OPTIMAL FLUSHING OF A POLDER USING MODEL PREDICTIVE CONTROL: LISSERTOCHT CATCHMENT

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Introduction

- More than **35%** of the world's population live within 100 km of the coast.
- Groundwater resources in these areas are the **main source** for
  - domestic
  - industrial
  - agricultural use
- Deltaic areas are under stress due to
  - climate change
  - sea level rise
  - decrease in fresh water availability

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Saline Groundwater Exfiltration and Salinization in Polders

- Saline groundwater moves towards surface water
- Salinized surface water will not be appropriate
  - drinking water production
  - agricultural and industrial use
- **Flushing** : using freshwater diverted from rivers for removing the saline surface water

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Near Future

- Salinization
  - Expected to increase due to sea level rise
- Freshwater Availability
  - Expected to decrease due to decreasing precipitation and increased consumption of upstream users

Problem becomes more severe..

Act efficiently when necessary..

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Control Objectives for a Polder

- Water Level
  - Always
- Water Quality
  - When necessary
- Freshwater
  - Minimum - Water is a scarce source / less pumping

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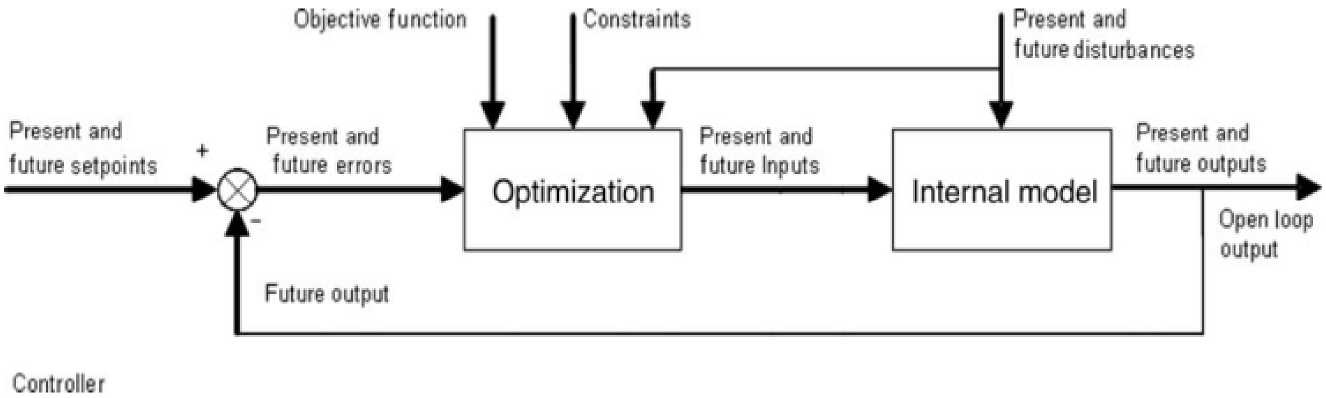
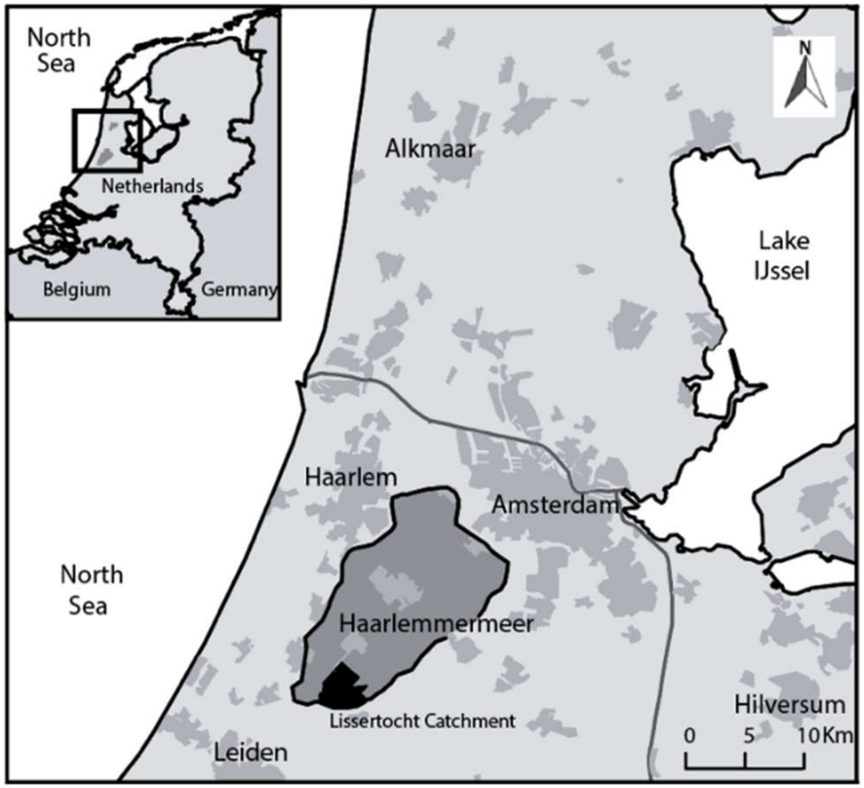
Multi-Objective Control Problem

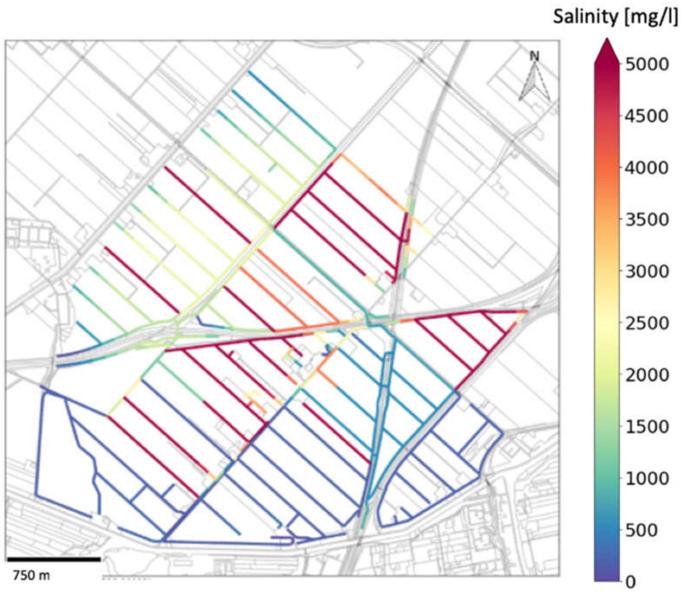
- Model Predictive Control

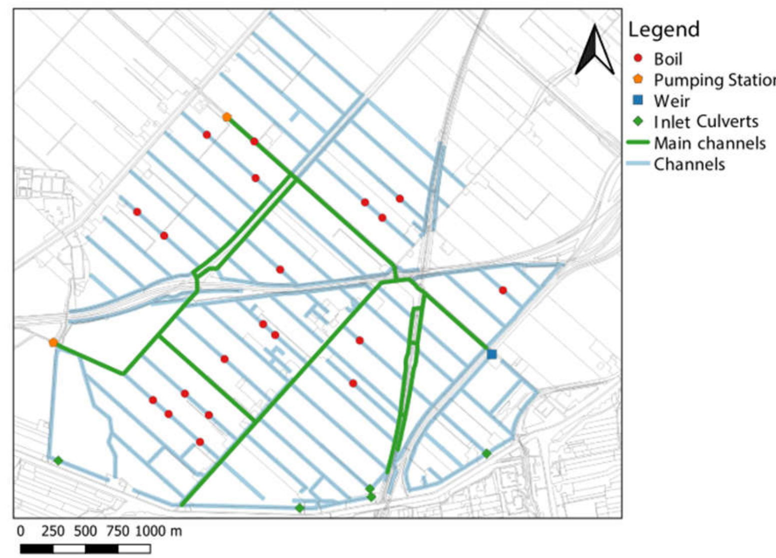


Case Study – Lissertocht Catchment



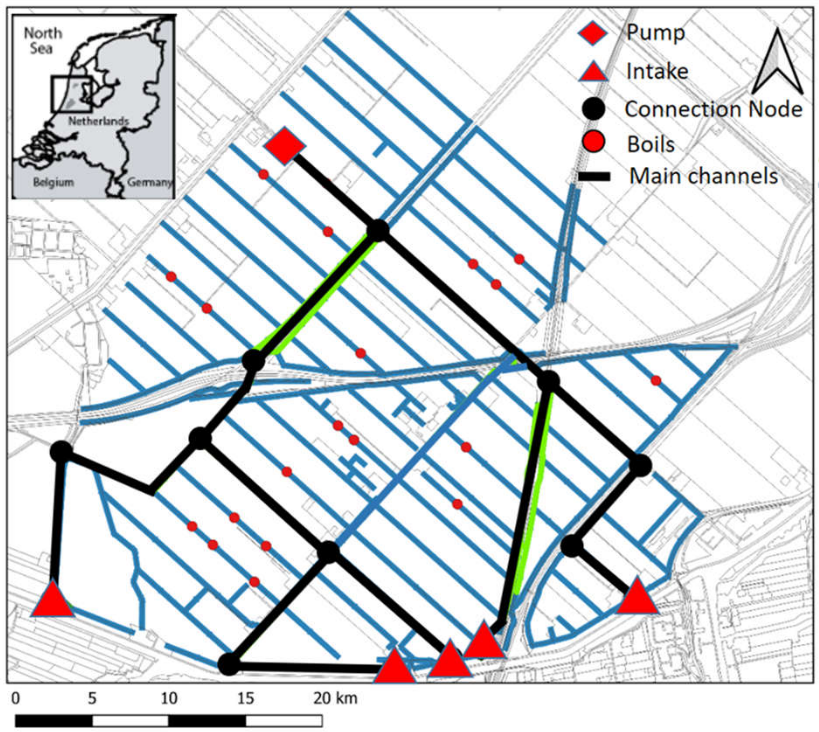
Lissertocht Catchment and Control



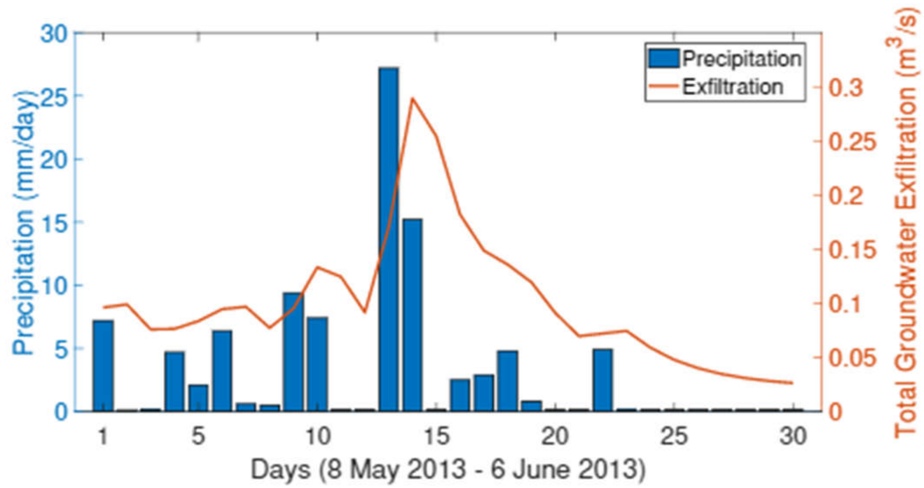


- Water Level = -6.45 m
- Salinity Threshold = 1500 g/m^3

Controlled Network

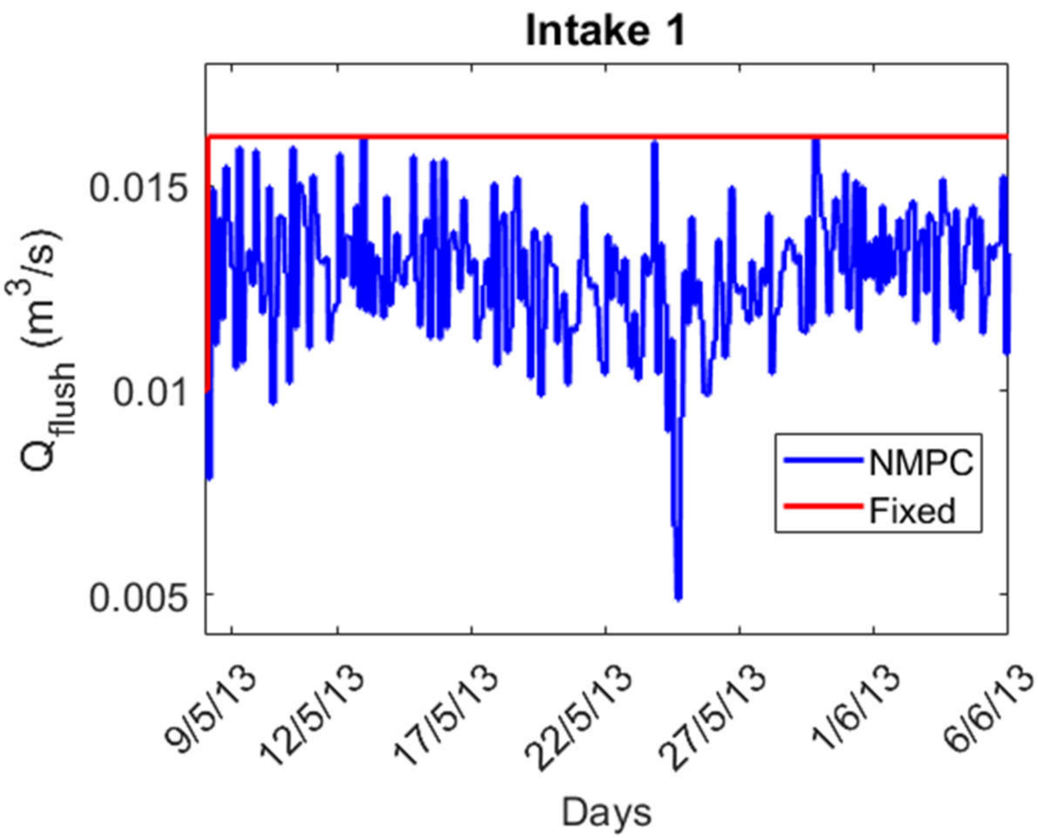


30 days test period

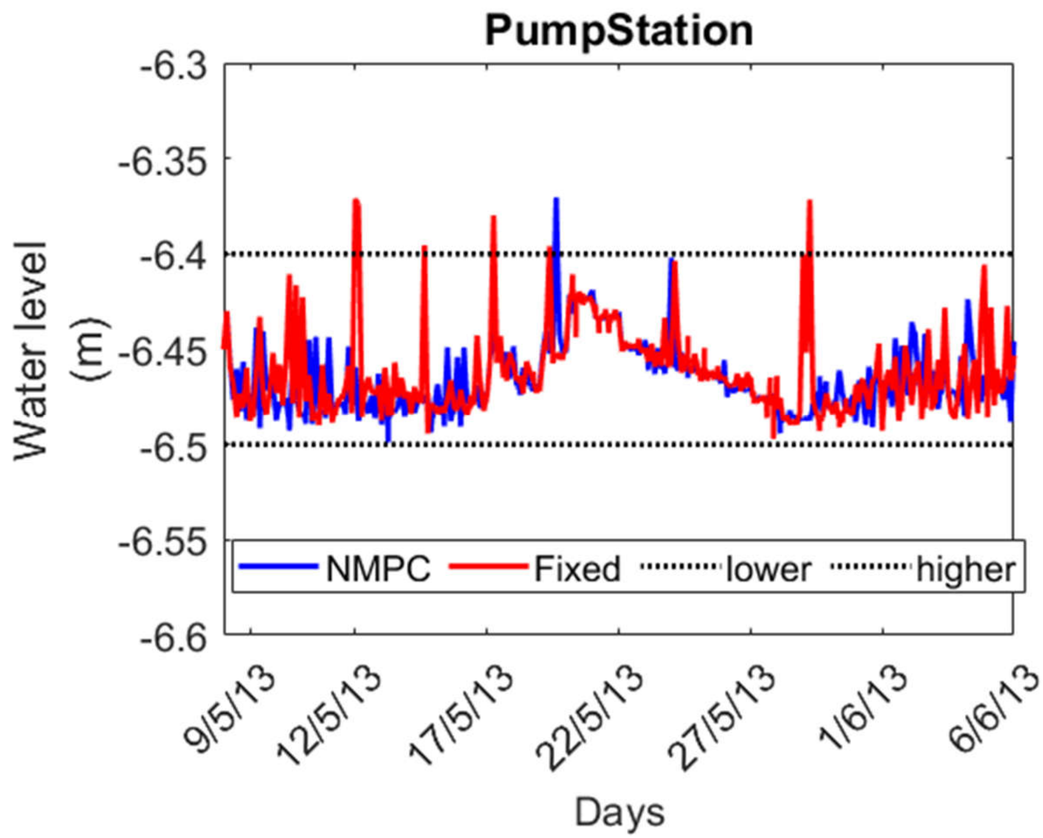


- Compared with fixed flushing

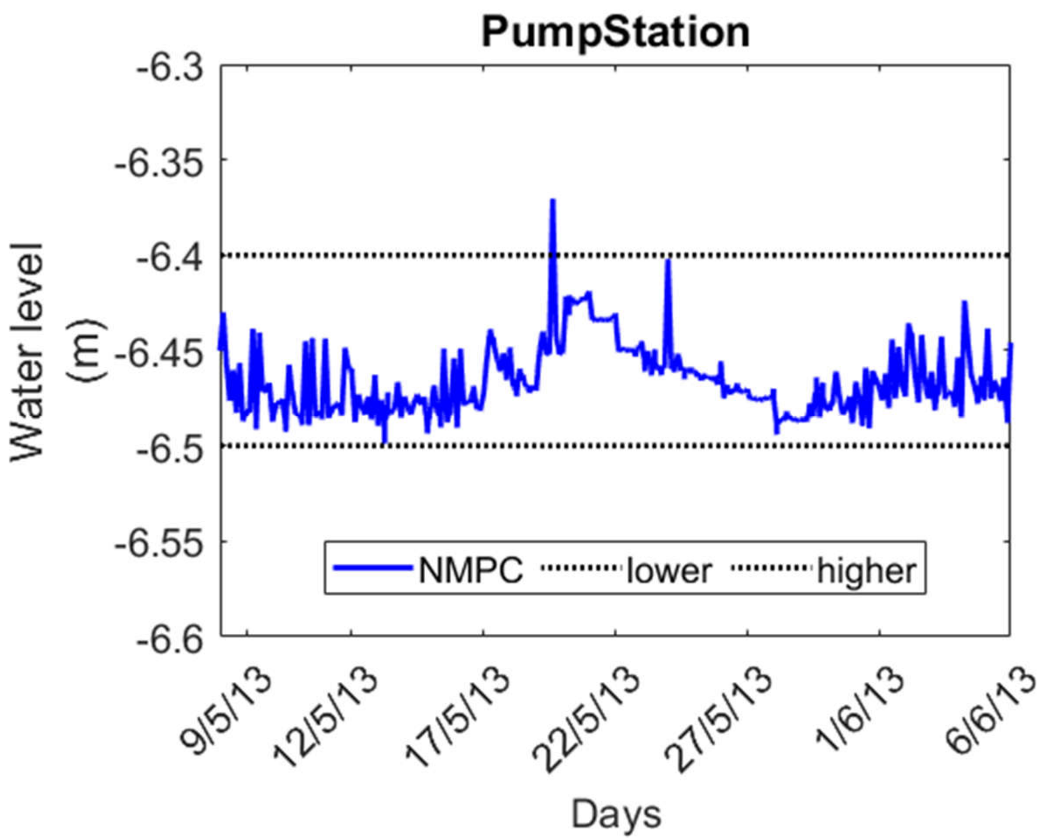
Results – Intake 1



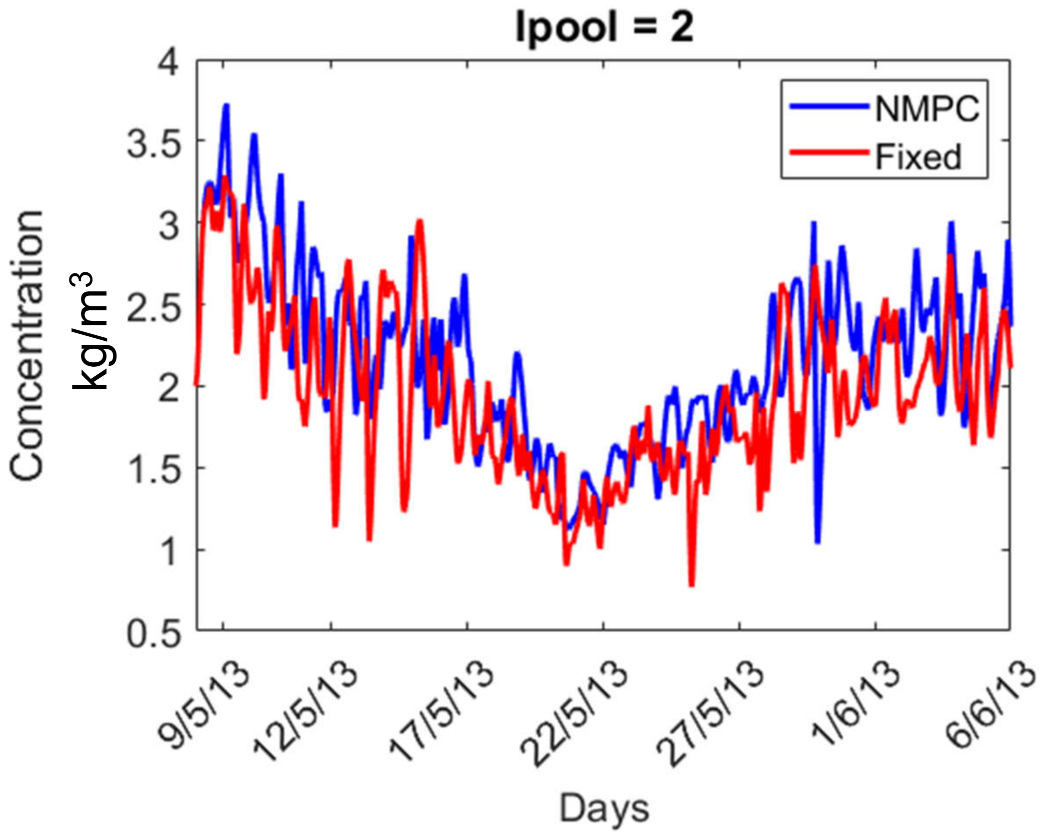
Results – Water Level



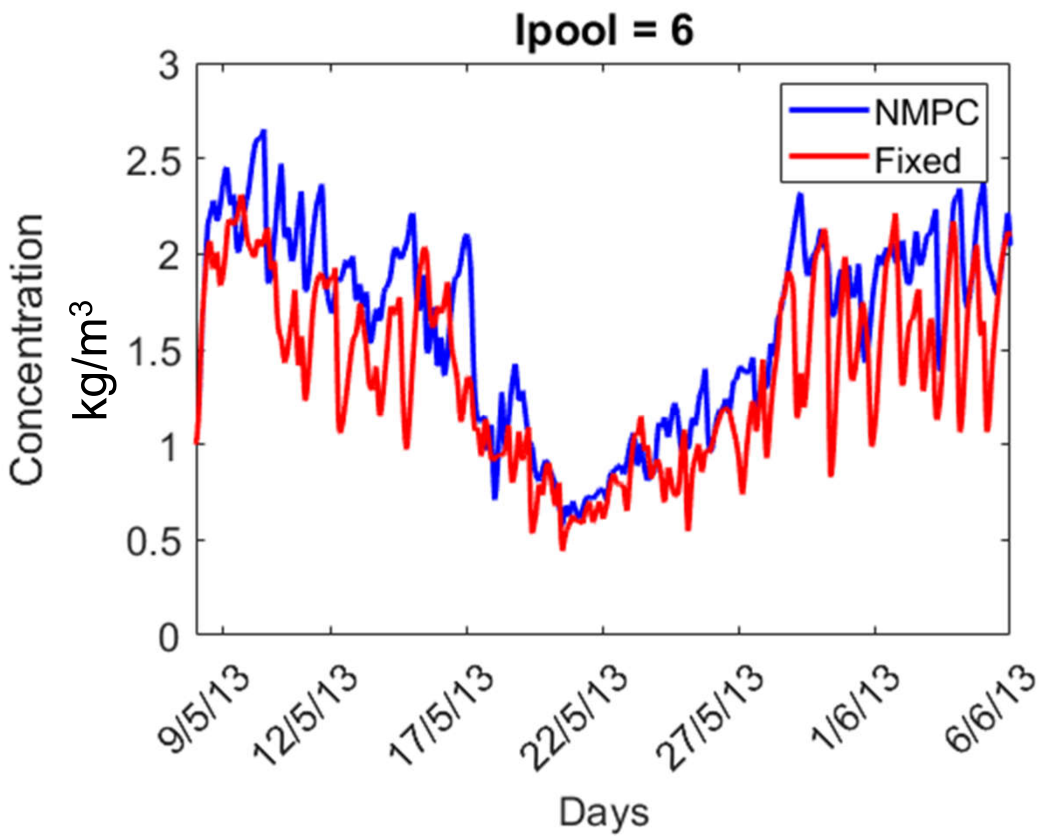
Results – Water Level



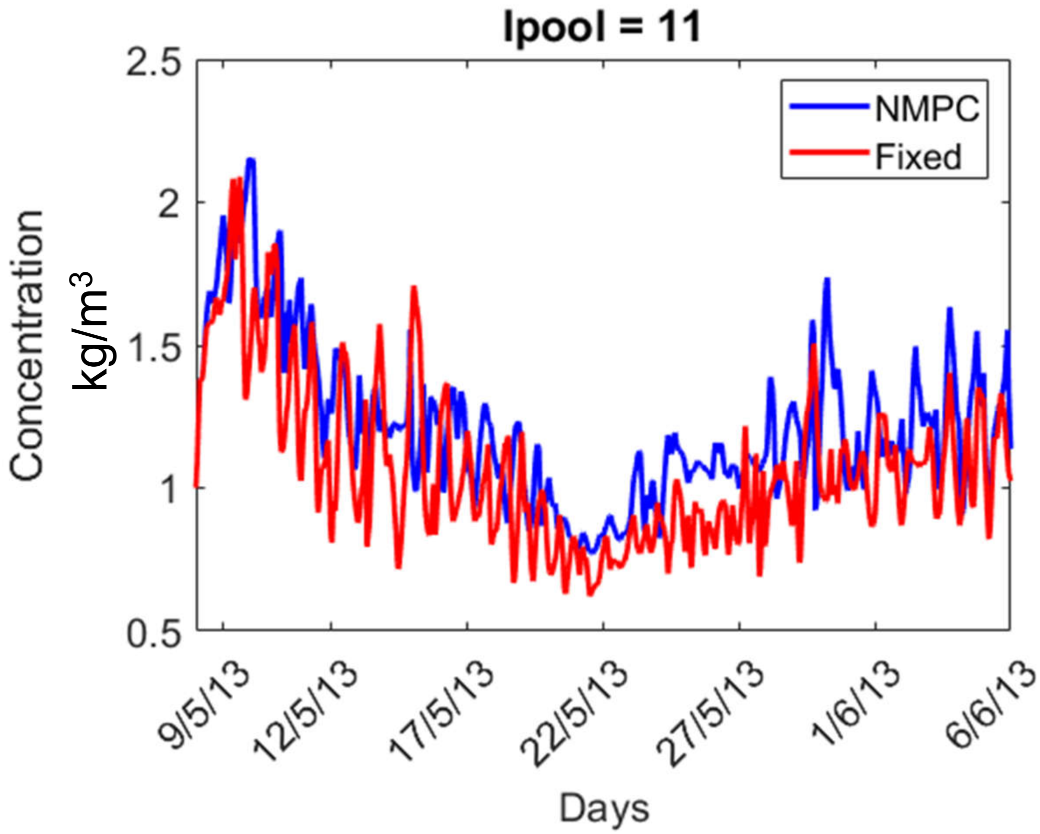
Results – Salinity Concentration



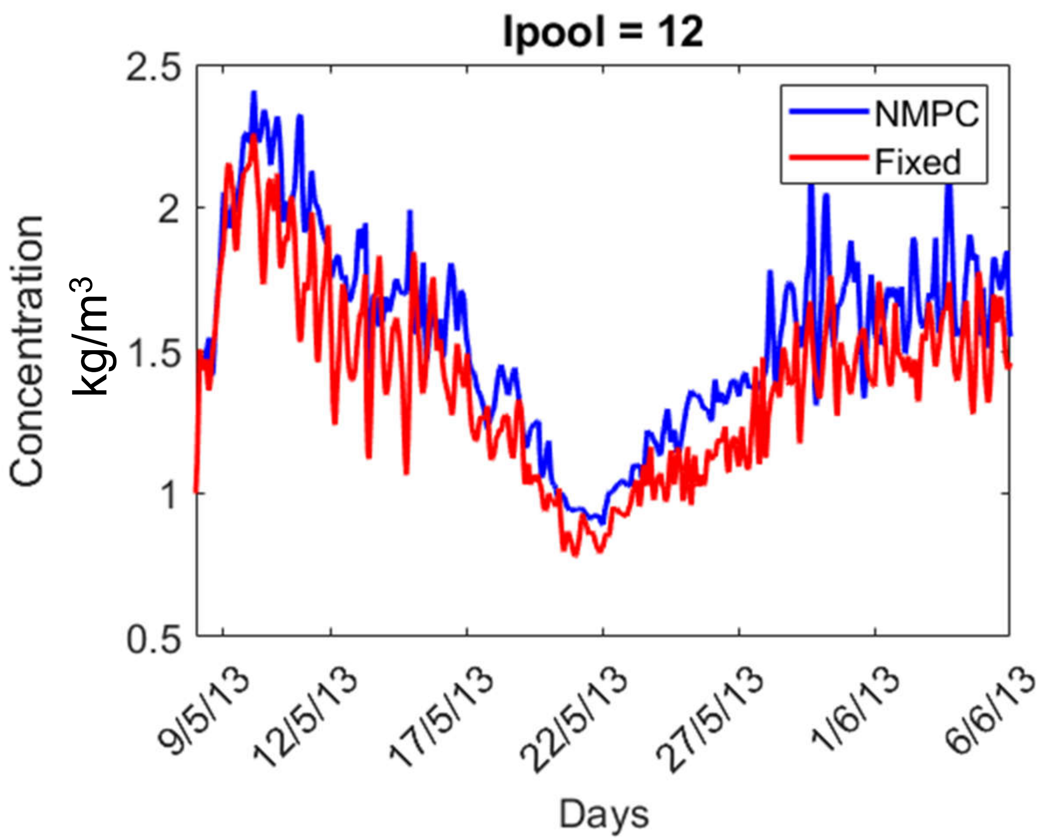
Results – Salinity Concentration



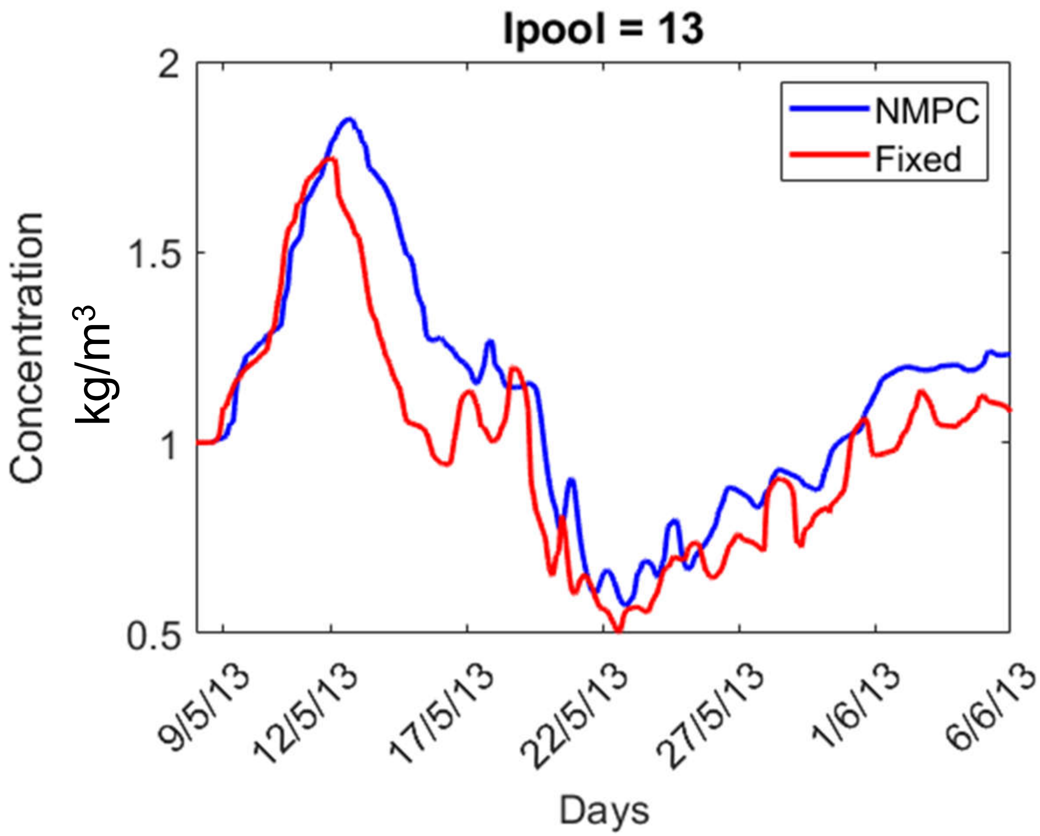
Results – Salinity Concentration



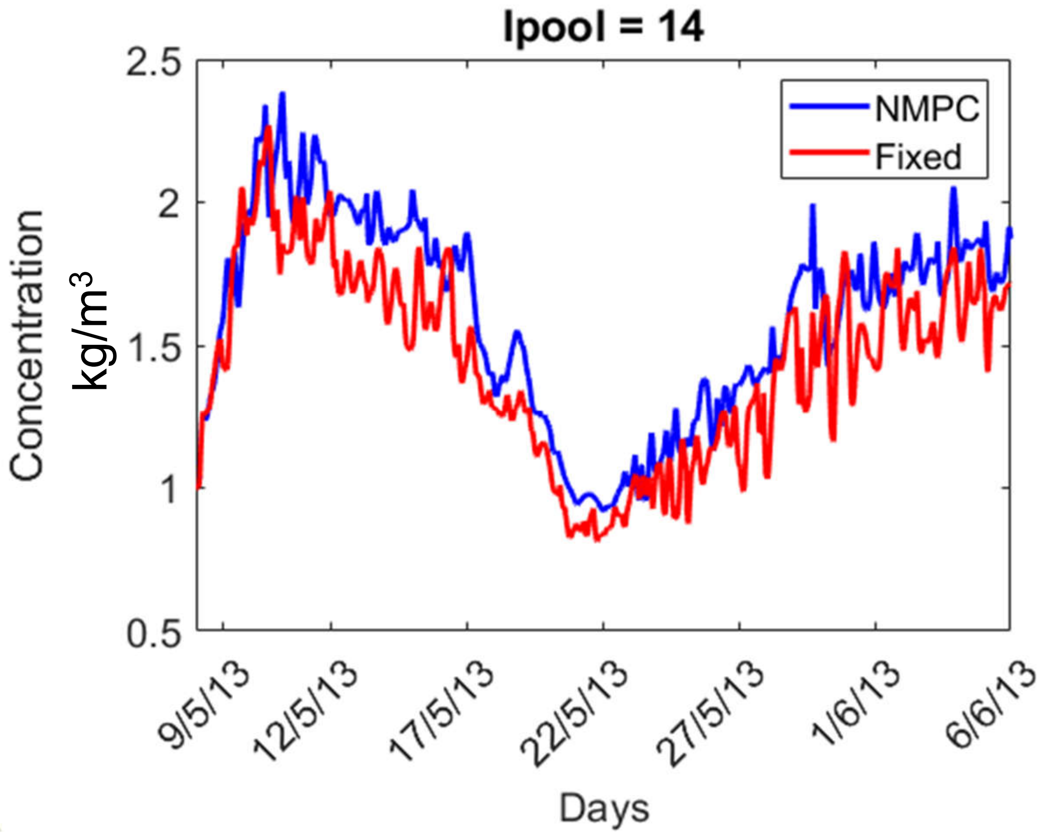
Results – Salinity Concentration



Results – Salinity Concentration



Results – Salinity Concentration



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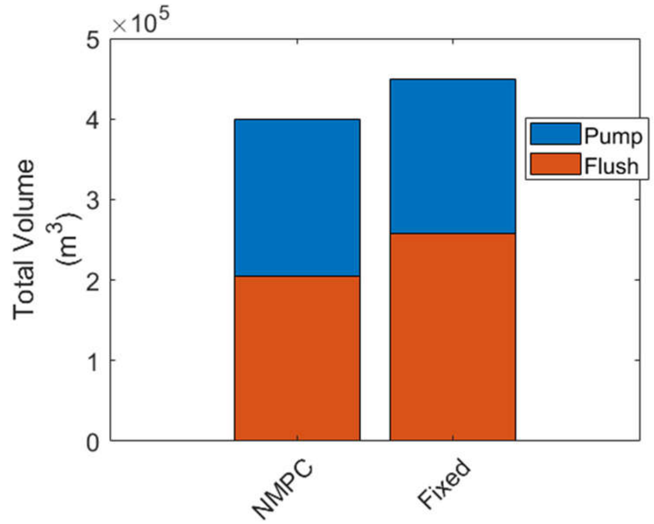
Comparison



	NMPC	Fixed
$\sum Q_{flush}$ (m^3)	$2.04*10^5$	$2.58*10^5$
$\sum Q_{pump}$ (m^3)	$3.98*10^5$	$4.49*10^5$

- %20.9 Freshwater
- %11.4 Pumping

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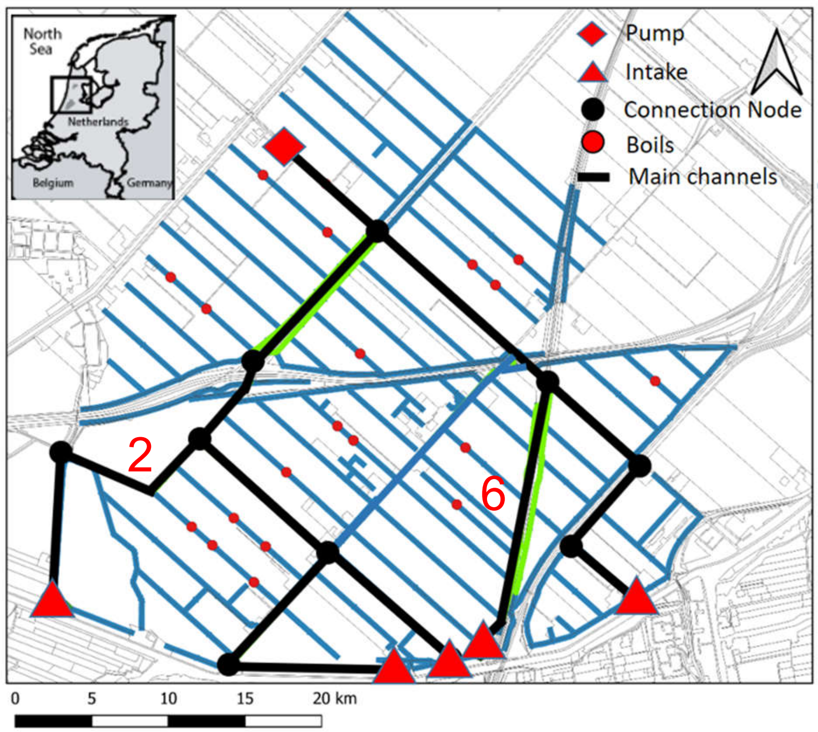
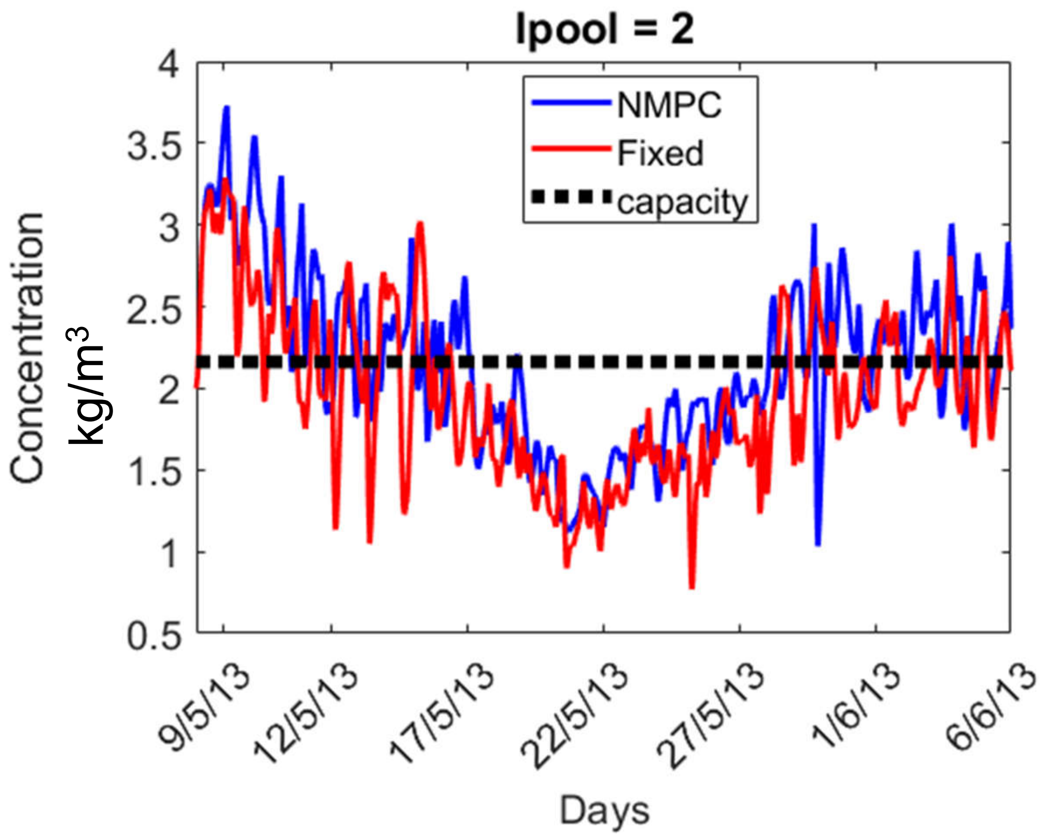
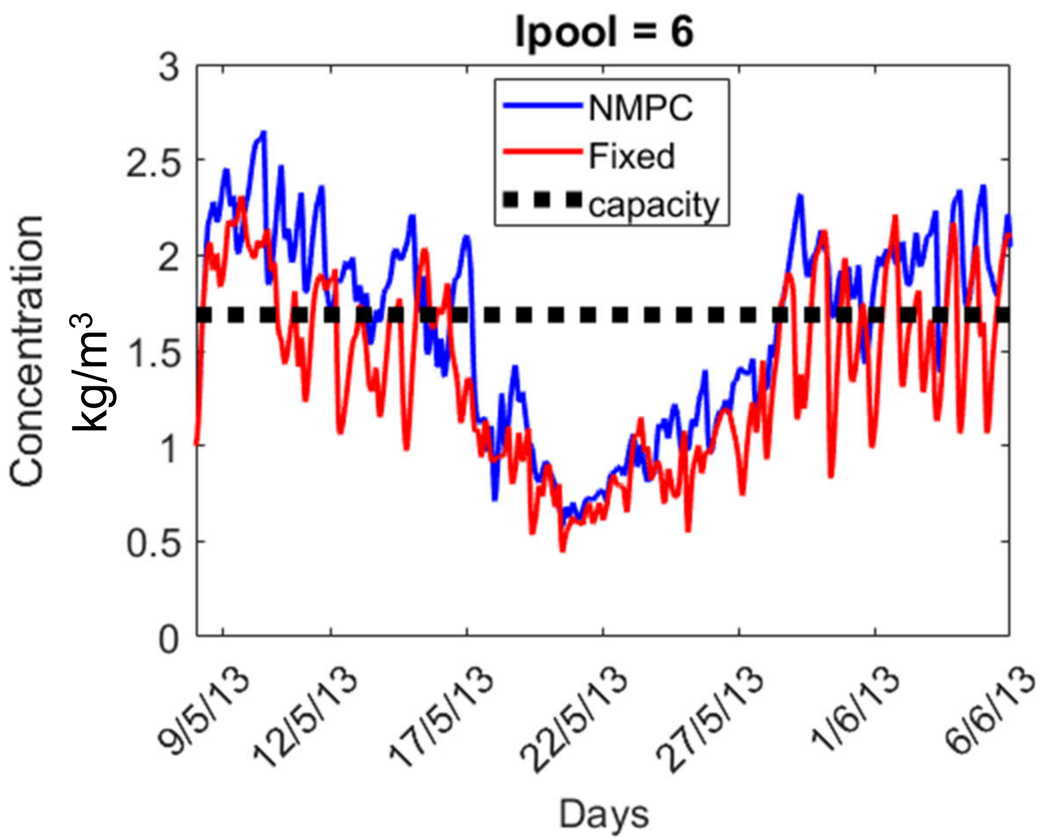
Bad Performance – Capacity?





Ipool = 2
NMPC
Fixed
capacity
Concentration
kg/m3
Days
0.5
1
1.5
2
2.5
3
3.5
4
9/5/13
12/5/13
17/5/13
22/5/13
27/5/13
1/6/13
6/6/13


Ipool = 6
NMPC
Fixed
capacity
Concentration
kg/m3
3
2.5
2
1.5
1
0.5
0
9/5/13
12/5/13
17/5/13
22/5/13
27/5/13
1/6/13
6/6/13
Days

Performance?

- Sufficiently good for the system capacity

Better Performance?

- Make it rain more
- Increase the intake capacity

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Conclusion

- MPC is effective for polders or other water systems
- Other quality parameters
- Limitations of current polder systems have to be addressed
- Farmer behaviour and farmer needs have to be implemented to the optimization

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WATER NEXUS

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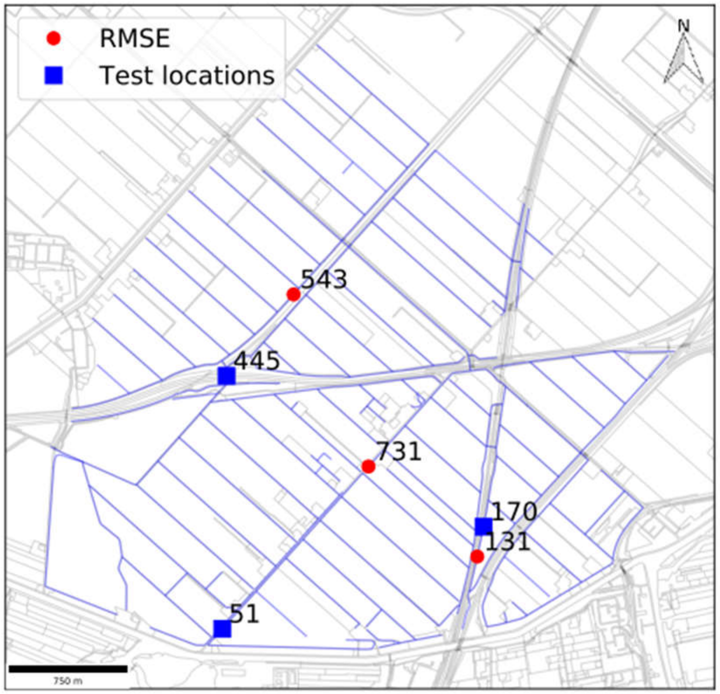
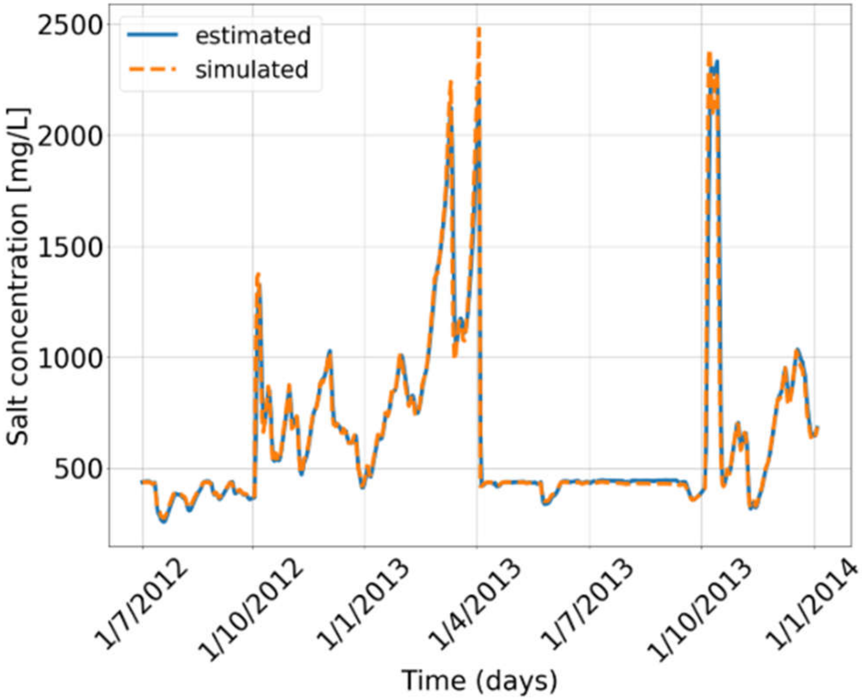

RMSE
Test locations
N
543
445
731
170
131
51
750 m


estimated
simulated
Salt concentration [mg/L]
2500
2000
1500
1000
500
1/7/2012
1/10/2012
1/1/2013
1/4/2013
1/7/2013
1/10/2013
1/1/2014
Time (days)