# Appendix A Matters of National Environmental Significance Search Results

Australian Government
Department of the Environment and Energy

# EPBC Act Protected Matters Report

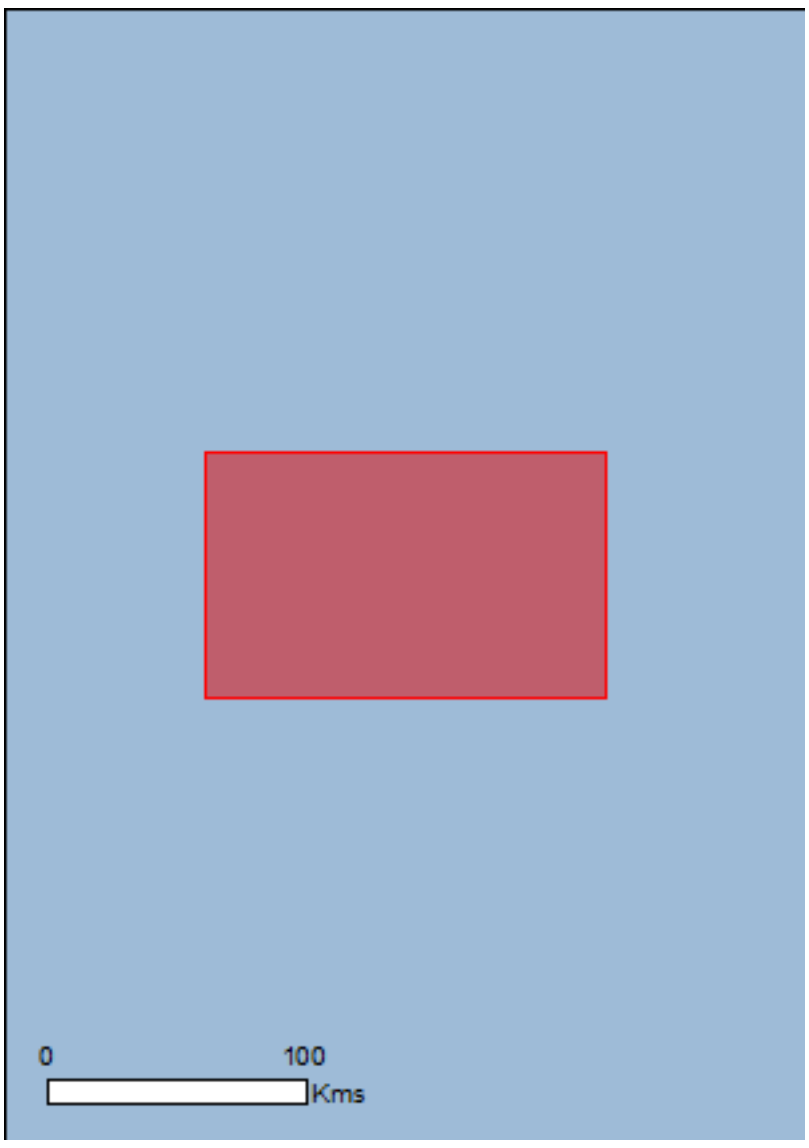
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 02/08/19 11:37:44

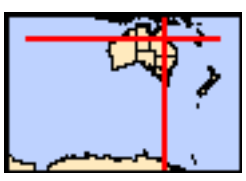







Coordinates

Buffer: 1.0Km



# Summary

## Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

| | |
|---|---|
| World Heritage Properties: | None |
| National Heritage Places: | None |
| Wetlands of International Importance: | None |
| Great Barrier Reef Marine Park: | None |
| Commonwealth Marine Area: | None |
| Listed Threatened Ecological Communities: | 4 |
| Listed Threatened Species: | 25 |
| Listed Migratory Species: | 17 |

## Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

| | |
|---|---|
| Commonwealth Land: | None |
| Commonwealth Heritage Places: | None |
| Listed Marine Species: | 22 |
| Whales and Other Cetaceans: | None |
| Critical Habitats: | None |
| Commonwealth Reserves Terrestrial: | None |
| Australian Marine Parks: | None |

## Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

| | |
|---|---|
| State and Territory Reserves: | 1 |
| Regional Forest Agreements: | None |
| Invasive Species: | 28 |
| Nationally Important Wetlands: | 5 |
| Key Ecological Features (Marine) | None |

# Details

## Matters of National Environmental Significance

### Listed Threatened Ecological Communities [ Resource Information ]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

| Name | Status | Type of Presence |
|---|---|---|
| Brigalow (Acacia harpophylla dominant and co-dominant) | Endangered | Community known to occur within area |
| Natural Grasslands of the Queensland Central Highlands and northern Fitzroy Basin | Endangered | Community likely to occur within area |
| Poplar Box Grassy Woodland on Alluvial Plains | Endangered | Community may occur within area |
| Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions | Endangered | Community likely to occur within area |

### Listed Threatened Species [ Resource Information ]

| Name | Status | Type of Presence |
|---|---|---|
| **Birds** | | |
| Calidris ferruginea<br>Curlew Sandpiper [856] | Critically Endangered | Species or species habitat may occur within area |
| Erythrotriorchis radiatus<br>Red Goshawk [942] | Vulnerable | Species or species habitat likely to occur within area |
| Geophaps scripta scripta<br>Squatter Pigeon (southern) [64440] | Vulnerable | Species or species habitat likely to occur within area |
| Neochmia ruficauda ruficauda<br>Star Finch (eastern), Star Finch (southern) [26027] | Endangered | Species or species habitat likely to occur within area |
| Numenius madagascariensis<br>Eastern Curlew, Far Eastern Curlew [847] | Critically Endangered | Species or species habitat may occur within area |
| Poephila cincta cincta<br>Southern Black-throated Finch [64447] | Endangered | Species or species habitat likely to occur within area |
| Rostratula australis<br>Australian Painted-snipe, Australian Painted Snipe [77037] | Endangered | Species or species habitat likely to occur within area |
| Tyto novaehollandiae kimberli<br>Masked Owl (northern) [26048] | Vulnerable | Species or species habitat may occur within area |
| **Mammals** | | |
| Dasyurus hallucatus<br>Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331] | Endangered | Species or species habitat likely to occur within area |

| Name | Status | Type of Presence |
|---|---|---|
| Macroderma gigas | | |
| Ghost Bat [174] | Vulnerable | Species or species habitat likely to occur within area |
| Petauroides volans | | |
| Greater Glider [254] | Vulnerable | Species or species habitat may occur within area |
| Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) | | |
| Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104] | Vulnerable | Species or species habitat known to occur within area |
| Rhinolophus robertsi | | |
| Large-eared Horseshoe Bat, Greater Large-eared Horseshoe Bat [87639] | Vulnerable | Species or species habitat may occur within area |
| Saccolaimus saccolaimus nudicluniatus | | |
| Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889] | Vulnerable | Species or species habitat likely to occur within area |
| Plants | | |
| Bulbophyllum globuliforme | | |
| Miniature Moss-orchid, Hoop Pine Orchid [6649] | Vulnerable | Species or species habitat likely to occur within area |
| Cycas ophiolitica | | |
| [55797] | Endangered | Species or species habitat likely to occur within area |
| Dichanthium setosum | | |
| bluegrass [14159] | Vulnerable | Species or species habitat likely to occur within area |
| Eucalyptus raveretiana | | |
| Black Ironbox [16344] | Vulnerable | Species or species habitat known to occur within area |
| Livistona lanuginosa | | |
| Waxy Cabbage Palm [64581] | Vulnerable | Species or species habitat known to occur within area |
| Omphalea celata | | |
| [64586] | Vulnerable | Species or species habitat likely to occur within area |
| Samadera bidwillii | | |
| Quassia [29708] | Vulnerable | Species or species habitat likely to occur within area |
| Reptiles | | |
| Denisonia maculata | | |
| Ornamental Snake [1193] | Vulnerable | Species or species habitat likely to occur within area |
| Egernia rugosa | | |
| Yakka Skink [1420] | Vulnerable | Species or species habitat known to occur within area |
| Lerista vittata | | |
| Mount Cooper Striped Skink, Mount Cooper Striped Lerista [1308] | Vulnerable | Species or species habitat known to occur within area |
| Sharks | | |
| Pristis pristis | | |
| Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756] | Vulnerable | Species or species habitat likely to occur within area |

## Listed Migratory Species [ Resource Information ]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

| Name | Threatened | Type of Presence |
|---|---|---|
| Migratory Marine Birds | | |

| Name | Threatened | Type of Presence |
|---|---|---|
| Apus pacificus | | |
| Fork-tailed Swift [678] | | Species or species habitat likely to occur within area |
| **Migratory Marine Species** | | |
| Crocodylus porosus | | |
| Salt-water Crocodile, Estuarine Crocodile [1774] | | Species or species habitat likely to occur within area |
| Pristis pristis | | |
| Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756] | Vulnerable | Species or species habitat likely to occur within area |
| **Migratory Terrestrial Species** | | |
| Cuculus optatus | | |
| Oriental Cuckoo, Horsfield's Cuckoo [86651] | | Species or species habitat may occur within area |
| Monarcha melanopsis | | |
| Black-faced Monarch [609] | | Species or species habitat likely to occur within area |
| Monarcha trivirgatus | | |
| Spectacled Monarch [610] | | Species or species habitat may occur within area |
| Motacilla flava | | |
| Yellow Wagtail [644] | | Species or species habitat may occur within area |
| Myiagra cyanoleuca | | |
| Satin Flycatcher [612] | | Species or species habitat known to occur within area |
| Rhipidura rufifrons | | |
| Rufous Fantail [592] | | Species or species habitat may occur within area |
| **Migratory Wetlands Species** | | |
| Actitis hypoleucos | | |
| Common Sandpiper [59309] | | Species or species habitat may occur within area |
| Calidris acuminata | | |
| Sharp-tailed Sandpiper [874] | | Species or species habitat may occur within area |
| Calidris ferruginea | | |
| Curlew Sandpiper [856] | Critically Endangered | Species or species habitat may occur within area |
| Calidris melanotos | | |
| Pectoral Sandpiper [858] | | Species or species habitat may occur within area |
| Gallinago hardwickii | | |
| Latham's Snipe, Japanese Snipe [863] | | Species or species habitat may occur within area |
| Numenius madagascariensis | | |
| Eastern Curlew, Far Eastern Curlew [847] | Critically Endangered | Species or species habitat may occur within area |
| Pandion haliaetus | | |
| Osprey [952] | | Species or species habitat known to occur within area |
| Tringa nebularia | | |
| Common Greenshank, Greenshank [832] | | Species or species habitat may occur within area |

## Other Matters Protected by the EPBC Act

| Listed Marine Species | | [ Resource Information ] |
|---|---|---|
| * Species is listed under a different scientific name on the EPBC Act - Threatened Species list. | | |
| Name | Threatened | Type of Presence |
| Birds | | |
| Actitis hypoleucos<br>Common Sandpiper [59309] | | Species or species habitat may occur within area |
| Anseranas semipalmata<br>Magpie Goose [978] | | Species or species habitat may occur within area |
| Apus pacificus<br>Fork-tailed Swift [678] | | Species or species habitat likely to occur within area |
| Ardea alba<br>Great Egret, White Egret [59541] | | Breeding known to occur within area |
| Ardea ibis<br>Cattle Egret [59542] | | Species or species habitat may occur within area |
| Calidris acuminata<br>Sharp-tailed Sandpiper [874] | | Species or species habitat may occur within area |
| Calidris ferruginea<br>Curlew Sandpiper [856] | Critically Endangered | Species or species habitat may occur within area |
| Calidris melanotos<br>Pectoral Sandpiper [858] | | Species or species habitat may occur within area |
| Chrysococcyx osculans<br>Black-eared Cuckoo [705] | | Species or species habitat known to occur within area |
| Gallinago hardwickii<br>Latham's Snipe, Japanese Snipe [863] | | Species or species habitat may occur within area |
| Haliaeetus leucogaster<br>White-bellied Sea-Eagle [943] | | Species or species habitat known to occur within area |
| Merops ornatus<br>Rainbow Bee-eater [670] | | Species or species habitat may occur within area |
| Monarcha melanopsis<br>Black-faced Monarch [609] | | Species or species habitat likely to occur within area |
| Monarcha trivirgatus<br>Spectacled Monarch [610] | | Species or species habitat may occur within area |
| Motacilla flava<br>Yellow Wagtail [644] | | Species or species habitat may occur within area |
| Myiagra cyanoleuca<br>Satin Flycatcher [612] | | Species or species habitat known to occur within area |

| Name | Threatened | Type of Presence |
|---|---|---|
| Numenius madagascariensis | | |
| Eastern Curlew, Far Eastern Curlew [847] | Critically Endangered | Species or species habitat may occur within area |
| Pandion haliaetus | | |
| Osprey [952] | | Species or species habitat known to occur within area |
| Rhipidura rufifrons | | |
| Rufous Fantail [592] | | Species or species habitat may occur within area |
| Rostratula benghalensis (sensu lato) | | |
| Painted Snipe [889] | Endangered* | Species or species habitat likely to occur within area |
| Tringa nebularia | | |
| Common Greenshank, Greenshank [832] | | Species or species habitat may occur within area |
| Reptiles | | |
| Crocodylus porosus | | |
| Salt-water Crocodile, Estuarine Crocodile [1774] | | Species or species habitat likely to occur within area |

## Extra Information

| State and Territory Reserves | [ Resource Information ] |
|---|---|
| Name | State |
| Hells Gate | QLD |

| Invasive Species | [ Resource Information ] |
|---|---|

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

| Name | Status | Type of Presence |
|---|---|---|
| Birds | | |
| Acridotheres tristis | | |
| Common Myna, Indian Myna [387] | | Species or species habitat likely to occur within area |
| Columba livia | | |
| Rock Pigeon, Rock Dove, Domestic Pigeon [803] | | Species or species habitat likely to occur within area |
| Lonchura punctulata | | |
| Nutmeg Mannikin [399] | | Species or species habitat likely to occur within area |
| Passer domesticus | | |
| House Sparrow [405] | | Species or species habitat likely to occur within area |
| Streptopelia chinensis | | |
| Spotted Turtle-Dove [780] | | Species or species habitat likely to occur within area |
| Sturnus vulgaris | | |
| Common Starling [389] | | Species or species habitat likely to occur within area |
| Frogs | | |
| Rhinella marina | | |
| Cane Toad [83218] | | Species or species habitat known to occur within area |

| Name | Status | Type of Presence |
|---|---|---|
| Mammals | | |
| Bos taurus<br>Domestic Cattle [16] | | Species or species habitat likely to occur within area |
| Canis lupus familiaris<br>Domestic Dog [82654] | | Species or species habitat likely to occur within area |
| Capra hircus<br>Goat [2] | | Species or species habitat likely to occur within area |
| Equus caballus<br>Horse [5] | | Species or species habitat likely to occur within area |
| Felis catus<br>Cat, House Cat, Domestic Cat [19] | | Species or species habitat likely to occur within area |
| Feral deer<br>Feral deer species in Australia [85733] | | Species or species habitat likely to occur within area |
| Lepus capensis<br>Brown Hare [127] | | Species or species habitat likely to occur within area |
| Mus musculus<br>House Mouse [120] | | Species or species habitat likely to occur within area |
| Oryctolagus cuniculus<br>Rabbit, European Rabbit [128] | | Species or species habitat likely to occur within area |
| Rattus rattus<br>Black Rat, Ship Rat [84] | | Species or species habitat likely to occur within area |
| Sus scrofa<br>Pig [6] | | Species or species habitat likely to occur within area |
| Vulpes vulpes<br>Red Fox, Fox [18] | | Species or species habitat likely to occur within area |
| Plants | | |
| Acacia nilotica subsp. indica<br>Prickly Acacia [6196] | | Species or species habitat may occur within area |
| Cryptostegia grandiflora<br>Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913] | | Species or species habitat likely to occur within area |
| Hymenachne amplexicaulis<br>Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754] | | Species or species habitat likely to occur within area |
| Jatropha gossypifolia<br>Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507] | | Species or species habitat likely to occur within area |
| Lantana camara<br>Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892] | | Species or species habitat likely to occur within area |
| Parkinsonia aculeata<br>Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, | | Species or species |

| Name | Status | Type of Presence |
|---|---|---|
| Horse Bean [12301] | | habitat likely to occur within area |
| Parthenium hysterophorus<br>Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566] | | Species or species habitat likely to occur within area |
| Salvinia molesta<br>Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665] | | Species or species habitat likely to occur within area |
| Vachellia nilotica<br>Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351] | | Species or species habitat likely to occur within area |

## Nationally Important Wetlands

[ Resource Information ]

| Name | State |
|---|---|
| Bowen River: Birralee - Pelican Creek | QLD |
| Burdekin-Bowen Junction and Blue Valley Weir Aggregation | QLD |
| Lake Dalrymple | QLD |
| Rollston River and Molly Darling Creek Aggregation | QLD |
| Turkey Mound Spring and Iron Pot Spring Aggregation | QLD |

# Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods.  Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc).  In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

# Coordinates

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# Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.


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# Appendix B Hydrobiology (2018) Fish Passage Report

**BRISBANE** | PERTH | PAPUA NEW GUINEA

Hydrobiology

Lee Benson
EM (Ecology Management) Pty Ltd

8 May 2018

**OPINION: NATURAL FISH PASSAGE AT BURDEKIN FALLS**

Dear Lee,

As requested, this letter provides a professional opinion on the extent of natural fish passage past the Burdekin Falls before construction of the current dam and Lake Dalrymple. This extent of such natural fish passage is relevant to considerations of the need to provision of fish passage past the dam. My opinion is based on the following:

- A brief literature review by Dare Lawrence and Garry Ogston of Hydrobiology to provide me with background information on the fishes of the catchment and their known natural and current distributions, including the previous considerations by Pusey on the need for fish passage (provided to me by you);
- A review of known genetic similarities between the Burdekin fish populations above and below the Falls, and in adjacent catchments supplied to me by Dr Peter Unmack of the University of Canberra; and
- Consideration of the geomorphology and river flow regime of the Falls.

In addition to the above sources, I have undertaken a limited literature review myself, and have some personal knowledge of the Falls before the construction of the dam, based on occasional fishing trips to the Falls when I lived in Townsville in the early 1980s.

## FISH SPECIES DISTRIBUTIONS

The literature review of by Lawrence and Ogston is provided in Appendix 1. It is noted in that review, and in correspondence from you that Pusey, in ACTFR (1999) stated that:

> "The impact of raising the BFD on fish passage is not an issue, unlike in other proposed developments, given that the Falls have historically been a barrier to fish movement (Pusey *et al*. 1998). The only species likely to be impacted would be the long-finned eel, which is largely already extinct in the upper Burdekin River because of the construction of the existing dam. Care would be needed to ensure that fish movements from the lower reaches to the confluence of the Bowen River are maintained."

This statement, while seemingly justifying the current lack of a fish passage mechanism on the dam, noted that at least one catadromous species (fish species that are resident in fresh water as adults, but migrate to sea to breed), the long-finned eel *Anguilla reinhardtii*, was able to naturally negotiate the Falls before the

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dam was built. The cause of the extinction of the upper Burdekin population is not clear, and it is not known how much Clare Weir may have contributed to its demise before a fish passage structure was fitted to it, but the fact that eels were once able to migrate upstream past the Falls shows that at least one species certainly did so.

No other catadromous species were able to migrate through the Falls. Barramundi *Lates calcarifer* are now regularly stocked into Lake Dalrymple, and it may be possible that under favourable high flow conditions some of these may manage to swim over the spillway and survive to migrate to sea to spawn (see discussion below regarding downstream migration).

Burrows *et al.* (2009) referenced Burrows (2001) to indicate that snakehead gudgeon *Giurus margaritacea*, generally regarded as likely to have a marine larval stage (e.g. see Allen *et al.* 2002) had been recorded from a site in the Cape River, above Burdekin Falls. That reference proved difficult to locate, but a copy that included the data appendix was sourced from Damien Burrows, of TropWater. The sampling was conducted in 2000 by Tim Marsden, then of the Department of Primary Industries, and included a record of a single snakehead from the Cape River site by backpack elecrofishing. No other reports found in the literature for this assessment have been found to have referenced that specimen, including other reports by authors with access to the dataset of Burrows (2001) including Pusey (2004) did not include that species in the list of known species for the upper catchment. Even though recorded by a well credentialed worker, this single species does not necessarily confirm the presence of that species above the Falls, as there is no indication the specimen was lodged with a museum or otherwise stored in a verifiable form, nor that if that specimen was confirmed that it had migrated above the Falls. For example, while uncommon, snakeheads are an attractively coloured species, and are sometimes kept as aquarium specimens by amateur collectors. It is probable that that specimen had been translocated to the upper catchment, and certainly more probably than that it had managed to pass the Burdekin Falls Dam or managed to persist since construction of the dam, but the possibility that it had managed to migrate to that location cannot be completely discounted. Note that the lifespan of this species is not known, nor was the size or age of the specimen recorded by Marsden. This very uncertain record is the only recording of a species other than the longfinned eel with a marine life history phase from above the Falls in any report accessed.

Of the approximately 40 species of freshwater fishes in the Burdekin catchment, the following are known to have had natural populations upstream and downstream of the Falls:

## SPECIES WITH NO AVAILABLE GENETIC INFORMATION

**Bony bream** *Nematalosa erebi*, which is widespread in most inland waters in Australia. Exactly how this species, which is notoriously difficult to handle and translocate, has managed to achieve such a wide distribution is not known. However, it indicates a ready capacity to disperse, and the presence of populations in adjacent catchments could readily have contributed to maintenance of the upper Burdekin population.

**Soft-spined catfish** *Neosilurus mollespiculum* is endemic to the Burdekin catchment. It is one of two endemic species, the other being smallhead grunter (see below). That both had natural populations above and below the Falls without further speciation suggests that they may have been able to move at least downstream past the Falls, but this has so far not been confirmed by genetic studies.

**Narrowfront tandan** *Neosilurus ater*, a widespread species across northern Australia and southern New Guinea that could have maintained populations in the upper Burdekin via exchange with adjacent catchments that support this species.

**Hyrtl's tandan** *Neosilurus hyrtlii,* which is another widespread species in northern Australia and southern New Guinea.

**Rendahl's tandan** *Porochilus rendahli,* which is another widespread eel-tailed catfish in northern Australia

**Spotted archerfish** *Toxotes chatareus* is again widespread in northern Australia and southern New Guinea, and while normally restricted to below natural passage barriers, may have been maintained in the upper Burdekin by exchange with adjacent catchments.

**Spangled perch** *Leiopotherapon unicolor* which occurs across northern Australia and has the ability to disperse readily between catchments across shallow catchment divides via surface flow during heavy rainfall (see Beumer 1976).

**Banded grunter** *Amniataba percoides* which is similarly widespread in northern Australia, although with less southward extension than for spangled perch.

**Sooty grunter** *Hephaestus fuliginosus* was also naturally widespread across north-east Australia but has also been widely stocked as a recreational fishing species. Unmack (Appendix 2) suggests that the history of stocking in the Burdekin catchment may make unravelling the natural population genetic relationships impossible to determine. From personal experience and more recent reports of fishermen it is clear that specimens of this species resided within the Falls during the dry season and were and are a target for fishers. This demonstrates that the species is able to at least partially ascend the Falls.

**Smallhead grunter** *Scortum parviceps* is the other endemic species to the system, which was also resident above and below the Falls naturally. It is also a target of recreational fishers within the Falls, indicating an ability to at least partially negotiate the Falls (note that in online fishing forums it does not seem to be reliably separated from sooty grunter by anglers). Again, this is suggestive of at least downstream gene flow to maintain the two populations historically and the ability of the species to at least partially negotiate the falls complex.

## SPECIES WITH GENETIC INFORMATION

**Long-finned eel** *Anguilla reinhardtii* is a single genetic stock in Australia, southern New Guinea, the Solomon Islands and New Zealand, all breeding in the Coral Sea gyre. The historic population upstream of the Falls could only have been maintained by upstream migration.

**Fly-specked hardyhead** *Craterocephalus stercusmuscarum* which Unmack (Appendix 2) notes from a very small dataset appeared to have generally similar genetics between the upper and lower populations, but with the upper population having some similarities with the Cooper Creek catchment population.

**Agassiz's glassfish** *Ambassis agassizii* has complex genetics in the Burdekin but with a general distinction between upper populations being closely related to other inland drainages and the lower population being more closely related to other coastal drainages.

**Eastern rainbowfish** *Melanotaenia splendida* which has complex genetics in the system and a cryptic Running River species that is yet to be described. There is considerable genetic overlap between the Burdekin populations and the populations of adjacent inland and coastal catchments, but with some distinction between the upper and lower populations within the Burdekin catchment

**Midgley's gudgeon** *Hypseleotris* sp. Midgley, which has distinct genetic differences between the upper and lower catchment populations.

Figure 1 shows the relationship of the Burdekin catchment with the adjacent catchments discussed above with respect to apparent gene flow.

Unmack (in Appendix 2) provided some indicative timescales for genetic divergence for a number of these species. The only species with clearly recent gene flow between the upper and lower catchment populations was for the eastern rainbowfish, but the available genetic data are very limited and so definitive statements are not possible with the current evidence. Note that with the limited data and uncertainty of genetic clocks for Australian freshwater fishes, any indicated isolation of less than or equal to around 100,000 y should be considered recent genetic mixing.


Figure 1 Burdekin River catchment relationship to adjacent catchments

## GEOMORPHOLOGY AND HYDROLOGY – POTENTIAL FOR FISH PASSAGE

The Burdekin Falls were not a single vertical waterfall, but a series of short falls, cascades and incised channels within an expanse of exposed rock within a wide gorge as shown in Figure 2. At low flows (a dam release is occurring in Figure 2 as an example), upstream migration would generally have been prevented by a series of small falls. That some species could be caught by anglers within the Falls before dam construction indicates that at least the downstream rapids to the right in Figure 2 were able to be traversed at some flow stages. The current dam was built at the crest of the Falls, above any substantial natural barriers (Figure 3), and so post-construction images largely show the natural flow patterns over the Falls, except for enhanced turbulence caused by the spillway and dissipation structures (Figure 4). Hence, the images in Figure 5 provide useful views on the nature of flood flows through the Falls area. Clearly the major flow steps shown in Figure 2 are drowned out in flood flows, and potential fish pathways without obvious vertical drops, and limited turbulence can be seen, particularly towards the right bank (away from the low-flow channel) and very close to the left bank. In very high flows, it is likely current velocities may have prevented any upstream migration of fishes because all flow is restricted to within the wider gorge, but it is possible that some fishes may have been able to migrate upstream during lesser flood flows. It is also evident that there would have been a number of pathways for fish to successfully migrate downstream during flood flows.


Figure 2 Burdekin Falls in October 2017 from GoogleEarth

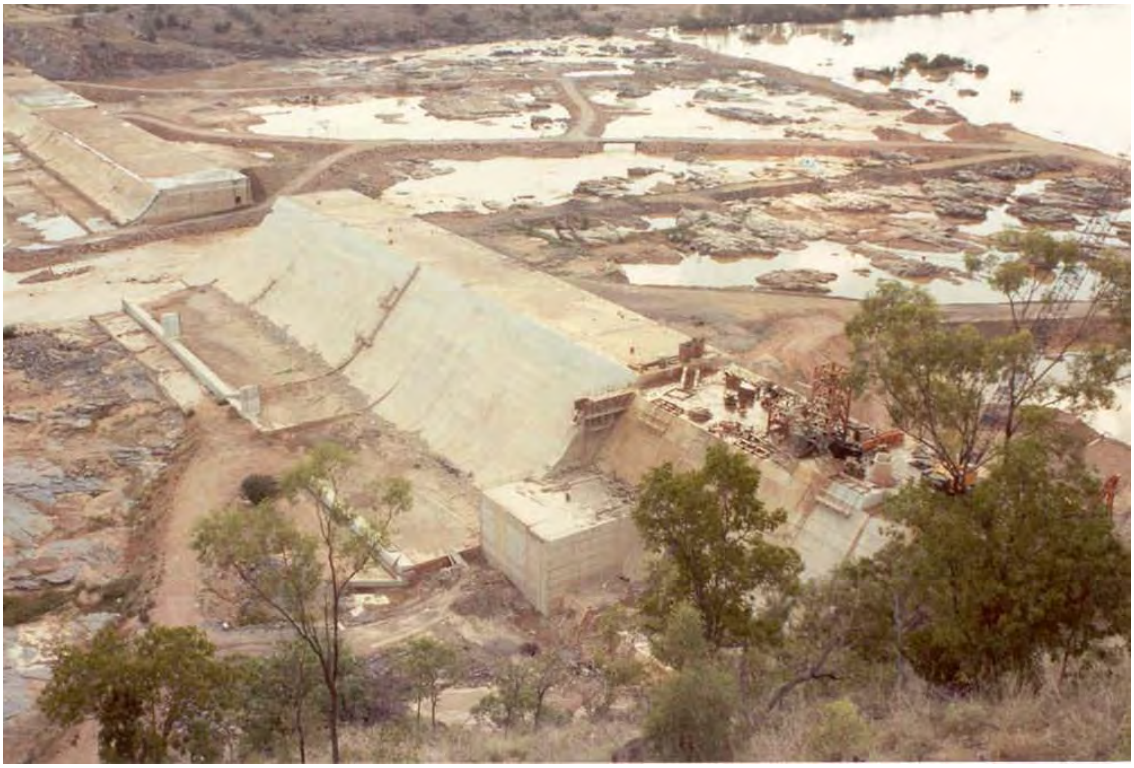


Figure 3 Burdekin Falls Dam during construction.


Figure 4 Burdekin Falls Dam spillway during flood flow

Figure 5 the Burdekin Falls during bankfull flood flows.

## DISCUSSION

The nature of the Burdekin Falls, the drowning out of low-flow vertical falls evident in images of flood flows over them, and the persistence of fish populations within the channels of the Falls during the dry season are all consistent with some species being able to migrate downstream at least during flood flows, and that some fishes, other than eels, may have been able to migrate upstream during some flood flows. This is consistent with the natural fish species distributions and the available genetic data. Some species were certainly unable to negotiate the Falls, and some other species seem to have diverged somewhat genetically between upstream and downstream populations. However, at least eastern rainbowfish do seem to have maintained genetic similarity between the upstream and downstream populations. For this small bodied species, this may have only been via downstream movement. Unfortunately, there are no genetic data available for the two endemic species, soft-spined catfish and smallhead grunter, but both were able to maintain both upper catchment and lower catchment populations, despite being unable to obtain even occasional recruits from adjacent catchments. The distribution patterns of these species alone are strongly indicative of at least downstream movement past the Falls. The only certain evidence for upstream migration was the historic distribution of long-finned eels, the uncertain record of snakehad gudgeon from the Cape River notwithstanding. Nonetheless, it is is certain that one species at least was able to naturally maintain an upper catchment population via upstream migration past the Falls.

It is also clear that the Falls were a natural passage barrier for most fishes and at most allowed for limited fish movement.

## OPINION

In my opinion, the available evidence, while unfortunately limited, is sufficient to demonstrate that there was natural fish migration through the Burdekin Falls before construction of the dam. It was of a limited nature, but historically maintained a population of one catadromous species above the Falls, and facilitated the persistence of both endemic species above and below the Falls.

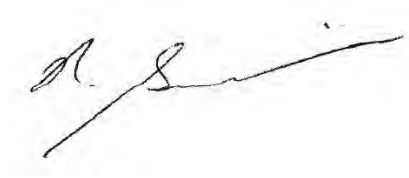
The apparently limited extent of that movement does not justify the expense of fitting a fish passage structure to the existing dam, or indeed to any further raised structure. I note that you have indicated that the cost for such a structure would potentially be tens of millions of dollars to fit to the structure. However, consideration should be given to some reestablishment of gene flow between the upstream and downstream populations of the species with upper and lower catchment populations that are not confirmed to have genetic distinctions indicating more than around 100,000 years of isolation.

As a number of species with upper and lower catchment populations have not been subject to genetic study at the necessary resolution, particularly the two endemic species, I recommend that the genetic similarities of the upper and lower catchment populations of these species be examined before any plans to facilitate such gene flow be further developed.

The natural restriction of fish movement past the Falls may require only limited translocation of specimens of the appropriate species to simulate the amount of natural gene flow before the construction of weirs and dams on the Burdekin River. As most of the species that do have natural populations above and below the Falls are riverine species, not lacustrine, it would be advisable that any such translocations should be into river reaches, not into the waters of Lake Dalrymple, to maximise the survival of the translocated specimens. The design of such a translocation strategy is difficult at present, but would be better informed if further genetic studies were undertaken to provide a better estimate of the extent of

geneflow, and hence the numbers of fishes that would need to be translocated to simulate that historic gene flow. A scope of work for such a study can be developed at your request.

Sincerely



**Dr Ross Smith**
Director
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# APPENDIX 1 – LITERATURE REVIEW

# 1.THE BURDEKIN FALLS DAM

The Burdekin Falls Dam is a mass concrete gravity dam with one uncontrolled spillway. It was completed in 1987 becoming the largest dam in the state (Table 1). It lies within the Burdekin Central Queensland drainage basin (Figure 1) and is a crucial part of water supply to surrounding regions. It operates in conjunction with the Clare and Gorge weirs on the Burdekin River and Val Bird and Giru weirs on the Haughton River making it a key asset in the Burdekin Haughton Water Supply Scheme (Shannon, 1987).

To date it supplies water for irrigation, industrial allotments and urban centres including Townsville. Due to population growth it has several proposed projects such as a dam raising, main channel augmentation and a hydro-electricity power station.


Figure 1 Map of all major water systems in the Burdekin drainage basin including all relevant dams and weirs.

Table 1. Characteristics of the Burdekin Falls Dam

| Characteristic | Description |
|---|---|
| **Storage capacity** | 1,860,000 ML |
| **Full supply level** | 154m AHD |
| **Catchment area** | 114, 200km$^2$ |
| **Height x length** | 55m x 876m |

## 1.1 RIVER SYSTEM

### 1.1.1 WQ

A study by Pusey (1998) surveying both upstream and downstream sites found that between-site group differences in water quality were not pronounced. Water temperatures were always above 20 °C, peaking at 31.3 °C during

November of 1989 (2 years after completion of the dam). A further study by the same author in 2004 found similar maximum temperature readings but an increased minimum of 27 °C. Dissolved oxygen never dropped below 4.51mg $O_2$. $l^{-1}$ and was often above 5. pH was always between 7 and 8.4 with conductivity ranging between 250 and 600 $\mu S.cm^{-1}$, decreasing downstream. Most sites had water depth under 2m with a low flow rate.

### 1.1.2 HABITAT/ FOOD

Pusey et al (1998) found that habitat structure was not greatly different over the sites. Sand and fine gravel were the dominant substrate throughout the catchment, adjacent rivers and tributaries. The Burdekin River is known to have coarser substrate, a deeper maximum depth and a higher flow rate upstream of Lake Dalrymple.

The dominant available food sources include invertebrates and algae (in low flow areas) with macrophytes dependant on season and water depth.

## 1.2 NATURAL BARRIER

Burdekin Falls historically functioned as a natural fish passage barrier to at least some species. Burdekin Falls has had an overriding influence on the distribution of the fish within the drainage (Pusey et al. 1998). Most species with a marine constituent to their ontology have been naturally successfully excluded from the upstream reaches due to the impassable barrier posed by the falls.

Pusey (in ACTFR 1999) stated; “The impact of raising the BFD on fish passage is not an issue, unlike in other proposed developments, given that the Falls have historically been a barrier to fish movement” The only species likely to be obstructed would be the long-finned eel, which is largely already extinct in the upper Burdekin River due to the construction of the existing dam (Pusey et al. 1998).

Care would be needed to ensure that fish movements from the lower reaches to the confluence of the Bowen River are maintained as it is often the small bottom-feeders that are affected by fish barriers (Knaepkens et al. 2007). The latter refers to the impacts of other barriers downstream of this confluence, particularly Clare Weir but this weir is now fitted with a fish transfer device. It is the only weir within the BHWSS to have a fishway. It is worth noting that Clare Weir is a crucial fishway for species that migrate to and from the Bowen River and tributaries

### 1.2.1 FISH DISTRIBUTIONS

Pusey et al. (1998) found that by national standards, the number of species present was low given the size of the catchment with the other smaller QLD rivers playing host to over 40 species.

A study by ATCFR (1999) found a total of 37 fish species (18 being native) in the freshwaters of the Burdekin river. Having said that 2 of those have never been recorded, their presence is simply hypothesized (*Hypseleoptris galii*, *Glossogobius* sp). Misidentification may be responsible for these inclusions.

Compiling studies by Pusey et al. (1998), Pusey et al. (2006) and Pusey et al. (2010) and the review by Unmack (Appendix 2 of this report) found a total of 40 fish species, belonging to 22 families (Table 2). Most surveyed species had insects (terrestrial or aquatic) as a part of their diet, the other major component being algae. Few recorded species were piscivorous with a select few consuming molluscs (mostly Plotosidae) and plankton. (e.g. Ambassidae, Pseudomugilidae)

# 2.DISTRIBUTION UPSTREAM AND DOWNSTREAM OF BFD

Before the construction of the dam, the Burdekin Falls was a natural passage barrier that hindered the colonisation of upstream habitats. Only *Anguilla reinhardtii* (Anguillidae) and possibly *Giurus margaritacea* (Eleotridae) (see main report body) have been recorded to have necessarily navigated upstream (Table 4).

Whilst many of the recorded fish species require upstream migrations to complete life cycles or for foraging, many in the lower Burdekin are able to use the Clare Weir fishway to reach the Bowen River and its tributaries.

## 2.1 INTRODUCED/ TRANSLOCATED SPECIES

Several fish species have been translocated to the Burdekin River and surrounding catchments, potentially since the early 1800s beginning with *Oxyeleotris lineolatus* (Eleotridae), which is suspected may have been translocated into the lower Burdekin around that time, but may have been native. The most heavily stocked species in recent years has been *Lates calcarifer*

with a total of over 600,000 individuals introduced, primarily to Lake Dalrymple, to date (table 3).

Table 2 Recorded species in Burdekin river and surrounding waterways upstream and downstream of the Burdekin Falls dam. Table includes their relative abundance, diet, origin and status. Abundance was determined relative to catch rates over the various surveys conducted over time.

| common name | species | family | diet | state | upper reaches | lower reaches | IUCN Red list status |
|---|---|---|---|---|---|---|---|
| **long finned eel** | *Anguilla reinhardtii* | **Anguillidae** | algivore / invertivore | native | x | x | not evaluated |
| **pacific short finned eel** | *Anguilla obscura* | **Anguillidae** | invertivore | native | | x | not evaluated |
| **mouth almighty** | *Glossamia aprion* | **Apogonidae** | algivore / invertivore | native | | x | not evaluated |
| **fork tailed catfish** | *Neoarius graeffei* | **Ariidae** | algivore / invertivore | native | | x | not evaluated |
| **fly-specked hardyhead** | *Craterocephalus stercusmuscarum* | **Atherinidae** | planktivore / invertivore | native | x | x | not evaluated |
| **Marjorie's hardyhead** | *Craterocephalus marjoriae* | **Atherinidae** | algivore / invertivore | native | x | | not evaluated |
| **freshwater longtom** | *Strongylura krefftii* | **Belonidae** | piscivore | native | | x | not evaluated |
| **Agassiz's glassfish** | *Ambassis agassizii* | **Chandidae** | planktivore / invertivore | native | x | x | not evaluated |
| **bony bream** | *Nematalosa erebi* | **Clupeidae** | detritivore | native | x | x | least concern |
| **western carp gudgeon** | *Hypseleotris klunzingeri* | **Eleotridae** | planktivore / invertivore | native / translocated | x | | not evaluated |
| **flathead gudgeon** | *Phylipnodon grandiceps* | **Eleotridae** | molluscivore / invertivore | native / translocated | x | | not evaluated |
| **purple-spotted gudgeon** | *Mogurnda adspersa* | **Eleotridae** | molluscivore / invertivore | native | | x | not evaluated |
| **sleepy cod** | *Oxyeleotris lineolatus* | **Eleotridae** | invertivore | Native / translocated | x | x | not evaluated |
| **empire gudgeon** | *Hypseleotris compressa* | **Eleotridae** | algivore / invertivore | native | | x | not evaluated |
| **flatheaded goby** | *Glossogobius giurus* | **Gobiidae** | invertivore | native | | x | least concern |
| **snub-nosed garfish** | *Arramphus sclerolepis* | **Hemiramphidae** | algivore / invertivore | native | | x | not evaluated |
| **barramundi** | *Lates calcarifer* | **Centropomidae** | piscivore / invertivore | translocated | x | x | not evaluated |
| **tarpon** | *Megalops cyprinoides* | **Megalopidae** | piscivore / invertivore | native | | x | not evaluated |

| common name | species | family | diet | state | upper reaches | lower reaches | IUCN Red list status |
|---|---|---|---|---|---|---|---|
| **eastern rainbowfish** | *Melanotaenia splendida* | **Melanotaeniidae** | algivore / invertivore | native | x | x | not evaluated |
| **yellowbelly** | *Macquaria ambigua* | **Percichthyidae** | piscivore / invertivore | translocated | x | | not evaluated |
| **Murray cod** | *Maccullochella peeli* | **Percichthyidae** | piscivore / invertivore | translocated | x | | critically endangered |
| **soft-spined catfish** | *Neosilurus mollespiculum* | **Plotosidae** | molluscivore / invertivore | native | x | x | not evaluated |
| **Hyrtl's tandan** | *Neosilurus hyrtlii* | **Plotosidae** | molluscivore / invertivore | native | x | x | not evaluated |
| **narrow-fronted tandan** | *Neosilurus ater* | **Plotosidae** | molluscivore / invertivore | native | x | x | not evaluated |
| **Rendahl's catfish** | *Porochilus rendahli* | **Plotosidae** | invertivore | native | x | x | not evaluated |
| **eel-tailed catfish** | *Tandanus tandanus* | **Plotosidae** | invertivore / detritivore | native / translocated | x | x | not evaluated |
| **eastern gambusia** | *Gambusia holbrooki* | **Poeciliidae** | algivore / invertivore | exotic | | x | least concern |
| **pacific blue eye** | *Pseudomugil signifer* | **Pseudomugilidae** | planktivore / invertivore | native | | x | not evaluated |
| **bullrout** | *Notesthes robusta* | **Scorpaenidae** | invertivore | native | | x | not evaluated |
| **silver perch** | *Bidyanus bidyanus* | **Terapontidae** | algivore / invertivore | translocated | x | | vulnerable |
| **small headed grunter** | *Scortum parviceps* | **Terapontidae** | algivore / invertivore | native | x | x | not evaluated |
| **spangled perch** | *Leiopotherapon unicolor* | **Terapontidae** | algivore / invertivore | native | x | x | not evaluated |
| **banded grunter** | *Amniataba percoides* | **Terapontidae** | algivore / invertivore | native / translocated | x | x | not evaluated |
| **sooty grunter** | *Hephaestus fuliginosus* | **Terapontidae** | algivore / invertivore | stocked | x | x | not evaluated |
| **seven spot archerfish** | *Toxotes chatereus* | **Toxotidae** | invertivore | native | x | x | not evaluated |
| **snakehead gudgeon** | *Giurus margaritacea* | **Eleotridae** | invertivore / detritivore | native | x | x | least concern |
| **Running River** | *Melanotaenia sp.* | **Melanotaeniidae** | algivore / invertivore | native | x | | not evaluated |
| **Midgely's carp gudgeon** | *Hypseleotris sp.* | **Eleotridae** | invertivore | native | x | x | not evaluated |

| common name | species | family | diet | state | upper reaches | lower reaches | IUCN Red list status |
|---|---|---|---|---|---|---|---|
| **Burdekin mogurnda** | *Mogurnda* sp. "burdekin" | **Eleotridae** | invertivore | native | x | | not evaluated |
| **Flinders Ranges mogurnda** | *Mogurnda clivicola* | **Eleotridae** | Invertivore | Native | X | | not evaluated |

Table 3 Recorded exotic and translocated species in Burdekin River and surrounding waterways upstream and downstream of the Burdekin Falls dam. Pale orange shading indicates translocated, bright orange shading indicates exotic to Australia and green shading indicates uncertain whether translocated or native to this part of the catchment.

| common name | species | family | diet | state | upper | lower |
|---|---|---|---|---|---|---|
| **western carp gudgeon** | *Hypseleotris klunzingeri* | **Eleotridae** | planktivore / invertivore | native / translocated | x | |
| **flathead gudgeon** | *Phylipnodon grandiceps* | **Eleotridae** | molluscivore / invertivore | native / translocated | x | |
| **sleepy cod** | *Oxyeleotris lineolatus* | **Eleotrididae** | invertivore | translocated | x | x |
| **barramundi** | *Lates calcarifer* | **Latidae** | piscivore / invertivore | translocated | x | x |
| **yellowbelly** | *Macquaria ambigua* | **Percichthyidae** | piscivore / invertivore | translocated | x | |
| **murray cod** | *Maccullochella peeli* | **Percichthyidae** | piscivore / invertivore | translocated | x | |
| **eastern mosquitofish** | *Gambusia holbrooki* | **Poeciliidae** | algivore / invertivore | exotic | | x |
| **silver perch** | *Bidyanus bidyanus* | **Terpontidae** | algivore / invertivore | translocated | x | |
| **sooty grunter** | *Hephaestus fuliginosus* | **Therapontidae** | algivore / invertivore | translocated | x | x |

Table 4. Recorded species in Burdekin river and surrounding waterways upstream and downstream of the Burdekin Falls dam by presence in each zone or both. Table includes known movement patterns and any relevant notes that are largely generic (i.e. not specific to the Burdekin catchment) and largely taken from the species descriptions of Pusey *et al*. (2004). Yellow shading indicates persistence in this area is uncertain. Orange shading indicates translocated to that area, green shading indicates endemic to the catchment and red shading indicates exotic to Australia.

| species | family | observed | | movement | notes |
|---|---|---|---|---|---|
| | | upper | lower | | |
| **Above and Below Falls** | | | | | |
| ***Anguilla reinhardtii*** | **Anguillidae** | x | x | Catadromous, spawning in the Coral Sea | Declining numbers upstream |
| ***Craterocephalus stercusmuscarum*** | **Atherinidae** | x | x | Short-range movements most likely | Uncommon in more turbid areas. Upstream recolonisation when elevated discharge cues |
| ***Ambassis agassizii*** | **Chandidae** | x | x | Limited although observed to recolonise newly inundated reaches | |
| ***Nematalosa erebi*** | **Clupeidae** | x | x | Unknown but make substantial movements | All fish present in upper were also present in upper tributaries |
| ***Oxyeleotris lineolatus*** | **Eleotridae** | x | x | Juveniles disperse from the natal habitat. Upstream movements by adults during warmer months | Present in lower catchment prior to 1976 likely due to translocation in 1880s, absent from tributaries |
| ***Melanotaenia splendida*** | **Melanotaenidae** | x | x | Unknown, little gene flow whilst lowland populations probably use floodplains | Small-bodied species unable to move readily upstream or downstream in high currents |
| ***Neosilurus mollespiculum*** | **Plotosidae** | x | x | Makes mass upstream movements during high flow events | Few in lower reaches. Appears dependant on access to tributaries |
| ***Neosilurus hyrtlii*** | **Plotosidae** | x | x | Makes mass upstream movements during high flow events | |
| ***Neosilurus ater*** | **Plotosidae** | x | x | Makes mass upstream movements during high flow events | Presence upstream likely due to translocation |
| ***Porochilus rendahli*** | **Plotosidae** | x | x | Known to migrate to lowland muddy areas for spawning in some catchments | |
| ***Tandanus tandanus*** | **Plotosidae** | x | x | Unknown | Has been observed to be able to use fishways |
| ***Leiopotherapon unicolor*** | **Therapontidae** | x | x | Upstream migrations made by juveniles and subadults and able to disperse through overland flow | Floods important for dispersal |
| ***Amniataba percoides*** | **Therapontidae** | x | x | Upstream migrations made by juveniles and subadults | Has been stocked in upper catchments of Burdekin drainage basin and elsewhere in QLD |
| ***Hephaestus fuliginosus*** | **Therapontidae** | x | x | Upstream and downstream migrations to areas of suitable habitat, including tributaries | |
| ***Scortum parviceps*** | **Therapontidae** | x | x | Unknown | Mostly only found in fresh waters, does not tolerate higher salinities well |
| ***Toxotes chatereus*** | **Toxotidae** | x | x | Unknown | |
| ***Giurus margaritacea*** | **Eleotridae** | x | x | Movement upstream to spawning grounds and generally considered to have a marine larval phase | Territorial adults may restrict invasion by subadults. Has been observed to negotiate Clare Weir |
| ***Hypseleotris* sp.** | **Eleotridae** | x | x | Juveniles transported downstream to estuarine environments, followed by upstream movement by juveniles | |
| ***Lates calcarifer*** | **Centropomidae** | x | x | Catadromous, seasonally migrates to estuarine and near shore areas to spawn | |
| **Below Falls Only** | | | | | |
| ***Anguilla obscura*** | **Anguillidae** | | x | Catadromous, spawning in the Coral Sea | |
| ***Glossamia aprion*** | **Apogonidae** | | x | Unknown | |
| ***Neorius graeffei*** | **Ariidae** | | x | Generally breeds in freshwater but males commonly migrate to estuaries to brood young | |
| ***Strongylura krefftii*** | **Belonidae** | | x | Unknown but likely to involve downstream movements by adults for spawning | Barriers to movement likely to impact on this species |

| species | family | observed | | movement | notes |
|---|---|---|---|---|---|
| | | upper | lower | | |
| ***Glossogobius giurus*** | **Gobiidae** | | x | Larvae require dispersal to marine environments and juveniles make return upstream | |
| ***Arramphus sclerolepis*** | **Hemiramphidae** | | x | Unknown. Able to complete lifecycle in freshwater or brackish water | Had been noted far upstream in the lowland reached in past. Sleepy cod outcompeting it |
| ***Megalops cyprinoides*** | **Megalopidae** | | x | Catadromous with adults and juvenile making upstream movements | |
| ***Gambusia holbrooki*** | **Poeciliidae** | | x | Unknown | |
| ***Pseudomugil signifer*** | **Pseudomugilidae** | | x | Probably limited, small-bodies species with patchy distribution within the catchment | Likely outcompeted by mosquitofish |
| ***Notesthes robusta*** | **Scorpaenidae** | | x | Downstream movements in winter, upstream movements recorded from July to November | |
| ***Mogurnda adspersa*** | **Eleotridae** | | x | Little recorded movement but is a widespread species | |
| ***Hypseleotris compressa*** | **Eleotridae** | | x | Juveniles transported downstream to estuarine environments, upstream movement by juveniles | |
| **Above Falls Only** | | | | | |
| ***Craterocephalus marjoriae*** | **Atherinidae** | x | | Limited | Has not been observed to use fishways or tidal barrages |
| ***Hypseleotris klunzingeri*** | **Eleotridae** | x | | Unknown, have been observed to use fishways | Possible confusion with juvenile *H. compressa* in some collections. Likely to have been translocated into upper catchment |
| ***Phylipnodon grandiceps*** | **Eleotridae** | x | | Unknown | Largely a freshwater species but has been recorded from tidal waters |
| ***Macquaria ambigua*** | **Percichthyidae** | x | | Upstream freshwater spawning migration | Population in the Burdekin due to escape from aquaculture facility / translocation |
| ***Maccullochella peeli*** | **Percichthyidae** | x | | Little movement recorded with high fidelity to home snags and waterholes | Translocated a long time ago, but no longer stocked |
| ***Bidyanus bidyanus*** | **Terpontidae** | x | | Unknown | |
| ***Melanotaenia*** **sp. Running River** | **Melanotaenidae** | x | | Little recorded movement | |
| ***Mogurdna*** **sp. "burdekin"** | **Eleotridae** | x | | Little recorded movement | |
| ***Mogurnda clivicola*** | **Eleotridae** | x | | Little recorded movement | |

# 3.CONCLUSION

- It is uncertain to what extent fish may have naturally migrated upstream or downstream past the Burdekin Falls, because of a lack of records of movement before the installation of the Clare Weir and the Burdekin Falls Dam.
- The natural distribution of fishes in the catchment is further obscured by a long history of poorly recorded fish translocations
- In any current assessment of historic, natural fish passage past the Falls in either direction, emphasis must be placed on genetic similarities between populations above and below the falls as an indicator of past gene flows. This is due to the substantial knowledge gaps in the available literature.

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# APPENDIX 2 – GENETIC REVIEW BY PETER UNMACK, CANBERRA UNIVERSITY

The Burdekin system has an unusually complex biogeographic history, quite likely due to the impact that Burdekin Falls had on the ease on which fish could move between the lower and upper reaches. Most river systems in Australia tend to have a single genetic type or closely related group of haplotypes. In a few cases multiple lineages within a species may be present within a river system, but this is generally rare and often limited to one or two species out of the total fish biota found within a river system. The Burdekin River stands out as one of the best examples where this is not the case. Of the species genetically examined from the lower vs upper reaches (separated by Burdekin Falls historically, but by the Burdekin Falls Dam today) almost all of them have differences. In some cases these are relatively small, in other cases larger genetic divergences are present. Part of this is due to mixing of the fish biota between adjacent river systems. The biota of the Cooper Creek drainage from the Lake Eyre Basin have clearly mixed a lot with those of the Burdekin (especially the Belyando sub-basin). In many cases it appears that these exchanges have been in both directions between these rivers. In other cases there have mixes from Gulf rivers (at least in Rainbowfishes) and with the Herbert River to the north. In most cases there are very "shallow" drainage divides, meaning with little elevational difference between the watersheds which could facilitate movement between river basins during especially wet period which allow fishes to disperse via overland flows. In contrast, much of the biota of the lower Burdekin is always closely related to populations from surrounding coastal river basins. Thus the upper system has been influenced by interactions with adjacent river basins across drainage divides while the lower system has mostly been influenced by connections between river basins with adjacent river mouths which would facilitate movement during low sea level periods or during major flooding of the relatively flat coastal plain.

It must be noted that most of these observations are based on fairly limited genetic data, meaning often only 2-5 populations have been examined, and often with only 2 individuals per population. Clearly more work is needed to solidify the patterns. However, in many cases the preliminary data tends to stand up to a reasonable extent, with greater sampling better able to detect the genetic mixing of populations that are closer to the barrier separating the upper and lower portions of the Burdekin system.

Here we provide a short species by species (or by groups of species) summary based on diadromous fishes, those restricted to the lower Burdekin and those found across the Burdekin system.

## Diadromous (some obligate or facultative marine phase) species

These species have either obligate or facultative life history stages that use salt water environments as part of their life cycle. Only the long-finned eels have been found above Burdekin Falls, but they are well known to be able to easily pass barriers.

*Anguilla obscura*
*Anguilla reinhardtii*
*Neoarius graeffei*
*Arrhamphus sclerolepis*
*Strongylura krefftii*
*Megalops cyprinoides*
*Lates calcarifer*
*Giurus margaritacea*
*Hypseleotris compressa*
*Glossogobius giuris*

## Obligate freshwater species

### Species found only below the Falls

At least 5 species appear to have only been native below Burdekin Falls

*Tandanus tandanus*

Recorded as being introduced in the Burdekin above Burdekin Falls, and it is unclear whether fish in the lower Burdekin are native or introduced.

*Pseudomugil signifer*

Only been recorded from the upper reaches of the Broken River near Eungella. This is a tributary of the Bowen River, which in turn is a tributary of the lower Burdekin River.

*Glossamia aprion*

Only one population from near Ayr has been examined. It was closely related to other nearby coastal populations.

*Mogurnda adspersa*

"True" *Mogurnda adspersa* have only genetically assessed from the upper reaches of the Broken River near Eungella [although a coastal population near Ayr is known to also exist]. Other *Mogurnda* populations are discussed below.

*Oxyeleotris lineolata*

Recorded as being introduced in the Burdekin above Burdekin Falls, unclear whether fish in the lower Burdekin are native or introduced.

## Native species found above and below Burdekin Falls

*Nematalosa erebi*
*Neosilurus ater*
*Neosilurus hyrtlii*
*Neosilurus mollespiculum*
*Porochilus rendahli*
*Toxotes chatareus*
*Amniataba percoides*
*Hephaestus fuliginosus*
*Leiopotherapon unicolor*
*Scortum parviceps*

Little if any information exists on genetic patterns in these species within the Burdekin system. For one, *Hephaestus fuliginosus* there have been multiple introductions which likely make determining their natural distinctiveness impossible.

*Craterocephalus stercusmuscarum*

We examined one population above and below Lake Dalrymple. These had slight difference between them, but were based on only a couple fish from each of two sites. The upper population was very closely related to fish from the Cooper Creek system.

*Melanotaenia splendida*
*Melanotaenia* sp. "Running River"

Rainbowfishes in the Burdekin system have very complex patterns with biogeographic connections and transfers between almost all surrounding river basins into the Burdekin system. Populations of *Melanotaenia splendida* near Ayr are related to nearby populations from other coastal rivers. Above Lake Dalrymple there are a series of distinct forms which we've referred to as the Running River Rainbowfish and the Burdekin Rainbowfish, with the former considered to be a different species, while Burdekin Rainbowfish represent a mix between Running River Rainbowfish and *M. splendida*. Most populations of rainbowfish above Lake Dalrymple have a mix of Running River types and *M. splendida*.

*Ambassis agassizii*

This species likely has quite complex patterns with the Burdekin system. Below Lake Dalrymple the one sampled population was related to other lowland populations to the north. Populations above appear to mixed between Lake Eyre Basin fish (e.g., Cooper Creek) and those from the Lower Burdekin.

*Hypseleotris klunzingeri*

Currently only known from Lake Dalrymple where it is common. That population is fairly closely related to the Fitzroy River populations. Based on the genetic results they tentatively appear to be native.

*Hypseleotris* sp. Midgley

Widespread and common throughout the Burdekin system. Two deeper lineages are present, plus two shallow lineages within one of the deeper lineages. The first deeper lineage contains animals from the lower Burdekin (near Ayr) which are most closely related to other surrounding coastal populations to the north and south. The second deeper lineage is found from Lake Dalrymple and upstream. Two shallow lineages are present, animals from the upper Belyando are closely related to those from the adjacent Cooper Creek system. The second shallow lineage is more closely related to animals from the Herbert River, these include animals from the Basalt and Keelbottom rivers. Of the two examined from Lake Dalrymple one had the "Cooper" lineage, the other had the "Herbert" lineage.

*Mogurnda clivicola*
*Mogurnda* sp. "Burdekin"

We have examined a small number of animals from ~15 locations from above Burdekin Falls Dam. Fish from upper Belyando River were *M. clivicola*, otherwise only known from 3 disjunct populations within the Lake Eyre Basin (including the adjacent Cooper Creek). Most populations examined in Burdekin River and it's tributaries above Lake Dalrymple had a Burdekin specific endemic species with the exception of upper Running River near Paluma which had a fish related to nearby coastal populations of "*M. adspersa*" (the taxonomy of *M. adspersa* will change in the future as there are clearly several species within *M. adspersa*).

## Divergence times

I've crudely estimated divergence times between populations from the lower vs upper Burdekin system based on their degree of genetic divergence, but these dates should not be taken literally, but in a relative manner. Essentially, if populations are the same, or only differ by one or two base pairs of mitochondrial data they are almost certainly had some gene flow within the last ~100,000 years, but if they differ by 1-2% sequence divergence then they are closer to the million year scale of separation.

*Craterocephalus stercusmuscarum*

Seven base pairs of divergence, thus ~200-400,000 years

*Melanotaenia splendida*
*Melanotaenia* sp. "Running River"

*Melanotaenia splendida* has shared haplotypes above and below, thus there has been recent gene flow from downstream most likely, but some upstream rainbowfish populations have maintained distinctive populations and resisted gene flow from *M. splendida*. Difficult to age estimate as there has been past mixing (introgression).

*Ambassis agassizii*

Separate species are present, estimated at 2-4 million years divergence. But as noted above, some mixing has occurred, but difficult to estimate the timing/age of that mixing.

*Hypseleotris klunzingeri*

Only one base pair of divergence between Burdekin and Fitzroy populations, should be within the last 100,000 years.

*Hypseleotris* sp. Midgley

These are 1-2% divergent for cytochrome b (a mitochondrial gene) which would put their divergence at roughly 500,000 to a million years.

*Mogurnda clivicola*
*Mogurnda* sp. "Burdekin"

We haven't sampled the same genes for *Mogurnda* as the other groups which makes age estimates a bit more difficult, plus we've only done limited mitochondrial DNA too. These are sister species, but both are substantially different to *M. adspersa*, at least a million or few million years of divergence.

# Appendix C Macroinvertebrate Taxa List November-December 2018 and June 2019

Table C.1 Macroinvertebrate Taxa List November-December 2018 and June 2019.

| SITE | HABITAT | GROUP | Acarina | Araneae | Bivalvia | Bivalvia | Bivalvia | Bivalvia | Branchiura | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Decapoda | Decapoda | Decapoda | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Ephemeroptera | Ephemeroptera | Ephemeroptera |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FAMILY | Acarina | Araneae | Bivalvia | Corbiculidae | Hyriidae | Sphaeriidae | Argulidae | Carabidae | Chrysomelidae | Curculionidae | Dytiscidae | Elmidae | Gyrinidae | Hydraenidae | Hydrochidae | Hydrophilidae | Limnichidae | Noteridae | Psephenidae | Scirtidae | Staphylinidae | Decapoda | Atyidae | Palaemonidae | Diptera | Ceratopogonidae | Chaoboridae | Chironomidae | s-f Chironominae | Culicidae | Ephydridae | s-f Orthocladiinae | Simuliidae | Tabanidae | s-f Tanypodinae | Tipulidae | Baetidae | Caenidae | Leptophlebiidae |
| **June 2019** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BUD2 | EDGE | | – | ✓ | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | – | – | – | – | ✓ | ✓ | – | ✓ | ✓ | – |
| BUD2 | BED | | – | – | – | ✓ | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | ✓ | – | ✓ | – | – | – | – | – | ✓ | – | – | ✓ | – | – | ✓ | – |
| UBR2 | EDGE | | – | – | – | ✓ | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | ✓ | ✓ | – | ✓ | – | – | ✓ | – | ✓ | ✓ | – | ✓ | ✓ | – | ✓ | ✓ | – |
| UBR2 | BED | | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | ✓ | – | – | ✓ | ✓ | – |
| UBR2 | RIFFLE | | ✓ | – | – | ✓ | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | ✓ | – | – | – | – | ✓ | – | – | – | – | ✓ | – | ✓ | ✓ | ✓ | – | ✓ | – | ✓ | ✓ | ✓ | ✓ |
| CAP2A | EDGE | | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | – | – | ✓ | ✓ | – | – | ✓ | – |
| CAP2A | BED | | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | – | – | – | ✓ | – | – | ✓ | – |
| CAP2A | RIFFLE | | – | – | – | – | – | – | – | – | – | – | – | ✓ | ✓ | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | – |
| LBR1A | EDGE | | – | – | – | ✓ | ✓ | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | – | – | – | – | ✓ | – | – | – | – | – |
| LBR1A | BED | | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | ✓ | – | – | – | – | – | ✓ | – | – | – | – | – | ✓ | – | – | ✓ | – |
| GW | EDGE | | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | ✓ | ✓ | ✓ | – | ✓ | – | – | ✓ | – | – | – | – | – | ✓ | ✓ | ✓ | – | – |
| GW | BED | | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | ✓ | – | – | – | – | – | – |
| GW | RIFFLE | | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | ✓ | – | – | – | – | – | – |
| SEH2 | EDGE | | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | ✓ | ✓ | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | ✓ | ✓ | – | ✓ | ✓ | – |
| SEH2 | BED | | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | – | – | ✓ | ✓ | – | – | ✓ | – |
| SEH2 | RIFFLE | | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | – | ✓ | ✓ | ✓ | ✓ | – |
| SEH1 | EDGE | | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | ✓ | ✓ | – | – | ✓ | – | – | – | – | – | ✓ | – | – | – | – | – |
| SEH1 | BED | | ✓ | ✓ | – | – | – | – | ✓ | – | – | – | ✓ | – | – | – | – | ✓ | – | – | – | – | – | – | ✓ | ✓ | – | – | ✓ | – | ✓ | – | – | ✓ | – | – | ✓ | – | ✓ | ✓ | – |
| BUD3 | EDGE | | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | – | – | – | ✓ | – | – | – | – |
| BUD3 | BED | | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | ✓ | ✓ | – | – | – | – | – | ✓ | – | ✓ | – | – |
| SUT1 | EDGE | | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | ✓ | ✓ | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | – | ✓ | ✓ | – | – | – | – | ✓ | – | ✓ | ✓ | – |
| SUT1 | BED | | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | ✓ | – | ✓ | – | – |
| SUT2A | EDGE | | ✓ | ✓ | – | – | – | – | – | – | ✓ | ✓ | ✓ | – | – | ✓ | ✓ | ✓ | – | – | – | – | ✓ | – | – | – | – | ✓ | – | – | ✓ | – | – | – | – | – | ✓ | – | ✓ | – | – |
| SUT2A | BED | | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | ✓ | – | – | – | – | – | – | – | ✓ | ✓ | – | ✓ | – | – | ✓ | – | – | ✓ | – | ✓ | – | – |

| SITE | HABITAT | GROUP | Acarina | Araneae | Bivalvia | Bivalvia | Bivalvia | Bivalvia | Branchiura | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Coleoptera | Decapoda | Decapoda | Decapoda | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Diptera | Ephemeroptera | Ephemeroptera | Ephemeroptera |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FAMILY | Acarina | Araneae | Bivalvia | Corbiculidae | Hyriidae | Sphaeriidae | Argulidae | Carabidae | Chrysomelidae | Curculionidae | Dytiscidae | Elmidae | Gyrinidae | Hydraenidae | Hydrochidae | Hydrophilidae | Limnichidae | Noteridae | Psephenidae | Scirtidae | Staphylinidae | Decapoda | Atyidae | Palaemonidae | Diptera | Ceratopogonidae | Chaoboridae | Chironomidae | s-f Chironominae | Culicidae | Ephydridae | s-f Orthocladiinae | Simuliidae | Tabanidae | s-f Tanypodinae | Tipulidae | Baetidae | Caenidae | Leptophlebiidae |
| **November-December 2018** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BUD2 | Edge | | ✓ | – | ✓ | ✓ | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | – | – | ✓ | ✓ | – | – | – | – |
| BUD1 | Edge | | ✓ | – | ✓ | ✓ | ✓ | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | ✓ | ✓ | – |
| BUD1 | Macrophyte | | ✓ | – | ✓ | ✓ | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | – | ✓ | – | – | ✓ | – |

Table C.2 Macroinvertebrate Taxa List November-December 2018 and June 2019 (cont.).

| SITE | HABITAT | GROUP | Gastropoda | Gastropoda | Gastropoda | Gastropoda | Gastropoda | Gastropoda | Hemiptera | Hemiptera | Hemiptera | Hemiptera | Hemiptera | Hemiptera | Hemiptera | Hemiptera | Hemiptera | Hemiptera | Isopoda | Lepidoptera | Nematoda | Odonata | Odonata | Odonata | Odonata | Odonata | Odonata | Odonata | Odonata | Odonata | Odonata | Trichoptera | Trichoptera | Trichoptera | Trichoptera | Trichoptera | Trichoptera | Trichoptera | OTHER | Cladocera | Copepoda | Ostracoda |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FAMILY | Ancylidae | Bithyniidae | Hydrobiidae | Physidae | Planorbidae | Thiaridae | Hemiptera | Corixidae | Gerridae | Mesoveliidae | Nepidae | Notonectidae | Pleidae | Veliidae | Corallanidae | Crambidae | Nematoda | Coenagrionidae | Cordulephyidae | Cordulidae | Gomphidae | Isostictidae | Libellulidae | Lindeniidae | S.O. | S.O. Zygoptera | Oligochaeta | Trichoptera | Calamoceratida | Ecnomidae | Hydropsychidae | Hydroptilidae | Leptoceridae | Philopotamidae | OTHER | Cladocera | Copepoda | Ostracoda |
| **June 2019** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BUD2 | EDGE | | – | – | – | – | ✓ | ✓ | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | ✓ | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | – | – | – | – |
| BUD2 | BED | | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | ✓ | – | – | ✓ | – | – | – | – | – | – | – | – | – |
| UBR2 | EDGE | | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | ✓ | – | – | – | ✓ | – | – | – | ✓ | – | ✓ | – | – | – | – | – | – |
| UBR2 | BED | | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | ✓ | – | – | – | – | – | – | – | – |
| UBR2 | RIFFLE | | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | ✓ | – | ✓ | – | ✓ | – | – | – | – | – | ✓ | – | ✓ | ✓ | – | – | – | – | – |
| CAP2A | EDGE | | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | ✓ | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ✓ | – | – | – | – | – | – |
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