Pumping stations and water transport CT5550

Introduction
ct5550

February 8, 2008

Delft University of Technology

Introduction

- Jan Vreeburg
- Room 4.65
  - Thursday and Friday
- Rest of the time: Kiwa Water Research
  - Knowledge institute for the drinking water companies

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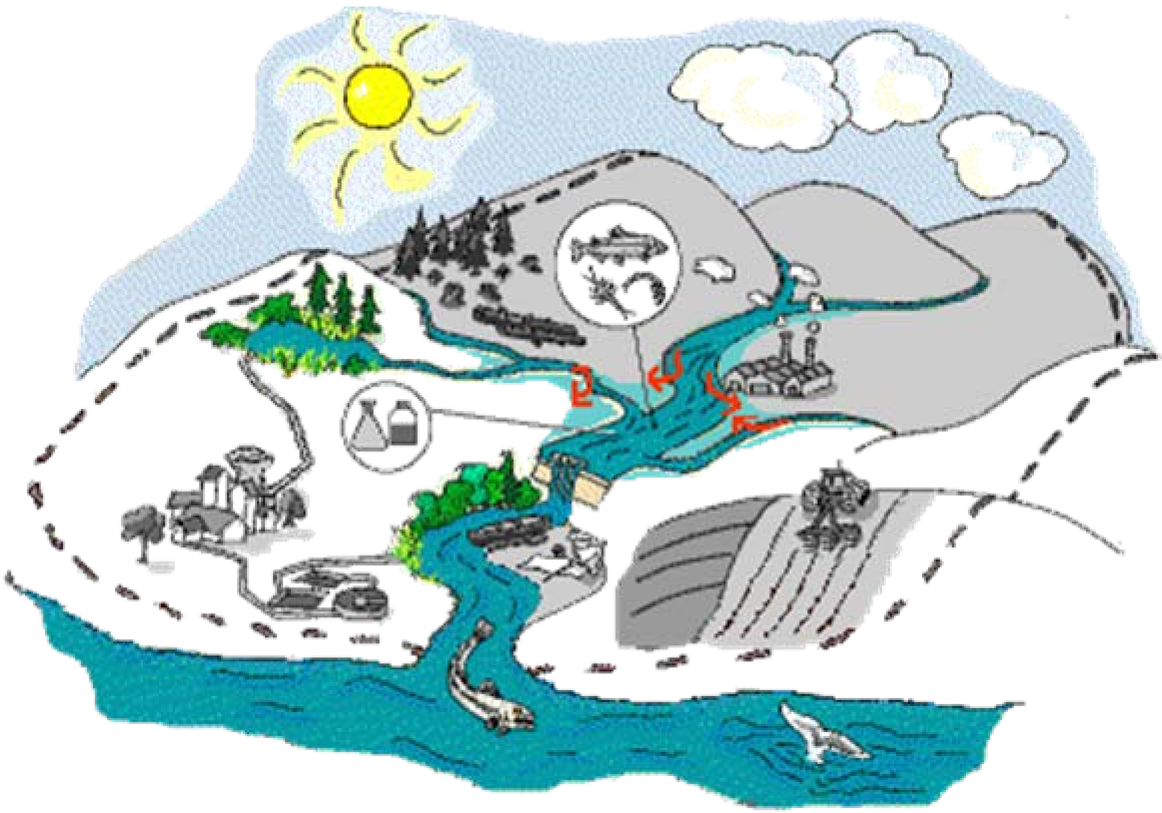
Course information

- Lecture notes
  - Published on Blackboard
- Presentations
  - Published on Blackboard (slides 2006)
  - Updates for 2008 shortly before lectures
- Exercise
  - Available from today

Water transport through pipes Introduction

- Water flows through pipes from high energy level to a low energy level (gravity flow)
- Natural energy input is evaporation
- Natural flow is gravity flow

Water cycle (hydrological cycle)



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Roman aqueduct

Roman Cloacla Maxima

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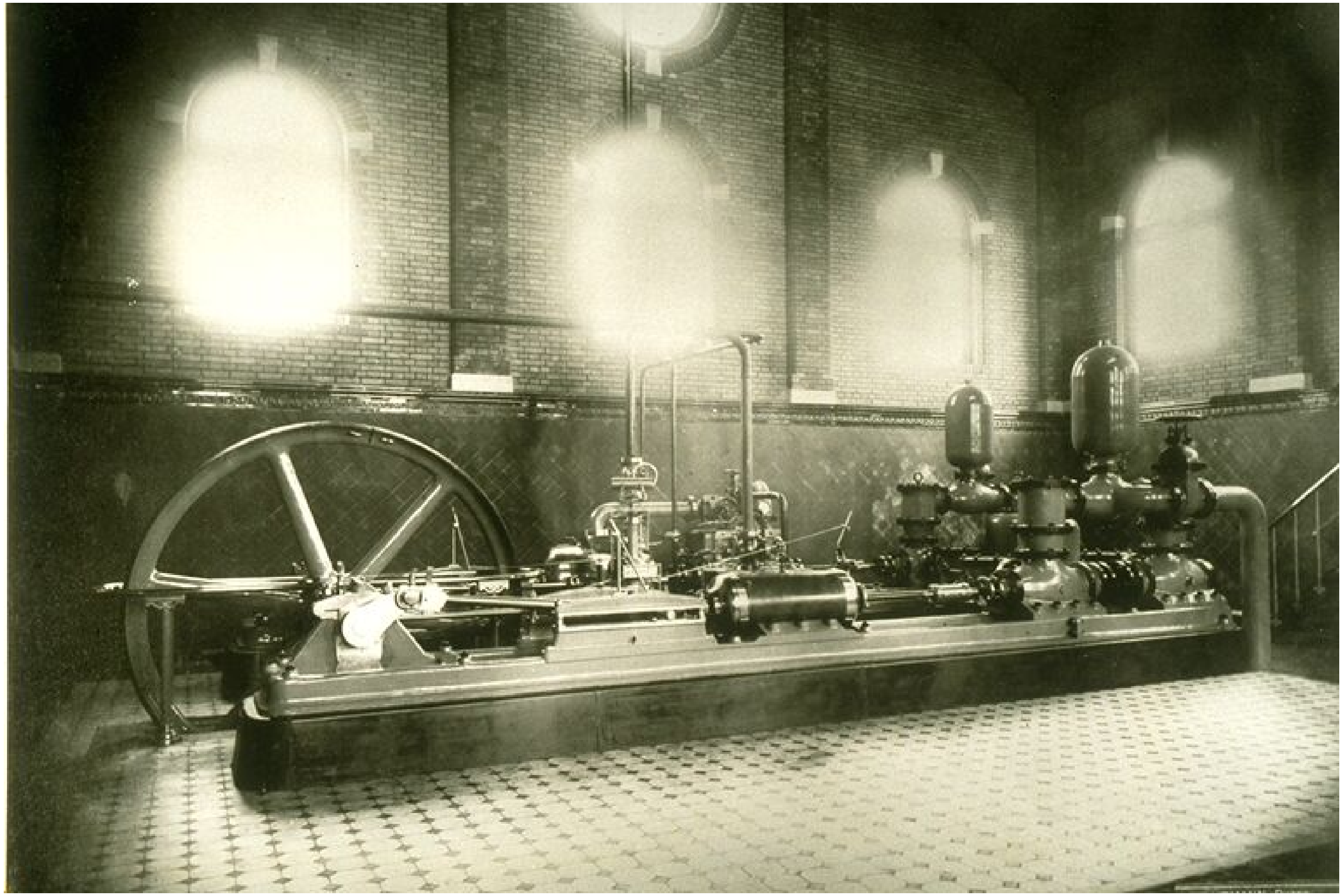
Water transport through pipes Introduction

- Water transport through pipes on a large scale is possible due to:
  - Pumping with the help of external power: adding energy
  - Industrial manufacturing of pipes

External pumping power



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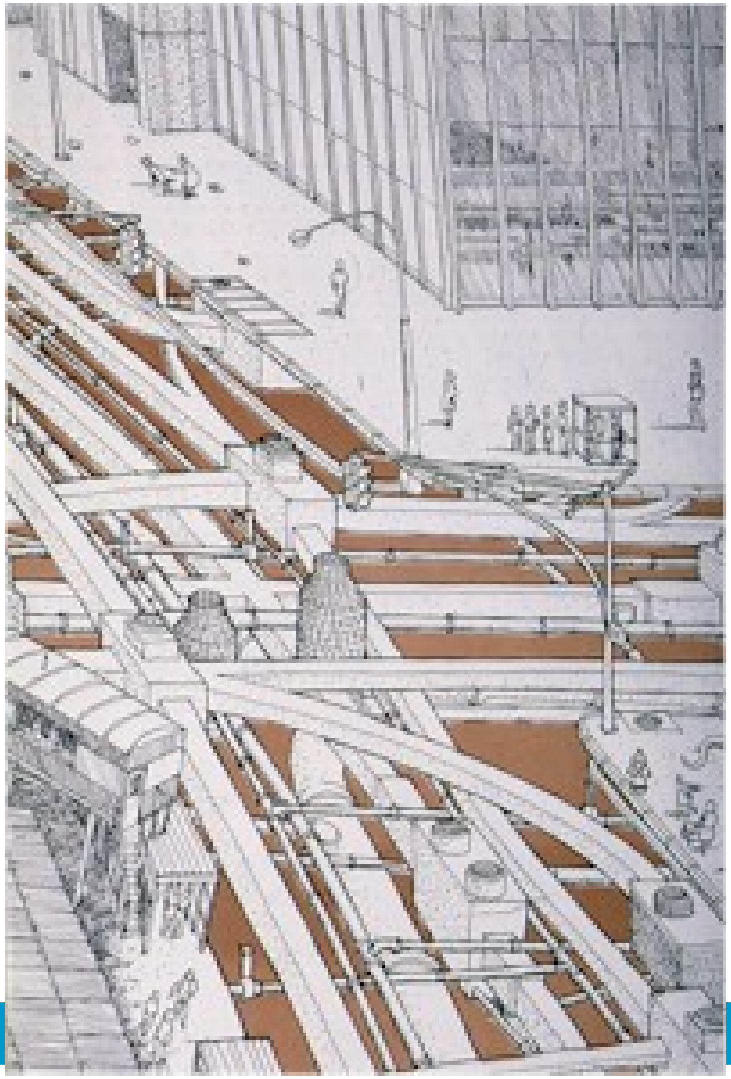
Size of pipe systems

- 110.000 km drinking water
- 82.000 km sewerage system
- 100.000 km gas pipe system
- 120.000 km electricity pipe system
- .... Km cable system
- ect.

It’s a busy underground



How normal and convenient is continuous water supply

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And if it fails

The invisible service

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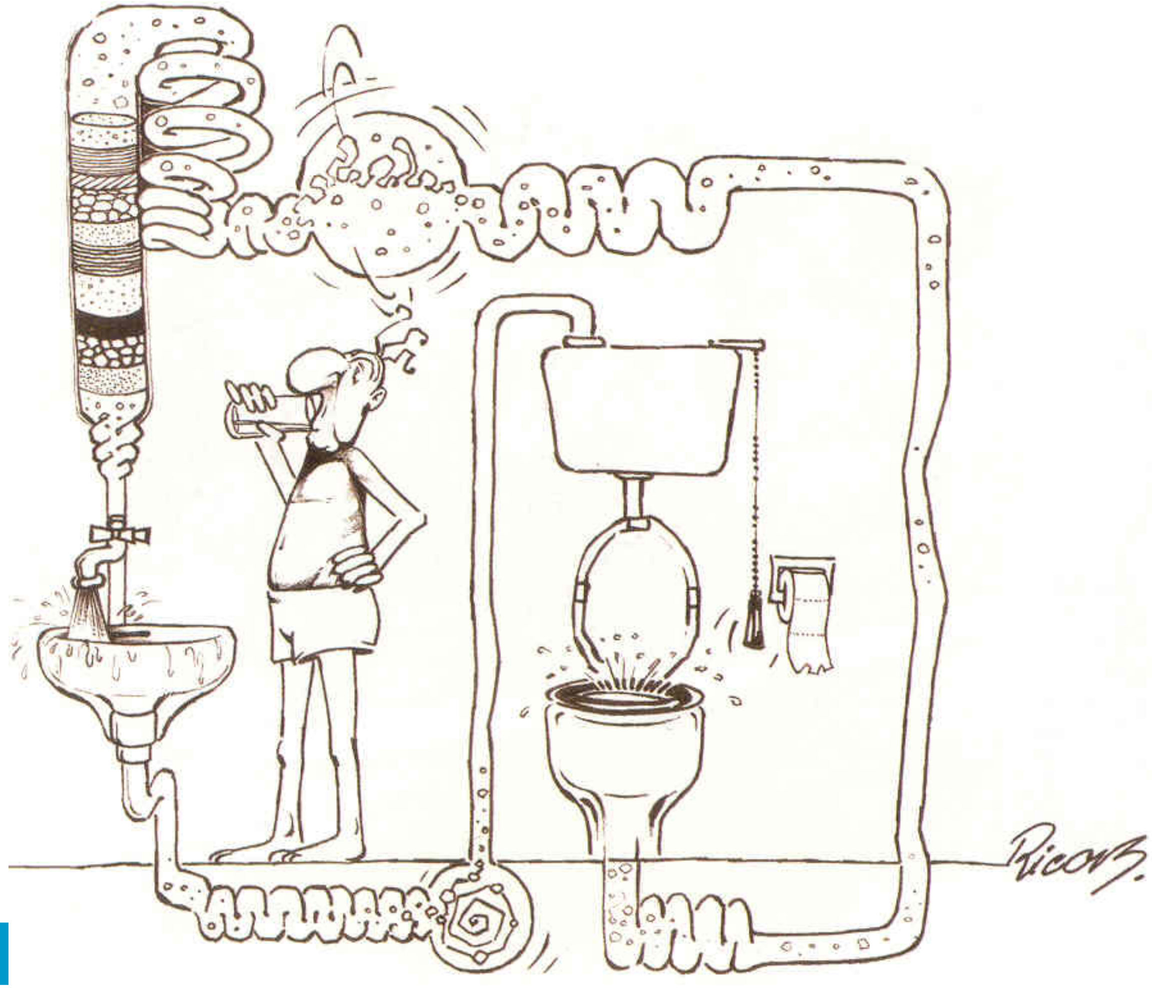
The water cycle
Drinking water/sewerage



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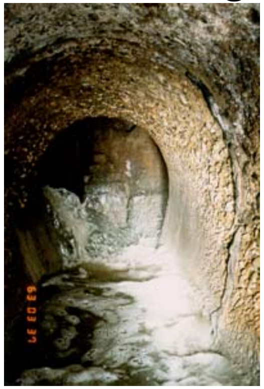
The drinking water/sewerage water cycle

Ground water

Drinking water

Sewerage



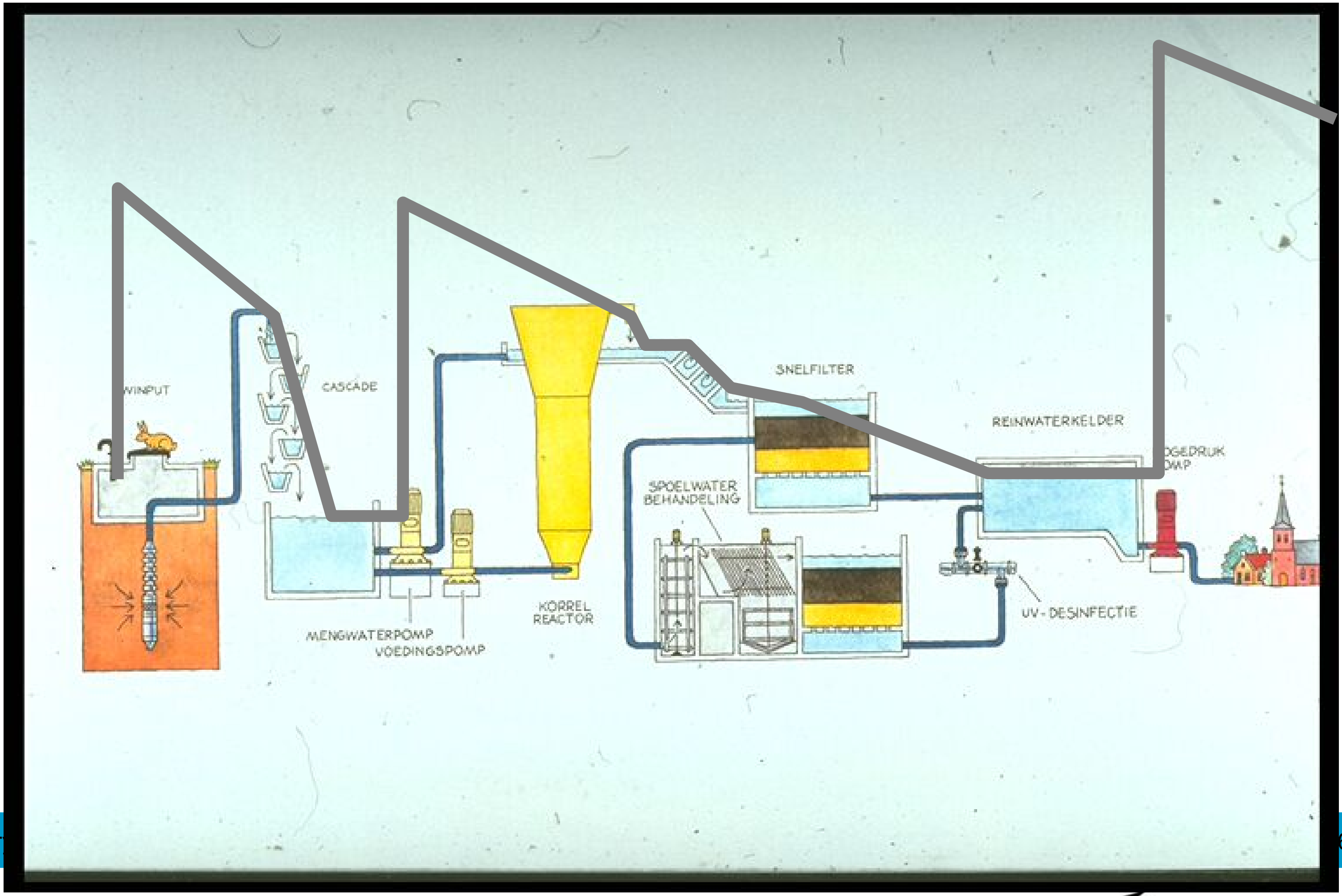
Surface water

Sewerage treatment

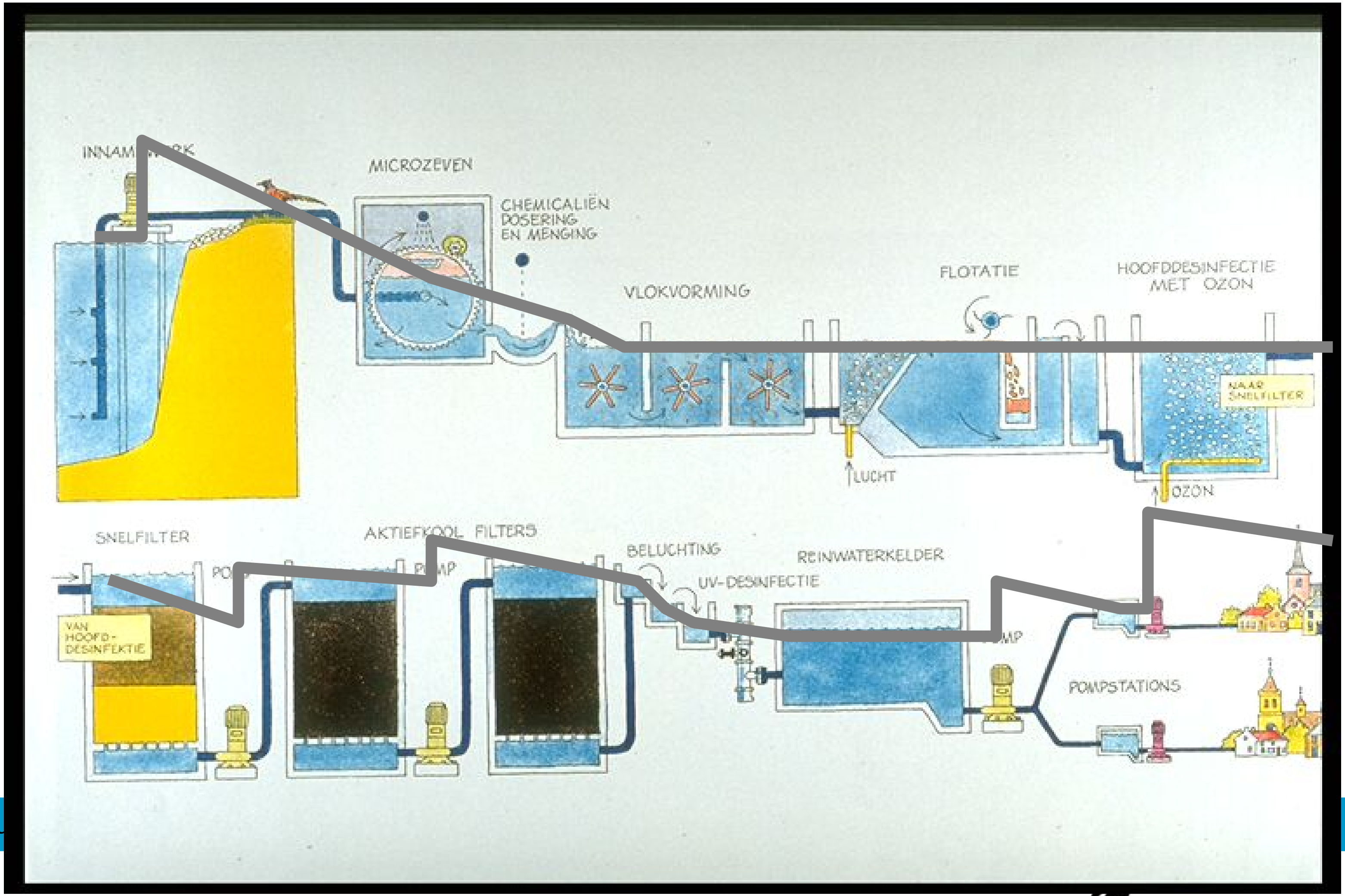
The water cycle
Drinking water/sewerage

- Pumping of raw water:
  - groundwater: deep well
  - surface water
- Treatment
  - Conventional: Gravity flow
  - Membrane: Pressurised filtration

Hydraulic grade line ground water station



Hydraulic grade line surface water station



Membrane installation

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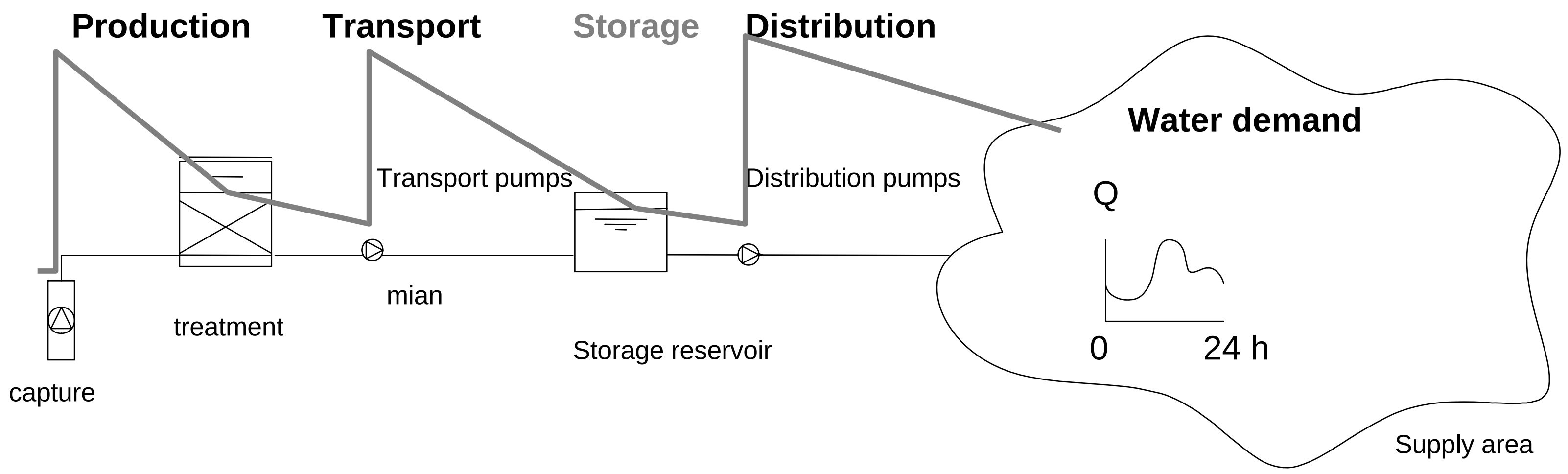
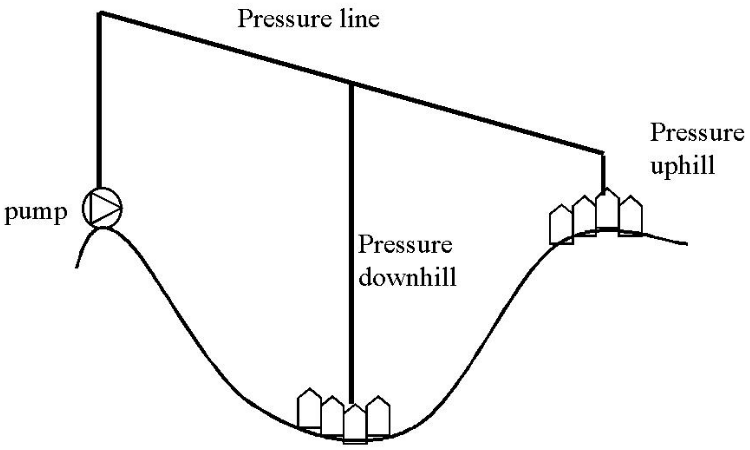
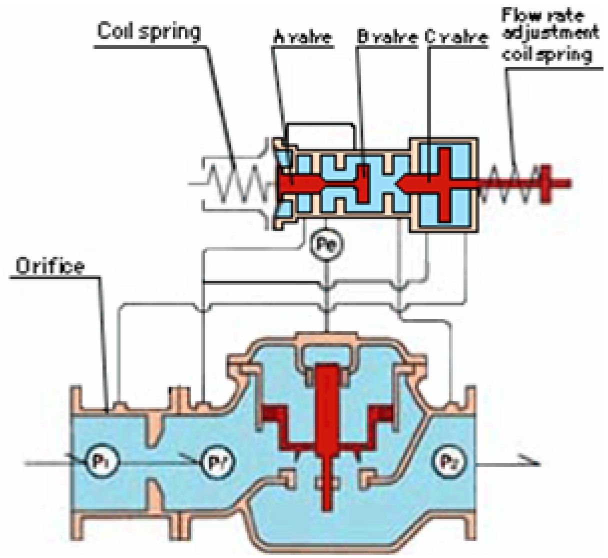
The water cycle
Drinking water/sewerage

- Storage of water
- Pressurised transport to points of use
- Hydraulic grade line/energy line



Pressure and energy





Energy consumption

- Energy input = increasing potential energy: E=mgh
- 1 cubic meter lift 1 meter:
  E = 1000*9,81*1 = 9810 Ws = 2,7Wh

Energy consumption

- Groundwater + treatment
  - Water lift: From ground water level till ‘top’ of treatment: 20 meter max: $\pm$55Wh/m^3
- Surface water + treatment
  - Water lift: from surface water level till ‘top’ of treatment: 20 meter max $\pm$55Wh/m^3
- Membrane filtration
  - Extra lift: 50 meter (in total 70) $\pm$193W/m^3

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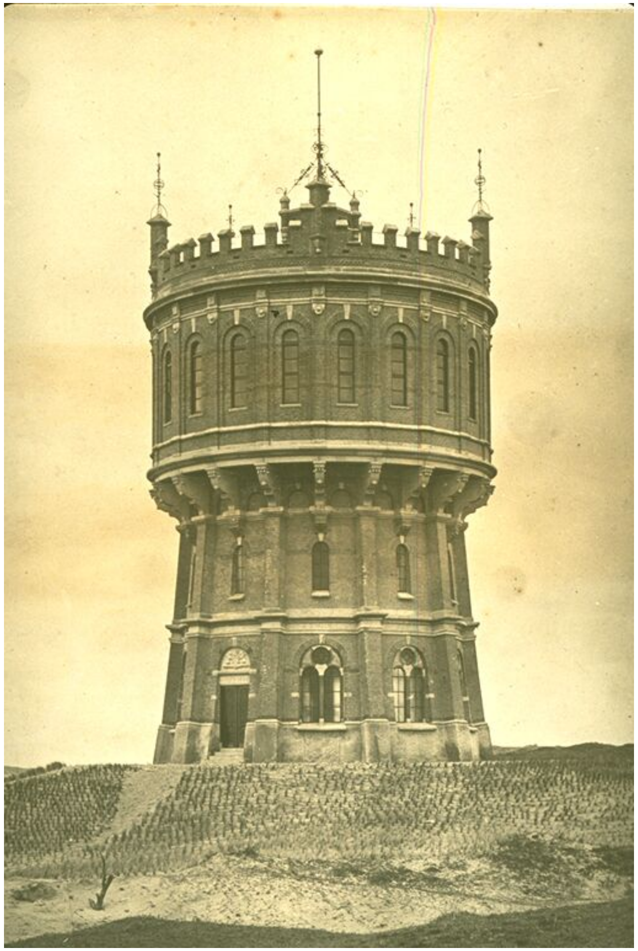
High level storage



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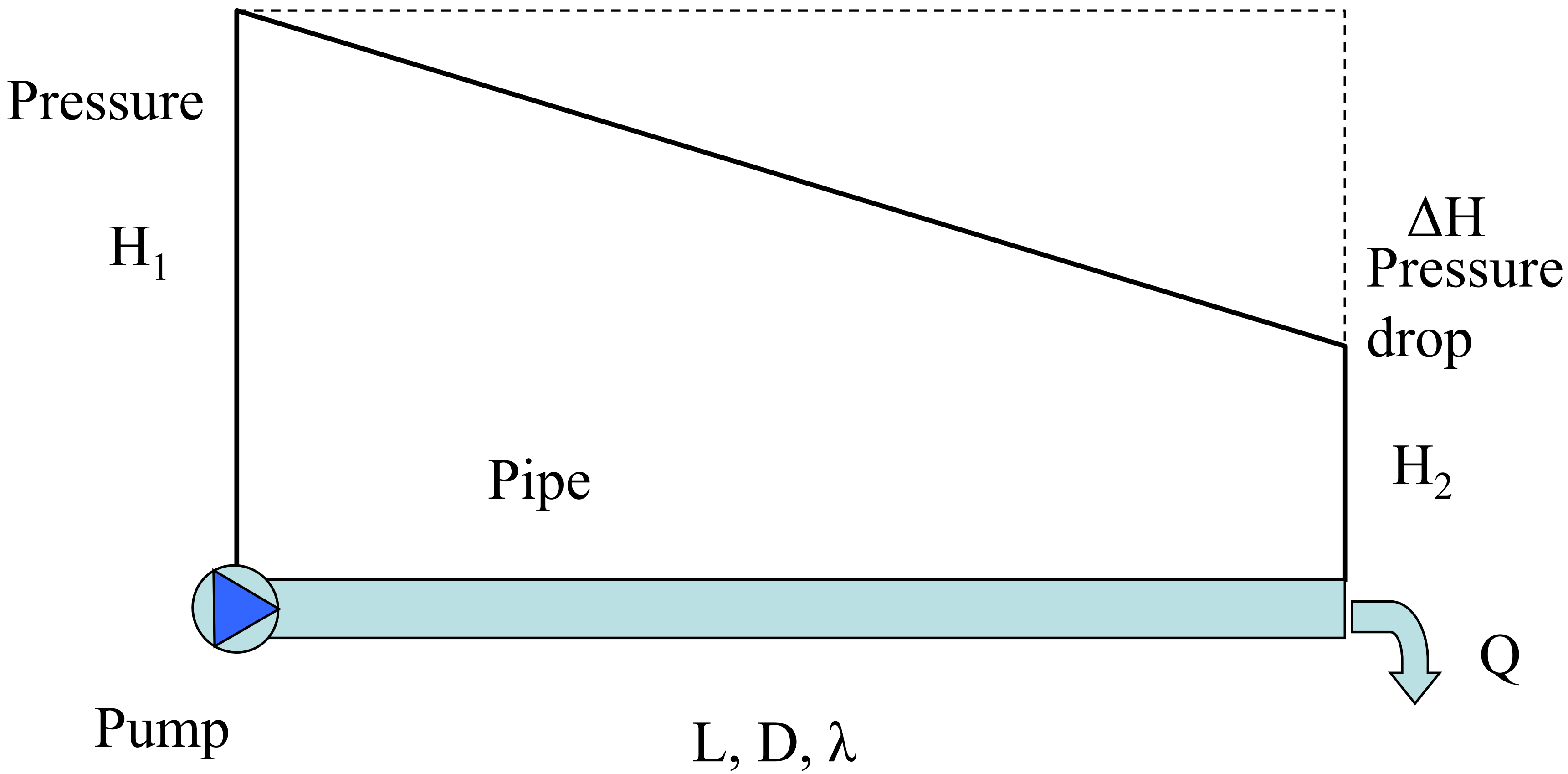
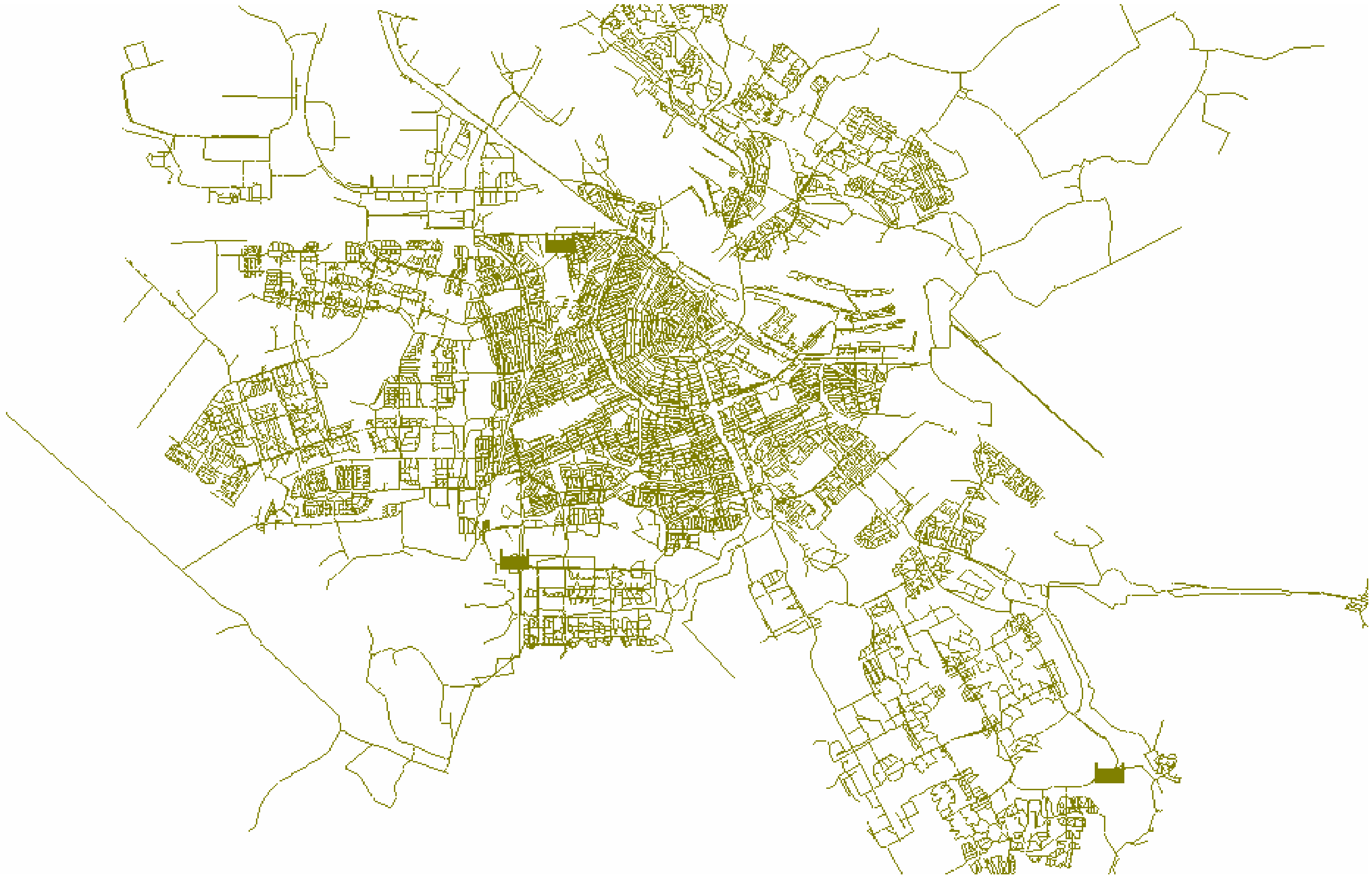
Pressurised transport

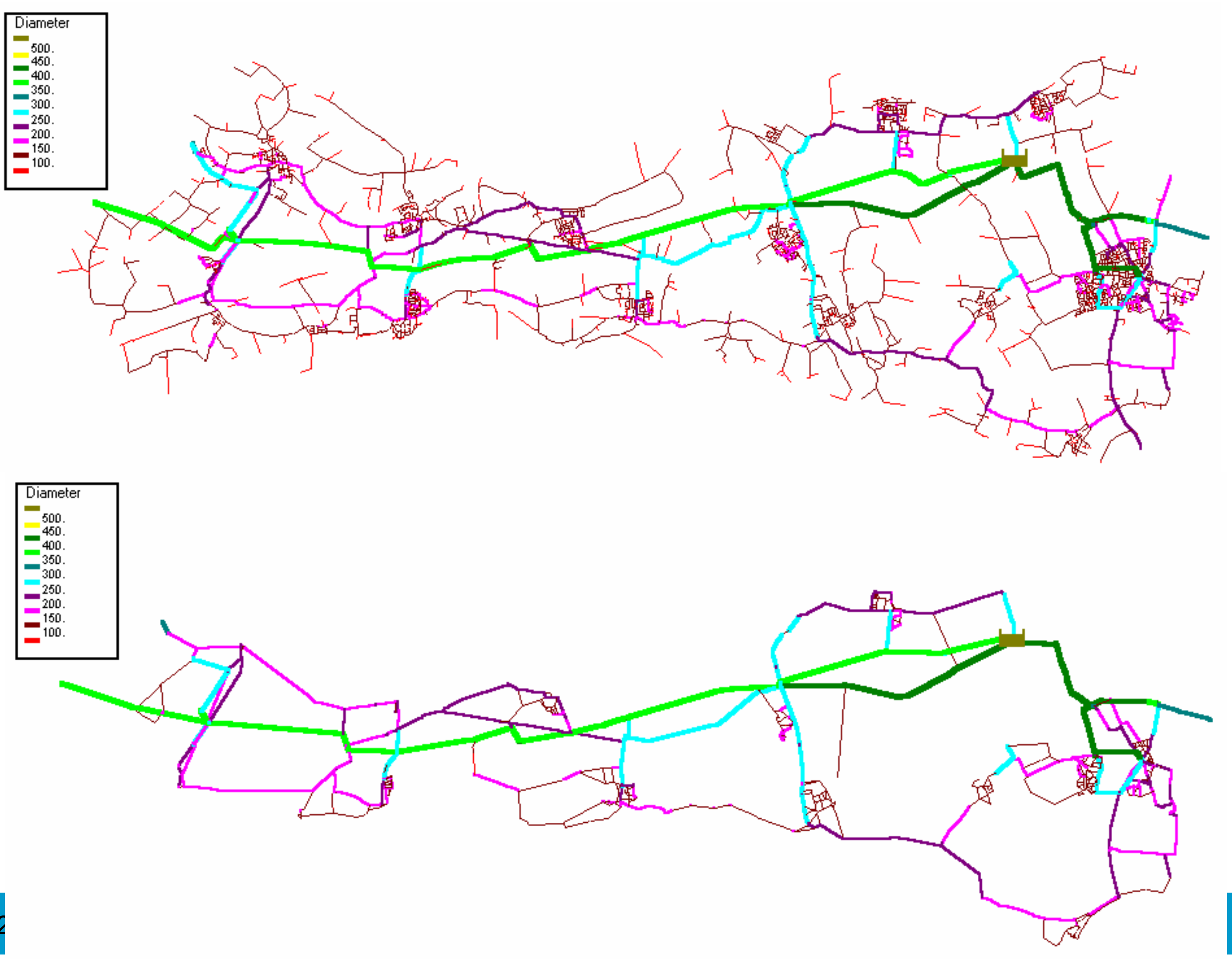


Demand

Typical drinking water network

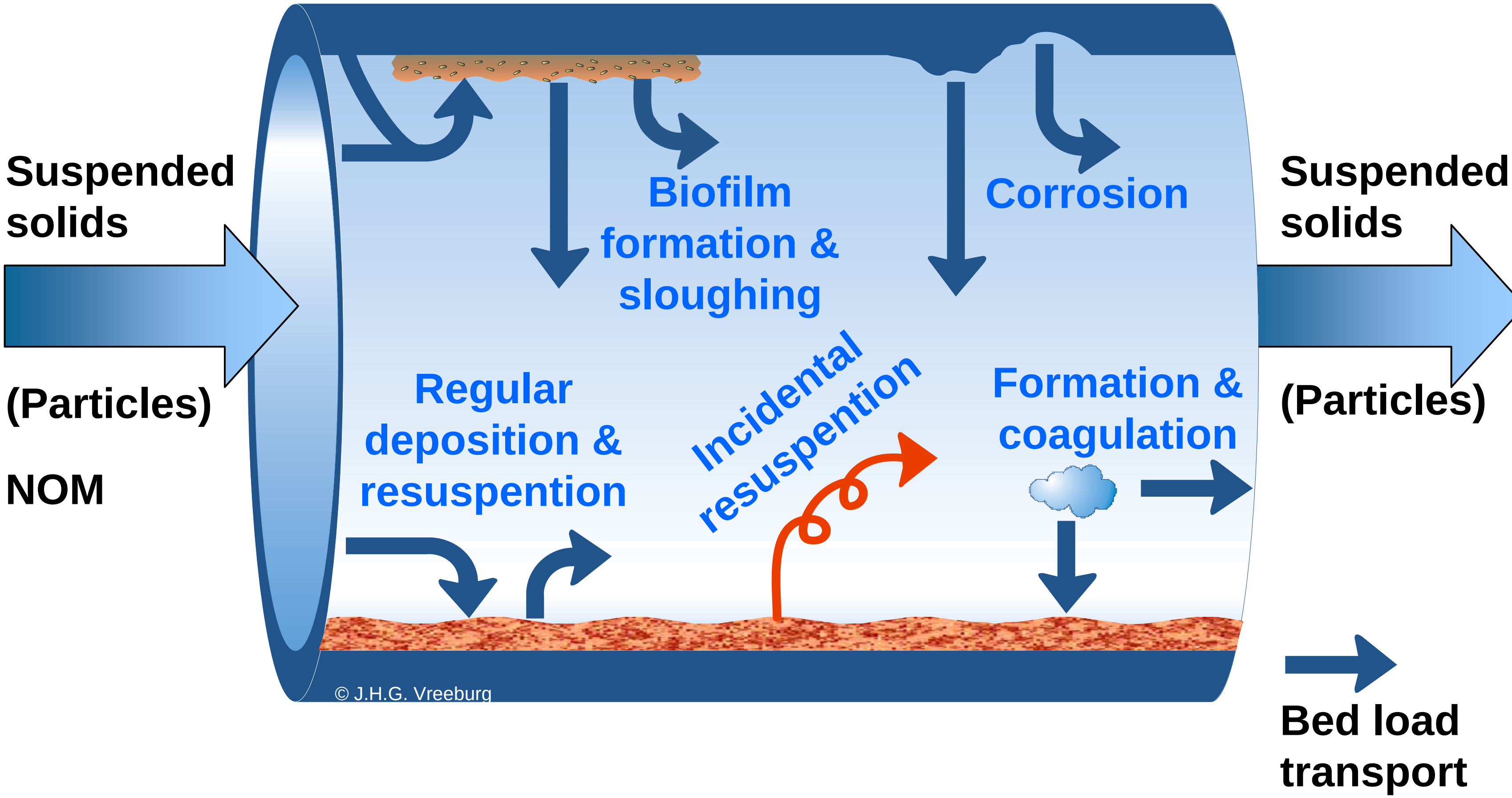


Transport network: Hydraulic equivalence



Drinking water quality aspects

Drinking water quality aspects



Test pipe rig Ø100

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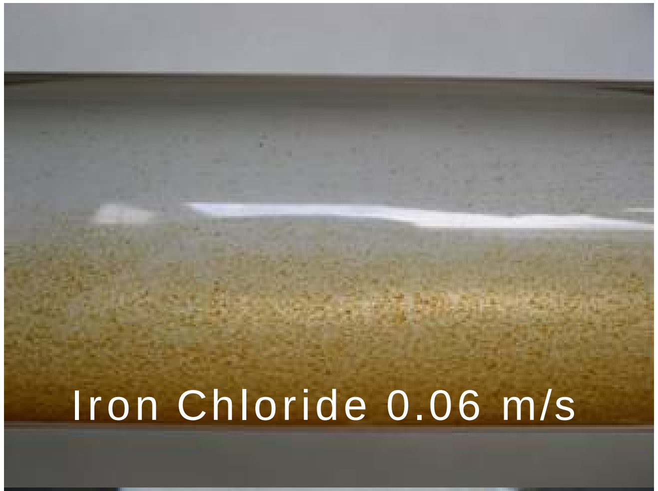
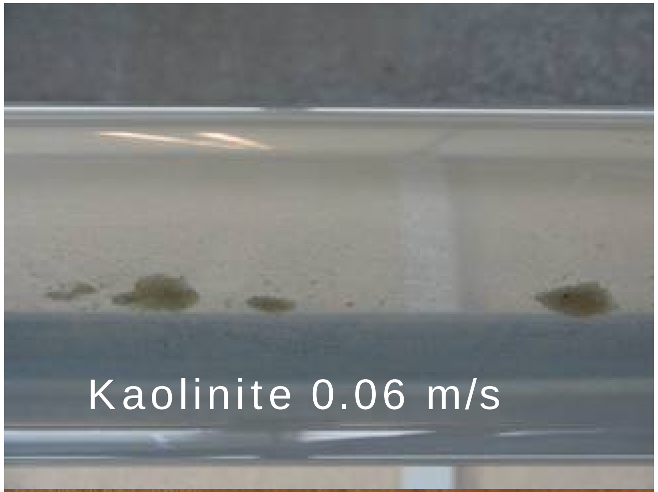
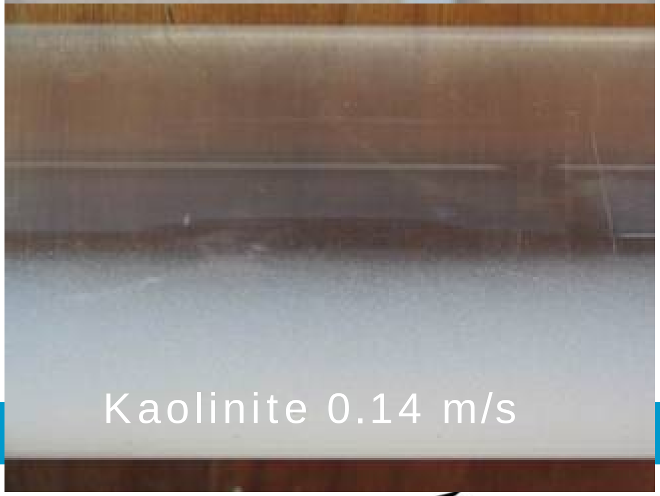
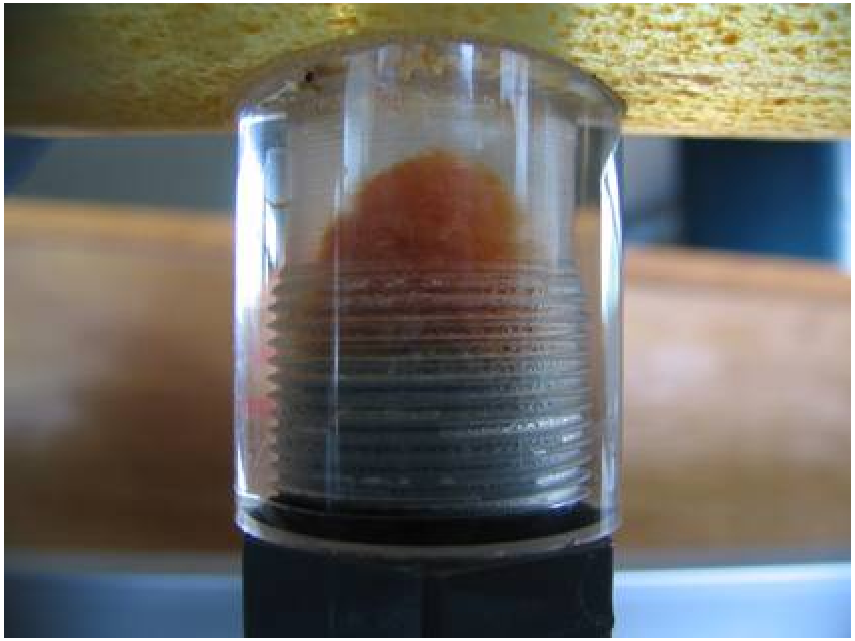
Gravitational settling is not the only process

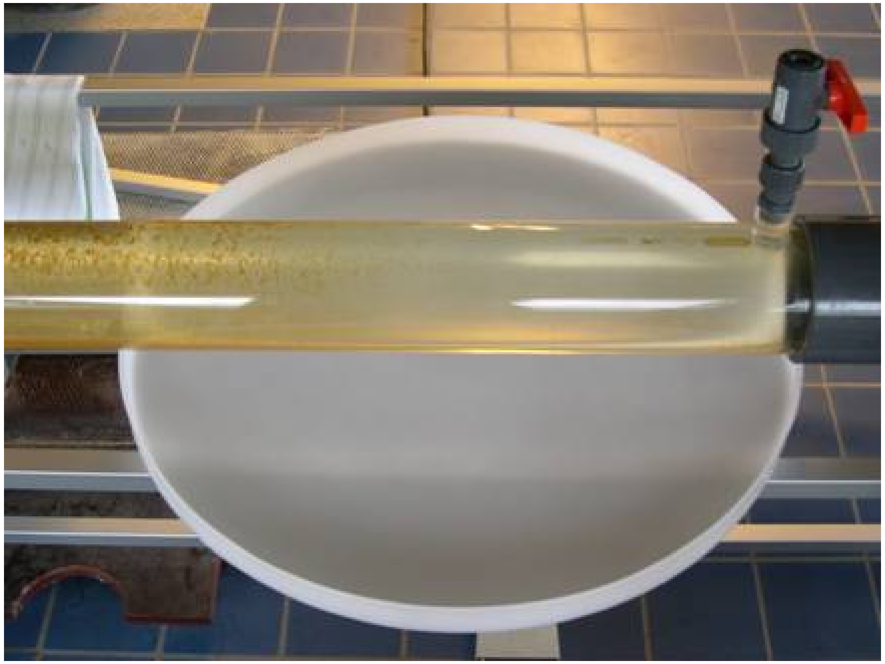






Bed load transport and influence 'bend turbulence'





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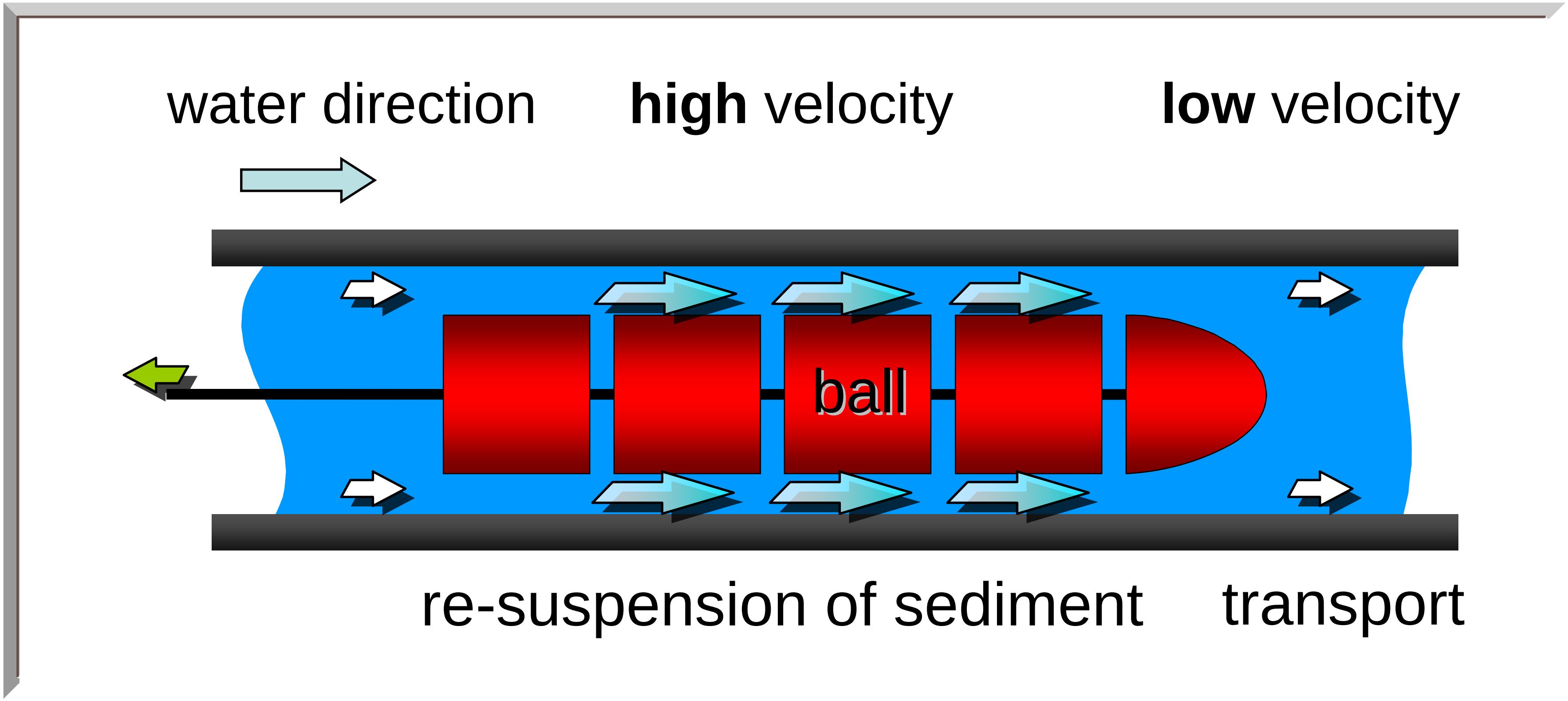
Innovative cleaning methods



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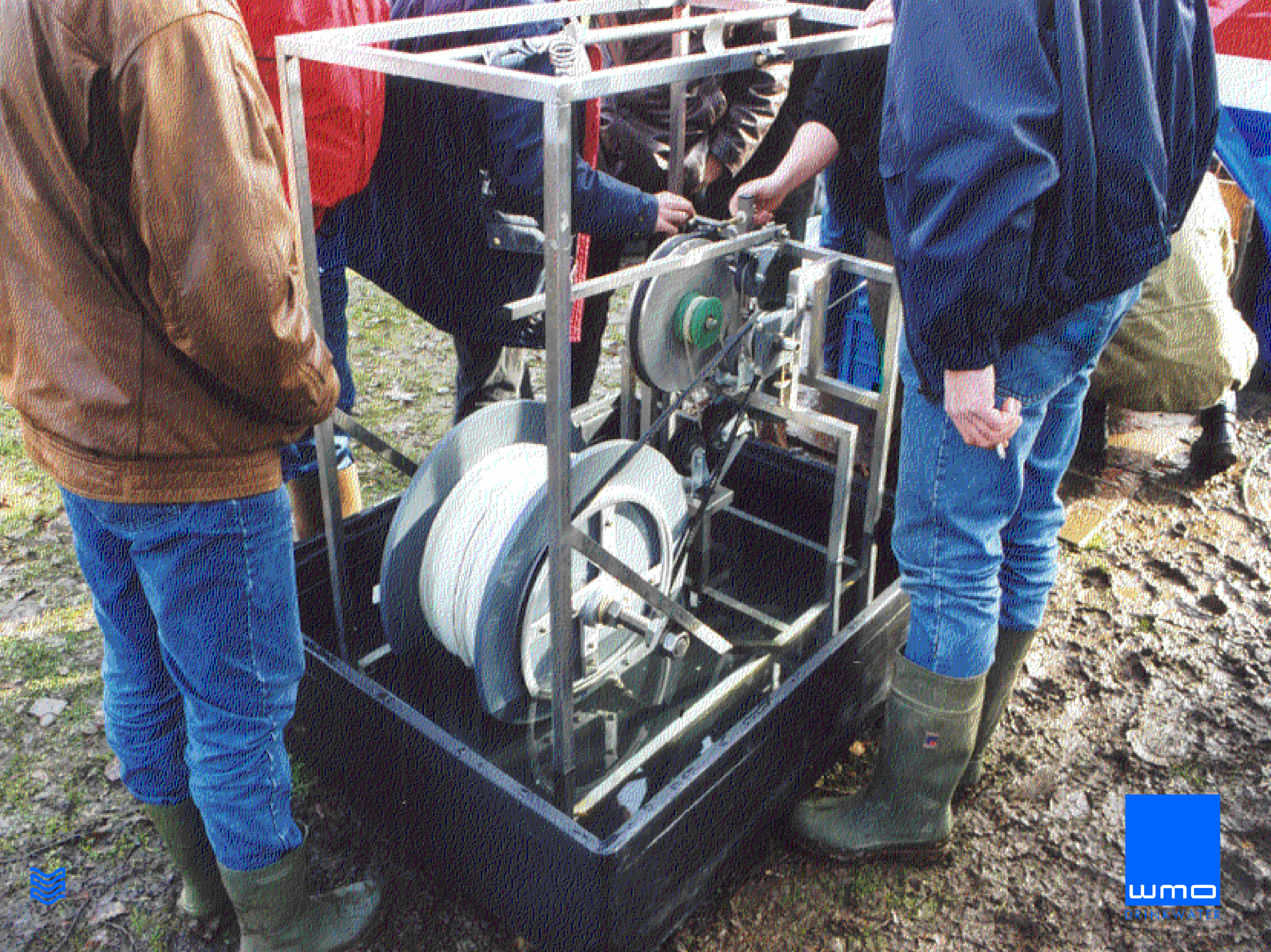
wmo
DRINKWATER


wmo
DRINKWATER

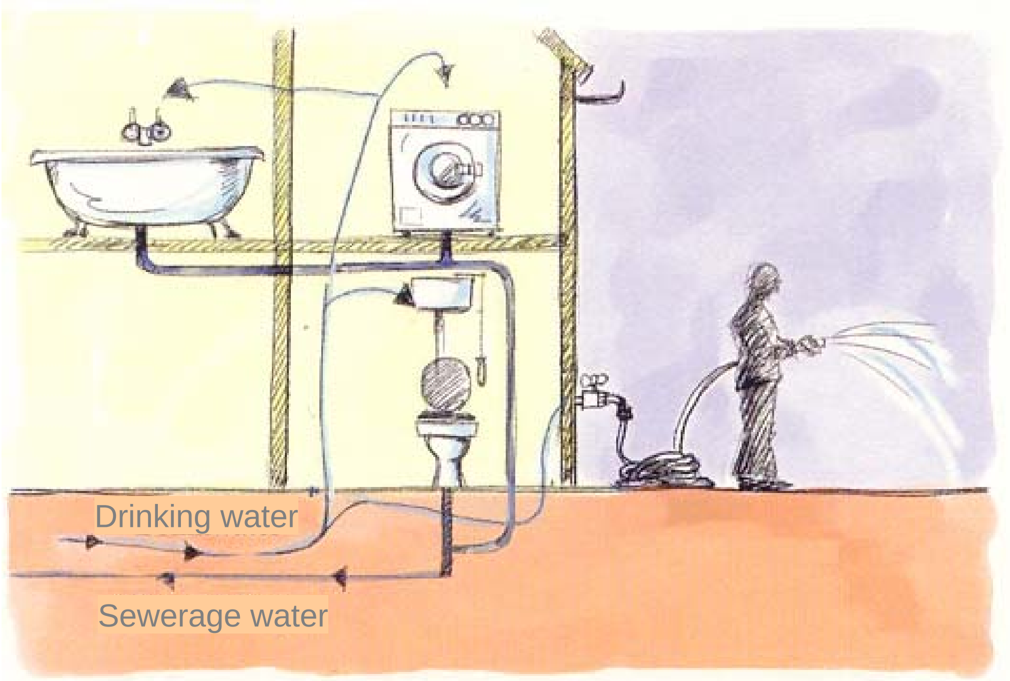


Energy consumption

- Transport friction loss ±40 MWC : ±110Wh/m^3

The water cycle
Drinking water/sewerage

- Transformation from drinking water to sewerage water



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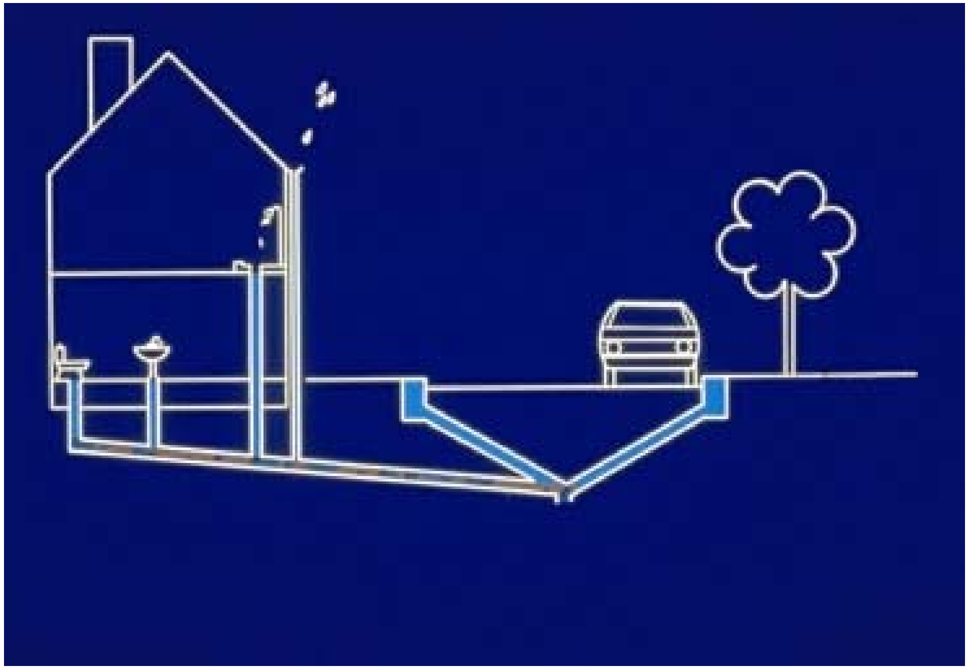
The water cycle
Drinking water / sewerage

- Transport to drainage system with gravity flow



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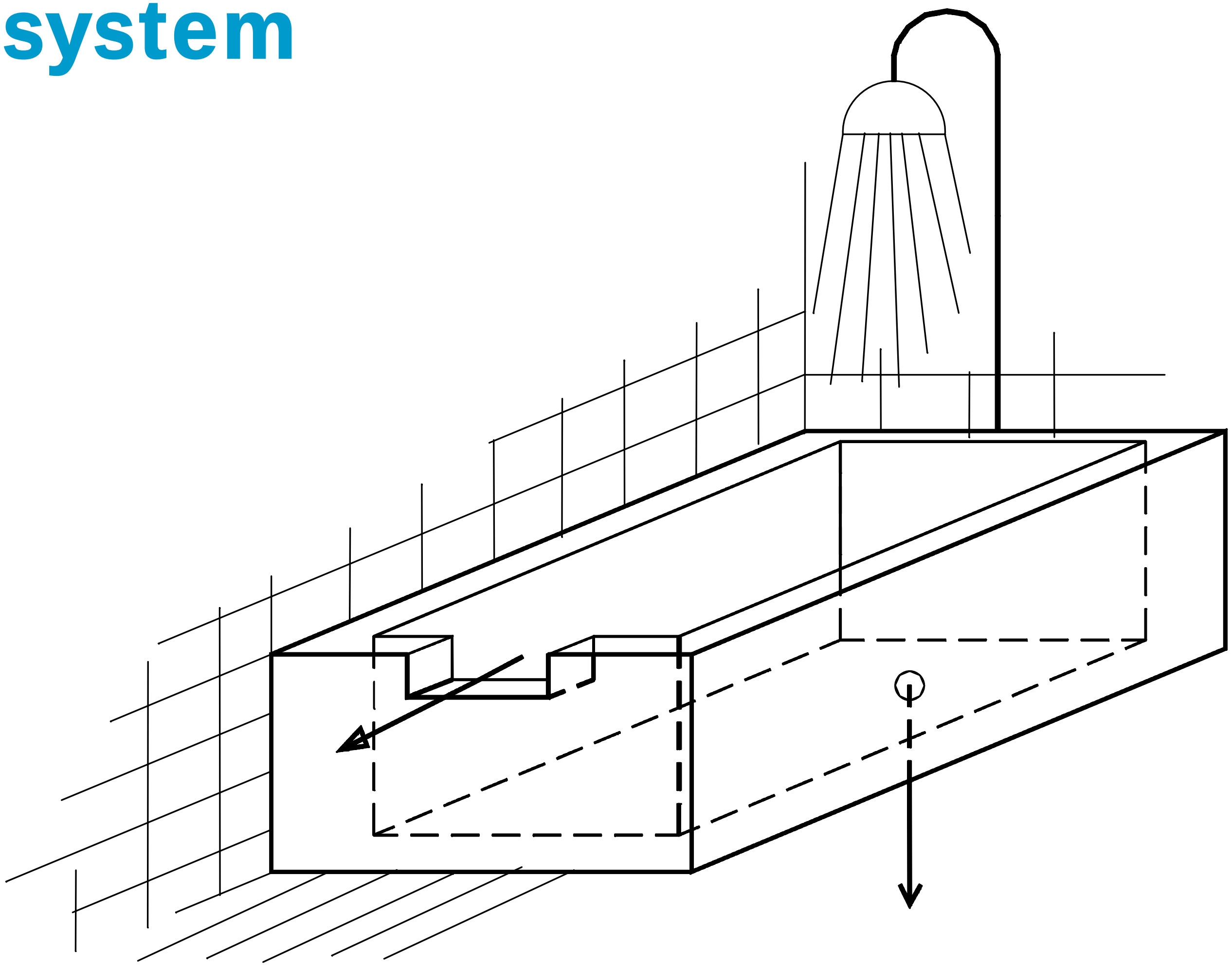
Urban drainage system

The water cycle
Drinking water/sewerage

- Collection in storage on district/neighbourhood level
- Pressurised flow to treatment plant
- Gravity flow in treatment
  Hydraulic line treatment plant
- Treated water wasted on surface water
  Picture of sewerage outlet

Schematic sewerage/urban drainage system



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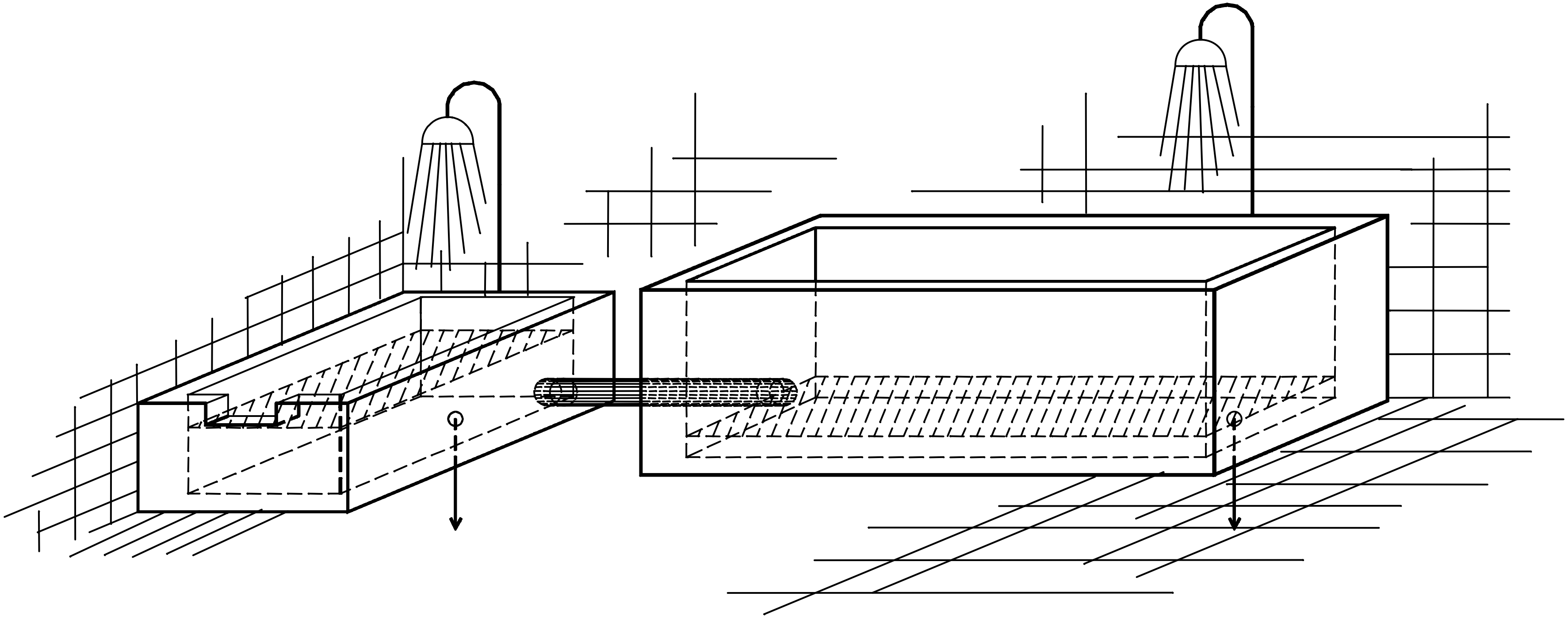
Schematic sewerage/urban drainage system



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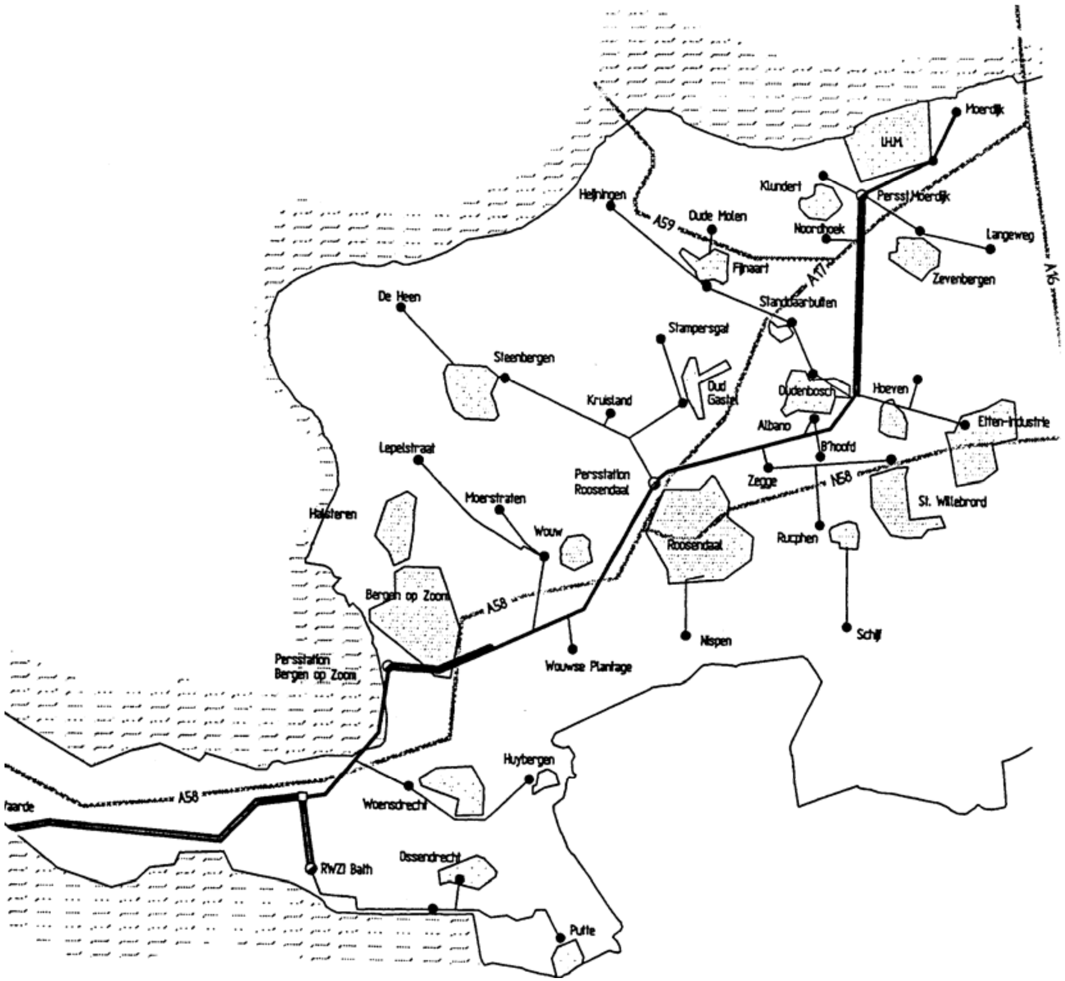
Pressurised sewer system



Overflow urban drainage system

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The water cycle
Drinking water/sewerage

- Energy consumption
  - Intake + treatment
    - Conventional: 55 Wh/m^3
    - Membrane: 193 Wh/m^3
  - Transport drinking water: 110 Wh/m^3
  - Transport sewerage water: 110 Wh/m^3
  - Treatment: 55 Wh/m^3
- Total: 470 Wh/m^3 (using membranes)
- Yearly demand $\pm$50m^3: 23,5 kWh/year

The water cycle: rain water/irrigation

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The water cycle: rain water/irrigation

- Water falls on paved areas
- Collection in rain water systems
- Combined systems:
  - Collection on district level, transport to treatment plant
  - Overflow to surface water
- Separate systems
  - Direct overflow to surface water

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The water cycle: rain water/irrigation

- Low pressure pumping station to let out the water
- Energy consumption:
  - 750 mm rainfall
  - 5 to 6 meters rise over quarter of the Netherlands
  - ±130 MWh/year

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Polder scenery

Content

- Hydraulics of closed pipes
  - pressurised
  - free surface
  - water hammer
- Network calculation
  - ALEID/EPANET

Content

- Practical applications
  - Design pipe systems on transport level
- Water quality with respect to hydraulics
- Reliability of networks
- Design of distribution networks
- Latest developments research water quality (Thesis opportunities)
- Operation and maintenance

Goals CT5550

- Acquire ability to
  - design transportation network
  - identify critical situations for water hammer
  - design a pumping station in terms of capacity, lay out and operation of pumps
  - Analyse drinking water system with ALEID and/or EPANET
  - Identify critical areas for water quality deterioration in a network
  - Identify critical areas for reliability

Course set up

- Lectures (9 chapters +1)
- Exercises and small sums
- Computer exercise
- Design exercise (50%)
  - Design small network using network calculation program
- Oral examination based on the design exercise (50%)

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Time table CT 5550: 2007 (1)

Friday Feb 8	•Introduction •Theoretical background •Pumps and pumping stations •Exercises, sums
Friday Feb 15	•Network modelling •Network design •Reliability •Water quality in networks •Introduction ALEID
Friday Feb 22	•Excursion to PWN •Practical applications •Exercise

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Time table CT 5550: 2007 (2)

Friday Feb 29 	•Drinking water demand Mirjam Blokker Kiwa WR •Design of drinking water distribution networks •Water Hammer (Ivo Pothof) •Design exercise
Friday March 7	•Design exercise (Q&A)
Friday March 14	•Latest developments research (Thesis opportunities!) •Operation and Maintenance •Design exercise (Q&A)

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Exam procedure

- Oral examination based on design exercise
- Hand in exercise one week before the oral examination (Room 4.55 mrs Hubert)
- Appointment list available at room 4.65
- Period March 14 onwards (Thursday or Friday)