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Developing a new environmental flow rule for Warragamba Dam: application of flow, ecological and economic modelling in the *2017 Metropolitan Water Plan*

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- The Hawkesbury-Nepean River supplies more than 85% of Sydney's water
- Warragamba is the largest dam on the river system, holds the equivalent of four "Syd Harbs" (2,031 GL)
- Environmental flows commenced from the Upper Nepean dams in 2008 - 2010
- Response to aquatic plant outbreaks, poor water quality, toxic algal blooms
- Currently, 22ML/d (winter) or 30ML/d (summer) released into the Warragamba River (for potable supply and dilution flows)

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E-flows in the Hawkesbury-Nepean

- Variable e-flows are released, based on inflows to the dams
- Rather than targeting an iconic species, the e-flows reintroduce variability
- All aspects of the riverine environment are predicted to improve with new e-flows from Warragamba Dam:
  - Return flows to a more natural regime
  - Improve water quality through dilution, destratification of pools
  - Reduce floating aquatic weed infestations (improves amenity and boating)
  - Increase the frequency of fish migration opportunities

E-flows in the Hawkesbury-Nepean

E-flow regimes for major dams and weirs (other than Warragamba Dam) were developed by the Hawkesbury-Nepean River Management Forum in 2004, and commenced in 2008 – 2010 (Nepean, Avon, Cataract and Cordeaux dams)

- E-flows are variable, with a transparent / translucent rule of "80 / 20"

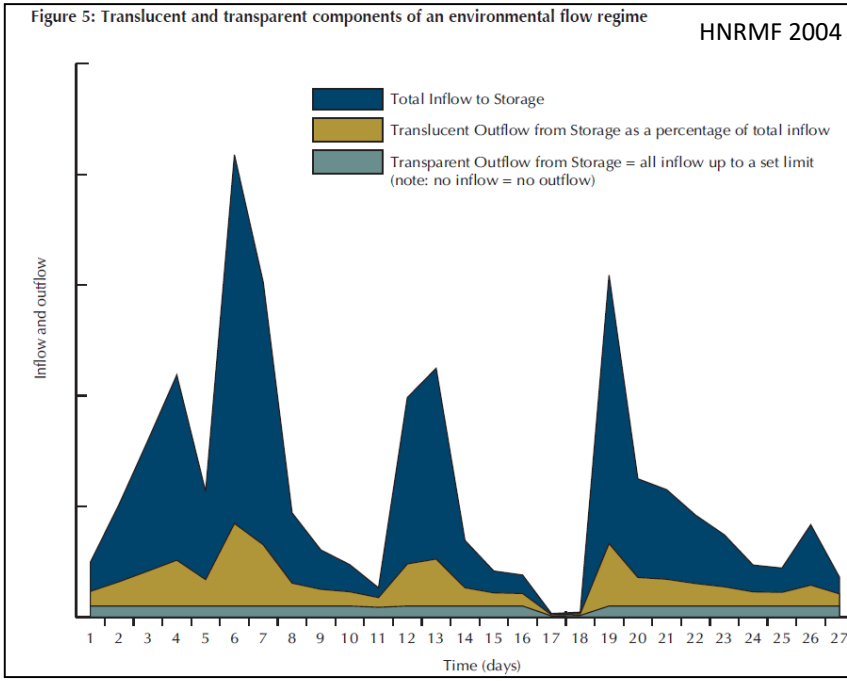
Transparent

- All inflows up to the 80th percentile (low flow) are released as though the dam isn't there. e.g. for Nepean Dam, the 80th %ile = 28 ML/d
- Ensures protection of low flows

Translucent

- A proportion of the inflows above the 80th %ile are released, e.g. 20%
- Provides flow variability downstream and allows water to be retained within the storage

So if Nepean Dam has an inflow of 100ML, then
28 + (72 x 0.2) = 43ML is released



For the Warragamba e-flow assessment

Staged modelling approach taken:

- Dam releases, based on inflows to the dams, water supply, evaporation – Wathnet (WaterNSW)
- River flows downstream, including other e-flows, tributary flows, extraction – IQQM (DPI Water)

- Water quality – dilution model
- Changes in floating weeds – Eco Modeller
- Changes in fish migration opportunities – Eco Modeller | Reinfelds

- MetroNet used for economic modelling of options | Fane

For Warragamba Dam, we modelled:

- 95/20 (rule proposed by the H-N Forum)
- 80/20 (other dams in the Sydney drinking water catchment)
- 90/10 (between the two)

All "used too much water", i.e. were too expensive in the cost benefit analysis

Alternative scenarios looked at reducing releases based on the storage level, i.e. scaling the e-flow to the available water supply. Saved water, without greatly decreasing benefits (90/5, 95/5, 90/10 half, 90/10 scaled)

Chose the <u>90/10 scaled</u> option
(90th %ile transparency (70ML) + 10% translucency) x total dam storage %

So, at 80% of total storage, with 200ML inflow ….
release = (70 + ((200 – 70) * 0.1)) * 0.8 = **66ML released, retain 134ML**

[Without scaling, 83ML would be released - save 17ML]

Assessing the benefits of Warragamba e-flows

- Needed a method to assess the $ value of the environmental benefits
- Looked at what people were willing to pay for – the Attributes:
  - Improvements in length of river suitable for swimming
  - River length free of invasive floating aquatic plants
  - Improvements in fish abundance, as measured by the average time to catch a fish
- Attributes needed to be:
  - Independent – i.e. no overlap of parameters
  - Able to have a cost associated with them

- Choice modelling, travel cost surveys, community workshops and community sentiment monitor surveys were all used to objectively determine the dollar value people place on river health

Assessment of benefits

Using information / data and modelled flows, we compared the Base Case (current situation) flows, water quality and ecological data with predicted improvements under various e-flow regimes.

For the water quality, we used available data at Penrith and Yarramundi (21km and 40km downstream of Warragamba Dam respectively)

- 3-4 weekly data for TSS, enterococci, chlorophyll-a, EC for ~ 10 years
- Flow data (daily, measured)
- For the e-flow options, used modelled releases from the dam and known dam water quality to estimate what the water quality in the river would have been under different e-flow options
- Estimated time that the sites would have been compliant with the relevant wq guidelines for swimming

- **Water quality**

Length of river swimmable, based on the dilution model

	Penrith		Yarramundi	
	% time compliant	Km swimmable	% time compliant	Km swimmable
Base Case	40	11.7	29	5.0
90/5	49	14.4	41	7.0
90/10 scaled	48	14.1	41	7.0
95/5	48	14.1	38	6.4

- **Time to catch a fish**
- **Floating weeds**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Benefits

- Benefits of e-flows were determined by:
  - River length suitable for swimming
  - Time to catch a bass
  - River length free of floating weeds

Costs

- Costs of e-flows were determined by:
  - Infrastructure
  - Reduction in water supply yield
  - Increased time in water restrictions
  - Increased likelihood of a new drought supply
  - Bringing forward the need for supply augmentation
  - Increased frequency of and longer run times of the Sydney Desal Plant
  - Increased frequency and duration of Shoalhaven transfers
- Future demand was uncertain – chose a range of demand forecasts including low, business as usual and high demand

Economic modelling

- **The 90/10 scaled e-flow option has a BCR of 4.0**
- At a 7% discount rate, the BCR is strongly positive
- At an increased demand, the BCR remains above 2, even at +15% increase in water use

Cost / benefit parameter	$m at 7%
Benefits	
Environment & recreation	$447.7
Hydroelectricity	$10.2
Greenhouse	$3.2
Flood mitigation	$6.8
Total benefits	**$467.9**
Costs	
Dam modifications	$52.5
E-flow operating	$1.4
Hydroelectricity	$12.5
Water yield loss	$50.8
Total costs	**$117.1**
Net present value	**$351**
BCR	**4.0**

It was noted during an independent assessment of the approach that the environmental benefits were likely to be understated (some non-use benefits may not have been monetised) and the yield costs of e-flows may have been overstated

It is estimated that the introduction of Warragamba e-flows will cost Sydney Water customers around **$5.38 per year** per household

Releasing a scaled, variable e-flow

FIGURE 9A: High dam storage levels, high rainfall – high environmental flow release

FIGURE 9B: High dam storage levels, low rainfall – moderate environmental flow release

FIGURE 9C: Low dam storage levels, high rainfall – moderate environmental flow release

FIGURE 9D: Low dam storage levels, low rainfall – low environmental flow release

From the *2017 Metropolitan Water Plan*