8. General impacts

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8.1 Overview

This chapter provides an overview of potential general impacts of the Lower Fitzroy River Infrastructure Project (Project). This includes an assessment of impacts relating to river morphology and stream flow hydrology, water quality, ecology, extreme environmental events, hazardous substances, weed and pest species as well as socio-economic impacts. This chapter addresses the requirements of Part C of the terms of reference for the environmental impact statement (EIS) in relation to general impacts.

8.2 River morphology and stream flow hydrology

8.2.1 Disruption and diversion of flows during construction

Downstream flows (and operational releases as applicable to the existing Eden Bann Weir) will be maintained throughout the construction period and it is not expected that flows will be adversely impacted as a result of the Project's construction. Furthermore, it is not expected that construction of the Project will be adversely impacted by flood flows.

Raising Eden Bann Weir and construction of Rookwood Weir are each scheduled in four phases dictated by alternating wet and dry seasons over an approximate two to two-and-a-half-year period. For the most part, construction activities to be undertaken during the wet season (and by inference a period of high flow) will be confined to works outside of the river bed (such as site establishment during the first wet season) or in areas of advanced construction (that is during the second wet season following excavation of abutments and establishment of coffer dams during the first dry season). Further, as appropriate in-stream diversion strategies (including coffer dams at both sites) will be implemented to temporarily divert flows away from the Project construction activities but retain flows within the river channel. All works will be undertaken in accordance with the Project environmental management plan (EMP) (Chapter 13 Environmental management system) and subsequent site-specific construction EMPs, in consideration of work schedules and seasonal constraints.

Eden Bann Weir is an existing structure that has varying flood immunity for different work areas across its length. Work in the river channel downstream of the existing spillway is limited to the depth of flow of water that can be channelled around areas so that work can continue. Work adjacent to the spillway needs to be protected by low height cofferdams. These offer limited immunity to flooding. Work to be carried out on both abutments can be carried out over a longer period as the abutments themselves offer a higher level of immunity to flooding. Through analysis of flood levels during the summer months, relative cofferdam levels and flood diversion capacity have been estimated.

In accordance with Queensland Fisheries requirements to maintain fish movement upstream and downstream during construction at Eden Bann Weir the following actions will be undertaken:

- The existing fish lock and outlet structure will remain operational throughout construction.
- At weir closure (completion of spillway construction) the existing and new fish movement structures are fully operational.

Eden Bann Weir operations are not expected to be adversely impacted during construction of the Project. Scheduling of construction activities at Eden Bann Weir will be undertaken in consultation with the asset owner/operator, namely SunWater, to ensure that operational releases (and

subsequently environmental flow and water allocation objectives) are maintained through the existing infrastructure or new infrastructure components as necessary.

Construction activities at the proposed Rookwood Weir limit (in-channel) river diversion will be confined to a single dry season. Initially low longitudinal cofferdams will be constructed to protect the works and secure the abutments with the river remaining in its natural course. To allow for dewatering and excavation of the weir abutment foundations longitudinal cofferdams above the riverbed will be constructed across the river with the river remaining in its natural course. Finally, river flows will be diverted through the partly completed outlet structure which will be open to fish passage. Larger floods will pass over the partly completed roller compacted concrete embankment. Temporary works, if not designed to withstand flood events, will be removed prior to flooding.

Existing river crossings (low level causeways) will be removed and replaced with low-level bridge infrastructure at one location upstream of Eden Bann Weir (Glenroy Crossing) and two locations upstream of the proposed Rookwood Weir (namely, Riverslea Crossing and Foleyvale Crossing). Further, the low-level crossing downstream of the proposed Rookwood Weir (namely Hanrahan Crossing) is to be augmented (installation of a bank of culverts) to accommodate operational releases made from Rookwood Weir. Downstream flows will be maintained throughout the construction period and it is not expected that flows will be adversely impacted as a result of the Project's construction.

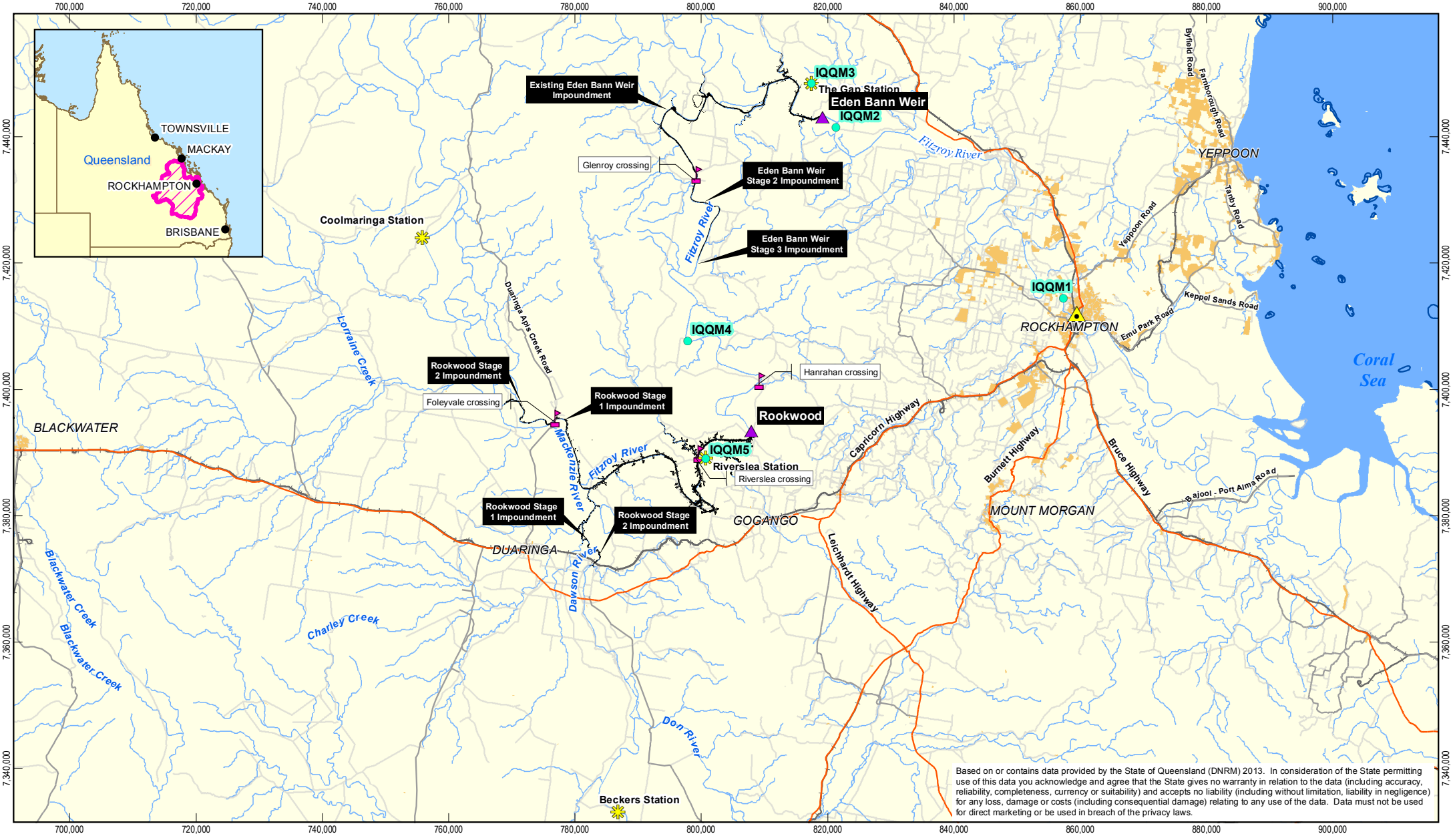
Chapter 2 Description of the action provides details with regard to construction phases and methods to be used. Operational releases and strategies are also described in Chapter 2 Description of the action.

8.2.2 Altered stream flow patterns

Hydrographs and flow duration curves developed for the base case (existing Eden Bann Weir) and development scenarios at locations within, upstream and downstream of Project areas shown on Figure 8-1 and described in Table 8-1, are presented in detail in Appendix P.

Table 8-1 Flow analysis data locations

Reference	Assessment location	Description
IQQM1	End of system	A location downstream of the Fitzroy Barrage and representative of the marine/estuarine environment. Approximately concurrent with Node 0
IQQM2	Wattlebank	Downstream of the existing Eden Bann Weir
IQQM3	The Gap	Located at the gauging station on the Fitzroy River at 142.1 km AMTD, approximately 1 km upstream from the existing Eden Bann Weir and situated within the current impoundment since 1994
IQQM4	-	An area downstream of the proposed Rookwood Weir but upstream of the existing Eden Bann Weir impoundment
IQQM5	Riverslea	At the Riverslea gauging station located on the Fitzroy River at 276 km AMTD within an unregulated stretch of the river approximately 11 km upstream of the proposed Rookwood Weir



1:800,000 (at A4)

0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- River Crossing
- Fitzroy Barrage
- Highway
- Major Road
- Streets (Local)
- Railway
- Waterway
- Fitzroy Basin
- Urbanised Area
- Impoundment Area
- Flow assessment locations
- Stream Gauges

Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision A
Date 14 Aug 2014

Gauging stations and flow assessment locations within and near to Project areas

Figure 8-1

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Level 9, 145 Ann Street Brisbane QLD 4000 Australia T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Railways, Roads, Fitzroy River Delta, Stream Gauges - 2010;
GHD: Impoundment Area, Crossings (2012), Flow assessment locations - 2014. Created by: MS *See Appendix for disclaimers and copyrights.

A summary is provided as follows:

- Eden Bann Weir Stage 2 (EB2)

  Analysis of flows pre- and post-development of EB2 at data locations downstream (IQQM1 and IQQM2) and upstream (IQQM3) can be summarised as follows:

  – Releases from EB2 do not significantly influence flows at the end of the system (IQQM1, downstream of the Fitzroy Barrage). Statistical analysis shows that for all years, there were no significant differences (across all significance levels) between the base case and the development scenario

  – The annual and monthly flow patterns post-development at IQQM2 (Wattlebank, immediately downstream of the weir) mimic the pre-development situation. Post-development there is a no change in the percentage of days with flows above 1,000 ML/d and a five per cent increase in the percentage of days with flows above 10 ML/d. This is consistent with an increased storage volume and releases required to achieve water allocation security objectives (WASOs) and environmental flow objectives (EFOs), in particular base flows. This will result in the downstream reaches remaining marginally wetter for longer durations

  – Flows into the impoundment (IQQM 3, The Gap) remain unchanged pre- and post-development

  – Operational releases from (and impoundment of) EB2 will not impact on flow regimes in upstream areas (IQQM4 and IQQM5).

- Rookwood Weir Stage 2 (RW2)

  – Releases from RW2 do not significantly influence flows at the end of the system (IQQM1, downstream of the Fitzroy Barrage). Statistical analysis shows that for all years, there were no significant differences (across all significance levels) between the base case and the development scenario

  – Annual flows downstream of Eden Bann Weir (IQQM2, Wattlebank), the Eden Bann Weir impoundment (IQQM3, The Gap) and downstream of Rookwood Weir (IQQM4) mimic pre-development regimes. This is consistent with the operational strategy whereby Eden Bann Weir would be maintained at its FSL while releases are made from Rookwood Weir, until Rookwood Weir is drawn down. The percentage of days with flows above 1,000 ML/d increases from 40 per cent to 60 per cent under the development scenario consistent with an increased storage volume and releases required to satisfy WASOs and EFOs, in particular base flows. This will result in the downstream reaches remaining wetter for longer durations

  – Flows into the proposed Rookwood Weir impoundment (IQQM5, Riverslea) remain unchanged pre- and post-development.

- RW2+EB3

  – Statistical analysis shows that for all years analysed, releases from the Project at its upper limits of development (RW2+EB3), with the exception of 1969, 1982 and 1994, do not significantly influence flows at the end of the system (across all three significance levels). This indicates that under the upper limit development scenario (with yield capped at 76,000 ML/a), minimal impacts on flow are expected to occur during years of high flow

  Annual flow in 1969 was 1,935 ML, an extreme low flow year. This result was due to the release of small volumes of water (between 300 ML and 900 ML) under the development

scenario during months that had zero or very little flow under the base case scenario, namely March to August

Annual flow in 1982 (367,382 ML) and 1994 (2,297,885 ML) is considered low and moderate, respectively. Analysis of the 1982 data shows significance levels of P = 0.1 (P = 0.073) between the base case and the development scenario. For 1994, the significance levels of P = 0.1 and P = 0.05 (P = 0.022) are recorded (Appendix P). Examination of the base case hydrographs and outflow data for these years identified that the majority of the flows occurred in March (a large outflow event in an otherwise dry year). The significant differences between the base case and development scenario arises due to an initial reduction in flow during the outflow event (in January and February) followed by the release of small volumes of water under the development scenario during months that had zero or very little flow under the base case scenario (June to October).

Seasonal base flow EFOs will be met for all theoretical yields during the January to April water flow season. During the May to August and September to December water flow seasons, the existing system (Eden Bann Weir Stage 1) does not meet the seasonal base flow objectives. All proposed infrastructure staging scenarios comply with medium to high flow EFOs except the upper limit development scenario (RW2+EB3). The upper limit scenario failed (slightly) against the 20 year daily flow volume objective. Once demands for the Project are realised and development of a specific infrastructure scenario is triggered, the Fitzroy ROP will be required to be amended to incorporate operating rules relative to the infrastructure built. It is expected that refinement of operating rules in development of the ROP will address non- compliance.

8.2.3 Altered flood flow regimes

Analysis of flood flows pre- and post-development indicate marginal to no significant changes to flow regimes upstream, within and downstream of Eden Bann Weir and the proposed Rookwood Weir. A raised Eden Bann Weir (Stage 2) has a small influence on water levels upstream during smaller magnitude floods (1 in 2 and 1 in 5 year AEP events). Negligible increases in water level are associated with higher magnitude floods as the weir is drowned by these flood flows. Rookwood Weir influences water levels upstream of the site during smaller magnitude floods (1 in 2 and 1 in 5 AEP events). The impact of the weir during larger magnitude events is small to negligible as the weir is drowned by these flood flows.

Statistical analysis shows that for the majority of years analysed, releases from the Project at its upper limits (that is Eden Bann Weir Stage 3 and Rookwood Weir Stage 2), do not significantly influence flows at the end of the system. This indicates that under the upper limit development scenario, minimal impacts on flow are expected to occur during years of high flow.

Additional information on changes in the flood flow regimes is provided in Appendix P.

8.2.4 Changes to river morphology (fluvial processes)

As detailed in Section 8.5.5, the operation of weirs is predicted to result in a change to the downstream flow regime between the weir and upper inundation limit of the preceding impoundment. The operation strategy for the impoundments will be dictated by environmental flow objectives dictated by the Water Resource (Fitzroy Basin) Plan 2011 (Fitzroy WRP) and implemented through the Fitzroy Basin Resource Operations Plan (Fitzroy ROP). The timing and quantity of releases downstream is likely to vary between seasons with the dry winter period expected to trigger the highest demand for water resources downstream. As a result, water flows downstream will increase during the dry season and the frequency and duration of no flow periods

will decrease. The increase in flows during the dry season has the potential to reduce the duration and severity of pool isolation and prolonging the presence of flowing riffles zones and runs.

The Fitzroy River carries a substantial sediment load during periods of flood. Anecdotal evidence from local landowners report sand banks of in excess of 5 m high being deposited in one flood event, and removed in the next event. As such, sediment management is an important part of the design of the weirs on the Fitzroy River.

Sediment movement is determined by the particle size of the sediment, and the velocities of the water transporting the sediment. Figure 8-2 (Ritter 2006) shows the relationships between velocity and particle size required for deposition, transport and erosion.

Sediment management on the Fitzroy River is to be achieved by transmission of the full sediment load under or through the weirs (as is currently the case). The Fitzroy Barrage is fitted with vertical lift gates that are lifted out of the stream flow during a flood event. This allows unimpeded transfer of sediment. The existing Eden Bann weir is of low height and allows transmission of the bulk of the sediment load over the weir because the velocities in the channel are high. Some sand however has deposited in a narrow zone directly upstream of the weir as shown in Figure 8-3.

Figure 8-2 Critical velocity (cm/s) for erosion, transportation and deposition of sediment

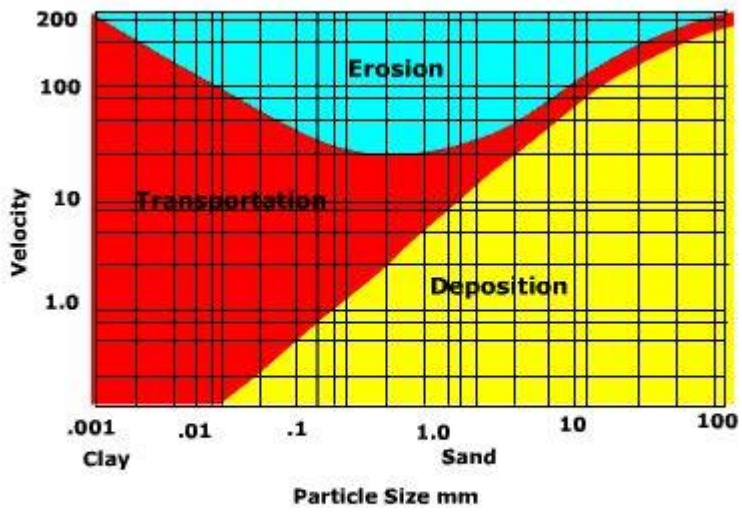


Figure 18.28 Critical velocity (cm/sec) for erosion, transportation and deposition

Source Ritter, 2006 The Physical Environment – An introduction to physical geography.

Figure 8-3 Sand deposition at Eden Bann Weir

All other sand is washed over the weir and downstream. Both the raised Eden Bann Weir and new weir at Rookwood will allow sediment to be swept over the weir as the velocities (as determined in hydraulic modelling) will be in excess of 5 m/s (and fall within the erosion range). Aside from local areas of lower velocity around weir structures where local deposition at the upstream face can be expected (and low level outlets are provided to assist in flushing any accumulated sediment downstream), the weirs are expected to provide unimpeded transfer of sediment down the river.

The presence of fish screens prohibits sediment management through the outlet works as the key objective of the screens is to reduce the velocities to below 0.3 m/s so the fish can swim away from them. This would allow sediment larger than sand size to deposit in front of the screens. A sweeping velocity in front of the screens is required to flush both sediment and fish toward the spillway during spill flows. Because of the interaction of these velocities with successful fishway operation, these velocities will be checked through computational fluid dynamics and physical scale modelling during detailed design. It is possible that a low level unscreened outlet would be required to promote sediment flushing during floods.

The silty sands found along the stream banks are highly erodible as is evident in the existing erosion gullies, 200 m upstream and 600 m downstream of the proposed Rookwood Weir axis on the left bank. The soil slopes surrounding the proposed weir structure on the left bank will require protection by means of rip-rap and rock mattresses to provide stability and erosion protection.

Flow velocities in excess of 5 m/ s have the potential to scour banks downstream of the weir infrastructure. While it is possible that some localised erosion may occur immediately downstream

of the weir sites, it is considered that the potential contribution to current sediment load will be negligible due to the very small area likely to be affected. Further, erosion protection works immediately downstream of the weirs in risk areas will reduce the potential for scour and erosion thereby minimising the potential to increase sediment loads.

At the proposed Rookwood Weir site, the alluvial nature of the western embankment required assessment of the potential effect of erosion caused by the weir development. When flow starts spilling over the top of the abutment, the tail water level will be sufficiently high such that no hydraulic jump will occur on the downstream embankment profile. This flow will be a falling jet, plunging into the tailwater below. The total fall is less than 1 m at this critical level. Notwithstanding this, there are expected to be recirculating velocities and other complex flow conditions at this abutment. These conditions are difficult to assess using simple weir hydraulics formulae. For the purposes of the EIS, an allowance of 40 m of roller compacted concrete and 24 m of rock mattresses for erosion protection to the embankment has been provided. Detailed hydraulic modelling in the detailed design stage will refine the protection requirements.

Bank slump within the weir impoundment has the potential to occur as a result of the bank soil becoming saturated through inflows followed by rapid drawdown and releases. Bank slump in downstream river reaches has the potential to occur in areas of scouring as a result of releases from the weir.

Retention of riparian vegetation on banks and slopes is proposed for the Project, inclusive of the future ponded areas. Retention of vegetation will help to protect the river banks from scouring when water levels rise. Vegetation on the banks and in riparian zones acts to bind and reinforce the bank and prevent slumping.

Outlet works at the proposed Rookwood Weir will be located generally within the main channel area so will not adversely impact on the riverbed and banks form. However approach and departure channels will be excavated into the slope of the eastern flank in weathered basalts. These weathered basalts are likely to be easily excavated to an average of about 1.5 m depth with a maximum of about 2 m and rippable to approximately 4 m. Below approximately 4 m, blasting will be required in generally moderately weathered to fresh basalt.

Project commitments during detailed design once Project development is triggered will include:

- Undertaking detailed geomorphic site assessment and will include:
  - A geomorphic condition assessment at selected sites upstream of the future inundation area, within the future ponded area and downstream of the weir
  - Stability assessments to describe pre-development characteristics of the river bed and banks, channel stability, the potential for slumping failure and erosion, amongst others. This is provide baseline conditions and establish the required stabilisation strategies to be implemented during construction.
- Further to geomorphic assessment, identify key indicators for long-term monitoring of geomorphic and fluvial characteristics and stream stability within the project development and immediate downstream stability risk area as part of an adaptive management programme
- In the event that scouring, erosion and slumping do occur during construction or operations, undertake rehabilitation and restoration of impacted areas in accordance with protocols and guidelines as defined in the management plan.

8.3 Water quality

8.3.1 Construction phase

Construction activities may result in temporary, localised impacts on water quality as follows:

- Increased turbidity through sediment laden runoff from erosion of areas of ground disturbance (excavation and earthworks, road construction) or vegetation removal and on-site cleaning activities (for example concrete batching plant, vehicle washdowns, etc)
- Increased turbidity and sedimentation as a result of in-stream works (earthworks, dewatering of foundations and cleaning foundations and grouting)
- Pollution of waterways through contaminant spillage (including hydrocarbons), release of untreated water from storages or through dewatering or disturbance of existing contaminated land.

Disturbance of the ground cover and vegetation clearing will be required for construction which has the potential to expose surfaces to runoff and erosion. Material, whether it is sediment or other contaminants (including nutrients and metals), has the potential to mobilise directly into the waterways via runoff.

Runoff from roads used during the construction may cause elevated levels of sediment and other potential contaminants entering the watercourses.

In aquatic ecosystems, increased suspended sediment loads can reduce light penetration, clog fish and invertebrate gills, decrease water temperature, lead to a reduction in dissolved oxygen concentrations and introduce sediment-bound contaminants into the water (Dunlop et al. 2005). Increased turbidity can also reduce photosynthesis in submerged macrophytes and benthic and planktonic algae. When sediment settles out it may bury habitat and smother sedentary organisms.

Aside from the existing Eden Bann Weir itself (where, during construction, hydrocarbons, chemicals and other materials will be stored), no potentially contaminated sites were identified within construction areas during the desktop Stage 1 site contamination assessment. Potential impacts from contamination as a result of construction activities are likely to be minimal as they are readily mitigated and managed through implementation of a construction EMP.

The presence of acid sulfate soils (ASS) within Project areas is considered to be unlikely. Potential degradation of water quality as a result of disturbance to ASS is therefore not expected.

Onsite sewerage treatment is not proposed. Onsite treatment of wastewater will be limited to greywater sources, stormwater runoff, washdown water (concrete batch plants) and water from excavation dewatering which will be captured within settling ponds.

Given the composition, temporary nature and localised extent of predicted impacts during construction and the distance to estuarine and marine waters (more than 80 km downstream) it is not expected that water quality within Keppel Bay (including the Fitzroy River Fish Habitat Area (FHA)), the Great Barrier Reef World Heritage Area (GBRWHA), Great Barrier Reef Marine Park (GBRMP) or Great Barrier Reef Coast Marine Park (GBR Coast MP) will be impacted as a result of construction activities.

Further to undertaking in-stream works during drier periods and sequencing works to avoid periods of high flows and rainfall events construction impacts will be managed through

development and implementation of a Construction EMP, inclusive of erosion and sediment controls. Management measures will include the following:

- Significant ground disturbing activities (including embankment excavations and construction of coffer dams) are scheduled to be undertaken during drier seasonal periods reducing the potential for erosion and sediment laden runoff entering the watercourse
- Installation of diversions and erosion controls such as sediment basins (amongst others) will direct clean water away from construction areas and allow site affected water to settle prior to re-entering the river. Diversions and erosion controls, including sediment basins will be designed having regard to Soil Erosion and Sediment Control – Engineering Guidelines for Queensland Construction Sites (Institution of Engineers Australia 1996) (or similar) and Urban Stormwater Quality Planning Guidelines 2010 (Department of Environment and Resource Management 2010a), including requirements for emergency planning as applicable
- Wastewater from all sources will be stored, treated and tested prior to release to the environment having regard for water quality objectives (WQOs) defined in the EPP Water (for the Fitzroy River Sub-basin in particular)
- Clearing of vegetation for site facilities and access will be restricted to minimum areas required to undertake the works reducing the extent of exposure of soil to erosion influences
- Storage and use of potentially contaminating and polluting materials such as hydrocarbons, service and refuelling areas will be restricted to defined and protected (bunded) areas
- Storage and handling of any actual contaminants will comply with relevant guidelines and Australian standards.

8.3.2 Operations phase

8.3.2.1 Initial filling phase

Construction of Eden Bann Weir and Rookwood Weir will be scheduled to be completed within a two and a half year period with final works concluding at the end of a dry season to allow for impoundment during the following wet season. It is expected that impoundment of Eden Bann Weir and Rookwood Weir will occur within a single wet season over a relatively short period (in the order of a week to one or two months). Modelled data shows that even in a representative dry year (using the 10th percentile) full supply volumes will be achieved within these relatively short periods. It is expected that full supply volumes and overtopping/spilling will be achieved annually.

Prior to the first fill, it is not intended to clear vegetation from within the proposed impoundment. Consequently that vegetation will decay (over time) releasing methane, carbon dioxide and nutrients and reducing dissolved oxygen levels in the water column. Nutrients will then be conveyed downstream and output to the Fitzroy estuary, particularly during flood events.

To assess the potential contribution of nutrients, an assessment was performed using the FullCAM program (Chapter 6 Methodology). The results in Table 8-2 show that that more than half the available total nitrogen (TN) and total phosphorus (TP) will be liberated in the first year of impoundment and will reduce significantly in each subsequent year for a period of approximately six years.

Table 8-2 Rates of decay for total nitrogen and total phosphorous

Year	Eden Bann Weir		Rookwood Weir	
	Decay rate - TN (tonnes/year)*	Decay rate - TP (tonnes/year)*	Decay rate - TN (tonnes/year)*	Decay rate - TP (tonnes/year)*
1	458	90	645 (TN)	127 (TP)
2	211	36	347	51
3	98	14	187	20
4	45	6	100	8
5	21	2	54	3
6	10	1	29	1
Total	842	149	1200	211

*Rounded

Figure 8-4 illustrates that for both TN and TP at Eden Bann Weir, the overall contribution of nutrients to the system is predicted to be low in the context of the overall quantities that are transported annually from the Fitzroy Basin to the GBRWHA (as described by Johnston et al. 2008). Moreover, the percentage contribution declines markedly after the first year to negligible proportions after several years. Figure 8-5 shows a similar trend for the proposed Rookwood Weir.

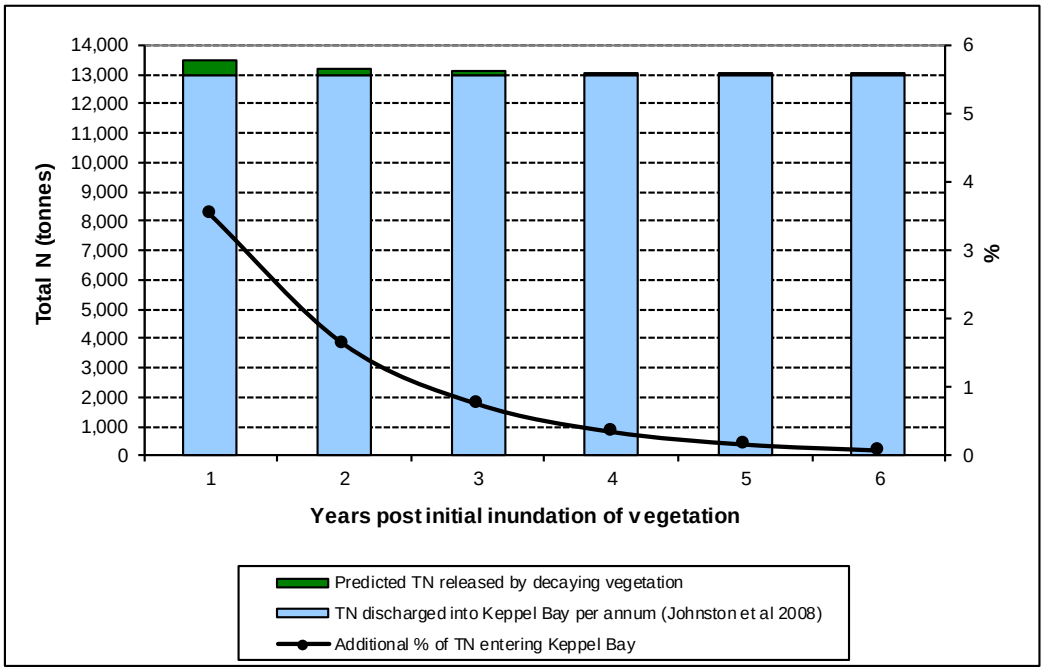
The combined contributions of liberated TN and TP from both Eden Bann Weir and Rookwood Weir are depicted in Figure 8-6. The combined values for both TN and TP are relatively small, and decrease markedly beyond the first year of operation. Importantly, data presented assumes that Eden Bann Weir will be raised and Rookwood Weir constructed simultaneously. As described in Chapter 1 Description of the action, the Project is expected to be staged in response to demand triggers. Consequently, rates of decay are unlikely to be cumulative and rather occur independently for each site over time.

While localised short-term increases in nutrient levels, as well as increased turbidity and reduced dissolved oxygen (DO) are expected to occur, wet season inflows, overtopping of the spillway, operational releases and releases through fishways and outlet works will dilute and flush nutrients and materials within and from the impoundment and it is not expected that elevated levels will persist for extended durations.

During detailed design, operational strategies (including initial operation) will be developed including water quality monitoring programs covering upstream, impoundment and downstream environments. Differential offtakes will facilitate mixing to improve the quality of water released.

Weir operations will generally mimic natural river flows and the weirs will reach full supply volumes and will be drawn down annually. Excluding TN and TP liberated as a result of decaying vegetation it is not expected that water quality characteristics in the initial years of operation will be significantly different from those during subsequent years of 'normal' operation as discussed in sections below.

Figure 8-4 Project (Eden Bann Weir) TN and TP contribution to existing annual loads



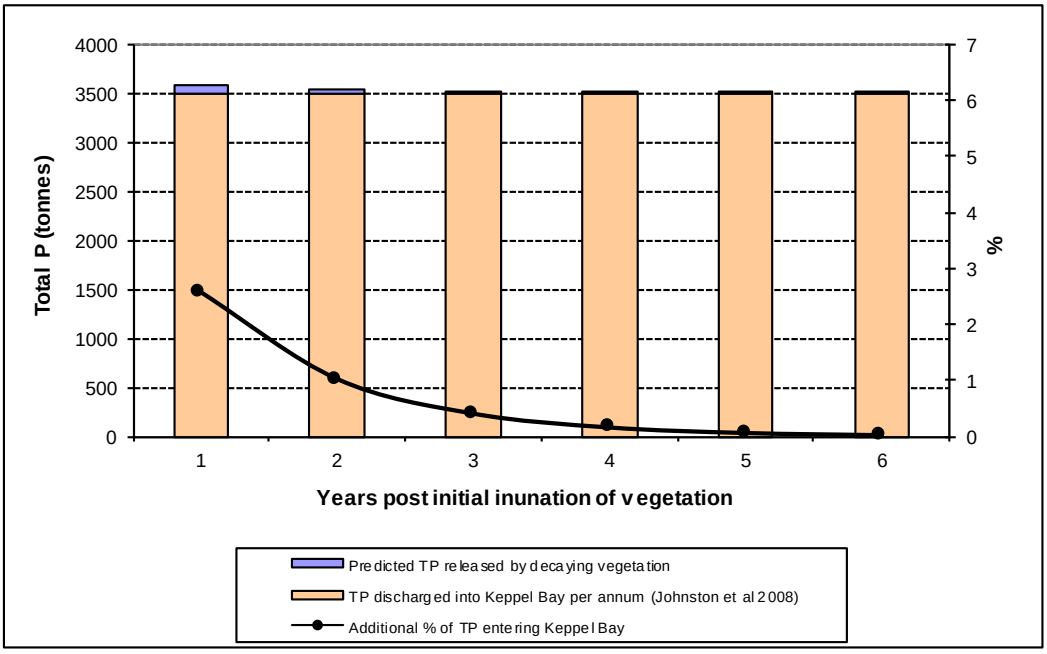
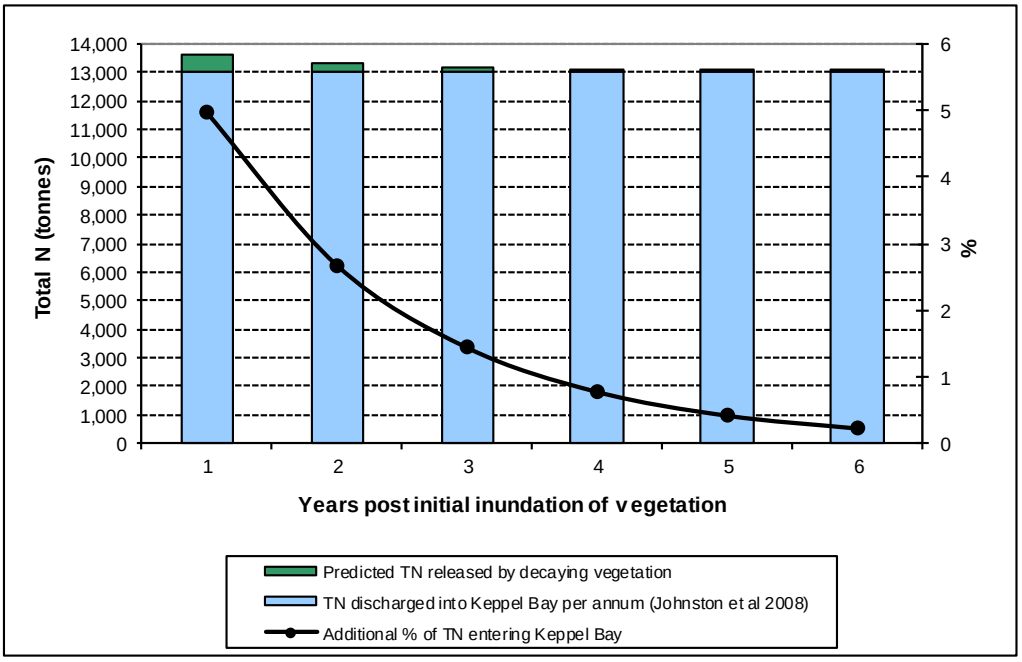


Figure 8-5 Project (Rookwood Weir) TN and TP contribution to existing annual loads



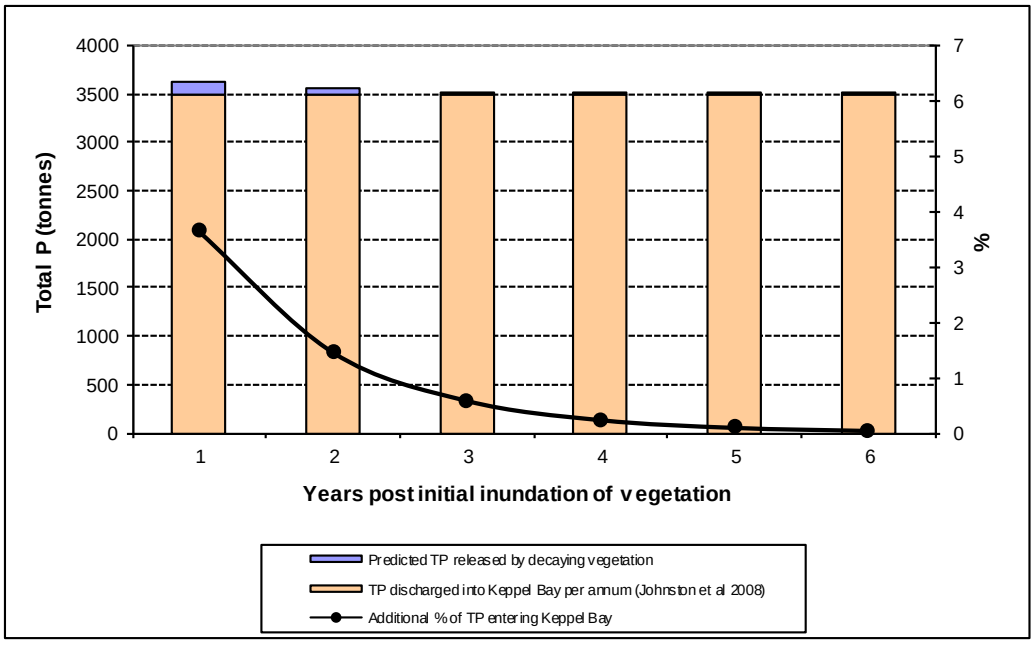
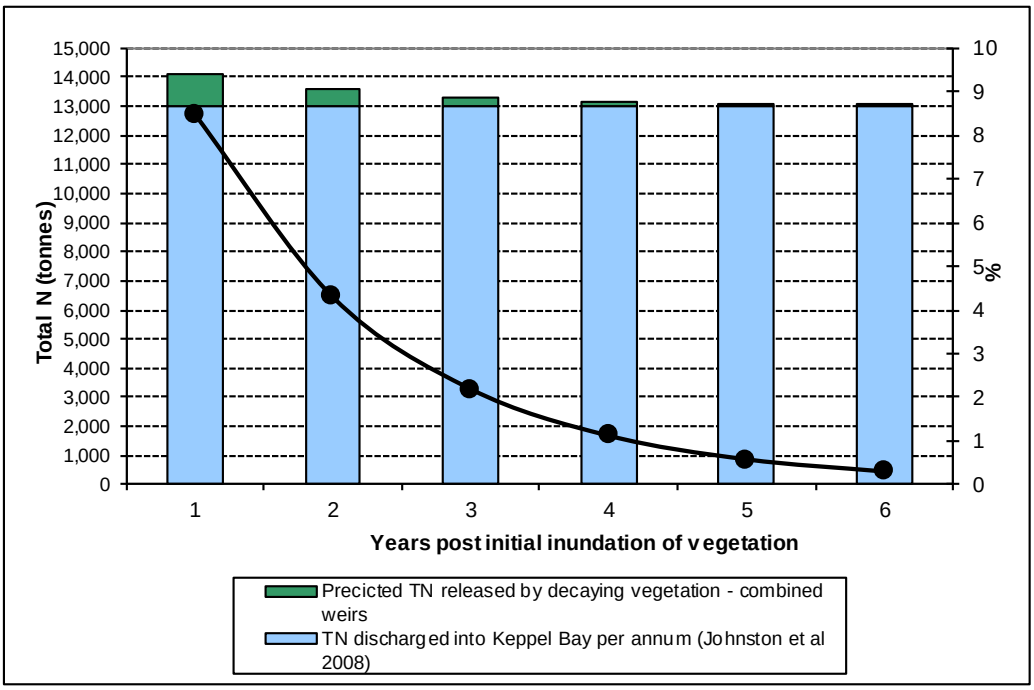
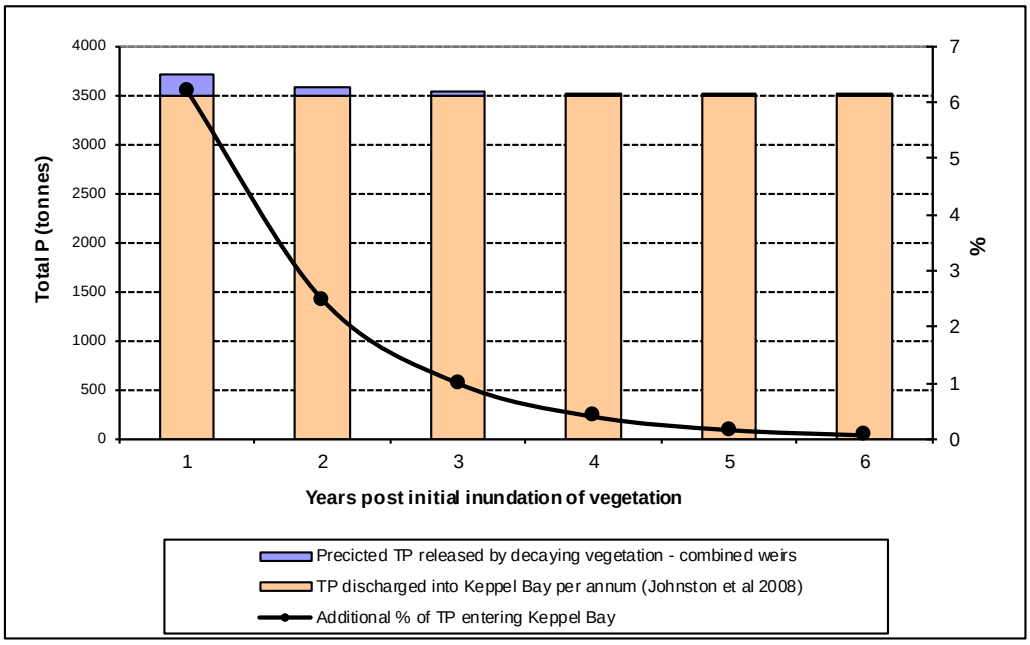


Figure 8-6 **Project (Eden Bann Weir and Rookwood Weir) TN and TP contribution to existing annual loads**





8.3.2.2 Normal operations phase

It is evident from existing conditions described in Chapter 7 Existing environment that water quality in the Project areas is heavily influenced by anthropogenic factors; particularly land use practices associated with cropping and grazing activities. It is expected that these existing anthropogenic impacts on water quality will persist following weir development. The Project will

not directly change or influence land use practices adjacent to the impoundments; it is not intended that adjacent land will be wholly acquired and/or stock excluded from river margins. Vegetation cover within the river bed and banks within the impoundment will be retained in the first instance but will decay and recede over time.

As is evidenced from operation of the existing Eden Bann Weir compared to un-impounded reaches of the Fitzroy, Dawson and Mackenzie rivers, the following water quality impacts are expected with regard to EVs, given Project operational strategies align with those employed at the existing Eden Bann Weir:

- DO
  - DO levels within the impoundments will vary through the water column, reducing with depth. Storages within the Fitzroy Basin are reported to be un-stratified most of the year, or only slightly stratified during the warmer months (September – January) (SKM 2010)
  - DO levels within the impoundments are expected to be lower compared to un-impounded reaches and will generally be less than the WQOs for lakes/reservoirs. It is noted however that DO levels recorded for Eden Bann Weir are currently less than the WQO, but are comparable to levels elsewhere in the natural system
  - Operationally it is predicted that the weirs will reach full supply volumes within relatively short periods annually and be drawn down over a period of approximately eight months every year thereby reducing the opportunity for stratification (reduced time at depth)
  - Differential (multi-level) offtakes will ensure that water released through outlet works is mixed, improving the DO (together with mediating temperature) to achieve the WQOs. This is currently achieved at Eden Bann Weir (Chapter 7 Existing environment).
- Turbidity
  - Existing turbidity levels within the Fitzroy, Dawson and Mackenzie rivers are greater than WQOs as a result of sediment entering the waterways from runoff and erosion
  - SedNet catchment modelling (Carroll et al. 2010) identifies hillslope erosion as the dominant source of sediment (67 per cent), followed by gully erosion (26 per cent) and channel erosion (seven per cent). Less than 30 per cent of suspended sediment is contributed by the Fitzroy sub-catchment (Nogoa and Comet sub-catchments reportedly contribute on average the highest volumes) (Carroll et al. 2010). The sediment load at The Gap/Eden Bann Weir is considered consistent with combined loads from the four major tributaries (Nogoa, Comet, Isaac and Dawson rivers) (Joo et al. 2005)
  - Turbidity within the impoundments are expected to exceed the WQOs as a result of existing land practices within the catchment and natural processes
  - The Project itself is not expected to alter the sediment load within the system. Project design facilitates that sediment will be swept over the weir as the velocities determined (through hydraulic modelling) are in excess of 5 m/s. Local deposition at the upstream face of the new weirs is expected and low level outlets will be provided to assist in flushing this sediment downstream. Aside from local areas of lower velocity around weir structures such as towers and intakes, the weirs are expected to provide unimpeded transfer of sediment downstream.
- Nutrients
  - Concentrations of TN and TP within the Fitzroy and Dawson rivers and at Eden Bann Weir are greater than the WQO. WQOs for TN and TP on the Mackenzie River are greater than

those set for the Fitzroy and Dawson rivers. TN and TP concentrations in the Mackenzie River are within WQO limits

  - As discussed above (Section 8.3.2.1) TN and TP concentrations will peak on first fill and decline over a six year period. The Project itself is not expected to alter the median concentration of TN and TP downstream within the Fitzroy River after this time.

- Blue green algae
  - An increase in blue green algae or cyanobacteria can cause an algal bloom and adversely impact on water quality. Poor water quality and the potential for toxicity can consequently result in impacts on aquatic fauna, cause disruption to drinking water supplies, recreational activities and water-dependent industries, and pose a risk to livestock, wildlife and human health (DSEWPaC 2012)
  - Blue green algae can occur when still or slow-flowing water, abundant sunlight and sufficient levels of nutrients, especially nitrogen and phosphorus, are present. In particular, blue green algae favours conditions created by stratification whereby surface water forms a warm top layer exposed to sunlight and nutrients with cooler bottom layers with low DO levels
  - The potential for blue green algae blooms to occur within the impoundments is considered to be low
  - Monitoring of blue green algae at Eden Bann Weir generally returned low hazard levels with the majority of readings below the hazard trigger level (0.4 mm^3/L for the combined total of all cyanobacteria). Further SKM (2010) reported that a review of storages within the Fitzroy Basin indicate that blue green algae blooms are not a feature of these storages
  - Both the Gladstone Area Water Board (GAWB) and SunWater monitor blue green algae within existing storages in the Boyne and Fitzroy Basins respectively and manage the potential risks through the implementation of established protocols and action plans. This includes the publishing of blue green algae levels as warnings to the public, landholders and water users. It is intended that the Project infrastructure will be managed in accordance with the existing measures
  - The impoundments will not facilitate recreational activities. For the most part the impoundments are flanked by private properties with few opportunities and no facilities for public recreational users to access the waterways. The risk of adversely impacting human health as a result of algal blooms developing is minimal.
- Salinity (EC)
  - Salinity (measured as EC) within the Project area waters is generally less than the WQOs (excluding periods associated with mine water releases)
  - EC recorded at Eden Bann Weir indicates that the EC of impoundment waters is comparable to un-impounded river reaches
  - The Project is not expected to impact salinity levels.

8.4 Terrestrial ecology

8.4.1 Impacts on terrestrial flora

A detailed report prepared by Nangura Environmental Services (2007) formed the basis of the flora assessment undertaken for the Project. Desktop assessments, vegetation mapping, field

surveys and bio-condition assessments were undertaken to determine existing flora values and potential impacts on flora values as a result of the Project.

Impacts on flora values within the Project footprint, assuming maximum development, are likely to be as follows:

- Conservatively, approximately 20.1 ha of Brigalow (*Acacia harpophylla* dominant and co-dominant) threatened ecological community (TEC) comprising 0.7 ha within the Eden Bann Weir project footprint and 19.4 ha within the Rookwood Weir Project footprint (1.6 ha construction footprint and 18.5 ha impoundment) (Chapter 10 Listed threatened species and ecological communities). For the Rookwood Weir Project impoundment it is likely that the total area of Brigalow TEC impacted by impoundment will be substantially less than the estimated 18.5 ha. Of this total, 8.1 ha have been field verified (Appendix H) while the remaining 10.4 ha were determined based on unverified State mapping. The estimated 18.5 ha also comprises mixed polygons, and where these polygons extend into adjacent alluvial areas, the percentage containing regional ecosystem (RE) 11.3.1 may occur outside of the proposed impoundment
- Approximately 1,947 ha of remnant vegetation with the Project footprint comprising:
  - Approximately 7 ha of endangered REs, 43 ha of of concern REs and 611 ha of least concern REs within the Eden Bann Weir Project footprint
  - Approximately 19 ha of endangered REs, 197 ha of of concern REs and 1070 ha of least concern REs within the Rookwood Weir Project footprint.
- Approximately 186 ha of high value regrowth within the Eden Bann Weir Project footprint and 372 ha of high value regrowth within the Rookwood Weir Project footprint
- Approximately 40 ha of mapped essential habitat within the Eden Bann Weir Project footprint and 16 ha of mapped essential habitat within the Rookwood Weir Project
- Up to 100 individual *Eucalyptus raveretiana* plants within the Rookwood Weir impoundment (Chapter 10 Listed threatened species and ecological communities).

The inundation of riparian vegetation as a result of the Project has the potential to disrupt connectivity between habitats, thereby further fragmenting habitats within the Project footprint. Fragmentation of riparian habitat and resulting impacts on terrestrial fauna species are described in Section 8.4.2.6.

Introduced plants and weeds are ubiquitous across the Eden Bann Weir and the proposed Rookwood Weir study areas. Eight weeds listed under Queensland legislation, five of which are Weeds of National Significance were recorded during field studies. A Weed Management Plan would be prepared and implemented to prevent the introduction of new weed species into the area and minimise the spread of weeds within the site (Section 8.9).

The need to clear remnant vegetation to facilitate construction activities at the weir sites, along existing and new access roads and at river crossings has however been avoided as far as is practicable based on current survey and design. Further opportunities for avoidance of endangered and of concern REs, in particular, associated with construction activities and access will be considered during detailed design. Inundation of riparian vegetation is an unavoidable consequence of the Project.

To mitigate the loss of vegetation resulting from construction site clearing activities, the following measures would be implemented:

- Clearing for site works will be restricted to the smallest practical area and only where necessitated by the approved construction of roads, services, access and cut and fill. The amount of time the area is cleared prior to construction will also be minimised
- Clearly demarcate no-go areas of highly sensitive vegetation, including all vegetation not to be cleared. All vegetation to be retained should be surveyed and clearly demarcated
- Where practicable, revegetation activities would be commenced in and adjacent to construction areas as soon as possible after the completion of construction
- Temporarily disturbed areas will be rehabilitated to replicate as closely as possible the habitat resources available prior to construction. This will include:
  - Utilising stockpiled topsoil and chipped and mulched was during landscaping and revegetation efforts
  - Revegetating areas that are temporarily disturbed using local indigenous species appropriate to the position in the landscape
  - Regular post-construction monitoring of rehabilitation areas.

Refer to Chapter 13 Environmental Management System for further detail on rehabilitation.

Impacts on threatened ecological communities and threatened terrestrial flora species are assessed in Chapter 10 Threatened species and ecological communities.

8.4.2 Impacts on terrestrial fauna

8.4.2.1 Overview

Activities associated with raising Eden Bann Weir and constructing Rookwood Weir have the potential to cause a number of direct and indirect impacts on local terrestrial fauna. As the infrastructure already exists, potential impacts associated with raising Eden Bann Weir are likely to be less extensive in magnitude and significance than developing a greenfield site at the proposed Rookwood Weir site. It is anticipated that the following construction activities may have short-term (over the two dry season construction period) impacts upon local fauna and flora assemblages:

- Vehicle and plant movement to, from and around the construction site
- Removal of vegetation within the immediate construction footprint, storage / stockpiling areas and access tracks
- Storage of potentially hazardous materials
- Acquisition of materials (aggregate) for use in construction
- Flow diversion.

Following construction, filling of the impoundments also has the potential to impact local fauna and flora assemblages through the inundation of riparian vegetation.

Potential impacts associated with construction activities and inundation include:

- Individual fauna injury and mortality
- Disruption to behaviour of localised wildlife assemblages
- Loss of terrestrial habitat
- Increased predation and competition

- Degradation of habitats
- Increased presence of feral animal species.

During the operations phase of the Project, potential impacts may result from:

- Vehicle movements associated with ongoing maintenance activities

Potential impacts to terrestrial fauna associated with the above may include:

- Fauna injury and mortality.

Each potential impact and associated mitigation measures for the construction and operation of the Project are discussed below.

Impacts on threatened terrestrial fauna species are assessed in Chapter 10 Threatened species and ecological communities.

8.4.2.2 Individual fauna injury and mortality

Construction activities at and adjacent to the Eden Bann Weir and Rookwood Weir will involve a temporary increase in vehicular traffic and plant movement to, from and at the site, including traffic on the new permanent access road. This has the potential to increase the incidence of wildlife and livestock mortality from vehicle strike. The clearing of a limited amount of vegetation to facilitate construction (including access and storage areas) may result in direct mortality to individual animals residing in trees, ground cover, litter or debris to be cleared.

Fauna mortality may also result from the drowning of less mobile animals during the initial filling of the impoundments. Native fauna in the Fitzroy system have adapted to a system in which flooding (often rapid and extensive) is a regular event and most animals are able to seek refuge above rising flood water. This is expected to be the case with the rising impoundment. However, initial inundation of terrestrial habitats both above the high water mark of the existing Eden Bann Weir impoundment and upstream of the proposed Rookwood Weir impoundment may result in the injury and mortality of less-mobile animals that are unable to retreat from the rising water. Small terrestrial animals within the impoundment such as skinks, geckos, rodents and juvenile animals in nests or borrows, may be trapped by rising water.

Beyond the initial filling of the weirs, regular drawdown and filling of the storage during operation is considered unlikely to result in significant fauna mortalities. Vegetation is expected to re-establish on riverbanks at the full supply levels and loss of vegetation from within the impoundment will deter use of the impoundment for foraging and breeding by terrestrial fauna species. The water level within the existing Eden Bann Weir impoundment already fluctuate due to seasonal variations in inflows and managed water extraction and this cycle will continue and is likely to have a minimal long-term impact on terrestrial faunal assemblages upstream. Water levels within the Fitzroy, Mackenzie and Dawson rivers associated with the Rookwood Weir fluctuate annually in their natural state (high flows and flood to no or very low flow) and it is likely that the operation of the weir will have a minimal long-term impact on upstream terrestrial fauna.

Vehicle movements during operation are not anticipated to be more than a few times a week and as such operational impacts on fauna due to vehicle strike are considered negligible.

The following mitigation measures are proposed to minimise fauna injury and mortality:

- Enforcing on-site speed limits to restrict the incidence of vehicle strike
- Minimise need to travel near dawn or dusk by adhering to defined daytime work hours

- Educating employees regarding the presence of conservation significant fauna
- Erecting temporary fencing to exclude mobile animals such as macropods, echidnas and livestock from the construction area
- Establish stock fencing, gates and cattle grids on the new permanent access road as required
- Checking of trenches, excavations and machinery daily for the presence of reptiles
- Fauna spotters present prior to and during clearing activities
- Cleary demarcate no-go areas in relation to highly sensitive vegetation, including all vegetation not to be cleared
- Sequential clearing of vegetation to allow resident fauna the opportunity to disperse away from the immediate construction area
- A suitably-qualified and licensed practitioner to be present on site to treat or euthanize injured animals.

8.4.2.3 Disruption to behaviour of localised wildlife assemblages

Construction activities will cause a temporary localised increase in light, noise and vibration adjacent to construction sites. This has the potential to cause short-term disruption to the behaviour and activities of nearby wildlife. There are no noteworthy communal nesting, breeding, roosting or foraging resources directly adjacent to the construction areas. Nevertheless, construction activities have the potential to deter terrestrial wildlife from foraging, drinking or nesting within the vicinity of construction activities.

Construction noise and vibration impacts are localised, intermittent and/or of short duration, likely to move within the construction areas and as far as practicable confined to daylight hours. Proposed mitigation during the construction phase to minimise the impacts of noise, light and vibration disturbance include:

- Service and maintain all plant and equipment to minimise machinery noise as much as possible
- Work areas will be inspected daily for the presence of fauna and if found fauna will be relocated away from work areas
- Minimise night works by adhering to defined daytime work hours
- Employ directional lighting with protective guards.

8.4.2.4 Loss of terrestrial habitat due to clearing

A small amount of open eucalypt woodland would be cleared for the construction of the weirs, crossings and new right bank access road at Eden Bann Weir. While this may impact upon smaller, less mobile animals (small reptiles, rodents and frogs), the extent of clearing of vegetation is limited and unlikely to constitute a substantial impact on local faunal assemblages which are adapted to a fragmented landscape. The existing vegetation at the Rookwood Weir site is fragmented and degraded by cattle, and as such, is unlikely to represent important fauna habitat, particularly for conservation significant species.

Where possible, design of weir construction area, access roads and river crossings has sought to minimise the amount of vegetation cleared. Measures to mitigate the loss of habitat resulting from construction activities are described in Section 8.4.1.

8.4.2.5 Loss of terrestrial habitats due to impoundment

Overview

As described in Section 8.4.1, raising Eden Bann Weir and construction of Rookwood Weir will result in the impoundment of terrestrial vegetation within the riparian zone throughout the Project footprint, both along the main Fitzroy River channel, and in the lower reaches of tributaries and adjoining creeks. Impoundment of riparian vegetation will result in the loss and alteration of potential fauna habitat. Vegetation within the impoundment will not be pre-cleared. At first inundation, it is anticipated that an immediate loss of remaining ground cover in the inundation area will occur. Larger vegetation such as trees will remain for a period of time before dieback occurs. Given that water levels in the impoundment will rise and fall with filling and drawdown (as already occurs within the existing Eden Bann Weir impoundment), habitat loss at the limits of the impoundment will occur more gradually, in response to intermittent inundation.

An assessment of the implications of raising Eden Bann Weir and constructing Rookwood Weir on native vegetation undertaken by Nangura (2007) (Appendix H) concluded that potential impacts on fringing vegetation will be greatest in the lower quarter of the Project footprint (closest to the weir walls where the deepest ponding will occur). Upstream of the confluence of the Dawson and Mackenzie Rivers the inundation area will be shallower and direct impacts on vegetation from inundation will likely be confined to in-stream habitats (sand banks) (Nangura 2007).

Raising Eden Bann Weir and subsequently increasing the impounded area is expected to drown out eucalypts in the lower reaches and despite their tolerance for temporary inundation, fringing *Melaleucas* under extended periods of inundation will be eventually drowned and lost. At the Rookwood Weir site, sand banks and islands within and adjacent to the river will be lost within the inundation extent.

The impacts of loss / alteration of terrestrial habitat on fauna species is discussed below.

Potential impacts on birds

Potential impacts on birds associated with habitat loss and / or alteration within the Project footprint include:

- Loss of mature trees over time (months to years) in the riparian zone that provide foraging, roosting and nesting resources for a range of woodland and forest birds
- Short-term reduction in dense, low growing (< 4 metres) riparian vegetation along the main river channel and creeks that provide habitat for small woodland and forest birds
- Short-term loss of overhanging vegetation that provides perching habitat for kingfishers, cormorants and raptors. The loss of this overhanging vegetation also reduces suitable nesting habitat for birds including cormorants and egrets
- Short-term loss of existing marginal and emergent vegetation in shallow water aquatic habitats utilised by waterbirds such as crakes, rails, ducks, egrets, herons and storks
- Inundation of sand banks and other features which may support waterbird nesting
- Creation of aquatic habitat, of particular benefit to many waterbird species.

In the short-term, more cryptic species that inhabit dense riparian vegetation may become less prevalent. It is important to note that as the riparian zone is highly disturbed through clearing, weed infestation and cattle grazing in many parts of the Project footprint, dense native

understorey vegetation supporting large communities of small, cryptic forest birds were not observed to be present. The increased water level associated with raising Eden Bann Weir and constructing Rookwood Weir is therefore unlikely to impact notably on such birds.

Waterbirds may benefit from the larger inundation area. The creation of more slow-flowing deep water habitat is likely to benefit ducks, pelicans, geese and pygmy-geese. Although inundation of existing emergent and marginal vegetation may have short-term impacts on wading birds and cryptic species, it is likely to serve medium- to long-term benefits in the creation of more linear habitat that is likely to be recolonised by emergent and marginal vegetation. The permanency of water in the impoundment and lower reaches of adjoining creeks flowing into it is likely to foster greater habitat utilisation by water birds. The potential loss of nesting and perching sites for cormorants and darters may result in a spatial shift (i.e. upstream) for nesting, although it is likely that overhanging vegetation will still be present in downstream reaches of the impoundments.

For the most part, impacts are considered to be short-term and bird populations have the ability to move to other areas and return once vegetation has re-established above the impoundment.

Potential impacts on mammals

Potential impacts on mammals within the Project footprint as a result of habitat loss and / or alteration include:

- Loss or reduction of foraging, breeding and shelter resources for ground-dwelling mammals
- Loss or reduction of shelter habitat for arboreal mammals reliant on tree hollows and shedding bark
- Loss or reduction of food resources, such as leaves, nectar, pollen, fruit, sap and invertebrates, for arboreal mammals.

Loss of vegetation will reduce the local availability of resources for terrestrial mammals. Mature trees, particularly *Melaleuca spp*., *Eucalyptus spp*. and *Corymbia spp*., provide shelter and foraging resources for arboreal mammals and bats, while localised microhabitats on the ground provide resources for ground-dwelling mammals. It is possible that increased competition for diminished resources may arise, particularly in fragmented, narrow riparian habitat strips abutted by agricultural land.

The predicted proportional inundation of mapped remnant vegetation within a 1 km buffer of the Project footprint is 15 per cent. This proportion drops to ten per cent within a 2 km buffer of the river. At the landscape scale, this proportionally small loss / alteration of habitat may cause localised increases in competition for resources for common native mammals (macropods, native rodents, possums, gliders, flying foxes and microchiropteran bats). Suitable habitat for these species is present throughout the wider study area, with large tracts of land to the north and west of the Project footprint mapped as state significant habitat remnants (Chapter 7 Existing environment).

Potential impacts on reptiles

Potential impacts on terrestrial reptiles within the Project footprint include:

- A reduction in availability of habitats supporting a structurally complex ground layer, that is inundation of riparian habitats supporting fallen timber, log piles, leaf litter and burrowing / cracking soils

- A temporary reduction in overhanging vegetation that comprises important habitat for the common and disturbance tolerant eastern water dragon (*Physignathus lesueurii*).

Terrestrial reptile species (common skinks, legless lizards, geckos, dragons and snakes) encountered during background reviews and field surveys in the Project footprint were generalist species that are likely to be widespread and relatively abundant in the study area and the wider Central Queensland region. Suitable habitat for these species is prevalent within the Project footprint. Although disturbed and fragmented in places, this habitat is still likely to support viable assemblages of common terrestrial reptiles. Operation of a raised Eden Bann Weir and Rookwood Weir are unlikely to adversely affect regional population viability of these common species.

8.4.2.6 Fragmentation of riparian habitat

Much of the landscape surrounding the Project footprint has been cleared, predominantly for agriculture. Vegetation in these otherwise cleared or fragmented landscapes tends to be concentrated along the riparian fringe of the Fitzroy, Dawson and Mackenzie rivers and adjoining creeks. The impoundment of riparian vegetation resulting from operations of the Project has the potential to disrupt connectivity between habitats, thereby further fragmenting habitats within the Project footprint (and the wider study area). This is likely to be most prevalent in the lower reaches of the impoundment, where the raised water level is predicted to inundate riparian bankside vegetation (as opposed to in-stream vegetation only in the upper reaches of the impoundment). This reduction in connectivity along the riparian zone is likely to be most notable where only a thin strip of fringing riparian vegetation, abutted by cleared agricultural land, occurs. The inundation and drowning of this vegetation will disrupt the corridor along which fauna can move between more extensively vegetated habitats.

The widening of the river, and the reduced occurrence of shallow water and seasonally dry riverine habitats will also reduce the ability of terrestrial fauna (namely mammals and reptiles) to move back and forth across the river.

The potential impacts of reduced connectivity and subsequent habitat fragmentation on common terrestrial fauna (namely reptiles, small ground-dwelling and arboreal mammals and birds) may include:

- Greater competition (intraspecific and interspecific) for resources in increasingly isolated habitat patches in an already fragmented landscape
- Increased habitat degradation due to concentration of animals in isolated patches
- Dominance of isolated habitat patches by competitive, generalist species (plants and animals)
- Increased exposure to predation for animals that are forced to move across disturbed, open landscapes
- Greater magnitude of impact of environmental changes (fire, drought, disease etc.) when animals are unable to move between habitat patches due to hostile surrounding land use (unsuitable resources, greater risk of predation).

It is important to note that while impoundment associated with the weir developments has the potential to disrupt terrestrial fauna movement corridors, bioregional corridors of local, regional and state significance, will still prevail directly adjacent to the high water level of the inundation area. This is particularly notable immediately upstream of Eden Bann Weir on the northern bank and near Princhester and Marlborough Creeks. It is also notable in the upper reaches of the

Rookwood Weir impoundment, namely along the northern bank of the upper Fitzroy River, the eastern bank of the lower Mackenzie River, and the lower Dawson River. As inundation will be more extensive in the lower reaches of the impoundment, the persistence of these mapped corridors is important. Furthermore, large tracts of state significant bioregional corridor are mapped as occurring in the regional landscape, to the northeast, north and west (Goodedulla National Park and Duaringa State Forest) of the Project footprint. This is considered to be advantageous to more mobile species, particularly birds.

8.4.2.7 Degradation of habitat

Based on field observations, the largest contributors to habitat degradation within the Eden Bann Weir and Rookwood Weir study areas are historic land clearing associated with agriculture, livestock (within the riparian zone and in shallow water areas), feral animals and weeds (Section 8.9).

Vegetation clearing and earthworks, including the sourcing of aggregate from excavations or river bed deposits, associated with construction activities may result in point-source pollution from erosion, sedimentation, run-off and dust emissions. These impacts may have a localised adverse effect on local wildlife by reducing the quality of habitats (amount of refuges, microhabitats and food availability), smothering native vegetation with sediment, and increasing turbidity. This can lead to indirect secondary habitat degradation through weed infestation (terrestrial) and reduced water quality (aquatic). Habitat degradation during construction may also result from leaks and spills of environmentally hazardous substances.

The impoundment of riparian vegetation and the disruption to terrestrial habitats bordering the new high water level of the impoundments may also foster habitat degradation. This degradation may result from:

- Edge effects occurring in newly fragmented riparian habitat
- Isolation of remnant vegetation patches, allowing for domination by generalist and invasive plants and animals
- Increased competition for resources in riparian vegetation habitats due to a reduction in the overall extent of this habitat.

As was observed within the Project footprint, fragmented habitat patches occurring within a cleared landscape are susceptible to edge effects. The amount of habitat exposed to the adverse impacts of edge effects in a small fragmented patch is relatively higher compared to large, continuous, well-connected habitats. Adverse impacts associated with edge effects include:

- Increased penetration of light and wind into habitat patch, potentially altering vegetation communities
- Alteration to microclimate
- Increased invasion of exotic plants and animals
- Increased sensitivity to fire.

Releases of water from Eden Bann Weir and Rookwood Weir will be made in accordance with environmental flow objectives, defined in a Resource Operations Plan. Environmental flow objectives will be established to maintain base flow and first wet season flow downstream of the weirs, among other flow characteristics. The objectives will be set in accordance with the Water Resource (Fitzroy Basin) Plan 2011, and in consultation with the Department of Environment and

Heritage Protection. It is considered that releases from Eden Bann Weir and Rookwood Weir will have no adverse effect on the downstream riparian habitat.

Off-stream habitats are ephemeral in nature and, in the existing environment, may be inundated by seasonal flows. Off-stream habitats adjacent to the impoundments may be more readily inundated during seasonal flows, and remain inundated for longer periods. It is not considered that this change will negatively impact the value of these habitats. Off-stream habitats downstream of Eden Bann Weir and Rookwood Weir are not expected to be adversely impacted due to the maintenance of seasonal flows, in accordance with the Fitzroy ROP.

To minimise habitat degradation due to construction activities, the following mitigation measures will be implemented:

- Prepare and implement a Weed Management Plan that outlines practices to prevent the introduction of new weeds minimise the spread of declared weeds (Section 8.9)
- Ensure erosion and sediment control measures employed during construction are consistent with the practices described in the International Erosion Control Association, Best Practice Erosion and Sediment Control Guideline and/or Queensland Division of the Australian Institute of Engineers' Erosion and Sediment Control: Engineering Guidelines for Queensland Construction Sites
- The construction EMP will include a dust management plan
- Restrict speed limits and other traffic control mechanisms to minimise the generation of dust
- Rehabilitate disturbed ground surfaces as soon as is practicable to minimise exposed surface periods
- Suitably contain soil stockpiles, rubbish and waste materials on site until disposal
- Develop a Waste and Hazardous Materials Management Plan including fuel and chemical storage protocols and spill responses.

8.4.2.8 Encroachment of feral species

Construction activities may foster greater utilisation of the area by introduced fauna. This is discussed further in Section 8.9. During operations provision of a more permanent water source may encourage use of riparian areas by introduced fauna.

8.5 Aquatic ecology

8.5.1 Loss of aquatic habitat

Project construction will require the removal of vegetation, excavation of the bed and banks and resource extraction. These activities will result in the direct loss of aquatic habitat at the sites of impact. Aquatic habitat within the Eden Bann Weir construction area has been modified as a result of the existing weir while the aquatic habitat within the Rookwood Weir construction area includes natural pool-riffle-run habitats. The area of habitat to be lost as a result of construction activities is, however, relatively small in size (1.4 ha) compared to the availability of similar habitat upstream and downstream of the sites.

Additional loss of habitat has the potential to occur within the river crossing construction areas. The construction area at all river crossing sites will be kept to the minimum amount necessary to in order to minimise impact to aquatic flora and fauna. Due to the relatively small area of habitat to be impacted at these sites (up to 0.03 ha) and the availability of suitable habitat upstream and

downstream of the construction works, impacts to aquatic fauna are not expected as a result of this loss. Resource extraction for use in construction will be sourced from excavations within the construction footprints and future inundation areas where ever possible, to avoid impact to additional aquatic habitat.

The following measures would be implemented to minimise aquatic habitat loss during construction:

- The construction schedule of river crossing construction at Glenroy Crossing will be designed to avoid construction works that may impact on turtle habitat during the peak turtle nesting and hatching season (September to March)
- The construction footprints will be kept to the minimum amount necessary
- The construction footprints will be clearly marked with construction tape
- Resource extraction will not occur in Fitzroy River turtle important habitat areas (e.g. mapped essential habitat) or from within historical, confirmed or high potential turtle nesting habitat
- All construction personnel will be informed of their environmental responsibility with respect to the protection of aquatic fauna and their habitat. Site inductions will include information on the location of important habitat and potential turtle nesting habitat to prevent disturbance and/or destruction of these areas. Management actions relevant to the protection of aquatic habitat will be discussed and responsible persons identified.

8.5.2 Alteration of aquatic habitats

Approximately 942 ha of natural (not impounded) aquatic habitat will be impacted by the Project comprising 282 ha within the additional impoundment area at Eden Bann Weir and 660 ha within the Rookwood Weir impoundment assuming maximum development at each site. Currently approximately 35 per cent of the Fitzroy, Dawson and Mackenzie sub-catchments have been impounded as a result of in-stream water infrastructure as illustrated in Table 8-3. At maximum development, the Project will result in the inundation of an additional 114.5 km, increasing the area of impacted aquatic habitat within the sub-catchments by ten per cent:

- Raising of Eden Bann Weir (to Stage 3) is expected to inundate an additional 27.5 km of natural river habitat. Based on the aquatic habitat segment analysis, the reach of river to be inundated comprises approximately 14.5 km of natural pool habitat, 8.5 km of run habitat and 4.5 km of riffle habitat
- Approximately 87 km of river habitat will be inundated as a result of the proposed Rookwood Weir (Stage 2). Based on the aquatic habitat segment analysis, approximately 46.4 km of pool habitat, 29.1 km of run habitat and 21.2 km of riffle habitat along the lower Dawson, lower Mackenzie and Fitzroy rivers will be altered.

These habitats will be altered, primarily through conversion from a lotic (flowing) state to a more homogenous lentic-type habitat characterised by a deep, wide river channel. This will occur on commissioning and persist through operations as the weir fills and is drawn down annually.

The impounded habitat created as a result of the weirs will be generally characterised by a deep, wide river channel, slow to zero flow, poorer quality clay/silt substrate, lower density of in-stream debris and lower density of overhanging riparian vegetation. It is important to note, however, that due to the topography changing along the course of the river system, the depth and width of stream will change. The deep water benthic areas (in water depths > 5 m) that will dominate the

weir pool habitat directly behind the weir wall are expected to be uninhabitable to most aquatic fauna species due to low oxygen levels, little or no light penetration and relatively cold temperatures. The upper water column within the more open inundation area is likely to provide habitat for large bodied fish, some turtle species (Krefft's river turtle, Broad-shelled river turtle) and estuarine crocodile. While other species are likely use the inundated habitat intermittently, the low abundance of micro-habitats and food resources will generally limit permanent occupancy of more open water habitats.

Table 8-3 Current level of impoundment in rivers relative to the Project

River	Existing infrastructure	Length of river (km AMTD)	Level of impoundment (km AMTD)	Percentage %
Dawson River	Neville Hewitt Weir, Moura Weir, Theodore Weir, Orange Creek Weir, Gyranda Weir, Glebe Weir	356. 5	125.2	35%
Nogoa and Mackenzie Rivers	Tartrus Weir, Bingegang Weir, Bedford Weir, Fairbairn Dam	427.2	143.7	34%
Fitzroy River	Eden Bann Weir, Fitzroy Barrage	250.7	97.6	39%

In general, suitable habitat for aquatic fauna will be limited to the shallow littoral habitats along the perimeter of the inundated areas. These areas will contain a higher diversity of in-stream micro-habitats such as fallen logs and root mats and food resources. Snag material along the existing margins of the river that will be inundated is likely to be replaced by drowned-out vegetation about the high water mark of the impoundment.

Overall, the alteration of natural riverine habitats within the Eden Bann Weir Project footprint and Rookwood Weir Project footprint will reduce the heterogeneity of the river system and therefore the diversity of habitats available to aquatic fauna. It is important to note that the extent and duration of aquatic habitat alteration will be related to the amount of water stored in the impoundment (driven by climatic conditions (rainfall/drought) and management of the storage). While aquatic habitats nearer the weirs are likely to be inundated more permanently, habitats in the upper reaches of the weir impoundment will revert back to pool-riffle-run sequences (characteristic of the un-impounded reaches of the lower Dawson, lower Mackenzie and Fitzroy rivers) as the weir impoundment is drawn down and the volume of water in the storage is reduced. The linear extent of the reversion will be, as mentioned above, largely related to rainfall and drawdown of the storage. While these habitats may become temporarily available, the quality of the habitats for aquatic fauna is likely to be reduced due to extended periods of inundation within the impoundment. Reduced habitat quality may result from a reduction in macrophytes, macroinvertebrates and changes to substrate.

The lower reaches of the 19 named creeks (and smaller unnamed creeks) in the Eden Bann Weir Project footprint and Rookwood Weir Project footprint, and the connectivity and hydrology of the 55 off-stream water bodies within 1 km of the lower Dawson, lower Mackenzie and Fitzroy Rivers are likely to experience varying degrees of alteration. This includes the inundation of creek bed and banks and the inundation of off-stream water bodies (palustrine wetlands) as described below. The extent of this alteration will be more notable in and adjacent to the lower reaches of the weir impoundment.

No lacustrine wetland areas will be directly impacted by the Project. Two palustrine wetlands associated with the Rookwood Weir impoundment will be inundated. A Great Barrier Reef wetland protection area is mapped within 350 m of the upper most extent of the Rookwood Weir (Stage 2 only) impoundment on the Mackenzie River (at 334 km AMTD) (Chapter 7 Existing environment). Coinciding with this area is a wetland defined as being of high ecological significance. The Stage 2 Rookwood Weir impoundment is not expected to inundate these wetland areas and will not directly impact the functioning of the wetland ecosystem at this location.

Given the nature of water storage within the main river channel bed and banks, it is not expected that the Project will adversely impact off-stream wetland connectivity with the river, or adversely alter the seasonality, duration, frequency and volume of water entering and leaving the off-stream water bodies. Consequently, it is not expected that the Project will impact the specific habitat characteristic of the water bodies and their value for aquatic flora and fauna. Those habitats replenished by large flood flows are not expected to be affected by the proposed infrastructure and hydraulic/hydrological modelling indicates that the Great Barrier Reef wetland protection areas located adjacent to the Eden Bann Weir and Rookwood Weir Project footprints will not be impacted by the Project. Additional information on inundation extents during flooding events is provided in Appendix P.

The following mitigation measures are proposed to avoid/minimise the potential impact of Project commissioning on aquatic ecological values:

- Riparian vegetation within the impoundments will not be cleared prior to inundation and large woody debris will be retained. This will provide (in the short-term) sustained micro-habitats and resources for some species. It is expected however that over time vegetation will dieback and new vegetation will emerge in riparian areas above the full supply level
- The re-establishment of aquatic habitat within the impoundment will be encouraged through the following actions:
  - Avoiding rapid drawdowns of the storage area and controlling water levels to allow for the stabilisation of aquatic habitat around the margins of the impoundment
  - Rehabilitating and restoring areas impacted by scouring, erosion and slumping
  - Promoting the natural regeneration of trees and shrubs
  - Controlling introduced weeds and feral animals in accordance with the Project Weed Management Plan and Feral Animal Control Program.

8.5.3 Inundation of turtle nesting habitat

Nesting by Kreft's river turtle, saw-shelled turtle, broad-shelled turtle and eastern snake-necked turtle occurs on a variety of river bank substrates (Cann 1998, Limpus et al 2011a). Given the generalist nature of these species and the ability to utilise a variety of nesting habitats, it is not expected that adverse impacts will arise as a result of the Project. In comparison Fitzroy River turtle and white-throated snapping turtle nesting areas are primarily restricted to alluvial sand/loam banks with a relatively steep slope and low vegetation cover.

Isolated nesting for the Fitzroy River turtle occurs within the Project footprint. As described in Appendix L, nesting bank elevation data was compared to daily water levels in the impoundments during the nesting season to determine the potential availability of nesting banks for active protection of nests during this period. The assessment showed that during a wet year there is no possibility of protecting nests within the impoundment. In dry years there is the potential to protect

nests at some locations but an inflow that inundates all nesting banks could occur at any time. As such, the Project will result in the inundation of known and potential nesting habitat within the Project footprint during commissioning.

Some water storages, such as Ben Anderson Barrage on the Burnett River, are able to manage water levels within the impoundments during nesting periods through regulated inflows from upstream storages (for example Paradise Dam releases) to prevent nest inundation within the impoundment. At the proposed Rookwood Weir, there are no such structures upstream from which regulated releases can be made to maintain a nominated water level within the proposed impoundment. Similarly, while there is potential for the proposed Rookwood Weir to regulate flows to Eden Bann Weir to some degree, given the nature and operation of weir storages and reliance on natural inflows this ability would be limited and are likely to be superseded by naturally occurring high river flows that overtop the spillway. As such, the Project cannot feasibly manage water levels to a nominated level in order to effectively avoid or minimise impacts on existing nesting habitat within the proposed impoundments.

The loss of nesting habitat within the Project footprints has the potential to disrupt the breeding cycle of these species by restricting nesting to sub-optimal habitats and reducing reproductive success (DERM 2010). Due to specific nesting requirements and the extremely high nest predation rates throughout the catchment, the loss of turtle nesting habitat within the Project footprint is considered significant (Chapter 10 Threatened species and ecological communities). The maximum total area of nesting habitat impacted by the Project (Eden Bann Weir Stage 3 and Rookwood Weir Stage 2) has been calculated as 5.71 ha (Appendix L).

Suitable nesting habitat for the Fitzroy River turtle is expected to persist in the upper reaches of the impoundments with potential nesting habitat remaining above full supply level within the Rookwood Weir Project footprint. Suitable nesting habitat is also expected to be naturally created in flood deposition areas over time. The existence of aggregated nesting in the upper reaches of the Fitzroy River Barrage (Fitzroy River turtle and white throated snapping turtle) and the Tartrus Weir impoundment (Fitzroy River turtle), demonstrate that the species has the ability to colonise new habitat where suitable conditions do occur. The turtle species have also demonstrated adaptability to fluctuations in nesting habitat conditions following natural events such as flooding (Dr Col Limpus pers comm.). The implementation of a Weed Management Plan and Feral Animal Control Program (Section 8.9) will assist in increasing the quality of potential nesting habitat for turtle nesting and the potential for successful recruitment of hatchlings within the Project footprints (Chapter 10 Threatened species and ecological communities).

8.5.4 Habitat degradation

Construction activities within the construction footprints have the potential to result in the degradation of habitat within and immediately downstream of these sites. Habitat degradation may occur as a result of:

- Sedimentation and erosion

  Unmitigated point-source pollution from sedimentation and run-off may alter the chemical and physical characteristics of habitat within and downstream of the construction areas. Specific impacts may include reduced water quality (increased turbidity; decreased oxygen levels; reduced light penetration), change in channel morphology, alteration of substrate composition and smoothing of aquatic vegetation and organisms (Wood and Armitage 1997; Wheeler et

al. 2005). A Drainage, Erosion and Sediment Control Plan will be developed and implemented to minimise potential impact to aquatic habitat as a result of construction activities.

- Increased weed and pest species (Section 8.9)
- Light, noise and vibration disturbance

  During the period of construction there is expected to be a localised increase in light, noise and vibration adjacent to the construction areas. This has the potential to cause short-term disruption to aquatic fauna behaviour in adjacent habitats during the period of construction.
- Storage and spillage of hazardous materials

  Use of construction machinery in and around aquatic habitats has the potential to result in the spillage of contaminants, such as fuels and lubricants through spillage. In severe cases, chemical pollution of the aquatic environment could result in mortality of aquatic fauna and long-term degradation of aquatic habitat. The development of a Waste and Hazardous Materials Management Plan will substantially reduce the potential for spillage and likelihood of impact.
- Flow diversion and control

  Diversion of flow within the construction areas has the potential to degrade aquatic habitat immediately upstream and downstream. Weir construction will be primarily undertaken over two consecutive dry seasons when flows within the river are low and natural/existing conditions will be maintained for as long as possible. A flow diversion strategy (Chapter 2 Project description) will maintain flows within the Rookwood Weir construction area while the existing fish lock will be used to maintain flows within the Eden Bann Weir construction area.

These impacts may have a localised effect on aquatic fauna by reducing habitat value (e.g. amount of refuges, microhabitats and food availability) within the immediate downstream area and disrupting fauna behaviours. Reduced water quality may also decrease the abundance of sensitive species and change aquatic fauna community structure. The potential ecological consequences may include a temporary and localised decrease in fauna abundance, reduction in health and disruption to breeding. The impacts will be however, primarily restricted to the habitat areas directly adjacent to construction areas (at weir sites and river crossings) and are not expected to persist at large distances away from these sites. The mitigation measures proposed are considered sufficient such that no adverse impact is expected.

The following measures would be implemented to avoid/minimise aquatic habitat degradation during construction:

- Water flows downstream of the construction areas will be maintained to prevent the drying of aquatic habitat and to maintain water quality
- Weir construction will be primarily undertaken over two consecutive dry seasons when flows within the river are low and natural/existing conditions will be maintained for as long as possible to minimise degradation of habitat downstream
- Night lighting will be minimised where practicable. No lighting shall be placed in the vicinity of a confirmed turtle nesting habitat adjacent to the construction areas. Any lighting installed will be designed and mounted so that no spill over light occurs within these habitat areas (such as directional lighting with protective guards)

- A Drainage, Erosion and Sediment Control Plan will be developed and implemented. Management actions will be in accordance with the Best Practice Erosion and Sediment Control Guidelines (International Erosion Control Association (IECA) 2008)
- A Water Quality Management Plan will be developed and implemented in accordance with the Project construction EMP
- A Waste and Hazardous Materials Management Plan will be developed and implemented.
- Aquatic habitats immediately upstream and downstream of the construction footprints and river crossing construction areas will be monitored for signs of degradation during the construction phase. Aquatic fauna in isolated pools will be relocated if conditions have deteriorated or are considered likely to deteriorate.

8.5.5 Changes to downstream flow regime

The operation of weirs is predicted to result in a change to the downstream flow regime between the weir and upper inundation limit of the preceding impoundment. Based on the aquatic habitat segment analysis, aquatic habitats downstream of Rookwood Weir (to the existing Eden Bann Weir impoundment) that will potentially be impacted by operations of the proposed weir comprise 38.2 km of pool habitat, 12.1 km of run habitat and 3.7 km of riffle habitat. Further to this, six named creeks join the Fitzroy River between the proposed Rookwood Weir site and the upper limit of the Eden Bann Weir Project footprint, while eight off-stream water bodies were identified within 1 km of the Fitzroy River between the proposed Rookwood Weir site and the upper limit of the Eden Bann Weir Project footprint. Aquatic habitats downstream of Eden Bann Weir (to the Fitzroy Barrage) that are currently subject to downstream impacts, and which will continue to be impacted post-raising of the weir, comprise 25.5 km of pool habitat, 8.9 km of run habitat and 3.7 km of riffle habitat. Further to this, 13 named creeks join the Fitzroy River between Eden Bann Weir and the Fitzroy Barrage, while 32 off-stream water bodies were identified within 1 km of the Fitzroy River between Eden Bann Weir and Fitzroy Barrage.

The operation strategy for the impoundments will be dictated by environmental flow objectives dictated by the Fitzroy WRP and implemented through the Fitzroy ROP. As described in Section 8.2.2, preliminary modelling indicates that all mandatory environmental flow objectives will be achieved for the Project, except for the upper limit of development combined at both sites (that is Eden Bann Weir Stage 3 and Rookwood Weir Stage 2) in relation to the 20 year daily flow volume. Once demands for the Project are realised and development of a specific infrastructure scenario is triggered, the Fitzroy ROP will be required to be amended to incorporate operating rules relative to the infrastructure built. It is expected that refinement of operating rules in development of the ROP will address non- compliance.

The timing and quantity of releases downstream is likely to vary between seasons with the dry winter period expected to trigger the highest demand for water resources downstream. As a result, when compared to existing conditions, water flows downstream will increase during the dry season and the frequency and duration of no flow periods will decrease. The increase in flows during the dry season has the potential to improve the quality of aquatic habitat downstream by reducing the duration and severity of pool isolation and prolonging the presence of flowing riffles zones and runs. The increase in habitat availability during the dry season will provide additional resources for aquatic fauna during times when conditions are limiting. The diversity and abundance of macrophytes and macroinvertebrates is likely change with a potential increase in

species that prefer flowing conditions and a reduction in species that prefer slow flowing and ephemeral habitats.

Flood flows entering the impoundment are likely to be captured and stored until the weir reaches its full supply level. This will result in the reduction of flows downstream (or at least a lag in the flow downstream) and is most likely to occur at the start of summer when the storage volume is predicted to be at a minimum in most years. Once the weir reaches its full supply level, downstream flows will increase. Large flood flows, > 9000 m^3/s (weir drown-out) will, however, not be affected by the proposed infrastructure.

The greatest number of fish move within the river system during large flow events which often take place during summer (Marsden and Power 2007). For catadromous fish (e.g. barramundi and eels), high flows and floods are especially important for downstream migration as high flow events can allow fish to move over weirs in order to enter estuarine and marine waters for spawning. Barramundi have shown increased recruitment and strong year-class associations with high flows when fish migrate laterally into connected floodplains (Staunton-Smith et al. 2004). As such, catadromous fish have evolved a migration strategy that corresponds to and takes advantage of flooding events.

Fitzroy River turtle and white-throated snapping nesting habitats located downstream of the Project footprints may become degraded due to these changes in water flows. Nesting banks naturally change over time with substrates being eroded and redeposited under different flow conditions. The overall reduction in water flows that are expected to occur as a result of the impoundments may disrupt the natural rejuvenation of downstream banks potentially reducing their suitability for nesting. Changes to downstream water flows may also lead to an increase in macrophytes along stream margins which may prevent access to nesting areas (Tucker 2000; Hamann et al. 2007). Large flood flows, > 9000 m^3/s (weir drown-out) will, however, not be affected by the proposed infrastructure, and as such, sufficient sediment transport (past the weir structure) is expected to occur to maintain downstream nesting habitats and the high flows will remove macrophytes that may have become established.

Operational water releases that result in increased water levels during the turtle nesting periods could also lead to the inundation of nests downstream (Cann 1998). Based on the predicted demand triggers, there is expected to be an increase in downstream flows during the dry season with peak water releases occurring immediately prior to the pre-summer floods. An increase in water flows during early September is unlikely to affect nests of the Fitzroy River turtle, as the releases are likely to have commenced prior to the peak laying period and therefore eggs will be laid above the water line and not drowned. Early nesting of these species during August may be affected by inundation.

As large flood flows, > 9000 m^3/s (weir drown-out) will not be affected by the proposed infrastructure, impacts to off-stream water bodies located downstream of the Project footprint are not expected. Additional information on changes in the downstream flow regime is provided in Appendix P.

The following mitigation measures are proposed to minimise the potential impact of the Project as a result to changes to the downstream flow regime:

- The operation strategy of the weirs will be dictated by the environmental flow objectives defined in the Fitzroy WRP and implemented through the Fitzroy ROP (as amended). These objectives will aim to minimise environmental impacts as a result of the water infrastructure

and will mimic natural flow conditions as much as possible. Where required, yield adjustments and operating rules will be amended to comply with the Fitzroy WRP and Fitzroy ROP

- Subject to compliance with the Fitzroy WRP and Fitzroy ROP, water release volumes and timing will be controlled to minimise the inundation of turtle nests downstream of the weir during nesting season. Further modelling will be undertaken during detailed design to facilitate this
- As part of the operational phase Turtle Monitoring Program, important nesting habitats downstream of the Project footprint (Alligator Creek) will be monitored for signs of degradation as a result of changes in the downstream flow regime.

8.5.6 Fauna injury and mortality

Aquatic fauna residing within the construction footprints may experience direct injury and/or mortality. Similarly, aquatic fauna moving upstream or downstream within these areas are at risk of being trapped or injured in the active construction zones. Construction activities may also foster greater utilisation of the area by introduced animals. The incorrect disposal of rubbish and other refuse may encourage introduced species (including pigs, dogs, foxes, and cats) to the area, which in turn may increase predation pressure on turtle nests leading to an increased injury/mortality rate for the species.

The increase in vehicular activity associated with construction has the potential to increase the incidence of turtle mortality via collision with motor vehicles. This is particularly relevant for the eastern long-necked turtle and broad-shelled river turtle which make long-distance overland migrations in response to habitat degradation (e.g. drying of ephemeral pools) and nesting.

During operation, injury and mortality can occur when aquatic fauna (in particular freshwater turtles and fish species) are swept over the spillway during periods of high flow, when they contact hard structures in the turbulence of downstream pools and when high velocity water is released during regulated flow discharges. Injury and mortality can also occur when fauna are trapped against trash screens or within fish transfer devices (Larinier 2000; Limpus et al. 2011a).

Fish species are particularly susceptible to shearing and abrasion injuries from contact with hard structures in the downstream pool and contact with the spillway during flooding events. Fish are also vulnerable to gill, eye and internal organ damage from the sudden changes in velocity and pressure that occur as the fish are swept over the spillway (Larinier 2000). Fish larvae are also known to suffer high levels of mortality (e.g. 95 per cent in golden perch) as a result of undershot gates (Baumgartner et al. 2006). Freshwater turtle injury and mortality is commonly associated with entrapment on trash screens, contact with hard surfaces and aggregations of turtles within areas of intermittent flow velocity. Particularly high levels of turtle injury and mortality are associated with their interaction with stepped weir designs (Limpus et al. 2011a).

A detailed design process has been undertaken for the Project to minimise risk of fish and turtle injury and mortality at Eden Bann Weir and Rookwood Weir. The key design features responsible for high levels of fauna injury and mortality described above (stepped spillway, dissipater teeth, high turbulence, insufficient pool length and depth, high velocity trash screens) have been completely avoided in Project design thereby substantially reducing the risk of injury and mortality to fish and turtles. Further detail on specific design features for minimising impacts to turtles is provided in Appendix M. Additional mitigation strategies will be implemented in the operation of the structure to further reduce the potential risk of injury and mortality.

The following measures would be implemented to avoid/minimise injury and mortality to aquatic fauna during construction:

- Prior to any initial or new disturbance to aquatic habitat within the construction areas, all impact areas will be inspected by a fauna spotter/catcher for the presence of aquatic fauna. Pre-clearance surveys will be undertaken immediately prior to disturbance works. Aquatic fauna captured will be relocated and relevant measures implemented to exclude fauna access to active constructions areas (e.g. erection of exclusion fencing/netting, bund walls)
- A fauna spotter/catcher will be located on site during all works that have the potential to cause injury or mortality to aquatic fauna located in the area. The fauna spotter/catcher will identify, capture and relocate aquatic fauna and/or nests as required to avoid impact
- If injury occurs, injured fauna will be immediately removed and taken to a qualified veterinary or wildlife carer for treatment. Suitable veterinarians and wildlife carers in nearby areas and Rockhampton will be identified and commercial arrangements established to guarantee the financial costs of treatment and rehabilitation
- All construction personnel will be informed of environmental responsibility with respect to minimising the risk of fauna injury or mortality. Site inductions will include information on the identification of conservation significant species, location of any confirmed nesting habitat areas within or adjacent to the construction areas and relevant management actions
- The weir operating strategy will avoid/minimise risk of aquatic fauna injury and mortality. Specific operational actions will include:
  - Controlling the flow of water through release values to provide gradual increments in water release volume
  - During planned releases, increase water release during dawn and dusk periods when turtles are more likely to be away from weir infrastructure
  - Operate the flood gate next to the fishway independently and initiate the gate opening sequence with this gate to build tailwater in the stilling basin.

Fishing practices can cause injury and mortality to aquatic fauna within impoundments from entrapment in traps, boat/propeller strikes and interaction with and ingestion of fishing hooks (Tucker 2000; Hamann et al. 2007; Limpus et al. 2011a). The Project will not promote or facilitate recreational activities and combined with the remote locations and limited access opportunities, impacts on aquatic fauna as a result are not expected.

8.5.7 Restriction of movement

Water flow within the construction areas may be impacted during the construction period and upstream and downstream movement of aquatic fauna temporarily restricted within the Rookwood Weir construction area. Weir construction will be primarily undertaken during two consecutive dry seasons when flows are reduced and the river exists as a series of isolated pools. Movement of aquatic fauna during this period is likely to be low. The existing fish lock at Eden Bann Weir will remain in operation during construction on the right bank to maintain flows and provide fish passage. During this time, the turtle passage facility will be constructed. The turtle passage facility will provide safe turtle movement past the Eden Bann Weir construction area when construction works move to the left bank. An in-stream flow diversion strategy will maintain flows at the proposed Rookwood Weir site and provide safe aquatic fauna passage during construction phase flow events.

Existing low level causeways at river crossings will remain in situ during bridge construction to facilitate water flow and maintain fauna passage. The existing low level causeways will be decommissioned once bridge construction is complete. Construction at river crossings will primarily be undertaken during the dry season when flows are reduced and the river is likely to exist in isolated pools. Flow diversion will be put in place during construction to maintain flows and provide safe aquatic fauna passage where required. Movement of aquatic fauna is not expected to be impacted at river crossing construction areas.

During operation, in-stream structures such as weirs represent an impediment to the movement of aquatic fauna. This disruption to connectivity along the continuum of the river not only serves to fragment populations and habitats, but also potentially impedes the life-history behaviour of aquatic fauna occurring within the system. The existing weir at Eden Bann and the proposed Rookwood Weir have the potential to impede or prevent aquatic fauna movement upstream and downstream. Without suitably designed aquatic fauna passages that facilitate movement, this barrier to movement may adversely affect that viability of local and regional populations, through disruption to critical behaviours (e.g. breeding, dispersal). At a taxon level, potential impacts of inhibited up- and downstream aquatic fauna passage are described in the following sections.

The following mitigation measures are proposed to minimise impacts on aquatic fauna due to impeded up and downstream passage:

- A fishway design process has been undertaken in accordance with Queensland Fisheries Design Process criteria. This process involved the selection and refinement of fishway design specifications and success criteria and the development of fishway designs for both Eden Bann Weir and Rookwood Weir. State fish biologists participated in the fishway design process and provided key technical input and review
- A Fish Monitoring Program will be designed and implemented to monitor the effectiveness of fish passage infrastructure. The monitoring program will be undertaken annually for a period of five years and will include areas upstream of the inundation area, within the impoundment and downstream of the weirs
- A species specific and Project specific turtle passage facility (turtle ramp) is currently designed to concept level for each weir. Discussions with the Queensland Department of Environment and Heritage Protection will be held during the detailed design phase to further refine the design of the turtle ramp at each weir from concept through to detailed design. Operability of the turtle ramps will be maintained through the life of the Project. A detailed description of the turtle ramp design features is provided in Appendix L. A turtle movement study will be implemented on commencement of a Project trigger to improve current knowledge of Fitzroy River turtle movement patterns, home range and seasonal variations through monitoring and tracking. The study would be implemented through a university research program in collaboration with DEHP. The study would further inform the requirements of turtle passage and will facilitate quantifiable performance criteria to measure the effectiveness of the passage once operational
- A monitoring program will be developed and implemented to evaluate the performance of the turtle ramps at each weir. In the event that the turtle passage infrastructure proves ineffective (based on criteria and timeframes developed with and approved by DEHP through the turtle movement study) adaptive management actions will be implemented (for example alternative ramp surfaces, altered attraction flows or capture and transfer where Fitzroy River turtle (and other turtles) are found to be aggregating downstream of the weirs).

8.6 Marine ecology

The Fitzroy delta system supports a number of sensitive environmental areas and conservation significant species. The flow regime in this region is currently regulated by releases from the Fitzroy Barrage and habitats have been modified as a result of existing human land use. Analysis of flow data revealed that there no statistical differences between current modelled flow regimes and the flow regimes projected with any additional infrastructure associated with the Project in place (Section 8.2.2). Impacts to the sensitive environmental areas and conservation significant species in the areas downstream of the Fitzroy Barrage including the delta are therefore not anticipated. Impacts to marine species are assessed in Chapter 11 Migratory and marine species. Impacts on the GBRWHA and the GBRMP are assessed in Chapter 9 World Heritage properties and National Heritage places. Impacts on State areas (GBR Coastal MP and Fitzroy Fiver FHA) are addressed in Volume 1.

8.7 Extreme environmental events

8.7.1 Flooding

Flooding during the construction stage has the potential to:

- Damage property and partially completed structures
- Place staff at risk
- Increase erosion resulting in unstable banks and a reduction in water quality
- Hinder access to sites.

Construction will be scheduled to avoid the wet seasons as far as practical. In dry years when construction can continue through spring and summer, activities will be primarily focussed on low risk works, such as works not in the river bed. Weather forecasts will be used to determine the risk. BoM issues regular weather forecasts as well as flood and severe weather warnings. The construction contractor will be responsible for monitoring warnings and taking actions to minimise damage during construction and, if required, evacuate site workers, plant and equipment. The construction contractor will also be responsible for ensuring that the site layout locates any immoveable and high risk items, such as fuel storage tanks and waste storage areas, outside any high flood risk areas.

The strategy for flood management would be to isolate the works area via construction of coffer dams at appropriate upstream and downstream locations and installation of an in-stream diversion channel around the works. Coffer dams will not store large volumes of water and diversion strategies will allow river flows to pass the construction areas.

Construction access to sites is proposed to be augmented. It is acknowledged that there may be periods that access by road is restricted as a result of flooding and the construction schedule and evacuation procedures will consider such events.

During operations, the weir operator would be responsible to monitor floods likely to impact on the weirs and on the surrounding land use. A flood warning system is in place for the Project area and is operated by BoM. Emergency Management Plans will be developed to facilitate emergency response actions. During detailed design, appropriate locations and levels for permanent site facilities (such as controls rooms) will be determined. Flooding is discussed further in detail in Appendix P.

8.7.2 Tropical cyclones

Tropical cyclones influencing the Project area have the potential to result in strong winds, heavy rain and flooding. Similar to flooding above, strong winds during construction and operation have the potential to:

- Damage property and temporary and permanent structures
- Place staff at risk
- Increase dust generating activities during dry ambient conditions.

The operations control building has been defined as an Importance Level 4 structure that is 'buildings or structures that are essential to post-disaster recovery or associated with hazardous facilities' (Australian Standard 1170.0 - 2002 Structural design actions – Part 0: General principles). The control building has a design wind speed for a 1:2,000 AEP event.

8.7.3 Severe storms

As for tropical cyclones (Section 8.7.2), severe storms have the potential to result in flooding and strong winds. Power and communications to the weir sites may be disrupted during severe storms. Back-up power is proposed to be installed sufficient to operate the weir and provide capacity for communications and telemetric operations. Consistent with the management of impacts from flooding and strong cyclonic winds, severe storm conditions will be considered further and addressed in planning and design and will be managed through the implementation of EMPs during construction and operation.

Strong wind conditions that may occur during dry periods of construction activity may generate significant local dust. Dust control measures will be further considered and managed through the implementation of a construction EMP.

8.7.4 Extreme temperatures

Maximum temperatures in Queensland typically occur between November and February but days of excessive heat can occur anytime between October and March. Heatwave conditions will be managed through the implementation of EMPs during construction and operation. The preparation and implementation of workplace health and safety procedures would reduce the risk of dehydration, heat stroke and sunburn to site staff. Appropriate design standards will facilitate functionality of operational components, for example the operational control building is fitted with appropriate air-conditioning to protect electrical equipment.

8.7.5 Bushfires

The Project is located within bushfire hazard area under relevant local government planning schemes. The following preventative measures will be implemented to reduce bushfire risk:

- Construction areas will be cleared of vegetation that may present a fire risk
- If any vegetation needs to be burnt, it will be done in consultation with the local emergency department and in accordance with permits and approvals
- Fire breaks will be maintained around areas identified as being potential sources of ignition
- Bushfire response measures will be incorporated into the site incident management plan and on-site firefighting capability will be maintained
- Staff will be educated in relation to bushfire prevention

- Staff will be trained in procedures for welding, and other activities with high risk of starting fires.

8.7.6 Earthquakes and landslides

The Project area is expected to experience earthquake intensities of Modified Mercalli Intensity[1] (MMI) 3 approximately every 18 years (ESS 2009). Intensities of MMI 6 (when standard housing experiences damage) are predicted by statistical analysis to occur approximately once every 871 years for Rookwood Weir and once every 902 years for Eden Bann Weir (ESS 2009).

An Earthquake Risk Plan will be developed for the Project, considering the likelihood of earthquakes in the area and management of those risks. In the detailed design stage appropriate earthquake design standards will be applied considering the following:

- Queensland Dam Safety Management Guidelines (Department of Natural Resources and Mines (DNRM) 2002)
- Guidelines on Design of Dams for Earthquakes (Australian National Committee on Large Dams (ANCOLD) 1998).

Geotechnical investigations have identified that the weir sites are optimal locations for the water infrastructure. Based on geotechnical investigations the potential risk of a landslide hazard is considered negligible.

8.8 Hazardous substances

The Project will use a number of environmentally hazardous substances including those listed in the Australian code for the transport of dangerous goods by road and rail (ADG Code). An indicative list of these substances is provided in Table 8-4. Table 8-5 describes the likely quantities, storage and transport of environmentally hazardous substances used at the sites.

Table 8-4 Indicative list of environmentally hazardous substances

Chemical name	Concentration (%w t)	Dangerous goods class	Hazchem code	UN number	Packaging group	Purpose/use
Diesel	N/A	3 (Class C1)*	3[Z]	1202	III	Fuel for heavy vehicle operations
Oils (lubrication/ hydraulic oils)	N/A	3 (Class C2)**	N/A	N/A	N/A	Lubricate plant and equipment and replenish hydraulic systems
Acetylene (dissolved)	> 98%	2.1	2[S]E	1001	N/A	Welding
Oxygen	> 98%	2.2	2[S]	1072	N/A	Welding
Waste oil	N/A	N/A	N/A	N/A	N/A	Waste oil from equipment/ machinery

[1] MMI provides a physical description of the effects of shaking that can be expected at a specific locality and indicates the severity of an earthquake (ESS 2009).

Chemical name	Concentration (%w t)	Dangerous goods class	Hazchem code	UN number	Packaging group	Purpose/use
Ammonium nitrate	100%	5.1	1[Y]	1942	III	Blasting on site
Detonators	N/A	1.1	E	0360	N/A	Blasting on site

*Class 1 – a combustible liquid that has a flashpoint of 150^{o}C or less

**: Class C2 – a combustible liquid that has a flashpoint exceeding 150^{o}C

N/A: None allocated

Table 8-5 Likely quantities, storage and transport of environmentally hazardous substances

Chemical name	Indicative maximum inventory onsite	Indicative storage details	Transport and handling details	Storage location
Diesel	100 kL	2 x 50 kL aboveground storage tanks	Road transport by 57 kL fuel tanker to construction site. Manual transfer to vehicles onsite	Fuel farm
Oils (lubrication/ hydraulic oils)	2 kL	Above ground tanks	Road transport to construction site	Fuel farm and maintenance area
Acetylene (dissolved)	2 kL	Waste oil bins, bunded	Road transport to site in individual cylinders. Manual transfer to licensed contractor vehicles for recycling	Fuel farm, refuelling and maintenance areas
Oxygen	245 m^3	In standard bottles	Road transport to construction site by trucks. Manual transfer to storage	Store at construction site
Waste oil	245 m^3	In standard bottles	Road transport to construction site by trucks. Manual transfer to storage	Store at construction site
Ammonium nitrate	Minimum quantity as required	Containers	Road transport to construction site by trucks	Store at construction site
Detonators	Minimum quantity as required	Containers	Road transport to construction site by trucks	Store at construction site

Leaks and spills of environmentally hazardous substances have the potential to occur from incidents during construction as follows:

- Fuel tanker crash with rupture of one or more tanks – single vehicle or involving another vehicle
- Vehicle carrying lubricating oils/waste oils crashes and ruptures oil container – single vehicle or involving another vehicle
- Vehicle carrying acetylene or oxygen gas cylinders crashes and results in gas leakage – single vehicle or involving another vehicle
- Fire or explosion from storage of chemicals and explosives on site

- Spill or leak from diesel storage tanks or from oil or waste oil storage.

The following mitigation measures would be implemented to reduce risks associated with the use, transport, handling and storage of hazardous substances:

- Trucks used to transport hazardous substances from Rockhampton will comply with all aspects of the ADG Code
- Aboveground storage tanks will be designed as per AS 1940:2004 – The storage and handling of flammable and combustible liquids
- Acetylene bottles will be kept upright, in the secure area within the stores compound on a firm floor to prevent falling. Bottles will not be stored near sources of ignition, oxidising agents, poisons, flammable liquids or combustible materials
- The contractor responsible for transport of ammonium nitrate will comply with the requirements of *AS1678.5.1.002-1998 Emergency procedure guide – Transport Ammonium nitrate*
- Explosives storage will be approved under the Explosive Act 1999. Explosives storage and use on site will meet the requirements of AS 2187:1998 Explosives – Storage, transport and use and AS 4326-2008 The storage and handling of oxidising agents
- The explosives storage area design will:
  - Be located away from drains, channels or pits
  - Be located away from possible sources of heat, fire or explosion, such as oil storage, flammable liquids and combustible materials
  - Be established such that it can be secured and will be designed in compliance with the size and volume of explosives on site. Bund containment and earth mounding will be constructed on-site and the explosives area installed with security monitoring.
- All tank transfer operations will be conducted on impervious surfaces. A dedicated fuel tanker delivery and turn around area is to be provided to minimise risk of vehicle accident. Dedicated filling points for on-site fuel trucks will also be provided with impervious surfaces and containment using rollover bunds
- Activities using oils will generally be conducted on a hard stand area, and drip trays will be provided at appropriate locations including during the transfer operations
- Regular inspection of the storages and piping will be done by the construction staff
- Daily checks of the bunds for stormwater accumulation will be undertaken and procedures developed for management of water in the bunded areas. No contaminated stormwater will be discharged to the river
- Regular inspections and maintenance will be planned for all electrical equipment and fittings
- Adequate security provisions and access control will be provided for the storage areas
- A pest control system will be provided to limit the potential for damage from animals (including stock)
- Smoking will be prohibited outside of designated areas and ‘no smoking’ notices will be prominently displayed

- Spill kits will be available for placement on spillages to assist with clean up. The material will be collected and placed in a labelled container for disposal off-site through a licensed contractor
- All spillages will be prevented from entering drains or water courses. Absorbent material will be placed on the spillages which will be collected for disposal and any contaminated soil removed to a bioremediation pad
- Suitable fire fighting systems will be provided. In the event of fire, emergency response will include the use of carbon dioxide, dry chemical or foam and personnel who engage in emergency response activities will wear breathing apparatus
- On-site emergency response teams will be trained to undertake the necessary actions to address fire and other incidents that may arise with areas used for storage of hydrocarbon products and other hazardous materials
- Personal protective equipment (PPE) for exposure control will consist of impervious material gloves for hand protection, safety glasses or face shield for eye protection and suitable personal clothing for body protection. All PPE will conform to the relevant Australian Standards
- Other precautions which will be taken include prompt cleaning of spillages, keeping walls, floors and equipment clean, and locating electrical equipment where it cannot come into contact with the stored materials
- Public access to the construction site will be prohibited.

8.9 Weed and pest species

Construction activities have the potential to introduce and / or spread weeds, which can increase the edge effects associated with vegetation clearing. Generally, the landscape surrounding the site of Eden Bann Weir and the proposed Rookwood Weir is highly fragmented, and as such, isolated patches of vegetation are presently exposed to these processes. Earthworks and increased vehicle movements associated with construction activities at the weir site have the potential to exacerbate local weed infestation.

Construction activities may foster greater utilisation of the area by introduced fauna. The incorrect disposal of rubbish and other refuse may encourage competitive introduced species including pigs (*Sus scrofa*), dogs (*Canis familiaris*), foxes (*Vulpes vulpes*) and cats (*Felis catus*) to the area, which in turn may increase predation pressure on local native wildlife. These species may also out-compete resident native predators.

A Weed Management Plan would be prepared for the construction phase that outlines measures to prevent the introduction of new weed species into the area and minimise the spread of declared weeds within the site. Measures would include:

- Existing aquatic weeds within the construction footprints will be removed prior to construction activities
- Vehicles, plant and equipment will be cleaned prior to entering site, at a registered and approved facility, to prevent the introduction of weeds
- Machinery used for clearing and grading will have their wheels cleaned with an air compressor before entering and leaving the site

- Key personnel on site will be capable of identifying declared weed species within the site / surrounding area and prevent their spread and translocation. During an initial site inspection, declared weeds will be identified and flagged and recorded in site register. Declared weeds will be treated to prevent spread using methods consistent with advice from the Department of Agriculture, Fisheries and Forestry (DAFF), Rockhampton Regional Council (RRC) and Central Highlands Regional Council (CHRC).

To reduce the likelihood of introduced animals becoming more prevalent within and adjacent to the construction footprints the following mitigation measures would be implemented:

- All rubbish and other refuse that may potentially attract introduced animals (food scraps) should be appropriately disposed of in sturdy waste disposal receptacles that are frequently emptied
- No domestic animals should be allowed on the construction site
- Manage pest species in coordination with adjacent landholders and catchment management groups.

A Feral Animal Control Program will be developed and implemented for the Project in collaboration with local council, community groups and landholders. Specific measures may include culling, baiting and trapping of pigs, foxes, wild dogs and feral cats.

During operation, the Project is likely to result in an increase in the abundance of predators within the Eden Bann Weir and Rookwood Weir impoundments, potentially resulting in an increase in predation of the turtles and nests. The creation of impounded pool habitat is expected to increase the availability of suitable habitat for large predatory fish (such as long-finned eels and golden perch) and the estuarine crocodile. An increase in abundance of these species within the impoundments, either through natural immigration or stocking for recreational purposes (fish species only), may result in a direct increase in the predation of turtles (Tucker 2000; Hamann et al. 2007; Limpus et al. 2011a).

The increase in permanent water resource availability associated with the weir impoundments may increase the abundance of terrestrial predators such as feral pigs, water rats and goannas, thereby further increasing predation pressure on nesting habitat remaining within the Project footprints. Impacts resulting from increased predation as they apply to specific species are addressed in Chapter 10 Listed threatened species and ecological communities.

Identification and management of weed and pest species will be undertaken in accordance with the plans and strategies set out by Biosecurity Queensland (Department of Agricultural, Fisheries and Forestry). As such, identification and management of declared pests will be undertaken in accordance with the *Land Protection (Pest and Stock Route Management) Act 2002* (Qld)*, Plant Protection Act 1989* (Qld) and the *Public Health Act 2005* (Qld). Likewise, management of declared local pests will be undertaken in accordance with relevant local government strategies and plans, including the Rockhampton Regional Council Pest Management Plan 2012-2016 and the Central Highlands Regional Council Draft Area Pest Management Plan 2014-16. A Weed Management Plan would be prepared for the operations phase that outlines measures to prevent the introduction of new weed and/or species into the area and minimise the spread of declared weeds within the Project areas.

8.10 Socio-economics

The most significant benefit of the Project will be the increase in availability and reliability of water. The Project will facilitate and enable development in the region, thus benefiting the regional, state and national economies.

It is expected that development of the Project will be staged in response to demand triggers. In total, a workforce of approximately 150 persons is anticipated across the approximate two year construction period at each weir with the majority of these employees likely to be sourced from the regional study area. Project will impact positively on regional employment and will provide employment opportunities to local communities (Appendix R).

It is also likely there will be a demand for local businesses to service some requirements of the construction and operations activities as well as needs of the temporary workforce (e.g. local food suppliers, petrol stations and hardware stores).

Impacts within the local study area may include loss of land currently used for grazing, agricultural infrastructure (such as pumps and fencing), severance of and/or loss of access to land, cattle bogging and changes to water allocations. Improved flood immunity of several river crossings will facilitate the movement of people, machinery and equipment and stock in periods of flooding and maintain access to services and facilities such as schools and health facilities, social and recreational clubs and networks. Further impoundment of water will benefit the taking of water for stock and domestic use by riparian landholders in the local study area (in accordance with the *Water Act 2000* (Qld)), through provision of a more constant and reliable supply.

The resident near the Eden Bann Weir site and residents along the construction access roads may experience nuisances and disruptions as a result of increased noise, dust and access constraints. Construction is planned to be intermittent, occurring primarily during the dry season and over a relatively short term. The number of additional heavy vehicles using access roads would be approximately 32 heavy vehicles per day. This is a relatively large increase compared to the existing low levels of vehicles using these roads. However, the number of residences in close proximity to these roads is low and therefore while it is likely that some nuisance impact will occur, the consequence is considered minor.

During construction, traffic will mainly be related to transporting the workforce to and from the site, and supplying cement and fly ash and other construction material. Increased traffic volumes may increase the risk of accidents involving single vehicles, other road users or livestock. Increased traffic volumes and loads may also damage local roads.

Consultation with landholders and local community members has revealed widespread aspirations for benefits from the proposed construction of Rookwood Weir to flow to the local community. These include aspirations for additional water entitlements and expectations that river crossings will be improved. While these aspirations in themselves do not constitute a significant positive or negative impact, the way in which they are addressed by the Project will potentially affect the local community's perception about the Project and its proponents.

The following measures have been implemented and/or are proposed to mitigate and manage social impacts:

- A Stakeholder Engagement Plan/Strategy has been prepared for the Project. The strategy is ongoing and includes a range of communication techniques such as a Project website, a 1800 number, dedicated email address, and Project updates and information sessions at key milestones

- A Near Neighbour Policy and a Grievance Management Process (or similar) will be developed and implemented to monitor and record complaints to ensure any stakeholder or community concerns are addressed appropriately and in a timely manner
- A Project Land Acquisition Strategy has been facilitated through the appointment of dedicated land liaison officers for key periods during Project planning. Landholders potentially directly impacted by the Project, have had the opportunity to discuss how their properties and businesses operate (inclusive of existing and future water entitlements) for consideration within the EIS
- Issues relating to the loss of land and/or loss of access to land along with impacts on productivity will be negotiated and agreed on a one-on-one basis with directly impacted landholders. Consideration will be given to the use of the land, relocation of temporary infrastructure as far as is practicable and reinstatement and rehabilitation. Further advance and ongoing communication with regard to the Project will facilitate that individuals are able to plan for their own operational needs
- A Land Access Protocol has been developed and implemented. This included:
  - Seven days advance notice of access requirements
  - Liaison with landholders regarding their land activities at the time of the access (for example mustering, sensitive stock)
  - All Project personnel to be identifiable through letters of introduction and clear explanation to landholders of activities proposed.
- A Weed Management Plan has been developed and implementation will continue through the construction and operation phase
- A recruitment plan will be developed including the provision of appropriate contractual arrangements with construction contractors and the use of local recruiters, that will facilitate opportunities for local employment
- A Project procurement plan will be developed that considers the engagement of local businesses to provide services to the Project. In line with the Australian Industry Participation Policy, the Project procurement plan will consider advertising work packages on the Industry Capability Network (ICN) Gateway. Services, equipment and material required for the Project are considered typical for construction projects in the region and therefore are likely to be locally available
- Pavement impact assessments will be undertaken as applicable (for example Third Street and Atkinson Road, amongst others) along with road traffic safety audits and dilapidation surveys to inform discussion and negotiation with the Department of Transport and Main Roads (DTMR) and RRC with regard to upgrades and maintenance of state controlled and local roads in the local and regional Project areas. As a minimum, road condition and access will be maintained at pre-construction conditions
- A Traffic Management Plan will be implemented and will include:
  - Enforced speed limits and improved signage
  - Increased signage and the use of traffic controllers (as appropriate)
  - Augmentation of the Capricorn Highway/Third Street intersection at Gogango
  - Time restrictions for traffic operations, with limited night time activities (as far as is practicable)

  - Road maintenance, reinstatement and rehabilitation
  - Notification and updates to stakeholders in the local study area regarding traffic movements, particularly during commissioning and decommissioning.
- Management of nuisance-type impacts will include:
  - Time restrictions on activities
  - Maintaining and operating construction equipment, plant and machinery in accordance with manufacturer's guidelines
  - Dust suppression through water application
  - Notification to residents and stakeholders (as applicable) of noise generating activities.
- Emergency services will be consulted in the development of the site emergency management plan.

8.11 Decommissioning

Impacts described above relate to the construction and operation of the Project however, potential short and long term environmental impacts may also arise as a result of weir decommissioning. Potential environmental impacts to be addressed during decommissioning and rehabilitation will include:

- Restoration and stabilisation of river banks at the weir sites and land upstream of the sites that would no longer be inundated
- Treatment/removal of sediments that present a risk to downstream water quality and ecosystem health
- Identification of any potential contamination that may have occurred during the operational phase and development of appropriate remediation strategies.

Development of a weed and pest management plan including a monitoring and inspection programme will be implemented during and for a period following decommissioning and rehabilitation.