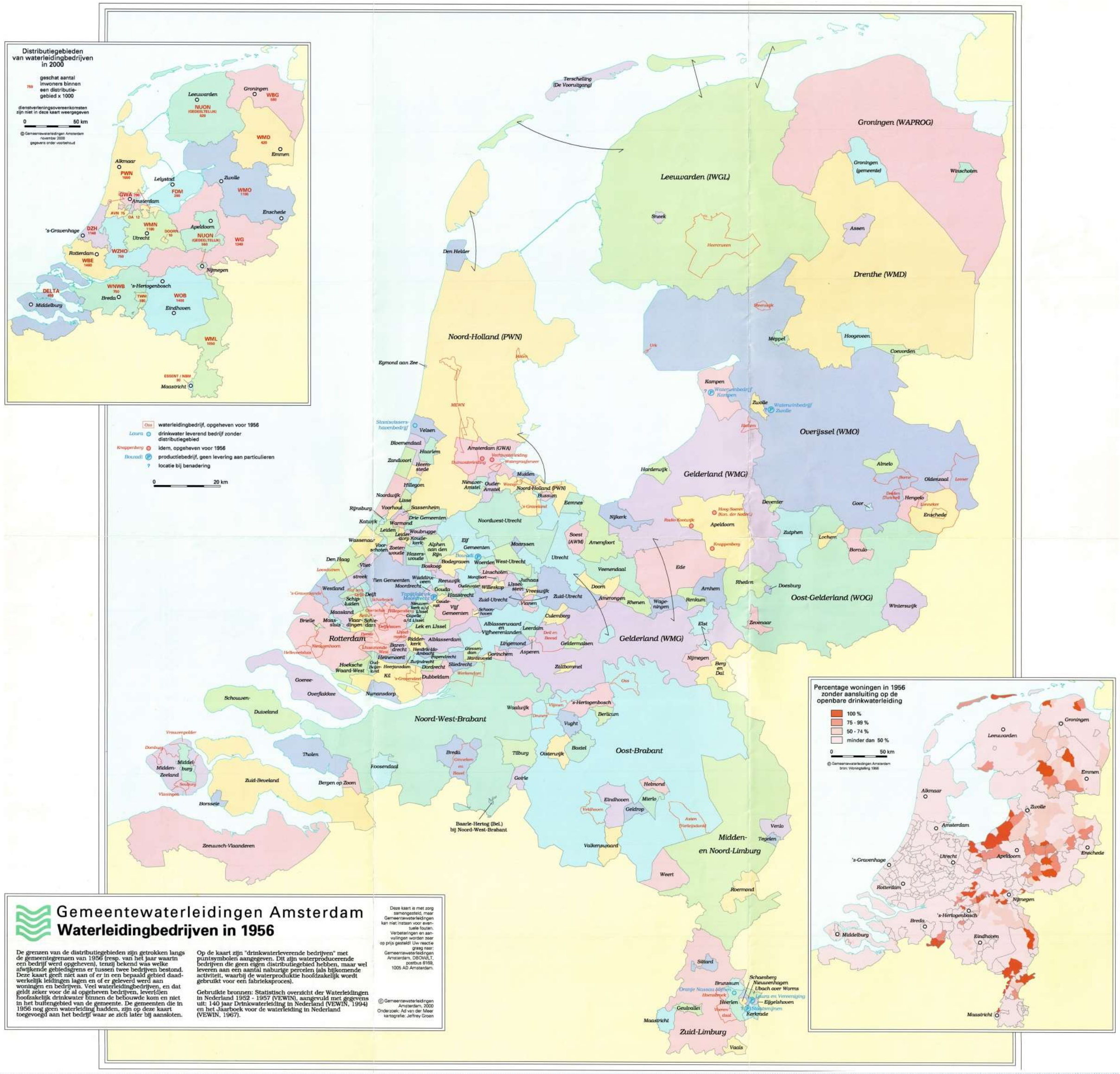
Smart Design and Operation of Water Distribution Networks in the Netherlands

Mirjam Blokker

From Kiwa to KWR
1948

Kiwa N.V. established in 1948 by the Dutch drinking water sector

Joint quality control of water mains' materials and fittings (Rijswijk)



From Kiwa to KWR

1971: Set up of research department

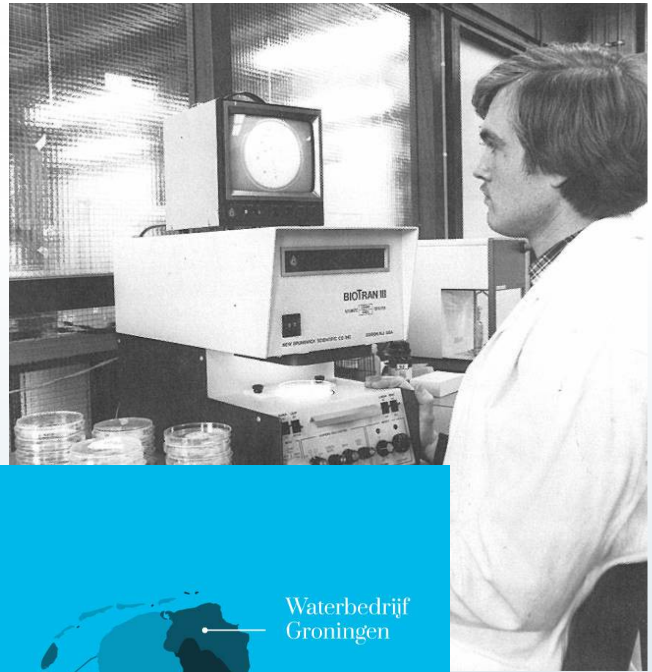
1972: Joint research programme

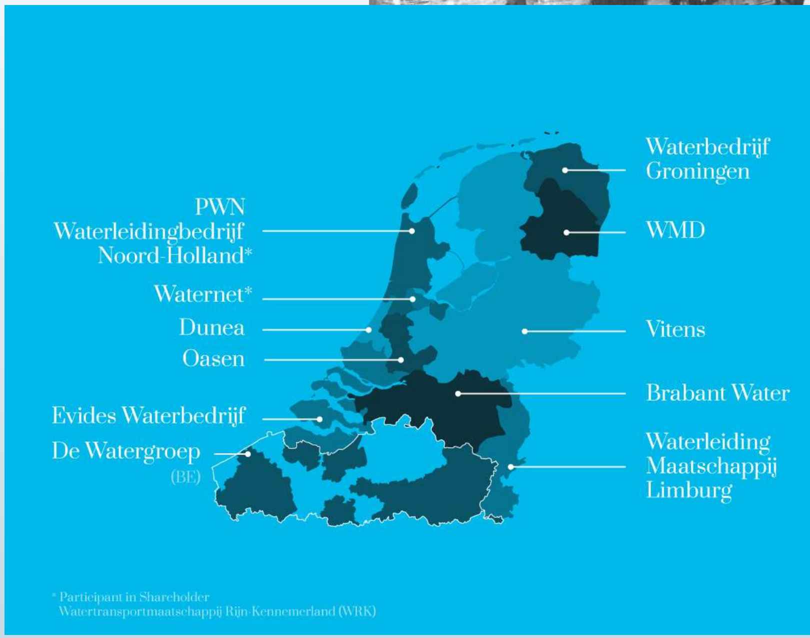
1979: Nieuwegein location opened

2006: Splitting of certification from Water Research

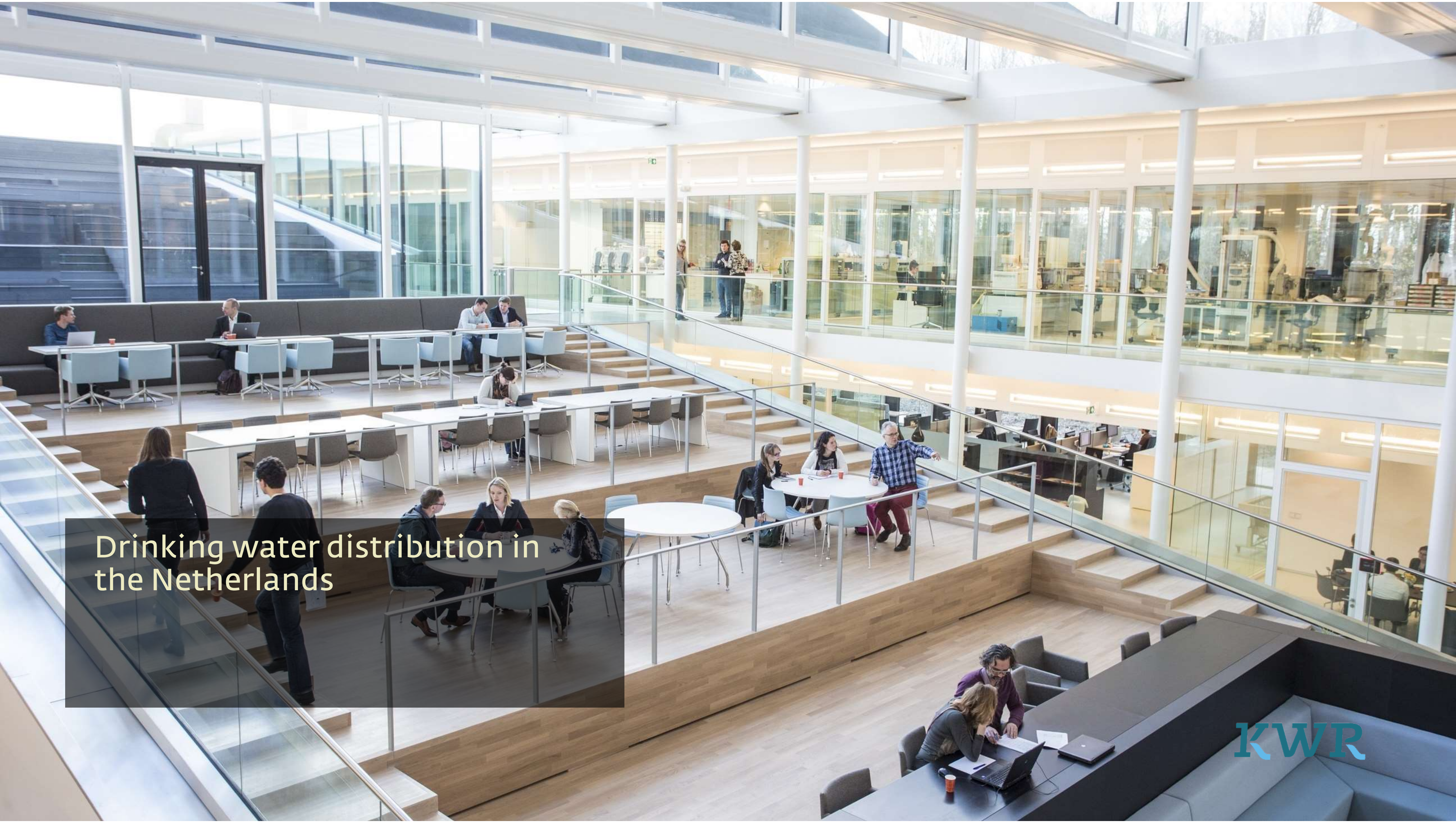
2008: Kiwa Water Research becomes KWR

2016: First international shareholder

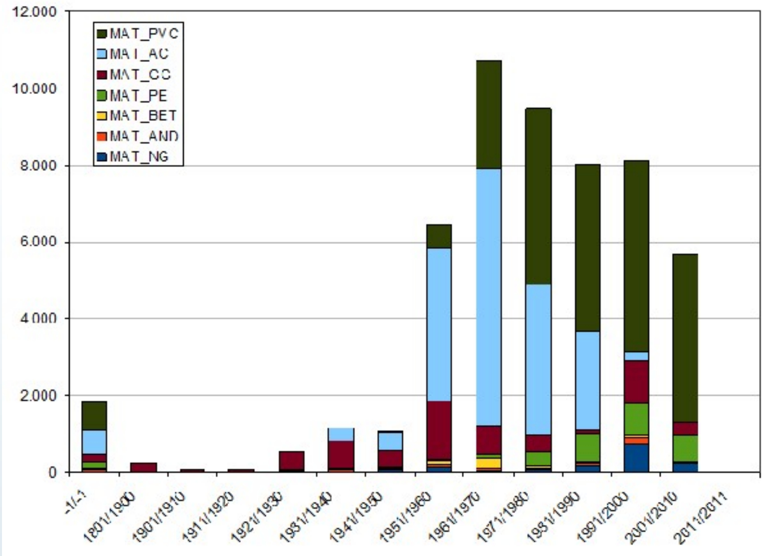


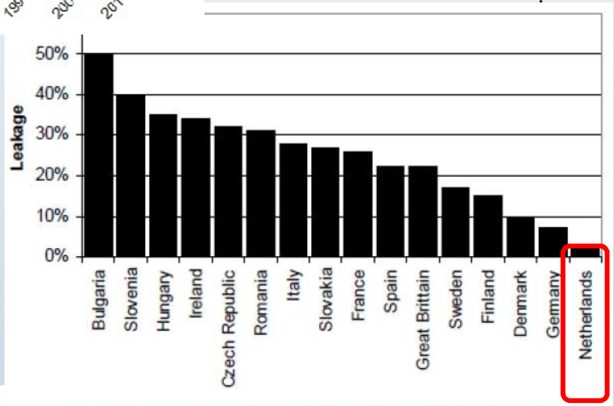


Drinking water distribution in the Netherlands



Dutch drinking water distribution network





Leakage rates (VEWIN, 2005, DVGW, 2008)

Network:

- 120,000 km
- 50% PVC; 30% AC; 10% CI
- Ca. 3% leakage
- Replacement from 0,5% per year → 1% per year

Research questions:

- Which mains to replace when?
- How to balance investments, performance and risk?
- How to maintain high standards?
- How to work in a busy urban environment?

Typical for Dutch drinking water distribution

PRACTICE

Focus on quality, long term

Fee covers all cost (ca. €2,- /m³)

No residual chlorine

Low leakage

- <5 %

low burst rate

- 0.08/km/year

Low number of customer complaints on discolouration

- <1 per 1000 customers per year

RESEARCH based vision on:

Network design

- Blueprints
- Self-cleaning networks

Network operation

- Cleaning (flushing)
- Valves & hydrants maintenance

Network replacement

- Failure registration
- Inspection
- Models

Current RESEARCH on:

Asset Management:

- replacement planning for AC pipes
- failure and inspection data

Water quantity

- Demand model (SIMDEUM)

Water quality:

- QMRA in the distribution network
- Biological stable water
- Sensor placement and interpretation

Typical for Dutch drinking water distribution

PRACTICE

Focus on quality, long term

Fee covers all cost (ca. €2,- /m³)

No residual chlorine

Low leakage

- <5 %

low burst rate

- 0.08/km/year

Low number of customer complaints on discolouration

- <1 per 1000 customers per year

RESEARCH based vision on:

Network design

- Blueprints
- Self-cleaning networks

Network operation

- Cleaning (flushing)
- Valves & hydrants maintenance

Network replacement

- Failure registration
- Inspection
- Models

Current RESEARCH on:

Asset Management:

- replacement planning for AC pipes
- failure and inspection data

Water quantity

- Demand model (SIMDEUM)

Water quality:

- QMRA in the distribution network
- Biological stable water
- Sensor placement and interpretation

No residual chlorine
Best practice

1. Use the best source available:
   - microbiologically safe groundwater,
   - surface water with soil passage,
   - direct treatment of surface water in a multiple barrier treatment;
2. Use a preferred physical process treatment (such as sedimentation, filtration and UV-disinfection). If necessary, also oxidation can be used by means of ozone or peroxide , but chlorine is avoided;
3. Prevent ingress of contamination during distribution;
4. Prevent microbial growth in the distribution system by production and distribution of biologically stable (biostable) water and the use of biostable materials;
5. Monitor for timely detection of any failure of the system to prevent significant health consequences.

Smeets, P., Medema, G. J. and van Dijk, J. C. (2009). "The Dutch secret: how to provide safe drinking water without chlorine in the Netherlands." *Drink. Water Eng. Sci.*, 2, 1-14. http://www.drink-water-eng-sci.net/2/1/2009/dwes-2-1-2009.html

barriers against ingress of microbial contaminants

Typical for Dutch drinking water distribution

PRACTICE

Focus on quality, long term

Fee covers all cost (ca. €2,- /m³)

No residual chlorine

Low leakage

- <5 %

low burst rate

- 0.08/km/year

Low number of customer complaints on discolouration

- <1 per 1000 customers per year

RESEARCH based vision on:

Network design

- Blueprints
- Self-cleaning networks

Network operation

- Cleaning (flushing)
- Valves & hydrants maintenance

Network replacement

- Failure registration
- Inspection
- Models

Current RESEARCH on:

Asset Management:

- replacement planning for AC pipes
- failure and inspection data

Water quantity

- Demand model (SIMDEUM)

Water quality:

- QMRA in the distribution network
- Biological stable water
- Sensor placement and interpretation

The story of water quality and asset management

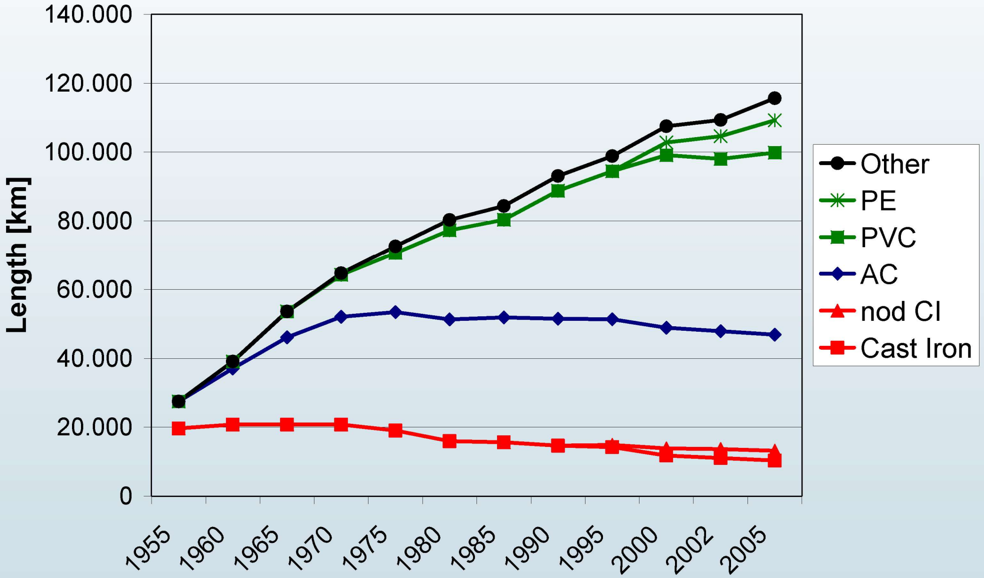
Once upon a time……

There was a water quality problem

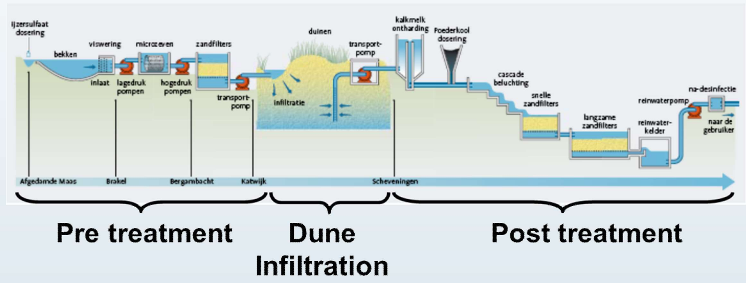
With an obvious cause

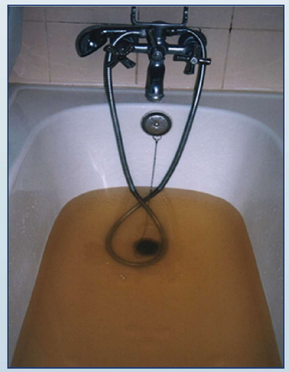
However….

There is so little cast iron



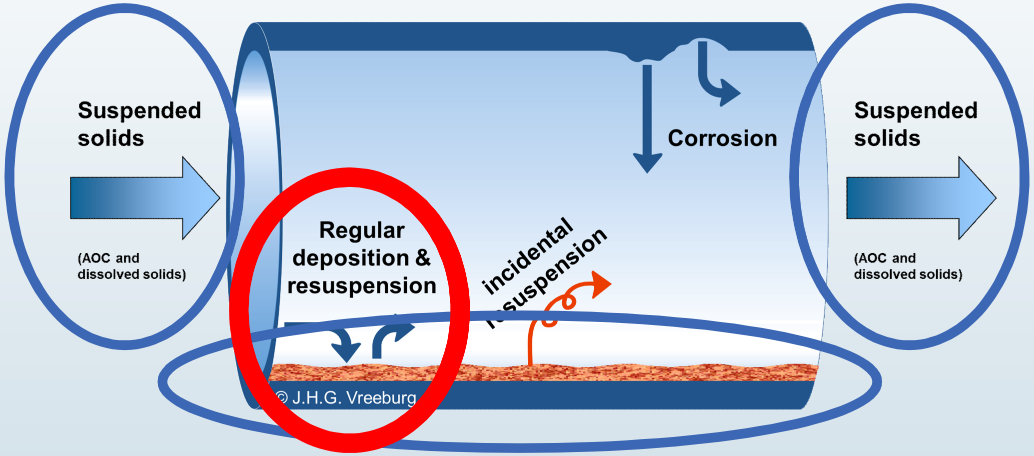
Something happens between treatment and distribution





Consequences of particle related processes

- Discolouration only occurs in the presence of sediment: Controlling the sediment = controlling the discolouration
- Balance between incoming and outgoing sediment indicates the sediment build-up
- Hydraulic processes govern the deposition and resuspension

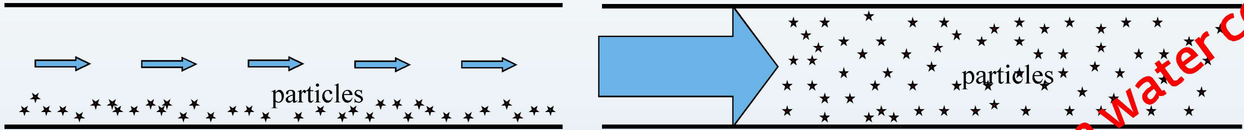


Self-Cleaning Network

Normal network

v_{max} = 0,07 m/s (normal)

v > 0.4 – 1.5 m/s (disturbed)

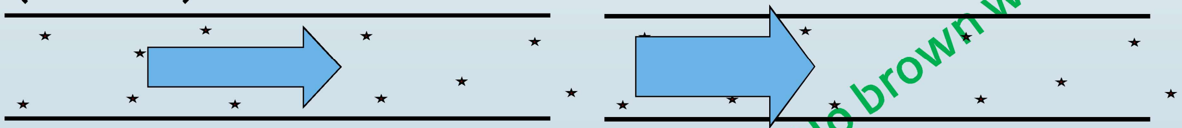


Brown water complaints

Self-cleaning network

$v_{max} \geq$ 0.2 m/s, unidirectional (normal)

v >0.4 – 1.5 m/s (disturbed)



No brown water complaints

- Unidirectional flow ➔ branched structure
- Velocity 0.2 m/s once a day ➔ Reducing diameter to the end (110, 63, 40 mm) & flowing ends
- No corroding pipe material ➔ PVC
- Enough head available at max water use

Self cleaning networks
Characteristics

Self-cleaning networks:

- Last part of the network
- Unidirectional flow, no stagnant zones
- Minimum flow at peak hour

Leading to

- Shorter lengths (no loops) and smaller pipe diameters ➔ cheaper network
- Less discolouration incidents (no flushing)
- Good security of supply
- Smaller hydrant capacity

Vreeburg, J. H. G., Blokker, E. J. M., Horst, P. and van Dijk, J. C. (2009). "Velocity based self cleaning residential drinking water distribution systems." *Water Science & Technology*, 9(6), 635-641, doi:10.2166/ws.2009.689.

Typical for Dutch drinking water distribution

PRACTICE

Focus on quality, long term

Fee covers all cost (ca. €2,- /m³)

No residual chlorine

Low leakage
- <5 %

low burst rate
- 0.08/km/year

Low number of customer complaints on discolouration
- <1 per 1000 customers per year

RESEARCH based vision on:

Network design
- Blueprints
- Self-cleaning networks

Network operation
- Cleaning (flushing)
- Valves & hydrants maintenance

Network replacement
- Failure registration
- Inspection
- Models

Current RESEARCH on:

Asset Management:
- replacement planning for AC pipes
- failure and inspection data

Water quantity
- Demand model (SIMDEUM)

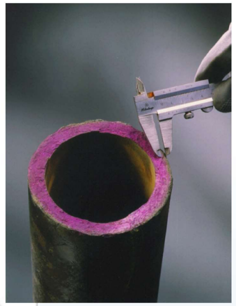
Water quality:
- QMRA in the distribution network
- Biological stable water
- Sensor placement and interpretation

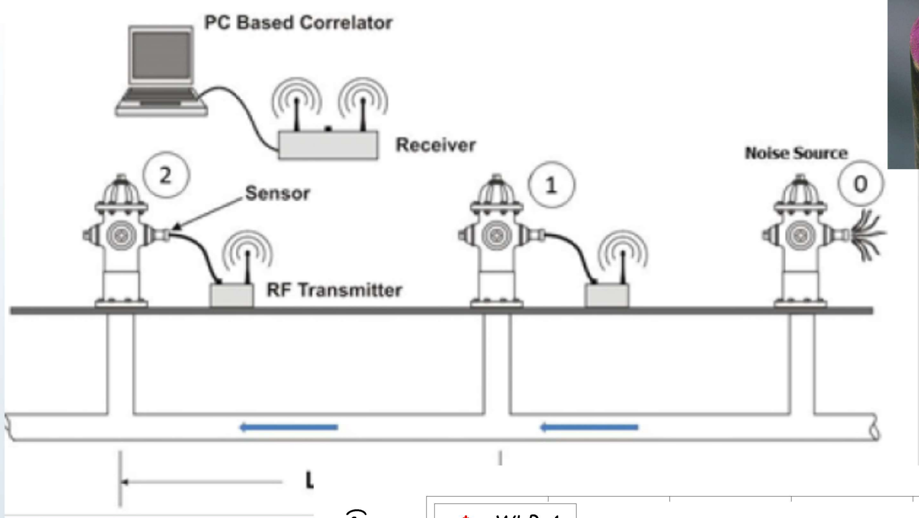
AM: replacement planning of AC pipes

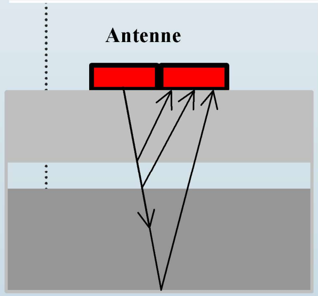
Current research (1)

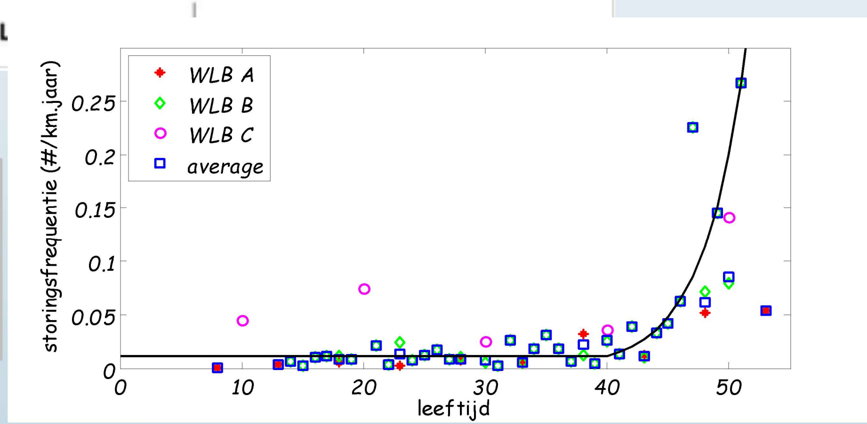
Combining information:

- **Pipe degradation mechanisms: strength lost due to internal / external cement leaching**
- **Failure registration data (USTORE)**
- **Exit assessment on leaching (phenolphtaleine staining)**
- **Inspection with Georadar, Echo pulse**





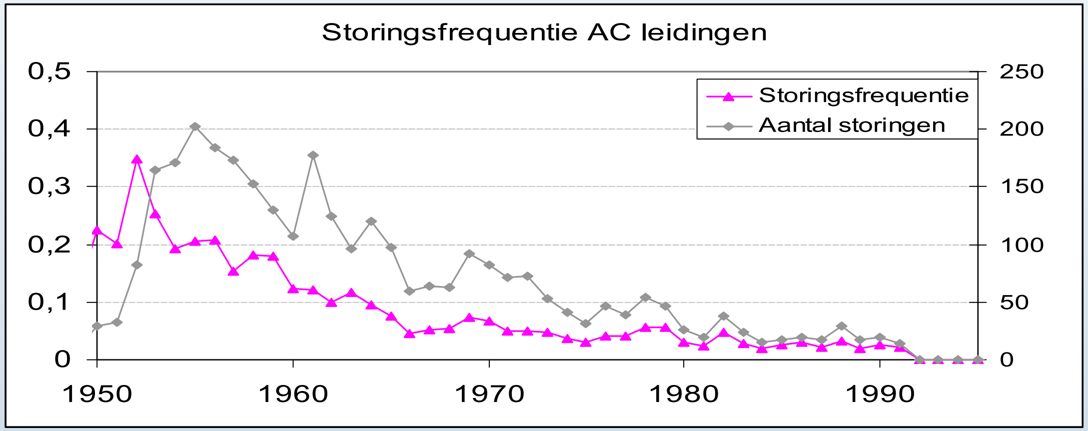


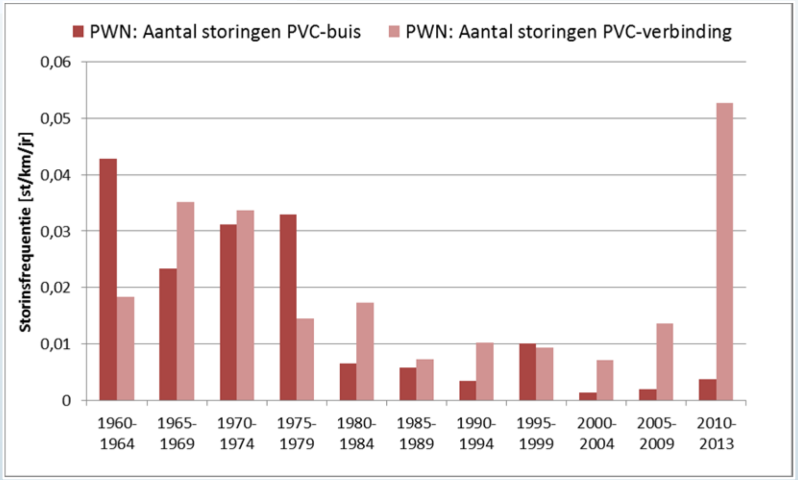


Beuken, R., Horst, P., Diemel, R. and Mesman, G. A. M. (2014). "Mains condition assessment by echopulse, a validation of results." *16th Conference on Water Distribution System Analysis, WDSA 2014*.

Registration of bursts with USTORE

- 8 drinking water companies
- 18.000 bursts
- Developments:
  - Quality system
  - Belgium companies joining





Bathtub curve PVC,

- Younger mains: joints
- Older mains: joints and pipes

Typical for Dutch drinking water distribution

PRACTICE

Focus on quality, long term

Fee covers all cost (ca. €2,- /m³)

No residual chlorine

Low leakage

- <5 %

low burst rate

- 0.08/km/year

Low number of customer complaints on discolouration

- <1 per 1000 customers per year

RESEARCH based vision on:

Network design

- Blueprints
- Self-cleaning networks

Network operation

- Cleaning (flushing)
- Valves & hydrants maintenance

Network replacement

- Failure registration
- Inspection
- Models

Current RESEARCH on:

Asset Management:

- replacement planning for AC pipes
- failure and inspection data

Water quantity

- Demand model (SIMDEUM)

Water quality:

- QMRA in the distribution network
- Biological stable water
- Sensor placement and interpretation

Drinking water

THAT LOOKS GOOD

THAT TASTES GOOD

IS ALWAYS AVAILABLE

IS NOT EXPENSIVE