

Warrego Hydrology: what is, what was and what might have been.

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Key Points

- Counterfactual flow/inundation modelling is pre-requisite to understand impacts of environment watering
- Hydrodynamic modelling is capable of deriving counterfactual scenario information
- Modelled data show environmental water purchases have increased Warrego flow into the Darling by 40%
- The northern basin rivers are considerably different to those in the southern MDB

Abstract

The Commonwealth Environmental Water Office Long Term Intervention Monitoring Project monitors the contribution of Commonwealth environmental water (CEW) in the Murray-Darling Basin. There are seven selected areas that are the focus of much of the on-ground monitoring effort. The Junction of the Warrego and Darling Rivers selected area is set primarily at the confluence of the Warrego and Darling Rivers on the former Toorale Property.

The Warrego River is not regulated by large headwater dams; in-stream structures (dams) store relatively small amounts of water and in some cases can be used to divert water into floodplain wetlands. The river is ephemeral with no-flows (0 ML/day) occurring for over 25% of the time. CEW is not delivered into this system per se, rather it is not abstracted and the retained water can be managed to either flow to the Darling or onto the extensive Warrego Western Floodplain.

This presentation details hydrodynamic models developed for the Warrego channel and Western Floodplain. An examination of measured flows and inundation over a 3-year period is compared to flow scenarios that might have occurred under irrigation or grazing farming practices prior to the Commonwealth acquiring the property and its water licenses. These alternate or counter-factual scenarios provide an important basis for understanding the contribution to CEW on the environment.

Keywords

Warrego River, Counterfactual modelling, Environmental water

Introduction

What does environmental water do?

That is the fundamental question the Commonwealth Environmental Water Office Long Term Intervention Monitoring Project (LTIM) is trying to answer (CEWO 2018). It isn't an easy question, it is highly complex, and the answer varies depending on water quantity, quality, location and time. To help answer the question the LTIM project is collecting data at 7 locations (Selected Areas), looking at multiple environmental indicators over multiple years with a range of actual water deliveries.

Full Paper

Frazier et al. – Warrego hydrology: actual versus counterfactual

Having a range of actual water deliveries to examine helps to understand the likely boundaries of environmental change that might occur as a result of watering. However, the question of what would have happened without the environmental watering remains. Given that we can measure the actual effects of environmental water delivery, can we assess the counterfactual case?

The aim of this paper is to compare the actual channel and floodplain hydrology of the Warrego River within the target area to the likely (counterfactual) hydrology without the influence of commonwealth environmental water. The results of this analysis are required to understand the effects of environmental water on other environmental and ecological indicators.

Study Area

The Junction of the Warrego-Darling Selected Area is one of seven Selected Areas for the LTIM project (Figure 1). The site occupies the former Toorale Property and contains the southern reach of the Warrego River that extends from above Boera Dam to the confluence with the Darling River. The extensive Western Floodplain receives water that spills from the Warrego River at Boera Dam.

The Warrego River is ephemeral. Flow duration analysis shows that the system is dry over 25% of the time with flows less than 10 ML/d occurring over 55% of the time (Figure 2). The channel is poorly defined; at many places multiple flow paths take the place of a single well-defined channel (Figure 3). The Warrego fills Boera Dam and spills onto the Western Floodplain (Figure 4) with a frequency of approximately 1 in 2 years (Aurecon 2009), although this can be manipulated through the operation of flow control pipes at Boera that can deliver up to 600 ML/d of downstream flow to the Warrego River. The average slope of the channel and floodplain are very low, less than 1:4000. The channel (bed and bank) and floodplain soils are predominantly medium to heavy clays that crack extensively when dry and can hold considerable volumes of water when first wet.

Methods

Channel model

A simple flow model of the Warrego channel was used to assess the change in hydrology between the different management scenarios. A flow loss factor between Boera Dam and the confluence of the Warrego and Darling rivers was calculated based on the known releases out of Boera Dam and the corresponding flows at Dicks dam which is around 2/3rds of the way to the confluence (Figure 1). Allowing for travel times, a loss factor of 50% was calculated.

Western Floodplain Model

Since the Western Floodplain acts as a closed system, i.e. flows do not generally reach the Darling River, a HEC-RAS model was considered appropriate and a Water Balance modelling approach was undertaken (ELA 2017).

A 5 m DEM derived from 2009 Lidar data was used to determine inundation extents and volumes possible given a series of water levels measured in Boera Dam. To enable this process the open system DEM was 'levelled' into a closed system by adjusting DEM height based on average height measurements from 20 locations along the floodplain. The adjusted DEM was used to derive inundation area and volume in relation to a set of Boera water levels in 5 cm increments.

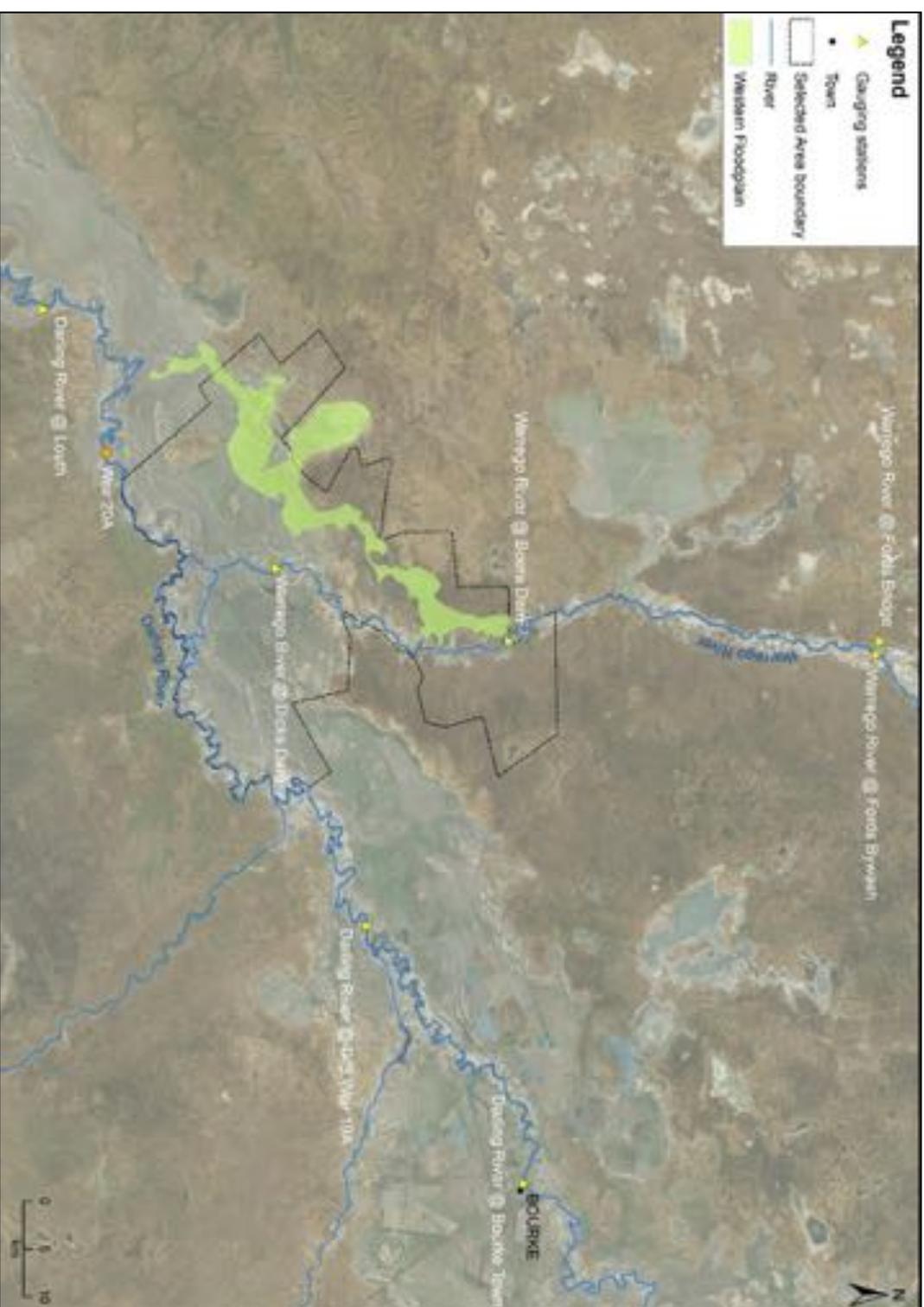


Figure 1: Warrego-Darling Selected Area

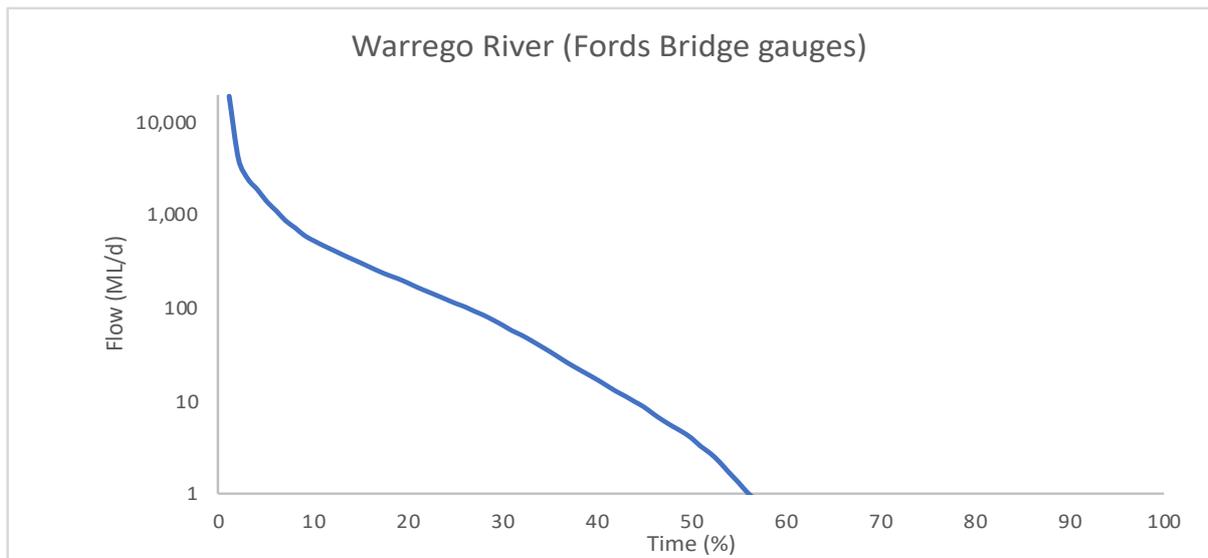


Figure 2: Flow duration curve for the Warrego River at Fords Bridge Gauges (records from December 1972)



Figure 3: One of the multiple flow paths of the Warrego River, photo taken between Boera and Dicks Dams



Figure 4: Western Floodplain

Full Paper

Frazier et al. – Warrego hydrology: actual versus counterfactual

Climate data including rainfall and solar radiation were taken from the Cobar Meteorological Office (048027 Cobar MO).

The model was developed to represent the wetted surface area of the floodplain based on the volume of water and antecedent environmental conditions within the floodplain. The overall calculation is the sum of the surface area taken up by water within the floodplain, plus the additional surface area still wet from being recently covered by water. It is represented by the equation below.

$$SA_w = SA_v + SA_s$$

Where

SA_w = total wetted surface of the western floodplain

SA_v = surface area of water within the western floodplain

SA_s = surface area of wet soil outside of water region

System inputs and outputs based on recorded flow data and climate records were combined with parameter estimates based on field survey and empirical studies and these were used to derive the overall water balance model.

Modelled wetted area results were compared to mapped inundation extents derived from Landsat data and found to be satisfactory.

Actual vs Counterfactual Comparisons

To compare the channel flow and floodplain inundation regime between actual (recorded data) and counterfactual data three hydrological regimes were assessed for the period between 1/1/2015 and 13/3/18. The actual hydrology was described using flow records from Fords Bridge gauges, water levels at Boera Dam, flow releases from Boera and gauge records at Dicks Dam. These were then used to derive flow and inundation parameters using the Water Balance models.

Prior to 2008 the site was operated as Toorale Station and included extensive areas of irrigated cropping and grazing land use. Toorale had several water licences on the Warrego River, which allowed the property managers to transfer water from Boera Dam onto the Western Floodplain to stimulate pasture growth for grazing (up to 9,720 ML annually), and to abstract water from the Warrego River, to use for irrigated agriculture (up to 6,000 ML annually). Before these water licences became effective, when a flow event reached Boera Dam, water had to be released from Boera Dam to flow down the Warrego River and make connection with the Darling River. Then, depending on flow conditions in the Darling River, the Boera Dam gates could be shut to let water flow onto the Western Floodplain (triggering the Western Floodplain water licence) or water could be extracted from Ross Billabong for irrigation purposes (triggering the irrigation licence).

To generate counterfactual hydrological information for the site we generated two scenarios:

1. Irrigation scenario that assumes maximum water abstracted for irrigation use within license conditions
2. Grazing scenario that assumes maximum water directed onto the western floodplain to stimulate pasture growth within licence conditions

The data from the actual, irrigation scenario and grazing scenario were compared to determine the impact of these land use scenarios on Warrego channel flows and Western Floodplain inundation.

Results

Channel flow scenarios

The Warrego River is ephemeral with long periods of no flow interspersed with flow/flood events that are generally caused by rainfall in the upper catchment (Figure 5). Flows during the study period displayed a number of pulses within the channel with flow losses between Fords and Dicks Dam reducing flow peaks by approximately two thirds.

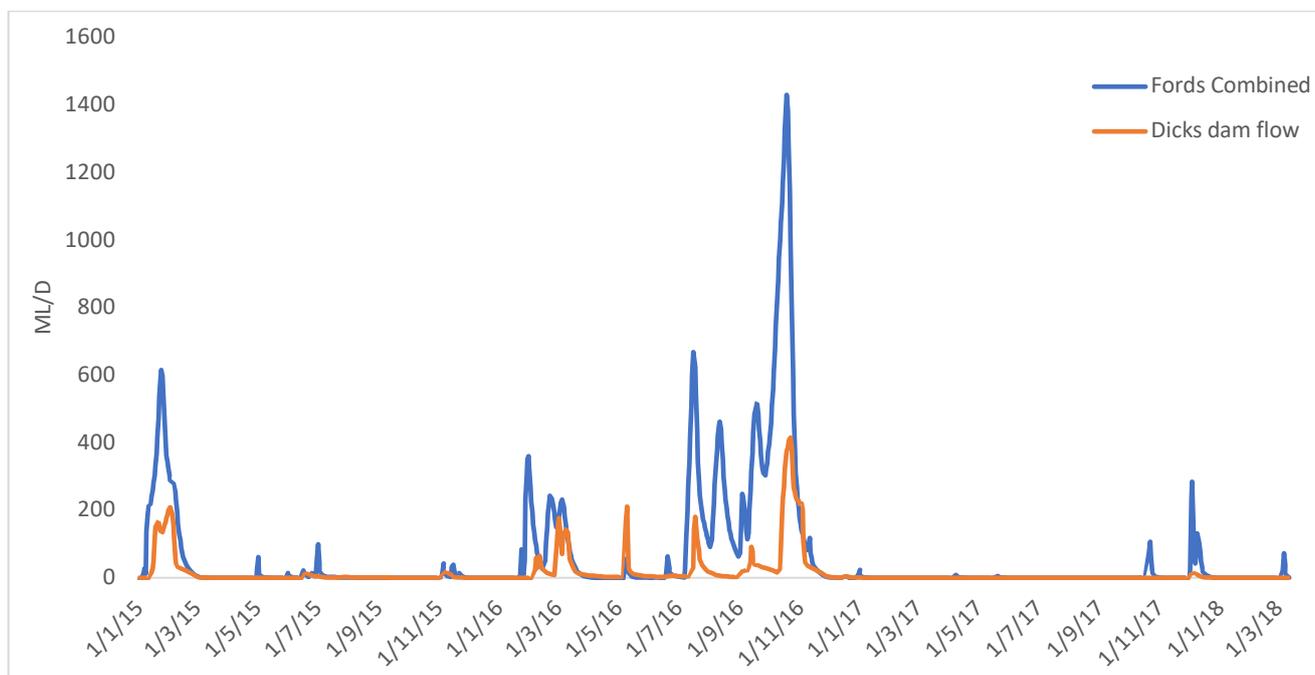


Figure 5: Hydrograph during study period

Modelling of flow reaching the Darling River confluence during this time indicated a total flow volume of 14,325 ML Darling inflow from the actual flows. Under the irrigation scenario 10,125 ML was estimated to reach the Darling, with flow assumed to be diverted at Peebles Dam into Ross Billabong for irrigation. Under the grazing scenario 10,125 ML was estimated to reach the Darling, with flow assumed to be diverted onto the Western Floodplain at Boera Dam. This suggests that by managing the water for environmental purposes (actual scenario) an additional 4,000 ML or around 40% more water was provided to the Darling system.

Western Floodplain inundation scenarios

Assessment of changes to Western Floodplain inundation were confined to the period of largest flow and resulting inundation that occurred in 2016. Modelling showed little change in maximum inundation between each of the 3 scenarios (actual, irrigation and grazing) (Figure 6). The grazing scenario showed the greatest inundation extent and duration although it was very similar to the actual scenario. However, the irrigation scenario reduced the duration of floodplain inundation significantly, particularly at the initial stages of inundation.

By multiplying the number of days of inundation with the area of inundation a measurement unit of hectare.days (ha.d) is created. This calculation shows the grazing regime with 606,507 ha.d of inundation, actual scenario with 585,872 ha.d and irrigation with 522,960 ha.d. The difference between the actual inundation and irrigation scenario is 62,911 ha.d.

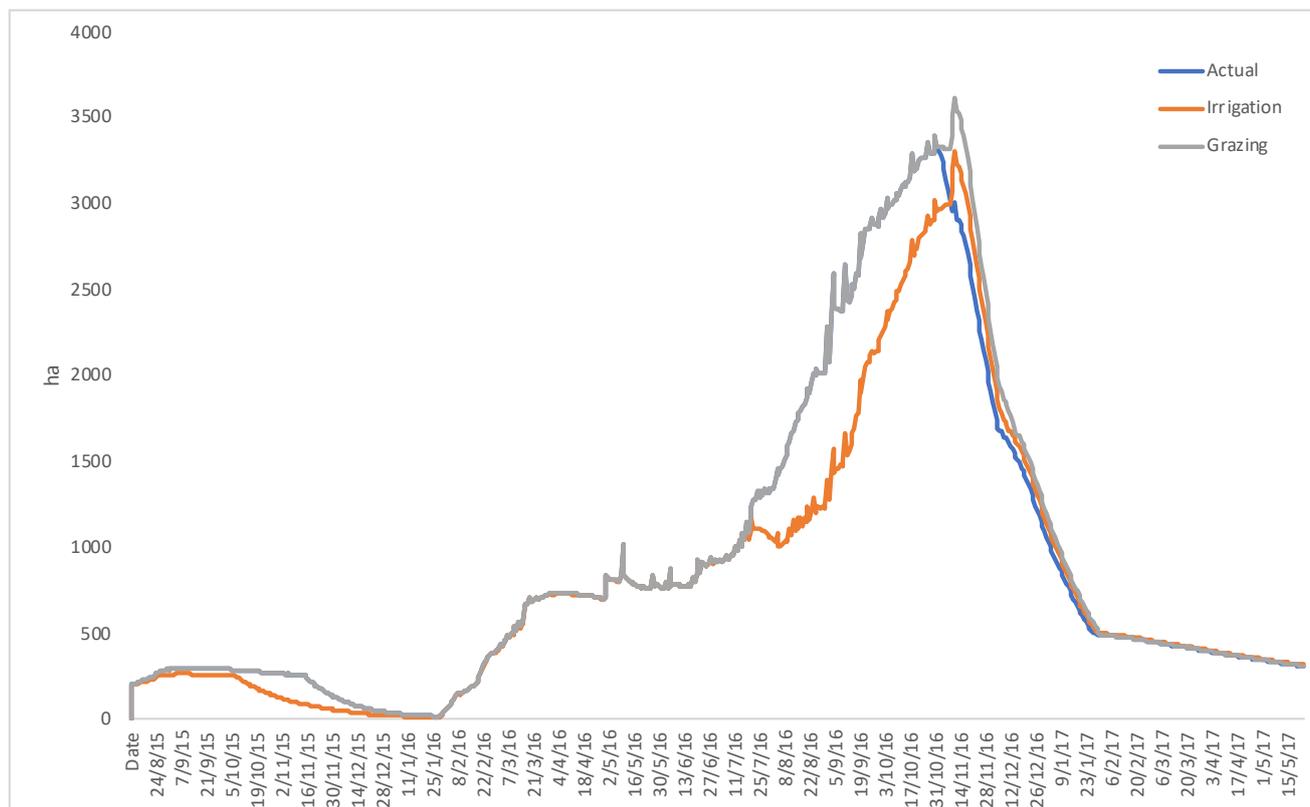


Figure 6: Modelled floodplain inundation extent and duration, Western Floodplain

Conclusions

This study aimed to compare actual channel and floodplain hydrology for the Warrego River within the Warrego-Darling Selected Area boundaries. Flow and inundation models developed for the channel and floodplain along with licence conditions and ‘likely’ operational approaches were used to determine the changes in hydrology between irrigation and grazing land uses and the current approach to water management. Modelling was able to quantify changes to flows delivered through the system to the Darling River showing an increase of Warrego water flowing into the Darling of 40% (over 4,000 ML during the study period). Floodplain inundation assessment showed that the grazing scenario and actual scenario showed similar patterns of inundation. However, the irrigation scenario showed a substantial reduction in inundation duration and extent.

While the changes in hydrology shown are expected as the Commonwealth has purchased water deliberately to return flow to the Warrego and Darling, this study was able to quantify the extent of these impacts both in flow volume and floodplain inundation.

Acknowledgments

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Full Paper

Frazier et al. – Warrego hydrology: actual versus counterfactual

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