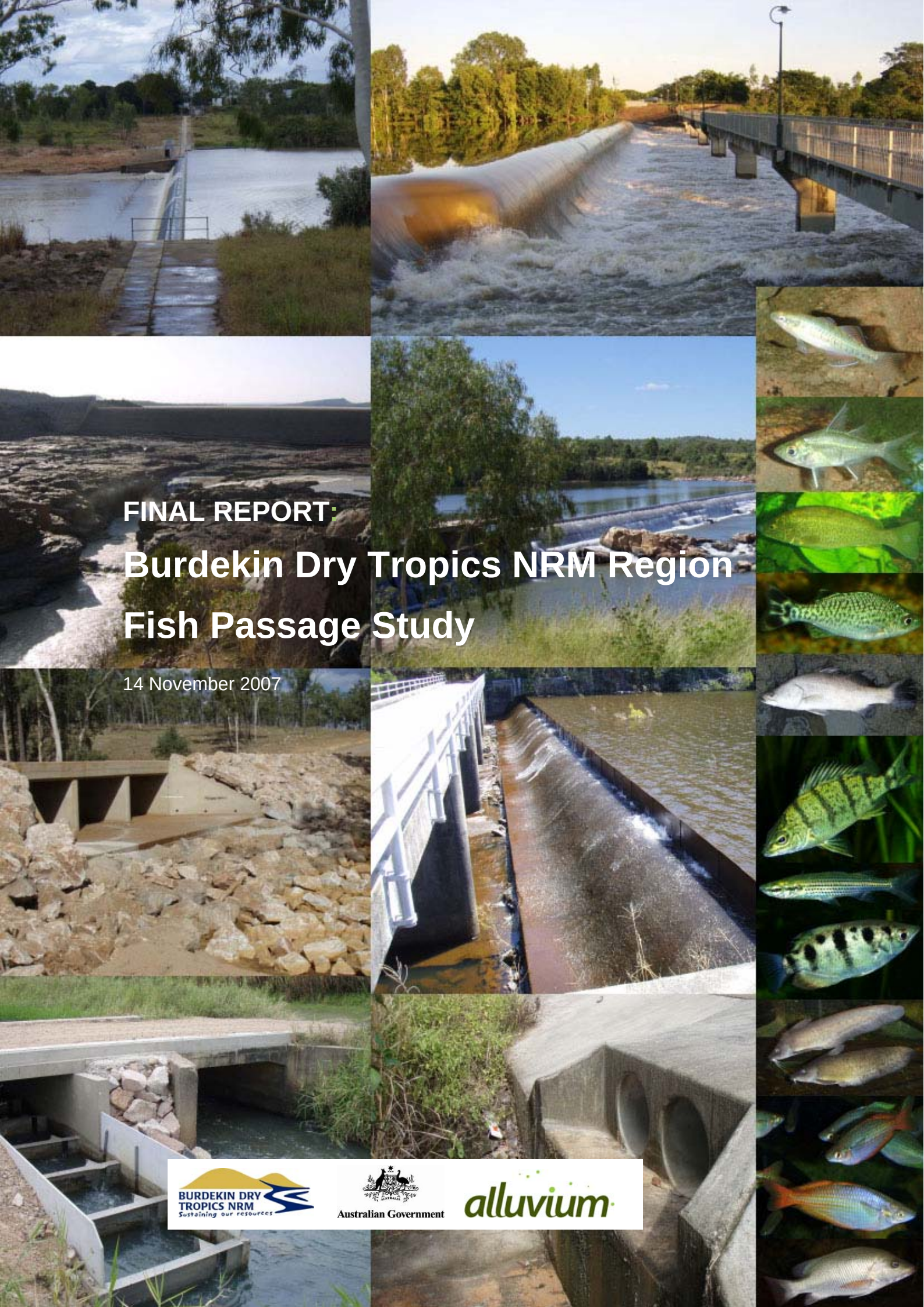


FINAL REPORT:

Burdekin Dry Tropics NRM Region Fish Passage Study

14 November 2007

BURDEKIN DRY TROPICS NRM
Sustaining our resources

Australian Government

alluvium

Document history

L:\Projects\2007\P207009_Fish_Passage_Study\1_Deliverables\BDTNRM_Fish_Passage_Study_Final_Report_V03.doc

REVISION

ISSUE DATE	VERSION NO.	AUTHOR(S)	CHECKED	APPROVED
November 2007	V03	Jason Carter, Jim Tait, Ross Kapitzke, Jamie Corfield	S Carter	R Lucas

DISTRIBUTION

VERSION NO.	ISSUED TO	DESCRIPTION
V01	Diana O'Donnell	Project Manager – Burdekin Solutions

Acknowledgments

The project team wish to acknowledge the assistance of the following people and organisations that have helped with the development and delivery of this study.

Organisation	People
Burdekin Dry Tropics NRM	David Reid
	Diana O'Donnell
	Doug Willis
	Jenni Edmunds
	Deb Cavanagh
Main Roads	Maxine Maguire
Queensland Rail	Mathew Fry
Sunwater	Jason Williams
NQ Water	Rob Hunt
North Burdekin Water Board	Andrew Kelly & Tino Molino
South Burdekin Water Board	Bill Lowis & Charlie Papale
Department of Defence	Alan McManus

A special thank you is warranted for the following expert reviewers who have provided valuable input including sources of information, review of drafts and provision of editorial comments.

Organisation	People
Australian Centre for Tropical Freshwater Research	Alan Webb
	Leo Lymburner
	Vern Veitch
	Damien Burrows
Department of Primary Industries and Fisheries	Tim Marsden
	Alf Hogan
	Malcolm Pearce
James Cook University	Dr Marcus Sheaves

Thanks also to the individuals and the following organisations that attended public meetings to provide information about potential fish barriers in their area. Your information, advice and comments were all valuable.

Bowen River Stocking Association	Department of Natural Resources and Water
Burdekin Shire Council	Department of Primary Industries and Fisheries
Charters Towers City Council	Ecowise Environmental
Charters Towers Fish Stocking Association	James Cook University
Conservation Volunteers Australia	South Burdekin Water Board
Dalrymple Landcare Committee	Twin Cities Fish Stocking Association
Department of Main Roads	Xstrata Coal

Contents

List of tables

List of figures

1 Executive Summary

1.1 Project Aims

This project has been commissioned by Burdekin Dry Tropics Natural Resource Management (BDTNRM) to help to achieve Management Action Target SWW2.2.1 of the Burdekin Dry Tropics (BDT) regional Natural Resources Management (NRM) Plan which states:

"By 2010, identify all fish passage barriers and prioritise which should be removed/improved and undertake work."

And the following Management Action:

"Identify all fish passage barriers and prioritise which should be removed/improved and undertake to gain agreement from the necessary parties involved to have them removed or where practical redesigned."

The project's three key components are:

- Development of a fish barrier assessment methodology;
- Collection of data and assessment of barriers based on the agreed methodology; and
- Prioritisation of fish barriers for removal or modification.

Objectives and scope

The study's key objectives are:

- To identify, map and collate relevant information on as many potential fish passage barriers as practical and identify the most ecologically significant fish barriers in the BDTNRM Region;
- To examine the feasibility and risks associated with a removal or modification program for priority fish barriers;
- To determine the efficacy of removal or modification of the priority barriers for the protection of native fish species within their natural range; and
- To prioritise fish barriers for removal or modification and to establish planning level cost estimates.

1.2 Results and Conclusions

The study area

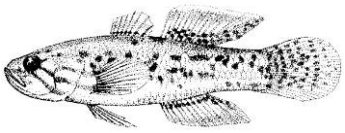
The study covered the BDTNRM region, which is comprised principally of the sub-basins of the Black, Ross, Haughton, Burdekin and Don Rivers.

Freshwater fish species

The study has taken a broad view of which species can be considered as freshwater fish. Some species could be argued to be marine, non-dependent on freshwater habitats and as only spending a limited time in freshwater. Nevertheless we have taken a functional ecological view that the species listed are recorded frequently enough in freshwater habitats to be considered part of the BDTNRM freshwater fish community.

A total of 76 species are identified in literature and other information sources. Of those, 58 are Australian species. Three of these are believed to have been misidentified (leather grunter, *Scortum hillii*, triangular shield catfish, *Arius leptaspis* and the firetailed gudgeon, *Hypseleotris galii*) and are not included in the study assessments. Of the remaining 55 Australian species two

are considered to have been introduced from other river basins (yellowbelly, *Macquaria ambigua* and eel-tailed catfish, *Tandanus tandanus*). In addition there are 17 exotic species listed most of which have been introduced into the Ross River. Among these, the highly invasive tilapia is now found in the Ross River basin, Black River basin and in the upper Burdekin River, where it continues to spread. Of the 53 species that naturally occurred in the region prior to European settlement, a number have since been translocated within the region mostly for recreational fishing. Species that are now found outside their natural range include sleepy cod, *Oxyeleotris lineolatus*, barramundi, *Lates calcarifer* and sooty grunter, *Hephaestrus fuliginosus*.



Purple-spotted gudgeon
Mogurnda adspersa

A number of species have had their natural range reduced due in some cases to land use changes but primarily due to barriers to their movement for breeding and dispersal.

Types and numbers of barriers to fish passage

The various barrier types across the region that were considered in this study are:

- Natural barrier (waterfalls)
- Dams
- Weirs
- Sand dams / crossings
- Tidal intrusion barrages – ponded pasture bunds
- Weed / macrophyte choked reaches
- Road and rail crossings (culverts, causeways and fords)
- Other instream structures (e.g. Water Board control gates).

Clare Weir

The method used to identify and assess these potential barriers consisted of:

- literature review;
- examination of topographic mapping and field identification;
- stakeholder advice on barrier location and characteristics;
- compilation of data in a Geographic Information System (GIS); and
- development of a GIS tool to assist with the identification of priority barriers.

There are thousands of potential barriers throughout the region and it was not possible with available resources to assess them all in the field. Therefore, to enable rationalisation of those thousands into a manageable number in a priority order, a two-stage process was developed:

1: Desktop assessment: This was a GIS based assessment that identified all known potential barriers numbering over 12,000. By filtering those on small streams, track crossings and known bridges this number was reduced to just over 1,000 to be reviewed in more detail and high priority ones assessed in the field.

Potentially significant barriers were then rated using a number of attributes for the barrier sites established from the available data. An emphasis was placed on barrier significance (barrier type and degree of obstruction to fish migration), habitat values, and other ecological attributes including: species diversity; conservation values; if other barriers exist downstream; length and condition of upstream habitat that would become accessible; and fish movement requirements (criteria are listed below and detailed in Appendix 3, section 3.3).

2: Following consultation on the Draft Report a further review of priority barriers was undertaken through field assessment, consultation with the community and Expert Panel

review. Additional attributes were also considered when reviewing the priority order. This included such attributes as cost, feasibility, effectiveness of modifications and community support.

Field assessments and community input proved some not to be barriers. The type and locations of the 1,047 potential barriers are summarised by sub-basin in Table E1.

Table E1: Total number of identified potential barriers by type

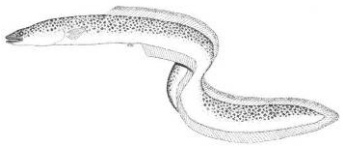
	Number of potential barriers identified by Sub basin					
Barrier Type	**Burdekin River**	**Black River**	**Ross River**	**Haughton River**	**Don River**	**TOTAL**
Natural barrier (waterfalls)	10		1			11
Dams	114		2		3	119
Weirs	5	1	4	2		12
Sand dams / crossings	10#				1	11
Tidal intrusion barrages – ponded pasture bunds	4		1	38	6	49
Weed / macrophyte choked reaches				23	2	25
Road and rail crossings (culverts and fords)	704	8	25	49	34	820
TOTAL	847	9	33	112	46	1,047

The sand dams on the Burdekin River were assessed in part in the field and in part through discussion with staff from the North Burdekin and South Burdekin Water Boards, Sunwater and Department of Primary Industries and Fisheries. At the time of preparing this report a code of practice for the management of flows past the sand dams was being developed jointly between Sunwater, the North and South Burdekin Water Boards and the Department of Natural Resources and Water. Taking these factors into consideration, only two of the sand dams (Rita Island and the rocks) have been identified as highly significant barriers worthy of further investigation and modification. The other sand dams all have low gradient bypass flow paths that are not considered to be barriers.

The total list of 1,047 potential barriers was assessed using a GIS based assessment process that identified the Stage 1 list of priority barriers on the basis of: fish values; habitat values and threats as follows:

FISH VALUES

- Conservation Significance
- Cultural Significance (still to be discussed with Traditional Owners)
- Fishery Significance
- Species movement requirements.



Longfinned eel
Anguilla reinhardti

HABITAT VALUES

- Upstream habitat quality (catchment condition as a surrogate for river condition)
- Stream order
- Position of barrier in the catchment

- Distance to next barrier upstream
- Uninterrupted stream length upstream
- Presence/absence of downstream barrier.

THREATS

- Barrier type significance (barrier type and degree of obstruction to fish migration).

After undertaking the Stage 1 assessment the top 50 priority barriers were then subject to further investigation as Stage 2. Consultation with experts, regional communities and organisations that have ownership of or management responsibility for barriers was an integral component of this study. Field inspections of selected Stage 1 priority barriers and consultation with stakeholders regarding potential barriers enabled a refining of the barrier list to: remove those that are not barriers (e.g. bridges); and add barriers that were not identified in the desktop review and draft report. From that process a final list of barriers in priority order was developed.

Two types of recommendations have been made:

- **general recommendations** (listed in numerical order 1 to 11) including: a list of priority barriers for remediation; to increase knowledge of fish species distribution throughout the region; to integrate fish barrier assessments and remediation as part of holistic river management planning in selected catchments; to manage GIS data compiled and created as part of this project; and to monitor and evaluate the success of barrier remediation. and
- **specific recommendations** (listed in alphabetical order A to CC) for each barrier as listed in Table E2.

1.3 Recommendations

Recommendation 1: Negotiations to modify or remove identified barriers should be undertaken in the order of priority identified by the project method, as shown in Table E2. Maps showing the location of these potential barriers are provided as Appendix 5.

Table E2: Top priority barriers for further investigation

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.
BAR10 Clare Weir	Burdekin River	1	Although a fish passage device (fish lift) is already installed on this structure its operation has been greatly restricted due to mechanical problems. The identification of this barrier as the highest priority is based on it being a major barrier on the lower reaches of the main stem of the regions main river channel, a habitat utilised by the broadest spectrum of migratory species. This significance reinforces: the need for the fish passage device; the need to reinstate an effective device and to maintain its operation as soon as possible both now and after every flow event that results in maintenance being required. **Recommendation 1A: Support and encourage Sunwater in efforts to repair and maintain Clare Weir fish lift.**	15 & 16

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.
BAR397 2 Sand Dams on Lower Burdekin River	Burdekin River	2 & 3	These non-permanent barriers have scored highly due to their position in the catchment and their potential to be seasonally significant barriers to many species. Field inspections and discussions with the Burdekin Water Boards have identified that two of the sand dams on the lower Burdekin River are potential barriers for extended periods of time and should be investigated in more detail. They are Rita Island and "the rocks". **Recommendation 1B: In cooperation with the Burdekin South and Burdekin North Water Boards, undertake further assessment and design, as appropriate, of fish passage options for Rita Island and "the rocks" sand dams.**	15
BAR16 Val Bird Weir	Haughton River	4	This major structure is known to be fully drowned out during large flow events but nevertheless has been demonstrated to be a major barrier to fish movement upstream resulting in the loss of catadromous species including Jungle Perch from protected National Park tributary catchments (i.e. Majors, Spring and Double Creeks). **Recommendation 1C: As a high priority, work in cooperation with Sunwater to investigate this structure for modification.**	7
BAR1054 Aplins Weir	Ross River	5	This weir ranks highly due to its position in the catchment and potential number of species that are affected. Whilst there are two additional weirs and the Ross Dam upstream, this weir is nevertheless considered to be worth modifying due to its location below a large perennial waterbody. The existing high levels of public recreational use and associated economic values and its high profile are also relevant rationales for promoting the value of fish passage devices at this site. **Recommendation 1D: Aplins weir should be investigated for modification. Options include vertical slot fishway, rock ramp fishway, fishlock and hydraulic lift.**	4
BAR1091 Track crossing	Stuart Creek	6	This raised track crossing with a pipe culvert has been identified as preventing the upstream movement of a range of fish species. Removal of this barrier would result in the mobilisation of sediment trapped upstream. This sediment would need to be removed before the culvert could be removed. **Recommendation 1E: Work with stakeholders to investigate for removal or modification.**	4

BAR12 Bowen River Weir	Bowen River	7	This weir has already been identified by SunWater as a priority for remediation for fish passage. This study supports the need for such modification. It is a major barrier on a large river that has high habitat values. **Recommendation 1F: Work in close cooperation with Sunwater and DPI&F to support the modification of Bowen River Weir including decommissioning of the existing damaged fish passage device and the design and construction of a new functional device.**	26
BAR15 Giru Weir	Haughton River	8	This major structure is also known to be fully drowned out during large flow events but is nevertheless thought to be a partial barrier to fish movement upstream. The structure has existing structural features that help facilitate some fish passage under a range of flows and the cost of options for modifying this structure are likely to be an order of magnitude lower than those for Val Bird Weir (see barrier rank 5) and may be justified for servicing the upstream reach irrespective of a fish passage device being fitted to Val Bird Weir. **Recommendation 1G: As a high priority, work in cooperation with Sunwater to investigate this structure for modification.**	7
BAR17 Alligator Creek Weir	Alligator Creek	9	This weir requires investigation to determine its effect as a barrier and options for installation of a fish passage device. Known to flood completely out on higher flows, it is exposed on non-peak flows and anecdotal reports suggest that populations of catadromous species in the system, i.e. barramundi have been impacted by its presence. **Recommendation 1H: Work with landholder to discuss this structure and seek cooperation to further investigate its significance as a barrier and options for modification.**	6
BAR20 BAR23 BAR25 BAR28 BAR62 BAR539 BAR1033 BAR1038 Road and rail crossings, earth bunds and	Sheepstation Creek system	10	Sheepstation Creek has been identified as a priority. There are a number of potential barriers on this system, which have been grouped together for a holistic assessment. The most effective approach to managing this and other barriers on the system is to work in cooperation with landholders, the North Burdekin Water Board and other stakeholders to examine options and an agreed order for the modification of barriers starting at the downstream end of the system and working progressively upstream. **See general recommendation 3: Work in co-operation with North Burdekin Water Board and Burdekin Shire Council and other stakeholders to**	9

weed chokes			**further investigate Sheepstation Creek.** **Recommendation 1I: Undertake wet season sampling of water quality (particularly dissolved oxygen) and fish movement above and below downstream barriers to determine the effect of weed chokes on water quality and fish movement.** **Recommendation 1J: Undertake wet season investigation of flow paths and use of floodplain distributaries for fish movement in the lower Sheepstation Creek to determine the most appropriate barrier modification strategy.**	
BAR1040 BAR871 BAR870 BAR869 Road crossings, earth bunds and weed choke	Saltwater Creek system (including lower Burdekin tributaries to the north, Merryplain Creek and MacDonald Creek)	11	Road crossings, earth bunds and weed chokes on the Saltwater Creek system (and lower Burdekin tributaries to the north, Merryplain Creek and MacDonald Creek), which are used by South Burdekin Water Board as part of their irrigation infrastructure network. **See general recommendation 3: Work in cooperation with South Burdekin Water Board and Burdekin Shire Council to examine this whole system and develop a holistic management plan.**	11
BAR53 BAR1075 BAR1076 Earth bunds, Weed chokes and road and rail crossings	Plantation Creek tributary	12	Plantation Creek has been identified as a priority. There are a number of potential barriers on this system, which have been grouped together for a holistic assessment. As with Sheepstation Creek, the most effective approach to managing this and other barriers on the system is to work in cooperation with landholders, the North Burdekin Water Board and other stakeholders to examine options and an agreed order for the modification of barriers starting at the downstream end of the system and working progressively upstream. **See general recommendation 3: Work in cooperation with North Burdekin Water Board, landholders, Burdekin Shire Council and other stakeholders to further investigate barriers on Plantation Creek.** **Recommendation 1K: Undertake wet season sampling of water quality (particularly dissolved oxygen) and fish movement above and below downstream barriers to determine the effect of weed chokes on water quality and fish movement.**	9
BAR9 Charters Towers Weir	Burdekin River	13	This barrier is the highest ranking barrier upstream from the Burdekin Falls Dam. Its position on the main channel and the extended periods of flow when it presents a complete barrier make it worthy of investigation. Whilst it is recognised that it is fully	17A

			drowned out in high flows, the number and diversity of potadromous species of fish that may move on non-peak flows when this is a complete barrier is potentially significant. **Recommendation 1L: In cooperation with DPI&F, this structure should be investigated for modification.**	
BAR1068 Burdekin Falls Dam	Burdekin River	14	The Falls Dam is a major barrier to upstream movement but is located on a natural historical fish passage barrier the Burdekin Falls. However, the dam structure has been identified to be a significant barrier to eels which historically migrated past the falls to upper catchment areas in large numbers. Eel species have high ecological (top order predators), and fishery values and are currently greatly restricted in their upstream movement by the dam wall. **Recommendation 1M: Investigate options to facilitate eel movement. This may be transport of elvers and adults from the base of the dam over the wall or possibly, low tech structural works to enable eels to negotiate the wall.**	16 & 17A
BAR11 Gorge Weir	Burdekin River	15	This weir has been recently reactivated operationally to supply water for the Moranbah pipeline. At 8 metres high it represents a significant barrier for the Burdekin River and tributaries upstream to Burdekin falls. Its ranking lower than other major weirs is a reflection of the relatively high position it occupies in its catchment and fewer fish species that are affected by it. **Recommendation 1N: This structure should be investigated for modification but the expected high cost of modification is likely to relegate this barrier to a lower implementation priority.**	16
BAR828 Road crossing	Kirknie Creek	16	This raised crossing with box culverts is a potential barrier. **Recommendation 10: requires further investigation and discussion with stakeholders to examine feasibility of modification.**	16
BAR64 BAR61 BAR19 Earth Bunds	Barramundi Creek tributary	17	Barramundi Creek has been identified as a priority. There are a number of potential barriers on this system, which have been grouped together for a holistic assessment. Barriers BAR64, BAR61 & BAR19 are earth bunds, which are known to flood out under a broad range of flows. Catadromous species have been recorded immediately above structure. **Recommendation 1P: The Landholder is interested in modifying this barrier and should be supported subject to appropriate assessment.**	7

BAR 1092 Farm track and BAR1078 weed choke			Barriers BAR1092 & BAR1078 are a farm track and a weed choke downstream from Horseshoe Lagoon and are known to be preventing the movement of catadromous species into the Lagoon. **Recommendation 1Q: support investigations into the modification of this crossing and removal of the weed choke.**	
BAR29 BAR1071 Earth Bunds	Alva Creek	18	This is a combination of earth bund and road crossing known locally as Alva Creek Dam. **Recommendation 1R: Work in cooperation with South Burdekin Water Board, Burdekin Shire Council and other stakeholders to discuss the feasibility of modifying this barrier.**	9
BAR1039 together with other identified and unidentified barriers on these systems. Identified barriers are BAR314 BAR58 BAR59 BAR535 BAR86 BAR87 weed chokes and road crossings	Cromarty Ck tributary network including Crooked, Ironbark and Palm Creek Catchments and Pink Lilly, Healys and Reed Bed Lagoons.	19	This adjoining group of catchments was not identified in draft assessments and reporting due to limited site barrier data. However, since the draft reporting stage, further assessment has been made of the significance of these systems as the major northern distributary drainage network of the lower Haughton River basin and the extent and quality of perennial floodplain lagoonal nursery and adult fishery habitat. That assessment (J Tait) underpins the nominated priority ranking of this site. Ironbark Creek also has a potential functional role as a natural connected bypass for the Val Bird Weir. **Recommendation 1S: Work in cooperation with Haughton Catchment Committee, Burdekin Shire Council, Sunwater, landholders and other stakeholders to undertake a holistic assessment of barriers within these sub catchment systems including the functional potential of Ironbark Creek as a Val Bird Weir bypass channel and prioritise remediation options.**	7
BAR54 Weir	Leichhardt Creek 1	20	This barrier is a concrete weir. It is in a state of partial disrepair and appears to be undermined, with flows under the weir that are preventing fish passage at lower flows. Whilst drowned out at high flows this barrier is nevertheless likely to be a significant barrier for extended periods. **Recommendation 1T: Work with stakeholders to investigate for modification.**	2
BAR7 Gleesons Weir	Ross River	21	Whilst this is one of four major structures on the Ross River it is nevertheless considered to be worth considering for modification due to its location below large perennial water bodies and social and economic values as per Barrier 1054, Aplins Weir, including its high profile and opportunity to promote the value of fish passage devices.	4

			Recommendation 1U: This structure should be investigated for modification only if Aplins Weir is modified.	
BAR6 Black Weir	Ross River	22	Whilst this is one of four major structures on the Ross River it is nevertheless considered to be worth considering for modification due to its location below a large perennial water body and social and economic values as per Barrier 1054, Aplins Weir, including its high profile and opportunity to promote the value of fish passage devices. **Recommendation 1V: This structure should be investigated for modification only if Aplins Weir and Gleesons Weir are modified.**	4
BAR1082 BAR1084 Earth bunds	Rita Island Distributaries	23	These earth bunds on the Rita Island distributary system may be outflanked and/or overtopped at relatively low flows. However, their impacts are currently unknown and warrant further investigation. **See general recommendation 3: Work in cooperation with stakeholders to examine this whole system, reassess its importance for fish passage and develop a holistic management plan if assessed as a priority.**	11
BAR1006 Collinsville Elphinstone Road	Hazelwood Creek becoming Little Bowen River	24	This crossing is a low level concrete causeway on a rock bar. The rock bar has a drop of approximately 2 metres on the downstream side of the crossing, which implies that the crossing is a minor barrier compared to the natural rock bar but may represent a barrier at low flows due the broad flat road surface. **Recommendation 1W: Undertake further field assessment as this site.** **See also general recommendation 5: That the field assessment of all road and rail crossings be undertaken to provide a high level of confidence in the ranking of these potential barriers.**	26
BAR563 Road crossing	Burdekin River	25	This road crossing has been identified as a potential barrier is requires further investigation. **Recommendation 1X: requires further investigation and discussion with stakeholders to examine need for and feasibility of modification.**	17A
BAR552 Tondara Road crossing	Bogie River	26	Raised road crossing that could be a significant barrier. **Recommendation 1Y: requires further investigation and consultation with stakeholders.**	16
BAR1009 Minor road crossing	Exe Creek	27	Raised road crossing that could be a significant barrier at low to medium flows. **Recommendation 1Z: requires further**	16

			investigation of this site and consultation with stakeholders.	
BAR1010 Collinsville Elphinstone Road crossing	Hazelwood Creek becoming Little Bowen River	28	Raised road crossing that could be a significant barrier at low flows. **Recommendation 1AA: requires further investigation and consultation with stakeholders.**	16
BAR1013 Minor Road crossing	Hazelwood Creek	29	Detail unknown. **Recommendation 1BB: requires further investigation.**	16
BAR8 Ross River Dam	Ross River	30	This major structure is not likely to be suitable for the installation of a fish passage device due to its height. However, facilitation of eel passage may be worthy of further investigation although eels are known to have been able to bypass the dam wall prior to recent modifications. **Recommendation 1CC: Worthy of further investigation post dam modifications to determine if eel movement is being prevented.**	4 & 5
BAR2 Eungella Dam	Broken River	31	This major structure is not likely to be suitable for the installation of a fish passage device due to its height. However, facilitation of eel passage may be worthy of further investigation subject to the findings of investigations for Burdekin Falls Dam. **Recommendation 1DD: Undertake further investigation subject to the findings of investigations for Burdekin Falls Dam.**	16

Recommendation 2: Further fish surveys should be undertaken for those catchments where limited data is currently available. Specifically:

- Don River basin – All catchments, with a focus on the Don River in both dry season and wet season. At the time of preparing this report survey data for this catchment had recently been collected by the Australian Centre for Tropical Freshwater Research (ACTFR) as part of the water for Bowen pre-feasibility assessment process but was not able to be released at the time. This recommendation may be revised when access to that data becomes available.
- Black River basin – all catchments. The very limited fish distribution data for these stream systems is particularly conspicuous considering the perennial nature of these streams and their proximity to Townsville.
- Burdekin River catchment – Belyando and Suttor Rivers are poorly researched in terms of their fish fauna and require further surveys, the impetus for which is underpinned by the known relatively recent establishment of two predatory translocated species (Yellow Belly and Sleepy Cod) in this catchment.

Recommendation 3: The lower Burdekin Delta and Floodplain distributary streams including Cromarty catchment, Barramundi, Sheepstation, Kalamia, Alva and Plantation Creeks included in the Haughton River basin through to Rita Island distributaries (north of the Burdekin River), Macdonald Creek (south of the Burdekin River) and Saltwater Creek in the Don River basin have multiple potential barriers and flow paths associated with their floodplain flow path origins and use

for irrigation supply by Sunwater and the North and South Burdekin Water Boards. The drainage lines and direction of flows at varying flow events, nature of instream structures and seasonal and permanent occurrences of aquatic weed choked reaches is not well understood or captured by available data.

Due to a lack of detailed knowledge it is not currently possible to make specific recommendations for many of these barriers though they are collectively afforded a high priority due to the extent of perennial floodplain lagoonal habitat, lower catchment location and associated diverse fish fauna. It is therefore recommended that:

- These floodplain / delta systems undergo a holistic assessment conducted in close cooperation with the water resource managers and to develop whole of system management plans that deliver operational guidelines as well as proposed works for potential passage barrier forming structures, instream conditions and operational practices.

Recommendation 4: The following river / drainage systems should be further assessed and a barrier remediation program developed for multiple barriers.

- Ross River requires an integrated approach to barrier remediation. Aplins Weir is the most downstream barrier and could be modified to provide fish passage to a large perennial river reach and to tributary streams. The benefit of modifying Aplins Weir would be increased if the upstream weirs (Gleesons and Black) were also modified but costs/benefits including of rectifying individual structures need to be investigated further.
- The Don River has a number of potential barriers on its main channel. At the time of completing this Report insufficient information was available to determine to what degree, if any, those barriers affect fish passage. When these barriers are elevated to a higher priority as barriers currently higher on the list are rectified, the potential barriers on the Don River should be assessed as a group and not in isolation.

Recommendation 5: Identified potential fish passage barriers associated with road and rail crossings need to be the focus of a specific field based site data collection program to better assess the significance of potential barriers and serve a more informed prioritisation of road and rail crossing fish passage works.

Recommendation 6: A monitoring program for each structure should be an integral component included in both design and operational stages of any fish passage devices and the results widely publicised.

Recommendation 7: The GIS data collated for this project together with the GIS tool for the identification of priority barriers should be maintained and updated as new information becomes available. The GIS tool will enable informed decisions to be made when undertaking barrier modifications in future years.

Recommendation 8: GIS data, particularly in relation to catchment boundaries should be standardised for all future BDTNRM projects.

Recommendation 9: That BDTNRM host a workshop focussed on fish barrier remediation for road and rail crossing techniques and targeted at local government, Main Roads, Queensland Rail and cane rail operators. The purpose of the workshop would be to bring together expertise in fish passage techniques and the owners/managers of road and rail crossing barriers within the BDTNRM region and to focus on best practice applications.

Recommendation 10: BDTNRM actively aid the consolidation of information on fish barrier remediation for weirs.

In 2008 work in cooperation with Sunwater and DPI&F to review the cost and design options for all fish passage devices that may be suitable for weirs (including fish lifts, fishlocks, vertical slot fishways and low gradient channel by-passes) and make findings available for application to other weirs.

That BDTNRM support a DPI&F initiative to host an international conference on fish barrier remediation targeted for 2010 in North Queensland.

Recommendation 11: Work in cooperation with Sunwater and DPI&F to review the cost and design options for all fish passage devices that may be suitable for weirs (including fish lifts, fishlocks, vertical slot fishways and low gradient channel by-passes) and make findings available for application to all weirs.

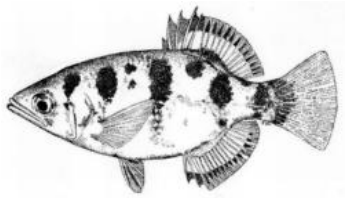
2 Project Aims

This project has been commissioned by Burdekin Dry Tropics Natural Resource Management (BDTNRM) to help to achieve Management Action Target SWW2.2.1 of the Burdekin Dry Tropics (BDT) regional Natural Resources Management (NRM) plan which states:

"By 2010, identify all fish passage barriers and prioritise which should be removed/improved and undertake work."

And the following Management Action:

"Identify all fish passage barriers and prioritise which should be removed/improved and undertake to gain agreement from the necessary parties involved to have them removed or where practical redesigned."



Archer Fish
Toxotes chatereus

The project's three key components are:

- Development of a fish barrier assessment methodology;
- Collection of data and assessment of barriers based on the agreed methodology; and
- Prioritisation of fish barriers for removal or modification.

Objectives and scope

The Fish Passage Study has covered all BDTNRM region catchments and has the following Key Objectives:

- To identify, map and collate relevant information on as many potential fish passage barriers as practical and identify the most ecologically significant fish barriers in the BDTNRM Region;
- To examine the feasibility and risks associated with a removal or modification program for priority fish barriers;
- To determine the efficacy of removal or modification of the priority barriers for the protection of native fish species within their natural range; and
- To prioritise fish barriers for removal or modification and to establish planning level cost estimates.

3 Results

The project method is detailed in Appendix 3. In summary the method consisted of:

- literature review;
- compilation of data in a Geographic Information System (GIS);
- development of a GIS tool to aid the development of a list of priority barriers;
- field assessments of priority barriers; and
- expert panel review.

A number of public meetings were also held to provide an opportunity for information exchange between the project team and the general public. Information gathered during those meetings was also used to refine fish distribution and fish barrier information.

There are thousands of potential barriers throughout the region and it was not possible with available resources to assess them all in the field. Therefore, to enable rationalisation of those thousands into a manageable number in a priority order a two-stage process was developed:

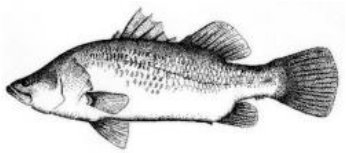
1: Desktop assessment: This was a GIS based assessment that identified all known barriers and applied a logical process to filter the large number of potential barriers to a number that could be reviewed in more detail and assessed in the field. This process concentrated on ecological attributes including species diversity, fisheries and conservation values and fish movement requirements.

2: Following consultation on the Draft Report a further review of priority barriers was undertaken through field assessment and Expert Panel review. Additional attributes were also considered when reviewing the priority order. This included such attributes as cost, feasibility, effectiveness of modifications and community support.

The results of the project are as follows.

3.1 The region and drainage divisions

The study covered the BDTNRM region, which is aligned with the national drainage divisions established by the Australian Water Resources Council. The BDTNRM region lies entirely within the East Coast Drainage division and is comprised of the sub-basins of the Black, Ross, Haughton, Burdekin and Don Rivers, which are shown in Figure 1, page 17 and listed in Table 7, page 18.



Barramundi
Lates calcariifer

This study has been undertaken for the whole region but the assessments and results are presented by both whole region and identified by sub basins to enable the results and recommendations to be used for sub regional area analysis.

3.2 Major streams

The major streams have been identified based on available information about fish species distribution and to a scale that provides useful information for this study. Finer levels of detail were not practical within available resources and without new field surveys. The major catchments within each sub-basin are listed in Table 7 and shown in Figures 2 to 6, pages 19 to 23. Where a stream has a name the same as another stream within the region a suffix number has been added to distinguish it from other streams with the same name.

In addition to the major streams a number of small, short run coastal streams discharge directly to the Great Barrier Reef lagoon. Little information about freshwater fish species is available for these small streams, which include a number of coastal streams on the mainland including Cape Cleveland and Cape Upstart. Islands including Magnetic Island and the Palm Island group are included in this category. Nevertheless it is likely that these streams are seasonally valuable particularly for marine vagrant species.

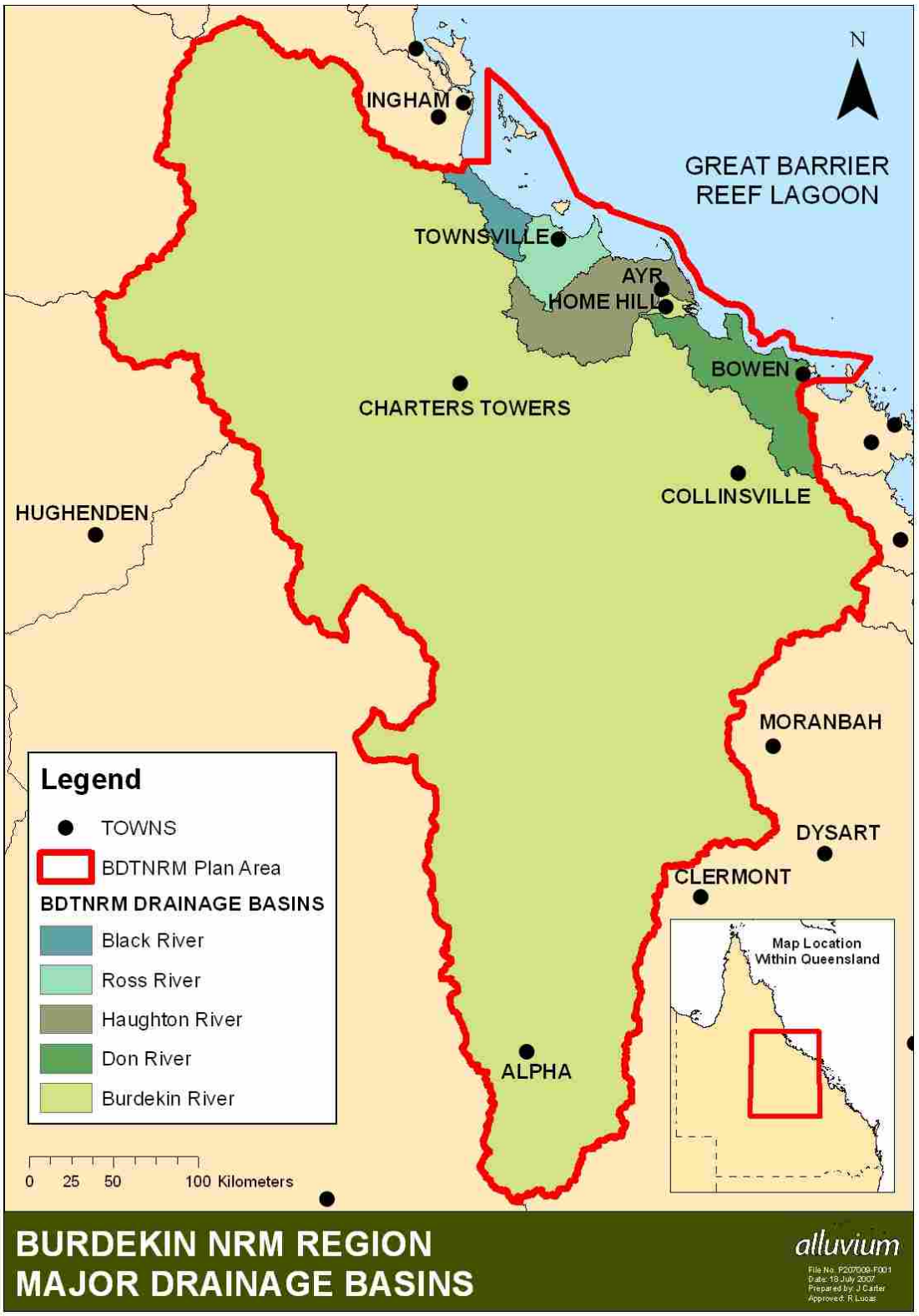


Figure 1: BDTNRM region and sub-basins

Table 1: Sub-basins and major streams

SUB-BASIN	SUB-REACHES	MAJOR STREAMS/CATCHMENTS	AREA and % OF REGION
Burdekin River Basin	Upper Burdekin (above Burdekin Dam)	Burdekin River	113,080 km^2 (92.58%)
		Cape River	
		Campaspe River	
		Fanning River	
		Keelbottom Creek	
		Fletcher Creek	
		Star River	
		Running River	
		Belyando River	
		Suttor River	
		Douglas Creek	
	Lower Burdekin (below Burdekin Dam)	Burdekin River below Clare weir	
		Burdekin River above Clare weir	
		Burdekin Delta Distributaries	
	Bowen	Bowen River	
		Broken River	
Black River		Crystal Creek	908 km^2 (0.74%)
		Ollera Creek	
		Rollingstone Creek	
		Saltwater Creek 1	
		Sleeper Log Creek	
		Leichhardt Creek 1	
		Bluewater Creek 1	
		Deep Creek 1	
		Black River	
Ross River Basin		Bohle River	1,468 km^2 (1.20%)
		Ross River	
		Aligator Creek	
Haughton River Basin		Haughton River	3,490 km^2 (2.86%)
		Barratta Creek	
		Sheepstation Creek 1	
		Alva Creek	
		Kalamia Creek	
		Mud Creek	
		Plantation Creek	
Don River Basin		Saltwater Creek 2	3,191 km^2 (2.61)
		Yellow Gin Creek	
		Wangaratta Creek	
		Rocky Ponds Creek	
		Monongle Creek	
		Armstrong Creek	
		Sandy Creek 1	
		Elliot River	
		Saltwater Creek 3	
		Kangaroo Creek 1	
		Splitters Creek	
		Euri Creek	
		Don River	

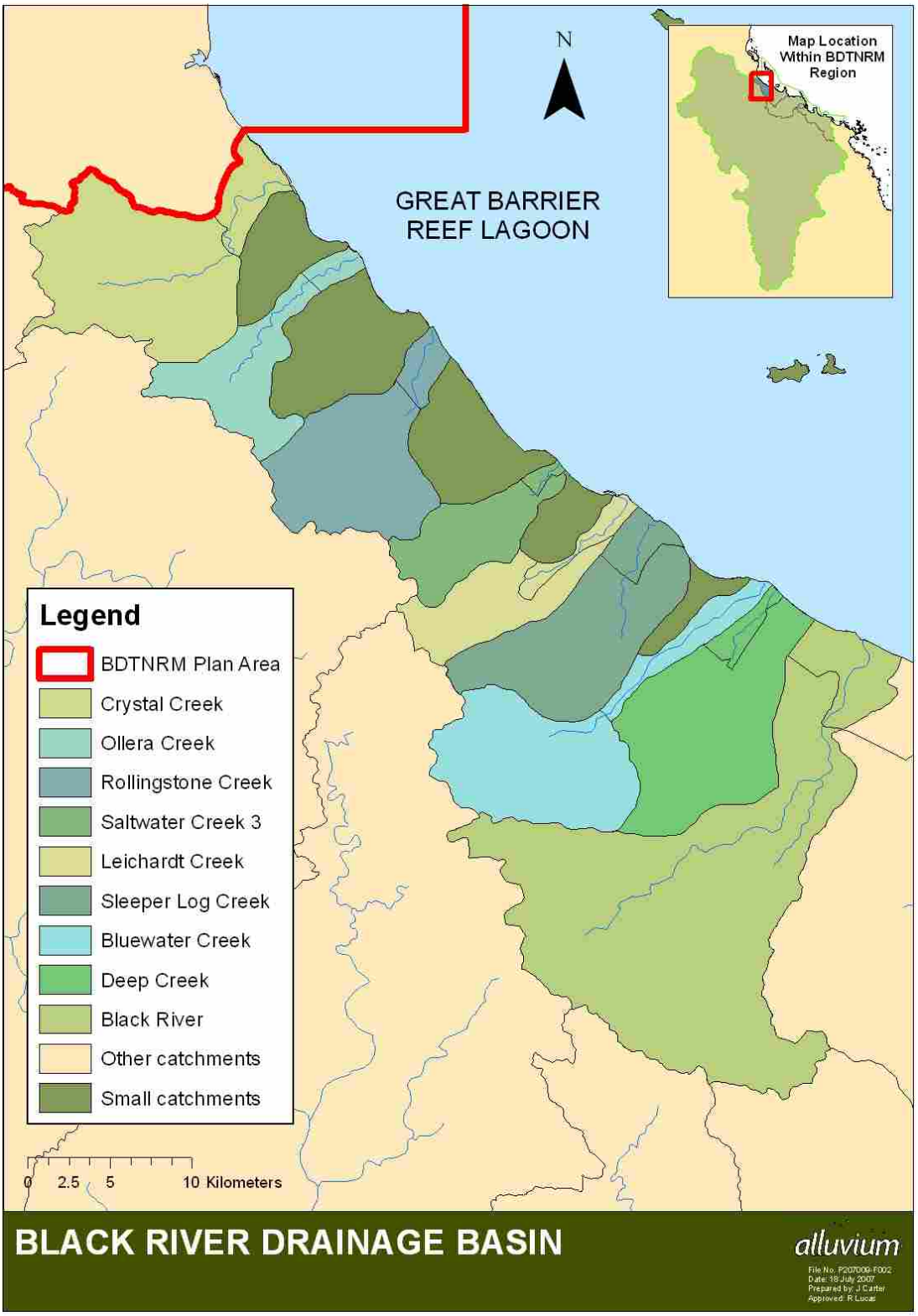


Figure 2: Black River Basin catchments

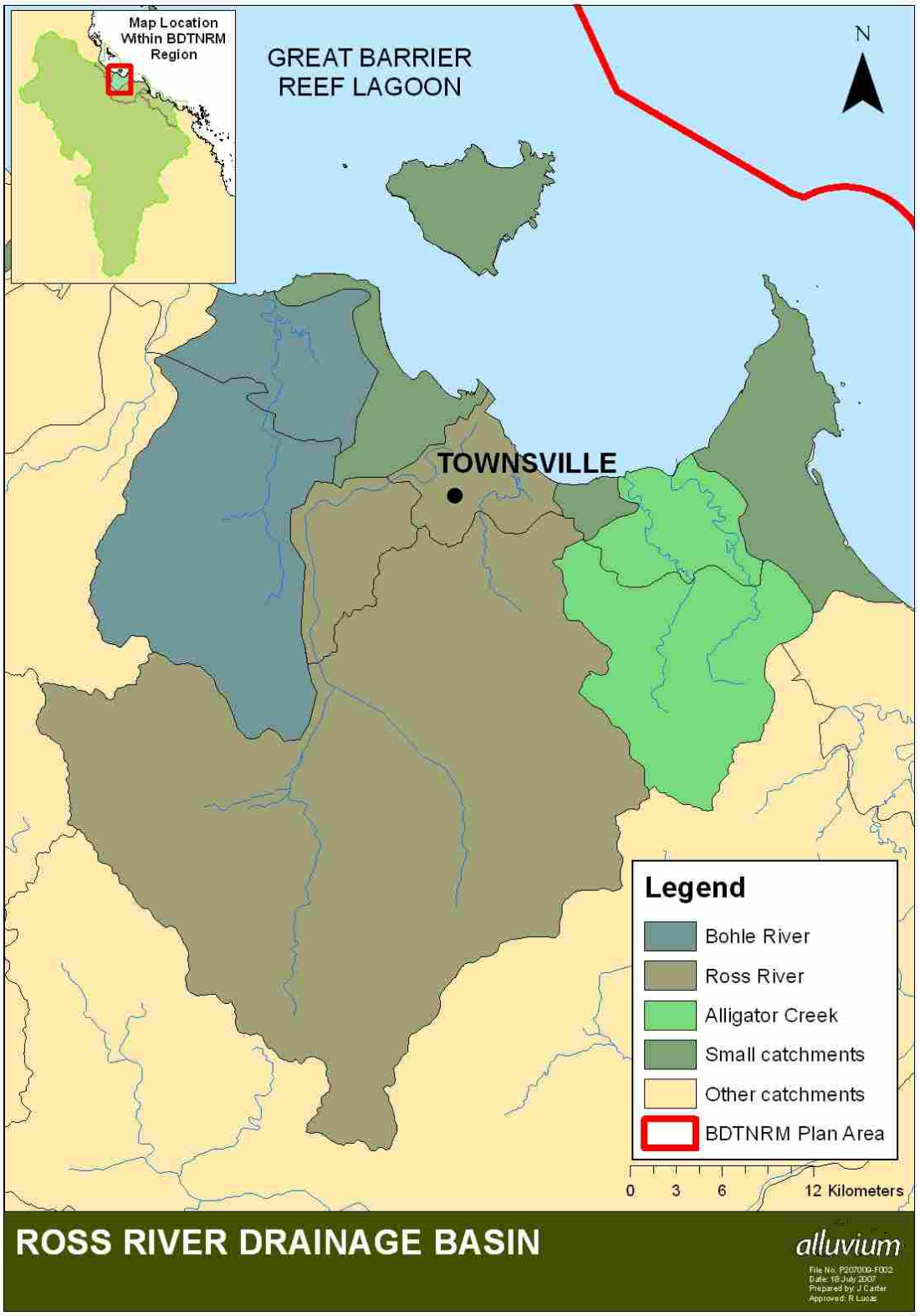


Figure 3: Ross River Basin catchments

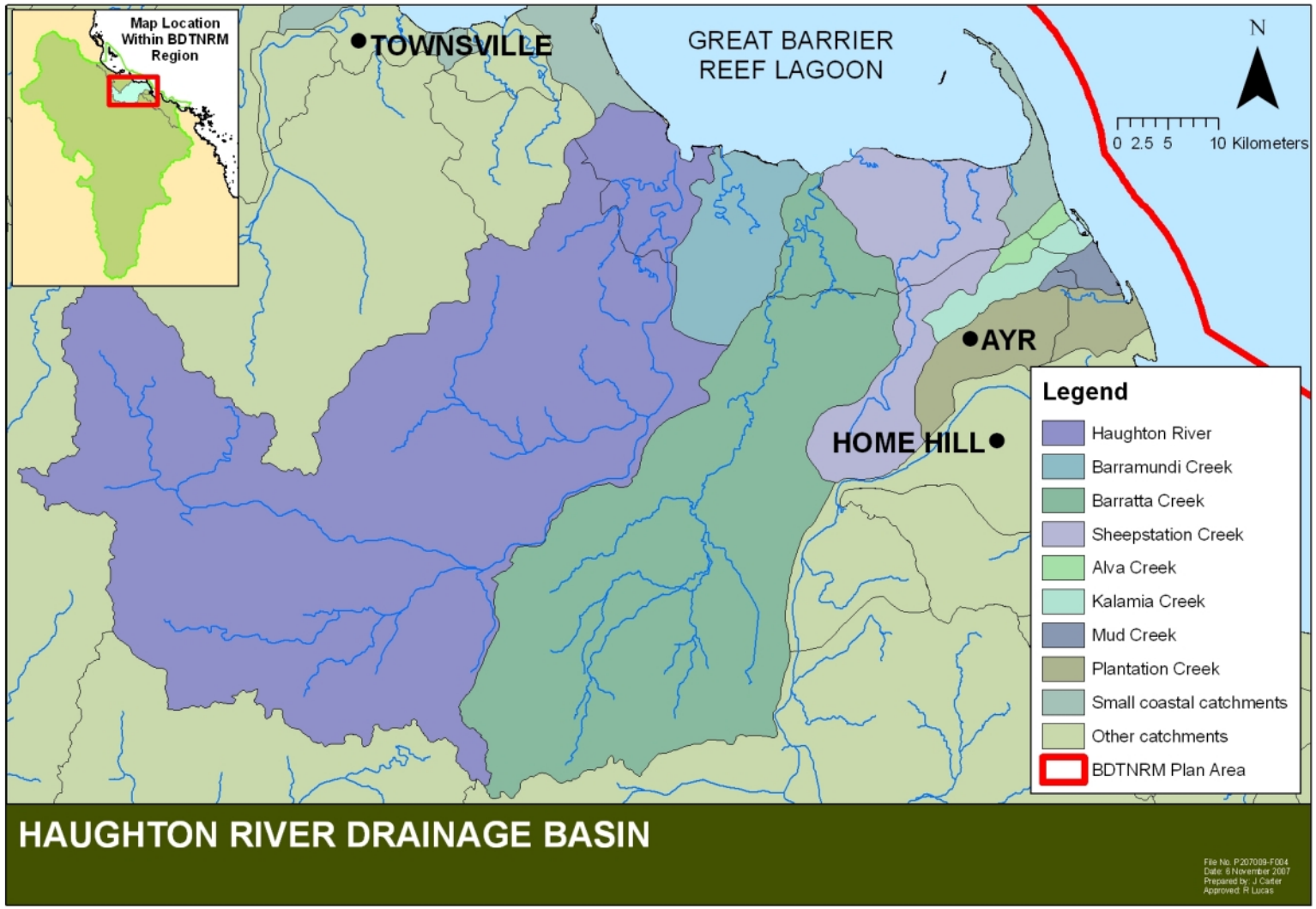

Map Location Within BDTNRM Region
TOWNSVILLE
GREAT BARRIER REEF LAGOON
N
0 2.5 5 10 Kilometers
AYR
HOME HILL
Legend
Haughton River
Barramundi Creek
Barratta Creek
Sheepstation Creek
Alva Creek
Kalamia Creek
Mud Creek
Plantation Creek
Small coastal catchments
Other catchments
BDTNRM Plan Area
HAUGHTON RIVER DRAINAGE BASIN
File No. P207009-F004
Date: 6 November 2007
Prepared by: J Carter
Approved: R Lucas

Figure 4: Haughton River Basin catchments

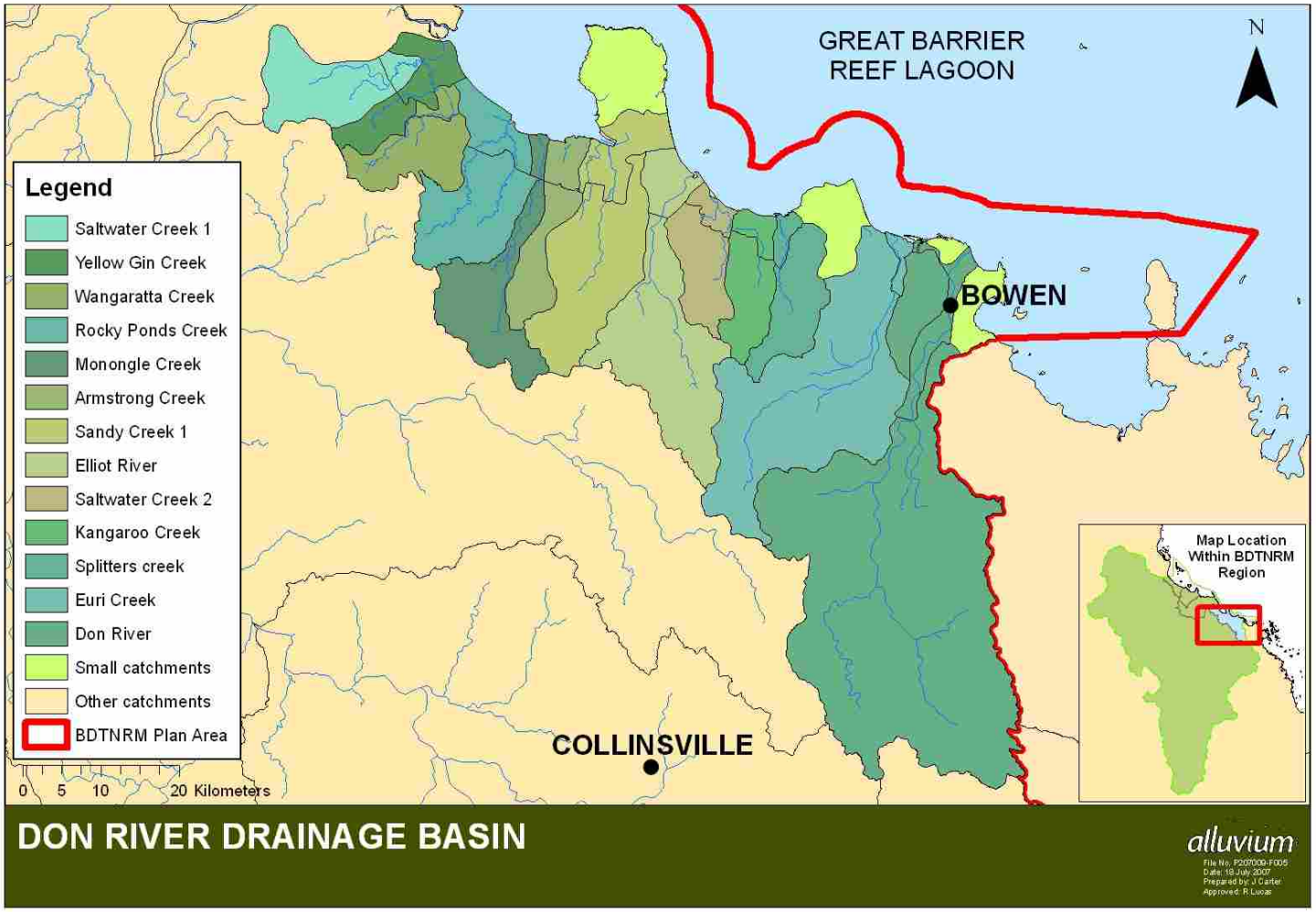


Figure 5: Don River Basin catchments

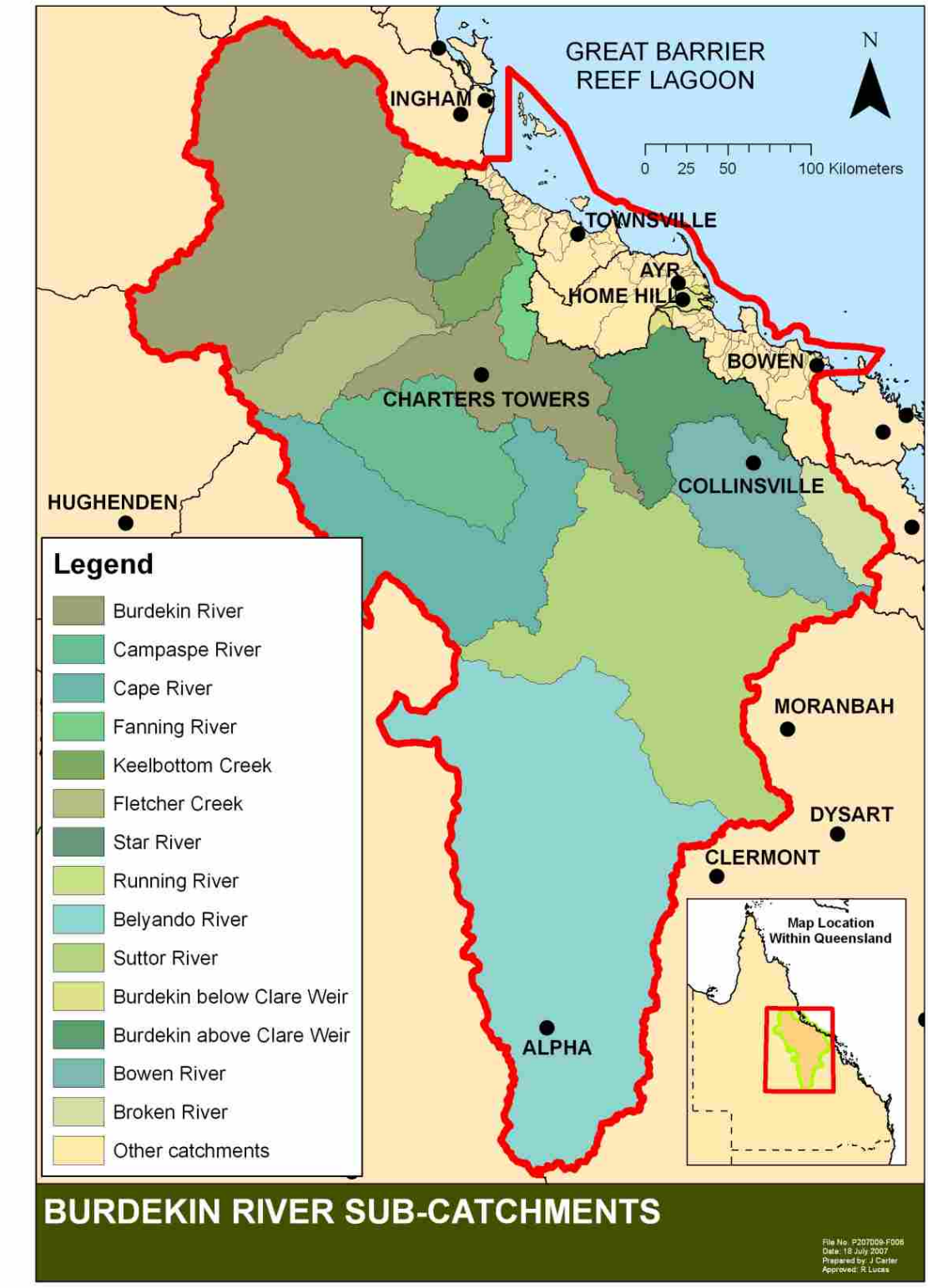


Figure 6: Burdekin River catchments

3.3 Distribution of fish species

The natural distribution of fish species is largely governed by interactions between their physiological tolerances, life history habitat requirements and access to suitable habitat through evolutionary and contemporary time scales. For obligatory freshwater species one of the most significant distribution barriers is that presented by drainage catchment boundaries. For such species opportunities to move between catchments are limited to flood events that form linkages between adjoining catchments, rare 'catchment captures' that occur when head erosion in one drainage network cuts into an adjoining catchment's drainage network and periods of past sea level lows when adjoining catchments formed confluences in their lower reaches (Unmack 2001[1]). Within a catchment natural fish distribution barriers include physical features such as waterfalls and environmental conditions outside a species' physiological tolerances and suitable habitat requirements in terms of flow and temperature regimes, water quality characteristics and other in-stream habitat and ecosystem characteristics, e.g. depth, substrate, presence of suitable cover, primary productivity and prey / predator abundances etc.

These natural distribution barriers are important for structuring native fish and other in-stream biotic communities and have played a key role in the evolutionary processes that have given rise to Australia's regionally distinct freshwater fish faunas. One common feature of Australia's freshwater fish fauna related to the continent's isolation and historical and contemporary arid climate is an overall low number of species with a large proportion of members of secondary freshwater fish families. These species have evolved in geologically recent times from typically marine fish families as opposed to primary freshwater fish families that have evolved entirely in freshwater. As well as limiting the number of fish species found in Australia's inland waters this evolutionary history also means that many members of Australia's freshwater fish community still have physiological requirements for accessing marine or brackish habitats at some stage in their life cycle.

The native freshwater fish community of the Burdekin Dry Tropics Region includes 53 species (see section Table 2, page 25) that occur naturally (without translocation by people) the great majority of which (~90%) have some requirement for undertaking migratory movements at some stage of their life cycle (Pusey 2005). The scale of migratory movement required by different species life histories ranges from smaller scale movements between habitat types within a river reach (e.g. from river channel to floodplain or from pool to riffle habitats) as is the case for many potadromous species (see Table 2), to large scale inter or intra catchment migrations. In the case of some catadromous species (see Table 2) breeding or dispersal movements can extend to offshore sites within the Great Barrier Reef or to coastal areas beyond the home river basin. In the extreme case of Anguillid eels a one way migration of adults is undertaken to deep sea breeding sites thousands of kilometres away in the Coral Sea.

For migratory life cycles to be successful fish require free access between these critical chains of habitats that meet their needs as larvae through to reproducing adults. To the same extent that natural distribution barriers have played an important role in structuring Australian freshwater fish communities, artificial fish passage barriers resulting from human land and water resource use patterns have produced major impacts on fish distribution and abundance.

As for most developed regions of Australia artificial fish passage barriers within the BDTNRM Region have been created by the construction of instream structures to service water resource

[1] Unmack, P.J., 2001. Biogeography of Australian freshwater fishes. *Journal of Biogeography* 28: 1053–1089.

development and transport infrastructure and by modified stream reach conditions associated with land and water resource development and other ecological disturbances such as weeds.

3.4 The diversity of species

This study has taken a broad view of which species can be considered as freshwater fish. Some species could be argued to be marine, non-dependent on freshwater habitats and as only spending a limited time in freshwater. Nevertheless we have taken a functional ecological view that the species listed are recorded frequently enough in freshwater habitats to be considered part of the BDTNRM freshwater fish community.

A total of 76 species are identified in literature and other information sources. Of those, 58 are Australian species. Three of these are believed to have been misidentified (leather grunter, *Scortum hillii*, triangular shield catfish, *Arius leptaspis* and the firetailed gudgeon, *Hypseleotris galii*) and are noted but not included in the study assessments. Of the remaining 55 Australian species two are considered to have been introduced from other river basins (yellowbelly *Macquaria ambigua* and eel-tailed catfish, *Tandanus tandanus*). In addition there are 17 exotic species listed most of which have been introduced into the Ross River. Among these, the highly invasive tilapia is now found in the Ross River basin and in the upper Burdekin River, where it continues to spread (D Burrows pers. com. 2007). Of the 53 species that naturally occurred in the region prior to European settlement, a number have since been translocated within the region mostly for recreational fishing. Species that are now found outside their natural range include sleepy cod, *Oxyeleotris lineolatus*, barramundi *Lates calcarifer* and sooty grunter, *Hephaestrus fuliginosus*.

A number of species have had their natural range reduced due in some cases to land use changes but primarily due to barriers to their movement for breeding and dispersal.

There are a number of ways in which fish species may be divided or grouped. A most common way is by Family grouping. However, because the BDTNRM Fish Passage Study was principally interested in the movement of fish within catchments of the region, species have been grouped into six categories according to their movement requirements and life history. Species categories according to their life history are described in Table 2.

Table 2: Species categories based on life history and movement

CATEGORY	DEFINITION	NO. IN CATEGORY
Catadromous	Species that may spend much of their lives in freshwater before migrating as adults to the sea or brackish / estuarine areas to spawn.	12
Anadromous	Species that may spend much of their lives in the sea (or marine/ estuarine habitats) before migrating as adults to fresh water to spawn.	2
Marine Vagrant / Facultative Freshwater	Marine or estuarine breeding species that are not dependent on access to freshwater though may spend limited to substantial time in freshwater, usually lower reaches.	16
Amphidromous	Species that migrate between freshwater and the sea at some stage in their life cycle but not for the purposes of reproduction.	3
Potadromous	Species which undertake breeding or dispersal migrations wholly within freshwater.	24#
Sedentary	Species that don't actively or directionally migrate that can fulfil their entire life cycle within a single wetland, pool or river reach.	16*

Three other native species have been recorded from the region but are believed to have been misidentified. This figure of 24 includes three exotic species.

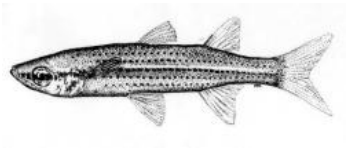
* This figure includes 2 native species and 14 exotic species.

A summary of the species based on these categories and their distribution is provided as Appendix 1. Descriptions of individual species and maps of their current and historical distributions are provided as Appendix 2.

3.5 Types and numbers of barriers to fish passage

The various barrier types across the region that were considered in this study are:

- Natural barriers (waterfalls)
- Dams
- Weirs
- Sand dams / crossings
- Tidal intrusion barrages – ponded pasture bunds
- Weed / macrophyte choked reaches
- Road and rail crossings (culverts, fords and causeways)
- Other instream structures (e.g. Water Board control gates).



Fly-specked hardyhead
Craterocephalus stercusmuscarum

Details of the method used to identify and assess these barriers are provided in Appendix 3. Details of the barriers types and options for remediation are provided in Appendix 4. Initial assessments identified over 12,000 potential barriers across the region. This number was reduced to 1,047 highest priority potential barriers by removing small streams, track crossings and known bridges as part of the assessment process. The results of the assessment of the 1,047 highest priority potential are summarised in Table 3 by sub basin.

Table 3: Total number of identified potential barriers by type

	Number of potential barriers identified by Sub basin					
Barrier Type	**Burdekin River**	**Black River**	**Ross River**	**Haughton River**	**Don River**	**TOTAL**
Natural barrier (waterfalls)	10		1			11
Dams	114		2		3	119
Weirs	5	1	4	2		12
Sand dams / crossings	10#				1	11
Tidal intrusion barrages – ponded pasture bunds	4		1	38	6	49
Weed / macrophyte choked reaches				23	2	25
Road and rail crossings (culverts and fords)	704	8	25	49	34	820
TOTAL	847	9	33	112	46	1,047

The sand dams on the Burdekin River were assessed in part in the field and in part through discussion with staff from the North Burdekin and South Burdekin Water Boards, Sunwater and Department of Primary Industries and Fisheries. At the time of preparing this report a code of practice for the management of flows past the sand dams was being developed jointly between Sunwater, the North and South Burdekin Water Boards and the Department of Natural Resources and Water. Taking these factors into consideration, only two of the sand dams (Rita Island and the rocks) have been identified as highly significant barriers worthy of further investigation and modification. The other sand dams all have low gradient bypass flow paths that are not considered to be barriers.

3.6 Regional scale priority barriers for remediation

To determine an order of priority for further investigation and remediation all of the 1,047 potential barriers across the region were assessed based on the threat of the individual barriers and a range of fish and habitat values as follows:

THREATS

- Barrier type.

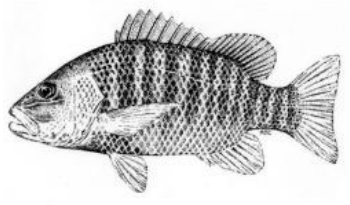
FISH VALUES

- Conservation Significance
- Cultural Significance
- Fishery Significance
- Species movement requirements.

Barred grunter
Amniataba percoides

HABITAT VALUES

- Upstream habitat quality (Land use as a surrogate for river condition)
- Stream order
- Position of barrier in the Catchment
- Distance to next barrier upstream
- Uninterrupted stream length upstream
- Presence/absence of downstream barrier.



Mangrove Jack
Lutjanus argentimaculatus

Full details of the method are described in Appendix 3. From that assessment the top priority barriers are identified and provided as a summary in Table 4.

Priority barriers as identified by the GIS tool and limitations of the GIS tool

The GIS tool provided a defensible filtering method to identify the highest priority barriers. The accuracy of the scoring system for any given barrier is limited to the level of accuracy of the data available for that barrier. For example, a threat value of MEDIUM was applied to all road and rail crossings where no first hand assessment had been undertaken (within the resources available during the project the number of roads and rail crossings prevented a field assessment of all potential barriers). As field inspections were undertaken, the threat level of each barrier was reassessed and, as per the assessment, the threat value was either retained, reduced, increased or in some cases identified as NONE. Where a barrier was identified as threat value NONE it was removed completely from the list of potential barriers.

As a specific example, the GIS tool initially identified the Burdekin Falls Dam as a higher priority for investigation of remediation options. This was because the GIS tool incorrectly identified that all species above the Dam are affected by its presence. In fact, only two species (longfinned and Pacific eels) have their upstream movement affected by the Dam. Therefore, the conservation, fisheries and movement requirements of all species except for eels were removed from the assessment of the Burdekin Falls Dam. This had the effect of reducing the Dam from a priority order number 3 to number 7. Whilst this may not initially appear to be a significant reduction, it does remain a high priority because of the extent of habitat upstream from the Dam and the fact that the dam is preventing all but a small number of eels from moving upstream. Burdekin Falls Dam is a special case and investigation is recommended

into the feasibility of eel movement and it has therefore been kept as a priority for further investigation.

Priority barriers following field assessments and expert panel review

The project team reviewed the priority barriers identified by the GIS tool and applied their collective local knowledge and expertise to assessing that initial priority list and to revising the list based upon their collective assessment. That initial revised priority list of barriers was then included in the Draft Report and further investigations and assessments were undertaken through field inspections and by expert panel and team member review.

A number of key points were identified during the priority barrier assessment process:

- A number of large structures, dams and weirs, have ranked highly due to their major impacts in preventing fish movement upstream.
- The Burdekin Delta is a high priority for the remediation of barriers due to the diversity of fish species affected and the high value of habitat (both instream and floodplain wetlands).
- The value of remediation works on barriers will be increased if creek systems are considered holistically rather than individual barriers within those systems. Systems that should be treated in this holistic manner are:
    1. Sheepstation Creek
    2. Barramundi Creek
    3. Plantation Creek
    4. Alva Creek
    5. Kalamia Creek
    6. Rita Island distributaries
    7. Saltwater Creek (and the Burdekin distributary to the north, Macdonald Creek)
    8. Don River.
- When assessing a whole system such as Sheepstation Creek it can be expected that remediation works are most valuable if works are undertaken commencing at the downstream end. However, there may be some exceptions where a downstream barrier is not a complete barrier and where a barrier higher up the system may be a greater threat to upstream movement. An example of this is Val Bird weir on the Haughton River which, whilst upstream from Giru weir, is never-the-less considered to be a greater barrier to fish movement upstream and is therefore a higher priority for remediation than Giru Weir.

The final priority barrier list has therefore taken into consideration, all of the above factors and is presented as Table 4.

A more detailed description of the priority barriers and recommendations for remediation options and costs is provided in Section 4 – Recommendations.

Table 4: Top priority barriers for further investigation and remediation

Barrier Code	Structure Type	Name	Stream Name	Rank
BAR10	Weir	Clare Weir	Burdekin River	1
BAR1093	Sand dam	Rita Island	Burdekin River	2
BAR1089	Sand dam	The Rocks	Burdekin River	3
BAR16	Weir	Val Bird Weir	Haughton River	4
BAR1054	Weir	Alpins Weir	Ross River	5
BAR1091	Road crossing	Stuart Creek	Stuart Creek	6
BAR12	Weir	Bowen River Weir	Bowen River	7
BAR15	Weir	Giru Weir	Haughton River	8
BAR17	Weir	Lower Alligator Creek	Alligator Creek	9
BAR28, BAR20, BAR25, BAR1033, BAR1038, BAR62, BAR1100, BAR23, BAR539	Earth bunds, road and rail crossings, weed chokes	Various	Sheepstation Creek	10
BAR871, BAR869, BAR870, BAR1040	Earth bunds, road crossing and weed chokes	Various	Saltwater Creek & Macdonald Creek	11
BAR1075, BAR1076, BAR53	Earth bund and weed chokes	Various	Plantation Creek	12
BAR9	Weir	Charters Towers Weir	Burdekin River	13
BAR1068	Dam wall	Burdekin Falls	Burdekin River	14
BAR11	Weir	Gorge Weir	Burdekin River	15
BAR828	Road crossing	Minor road	Kirknie Creek	16
BAR19, BAR61, BAR64 BAR1092 BAR1078	Earth bunds Farm track Weed choke	unnamed	Barramundi Creek	17
BAR29, BAR1071	Earth bunds	Alva Creek	Alva Creek	18
BAR1039	Weed chokes and road crossings	Cromarty Creek network	Cromarty Creek, Palm Creek, Ironbark Creek and Palm Creek	19
BAR54	Weir	Leichhardt Creek Weir	Leichhardt Creek	20
BAR7	Weir	GLEESON WEIR	Ross River	21
BAR6	Weir	BLACK WEIR	Ross River	22
BAR1082, BAR1084	Earth bunds	unnamed	Rita Island distributaries	23
BAR1006	Road crossing	Collinsville Elphinstone Road	Hazelwood Creek	24
BAR563	Road crossing	Minor Road	Burdekin River	25
BAR552	Road crossing	Tondara Road	Bogie River	26
BAR1009	Road crossing	Minor road	Exe Creek	27
BAR1010	Road crossing	Collinsville Elphinstone Road	Little Bowen River	28
BAR1013	Road crossing	Minor road	Hazelwood Creek	29
BAR8	Dam wall	ROSS RIVER DAM	Ross River	30
BAR2	Dam wall	EUNGELLA DAM	Broken River	31

3.7 Sub-basin and catchment scale priority barriers for remediation

Whilst the primary aim of the study has been to identify those barriers that are the highest priority on a regional scale there is also value in identifying priority barriers on a sub-basin and catchment basis so that those groups and individuals that have a local focus can use the findings of the study to assist with decision making at those scales. The following sections provide a description of fish passage issues and barrier priorities at the sub-basin and catchment scale.

3.7.1 Black River Basin

In addition to the non-perennial Black River, the Black River Basin includes a number of perennial coastal stream catchments that extend to the northern margin of the Burdekin Dry Tropics region including Bluewater, Leichhardt, Saltwater, Rollingstone, Hencamp, Ollera and Crystal Creeks. Despite the wetter nature of these coastal catchments their water resources have not yet been extensively developed and they remain largely free of major in-stream structures and barriers to fish movement. Three small structural barriers are known within the basin including an earth barrage at the tidal interface of lower Rollingstone Creek (although it is thought that this is disused and not now functioning as a barrier to fish passage), a small pumping pool weir within lower Leichhardt Creek and an equivalent structure in the lower reaches of Bluewater Creek. All are overtopped by elevated flows and none are known to be functioning as significant fish passage barriers though no field assessment of the significance of the Leichhardt and Rollingstone Creek structures has been conducted. A potentially more significant though as yet unquantified fish passage barrier issue for the basin are a number of culvert road crossings in the mid and upper reaches of several of these streams including Crystal, Rollingstone, Leichhardt, Bluewater and Deep Creeks (see Appendix 5 Maps 1-3).

Jungle perch
Kuhlia rupestris

3.7.2 Ross River Basin

The Ross River basin is comprised of the Bohle and Ross River and Stuart and Alligator Creek catchments. Given its proximity to Townsville the Ross River has always formed an important water resource for the city and it has been harnessed historically by three weirs (Aplins, Gleesons and Black weirs) and more recently by the Ross River Dam. The size of the weir structures and their position low in the catchment means that they are significant and proven fish passage barriers for a large number of species. These weirs represent a significant basin and regional scale priority for fish passage rectification works with the lowermost weir (Aplins) the highest priority for remediation. The scale of the Ross River Dam negates cost effective fish passage rectification and it is not nominated as a priority for works (except perhaps to facilitate the movement of eels). A small weir that functions as a tidal barrage also occurs on Alligator Creek to the south of Townsville. Although this structure is overtopped on elevated flows it functions as a barrier under most other flow conditions and affects the recruitment of species to the upper reaches of Alligator Creek which includes the Cape Bowling Green Bay National Park. This structure is also an important priority for rectification works which, given the small scale of the structure should be readily rectified. As for most basins within the region the significance of road and rail crossings as fish passage barriers cannot be readily ascertained from available information and these should form the focus for further assessment work. A defunct road crossing on the mid reaches of Stuart Creek is a proven fish passage barrier and is nominated as a priority for removal due to the diversity and refugial values of this catchment for the basin's freshwater fish community (see Appendix 5 Maps 4-5).

Aplins Weir

3.7.3 Haughton River Basin

The Haughton River basin extends from the Haughton River catchment south to include Barratta Creek and the floodplain and delta distributary streams of the lower Burdekin River. Two weirs in the lower reaches of the Haughton River (Val Bird and Giru) represent regionally significant fish passage barriers. The larger upstream structure (Val Bird Weir) is the most significant barrier and should be the highest priority for works. Impacts of this structure extend to tributary streams within Mt Elliot (Cape Bowling Green Bay) National Park, i.e. Majors, Double and Spring Creeks and perennial wetlands including lagoons associated with the Directory of Important Wetlands in Australia[2] (DIWA) listed Serpentine Lagoon, which have lost catadromous fish species, i.e. Jungle Perch and Barramundi. While the Barratta Creek system represents a rare example of a coastal catchment relatively free of structural fish passage barriers, floodplain drainages to the north, i.e. Healy's Lagoon / Reed Beds, Barramundi Creek / Horseshoe Lagoon and Lower Burdekin Delta distributary streams to the south (Sheepstation, Kalamia, Alva, Mud and Plantation creeks) contain a large number of barrier features including North Burdekin Water Board infrastructure, numerous ponded pasture bunds and associated weed choked reaches. Structural rectification and operational guidelines to reduce the fish passage barrier potential of Water Board infrastructure in the lower Burdekin should be a regional priority that needs to be progressed at a delta / floodplain system scale in conjunction with water resource managers. Impacts associated with these structures and ponded pasture bunds and associated weed chokes need to be better quantified by site based fish survey to further works prioritisation.

Val Bird Weir

The impacts of weed chokes on fish passage have already been demonstrated at Healy's[3] and Horseshoe Lagoon and Sheepstation Creek and these systems are priority sites for rectification works given their historical importance as nursery swamps for fishery species including barramundi. Several road crossings within the basin have also been identified as potentially significant fish passage barriers including numerous culvert crossings within the water Board operational areas of the delta, the Giru-Woodstock Road crossing adjacent Serpentine lagoon, and a farm crossing downstream of Horseshoe Lagoon. All identified potential road crossing barriers warrant further site inspection to refine works prioritisation (see Appendix 5 Maps 6-7).

3.7.4 Don River Basin

The Don River basin extends from Saltwater Creek 1, which represents the southern boundary of the lower Burdekin delta distributary streams south across a number of largely non-permanent short coastal catchments to the Don River itself which is largely an ephemeral system in most years. This basin is very data poor in terms of fish that occur within the systems and in terms of the presence and nature of fish passage barriers. Saltwater Creek 1 like other lower Burdekin

---

[2] Environment Australia (2001) A Directory of Important Wetlands in Australia. Third Edition, Environment Australia, Canberra.

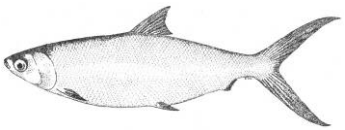
[3] Veitch, V. & Burrows, D. (2006) Fish Passage Issues of Healey's Lagoon Following Investigation of Water Quality Issues Impacting on Fish Migration, Report No. 06/22, Australian Centre for Tropical Freshwater Research, James Cook University, Townsville.

delta distributary systems is impacted by a combination of South Burdekin Water Board infrastructure, coastal bunds and associated weed chokes and needs to be included in a focussed assessment of the broader delta distributary stream system. The presence of significant areas of perennial deepwater lagoon habitat in the upper reaches of Saltwater Creek and other delta distributary creek systems highlights the priority afforded to improving fish passage in the system. Road and rail crossings and sand dams in the lower Don River comprise the other basin fish passage barrier issues albeit of unknown significance (see Appendix 5 Maps 12-16).

3.7.5 Burdekin River below Burdekin Falls Dam

The Burdekin River is the largest within the region and structural barriers within its lower catchment represent the most significant within the region. The size and lower catchment location of the Clare Weir makes it the most significant fish passage barrier of the lower Burdekin and the region. Although fitted with a fish lift this device has remained inoperable since shortly after its commission and therefore the Clare Weir remains the highest priority for rectification works and it is strongly recommended that support and encouragement be given to Sunwater in efforts to repair and maintain the fish lift.

It is also strongly recommended that BDTNRM work in cooperation with Sunwater and DPI&F to review the cost and design options for all fish passage devices that may be suitable for weirs (including fishlock, hydraulic lifts, vertical slot ladders and low gradient channel by-pass) and make findings available for application to other weirs.



Milkfish
Chanos chanos

Upstream of Clare Weir other major structural barriers are associated with weirs at Collinsville on the Bowen River and the Gorge Weir in the reach below the Burdekin Falls. The former is a higher priority in terms of the feasibility of rectification works, though significant upstream habitat would also be accessible by facilitating fish passage past the Gorge Weir and assessment of options is warranted. The smaller Blue Valley Weir downstream of the Burdekin / Bowen River confluence has not been demonstrated to be a significant fish passage barrier under a wide range of low conditions and is not nominated as a priority for further investigation. Other lower Burdekin basin fish passage barrier priorities for further investigation in the first instance are associated with road crossings including potentially significant ones identified at Kirknie Creek, Elphinstone Road across the Little Bowen River and several road crossings of tributary streams of the lower Burdekin (see Appendix 5 Map 16).

3.7.6 Burdekin River above Burdekin Falls Dam

The Burdekin Falls is the most significant natural barrier in the region and has historically limited the movement of all species upstream except for eels. The upper Burdekin Basin includes river catchment of the seasonally arid Burdekin rangelands including the Suttor and Belyando Rivers that extend south to the basin's boundary with the Fitzroy River the inland catchments of which they are similar. To some degree the significance of fish passage barriers in the Burdekin River system above the Burdekin Falls Dam is reduced due to the near absence of migratory marine dependent species. However, there are a host of potadromous species within the upper Burdekin basin for which inter-basin movement is critical for their recruitment success and longer terms species vigour in terms of genetic viability. While most rectification options are unfeasible for the Burdekin Falls Dam, it is implicated in significant impacts on eel migration to upper catchment streams where eel species also function as important keystone predators in lower order streams. For these reasons, the assessment of feasible options for rectifying eel passage past the Burdekin Falls Dam is nominated as a priority. Upstream of the Burdekin Falls Dam, the Charters

Burdekin Falls and Dam

Towers Weir is known to impact on the movement of potadromous species including eel tailed catfish and Sooty Grunter therefore, this structure is nominated as a rectification priority. Beyond these major structures other upper Burdekin basin fish passage barrier priorities for further investigation in the first instance are associated with road crossings (see Appendix 5 Maps 17-26).

3.8 Planning level costs for barrier remediation

Every barrier will be unique in some aspects so specific costs can not be provided for all barriers. However, to give an indication of costs that can be expected for constructing different types of fishways for various barriers Table 5 provides examples of works undertaken in the Burdekin and Whitsunday regions. Table 6 provides a very general guide to design and construction costs for the identified priority barriers.

Table 5: Examples of costs of works undertaken in the Burdekin and Whitsunday regions

Type of fishway and description	Design and Construction Costs
Clare Weir – fish lift	$2.2m
Sheepstation Creek – vertical slot fishway #	$25,000
Reliance Creek – rock ramp #	$10,000
Solander Road – rock ramp / cascade, 2 apron offset baffles, 2 pipe baffles, culvert exit works	$75,000

design of these structures was undertaken by Department of Primary Industries and are less than fully commercial cost.

Table 6: General guide to design and construction costs#

Barrier Code	Name	Rank	Remediation option	Cost Est
BAR10	Clare Weir - Burdekin River	1	repair only	N/A
BAR1093	Rita Island sand dam - Burdekin River	2	Rock ramp	<$100k
BAR1089	The Rocks sand dam - Burdekin River	3	Rock ramp	$400k
BAR16	Val Bird Weir - Haughton River	4	Rock ramp	$400k
BAR1054	Alpins Weir - Ross River	5	Vertical slot fishway or hydraulic lift	$200k to $2m
BAR1091	Stuart Creek road crossing - Stuart Creek	6	Remove crossing and desilt upstream channel	$150k
BAR12	Bowen River Weir - Bowen River	7	Vertical Slot fishway or Hydraulic Lift	up to $2.5m
BAR15	Giru Weir - Haughton River	8	Rock ramp	$300k
BAR17	Lower Alligator Creek weir - Alligator Creek	9	Rock ramp	$250k
BAR28, BAR20, BAR25, BAR1033, BAR1038, BAR62, BAR1100, BAR23, BAR539	Various - Sheepstation Creek	10	Modification of earth bunds Vertical slot fishway clear weed chokes	$20k X 2 $50k X 6 $150k X 1
BAR871, BAR869 BAR870 BAR1040	Various - Saltwater Creek & Macdonald Creek	11	Modification of earth bunds Vertical slot fishway clear weed chokes	$50k X 2 $150k X 1
BAR1075, BAR1076, BAR53	Various - Plantation Creek	12	Modification of earth bunds clear weed chokes	$40k X 2 $150k X 1

Barrier Code	Name	Rank	Remediation option	Cost Est
BAR9	Charters Towers Weir - Burdekin River	13	Rock ramp on existing rock bar	$500k
BAR1068	Burdekin Falls Dam - Burdekin River	14	Eel passage device to be investigated	unknown
BAR11	Gorge Weir - Burdekin River	15	Hydraulic lift	$2.5m
BAR828	Minor road crossing - Kirknie Creek	16	Modification of culverts and construction of rock ramp	$150k
BAR19, BAR61, BAR64 BAR1092 BAR1078	unnamed - Barramundi Creek	17	Modification of bunds Modification of farm Track Weed choke	$5k X 3 $20k $30k
BAR29, BAR1071	Alva Creek earth bunds - Alva Creek	18	Modification of bunds and road crossing	$150k
BAR1039	Cromarty Creek network	19	Clear weed chokes Alter road crossings	$150k X 2 $100k X 4
BAR54	Leichhardt Creek Weir - Leichhardt Creek	20	Rock ramp	$60k
BAR7	GLEESON WEIR - Ross River	21	Rock ramp or vertical slot weir	$250k
BAR6	BLACK WEIR - Ross River	22	Rock ramp or vertical slot weir	$500k
BAR1082, BAR1084	Earth bunds – Rita Island	23	Modification of earth bunds	$40k X 2
BAR1006	Collinsville Elphinstone Road crossing - Little Bowen River	24	Modification of crossing	$100k
BAR563	Minor road crossing - Burdekin River	25	Modification of crossing	$250k
BAR552	Tondara Road crossing - Bogie River	26	Modification of crossing	$100k
BAR1009	Minor road crossing - Exe Creek	27	Modification of crossing	$100k
BAR1010	Collinsville Elphinstone Road - Little Bowen River	28	Modification of crossing	$100k
BAR1013	Minor road crossing - Hazelwood Creek	29	Modification of crossing	$100k
BAR8	ROSS RIVER DAM - Ross River	30	Eel passage device to be investigated	unknown
BAR2	EUNGELLA DAM - Broken River	31	Eel passage device to be investigated	unknown

 # These costs are provided as a general guide only. Detailed costs can only be calculated after detailed site investigations and designs have been undertaken. Initial ideas on the most suitable fish passage device may be revised in view of the findings of further investigations.

4 Conclusions and Recommendations

Since European settlement the BDTNRM region has suffered a decline in fish distribution due (in substantial part) to artificial barriers constructed across watercourses and floodplains. There are options available for the modification (or removal in some cases) of those barriers but with more than a thousand potential priority barriers identified in this study, this can be expected to take many years. Nevertheless this study has identified which barriers should be modified, subject to further investigations and in a priority order that will provide the greatest benefits for the re-establishment of fish movement over the greatest area for a diversity of species.

Empire gudgeon
Hypseleotris compressa
(photo: J Carter)

The recommendations to achieve these benefits are split into two types:

- **general recommendations** (listed in numerical order 1 to 11) including: a list of priority barriers for remediation; to increase knowledge of fish species distribution throughout the region; to integrate fish barrier assessments and remediation as part of holistic river management planning in selected catchments; to manage GIS data compiled and created as part of this project; and to monitor and evaluate the success of barrier remediation, and
- **specific recommendations** (listed in alphabetical order A to CC) for each barrier as listed in Table E2.

4.1 Recommendations for the top priority potential barriers

Recommendation 1: Negotiations to modify or remove identified barriers should be undertaken in the order of priority identified by the project method, as shown in Table 4. Maps showing the location of these potential barriers are provided as Appendix 5.

Table 4: Priority barriers to undertake discussions and negotiations to modify or remove

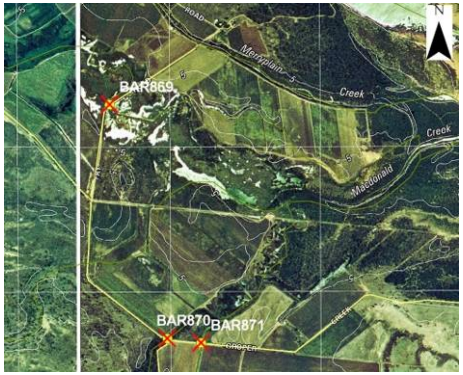
Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR10 Clare Weir	Burdekin River	1	Although a fish passage device (fish lift) is already installed on this structure its operation has been greatly restricted due to mechanical problems. The identification of this barrier as the highest priority is based on it being a major barrier on the lower reaches of the main stem of the regions main river channel, a habitat utilised by the broadest spectrum of migratory species. This significance reinforces: the need for the fish passage device; the need to reinstate an effective device and to maintain its operation as soon as possible both now and after every flow event that results in maintenance being required. **Recommendation 1A: Support and encourage Sunwater in efforts to repair and maintain Clare Weir fish lift.**	15 & 16	 (Photo: J Carter)
BAR397 2 Sand Dams on Lower Burdekin River	Burdekin River	2 & 3	These non-permanent barriers have scored highly due to their position in the catchment and their potential to be seasonally significant barriers to many species. Field inspections and discussions with the Burdekin Water Boards have identified that two of the sand dams on the lower Burdekin River are potential barriers for extended periods of time and should be investigated in more detail. They are Rita Island and "the rocks". **Recommendation 1B: In cooperation with the Burdekin South and Burdekin North Water Boards, undertake further assessment and design, as appropriate, of fish passage options for Rita Island and "the rocks" sand dams.**	15	 Rita Island sand dam, possible location for rockramp fishway (Photo:J Carter)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
					 The rocks spillway (Photo: J Tait)
BAR16 Val Bird Weir	Haughton River	4	This major structure is known to be fully drowned out during large flow events but nevertheless has been demonstrated to be a major barrier to fish movement upstream resulting in the loss of catadromous species including Jungle Perch from protected National Park tributary catchments (i.e. Majors, Spring and Double Creeks). **Recommendation 1C: As a high priority, work in cooperation with Sunwater to investigate this structure for modification.**	7	 (Photo: J Tait)

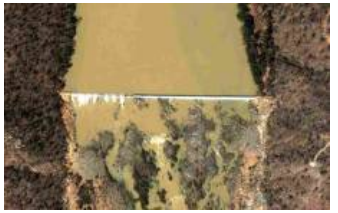
Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR1054 Aplins Weir	Ross River	5	This weir ranks highly due to its position in the catchment and potential number of species that are affected. Whilst there are two additional weirs and the Ross Dam upstream, this weir is nevertheless considered to be worth modifying due to its location below a large perennial waterbody. The existing high levels of public recreational use and associated economic values and its high profile are also relevant rationales for promoting the value of fish passage devices at this site. **Recommendation 1D: Aplins weir should be investigated for modification. Options include vertical slot fishway, rock ramp fishway, fishlock and hydraulic lift.**	4	 (Photo J Carter)
BAR1091 Track crossing	Stuart Creek	6	This raised track crossing with a pipe culvert has been identified as preventing the upstream movement of a range of fish species. Removal of this barrier would result in the mobilisation of sediment trapped upstream. This sediment would need to be removed before the culvert could be removed. **Recommendation 1E: Work with stakeholders to investigate for removal or modification.**	4	 (Photo: J Tait)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR12 Bowen River Weir	Bowen River	7	This weir has already been identified by SunWater as a priority for remediation for fish passage. This study supports the need for such modification. It is a major barrier on a large river that has high habitat values. **Recommendation 1F: Work in close cooperation with Sunwater and DPI&F to support the modification of Bowen River Weir including decommissioning of the existing damaged fish passage device and the design and construction of a new functional device.**	26	 (Photo: J Carter)
BAR15 Giru Weir	Haughton River	8	This major structure is also known to be fully drowned out during large flow events but is nevertheless thought to be a partial barrier to fish movement upstream. The structure has existing structural features that help facilitate some fish passage under a range of flows and the cost of options for modifying this structure are likely to be an order of magnitude lower than those for Val Bird weir (see barrier rank 5) and may be justified for servicing the upstream reach irrespective of a fish passage device being fitted to Val Bird weir. **Recommendation 1G: As a high priority, work in cooperation with Sunwater to investigate this structure for modification.**	7	 (Photo: J Tait)

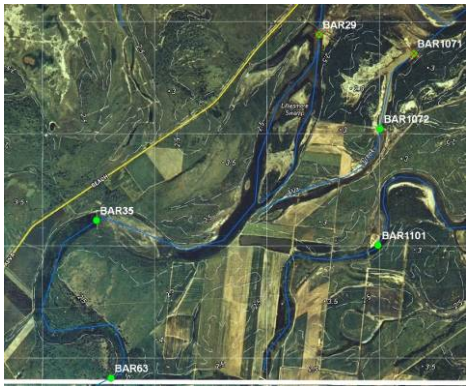
Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR17 Alligator Creek Weir	Alligator Creek	9	This weir requires investigation to determine its effect as a barrier and options for installation of a fish passage device. Known to flood completely out on higher flows, it is exposed on non-peak flows and anecdotal reports suggest that populations of catadromous species in the system, i.e. barramundi have been impacted by its presence. **Recommendation 1H: Work with landholder to discuss this structure and seek cooperation to further investigate its significance as a barrier and options for modification.**	6	 (Photo: J Tait)
BAR20 BAR23 BAR25 BAR28 BAR62 BAR539 BAR1033 BAR1038 Road and rail crossings, earth bunds and weed chokes	Sheepstation Creek system	10	Sheepstation Creek has been identified as a priority. There are a number of potential barriers on this system, which have been grouped together for a holistic assessment. The most effective approach to managing this and other barriers on the system is to work in cooperation with landholders, the North Burdekin Water Board and other stakeholders to examine options and an agreed order for the modification of barriers starting at the downstream end of the system and working progressively upstream. **See general recommendation 3: Work in cooperation with North Burdekin Water Board and Burdekin Shire Council and other stakeholders to further investigate Sheepstation Creek.** **Recommendation 1I: Undertake wet season sampling of water quality (particularly dissolved oxygen) and fish movement above and below downstream barriers to determine the effect of weed chokes on water quality and fish movement.** **Recommendation 1J: Undertake wet season investigation of flow paths and use of floodplain distributaries for fish movement in the lower Sheepstation Creek to determine the most appropriate barrier**	9	 Earth bund and weed choke lower reaches (Photo: J Tait)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
			modification strategy.		 One of many crossings and potential barriers, mid reaches (Photo: J Tait)
BAR1040 BAR871 BAR870 BAR869 Road crossings, earth bunds and weed choke	Saltwater Creek system (including lower Burdekin tributaries to the north, Merryplain Creek and MacDonald Creek)	11	Road crossings, earth bunds and weed chokes on the Saltwater Creek system (and lower Burdekin tributaries to the north, Merryplain Creek and MacDonald Creek), which are used by South Burdekin Water Board as part of their irrigation infrastructure network. **See general recommendation 3: Work in cooperation with South Burdekin Water Board and Burdekin Shire Council to examine this whole system and develop a holistic management plan.**	11	 (Photo: NRW 1:25,000 orthophoto)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR53 BAR1075 BAR1076 Earth bunds, Weed chokes and road and rail crossings	Plantation Creek tributary	12	Plantation Creek has been identified as a priority. There are a number of potential barriers on this system, which have been grouped together for a holistic assessment. As with Sheepstation Creek, the most effective approach to managing this and other barriers on the system is to work in cooperation with landholders, the North Burdekin Water Board and other stakeholders to examine options and an agreed order for the modification of barriers starting at the downstream end of the system and working progressively upstream. **See general recommendation 3: Work in cooperation with North Burdekin Water Board, landholders, Burdekin Shire Council and other stakeholders to further investigate barriers on Plantation Creek.** **Recommendation 1K: Undertake wet season sampling of water quality (particularly dissolved oxygen) and fish movement above and below downstream barriers to determine the effect of weed chokes on water quality and fish movement.**	9	 Weed choke and earth bund on downstream reach (Photo: J Tait)  Road and Rail Crossing barriers (Photo: J Carter)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR9 Charters Towers Weir	Burdekin River	13	This barrier is the highest ranking barrier upstream from the Burdekin Falls Dam. Its position on the main channel and the extended periods of flow when it presents a complete barrier make it worthy of investigation. Whilst it is recognised that it is fully drowned out in high flows, the number and diversity of potadromous species of fish that may move on non-peak flows when this is a complete barrier is potentially significant. **Recommendation 1L: In cooperation with DPI&F, this structure should be investigated for modification.**	17A	 (Photo: J Carter)
BAR1068 Burdekin Falls Dam	Burdekin River	14	The Falls Dam is a major barrier to upstream movement but is located on a natural historical fish passage barrier the Burdekin Falls. However, the dam structure has been identified to be a significant barrier to eels which historically migrated past the falls to upper catchment areas in large numbers. Eel species have high ecological (top order predators), and fishery values and are currently greatly restricted in their upstream movement by the dam wall. **Recommendation 1M: Investigate options to facilitate eel movement. This may be transport of elvers and adults from the base of the dam over the wall or possibly, low tech structural works to enable eels to negotiate the wall.**	16 & 17A	 (Photo J Carter)
BAR11 Gorge Weir	Burdekin River	15	This weir has been recently reactivated operationally to supply water for the Moranbah pipeline. At 8 metres high it represents a significant barrier for the Burdekin River and tributaries upstream to Burdekin falls. Its ranking lower than other major weirs is a reflection of the relatively high position it occupies in its catchment and fewer fish species that are affected by it. **Recommendation 1N: This structure should be investigated for modification but the expected high cost of modification is likely to**	16	 (Photo: Google Earth)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
			relegate this barrier to a lower implementation priority.		
BAR828 Road crossing	Kirknie Creek	16	This raised crossing with box culverts is a potential barrier. **Recommendation 1O: requires further investigation and discussion with stakeholders to examine feasibility of modification.**	16	 (Photo: J Carter)
BAR64 BAR61 BAR19 Earth Bunds BAR 1092 Farm track and BAR1078 weed	Barramundi Creek tributary	17	Barramundi Creek has been identified as a priority. There are a number of potential barriers on this system, which have been grouped together for a holistic assessment. Barriers BAR64, BAR61 & BAR19 are earth bunds, which are known to flood out under a broad range of flows. Catadromous species have been recorded immediately above structure. **Recommendation 1P: The Landholder is interested in modifying this barrier and should be supported subject to appropriate assessment.** Barriers BAR1092 & BAR1078 are a farm track and a weed choke downstream from Horseshoe Lagoon are known to be preventing the movement of catadromous species into the Lagoon. **Recommendation 1Q: support investigations into the modification of this crossing and removal of the weed choke.**	7	 BAR 61 (Photo: J Carter)  BAR19 (Photo: J Carter)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
choke					 BAR1092 & BAR1078 (Photo: Google Earth)
BAR29 BAR1071 Earth Bunds	Alva Creek	18	This is a combination of earth bund and road crossing known locally as Alva Creek Dam. **Recommendation 1R: Work in cooperation with South Burdekin Water Board, Burdekin Shire Council and other stakeholders to discuss the feasibility of modifying this barrier.**	9	 (Photo: NRW 1:25,000 orthophoto)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR1039 together with other identified and unidentified barriers on these systems. Identified barriers are BAR314 BAR58 BAR59 BAR535 BAR86 BAR87 weed chokes and road crossings	Cromarty Ck tributary network including Crooked, Ironbark and Palm Creek Catchments and Pink Lilly, Healys and Reed Bed Lagoons.	19	This adjoining group of catchments was not identified in draft assessments and reporting due to limited site barrier data. However, since the draft reporting stage, further assessment has been made of the significance of these systems as the major northern distributary drainage network of the lower Haughton River basin and the extent and quality of perennial floodplain lagoonal nursery and adult fishery habitat. That assessment (J Tait) underpins the nominated priority ranking of this site. Ironbark Creek also has a potential functional role as a natural connected bypass for the Val Bird Weir. **Recommendation 1S: Work in cooperation with Haughton Catchment Committee, Burdekin Shire Council, Sunwater, landholders and other stakeholders to undertake a holistic assessment of barriers within these sub catchment systems including the functional potential of Ironbark Ck as a Val Bird Weir bypass channel and prioritise remediation options.**	7	 Cromarty Creek network (Photo: Spot Image)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR54 Weir	Leichhardt Creek 1	20	This barrier is a concrete weir. It is in a state of partial disrepair and appears to be undermined, with flows under the weir that are preventing fish passage at lower flows. Whilst drowned out at high flows this barrier is nevertheless likely to be a significant barrier for extended periods. **Recommendation 1T: Work with stakeholders to investigate for modification.**	2	 (Photo: J Carter)
BAR7 Gleesons Weir	Ross River	21	Whilst this is one of four major structures on the Ross River it is nevertheless considered to be worth considering for modification due to its location below large perennial water bodies and social and economic values as per Barrier 1054, Aplins Weir, including its high profile and opportunity to promote the value of fish passage devices. **Recommendation 1U: This structure should be investigated for modification only if Aplins is modified.**	4	 (Photo: J Carter)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR6 Black Weir	Ross River	22	Whilst this is one of four major structures on the Ross River it is nevertheless considered to be worth considering for modification due to its location below a large perennial water body and social and economic values as per Barrier 1054, Aplins Weir, including its high profile and opportunity to promote the value of fish passage devices. **Recommendation 1V: This structure should be investigated for modification only if Aplins Weir and Gleesons Weir are modified.**	4	 (Photo: J Carter)
BAR1082 BAR1084 Earth bunds	Rita Island Distributaries	23	These earth bunds on the Rita Island distributary system may be outflanked and/or overtopped at relatively low flows. However, their impacts are currently unknown and warrant further investigation. **See general recommendation 3: Work in cooperation with stakeholders to examine this whole system, reassess its importance for fish passage and develop a holistic management plan if assessed as a priority.**	11	 (Photo: NRW 1:25,000 orthophoto)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR1006 Collinsville Elphinstone Road	Hazelwood Creek becoming Little Bowen River	24	This crossing is a low level concrete causeway on a rock bar. The rock bar has a drop of approximately 2 metres on the downstream side of the crossing, which implies that the crossing is a minor barrier compared to the natural rock bar but may represent a barrier at low flows due the broad flat road surface. **Recommendation 1W: Undertake further field assessment as this site.** **See also general recommendation 5: That the field assessment of all road and rail crossings be undertaken to provide a high level of confidence in the ranking of these potential barriers.**	26	 (Photo: J Carter)
BAR563 Road crossing	Burdekin River	25	This road crossing has been identified as a potential barrier is requires further investigation. **Recommendation 1X: requires further investigation and discussion with stakeholders to examine need for and feasibility of modification.**	17A	No photo
BAR552 Tondara Road crossing	Bogie River	26	Raised road crossing that could be a significant barrier. **Recommendation 1Y: requires further investigation and consultation with stakeholders.**	16	 (Photo: J Carter)

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR1009 Minor road crossing	Exe Creek	27	Raised road crossing that could be a significant barrier at low to medium flows. **Recommendation 1Z: requires further investigation of this site and consultation with stakeholders.**	16	 (Photo: J Carter)
BAR1010 Collinsville Elphinstone Road crossing	Hazelwood Creek becoming Little Bowen River	28	Raised road crossing that could be a significant barrier at low flows. **Recommendation 1AA: requires further investigation and consultation with stakeholders.**	16	 (Photo: J Carter)
BAR1013 Minor Road crossing	Hazelwood Creek	29	Detail unknown. **Recommendation 1BB: requires further investigation.**	16	No photo

Barrier Code	Stream Name	Rank	Comments/Recommendations	Map No.	
BAR8 Ross River Dam	Ross River	30	This major structure is not likely to be suitable for the installation of a fish passage device due to its height. However, facilitation of eel passage may be worthy of further investigation although eels are known to have been able to bypass the dam wall prior to recent modifications. **Recommendation 1CC: Worthy of further investigation post dam modifications to determine if eel movement is being prevented.**	4 & 5	 Ross River Dam (Photo: J Carter)
BAR2 Eungella Dam	Broken River	31	This major structure is not likely to be suitable for the installation of a fish passage device due to its height. However, facilitation of eel passage may be worthy of further investigation subject to the findings of investigations for Burdekin Falls Dam. **Recommendation 1DD: Undertake investigation subject to the findings of investigations for Burdekin Falls Dam.**	16	 Eungella Dam (Photo: Spot Image)

4.2 Recommendations for further investigations and planning

Fish survey data

One of the key gaps in our knowledge during this study has been the lack of survey data for the distribution and number of species across the region. This is particularly the case in the upper Burdekin catchments including the Belyando, Suttor, Bowen, Broken, Cape and Campaspe River catchments. There is also a similar lack of survey data for many of the coastal streams of the Don and Black River basins.

Recommendation 2: Further fish surveys should be undertaken for those catchments where limited data is currently available. Specifically:

- Don River basin – All catchments, with a focus on the Don River in both dry season and wet season. At the time of preparing this report survey data for this catchment had recently been collected by the Australian Centre for Tropical Freshwater Research (ACTFR) as part of the water for Bowen pre-feasibility assessment process but was not able to be released at the time. This recommendation may be revised when access to that data becomes available.
- Black River basin – all catchments. The very limited fish distribution data for these stream systems is particularly conspicuous considering the perennial nature of these streams and their proximity to Townsville.
- Burdekin River catchment – Belyando and Suttor Rivers are poorly researched in terms of their fish fauna and require further surveys, the impetus for which is underpinned by the known relatively recent establishment of two predatory translocated species (Yellow Belly and Sleepy Cod) in this catchment.

Recommendation 3: The lower Burdekin Delta and Floodplain distributary streams including Cromarty catchment, Barramundi, Sheepstation, Kalamia, Alva and Plantation Creeks included in the Haughton River basin through to Macdonald Creek (south of the Burdekin River) and Saltwater Creek in the Don River basin have multiple potential barriers and flow paths associated with their use for irrigation supply by Sunwater and the North Burdekin and South Burdekin Water Boards. The drainage lines and direction of flows at varying flow events, nature of instream structures and seasonal and permanent occurrences of aquatic weed choked reaches is not well understood or captured by available data.

Due to a lack of detailed knowledge it is not currently possible to make specific recommendations for many of these barriers. It is therefore recommended that:

- These floodplain / delta systems undergo a holistic assessment conducted in close cooperation with the water resource managers and to develop whole of system management plans that deliver operational guidelines as well as proposed works for potential passage barrier forming structures, instream conditions and operational practices.

Holistic catchment approach

The identified barriers can be, in many cases, tackled on an individual basis so that modification can be expected to deliver benefits in upstream watercourses and wetlands. However, a number of barriers will only be worth modifying if they are modified in conjunction with other barriers on the same stream system. The following systems are recommended for such a holistic approach.

Recommendation 4: The following river / drainage systems should be further assessed and a barrier remediation program developed for multiple barriers.

- Ross River requires an integrated approach to barrier remediation. Aplins Weir is the most downstream barrier and could be modified to provide fish passage to a large perennial river reach and to tributary streams. The benefit of modifying Aplins Weir would be increased if the upstream weirs (Gleesons and Black) were also modified but costs/benefits including of rectifying individual structures need to be investigated further.
- The Don River has a number of potential barriers on its main channel. At the time of completing this Report insufficient information was available to determine to what degree, if any, those barriers affect fish passage. When these barriers are elevated to a higher priority as barriers currently higher on the list are rectified, the potential barriers on the Don River should be assessed as a group and not in isolation.

Road and Rail crossings

The GIS based prioritisation system developed by this project provides a framework for prioritising structures for field based assessment in the first instance but there are a large number of crossings, the vast majority of which could not be assessed in the field as part of this study.

Recommendation 5: Identified potential fish passage barriers associated with road and rail crossings need to be the focus of a specific field based site data collection program to better assess the significance of potential barriers and serve a more informed prioritisation of road and rail crossing fish passage works.

GIS Data

This study has collated a range of GIS data and created additional data. During the course of the study it became clear that some of the data obtained from various sources is not compatible with other data and that with some relatively minor modifications compatibility could be achieved.

Recommendation 6: GIS data, particularly in relation to catchment boundaries should be standardised for all future BDTNRM projects and the GIS data collated for this project together with the GIS tool for the identification of priority barriers should be maintained and updated as new information becomes available. The GIS tool will enable informed decisions to be made when undertaking barrier modifications in future years.

Recommendation 7: The GIS data collated for this project together with the GIS tool for the identification of priority barriers should be maintained and updated as new information becomes available. The GIS tool will enable informed decisions to be made when undertaking barrier modifications in future years.

Monitoring and Evaluation

The value of monitoring and evaluation is widely recognised for natural resource management works and is a requirement of all BDTNRM projects. When modifications to barriers are made in the future a monitoring program for each structure should be an integral component included in both design and operational stages. One of the debates about fish passage devices is “which types are the most effective”? Lessons learned from operational devices must be incorporated into the decision-making process when determining which type of devise is the most appropriate for any given barrier.

Recommendation 8: A monitoring program for each structure should be an integral component included in both design and operational stages of any fish passage devices and the results widely publicised.

Increasing knowledge of appropriate fish barrier remediation techniques

There are relatively few fish passage devices fitted to barriers in the region. Whilst good research and work has already been undertaken to date including that by Department of Primary Industries

and Fisheries (DPI&F), James Cook University, School of Engineering and SunWater, there would be benefit in facilitating forums for experts and managers to discuss current best practice techniques and share experiences of past works. In particular there would be benefit in workshopping best practice for fish passage over larger structures such as weirs and dams and to consider options for the movement of eels over or around the large dams, especially Burdekin Falls Dam.

Including the owners and managers of the barriers as an integral part of the forums is most likely to maintain the momentum to implement the most appropriate on-ground works.

Recommendation 9: That BDTNRM host a workshop focussed on fish barrier remediation for road and rail crossing techniques and targeted at Local Government, Main Roads, Queensland Rail and cane rail operators. The purpose of the workshop would be to bring together expertise in fish passage techniques and the owners/managers of road and rail crossing barriers within the BDTNRM region and to focus on best practice applications.

Recommendation 10: BDTNRM actively aid the consolidation of information on fish barrier remediation for weirs.

In 2008 work in cooperation with Sunwater and DPI&F to review the cost and design options for all fish passage devices that may be suitable for weirs (including fish lifts, fishlocks, vertical slot fishways and low gradient channel by-passes) and make findings available for application to other weirs.

That BDTNRM support a DPI&F initiative to host an international conference on fish barrier remediation targeted for 2010 in north Queensland.

Recommendation 11: Work in cooperation with Sunwater and DPI&F to review the cost and design options for all fish passage devices that may be suitable for weirs (including fish lifts, fishlocks, vertical slot fishways and low gradient channel by-passes) and make findings available for application to all weirs.

Appendix 1 Fish Species of the Burdekin Dry Tropics Region

Appendix 2 Summary Tables of Fish Species and distribution

Summary of fish species and distribution

The assigned geographic distribution in the following tables is based on the basins, sub reaches and major streams shown in Section 3, Table 1, page 18 with additional reach breakdown based upon the extent that marine vagrant species are thought to range. Where the extent of marine vagrants is judged to occur the suffix "MV" has been attached. Judgement of the geographic range of marine vagrants recognises variability between seasons and years. It is also recognised that some species such as Silver biddies may extend much further inland than other marine vagrants. Nevertheless, the extent of marine vagrants as defined in this study is considered to be a reasonable representation for the purposes of identifying the potential impact of barriers.

Notes for the following Table 7, Table 8 & Table 9:

- *The numbered prefixes relate to 1 – literature reference, 2- personal observations, 3 – personal expectations (where highly confident).*
- *The lettered suffixes relate to E – error or believed to be misidentified (record noted but ignored for this project), H - Historical record – i.e. now believed does not reflect contemporary distribution because the record was before barrier constructed, T – Translocated, not natural distribution and S – Stocked not natural recruitment.*
- *The SMALL COASTAL STREAMS are all other creeks that fall outside the main catchments listed from 1 to 81 and are short run creeks that discharge directly to sea.*
- *Primary reference source: Pusey, B. J. (2005) Appendix H – Burdekin WRP - Freshwater Fish of the Burdekin River and Associated Drainages: Biodiversity, Distribution, Flow-related Ecology and Current Condition, River Research Pty. Ltd.*
- *Additional sources of data include the Australian Centre for Tropical Freshwater Research (ACTFR) Northern Australia Freshwater Fish database (in press) and Alan Webb - Non-native fishes reported from Ross River catchment (unpublished).*

Table 7: Catadromous, anadromous and marine vagrant / facultative freshwater species list and distribution

		CATADROMOUS												ANADROMOUS		MARINE VAGRANT / FACULTATIVE FRESHWATER SPECIES																
Reach No.	NAME	**Long-finned eel** *Anguilla reinhardtii*	**Pacific eel** *Anguilla obscura*	**Sea Mullett** *Mugil cephalus*	**Barramundi** *Lates calcarifer*	**Mangrove Jack** *Lutjanus argentimaculatus*	**Tarpon** *Megalops cyprinoides*	**Jungle perch** *Kuhlia rupestris*	***Snakehead gudgeon*** *Giurus margaritacea*	**Empire gudgeon** *Hypseleotris compressa*	**Freshwater Long tom** *Strongylura kreffrii*	**Snub-nosed garfish** *Arrhamphus sclerolepis*	**Pacific blue-eye** *Pseudomugil signifer*	**Southern spratt** *Herklotsichthys castelnaui*	**Fork-tailed catfish** *Arius graeffei*	**Bluetail mullet** *Valamugil buchanani*	**Diamond-scale mullet** *Liza vaigiensis*	**Silver Jewfish** *Nibea soldado*	**Anchovy** *Thryssa Hamiltoni*	**Pikey black bream** *Acanthopagrus berda*	**Sawfish** *Pristis* sp.	**River whaler shark** *Carcharhinus leucas*	**Silver batfish** *Monodactylus argenteus*	**Spotted Scat** *Scatophagus argus*	**Banded Scat** *Selenotoca multifasciata*	**Giant herring** *Elops hawaiensis*	**Threadfin Silver biddy** *Gerres filamentosus*	**Common Silver Biddy** *Gerres subfasciatus*	**Milkfish** *Chanos chanos*	**Crescent prech Terapon jarbua**	**Spangled gudgeon** *Ophiocara porocephala*
	Black River																															
1	CRYSTAL CREEK MV	2	3	2	2	2	2	2	2	2		2	2	3		3	3		3	3		3	2	2		3	2	3	2	3	3
2	CRYSTAL CREEK	2	3	2	2	2	2	2	2	2		2	2	3																		
3	OLLERA CREEK MV	2	3	2	1	1	2	1	1	1		2	1	3		3	3		3	3			2	1		3	1	3	1	1	3
4	OLLERA CREEK	2	3	2	1	1	2	1	1	1		2	1	3																		
5	ROLLINGSTONE CREEK MV	2	3	2	2	2	2	2	2	2		2	2	3		3	3		3	3			2	2		3	2	3	2	3	3
6	ROLLINGSTONE CREEK	2	3	2	2	2	2	2	2	2		2	2	3																		
7	SALTWATER CREEK 3 MV	2	3	2	2	2	2	2	2	2		2	2	3		3	3		3	3			3	2		3	2	3	2	3	3
8	SALTWATER CREEK 3	2	3	2	2	2	2	2	2	2		2	2	3																		
9	LEICHHARDT CREEK 1 MV	1	3	2	2	2	2	1	2	1		2	2	3		3	3		3	3			2	2		3	2	3	2	3	3
10	LEICHHARDT CREEK 1	1	3	2	2	2	2	1	2	1		2	2	3																		
11	SLEEPER LOG CREEK MV	2	3	2	2	2	2	2	2	2		3	2	3		3	3		3	3			3	2		3	2	3	2	3	3
12	SLEEPER LOG CREEK	2	3	2	2	2	2	2	2	2		3	2	3																		
13	BLUEWATER CREEK 1 MV	2	3	2	2	2	2	2	1	1		2	2	3		3	3		3	3			3	2		3	1	3	2	3	3
14	BLUEWATER CREEK 1	2	3	2	2	2	2	2	1	1		2	2	3																		
15	DEEP CREEK 1 MV	2	3	2	2	2	2	2	2	2		3	2	3		3	3		3	3			3	2			2	3	3	3	
16	DEEP CREEK 1	2	3	2	2	2	2	2	2	2		3	2	3																		
17	BLACK RIVER MV	1	3	1	1	1	1	2	2	2		2	1	3		3	3		3	3			3	1	1		1	1	2	1	
18	BLACK RIVER	1	3	1	1	1	1	2	2	2		2	1	3																		
	Ross River																															
19	BOHLE RIVER MV	2	3	2	2	2	2	3	2	1	2	2	2	3		3	3		3	3	3	3	2	3	3	3	2	3	2	3	3
20	BOHLE RIVER	2	3	2	2	2	2	3	2	1	2	2	2	3																		
21	ROSS RIVER	2	3	3H	3H			3H	2H	2	2	2	2																			
22	ROSS RIVER BELOW ROSS DAM	2	3	3H	3SH	2HS	3H	3H	2H	2	2	2	2																			
23	ROSS RIVER BELOW APLINS WEIR	2	3	2	3	2	2	2				2		3	3	3	3		3	3	3	3	3	3	3	2			2	3	
24	ALLIGATOR CREEK BELOW WEIR	2	3	2	2	2	2	2	2	2	2	2	2	3		3	3		3	3	3	3	3	2	3	3	2	3	2	3	3
25	ALLIGATOR CREEK	2	3	2	2	2	2	2	2	2	2	2	2	3																		
	Haughton River																															
26	HAUGHTON RIVER BELOW GIRU WEIR	1	3	2	1	1	1	1	1	2	2	2	1	3	2	3	3	3	3	3	3	1	3	3	3	2	2	3	3	3	3
27	HAUGHTON RIVER	1	3	2H	1	1	1	1	1	2	2	2	1		2																	
28	BARRAMUNDI CREEK	2	3	2	2	3	2	3H	3	2	2	3	3	3	2	3	3		3	3	3		3	3		3	3	3	3	3	3
29	BARRATTA CREEK MV	1	3	2	1	1	1	1	2	1	2	2	2	3	1	3	3	3	3	3	3		3	2	3	2	1	3	1	3	3
30	BARRATTA CREEK	1	3	2	1	1	1	1	2	1	2	2	2	3	1											3			3			
31	SHEEPSTATION CREEK 1 MV	2	3	2	2	3	2	3H	3	2	2H	3	3	3	2	3	3		3	3	3			3		3	3	3	3	3	3
32	SHEEPSTATION CREEK 1	2	3	2	2	3	2	3H	3	2	2H	3	3	3	2											3H			3H			
33	ALVA CREEK MV	3	1	2	2	3	2	1H	3	2	1H	3	3	3	3	3	3		3	3	3		3	3	3	3	3	3	3	3	3
34	ALVA CREEK	3	1	2	2	3	2	1H	3	2	1H	3	3	3	3																	
35	KALAMIA CREEK MV	3	1	2	2	3	2	1H	3	2	1H	3	3	3	3	3	3		3	3	3		3	3	3	3	3	3	3	3	3
36	KALAMIA CREEK	3	1	2	2	3	2	1H	3	2	1H	3	3	3	3																	
37	MUD CREEK MV	3		2	2	3	2		3	3		3	3	3	3	3	3		3	3				3		3	3	3	3	3	
38	MUD CREEK	3		2	2	3	2		3	3			3	3	3																	
39	PLANTATION CREEK MV	2	3	2	2	3	2	3H	3	2	2	3	3	3	2	3	3		3	3	3		3	3		3	3	3	3	3	3
40	PLANTATION CREEK	2	3	2	2	3	2	3H	3	2	2	3	3	3	2																	
	Don River																															
41	SALTWATER CREEK 1 MV	2	3	2	2	3	2		3	2	2	3	3	3	2	3	3		3	3			3	3	3	3	3	3	3	3	3
42	SALTWATER CREEK 1	2	3	2	2	3	2		3	2	2	3	3	3	2																	
43	YELLOW GIN CREEK MV	3	3	3	2	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
44	YELLOW GIN CREEK	3		3	2		3			3			3																		
45	WANGARATTA CREEK MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
46	WANGARATTA CREEK	3		3	3		3			3			3																		
47	ROCKY PONDS CREEK MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
48	ROCKY PONDS CREEK	3		3	3		3			3			3																		
49	MONONGLE CREEK MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3

		CATADROMOUS												ANADROMOUS		MARINE VAGRANT / FACULTATIVE FRESHWATER SPECIES															
Reach No.	NAME	**Long-finned eel** *Anguilla reinhardtii*	**Pacific eel** *Anguilla obscura*	**Sea Mullett** *Mugil cephalus*	**Barramundi** *Lates calcarifer*	**Mangrove Jack** *Lutjanus argentimaculatus*	**Tarpon** *Megalops cyprinoides*	**Jungle perch** *Kuhlia rupestris*	***Snakehead gudgeon*** *Giurus margaritacea*	**Empire gudgeon** *Hypseleotris compressa*	**Freshwater Long tom** *Strongylura kreffrii*	**Snub-nosed garfish** *Arrhamphus sclerolepis*	**Pacific blue-eye** *Pseudomugil signifer*	**Southern spratt** *Herklotsichthys castelnaui*	**Fork-tailed catfish** *Arius graeffei*	**Bluetail mullet** *Valamugil buchanani*	**Diamond-scale mullet** *Liza vaigiensis*	**Silver Jewfish** *Nibea soldado*	**Anchovy** *Thryssa Hamiltoni*	**Pikey black bream** *Acanthopagrus berda*	**Sawfish** *Pristis* sp.	**River whaler shark** *Carcharhinus leucas*	**Silver batfish** *Monodactylus argenteus*	**Spotted Scat** *Scatophagus argus*	**Banded Scat** *Selenotoca multifasciata*	**Giant herring** *Elops hawaiensis*	**Threadfin Silver biddy** *Gerres filamentosus*	**Common Silver Biddy** *Gerres subfasciatus*	**Milkfish** *Chanos chanos*	**Crescent prech Terapon jarbua**	**Spangled gudgeon** *Ophiocara porocephala*
50	MONONGLE CREEK	3		3	3	3	3			3		3	3	3																	
51	ARMSTRONG CREEK MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3		3	3	3	3
52	ARMSTRONG CREEK	3		3	3		3			3			3																		
53	SANDY CREEK 1 MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
54	SANDY CREEK 1	3		3	3		3			3			3																		
55	ELLIOT RIVER MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
56	ELLIOT RIVER	3		3	3	3	3			3		3	3	3																	
57	SALTWATER CREEK 2 MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
58	SALTWATER CREEK 2	3		3	3		3			3			3																		
59	KANGAROO CREEK 1 MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
60	KANGAROO CREEK 1	3		3	3		3			3			3																		
61	SPLITTERS CREEK MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
62	SPLITTERS CREEK	3		3	3		3			3			3																		
63	EURI CREEK MV	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
64	EURI CREEK	3		3	3	3	3			3		3	3																		
65	DON RIVER MV	1		3	3	3	3			3		3	3	3		3	3		3	3			3	3	3	3	3	3	3	3	3
66	DON RIVER	1		3	3	3	3			3		3	3	3																	
	Burdekin																														
	Upper Burdekin (above Burdekin Dam)																														
67	BURDEKIN RIVER	1H	1H		1TS						1HE				1HE																
68	CAPE RIVER	3H								1E																					
69	CAMPASPE RIVER	3H																													
70	FANNING RIVER	3H								1E																					
71	KEELBOTTOM CREEK	3H								1E																					
72	FLETCHER CREEK 1	1H																													
73	STAR RIVER	1H			1TS					1E																					
74	DOUGLAS CREEK (incorporated into Burdekin River)																														
75	RUNNING RIVER	1H																													
76	BELYANDO RIVER	1H																													
77	SUTTOR RIVER	3H																													
	Lower Burdekin (below Burdekin Dam)																														
78	BURDEKIN RIVER BELOW CLARE WEIR	1	1	1	1	1	1	2	3	1	1	1	3	1	1	1	1	3	3	3		2	1	1	2	2		2	2	3	1
79	BURDEKIN RIVER ABOVE CLARE WEIR	1	1	1	1S	2H	1H	3H		1	1	1	3	1	1		1														
	Bowen																														
80	BOWEN RIVER	1	3	2H	1S	2H	1H	1H		1	1	1	1		1									3H		3H					
81	BROKEN RIVER	1			1H		1H	1H					1		1																
99	SMALL COASTAL STREAMS	3		3	3	3	3			3		3	3	3		3	3		3	3			3	3			3	3	3	3	3

Table 8: Amphidromous and potadromous species list and distribution

		AMPHIDROMOUS			POTADROMOUS																										
Reach No.	NAME	**Flathed goby** *Glossogobius giurus*	**Speckled goby** *Redigobius bikolanus*	**Roman nose goby** *Awaous acritosus*	**Bony bream** *Nematalosa erebi*	**Black catfish** *Neosilurus ater*	**Hyrtl's tandan** *Neosilurus hyrtlii*	**Soft-spined catfish** *Neosiluris mollespiculum*	**Rendahl's catfish** *Porochilus rendahli*	**Eel-tailed catfish** *Tandanus tandanus*	**Banded grunter** *Amniataba percoides*	**Spangled perch** *Leiopotherapon unicolor*	**Sooty grunter** *Hephaestus fuliginosus*	**Small-headed grunter** *Scortum parviceps*	**Leather grunter** *Scortum hillii*	**Seven-spot Archerfish** *Toxotes chatareus*	**Fly-specked hardyhead** *Craterocephalus stercusmuscarum*	**Eastern rainbowfish** *Melanotaenia splendida splendida*	**Agassi's glassfish** *Ambassis agassizii*	**Sailfin glassfish** *Ambassis agrammus*	**Midgley's Carp gudgeon** *Hypseleotris* spp.	**Western carp gudgeon** *Hypseleotris klunzingeri*	**Purple-spotted gudgeon** *Mogurnda adspersa*	**Flat-headed or Big-headed gudgeon** *Philypnodon grandiceps*	**Sleepy cod** *Oxyeleotris lineolatus*	**Yellowbelly** *Macquaria ambigua*	**Fork-tailed catfish** *Arius leptaspis*	**Firetail gudgeon** *Hypseleotris galii*	**Tilapia** *Oreochromis mossambicus*	**Burton's mouth breeder** *Hyplochromis burtoni*	**Oscar** *Astronotus acellatus*
	Black River																														
1	CRYSTAL CREEK MV	3	3	1	2	3	2					2				2	2	2	2	3	2	3	2								
2	CRYSTAL CREEK	3	3	1	2	3	2					2				2	2	2	2	3	2	3	2								
3	OLLERA CREEK MV	3	3	3	2	3	1					1				2	2	1	2	3	2	3	2								
4	OLLERA CREEK	3	3	3	2	3	1					1				2	2	1	2	3	2	3	2								
5	ROLLINGSTONE CREEK MV	3	3	3	2	3	2					2				2	2	2	2	3	2	3	2								
6	ROLLINGSTONE CREEK	3	3	3	2	3	2					2				2	2	2	2	3	2	3	2								
7	SALTWATER CREEK 3 MV	3	3	3	2	3	2					2				2	2	2	2	3	2	3	2								
8	SALTWATER CREEK 3	3	3	3	2	3	2					2				2	2	2	2	3	2	3	2								
9	LEICHHARDT CREEK 1 MV	3	3	3	2	3	2					1				2	1	1	2	3	2	3	1								
10	LEICHHARDT CREEK 1	3	3	3	2	3	2					1				2	1	1	2	3	2	3	1								
11	SLEEPER LOG CREEK MV	3	3		2	3	2					2				2	2	2	2	3	2	3	2								
12	SLEEPER LOG CREEK	3	3		2	3	2					2				2	2	2	2	3	2	3	2								
13	BLUEWATER CREEK 1 MV	3	3	3	2	3	2					2				2	1	1	1	3	2	3	2						1		
14	BLUEWATER CREEK 1	3	3	3	2	3	2					2				2	1	1	1	3	2	3	2						1		
15	DEEP CREEK 1 MV	3	3		2	3	2					2				2	2	2	2	3	2	3	2						1		
16	DEEP CREEK 1	3	3		2	3	2					2				2	2	2	2	3	2	3	2						1		
17	BLACK RIVER MV	1	3	1	2	3	1				1	1				2	1	1	1	3	1	3	2	1					1		
18	BLACK RIVER	1	3	1	2	3	1				1	1				2	1	1	1	3	1	3	2	1					1		
	Ross River																														
19	BOHLE RIVER MV	3	3		2	3	2		3		3	1				2	1	1	1	3	2	3	2		2				1		
20	BOHLE RIVER	3	3		2	3	2		3		3	1				2	1	1	1	3	2	3	2		2				1		
21	ROSS RIVER	3	3	1	2	1	2		3		2	2				2	2	2	2	3	2	3	2		2						
22	ROSS RIVER BELOW ROSS DAM	3	3	1	2	1	2		3		2	2				2	2	2	2	3	2	3	2		2				1	1	1
23	ROSS RIVER BELOW APLINS WEIR				2											2															
24	ALLIGATOR CREEK BELOW WEIR	3	3	3	2	3	2		3		2	2				2	2	2	2	3	2	3	2		3				1		
25	ALLIGATOR CREEK	3	3	3	2	3	2		3		2	2				2	2	2	2	3	2	3	2		3				1		
	Haughton River																														
26	HAUGHTON RIVER BELOW GIRU WEIR	3	3	1	1	2	2		3		1	1	1			2	1	1	1	1	1	3	2		1						
27	HAUGHTON RIVER	3	3	1	1	2	2		3		1	1	1			2	1	1	1	1	1	3	2		1						
28	BARRAMUNDI CREEK	3	3		2	2	2		3		2	2				2	2	2	2	3	2	3	2		2						
29	BARRATTA CREEK MV	1	3		1	1	1		3		1	1	2			1	1	1	1	1	1	3	1		3						
30	BARRATTA CREEK	1	3		1	1	1		3		1	1	2			1	1	1	1	1	1	3	1		3						
31	SHEEPSTATION CREEK 1 MV	3	3		2	2	2		3		2	2				2	2	2	2	3	2	3	2		2						
32	SHEEPSTATION CREEK 1	3	3		2	2	2		3		2	2				2	2	2	2	3	2	3	2		2						
33	ALVA CREEK MV	3	3		2	3	3		3		3	2				2	3	3	3	3	2	3	3		3						
34	ALVA CREEK	3	3		2	3	3		3		3	2				2	3	3	3	3	2	3	3		3						
35	KALAMIA CREEK MV	3	3		2	3	3		3		3	2				2	3	3	3	3	2	3	3		3						
36	KALAMIA CREEK	3	3		2	3	3		3		3	2				2	3	3	3	3	2	3	3		3						
37	MUD CREEK MV	3	3		3				3			3				3		3	3	3	3	3			3						
38	MUD CREEK	3	3		3				3			3				3		3	3	3	3	3			3						
39	PLANTATION CREEK MV	3	3		2	2	2		3		2	2				2	2	2	2	3	2	3	2		2						
40	PLANTATION CREEK	3	3		2	2	2		3		2	2				2	2	2	2	3	2	3	2		2						
	Don River																														
41	SALTWATER CREEK 1 MV	3	3		2	3	3		3		3	2				2	3	2	2	3	2	3	2		3						
42	SALTWATER CREEK 1	3	3		2	3	3		3		3	2				2	3	2	2	3	2	3	2		3						
43	YELLOW GIN CREEK MV	3	3		3		3					3				3		3	3	3	3	3	3								
44		3	3		3		3					3				3		3	3	3	3	3	3								
45	WANGARATTA CREEK MV	3	3		3		3					3						3	3	3	3	3	3								
46	WANGARATTA CREEK	3	3		3		3					3						3	3	3	3	3	3								

		AMPHIDROMOUS			POTADROMOUS																												
Reach No.	NAME	**Flathed goby** *Glossogobius giurus*	**Speckled goby** *Redigobius bikolanus*	**Roman nose goby** *Awaous acritosus*	**Bony bream** *Nematalosa erebi*	**Black catfish** *Neosilurus ater*	**Hyrtl's tandan** *Neosilurus hyrtlii*	**Soft-spined catfish** *Neosiluris mollespiculum*	**Rendahl's catfish** *Porochilus rendahli*	**Eel-tailed catfish** *Tandanus tandanus*	**Banded grunter** *Amniataba percoides*	**Spangled perch** *Leiopotherapon unicolor*	**Sooty grunter** *Hephaestus fuliginosus*	**Small-headed grunter** *Scortum parviceps*	**Leather grunter** *Scortum hillii*	**Seven-spot Archerfish** *Toxotes chatareus*	**Fly-specked hardyhead** *Craterocephalus stercusmuscarum*	**Eastern rainbowfish** *Melanotaenia splendida splendida*	**Agassi's glassfish** *Ambassis agassizii*	**Sailfin glassfish** *Ambassis agrammus*	**Midgley's Carp gudgeon** *Hypseleotris* spp.	**Western carp gudgeon** *Hypseleotris klunzingeri*	**Purple-spotted gudgeon** *Mogurnda adspersa*	**Flat-headed or Big-headed gudgeon** *Philypnodon grandiceps*	**Sleepy cod** *Oxyeleotris lineolatus*	**Yellowbelly** *Macquaria ambigua*	**Fork-tailed catfish** *Arius leptaspis*	**Firetail gudgeon** *Hypseleotris galii*	**Tilapia** *Oreochromis mossambicus*	**Burton's mouth breeder** *Hyplochromis burtoni*	**Oscar** *Astronotus acellatus*
47	ROCKY PONDS CREEK MV	3	3		3		3					3						3	3	3	3	3	3										
48	ROCKY PONDS CREEK	3	3		3		3					3						3	3	3	3	3	3										
49	MONONGLE CREEK MV	3	3		3	3	3				3	2					3	3	3	3	3	3	3										
50	MONONGLE CREEK	3	3		3	3	3				3	2					3	3	3	3	3	3	3										
51	ARMSTRONG CREEK MV	3	3		3		3					3						3	3	3	3	3	3										
52	ARMSTRONG CREEK	3	3		3		3					3						3	3	3	3	3	3										
53	SANDY CREEK 1 MV	3	3		3		3					3						3	3	3	3	3	3										
54	SANDY CREEK 1	3	3		3		3					3						3	3	3	3	3	3										
55	ELLIOT RIVER MV	3	3		3	3	3				3	2					3	3	3	3	3	3	3										
56	ELLIOT RIVER	3	3		3	3	3				3	2					3	3	3	3	3	3	3										
57	SALTWATER CREEK 2 MV	3	3		3		3					3						3	3	3	3	3	3										
58	SALTWATER CREEK 2	3	3		3		3					3						3	3	3	3	3	3										
59	KANGAROO CREEK 1 MV	3	3		3		3					3						3	3	3	3	3	3										
60	KANGAROO CREEK 1	3	3		3		3					3						3	3	3	3	3	3										
61	SPLITTERS CREEK MV	3	3		3		3					3						3	3	3	3	3	3										
62	SPLITTERS CREEK	3	3		3		3					3						3	3	3	3	3	3										
63	EURI CREEK MV	3	3		3	3	3				3	2					3	3	3	3	3	3	3										
64	EURI CREEK	3	3		3	3	3				3	2					3	3	3	3	3	3	3										
65	DON RIVER MV	3	3		3	3	1				1	1					3	1	3	3	3	3	1										
66	DON RIVER	3	3		3	3	1				1	1					3	1	3	3	3	3	1										
	BurdekiN																																
	Upper Burdekin (above Burdekin Dam)																																
67	BURDEKIN RIVER				1	1	1	1	3	1	1	1	1	1	1E	1	1	1	1		1	3	1	1	1T	1			1				
68	CAPE RIVER				1	1	1		1			1		1			1	1	1		1	3	1		1T	1							
69	CAMPASPE RIVER				1	1	1		1			1	1	1	1E	1	1	1	1		1	3	1		1T	1							
70	FANNING RIVER				1	1	3	1	1		1	1	1	1		1	1	1			1	3	1		1T								
71	KEELBOTTOM CREEK				1	1	1	1	3		1	1	1	1		1	1	1	1		1	3	1		1T				1				
72	FLETCHER CREEK 1				1	1	3	1	1		1	1		1	1E	1	1	1	1		1	3	1										
73	STAR RIVER	1E	1E		1	1	1	3	1		1	1	1	1		1	1	1	1		1	3	1		1T								
74	DOUGLAS CREEK (incorporated into Burdekin River)											1																				
75	RUNNING RIVER				1	1	3	1			1	1	1	1			1	1	1		1	3	1										
76	BELYANDO RIVER				1	1	1		1			1		1		1	1	1	1		1	3	1	1	1T	1		1E					
77	SUTTOR RIVER				1	1	1		3			1		1			1	1	1		1	3	1		3T	3							
	Lower Burdekin (below Burdekin Dam)																																
78	BURDEKIN RIVER BELOW CLARE WEIR	1	1	3	1	2	1	1	1		1	1	1	1	1E	1	1	1	1	3	1	3	1	3	1		1E						
79	BURDEKIN RIVER ABOVE CLARE WEIR	1H	1	3	1	2	1	1	1		1	1	1	1	1E	1	1	1	1	3	1	3	1	3	1	1	1E						
	Bowen																																
80	BOWEN RIVER		1	1	1	1	1	1	1		1	1	1	1	1E	1	1	1	1		1	3	1		1								
81	BROKEN RIVER				1	3	1		3		1	1	1	3		1	1	1	1		1	3	1		1		1E						
99	SMALL COASTAL STREAMS	3	3													3																	

Table 9: Sedentary species list and distribution

		SEDENTARY SPECIES															
Reach No.	NAME	**Mouth almighty** *Glossamia aprion*	**Swamp eel** *Ophisternon bengalense*	**Three-spot gourami** *Trichogaster trichopterus*	**Mosquitofish** *Gambusia holbrooki*	**Sailfin Molly** *Poecilia latipinna*	**Guppy** *Poecilia reticulata*	**Firemouth Cichlid** *Thorichthys meeki*	**Jewel Cichlid** *Hemichromis guttatus*	**Burton's Mouthbreeder** *Haplochromis burtoni*	**Oscar** *Astronotus ocellatus*	**Green Terror** *Aequidens rivulatus*	**Banded Cichlid** *Heros severus*	**Convict Cichlid** *Archocentrus nigrofasciatum*	**Red Devil** *Amphilophus citrinellum*	**Pearl Cichlid** *Geophagus brasiliensis*	**Blue Eye Cichlid** *Archocentrus spilurus*
1	CRYSTAL CREEK MV	2	3														
2	CRYSTAL CREEK	2	3														
3	OLLERA CREEK MV	2	3														
4	OLLERA CREEK	2	3														
5	ROLLINGSTONE CREEK MV	2	3														
6	ROLLINGSTONE CREEK	2	3														
7	SALTWATER CREEK 3 MV	2	3														
8	SALTWATER CREEK 3	2	3														
9	LEICHHARDT CREEK 1 MV	1	3														
10	LEICHHARDT CREEK 1	1	3														
11	SLEEPER LOG CREEK MV	2	3														
12	SLEEPER LOG CREEK	2	3														
13	BLUEWATER CREEK 1 MV	1	3														
14	BLUEWATER CREEK 1	1	3														
15	DEEP CREEK 1 MV	3	3														
16	DEEP CREEK 1	3	3														
17	BLACK RIVER MV	2	1		1		1									1	1
18	BLACK RIVER	2	1		1		1									1	1
19	BOHLE RIVER MV	2	3		1		2										
20	BOHLE RIVER	2	3		1		2										
21	ROSS RIVER	2			1												
22	ROSS RIVER BELOW ROSS DAM	2	3		1		1	1	1	1	1	1	1			1	1
23	ROSS RIVER BELOW APLINS WEIR		3														
24	ALLIGATOR CREEK BELOW WEIR	2	3		1		2										
25	ALLIGATOR CREEK	2	3		1		2										
26	HAUGHTON RIVER BELOW GIRU WEIR	2	3		1	1											
27	HAUGHTON RIVER	2	3		1	1											
28	BARRAMUNDI CREEK	2	3		2												
29	BARRATTA CREEK MV	2	3	2	2									1#	1#		
30	BARRATTA CREEK	2	3	2	2									1#	1#		
31	SHEEPSTATION CREEK 1 MV	2	3	3	2												
32	SHEEPSTATION CREEK 1	2	3	3	2												
33	ALVA CREEK MV	3	3		2												
34	ALVA CREEK	3	3		2												
35	KALAMIA CREEK MV	3	3		2												
36	KALAMIA CREEK	3	3		2												
37	MUD CREEK MV	3	3		3												
38	MUD CREEK	3	3		3												
39	PLANTATION CREEK MV	2	3		2												
40	PLANTATION CREEK	2	3		2												
	Don River																
41	SALTWATER CREEK 1 MV	2	3		2												
42	SALTWATER CREEK 1	2	3		2												
43	YELLOW GIN CREEK MV	3			3												
44		3			3												
45	WANGARATTA CREEK MV	3			3												
46	WANGARATTA CREEK	3			3												

		SEDENTARY SPECIES															
Reach No.	NAME	**Mouth almighty** *Glossamia aprion*	**Swamp eel** *Ophisternon bengalense*	**Three-spot gourami** *Trichogaster trichopterus*	**Mosquitofish** *Gambusia holbrooki*	**Sailfin Molly** *Poecilia latipinna*	**Guppy** *Poecilia reticulata*	**Firemouth Cichlid** *Thorichthys meeki*	**Jewel Cichlid** *Hemichromis guttatus*	**Burton's Mouthbreeder** *Haplochromis burtoni*	**Oscar** *Astronotus ocellatus*	**Green Terror** *Aequidens rivulatus*	**Banded Cichlid** *Heros severus*	**Convict Cichlid** *Archocentrus nigrofasciatum*	**Red Devil** *Amphilophus citrinellum*	**Pearl Cichlid** *Geophagus brasiliensis*	**Blue Eye Cichlid** *Archocentrus spilurus*
47	ROCKY PONDS CREEK MV	3			3												
48	ROCKY PONDS CREEK	3			3												
49	MONONGLE CREEK MV	3			3												
50	MONONGLE CREEK	3			3												
51	ARMSTRONG CREEK MV	3			3												
52	ARMSTRONG CREEK	3			3												
53	SANDY CREEK 1 MV	3			3												
54	SANDY CREEK 1	3			3												
55	ELLIOT RIVER MV	3			3												
56	ELLIOT RIVER	3			3												
57	SALTWATER CREEK 2 MV	3			3												
58	SALTWATER CREEK 2	3			3												
59	KANGAROO CREEK 1 MV	3			3												
60	KANGAROO CREEK 1	3			3												
61	SPLITTERS CREEK MV	3			3												
62	SPLITTERS CREEK	3			3												
63	EURI CREEK MV	3			3												
64	EURI CREEK	3			3												
65	DON RIVER MV	3			3												
66	DON RIVER	3			3												
67	BURDEKIN RIVER	1HE			3												
68	CAPE RIVER																
69	CAMPASPE RIVER																
70	FANNING RIVER																
71	KEELBOTTOM CREEK				2												
72	FLETCHER CREEK 1																
73	STAR RIVER																
74	DOUGLAS CREEK (incorporated into Burdekin River)																
75	RUNNING RIVER																
76	BELYANDO RIVER																
77	SUTTOR RIVER																
78	BURDEKIN RIVER BELOW CLARE WEIR	1	3		1												
79	BURDEKIN RIVER ABOVE CLARE WEIR	1			1		1										
80	BOWEN RIVER	1															
81	BROKEN RIVER																
99	SMALL COASTAL STREAMS																

1# East Barratta Creek only

Appendix 3 Method

A3.1 IDENTIFICATION OF FISH SPECIES AND GEOGRAPHIC SPREAD

The identification of fish species and their geographic spread was undertaken through a desktop assessment. Much of the information is based on the work of Pusey (2005) (additional references are listed below). The Australian Centre for Tropical Freshwater Research (ACTFR) also provided access to their Northern Australian Fish (NAF) database (in press), which contains the most current available fish survey data for tropical Australia. Allan Webb also from ACTFR provided information of the expanding list of exotic fish species recorded from the immediate Townsville region, principally the Ross River. Additional information about species distribution is the author's experience (principally, Jim Tait) and knowledge of the region. Descriptions of species are based upon Allen et. al. (2002) and Pusey et. al. (2004) with additional detail and comments by the authors of this study. A description of each species and a map showing its distribution across the region is provided as a stand-alone publication and as Appendix 1.

Once the number and range of species was completed the information was linked to the watercourse layer of the GIS data (see section A3.3.2 stream order). The results of the assessment are provided in Section 3.3 and 3.4.

References used and further reading:

Australian Centre for Tropical Freshwater Research (in press) Northern Australian Fish (NAF) database.

Burrows, D.W. (July 2002) ***Fish Stocking and the Distribution and Potential Impact of Translocated Fishes in Streams of the Wet Tropics Region, Northern Queensland***, Report to the Wet Tropics Management Authority, ACTFR Report No. 02/04.

Burrows, D. Veitch, V., Loong, D., Perna, C. & Butler, B. (June 2006) **Monitoring of the Health and Fish Passage Issues of Healey's Lagoon Following Removal of an Extensive Mat of Floating Aquatic Weeds,** ACTFR Report No. 06/11.

Loong, D., Burrows, D., Faithful, J. & Butler, B. (September 2006) ***TOWNSVILLE FIELD TRAINING AREA (TFTA) ECOLOGICAL MONITORING: Monitoring of Water Quality, Fish, Aquatic Invertebrates and Stream Sediments on the Townsville Field Training Area (TFTA) November 2005-July 2006***, ACTFR Report No. 06/15.

Perna, C. (November 2003) ***Fish Habitat Assessment and Rehabilitation in the Burdekin Delta Distributary Streams,*** ACTFR Report No. 03/22.

Pusey, B. Kennard, M. Arthington, A. (2004) ***Freshwater Fishes of North-eastern Australia***, CSIRO Publishing. (Available from http://www.publish.csiro.au/)

Pusey, B. J. (2005) Appendix H – Burdekin WRP - ***Freshwater Fish of the Burdekin River and Associated Drainages: Biodiversity, Distribution, Flow-related Ecology and Current Condition***, River Research Pty. Ltd.

Unmack, PJ., (2001) ***Biogeography of Australian freshwater fishes.*** Journal of Biogeography, 28, 1053 - 1089.

Veitch, V. & Sawynok, B. (January 2005) ***Freshwater Wetlands and Fish: Importance of Freshwater Wetlands to Marine Fisheries Resources in the Great Barrier Reef***, Sunfish Queensland Inc.

Veitch, V. & Burrows, D. (November 2006) ***Fish Passage Issues of Healey's Lagoon Following Investigation of Water Quality Issues Impacting on Fish Migration***, ACTFR Report No. 06/22.

A3.2 FISH BARRIER IDENTIFICATION AND PRIORITISATION

Introduction

The project team considered various methods for ranking barriers to fish passage in order of priority. Methods reviewed and considered included:

- Marsden et. al. (2006) “Freshwater Fish Habitat Rehabilitation in the Mackay Whitsunday Region”.
- Gordos et. al. (2007) “Audit and remediation of fish passage barriers in coastal NSW”.

While the methods used in those studies were considered to be appropriate for those studies, the project team felt that a method specific to the BDTNRM region was required due to:

- The size of the region, which necessitated an assessment methodology that operates on a remote sensing / GIS information basis, to enable the assessment of a large number of potential barriers over such a large area.
- The desire to distinguish between sites of varying fish passage barrier significance (barrier type and degree of obstruction to fish migration) for an area the size of the Burdekin region.
- The limited availability of site based information in this study.
- The need to consider a diverse range of barrier types, not all of which have been considered in other studies.

Therefore, a specific method for this study was developed, tested and applied.

Overview

There are thousands of potential barriers throughout the region and it was not possible with available resources to assess them all in the field. Therefore, to enable rationalisation of those thousands into a manageable number in a priority order a two-stage process was applied:

Stage 1: Desktop assessment: This was a GIS based assessment that identified all known potential barriers and applied a logical process to filter the large number of potential barriers to a number that could be reviewed in more detail and assessed in the field. This process used a number of attributes for the barrier sites established from the available data, with an emphasis placed on barrier significance (barrier type and degree of obstruction to fish migration), habitat values, and other ecological attributes in recognition of the principal project aim “To identify, map and collate relevant information on the most ecologically significant fish barriers in the BDTNRM Region”.

Stage 2: Review: Through field assessment, community consultation and Expert Panel review, barrier identification was updated, the significance of particular barriers revised using more detailed information, and additional attributes considered when reviewing the Stage 1 GIS based priority order. This included such attributes as cost, feasibility, effectiveness of modifications and community support.

A3.3 FISH BARRIER IDENTIFICATION AND PRIORITISATION: Stage One - Desktop Assessment

Identification of potential barriers

The individual barriers were identified by the following methods:

Barrier Type	Method of identification
Natural barrier (waterfalls)	Digital data from Geosciences Australia 1:250 000 scale mapping.
Dams	Digital data from Geosciences Australia 1:250 000 scale mapping, NRW Landuse mapping and satellite imagery.
Weirs	Study team knowledge and discussions with infrastructure owner/managers, Sunwater and NQ Water.
Sand dams / crossings	Study team knowledge, discussions with government agency staff, Water Board staff, satellite imagery and aerial photography for 2006 and from 1:25 000 ortho photo maps from DNR&W where available.
Tidal intrusion barrages – ponded pasture bunds	Original mapping for this project based on satellite imagery provided by BDTNRM and aerial photography for 2006 and from 1:25 000 ortho photo maps from DNR&W where available.
Weed / macrophyte choked reaches	Original mapping for this project based on satellite imagery provided by BDTNRM and aerial photography for 2006 and from 1:25 000 ortho photo maps from DNR&W where available.
Road and rail crossings (culverts, causeways and fords)	A combination of: • Digital data from Geosciences Australia 1:250 000 scale mapping intersecting roads and rail network with stream layer. • Data provided in spreadsheet format by Main Roads and Queensland Rail and converted by the project team to GIS shape file and cross checked with intersection layer. • Information provided by Department of Defence for their land.
Other instream structures (e.g. Water Board control gates)	Discussions and information provided by North and South Burdekin Water boards.

All information was refined following review of the Draft Report by the project expert panel and through community meetings and input.

Priority setting method

Various ecological, social and economic attributes were considered to be important in assisting with the assessment of priority order. Not all of those attributes were able to be included in the initial, desktop ranking process due to lack of or poor quality data.

Those attributes that were considered for the desktop assessment were grouped under three themes as follows:

FISH VALUES

- Conservation Significance
- Fishery Significance
- Cultural Significance
- Species movement requirements.

HABITAT VALUES

- Upstream habitat quantity (Perennial water in Ha)
- Upstream habitat quantity (Ephemeral water in Ha)
- Upstream habitat quality (Land use as a surrogate for river condition)
- Stream order
- Position of barrier in the catchment
- Distance to next barrier upstream
- Uninterrupted stream length upstream (NB this includes tributary drainages)
- Proximity to downstream aquatic refugia (where aquatic habitat above barrier is non-perennial)
- Presence/absence of downstream barrier.

THREATS

- Barrier significance (barrier type and degree of obstruction to fish migration).

These themes and attributes were assigned a scoring system linked to GIS (ArcView format) based mapping. The mapping has been undertaken predominantly at the scale of 1:250,000 using digital data from Geosciences Australia. Additional data has been sourced from various agencies and organisations whilst original data has been developed specifically for this project.
Mapping at 1:100,000 scale was considered but not used because: the available mapping at that scale is incomplete for the region; and the additional detail at 1:100,000 scale is almost entirely first order streams, which are not considered as high value in the priority setting exercise due to their position in the catchment and generally ephemeral nature. Barriers on watercourses of a finer scale than first order streams as mapped at 1:250,000 scale were considered to be most unlikely to appear sufficiently high on a priority ranking list at a regional scale to warrant inclusion.
Exceptions could occur where:

1. A spring fed first order stream supports perennial habitat for a rare species. However, no such example was known to the project team but an opportunity was nevertheless provided in the community engagement and expert panel review process to include any examples that were unknown to the project team (at the time of completing the Final Report no such examples were identified).
2. A first order stream flowed from a wetland, which itself has a significant fish habitat value. This occurs particularly on the lower floodplains of the Burdekin River, Haughton River and Barratta Creek and also in the coastal catchments of the Don River basin. In these areas detailed checks were undertaken using satellite imagery and aerial photography. All potential barriers that could be identified were mapped. This was done to recognise the value of these floodplain wetlands, which would not otherwise have been included in the assessment process.

Ranking System

There are two aspects to the ranking system developed for this project. Firstly the fish values (4 attributes) and habitat values (9 attributes) were established for each site using a 4-class scoring system. These scores were aggregated (added together) for each site, and the threat

value (barrier significance) applied to the aggregate score to develop an overall score to be used for ranking the Stage 1 priority sites.

Due to the large number of barriers in the BDTNRM region, the score intervals within the fish value and habitat value attributes were chosen to assist in differentiating between priority barriers for management attention. The assessment was undertaken using a logarithmic scale for assigning scores within the 4-class system for each of these value attributes. Alternative methods using a non-logarithmic scale were also tested and considered in order to ensure that barriers that rate highly in several key attributes (e.g. conservation significance, barrier location in catchment) did not dominate in the ranking process and preclude consideration of other potential barriers that rated in a broad range of attributes. However, the project team selected the logarithmic scale for value attributes as providing a reliable discrimination between barriers.

The threat values established for the barrier significance attribute at each site were applied (value x threat) to the aggregate fish value and habitat value scores (determined by summing the 9 usable attribute value scores for the site). A non-logarithmic scale was adopted for the barrier significance attribute, initially using a 4-class system to differentiate between various barrier types and their degree of obstruction to fish migration. Alternative methods using a logarithmic scale and a larger number of scoring classes for the threat attribute were also considered in order to discriminate more effectively between potential barriers. However, insufficient information about individual barriers prevented the use of a larger number of scoring classes.

A3.3.1 FISH VALUES

A two step process was applied to calculate a score for the Fish Values theme for each barrier.

Step 1: A number of attributes were considered for each fish species (conservation significance, fisheries value, species movement requirements and cultural value with a value and score (high - 100, medium - 10, low – 1 or none - 0) assigned to each. The allocated values for each species are shown in Table 13 and Table 14. It should be noted that although discussions with Traditional Owners were not able to be held within the timeframe of delivering this Final Report, the ability to add this value in the future has been left in place so that if it is deemed appropriate by Traditional Owners in the future, Cultural Values can be included.

Step 2: A total score for any one catchment or reach within a catchment was derived by:

1. Adding the total score for all species that occur within the catchment or reach.
2. Normalising the total score for each Fish Value where the totals fell within particular ranges. These are shown in the following tables. A barrier which lies within a particular catchment or reach receives that score as part of the overall calculation.

CONSERVATION SIGNIFICANCE

Table 10: Conservation significance values

Value	Description	Score
High	Listed under State (*Queensland Nature Conservation Act 1992*) and/or Commonwealth (*Environment Protection and Biodiversity Conservation Act 1999*) or endemic to Basin / Region and rare or restricted or undergoing range reductions.	100
Medium	Endemic to the BDTNRM region (but not rare or restricted or undergoing range reductions) or not endemic but rare or restricted or undergoing range reductions within the BDTNRM region.	10
Low	Common/Abundant within and not endemic to the BDTNRM region but undergoing range and/or population reductions within the region or elsewhere	1
None	Common/Abundant within and outside of the BDTNRM region and or exotic / translocated.	0

Table 11: Fishery significance (commercial/recreational)

Value	Description	Score
High	Primary target species for both recreational and commercial fishers	100
Medium	Primary target species for either recreational or commercial fishers	10
Low	Occasional target species for either recreational or commercial fishers	1
None	No recreational or commercial value.	0

Details of the allocated values are shown in Table 14 and Table 15.

Table 12: Cultural significance

Value	Description	Score
High	Primary food or other cultural significance	100
Medium	Secondary food or other cultural significance	10
Low	No food values but other cultural significance	1
None	No cultural significance (Exotic species only).	0

This is largely Traditional Owner significance. Whilst discussions with Traditional Owners were not able to be held within the timeframe of delivering this Final Report, the ability to add this value in the future has been left in place so that if it is deemed appropriate by Traditional Owners in the future, Cultural Values can be included.

Table 13: Species movement requirements

Value	Description	Score
High	Access between estuarine and upper catchment areas critical for life history and/or maintenance of population sizes / recruitment levels	100
Medium	Movement between river reaches required to complete lifecycle and maintain recruitment levels	10
Low	Movement occurs within reaches or from estuary to lower freshwater reaches but not necessary for completion of lifecycle or maintenance of recruitment levels	1
None	Sedentary. No movement required to complete lifecycle.	0

Not all species require movement during their lifecycle and the extent to which species require movement varies between species. Therefore, a judgment for each species has been made as to the necessary movement requirements of each species in order for them to complete their lifecycles. Details of the allocated values for each species are shown in Table 14 and Table 15. The scores by catchment and reach are shown in Table 18.

None of the exotic species were included in the scoring assessments.

Table 14: Fish Values - Catadromous, Anadromous, Marine Vagrants and Amphidropmous species

			VALUES			
		SPECIES	Conservation	Fisheries	Cultural	Species Movement Requirements
CATADROMOUS	1	Longfinned eel	LOW	HIGH		HIGH
	2	Pacific shortfinned eel	LOW	HIGH		HIGH
	3	Sea Mullett	NONE	MEDIUM		HIGH
	4	Barramundi	LOW	HIGH		HIGH
	5	Mangrove jack	LOW	HIGH		HIGH
	6	Tarpon	NONE	MEDIUM		HIGH
	7	Jungle perch	MEDIUM	MEDIUM		HIGH
	8	Snakehead gudgeon	NONE	LOW		HIGH
	9	Empire gudgeon	NONE	NONE		MEDIUM
	10	Freshwater Long tom	MEDIUM	LOW		MEDIUM
	11	Snub-nosed garfish	NONE	MEDIUM		MEDIUM
	12	Pacific blue-eye	NONE	NONE		MEDIUM
ANADROMOUS	13	Southern spratt	NONE	NONE		HIGH
	14	Fork-tailed catfish	NONE	MEDIUM		HIGH
MARINE VAGRANTS	15	Bluetail mullet	NONE	MEDIUM		LOW
	16	Diamond-scale mullet	NONE	MEDIUM		LOW
	17	Silver Jewfish	NONE	LOW		LOW
	18	Anchovy	NONE	NONE		LOW
	19	Pikey black bream	NONE	HIGH		LOW
	20	Sawfish	HIGH	NONE		LOW
	21	River whaler shark	NONE	LOW		LOW
	22	Silver batfish	NONE	NONE		LOW
	23	Spotted Scat	NONE	NONE		LOW
	24	Banded Scat	NONE	NONE		LOW
	25	Giant herring	NONE	MEDIUM		LOW
	26	Threadfin Silver biddy	NONE	NONE		LOW
	27	Common Silver Biddy	NONE	NONE		LOW
	28	Milkfish	NONE	MEDIUM		LOW
	29	Crescent Perch	NONE	NONE		LOW
	30	Spangled gudgeon	NONE	NONE		LOW
AMPHIDROMOUS	31	Flathed goby	NONE	NONE		HIGH
	32	Speckled goby	NONE	NONE		HIGH
	33	Roman Nose Goby	NONE	NONE		HIGH

Table 15: Fish Values - Potadromous and Sedentary species

			VALUES			
		SPECIES	Conservation	Fisheries	Cultural	Species Movement Requirements
POTADROMOUS	34	Bony bream	NONE	NONE		LOW
	35	Black catfish	NONE	MEDIUM		MEDIUM
	36	Hyrtl's tandan	NONE	MEDIUM		MEDIUM
	37	Soft-spined catfish	HIGH	MEDIUM		MEDIUM
	38	Rendahl's catfish	NONE	NONE		LOW
	39	Eel-tailed cafish	NONE	MEDIUM		LOW
	40	Banded grunter	NONE	NONE		LOW
	41	Spangled perch	NONE	LOW		MEDIUM
	42	Sooty grunter	NONE	MEDIUM		MEDIUM
	43	Small-headed grunter	HIGH	LOW		MEDIUM
	44	Leather grunter	N/A	N/A	N/A	N/A
	45	Seven-spot archerfish	LOW	MEDIUM		MEDIUM
	46	Fly-specked hardyhead	NONE	NONE		LOW
	47	Eastern rainbowfish	NONE	NONE		LOW
	48	Agassi's glassfish	NONE	NONE		LOW
	49	Sailfin glassfish	LOW	NONE		MEDIUM
	50	Midgley's Carp gudgeon	NONE	NONE		LOW
	51	Western carp gudgeon	NONE	NONE		LOW
	52	Purple-spotted gudgeon	LOW	NONE		LOW
	53	Flat-headed or Big-headed gudgeon	MEDIUM	NONE		MEDIUM
	54	Sleepy cod	NONE	MEDIUM		LOW
	55	Yellowbelly	NONE	MEDIUM		MEDIUM
	56	Fork-tailed catfish	N/A	N/A	N/A	N/A
	57	Firetail gudgeon	N/A	N/A	N/A	N/A
	58	Tilapia	NONE	NONE		NONE
	59	Burton's Mouthbreeder	NONE	NONE		NONE
	60	Oscar	NONE	NONE		NONE
SEDENTARY	61	Mouth almighty	NONE	NONE		NONE
	62	Swamp eel	MEDIUM	NONE		MEDIUM
	63	Three-spot gourami	NONE	NONE		NONE
	64	Mosquitofish	NONE	NONE		NONE
	65	Sailfin Molly	NONE	NONE		NONE
	66	Guppy	NONE	NONE		NONE
	67	Firemouth Cichlid	NONE	NONE		NONE
	68	Jewel Cichlid	NONE	NONE		NONE
	69	Green Terror	NONE	NONE		NONE
	70	Banded Cichlid	NONE	NONE		NONE
	71	Convict Cichlid	NONE	NONE		NONE
	72	Red Devil	NONE	NONE		NONE
	73	Pearl Cichlid	NONE	NONE		NONE
	74	Blue Eye Cichlid	NONE	NONE		NONE
	75	Platy	NONE	NONE		NONE
	76	Swordtail	NONE	NONE		NONE

Table 16: Conservation Significance scores by catchment or reach

Reach No.	Catchment	No. of Species in Value Category					Conservation Value Score	Normalised Score #
		H	M	L	N	TOTAL		
1	CRYSTAL CREEK MV	0	2	7	33	42	27	10
2	CRYSTAL CREEK	0	2	7	20	29	27	10
3	OLLERA CREEK MV	0	2	7	32	41	27	10
4	OLLERA CREEK	0	2	7	20	29	27	10
5	ROLLINGSTONE CREEK MV	0	2	7	32	41	27	10
6	ROLLINGSTONE CREEK	0	2	7	20	29	27	10
7	SALTWATER CREEK 3 MV	0	2	7	32	41	27	10
8	SALTWATER CREEK 3	0	2	7	20	29	27	10
9	LEICHHARDT CREEK 1 MV	0	2	7	32	41	27	10
10	LEICHHARDT CREEK 1	0	2	7	20	29	27	10
11	SLEEPER LOG CREEK MV	0	2	7	31	40	27	10
12	SLEEPER LOG CREEK	0	2	7	19	28	27	10
13	BLUEWATER CREEK 1 MV	0	2	7	32	41	27	10
14	BLUEWATER CREEK 1	0	2	7	20	29	27	10
15	DEEP CREEK 1 MV	0	2	7	29	38	27	10
16	DEEP CREEK 1	0	2	7	19	28	27	10
17	BLACK RIVER MV	0	3	7	32	42	37	10
18	BLACK RIVER	0	3	7	21	31	37	10
19	BOHLE RIVER MV	1	3	7	36	47	137	100
20	BOHLE RIVER	0	3	7	22	32	37	10
21	ROSS RIVER	0	2	6	22	30	26	10
22	ROSS RIVER BELOW ROSS DAM	0	3	7	22	32	37	10
23	ROSS RIVER BELOW APLINS WEIR	1	2	5	17	25	125	100
24	ALLIGATOR CREEK BELOW WEIR	1	3	7	37	48	137	100
25	ALLIGATOR CREEK	0	3	7	23	33	37	10
26	HAUGHTON RIVER BELOW GIRU WEIR	1	3	7	40	51	137	100
27	HAUGHTON RIVER	0	3	7	24	34	37	10
28	BARRAMUNDI CREEK	1	3	7	35	46	137	100
29	BARRATTA CREEK MV	1	3	7	38	49	137	100
30	BARRATTA CREEK	0	3	7	26	36	37	10
31	SHEEPSTATION CREEK 1 MV	1	3	7	34	45	137	100
32	SHEEPSTATION CREEK 1	0	3	7	25	35	37	10
33	ALVA CREEK MV	1	3	7	36	47	137	100
34	ALVA CREEK	0	3	7	23	33	37	10
35	KALAMIA CREEK MV	1	3	7	36	47	137	100
36	KALAMIA CREEK	0	3	7	23	33	37	10
37	MUD CREEK MV	0	1	5	29	35	15	1
38	MUD CREEK	0	1	5	18	24	15	1
39	PLANTATION CREEK MV	1	3	7	35	46	137	100
40	PLANTATION CREEK	0	3	7	23	33	37	10
41	SALTWATER CREEK 1 MV	0	2	7	36	45	27	10
42	SALTWATER CREEK 1	0	2	7	23	32	27	10
43	YELLOW GIN CREEK MV	0	0	7	29	36	7	1
44	YELLOW GIN CREEK	0	0	5	14	19	5	1
45	WANGARATTA CREEK MV	0	0	5	29	34	5	1
46	WANGARATTA CREEK	0	0	4	14	18	4	1
47	ROCKY PONDS CREEK MV	0	0	5	29	34	5	1
48	ROCKY PONDS CREEK	0	0	4	14	18	4	1

Reach No.	Catchment	No. of Species in Value Category					Conservation Value Score	Normalised Score #
		H	M	L	N	TOTAL		
49	MONONGLE CREEK MV	0	0	5	32	37	5	1
50	MONONGLE CREEK	0	0	5	19	24	5	1
51	ARMSTRONG CREEK MV	0	0	5	28	33	5	1
52	ARMSTRONG CREEK	0	0	4	14	18	4	1
53	SANDY CREEK 1 MV	0	0	5	29	34	5	1
54	SANDY CREEK 1	0	0	4	14	18	4	1
55	ELLIOT RIVER MV	0	0	5	32	37	5	1
56	ELLIOT RIVER	0	0	5	19	24	5	1
57	SALTWATER CREEK 2 MV	0	0	5	29	34	5	1
58	SALTWATER CREEK 2	0	0	4	14	18	4	1
59	KANGAROO CREEK 1 MV	0	0	5	29	34	5	1
60	KANGAROO CREEK 1	0	0	4	14	18	4	1
61	SPLITTERS CREEK MV	0	0	5	29	34	5	1
62	SPLITTERS CREEK	0	0	4	14	18	4	1
63	EURI CREEK MV	0	0	5	32	37	5	1
64	EURI CREEK	0	0	5	18	23	5	1
65	DON RIVER MV	0	0	5	32	37	5	1
66	DON RIVER	0	0	5	19	24	5	1
67	BURDEKIN RIVER	2	1	5	15	23	215	100
68	CAMPASPE RIVER	1	0	2	12	15	102	100
69	CAPE	1	0	3	13	17	103	100
70	FANNING RIVER	2	0	3	12	17	203	100
71	KEELBOTTOM CREEK	2	0	3	13	18	203	100
72	FLETCHER CREEK 1	2	0	3	11	16	203	100
73	STAR RIVER	2	0	4	13	19	204	100
74	DOUGLAS CREEK (incorporated into Burdekin River)	0	0	0	0	0		
75	RUNNING RIVER	2	0	2	11	15	202	100
76	BELYANDO RIVER	1	1	3	12	17	113	100
77	SUTTOR RIVER	1	0	2	12	15	102	100
78	BURDEKIN RIVER BELOW CLARE WEIR	3	4	7	38	52	347	100
79	BURDEKIN RIVER ABOVE CLARE WEIR	2	3	7	30	42	237	100
80	BOWEN RIVER	2	2	6	25	35	226	100
81	BROKEN RIVER	1	1	4	16	22	114	100
99	SMALL COASTAL STREAMS	0	0	4	19	23	4	1

 # Normalised scores as follows:

HIGH = > 100 score + 100

MEDIUM = 20 to 100 score + 10

LOW = <20 score = 1

NONE – No catchments or reaches were considered as having a conservation significance of 0. Therefore no normalised scores of 0 are allocated.

Table 17: Fisheries Significance values and scores by catchment or reach

Reach No.	Catchment	No. of Species in Value Category					Fisheries Value Score	Normalised Score#
		H	M	L	N	TOTAL		
1	CRYSTAL CREEK MV	5	11	3	23	42	613	100
2	CRYSTAL CREEK	4	7	2	16	29	472	10
3	OLLERA CREEK MV	5	11	2	23	41	612	100
4	OLLERA CREEK	4	7	2	16	29	472	10
5	ROLLINGSTONE CREEK MV	5	11	2	23	41	612	100
6	ROLLINGSTONE CREEK	4	7	2	16	29	472	10
7	SALTWATER CREEK 3 MV	5	11	2	23	41	612	100
8	SALTWATER CREEK 3	4	7	2	16	29	472	10
9	LEICHHARDT CREEK 1 MV	5	11	2	23	41	612	100
10	LEICHHARDT CREEK 1	4	7	2	16	29	472	10
11	SLEEPER LOG CREEK MV	5	11	2	22	40	612	100
12	SLEEPER LOG CREEK	4	7	2	15	28	472	10
13	BLUEWATER CREEK 1 MV	5	11	2	23	41	612	100
14	BLUEWATER CREEK 1	4	7	2	16	29	472	10
15	DEEP CREEK 1 MV	5	10	2	21	38	602	100
16	DEEP CREEK 1	4	7	2	15	28	472	10
17	BLACK RIVER MV	5	10	2	25	42	602	100
18	BLACK RIVER	4	7	2	18	31	472	10
19	BOHLE RIVER MV	5	12	4	26	47	624	100
20	BOHLE RIVER	4	8	3	17	32	483	10
21	ROSS RIVER	3	8	3	16	30	383	10
22	ROSS RIVER BELOW ROSS DAM	4	8	3	17	32	483	10
23	ROSS RIVER BELOW APLINS WEIR	5	10	1	9	25	601	100
24	ALLIGATOR CREEK BELOW WEIR	5	12	4	27	48	624	100
25	ALLIGATOR CREEK	4	8	3	18	33	483	10
26	HAUGHTON RIVER BELOW GIRU WEIR	5	14	5	27	51	645	100
27	HAUGHTON RIVER	4	10	3	17	34	503	100
28	BARRAMUNDI CREEK	5	13	3	25	46	633	100
29	BARRATTA CREEK MV	5	14	4	26	49	644	100
30	BARRATTA CREEK	4	12	3	17	36	523	100
31	SHEEPSTATION CREEK 1 MV	5	13	3	24	45	633	100
32	SHEEPSTATION CREEK 1	4	11	3	17	35	513	100
33	ALVA CREEK MV	5	13	3	26	47	633	100
34	ALVA CREEK	4	9	3	17	33	493	10
35	KALAMIA CREEK MV	5	13	3	26	47	633	100
36	KALAMIA CREEK	4	9	3	17	33	493	10
37	MUD CREEK MV	4	10	2	19	35	502	100
38	MUD CREEK	3	5	2	14	24	352	10
39	PLANTATION CREEK MV	5	13	3	25	46	633	100
40	PLANTATION CREEK	4	9	3	17	33	493	10
41	SALTWATER CREEK 1 MV	5	12	3	25	45	623	100
42	SALTWATER CREEK 1	4	8	3	17	32	483	10
43	YELLOW GIN CREEK MV	5	9	1	21	36	591	100
44	YELLOW GIN CREEK	2	4	1	12	19	241	10
45	WANGARATTA CREEK MV	4	8	1	21	34	481	10
46	WANGARATTA CREEK	2	3	1	12	18	231	10
47	ROCKY PONDS CREEK MV	4	8	1	21	34	481	10
48	ROCKY PONDS CREEK	2	3	1	12	18	231	10

Reach No.	Catchment	No. of Species in Value Category					Fisheries Value Score	Normalised Score#
		H	M	L	N	TOTAL		
49	MONONGLE CREEK MV	4	9	1	23	37	491	10
50	MONONGLE CREEK	3	5	1	15	24	351	10
51	ARMSTRONG CREEK MV	4	8	1	20	33	481	10
52	ARMSTRONG CREEK	2	3	1	12	18	231	10
53	SANDY CREEK 1 MV	4	8	1	21	34	481	10
54	SANDY CREEK 1	2	3	1	12	18	231	10
55	ELLIOT RIVER MV	4	9	1	23	37	491	10
56	ELLIOT RIVER	3	5	1	15	24	351	10
57	SALTWATER CREEK 2 MV	4	8	1	21	34	481	10
58	SALTWATER CREEK 2	2	3	1	12	18	231	10
59	KANGAROO CREEK 1 MV	4	8	1	21	34	481	10
60	KANGAROO CREEK 1	2	3	1	12	18	231	10
61	SPLITTERS CREEK MV	4	8	1	21	34	481	10
62	SPLITTERS CREEK	2	3	1	12	18	231	10
63	EURI CREEK MV	4	9	1	23	37	491	10
64	EURI CREEK	3	5	1	14	23	351	10
65	DON RIVER MV	4	9	1	23	37	491	10
66	DON RIVER	3	5	1	15	24	351	10
67	BURDEKIN RIVER	3	7	2	11	23	372	10
68	CAMPASPE RIVER	1	3	2	9	15	132	1
69	CAPE	1	5	2	9	17	152	1
70	FANNING RIVER	1	6	2	8	17	162	1
71	KEELBOTTOM CREEK	1	6	2	9	18	162	1
72	FLETCHER CREEK 1	1	4	2	9	16	142	1
73	STAR RIVER	2	6	2	9	19	262	10
74	DOUGLAS CREEK (incorporated into Burdekin River)	0	0	0	0	0		
75	RUNNING RIVER	1	4	2	8	15	142	1
76	BELYANDO RIVER	1	4	2	10	17	142	1
77	SUTTOR RIVER	1	3	2	9	15	132	1
78	BURDEKIN RIVER BELOW CLARE WEIR	5	15	6	26	52	656	100
79	BURDEKIN RIVER ABOVE CLARE WEIR	4	13	4	21	42	534	100
80	BOWEN RIVER	4	12	4	15	35	524	100
81	BROKEN RIVER	2	8	2	10	22	282	10
99	SMALL COASTAL STREAMS	4	7	0	12	23	470	10

 # Normalised scores as follows:

HIGH = > 500 score + 100

MEDIUM = 200 to 499 score + 10

LOW = 0 to 199 score = 1

NONE – No catchments or reaches were considered as having a fisheries significance of 0. Therefore no normalised scores of 0 are allocated.

Table 18: Species Movement values and scores by catchment or reach

Reach No.	Catchment	No. of Species in Value Category					Species Movement Value Score	Normalised Score
		H	M	L	N	TOTAL		
1	CRYSTAL CREEK MV	12	8	20	2	42	1300	100
2	CRYSTAL CREEK	12	8	7	2	29	1287	100
3	OLLERA CREEK MV	12	8	19	2	41	1299	100
4	OLLERA CREEK	12	8	7	2	29	1287	100
5	ROLLINGSTONE CREEK MV	12	8	19	2	41	1299	100
6	ROLLINGSTONE CREEK	12	8	7	2	29	1287	100
7	SALTWATER CREEK 3 MV	12	8	19	2	41	1299	100
8	SALTWATER CREEK 3	12	8	7	2	29	1287	100
9	LEICHHARDT CREEK 1 MV	12	8	19	2	41	1299	100
10	LEICHHARDT CREEK 1	12	8	7	2	29	1287	100
11	SLEEPER LOG CREEK MV	11	8	19	2	40	1199	100
12	SLEEPER LOG CREEK	11	8	7	2	28	1187	100
13	BLUEWATER CREEK 1 MV	12	8	19	2	41	1299	100
14	BLUEWATER CREEK 1	12	8	7	2	29	1287	100
15	DEEP CREEK 1 MV	11	8	17	2	38	1197	100
16	DEEP CREEK 1	11	8	7	2	28	1187	100
17	BLACK RIVER MV	12	9	19	2	42	1309	100
18	BLACK RIVER	12	9	8	2	31	1298	100
19	BOHLE RIVER MV	11	9	25	2	47	1215	100
20	BOHLE RIVER	11	9	10	2	32	1200	100
21	ROSS RIVER	10	9	10	1	30	1100	100
22	ROSS RIVER BELOW ROSS DAM	11	9	10	2	32	1200	100
23	ROSS RIVER BELOW APLINS WEIR	9	2	13	1	25	933	100
24	ALLIGATOR CREEK BELOW WEIR	12	9	25	2	48	1315	100
25	ALLIGATOR CREEK	12	9	10	2	33	1300	100
26	HAUGHTON RIVER BELOW GIRU WEIR	13	10	26	2	51	1426	100
27	HAUGHTON RIVER	12	10	10	2	34	1310	100
28	BARRAMUNDI CREEK	12	9	23	2	46	1313	100
29	BARRATTA CREEK MV	12	10	25	2	49	1325	100
30	BARRATTA CREEK	12	10	12	2	36	1312	100
31	SHEEPSTATION CREEK 1 MV	12	9	22	2	45	1312	100
32	SHEEPSTATION CREEK 1	12	9	12	2	35	1302	100
33	ALVA CREEK MV	12	9	24	2	47	1314	100
34	ALVA CREEK	12	9	10	2	33	1300	100
35	KALAMIA CREEK MV	12	9	24	2	47	1314	100
36	KALAMIA CREEK	12	9	10	2	33	1300	100
37	MUD CREEK MV	10	6	17	2	35	1077	100
38	MUD CREEK	10	5	7	2	24	1057	100
39	PLANTATION CREEK MV	12	9	23	2	46	1313	100
40	PLANTATION CREEK	12	9	10	2	33	1300	100
41	SALTWATER CREEK 1 MV	11	9	23	2	45	1213	100
42	SALTWATER CREEK 1	11	9	10	2	32	1200	100
43	YELLOW GIN CREEK MV	9	7	19	1	36	989	100
44	YELLOW GIN CREEK	6	6	6	1	19	666	10
45	WANGARATTA CREEK MV	8	6	19	1	34	879	10
46	WANGARATTA CREEK	6	5	6	1	18	656	10
47	ROCKY PONDS CREEK MV	8	6	19	1	34	879	10

Reach No.	Catchment	No. of Species in Value Category					Species Movement Value Score	Normalised Score
		H	M	L	N	TOTAL		
48	ROCKY PONDS CREEK	6	5	6	1	18	656	10
49	MONONGLE CREEK MV	8	7	21	1	37	891	10
50	MONONGLE CREEK	8	7	8	1	24	878	10
51	ARMSTRONG CREEK MV	8	6	18	1	33	878	10
52	ARMSTRONG CREEK	6	5	6	1	18	656	10
53	SANDY CREEK 1 MV	8	6	19	1	34	879	10
54	SANDY CREEK 1	6	5	6	1	18	656	10
55	ELLIOT RIVER MV	8	7	21	1	37	891	10
56	ELLIOT RIVER	8	7	8	1	24	878	10
57	SALTWATER CREEK 2 MV	8	6	19	1	34	879	10
58	SALTWATER CREEK 2	6	5	6	1	18	656	10
59	KANGAROO CREEK 1 MV	8	6	19	1	34	879	10
60	KANGAROO CREEK 1	6	5	6	1	18	656	10
61	SPLITTERS CREEK MV	8	6	19	1	34	879	10
62	SPLITTERS CREEK	6	5	6	1	18	656	10
63	EURI CREEK MV	8	7	21	1	37	891	10
64	EURI CREEK	7	7	8	1	23	778	10
65	DON RIVER MV	8	7	21	1	37	891	10
66	DON RIVER	8	7	8	1	24	878	10
67	BURDEKIN RIVER	3	8	11	1	23	391	10
68	CAMPASPE RIVER	1	4	9	1	15	149	1
69	CAPE	1	6	9	1	17	169	1
70	FANNING RIVER	1	7	9	0	17	179	1
71	KEELBOTTOM CREEK	1	7	10	0	18	180	1
72	FLETCHER CREEK 1	1	6	9	0	16	169	1
73	STAR RIVER	2	7	10	0	19	280	1
74	DOUGLAS CREEK (incorporated into Burdekin River)	0	0	0	0	0		
75	RUNNING RIVER	1	6	8	0	15	168	1
76	BELYANDO RIVER	1	6	9	1	17	169	1
77	SUTTOR RIVER	1	4	9	1	15	149	1
78	BURDEKIN RIVER BELOW CLARE WEIR	13	13	24	2	52	1454	100
79	BURDEKIN RIVER ABOVE CLARE WEIR	12	13	15	2	42	1345	100
80	BOWEN RIVER	11	11	12	1	35	1222	100
81	BROKEN RIVER	5	7	10	0	22	580	10
99	SMALL COASTAL STREAMS	8	4	11	0	23	851	10

 # Normalised scores as follows:

HIGH = > 800 score = 100

MEDIUM = 300 to 799 score = 10

LOW = 0 to 299 score = 1

NONE – No catchments or reaches were considered as having a species movement requirement of 0. Therefore no scores of 0 are allocated.

A3.3.2 HABITAT VALUES

The Habitat Values theme for barriers that may be modified or removed was determined for each barrier by adding the weighted scores for each attribute as follows:

Upstream habitat quantity (Perennial water in Ha)

Value	Description	Score
High	WR3 > 1,000 ha	100
Medium	WR3 500-1,000 ha	10
Low	WR3 0-500 ha	1
None	WR0 and NA - No perennial water upstream	0

The data that can be used to assess this is from the "Water Regime Modifiers" information from the EPA Wetlands digital data[4]. However, there were difficulties in operating this value within the GIS system. This was due to the need to "split" water bodies at each barrier so that a calculation could be made to determine the area above and below each structure. This attribute was therefore not included because: (a) there is a need to check that all potential barriers (particularly road and rail crossing) identified to date, are actual barriers. To do this a field assessment of all barriers will be required and (b) if this attribute is included without having assed all barriers in the field then a false value for any given barrier could be given. However, this attribute could be included in future assessments if all road and rail crossing are assessed in the field to determine whether or not they are actual barriers.

Upstream habitat quantity (Ephemeral water in Ha)

Value	Description	Score
High	WR2 and/or WR1 > 1,000 ha	100
Medium	WR2 and/or WR1 500-1,000 ha	10
Low	WR2 and/or WR1 0-500 ha	1
None	WR0 and NA - No perennial water upstream	0

As per perennial water, the data that can be used to assess this is from the "Water Regime Modifiers" information from the EPA Wetlands digital data.

Upstream habitat quality

Value	Description	Score
High	A or A+ rating	100
Medium	B or B+ rating	10
Low	C or C+ rating	1
None	D or D+ rating	0

Detailed information for stream habitat quality for the region is not available. Various data that is available was considered including:

[4] "**WETLAND MAPPING** AND CLASSIFICATION FOR THE GREAT BARRIER REEF CATCHMENT" Version 1.0 – 18 December 2006.

- National Land and Water Resources Audit (NLWRA) (2001) mapping of Assessment of River Condition Environment index. However, that information is mapped at 2,500,000 scale and does not cover all stream lengths in the project area as mapped at 1:250,000 scale and was therefore not considered practical for direct use in this project.
- Land use mapping from Queensland NR&W and NLWRA. However, this was considered too broad for this project.

The data that has been used to determine stream habitat quality is the Tropical Rapid Assessment of Riparian Condition (TRARC) information detailed in the report "Assessing the condition of riparian vegetation in the Burdekin catchment using satellite imagery and field surveys" (Lymburner and Dowe, 2006[5]) and its associated GIS data.

Lymburner and Dowe, 2006, divided the region into 52 subcatchments based on the characteristics of their riparian zones. The condition of riparian zones was then quantified by the application of the TRARC method. Each of the 52 subcatchments were rated as at 2004 from A to D, based on land condition ratings used for grazing management.

For the purpose of this study the project team considered this data was the most appropriate available. Although it does not take into consideration the quality of instream habitat, which can be severely impacted by sedimentation or other habitat degradation while still providing a high riparian condition score, the TRARC scoring system does consider erosion including gully development within the catchment (Lymburner pers com). The latter has inferences for the quality of adjacent instream habitat.

Where a barrier lays within one of these catchments the score for that catchment is attached accordingly. Where a barrier lays within a lower scoring catchment but nevertheless downstream from a higher scoring catchment the higher score will still apply. This has been done in order to take into account the opportunity to maximise fish passage upstream to higher quality habitat.

Stream Order

Value	Description	Score
High	5th Order and greater	100
Medium	4th Order	10
Low	3rd Order	1
None	2nd Order	0

Barriers on 1st order streams were not assessed although the location of all crossings was undertaken and is available in the GIS database.

The Geosciences Australia 1:250,000 scale stream layer was used as the basis for developing the regional stream network, which was then refined by:

- Merging all of the stream layers for all 1:250,000 map sheets that cover the BDTNRM region (19 whole or part map sheets) and retaining the attribute data.
- Joining all disconnected streams to the network manually by overlaying onto the BDTNRM rectified satellite imagery.

[5] Lymburner, L & Dowe, J. (2006) ACTFR Report No. 06/21 "A Component of the Coastal Catchments Initiative Report: Assessing the condition or riparian vegetation in the Burdekin Region catchment using satellite imagery and field surveys". Australian Centre for Tropical freshwater Research, Townsville.

- Defining a single channel line where multiple channels were mapped and connecting all tributaries. The main channel was predominantly identified by the main channel attribute in the stream layer data. Where this was not possible, a judgement was made by examining the BDTNRM satellite imagery.
- Making the network traceable.
- Ordering all streams using the Strahler[6] ordering system and adding that ordering to the watercourses attribute table.
- Calculating the length of each segment and adding that to the attribute table.

Position of Barrier in the Catchment

Value	Description	Score
High	>80% of stream length above the barrier in relation to the total stream length.	100
Medium	50-80% of stream length above the barrier in relation to the total stream length.	10
Low	25-50% of stream length above the barrier in relation to the total stream length.	1
None	<25% of stream length above the barrier in relation to the total stream length.	0

This category differs from the Strahler stream order category in that short length coastal streams will have a lower stream order at the point of discharge to the sea compared to larger catchments, particularly the Burdekin River. Position of a barrier within a catchment is therefore an independent consideration and has been defined as the percentage of stream length above the barrier in relation to the total stream length within the catchment.

It should be noted that due to the position of the Burdekin Falls within the Burdekin catchment and the fact that the Falls are a natural barrier to the upstream movement of all species except eels that this attribute was assed for the Burdekin River catchment as two separate catchments: above and below the Burdekin Falls. This also applies to the attribute “Distance to next barrier upstream” , “Uninterrupted stream length” and “presence/absence of downstream barrier”.

Distance to next barrier upstream

Value	Description	Score
High	> 100 kms	100
Medium	50-100 kms	10
Low	10-50 kms	1
None	<10 kms	0

This is the distance to the next barrier on the main channel. In the absence of field assessments of all road and rail crossings this attribute may give an inaccurate value where a potential barrier is not an actual barrier. Never-the-less this is an important attribute and has therefore been included. This attribute would become more accurate if a field assessment of all barriers is undertaken and false barriers are removed from the GIS data in the future.

[6] Strahler Stream Ordering system - Strahler, A. N. (1952). Dynamic basis of geomorphology. Geological Society of America Bulletin, 63, 923-938.

Uninterrupted stream length upstream

Value	Description	Score
High	> 1,000 kms	100
Medium	500-1,000 kms	10
Low	500-1,000 kms	1
None	<500 kms	0

This calculates the total uninterrupted stream network length rather than just the main channel upstream of the barrier for which this calculation applies. As with the “distance to the next barrier upstream”, in the absence of field assessments of all road and rail crossings this attribute may give an inaccurate value where a potential barrier is not an actual barrier. Never-the-less this is also an important attribute and has therefore been included. This attribute would also become more accurate if a field assessment of all barriers is undertaken and false barriers are removed from the GIS data in the future.

Proximity to downstream aquatic refugia

Value	Description	Score
High	<1 km	100
Medium	>1 - 10 kms	10
Low	10 - 50 kms	1
None	> 50 kms	0
None	If permanent refugia upstream	0

This attribute considers whether or not permanent aquatic refugia exists upstream of the barrier. If YES then the value of removing the barrier is less important because fish populations can be expected to recolonise the upstream reach from that refugia. If NO then removing the barrier becomes more important as there is no other way of fish recolonising that upstream reach, at times where the structure acts as a barrier.

While the project team originally intended to include this value in the assessment it was ultimately not used due to the lack of sufficiently detailed data on the location of downstream refugia. Neither the EPA wetlands data nor Geosciences Australia 1:250,000 scale digital mapping data were considered sufficiently accurate to be used with confidence. Nevertheless the project team considers that this could be valuable data if available and it is recommended that further investigation be undertaken in the future into the presence / absence of refugia habitat upstream of barriers in the region and should be considered at the planning stage for new structure development.

Presence/absence of downstream barrier

Value	Description	Score
High	No barriers downstream	100
Medium	1 or more partial barriers downstream	10
Low	1 or more complete barriers downstream	1
None	1 or more natural barriers downstream	0

Greater benefits can be expected from modifying or removing a barrier if there are no barriers downstream. The logic being that all downstream barriers need to be modified or removed to

enable free passage up to any other barrier upstream. The exceptions will occur where there are self-sustaining populations established upstream that do not need to migrate downstream but would benefit (by genetic dispersal) through additional movement upstream.

A3.3.3 THREATS

The assessment of the degree of threat that a barrier represents may be difficult to calculate precisely and some subjectivity in scoring has been necessary. There is insufficient information available to enable a detailed, desktop assessment of all barriers. Therefore all types of barriers have been placed into four categories. The threat values and descriptions for barrier type are based on the broad experience of the authors and limited information in literature and information provided by owners and managers of some barriers including: Queensland Department of Main Roads; Queensland Rail; NQ Water and SunWater.

The barrier significance groupings adopted for this study are:

Barrier significance (barrier type and degree of obstruction to fish migration)

Threat	Description	Score
High	Tidal barrage, dams, weirs or other structures – complete barrier to all species at all migration flows.	10
Medium	Dams, weirs or other structures or physical / chemical / biological barriers – that are barriers to most species in most flow events.	7
Lower	Dams, weirs or other structures or physical / chemical / biological barriers – that are barriers to some species under a limited set of flow conditions.	3
None	Natural barrier	0

The high threat, complete barriers to upstream passage are generally well known, easy to identify and there are few of them. Similarly, natural, complete barriers are generally well known and easy to identify. Lower threat barriers that only operate under a more limited set of flow conditions are the most difficult to identify in the absence of good site information and/or seasonally stratified fish survey data above and below the partial barrier. Conservatively the vast majority of identified potential barriers have been grouped into the medium threat category on the assumption that they represent a barrier in all but large flow events.

Over time, this data can be refined as additional information and field inspection provides a more reliable source for assessment. However, in the absence of any other information all remaining barriers have been treated as an equal threat to fish passage. The number of threat categories may be expanded in the method and final report as more field-based information becomes available that could help discriminate between barriers in terms of their significance.

A3.3.3.1 Types of barriers

The various barriers across the region were identified and in the Stage 1 assessment, the barrier significance for these structures were grouped into the four categories shown above. The categories were chosen to group the range of barrier types and because options for remediation are common to some of those categories. The barrier types (and threat assessments in brackets) are:

- Dams (HIGH)
- Weirs and barrages (MEDIUM)
- Tidal intrusion barrages – ponded pasture bunds (MEDIUM)
- Other instream structures (e.g. Water Board control gates) (MEDIUM)
- Weed / macrophyte choked reaches (MEDIUM)

- Sand dams / crossings (LOW)
- Road and rail crossings (culverts, causeways and fords) (all MEDIUM in the first assessment except where known to be HIGH or LOW)
- Natural barrier (waterfalls) (NONE).

Where details of specific barriers were known to the project team and/or through field assessments, a different threat assessment may have been applied.

A number of attributes that could be considered as barriers have not been included in the assessment for the following reasons:

- Altered hydrological regimes through pumping of irrigation water were considered but not included in the identified barriers as the extent and scale of available data was insufficient to assess impacts on fish passage which in the case of artificial flows may provide passage opportunities greater than the natural, pre-European settlement regime.
- Loss of habitat through vegetation clearance (including associated increased water temperatures following loss of vegetation cover) and siltation (infilling of waterholes and smothering of other instream habitat) were not considered due to a lack of suitable scale data, no known demonstration of these factors acting as fish passage barriers within the region and the fact that land management and riparian management are being tackled by BDTNRM in other projects and are outside the scope of this study.
- Reduced water quality associated with point or diffuse source pollution was not identified as a fish barrier in this project as the relationship between diffuse and/or point source pollution and fish passage has not been established in the region and these issues are being tackled by BDTNRM in other projects and are outside the scope of this study.
- Conservation significance / tenure of the catchment above the site and the value / potential for protection of high values for the catchment / stream / habitat.

Nevertheless, the project team recognises that improving the quality and quantity of fish habitat is a vital component in sustaining and re-establishing fish species including in areas where populations have been impacted by passage barriers.

However, the physical structures associated with modified hydrological regimes can be physical barriers and these have been included in the study. Impacts from poor water quality as a result of weed infestations have also been included.

A description of the barrier types identified in the study follows.

Dams

In this study dams are considered to be large structures (usually many metres high) that retain water across a full valley width for the purpose of water storage. The four major dams in the region are Burdekin Falls, Eungella, Paluma and Ross River. Eungella and Paluma are in upper catchment areas with reduced species diversity and have a poor representation of marine dependent species. Ross River Dam is a large structure in a smaller catchment and has three additional fish barriers (weirs) downstream from it. Burdekin Falls Dam, whilst a significant sized structure only represents a barrier to eels (although reports of the capture of small eels in recent years by the Charters Towers Fish Stocking Association members shows that at least some eels

are managing to negotiate the Dam wall[7]), which were the only species that historically could migrate upstream past the natural barrier of the Burdekin Falls.

In addition to these four major dams there are many smaller dams that have been constructed for agricultural and mining purposes. Most of these are on minor watercourses, not identified on the stream network used for this study whilst many others are on first order watercourses and have therefore not been identified as a priority. Nevertheless these dams have been identified and can be considered further in a fish passage context at a smaller catchment scale should a subregional group be interested. Those agricultural and mine dams that are located on second order watercourses or larger have been included in the assessment.

Weirs and barrages

Weirs and barrages are generally smaller structures than dams and are constructed across the full width of a river channel rather than across a full valley width. Weirs are also generally constructed to pond river flows for diversion for agricultural or other uses and are sometimes, but not always, fed by flows from upstream dams to maintain capacity.

Weirs are potentially the most significant fish barrier type due to their location most often lower in catchments and the large number of affected marine dependent species. They can also significantly impact non-marine dependent fish populations where they restrict gene flow between the upstream and downstream meta-populations or impact potential population size by forming a barrier between downstream refugia / recruitment areas and less perennial upstream habitats. This is because if the upstream non-perennial habitat dries up in any year, fish can only recolonise if they are able to pass the barrier.

While fish passage past weirs is sometimes possible under very high flow conditions, more study is required to establish the extent, diversity and size classes of passed species.

Of all the weirs in the study area, only Clare Weir has been fitted with a fish passage structure (a fish lift) but its efficiency at allowing fish passage (range and age groups of species) is not fully understood and warrants greater independent assessment. At the time of completing this report the Clare Weir fish lift was unserviceable and the Clare Weir still functions as a regionally significant fish passage barrier.

Sand dams / Crossings

Sand dams are usually temporary structures that do not survive wet season flows though in some instances these structures may be established for a significant proportion of the base flow period. Their purpose is to prevent tidal inflows and potential associated saline intrusion to shallow floodplain aquifers and to pond freshwater for irrigation pumping and aid in fresh groundwater recharge. Sand dams have been established on the lower Burdekin and Don Rivers.

Sand Dams have not been studied in detail to assess their potential to restrict fish passage but some may be significant in creating impacts on the movement of lower reach catadromous species, marine vagrants and larval fish. It is thought that sand dams in the lower Burdekin River may impact upon the endangered Sawfish, *Pristis microdon* (although it is thought that gill netting has been responsible for the most significant impact, (Marcus Sheaves pers comm.)).

The sand dams are all different in their form but all serve the same function, they pond water in-channel to create a pumping pool to deliver water to Water Board irrigation networks. The sand dams on the Burdekin River were assessed in part in the field and in part through discussions

[7] Colin Digby (2007) Pers comm.

with staff from the Water Boards, Sunwater and Department of Primary Industries and Fisheries. At the time of preparing this report a code of practice for the operation of the sand dams was being developed jointly between Sunwater, the North Burdekin and South Burdekin Water Boards and the Department of Natural Resources and Water. Taking these factors into consideration, only two of the sand dams (Rita Island and the rocks) have been identified as significant barriers worthy of further investigation and modification. The other sand dams all have low gradient bypass flows that are not considered to be barriers.

In addition to the sand dams, there are seasonal crossings constructed on some rivers for vehicle access. These crossings are usually sand formed into a low causeway with the addition of a culvert or culverts to allow low flows. No assessment of the impacts of these crossings has previously been undertaken as they are usually on private property and the location of them is generally not widely known. Identification of such crossings to the Draft Report stage has also been confined to remote sensing. However, the Burdekin North and South Water Boards have been very helpful and field inspections will allow a more qualified assessment that will be included in the final report.

Tidal Intrusion Barrages – Ponded Pasture Bunds

These structures are grouped into a single category and refer primarily to earth embankments constructed low in catchments on floodplain drainages to prevent tidal saltwater intrusion into coastal shallow aquifers used for irrigation and/or to create ponded pastures and watering points in coastal grazing lands. They are often only low structures that are inundated by flood or elevated flows but their impacts can be compounded when they operate in concert with weed infestation and associated poor water quality.

Because these barrages/bunds occur low in catchments they are potentially very significant as they exclude many estuarine dependent species including a large proportion of recruitment of key fishery species (i.e. barramundi) to nursery swamps and floodplain habitats. The extensive loss or extreme modification of this wetland habitat represents perhaps the most significant negative impact on a suite of estuarine dependant species (Marcus Sheaves pers comm.).

Until this study, these barrages/bunds have been poorly mapped and they have not been surveyed to assess their impact levels, which is a key knowledge gap.

Weed / Macrophyte Infested Reaches

Weed infestation is potentially a very significant barrier as it often occurs low in catchments and excludes many estuarine dependent species including a large proportion of recruitment of key fishery species to nursery swamps and floodplain habitats.

The impacts of weed infestation are largely realised through the degradation of dissolved oxygen levels[8]. The most common problem weed species include exotic floating species (water hyacinth, *Eichhornia crassipes*, salvinia, *Salvinia molesta*, Water lettuce, *Pistia stratiotes*) and/or exotic (pasture grasses such as Hymenachne, *Hymenachne amplexicaulis, and* para grass*, Brachiaria mutica*) or native emergent species (cumbungi, *Typha domingensis*, rice grass *Leersia hexandra*).

Weed infestations are dynamic over and between years and may be cleared by large (greater than 1 in 20 annual return interval) flood flows though they may not be affected by smaller flood events.

[8] See Perna, C (2005) ***Fish Habitat Assessment and Rehabilitation in the Burdekin Delta Distributary Streams***, ACTFR Report No, 03/22, Australian Centre for Tropical Freshwater Research.

The exact locations of weed infestations are poorly surveyed for impact levels and until this study have not been mapped for location.

Road and Rail Crossings and Other Instream Structures

Road crossing are the most common type of fish barrier in the region but until this study they have been poorly documented in terms of location, number and potential impact on fish passage. In total, more than 12,000 road and rail crossings were identified as part of this study and whilst not all of them are barriers to fish passage, many of them are at least partial barriers.

Culverts are the most common type of crossing and they are generally made from round pipes or square box sections and sometimes (rarely) arches. The most common material for construction is concrete but they are also made from metal and plastic.

The primary problems with culverts in relation to fish passage are[9]:

- the water velocity is too high
- the water turbulence is too great
- the water in or over the crossing is too shallow
- there are no resting places for fish moving through the structure
- there is a drop on the downstream side of the crossing
- the crossing has not been maintained (i.e. is overgrown or full of debris).

Like weirs, the impact of culverts and other structures is potentially greatest when located low in catchments where a larger number of marine dependent species are affected or elsewhere in the catchment where they create a barrier between downstream refugia / recruitment areas and less perennial upstream habitats or between residential pool habitat and upstream breeding (i.e. riffle) sites.

Besides road crossings other key structures include North and South Burdekin Water Board drop board structures, channel hardening structures for stormwater reception and other urban drainage infrastructure.

A3.3.4 Stage One – Results of Stage One Scoring

The results for the Top 35 potential barriers as scored by the Stage One process are shown in Table 19.

Table 19: Top 35 barriers for further investigation and remediation

Barrier Code	Structure Type	Name	Stream Name	Score	Rank
BAR10	Weir	CLARE WEIR	Burdekin River	7110	1
BAR12	Weir	BOWEN RIVER WEIR	Bowen River	6120	2
BAR1068	Dam Wall	BURDEKIN FALLS	Burdekin River	5300	3
BAR1054	Weir	ALPINS WEIR	Ross River	5120	4
BAR15	Weir	GIRU WEIR	Haughton River	5030	5
BAR397	Sand dam		Burdekin River	4970	6
BAR908	Road crossing	Mount Wyatt Road	Bowen River	4410	=7
BAR9	Weir	CHARTERS TOWERS WEIR	Burdekin River	4410	=7

[9] Coterell, E. (1998) ***Fisheries Guidelines for the Design of Stream Crossings***, Fisheries Group, Queensland Department of Primary Industries.

Barrier Code	Structure Type	Name	Stream Name	Score	Rank
BAR16	Weir	VAL BIRD WEIR	Haughton River	4230	9
BAR11	Weir	GORGE WEIR	Burdekin River	4220	10
BAR17	Weir	LOWER ALLIGATOR CREEK	Alligator Creek	4030	11
BAR456	Road crossing	Blue Range Road	Burdekin River	3710	12
BAR28	Earth bund		Sheepstation Creek distributary	3514	=13
BAR23	Earth bund		Hughes Creek	3514	=13
BAR29	Earth bund		Alva Creek	3507	15
BAR232	Road crossing	Lava Plains Mount Fox Road	Burdekin River	3017	16
BAR89	Rail crossing	Un-named rail line	Barratta Creek	2954	0*
BAR40	Earth bund		Barratta Creek	2947	0*
BAR1006	Road crossing	Collinsville Elphinstone Road	Little Bowen River	2947	17
BAR25	Earth bund		Sheepstation Creek distributary	2891	18
BAR828	Road crossing	Minor road	Kirknie Creek	2884	=19
BAR38	Earth bund		Sheepstation Creek	2884	=19
BAR1033	Rail crossing		Sheepstation Creek	2884	=19
BAR39	Earth bund		Barratta Creek	2877	=19
BAR990	Road crossing	Minor road	Suttor River	2835	0*
BAR54	Weir		Liechhardt Creek	2828	23
BAR537	Road crossing	Minor road	Haughton River trib (below Giru Weir)	2821	24
BAR871	Road crossing	Groper Creek Road	Burdekin River distributary	2814	25
BAR20	Earth bund		Sheepstation Creek	2814	=26
BAR870	Road crossing	Groper Creek Road	Burdekin River distributary	2807	=26
BAR869	Road crossing	Fry Road	Burdekin River distributary	2807	=26
BAR64	Earth bund		Barramundi Creek	2807	0*
BAR61	Earth bund		Barramundi Creek	2807	29
BAR53	Weed choke		Plantation Creek tributary	2807	0*
BAR19	Earth bund		Barramundi Creek	2807	0*
BAR8	Dam wall	ROSS RIVER DAM	Ross River	2330	=30
BAR6	Weir	BLACK WEIR	Ross River	2330	=30
BAR7	Weir	GLEESONS WEIR	Ross River	2320	=30
BAR552	Road crossing	Tondara Road	Bogie River	2317	=33
BAR1010	Road crossing	Collinsville Elphinstone Road	Little Bowen River	2317	=33
BAR1009	Road crossing	Minor road	Exe Creek	2317	=33

* Recommended to be removed from priority list (see Section 4.1 – Recommendations)

The project team discussed the desirability or otherwise of including Fisheries Values in the scoring system. One school of thought is that Fisheries Values should not be included as the study should concentrate on biodiversity values. To test the effect that removing Fisheries Values would have on the priority list, they were removed from the process and then the process was re-run. There was some reordering of the list but in general the highest priority barriers remain unchanged. Therefore, Fisheries Values have been kept as part of the assessment process.

A3.3.6 Stage One – Discussion of Results

The project team considered and tested a second stage process to provide further discrimination between barriers by applying an additional weighting to themes. However, whilst the second stage theme weighting process was worthwhile testing, it was decided that it ultimately did not add value to the decision-making process. The results of the Stage One process were therefore adopted as desirable for further investigation.

A3.4 FISH BARRIER IDENTIFICATION AND PRIORITISATION: Stage Two - Review

Following completion of the consultation process on the Consultation Draft Report the potential barriers data were updated with field assessment findings and new information from the consultation process.

In the absence of field assessments or other information, all earth bunds and road and rail crossings were assigned a threat value of “Medium”. Without confirmation of the true threat of any given barrier it is not possible to make a more informed decision.

Following the desktop review and initial GIS based barrier ranking process further attributes were considered that could not be applied in a purely desktop exercise as part of the Consultation Draft Report. This was undertaken following: field assessment, community consultation and Expert Panel review.

The top priority barriers as identified in the GIS process and initial review were reassessed with consideration of the following additional attributes:

- Remediation Feasibility
- Remediation Effectiveness
- Cost/benefit
- Level of community support

Exotic fish were also considered as a possible attribute when considering the value of remediation of barriers but it was ultimately not used. The logic of this approach is that, in a perhaps pessimistic but realistic view, if an exotic fish species is found on the downstream side of a barrier but not upstream it is almost inevitable that it will eventually become established upstream. In any event no cases are known of a barrier preventing upstream movement of an exotic fish in the region.

References

Australian Centre for Tropical Freshwater Research (in press) Northern Australian Fish (NAF) database.

Burrows, D.W. (July 2002) ***Fish Stocking and the Distribution and Potential Impact of Translocated Fishes in Streams of the Wet Tropics Region, Northern Queensland***, Report to the Wet Tropics Management Authority, ACTFR Report No. 02/04.

Burrows, D., Faithful, J., Kutt, A., Tait, J. and Blunden, L. (1999). *Environmental study of a Proposed Dam at Mount Douglas on the Belyando River*. ACTFR Report No 99/28.

Burrows, D., Veitch, V., Loong, D., Perna, C. & Butler, B. (June 2006) **Monitoring of the Health and Fish Passage Issues of Healey's Lagoon Following Removal of an Extensive Mat of Floating Aquatic Weeds,** ACTFR Report No. 06/11.

Digby, C. (2007) pers comm. Charters Towers Fish Stocking Association.

Loong, D., Burrows, D., Faithful, J. & Butler, B. (September 2006) ***TOWNSVILLE FIELD TRAINING AREA (TFTA) ECOLOGICAL MONITORING: Monitoring of Water Quality, Fish, Aquatic Invertebrates and Stream Sediments on the Townsville Field Training Area (TFTA) November 2005-July 2006***, ACTFR Report No. 06/15.

Perna, C. (November 2003) ***Fish Habitat Assessment and Rehabilitation in the Burdekin Delta Distributary Streams,*** ACTFR Report No. 03/22.

Pusey, B. Kennard, M. Arthington, A. (2004) ***Freshwater Fishes of North-eastern Australia***, CSIRO Publishing. (Available from http://www.publish.csiro.au/)

Pusey, B. J. (2005) Appendix H – Burdekin WRP - ***Freshwater Fish of the Burdekin River and Associated Drainages: Biodiversity, Distribution, Flow-related Ecology and Current Condition***, River Research Pty. Ltd.

Roth, C.H., Lawson. D. & Cavanagh, D. (December 2002) ***Overview of Key Natural Resource Management Issues in the Burdekin Catchment with Particular Reference to Water Quality and Salinity*** – Burdekin Catchment Condition Phase 1, CSIRO Land and Water & Department of Natural Resources and Mines.

Strahler, A. N. (1952). ***Dynamic basis of geomorphology.*** Geological Society of America Bulletin, 63, 923-938.

Veitch, V. & Sawynok, B. (January 2005) ***Freshwater Wetlands and Fish: Importance of Freshwater Wetlands to Marine Fisheries Resources in the Great Barrier Reef***, Sunfish Queensland Inc.

Veitch, V. & Burrows, D. (November 2006) ***Fish Passage Issues of Healey's Lagoon Following Investigation of Water Quality Issues Impacting on Fish Migration***, ACTFR Report No. 06/22.

Appendix 4 Barrier Types and Remediation Options

A4 Barrier types remediation options

A4.1 General requirements for passage for native fish

The major impediments to fish migration at waterway structures are hydraulic characteristics such as water surface drop (at weirs, dams, control structures, causeways, culvert outlets), high velocities through structures (e.g. culvert barrels), shallow water depth (e.g. culvert apron slabs), lack of resting place (e.g. culvert barrels), and turbulence (e.g. weir dissipation areas).

To overcome these barriers and allow for fish passage, the barrier aspect of the structure should be removed or the hydraulic conditions should be modified within part of the structure to provide conditions tolerable for fish movement. Fish passage devices at weirs, culverts and other structures can be developed to provide these conditions.

A4.2 Natural barriers

The only significant natural barriers in the region are waterfalls of which there are many, however, the only natural barrier of regional significance is Burdekin Falls, which historically has been a barrier to the upstream movement of all species except eels. In addition to Burdekin Falls there are ten waterfalls that have been included in this study in the upper Burdekin catchment and one in the Alligator Creek catchment. All other waterfalls are on smaller streams, high in catchments and have not been considered in this study.

Since the construction of the Burdekin Falls Dam just a few hundred metres upstream from Burdekin Falls, all species including eels are now prevented from moving upstream and this is discussed in the following section.

For the purposes of this study, natural barriers are clearly just that (i.e. “natural”), so no recommendations are warranted to provide fish passage.

A4.3 Dams

In this study dams are considered to be large structures (usually many metres high) that retain water across a full valley width for the purpose of water storage. The four major dams in the region are Burdekin Falls, Eungella, Paluma and Ross River. Eungella and Paluma are in upper catchment areas with reduced species diversity and have a poor representation of marine dependent species. Ross River Dam is a large structure in a smaller catchment and has three additional fish barriers (weirs) downstream from it. Burdekin Falls Dam, whilst a significant sized structure only represents a barrier to eels, which were the only species that historically could migrate upstream past the natural barrier of Burdekin Falls. A small number of eels have been caught upstream from the Dam (C Digby pers. comm. 2007), presumably having negotiated the dam wall. Burdekin Falls Dam never-the-less represents a significant barrier to eels.

In addition to these four major dams there are many smaller dams that have been constructed for agricultural and mining purposes. Most of these are on minor watercourses, not identified on the stream network used for this study whilst many others are on first order watercourses and have therefore not been identified as a priority. Nevertheless these dams have been identified and can be considered further in a fish passage context at a smaller catchment scale should a subregional group be interested. Those agricultural and mine dams that are located on second order watercourses or larger have been included in the assessment.

<u>REMEDIATION OPTIONS</u>

The modification of dams to facilitate fish passage is not considered feasible in the cases of the four large dams because of: cost; limited benefits due to the few species affected; the relatively limited additional habitat upstream from the dams. Passage over Burdekin Falls Dam and others if need be may be feasible and worthwhile for eels.

These dams can be considered a broader issue than just fish barriers as they are often the site for stocking of translocated native species and may therefore impact upon populations of locally occurring native species. However, this issue is not considered within the scope of this study.

A4.4 Weirs

Weirs are generally smaller structures than dams and are constructed across the full width of a river channel rather than across a full valley width. Weirs are also generally constructed to pond river flows for diversion for agricultural or other uses and are sometimes, but not always, fed by flows from upstream dams to maintain capacity.

Weirs are potentially the most significant fish barrier type due to their location most often lower in catchments and the large number of affected marine dependent species. They are significant where they restrict fish populations by forming a barrier between downstream refugia / recruitment areas and less perennial upstream habitats. This is because if the upstream non perennial habitat dries up in any year fish can only recolonise if they are able to pass the barrier.

Whilst fish passage over some weirs is possible under highly elevated flow conditions, more study would be required to establish the extent and diversity of passed species over regionally significant weirs.

Of all the weirs in the study area, only Clare Weir has been fitted with a fish passage structure (a fish lift), but its efficiency in terms of providing adequate fish passage to a range of species and size classes has, to date, been less than effective and warrants further assessment.

REMEDIATION OPTIONS

Options for the remediation of weirs include:

- Vertical slot ladders;
- By-pass channels;
- Rock ramps;
- Hydraulic lifts; and
- Fishlocks.

The cost of remediation of weirs can be large due to their height and the need for large structural works, however, the benefits of remediation can be large in environmental and socio-economic terms.

Decommissioning

Decommissioning structures that are no longer needed may be the preferred option where practical. The removal of a structure may require additional rehabilitation works to stream bed and banks (such as desilting and revegetation) but will ultimately remove the need for any ongoing maintenance and should be the first option to be considered. However, decommissioning is only likely to be suitable for a few structures such as Blue Valley Weir and then only after agreement with stakeholders.

Lowering structure heights

Similar to decommissioning, lowering the height of a weir to allow passage at a greater range of flows could be considered, although it is recognised that this option is unlikely to be desirable or practical in most cases. In some instances, water license holders that abstract from a weir may regard potential lowering of weir height as a threat to the quality of abstracted water if there is an increased risk of salt water intrusion.

Altering flow operations

Some weirs may be able to be adapted to allow flows through when not required for their normal operational use. This may include temporary removal of control gates and may be particularly useful for fish passage on the rising and falling stages of flood flows when many species are most likely to be migrating. Again, this option is likely to have limited application due to potential conflicts with operational imperatives but it should, nevertheless be considered.

Fish lifts and locks

Fish lifts and fishlocks can move fish past structures from 3 to 10 metres high where a conventional 1 in 20 slope vertical-slot fishway would be too long. Both act to attract fish into a chamber which is then closed, filled with water to the upstream level, and then opened to release the fish. A fish lift has been fitted by Sunwater to Clare Weir on the Lower Burdekin River. The fishlock works by attracting fish into a chamber by using an artificial flow. A door to this chamber closes periodically and the chamber is then raised hydraulically to the higher water level above the wall so that the fish can be released[10].

In addition to the Clare Weir fish lift, four fishlocks are currently operating on weirs in Queensland. The first was built on the Pioneer River at Dumbleton Weir west of the city of Mackay in 1992. The second fishlock, built in 1994, is at Eden Bann Weir on the Fitzroy River north-west of the city of Rockhampton, and the third fishlock is at Walla Weir on the Burnett River, near the city of Bundaberg. The most recent is the fishlock on Neville Hewitt Weir at Baralabah on the Dawson River[11].

Rock ramp

Rock ramps are, as the name suggests, constructed from rocks, which create a series of steps by breaking up water flow and holding it back, forming a series of resting pools. Rock ramps can be constructed over the full width of a channel or over part of a channel depending upon the site specific requirements. A diagrammatic example is shown in Figure 8 and a working example in Figure 11 and Figure 12.

[10] Further information about Clare Weir fish lift can be obtained from Sunwater at: http://www.sunwater.com.au/feature_project_02.htm
[11] http://www2.dpi.qld.gov.au/fishweb/1932.html

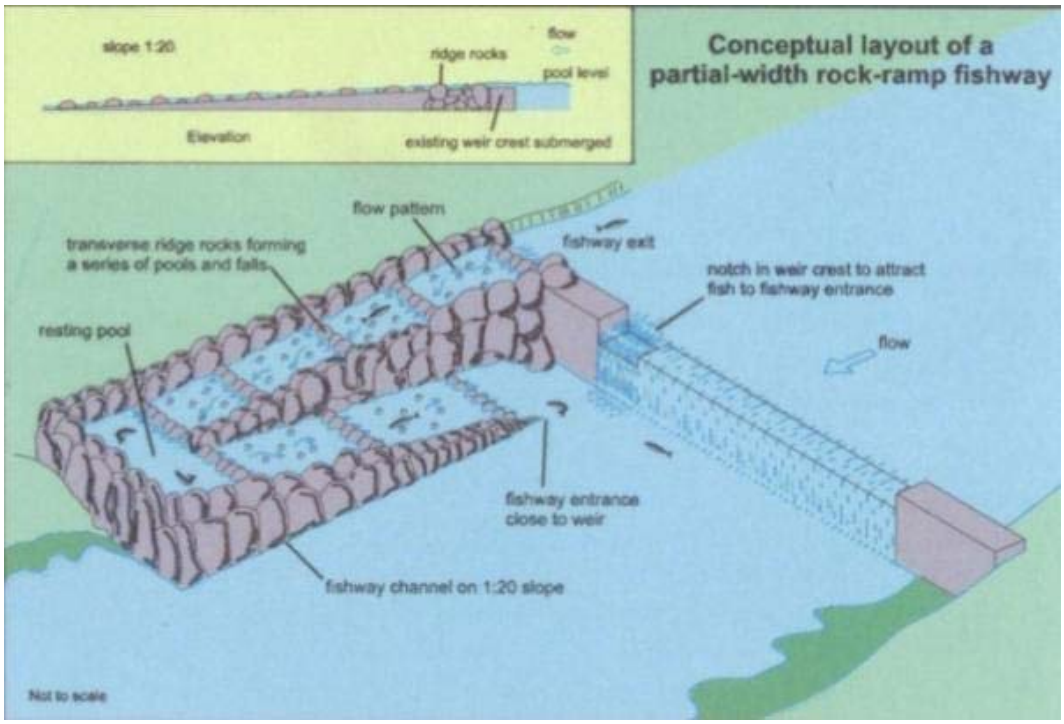


Figure 7: Rock Ramp Fishway[12] (Drawing by Paragraphics)

Vertical slot fishway

Vertical slot fishways are constructed from concrete and other materials and have a series of baffles that hold water back in steps and pools. This type of fishway is usually constructed over a partial channel width rather than full width, usually as a structure on the side of the channel. A diagrammatic example is shown in Figure 8 and a working example in Figure 9 and Figure 10, page 100.

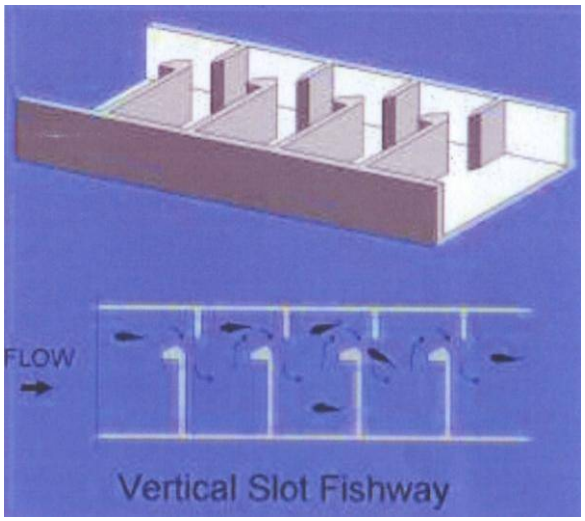


Figure 8: Vertical Slot Fishway[11] (Drawing by Paragraphics)

[12] Drawing by Paragraphics in Building Fish Freeways, Murray Darling Basin Commission, 2007)

Vertical-slot fishways can be used for medium-sized weirs up to six metres high. A fishway over seven metres in height has recently been built on the Dawson River and is being monitored to ensure fish are able to ascend this height of fishway. This is likely to be the maximum height for this fishway type. One of the advantages of a v-slot fishway is that many old and ineffective fishways can be modified to the vertical-slot pattern. This design generally consists of a concrete channel extending from the top of the weir (headwater) to the base of the weir (tailwater). Concrete walls or baffles are then inserted along the length of the channel to slow the velocity of the water. One limitation of this type of fishway is that not all fish size classes will pass through them, depending upon flow velocities achieved within the fishway.

Vertical-slot fishways are designed on a low slope (1-on-20 gradient) to produce slow water velocities (1 metre per second) and low turbulence. New fishways are designed to work over 95% of river flows. The older ineffective fishways that they replace were often of a similar design but did not include a vertical slot; they were also much steeper (gradients of 1-on-10 or even 1-on-5), with water velocities as high as 2.5 metres per second and approximately six times more turbulent.

Ten fishways in Queensland have been built using the new vertical-slot fishway design. There are two which were built in 1994 on the Fitzroy River, near the city of Rockhampton. Following the success of the Fitzroy River fishways a further two vertical-slot fishways were constructed in late 1997: one on the Burnett River in the city of Bundaberg, the other on the Condamine River south-west of the city of Dalby. A further vertical-slot fishway has replaced an ineffective fishway on the Kolan River, north of Bundaberg. More recently, a total of four v-slot fishways have been built on the Mary, Dawson and Logan river catchments[11].

Denil fishway

Denil fishways are engineered fishways that can be built on a slightly steeper slope than rock ramps. They consist of a series of U-shaped baffles that are installed into a concrete channel, forming a series of short steps and pools. The baffles break up flows within the channel allowing fish to rest between baffles.

A4.5 Sand dams / Crossings

Sand dams are usually temporary structures that do not survive wet season flows though in some instances these structures may be established for a significant proportion of the base flow period. Their purpose is to pond water and aid in groundwater recharge to prevent saline intrusion in lower floodplains. Sand dams have been established on the lower Burdekin and Don Rivers.

Similarly, there are seasonal crossings constructed on some rivers for vehicle access. These crossings are usually sand formed into a low causeway with the addition of a culvert or culverts to allow low flows. No assessment of the impacts of these crossings has previously been undertaken as they are usually on private property and the location of them is generally not widely known. Identification of such crossings has also been difficult in this study because no formal record of their construction exists and the only way to identify their existence is through remote sensing.

REHABILITATION METHODS

It is potentially feasible to establish fish passage protocols / structures for the operation of these structures. Options include rock ramps. However, the level of their impact needs to be assessed in each case to determine the best remediation option.

A4.6 Tidal Intrusion Barrages – Ponded Pasture Bunds

These structures are grouped into a single category and refer primarily to earth embankments constructed low in catchments on floodplain distributary channels to prevent saltwater intrusion into grazing land and/or to create ponded pastures. They are often only low structures that are inundated

by flood or elevated flows but their impacts can be compounded when they operate in concert with weed infestation and poor water quality.

Because these barrages/bunds occur low in catchments they are potentially very significant as they may exclude many estuarine dependent species, including a large proportion of recruitment of key recreational species, to nursery swamps and floodplain habitats. The extensive loss or extreme modification of important wetland habitats associated with these bunds represents perhaps the most significant negative impact on a suite of estuarine dependant species (Marcus Sheaves pers comm.).

Until this study, these barrages/bunds have been poorly mapped and they have not been surveyed to assess their impact levels, which is a key knowledge gap.

REHABILITATION METHODS

Because these structures are generally low earth embankments they may be relatively easy to modify to enable fish passage. Rock ramp and vertical slot fishways may be an option or rehabilitation may simply require controlled management of weed infestations. The removal of some structures that are no longer required and / or functioning effectively should also be investigated as an option in order to restore some of the lost brackish wetlands in significant areas.

A4.7 Weed / Macropyte Infested Reaches

Weed infestation is potentially a very significant barrier as it often occurs low in catchments on floodplain wetland habitats and can form a passage barrier to many estuarine dependent species including a large proportion of recruitment of key commercial and recreational species, preventing their access to nursery swamps and floodplain wetlands.

The impacts of weed infestation are largely realised through the degradation of dissolved oxygen levels[13]. The most common problem weed species include exotic floating species (water hyacinth, *Eichhornia crassipes*, salvinia, *Salvinia molesta*, Water lettuce, *Pistia stratiotes*) and/or exotic (pasture grasses such as Hymenachne, *Hymenachne amplexicaulis, and* para grass*, Brachiaria mutica*) or native emergent species (cumbungi, *Typha* sp., rice grass, *Leersia hexanadra)*.

Weed infestations are dynamic over and between years and may be cleared by large (greater than 1 in 20 annual return interval) flood flows though they may not be affected by smaller flood events.

The exact location and impact of weed infestations are poorly surveyed for impact levels and until this study have not been mapped for location.

REHABILITATION METHODS

Rehabilitation methods have been developed in the lower Burdekin with measured recovery of water quality and fish community conditions[14]. Control methods can potentially include mechanical harvesting, grazing, burning, herbicide treatment and hydrological management.

A4.8 Road and Rail Crossings & Other Instream Structures

Road crossings are the most common type of fish barrier in the region but until this study they have been poorly documented in terms of location, number and potential impact on fish passage. In total, more than 12,000 road and rail crossings were identified as part of this study and while not all of them constitute barriers to fish passage, many of them are at least partial barriers.

---

[13] See Perna, C (2005) ***Fish Habitat Assessment and Rehabilitation in the Burdekin Delta Distributary Streams***, ACTFR Report No, 03/22, Australian Centre for Tropical Freshwater Research.
[14] See Tait & Perna 2002.

Culverts are the most common type of crossing and they are generally made from round pipes or square box sections and sometimes (rarely) arches. The most common material for construction is concrete but they are also made from metal and plastic.

The primary problems with culverts in relation to fish passage are[15]:

- the water velocity is too high
- the water turbulence is too great
- the culvert is too dark
- the culvert is too long
- the culvert is too narrow
- the water in or over the crossing is too shallow
- there is a drop on the downstream side of the crossing
- the crossing has been placed at too great a slope
- the crossing has not been maintained (i.e. is overgrown or full of debris).

Like weirs, the impact of culverts and other structures is potentially greatest when located low in catchments where larger number of marine dependent species are present or in upper catchment areas where a barrier is located between downstream refugia / recruitment areas and less perennial upstream habitats.

Besides road crossings other instream structural barriers include North and South Burdekin Water Board drop board structures, channel hardening structures for stormwater reception and other urban drainage infrastructure.

REHABILITATION METHODS

The following information and discussion is targeted at the remediation of existing structures but it should be recognised that the inclusion of fish passage facility in new structures not yet constructed is more efficient due to cost savings, than fitting post construction. As with dams and weirs, consideration at the design and construction stage of new road and rail crossings can avoid or minimise fish passage problems.

Bridges and bed level fords in preference to culverts

In general, the construction of bridges is preferred to culverts because bridges present far less flow restriction and allow free flow of water and fish passage under them.

Where practical and subject to safety considerations, bed level fords should be used in preference to culverts. It must be recognised that even fords can be a fish passage problem if velocities are high over a smooth surface over a distance such that fish cannot negotiate them in a single swimming burst. Fords may also be a problem at low flows if there is a drop on the downstream side. Even a small drop can be a barrier to small fish.

Removal of unused crossings

Rail lines and roads are subject at times to decommissioning and relocation. In these cases unused crossings should be removed and if necessary additional remediation works undertaken to return the stream to as near natural condition as practical, thereby eliminating any fish passage issues.

[15] Coterell, E. (1998) ***Fisheries Guidelines for the Design of Stream Crossings***, Fisheries Group, Queensland Department of Primary Industries.

Construction type

In descending order of preference culverts should be of the following types:

- Arch culvert that retains the natural bed profile
- Box culvert with multiple culverts including a low flow culvert
- Multiple pipe culverts including a low flow culvert
- Single box culvert
- Single pipe culvert.

Remediation options for existing culverts

Where the removal of a culvert or replacement with a bridge or ford is not practical, a range of options are available to modify existing culverts. Because every barrier is unique in some aspects “off-the-shelf” solutions are neither desirable nor recommended. Rather, consideration needs to be given to each case and a solution developed, which may include one or more of the following techniques, based largely on operating examples in the Burdekin and surrounding regions.

Vertical Slot Fishway

As with weirs, a vertical slot fishway can be installed to bypass a control structure. A working example of this option has been constructed on Sheepstation Creek on the Burdekin River floodplain near Ayr[16].

[16] Funding for this fish way was through NHT Envirofund & Burdekin Fish Restocking Association. Design was by DPI%F and North Burdekin Waterboard. Construction was by DPI&F, BQC Quarries and North Burdekin Waterboard.

Looking downstream into the top of the fishway a series of aluminium baffles breaks up the flow creating a series of small steps. At the exit of the fishway a trash rack system has been installed to deflect debris into the main flow path and over the regulator. Drop board structure has also been installed to allow maintenance of the fishway. (Note also the turtle exclusion devices (TEDs), which consist of high panels along the edge to stop turtles entering and becoming trapped.)

Figure 9: Upstream side looking upstream (design DPI&F[17])

Looking upstream from the bottom of the fishway the aluminium baffles continue until water levels equal the tailwater level. The entrance to the fishway has been located near to the main flow in the channel to ensure maximum attraction of fish into the fishway. The covered section of the fishway under the road has sufficient light to ensure fish can still pass through. (Note also TEDs.)

Figure 10: Downstream side looking upstream (design DPI&F[17])

Rock Ramp

As with weirs, a rock ramp fishway can be installed to assist fish pass through a culvert where there is a downstream drop and the need to create lower velocity flows thorough the culvert. A working example has been constructed on Reliance Creek in the Mackay Whitsunday NRM region and is shown in Figure 11 and Figure 12.

[17] Further information can be obtained from Tim Marsden, Fisheries Biologist, DPI&F: Tel (07) 4951 4509; Email: timothy.marsden@dpi.qld.gov.au

Looking downstream towards the bottom of the fishway a series of rock ridges break up the flow of the water into a series of small steps approximately 100mm high. The entrance (bottom) of the fishway is located near to the drop below the culvert to maximise the attraction of fish to the fishway.

Figure 11: Looking Downstream (source DPI&F[17])

Looking upstream from the bottom of the fishway the 180° turn in the fishway is in the foreground. This enables the entrance of the fishway to be nearer the bottom of the drop from the culvert. The exit (top) of the fishway is located at the downstream edge of the bank side culvert barrel. Water is backed up through the culvert barrel to reduce velocities and enable fish to leave the fishway.

Figure 12: Looking upstream (source DPI&F[17])

Baffles installed in culverts

A range of different baffles can be fitted to both pipe and box culverts. These baffles perform the same general function in that they provide resting pools and locally acceptable velocity conditions between these pools at low flows, to allow fish to move in a burst and rest pattern through the fishway. A range of different baffles types have been developed including some specifically designed and tested for North Queensland conditions by the School of Engineering, James Cook University in Townsville. Examples of the type of baffles that can be installed are the “offset”, “EL” and “quad” all of which have been successfully installed and tested on University Creek in Townsville.

Solander Road crossing. Due to the drop downstream from the culverts, a rock ramp has been constructed to enable fish passage up to the culvert apron.

Figure 13: Looking Upstream

Solander Road crossing. Two types of apron baffle fishway.

Figure 14: Looking Upstream

The hydraulic characteristics of the Solander Road crossing typify many pipe culverts / causeways that present major barriers to fish passage as a result of (i) excess turbulence downstream of the culvert at high flows; (ii) water surface drop downstream of the apron at low flows; (iii) shallow water depths on the downstream apron at low flows; (iv) high velocities at the culvert outlet and on the apron downstream; (v) high velocities and excess turbulence within the culvert barrel; (vi) regular cross section and lack of resting place along the culvert barrel; and (vii) high velocities, turbulence and constriction at the culvert inlet during high and low flows[18]. The combination of these factors presented an almost complete barrier to all species before modification.

Remediation included four fishway components: A rockramp / cascade fishway downstream from the culvert apron, an apron baffle fishway and a pipe baffle; and fishway exit work upstream from the culvert.

[18] Kapitzke, R (2007) Not just a few packing crates: *Prototype fishways carry concepts through to catchment revival*, A paper presented at the Burdekin Dry Tropics NRM River Management Workshop: "River Management in North Queensland", Townsville 28-30 March 2007.

Appendix 5 Barrier Location Maps

MAP INDEX

Map No.	Basin	Catchments
1	Black River	Crystal Creek, Ollera Creek
2		Rollingstone Creek, Saltwater Creek 3, Leichhardt Creek 1
3		Bluewater Creek, Deep Creek, Black River
4	Ross River	Bohle Creek, Ross River (below Ross Dam)
5		Ross River (above Ross Dam)
6		Alligator Creek
7	Haughton River	Lower Haughton River and Barramundi Creek
8		Haughton River
9		Lower Barratta Creek, Sheepstation Creek, Kalamia Creek, Alva Creek, Mud Creek, Plantation Creek.
10		Upper Barratta Creek
11	Don River	Saltwater Creek 1, Yellow Gin Creek, Wangaratta Creek, Rocky Ponds Creek
12		Monongle Creek, Armstrong Creek, Sandy Creek, Elliot River, Saltwater Creek 2, Kangaroo Creek, Splitters Creek, Euri Creek.
13		Lower Don River and Euri Creek
14		Upper Don River and Euri Creek
15	Burdekin River	Burdekin River (below Clare Weir)
16		Burdekin River (above Clare Weir)
17A		Upper Burdekin River (above Burdekin Falls Dam to Keelbottom Creek)
17B		Upper Burdekin River (above Keelbottom Creek)
18		Campaspe River
19		Cape River
20		Fanning River & Keelbottom Creek
21		Star River & Running River
22		Lower Belyando River
23		Upper Belyando River
24		Lower Suttor River
25		Upper Suttor
26		Bowen & Broken Rivers