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Cost analysis of a buy-back program of water rights for Chile

Water Markets Workshop – ANU

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Outline

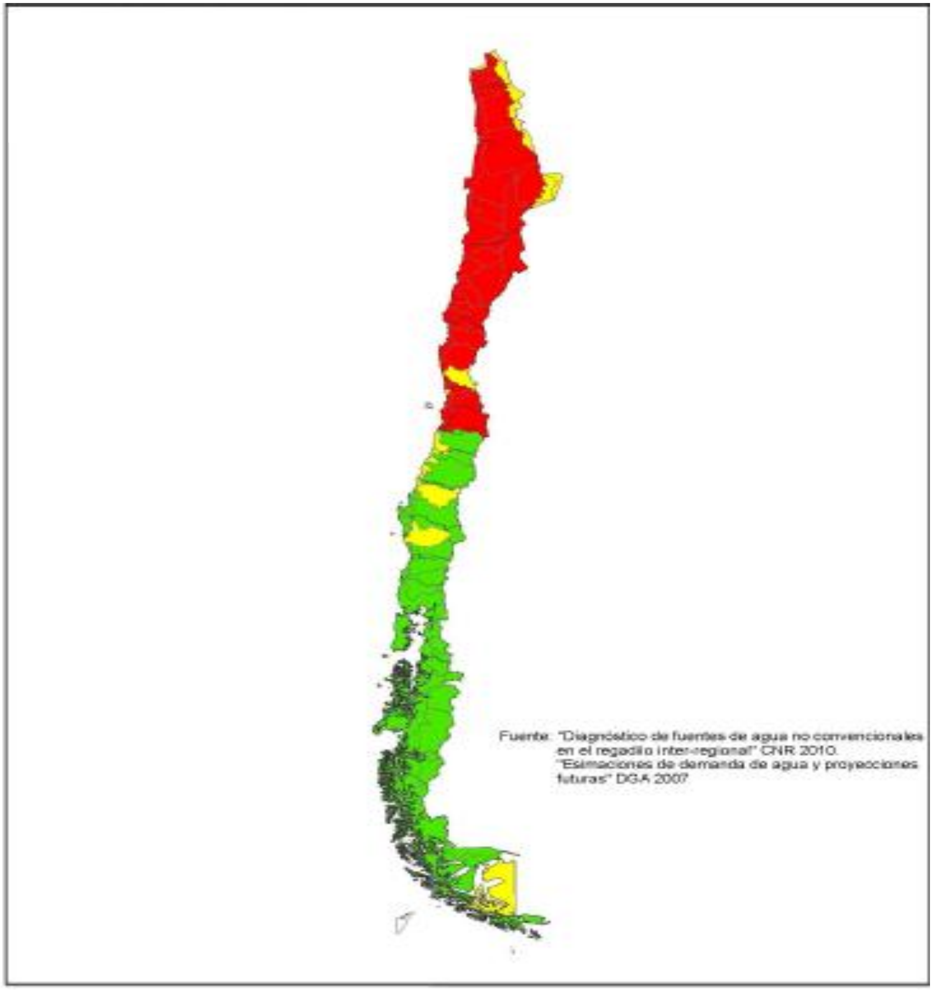
1. Background
2. Purpose and contribution of the study
3. Relevant information for the analysis
4. Methodology
5. Results
6. Conclusions

1. Background – Chilean case I

- Water supply
  - Chile is a privileged country in terms of water resources (average runoff is almost 10 times greater than the world average)
  - BUT distribution is uneven, arid conditions prevail in the northern half of the country (World Bank 2011)
- Water demand
  - Fast growth during the last 30 years (6 % in average)
  - Economic activity relies heavily in natural resources exploitation that demand significant amount of water (forestry, mining, etc.)

→ Rivers present problems associated with EF and water quality, specially in the northern half of the country (State of the Environment Report, 2012)

Hydrological projections for 2020



Deficit

At risk

No problem

- Chile is specially vulnerable to climate change

1. Background – Chilean case II

- Quality
  - Increasingly deteriorating (e.g. excess of nutrients) (MMA 2012)
  - Actual approach: regulation through secondary standards (SS)
    - Goal is to protect ecosystems by limiting pollutants concentration
- EF
  - Legislation
    - 1981: Permanent and transferable water rights (WR) can be granted to individuals (nothing about EF)
    - 1994: EF considerations were included in environmental impact assessment studies
    - 2005: EF must be considered in the allocation of new rights
  - **Effect:** Reduced availability of EF mainly due to over allocation of water rights (Geo Chile 2008)
  - Possible options to restore EF: **buy back allocated WR**

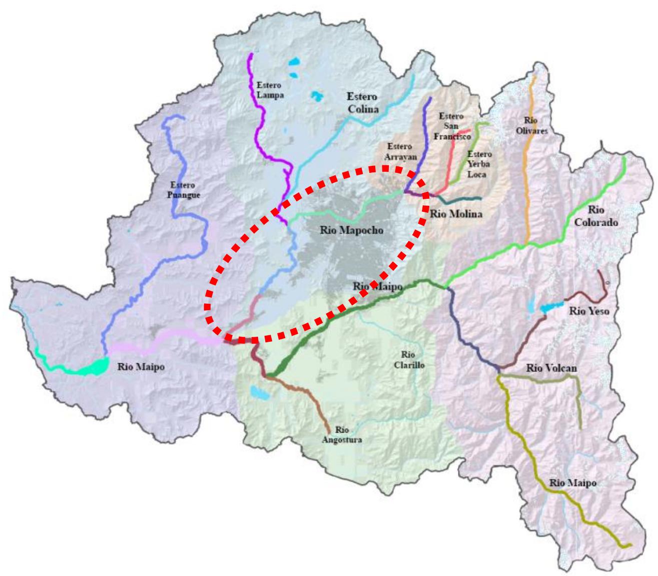
2. Purpose and contribution of the study

- **Purpose**: If a buy-back program (BBP) is implemented in a regulated Chilean Basin:
  - What are the costs for the public sector?
  - Are there any savings due to less investment to comply with the regulation?
  - Is a BBP an efficient and effective measure for addressing water pollution problems?
- **Contribution**
  - First analysis of a BBP in Chile
  - Applied case based on present concerns (The World Bank (2011) & personal communication)
  - Lack of similar studies (Aftab 2007)

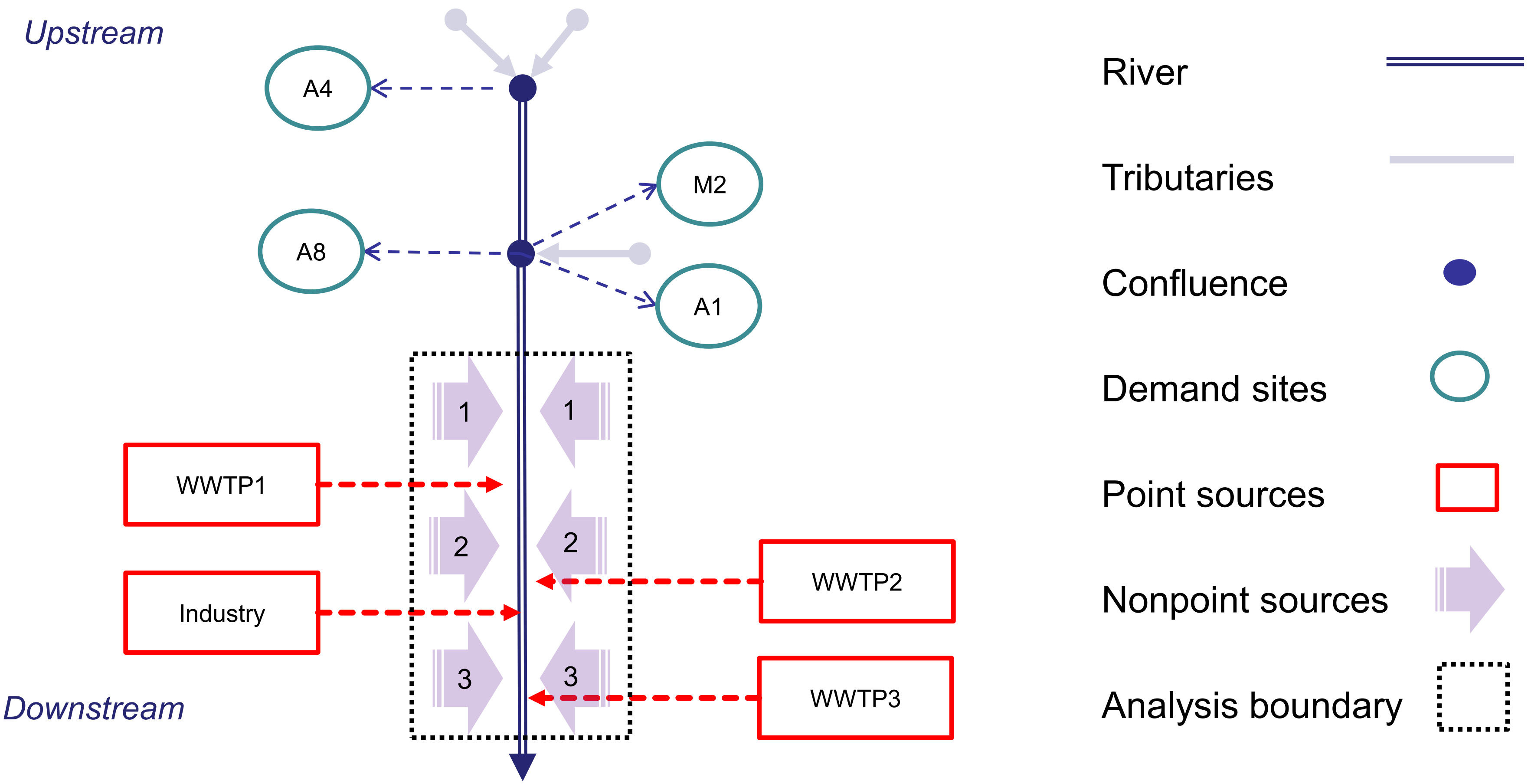
3. Relevant information for the analysis

Spatial analysis

- Analysis focused in Mapocho river (Maipo Basin)
- EF and WQ problems
- Currently undertaken the process of implementing a secondary standard



3. Relevant information for the analysis **Mapocho river diagram**



Source: Own elaboration based on Cai et al. (2006)

3. Relevant information for the analysis

- Secondary standard to comply
  - Maximum average concentration of total nitrogen (TN) (10 mg/L)

- Type of measures considered
  - Point sources
    - 15 abatement technologies options for pollution control
  - Nonpoint sources
    - Riparian protection

4. Methodology

i. Buy-back program costs

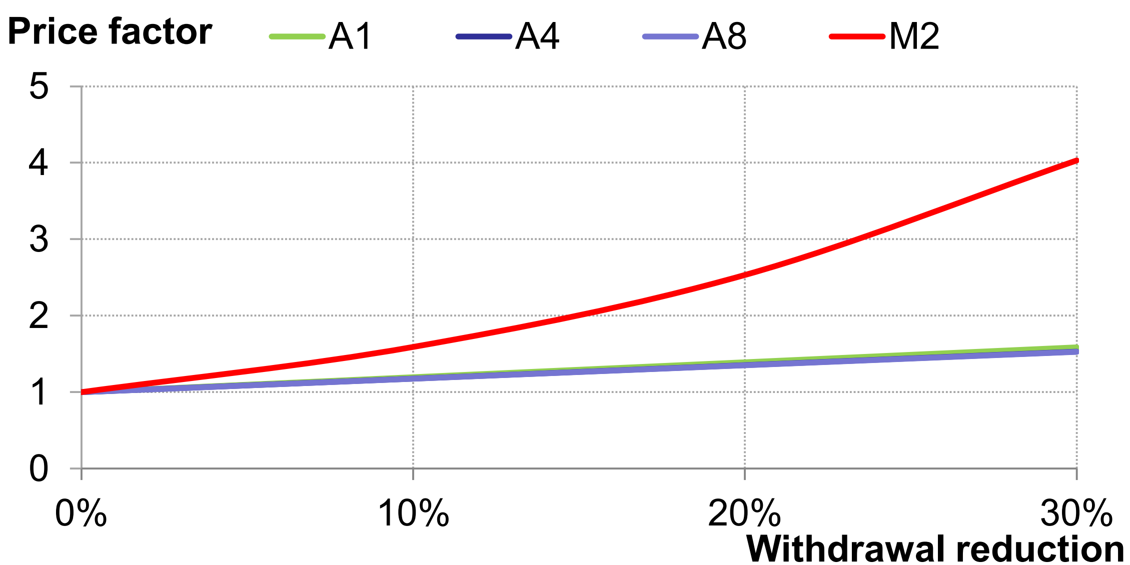
ii. Savings in SS compliance costs

4. Methodology – Buy-back costs

- Objective of the BBP
  - Restore EF according to actual legislation (10% of annual average flow = 440l/s)

- Given the amount of EF to purchase, government will buy the pool of WR that **minimizes** total **costs**

- **WR price varies according to value of water marginal productivity**



Source: Own elaboration based on Cai et al. (2006)

4. Methodology – Savings in SS compliance costs I

- Scenarios:
  - **Baseline**: SS compliance with EF=0
  - **Buy-back**: SS compliance with EF>0

- Savings :
  - Difference between SS compliance costs (Baseline – BBP)

4. Methodology – Savings in SS complying costs II

- SS compliance costs:

$$\min_{x_i, y_j} \left\{ \sum_i^{PS} C_{at}(x_i) + \sum_j^{NPS} C_{rp}(y_j) \right\} \quad \text{s.t.} \quad TN_f(x_i, y_j) \le TN_m(x_i, y_j)$$

- Where:
  - **X_i: Technology implemented** for ith PS
  - **Y_j: Length of protected riparian** area for jth NPS
  - C_{at} , C_{rp}: **Costs** of abatement technology and riparian protection
  - TN_f,TN_m: Final and max **TN concentration**

The model accounts for

- Uncertainty:
  - Abatement efficiencies for PS and NPS
  - Water rights prices
- Different hydrological years modeled
- Emission - concentration relationship from QUAL2K (stream water quality model)

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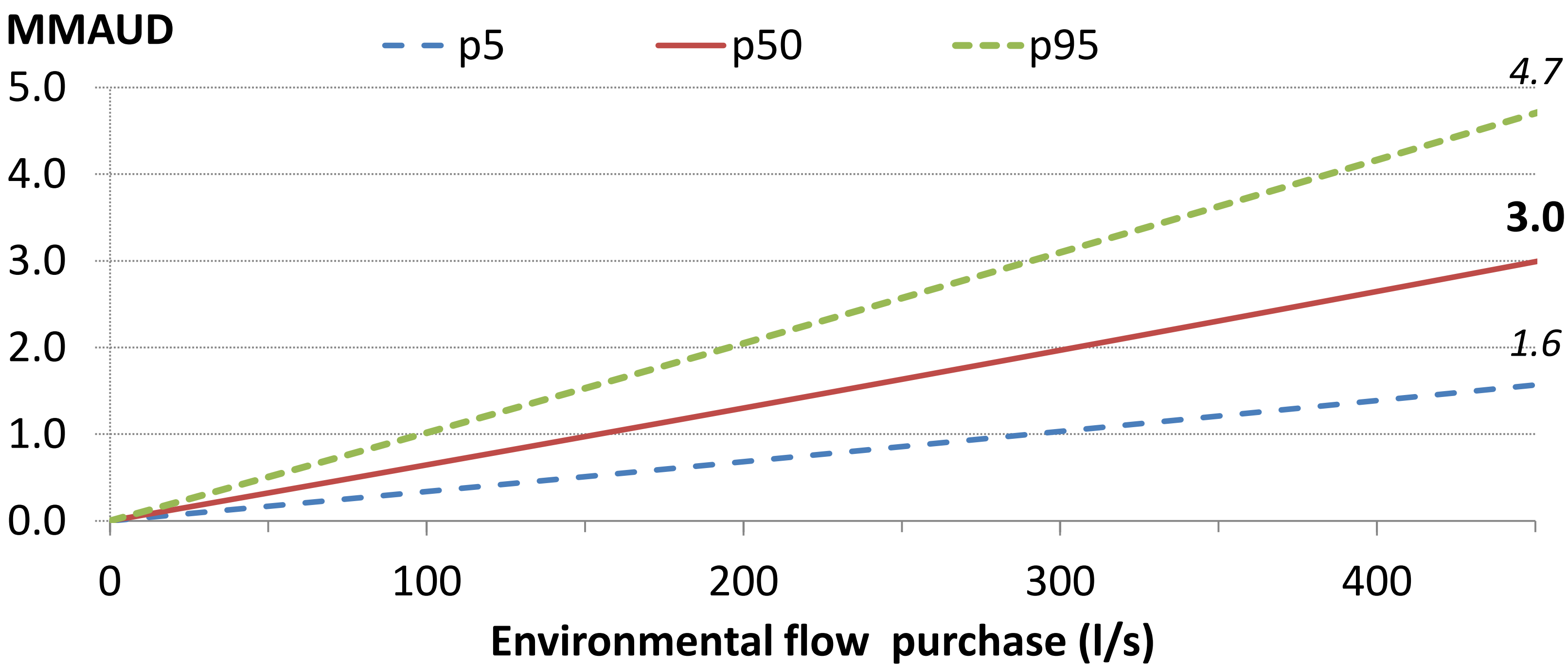
Results – **Buy-back program**

Total costs (percentiles 5, 50, 95)



Note: Net present values. Discount rate: 6%. Horizon: 50 years. Hydrological year: 50 per cent of exceedance probability

- The purchase of 440 l/s requires expenditures of around **AUD 3 million**
- Value ranges from **1.6 to 4.7** million of AUD (90 per cent of confidence)

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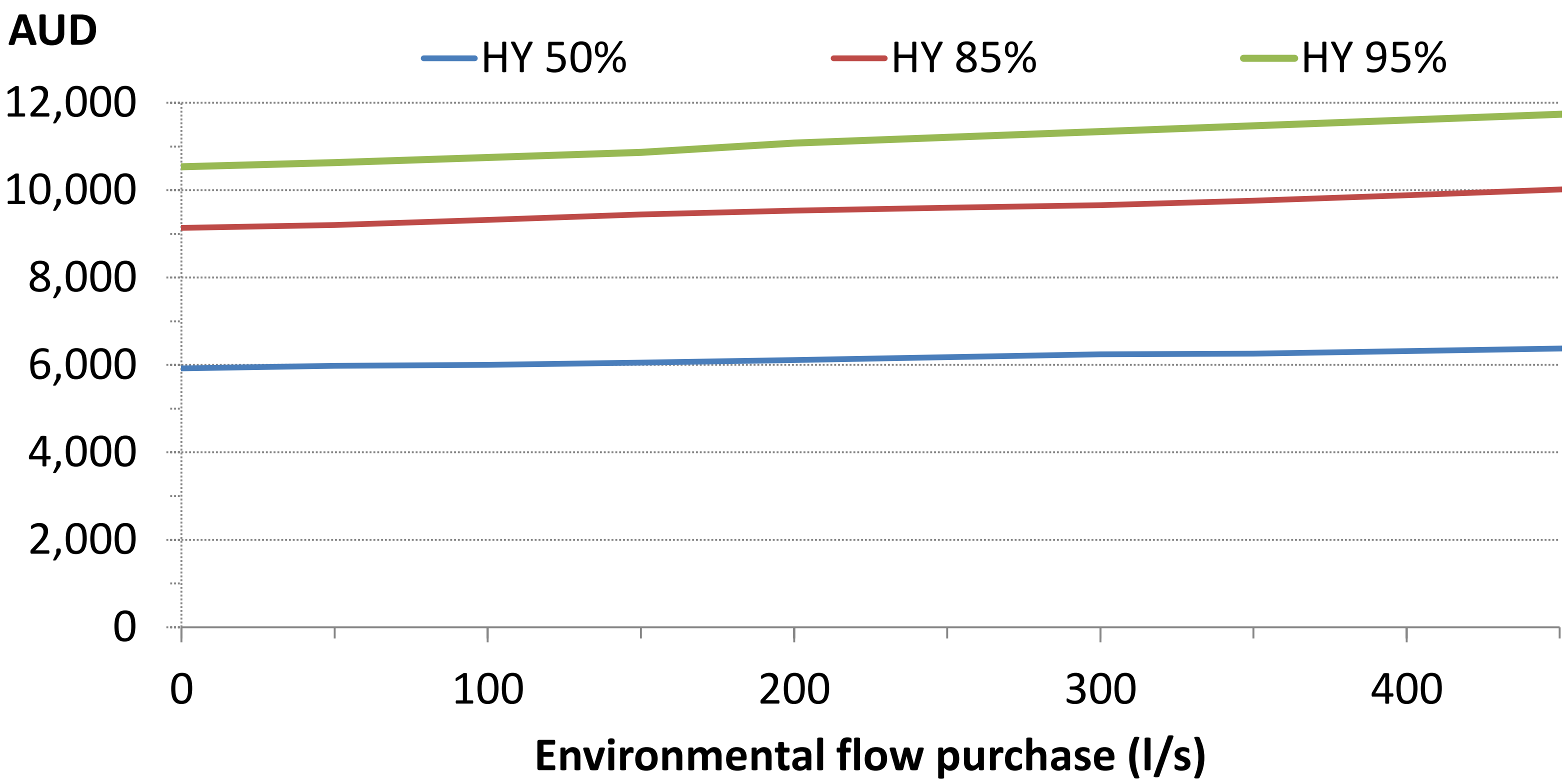
Results – **Buy-back program**

Marginal price of WR for different hydrological years

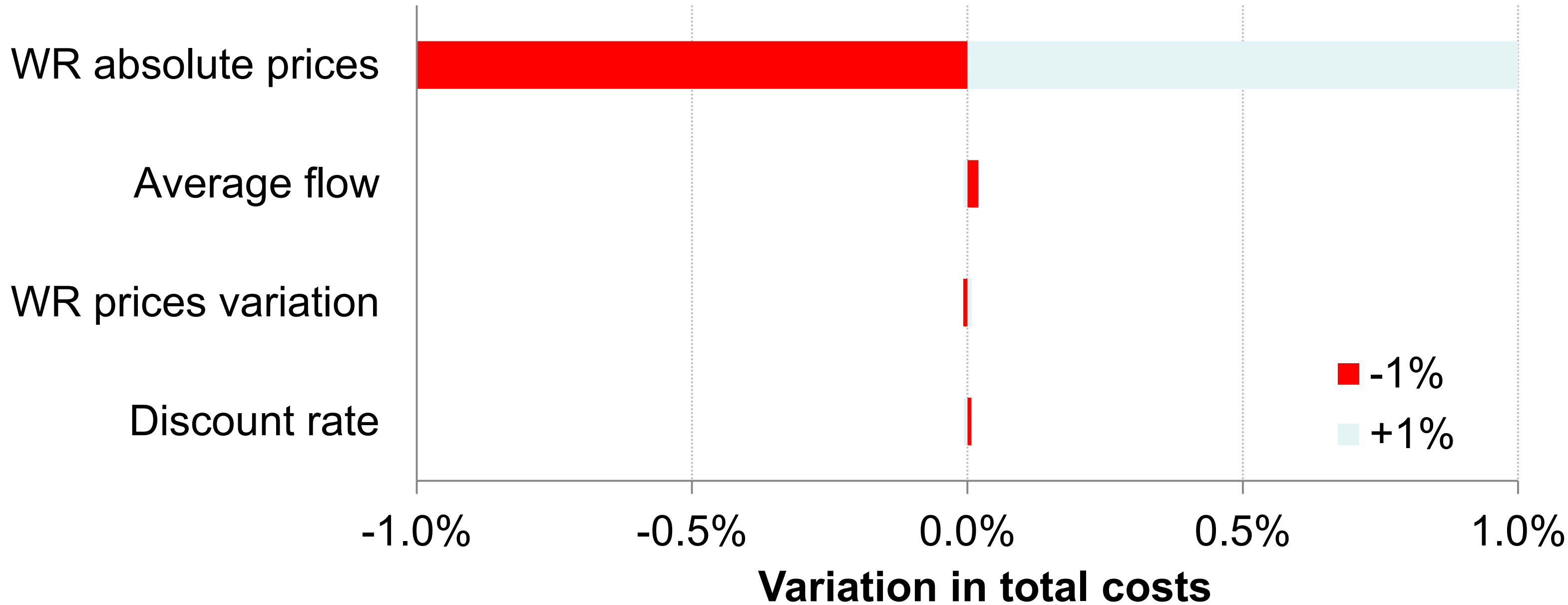


Note: Net present values (discount rate: 6%, horizon: 50 years)

- Variation 0 v/s 440 EF : **8 %** (HY 50%) to **11%** (HY 95%)

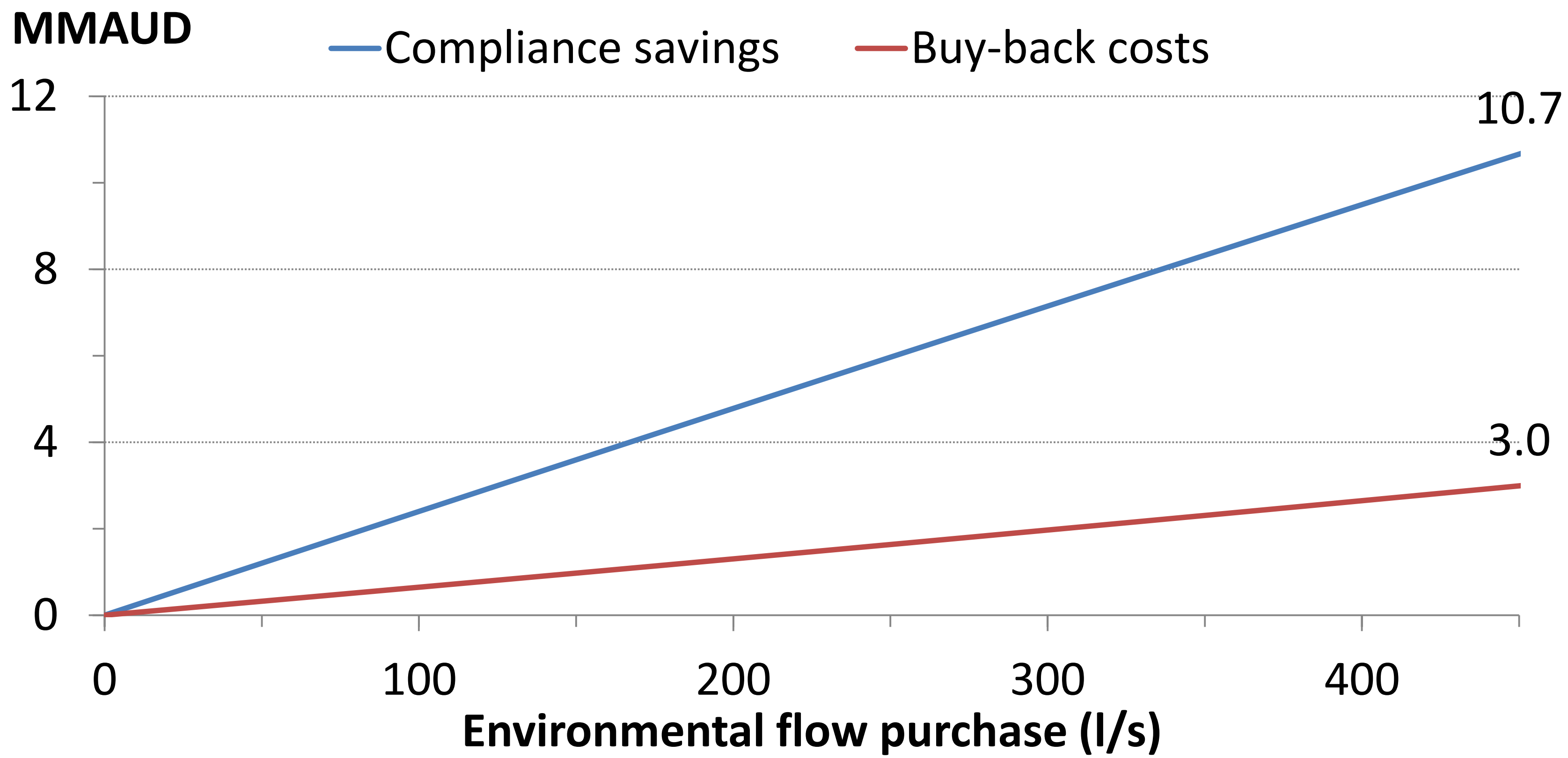
Results – **Buy-back program**

Sensitivity analysis



- Variation in total costs according to inputs variation
- Buy back costs depends more heavily on WR absolute prices and, in a lesser extent, on average flow

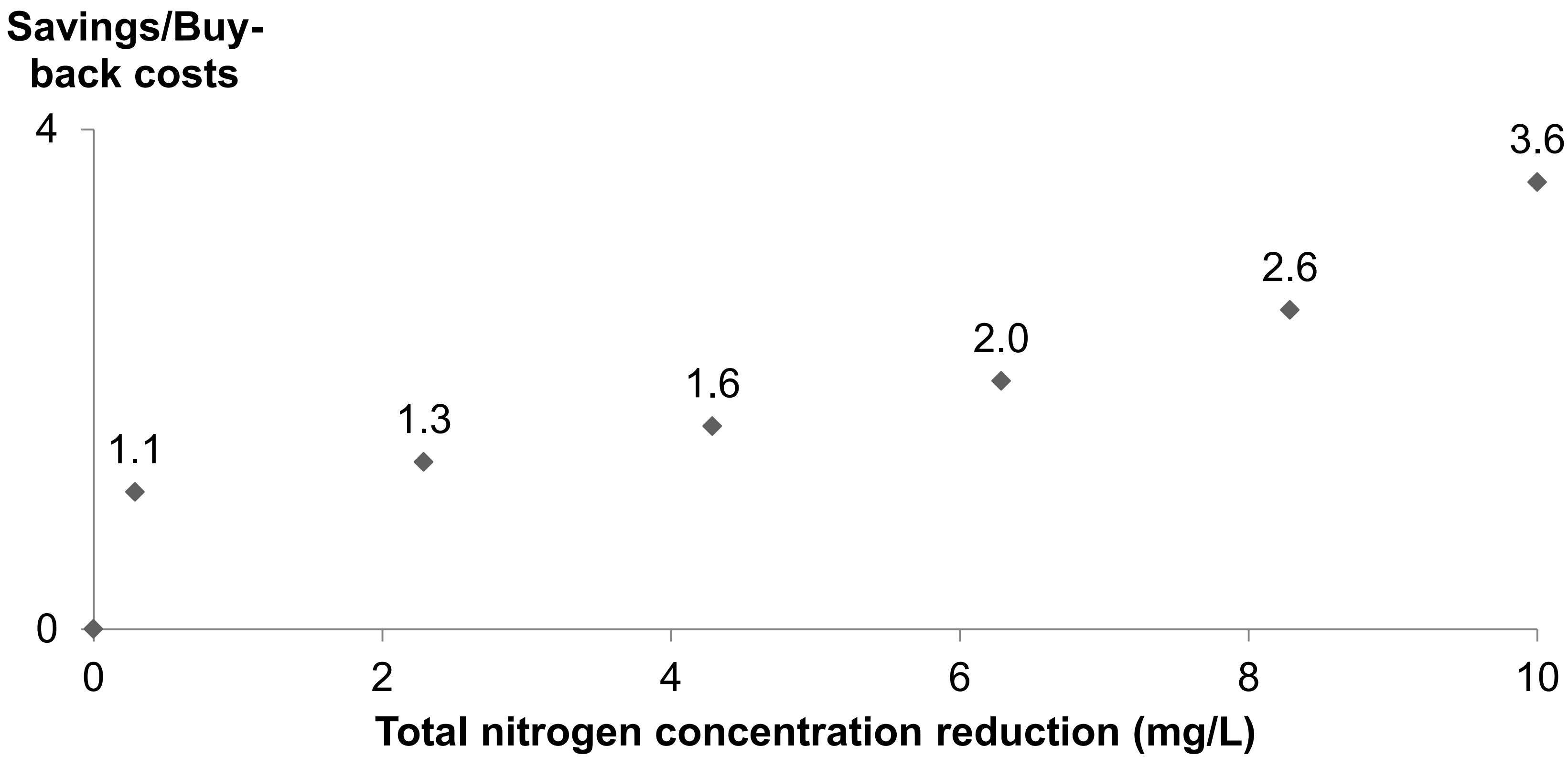
Results – **Savings v/s BBP costs**



Note: Net present values (discount rate: 6%, horizon: 50 years), TN reduction from 20 to 10 mg/L. Hydrological year: 50 per cent of exceedance probability

- Ratio Savings/Buy-back cost ~ 4

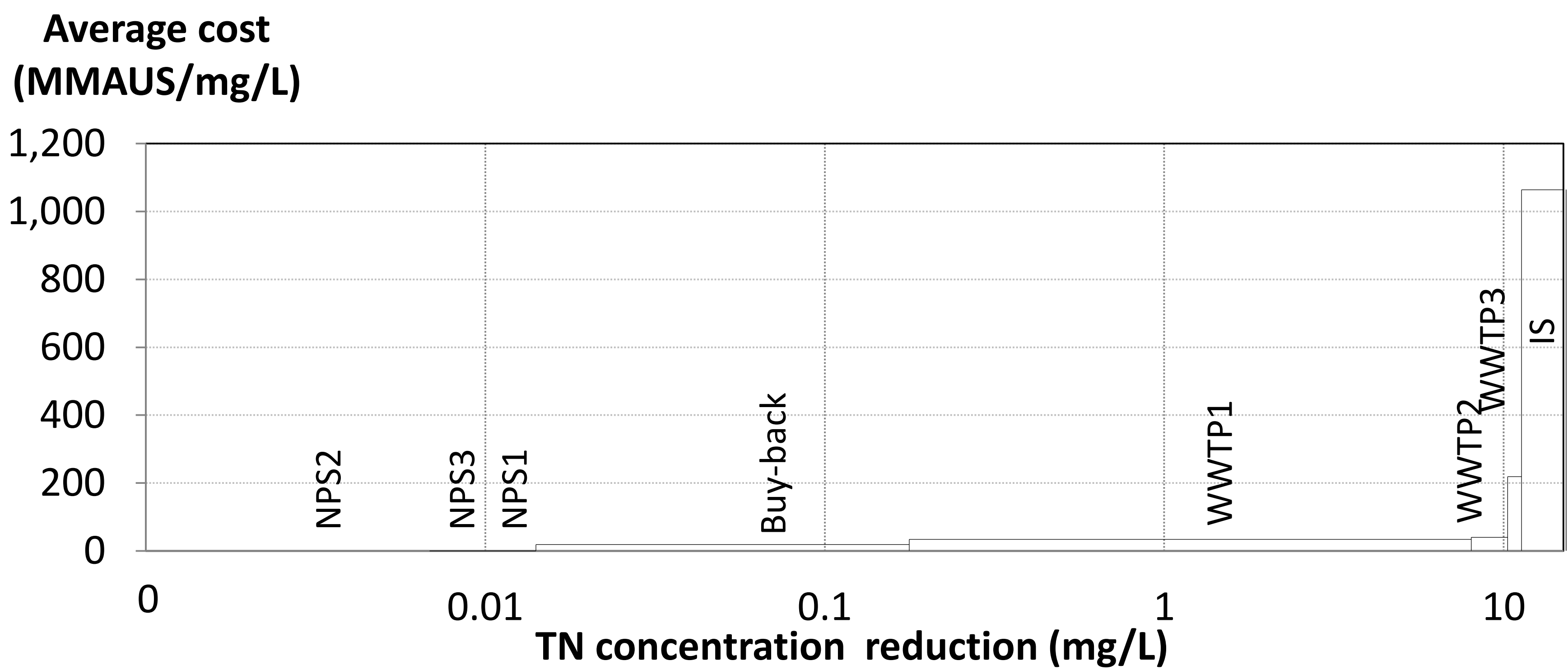
Results – Ratio savings v/s BBP costs



Note: 440 l/s purchase. Hydrological year: 50 per cent of exceedance probability

- ↑ strict the desire concentration level → ↑ savings in compliance

Results - **Average cost of measures**



Note: Logarithmic scale. Net present value. Discount rate: 6 per cent. Horizon: 50 years. Hydrological year: 50 per cent of exceedance probability. Purchase of 440 l/s. Reduction of 15 mg/L of TN.

- BBP efficiency worse than NPS measures, but better than PS
- Nevertheless, BBP and NPS effectiveness are limited

Conclusions I

- Buy-back costs ~ 3 MMAUD for 440 l/s
- Savings in compliance costs may be 4 times greater than Buy-back expenses
- BBP as a measure to control nutrient pollution:
  - Not as efficient as NPS measures (coincides with other studies (Aftab et. Al 2007))
  - BBP may outperform PS control measures (no other studies)
  - Efficient but limited effectiveness

Conclusions II

- Distributive effects:
  - Public sector perceive the costs and private sector the savings
  - Opportunity to transfer costs to the private sector

- Policy questions
  - Is it worthy?
    - Assessment of benefits needed
  - How politically feasible it is?
    - Strong opposition to the immobilization of goods
    - Strong opposition to the State paying for national resources

Conclusions III

- Analysis comply with water policy recommendations (EU's Water Framework directive, OECD 2012):
  - Integrated analysis (quality and quantity)
  - Based on the cost- effectiveness of the measures

THANKS

ANNEX

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Data

- Prices of water rights (Donoso et al. 2007; ODEPA 2010))
- Water flow availability (DGA 2003)
- Hydrological scenarios (ECLAC 2009)
- Marginal productivity of water (Cai et al. 2006)

Australia' s case

- Murray-Darling Basin has faced ecosystems' deterioration due to reduced water flow availability for the environment (Jones et al. 2002)
- This impelled efforts of the Australian government for recovering Murray-Darling Basin's health.
- From 2008 'Water for the future' plan is active, with the purpose of recover environmental flows mainly by a buy back of water allocations (SEWPaC 2010).

Abatement technologies

Tecnologia	N	NH3	NH4	NKT	NO3
Lagunas Aireadas				63%	
Lodos Activados				23%	
Lodos Activados+complemento Nt	80%			80%	
Lombrifiltro				70%	
Reactor Anaerobico				70%	
Reactor Anaerobico				70%	
Reactor Aerobico de Lecho Fijo Sumergible (RALFS)				90%	
Reactores Biologicos Secuenciales (SBR)				90%	
Wetlands				90%	
Arrastre por Aire (Air Sripping)		93%			
Electrodialisis					95%
Electroxidacion		95%			
Intercambio Ionico			99%		99%
Nanofiltracion					90%
Oxidacion con Aire Humedo		95%			

Methodology – Savings in complying costs

- For every PS the abatement costs are given by

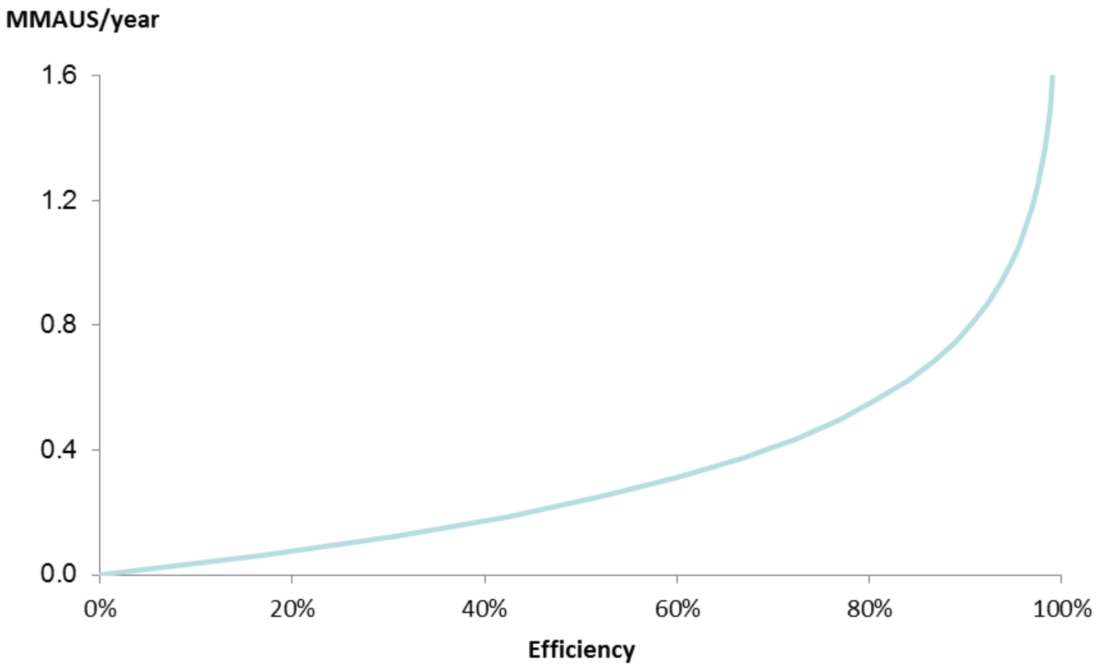
$$Min \sum_i C_i$$

s.t.

$$E_p = E_{0_p} \times \prod_i (1 - ef_{p,i})^{x_i} \leq Limit$$

Example: Costs variation according to efficiency

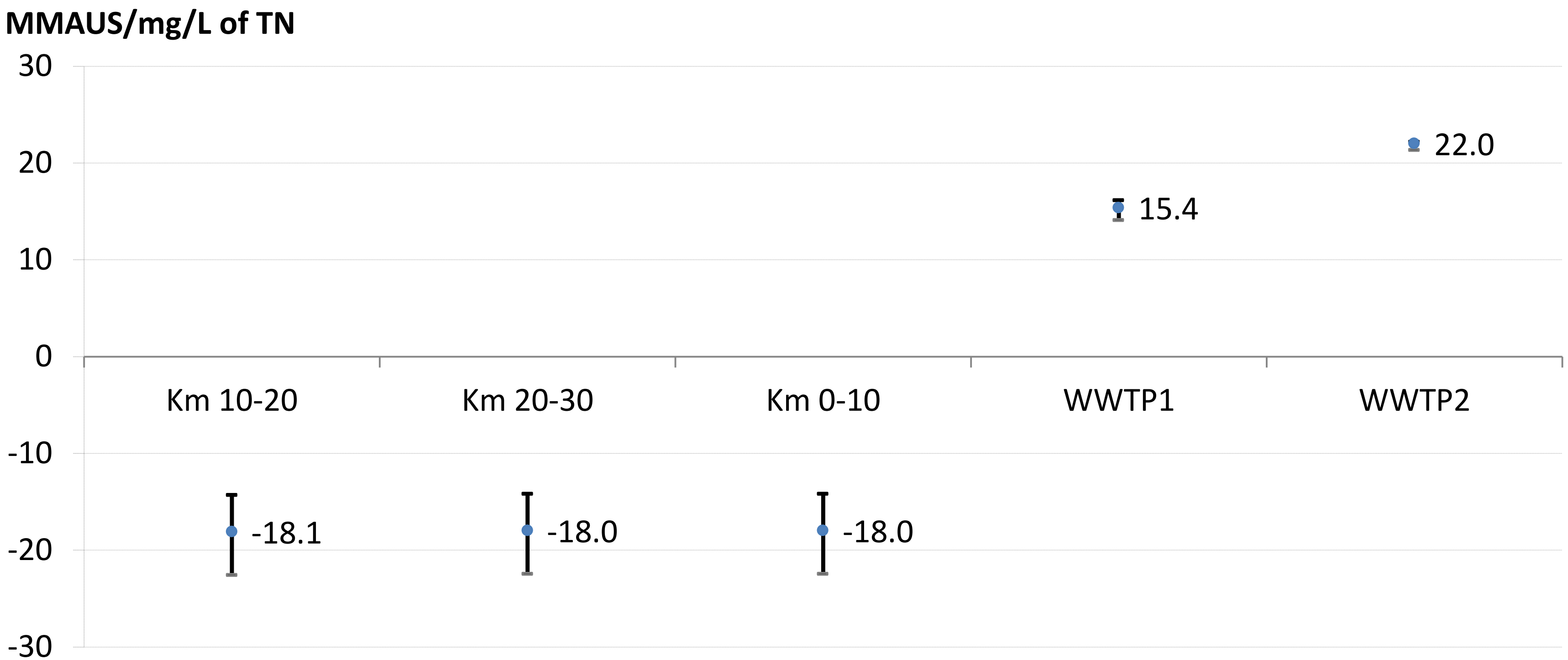
- Efficiency : 60%
- Costs: 300.000 AUD per year



Average costs and TN reduction

Measure	Average cost (AUS/mg/L)	TN concentration reduction (mg/L)
Km 10-20	205,120	0.007
Km 20-30	330,072	0.003
Km 0-10	332,071	0.004
EF	18,302,890	0.163
WWTP_Farfana	33,681,590	7.853
WWTP_Trebal	40,308,026	2.256
WWTP_Talagante	219,318,540	1.000
IM_Trusal	1,063,774,446	4.000

Average costs: Difference between measures and Buy-back



Note: Net present value. Discount rate: 6 per cent. Horizon: 50 years. Hydrological year: 50 per cent of exceedance probability. Purchase of 440 l/s.

- Difference are significative with 90 per cent of confidence