

Secular Regime Shifts, Global Warming and Sydney's Water Supply

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Sydney's Water Crisis due to:

1. A return to DDR conditions since 1991
2. A population increase of 50,000/year
3. The failure to reduce water usage
4. The failure to recycle water already available
5. and perhaps early impacts of global warming

Aims:

1. To define FDRs and DDRs and indicate impacts of the present DDR
2. To outline present global warming predictions and speculate on their impacts to date
3. To outline some ways of managing the crisis

Map of Sydney's water catchments



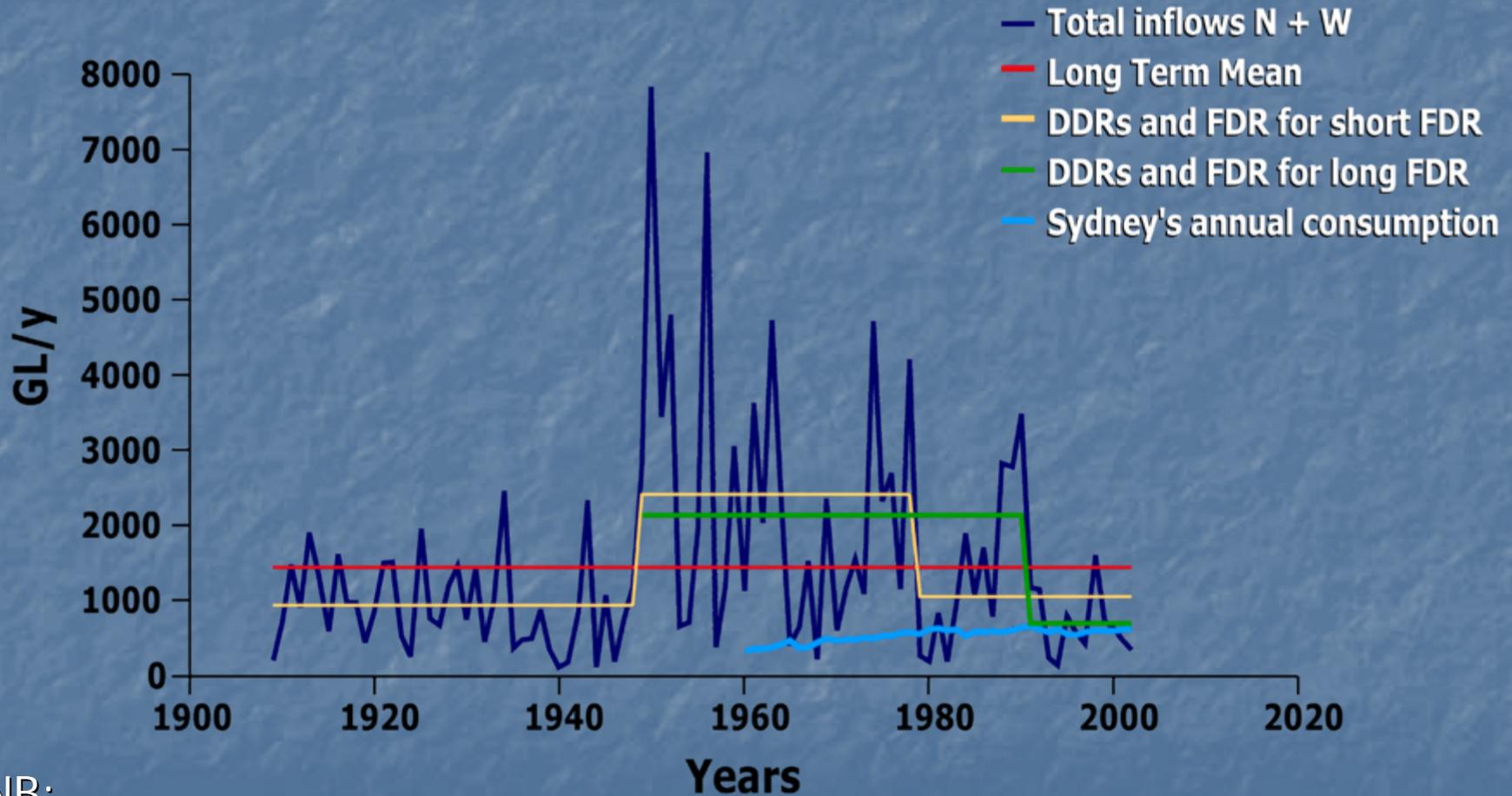
- Flood Dominated Regimes (FDRs) and Drought Dominated Regimes (DDRs) have been known for >30 years.
- Even in 19th Century Josephson was aware of temporal variations at Windsor Bridge (records since 1799)

Flood stages at Windsor Bridge

Period	8–10	10–12	>12m	Regime
1799–1820	0	0	5	5 in 22y FDR
1821–1856	0	0	0	0 in 26y DDR
1857–1900	13	10	5	28 in 44y FDR
1901–1948	3	3	0	6 in 48y FDR
1949–1990	23	6	7	36 in 42y FDR
1991–2006	0	1	0	1 in 16y DDR

- Changed regimes initially used to understand variations in flood magnitudes and frequencies and their impacts on channel changes
- In FDRs floods are bigger and more frequent ($w+$, $d-$)
- In DDRs floods are smaller and less frequent ($w-$, $d+$)
- More recently SCA data on temporal variations on inflows to dams

Total annual inflows, LTM, means for DDRs and FDR and Sydney's consumption

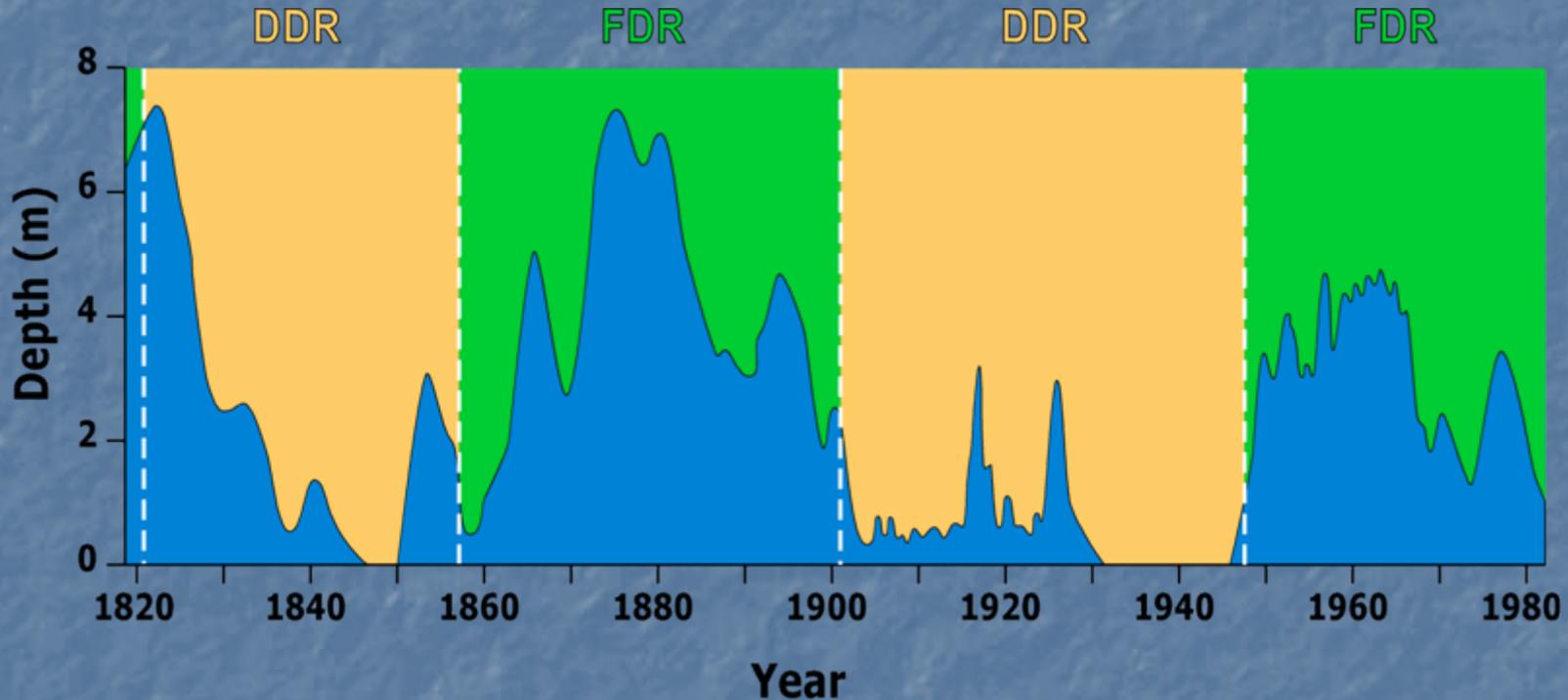


NB:

- 1949 to 1990 >2300 GL/y
- 1991 to 2006 <600GL/y

Support for regime shifts

- Lake George – natural evaporimeter



- Pre-European oxidized sediments in Redhead Lagoon
- Longer-term temporal shifts in Antarctic ice-core studies

Rainfall changes not so great as runoff

- Means of 15 rainfall stations with records from late 19th Century
- Post 1901 DDR reductions -9 to -24% (none with records from 1857)
- Post 1949 FDR increases: +13 to +31%
- Post 1991 DDR reductions: -16 to -35%

Causes unknown

- Some suggested relations to SOI & ENSO but these cycles are much shorter
- Now the term PDO has been introduced to describe longer temporal variations
- Whatever the cause, there have been changes to rainfall of $\pm 30\%$ and more importantly RO is now only 25% of what it was!

Global Warming

- Presents enormous challenges for the future and a need to establish current impacts
 - Temperature will increase; precipitation will vary up or down
 - Evapotranspiration will increase and reduce both rainfall effectiveness and runoff
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- 2030 temps +0.2 to 2.1°C
 - 2070 temps +0.7 to 6.4°C
 - 2030 precipitation +7 to -13%
 - 2070 precipitation +20 to -40%

Precipitation changes by season:

	2030	2070
Summer	-13 to +13%	-40 to +40%
Autumn	-13 to +13%	-40 to +40%
Winter	-13 to +7%	-40 to +20%
Spring	-20 to +7%	-60 to +20%

(CSIRO, 2006)

- Lots of comments but no real data on current impacts
- Bigger decreases in P 1991–2006 than 1901–1948 by 0.4% to 17.4% (but two stations showed positive changes 4.9 and 7.8%)
- Pre 1901 and post 1991 are incomplete periods
- Higher temperatures have probably had some impacts

Sydney's Water:

- Lower runoff means much less in dams
- Water restrictions
- Less water for irrigation and environmental flows
- Annual population increase of 50,000 could mean an extra need of 7.3GL/y (at present rates of about 400L/h/d)

Alternatives Water Resources

- Rainwater harvesting (1GL/y on each km² near the coast; losses to storm-water runoff probably 1700GL/y)
- Recycle (most of 600GL/y is only used once)
- Desalination (high costs and high environmental impacts)
- More dams (high costs, very low runoff at present in distant catchments, pumping costs)
- Groundwater (large deep aquifers but very slow recharge rates; they provide river base flows)
- Use less water (400L/h/d is too much; 250L/h/d would save 40%)

Best options for the environment

1. Harvest rainwater (roof water could save the up to 30% used in gardens)
2. Recycle (Sydney refuses to drink recycled water)
3. Use less water (most system modifications have had little impact so far)

Conclusions

- The current drought is part of a DDR (not likely to end soon), plus current impacts of global warming
- Need to know more about the latter (as well as future impacts)
- Use more of the 'on-site' water (rain and once-used water) and less from distant drier catchments
- Lifestyle changes involving using less water will cost future generations less and mean a sustainable future