Dammed if we do, dammed if we do nothing

Dr Jamie Pittock, Program Leader
Australia & United States' Climate, Energy & Water Project
US Studies Centre & ANU Water Initiative
jamie.pittock@anu.edu.au

Presentation to the Society for Sustainability and Environmental Engineering, Brisbane, 23rd August 2011

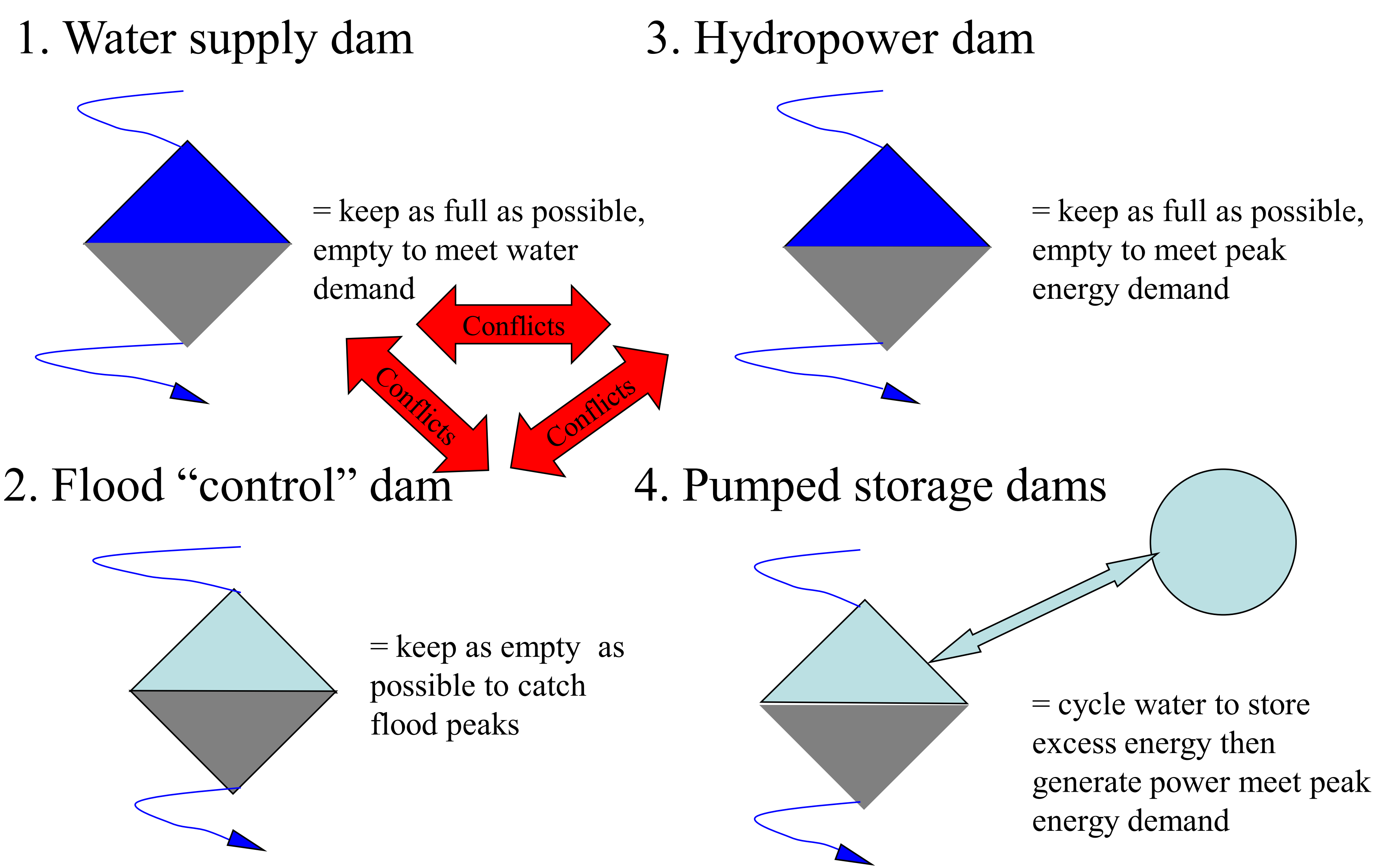
Queensland and Victorian floods in 2011

Leader of the Opposition, 7th January 2011: *"I think it's time that as a nation we put new dams back on our agenda and I think that the Queensland flood disaster makes this very timely indeed because dams can be flood mitigation devices as well as water storages. They can be a potential source of zero emissions power as well as water storages. They can be a source of environmental flows in dry times as well as just water shortages."*

Does this help society, sustainability or the engineering profession?

THE AUSTRALIAN NATIONAL UNIVERSITY

Dams and floods: inevitable trade offs



THE AUSTRALIAN NATIONAL UNIVERSITY

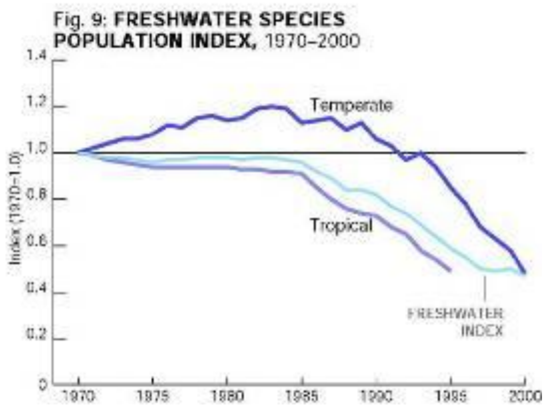
Trade offs

- **$21 billion spent on desalination plants in S & SE Australia in a decade**
- **$6.9 billion SEQ Water Grid**
- **SEQ Water Strategy 2010:** "Climate change may have a significant impact on the supply from our dams. The majority of climate modelling done to date indicates that SEQ is likely to become hotter and drier, with reduced inflows to dams and increased demand for water" (pg 4).
- "It is expected that [four new] desalination facilities will underpin our future water security, based on existing information and technology" (pg 6).
- "Raised operating levels in Wivenhoe Dam" (pg 6).

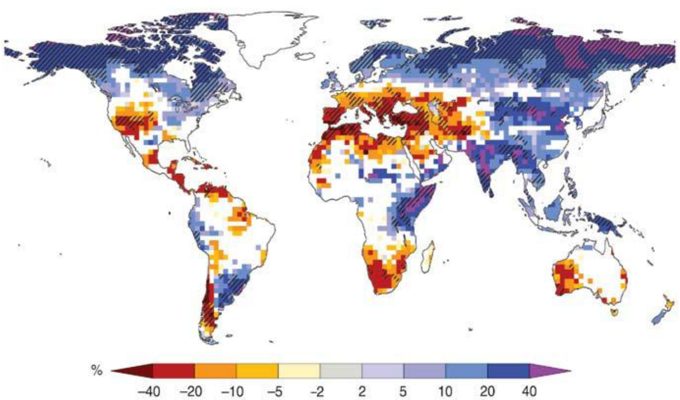
Source: 2011 http://www.watergrid.com.au/u/lib/Water_Grid_Map.pdf

Climate – water – biodiversity links

Source: WWF



Source: IPCC



Photos: (c) J Pittock

Climate change and water

Direct impacts:

- More or less precipitation
- More frequent floods and droughts
- Less snow and ice > greater seasonal fluctuations
- Greater evapotranspiration
- Reduced water quality
- More erosion
- Impacts on flora and fauna (eg. less fish)
- Sea water intrusion

Indirect impacts:

- More thirsty energy technologies (eg. hydro, biofuels, thermal electric, carbon capture)
- More water use in biological sequestration
- More water use in agriculture
- More water storage and transfer

Murray-Darling: climate variability and change

CSIRO scenario	Average surface water availability in 2030	End of system flows in 2030
2006 “Risks to shared water resources:	-10 to -23%	n/a
2008 extreme wet	+7%	+20%
2008 media	-12%	-37%
2008 extreme dry	-24%	-69%
(Actual, early 2010)	(inflows -63%)	(no outflows)

Soft or hard path solutions?

“Natural” floodplain

“Developed” floodplain

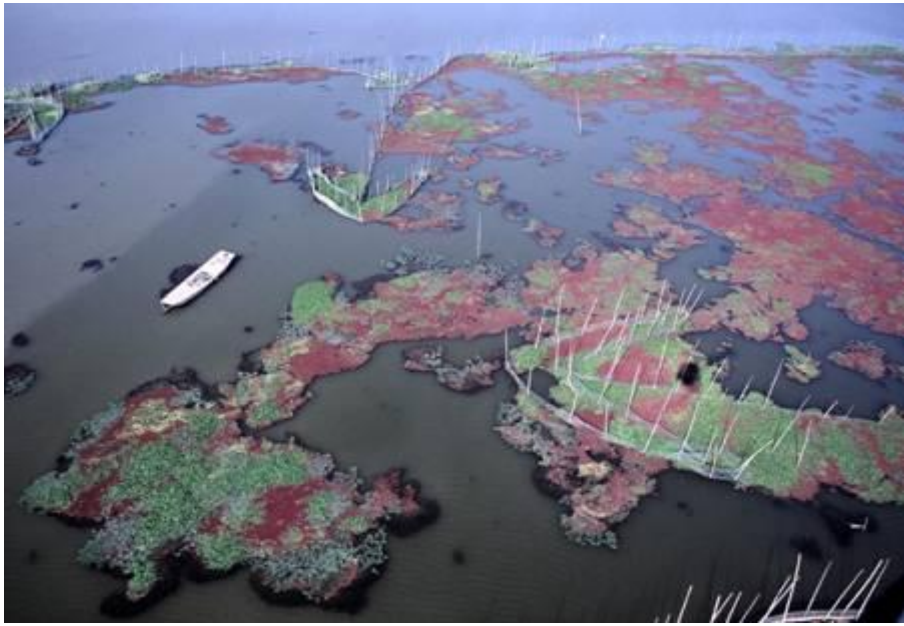
Xipanshanzhou polder, Dongting Lake, China
(c) WWF / J Pittock

ANU
THE AUSTRALIAN NATIONAL UNIVERSITY

Lakes in the central Yangtze River basin

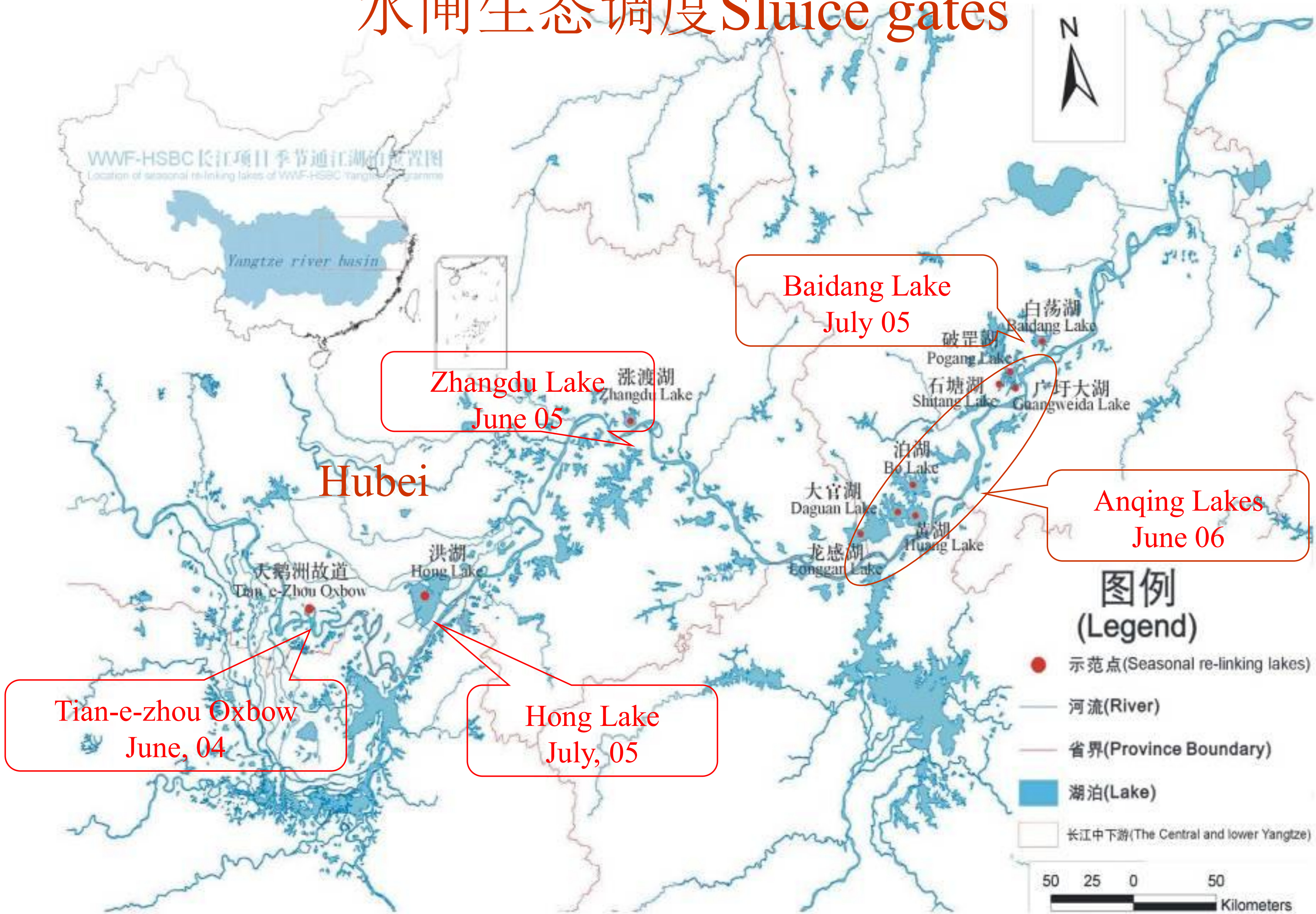
Photos x 3 © WWF China PO

- ➢Loss of lakes – big floods
- ➢Reconnection of 448 km2
- ➢Retention of 285 Mm3 water
- ➢Fisheries + 15%
- ➢Diversified livelihoods
- ➢Environmental benefits



Map © WWF international Photo © WWF / Yifei Zhang

水闸生态调度Sluice gates



Map © WWF China PO

Central Yangtze River lakes

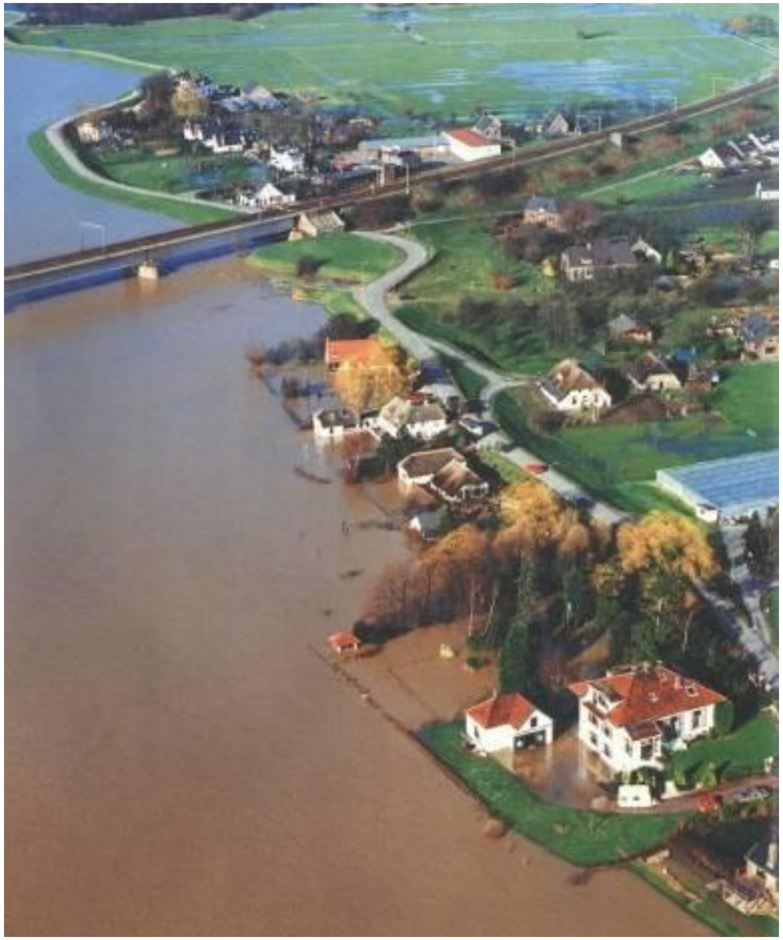
Photos x 5 © WWF China PO

Nijmegen, The Netherlands

Gerlderse Poort floodplain restored to a 2,500 ha nature reserve

Safe flood discharge at Arnhem and Nijmegen up from 15,000 m3/s in 2006, to 16,000 m3/s in 2015, and 16,500 m3/s in 2100

Peak flow reduced by 9 cm



Photos: City of Nijmegen

Before and after

Flood bypass channel under construction in Nijmegen

Photos: City of Nijmegen

Consequences for engineers: more work, more rewarding work, interventions with more benefits for society

What other engineering interventions can add such value?

Reoperating existing infrastructure

Safety:

- USA – 4,000 deficient dams, inc. 1,819 high hazard potential (ASCE 2009)
- China – 37,000 in a dangerous state, inc. 6,240 major at-risk (MWR 2008)

Climate change:

- Return intervals of floods increasing
- Changes in hydrology make designed use redundant
- Demand for better performance

Systematic triggers for reviews of infrastructure

- **Safety reviews**
- **Utility asset management systems,** eg. Hydropower Sustainability Assessment Protocol
- **Systems for optimization**
  - eg. Brazilian hydropower
  - 67 plants 20+ years old, potential 12.4+ GW
  - Dourados hydropower plant +60% capacity in 1997
- **Periodic re-licensing**
  - eg. US Federal Energy Regulatory Commission hydropower re-licensing
  - 500 dams removed since 1998

Dams are not forever …

We finally concluded that the best result was to remove the dam, given the fact that the license was coming up to be renewed, and there was very little electricity being generated, that it really made more sense to do it the right way and to just remove the dam. That's why we don't have indefinite licenses to run dams, so that we can take that second look at various times in our history and see whether or not the dam continues to serve the purpose it was originally granted the license for.

Former Governor of Maine, John McKernan Jr. on the removal of Edwards Dam on the Kennebec River (American Rivers 2007).

The Nature Conservancy

SAVING THE LAST GREAT PLACES ON EARTH

Penobscot River Project

Energy

Medway Dam

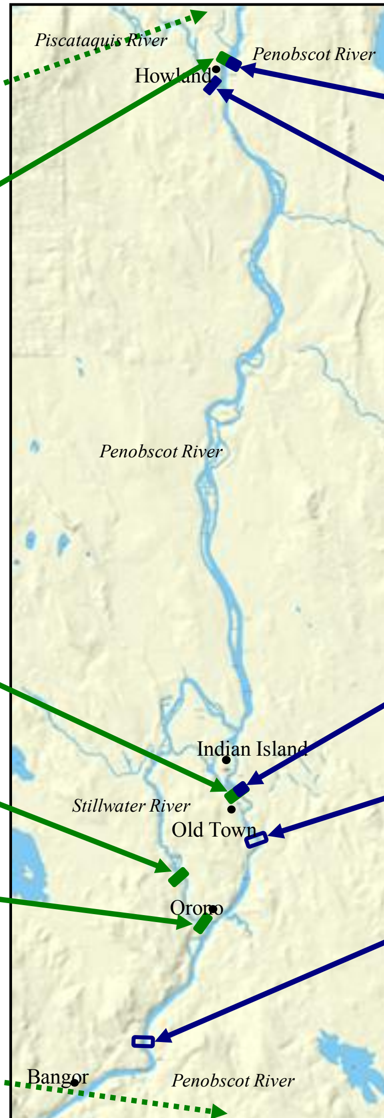
West Enfield Dam

Milford Dam

Stillwater Dam

Orono Dam

Ellsworth Dam
(Union River)



Fisheries

West Enfield Dam
Existing Fish Passage

Howland Dam
Decommission /
Innovative Fish Bypass

Milford Dam
New Upstream
Fish Passage

Great Works Dam
Decommission /
Removal

Veazie Dam
Decommission /
Removal

Dam Removal

Energy Increase

Fish Passage

Fish Passage &
Energy Increase

0 2 4
mi

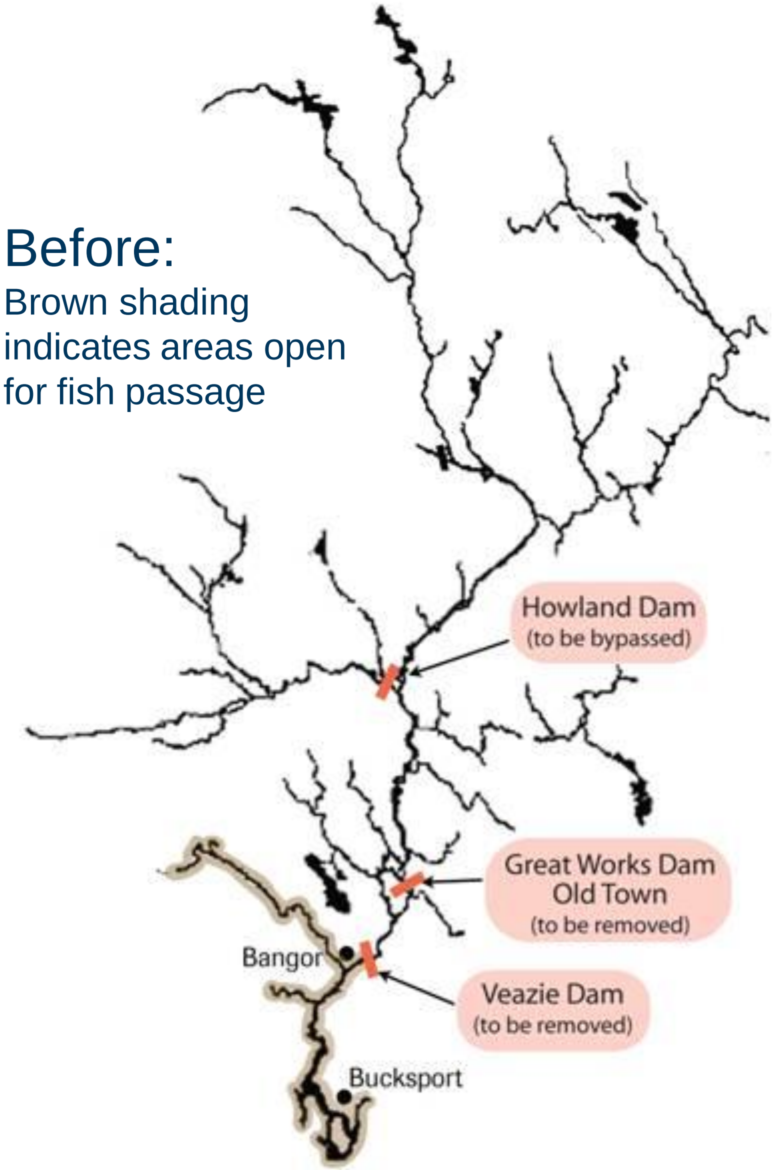
The Nature Conservancy

SAVING THE LAST GREAT PLACES ON EARTH

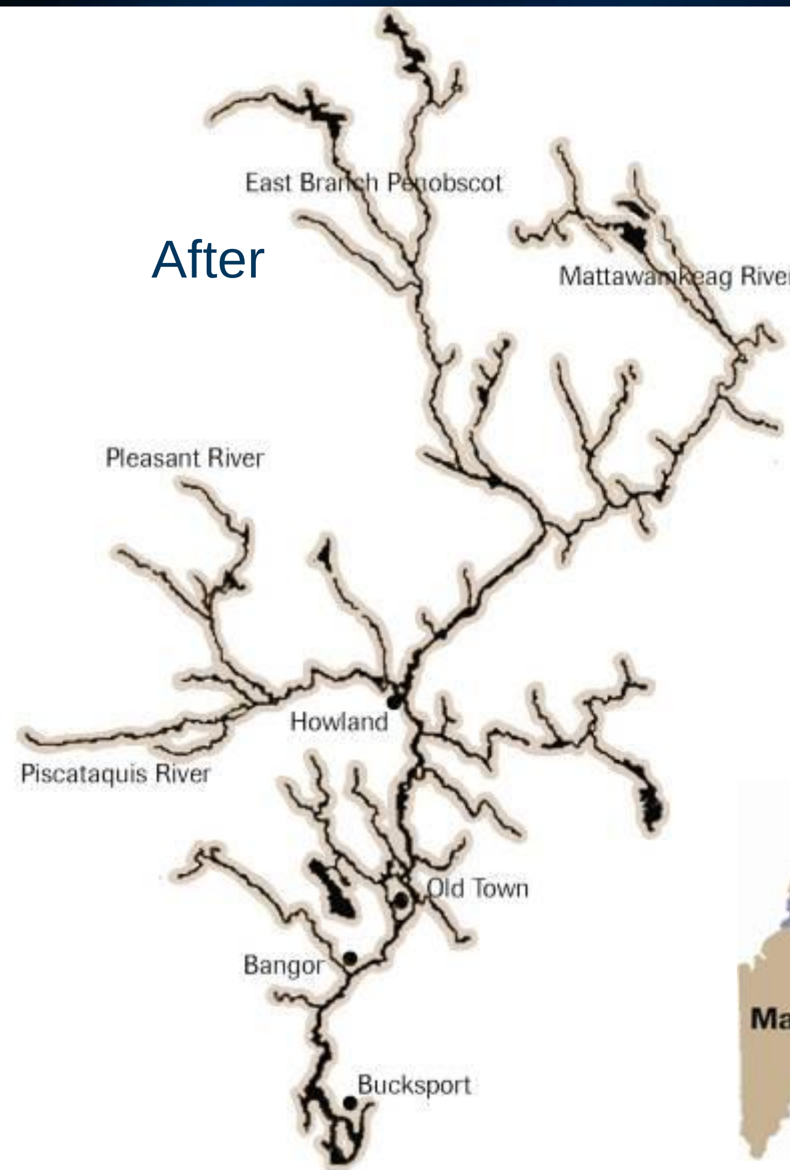
Penobscot River Project

Before:

Brown shading indicates areas open for fish passage

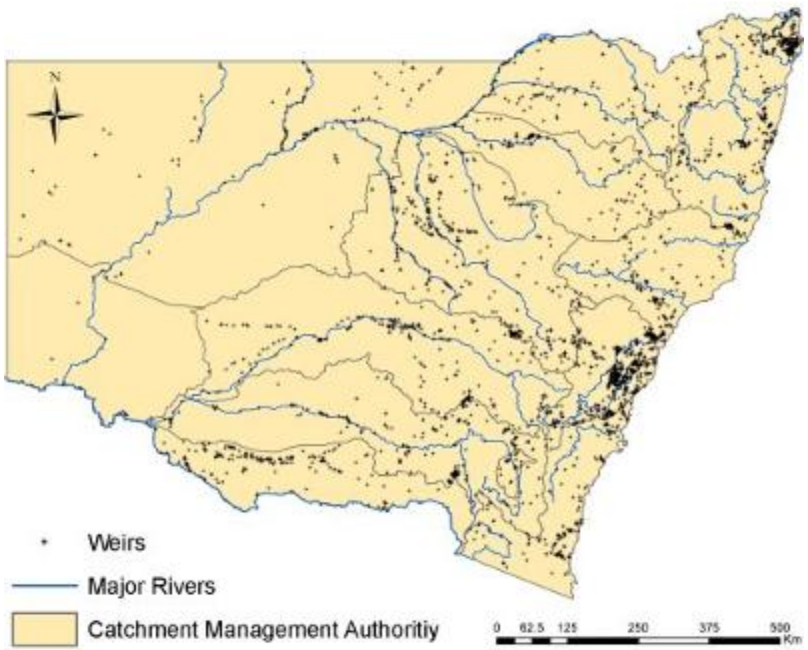


After



Bassin de la Loire
carte interactive
Loire River Basin
mouse over map
Mayenne
Sarthe
Loir
Orléans
Nantes
Tours
Blois
Barrage mobil de Blois 2005
Loire
Sèvre Nantaise
Indre
Cher
Nevers
Maison rouge 1998
Poitiers
Le Veurdre
Garlempe
Creuse
Clain
Vienne
Limoges
Chambonchard
Allier
Roanne
Villerest
Grangent
Poutès
Le Puy
Brives
Charensac
St Etienne de Vigan 1998
Naussac
La Palisse
Serre de la Fare
Centrales EDF
Barrages demantelés
Grands barrages
projets de grands barrages annullés
copyright ERN - SOS Loire Vivante

What about Australia?



Weirs in NSW: 4,000 weirs within the Murray Darling Basin alone.

Source: NSW Dept Primary Industries

- **45,000 large dams globally (WCD 2000)**
- **79,000 +7.6 m in USA (USACE 2009)**
- **87,000 in China (MWR 2008)**
- **Thousands more on the way …**

THE AUSTRALIAN NATIONAL UNIVERSITY

Better dam management

There are better technologies:

- Wildlife passage
- Thermal pollution mitigation
- Water release structures
- Fish-friendly & aerating turbines
- Re-regulating dams
- Sediment flushing

Photos © J Pittock, 2008

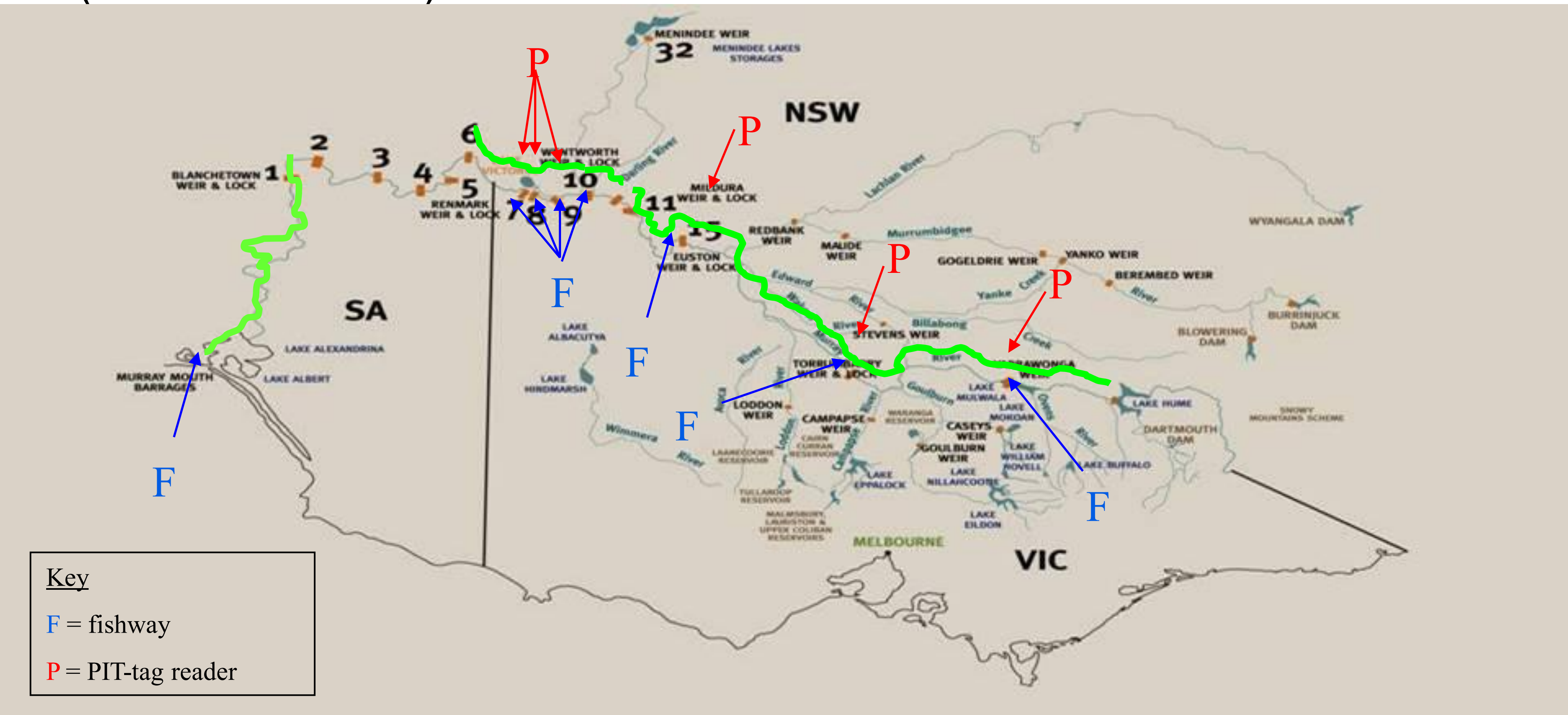
NSW weir review (2001)

Weirs	Number	%
Licensed	3,328	
Inspected by 2001, and recommended:	822	100
- Removal	81	10
- Add fish ways	130	16
- Better management	59	7
- Non-existent	149	18
- No action required	403	49

Source: NSW Department of Primary Industries

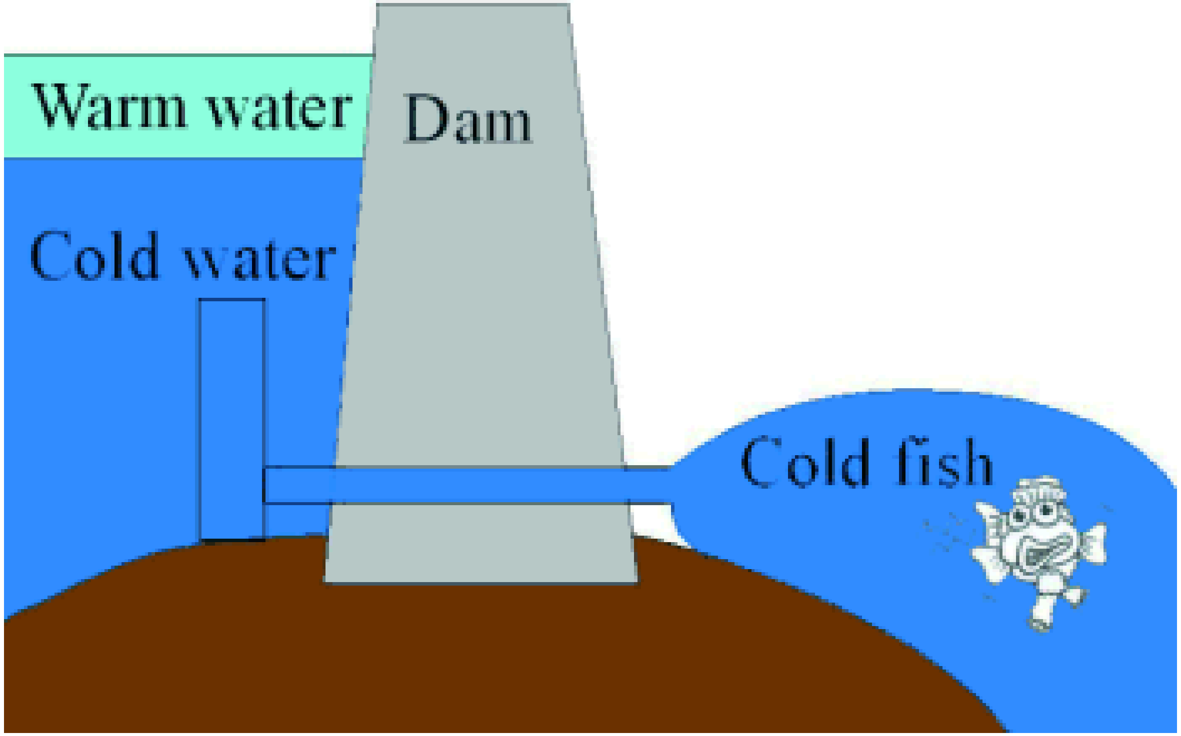
Sea to Hume Dam fish passage program

- AUD $45 million fish way construction and monitoring program
- Reinstate 2,200 km of fish passage
- (Source: MDBC)



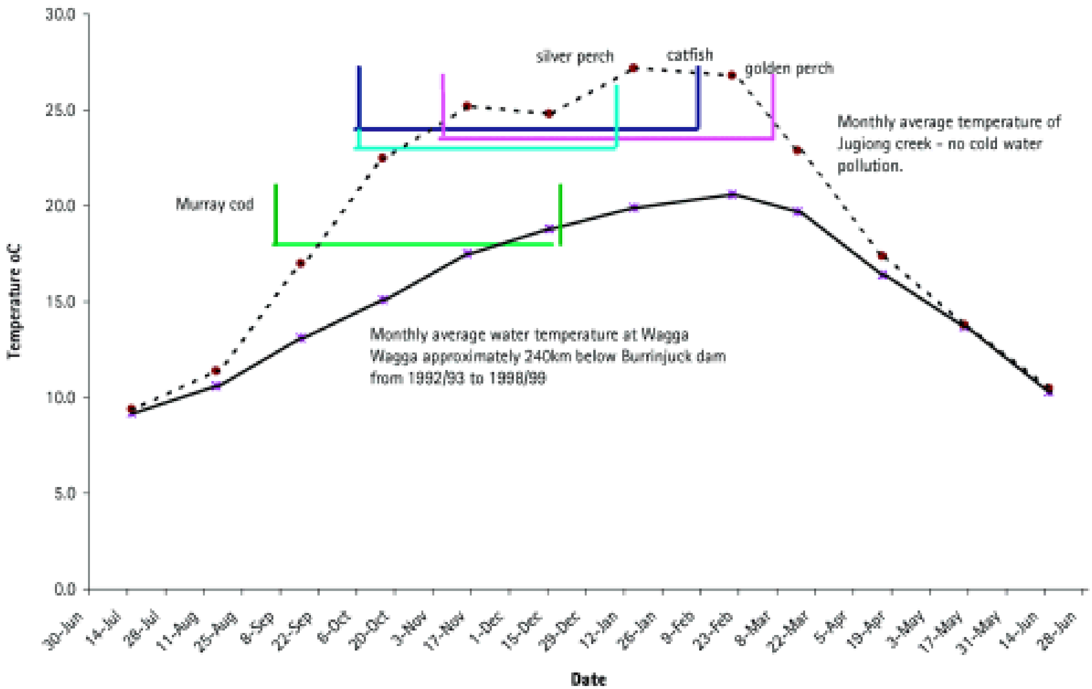
Thermal pollution from dams

- Water too cold or too hot for aquatic wildlife (fish)
- Can impact ~ 300 km downstream
- Engineering fixes at a price
- Current problem
- Future solution?



Example: native fish on the Murrumbidgee

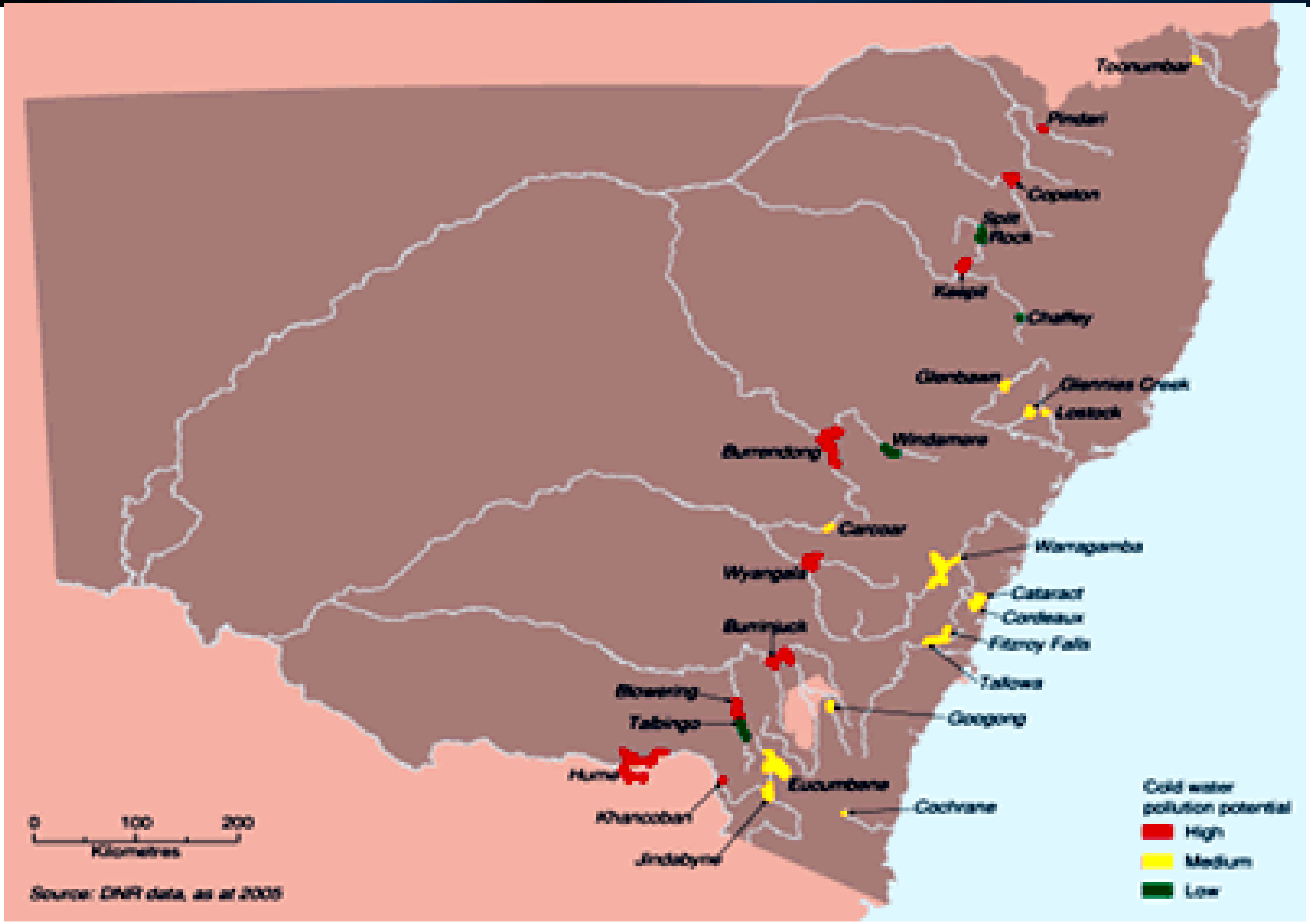
Murray cod © S Behera



Water temperature and native fish breeding Burrinjuck Dam, NSW.

Source: NSW Fisheries

Thermal pollution, NSW dams



Ideal periodic relicensing

1. A regulator
2. An owner
3. Periodic licencing
4. Safety managed
5. Relicensing based on four factors:
   - Safety
   - Social
   - Environmental
   - Economic
6. Public participation
7. Public interest
8. Upgrading triggers re-licensing
9. Transitional measures
10. User-pays
11. Abandoned & unsafe structures
12. Best technology
13. Minimize corruption

Further engineering contributions?

THE AUSTRALIAN NATIONAL UNIVERSITY

Energy storage:

- Renewable energy production from wind and solar can be intermittent
- Power grids can become unstable when generation ~ >15%
- Energy storage and peaking capacity is required

Lake George wind farm
(c) J Pittock

One solution

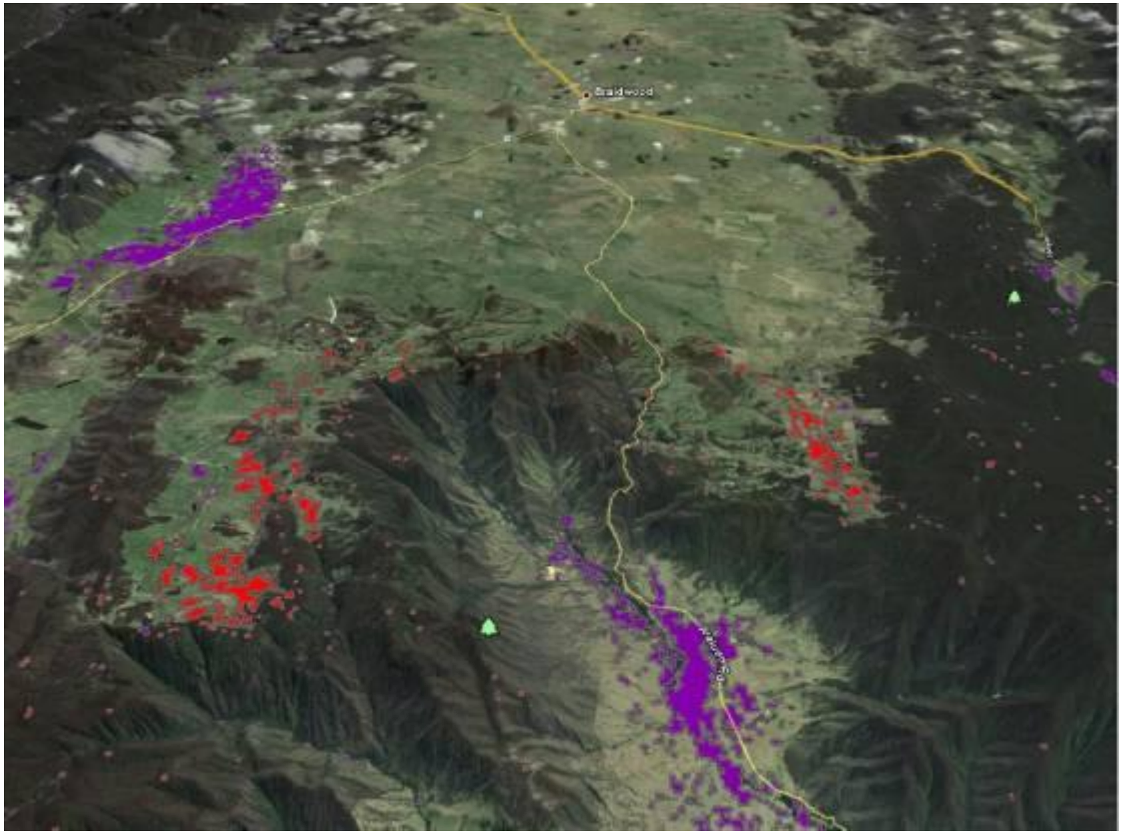
- Pumped storage uses excess electricity to pump water from a lower to an upper reservoir
- Hydropower produced to meet demand
- Around 80% efficiency
- Other technologies lack scale, are expensive or less developed

Tumut 3 1500 MW pumped hydro storage system in the Snowy Mountains © A Blakers

Widely deployed now

- Globally over 200 power stations with 130 GW capacity
- In Australia, 3 large stations of 2.5 GW capacity
- Global capacity ranges from 1 MW to 2,700 MW capacity per station with a median of 420 MW
- Requires two reservoirs separated by a >1:10 gradient and an altitudinal difference of 100-1,000 m
- Requires water
- Storing 24 hrs of Australia's electrical output would require storages covering 100 km^2 x 15 m depth

Araluen valley, NSW



Potential pumped hydro sites in the Araluen Valley near Canberra.

Indicative only. Source: Blakers, Pittock, Talent and Markham (2010)

Pros and cons

Drawbacks

- Could damage river ecosystems
- Location in areas of high altitudinal relief > culturally and environmentally important places
- Consumes water
- Limited by distance from high voltage power lines

Potential benefits

- Facilitate greater use of renewable energy
- More flexible than traditional hydropower: can be sited off rivers
- Could pay for renovations to old dams to reduce impacts
- In closed loops, could use low quality saline or waste water

Conclusion for engineers

1. Flood control structures involve trade offs with other services, such as water supply and the environment
2. The era of traditional dam construction projects is at an end – public opposition and the EPBC Act make major new projects unlikely
3. There are new opportunities for engineers to lead by applying their knowledge to generate solutions
4. Examples include:
   - "Soft path" flood control structures
   - Reoperating old water infrastructure
   - Re-engineering dams for pumped storage
5. Projects for sustainability need engineers

More information:

- Pittock, J., *Lessons for climate change adaptation from better management of rivers. Climate and Development, 2009. 1(3): p. 194-211.*
- Pittock, J., *Better management of hydropower in an era of climate change. Water Alternatives, 2010. 3(2): p. 444-452.*
- Pittock, J. and J. Hartmann, *Taking a second look: climate change, periodic re-licensing and better management of old dams. Marine and Freshwater Research, 2011. 62: p. 312-320.*
- Pittock, J. and C.M. Finlayson, *Australia's Murray-Darling Basin: freshwater ecosystem conservation options in an era of climate change. Marine and Freshwater Research, 2011. 62: p. 232–243.*