Utilizing Data and Sensors in the Biological Wastewater Treatment

Dr. Henri Haimi,
FCG Design and Engineering Ltd.

IWAMA webinar, 23 May 2017

Outline

- Background

- Instrumentation and data

- Process monitoring

- Process control

- Process modelling

- Future perspectives

- Conclusions

Background

Background

Drivers for more advanced automation solutions in WWTPs:

- Tightening of the treatment requirements

- WWTPs and unit-processes become more complex

- Optimization of operational costs

- Efficient use of the plant capacity
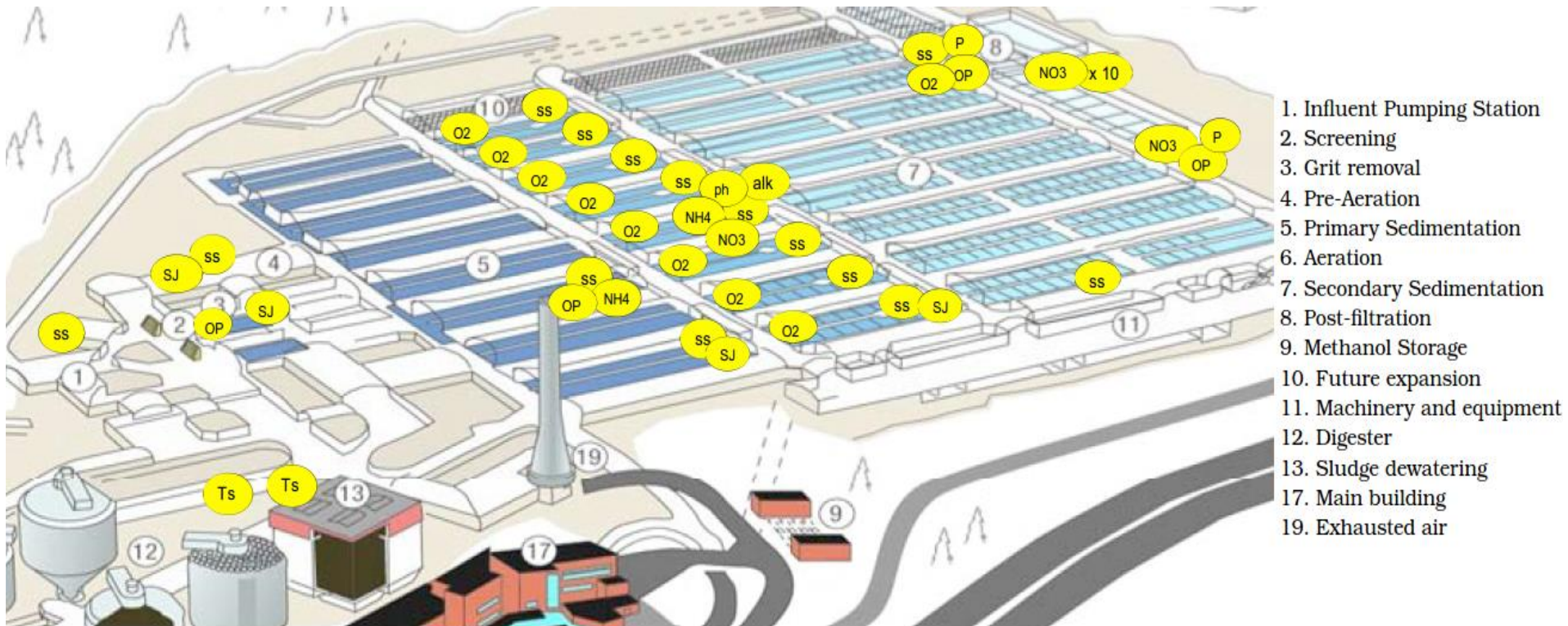
- Dynamic system

Background

Enablers of more advanced automation solutions in WWTPs:

- Improvements in on-line instrumentation and actuators

- Progress in information technology and telecommunication

- Increased process knowledge

- Know-how and education of the employees in WWTPs and the automation engineers

Instrumentation and data

Instrumentation and data

Figure: HSY Helsinki Region Environmental Services Authority

1. Influent Pumping Station
2. Screening
3. Grit removal
4. Pre-Aeration
5. Primary Sedimentation
6. Aeration
7. Secondary Sedimentation
8. Post-filtration
9. Methanol Storage
10. Future expansion
11. Machinery and equipment
12. Digester
13. Sludge dewatering
17. Main building
19. Exhausted air

Instrumentation and data

On-line measurements in WWTPs:

Water flow rate	Total solids of sludge
Liquid level	Sludge blanket level
Temperature	Total nitrogen, ammonium, nitrate
pH	Total phosphorus, phosphate
Redox potential	Organic matter (e.g. TOC)
Conductivity	Suspended solids
Dissolved oxygen	Biogas flow rate, CO_2, CH_4
Turbidity	Pressure

Instrumentation and data

- Plenty of operational data available

  - Thousands of digital signals in large plants

  - Information encoded in the historical data

- Maintance and quality monitoring of instrumentation highly important

  - Cleaning, calibration and reparing

  - Maintenance contracts with instrument suppliers

  - Maintenance plan for sensors and analysers

  - Cross-checking instrument data with laboratory and field measurements

Instrumentation and data

- Data management: on-line data, laboratory data, field measurements etc.

- Digital process logbooks that combine data from different sources

- Data validation, screening and filtering

Instrumentation and data
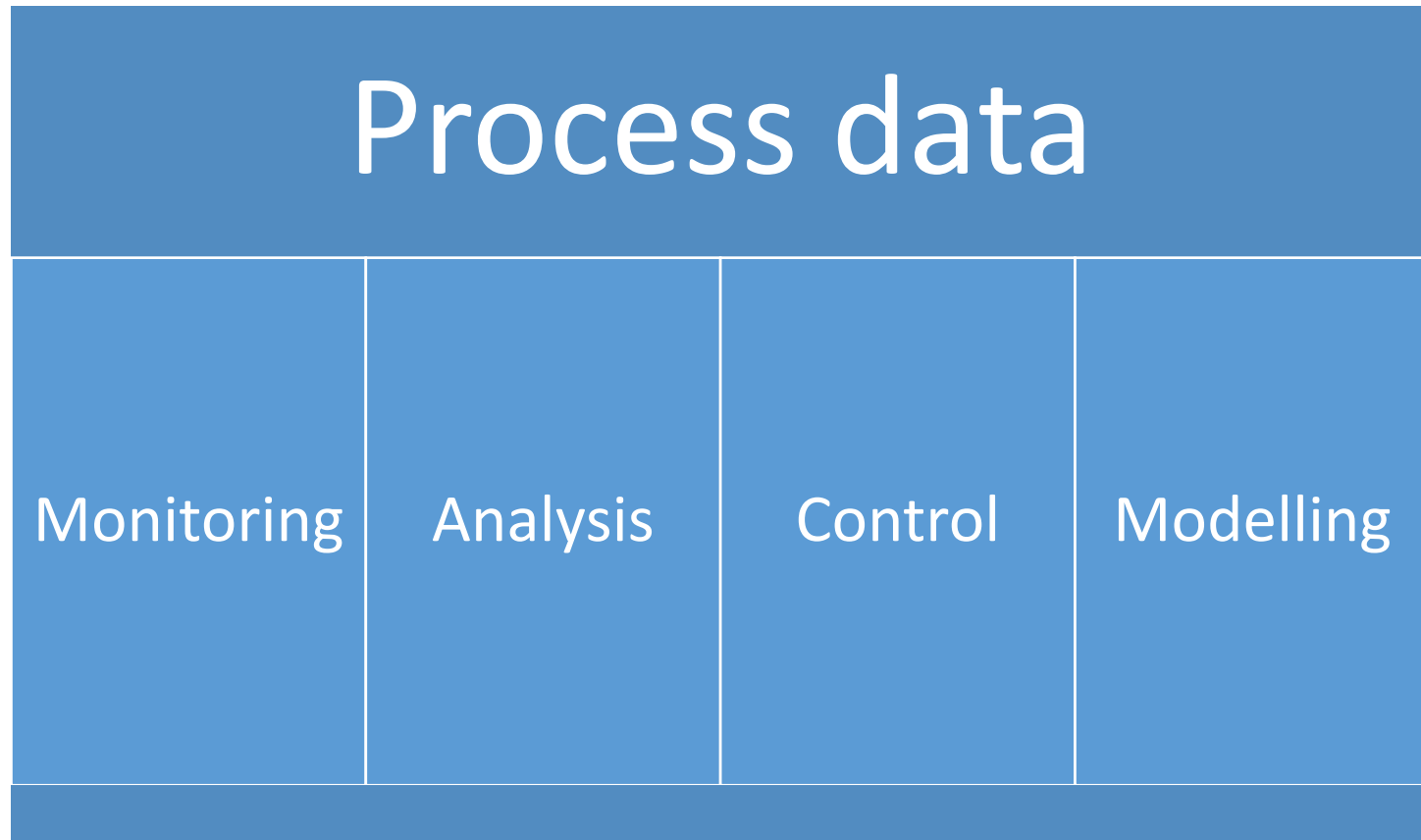
Process monitoring

Process monitoring

- Control room, field monitors, remote applications

- Upper and lower limit for variables

- Time series, scatter plots, histograms

- Calculated indexes for process monitoring

- Process and instrument states by sophisticated algorithms

- Isolation of source of the deviation from normal process state
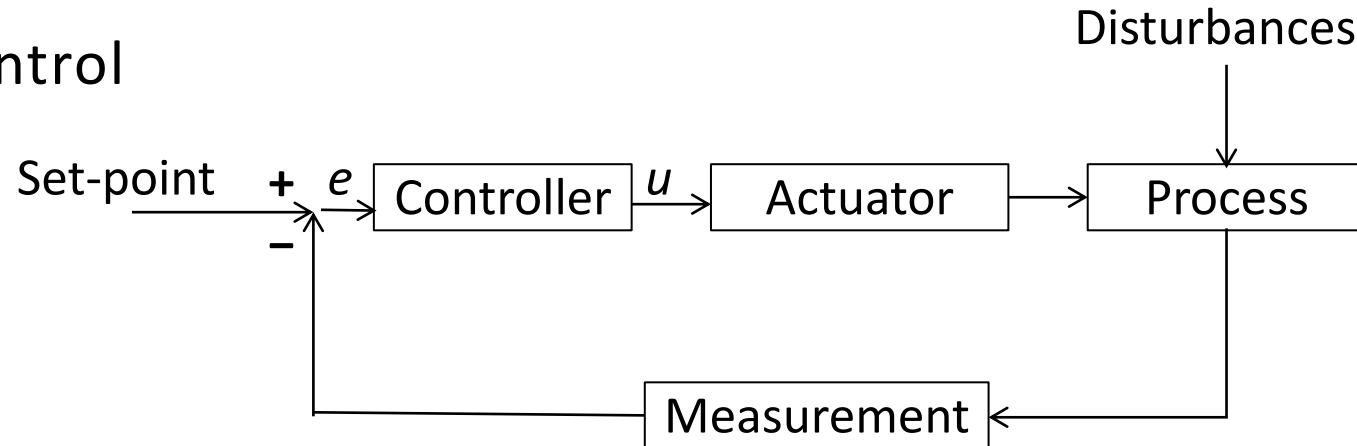
Process control

Process control

Levels of process control:

1. Manual control based on manual sampling and laboratoty analyses

2. Manual control based on on-line nutrient measurements

3. Automatic control based on on-line nutrient measurements, implemented in SCADA

4. Advanced control system including analysis of raw data, on-line controller tuning and automatic reporting tools

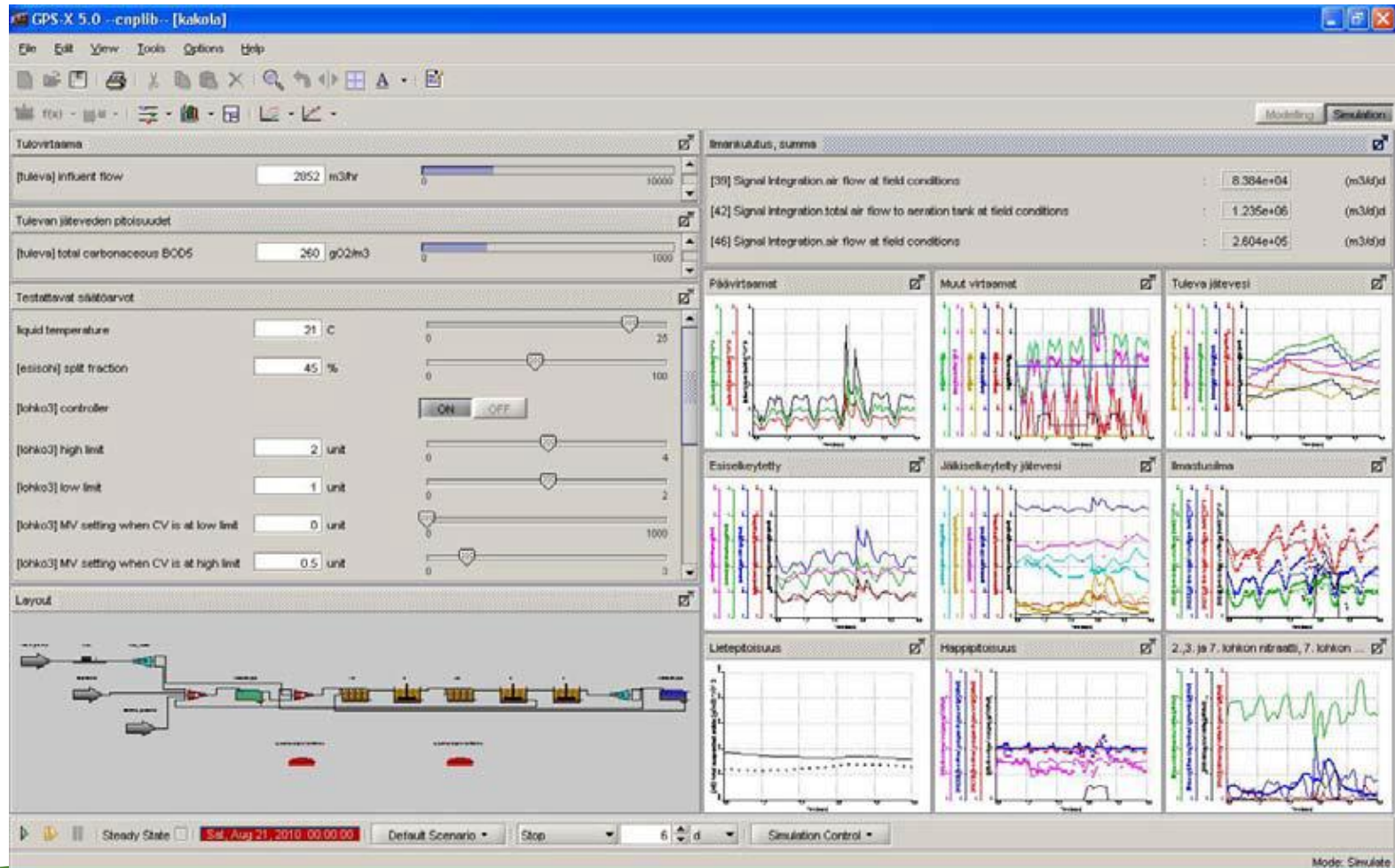# Process control

- Feedback control

Set-point $+$ e Controller u Actuator Process

Disturbances

$-$

Measurement

- Feedforward control

- Advanced control

  - Model predictive control
  - Rule-based control

Process modelling
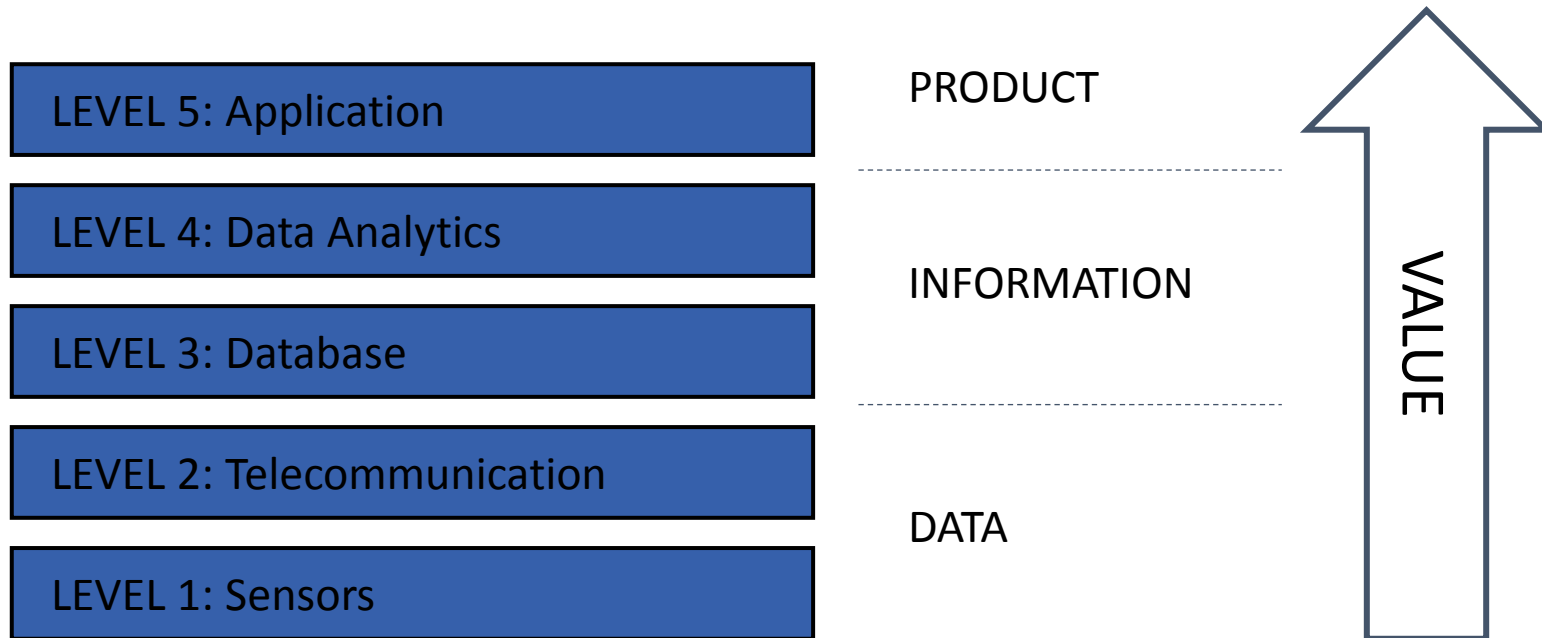
Process modelling

- Measured process data can be used in modelling treatment process and dynamic process simulations

- Many commercial modelling software available

- Use of treatment process models:

  - Optimization of process operation in different situations

  - Understanding system's behaviour

  - Training the employees

  - Testing different control systems

  - Process design

Process modelling
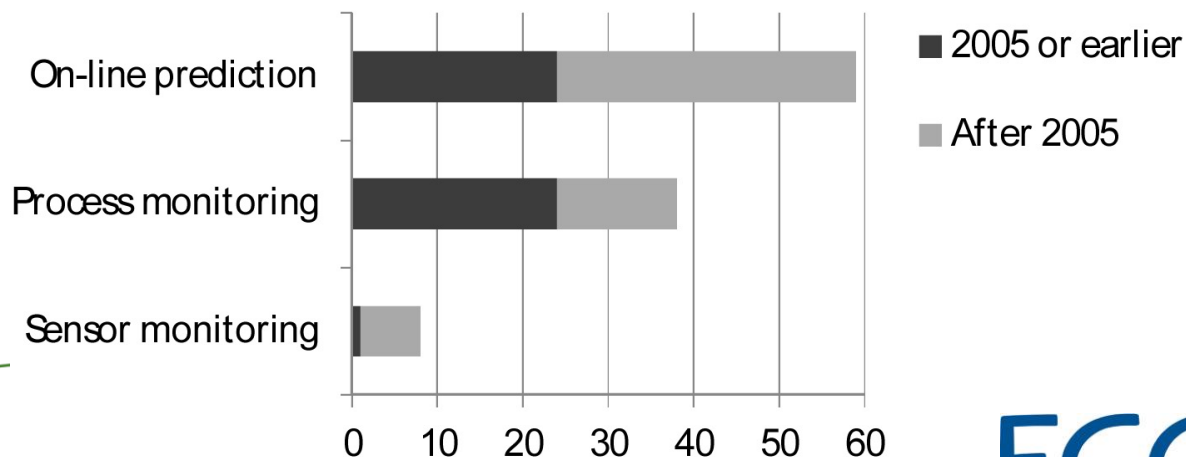
Future perspectives

Future perspectives

LEVEL 5: Application	PRODUCT	
LEVEL 4: Data Analytics	INFORMATION	VALUE
LEVEL 3: Database		
LEVEL 2: Telecommunication	DATA	
LEVEL 1: Sensors		

Modified from:
Collin & Saarelainen:
Teollinen Internet

FCG.

IWAMA
Interactive Water Management

Future perspectives

Soft-sensors

- Soft-sensor is a software where several measurements are processed together with a predictive model providing a virtual instrument
- Data-derived soft-sensors are built around process models derived from data
- Soft-sensors popular e.g. in process industry

Haimi H., Mulas M., Corona F., Vahala R. Data-Derived Soft-Sensors for Biological Wastewater Treatment Plants: An overview. Environmental Modelling & Software, 47(1):88-107, 2013.

Future perspectives

Soft-sensors

- NO_3-N concentrations used in the methanol dosage control in biological post-filtration
- Soft sensors for estimating NO_3-N in filters
- Back-up system in case of down-time of the instruments

Corona F., Mulas M., Haimi H., Sundell L., Heinonen M., Vahala R. Monitoring nitrate concentrations in the denitrifying post-filtration unit of a municipal wastewater treatment plant. *Journal of Process Control*, 23(2):158-170, 2013.

FCG. IWAMA
Interactive Water Management
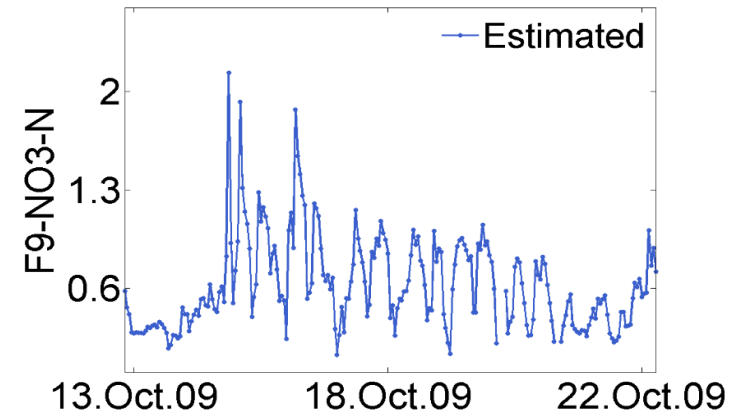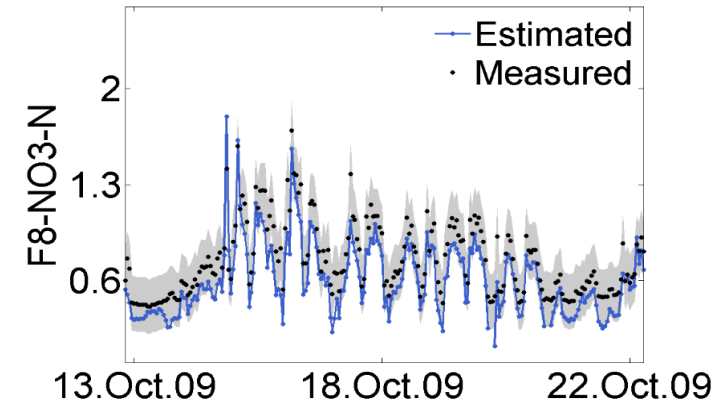
Future insights

Plant-wide control

- Process units in a WWTP are not isolated from each other

- Overall goal of the control and operation to be defined

- Maximum use of the whole plant

- Stuctured way to coordinate all the control actions

Future perspectives

Plant-wide control

- Intergation of sewer network and WWTP control
- Influent flow rate estimation based on weather forecasts
- Information for dealing with flow peaks
- Help for the by-passes control of ASP
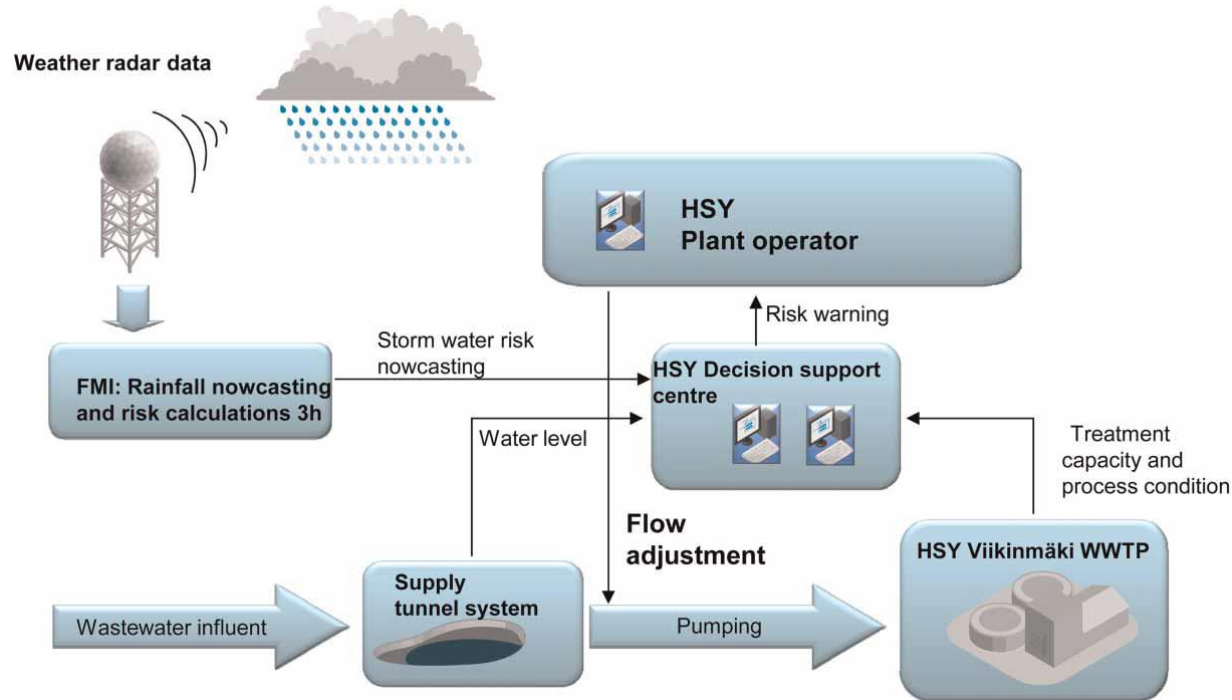
Heinonen *et al.*, 2013, Wat. Sci. Technol.

Conclusions

- Regular maintenance of the instrumentation

- Collect all the data in a digital diary

- Monitoring tools for detecting and isolating process disturbances

- Developments in instrumentation favours automated control

- Process modelling for testing different operational alternatives

- Software for extracting new information from a set of process measurements

- Integrated control of many process units

FCG. IWAMA
Interactive Water Management

Henri Haimi
Process Design Engineer

Finnish Consulting Group
FCG Design and Engineering Ltd.
Plant and Automation Design
henri.haimi@fcg.fi
www.fcg.fi/eng