Na^{+}) and chloride (Cl^{-}). Recharge comprises both distributed recharge and infiltration from rivers. The Daly and Katherine Rivers cross the area and these receive minor discharge from the aquifers. The underlying Tindall Limestone, which comprises UA NT24[1], dips beneath the Jinduckin Formation and forms the most productive aquifer.

Proterozoic Sedimentary GMUs (North-east NT, Bulman and Adelaide River)

Extending north-east from Beswick there are three GMUs referred to as Unincorporated Areas (UA) which would be traversed by the pipeline corridor (Figure 7-3). These are Proterozoic-aged sedimentary units of the 1) Northeast Northern Territory; 2) Bulman; and 3) Adelaide River GMUs; with sustainable groundwater yields of 500,000 ML; 22,000 ML; and 99,800 ML, respectively. Little is known of these GMUs; however, these Proterozoic units are generally gently folded, with shale and siltstone as the dominant rock type. Aquifers associated with these GMUs are fractured systems, predominantly at depths of less than 100 m.

McArthur Basin

The majority of the length of the KGGP would pass through the McArthur River Basin which has five GMU's and includes the Gove WCD. These include:

- Gently folded Proterozoic sandstone and shale are the dominant rocks but dolomite, siltstone and greywacke also occur. Aquifers are the fractured rock type, mostly developed shallower than 100 m. Bore yields are mostly less than 2 L/sec but higher yields occur near major fracture zones. Several mines use groundwater for processing and undertake varying levels of dewatering. Recharge is of the distributed type, probably less than 5 mm/year. Discharge occurs via springs and into riverbeds.
- Proterozoic dolomite comprising the Dook Creek Formation, a unit of the gently folded Proterozoic McArthur Basin. The aquifer associated with this formation is virtually untested but may contain a major groundwater resource. Recharge is of the distributed type, probably within the range 10 to 50 mm/year. Discharge occurs as baseflow into riverbeds. A dry season flow of 1000 L/sec in the Goyder River is supplied from discharge from the aquifer.
- Low-Yielding Proterozoic rocks (near the town of Bulman). This formation comprises various low permeability rocks in the gently folded Proterozoic McArthur Basin. Alternating sequences of shale and siltstone are the dominant rocks but dolerite and granite also occur. Aquifers are either absent or sparsely developed low-yielding fractured rocks. Saline waters occur adjacent to the coast and tidal rivers. Recharge is likely to be very low.
- Cretaceous sedimentary rocks. This formation comprises poorly consolidated, flat lying Cretaceous sands. The aquifer is virtually untested but may contain a major groundwater resource, similar to that in the Gove Water Control District to the northeast. Water quality is good with TDS values generally less than 100 $mg.L^{-1}$.
- Recharge is of the distributed type, probably within the range 10 to 50 mm/year. Discharge occurs as baseflow into riverbeds. Several of the area's streams maintain dry season flows of more than 100 L/sec.

[1] Unincorporated Area (UA) designated NT24

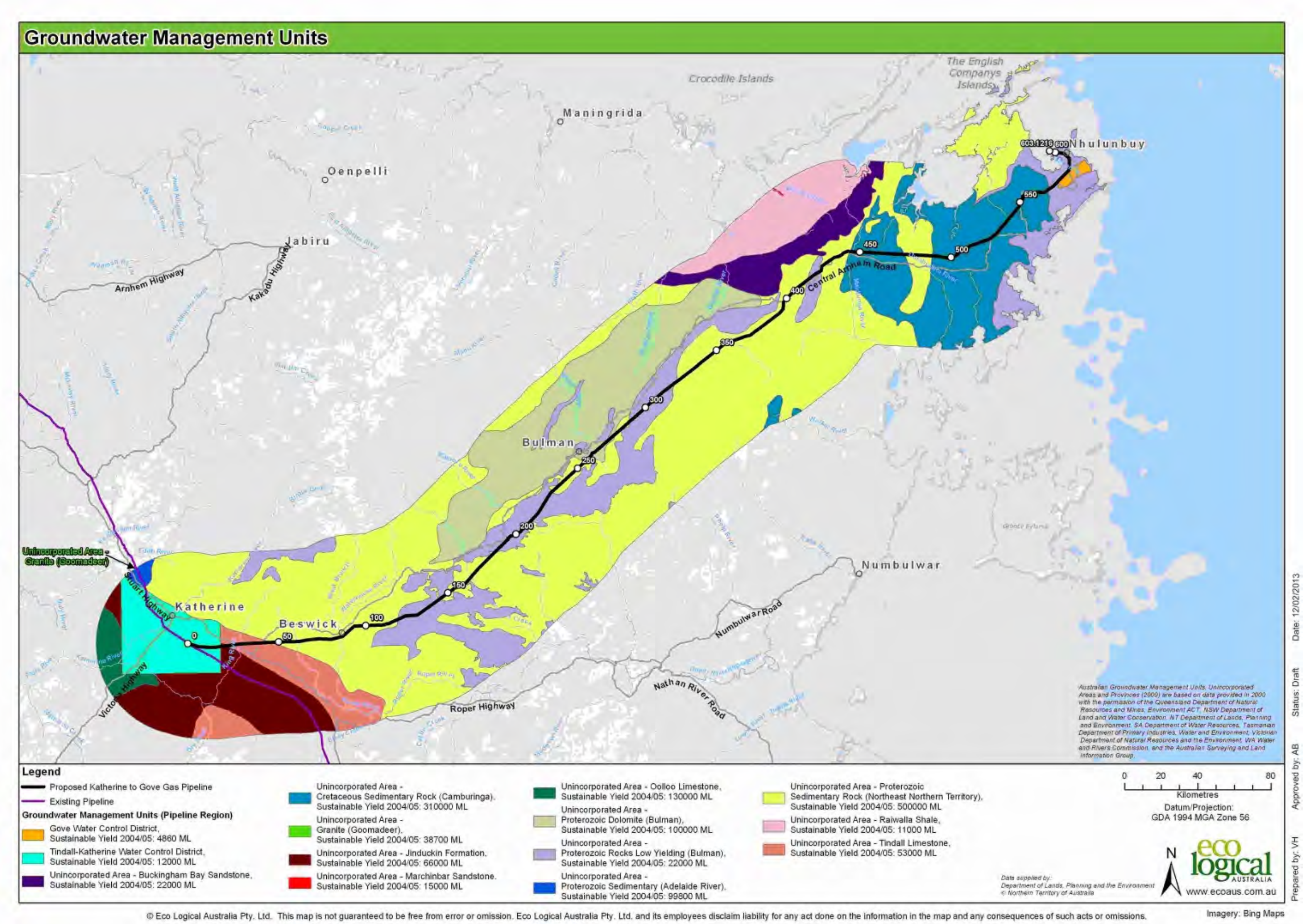

Figure 7-3: Groundwater Management Units (GMUs) KGGP Pipeline Region

Gove Water Control District (WCD)

This is a declared Water Control District, located in northeast Arnhem Land. The aquifer consists of poorly consolidated, flat lying Cretaceous sands in an outlier of the main body of the formation to the southwest. The settlements of Nhulunbuy and Yirrkala obtain their water supplies from the aquifer but the major user is the Gove bauxite mine. Production bores are typically 80 m deep and supply up to 60 L/sec each. The total supply from the borefield is 1,697 ML/year. Water quality is good with TDS values generally less than 100 $mg.L^{-1}$. Recharge is of the distributed type, probably within the range 10 to 50 mm/year. Discharge occurs as baseflow into riverbeds.

7.2 POTENTIAL IMPACTS OF CONSTRUCTION AND OPERATION

Construction of the gas pipeline has the potential to impact surface water and groundwater resources from:

- Extraction of surface water or groundwater required for construction activities.
- Physical changes to waterways and topography along the ROW.
- Potential contamination from stormwater; wastewater spills or disposal; or spills of hazardous chemicals.

Sections 7.2.1 to 7.2.3 provide a description of each of these potential impacts and management measures proposed to minimise these potential impacts.

7.2.1 Water extraction

Water is required for the following construction activities:

- Potable water for construction camps.
- Hydrotesting of pipeline.
- HDD (Horizontal Directional Drilling) creek crossings.
- Dust suppression.
- Washdown of vehicles, compaction of trench backfill and other miscellaneous purposes.

The estimated total volume of water required for the project is approximately 207-229 ML. A breakdown of the daily and total water demand for key water use activities is provided in Table 7-2.

Table 7-2: Projected water usage during construction period

ACTIVITY	VOLUME (ML)	DAILY DEMAND (KL/D)
Construction Camp Potable Water	50	300
Hydrotesting	24-46	variable
HDD	0.77	23
Dust suppression	132	800
Miscellaneous uses	Minor	<2

The management and protection of water resources in the Northern Territory is controlled under the NT *Water Act.* The *Water Act* governs the extent to which both surface and groundwater can be used, and for what purpose, and its disposal; however, Section 7 of the *Water Act* provides an exemption from the need for licensing of water extraction for mining and petroleum related activities and as such no such licences would be required. A general guideline that has been used by the Northern Territory Government has been to restrict the amount of water allowed to be extracted to 20% of recharge, in respect to groundwater, and 20% of instantaneous flow in respect of surface water. As can be seen from Table 7-3, it could be expected, using existing information, that this could be achieved in most cases.

Table 7-3: Estimated water demand and surface water sources (ML)

MONTH	STREAM	TOTAL DEMAND	ESTIMATED FLOW
Jul-14	King River	7.51	70
Aug-14		8.08	33
May-14	Beswick Ck	2	177
Jun-14		2	66
Jul-14		2	33
Aug-14		8.11	16
Sep-14		2	7
Jun-14	Waterhouse River	0.08	1250
Jul-14			625
Aug-14		17.12	295
Aug-14	Latram River	7.32	730
Sep-14			630
Jul-14	Giddy River	0.08	700
Aug-14			450
Sep-14		5.01	300
Jun-14	Mainoru River	2	1750
Jul-14		4.08	950
Aug-14			580
Sep-14		20.59	500
Oct-14		2	480
Jul-14	Wilton River	2.5	2300
Aug-14		2.58	1400
Sep-14		2.5	1220
Oct-14		24.74	1170
May-14	Cato River	2	5680
Jun-14		2	1130
Jul-14		4.08	725
Aug-14			470
Sep-14		2	310
Oct-14		34.20	250
Jul-14	Boggy Ck	2.5	1190
Aug-14		5.08	770
Sep-14			510
Oct-14		2.5	405
Sep-14	Goyder River	0.11	1470
Oct-14		13.13	1580
Nov-14		13.13	1860
Totals		**206.8**	**32083**

Water Supply and Adaptive Management Strategy

Pacific Aluminium has developed a preliminary Water Supply and Adaptive Management Strategy. The strategy proposes to use a combination of:

- Surface water from perennially flowing streams at the time of construction.
- Groundwater from existing or new bores.
- Municipal water supply from Katherine or Gove.

The preferred water supply source would be from surface water resources; however, given that construction is proposed predominantly during the dry season, when surface water resources are highly variable, alternative groundwater and municipal water supplies have also been considered.

Groundwater may be required in some locations where dry season flows may be too low for sustainable extraction. Groundwater would be supplied from existing or new bores. Where surface water or groundwater extraction cannot be undertaken or is of poor quality, water would be sourced from municipal supply at Katherine or Gove and trucked to the relevant location.

Preliminary estimations of water availability from each of these sources indicate that using either one or a combination of each of these water sources would provide adequate water for the KGGP Project. However, there are limited data on water resources within the project area, and therefore a work program has been proposed as part of an adaptive management strategy. This work program would include collection of simple flow calculations and use of low-tech gauges to obtain a better understanding of the dry season flow behaviour of watercourses potentially subject to water extraction.

A summary of the work program and preliminary Water Supply and Adaptive Management Strategy is provided in Table 7-4.

The preliminary Water Supply and Adaptive Management Strategy would be refined following the work program and prepared as a stand-alone document prior to construction of the KGGP Project.

The following subsections provide an overview of the preliminary evaluation of surface water, groundwater and municipal water supply for the project, consistent with the preliminary Water Supply and Adaptive Management Strategy.

Surface water evaluation

Table 7-3 provides the estimated monthly water demand and compares it to the estimated flow in each of the proposed surface water supply sources (derived from the monthly average depths of runoff listed in Table 7-1) and the catchment areas above the pipeline crossing locations on each watercourse).

The estimated total volume of water required for the project is approximately 207-229 ML, which is equivalent to less than 1% of the estimated total flow past the proposed extraction locations on the surface watercourses during the construction period. As stated above, the Northern Territory Government guideline generally aims to ensure that not less than 80% of the natural flow in surface watercourses is available for environmental flow requirements (NTG 2006). Therefore, it is considered that the proposed extraction of surface water by the KGGP Project would have an overall temporary and negligible impact on the hydrologic regimes and riverine ecology of the project area and pipeline region more generally.

However, projected demands proposed from the King River and Beswick Creek may represent 25-50% of the total flow in the streams for ‘average’ conditions during August and September. The

Table 7-4: Water Supply and Adaptive Management Strategy Work Program

WATER SOURCE	PROPOSED WORK PROGRAM FOR 2013 DRY SEASON
Surface water	• Collect flow information at potential extraction locations during the 2013 dry season. • Compare 2013 flow data to existing data to determine potential for surface water extraction and inform the Water Supply and Adaptive Management Strategy. • Continue flow monitoring during the construction period in 2014 to ensure impacts are mitigated, generally in line with the current NT guideline of restricting extraction to 20% of flow.
Groundwater	• Undertake field investigations during the 2013 dry season of existing groundwater bores that have been identified as a potential source of groundwater. At each borehole basic data will be collected such as: − Whether bores exist, if they are functional and capable of producing the required yields and the approvals required for obtaining water supplies. − Estimate of the capacity of each borehole to provide the necessary quantities and qualities of groundwater for the intended uses. − Identify any health issues, and/or potential environmental impacts from the temporary use/consumption of the groundwater and disposal options.
Municipal water	• From information obtained during the surface water and groundwater work programs, determine maximum potential usage of municipal water supply. • If required, consult with licence holder for the municipal supply to determine if water could be used for the project and the agreements or licence required.

planned extractions are above the 20% usage threshold and may cause moderate temporary impacts on the hydraulic regime and riverine ecology at that time. Water flow monitoring during the 2013 dry season would be used to confirm the potential flows and whether it may be necessary to obtain water for construction of the western end of the pipeline from alternative streams or from groundwater. Flow monitoring would also be required during the construction phase in order to implement mitigation strategies where practicable.

Groundwater evaluation

Groundwater may be required for only small volumes of water, where the surface water flow is not adequate to sustainably extract. Areas that may require supplementary groundwater supply are at King River, Beswick Creek, and Cato River. The Water Supply and Adaptive Management Strategy work program (Table 7-4) would be used to inform the potential maximum extraction from groundwater required for the KGGP Project.

When the maximum groundwater supply is determined, field investigations would be undertaken during the 2013 dry season, of existing groundwater bores that have been identified as a potential source of groundwater. At each borehole, basic data will be collected as per Table 7-4.

Dry season water resources in the pipeline region are particularly important for populations of Gouldian Finches, a threatened species recorded in the pipeline corridor as utilising a small waterhole near KP116. The finches have an absolute dependency on water in proximity to available breeding and feeding habitat. The pipeline corridor also traverses across a number of seasonal (ephemeral) wetlands which although likely to be dry during construction, provide habitat for wetland fauna during the wet season. Any extraction of groundwater will not be located in areas where extraction could foreseeably alter the hydrological regime of known Gouldian Finch water resources and/or regionally significant wetlands.

Municipal Evaluation

In the unlikely situation where there is inadequate surface water or groundwater resource, or the water quality is poor, two options for municipal supply have been identified:

- **Katherine** - a borefield three kilometres east of the town provides Katherine with approximately 40% of the annual supply of 4,039 ML from these groundwater bores.
- **Gove WCD** - the settlements of Nhulunbuy and Yirrkala obtain their water supplies from the aquifer but the major user is the Pacific Aluminium Gove mine and refinery. Production bores are typically 80 m deep and supply up to 60 L/sec each. The total supply from the borefield is 1697 ML/year.

Given the current use of these water supply systems, it is anticipated that this water could be used to supplement the small volumes that may be required where surface water or groundwater could not supply the western or eastern end of the KGGP Project, respectively.

7.2.2 Physical changes to watercourses (including increased sedimentation)

During the early project design phase, watercourse crossings played a key role (together with other environmental, social, economic and technical aspects) in determining the most appropriate route for the KGGP. Revisions were made to the preferred route in order to avoid areas of significant environmental or cultural sensitivities and to provide the best engineering option.

The proposed pipeline corridor would unavoidably cross a total of 217 water courses of which approximately 26 are defined as major watercourses and the remaining 189 as minor watercourses. Temporary physical changes to waterways would occur from ephemeral and perennial stream crossings. It is proposed to construct the watercourse crossings during the ‘dry’ season between June and November when the majority of streams will not be flowing. Major watercourse crossings are shown in Figure 7-4. The proposed methods for watercourse crossings are described in Chapter 2 and summarised below.

The method used at each watercourse crossing would be dependent on environmental factors, geotechnical constraints and landholder views regarding the significance of the watercourse. Horizontal Directional Drilling (HDD) and open-cut and would be the preferred construction methods.

Horizontal Directional Drilling

The HDD method would be preferred where the long term stability of the crossing is of concern or for ecological reasons, particularly to protect significant riparian vegetation or conservation values. HDD would also be used at any watercourse that is determined to be in flow by the construction contractor at the time of constructing the crossing. Minor flows at the time of construction would not necessitate HDD.

Confirmation of crossings requiring HDD will be the subject of further consideration during the engineering and design phase; however, nine watercourses have already been identified as potentially requiring to be crossed by HDD for the reasons above and are listed in Table 7-5 with their location and rationale for selection. Figure 7-5 locates these crossings along the pipeline corridor.

Table 7-6 provides further information on each of the stream crossings that may require HDD, including the minimum flow recorded at gauging stations.

The potential environmental impacts associated with a HDD installation during operations are generally minimised compared with traditional trenched crossing, as there is no surface disturbance of the stream bed and banks.

Some geotechnical investigations of the proposed HDD crossing sites have been undertaken by Golder Associates (2004) and further investigations are proposed during the 2013 dry season to refine this earlier work. The additional geotechnical investigation will confirm the subsurface conditions at the specified crossings. The objective of the field investigation works is to identify soil types, presence of rock, groundwater conditions (where groundwater is present) in order to assess the nature and condition of materials likely to be encountered for the design and construction at the proposed crossings. In addition, the field investigations are to provide the relevant site information necessary to determine cover depths required to minimize exposure and damage from scour and erosion and the risk of pipeline buoyancy during flood events.

Trenched crossings

If the stream is dry (not in flow) or has minor flows, or detailed geotechnical investigation of HDD determines the existence of a rock shelf or other conditions that indicate HDD is not technically feasible, then trenched crossings would be undertaken.

Trenching across watercourses involves in-stream excavation and pipe laying, conducted (if flow is occurring) within a temporarily dewatered section of the watercourse. Protection of the works from stream flows (if occurring) is achieved by temporarily diverting flow around the work area while ensuring minimal hydrological impact. Stream flow would be maintained by use of flume pipes or partial weirs. Silt fencing would be installed where required to reduce silt movement beyond the excavation and to contain stockpiled spoil.

Table 7-5: Indicative horizontal directional drilled (HDD) river crossings

WATERCOURSE	KP	RATOINALE FOR SELECTION
King River	29.5	Deep and wide river channel with steep banks that could be difficult to stabilise and rehabilitate.
Waterhouse River	83.7	Riparian vegetation and in-stream habitat of conservation significance – potential for significant impacts if construction machinery is transported across multiple braided channels.
Mainoru River	209.5	Riparian vegetation and in-stream habitat of conservation significance – potential for significant impacts if construction machinery is transported across multiple braided channels.
Wilton River	259.5	Riparian vegetation of conservation significance. Deep river channel with steep banks – specific attention is required to stabilise and rehabilitate. Note that access road across the river, adjacent to proposed pipeline alignment, would be used to transport equipment across river.
Goyder River	360.5	Riparian vegetation and in-stream habitats of conservation significance - potential for significant impacts if construction machinery is transported across multiple braided channels. Deep river channel with steep banks – specific attention is required to stabilise and rehabilitate.
Boggy Creek	511.5	Riparian vegetation and in-stream habitats of conservation significance. Deep river channel. Potential for impacts on hydrology of waterhole that has a small outflow.
Cato River	539.7	Riparian vegetation and in-stream habitats of conservation significance.
Giddy River	571.7	Riparian vegetation and in-stream habitats of conservation significance – potential for significant impacts on the vegetation island in the river channel. Banks require specific attention to stabilise and rehabilitate.
Latram River	581	Known habitat of *Pternandra coerulescens*, a plant species listed as Vulnerable under NT legislation. High level of recreational use as a waterway. Riparian vegetation and in-stream habitat of conservation significance.

Table 7-6: Proposed HDD watercourse crossings and minimum flow

Stream	KP (km)	Catchment Area (km^2)	Minimum 'Dry' Season Flow (L/s)
King River	29.5	365	5
Waterhouse River	83.7	3280	50
Mainoru River	209.5	1865	185
Wilton River	259.5	4505	445
Goyder River	360.5	995	560
Boggy Creek	511.5	135	130
Cato River	539.7	80	75
Giddy River	571.7	80	75
Latram River	581.0	85	220

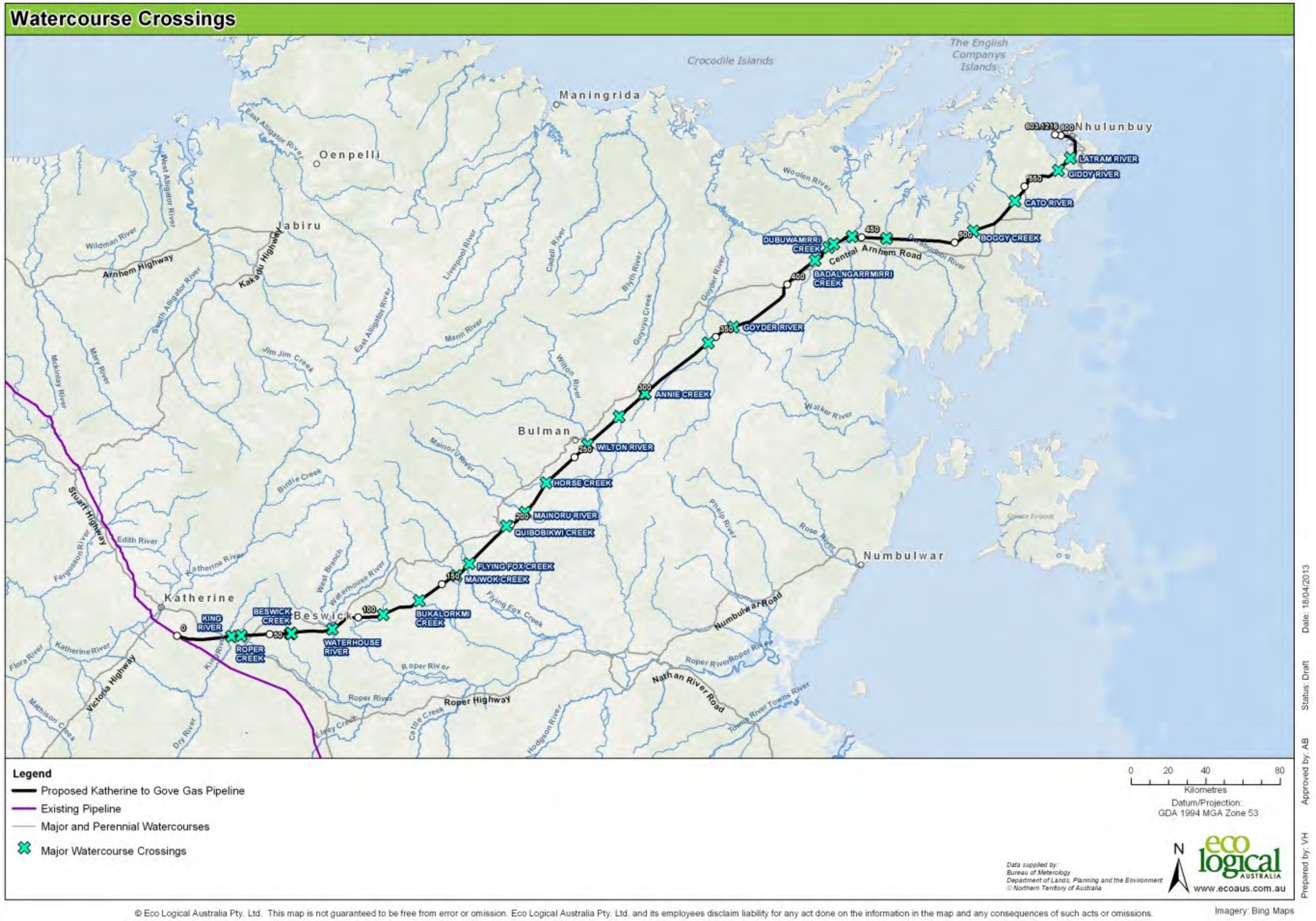

Figure 7-4: Major rivers crossed by the Katherine to Gove Gas Pipeline

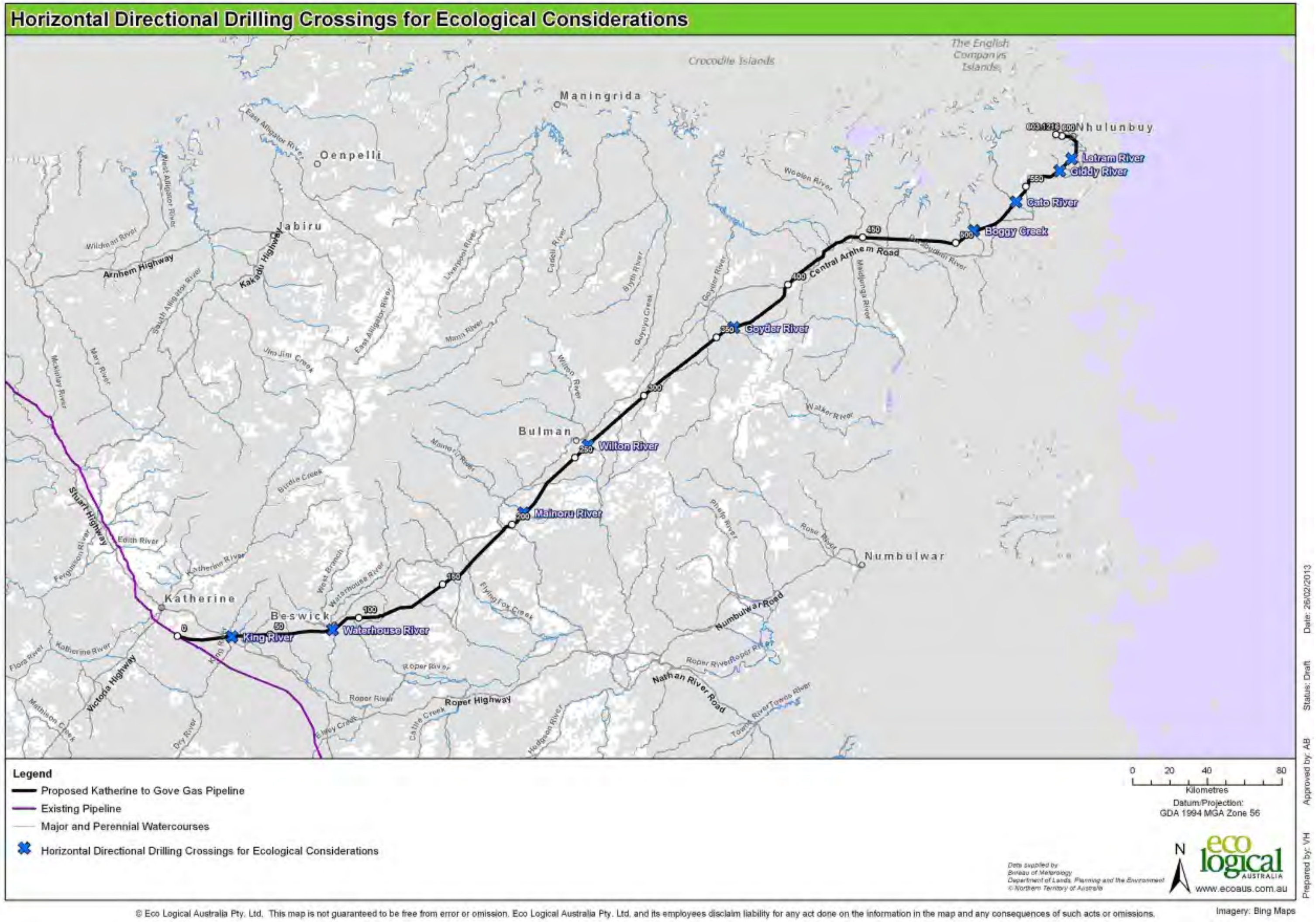

Figure 7-5: Watercourse crossings proposed for horizontal directional drilling

Following trenching, the stream bed would be reinstated to its original condition and profile. Temporary erosion and sediment control measures such as geofabric would be used to stabilise the stream bed.

Dry season water resources in the pipeline region are particularly important for populations of Gouldian Finches, a threatened species recorded in the pipeline corridor recorded utilising a small waterhole near KP116. Gouldian Finches have an absolute dependency on water in proximity to available breeding and feeding habitat. The pipeline corridor also traverses a number of seasonal (ephemeral) wetlands that, although likely to be dry during construction, provide habitat for fauna during the wet season. Drainage in and adjacent to known Gouldian Finch water sources and/or seasonal wetland areas will be reinstated as soon as practicable following construction.

7.2.3 Potential chemical contamination

Potential contamination from the KGGP Project may occur from the following key activities:

- Disposal of hydrostatic test water.
- Stormwater runoff.
- Wastewater disposal.
- Chemical leaks and spills.

The potential impacts and management of these activities are described in the following subsections and summarised in Table 7-8.

Hydrostatic test water

The disposal of hydrostatic test water to land would be carried out in a manner that ensures:

- Vegetation is not damaged.
- Soil erosion and soil structure damage is avoided.
- No surface ponding of released water occurs.
- The quality of groundwater is not adversely affected.
- No release of water to any surface waters.

It is proposed to dispose of hydrotest water by land application to stable (rocky) vegetated areas to minimise direct impacts on surface water quality and wetland environments. If a suitable site for land disposal cannot be located at an acceptable distance of the pipeline or with negotiated access, the hydrotest water may be disposed via an evaporation pond.

Evaporation ponds would not exceed approximately 1 ha in area (based on 9 ML maximum storage) and 1 m in depth in order to maximise the opportunity for hydrotest water to evaporate before the onset of the monsoon rainfall season. The evaporation ponds would be lined with geomembrane or clay to prevent seepage and potential local impacts to groundwater quality, levels and flow dynamics.

Hydrostatic test water may require minor amounts of biocides and oxygen scavengers to prevent corrosion of the pipeline, which has the potential for temporary small scale impacts on soil and vegetation. The source water may also have elevated levels of TDS or other contaminants. Prior to disposal, hydrostatic test water would be tested and where the limits shown in Table 7- are exceeded, water treatment would be undertaken.

Treatment of hydrotest water for disposal may comprise one or more of the following:

- Discharge onto geofabric to trap sediment and minimise erosion.
- Holding ponds for settling of sediments.
- Chemical treatment and absorption of organic pollutants with activated carbon.

Table 7-7: Limits for the application of hydrostatic test water to land (CMIT, 2005)

PARAMETER	LIMIT
pH	6.5 – 8.5 (Range)
Arsenic	2.0 mg/L (Maximum)
Cadmium	0.05 mg/L (Maximum)
Chromium VI	1.0 mg/L (Maximum)
Copper	5.0 mg/L (Maximum)
Iron	10.0 mg/L (Maximum)
Lead	5.0 mg/L (Maximum)
Manganese	10.0 mg/L (Average)
Zinc	5.0 mg/L (Maximum)
Nitrogen	35.0 mg/L (Maximum)
Phosphorus	10.0 mg/L (Maximum)
Electrical Conductivity	2000 µS/cm (Maximum)

(CMIT; Commonwealth Manufacturing and Infrastructure Technology Group)

The hydrotest water would be released to land for disposal in accordance with a Hydrotest Water Management Plan (consistent with the Provisional Hydrology and Water Quality Plan at Appendix O). The land disposal area should be located more than 100 m from the nearest watercourse and the hydrotest water quality for release to land would comply with the limits set out in Table 7-. The small volumes of water transferred and short durations of released hydrotest water are considered unlikely to significantly impact local hydrologic behaviour.

Stormwater management

The management of stormwater quality is focused on separation of runoff from potentially contaminated areas within the camps and facilities from 'clean' stormwater runoff and appropriate treatment of both streams.

Potentially contaminated stormwater is to be captured and transported off-site for treatment and disposal or is to be treated on-site prior to discharge.

Runoff from external areas is to be diverted around the camps and facility sites in order to minimise flows to be conveyed in the internal drainage system and to minimise hydraulic loading of treatment devices, where practicable and appropriate. The diversion of external runoff is not to result in concentration of flows, scouring or sedimentation in natural drainage lines or erosion of overbank areas and is to avoid or minimise removal of vegetation.

Surface runoff from within the camps is to be collected and conveyed via swale drains or pipes to treatment devices that may include detention basins for flow management, sediment basins, bio-retention basins or other devices for pollutant removal.

Mitigation works, including energy dissipaters and erosion prevention treatments, will be installed where required.

Wastewater management

The sanitary wastewater stream will comprise both grey water and sewage which will be treated on site and disposed of in accordance with statutory regulations, including *'Code of Practice for small on-site sewage and sullage treatment systems and the disposal and reuse of sewage effluent'* (NTG). Treated wastewater may be recycled for laundry and toilet use. Effluent disposal areas will be located with appropriate setbacks from construction camps and watercourses. The settled solids or sludge would be road transported and disposed of at sewage plants such as at Katherine, Darwin and Nhulunbuy.

Trade waste including oil and grease from workshops will be treated in dedicated treatment facilities in accordance with *'Guidelines for On-site Pre-treatment'* (PowerWater) prior to transport off-site and approved disposal.

Vehicle wash-down water will be directed to holding tanks for removal of weed seed prior to release.

Chemical spills or leaks

A number of chemicals and hazardous materials would be required for the construction of the KGGP Project, including hydrocarbon fuels and chemicals used for the hydrotesting procedure such as biocides and oxygen scavengers.

Refuelling and chemical storage areas that have the potential to generate contaminated stormwater containing concentrated loads of hydrocarbons or process chemicals would be stored and used according to the relevant Australian Standards and other guidelines (e.g. fuels and chemicals to be stored and handled in accordance with AS 1940 and AS 3780) to minimise the potential for contamination of stormwater runoff from the site.

To contain any contaminated runoff or spills and to prevent ingress of 'clean' runoff from other areas; bunded areas would be drained to internal sumps from which the captured contaminated stormwater is to be directed to an appropriate treatment process/device or removed for treatment and disposal at an approved location.

7.3 MITIGATION RESPONSES AND ASSESSMENT OF POTENTIAL IMPACTS

7.3.1 Environmental Management Plans

The following management plans (Appendix O) would include measures to minimise impacts on water resources:

- Hydrology and Water Quality Management Plan.
- Soil and Landform Management Plan.

7.4 SUMMARY – PREDICTED ENVIRONMENTAL OUTCOMES

After mitigation is applied, the construction and operation of the KGGP is not expected to result in significant impacts on hydrological values because:

- Construction will be temporary, with areas rehabilitated as soon as practical and restored back to original condition.
- Construction will occur largely during the dry season when many watercourses will be dry, or have much lower flow regimes.
- HDD construction methods will be used for at least nine watercourse crossings and at any watercourse crossings that are in-flow during construction (minor flows at the time of construction would not require HDD techniques).
- Sediment and erosion control measures will protect downstream water quality values.
- A number of EMPs will be developed to further mitigate any potential impacts to hydrological values.

Table 7-8: Mitigation for impacts on water resources

POTENTIAL IMPACT	PROPOSED MITIGATION (ACTION)		ANTICIPATED EFFECT OF MITIGATION
	AVOIDANCE	MINIMISATION	
Water extraction	• Monitor flows upstream and downstream of extraction location using staff gauge. • Cease extraction if upstream flow conditions significantly change. • Cease extraction if water level drops excessively at critical downstream location. • Any extraction of groundwater will not be located in areas where extraction could foreseeably alter the hydrological regime of known Gouldian Finch water resources and/or regionally significant wetlands.	• Work program undertaken and a water supply and adaptive management strategy to be developed and implemented.	• Water supply for the KGGP Project to have only temporary and negligible impact on hydraulic regime and riverine ecology the project area.
Physical disturbance of waterways	• The project has been designed to avoid significant topographical features where practicable. • HDD construction methods will be used at sensitive watercourse crossings and those in flow. • The total area to be disturbed would be restricted to the minimum area required to construct the pipeline and above ground facilities. • Construction activities involving substantial land disturbance would be confined to the dry season, wherever possible.	• Use trench method and reinstate bed and bank profiles at non-HDD watercourse crossings. • Soil conservation works would be installed to prevent mass movement and safely control runoff. • Sediment traps, level sills, and silt fences will be installed to minimise soil loss from the working areas, diversion banks and roll-over banks. • Construction at watercourses will be planned to ensure that the watercourse is open for as short a time period as practicable. • Sediment control fences will be installed at all rivers, creeks and watercourses where required to	• Duration and extent of disturbance to waterways are minimised. • Stream bed and banks are reinstated to original profile to minimise risk of long term impacts.

POTENTIAL IMPACT	PROPOSED MITIGATION (ACTION)		ANTICIPATED EFFECT OF MITIGATION
	AVOIDANCE	MINIMISATION	
		prevent silt entering waterways. • Maintenance works at watercourses will be confined to the dry season. • Rehabilitation of disturbed areas will be undertaken as soon as possible during the work season following construction, and prior to the onset of the wet season. • Monitoring of erosion will be undertaken regularly for the duration of construction and operation. • Rehabilitation progress will be monitored until areas are adequately stabilised and follow-up monitoring of rehabilitation success will be undertaken after the first wet season following construction. • Drainage in and adjacent to known Gouldian Finch water sources and/or seasonal wetland areas will be reinstated as soon as practicable following construction.	
Contamination	• No water used for any purpose during construction, commissioning or operation will be released directly to a water body. • Fuel and chemical storage would be above ground and will be located an appropriate distance from surface water resources. • Fuel and chemical storage, handling and distribution systems will be designed and constructed in accordance with Australian Standards, and will be fitted with	• Temporary drains and banks, stabilised to prevent erosion in areas of high water flows, will be installed where required to control surface runoff. • Hydrotest water will be disposed of by ground application in a stable environment • Provision of spill kits at all chemical storage facilities • No water will be extracted from a surface water body for any purpose prior to an evaluation of the potential	• The risk of accidental spills is minimised and effective management measures are deployed in the event of a spill.

POTENTIAL IMPACT	PROPOSED MITIGATION (ACTION)		ANTICIPATED EFFECT OF MITIGATION
	AVOIDANCE	MINIMISATION	
	leak detection systems. • A storm water and drainage management system will be developed and implemented for the facility sites including compressor and scraper stations	environmental impacts of the amount of water that will be extracted	