NEW ZEALAND INSTITUTE FOR THE STUDY
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Save it For a Sunny Day

The Value of Water Storage

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Motivation

- Many previous studies have calculated the value of water
  - e.g 2002 study of value of water in Manawatu-Wanganui region: hydropower $473m, agriculture $145m

- But what about the value of a water right?
  i.e. an individual water user's right (resource consent) to use water over a period of time
  - water is often an input into a production process
  - water rights are tradeable, but may be too few transactions to determine their value

Motivation (cont.)

- Focus on value of a water right for storage
- Why?
  - Storage is a large part of NZs existing water system via hydro-generation
  - Storage has the potential to address water shortages
- Value of a storage right depends on the features of the right
  - will present a conceptual framework for valuing a right
  - will determine what features affect this value

The basic approach

- What is the value of a storage right to (say) a hydro-generator?
- Two-period example: generator has right to use 1m^3 of water to generate electricity in each period, and gets \$P for every m^3 of water used

Value of storage right = NPV = $$P_0 + \frac{E[P_1]}{(1+r)}$$

The basic approach (cont.)

- But what about storage? Gives the generator the ability to wait
- Example: store 1m^3 of water in period 0, and release it in period 1 + generate from the additional 1m^3 of water in period 1

  Value of storage right = NPV = $\dfrac{2E[P_1]}{(1+r)}$

- Generator has options and these options have value

A simple model

- Split storage and generating roles of hydro-generator, focus only on storage
- Storage firm holds a perpetual storage right and has a storage lake of max. capacity $1m^3$
- If firm wants to store water, pay $\$P_t$
  (e.g. compensates downstream users for the lost revenue)
- If firm wants to release water, receives $\$P_t$
  (e.g. downstream users buy the water off the firm)

A simple model (cont.)

- In any time period t, enough water always flows down a river for the lake to be filled (i.e no variability in river flows)
- Firm also incurs some fixed cost c, from storage and release
- The lake is either completely full or completely empty
- If lake is currently empty, the firm has an “option to store”
  If lake is currently full, the firm has an “option to release”

Optimal timing to store or release

- At what price will the firm choose to exercise its options i.e. store water in an empty lake or release water from a full lake?

- Empty lake: if price is high, firm is better off waiting until price drops before storing. Will be some threshold P_S – if price drops below it firm will store

- Full lake: if price is low, firm is better off waiting until price rises before release. Will be some threshold P_R – if price rises above it firm will release

Valuing the storage right

Time period	Price	Lake empty or full?	Payoff
0	P_0	Empty lake	0
T_1	$P_{T_1} < P_S$	Exercises option to store: Full lake	$-P_{T_1}$
T_2	$P_{T_2} > P_R$	Exercises option to release: Empty lake	$P_{T_2} - c$

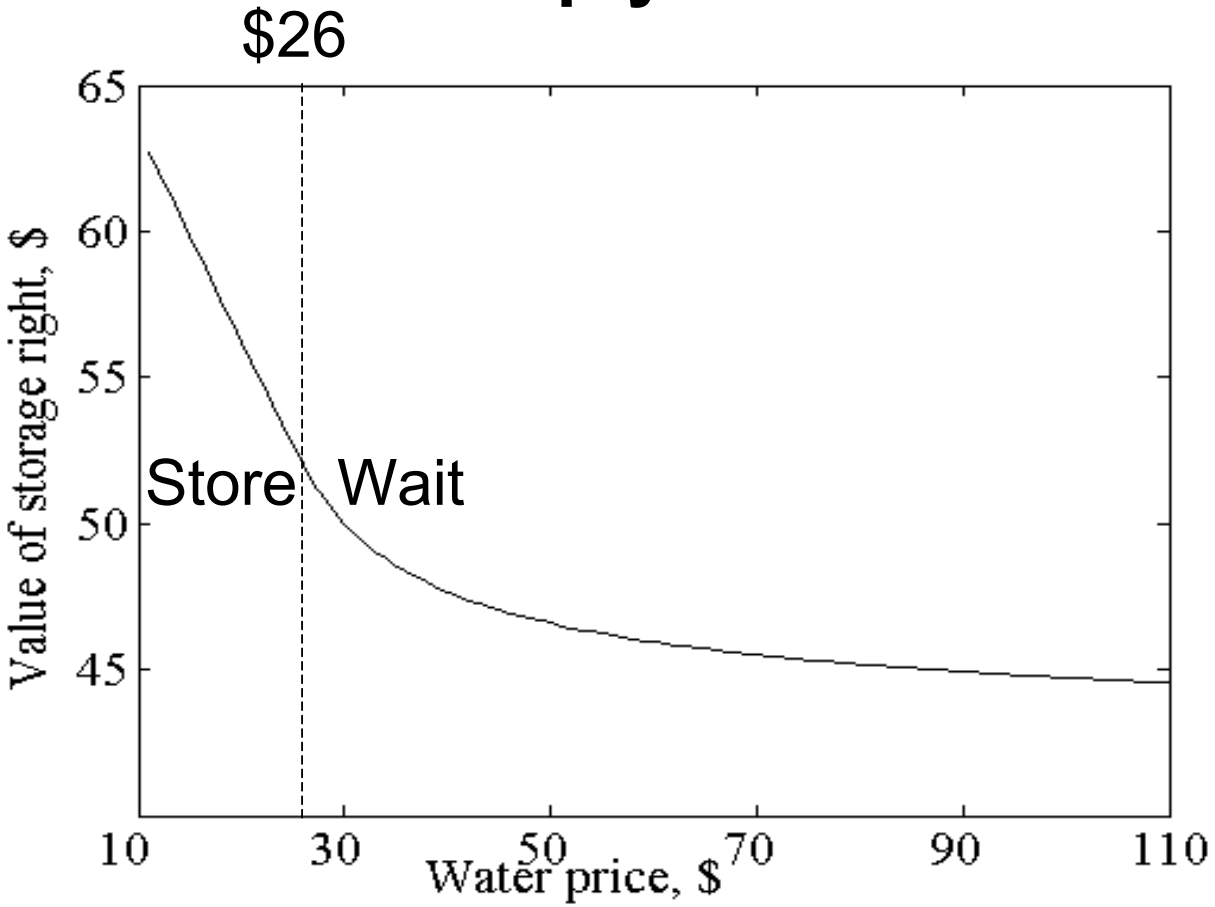
Value of the storage right = discounted sum

Getting results from the model

- Model prices as mean-reverting
- Prices are log-normally distributed with:
  long-run mean = 37
  long-run variance = 0.125
- Half-life: time taken for price to revert to half the distance between current price and mean = 8.3 months

The value of the storage right

Empty lake



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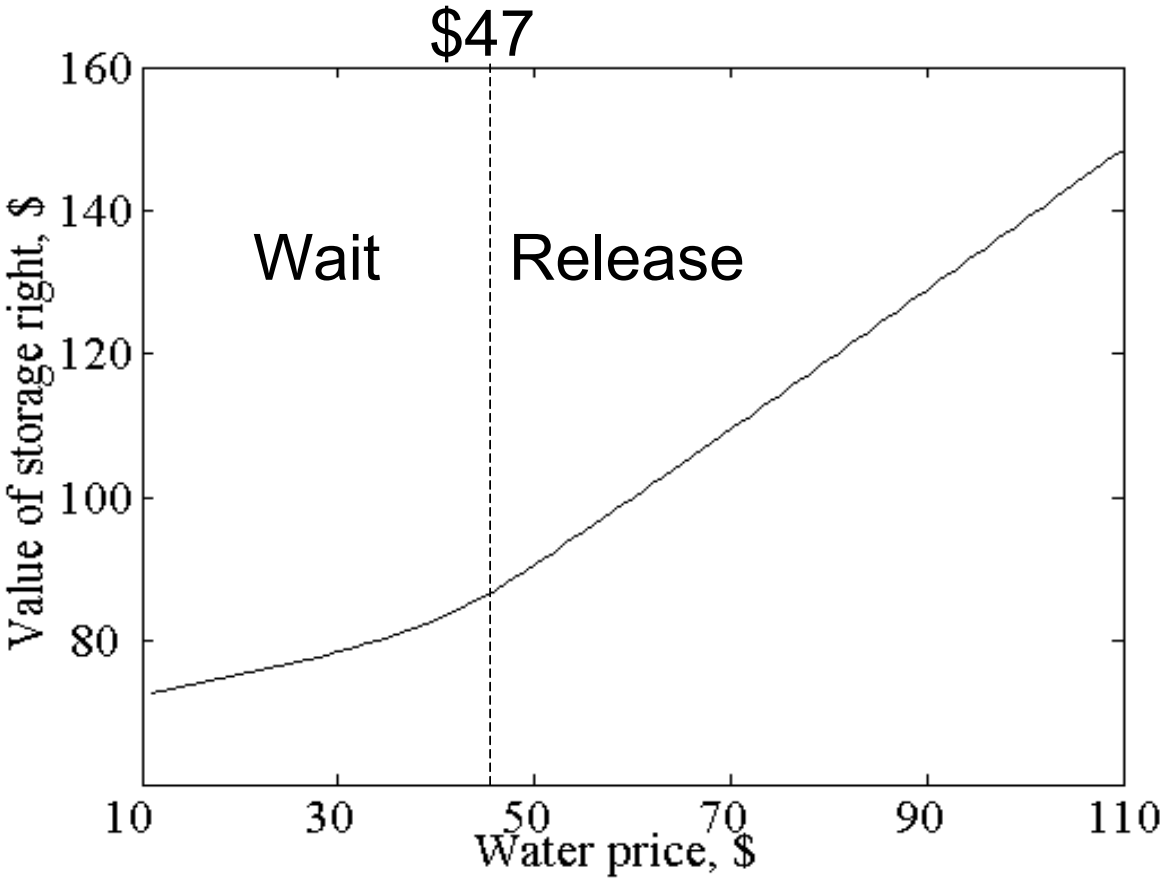
The value of the storage right

Full lake



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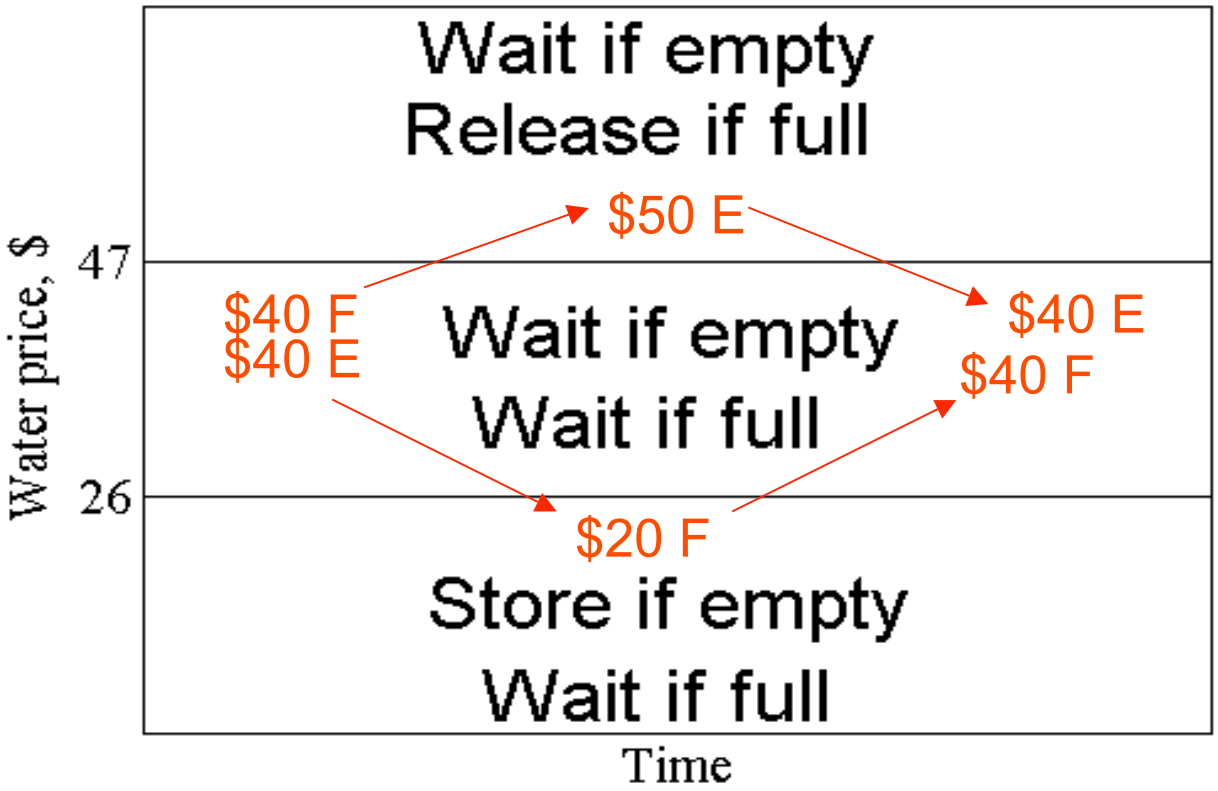
Hysteresis in storage

- Difference in threshold prices results from firm's ability to buy low and sell high
- Difference in threshold prices leads to "economic hysteresis"
- Hysteresis: a temporary cause leaves a permanent effect
- Economic hysteresis: a decision is not reversed even when the underlying cause is reversed

Hysteresis in storage (cont.)



Uncertain river flows

- Regime Switching model - introduce two regimes (or states): wet and dry
- Wet state – flows are high enough to fill the lake if it is empty
- Dry state – flows are too low: lake cannot be filled if it is empty. Firm has to wait till flows switch to the wet state
- Introduce two new parameters:
  λ_w = average rate of switching per year from wet to dry state
  λ_d = average rate of switching per year from dry to wet state

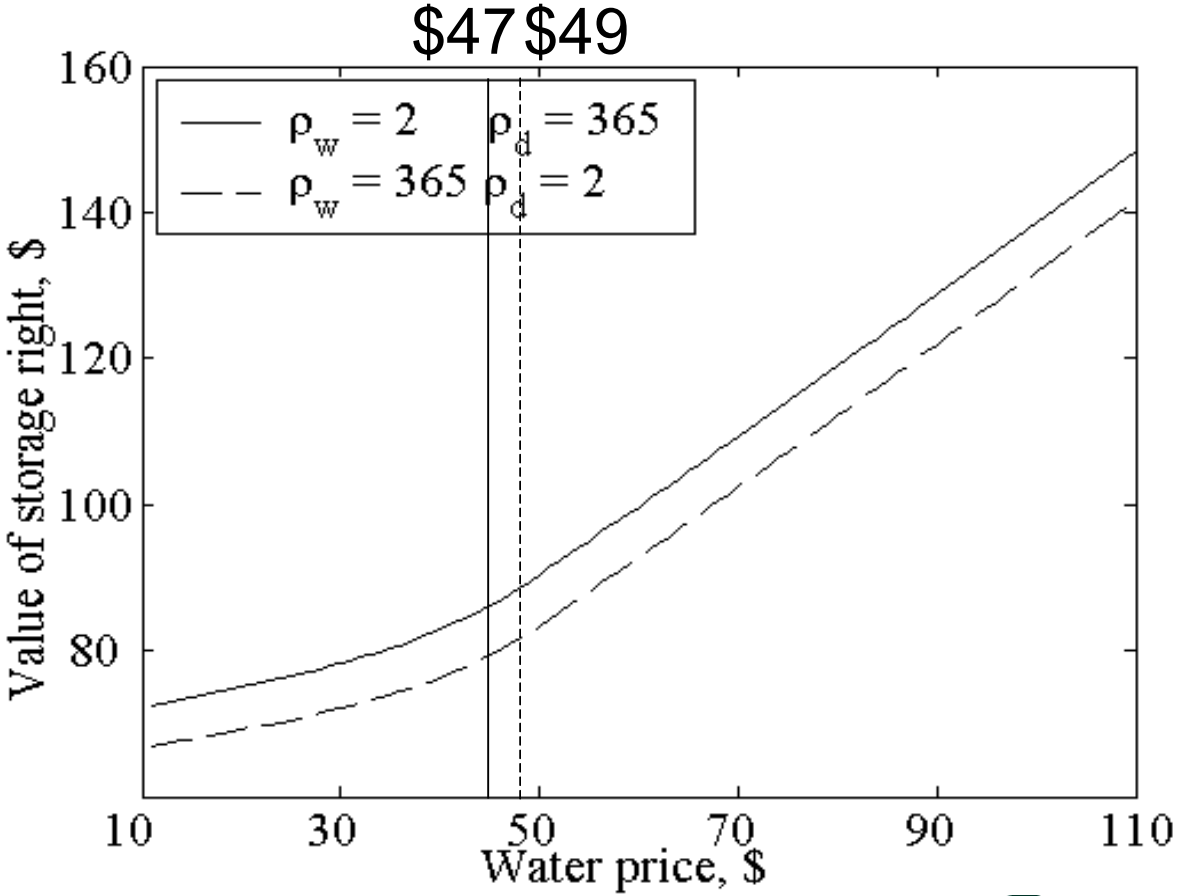
Stochastic inflows (cont.)

Time period	Price	Wet or dry?	Empty or full?	Payoff
0	P_0	Wet	Empty	0
⋮	⋮	⋮	⋮	⋮
T_1	$P_{T_1} < P_S$	~~Dry~~ Wet	~~Empty~~ Full	~~0~~ $-P_{T_1}$
⋮	⋮	⋮	⋮	⋮
T_2	$P_{T_2} > P_R$	Wet / Dry	Empty	P_{T_2}
⋮	⋮	⋮	⋮	⋮

Value of the storage right = discounted sum

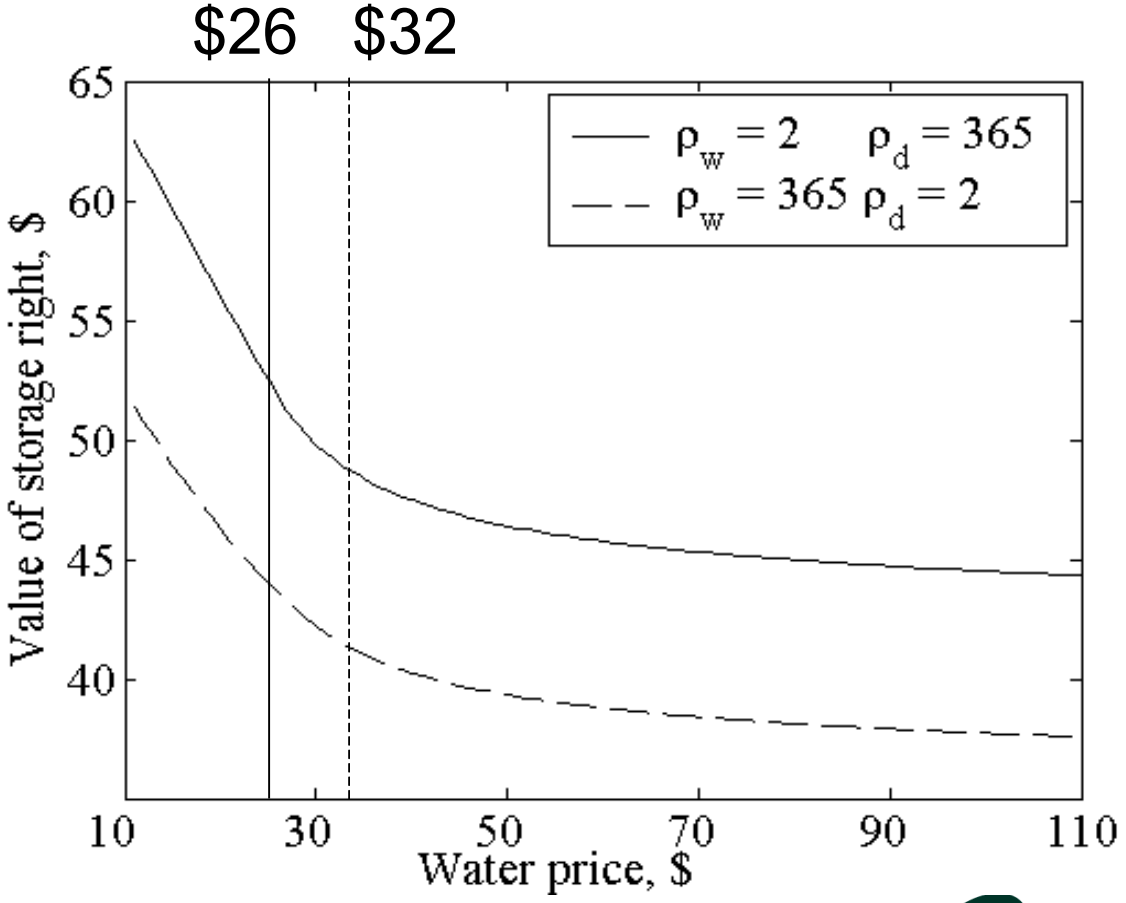
The value of the storage right

Full lake in dry state

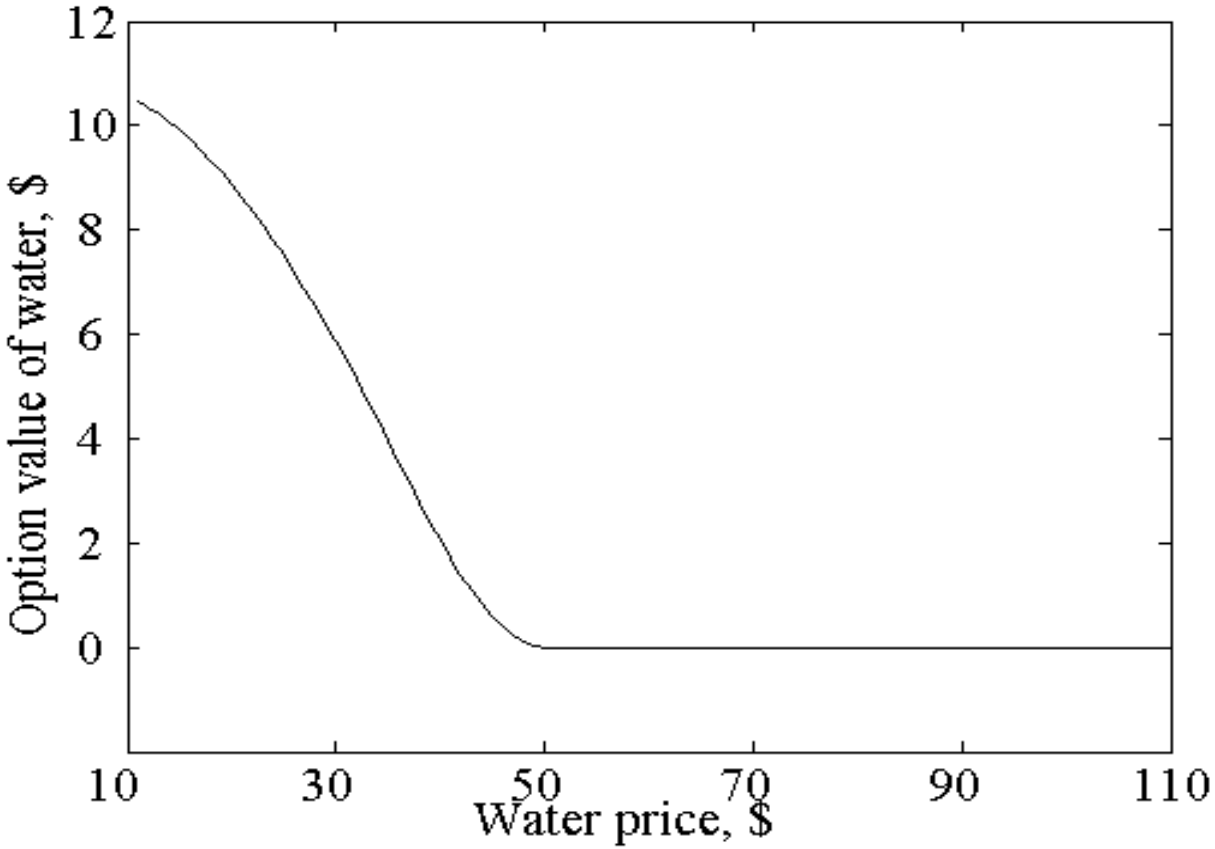


The value of the storage right

Empty lake in dry state



The option value of water?
Full lake - Empty lake



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Implications

- Provides a tool for valuing a water storage right
- Shows that the value of a water storage right depends on:
  - current lake level, current spot price, current river flows
- Determines the optimal timing of storage or release
- Suggests economic hysteresis may be present in water storage
  - may make it difficult to create incentives for particular behaviour in the short-term
- Water itself has option value

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