Impact of climate change on salinization during dry periods in Dutch polders and necessity of adaptation strategies

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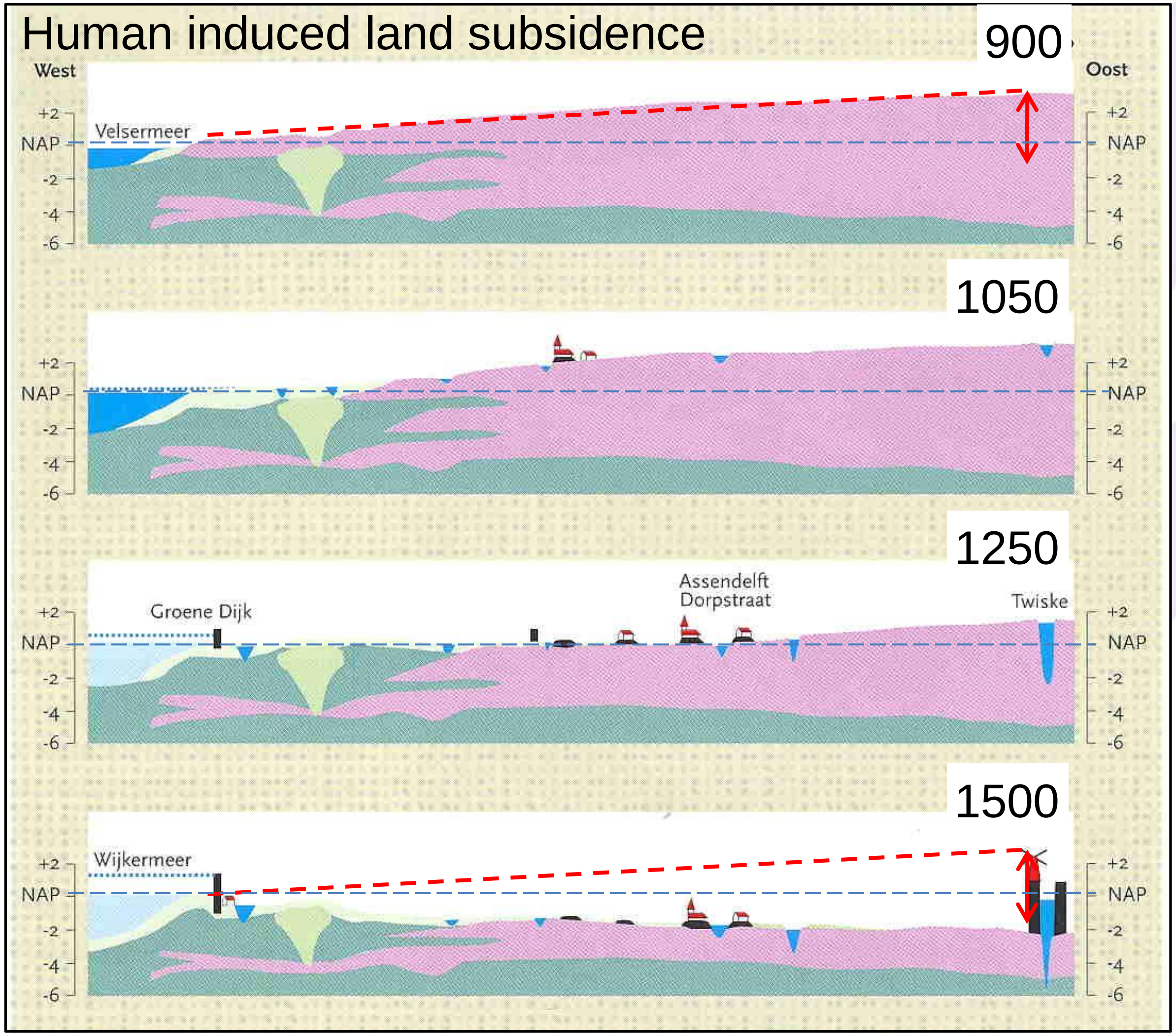
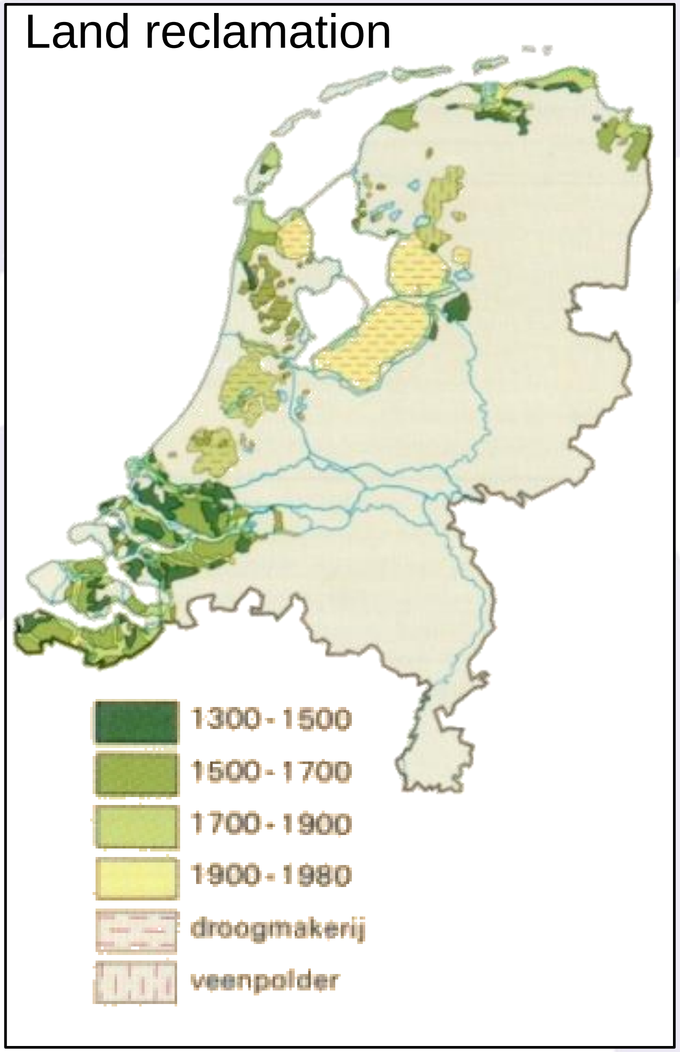
Acacia Water

Solutions in Groundwater

vrije Universiteit amsterdam

Human induced land subsidence and land reclamation since medieval times





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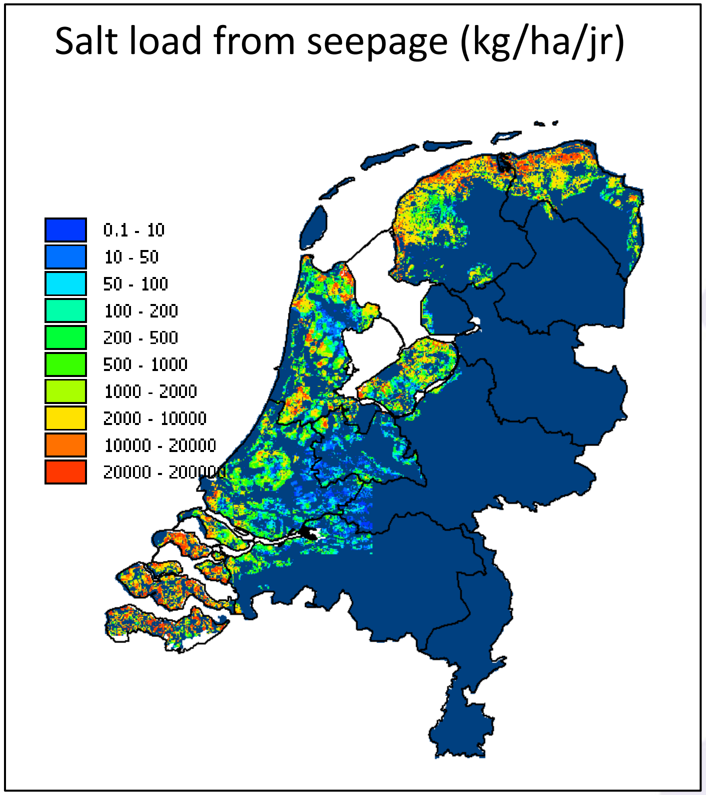
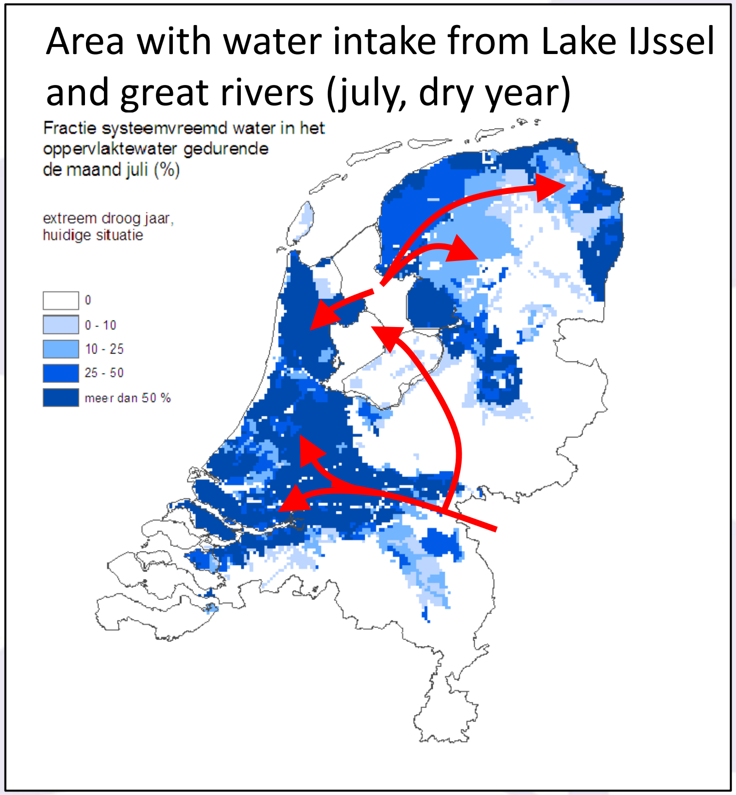
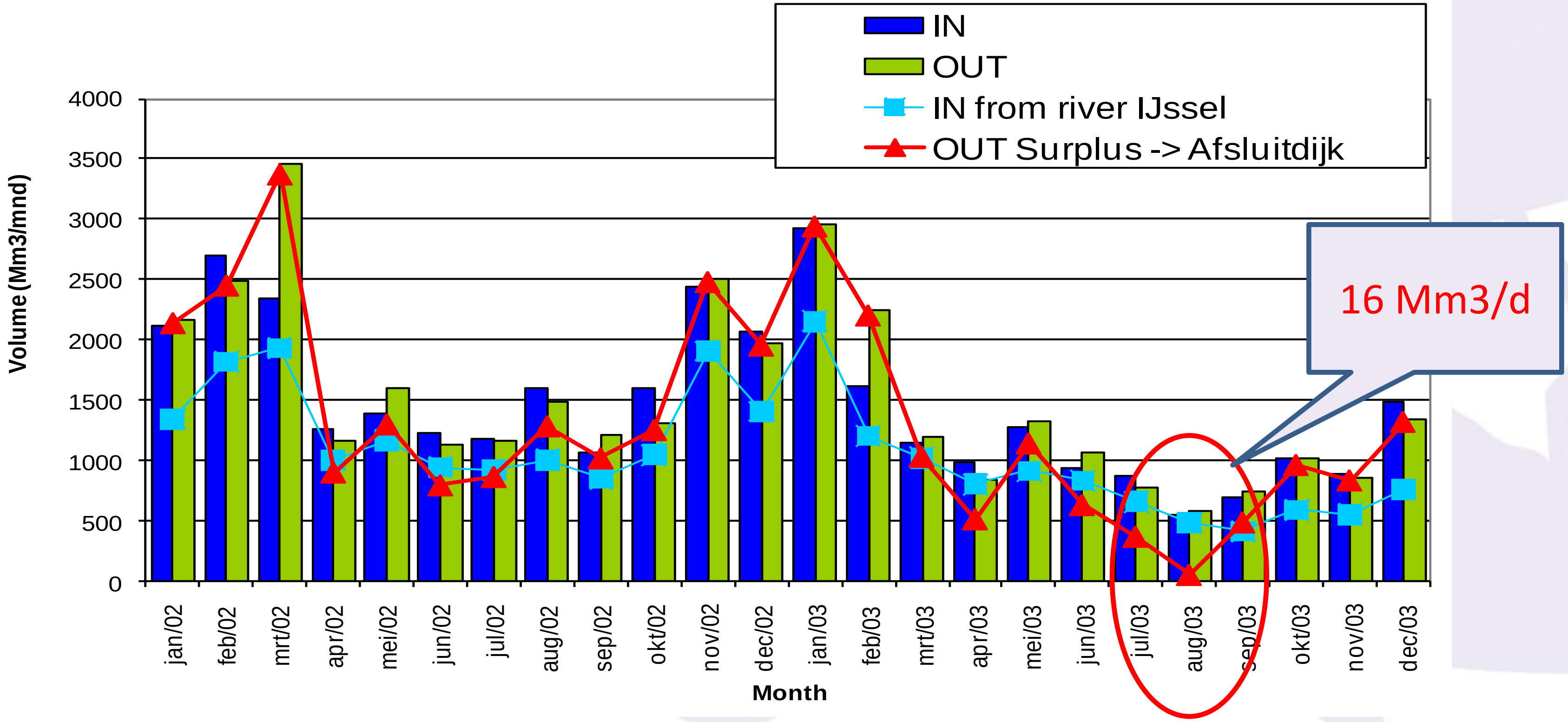
Flushing the water system





Purpose for water intake	
Supress high salt concentrations	45%
Compensate evaporation surface water -> safety dikes	35%
Sprinkler irrigation	15%
Other use	5%

Water shortage 2003



Year	Description	Recurrence (years) Current	Future (2050-scenario)
1976/1990	extremely salt	32.1	17.6
2003	salt	11.1	6.95
1996	average salt	3.33	2.51
1994	brackish	1.64	1.43
2002	moderate brackish	1.19	1.12

(Beersma, et.al 2005)

Climate change leads to an increased occurrence of periods with water shortage

• Increase of salinization – Sea level rise – Land subsidence – Meteorological changes	• More flushing to maintain water quality
• Increased evaporation	• Increase demand for sprinkler irrigation • More water needed to maintain water levels in surface water
• Trend for high yielding crops	• Increase demand for sprinkler irrigation and high quality water

- Decrease in water availability due to a decrease of water availability from the great rivers (Rhine)

Strategies for measures are being developed

- Adaptation (Salt tolerant crops, Convert agricultural area to nature reserve, …)
- Mitigation (Desalinization, Seasonal water storage, Pipeline from Germany, …)
- On national scale discussion on how to divide the water to different land use functions and parts of the country

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- What is the necessity for taking measures?
- Water intake is demand driven and not monitored
- Water shortage is estimated based on the historic actual intake

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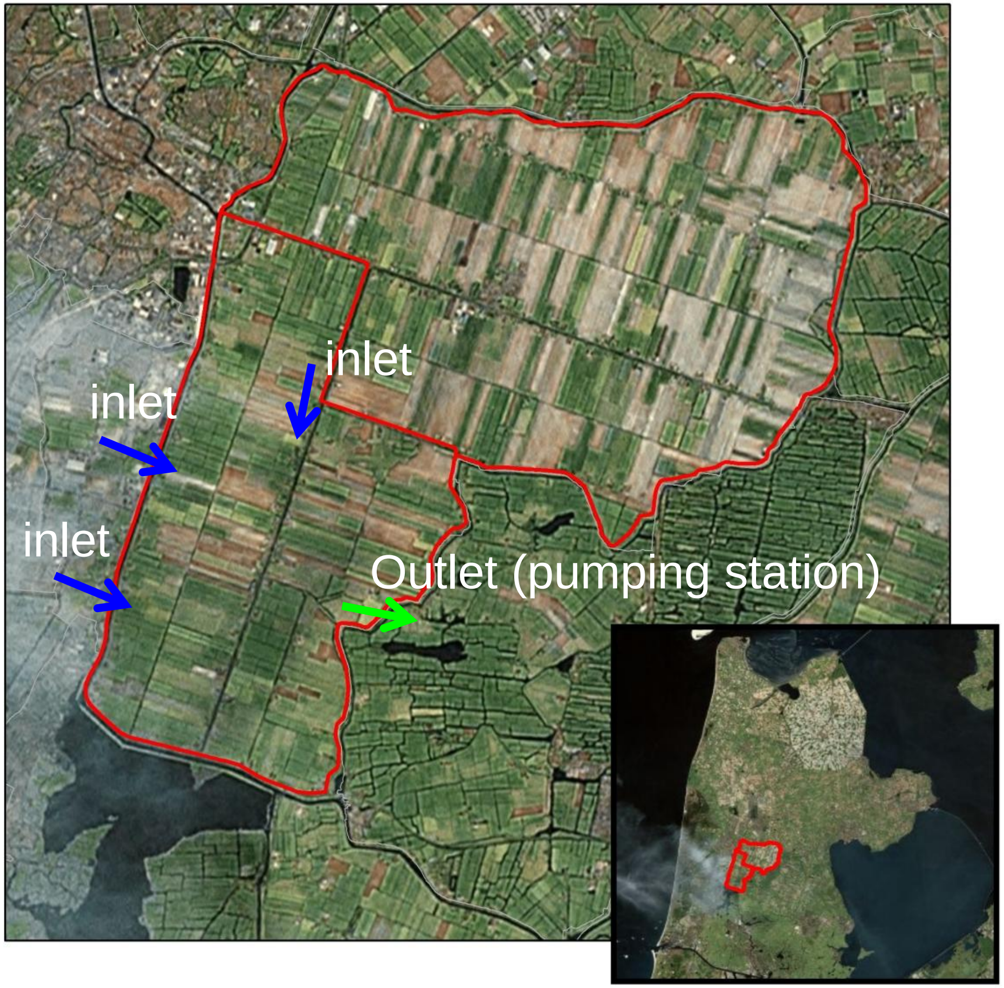
- How much water is needed to maintain good water quality for farming and safety of dikes
- Can the intake volume be reduced (current and under future climate scenarios)

Case polder Schermer

- Reclamed 17th century
- Surface area (± 1900 ha)
  - < 100 ha surface water
  - 1800 ha land
- One main inlet and
  several small inlets
  period april – october
  (appr. 30.000 m3/d)
- Outlet by pumping station
  (capacity 170 m3/min,
  appr. 244.000 m3/d)



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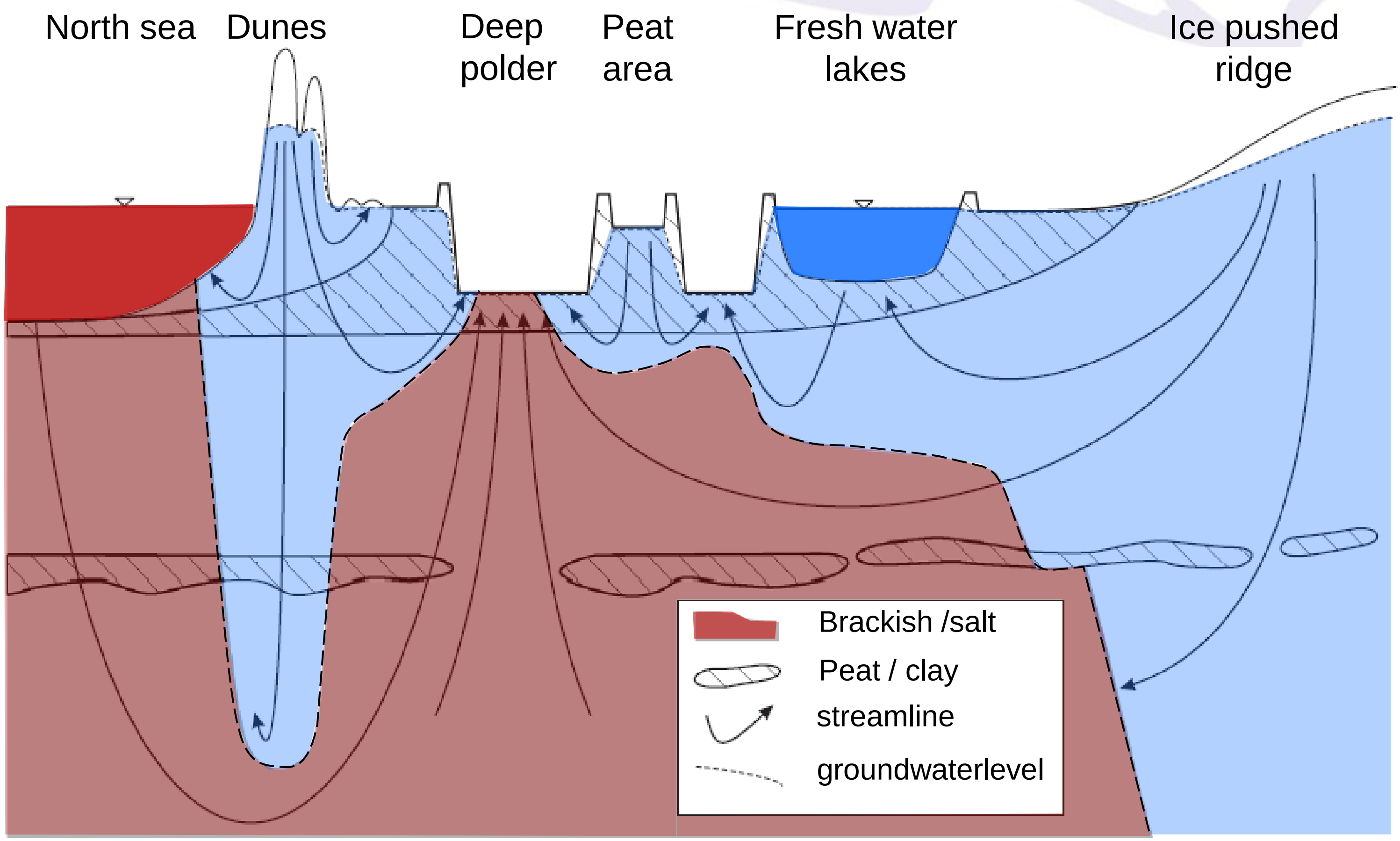
Typical cross-section

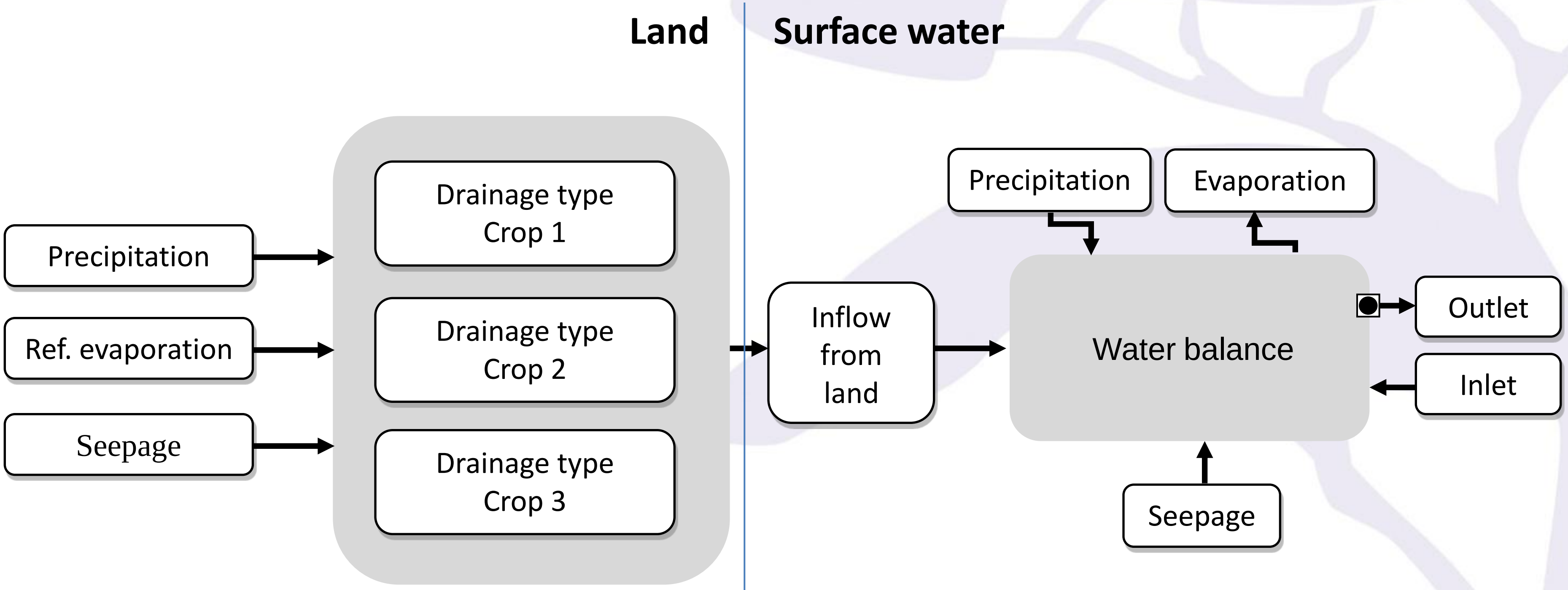
- Seepage
  - flux ± 0.5 mm/day
  - concentration 100 - 8000 mg/l

- Precipitation ±2.2 mm/d
- Evaporation ±1.6 mm/d
- Net Prec. ±0.6 mm/d



Water balance approach

- Fluxes and chloride balance on a daily basis
  - Water
  - Chloride

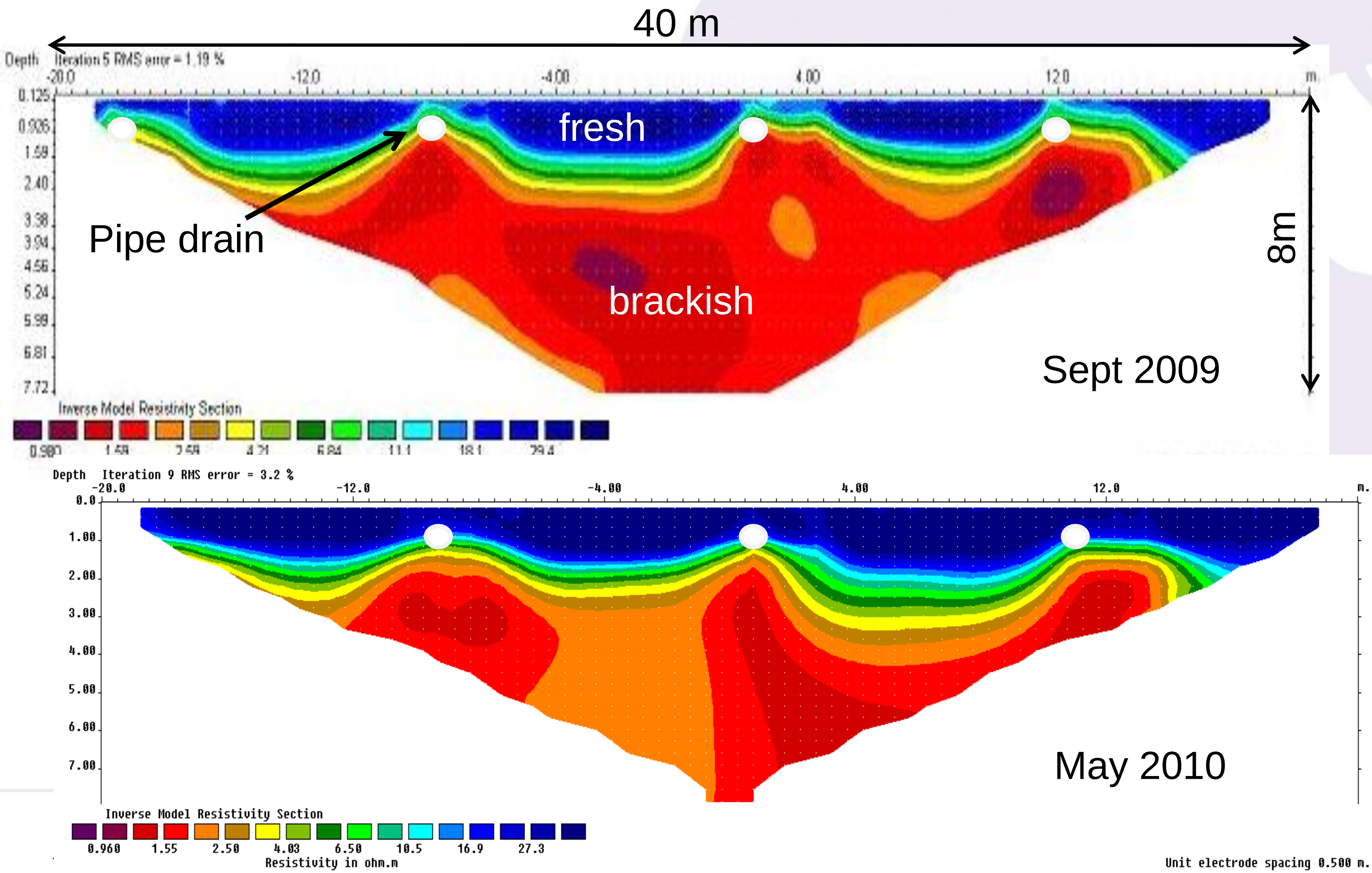


Unsaturated zone model SWAP
(Kroes, et.al. 2008)

Excel

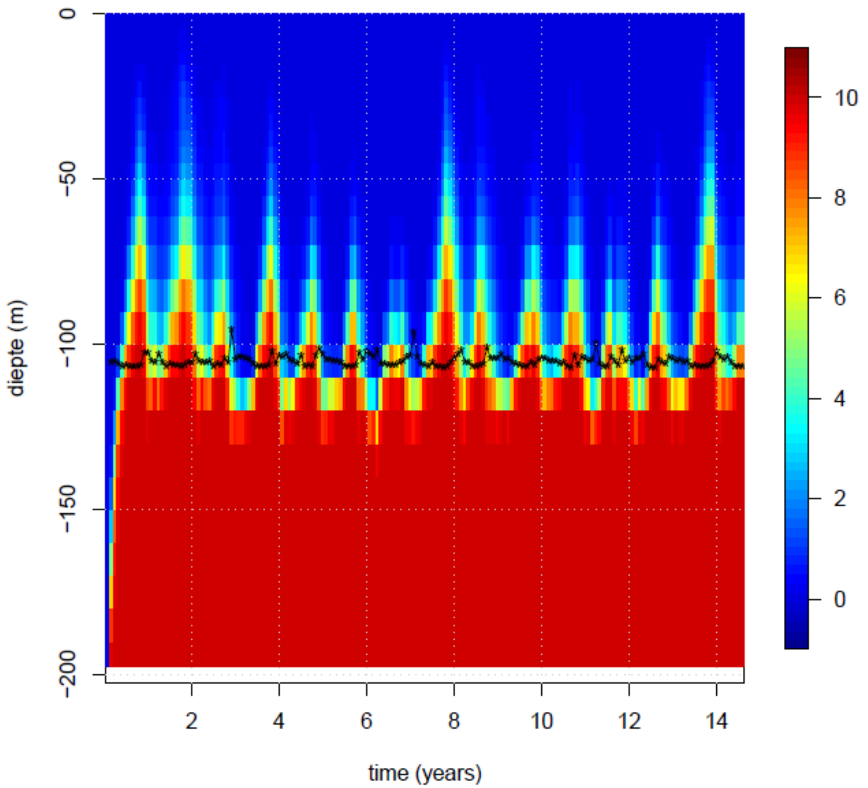
Measurements on fresh water lens and salt accumulation

- Geophysical measurements (CVES) on an agricultural field

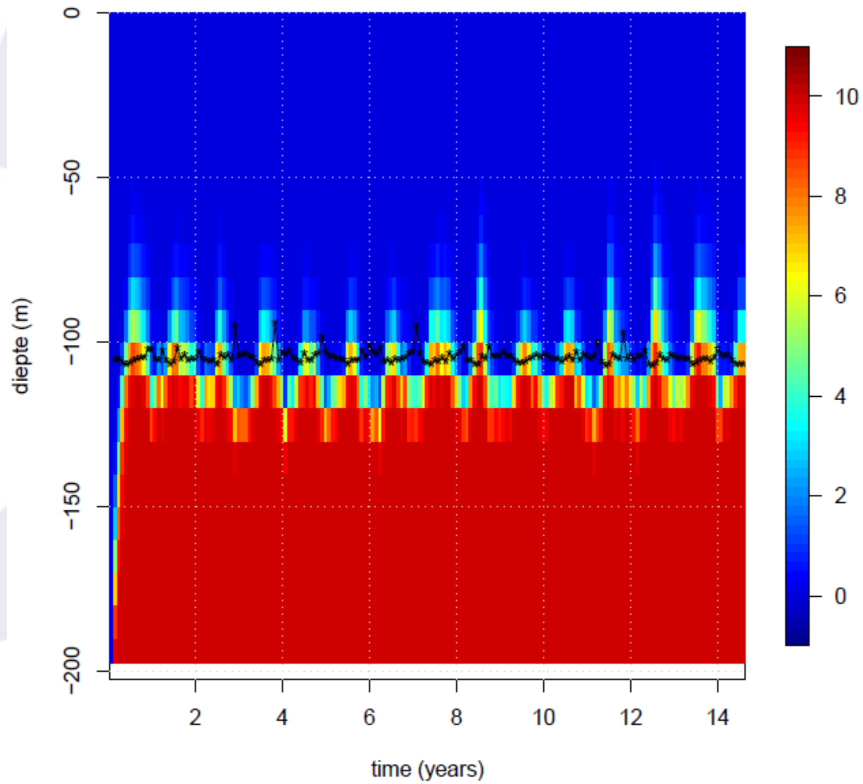


SWAP: Fresh water lens and salt accumulation

Grass



Potato



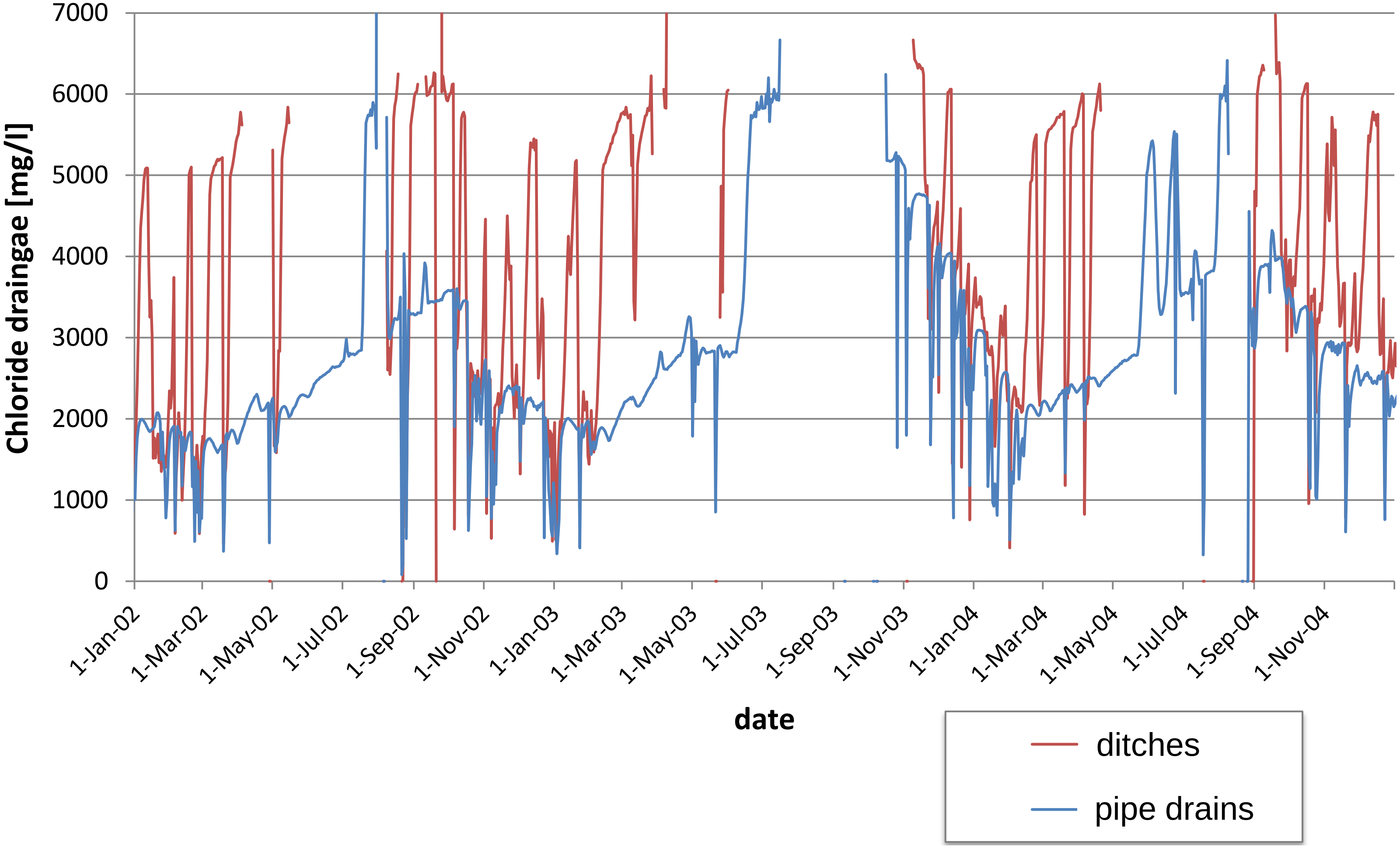
Rooting depth = 30cm

Transp (40cm/yr)> evap(8cm/yr)

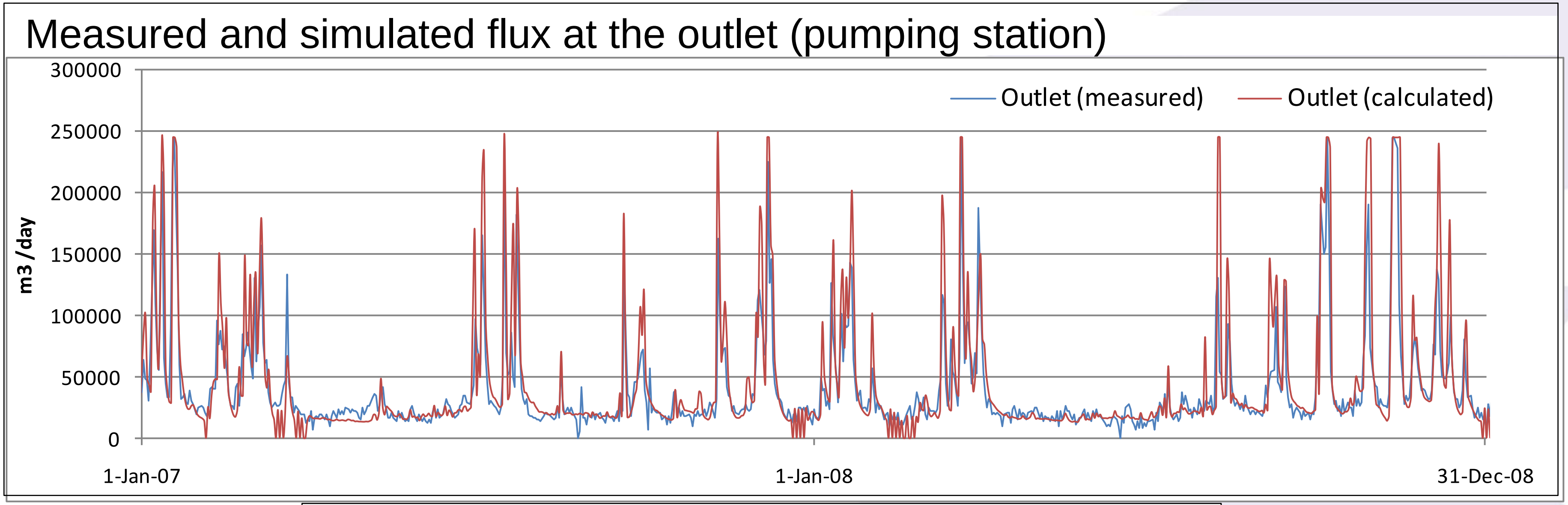
Rooting depth = 10-50cm

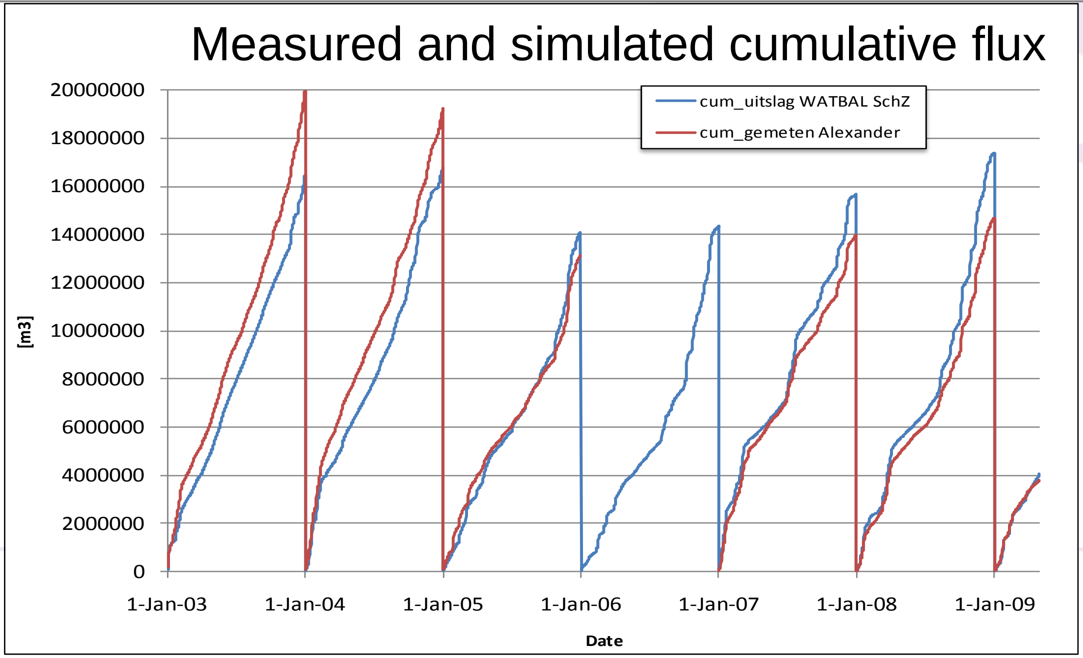
Transp (15cm/yr) ~ evap(18cm/yr)

SWAP: Chloride discharge from ditches and pipe drains



Water balance: Calibration results





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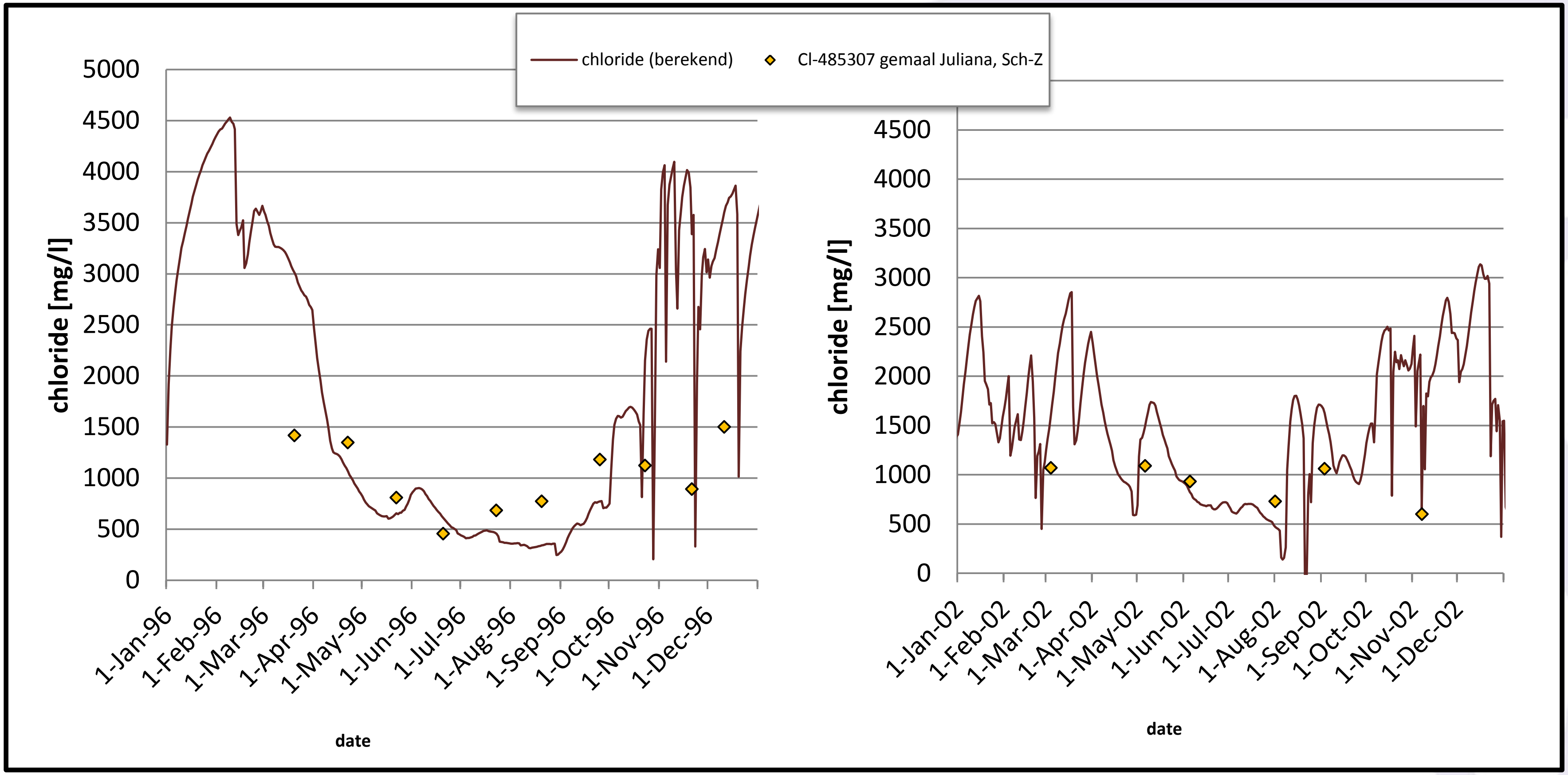
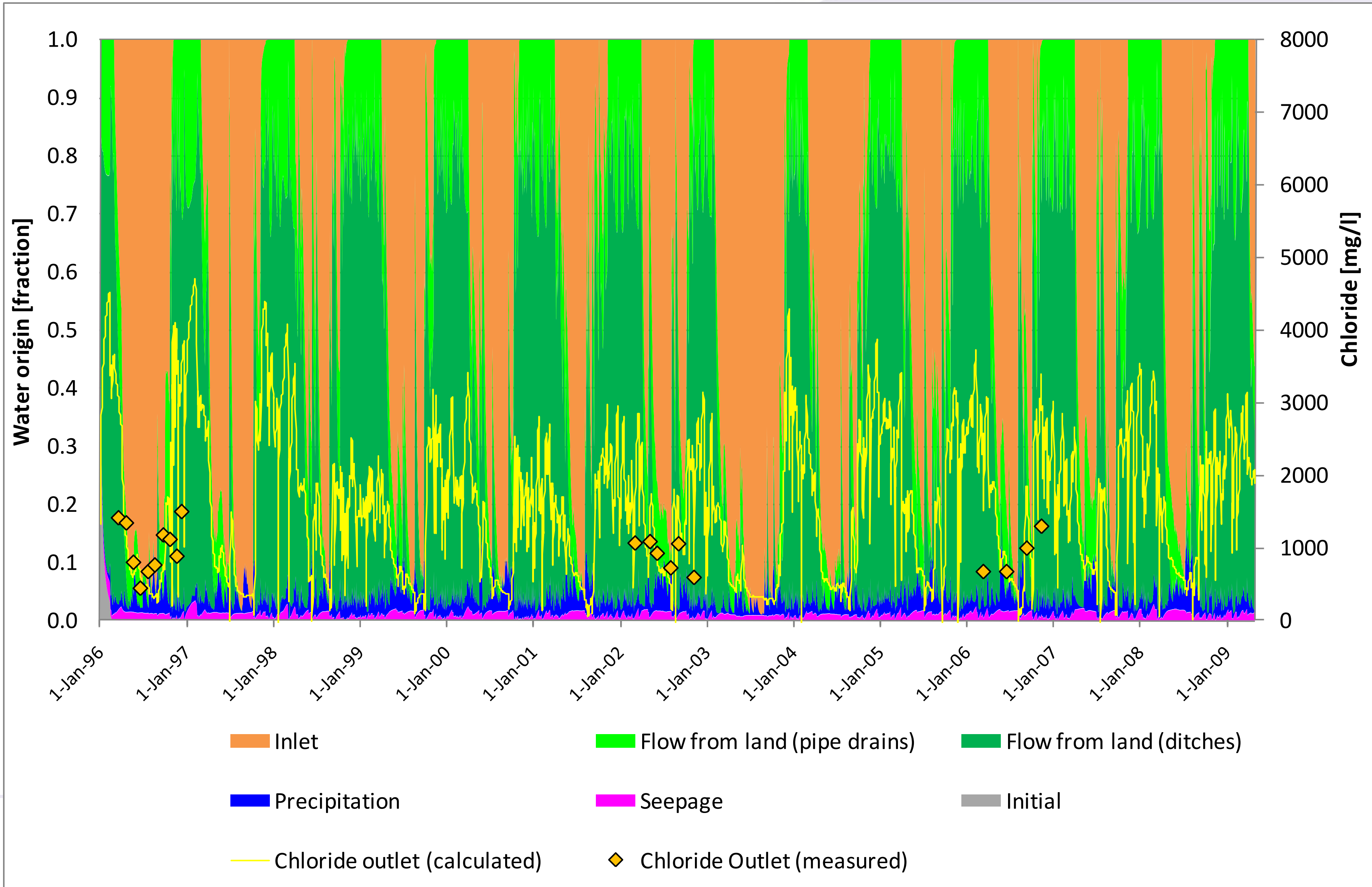
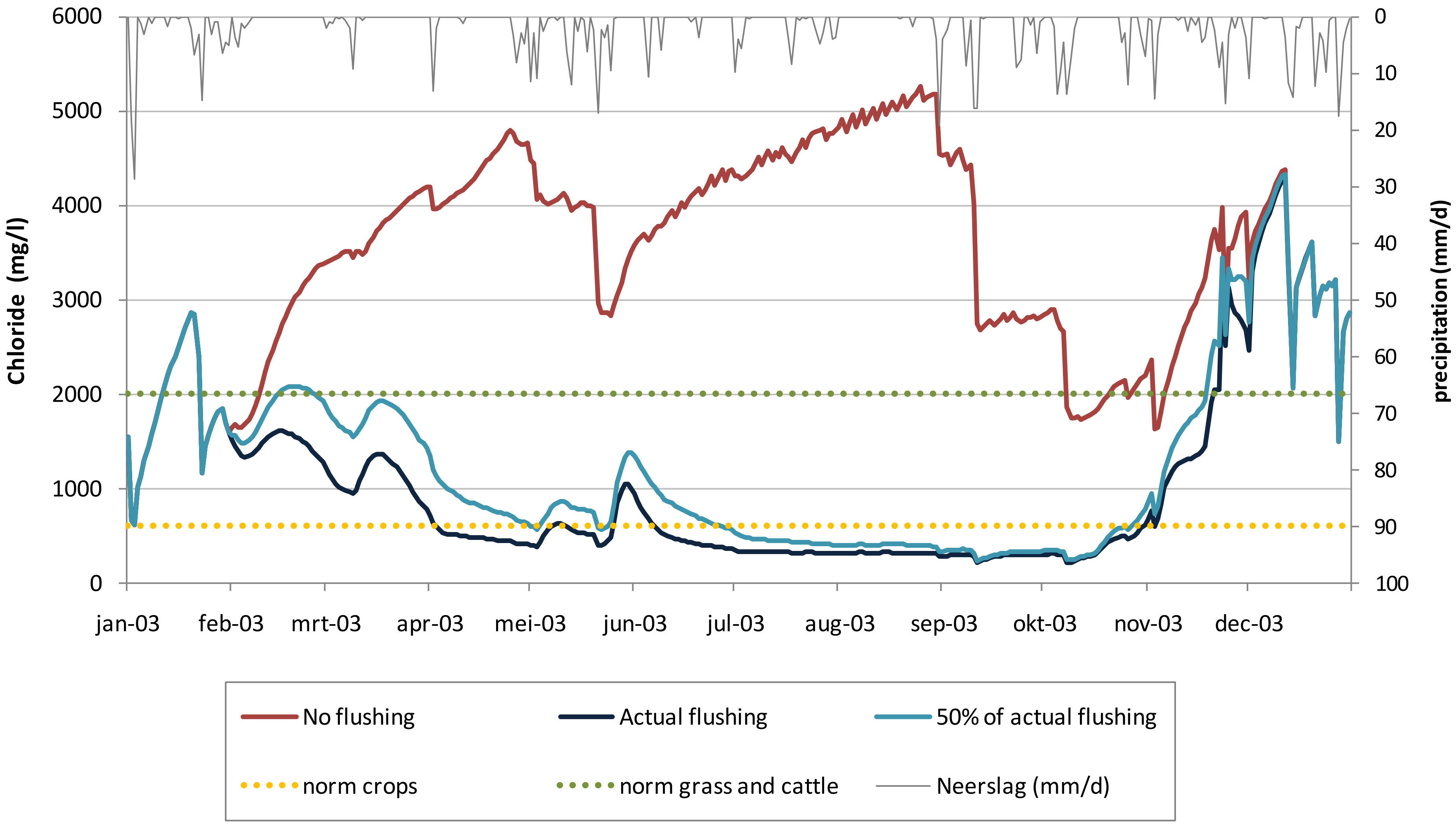


Water balance: Origin of the surface water in the polder



Chloride concentration with different inlet amounts



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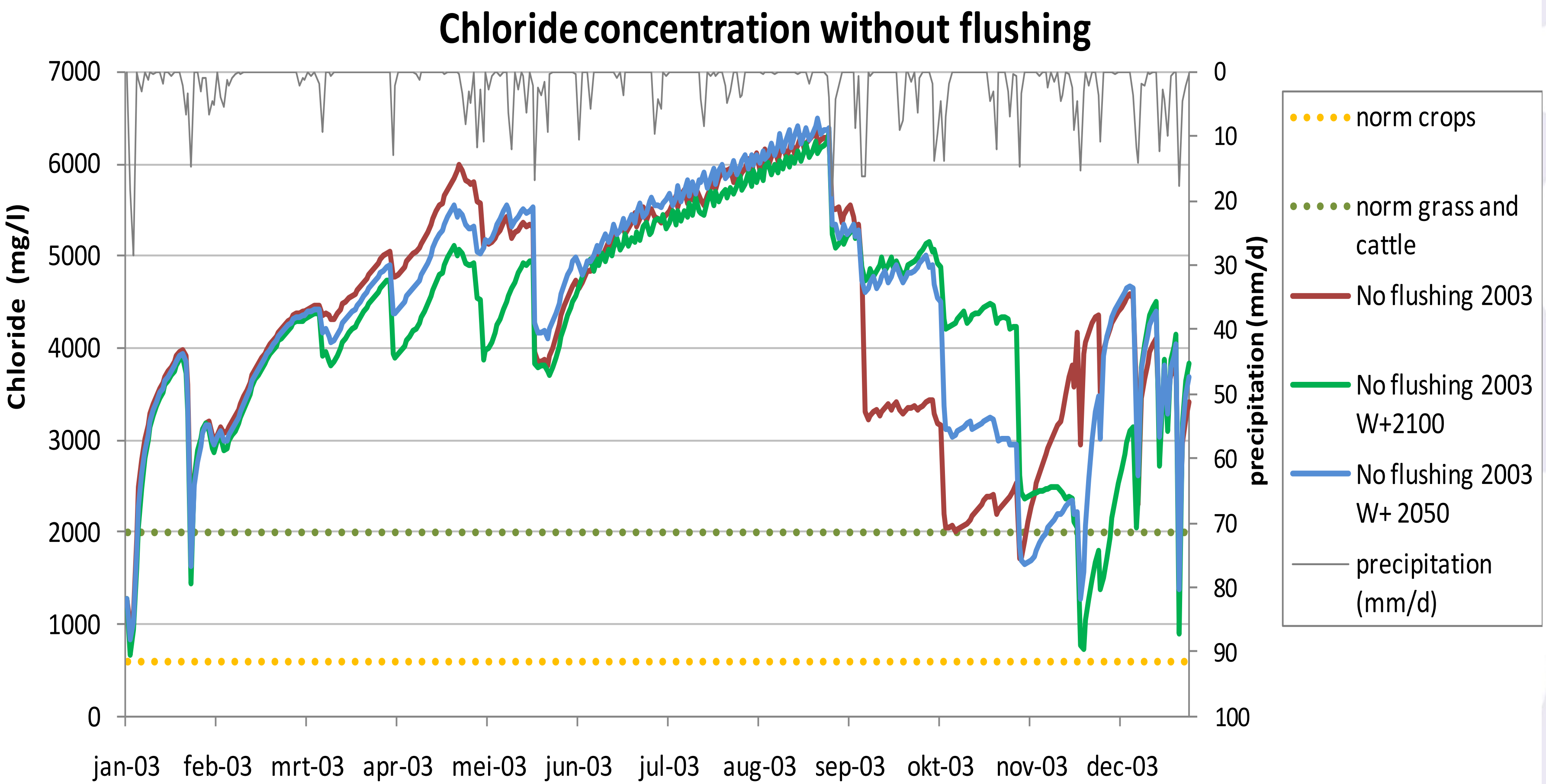
Climate scenarios

		2050				2100			
		G	G+	W	W+	G	G+	W	W+
Worldwide temperature rise		+1°C	+1°C	+2°C	+2°C	+2°C	+2°C	+4°C	+4°C
Winter	average precipitation increase	4%	7%	7%	14%	7%	14%	14%	28%
Summer	average precipitation increase	3%	-10%	6%	-19%	6%	-19%	12%	-38%
	potential evaporation increase	3%	8%	7%	15%	7%	15%	14%	30%

- Climate scenarios made available for all meteo stations by the Dutch Meteorological Institute
  - Precipitation with daily values
  - Potential evaporation with monthly averages

Chloride concentration with different climate scenarios (no flushing)



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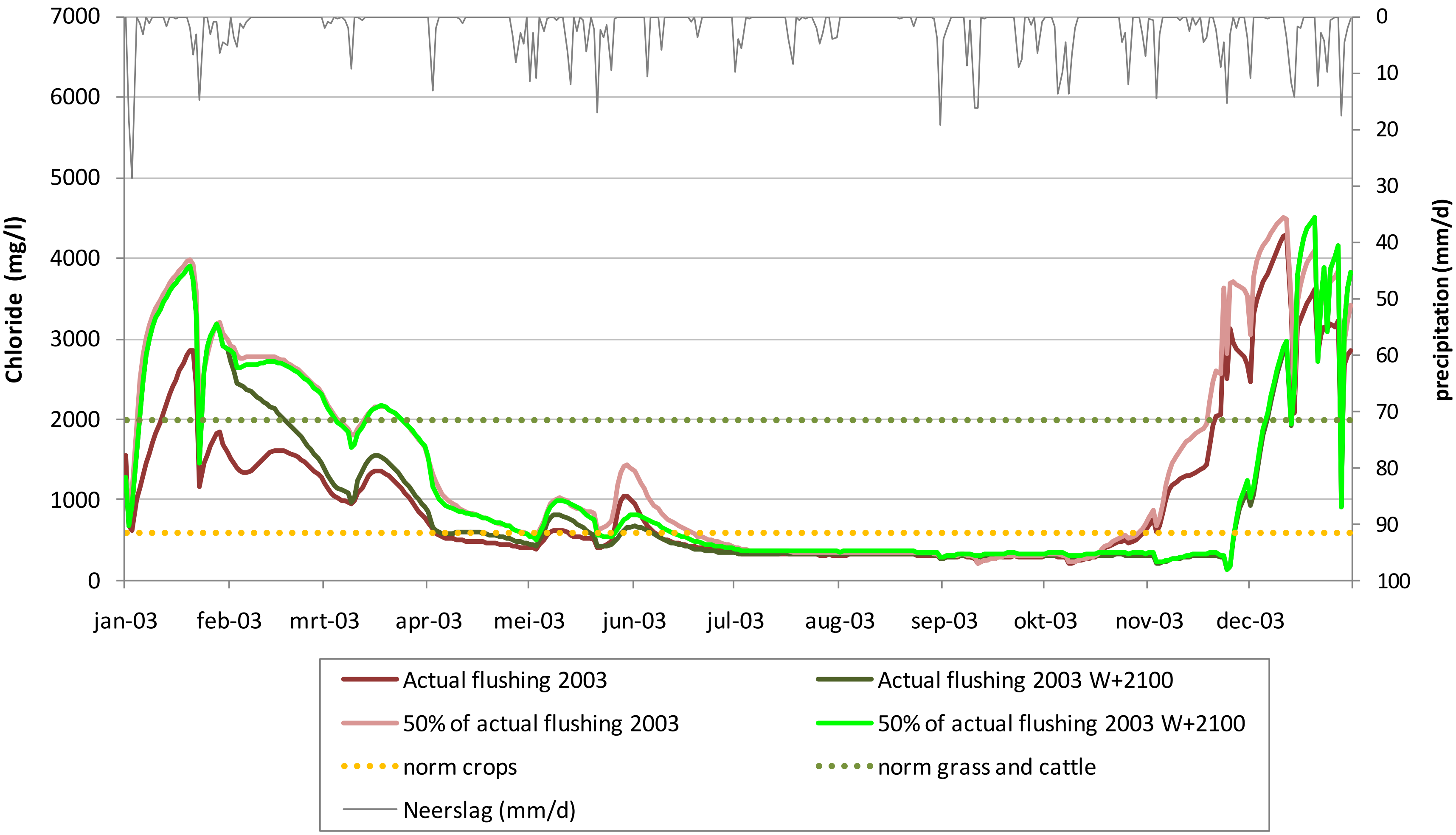
Chloride concentration with different climate scenarios (with flushing)



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Conclusions and further research

- Impact of meteorological change is limited, but
  - Increased salinization due to sea level rise and land subsidence is not accounted for
- In current climate and future climate scenarios a reduction of water intake by 50% is feasible
- Challenge to move forward to efficient distribution and monitoring intake. Which should lead to intake amounts adjusted to the specific purpose.
- Simulations show a decrease of thickness fresh water lens and salt/brackish water reaching the root zone
- Processes on a field scale are important but processes not fully understood. Currently working on:
  - Measurements in different polders for a period of 1-2 years. Water- and mass balance measurements on a field and polder scale
  - Development of fresh water lenses and salt accumulation in the unsaturated zone
  - Model simulations include (un)saturated density dependant flow and transport modeling

Thank you for your attention