Health and aesthetic aspects of water quality ja Water quality control in the networks

-GENERAL-

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WAT-E2110 - Design and Management of Water and Wastewater Networks

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Water quality in distribution

- Starting point
  - Good quality water from the treatment plant
  - Water quality changes in distribution
  - Stagnant water is not pleasurable
- Important prerequisites at the WTP (water treatment plant)
  - Reducing organics
  - Reducing nutrients
  - Disinfection
  - pH adjustment – preventing corrosion
  - Hardness adjustment – preventing excess calcareous fur

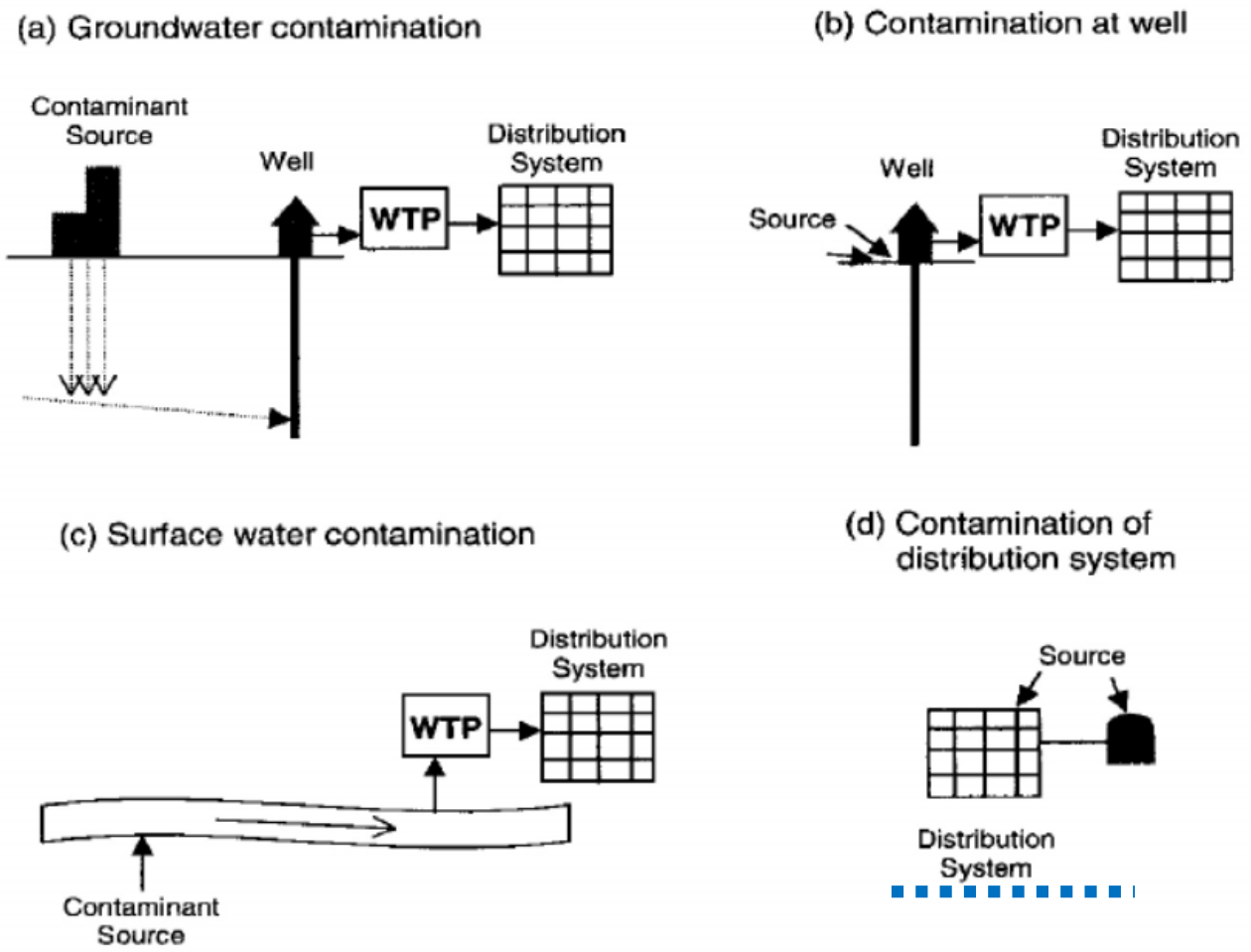
Concepts to ensure quality in distribution 

- Multible barriers is a concenpt to protect water consumers from waterborne deseases
  - Water treatment
  - Disinfection at WTP
  - Distribution system as the final barrier
- Approaches to reducing risks
  - Risk assessment
  - Monitoring
  - Distribution system modeling
  - Data integration

Taste & odor of water

- Typical indication of loss of water quality integrity
  - Consumer complaints
- Metals, volatile organic chemicals, microbial activity
- Algal growth in open storage – earthy, musty, fishy
- External contamination
  - Gasoline, soil, sewage
- Stagnant water, no chlorine residual
  - Stagnant household plumbing
- Backflow events, corrosion, leaching of new materials
- Color and turbid water
  - Corrosion of iron, shockwaves
- *“chlorinous “ taste and odor*

http://www.hazenandsawyer.com



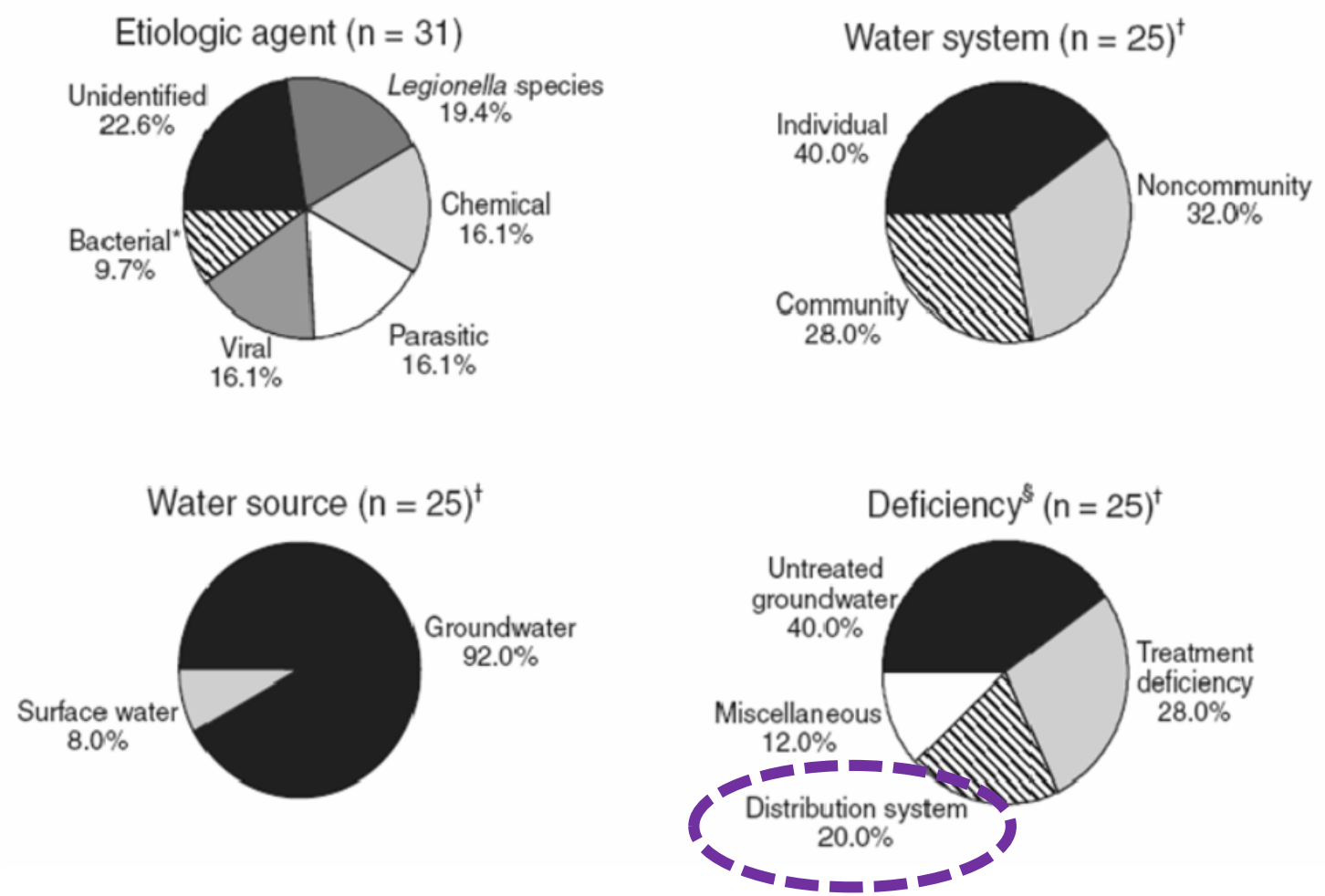
Contamination scenarios (Grayman et al. 2004a)

Contamination

- Microbiological contamination
- Chemical contamination
- Contamination is shown in distribution in monitoring results or customer complaints

Waterborne outbreaks by source

US 2001-2002
Microbiological and chemical outbreaks



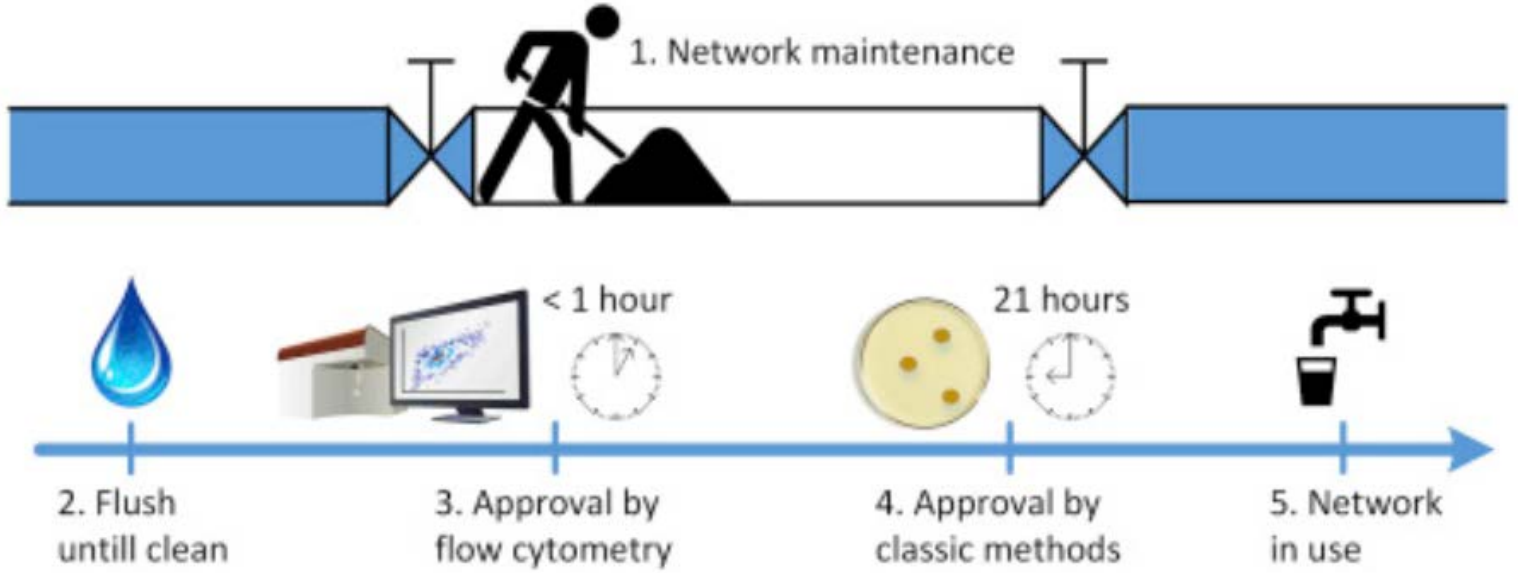
Quality requirements in Finland

- Microbiological requirements
  - Escherichia coli 0 cfu/100 ml
  - Enterococci 0 cfu/100 ml
- Chemical requirements
  - Metals (As, U, Pb, Ni, Cr, Cd etc.)
  - Non-metals (B, F, etc.)
  - DBPs (THMs)
  - Organic toxic compounds (Vinyl chloride, pesticides, etc.)
  - See full list and limiting concentrations at Finlex http://www.finlex.fi/fi/laki/alkup/2015/20151352
- Radioactive requirements
  - Radon, Tritium, Indicative dose

Recovering water quality integrity

- Flushing
  - To remove tastes, odors, turbidity and raise disnfectant level
- Switching disinfectants
  - Permanently, to maintain residual
  - Periodically to mitigate nitrification
- Corrosion control
- Changing water sources

Network maintenance



Van Nevel et al. 2016

- When doing maintenance the part of the network has to be closed by valves
- After maintenance the system has to be flushed
- Water quality has to be approved before using the pipes under maintenance

Water quality monitoring

- Sampling + analysis at laboratory
  - Planned monitoring
  - According to standard procedures
- Measuring online
  - Rarely done permanently,
  - Measuring campaign of days or weeks
  - Inexpensive parameters can be measured

Planned monitoring of distributed water

MetropoliLab

TESTAUSSELOSTE 2011-5438 1(2)
Vesi 05.05.2011

Tilaaja
2274241-9
HSY Vesi
Vedenpuhdistus, käyttölaboratorio
PL 315
00066 HSY

Maksaja
HSY Vesi
Ostolaskut
PL 303
00066 HSY

ilac-MRA
FINAS
Finnish Accreditation Service
T098 (EN ISO/IEC 17025)

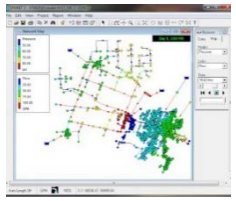
Näytetiedot	**Näyte**	Verkostovesi		
	Näyte otettu	03.05.2011	**Kellonaika**	
	Vastaanotettu	03.05.2011	**Kellonaika**	12.30
	Tutkimus alkoi	03.05.2011	**Näytteenoton syy**	Jatkuva valvonta
	Näytteen ottaja	Villikka Marjut, näytteenottaja		

Analyysi	Menetelmä	5438-1 Verkostovesi Vanttilan koulu, Nissintie 2, Espoo	5438-2 Verkostovesi Auroran pk. Kulloonmäentie 20, 02070 ESPOO	5438-3 Verkostovesi Kartanonpuiston Pk, Sokerilinnantie 5, 02600 ESPOO	5438-4 Verkostovesi Tiistilänraitin pk, Tiistilänkuja 7, Espoo	Yksikkö	Epävarmuus-%
Koliformiset bakteerit	* Colilert Quanti Tray	<1	<1	<1	<1	mpn/ 100 ml	
Escherichia coli	* Colilert Quanti Tray	<1	<1	<1	<1	mpn/ 100 ml	
Clostridium perfringens	* STM 461/2000	0	0	0	0	pmy/100 ml	
Kokonaiskloori Cl2	* SFS-EN ISO 7393-2:2000	0,15	0,03	0,25	0,11	mg/l	10

11/

- The water works organize <u>obligatory</u> quality monitoring themselves
- At Helsinki area the monitoring is subcontracted to a commercial, accredited laboratory Metropolilab
- Samples taken by accredited persons only
- Analyses by standard methods
- Ca. 1000 sampling addresses
- Samples collected and analyzed throughout the year according to a schedule

Typical quality report in obligatory monitoring

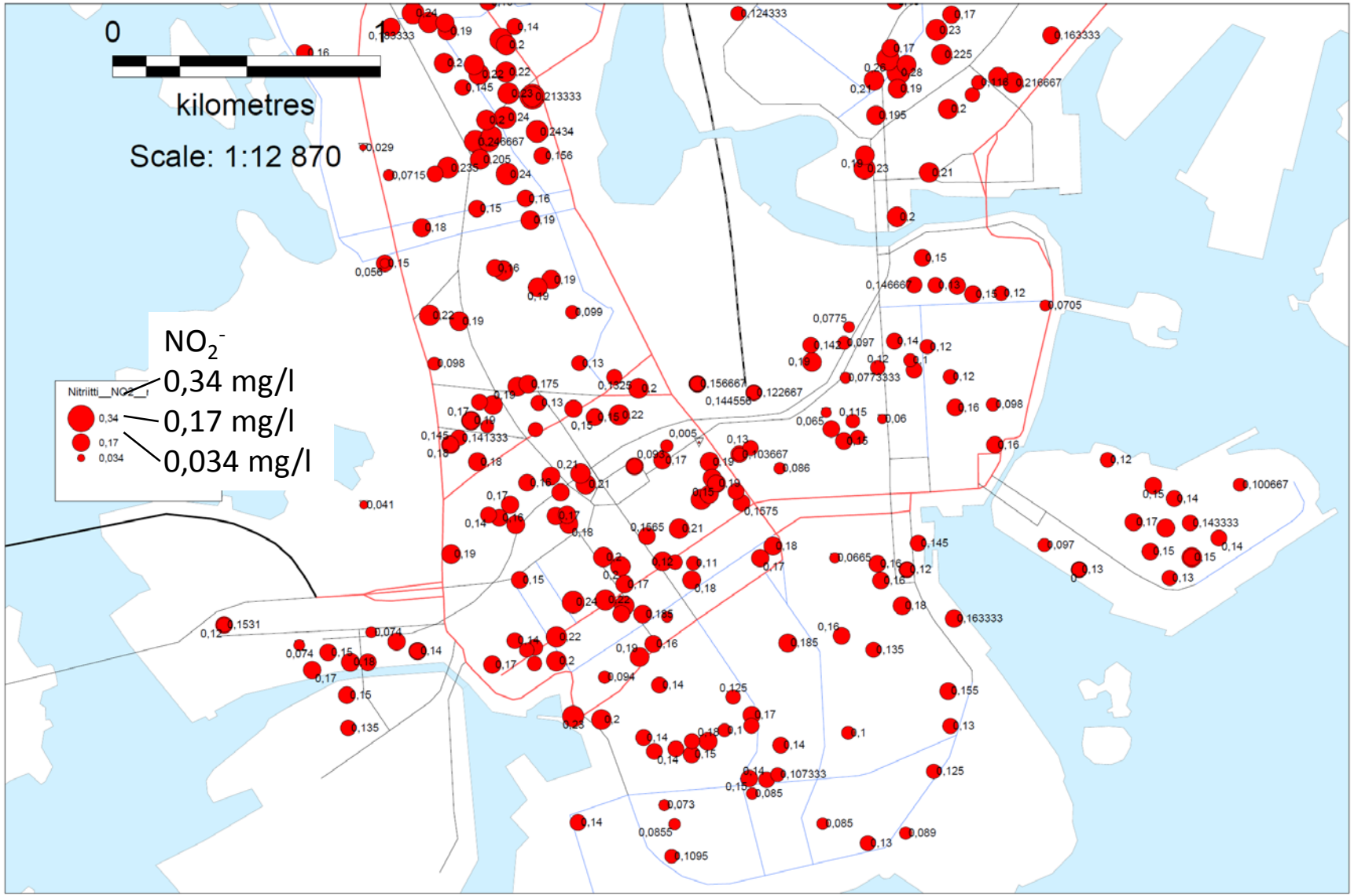


- Chloramine can be seen both in Cl_2 and NH_4^+ analyses
- Both analyses include also free forms
- Nitrite is formed from ammonium in nitrification
- Chlorine residual is below determination limit (0.03 mg/l) in 3 cases
- Chlorine residual 0.35 mg/l caused chlorinous odor in the water

	Analyysi Verkostovesi = distributed water	Menetelmä method	17450-1 Verkostovesi Nupurin pk, Brobackantie 1-3, 02820 ESPOO	17450-2 Verkostovesi Auroran pk. Kulloonmäentie 20, 02070 ESPOO	17450-3 Verkostovesi Lähderannan pk, Lähdepurontie 3, 02720 Espoo	17450-4 Verkostovesi Heikelintien Pk, Pohj. Heikelintie 12	Yksikkö unit	Epävarmuus-% uncertainty
Coliforms	Koliformiset bakteerit	* Colilert Quanti Tray	<1	<1	<1	<1	mpn/ 100 ml	
	Escherichia coli	* Colilert Quanti Tray	<1	<1	<1	<1	mpn/ 100 ml	
	Clostridium perfringens	* STM 461/2000	0	0	0	0	pmy/100 ml Cfu/100 ml	
Total residual chlorine	Kokonaiskloori Cl2	* SFS-EN ISO 7393-2:2000	0,35	< 0,03	< 0,03	< 0,03	mg/l	10
Turbidity	Sameus	* SFS-EN ISO 7027:2000	0,11	0,13	0,18	0,18	FNU	10
Color	Väriluku	* SFS-EN ISO 7887-4/95	< 5	< 5	< 5	< 5	mg Pt/l	15
	pH	* SFS 3021 1979	7,5	7,9	7,9	8,0		3
Conductivity	Sähkönjohtavuus	* SFS-EN 27888:1994	189	156	156	155	µS/cm	5
	Ammonium, NH4	* ISO 7150:1984	0,19	< 0,010	< 0,010	< 0,010	mg/l	15
	Nitriitti, NO2	* SFS 3029, autom.	0,13	< 0,010	< 0,010	< 0,010	mg/l	15
	Alkuaineiden määritys:	* ICP-MS	x	x	x	x		
	Mangaani, Mn	* ISO 17294-2	17	< 1	1,3	1,5	µg/l	20
	Rauta, Fe	* ISO 17294-2	7	35	73	66	µg/l	15
Odor	Haju	JTTM-1969	kloori chlorinous	imelähkö sl sweet	imelähkö sl sweet	ei sivuhajua	no odor	
Taste	Maku	JTTM-1969	ei sivumakua	ei sivumakua	ei sivumakua	ei sivumakua		
Temperature	Veden lämpötila	field measurement kenttämittaus	no taste 9,5	12,1	10,3	10,2	°C	

Sampling sites in Helsinki downtown (NO_2^- on map)

- Each circle is a site where distributed water was sampled
- Water quality in Helsinki downtown is monitored densely because quite a lot of people use water there



Obligatory monitoring data 2010-2013

Water quality actions in G200 AWWA standard

Section	Title	Requirement
4.1	***Water Quality***	
4.1.1	**Compliance with regulatory requirements**	Meet or exceed regulatory requirements.
4.1.2	**Monitoring and control**	
4.1.2.1	*Sampling plan*	Establish plan, review annually, analyze/trend data, have action plan to respond to changes.
4.1.2.2	*Sample sites*	Include all types of locations including dead ends and storage. Past problem areas require more sampling.
4.1.2.3	*Sample collection*	Use *Standard Methods*, standardized labels and chain of custody forms.
4.1.2.4	*Sample taps*	Protect from contamination. Inspect annually.

AWWA Standard G200: Distribution Systems Operation and Management (2015, **ISBN:** 9781625760760)

This standard describes critical requirements for the operation and management of potable water distribution systems, including maintenance of water quality, system management programs, and operation and maintenance of facilities, and verification.

Water quality actions in G200 AWWA standard, cont'd

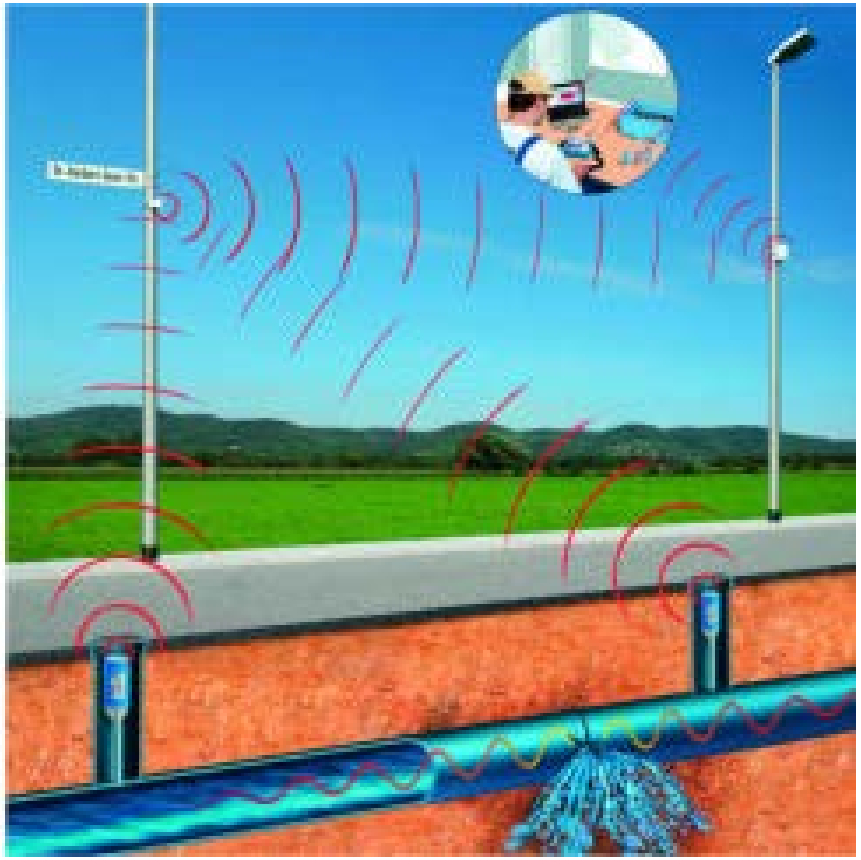
4.1.3	**Disinfectant residual maintenance**	
4.1.3.1	*Disinfectant residual*	Maintain detectable or HPC ≤ 500 CFU/mL.
4.1.3.2	*Nitrification control*	Monitor free ammonia, control chlorine-to-ammonia ratio.
4.1.3.2.2	Nitrification monitoring	Monitor nitrification indicator parameters.
4.1.3.3	*Booster disinfection*	
4.1.3.3.1		Document residual goals. Monitor compliance with goals.
4.1.3.3.2		Maintain operating procedures that take into account seasonal variation, quality, flow, and system operations.
4.1.3.3.3		Written Plan showing response to variation between goals and observed values.
4.1.3.4	*Disinfection byproduct monitoring and control*	
4.1.3.4.1		Monitor and control DBPs. Set goals for DBPs at critical points.
4.1.3.4.2		Have action plan to respond to levels that exceed goals.
4.1.4	**Requirements for utilities not utilizing a disinfectant residual**	Monitor and record HPC.
4.1.4.1	*Response program*	Have action plan to respond when HPC levels are above goals.

Water quality actions in G200 AWWA standard, cont'd

Section	Title	Requirement
4.1.5	**Internal corrosion monitoring and control**	
4.1.5.1	*Prevention and response program*	Have action plan to respond to internal corrosion and deposition.
4.1.6	**Aesthetic water quality parameters**	
4.1.6.1	*Color and staining*	Have action plan to address color and staining.
4.1.6.2	*Taste and odor*	Have action plan to address taste and odor.
4.1.7	**Customer relations**	
4.1.7.1	*Customer inquiries*	Have system to document customer inquires.
4.1.7.2	*Service interruptions*	Have system to document planned and unplanned service interruptions.
4.1.8	**System flushing**	Develop and implement a systematic flushing program.

To consider...

- Internet of things is coming
  - Includes water distribution
  - ”Smartwater”
  - Water flow measurement
  - Water quality measurements
  - ...hacking? A threat to distribution system integrity and also quality?

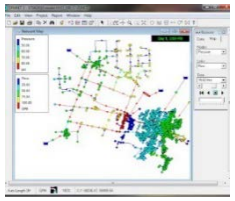


http://smart-industry.net/pipe-dreams/

Sign explanations

= The material is useful to remember during the workday of a water engineer

= You should remember this fact when woken 3 o’clock a.m. and understand during the working day (☺)



= Material concerning the topic of exercise