FINAL REPORT - PhD
TEMPLATE

CRDC ID: UNE1406

Project Title:Sustainable water extractions: Low flow refugia and critical flow thresholds.

Confidential or for public release? For Public Release

Part 1 – Contact Details & Submission Checklist

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Submission checklist.

Please ensure all documentation has been completed and included with this final report:

☒ Final report template (this document)
☒ Final Technical Report (see Part 3) – CRDC will accept the Thesis as the Technical Report
☒ Final Schedule 2: IP register
☐ Final Financial report - SER
☒ PDF of all journal articles (for CRDC's records)

Signature of Research Provider Representative:

Date submitted: _____1/12/21_____

Part 2 - Monitoring & Evaluation

This data forms part of CRDC's M&E data collection. Please complete all fields and add additional rows into each table if required.

Achievement against milestones in the Full Research Proposal

Milestone	Achieved/ Partially Achieved/ Not Achieved	Explanation
Collate existing data sets on low flow refugia.	*Achieved*	Existing data sets from DPIE and LLS collated.
Identify location of past and present low flow refugia.	*Achieved*	Refugia mapped based on historical and contemporary river profiles.
Identify changes to the spatial organisation of low flow refugia.	*Achieved*	Changes identified and quantified. In particular changes to the distance between deep waterholes quantified.
Field work undertaken at low flow refugia.	*Achieved*	Electrofishing undertaken to sample fish community.
Analysis of fish community structure.	*Achieved*	Analysis of community composition, biomass and abundance.
Threats to refugia identified.	*Achieved*	Gully erosion and water extraction investigated as a potential threat to refugia.
Identify low flow refugia in need to restoration.	*Achieved*	All low flow refugia are in need of restoration and protection.
Final report prepared.	*Achieved*	Final thesis complete.

Outputs produced *(Please refer to examples document to assist in completing this section).*

Output	Description
Thesis	*Final technical report*
Journal articles	*Waterholes paper submitted to journal (Geomorphology) and previously supplied to CRDC.* *Additional journals are expected to be submitted for publication in the future.*
Data sets	*Gully locations/character – spatial dataset.* *Refugia locations – spatial dataset.* *Fish community data.*
Briefing paper	*Final briefing paper on management options for the protection of low flow refugia.*

Outcomes from project outputs *(Refer to examples document).*

Outcome	Description
Fill existing knowledge gap relating to low flow refugia.	*A greater understanding of the location of low flow refugia on the Barwon-Darling River and how it has changed over time.*
Fill existing knowledge gap relating to low flow refugia.	*A greater understanding of how the spatial distribution of low flow refugia have changed over time influencing hydrological connectivity.*
Fill existing knowledge gap relating to physical and biological character of waterholes.	*A greater understanding of the biological and physical character of waterholes. In particular, a greater understanding of the fish assemblages that these waterholes are supporting.*

Part 3 – Technical Report

Projects may require different approaches to the structure of the Technical report. A detailed technical report should normally include the following items:

- *Table of contents (if necessary – depends on the length and complexity of your report);*
- *Executive summary*
- *Introduction*
- *Materials and methods*
- *Results*
- *Discussion*
- *Conclusions*
- *Key word index and*
- *A full list of industry and scientific publications, presentations, extension activities and other outputs.*

Please contact your R&D manager if you would like to adopt a different approach.

Final thesis has been provided to the CRDC to meet the requirements of the technical report.

Part 4 – Summary for public release

This summary will be published on Inside Cotton, CRDC's digital repository, along with the full final report (if suitable for public release). It is designed to provide a short overview of the project for all interested parties. Please complete all fields, ensuring that this exceeds no more than two pages.

Project title:	*Error! Reference source not found.*	
6Project details:	CRDC project ID:	***Error! Reference source not found.****UNE1406*
	CRDC goal:	*5. Driving RD&E impact (ES2)*
	CRDC key focus area:	*3.1 Science and innovation capability, and new knowledge*
	Principal researcher:	*Marita Pearson*
	Organisation:	*UNE*
	Start date:	*1/10/14*
	End date:	*1/12/21*
Objectives	• *Identify low flow refugia on the Barwon-Darling River.* • *Assess changes to the spatial organisation of low flow refugia.* • *Define the physical and biological character of low flow refugia.* • *Develop and understanding of the relationship between fish community structure and condition in relation to habitat complexity within refugia.* • *Develop management strategies for the protection and restoration of low flow refugia.* • *Develop final report.*	
Background	*Low flow habitat or 'refugia' are critical features of rivers flowing in arid or semi-arid regions of Australia. Refugia provide a safe haven for biota during unfavourable conditions such as no flow or low flow events. Organisms utilising refugia during these events will have a greater probability of survival and are critical for the recolonisation of affected areas once flows resume. However, refugia are increasingly becoming under pressure from land and water resource management and as a result there is concern that the quality and abundance of low flow refugia may be on the decline. The successful management and restoration of low flow refugia is currently impeded by the lack of knowledge, of, the location of refugia, the potential impact of both land and river activities on refugia and the flow thresholds required to maintain quality refugia. This research program was designed to fill these gaps and provide valuable scientific information that will contribute to the development of a management framework for low flow refugia on the Barwon-Darling River.*	
Research activities	*This project was separated into 4 tasks relating to waterholes (or low flow refugia). There being:* 1. *Map the location of past and present waterholes using a combination of historical and contemporary river bed*	

	profiles and determine how the depth and location of waterholes have changed over a 120 year period. 2. *Map and characterise gully erosion on the floodplain of the Barwon-Darling River. In doing so quantify the volume of sediment exported from these gullies to the river to determine their potential effect on waterholes. A combination of LiDAR and digital air photos was used to characterise gullies and explore their spatial and temporal variation across the floodplain.* 3. *Quantify how water resource development has impacted the capacity of the river to transport sediment and maintain waterhole features in the system. Modelled data was used to assess changes in the duration and frequency of events required to transport sediment downstream and onto the floodplain.* 4. *The influence of waterhole depth and habitat complexity o fish communities utilising waterholes was explored. Differences in community composition, abundance and biomass relating to depth and the presence of instream wood was investigated.*
Outputs	*The following findings came from this project:* - *Waterhole depths on the Barwon-Darling have changed sustainably in the past 120 years. The maximum depths of waterholes outside of the influence of weir pools have declined by as much as 7.3m, with a median decline of 1.6m. Associated with these changes have been an increase in the distance between deep waterholes and in some cases these distances have more than doubled.* - *Results from this study suggest that the volume of sediment contributed from alluvial floodplain gullies is 13 times higher than previous estimated for the Barwon-Darling catchment. This suggests that alluvial gullying is a major source of sediment missing from basin wide sediment budgets.* - *Results from this study indicated that modifications to the flow regime have resulted in a decline in the frequency and duration of events capable of transporting sediment. Conversely, the number of events that enable deposition have increased. Overbank flooding has halved limiting the potential for sediment to be moved laterally onto the floodplain.* - *Waterhole depth did not influence fish assemblage but habitat complexity did through the presence of in-stream wood which was significant to native fish species.*
Impacts	- *This project has provided several recommendations relating to the management of gully erosion on the floodplain. These recommendations are aimed at preventing the initiation of new gullies and minimising the impact of existing gullies. Recommendations have also been made regarding the consideration of targeted environmental flows to enable the transport of new sediment throughout the system.*

Key publications	Final report (thesis) to the CRDC. The following paper has been published and more are expected to come in the future. Pearson, M. R., Reid, M. A., Miller, C., & Ryder, D. (2020). Comparison of historical and modern river surveys reveal changes to waterhole characteristics in an Australian dryland river. *Geomorphology, 356*. doi:https://doi.org/10.1016/j.geomorph.2020.107089