Dec 12th, 1:30 PM - 3:10 PM

Barriers to Fish Passage in the Queensland Murray-Darling Basin Phase II: Validation of the “Keller” method for determining discharge at weir drown-out.

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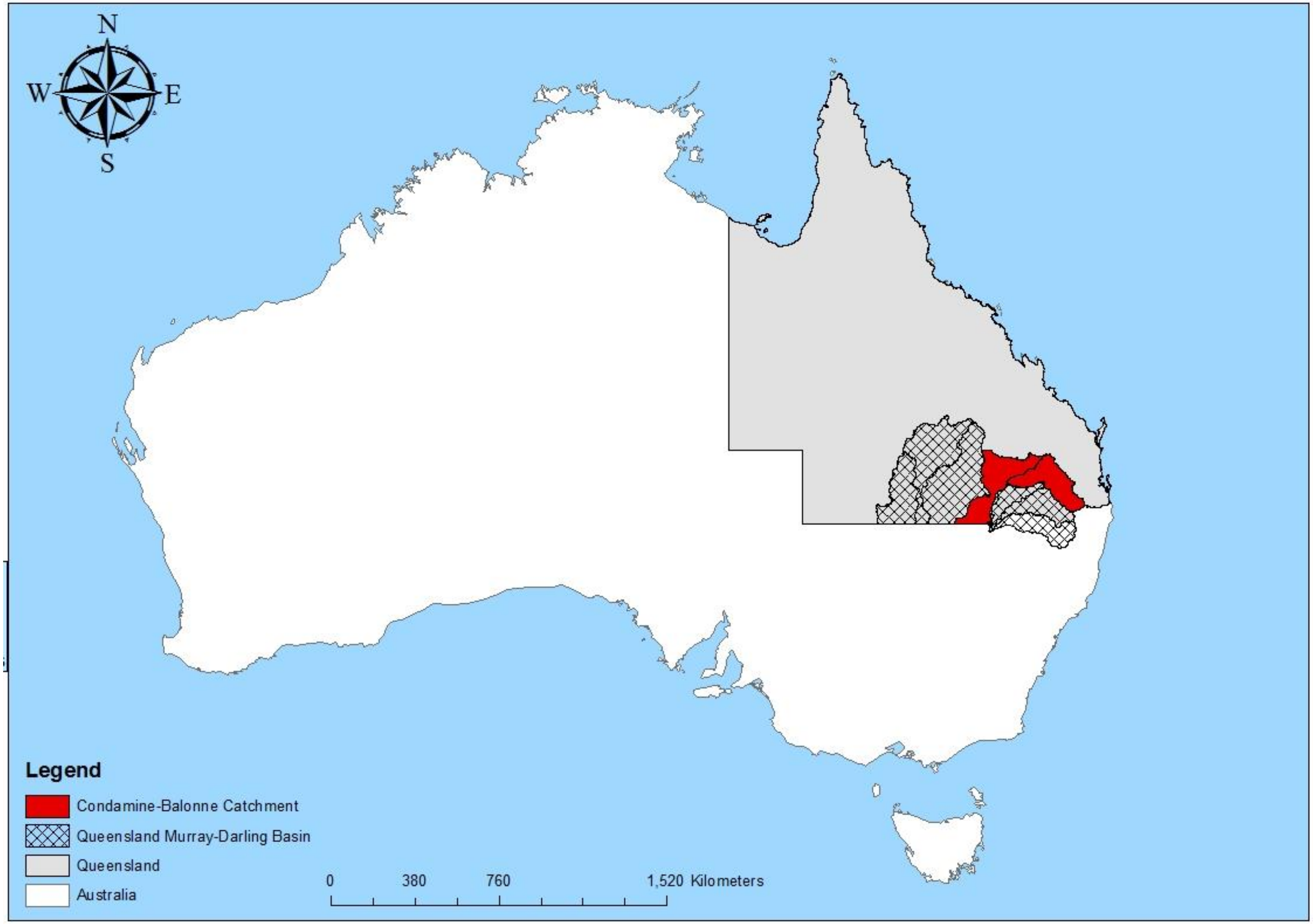
Evaluating Barrier Passability for Fish in the Queensland Murray-Darling Basin using Discharge at Weir Drown-out

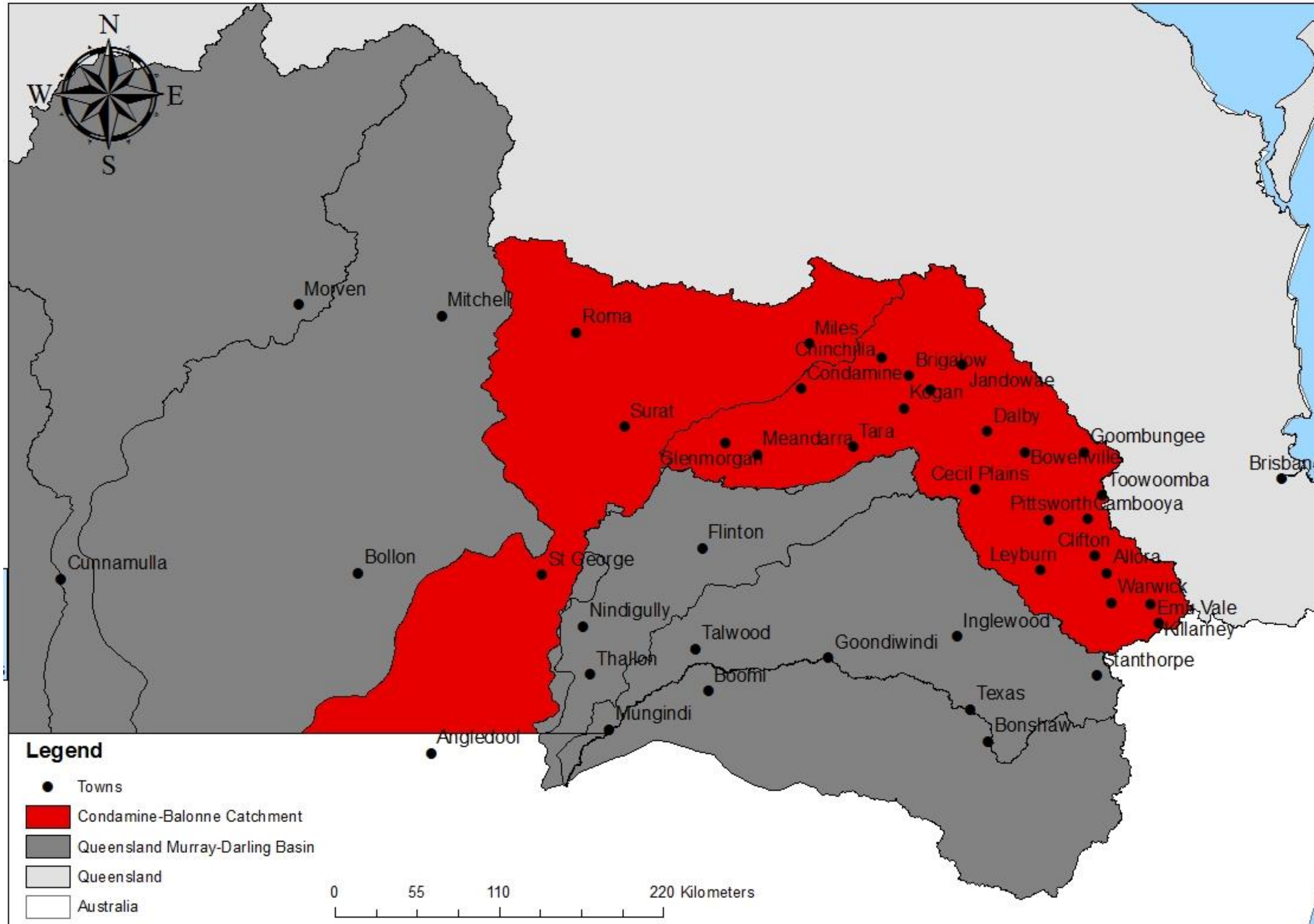
Janice Kerr, Andrea Prior, James Fawcett, Doug Harding and Tess Mullins
Environmental Flows Assessment Program

Cotswold Weir on the Condamine River.

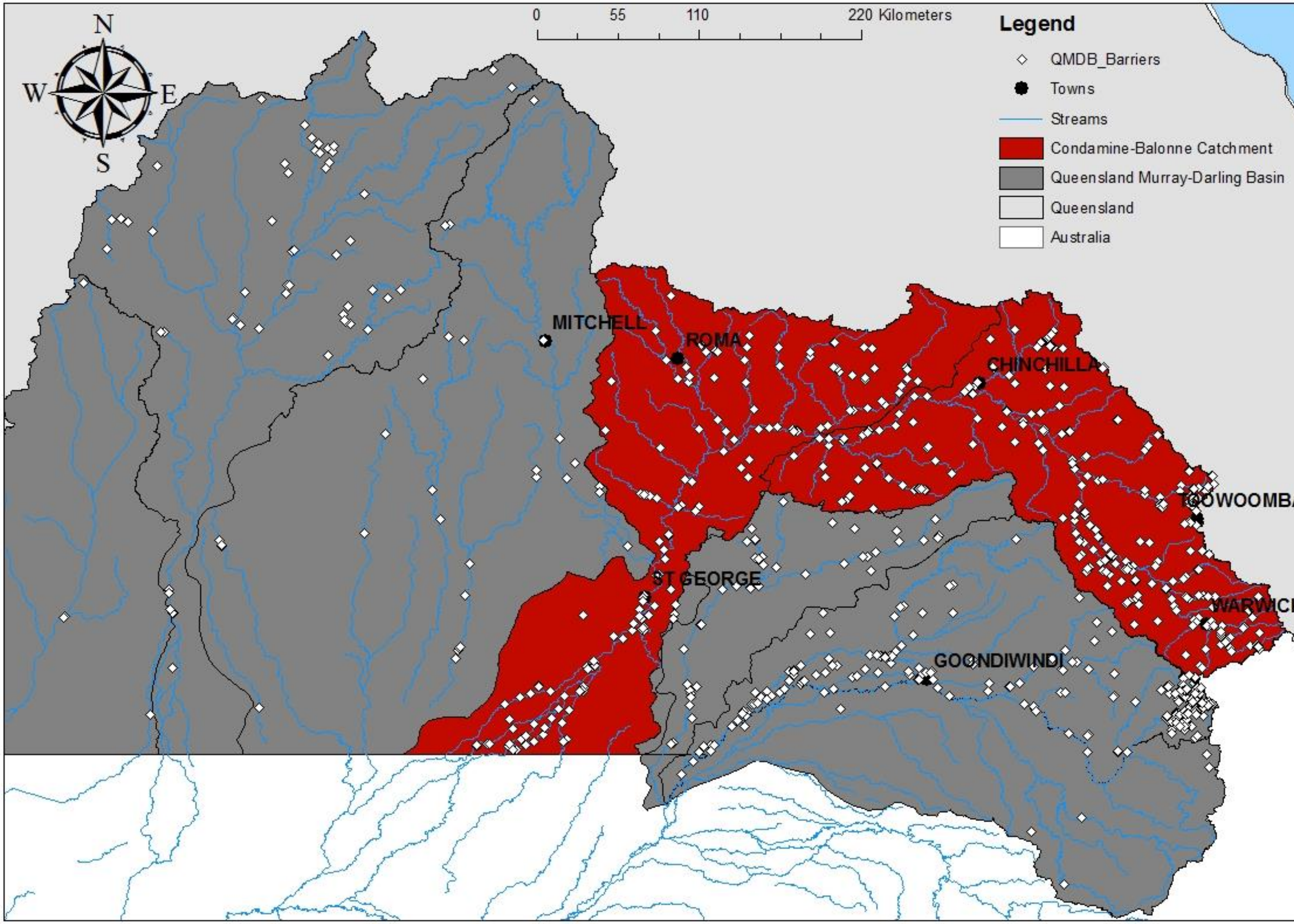
Barriers in the Queensland Murray-Darling Basin



Barriers in the Queensland Murray-Darling Basin



Barriers in the Queensland Murray-Darling Basin



Weir Drown-out

Surat Weir, Surat, Queensland. Photo: A. Prior.

Weir Drown-out

Surat Weir, Surat, Queensland. Photo: A. Prior.

Modelling risk to fish from altered flows including barriers

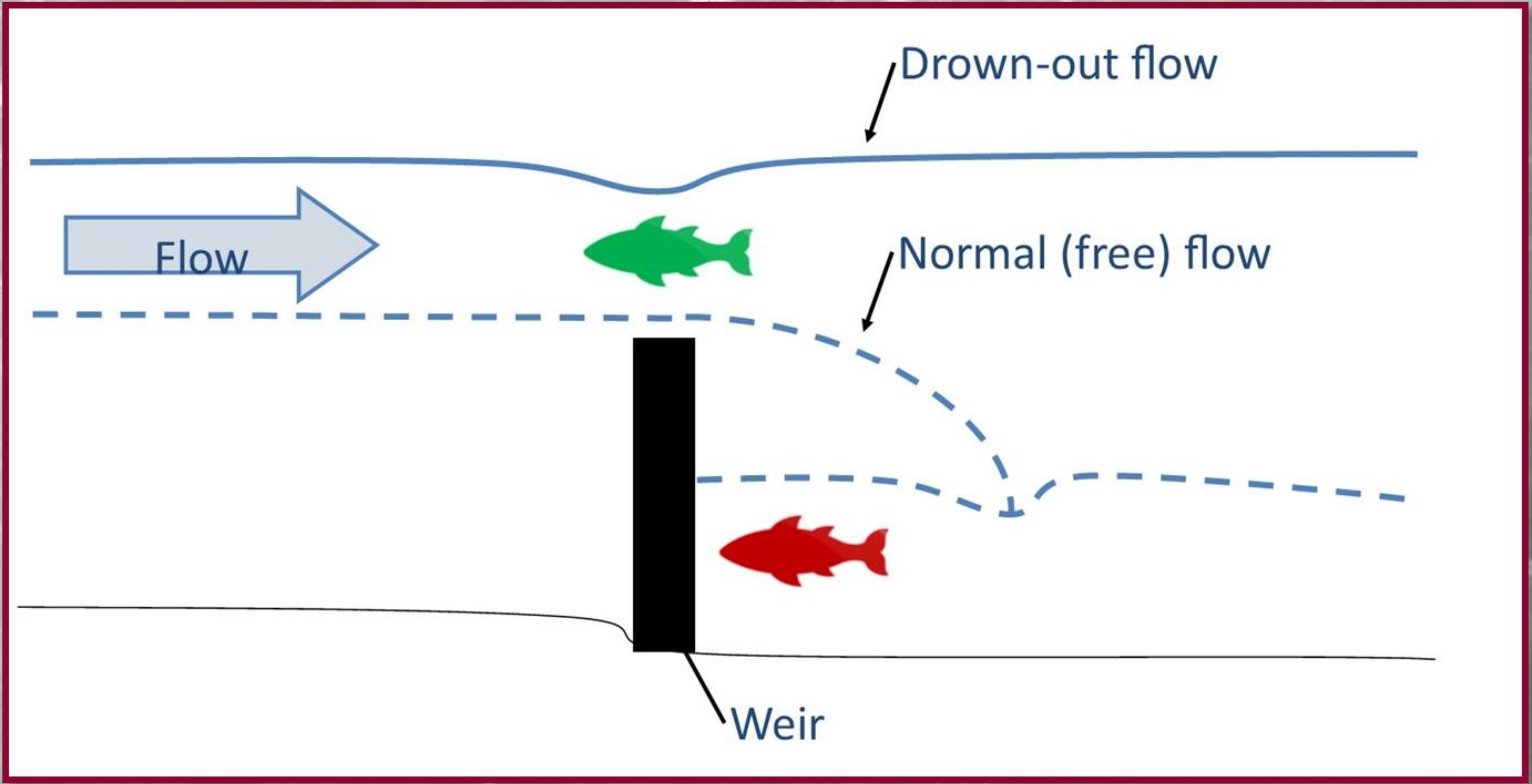
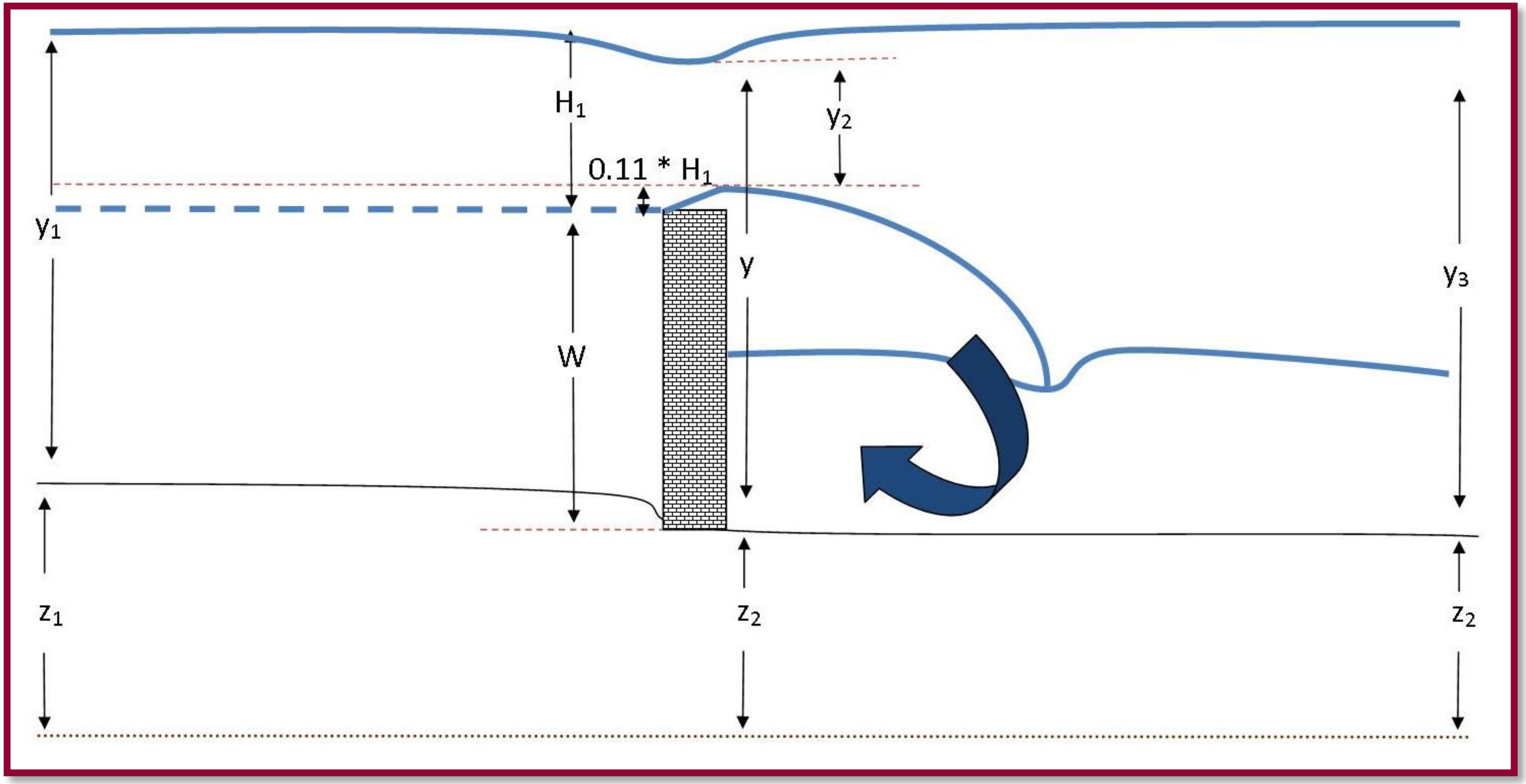
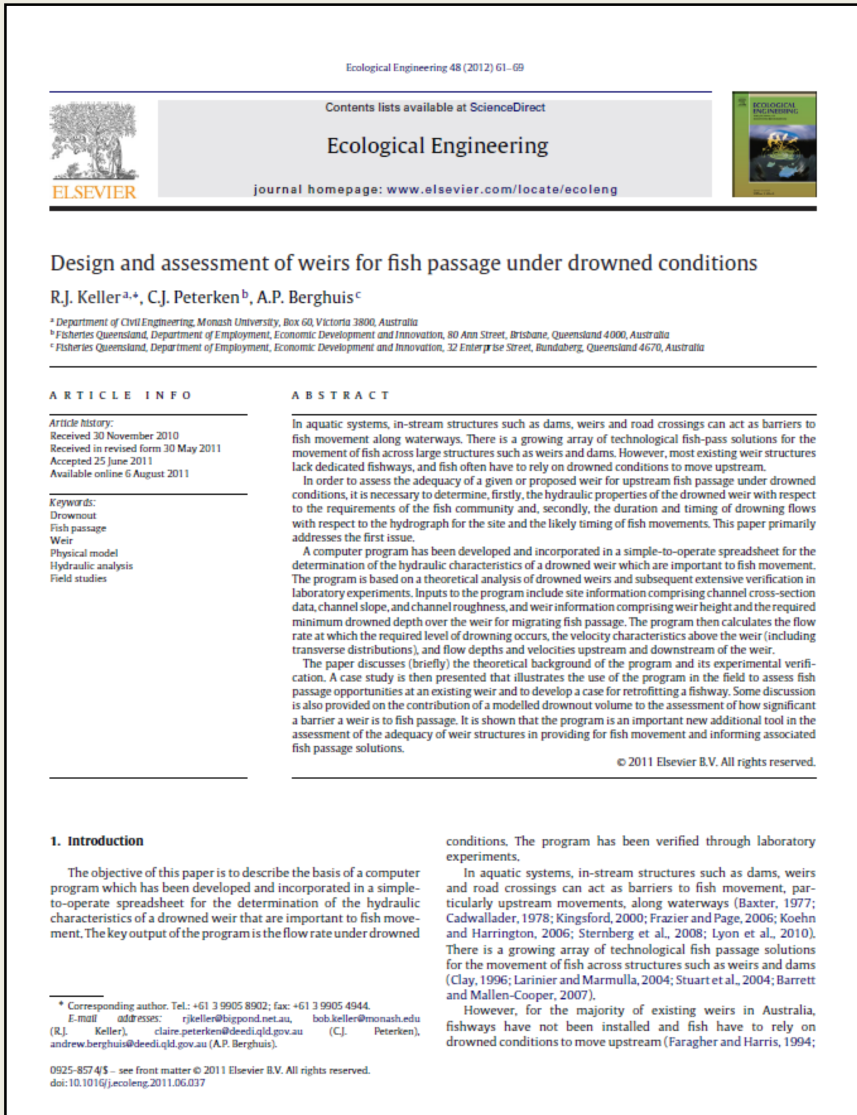


Photo: Hyrtl's tandan congregating below Cunnamulla Weir
http://www.finterest.com.au/wp-content/uploads/2013/08/MD1398-Figure-8.-Aggregations-of-Neosilurus-hyrtii-at-Cunnamulla-Weir-Photo-QLD-DEEDI-March-2010.jpg.

Modelling risk to fish from altered flows including barriers



Keller, Peterken and Berghuis 2012



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ELSEVIER

Design and assessment of weirs for fish passage under drowned conditions

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ABSTRACT

In aquatic systems, in-stream structures such as dams, weirs and road crossings can act as barriers to fish movement along waterways. There is a growing array of technological fish-pass solutions for the movement of fish across large structures such as weirs and dams. However, most existing weir structures lack dedicated fishways, and fish often have to rely on drowned conditions to move upstream.

In order to assess the adequacy of a given or proposed weir for upstream fish passage under drowned conditions, it is necessary to determine, firstly, the hydraulic properties of the drowned weir with respect to the requirements of the fish community and, secondly, the duration and timing of drowning flows with respect to the hydrograph for the site and the likely timing of fish movements. This paper primarily addresses the first issue.

A computer program has been developed and incorporated in a simple-to-operate spreadsheet for the determination of the hydraulic characteristics of a drowned weir which are important to fish movement. The program is based on a theoretical analysis of drowned weirs and subsequent extensive verification in laboratory experiments. Inputs to the program include site information comprising channel cross-section data, channel slope, and channel roughness, and weir information comprising weir height and the required minimum drowned depth over the weir for migrating fish passage. The program then calculates the flow rate at which the required level of drowning occurs, the velocity characteristics above the weir (including transverse distributions), and flow depths and velocities upstream and downstream of the weir.

The paper discusses (briefly) the theoretical background of the program and its experimental verification. A case study is then presented that illustrates the use of the program in the field to assess fish passage opportunities at an existing weir and to develop a case for retrofitting a fishway. Some discussion is also provided on the contribution of a modelled drownout volume to the assessment of how significant a barrier a weir is to fish passage. It is shown that the program is an important new additional tool in the assessment of the adequacy of weir structures in providing for fish movement and informing associated fish passage solutions.

1. Introduction

The objective of this paper is to describe the basis of a computer program which has been developed and incorporated in a simple-to-operate spreadsheet for the determination of the hydraulic characteristics of a drowned weir that are important to fish movement. The key output of the program is the flow rate under drowned conditions. The program has been verified through laboratory experiments.

In aquatic systems, in-stream structures such as dams, weirs and road crossings can act as barriers to fish movement, particularly upstream movements, along waterways (Baxter, 1977; Cadwallader, 1978; Kingsford, 2000; Frazier and Page, 2006; Koehn and Harrington, 2006; Sternberg et al., 2008; Lyon et al., 2010). There is a growing array of technological fish passage solutions for the movement of fish across structures such as weirs and dams (Clay, 1996; Larinier and Marmulla, 2004; Stuart et al., 2004; Barrett and Mallen-Cooper, 2007).

However, for the majority of existing weirs in Australia, fishways have not been installed and fish have to rely on drowned conditions to move upstream (Faragher and Harris, 1994;

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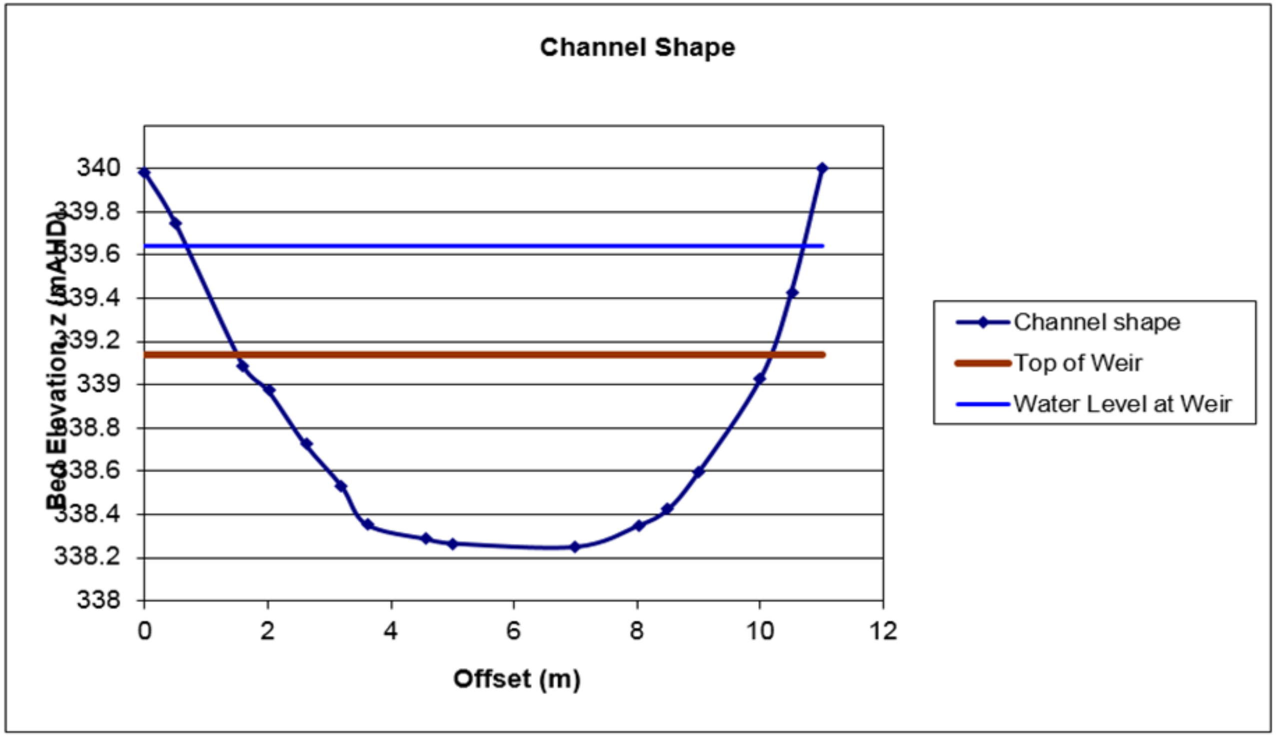
Reilly's Weir fishway on the Condamine River, Condamine, Queensland. Photo: Andrea Prior.

"Keller" spreadsheet

Inputs	
Cross Section Information	
Offset	Bed Elevation
x (m)	z (mAHD)
0	339.98
0.5	339.75
1.6	339.09
2	338.97
2.6	338.73
3.2	338.53
3.6	338.35
4.55	338.29
5	338.27
7	338.25
8	338.35
8.5	338.42
9	338.6
10	339.03
10.5	339.43
11	340



Screen shots illustrating the spreadsheet designed to calculate the stream discharge at weir drown-out by Keller, Peterken & Berghuis (2012).

“Keller” spreadsheet

SUB-W - Input Table

An analysis program for assessment of submerged weirs

About | Calculate

Input Table

Variable Name	Allowed Range	Value	Units
Weir Height	>0	0.889	m
Depth of Flow over Weir	>0	0.5	m
Sidewalls Manning's n	0.01-0.2	0.09	
Mannings n guidelines (sidewalls)	Rocks, weeds, shrubs and trees		
Downstream Channel Manning's n	0.01-0.2	0.025	-
Mannings n guidelines (channel)	Earth, some stones, weeds		
Downstream Channel Slope	0.00001-0.1	0.0001	-
Downstream boundary depth calculation		◉ Rating Table ○ Normal Depth	

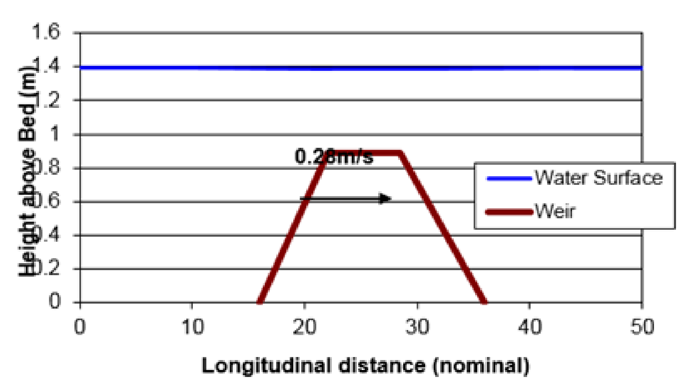
Oakey Creek at Fairview
Gauging Weir
Crump with v-notch

Outputs

Output Table

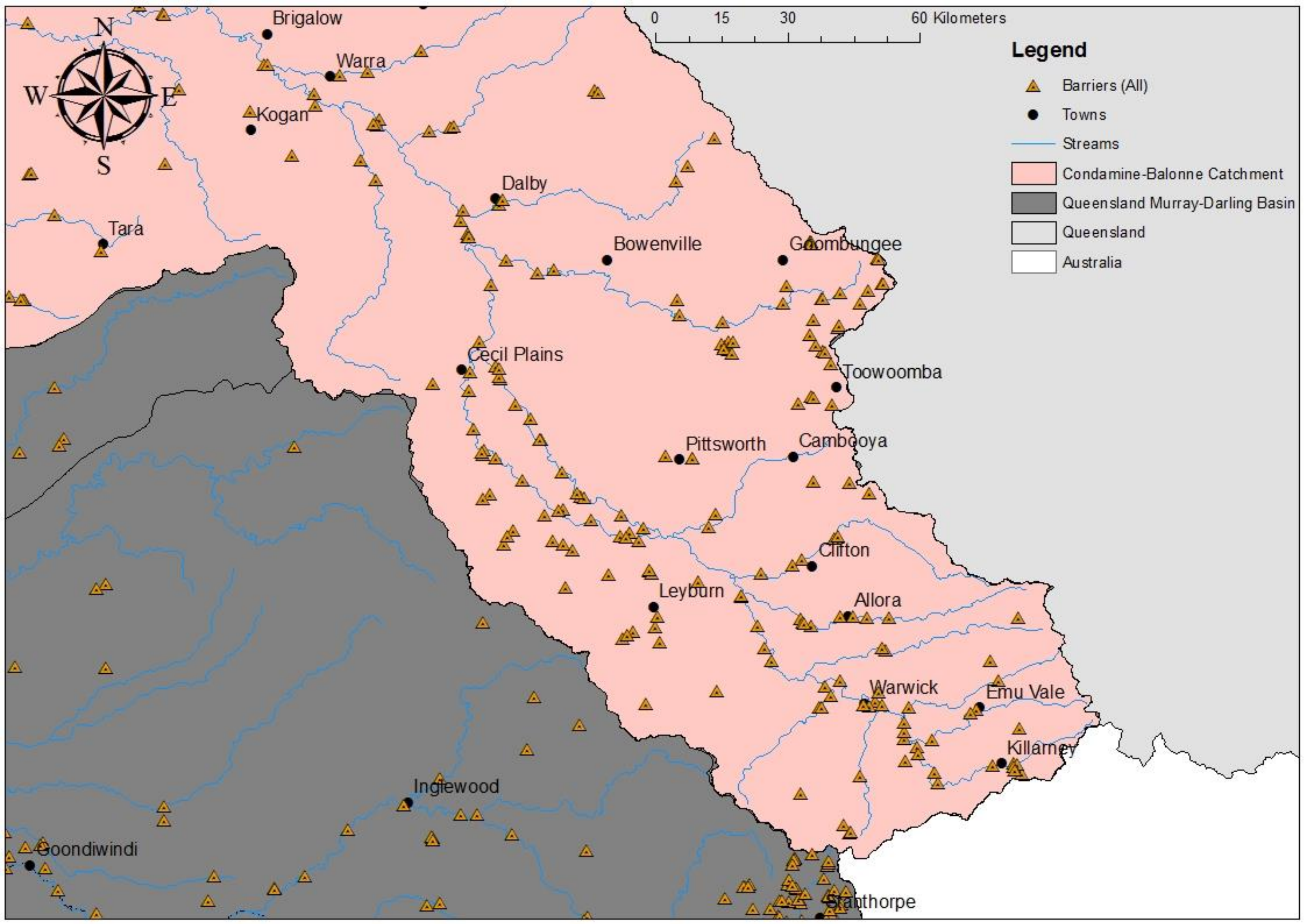
Flowrate (m^3/s)	1.247			
	Depth (m)	**Water surface elevation (mAHD)**	**Average Velocity (m/s)**	**Froude Number**
Upstream	1.394	339.644	0.121	0.038
Over Weir	0.500	339.695	0.28m/s	0.147
Downstream	1.392	339.642	0.121	0.038
Headloss (m)		0.002		
Crest Elevation (m AHD)		339.139		
Flow Width (m)		9.865		
Minimum depth of flow over weir (m)				

Representative Profiles



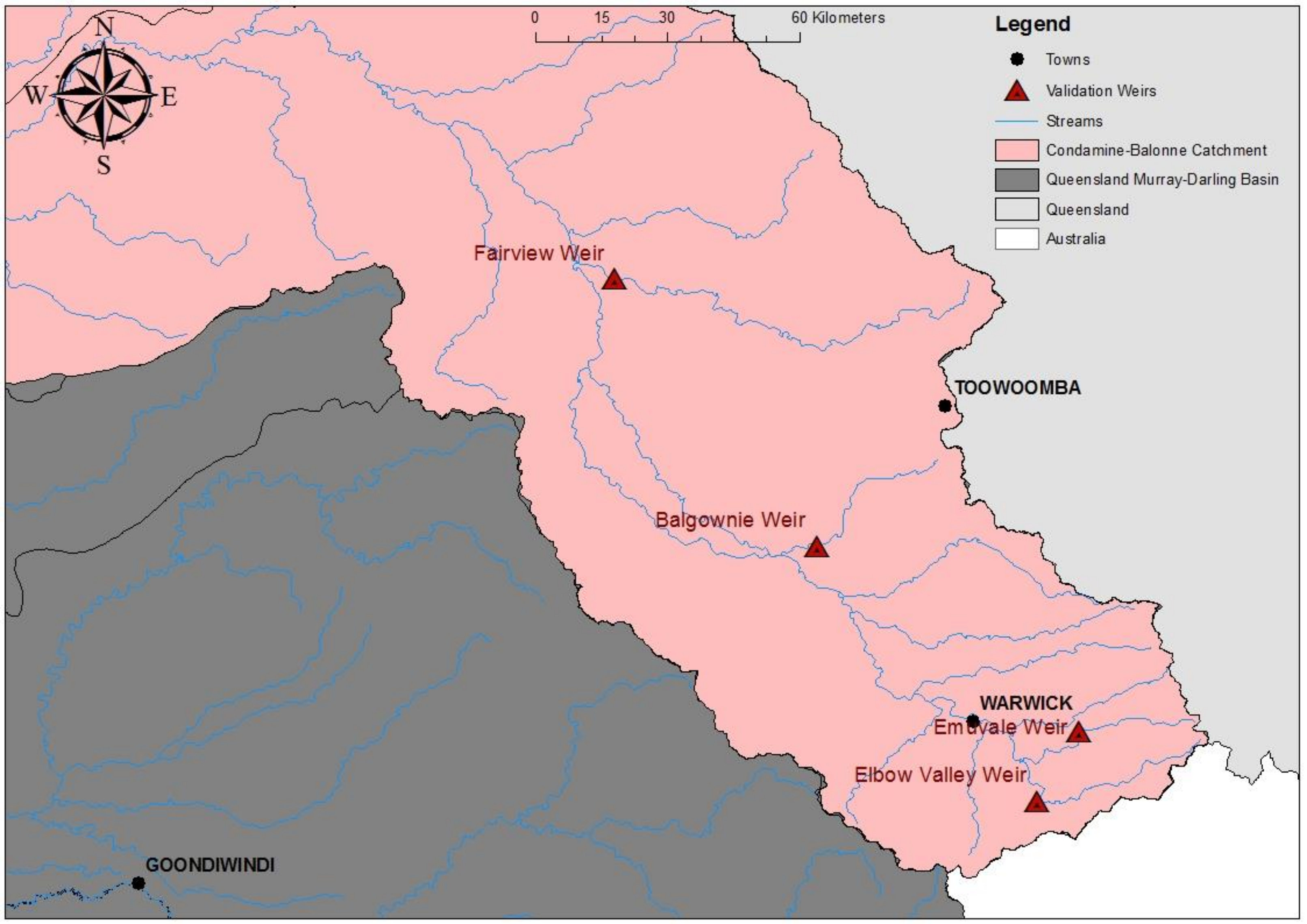
Screen shots illustrating the spreadsheet designed to calculate the stream discharge at weir drown-out by Keller, Peterken & Berghuis (2012).

Sites



N
S
W
E
0 15 30 60 Kilometers
Legend
Barriers (All)
Towns
Streams
Condamine-Balonne Catchment
Queensland Murray-Darling Basin
Queensland
Australia
Brigalow
Warra
Kogan
Dalby
Tara
Bowenville
Goombungee
Cecil Plains
Toowoomba
Pittsworth
Cambooya
Clifton
Leyburn
Allora
Warwick
Emu Vale
Killarney
Inglewood
Goondiwindi
Stanthorpe

Sites


N
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60 Kilometers
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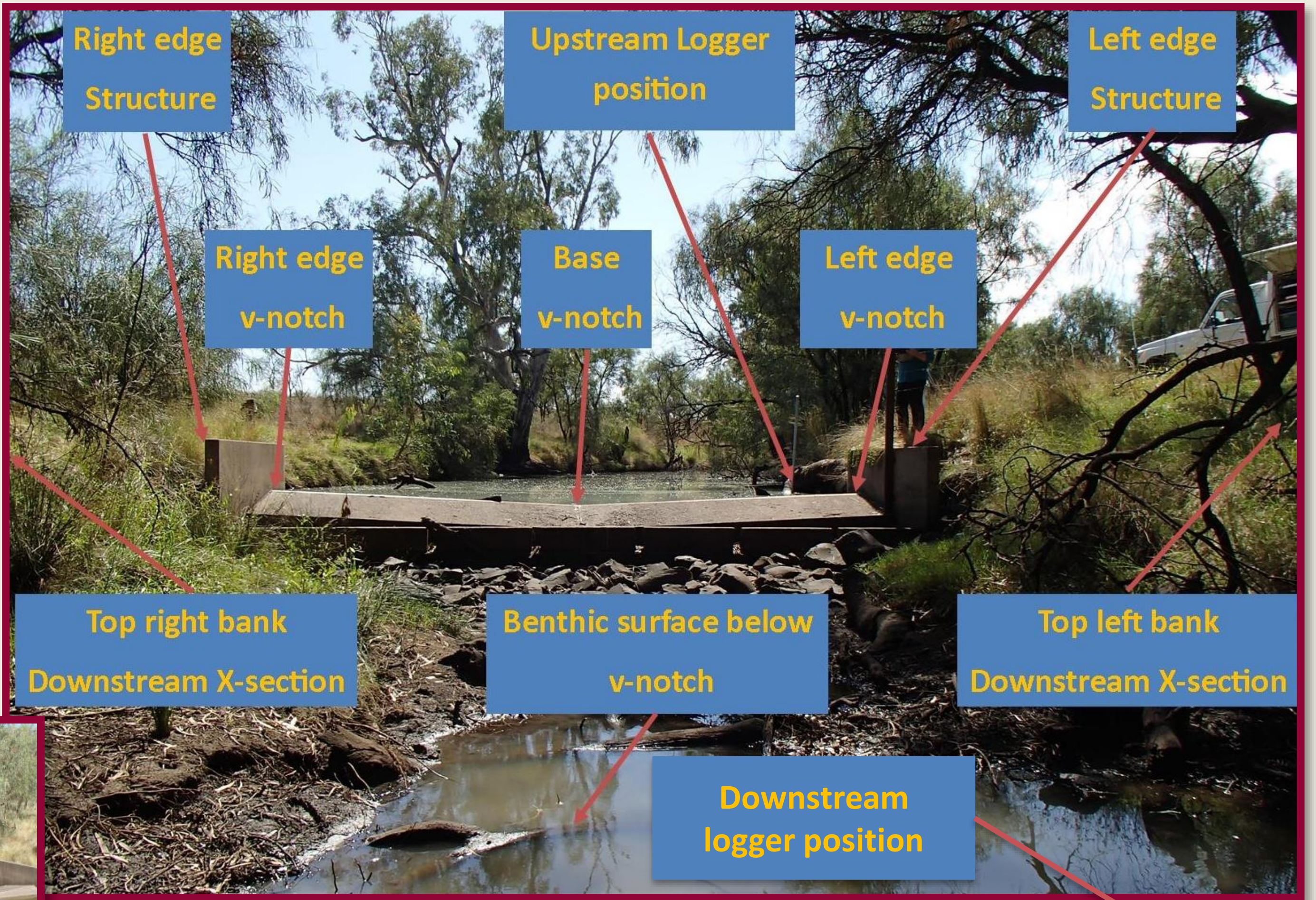
Towns
Validation Weirs
Streams
Condamine-Balonne Catchment
Queensland Murray-Darling Basin
Queensland
Australia
Fairview Weir
TOOWOOMBA
Balgownie Weir
WARWICK
Emuvale Weir
Elbow Valley Weir
GOONDIWINDI

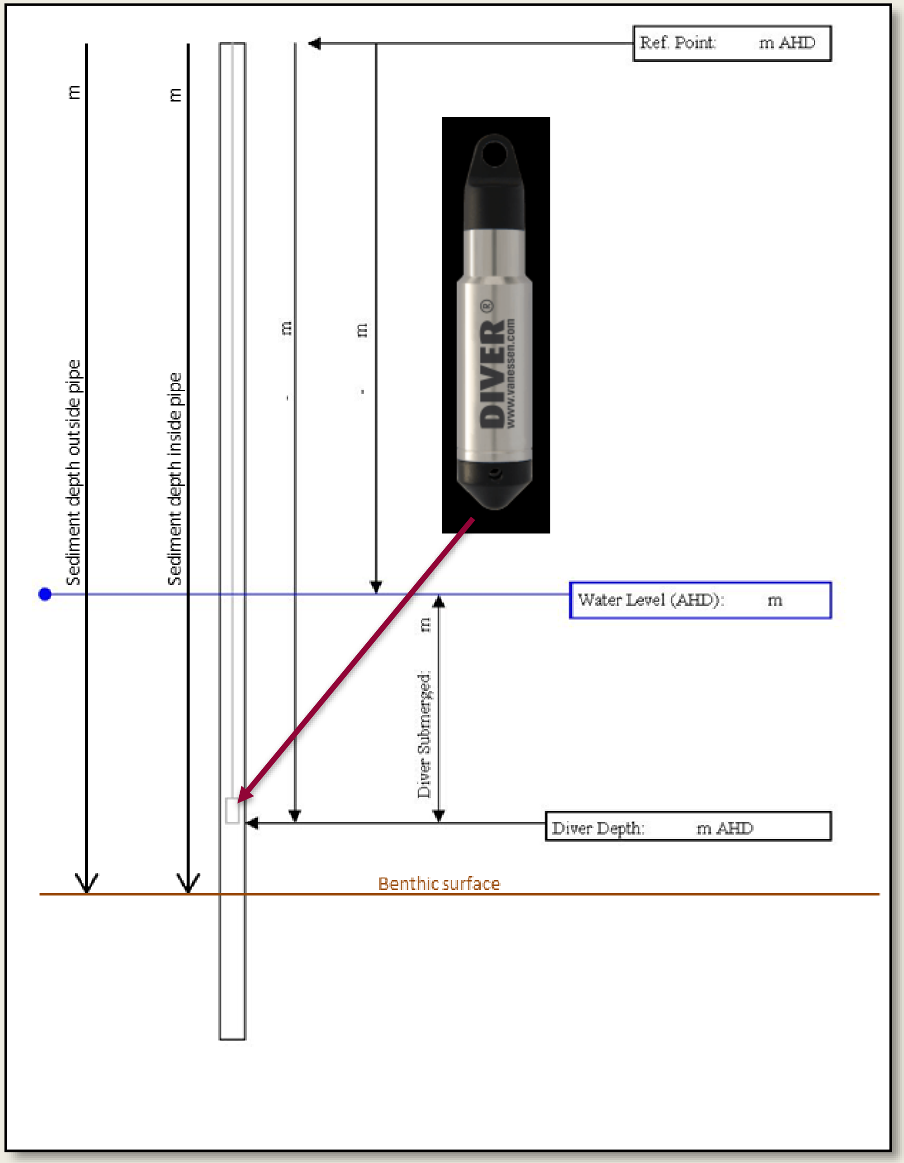
Surveying



Fairview Weir, Oakey Creek, Queensland. Photos: James Fawcett

Depth Loggers

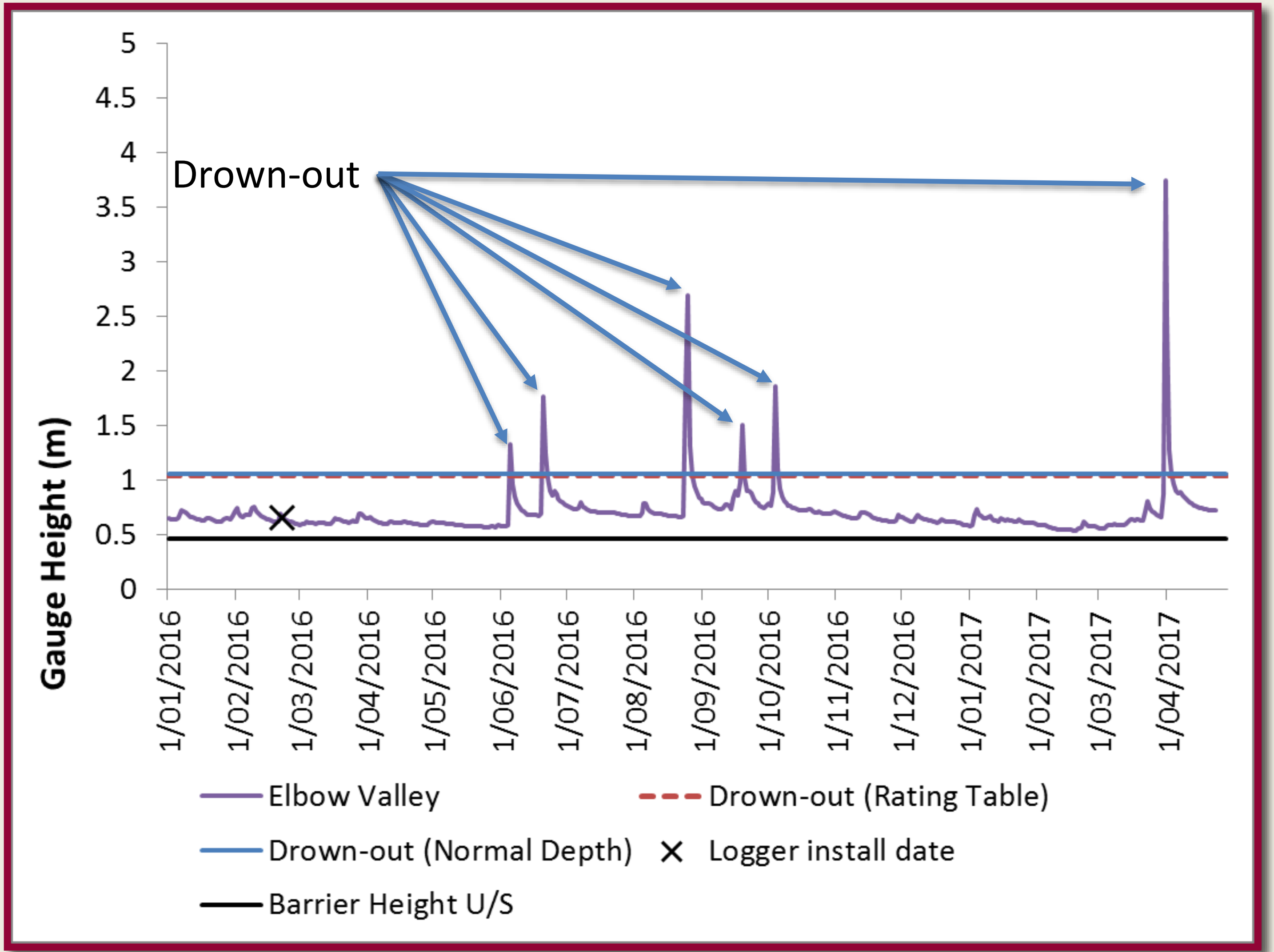
Upstream logger pole, Elbow Valley Weir, Condamine River, Queensland.



Results

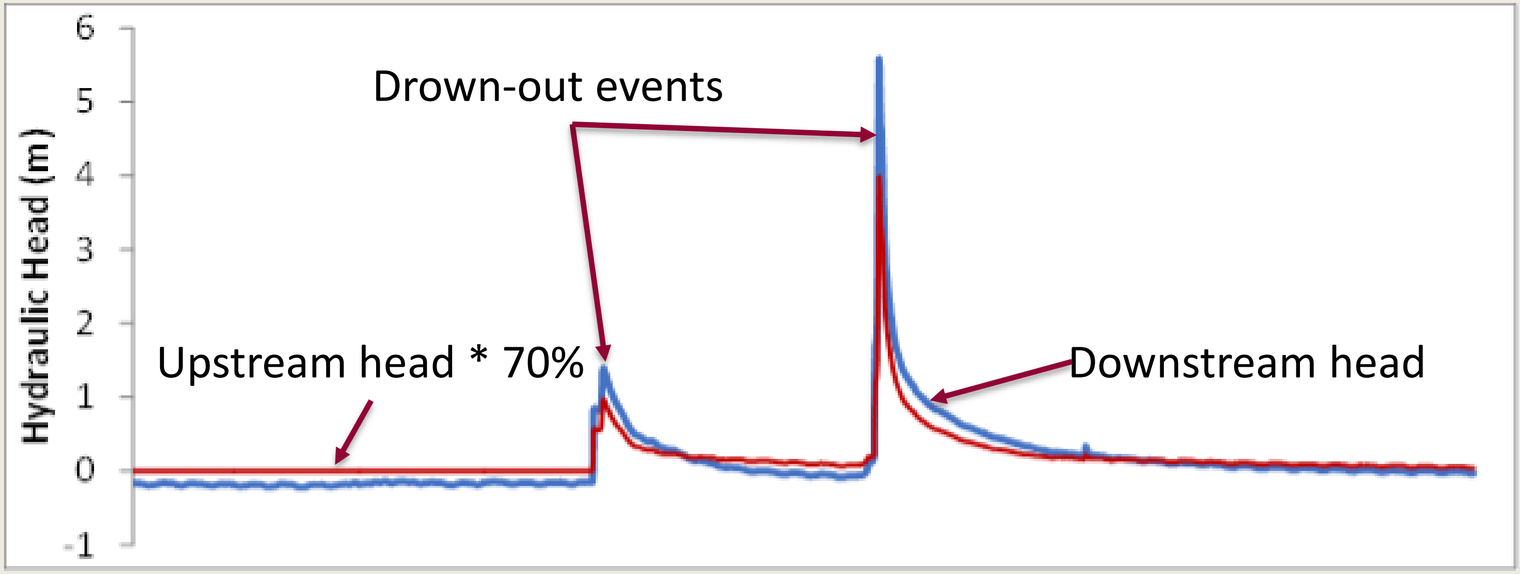
Elbow Valley

Results



Elbow Valley

Drown-out Thresholds

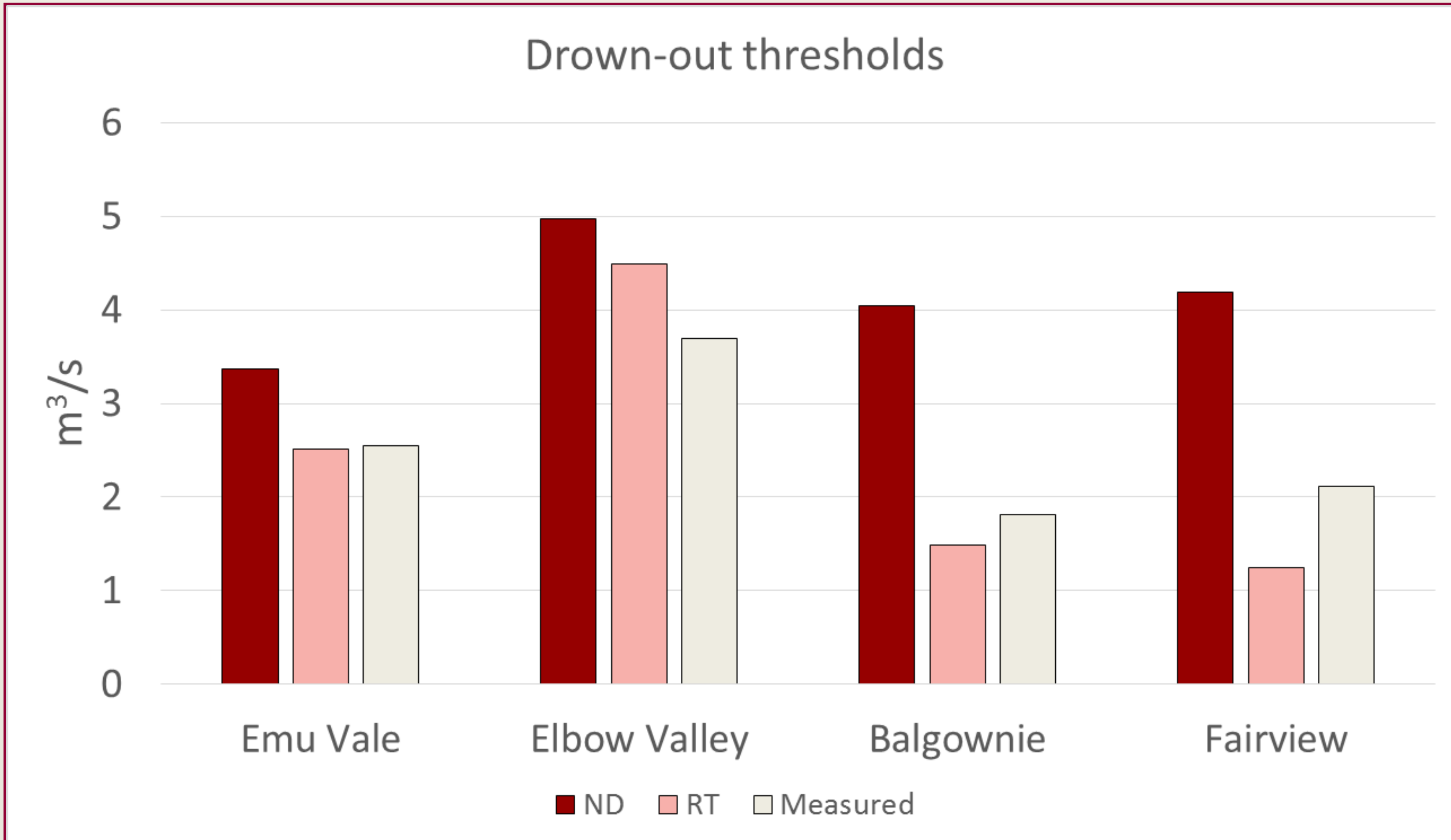


Elbow Valley Weir,
Condamine River

Drown-out Thresholds

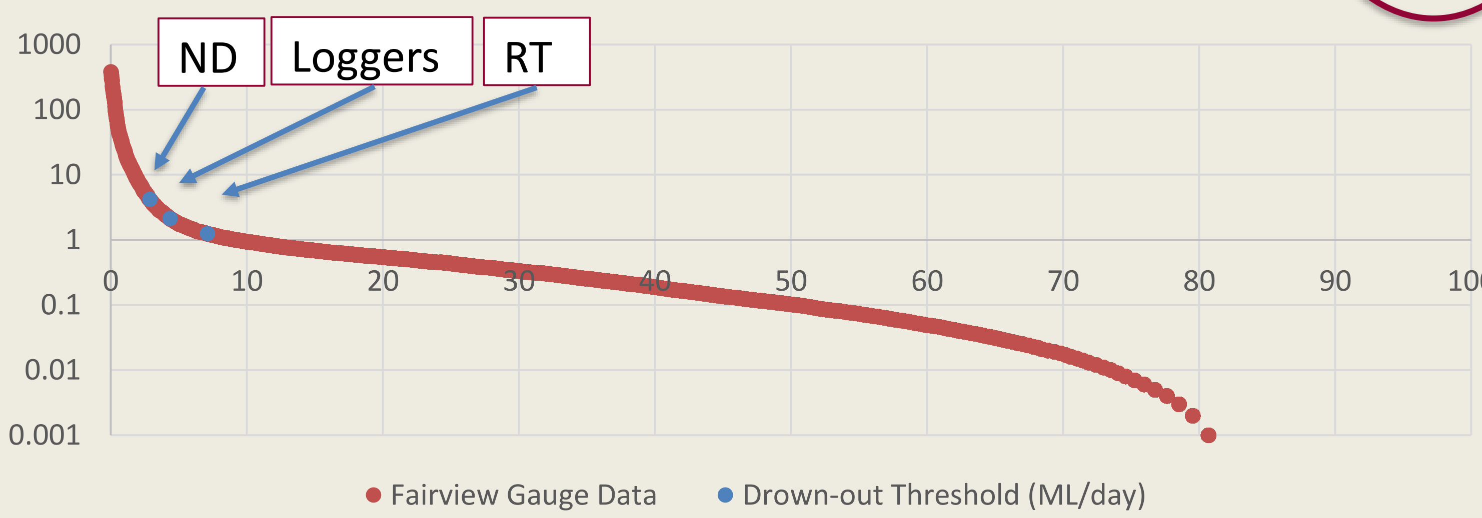
Location	Emu Vale	Elbow Valley	Balgownie	Fairview
Depth Over Weir (m)	0.50	0.50	0.50	0.50
ND Drown-out discharge (m^3/s)	3.37	4.97	4.04	4.19
RT Drown-out discharge (m^3/s)	2.51	4.49	1.49	1.25
Measured drown-out threshold (m^3/s)	2.55	3.69	1.81	2.12

Drown-out Thresholds

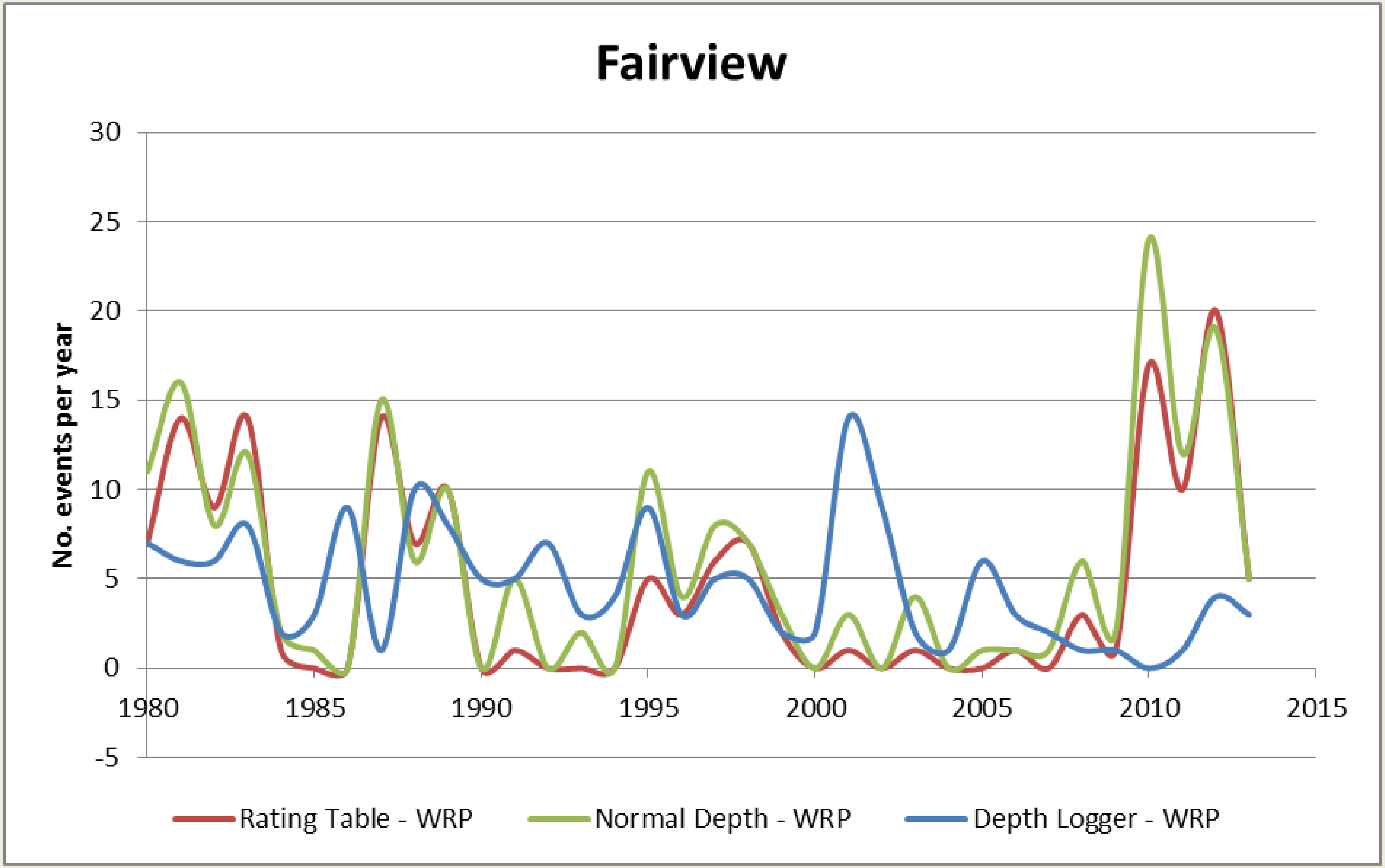


Daily Flow Exceedance

Location	Emu Vale	Elbow Valley	Balgownie	Fairview
Keller Method (ND) (%)	2.64	3.49	1.55	3.46
Keller method (RT) (%)	3.45	3.95	2.78	8.59
Measured (%)	3.41	5.03	2.42	5.28



Compare Frequency of Drown-out



The Wilcoxon Rank-Sum Test

Compared the frequency of drown-out events (Depth over weir 0.5 m) measured using depth loggers, “Measured”, to:

- Normal Depth Threshold
- Rating Table Threshold

	Emu Vale	Elbow Valley	Balgownie	Fairview
W_s	1958	1958	915	1314
SE_{ws}	119.83	119.83	67.64	88.79
n	44	44	30	36
Normal Depth vs Measured Depth				
W_{ND}	1929	1822.5	762	1461
Z-score $_{ND}$	-0.24(NS)	-1.13 (NS)	-2.26 (*)	-1.66 (NS)
Rating Table vs Measured Depth				
W_{RT}	1959.5	1866	880.5	1144.5
Z-score $_{RT}$	0.01 (NS)	-0.77 (NS)	-0.51 (NS)	-1.91 (NS)

P=0·05
“*” significant
“NS” = not significant
W is the Wilcoxon rank-sum statistic
W_s is the mean
SE_{ws} is the SE of *W*

Balgownie

Modelling fish population viability

- Water Planning Ecology (DES) uses the RAMAS meta-population model to predict the effects of changes in water resource management on the population viability of golden perch.

- This model requires information on the spatial distribution of stream connectivity at various flow magnitudes.
  - Estimates connectivity at the reach scale
  - Assesses risks to fish population viability

- Weir drown-out thresholds inform the connectivity component of the modelling.

Golden Perch (*Macquaria ambigua*). Photo: A. Prior.

Passability Scores

- Drown-out can be used to derive passability scores for modelling connectivity*
- Must be species specific.
- Must consider:
  - Upstream and downstream passage
  - Required duration, frequency, season, velocity
  - Size and life stage

*Bourne CM, Kehler DG, Wiersma Y F, Cote D. 2011. Barriers to fish passage and barriers to fish passage assessments: the impact of assessment methods and assumptions on barrier identification and quantification of watershed connectivity. Aquat Ecol. 45(3): 389-403.

Next steps – fish movement study

- Fish movement study
  - 62 acoustic receivers over 400km of river
  - Tag 120 fish: golden perch and Murray cod
  - Do instream barriers with and without fishways impede bi-directional migration?
  - When a fish does cross a barrier, what is the discharge?
  - Does this correlate with drown-out thresholds?
- Weir Drown-out
  - Repeat Keller method validation with 2-4 m high weirs.

Murray cod (*Maccullochella peelii*). Photo: A. Prior.

Summing Up

- We have validated the use of the Keller method with the Rating Table method option for use with low weirs.
- Drown-out thresholds vary with preceding and downstream flow conditions and flows that alter channel morphology
- Opportunities for movement do not guarantee fish will move, more work is required.

Questions