



## Målinger på overløb – hvor svært kan det være?

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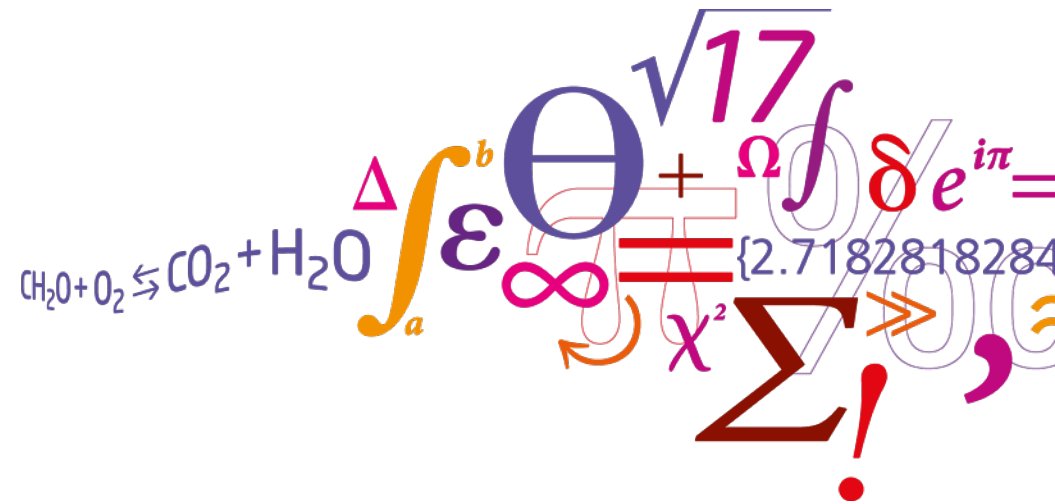
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# Målinger på overløb – hvor svært kan det være?

Lektor Luca Vezzaro

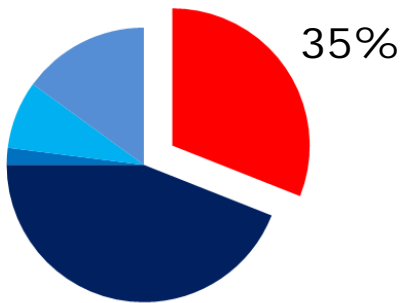
d. 29. Maj 2018



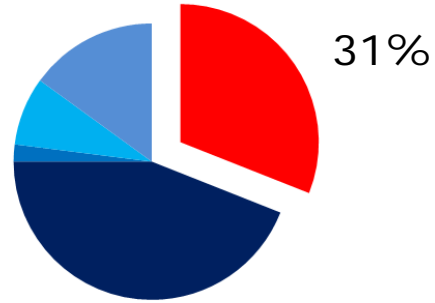
# Hvor stort er problemet?

## Pollutant contribution from point discharges in DK (2015)

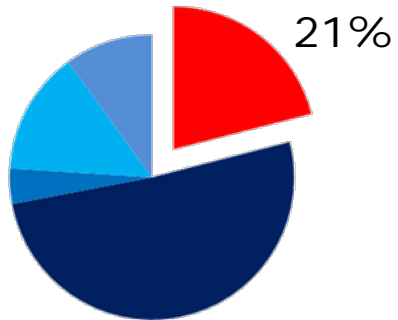
### Organic matter



### Phosphorous



### Nitrogen



■ wet weather discharges
 ■ aquaculture
 ■ low density housing
 ■ industry
 ■ WWTP

Source: Miljø- og Fødevarerministeriet Styrelsen for Vand- og Naturforvaltning (2017). Punktkilder 2015

- Hvordan får vi disse tal?

- Målinger / modeller

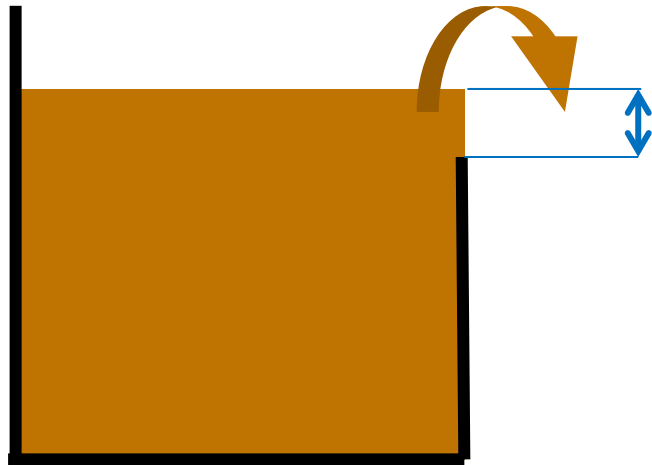
- Kvantitet

*Hvor meget overløbsvand blev udledt?*

- Kvalitet

*Hvor forurenede overløbsvandet var?  
(stofmængde / koncentrationer)*

# Hvor meget vand løber ud?



$$Q = C_d \frac{2}{3} B \sqrt{2g} H^{\frac{2}{3}}$$

Længde af overløbskanten

(kendt)

Koefficient (form af kanten)

(fra tabeller/bøger)

Vandhøjde over kanten

(den måler vi)

# Hydrauliske målinger



Overløbskanten

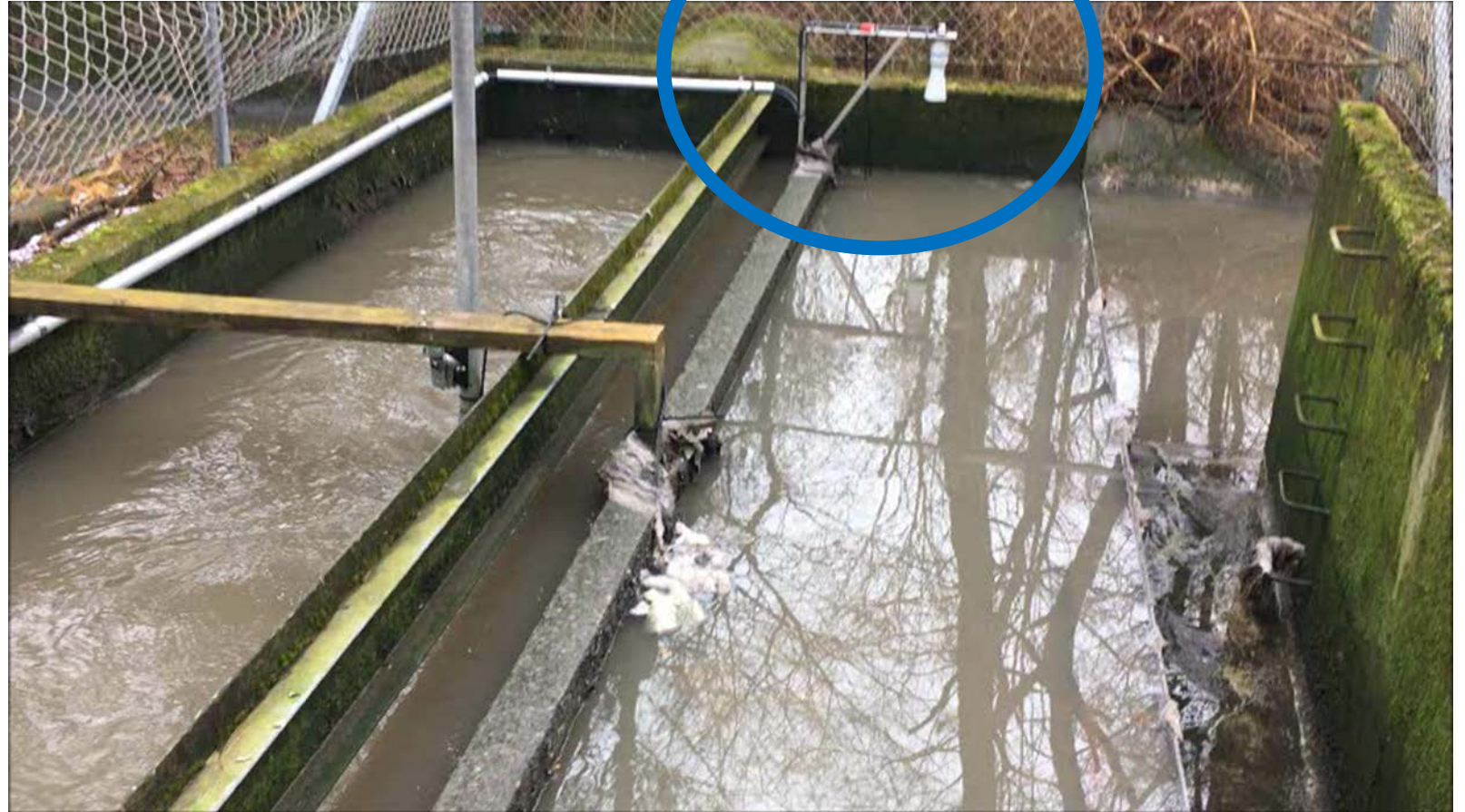


# Hydrauliske målinger

Niveaumåler

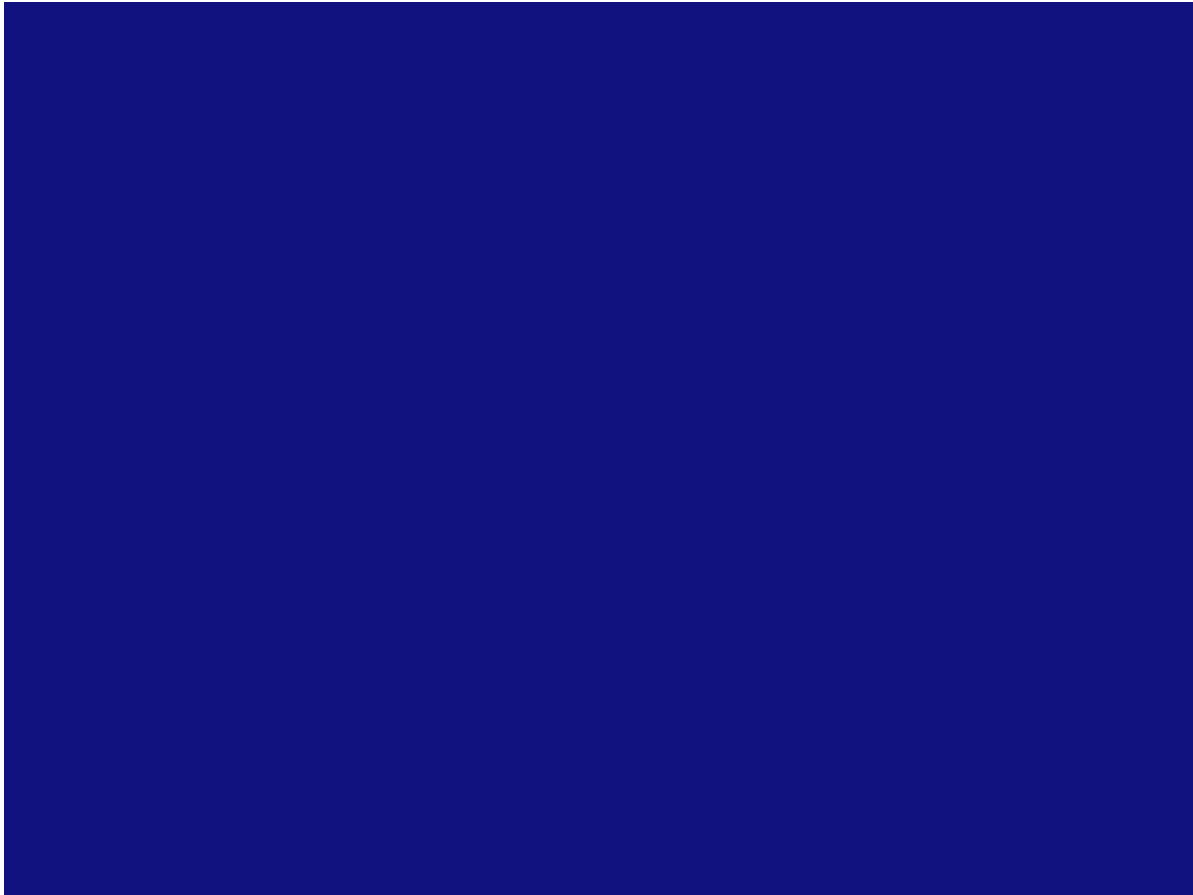


Overløbskanten



# Hydrauliske målinger (lidt mere kompliceret)

Video courtesy of our colleagues  
from TU Graz (Austria)



# Hydrauliske målinger (lidt mere kompliceret)

Video courtesy of our colleagues  
from TU Graz (Austria)

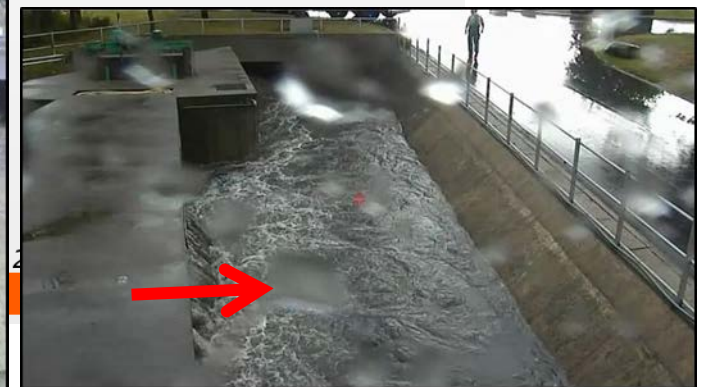
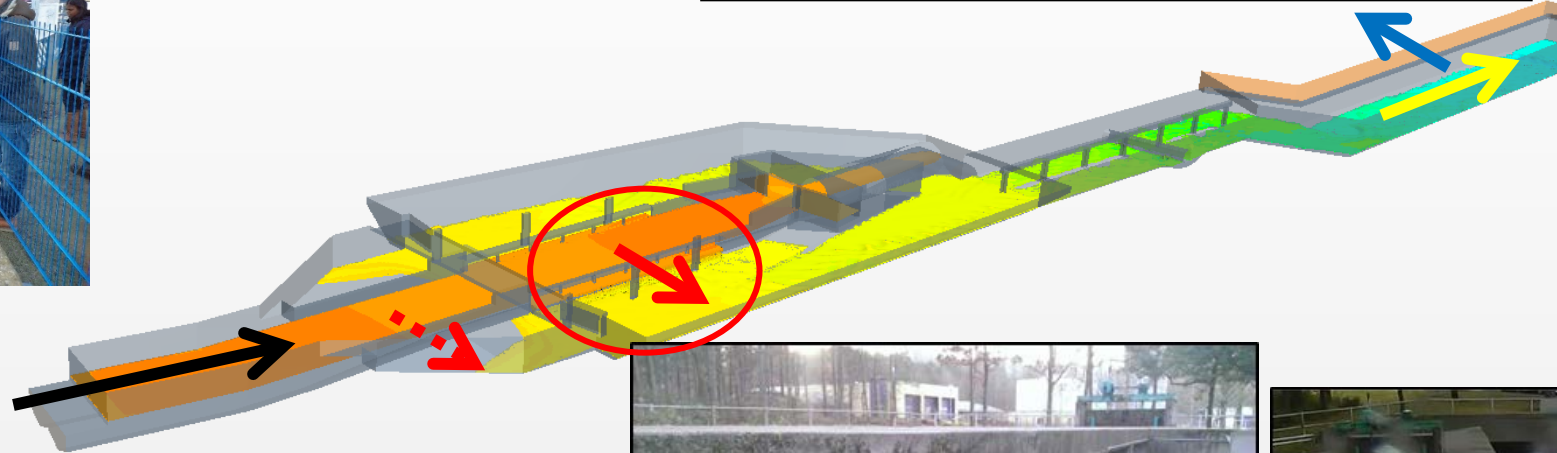




# Viby Renseanlæg (Aarhus)



IR-CCM+



# Kan vi stole på volume målinger?

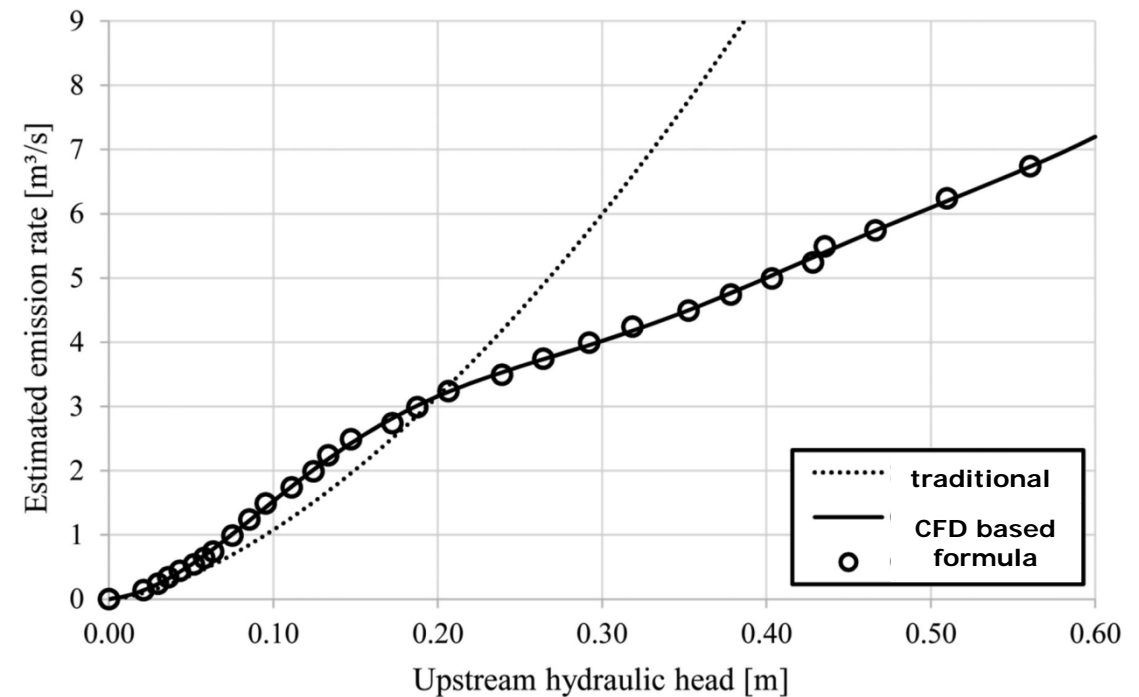
Deviation Measured vs. Estimated

Event no.	Traditional weir formula[%]
1	-28.74
2	-26.82
3	-25.52
4*	-31.73
5*	-27.12
Total	-28.36

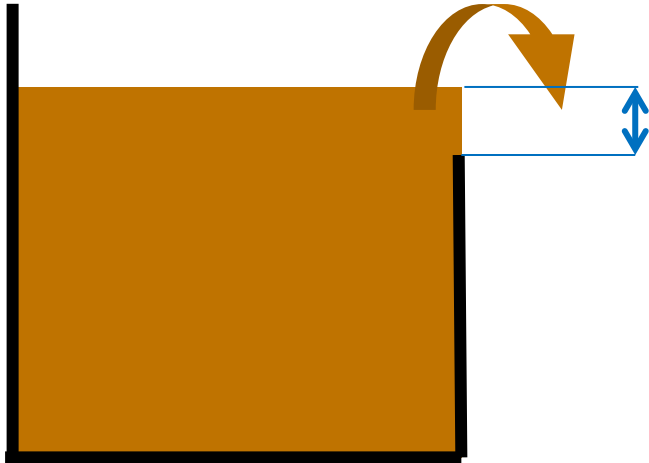
  
**25-30% error on volume**



**<5% error with  
CFD based formula**



# Hvor meget vand løber ud?



$$Q = C_d \frac{2}{3} B \sqrt{2g} H^{3/2}$$

Længde af overløbskanten

(kendt)

Vandhøjde over kanten

(den måler vi)

Koefficient (form af kanten)

~~(fra tabeller/bøger)~~

Den kan vi regne ud med CFD



På et repræsentativ sted

Hvad er energitab koefficient for en tilstoppet riste????

Der vil altid være en vis usikkerhed på volumen beregninger (både målt og modelleret)

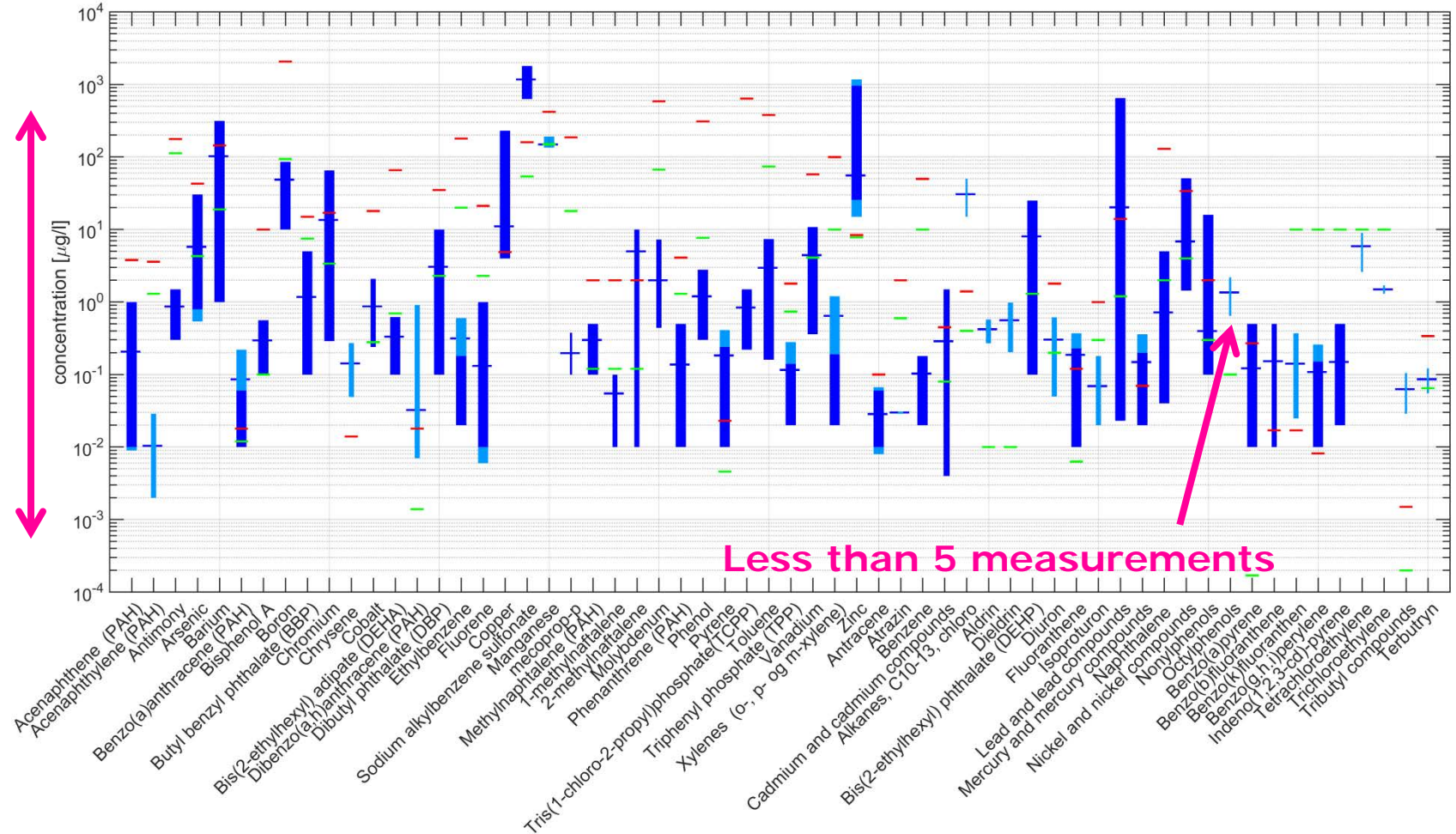
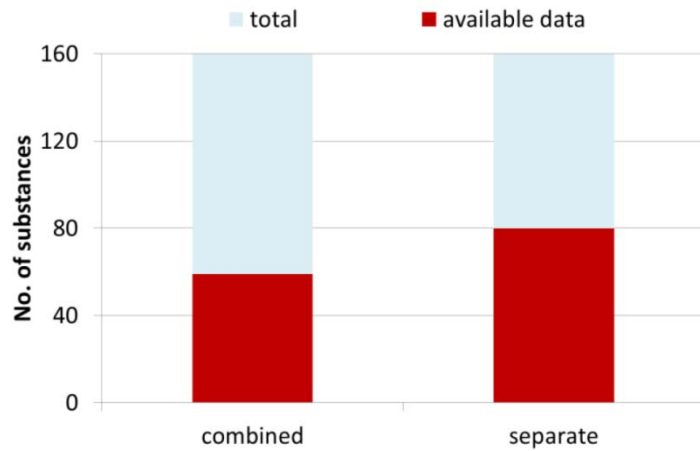
# Hvor forurennet er overløbsvandet?

- Koncentrationer i overløbsvandet er afhængig af forskellige processer
- Forskellige muligheder for at måle overløbskvantitet
  - Mulighed #1: Ingen Målinger  
*Man bruger typiske værdier fra litteratur*
  - Mulighed #2: Automatiske prøvetager
  - Mulighed #3: Online sensorer

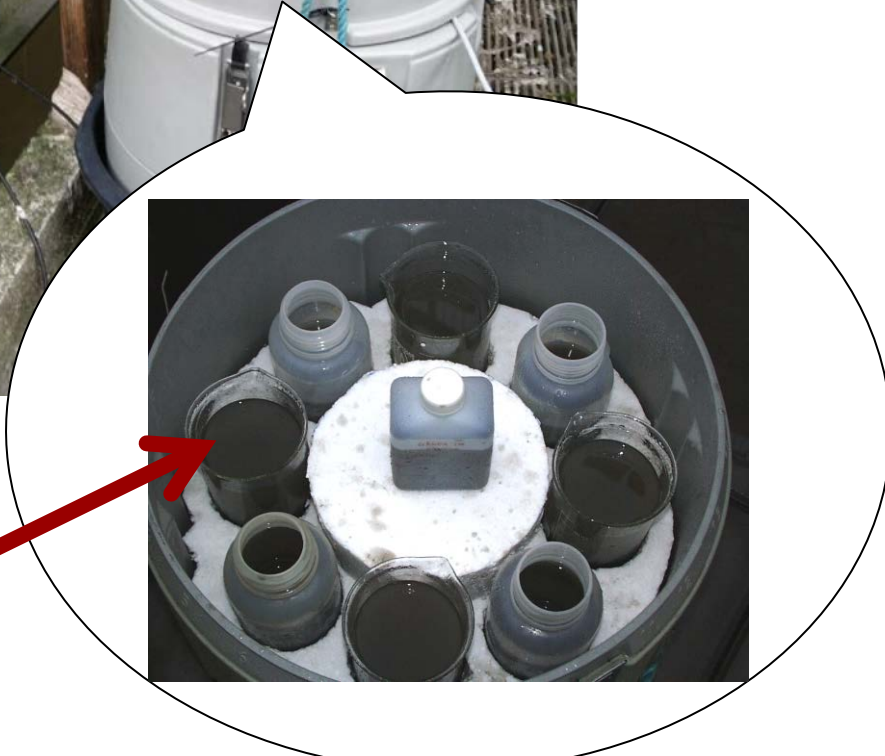
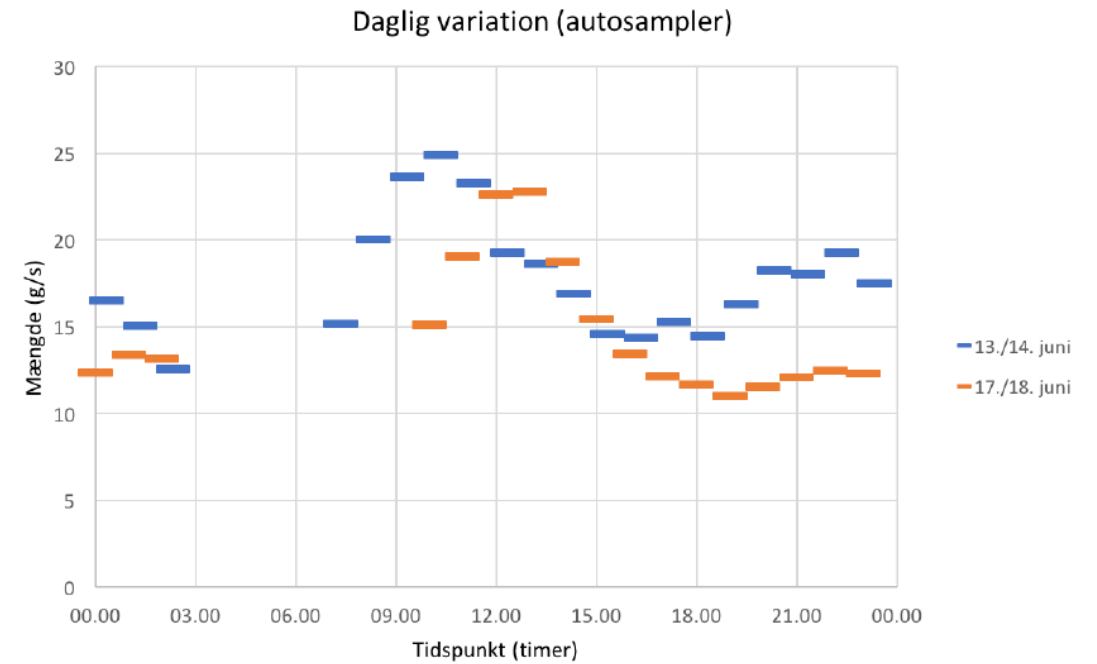
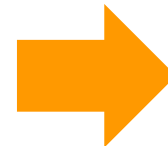


# #1: Målte koncentrationer i overløbsvand

- Rain-related discharges are high variable
  - rainfall
  - pollutant sources
- Data for non-traditional pollutants are limited



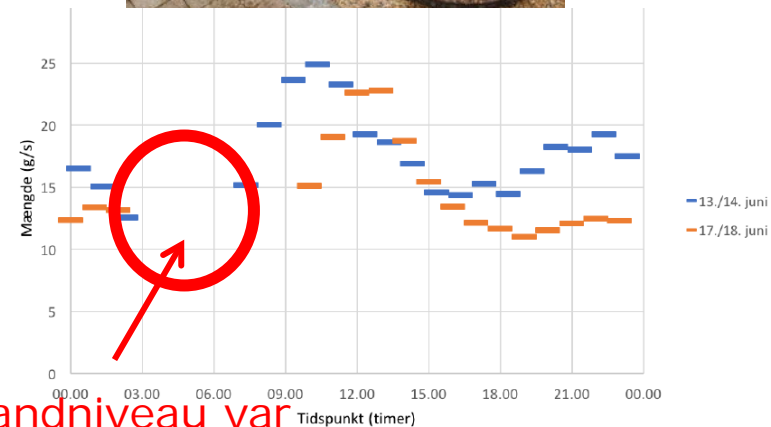
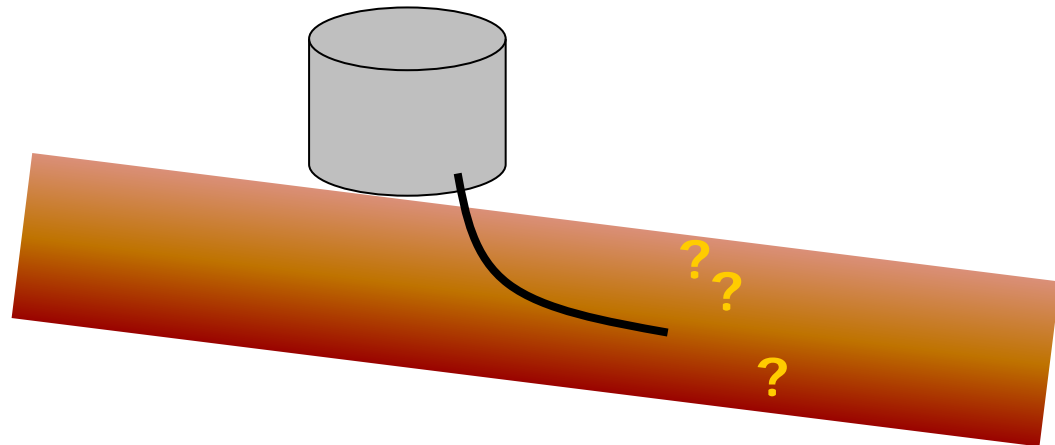
# #2 Automatiske prøvetager



Op to 24 flasker

# Hvad er problem med automatiske prøvetager?

- Problemer med installationen (adgang til overløbsbygværket)
- Placering af indsugning (hvor repræsentativ?)



Vandniveau var for lavt

- Man ved ikke hvornår overløb sker  
(*hvornår skal prøvetager tændes?*)



# #3 online sensorer

- En række vandkvalitet parameter kan måles med høj tidsopløsning (~ 1-5 minutter)

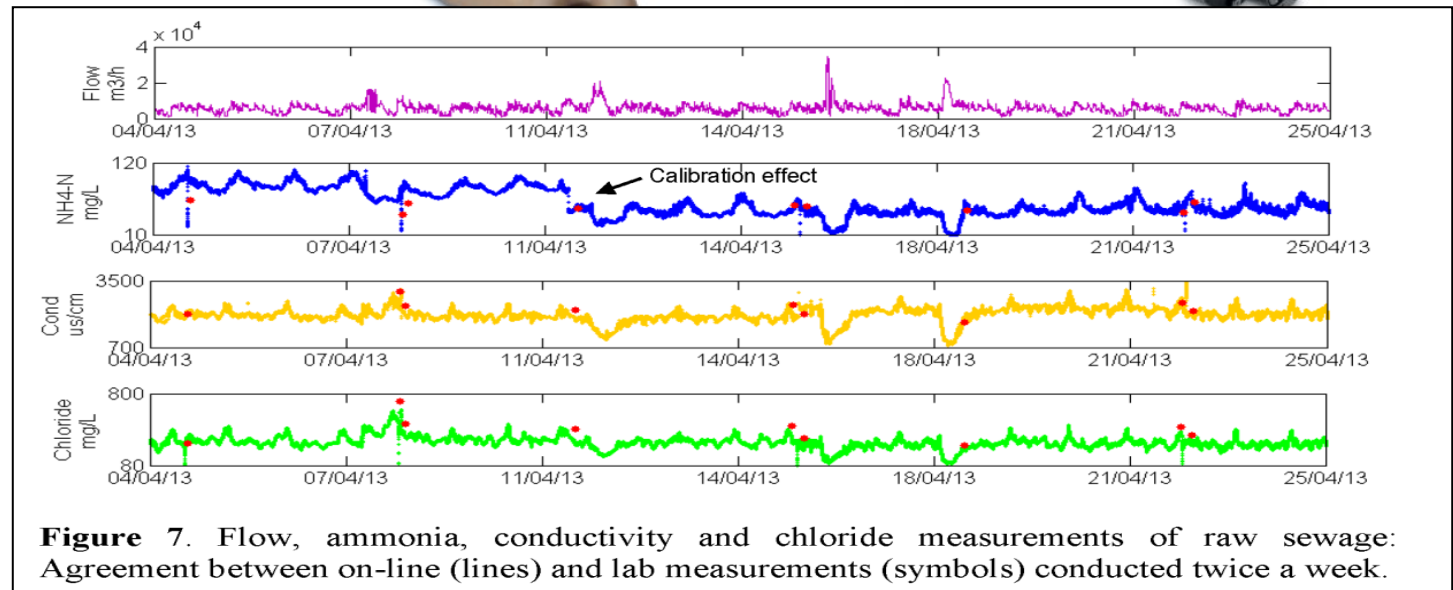


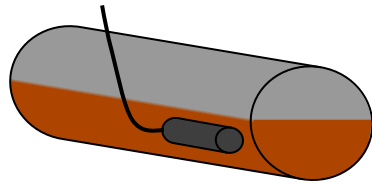
Photo: Ravi Kumar Chhetri



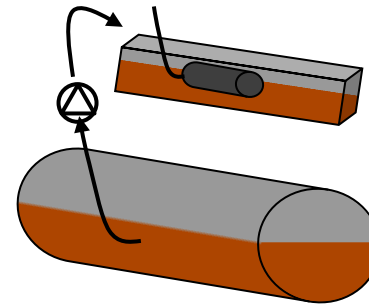
# Placering af sensorer

- Two main “sampling philosophies” used nowadays

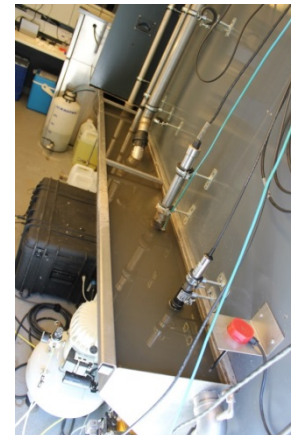
- In Situ  
(sensors are placed in sewer water)



- Ex situ  
(sewer water is pumped up)



- AMOK project  
(we had both)



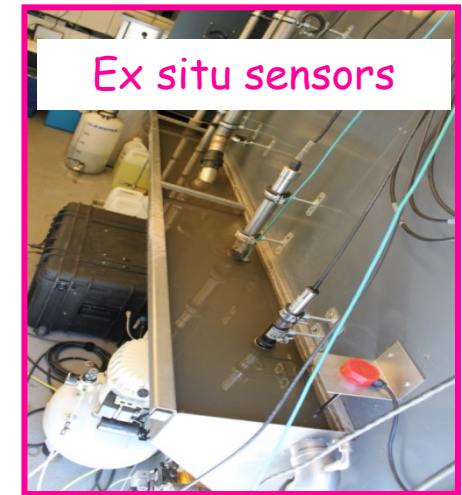
# AMOK project

## Testing site

- Advanced Monitoring of Sewer Overflow
  - CSO at inlet of Viby WTPP (Aarhus, Denmark)
  - Catchment:  $\approx 700$  ha combined +  $\approx 750$  ha separate
  - Max flow in wet weather  $1.26 \text{ m}^3/\text{s}$
- Five on-line measurements (in this study)
  - Flow, Temperature, Conductivity, Turbidity,  $\text{NH}_4$
  - One minute resolution



DDO© Copyright COWI (2015)



Ex situ sensors



In situ sensors

# AMOK – den perfekte dataset?

- Mere end 1.5 år målinger

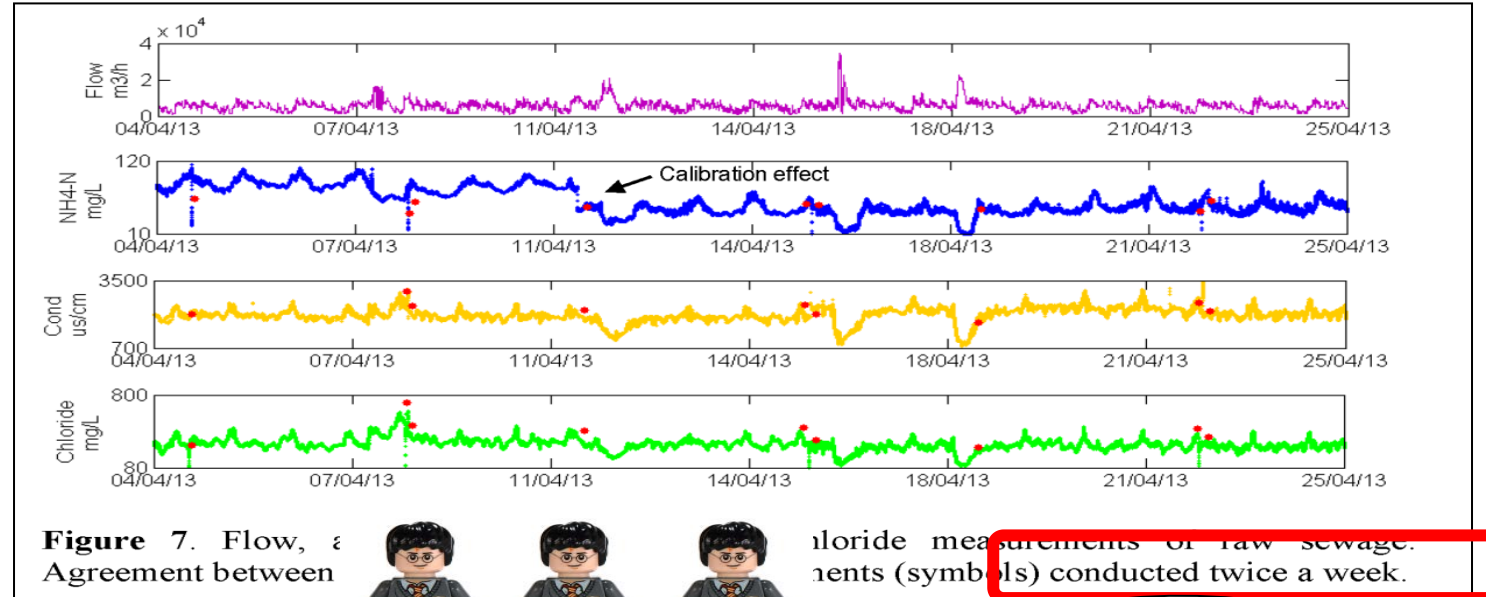
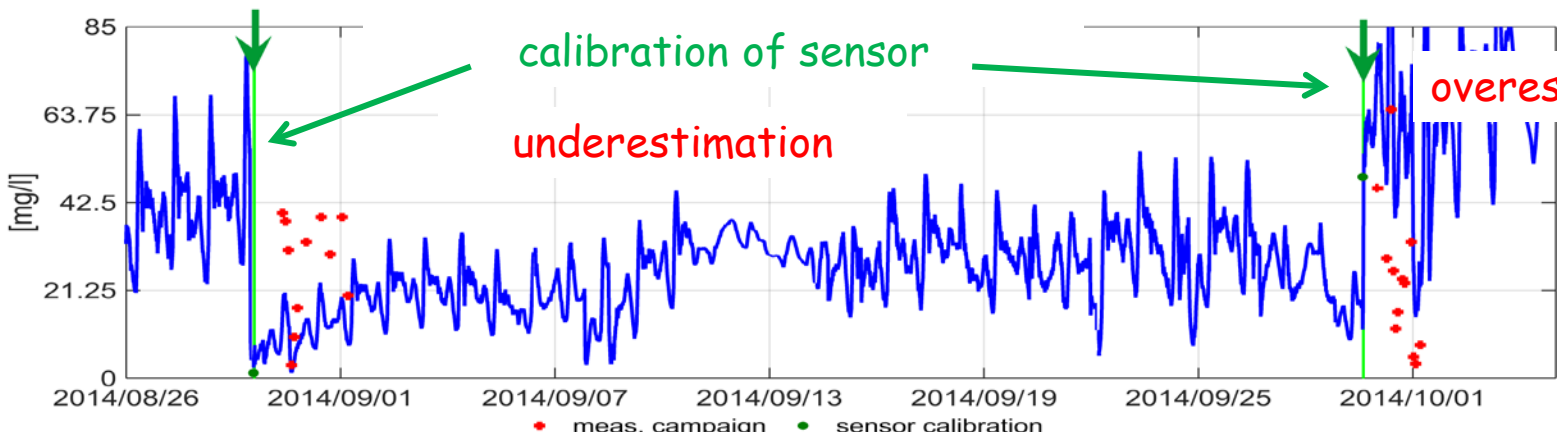


Figure 7. Flow,  $\epsilon$  Agreement between



chloride measurements of raw sewage. (symbols) conducted twice a week.



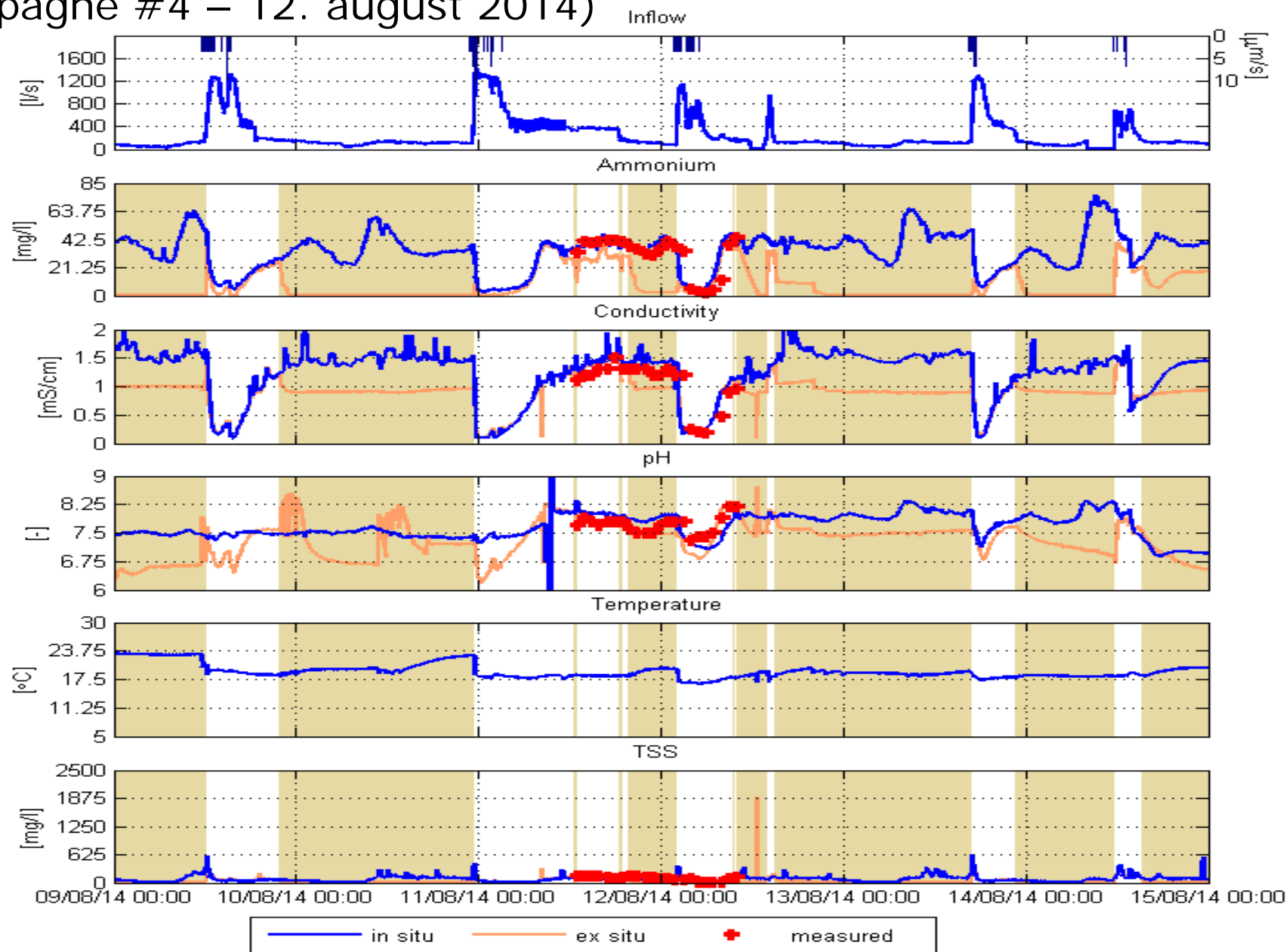
I have thousand other things to do!





# Resultat fra online sensorer

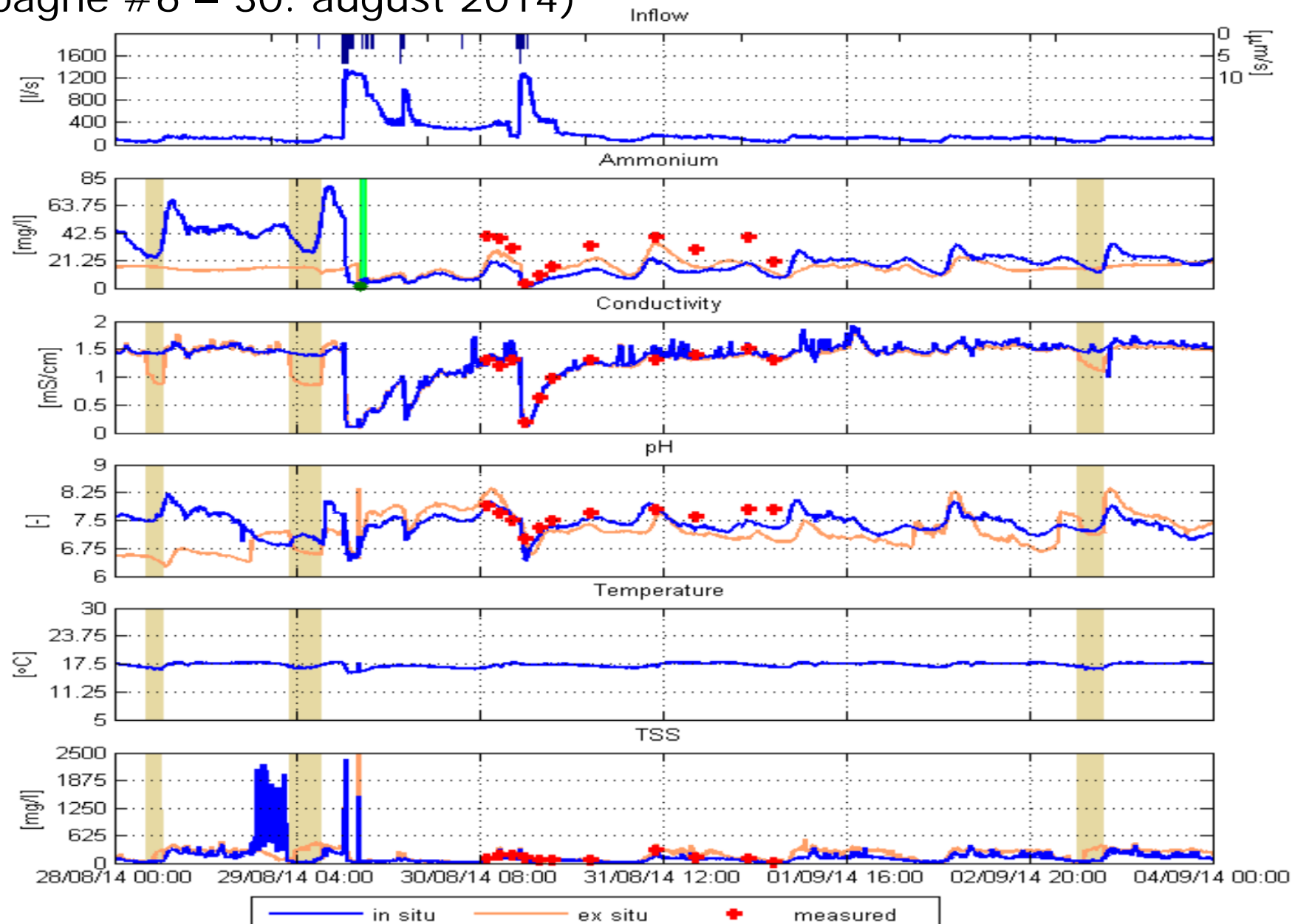
(Målekampagne #4 – 12. august 2014)





# Resultat fra online sensorer

(Målekampagne #6 – 30. august 2014)



# How long can we trust our sensors?

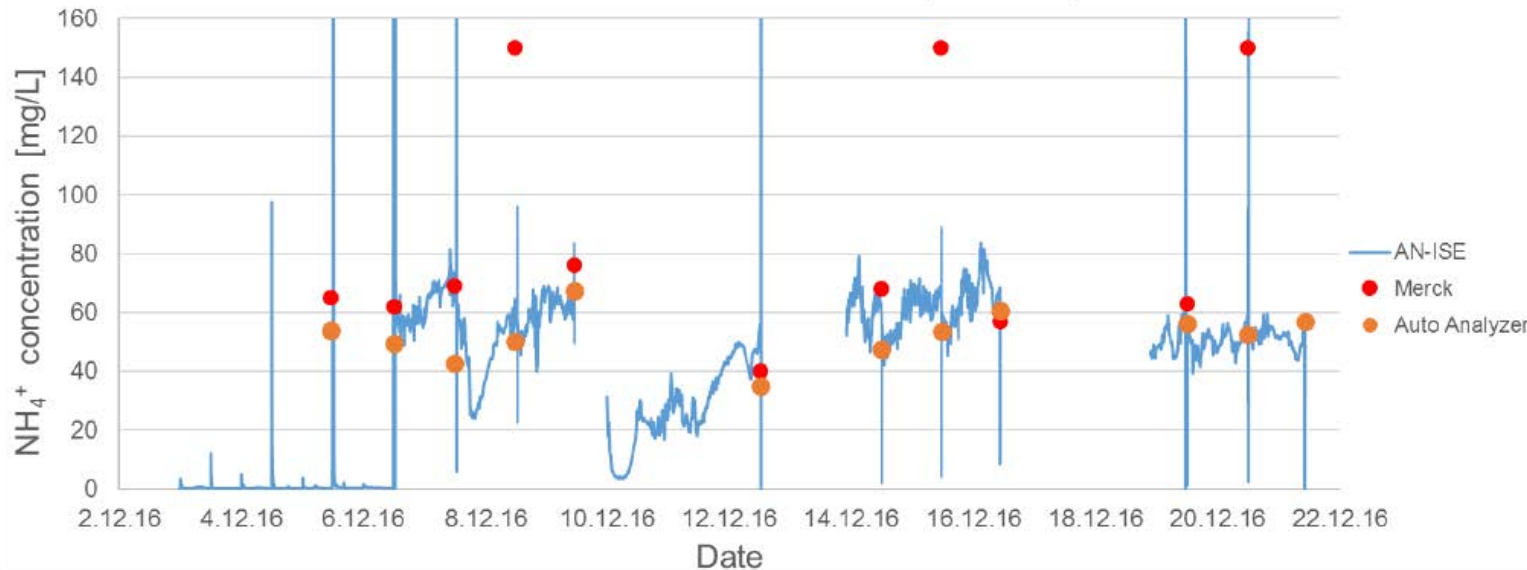


- Low-cost installation
- What happens if maintenance is not as good as it should?
- Three scenarios for sensor cleaning:
  - Every day (perfect world)
  - Once per week (typical Standard Operating Procedure)
  - Once every second week (not so ideal world)
- Comparison sensors vs. lab measurements

# How long can we trust our sensors?



AN-ISE: Baseline definition (Phase A)



- Low-cost installation
- What happens if maintenance is not as good as it should?
- Three scenarios for sensor cleaning:
  - Every day (perfect world)
  - Once per week (typical Standard Operating Procedure)
  - Once every second week (not so ideal world)
- Comparison sensors vs. lab measurements



# How long can we trust our sensors?

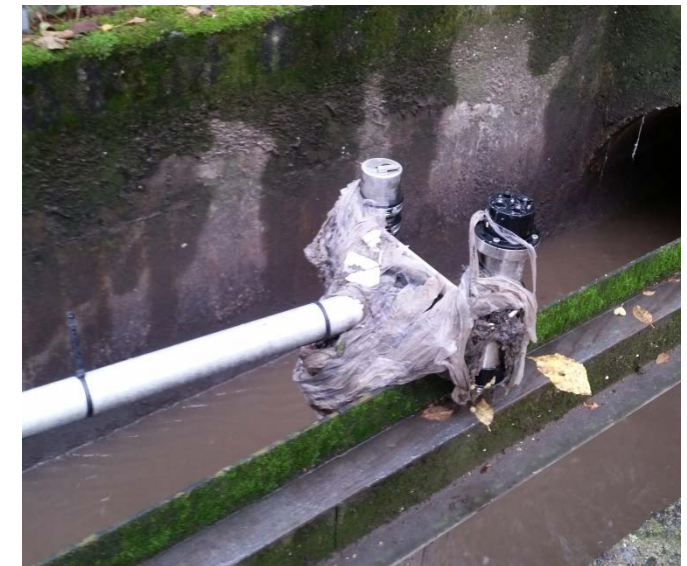
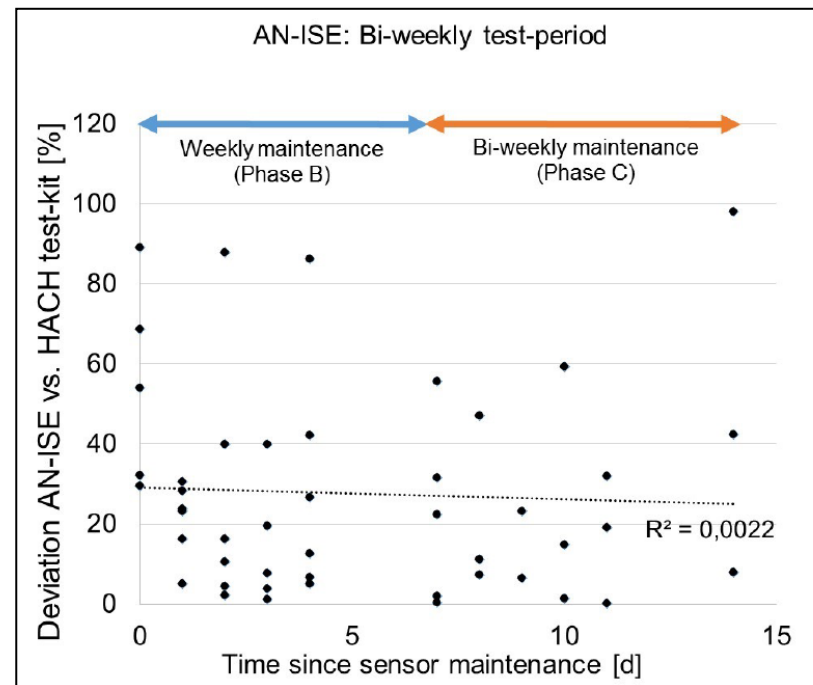
(Preliminary results)

- Three scenarios for sensor cleaning:
  - Every day (perfect world)
  - Once per week (typical Standard Operating Procedure)
  - Once every second week (not so ideal world)



Good precision (5-10%)

Measurement deteriorates already after 2-3 days





# Målinger på overløb – hvor svært kan det være?

## Hydraulik

- Q-h formler skal tilpasses til de enkelte overløbsbygværker
- Placering af vandniveau måler er afgørende for præcision
- CFD modellering kan hjælpe (både med Q-h formler of placering af niveau måler)

## Forurening

- Automatiske prøvetager kan anvendes kun for korte målekampagne
- Online sensorer giver et godt overblik over dynamikken af forureningsstoffer...
- ...men de kræver store indsats til vedligeholdelse

## Søges:

Billige vandkvalitet sensorer som kan overleve i en kloak næsten uden vedligeholdelse

# Thank you for listening!



A Combined Sewer Overflow

An overflow expert

luve@env.dtu.dk