IMPROVING CONNECTIVITY OF UNREGULATED FLOWS ACROSS THE LOWER OVENS RIVER FLOODPLAIN – ONE OF THE HEATHIEST FLOODPLAINS IN THE MURRAY-DARLING BASIN

JULIAN SKIPWORTH
Water Technology, 15 Business Park Drive,
Notting Hill, Victoria, Australia

BEN TATE
Water Technology, 15 Business Park Drive,
Notting Hill, Victoria, Australia

The lower Ovens River and its floodplain wetlands are a remarkable system in north-eastern Victoria, Australia which is in much better condition than many other river and floodplain systems in the Murray-Darling Basin. The absence of major water storages and abstractions from the upper catchment has resulted in less impact on the magnitude, frequency and duration of flooding. However there are still a number of issues to manage; namely vegetation clearance, pest species, the operation of the Murray River and backwatering from Lake Mulwala, and the construction of levees, channel banks and roads, some of which have disconnected wetlands from the river. The "Developing Capacity to Improve Connectivity of Unregulated Flows in the Lower Ovens Floodplain" study is a landmark project that integrates complex floodplain hydraulics, catchment hydrology, advanced GIS spatial analysis, ecology and environmental outcomes. The study concluded that much of the lower Ovens floodplain is in excellent condition. There are few barriers that significantly reduce connectivity; 90% of the wetlands are inundated on average at least every two years. A number of highly valuable datasets have been produced that relate wetland connectivity, frequency of wetland inundation and ecological condition. These datasets significantly improve understanding of the floodplains and expand the North East CMA's capacity to engage stakeholders when identifying options to improve management of environmental assets through the design and management of environmental infrastructure. The results of the study can serve as a benchmark for floodplain managers across the Murray-Darling Basin. The approach developed in this study could easily be applied to other river systems both domestically or internationally.

1 BACKGROUND

1.1 Study Area

The Ovens River is located in Victoria, Australia and flows from the heights of the snow fields, down through the Ovens River valley past towns such as Bright and Myrtleford where it meets the Buffalo River, then on to Wangaratta where it meets the King River. The Ovens River then flows on through the lower valley entering the Murray River at Lake Mulwala on the Victorian-New South Wales border. In total the Ovens River is approximately 150 km long from its headwaters to its confluence with the Murray River. The upper catchment is steep and dominated by native forest with some pine plantations, while the lower catchment is reasonably flat with a wide floodplain, anabranching waterways and characterised by extensive agriculture (pasture, grapes and orchards). Within the study area, the Ovens River is a sinuous stream with generally clay banks and a sandy to fine gravel bed. The floodplain, incised into the Shepparton Formation, features numerous wetlands created by meander cut-offs, with relatively frequent flooding of these floodplain features [1].

The total Ovens River catchment area is just over 7,500 km². Rainfall varies dramatically across the catchment, with average annual rainfalls ranging from 2,000 mm at Mount Hotham to just 400 mm at Yarrawonga. The Ovens River is largely unregulated, with minor storages on the Buffalo River and King River.

The lower section of the Ovens River downstream of Wangaratta has been declared a Heritage River due to its unique habitat and its importance for endangered fish species. It is this area that the study concentrated on in terms of assessment of barriers to connectivity.

2 IDENTIFICATION OF BARRIERS TO FLOW

2.1 Overview

The second stage of the study, following a data review and inception phase, consisted of a desktop assessment identifying potential barriers to flow and was completed incorporating multiple datasets and advanced spatial GIS techniques. A revised wetland dataset was developed which provided significantly more detail than existing datasets. Prior to completion of the desktop assessment, targeted field assessments were undertaken of potential barriers to flow. In selecting the barriers to assess in the field the results of the desktop analysis were utilised along with local knowledge. The field assessment focused on the Ovens River floodplain downstream of Wangaratta and 44 sites were assessed.

The desktop and field based assessments were combined into a single geodatabase. The geodatabase was used to link the barriers to flow to the environmental assets (i.e. wetlands) in the fifth stage of the broader study. Some examples of assessed barriers are shown in Figure 1.

Figure 1. Raised track crossings with box culverts (left) and pipe culvert (right)

3 HYDROLOGIC AND HYDRAULIC ANALYSIS

3.1 Hydrologic Modelling

The hydrological analysis consisted of detailed investigations of flood frequency, flow duration, spells analysis and baseflow analysis across the study area. Outputs from the hydrological analysis were used to better understand the hydrology of the study area and for input into the hydraulic modelling described below. Additional detail regarding the hydrological modelling is not provided in this paper but can be found in the study report [2].

3.2 Hydraulic Modelling

3.2.1 Approach

Two detailed hydraulic models were developed to accurately model the Lower Ovens Floodplain between Wangaratta and the Murray River using MIKE FLOOD hydraulic modelling software [3]. Due to the extensive area, two separate models were required. The models allow flood levels and wetland connectivity to be analysed over a range of flood events. The calibrated hydraulic models simulated flood flow behaviour through the Lower Ovens River as well as overbank flow throughout the floodplain. The hydraulic modelling approach consisted of the following components:

- One dimensional (1D) hydraulic model of key hydraulic structures;
- Two dimensional (2D) hydraulic model of key waterways and the broader floodplain; and
- Links between the 1D and 2D hydraulic models to integrate hydraulic structures with the adjacent 2D channel

An example of results from the detailed hydraulic modelling is shown in Figure 2 below and overlaid with barriers from the geodatabase.

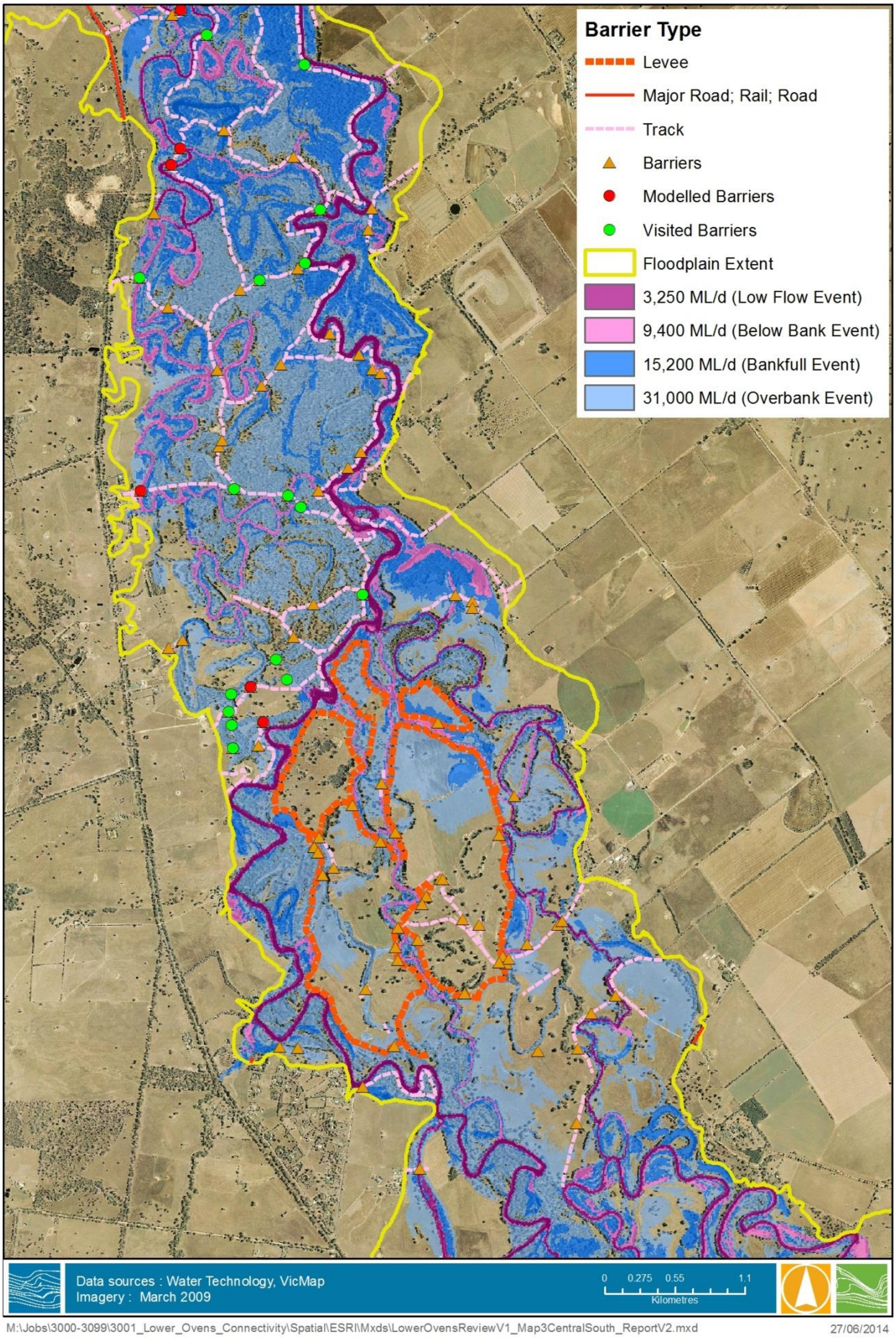

Figure 2. Example of hydraulic model results, with identified barriers overlaid.

A combination of 1D and 2D modelling can be a good solution for a complex river and floodplain system such as the lower Ovens by ensuring key hydraulic structures are accurately modelled in the 1D model while the complex overbank flow behaviour is well represented by the 2D model.

3.2.2 Topography

Accurately representing the topography of the floodplain was key to ensuring the modelling represented realistic floodplain behavior and connectivity of the wetlands. The model topography was developed from high resolution laser survey (LiDAR). In order to best represent the study area, while allowing for reasonable run times, the model topography was based on a 10 m grid resolution. A 10 m grid resolution was found to have sufficient accuracy to represent the Ovens River channel due it generally being a minimum of 30m in width between Wangaratta and the Murray River. At that resolution, the run-time for the larger upstream model for the largest modelled event was approximately three days which was deemed appropriate to meet the project objectives within the required time-frame.

A downside of resampling the fine laser survey data to the 10m model grid was that a large number of key hydraulic features smaller than 10 m in width were lost in the process such as levees and road crests. It was important that those features were included in the modelling as they can have a significant impact on flow patterns across floodplains. A method was developed to stamp detailed elevations from key floodplain features into the 10 metre model grid from the 1metre LiDAR. This includes all road and levee crests within the model extent and all barriers identified in the second stage of the project.

A review of the LiDAR dataset confirmed that the Ovens River water surface was captured in the LiDAR as opposed to the channel invert, which is normal for LiDAR survey. To ensure channel capacity was adequately represented the available cross-section survey was used to “burn” a more accurate channel into the 2D topography. The process involved burning a two cell wide channel along the length of the Lower Ovens River using inverts from the cross-section survey and longitudinal survey. For locations between surveyed points the invert was interpolated between the upstream and downstream survey points. Sensitivity testing of the resulting topography concluded the capacity was a reasonable approximation with a bankfull flow of 13,000-17,000 ML/d through much of the Lower Ovens River. That capacity correlated well with bankfull estimates determined from 1D modelling based on cross-section survey.

3.3 Modelled Events

In order to calibrate the hydraulic model and understand flood behaviour across a range of different magnitude flow events, six historic events were modelled; October 1993, September 1998, March 2012, February 2011, September 2001 and July 2008 (in order of decreasing magnitude). To ensure a full range of flows events were considered two additional design events were modelled by scaling the inflows from historic events. The October 1993 event was the largest event modelled and is the largest on record in the Ovens River catchment.

A summary of the range of modelled events is provided in Table 1 below. It can be seen that in terms of combined flow at the Wangaratta Ovens River and Reedy Creek gauges, a full range of events were modelled from a low flow design event of 3,250 ML/d through to the extreme event of October 1993, where a combined flow of 187,400 ML/d was recorded. The modelled events include a range of flow events representing low flow, below bank, bankfull and overbank conditions.

Table 1. Modelled events and peak flows at Wangaratta

EVENT	PEAK FLOW WANGARATTA GAUGE 403200 (ML/D)	PEAK FLOW REEDY CREEK GAUGE 403209 (ML/D)	COMBINED PEAK FLOW (ML/D)	EVENT TYPE
OCTOBER 1993	65,800	121,600	187,400	OVERBANK
SEPTEMBER 1998	46,800	74,500	121,300	OVERBANK
DESIGN EVENT 1	32,800	52,100	84,900	OVERBANK
MARCH 2012	25,400	21,100	46,500	OVERBANK
FEBRUARY 2011	18,800	12,000	30,800	OVERBANK
SEPTEMBER 2001	9,500	5,700	15,200	BANKFULL
JULY 2008	5,800	3,600	9,400	BELOW BANK
DESIGN EVENT 2	2,500	750	3,250	LOW FLOW

By linking the results of the 2D detailed modelling to the barrier assessment and wetland identification phases of the study a much greater understanding of floodplain behaviour, wetland connectivity and barriers to flow was gained.

Deliverables from the 2D modelling consisted of digital PDF maps showing flood extents, depth and velocity for the range of modelled events. The model results for all events were made available for viewing in the geodatabase. The flood mapping provided significant detail around flood behaviour and wetland connectivity in the Lower Ovens floodplain and fed into the fifth stage of the study which focused on establishing and prioritising management actions.

4 ECOLOGICAL ASSESMENT

4.1 Overview

The ecological assessment component of this project was designed to compile a register of maps of water dependent ecological assets within the lower Ovens River floodplain, and ranked on their value. This assessment continued on from the desktop assessment of wetlands, and involved further desktop review of assets (principally fish), and the field assessment of wetlands, floodplain vegetation and habitat.

The three standard conditions methods adopted were Index of Wetland Condition (IWC) [4], Rapid Habitat Assessment (RHA) [5] and Tree Health. The rational for selecting these methods, application of methods, and results is described in the study report [6].

4.2 Condition Data Summary

The general condition of the flood runners and wetlands was very good and evidence of flow stressed floodplain was not found downstream of the Boundary Creek offtake area, located near the upstream boundary of the Ovens-Warby National Park. General trends of condition decline near the edges of the forest and near high recreation areas of the floodplain were anticipated, and have been shown by the assessment results. The reduction in vegetation and habitat condition at the downstream end of the project area was consistent in all of the field condition assessment methods. The reasons for this poorer condition, although correlating with the Lake Mulwala backwater, are believed to be due to a range of factors in addition to the hydrologic disturbance. Additional detail regarding the findings of the ecological assessments can be found in the study report.

5 KEY ISSUES AND RECOMMENDATIONS

5.1 Overview

The final stage of the study involved compiling key findings of the preceding stages of the study, identifying issues/threats for the study area and recommending management actions to address those issues. The approach was based first on understanding the key findings of each stage of the project and then undertaking a risk based approach to prioritize the key issues/threats.

5.2 Floodplain Behaviour

Analysis of the key findings from the preceding phases of the project results provided vital intelligence which helped to better understand floodplain behaviour and identify key issues. Some of the findings related specifically to barriers on the floodplain, while others were not barrier-related but were identified as further issues which may warrant further investigation. The key findings related to floodplain flow behaviour are provided below:

- Approximately 80% of the floodplain is engaged in relatively frequent events of 30,000 ML/d (combined flow at Wangaratta), which is estimated at a 1 in 2 year ARI event. Within the Warby-Ovens National Park more than 90% of the floodplain is engaged in the same event. This demonstrates that the connectivity of the floodplain is very good. It was observed in the modelling results, that there were a couple of locations where barriers were restricting floodplain engagement in these relatively frequent events.
- Ninety-one percent of wetlands are inundated in the 1 in 2 year ARI event and 96% of wetlands are inundated in the 1 in 3 year event, which again demonstrates excellent connectivity of wetlands across the floodplain. Four percent of wetlands were deemed to have comparatively poor connectivity, being inundated less frequently than every 3 years on average.

- The modelling demonstrated that Murray River levels, as a result of the Lake Mulwala backwater, have a significant impact on the hydrological regime of wetlands in the lower reaches of the Ovens River floodplain. While reduced inundation can lead to ecologically-degraded wetlands, excessive or permanent inundation can also have a detrimental impact. This is a known problem in the area and was confirmed through field visits and ecological assessments which identified many of the wetlands through that area to be in poor condition as a result of the near-permanent inundation.
- The modelling and field visits identified a number of key crossings on major anabranches which could have an influence on wetland connectivity and fish passage, particularly when water levels at the crossings drop below crest level after a period of anabranch engagement. The existing crossings (e.g. pipe and box culvert crossings and raised ford crossings) impede native fish passage at certain low flow ranges.
- A number of minor waterway crossings were identified in the barrier desktop and field assessment which could influence floodplain flow across small flow ranges. The majority of these crossings observed in field visits were low profile, earthen crossings that do not incorporate formal crossing arrangements.
- A key finding from the ecological health assessments was that there was no discernible link between any one potential barrier to flow and assessed floodplain ecological health attribute.

The findings were compiled to produce a list of key issues which then underwent a risk assessment and prioritisation process. The list of key issues encompasses all issues identified in the preceding stages of the project that were judged to be a threat to normal floodplain flow behaviour and floodplain/wetland health and thus were deemed appropriate for progression to the risk assessment and prioritisation process.

5.3 Risk Assessment and Restoration Potential

A risk based approach was utilised to assess the key issues for the study area. Risk profiles were developed by assigning scores to the perceived value of a wetland/floodplain feature and the likelihood of this value having been or continually being impacted.

Following the risk assessment each specific issue was also assessed on its restoration potential. It is important to consider the restoration potential of a site when prioritising works to improve floodplain connectivity. In assigning a restoration potential, a judgement was made on the realistic potential for management actions to improve hydrologic connection, vegetation condition and/or fish passage at each identified site. Further details regarding the method used in the assessment of risk and restoration potential can be found in the study report [7].

5.4 Management Actions

The management actions identified within this section relate to the specific threats identified in Stage 5 of the study, the project objectives and the assessed components of wetland and floodplain health, namely:

- Hydrologic connection
- Vegetation condition
- Fish passage

The recommended management strategies will assist the North East Catchment Management Authority (CMA) to plan and implement further studies and works that aim to improve the condition of the lower Ovens River floodplain. Rationales are provided for each mitigation measure along with consideration of restoration potential. The recommended management actions also include approximate indicative costs associated with design and investigation. In most instances the potential for works to proceed to the construction stage will be dependent upon the feasibility established in a further investigative stage.

Based on the risk profile and restoration potentials determined in the proceeding stage of the assessment, the management actions were assigned a priority based on the prioritisation matrix shown in Table 2. Equal weighting was given to the risk profile and restoration potential assessments.

Table 3 is provided as an example to show the management action and prioritisation for three identified barriers/issues. Management actions and prioritisations for the full range of issues identified in the study area can be found in the study report.

Table 2. Prioritisation matrix based on the risk profile and value of impacted asset

Risk Profile	Restoration Potential		
	1 - Low	2 - Medium	3 - High
A – High	Medium-High	High	High
B – Medium	Medium	Medium-High	High
C - Low	Low-Medium	Medium	Medium-High
D - Insignificant	Low	Low-Medium	Medium

Table 3. Example of identified issue, management action and prioritisation.

Barrier/Issue Details	Management Action	Indicative Cost	Risk Profile	Restoration Potential	Action Priority
Earthen crossing on Frosts Track with no culverts present	Building upon the barrier assessment work undertaken as a component of this investigation, improve fish passage through waterway crossings on major floodplain channel features (e.g. well-connected anabranches such as Boundary Creek) through modification of the barrier. The process would include a review, coordinating the works with Park Victoria, detailed design and then upgrade/replacement of the crossing.	Design and Investigation: • Identification of all potential barriers to fish passage on the major anabranch networks (*Indicative cost: $20,000-30,000*). • Co-ordinate priorities for upgrading works in conjunction with Parks Victoria. • Detail Design (*Indicative cost per crossing structure: $5,000-20,000*). Construction: • Waterway crossing upgrade/replacement works (*Indicative cost per crossing structure: $10,000-50,000*).	Medium	High	High
Culvert crossing on Francis Track with six concrete box culverts present	Building upon the barrier assessment work undertaken as a component of this investigation, improve fish passage through waterway crossings on major floodplain channel features (e.g. well-connected anabranches such as Boundary Creek) through modification of the barrier. The process would include a review, coordinating the works with Park Victoria, detailed design and then upgrade/replacement of the crossing.	Design and Investigation: • Identification of all potential barriers to fish passage on the major anabranch networks (*Indicative cost: $20,000-30,000*). • Co-ordinate priorities for upgrading works in conjunction with Parks Victoria. • Detail Design (*Indicative cost per crossing structure: $5,000-20,000*). Construction: Waterway crossing upgrade/replacement works (*Indicative cost per crossing structure: $10,000-50,000*).	Low	High	Medium-High
Minor channel crossings located inside the Warby-Ovens	Investigation and modification of barriers to improve fish passage through waterway crossings on minor floodplain channel features (e.g. depressions connecting to terminal	Design and Investigation: • Identification of all potential barriers to fish passage on the minor floodplain channel features (*Indicative cost: $10,000-20,000*). • Co-ordinate priorities for upgrading works in	Low	High	Medium-High

Barrier/Issue Details	Management Action	Indicative Cost	Risk Profile	Restoration Potential	Action Priority
National Park	wetlands) located within the Warby-Ovens National Park.	conjunction with Parks Victoria. • Detail Design (*Indicative cost per crossing structure: $5,000-10,000*). Construction: • Waterway crossing upgrade/replacement works (Indicative cost per crossing structure: $5,000-20,000).			

6 SUMMARY

This paper has summarised the key stages and findings of the Developing Capacity to Improve Connectivity of Unregulated Flows in the Lower Ovens Floodplain study. The study has improved the understanding of floodplain flow dynamics and the connectivity between the channel, overbank areas, and environmental assets and has identified a number of actions to improving the management of unregulated flows to key environmental assets.

The study resulted in a number of specific barriers and issues being identified, which underwent an assessment of risk and restoration potential. Risk profiles were developed by assigning scores to the perceived value of a wetland/floodplain feature and the likelihood of this value having been or continually being impacted. Assessments of restoration potential were made based on judgement of the realistic potential for management actions to improve hydrologic connection, vegetation condition and/or fish passage at each identified site.

Management actions were then proposed for each of the specific issues, and were prioritised based on the risk profile and restoration potential, with both given equal weighting in the prioritisation process. The prioritisation process determined the modifying of two waterway crossings on significant anabranches as the highest priority management actions.

This project has clearly demonstrated why the lower Ovens River floodplain is in such good condition. It provides the link between floodplain wetland condition, hydrology, ecology, and river/floodplain/wetland connectivity. The lower Ovens River could be used as the benchmark for how a healthy river and floodplain can be achieved within the Murray-Darling Basin. Although the lower Ovens River, floodplain and wetlands are in great condition a number of issues/threats were identified and prioritised and management actions developed. These issues/threats should be considered further with a view to protecting and enhancing this magnificent environmental asset that is the lower Ovens River.

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REFERENCES

[1] Cottingham P. et al., "*Report of the Ovens Scientific Panel on the Environmental Conditions and Flows of the Ovens River*", Murray-Darling Freshwater Research Centre, (2001)

[2] Water Technology, *"Developing Capacity to Improve Connectivity of Unregulated Flows in the Lower Ovens Floodplain".* Report to North East Catchment Management Authority, Water Technology Pty. Ltd, Melbourne , Victoria, (2014)

[3] DHI, "*MIKE FLOOD*" [Computer Software] (2012)

[4] DEPI, "*Index of Wetland Condition Assessment Procedure*", Department of Primary Industries, Victoria, (2013)

[5] DSE, "*Assessing habitat quality using the 'Land manager self-assessment method', Work Sheet No 4*.", Victorian Government Department of Sustainability and Environment, Melbourne, (2004)

[6] Water Technology, *"Developing Capacity to Improve Connectivity of Unregulated Flows in the Lower Ovens Floodplain".* Report to North East Catchment Management Authority, Water Technology Pty. Ltd, Melbourne , Victoria, (2014)

[7] Water Technology, *"Developing Capacity to Improve Connectivity of Unregulated Flows in the Lower Ovens Floodplain".* Report to North East Catchment Management Authority, Water Technology Pty. Ltd, Melbourne , Victoria, (2014)