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Publication date
2017

Published in
Geophysical Research Abstracts (online)

Citation (APA)

Aydin, B., Abraham, E., Rutten, M., Delsman, J., & Oude Essink, G. H. P. (2017). Smart Salinity Management in Low-lying Deltaic Areas: A Model Predictive Control Scheme Applied to a Test Canal. *Geophysical Research Abstracts (online)*, 19, Article EGU2017-14448. <http://meetingorganizer.copernicus.org/EGU2017/EGU2017-14448.pdf>

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Smart Salinity Management in Low-lying Polders: A Model Predictive Control Scheme Applied to a Test Case

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Introduction

Saline groundwater exfiltration to surface water increases the surface water salinization and degrades the surface water quality in low-lying deltaic areas. The use of surface water will be less appropriate for agricultural, industrial and drinking water production due to salinization, and therefore, **freshwater** diverted from river is used for **flushing** canals and ditches in these areas.

Motivation

Due to expecting negative effects of climate change, sea level increase and decreasing freshwater availability, current water management strategies (fixed flushing throughout the dry season) for flushing control in low lying polders have to be revised. In our research we explore smarter strategies to explore:

Is it possible to flush the ditches of a polder using less water while keeping the quality and quantity constraints at set points?

How much freshwater can be saved by a smarter control?

Current practise of flushing is using the available capacity with a fixed discharge. In our test case presented here we assume the maximum capacity of the flushing discharge is $0.15 \text{ m}^3/\text{s}$ and the necessary amount of freshwater for the test period we demonstrate in this study is presented below with 10 buckets.



Total freshwater used is **270.000 m^3** throughout the simulation period presented in this study.

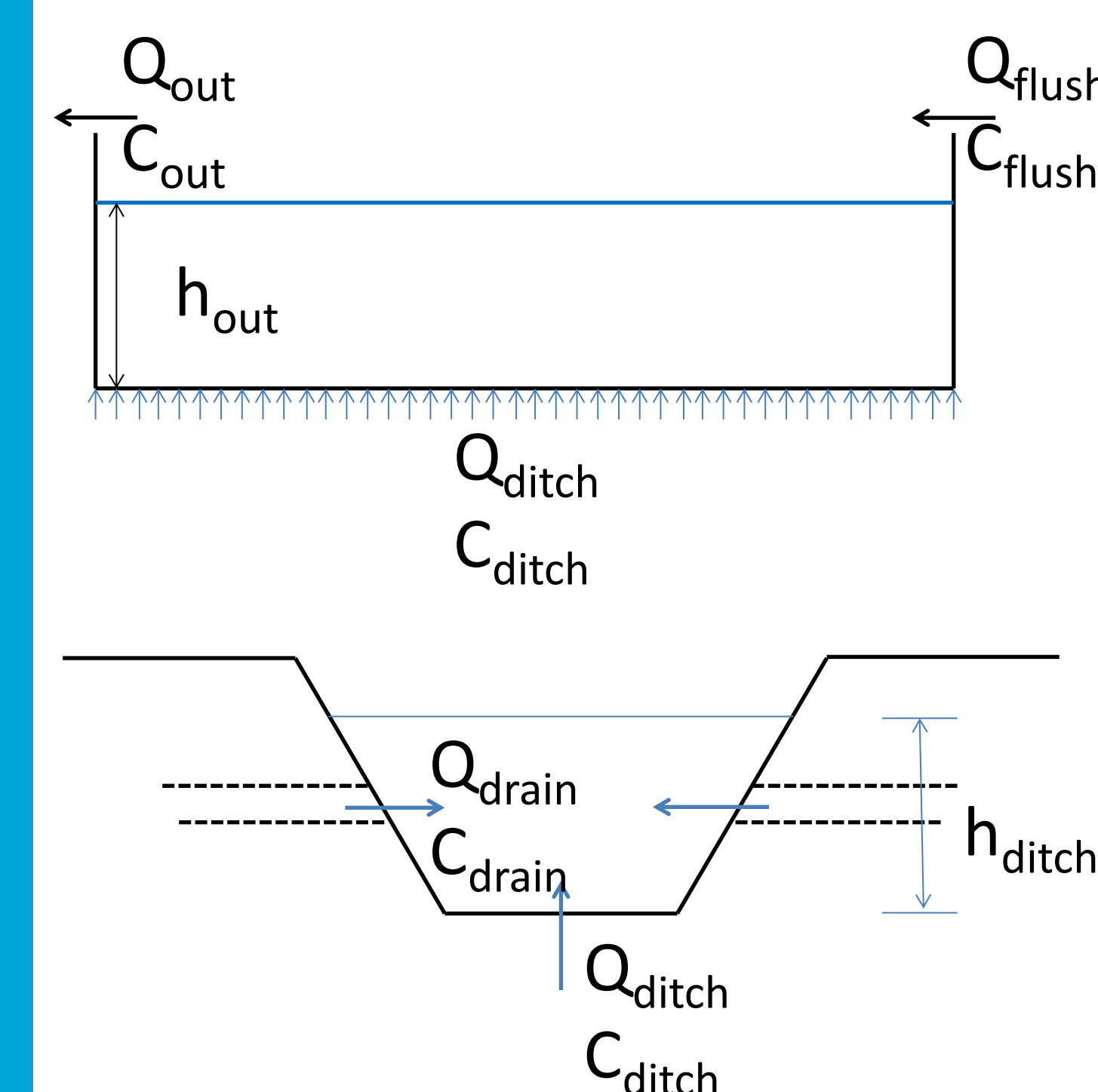
RSGEM

Rapid Saline Groundwater Exfiltration Model is a water balance model used for determining the saline groundwater exfiltration discharges and salinity concentrations which are used as disturbances by the controller.

Model Predictive Control

MPC is an optimization based control strategy which uses a process model to predict the future process outputs within a specified prediction horizon. Constraints, delays and uncertainties of the states and the inputs can be explicitly implemented to the objective function.

Test Canal and Control Objectives



Objective:

Downstream water level $h_{\text{out}} = -0.4 \text{ m}$
 Average Concentration $C_{\text{av}} < 0.5 \text{ g/m}^3$

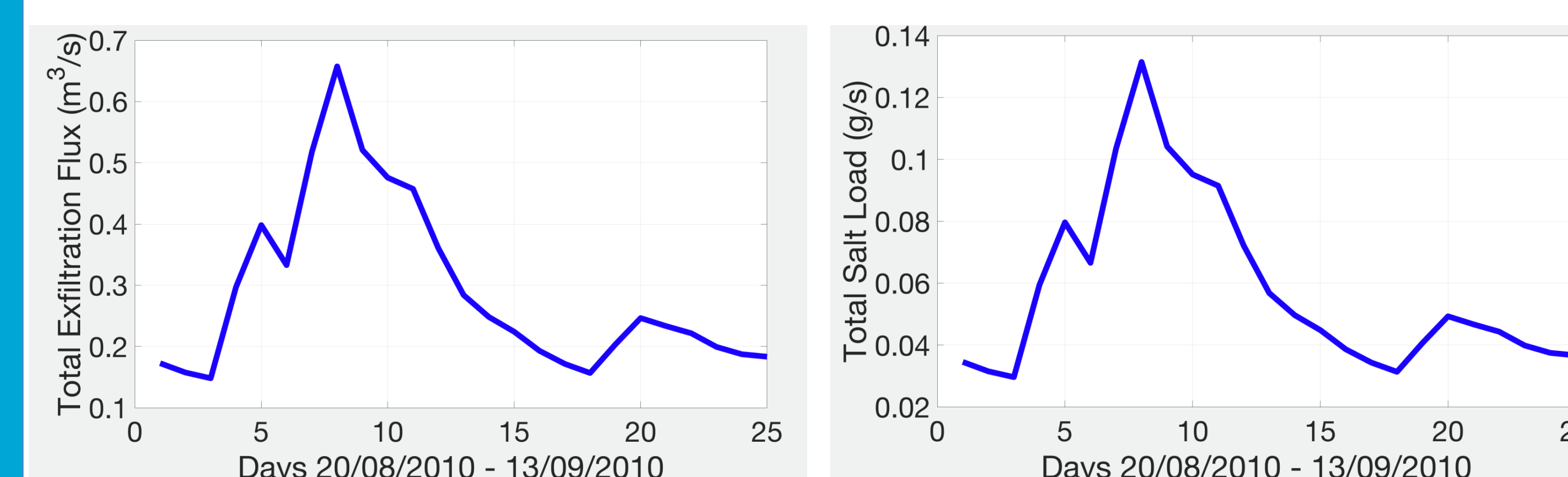
Disturbance:

Saline Groundwater Exfiltration (RSGEM)

Control:

Manipulating the change of : Q_{out} & Q_{flush}

Test Scenario



After running RSGEM for a longer simulation, 25 days with high saline groundwater exfiltration variation is selected like a real scenario. For this scenario two schemes are tested.

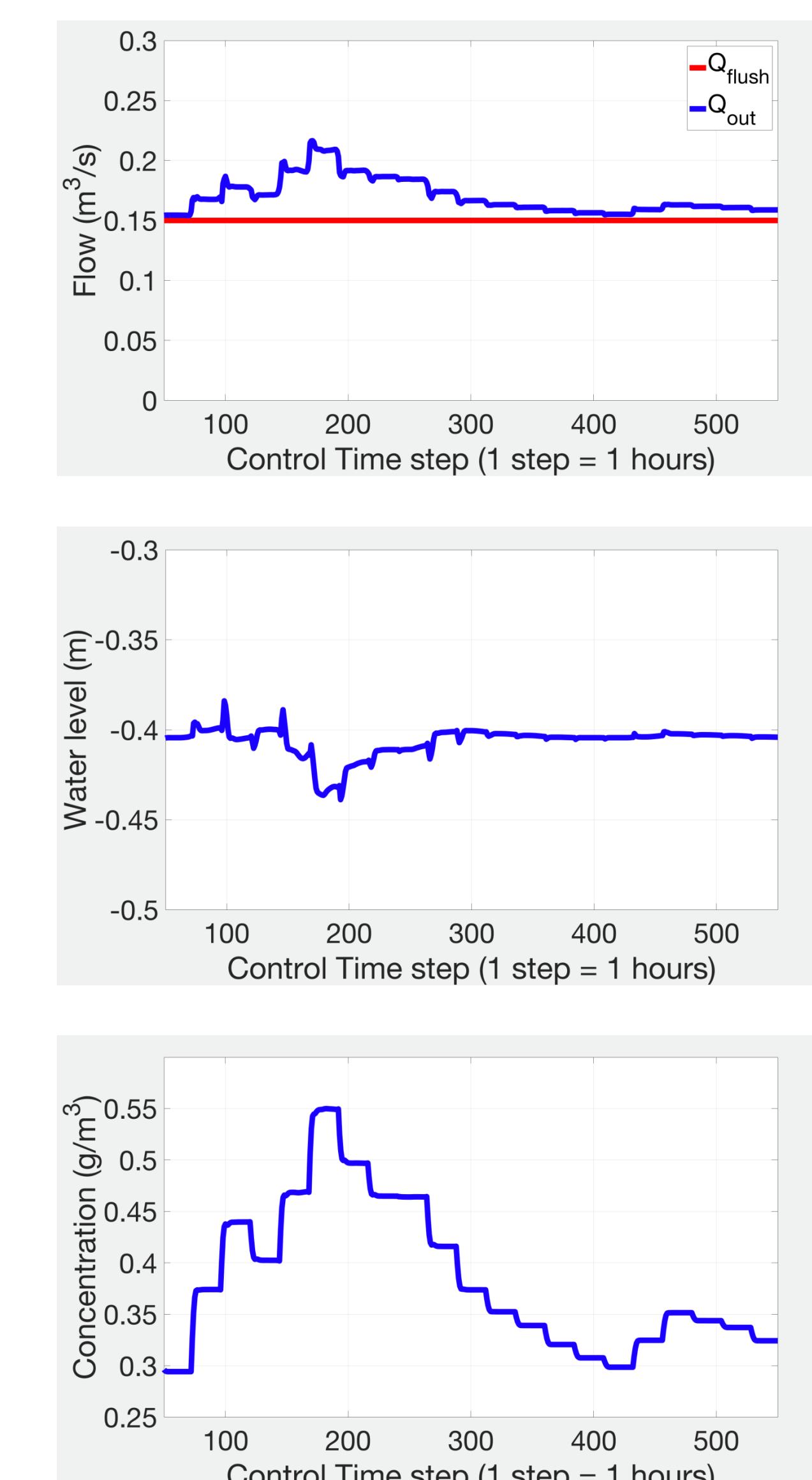
- Fixed Flushing
- Flushing with MPC (+ minimization of flushing discharge)

Acknowledgements:

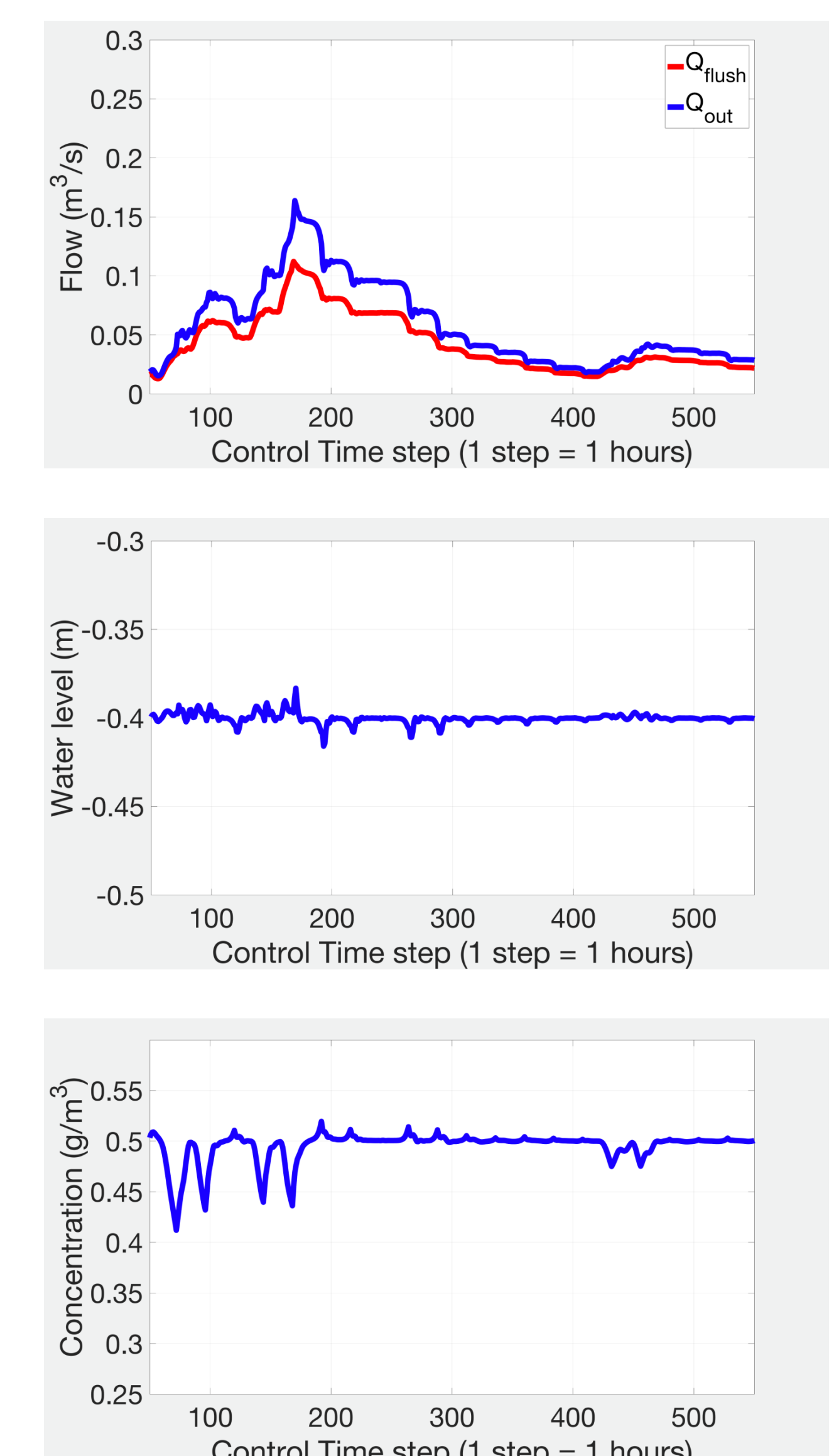
This research is financed by the Netherlands Organisation for Scientific Research, which is partly funded by the Ministry of Economic Affairs, and co-financed by the Netherlands Ministry of Infrastructure and Environment and partners of the Dutch Water Nexus consortium.

Results

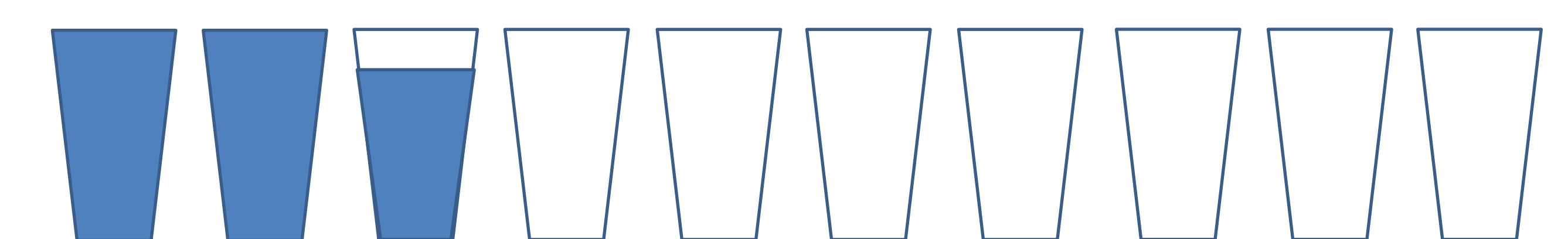
i) Fixed Flushing



ii) Flushing with MPC



Freshwater used for flushing with MPC



Total freshwater used for flushing is **78.123 m^3** (>70 % saved)
It is possible to flush with less water keeping the set points

Conclusion

The MPC scheme developed in this study can be used for salinity control of a polder ditch effectively. MPC uses the available information about the disturbances thus the flushing is done only when it is necessary. Therefore, the smart MPC scheme saves more than 70 % freshwater compared to the current flushing strategy.

