Chapter 5
Key ecological and geomorphological values

The purpose of this chapter is to:

- identify critical aquatic ecosystems and areas of high conservation value that are dependent on surface and connected subartesian water
- identify and, where possible, prioritise the key ecological and geomorphological values of the ecosystems and areas in relation to water
- identify specific values dependent on freshwater flows.

5.1 Geomorphological values

Geomorphological values can be categorised as follows:

- landscape features that provide ecological value
- geomorphological processes that create or sustain ecological values.

Landscape features that support ecological values include the bed topography (deepwater pools, riffles and the like), transient sediment deposits (point and medial bars), off-river flow paths and storages (floodrunners and wetlands), and the nature of the cross-section profile that controls the depth of flow for a given discharge.

Geomorphic processes that maintain ecological values are largely flow-related in the context of the plan timeframe. These include:

- lower flood flows above the sediment transport threshold for maintaining small-scale habitats (e.g., riffles)
- low to moderate flood flows for the O'Connell River to maintain long-term flux of sediment to Repulse Bay (nominally the two- to five-year ARI flood band as previously discussed)
- moderate to high flows (including floodplain flows) for resetting larger scale habitats and bed scour, flushing of colonising vegetation from medial bars, floodplain recharge and episodic delivery of sediment to Repulse Bay
- 'catastrophic' flows for estuary flushing (O'Connell River)
- large-scale resetting of landforms.

5.2 Threatened species, communities and ecosystems

5.2.1 Fish

None of the fish species currently known to occur in the plan area are threatened.

5.2.2 Threatened regional ecosystems

Based on the latest RE mapping, there are 13 of concern and three endangered flow-dependent regional ecosystems occurring in the plan area. The presence of a multitude of at-risk regional ecosystems highlights the extent of existing disturbance to riparian and alluvial ecosystems within the study catchment and the wider Central Queensland Coast Bioregion. All of these threatened regional ecosystems have high conservation value associated with their reduced aerial extent in the post-development landscape and their habitat value for dependent wildlife, and are protected to varying levels under the Queensland *Vegetation Management Act 1999*. Table 5-1 lists these

regional ecosystems and indicates their key flow and water resource dependencies and their occurrence within the plan area.

A large proportion of these regional ecosystems occur in the lower parts of the catchments, particularly in association with the extensive coastal alluvial plain between the Proserpine River and O'Connell River. The existence and extent of this alluvial plain is an example of a geomorphological value (see above) dependent on overbank flows. In general, the flow and water resource dependencies of the identified threatened regional ecosystems are related to one or more of a relatively constant set of biophysical processes, which include:

- landform genesis and maintenance (i.e., the large number of RE dependent on alluvial landforms and soils created by overbank flows)
- soil nutrient replenishment associated with wet-season flow inundation and alluvial deposition
- germination and recruitment opportunities associated with wet season flows and inundation, which create exposed freshly deposited soils, reduced cover of competing plants, seed transportation and deposition, and germination triggers associated with water logging and ponding
- soil wetting and shallow aquifer replenishment to sustain required moisture availability through the growing season
- soil and groundwater salinity balance established by the frequency and volume of wet-season freshwater flows from upstream, and tidal inundation and groundwater intrusion from downstream estuarine systems.

Table 5-1 At-risk flow-dependent regional ecosystems occurring in the Proserpine and O'Connell river catchment

Regional ecosystem	Status (VMA)	Description	Key flow dependencies	Occurrence
8.3.1 & 8.3.1a Scattered occurrence within PR-3, PR-4, PR-5 (lower reaches only), LE-1, LE-2, LE-3 (upstream reach only), AND-1, AND-2, AND-3, OC-1, OC-2, OC-3.	*of concern*	*Semi-deciduous notophyll or mesophyll vine forest in the vicinity of or fringing watercourses on alluvial plains*.	Within bank seasonal flows deliver moisture to this ecosystem, which sustains the vegetation community. There is also an association with perennial base flows and pools that are supported by fractured rock aquifers in upper catchment areas, and local Tertiary terrace aquifers in mid reaches.	Occurs in conjunction with other fringing RE types on the Proserpine River above and below the Peter Faust Dam and along larger tributaries; and scattered pockets and reaches along much of the mid to upper O'Connell and Andromache rivers and larger tributaries.

Regional ecosystem	Status (VMA)	Description	Key flow dependencies	Occurrence
8.3.6 & 8.3.6a Scattered throughout the plan area.	*of concern*	Eucalyptus tereticornis, Corymbia intermedia *and* Lophostemon suaveolens *(or* C. tessellaris-*dominant) open forest on alluvial levees and lower terraces.*	Within-bank seasonal flows required to deliver moisture to this ecosystem to sustain the vegetation community. Also dependent on overbank flows that form and replenish alluvial levees. Also usually some reliance on local shallow alluvial aquifers.	Occurs throughout the plan area on mid to upper reaches as isolated patches or part of a complex with RE 8.3.1, 8.3.3 and 8.3.5.
8.3.5 Scattered throughout the plan area.	*of concern*	Corymbia clarksoniana, Lophostemon suaveolens, Eucalyptus platyphylla *woodland; or* E. platyphylla *woodland on alluvial plains.*	Dependent on overbank flows that replenish alluvial soils and nutrients and create germination and establishment opportunities for juvenile canopy trees.	Occurs throughout the plan area on mid to upper reaches as isolated patches or part of a complex with RE 8.3.1, 8.3.3 and 8.3.6.
8.3.13a PR-6 LE-3	*of concern*	*Mixed Melaleuca woodlands on marine plains or alluvial plains.*	The extent of these areas is partially determined by the hydrological and soil salinity balance established by the frequency and volume of wet season freshwater flows and associated overbank alluvial deposition from upstream, and tidal inundation and groundwater intrusion from downstream estuarine systems. The spatial occurrence of these communities is also dependent on localised drainage and ponding patterns.	Occurs on the coastal plain adjacent to the lower Proserpine and on the Goorganga Plain.
8.3.13c PR-6 LE-3	*of concern*	Eucalyptus tereticornis *and/or* Corymbia tessellaris *woodland with a secondary tree layer of* Melaleuca *spp. on marine and alluvial plains adjacent to estuarine areas.*	Dependent on overbank flows that replenish alluvial soils. The extent of these areas is also determined by the balance established by the frequency and volume of wet season freshwater flows from upstream, and tidal inundation and groundwater intrusion from downstream estuary channels.	Occurs on the coastal plain adjacent to the lower Proserpine and on the Goorganga Plain.

Regional ecosystem	Status (VMA)	Description	Key flow dependencies	Occurrence
8.3.13d OC-4	*of concern*	Eucalyptus tereticornis *and or* C. tessellaris *woodland. Occurs on marine and alluvial plains adjacent to estuarine areas.*	Dependent on overbank flows that replenish alluvial soils. The extent of these areas is also determined by the balance established by the frequency and volume of wet-season freshwater flows from upstream, and tidal inundation and groundwater intrusion from downstream estuary channels.	Occurs on the coastal plain adjacent to the lower O'Connell.
8.3.2 PR-6 LE-3, LE-2 OC-4	*endangered*	Melaleuca viridflora *woodland often with emergent eucalypts and grassy or herbaceous ground layer, on seasonally inundated alluvial plains with impeded drainage.*	Dependent on direct inundation from seasonal rainfall, and/or overbank flows that replenish alluvial soils and nutrients and create germination and establishment opportunities for juvenile canopy trees.	Small pockets adjacent to the lower and mid Proserpine and Lethe Brook, and the lower O'Connell.
8.3.11 PR-6	*endangered*	Melaleuca *sp.* aff. viridflora *closed forest to woodland in broad drainage areas (wetlands).*	Dependent on direct inundation from seasonal rainfall, and/or overbank flows that replenish alluvial soils and nutrients and create germination and establishment opportunities for juvenile canopy trees. The spatial occurrence of these communities is also dependent on localised drainage patterns.	Patchy occurrence adjacent to the lower Proserpine.
8.3.13b PR-6 LE-3 OC-4	*of concern*	Melaleuca dealbata *woodland with grassy understorey on swampy marine or alluvial plain (wetland) adjacent to mangroves.*	The extent of these areas is determined by the hydrological and salinity balance established by the frequency and volume of wet-season freshwater flows from upstream, and tidal inundation and groundwater intrusion from downstream estuary channels.	Occurs on the coastal plain adjacent to the lower Proserpine and on the Goorganga Plain.
8.3.12 LE-2, LE-3 TH-1	*endangered*	*Grassland on alluvial and old marine plains.*	Dependent on direct inundation from seasonal rainfall, and/or overbank flows that replenish alluvial soils and nutrients.	Patchy occurrence on the Goorganga Plain to the east and west of the Bruce Highway.

Regional ecosystem	Status (VMA)	Description	Key flow dependencies	Occurrence
8.1.2 PR-6 OC-4	*of concern*	Samphire open forbland to isolated clumps of forbs on saltpans and plains adjacent to mangroves. Estuarine wetland.	The extent of these areas is determined by the balance established by the frequency and volume of wet season freshwater flows from upstream, and tidal inundation from downstream estuarine areas.	Small pockets adjacent to the lower Proserpine and lower O'Connell.
8.1.3 PR-6 LE-3 TH-1	*of concern*	Sporobolus virginicus *grasslands on marine sediments. Estuarine wetland.*	The extent of these areas is determined by the balance between the frequency and volume of wet-season freshwater flows from upstream, and inundation from the estuary.	Fairly extensive areas on the Goorganga Plain.
8.1.4 PR-6 LE-3	*of concern*	Paspalum *spp. and* Fimbristylis ferruginea *sedgeland or grassland (estuarine wetland). Includes areas of deep open water with clumps of* Schoenoplectus littoralis ± Eleocharis dulcis.	The extent of these areas is determined by the soil salinity balance established by the frequency and volume of wet season freshwater flows from upstream, and tidal inundation from the estuary.	Small pockets adjacent to the Proserpine River and on the lower Goorganga and Lethe Brook system.
8.1.5 PR-6 LE-3	*of concern*	Melaleuca *spp. and/or* Eucalyptus tereticornis *and/or* Corymbia tessellaris *woodland to open forest (estuarine wetland) with a ground stratum of salt-tolerant grasses and sedges, usually in a narrow zone.*	The extent of these areas is determined by the hydrological and soil salinity balance established by the frequency and volume of wet season freshwater flows from upstream, and tidal inundation and groundwater intrusion from the estuary.	Small pockets adjacent to the lower Proserpine and lower Lethe Brook system.

5.2.3 Threatened fauna

Table 5-2 lists the rare or threatened fauna likely to be encountered in flow-dependent ecosystems within the Proserpine and O'Connell catchments. This list is based on records held in the EPA's Wildnet database and is therefore constrained by the amount of fauna survey activity that has been conducted in the plan area. A total of 29 rare or threatened fauna species have been recorded from the Proserpine and O'Connell catchments including immediately adjacent areas. Seventeen of these species have a significant association with flow dependent ecosystems, and include residential species of riparian forests or wetlands, wide-ranging species that use riparian vegetation communities as movement corridors and marine species that use flow dependent coastal environments. An additional five species may also be encountered in flow dependent ecosystems within the Proserpine and O'Connell catchments. However, these ecosystems are not regarded as critical habitat for the species.

Table 5-2 Predicted occurrence of rare or threatened fauna within flow dependent ecosystems in the plan area.

Rare or threatened fauna		**NCA status** *	**EPBC status** *	**Source of record** ◄	**Habitat requirements**	**Key aspects of flow regime**
Species with a significant association with flow-dependent ecosystems						
Birds						
Accipiter novaehollandiae	Grey goshawk	R		w, e	Healthy fringing and frontage ecosystems	Base flow periodicity and overbank flow frequency and extent
Lophoictinia isura	Square-tailed kite	R		w	Healthy fringing and frontage ecosystems	Base flow periodicity and overbank flow frequency and extent
Nettapus coromandelianus	Cotton pygmy-goose	R		w	Deepwater wetlands	Aquifer discharge to refugial pools; lower-catchment flow to coastal wetlands
Tadorna radjah	Radjah shelduck	R		w	Fresh and saline coastal wetlands	Lower catchment flow to coastal wetlands
Esacus neglectus	Beach stone-curlew	V		w	Beach and inter-tidal habitats	River basin sediment and nutrient-export characteristics
Ephippiorhynchus asiaticus	Black-necked stork	R		w	Fresh and saline wetlands	Lower catchment flow to coastal wetlands; aquifer discharge to refugial pools
Geophaps scripta scripta	Squatter pigeon (southern subspecies)	V	V	w,e	Permanent freshwater pools	Aquifer discharge to refugial pools; base-flow periodicity
Haematopus fuliginosus	Sooty oystercatcher	R		w	Beach and inter-tidal habitats	River basin sediment and nutrient-export characteristics
Sterna albifrons	Little tern	E		w	Beach and inter-tidal habitats	River basin sediment and nutrient-export characteristics
Rallus pectoralis	Lewin's rail	R		w	Fresh and saline wetlands	Lower catchment flow to coastal wetlands; aquifer discharge to refugial pools
Rostratula australis	Painted snipe	V	V	e	Fresh and saline wetlands	Lower catchment flow to coastal wetlands; aquifer discharge to refugial pools
Numenius madagascariensis	Eastern curlew	R		w	Beach and inter-tidal habitats	River basin sediment and nutrient-export characteristics

Rare or threatened fauna		NCA status *	EPBC status *	Source of record ▲	Habitat requirements	Key aspects of flow regime
Mammals						
Dugong dugon	Dugong	V		w	Seagrass beds	River basin sediment and nutrient-export characteristics
Xeromys myoides	False water-rat	V	V	w,e	Mangrove and saline wetlands	River basin sediment and nutrient-export characteristics; lower-catchment flow to estuarine wetlands
Reptiles						
Caretta caretta	Loggerhead turtle	E	E	w,e	Near-shore marine habitats	River basin sediment and nutrient-export characteristics
Chelonia mydas	Green turtle	V	V	w,e	Near-shore marine habitats	River basin sediment and nutrient-export characteristics
Natator depressus	Flatback turtle	V	V	w,e	Near-shore marine habitats	River basin sediment and nutrient-export characteristics
Crocodylus porosus	Estuarine crocodile	V		w	Coastal and estuarine wetlands	Lower catchment flow to coastal wetlands; river-basin sediment and nutrient-export characteristics
Species that may be encountered in flow-dependent ecosystems but not critical habitat						
Birds						
Calyptorhynchus lathami	Glossy black-cockatoo	V		w	Fringing woodland and beach ridge woodland containing she oak	Base flow periodicity; river basin sediment and nutrient-export characteristics
Ninox rufa queenslandica	Rufous owl	V		w	Healthy fringing ecosystems	Base flow periodicity; aquifer discharge to refugial pools;
Mammals						
Kerivoula papuensis	Golden-tipped bat	R		w	Healthy fringing ecosystems	Base flow periodicity; aquifer discharge to refugial pools;
Taphozous australis	Coastal sheathtail bat	V		w	Healthy fringing ecosystems	Base flow periodicity; aquifer discharge to refugial pools;
Reptiles						
Acanthophis antarcticus	Common death adder	R		w	Healthy fringing ecosystems	Base flow periodicity; aquifer discharge to refugial pools;

* E endangered; V vulnerable; R rare

▲ e EPBC website interactive search tool; w WildNet database

5.2.3.1 Wetland birds

The extensive wetland systems of the Goorganga Plain (discussed below) and adjoining areas provide a diversity of wetland habitats from marine and estuarine areas through brackish wetlands to freshwater areas, west of the Bruce Highway. All of the rare or threatened wetland birds included in Table 5-2 occur in significant numbers within this coastal habitat complex (i.e., cotton pygmy-goose, radjah shelduck, beach stone-curlew, black-necked stork, sooty oystercatcher, Lewin's rail, eastern curlew). Large artificial freshwater wetland systems occur within this area and provide valuable refuge habitat for many species. To a large extent these artificial features probably compensate for natural freshwater wetland areas that have been lost from the area during agricultural development. Most of these threatened wetland species would also utilise the in-stream wetland habitats of the main streams of the plan area, especially permanent waterholes.

The flow and water resource dependencies of the coastal wetland complexes within the plan area are detailed below.

5.2.3.2 Waders and shorebirds

Extensive shorebird roost sites and feeding areas occur between the mouths of the Proserpine and O'Connell rivers (Driscoll 1995). These species are accommodated by the inter-tidal areas of Repulse Bay. The exact contribution of sediment and nutrient deposition from the O'Connell and Proserpine rivers to sustain these habitats is not known, but it is likely that both systems play a significant role. Indeed, reduced discharge from the Proserpine River post-dam appears to have led to an increase in the area of tidal flats at the mouth of the Proserpine River due to a lack of flushing. The wider significance of the post-dam flow regime on the extent or productivity of inter-tidal flats elsewhere is not known. Many of the shorebirds present in the area during warmer months include migratory wader species that are protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

5.2.3.3 Marine fauna

Dugongs (*Dugong dugon*) occur in Repulse Bay and are occasionally sighted at the mouth of the Proserpine River. Repulse Bay supports significant seagrass beds that are utilised by the species, and a protection area for the species occurs adjacent to Conway National Park, indicating that key habitat for the species occurs in that area.

The estuarine areas of the plan area and the wider Repulse Bay area support the largest population of estuarine crocodile (*Crocodylus porosus*) on the east coast, south of Cape York.

The seagrass beds within Repulse Bay provide significant feeding areas for the green turtle (*Chelonia mydas*). The extent to which this species and other marine turtles utilise beach areas within the plan area for nesting is not currently known.

5.2.4 Threatened flora

The Wildnet database has records of six rare or threatened flora within or immediately adjacent to the Proserpine and O'Connell catchments. This contrasts with a much larger list produced by searches of the database for search areas that include adjoining upland areas associated with the Conway and Clarke Ranges. While the smaller number of species for the plan area may to some extent reflect a lack of detailed survey effort for flora, it probably accurately indicates a paucity of rare or threatened flora species away from the upland rainforest habitats. Indeed, of the six species identified for the plan area, only one species, *Eucalyptus raveretiana* (black ironbox) is associated with riparian areas. This species is common in the O'Connell and Andromache catchments, and also

occurs along the Thompson and Kelsey Creek and Lethe Brook systems. Stands of *E. raveretiana* on alluvial plains were described by a local landholder as occurring in the mid O'Connell and Horse Creek area and represent significant occurrences of this species, which is more typically confined to stream banks. The species was not encountered at sites visited along the Proserpine River but it is likely that the species does occur along the Proserpine River, although significantly reduced in extent due to the deterioration of the riparian vegetation corridor.

The seasonally inundated freshwater wetlands of the Goorganga Plain also provide potential habitat for the rare *Aponogeton queenslandicus*, a seasonally emergent aquatic plant that typically occurs in shallow temporary waters with a clay bottom and in full sun. There are currently no records of the species from the Mackay–Whitsunday area.

5.3 High-value areas

5.3.1 Goorganga Plain wetland

The Goorganga Plain wetland is part of a coastal floodplain with low beach ridges, coastal foreshores, inter-tidal areas and associated shallow marine waters and extends from Rocky Point near the mouth of the Proserpine River in the north to the mouth of the O'Connell River in the south. Thirteen types of wetland habitat are recognised within the aggregation: permanent shallow marine waters; permanent waters of estuaries; inter-tidal mud, sand and salt flats; inter-tidal salt marshes; inter-tidal forested wetlands (mangroves); brackish to saline marshes with narrow connections to the sea; freshwater lagoons and marshes in the coastal zone; permanent rivers and streams; riverine floodplains; seasonal freshwater lakes; seasonal freshwater ponds on inorganic soils; and seasonally flooded forests (Blackman et al. 1999).

The Goorganga Plain is the largest floodplain in the Mackay Coast bioregion and is notable for its hydrological integrity, extensive areas of seasonally inundated grassland, the continuity and quality of habitats from marine to freshwater, diversity of biota and fishery nursery values (Blackman et al. 1999; Hyland 2002). The national importance of the site's wetland values are reflected by its listing in the *Directory of Important Wetlands in Australia* (DIWA, DEH 2005). Wetlands listed in DIWA meet one to six criteria of importance:

1. The wetland is a good example of a wetland type occurring within a bio-geographic region of Australia.
2. The wetland plays an important ecological or hydrological role in the natural functioning of a major wetland system or complex.
3. The wetland is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.
4. The wetland supports 1 per cent or more of the national population of any native plant or animal taxa.
5. The wetland supports native plant or animal taxa or communities that are considered endangered or vulnerable at the national level.
6. The wetland is of outstanding historical or cultural significance.

The Goorganga Plain wetland meets the first five of these six criteria (Blackman et al. 1999). Other notable values of this wetland complex include: a rich mangrove assemblage (17+ species), reflecting the freshwater influences on the site (Duke 1985); a diverse submerged and emergent macrophyte community; more than 132 recorded bird species, including significant populations and a high diversity of international migratory waders; fauna species of conservation interest, (including several listed under the *Queensland Nature Conservation Act 1992* or the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999*) representative examples of a range of endangered and of-concern regional ecosystems; and significant areas of nursery and adult

habitat for commercially and recreationally important fish species, particularly barramundi.

The key flow and water-resource dependencies of this diverse and high-value wetland aggregation are representative of the broader plan area and include:

- peak flow events to maintain channel morphology and depth and to scour and reset macrophyte communities
- maintenance of shallow aquifer water levels through the dry season at levels that sustain perennial habitats provided by groundwater windows intersected by stream channels
- overbank flows to deposit and replenish alluvial soils, recharge shallow aquifers responsible for supporting vegetation communities, fill offstream floodplain wetlands and provide hydrological connectivity for aquatic biota movement between main channels, offstream water bodies and downstream estuarine areas
- flows of sufficient frequency, duration and volume to maintain soil, groundwater and wetland or estuary salinity regimes in habitats adjoining or within areas of tidal influence
- flow seasonality that includes no flow periods in the dry season to allow for seasonal water level draw down and increased tidal intrusion in near coastal areas important for resetting macrophyte communities and water salinity regimes
- tidal inflows required to connect coastal nursery swamps and reset salinity regimes
- large wet season flow events responsible for transporting coastline and intertidal-flat forming sediment to the coastal zone and associated nutrients to dependent ecosystems including mangroves, seagrass, and benthic environments.

There are insufficient data to fully assess the implications of existing water resource development on the maintenance of these processes. Some areas of potential risk that have been identified include:

- the reduced frequency of peak overbank flow events and altered seasonal-flow regime in the lower Proserpine River post-construction of the Peter Faust Dam
- surface and groundwater extraction in the Lethe Brook and Goorganga Creek catchments
- regulated flows and tailwater inputs within the Kelsey Creek and Lethe Brook subcatchments
- water harvesting, dam and bund wall construction within the Goorganga and Thompson creek subcatchments.

There are also a number of significant non flow-related condition impacts affecting this wetland, including vegetation clearing, soil and bank erosion, grazing pressure, altered fire regimes and weeds (see Chapter 4).

5.3.2 Intrinsic significance of flow dependent ecosystems

A growing body of research and literature over recent years points to the intrinsic significance of riparian ecosystems as a key component of habitat landscapes in a variety of climatic settings. This is largely attributed to the greater structural complexity of riparian vegetation, and the tendency for the productivity of these ecosystems to persist by virtue of their proximity to moisture. In areas such as the Proserpine and O'Connell catchments, where there is a pronounced variation in seasonal conditions, the significance of riparian ecosystems is likely to be heightened. As a result, all riparian ecosystems within the plan area that are at least relatively intact, represent significant habitat areas for native flora and fauna and provide critical functions, including:

- refugial areas for obligate riparian species (i.e., species that do not occur in non-riparian habitats)

- key areas for nomadic and transitory species for which riparian areas provide a significant component of an overall suite of habitats utilised
- refugial areas for non-riparian species that take advantage of the persistence of productivity of riparian areas during droughts when resources fail in non-riparian habitats.

Thus, while particular wetlands or riparian woodland locations can be identified as significant locations for certain species or groups of species (e.g., waterbird breeding sites, roosts for internationally significant wader birds), the critical significance of flow-dependent ecosystems for overall native flora and fauna communities is recognised.

5.3.3 Aquatic refugia and other high-conservation-value stream reaches

Notwithstanding the discussion above, a number of stream reaches and riparian locations with relatively higher conservation value, including greater significance for riparian flora and fauna or functional roles as seasonal refugia for aquatic biota or broader faunal communities, were observed within the plan area.

In a highly seasonal environment such as the plan area, any perennial pools or reaches along the study streams are likely to provide important seasonal refugia for both aquatic biota and riparian fauna. Perennial aquatic habitats created or sustained within the highly regulated systems of the plan area (i.e., lower Proserpine, PR-3 to PR-5, and Kelsey Creek) also have some or all of these values.

In some instances sites that have value as aquatic refugia may be relatively modified in terms of riparian vegetation condition (i.e., some pumping pools within the mid reaches of the O'Connell, OC-3) and their value is due primarily to their perennial nature, usually associated with their depth. However, sites with the highest conservation value include those that combine perennial aquatic habitats and aquatic refugia with higher integrity riparian vegetation, particularly that which is more diverse, structurally complex or representative of threatened vegetation types (e.g., rainforest and threatened alluvial levee regional ecosystems). For the broader faunal community, which has only a seasonal or non-obligate dependence on riparian and other flow-dependent ecosystems, ecological value is greatest where adjoining terrestrial ecosystems are contiguous with the stream reach.

Within the scope of this study it was not possible to comprehensively evaluate all stream reaches for their conservation values and such assessment is recommended as an appropriate focus for future research (Chapter 8). However, a non-exhaustive and exemplary list of riparian sites and stream reaches identified to have higher conservation values opportunistically observed during the field inspections and plan area fly-over is presented in Table 5-.

Table 5-3 Non-exhaustive list of riparian sites and stream reaches assessed to have higher conservation values[5]

Reach or site location	Nature of values	Flow and water-resource dependencies
Andromache River catchment		
Mares Nest Creek (MN-1)	Groundwater-fed perennial pool features, aquatic refugia, rainforest elements in riparian community and diverse macrophyte assemblage.	Groundwater recharge and discharge characteristics of upper catchment maintained.

[5] An indication of the relative extent of these reaches and site locations is provided in the maps in Appendix 7 of this report.

Reach or site location	Nature of values	Flow and water-resource dependencies
Upper reaches of the Andromache River (AND-2)	Groundwater-fed perennial pool features aquatic refugia, rainforest elements in riparian community and diverse macrophyte assemblage.	Groundwater recharge and discharge characteristics of upper catchment maintained. Surface water extraction does not 'dry' aquatic refugia or expose them to water-quality 'crashes' (elevated temperature, low dissolved oxygen, eutrophication).
Confluence of Mares Nest Creek and Andromache River (MN-1, AND-2)	Deepwater perennial pool refugia, high macrophyte diversity, intact riparian and ecotone vegetation and contiguous woodland.	As above
Main road crossing of upper Andromache River (AND-2)	Deepwater perennial pool aquatic refugia and catadromous fish habitat backed by rainforest-vegetated terraces and contiguous ecotonal and woodland vegetation.	As above
Confluence of Fish Creek and Andromache River (F-1, AND-2)	Deepwater perennial pool refugia, good fish habitat, intact riparian and ecotone vegetation and contiguous woodland.	As above
Uppermost reaches of Andromache River basin and intact tributaries (AND-1, AND-2, MN-1, F-1)	Uncleared catchment, intact riparian vegetation, integrity of hydrology and seasonal aquatic habitats.	Groundwater recharge and discharge, runoff and stream flow characteristics of upper catchment maintained.
O'Connell River Catchment		
Lower Boundary Creek (B-2)	Deepwater perennial pool refugia backed by reach sections with intact riparian and ecotone vegetation.	Groundwater recharge and discharge characteristics and associated stream flow of upper catchment maintained. Surface water extraction does not 'dry' aquatic refugia or expose them to water-quality 'crashes'.
Lower Horse Creek and its confluence with the mid O'Connell River (H-2, OC-2)	Springs in the alluvial terrace support (or supported) pockets of rainforest or swamp forest vegetation and provide perennial flows to sections of these streams. Deepwater pools provide aquatic refugia and high value fish habitat.	As above with additional management consideration of groundwater extraction from shallow aquifers adjoining the stream and their impact on stream flow, pool persistence and water quality.
Upper to mid reaches of the O'Connell River (lower OC-1, OC-2, OC-3)	Deepwater perennial pool refugia with high fish habitat values including for key recreational species (barramundi, mangrove jack) backed by reach sections with intact riparian and ecotone vegetation, including isolated examples of contiguous woodland.	Surface water extraction does not 'dry' aquatic refugia or expose them to water-quality 'crashes'.
Confluence of O'Connell River and Gibson Creek (OC-3, GB-1)	Deepwater perennial pool refugia backed by relatively intact riparian vegetation.	As above
Uppermost Reaches of intact tributary streams (H-1, B-1)	Uncleared catchment, intact riparian vegetation, integrity of hydrology and seasonal aquatic	Groundwater recharge and discharge, run off and stream flow characteristics of upper catchment

Reach or site location	Nature of values	Flow and water-resource dependencies
	habitats	maintained.
Proserpine River Catchment		
Upper reaches of Goorganga and Thompson creeks (G-1, TH-1)	Isolated perennial pools, deepwater fish habitats and contiguous riparian, ecotonal and woodland vegetation providing habitat corridor connectivity between the coast and coastal ranges.	Water levels in shallow aquifers responsible for perennial 'groundwater window' pool features maintained. Peak flows sustain deep channel morphology. Surface water extraction does not 'dry' aquatic refugia or expose them to water quality 'crashes'.
Stream reaches within the Goorganga Plain wetlands (LE-2, LE-3, G-1, G-2, TH-2)	Perennial aquatic habitats, fish, waterfowl and crocodile habitat, barramundi nursery.	As above, with additional consideration for maintenance of flow connectivity (freshwater and tidal) to offstream water bodies and downstream estuarine reaches.
Lower Myrtle Creek and tributary streams (lower MY-1, B-1)	Perennial aquatic habitats, fish habitat and a relatively contiguous corridor of riparian rainforest with isolated remnants of ecotonal vegetation and corridor linkages to woodland remnants and hills.	Wet season peak flows scour channel, removing macrophyte growth, and maintain deepwater habitats. Surface and adjoining groundwater extraction does not 'dry' aquatic refugia or expose them to water quality 'crashes'.
Proserpine River downstream of the Myrtle Creek confluence (PR-5)	Perennial aquatic refugia, deepwater fish and crocodile habitat, complex riparian rainforest vegetation with isolated examples of intact ecotonal vegetation.	Peak flows scour channel and maintain deepwater and flood runner habitats. Base flow and surface water extraction patterns prevent water quality crashes with particular recognition of the eutrophication risk presented by elevated nutrient loading.
Regulated reaches of the Proserpine River (PR-3, PR-4, PR-5)	Perennial deepwater aquatic refugia, fish and riparian fauna habitat, sections of relatively intact riparian vegetation.	Peak flows scour channel and maintain deepwater habitats. Base flow, surface and groundwater extraction patterns prevent water-quality crashes.
Confluence of Happy Valley Creek and Proserpine River (H-1, PR-4)	Deepwater perennial pool refugia and high value fish habitat backed by relatively intact riparian and ecotonal vegetation and contiguous woodland.	As above
Uppermost Reaches of Proserpine River Basin (PR-1, PR-2)	Uncleared catchment, intact riparian vegetation, integrity of hydrology and seasonal aquatic habitats.	Groundwater recharge and discharge, runoff and stream flow characteristics of upper catchment maintained.

5.3.4 Coastal and marine ecosystem complex, Fish Habitat Areas, Dugong Protection Areas and Great Barrier Reef Marine Park

The catchments of the plan area discharge to a relatively undisturbed and high-value estuarine, coastal and marine ecosystem complex and play a critical role in its formation, maintenance and productivity. The values of this ecosystem complex include habitat for EPBC and Nature Conservation Act listed fauna (dugong, marine turtles, estuarine crocodiles, false water rat, beach thick knee) and fishery production and nursery functions. The coastal elements of the Goorganga Plain wetland (discussed above) form the western margin of the broader marine ecosystem complex and contribute to its values. These values are recognised by a number of conservation management

measures that have been taken to protect biodiversity and fisheries productivity values of areas influenced by freshwater discharges from the plan area. Protective management areas include a declared Fish Habitat Area (FHA, Repulse Bay), a Dugong Protection Areas (DPAs) and the Great Barrier Reef Marine Park.

The Whitsunday section of the Great Barrier Reef Marine Park includes the eastern section of Repulse Bay. The mouths of the Proserpine and O'Connell rivers are not included in the park area, but discharge from these systems is likely to influence the park area.

The Northern Repulse Bay Dugong Protection Area is situated approximately three kilometres west of Conway Beach, adjacent to the Conway National Park, and is likely to be influenced by discharge from the Proserpine and O'Connell rivers. This DPA is a class-B area, which is one of a number of such areas that contain approximately 22 per cent of the dugong numbers in the Southern Great Barrier Reef. The Repulse Bay FHA boundary lies to the east of the mouths of the Proserpine and O'Connell rivers, running in a line due south of Rocky Point. However, this FHA is still influenced by discharges from the plan area.

Key flow and water resource dependencies of the coastal and marine ecosystem complex have been previously referred to in relation to the Goorganga Plain wetland (above). The key flow requirements of these valuable systems include:

- large wet season flow events responsible for transporting coastline and inter-tidal-flat forming sediment to the coastal zone and associated nutrients to dependent ecosystems and biota including mangroves, seagrass, benthic environments and juvenile finfish and crustaceans
- peak and base flow events that maintain seasonally variable salinity gradients within the estuary and near coastal waters, which are important for maintaining a particularly diverse mangrove assemblage and play important roles in breeding and recruitment triggers for finfish and crustaceans important to commercial and recreational fisheries.

5.3.5 National parks and other conservation reserves

A number of national parks occur in the vicinity of the plan area. However, only the upper reaches of the O'Connell River traverse any of these reserves where it flows through a narrow finger of Eungella National Park. Other nearby national parks include Dryander National Park near Myrtle Creek, and Conway National Park near the mouth of the Proserpine River. However, it is not anticipated that water resource use in these streams would affect these areas. The Andromache Conservation Park is situated in the mid-upper catchment of the Andromache River (AND-2) but does not abut the riparian zone of the stream.

A number of state forests occur within the study catchment, including in the vicinity of Peter Faust Dam, and in association with the Clarke Range in the southern part of the plan area. Apart from a narrow section of state forest traversed by the Andromache River near Mt Hector, it is only the upper headwaters of streams that are associated with state forest areas.

5.3.6 Functional landscape elements

In landscapes with fragmented habitat, where there has been clearing of natural ecosystems, basic ecological functions are often disrupted, leading to deleterious effects on flora and fauna. Primarily, fragmentation of the natural habitat landscape interrupts the natural movement and dispersal patterns of local and even regional flora and fauna. For instance, the extensive cane lands and cleared grazing country that straddle the Bruce Highway between the O'Connell River crossing and Proserpine effectively separate the wetland and woodland areas on the western periphery of the

coastal plain from similar habitats along the eastern coastal periphery of the coastal plain. While many fauna species are able to traverse this barrier of modified habitat (e.g., most wetland birds) many other fauna, such as ground mammals and reptiles, may not traverse this modified habitat and are, therefore, less able to disperse to new habitat areas or move around the landscape in response to events such as flood or fire.

Riparian habitats in relatively good condition prove valuable in such fragmented landscapes as they comprise linear habitat corridors that traverse the landscape and link up otherwise isolated habitat areas. Consideration of aerial imagery and regional ecosystem mapping of the plan area indicates a number of key riparian habitat corridors retaining more-or-less continuous riparian vegetation that provides important connectivity functions.

The Kelsey Creek, Lethe Brook and Goorganga Creek systems provide key riparian habitat corridors that link floodplain and coastal habitats to the east of the Bruce Highway with remnant floodplain habitats in the Kelsey Creek area, and westwards to upland habitats along the subcoastal range and beyond. This represents a substantial upland–lowland linkage. Slater Creek is a tributary of Lethe Brook that links the Lethe Brook corridor to remnant floodplain habitat areas in the Gunyarra area. The Goorganga Creek corridor is particularly noteworthy for the retention of ecotonal and contiguous floodplain woodland for most of its upper extent.

The riparian vegetation along the Andromache River provides a substantial habitat corridor linking upland habitats of the Clarke Range through grazing land and cane land with coastal hills near the confluence with the O'Connell River. This corridor also links up several isolated woodland patches along the way.

The flow and water resource dependencies of riparian vegetation communities have been previously identified under the discussion on threatened regional ecosystems. Key requirements include within bank and overbank flows to sustain soil moisture through the growing season, which in some instances will be supplied indirectly by shallow aquifer reserves and discharges. Additional needs associated with replenishment of alluvial soils, germination triggers and improved establishment opportunities can also be identified and are usually associated with inundating flow events. These may vary in magnitude dependent upon the riparian vegetation's location in relation to the stream channel. Reductions in flow frequency or magnitude and over-exploitation of shallow aquifer water resources can all have potential impacts on the sustainability of riparian vegetation corridors.

Although not strictly flow related, water resource development involving on-stream storages (dams) that drown riparian vegetation can also pose a threat to the functional wildlife corridor values of riparian areas.

5.4 Key flow-dependent ecological processes

5.4.1 In-stream processes

For seasonally variable streams such as those within the plan area, within-bank flows are critical for the persistence and condition of in-stream and fringing ecosystems including seasonal and permanent pools, and riparian gallery forests and woodlands. These ecosystems experience the highest level of exposure to stream flows given their proximity to or occurrence within the stream channel, and the flora and fauna that exist within these communities are generally reliant on the higher moisture availability. Within-bank seasonal flows replenish pool habitat and deliver moisture to the riparian vegetation. Even small, short flows can provide significant benefits for these communities. The diversity and complexity of the riparian and in-stream macrophyte community evident along most of the major stream reaches is indicative of persistent surface or subsurface base flows.

The relationships between flow regime and the condition and trend of riparian vegetation communities within the plan area have not been specifically studied and indeed these relationships are poorly understood for streams in general in central and lower northern Queensland. The seasonal rainfall and flow conditions under which these communities have developed suggest that the communities possess a natural tolerance to variations in annual flows, and that this tolerance may also cope with anthropogenic variations to flow regimes. However, the persistence of surface and subsurface base flows is likely to be a significant factor in maintaining the fringing riparian communities. Consequently, fringing vegetation may be less tolerant to water resource development that affects the base flow regime compared with, for instance, water use that occurs during higher flow events.

The permanent pools that are encountered throughout the plan area are likely to represent significant habitat resources for native fauna, including both riparian species and species from adjoining non-riparian habitats. For example, the seed-eating squatter pigeon (vulnerable) requires year-round free water close to feeding areas, and obligate riparian species such as the azure kingfisher will concentrate their foraging activities in permanent pools during intermittent flow periods. While wet season flows and, in some instances, groundwater fed springs are responsible for the occurrence of these features, the most significant natural process responsible for their persistence into the drier parts of the year is that these waters are not drawn down other than by natural processes such as evaporation, infiltration to the substrate and consumption by native animals.

Of particular significance for fauna utilising riparian vegetation communities is the onset of favourable habitat conditions triggered by seasonal flows. The onset of breeding activity and/or the probability of breeding success in many riparian species will be dependent on the occurrence of wet season flows. For instance, successful breeding by some freshwater turtles relies on the occurrence of early–mid wet season flows to enable the excavation of nests. Similarly, riparian birds such as the azure kingfisher may suffer reduced reproductive success if wet season flows do not provide the right condition for proliferation of invertebrate prey species. Persistence of the initial flows of the season is critical as this ensures the earliest possible onset of favourable habitat conditions for flora and fauna. A summary of the ecological dependencies on instream flows is presented in Table 5-.

Table 5-4 Summary of flow related ecological dependencies

Flow parameter	Ecological dependency
Base flow or groundwater level	• Maintenance of riffle and pool habitats by base flow in perennial reaches • Adequate recharge of fluvial aquifer and large, non-groundwater-dependent perennial pools to provide refugia during the dry season in intermittent reaches
Lower floods (1- to 2-year ARI)	• Regular elevated flows (not just major flood events but also lesser flows during below average rainfall years) to allow fish and other aquatic organism passage past natural and low level artificial passage barriers • Regular substantial freshwater inflows to estuaries to trigger recruitment or migration of estuarine organisms (e.g.prawns)
Moderate to high floods (> 3- to 5-year ARI)	• Flushing flows to reset vegetation cover and macrophyte-assemblage composition, providing habitat variability needed by other organisms • Regular elevated flows (not just major flood events but also lesser flows during below average rainfall years) to allow fish and other aquatic organism passage past natural and low level artificial passage barriers • Lack of peak flows in Proserpine River resulting in habitat degradation, vegetation overgrowth and reduced habitat and hydraulic linkage values of the river channels. • Delivery of sediments and associated nutrients to estuarine and coastal habitats to provide sediment replenishment and nutrient sources for dry-season marine productivity • Regular substantial freshwater inflows to estuaries to trigger recruitment or migration of estuarine organisms (e.g. prawns).

5.4.2 Overbank processes

Overbank flows and flows along flood runner channels are critical processes for the remnant frontage communities that occur on the alluvial deposits (terraces, levees, plains) that extend away from the channel. These communities have developed on the alluvial deposits historically laid down by overbank flows. Although formation of these areas occurs over geological time scales, current overbank flows are crucial in continuing the natural processes of formation of alluvial landforms and in maintaining deposition of nutrients that sustain the communities. As with fringing communities, frontage systems are dynamic and constantly changing in response to natural climatic variation and flow regimes. Within these systems, species will have differential tolerances to flooding, so that a period of frequent flooding may promote the incidence of flood tolerant species and a decline in flood sensitive species. Consequently, frontage ecosystems typically occur in the landscape as a heterogeneous mosaic of different ecosystems responding to fluctuations in topography and flooding regime.

In addition to the delivery of nutrients, overbank flows are critical to the maintenance of alluvial ecosystems via delivery of moisture, and by providing the appropriate conditions required for dispersal and establishment of plant propagules. Ongoing establishment of young trees and shrubs is critical to the persistence of the communities and is typically linked to the extent, periodicity and frequency of flood events. Other flood attributes identified by Capon (2001) that may be significant in determining the response of alluvial vegetation communities include:

- the depth of flooding relative to plant height via its potential affects on seedling survival
- the timing of floods, as seasonality will determine the germination response of different species
- the rate of drawdown of floodwaters, as this may affect the reproductive performance of adult plants and the establishment and survival of seedlings.

Overbank flows are critical for many floodplain and prior channel wetlands with floodwaters replenishing wetlands and pools. The lateral extent of flooding is a critical factor as it will determine the range of floodplain wetlands that are inundated (i.e., some wetland features may only be reached by the largest floods). Some of these floodplain wetlands may also be inundated by local rainfall and runoff. However, for the majority, flood flows from the Proserpine and O'Connell rivers and larger tributaries are likely to be significant processes.

The frequency and extent of overbank flows from the Proserpine River, Lethe Brook, and Goorganga Creek will be of particular significance for the extensive system of freshwater, brackish and saline coastal wetlands in this area. Wetland characteristics rely heavily on the balance between upstream freshwater inputs and tidally affected upstream flows from the myriad of estuarine channels that network the area. The natural hydrological regime in this area is already modified to some extent by road and rail infrastructure and agricultural development.

5.4.3 Groundwater processes

Key groundwater processes with surface water flow linkages are discussed below.

Recharge: For Recent alluvium aquifers recharge occurs quickly (one–two months) and is dependent on channel water level. For older fractured rock aquifers (in upper catchment reaches, predominantly) recharge depends on infiltration, overbank flows and duration of channel water levels. No information is presently available about duration. For Tertiary terrace aquifers, no information is presently available about recharge rate and dependencies on overbank or channel

water levels.

Depletion: For recent alluvium aquifers depletion can occur relatively quickly. For older fractured rock aquifers and Tertiary terrace aquifers little or no information is currently available about depletion rate and quantity relationships.

Groundwater windows: In upper catchment areas fractured bedrock aquifers are the most important contributor to maintenance of freshwater pools and baseline channel flow. There are anecdotal reports that saline (presumably high Mg-Ca-HCO_3) seeps have developed following tree clearing in mid-catchment locations underlain by Tertiary terrace aquifers. There are also mid catchment reaches where stream channels have been incised in Tertiary terrace sediments, resulting in maintenance of freshwater pools when there is no surface stream flow. In lower catchment reaches imposed bed-level changes due to sand and gravel extraction change the balance between recharge and depletion. In tidal reaches saline intrusion is likely to occur when the depletion rate exceeds the freshwater recharge rate.

5.4.4 Coastal and estuarine processes

The coastal and estuarine ecosystems of the plan area are relatively extensive and of national and international significance given the presence of nationally listed threatened species and trans-equatorial migratory waders. They comprise inter-tidal and saline flats, relatively extensive mangrove forests and shrublands occurring as a mosaic with littoral forests, sedgelands and grasslands, mangrove lined channels and estuaries, and seagrass meadows. Flood flows are the basis of the critical processes for these ecosystems as they inundate the seasonal wetlands and deliver sediment to the inter-tidal environment. Delivery of sediments is a critical process as it sustains the near-shore environments that are significant for migratory waders, dugongs, marine turtles and local fisheries. It is unclear to what extent the post-dam changes to flow patterns in the Proserpine River have already affected coastal processes in Repulse Bay.