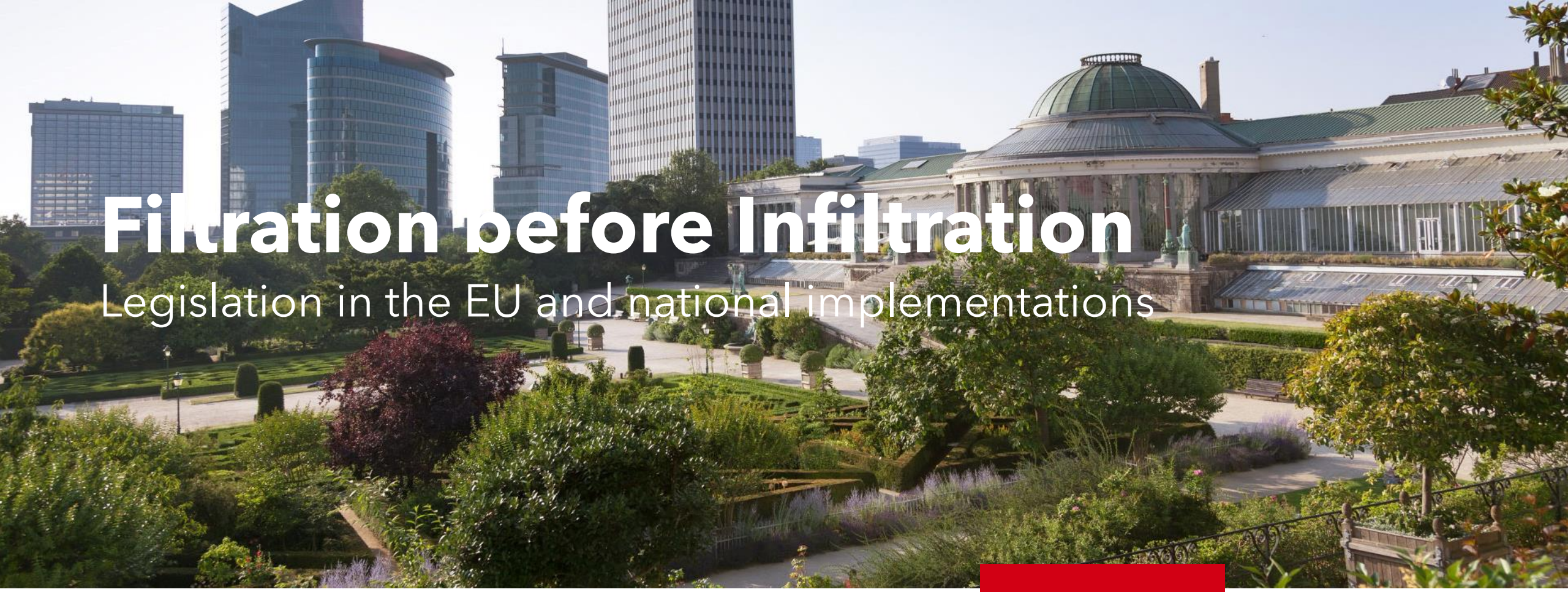


Filtration before Infiltration

Legislation in the EU and national implementations

ROCKWOOL®

RAINWATER SYSTEMS

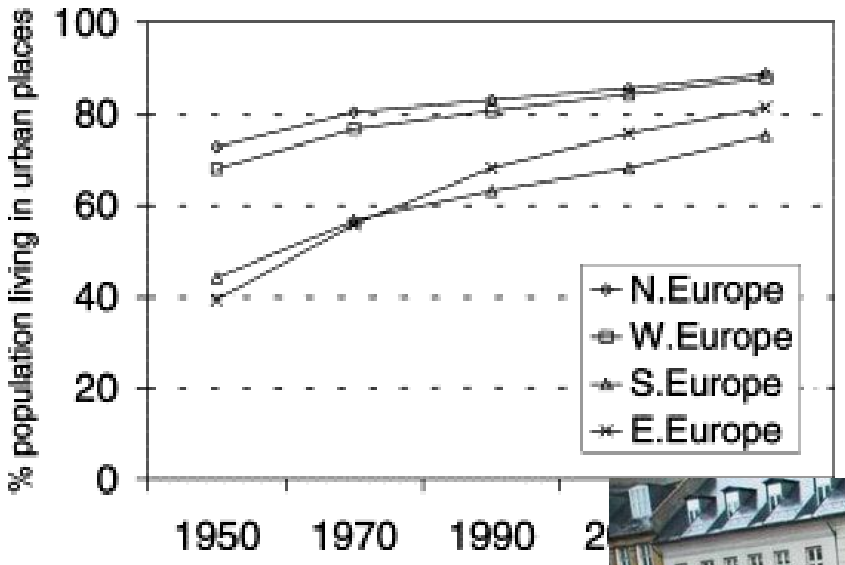
September 2, 2024

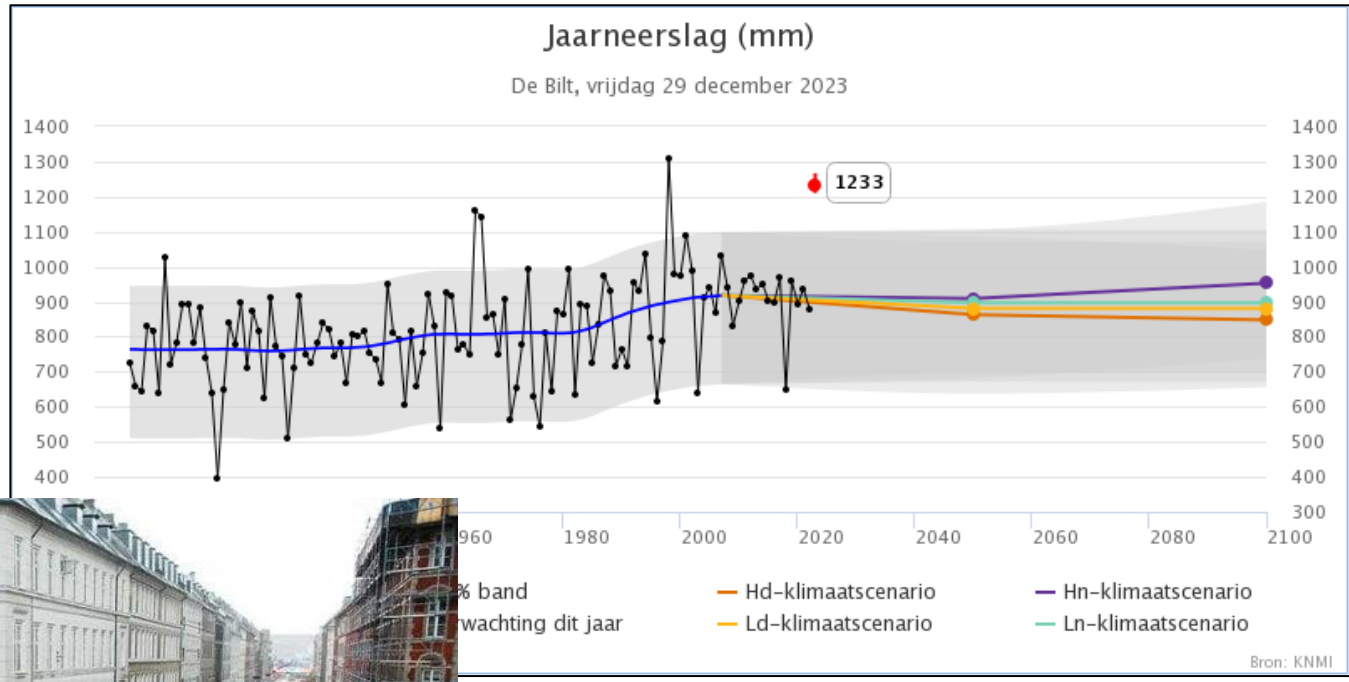
Agenda

1. Vision of European Union
2. Implementation in different countries
3. Netherlands
4. Field tests

Vision of European Union

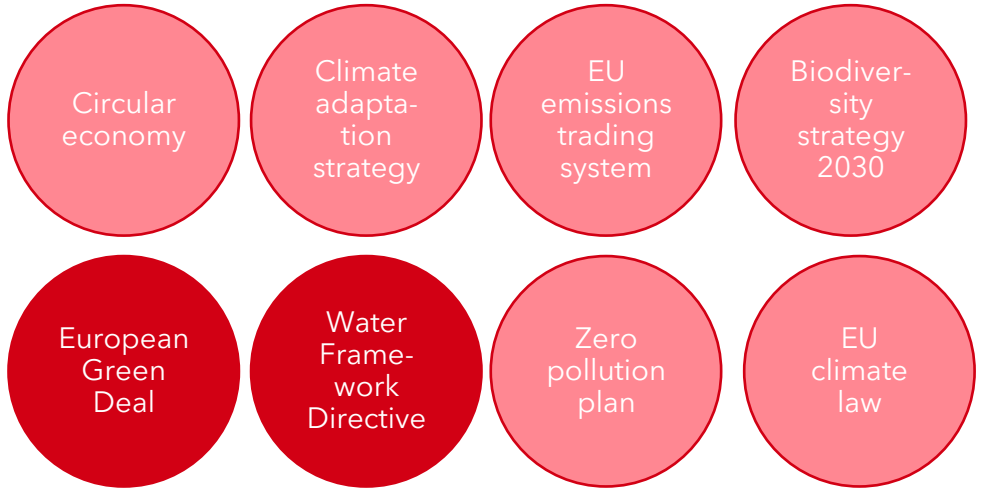
Climate extremes and growing urbanization





Laws and regulations

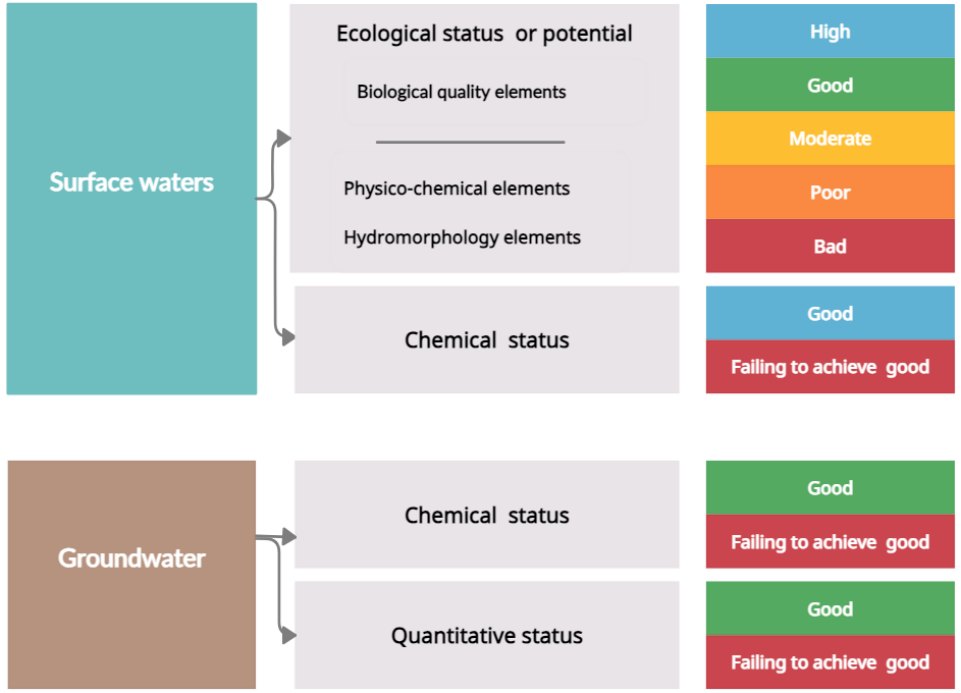
Legislation drives a more green, sustainable & climate adaptive Europe with targets set for 2027,2030, 2040, 2050.



The **Water Framework Directive** (2000/60/EC) requires EU Member States to achieve **good ecological and chemical status in all bodies of surface water and groundwater by 2027**
(*most likely postponed)

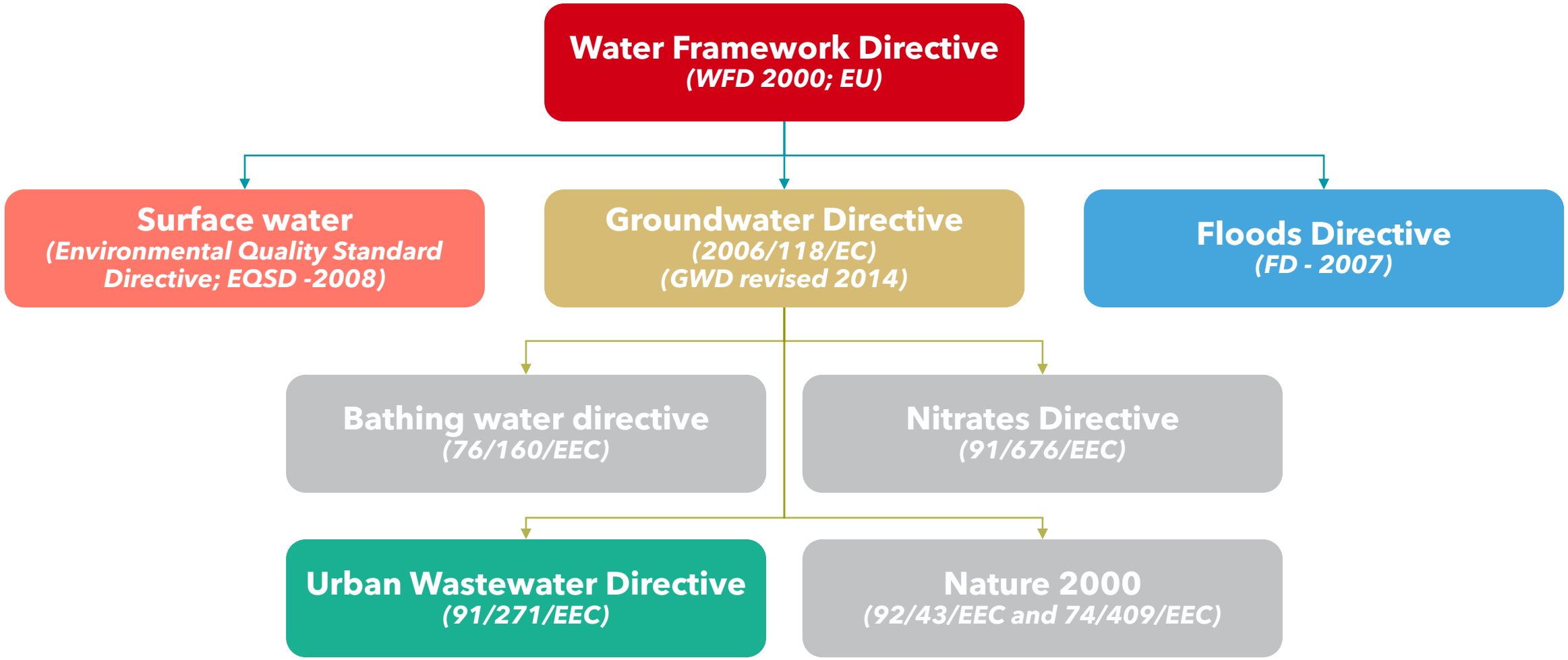
- Missing deadlines results in fines, national law suites and withdrawal of permits for other activities (e.g. building projects).

As part of the **European Green Deal**, new legislative proposals on integrated water management, focused on regulating polluting substances are being worked on



The European Water Framework Directive requires EU member state to achieve water bodies of 'good' quality by 2027.

Water Framework Directive



A closer look at legislation at EU level

The purpose of this Directive is to establish a framework for the **assessment and management of flood risks**, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods in the Community.

Floods Directive
(FD - 2007)

Surface water
(Environmental Quality Standards Directive: EQSD -2008)

This Directive lays down environmental quality standards (EQS) for priority substances and certain other pollutants, with the aim of **achieving good surface water chemical status** and in accordance with the provisions and objectives of Article 4 of that Directive.

Groundwater Directive
(2006/118/EC)
(GWD revised:2014)

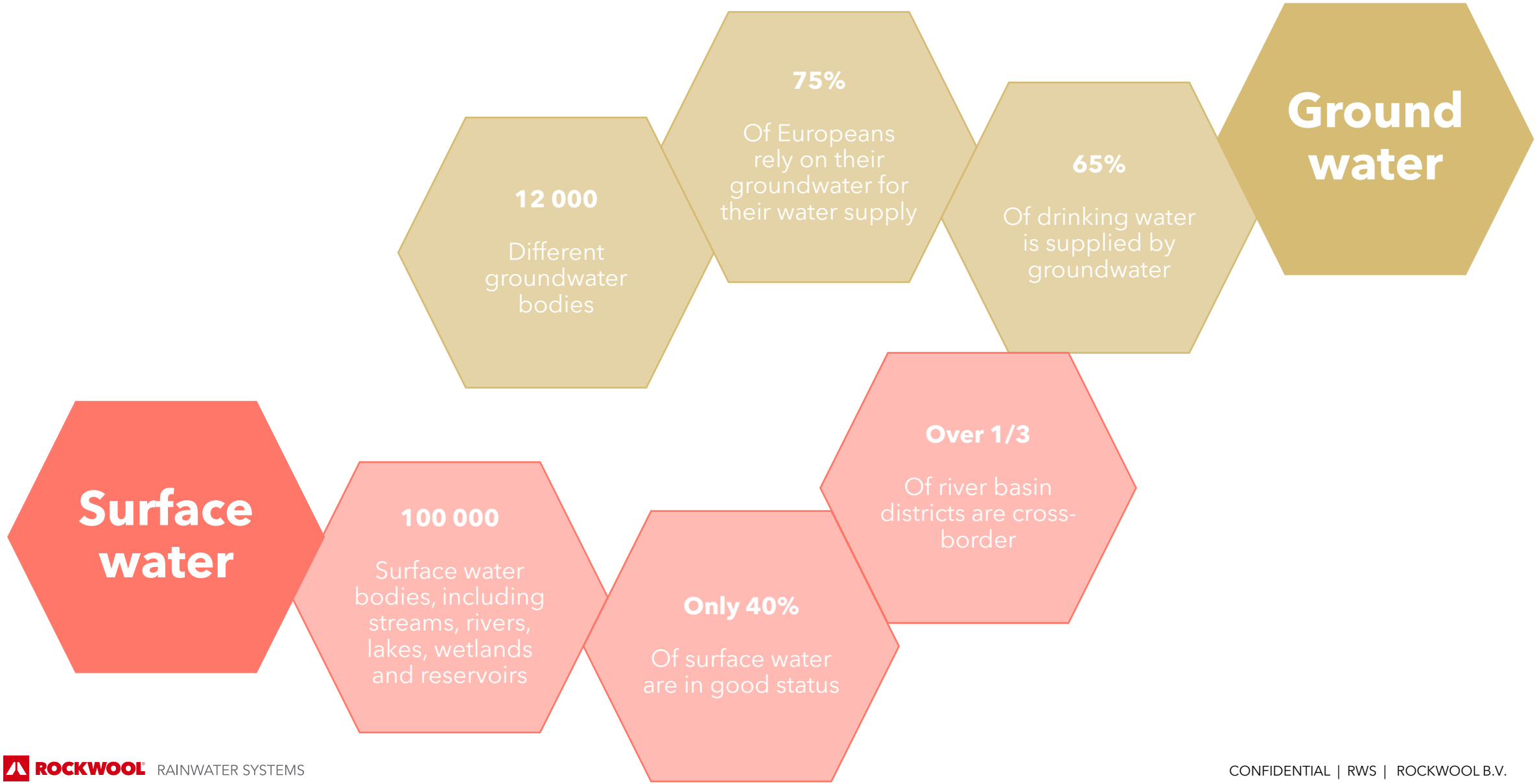
This Directive establishes specific measures in order **to prevent and control groundwater pollution**. These measures include in particular:

- criteria for the assessment of good groundwater chemical status
- criteria for the identification and reversal of significant and sustained upward trends and for the definition of starting points for trend reversals.

Shortened overview of the different EU water policies

Law	Objective	Status
Water Framework Directive 2000/60/EC (WFD)	All water bodies achieve good ecological and good chemical status	Under revision: +25 priority substances (total 74) • PFAS • pesticides, • bisphenol A (plasticizer) • pharmaceuticals • anti-convulsants • antibiotics
Environmental Quality Standard Directive (EQSD -2008)	Threshold values for achieving good chemical status as required by WFD	Under revision: stricter quality standards for metals and industry chemicals
Groundwater Directive (2006/118/EC)	Groundwater quality standards for list of pollutants and	Under revision: • PFAS • Pharmaceuticals • Anticonvulsants • antibiotic • Pesticide degradation products
Nitrates Directive (91/676/EEC)	protect water quality by preventing nitrates from agricultural sources that pollute ground and surface waters. (<50mg/l)	4-yearly reports by the Member States
Floods Directive (Directive 2007/60/EC)	all EU countries are required to • assess all areas where significant floods could take place • map the flood extent and assets and humans at risk in these areas • take adequate and coordinated measures to reduce this flood risk	6 yearly cycles aiming to reduce risk of flood damage in the EU (2010-15 | 2016-21 | 2022-27) Acted on in the national water programme for the Netherlands
Bathing water directive (76/160/EEC)	'Good' bathing water quality throughout the EU	95.9% meet minimum water quality standards Under revision: check if current parameters are still fit for purpose
Urban Waste Water Treatment Directive (91/271/EEC)	Towns, cities and settlements properly collect and treat wastewater	Under revision (a.o:) • make industry pay to treat micropollutants • require EU countries to monitor pathogens in wastewater

Water Framework Directive



https://environment.ec.europa.eu/topics/water/surface-water_en;
https://environment.ec.europa.eu/topics/water/groundwater_en

Lists are reviewed, and updated if necessary, every 6 years.

Groundwater Directive *(2006/118/EC + 2014/80/EC)*

Pollutants	Quality standard
Nitrates	50 mg/L
	0,1 ug/L
Pesticides	0,5 ug/L total

Minimum list of pollutants for which member states has to consider a threshold:

- **Substances or ions or indicators which may occur both naturally and/or as a result of human activities**: Arsenic, Cadmium, Lead, Mercury, Ammonium, Chloride, Sulphate, Nitrites, Phosphorous (total), Phosphates.
- **Man-made synthetic substances**: trichloroethylene, tetrachloroethylene,
- **Parameters of saline or other intrusions**: conductivity

Implementation of measures to reverse significant and sustained upwards trends need to be taken when 75% of the starting value is reached.

https://environment.ec.europa.eu/topics/water/groundwater_en

Surface water Directive *(2008/105/EC + 2013/39/EU)*

Pollutants	AA-EQS inland surface water	AA-EQS other surface water	MAC-EQS inland surface water	MAC-EQS other surface water	Identified as priority hazardous substance
alachlor	0,3	0,3	0,7	0,7	
anthracene	0,1	0,1	0,4	0,4	yes
atrizine	0,6	0,6	2	2	
benzene	10	8	50	50	
brominated diphenylether			0,14	0,014	yes
cadmium	0.08-0.25	0,2	0.45-1.5	0.45-1.5	yes
cabron tetrachloride	12	12	not applicable	not applicable	yes
C10-C13 chloroalkeanes	0,4	0,4	1,4	1,4	
chlorfenvinphos	0,1	0,1	0,3	0,3	
chlorpyrifos	0,03	0,03	0,1	0,1	
cyclodiene pesticides	0,01	0,005	not applicable	not applicable	
DDT total	0,025	0,0025	not applicable	not applicable	
para-para-DDT	0,01	0,01	not applicable	not applicable	
dichloroethane	10	10	not applicable	not applicable	
1,2 dichloromethane	20	20	not applicable	not applicable	
di(2-ethylhexyl)phthalate (DEHP)	1,3	1,3	not applicable	not applicable	yes
diuron	0,2	0,2	1,8	1,8	
endosulfan	0,005	0,0005	0,01	0,004	yes
flouranthene	0,0063	0,063	0,12	0,12	
hexachlorobenzene			0,05	0,05	yes
hexachlorobutadiene			0,6	0,6	yes
hexachlorocyclhexane	0,02	0,002	0,04	0,02	yes
isoproturon	0,3	0,3	1	1	
lead	1,2	1,3	14	14	
hexabromocyclodecanes	0,0016	0,0008	0,5	0,05	yes
heptachlor (epoxide)	2,00E-07	1,00E-08	3,00E-04	3,00E-05	yes
terbutryn	6,50E-02	6,50E-03	3,40E-01	3,40E-02	

https://environment.ec.europa.eu/topics/water/groundwater_en

Surface water Directive *(2008/105/EC + 2013/39/EU)*

Pollutants	AA-EQS inland surface water	AA-EQS other surface water	MAC-EQS inland surface water	MAC-EQS other surface water	Identified as priority hazardous substance
mercury			0,07	0,07	yes
naphthalene	2	2	130	130	
nickel	4	8,6	34	34	
nonylphenol	0,3	0,3	2	2	yes
octylphenol	0,1	0,01	not applicable	not applicable	
pentachloro-benzene	0,007	0,0007	not applicable	not applicable	yes
pentachloro-phenol	0,4	0,4	1	1	
polyaromatic hydrocarbons (PAH)	1,70E-04	1,70E-04	0,27	0,027	yes
simaize	1	1	4	4	
tetrachloro-ethylene	10	10	not applicable	not applicable	
trichloroethylene	10	10	not applicable	not applicable	yes
tributyltin compounds	0,0002	0,0002	0,0015	0,0015	
trichloro benzenes	0,4	0,4	not applicable	not applicable	
trochloromethane	2,5	2,5	not applicable	not applicable	
trifluralin	0,03	0,03	not applicable	not applicable	yes
Dicofol	1,30E-03	3,20E-05	not applicable	not applicable	yes
perfluorooctane sulfonic acid (PFOS)	6,50E-04	1,30E-04	36	7,2	yes
quinxyfen	0,15	0,015	2,7	0,54	yes
dioxins			not applicable	not applicable	yes
aclonifen	0,12	0,012	0,12	0,012	
bifenox	0,012	0,0012	0,04	0,004	
cybutryne	0,0025	0,0025	0,016	0,016	
cypermethrin	8,00E-05	8,00E-06	6,00E-04	6,00E-05	
dichlorvos	6,00E-04	6,00E-05	7,00E-04	7,00E-05	

https://environment.ec.europa.eu/topics/water/surface-water_en

Inland surface waters encompass rivers and lakes and related artificial or heavily modified water bodies

Surface water watch list *(2015/495 + 2018/840 + 2020/1161 + 2022/1307)*

Pollutants	MAC value (ng/L)
17-Alpha-ethinylestradiol (EE2)	0,035
17-Beta-estradiol (E2), Estrone (E1)	0,4
Diclofenac	10
2,6-Ditert-butyl-4-methylphenol	3 160
2-Ethylhexyl 4-methoxycinnamate	6 000
Macrolide antibiotics	90 – 19
Methiocarb	10
Neonicotinoids	9 – 8,3
Oxadiazon	88
Tri-allate	670
Metaflumizone	65
Amoxicillin	78
Ciprofloxacin	89
Sulfamethoxazole	100
Trimethoprim	100
Venlafaxine + O-desmethylvenlafaxine	6

Pollutants	MAC value (ng/L)
Clotrimazole	20
Fluconazole	250
Imazalil	800
Ipconazole	44
Metconazole	29
Miconazole	200
Penconazole	1 700
Prochloraz	161
Tebuconazole	240
Tetraconazole	1 900
Dimoxystrobin	32
Famoxadone	8,5
Azoxystrobin	200
Diflufenican	10
Fipronil	0,77
Clindamycin	44

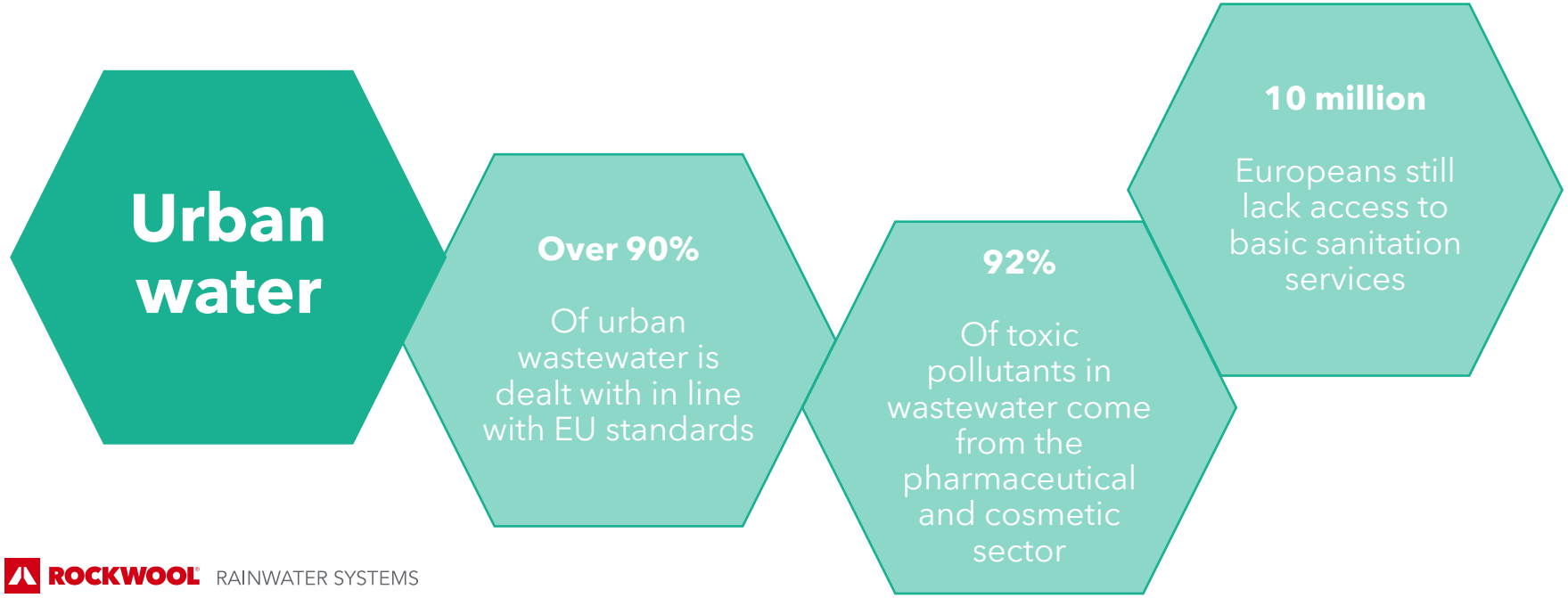
Pollutants	MAC value (ng/L)
Ofloxacin	26
Metformin	156 000
Guanylurea	100 000
Butylmethoxydi-benzoylmethane	3 000
Octocrylene	266
Benzophenone-3	670

https://environment.ec.europa.eu/topics/water/surface-water_en

A Watch List mechanism was established in 2013 to improve the available information on identifying the substances of greatest concern. Member States have to monitor the substances on the list at least once per year for up to four years.

Urban Wastewater Directive

Urban wastewater is one of the main sources of water pollution if it is not collected and treated according to EU rules. It contains organic matter, nitrogen and phosphorous. These are all removed when properly treated, otherwise they can lead to eutrophication. It also can be contaminated with harmful chemicals, bacteria and viruses which, when untreated and discharged into the environment, affect our health and damages our rivers, lakes and coastal water.



https://environment.ec.europa.eu/topics/water/urban-wastewater_en

Urban Wastewater Directive *(1991/271/EEC)*

Parameter	Unit	Concentration	Min. % of reduction
Biochemical oxygen demand (BOD)	mg/L O_2	25	70-90
Chemical oxygen demand (COD)	mg/L O_2	125	75
total suspended solids	mg/L	35	90
total phosporous	mg/L P	2	80
total nitrogen	mg/L N	15	70-80

https://environment.ec.europa.eu/topics/water/urban-wastewater_en

Drinking water Directive (2006/118/EC)

	Paramater	Unit	Guide level	MAC value	Analysis Technique
	Organoleptic				
1	color	mg/L in Pt/Co scale	1	20	photometric
2	turbidity	mg/L SiO2	1	10	silica method - Formazine test
3	odour	dilution number	0	2 at 12 0C 3 at 25 0C	dilutions
4	taste	dilution number	0	2 at 12 0C 3 at 25 0C	dilutions

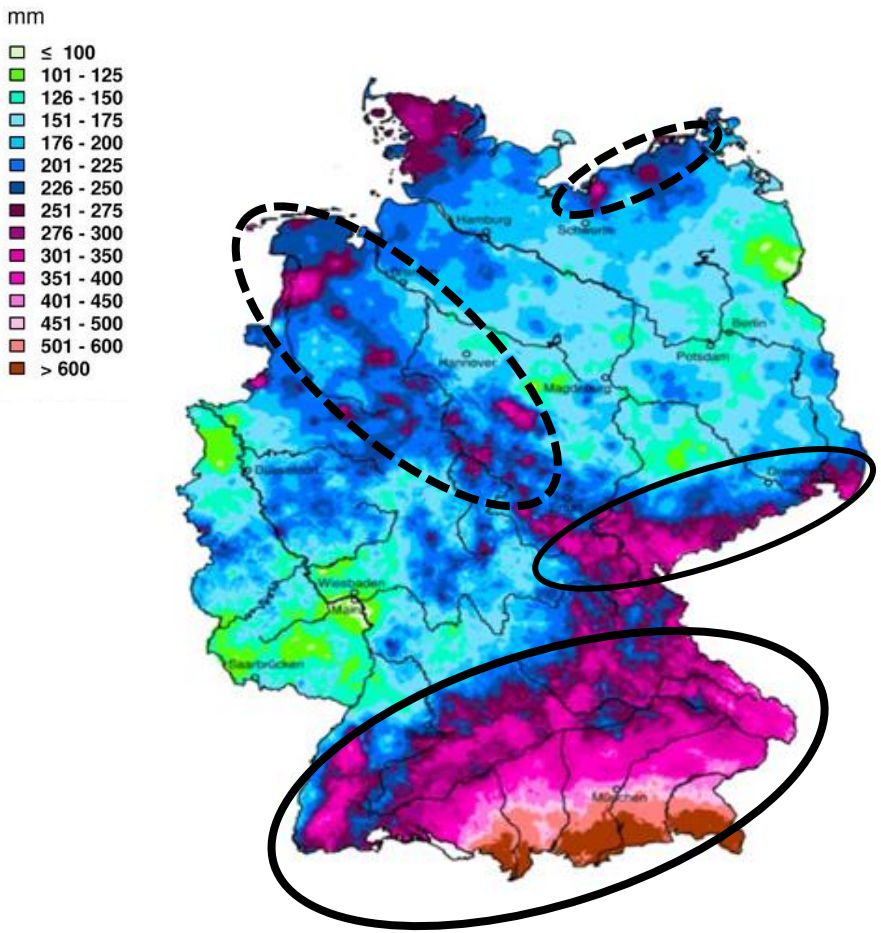
Other classes:

- **Physico-chemical parameters**: T, pH, uS, [Cl], [SO_4], [SiO_2], [Ca], [Mg], [K], [Na], [Al], [CO_2], %O_2, dry rest
- **Substances**: [NO_3], [NO_2], [NH_4], [$N]_{kj}$, oxidation in $KMnO_4$, TOC, [S], [phenol], [B], [Fe], [Mn], [Cu], [Zn], [P_2O_5], [F], [Co], [Ba], [Ag], lauryl stearate, organochlorides, hydrocarbons.
- **Toxic substances**: [As], [Be], [Cd], [CN], [Cr], [Hg],[Ni], [Pb], [Sb], [Se], [V], pesticides and PAHs.
- **Microbiological parameters**: total and fecal coliforms, streptococci, sulphate reducing clostridia, total bacteria count for human consumption and closed containers.
- **Softened water requirements**: water hardness and alkalinity.

Implementation in different countries

Germany

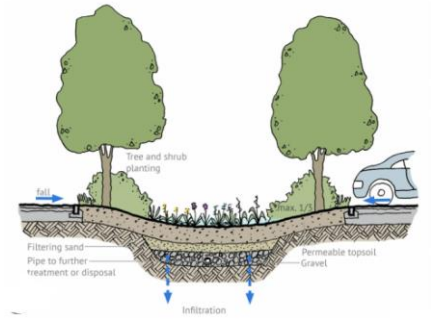
Average summer precipitation in Germany



- During summer, the amount of rainfall is higher in most regions, than during the winter assuming higher risks of flooding in southern and northern regions
- Averaged over Germany, the precipitation total measured for summer 2020 was 228.2 mm, which is 11.5 mm (or 4.8 %) less than the average over the period 1981-2010
- There is a requirement to filter rainwater before you are allowed to infiltration water into the groundwater or discharge it on surface water.
- Filter need to be accessible and replaced every 4 years according to legislation.

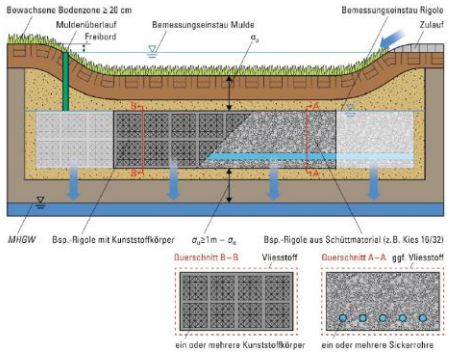
Widely accepted treatment solutions

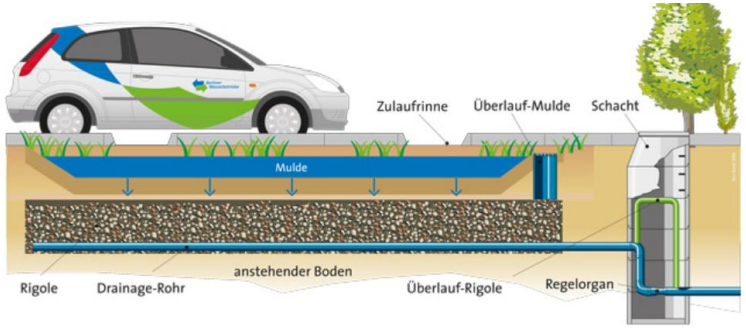
- **Oberbodenpassage (Filter strip)**



Central treatment plants

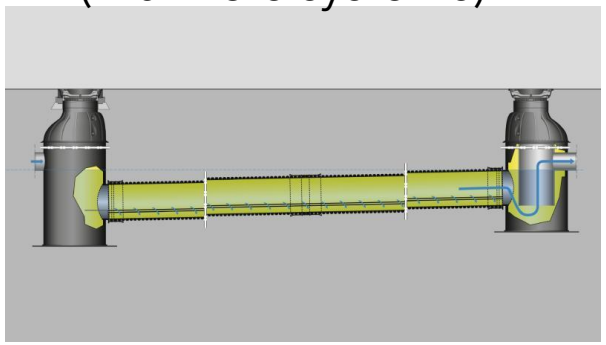
- **Retentionsbodenfilter (Bioretention filter)**
- **Mulden Rigolen**





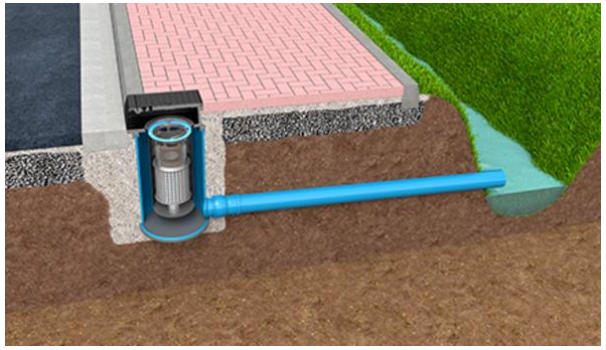
- **Decentral treatment systems**

a. Schacht/Kompaktsysteme (Manhole systems)



b. Gutter systems

c. Gully systems



d. Permeable surfaces (infiltration only)

Need for Trennerlass or DIBt certification when it comes to filtration of rainwater

Classification origin of stormwater management

1. Origin of water	Road run-off water 		Roofs 
2. Degree of pollution Leading parameters: AFS_{63}*, MKW**, Heavy metals	I *(slightly contaminated)* AFS_{63}: 280 kg/(ha*a)	II *(moderate contaminated)* AFS_{63}: 530 kg/(ha*a)	III *(highly contaminated)* AFS_{63}: 760 kg/(ha*a)
3. Target compartment	Groundwater (infiltration)		Surface water (discharge into)
4. Regulations	DWA 138 + DWA 179		DWA 102

Removal of pollutants can take place via sedimentation, filter systems or a combination of both

*AFS = "Abfiltrierbare Stoffe", particle size 0.45 µm- 63 µm
** MKW = Mineralölkohlenwasserstoff

Discharge into surface water

In order to discharge mixed (sewer) water and stormwater into surface waterbodies (e.g. lakes / open ponds etc), either centralized or decentralized treatment systems can be used:

- Centralized treatment requires extensive network of pipes and pumps for the collection or distribution of water or wastewater.
- Decentralized treatment uses right-sized plants that serve remote communities or that are dispersed throughout a broader community, with each serving a smaller population near the point of use.

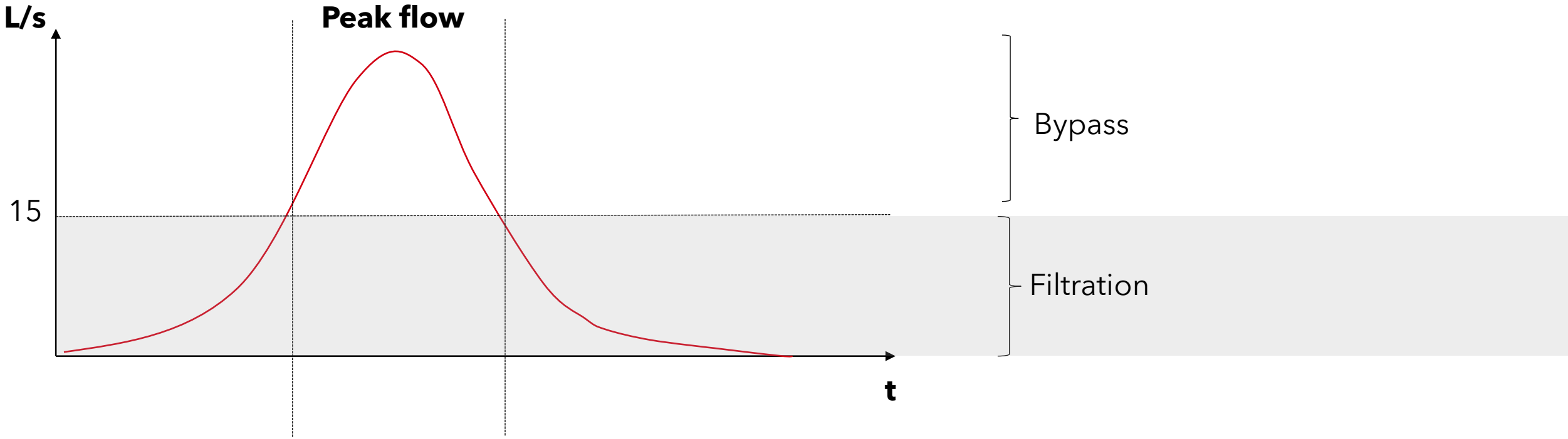
The water often originates from a combination (or mixed) water source, leading to the required removal of so-called '"*Abfiltrierbare Stoffe*", or solid particles with a particle size between 0.45 µm- 63 µm (abbrev AFS_{63}).

Pollutant	Typical inlet [g/m²]	Typical outlet [mg/L]	Reduction [%]		
AFS_{63} (solid particles)	50	n.a.	CAT I: 80	CAT II: 80	CAT III: 80

DIBt: The annual load of the above-mentioned pollutant needs to be tested at three specific rainfall intensities (2.5; 6; 25 L/(s ha) or 0.9; 2.2; 9.0 mm/h)

Discharge into surface water

There is a restriction set for the flow rate of the incoming water stream, were a bypasses for peak flows **>15L/(s*ha)** is allowed



Infiltration into groundwater

Group	Description	Category
D1	Roofs without metal (<20m2)	I
W1	Pedestrian, bycicle, residential streets (no car traffic)	I
V1	Residential streets (<300 vehicles, <50 housing units), low-frequency parkings	I

Infiltration into groundwater

Group	Description	Category
D1	Roofs without metal (<20m2)	I
W1	Pedestrian, bycicle, residential streets (no car traffic)	I
V1	Residential streets (<300 vehicles, <50 housing units), low-frequency parkings	I
D2	Roofs without metal (<20m2) in industrial areas	II
M2	Roofs with metal (<20m2)	II
W2	Shopping streets, market places, outdoor event areas	II
V2a	<2,000 cars, outside of industrial areas >300 cars inside industrial areas	II
V2b	2,000<cars<15,000, outside of industrial areas 300<cars<2,000, inside industrial areas Parking areas with medium frequency	II
F2	Airport areas (no de-icing)	II
L2	Agricultural yards (excl. Group L3)	II

Infiltration into groundwater

Group	Description	Category
D1	Roofs without metal (<20m2)	I
W1	Pedestrian, bycicle, residential streets (no car traffic)	I
V1	Residential streets (<300 vehicles, <50 housing units), low-frequency parkings	I
D2	Roofs without metal (<20m2) in industrial areas	II
M2	Roofs with metal (<20m2)	II
W2	Shopping streets, market places, outdoor event areas	II
V2a	<2,000 cars, outside of industrial areas >300 cars inside industrial areas	II
V2b	2,000<cars<15,000, outside of industrial areas 300<cars<2,000, inside industrial areas Parking areas with medium frequency	II
F2	Airport areas (no de-icing)	II
L2	Agricultural yards (excl. Group L3)	II
V3	>2,000 cars, inside industral areas > 15,000 cars, outside of industrial areas Parking areas with high frequency	III
F3	Airport areas (de-icing)	III
A3	Waste (water) treatment areas	III
L3	Agricultural yards with (liquid) manure	III
G3	Track systems, industrial residues etc	III

Slighlty contaminated

Moderate contaminated:
treatment by **decentral systems**

Highly contaminated
treatment by **central systems**

Infiltration into groundwater

In the planning, construction and operation of infiltration systems, the condition of the soil and water protection must be observed. Protective measures for the soil and groundwater are:

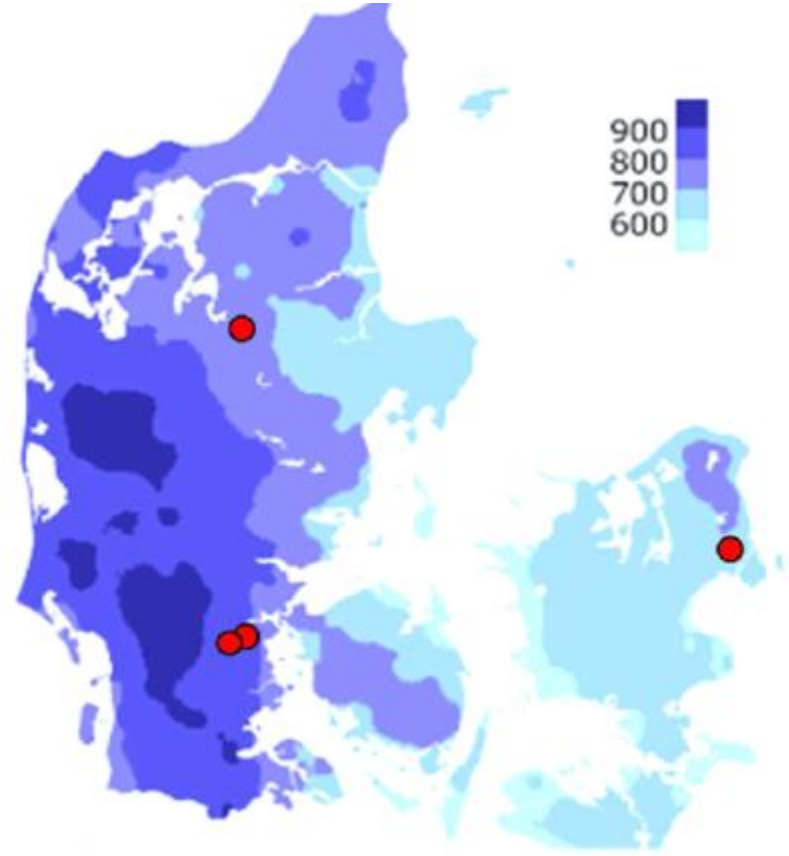
- Reduction in material emissions,
- Reduction of substance entry into paved areas
- Treatment of storm runoff before infiltration
- Restriction of infiltration of polluted drains

Pollutant	Typical inlet [g/m²]	Reduction [%]		
		CAT I	CAT II	CAT III
AFS_{63} (solid particles)	50	40	92	No infiltration, cleaning via central system
Copper (Cu; dissolved)	Various	50	80	
Zinc (Zn, dissolved)		50	70	
Mineral oil		50	80	

DIBt: The annual load of the above-mentioned pollutants needs to be tested at three specific rainfall intensities (2.5; 6; 25 L/(s ha) or 0.9; 2.2; 9.0 mm/h)

Denmark

Annual precipitation in Denmark (1991 – 2019)



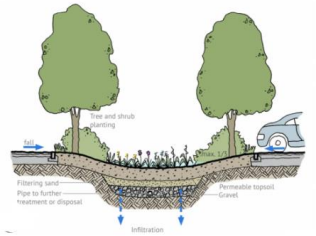
- During summer, the amount of rainfall is higher in most regions, than during the winter assuming higher risks of flooding in southern and northern regions
- In general terms, there is a larger amount of precipitation in South-west of Denmark during both summer and winter seasons
- Annual average precipitation during 2011–2019 ranged from 646 to 933 mm, and rainfall during spring (April, May and June) from 139 to 177 mm.
- There is a requirement to filter rainwater before you are allowed to infiltration water into the groundwater or discharge it on surface water.
- There are no requirements on the lifetime of a filter, however there is a tendency to make the filter accessible for inspection and replace it if needed.

https://www.dmi.dk/

Widely accepted treatment solutions

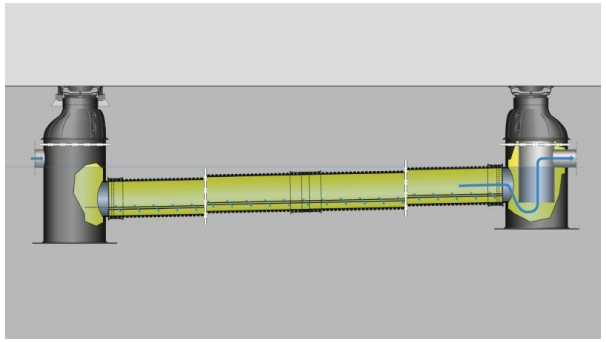
- **Rainwater detention ponds**

(currently seen as best available technology)



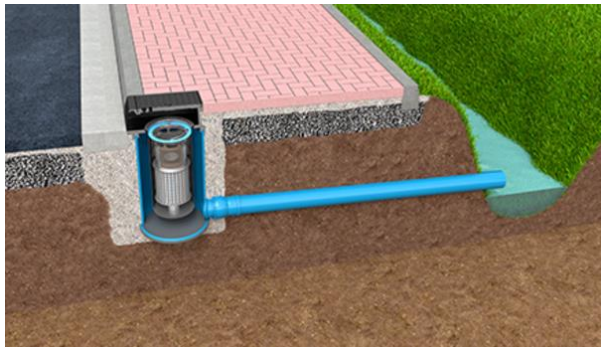
- **Decentralized treatment systems**

a. Manhole systems



b. Gutter systems

c. Gully systems



d. Permeable surfaces (infiltration only)

Discharge into surface water

In order to discharge mixed (sewer) water and stormwater into surface waterbodies (e.g. lakes / open ponds etc), either centralized or decentralized treatment systems can be used.

Pollutant	Typical inlet [mg/L]	Reduction requirements [%]
Solid particles	90	70-90
Copper (Cu)	0,015	60-80
Zinc (Zn)	0,1	40-85
Phosphates (P, total)	0,3	60-80
Phosphates (P, dissolved)	0,15	50-75
Chemical oxygen demand (COD)	55	30-60
Biological oxygen demand (BOD)	6	20-40
Nitrogen (N)	2	20-60

Infiltration into groundwater

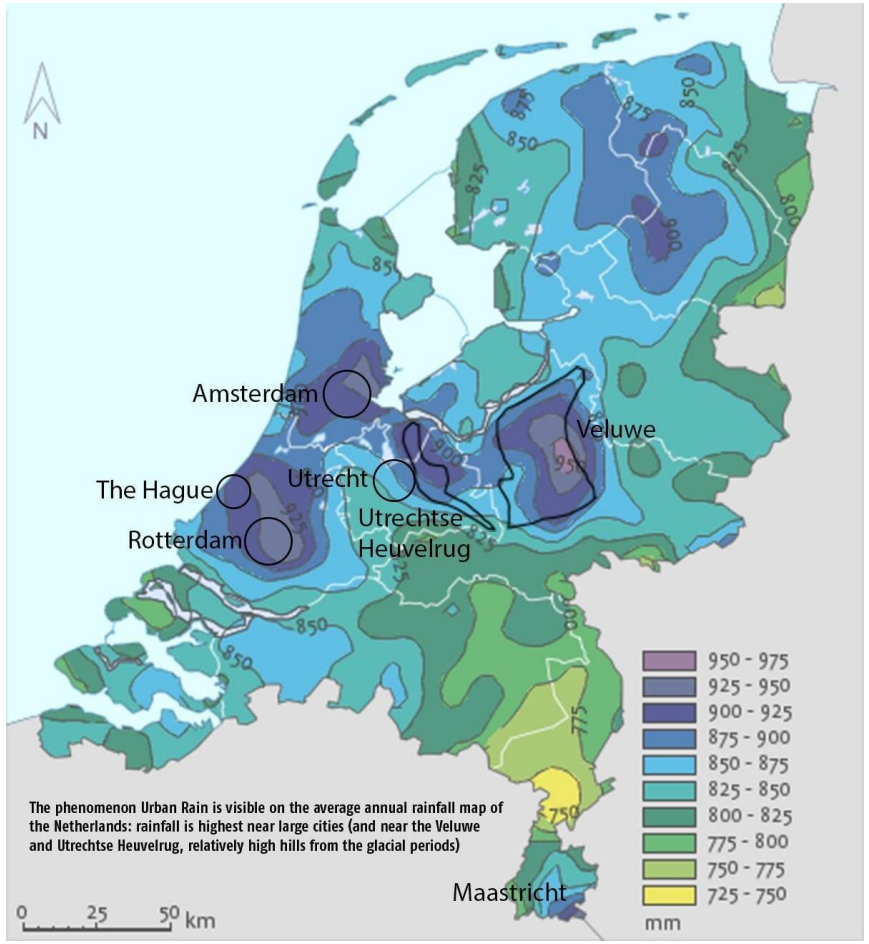
- Infiltration of rainwater should comply to the current 'Best Available Technology' (BAT), which are the open water retention ponds.
- All regulations for surface water apply here, with additional limitations on the outlet concentration

Pollutant	Typical inlet [mg/L]	Required outlet [mg/L]	Reduction requirements [%]
Solid particles	90	-	70-90
Copper (Cu)	0,015	0,005	60-80
Zinc (Zn)	0,1	0,03	40-85
Phosphates (P, total)	0,3	< 0,05	60-80
Phosphates (P, dissolved)	0,15	< 0,05	50-75
Chemical oxygen demand (COD)	55	-	30-60
Biological oxygen demand (BOD)	6	-	20-40
Nitrogen (N)	2	-	20-60

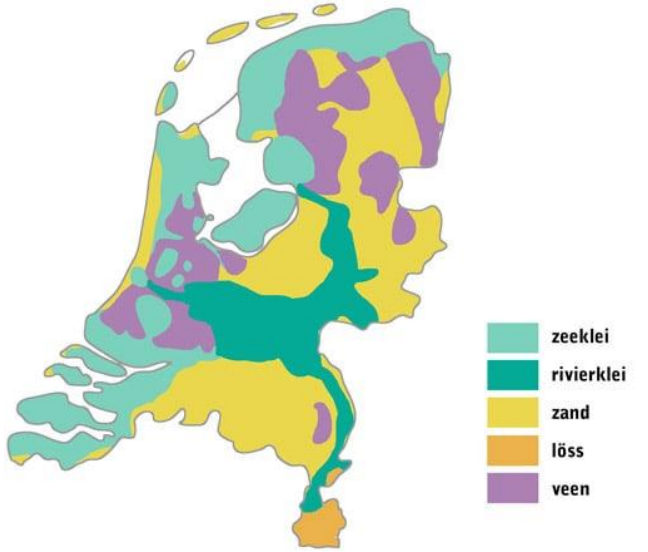
Netherlands

Netherlands

Annual precipitation in Netherlands (1981 - 2010)



- During autumn, the amount of rainfall is higher in most regions, than during the winter assuming higher risks of flooding in the Randstad regions
- Although there is a requirement to filter rainwater before you are allowed to infiltration water into the groundwater or discharge it on surface water, follow-up is still scarce.
- Besides rainfall, the type of soil is important as well when looking at filtering water before infiltration.



Measurements to increase quality of water

- **Natura 2000:** Natura 2000 is a European network of protected natural areas. In Natura 2000 areas, certain animal species and their natural habitat are protected to preserve biodiversity. Rijkswaterstaat has 2 roles within Natura 2000: that of initiator and water manager.

- **Kaderrichtlijn water (KRW, WFD in EU) :** Rijkswaterstaat improves ecological water quality. The measures that Rijkswaterstaat is taking for this are based, among other things, on the European Water Framework Directive (KRW).

- **Approach for large water (PAGW):** In addition to the WFD and Natura 2000 programs, additional measures are needed until 2050 to make national waters future-proof. Climate changes are also taken into account in this national program.

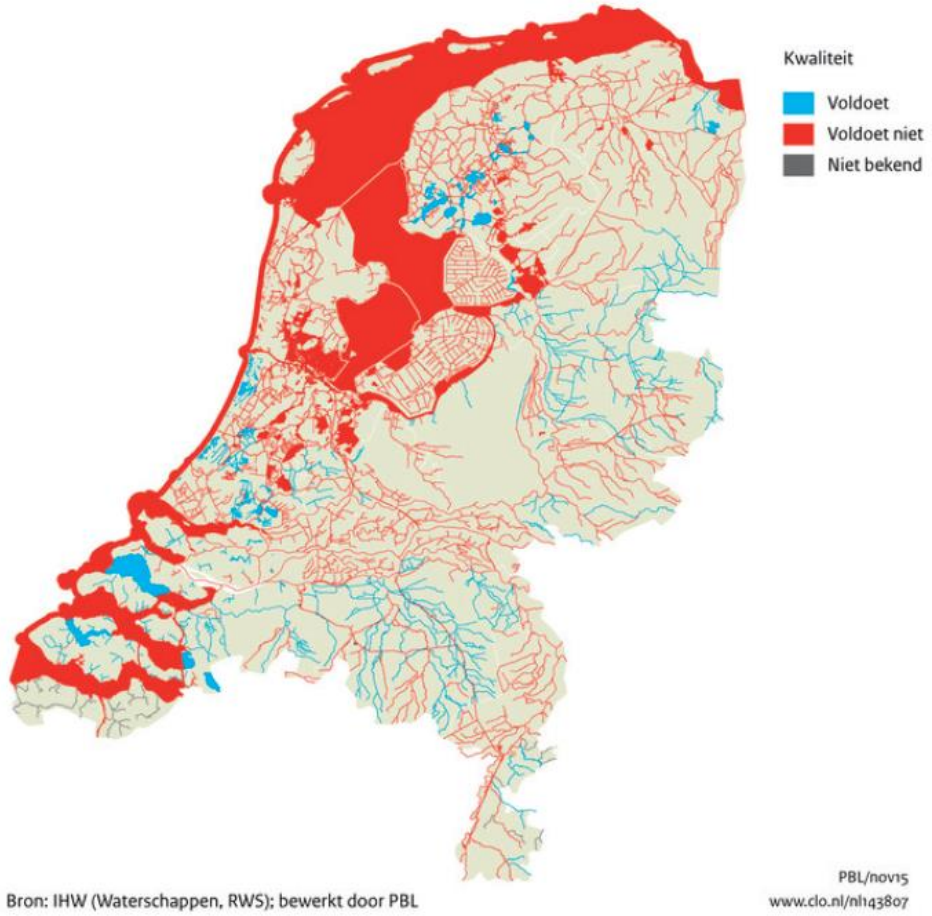
Stowa guidelines focus on following pollutants

Pollutant	Residential roofs (Av.)	Residential roofs & roads (Av.)	Industrial roofs & roads (Av.)	Non-residential roads (Av.)
Cadmium (Cd) [µg/L]	0,29	0,18	1,4	0,49
Copper (Cu) [µg/L]	34	21	20	28
Mercury (Hg) [µg/L]	0,045	0,026	0,26	0,055
Lead (Pb) [µg/L]	324	21	68	12
Nickel (Ni) [µg/L]	3,4	4,1	12	3,8
Zinc (Zn) [µg/L]	95	144	594	115
Antrachene [µg/L]	0,0096	0,0076	0,0066	0,0032
Benzo(a)pyrene [µg/L]	0,016	0,048	0,033	0,012
Mineral oil [µg/L]	233	102	1813	349
Chem. Ox. Dem. (COD) [mg O/L]		36	68	42
P-total [mg P/L]		0,3	0,52	1,5
N-kjeldahl [mg N/L]		2,1	9,9	2,1
Nitrate (NO_3-N) [mg N/L[		1,5	0,66	1,4
Total suspended solids (TSS) [mg/L]	196	38	48	56
E. Coli [#/100 ml)		$2,4 \times 10^4$	1135	-

https://www.stowa.nl/sites/default/files/assets/PUBLICATIES/Publicaties%202020/2020-05%20STOWA%202020-05%20Kwaliteit%20van%20afstromend%20hemelwater%20in%20Nederland.pdf

Quality of water in the Netherlands

- PFAS (including PFOS and PFOA) are included in the list of new pollutants for STOWA.
- No official norms taken along in the KRW for cleaning runoff rainwater and subsequent discharge onto surface water. As such, the surface water directive as implemented by the EU are used.[1;2]
- Most of the surface water does not adhere to the legislation for water bodies.



[1] See slides 11-13 of this presentation; [2] Article 21: wetten.nl - Regeling - Besluit kwaliteitseisen en monitoring water 2009 - BWBR0027061 (overheid.nl)

Quality of water in the Netherlands

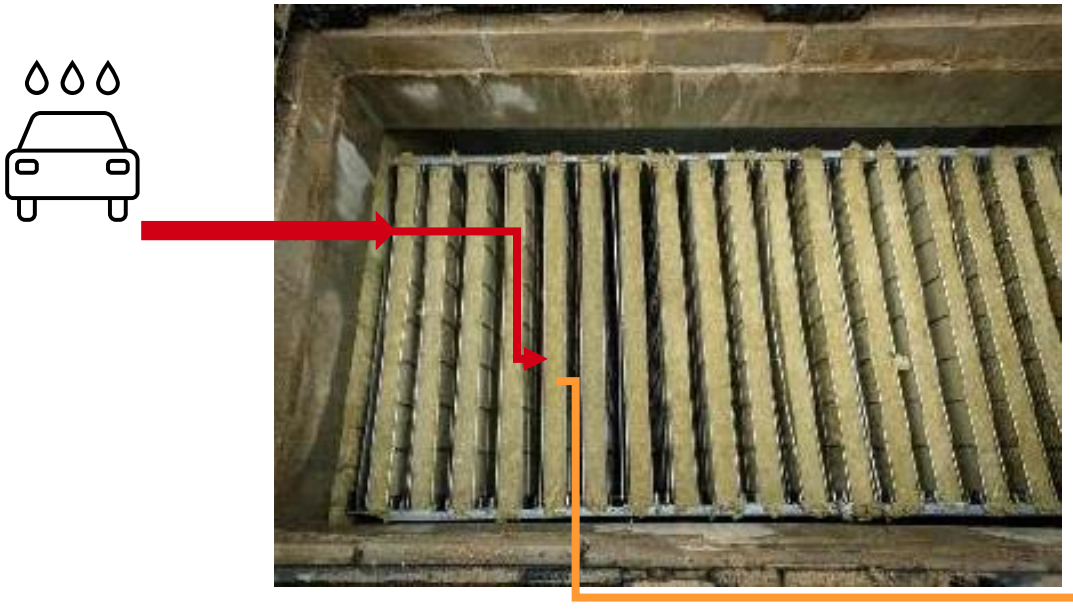
- Values in the table show that mainly the metals (Cd, Hg, Pd and Zn) show much higher values as compared to quality norms
- Other values from the STOWA guidelines were not taken along in this comparison

Pollutant	Residential roofs & roads (Av.)	Industrial roofs & roads (Av.)	Annual average	MAC
Cadmium (Cd) [µg/L]	0,18	1,4	0,08 – 0,25	0,45 – 1,5
Copper (Cu) [µg/L]	21	20	2,4	-
Mercury (Hg) [µg/L]	0,026	0,26	0,00007	0,07
Lead (Pb) [µg/L]	21	68	1,2	14
Nickel (Ni) [µg/L]	4,1	12	4	34
Zinc (Zn) [µg/L]	144	594	7,8	15,6
Antrachene [µg/L]	0,0076	0,0066	0,1	0,1
Benzo(a)pyrene [µg/L]	0,048	0,033	0,00017	0,27

[1] See slides 11-13 of this presentation; [2] Article 21: wetten.nl - Regeling - Besluit kwaliteitseisen en monitoring water 2009 - BWBR0027061 (overheid.nl)

Field Tests

Stone wool filter design



Lamella filter

Filter > 45µm SS

Thin stone wool slab (5 cm)

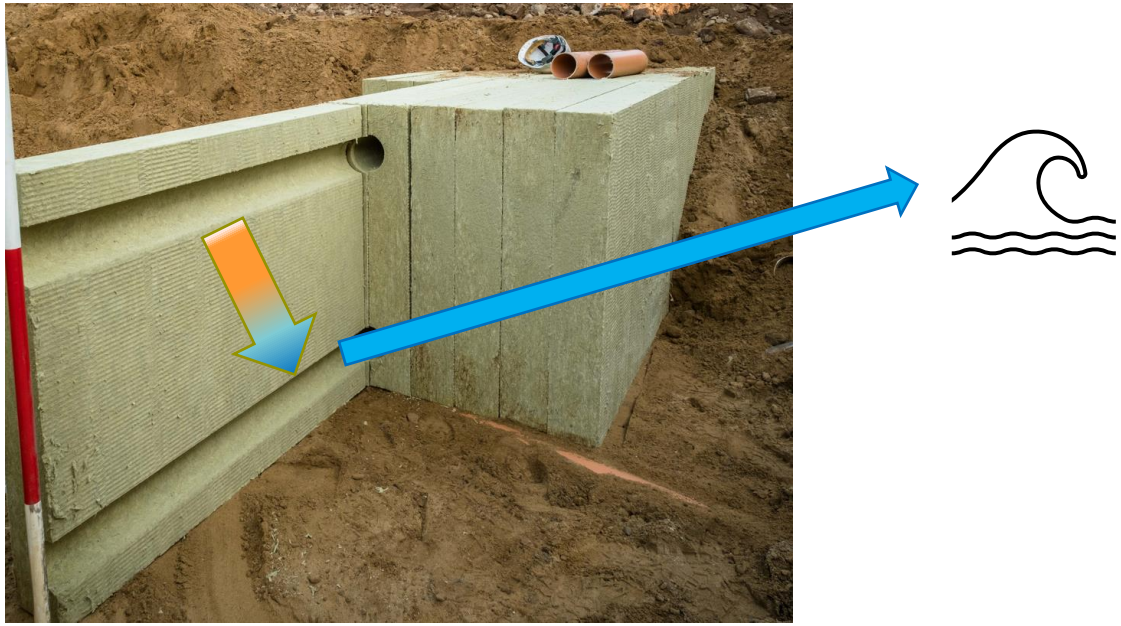
Short residence time < 15 min

Filter buffer

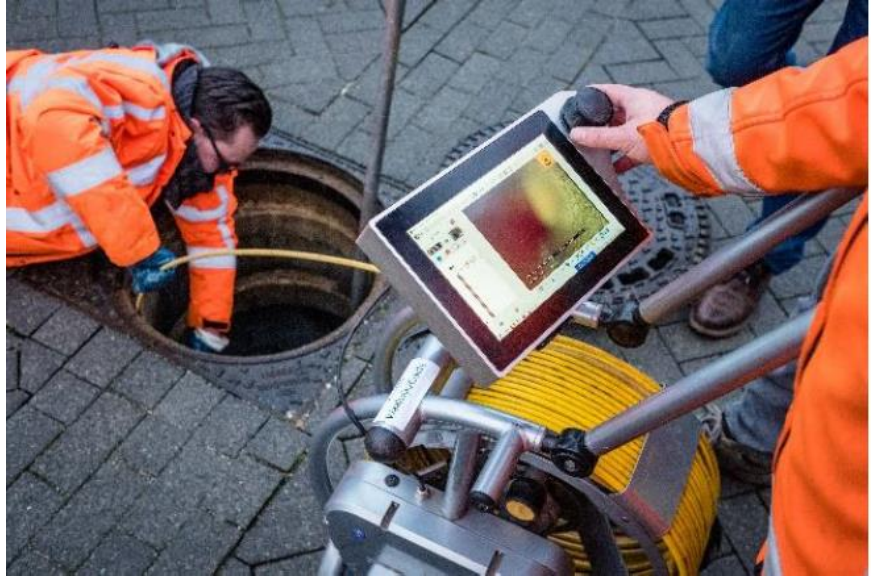
Filter < 45µm SS + dissolved particles

Distance in / out > 1m

Long residence time > 15 min.



Inspection of filter buffers



Use of robot of push camera rod for inspection of the inlet channels.
Inspect systems of up to 5 years in the field.

Findings:

- In general amount of sediment is minimal.
- No relation between surroundings and amount / type of sediment in the channels
- Channels filled with 50% sediment load can still be inspected and cleaned.

Lifetime of filter buffer

Asses hydraulic robustness of Rockflow filter:

- Does it clog over time? i.e. do the pores of the Rockflow gradually fill with particles?
- Explain possible risk of clogging, how to clean and maintain over a 50-year life span.

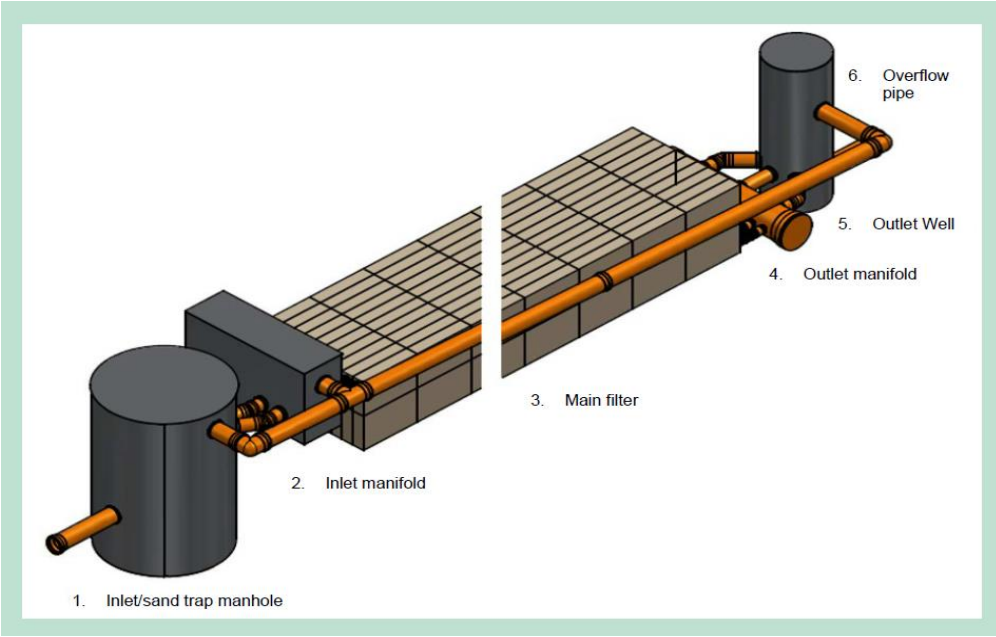
Yearly material load: 100 mg/L based on 800 mm precipitation

Material load of 53 years used where a reduction in hydraulic conductivity of factor 4 is seen.

k-value before: 50 – 200 m/24 h
k-value after: 15 – 50 m/24 h

Current field test installed in Denmark (Risvang Alee)

- Filter of ~ 30 m^3 with a catchment area of 1 hectare of rainwater runoff (75 L/s) installed
- Urban municipality, where > 5,000 cars per day drive on the road
- The filter was installed in 2017 of which samples of the inlet and outlet water stream have been taken
- Recently (2020) the stone wool has been replaced, as the older system could not be cleaned



Analysis results field test

Pollutant	Unit	Stone wool		Retention water pond		Criteria DK
		Mean outlet	% removal	Mean outlet	% removal	
Suspended solids	mg/L	10 *(5-22)*	84 *(19-88)*	12 *(5-20)*	80 *(70-90)*	
Chemical oxygen demand (COD)	mg/L	17 *(5-22)*	73 *(19-88)*	30 *(10-60)*	45 *(30-60)*	
Biological oxygen demand (BOD)	mg/L	0.5 *(1-2.4)*	86 *(65-97)*	4 *(1-8)*	30 *(20-40)*	
Total; phosphor	mg/L	0.22 *(0.13-0.31)*	63 *(32-78)*	0.09 *(0.05-0.2)*	70 *(60-80)*	
Dissolved phosphate	mg/L	0.10 *(0.09-0.11)*	12 *(-44-43)*	0.05 *(0.03-0.1)*	70 *(50-75)*	
Total; nitrogen	mg/L	1.3 *(0.9-1.6)*	37 *(15-59)*	1.2 *(0.7-2)*	40 *(20-60)*	
Total; copper	µg/L	13 *(7-22)*	65 *(14-80)*	5 *(2-8)*	75 *(60-80)*	
Total; zinc	µg/L	36 *(19-52)*	67 *(17-83)*	30 *(5-60)*	75 *(40-85)*	
PAHs, C5-C10	µg/L	< 25	N/A	N.A.	N.A.	
PAHs, C10-C25	µg/L	68 *(<50-68)*	48 *(48-100)*	N.A.	N.A.	
PAHs, C25-C40	µg/L	220 *(120-320)*	55 *(52-100)*	N.A.	N.A.	
PAHs, C5-C40	µg/L	25 *(<100-380)*	58 *(52-100)*	N.A.	N.A.	

Important to take along

- Legislation as stipulated in the WFD requires monitoring and fulfillment of water quality standards.
- On country level however, this can be translated to a total mixture of pollutants tested as once (like in DK) or separate tests performed on the single pollutants (like in DE).

On average the following conclusions can be drawn, based on a combination of lab and field tests:

- Lab tests are performed on single pollutions, showing (on average) lower removal rates (%) as compared to the removal rates (%) as seen in the field tests. This is a direct result from the fact that rainwater contains a mixture of solid particles (of various size) and dissolved pollutants. This is valid for all classes of pollutions (solids, dissolved materials or mineral oil).
- Time is a crucial factor when it comes to filtration, as the presence of solid particles enables the build up of a ‘filter cake’ in front of the filter. That cake is capable of captures pollutants and thus increase the efficiency of the overall filter.

Thank you

ROCKWOOL B.V.

Delfstoffenweg 2
6045 JH Roermond
The Netherlands

CVR No. 13014428

Tel.: +31 4 75 35 34 13
www.rain.rockwool.com

ROCKWOOL® RAINWATER SYSTEMS