

Modern urban stormwater management

Main drivers:

- Climate change
- Growing cities

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Empty office at noon
Find Corona
and the mistake

Objectives of Rainwater management

New Challenges

- Basic task:
Proper drainage of the settlements

- Pollution – water quality
Storm watertreatment

- Heavy rainfall, flush floods
Flood protection

- Climate of the city

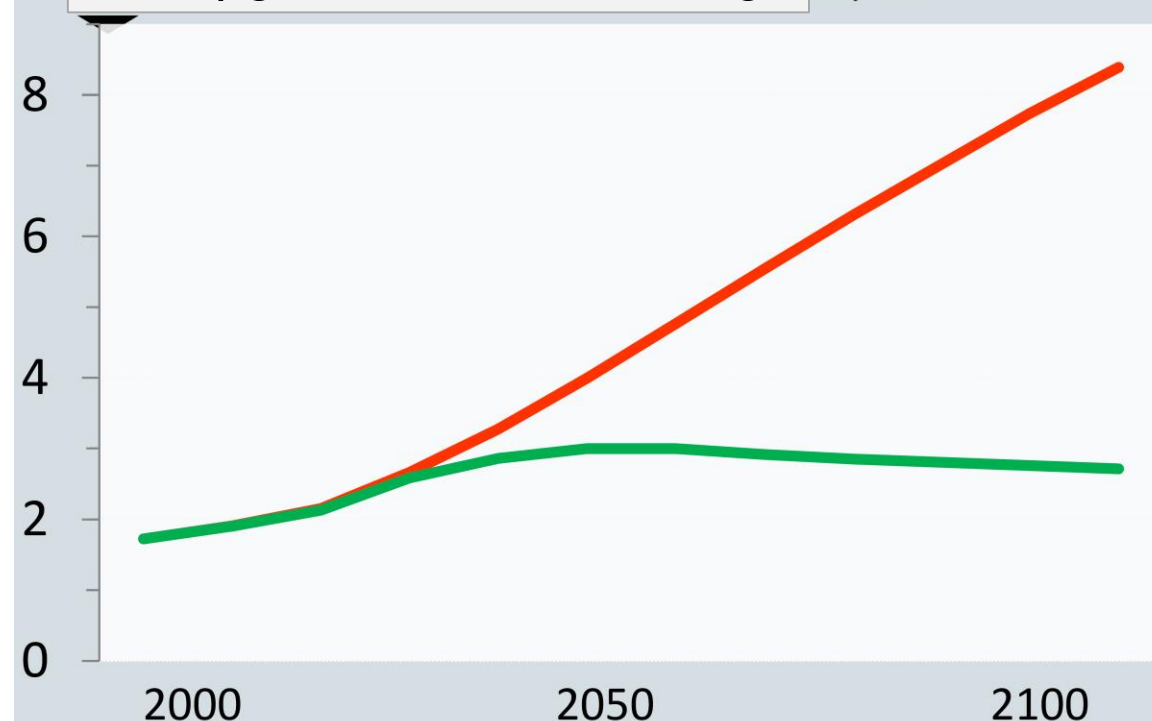
- ➔ Heat island
- ➔ Drought
- ➔ Growing cities
Sealing
- ➔ Loss of biotope





Future Development of CO₂-emissions will be crucial

Antropogenic radiative forcing W/m²



Change of the global temperature

● RCP 8.5: **+ 4,8 °C**

„Further as usual“ scenario

„climate protection“ scenario

● RCP 2.6: **+ 1,7 °C**

2°C aim can only be reached with negative emissions

Droughts – example empty reservoir



Quelle: DPA

Göttinger Tageblatt, 06.09.2018

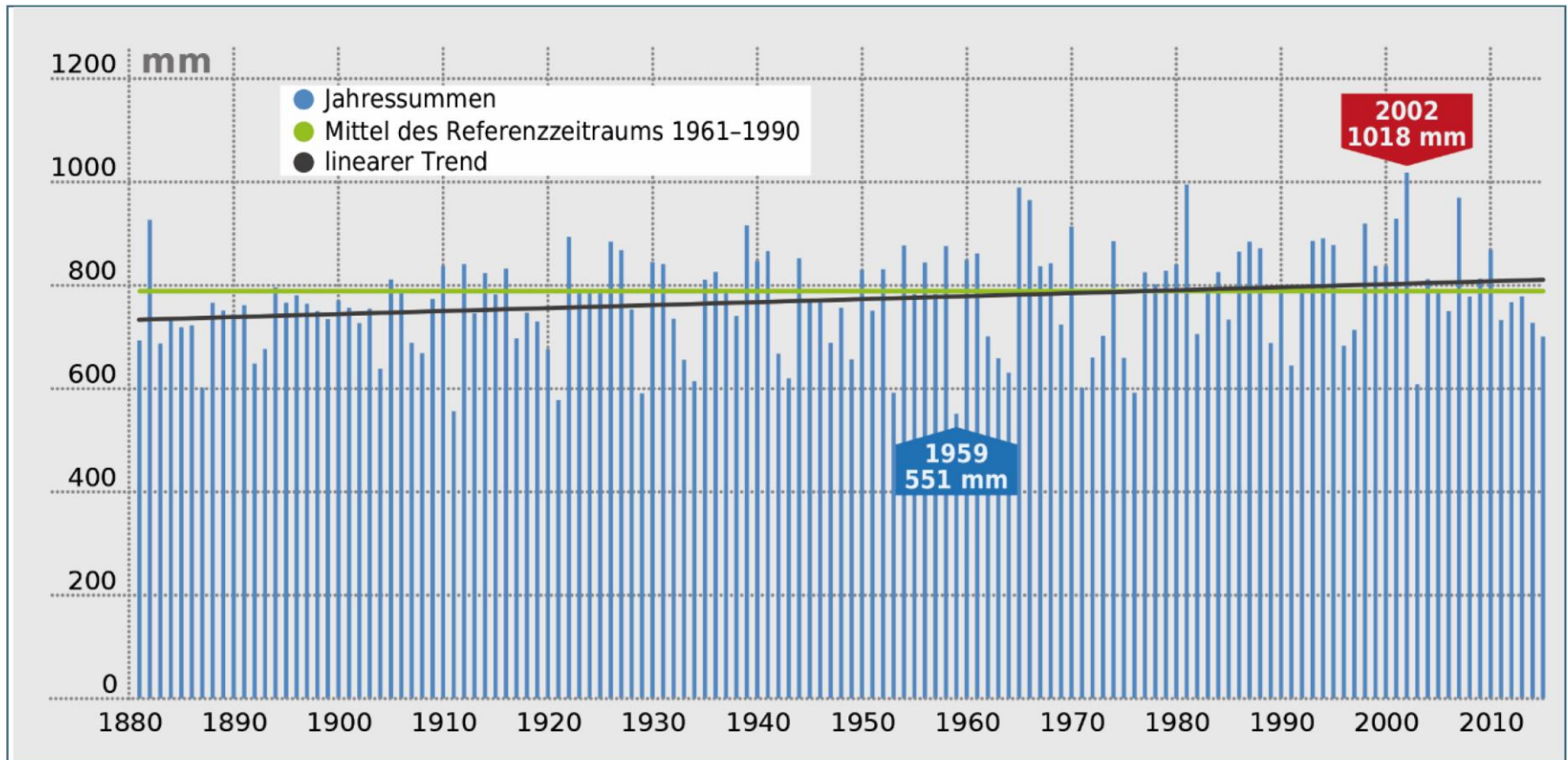
+++ Trockenheit Harz Okertalsperre +++

Droughts – fire in the forrest



Has the amount of rain already changed?

Linear yearly Trend in Germany 1881 bis 2015



(DWD 2016)

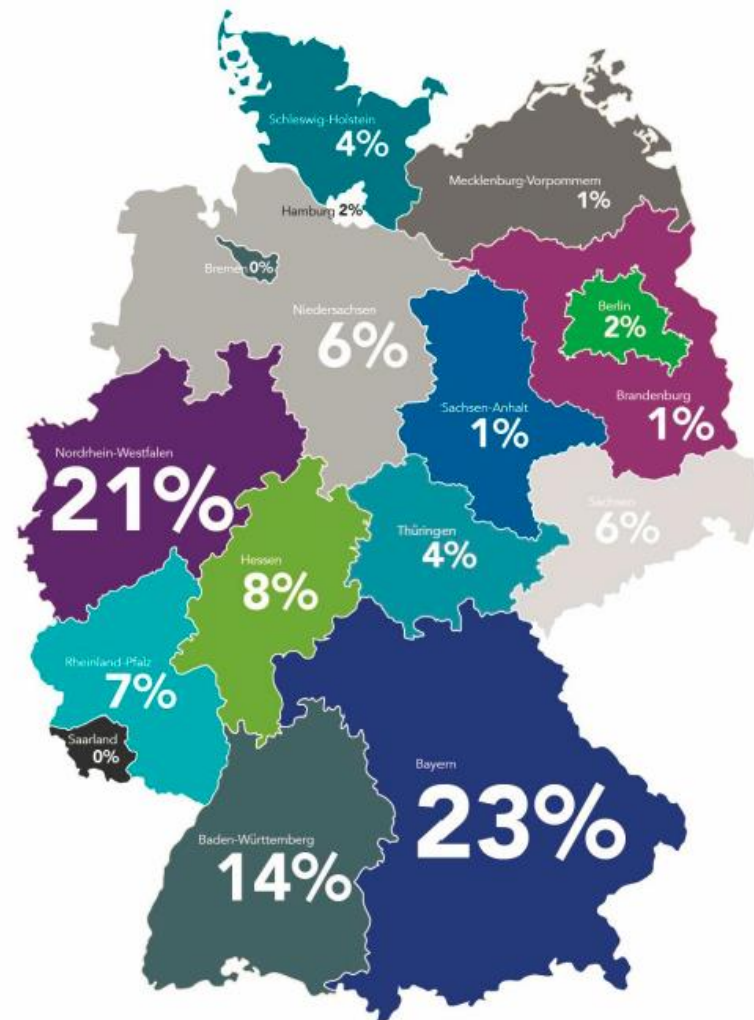
Extreme rain events

Example Germany

Extreme rain events will take place
more often in future (mainly in Summer)!
They can appear everywhere!

The German weather service (DWD)
alarms about extreme rain events

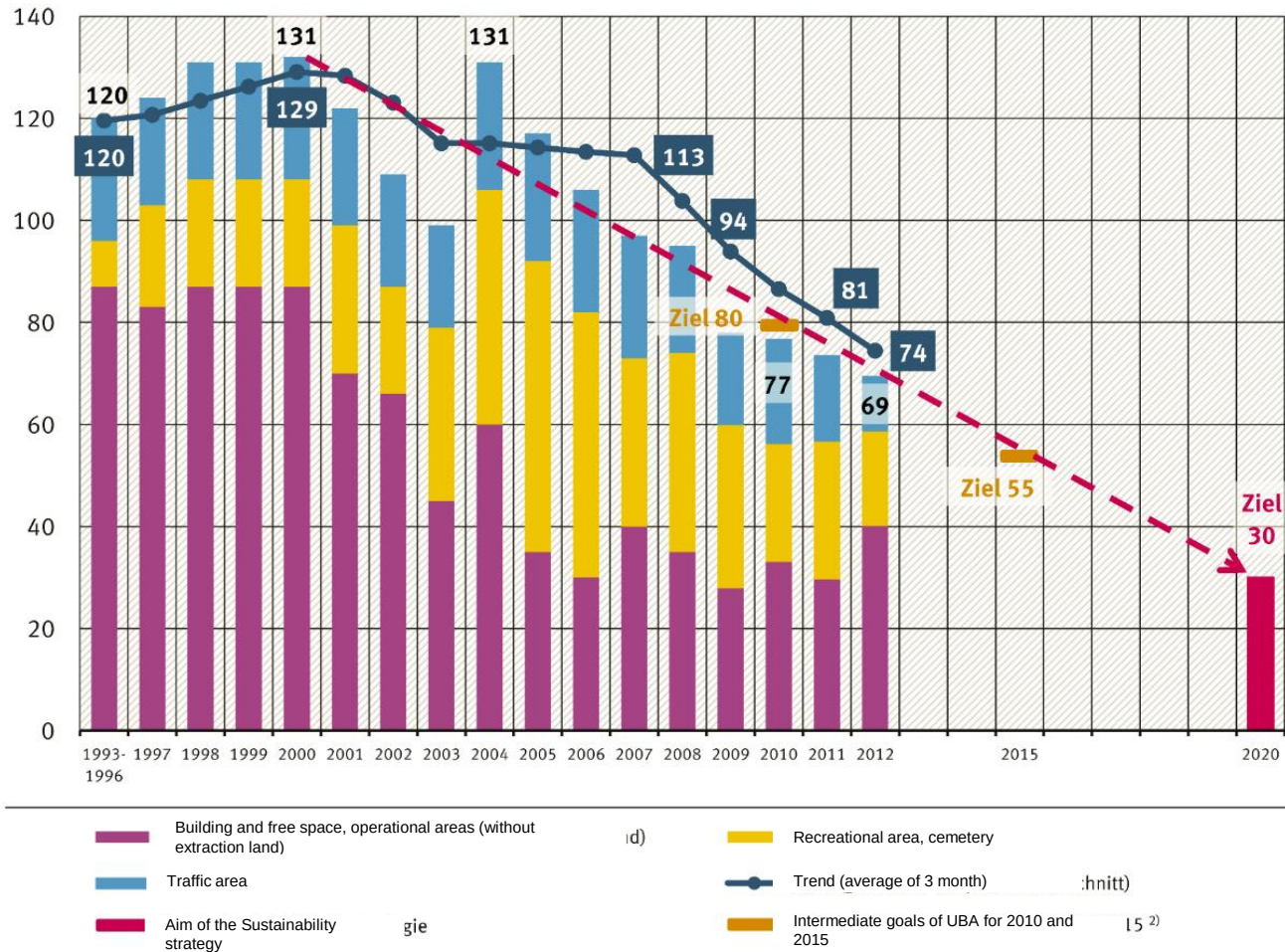
- Step 1: rain amount ≥ 10 mm / 1 h
or ≥ 20 mm / 6 h
(distinctive weather alarm)
- Step 2 rain amount ≥ 25 mm / 1 h
or ≥ 35 mm / 6 h
(severe weather warning)".



©Initiative Verantwortung Wasser und Umwelt des BDB e. V.

Space availability

Annual growth of settlement and traffic areas in Germany in ha/d



Adaption methods: Dutch sarcasm



Dutch cow
ready for sea
level rise:
Waddensee
Year 20XX

Conclusion for the Drainage concept

Common municipal task „precaution measures for flooding events“

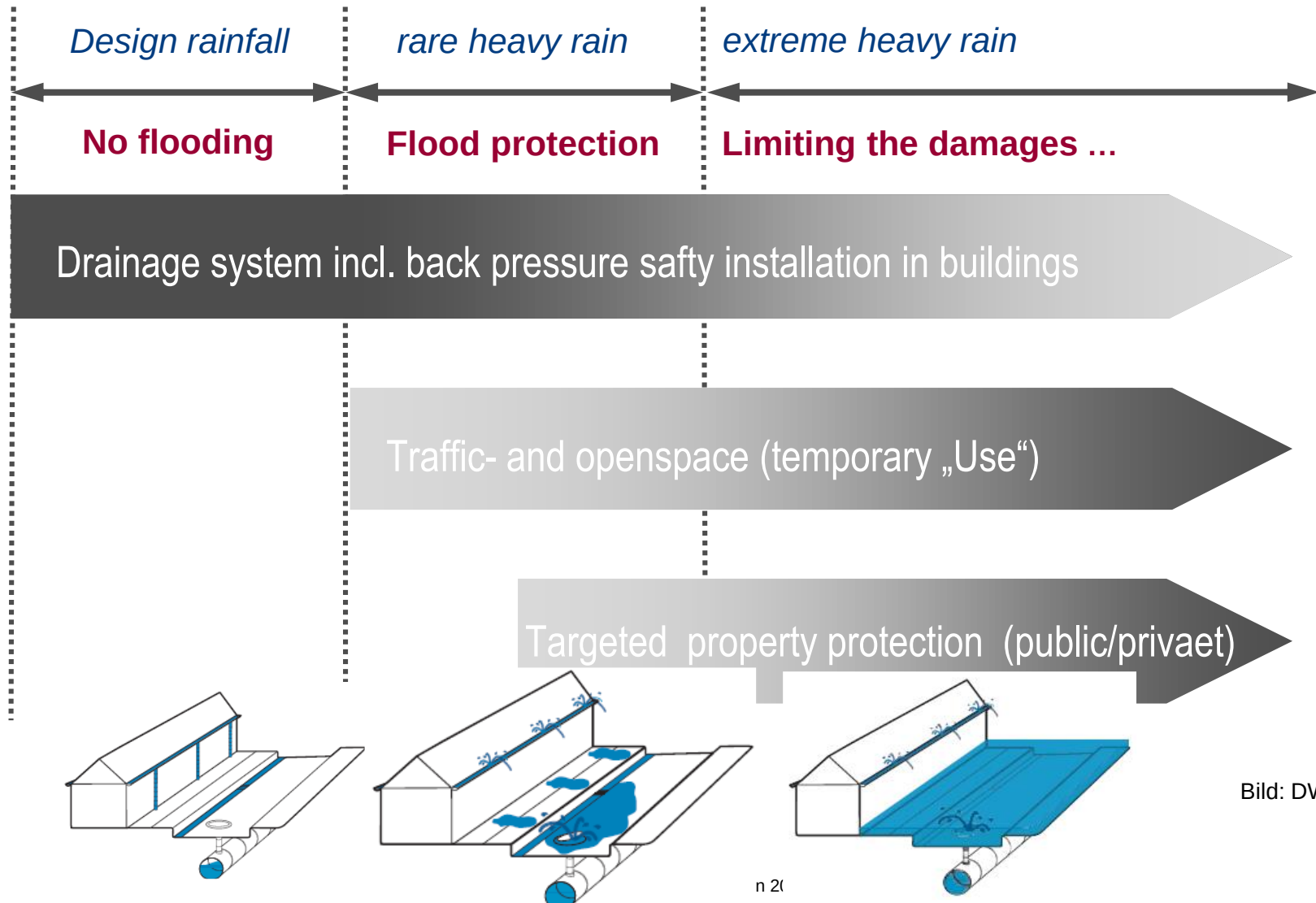
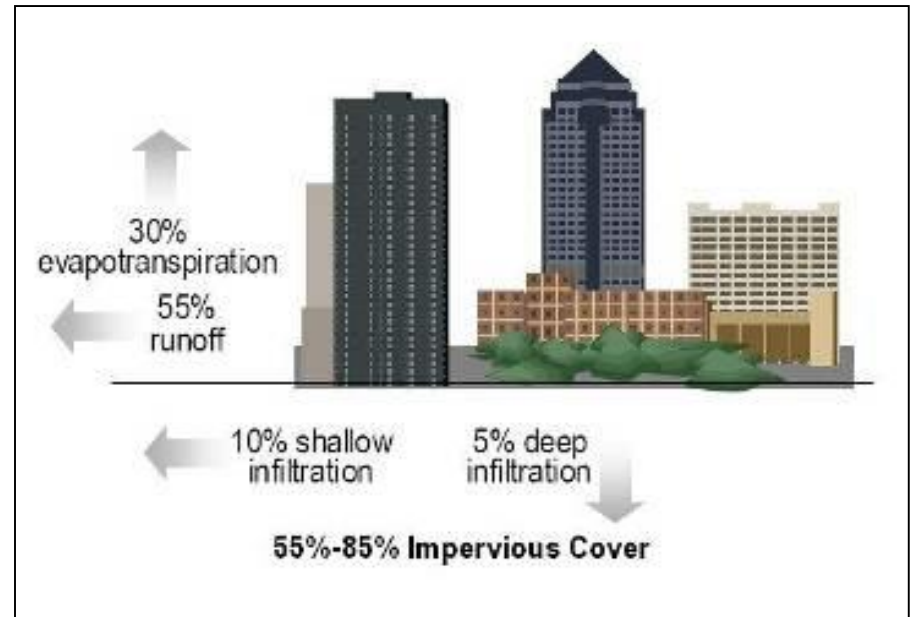
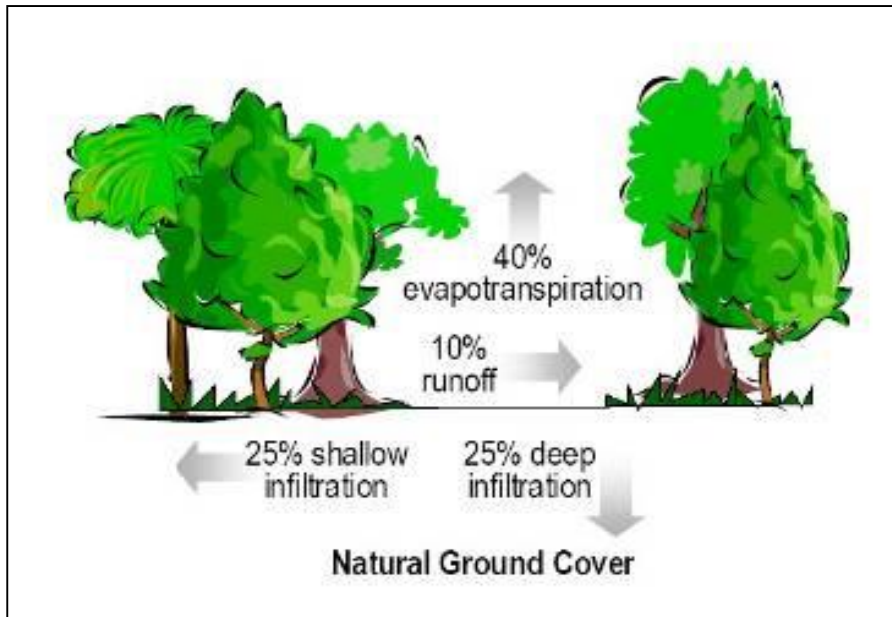


Bild: DWA, 2011

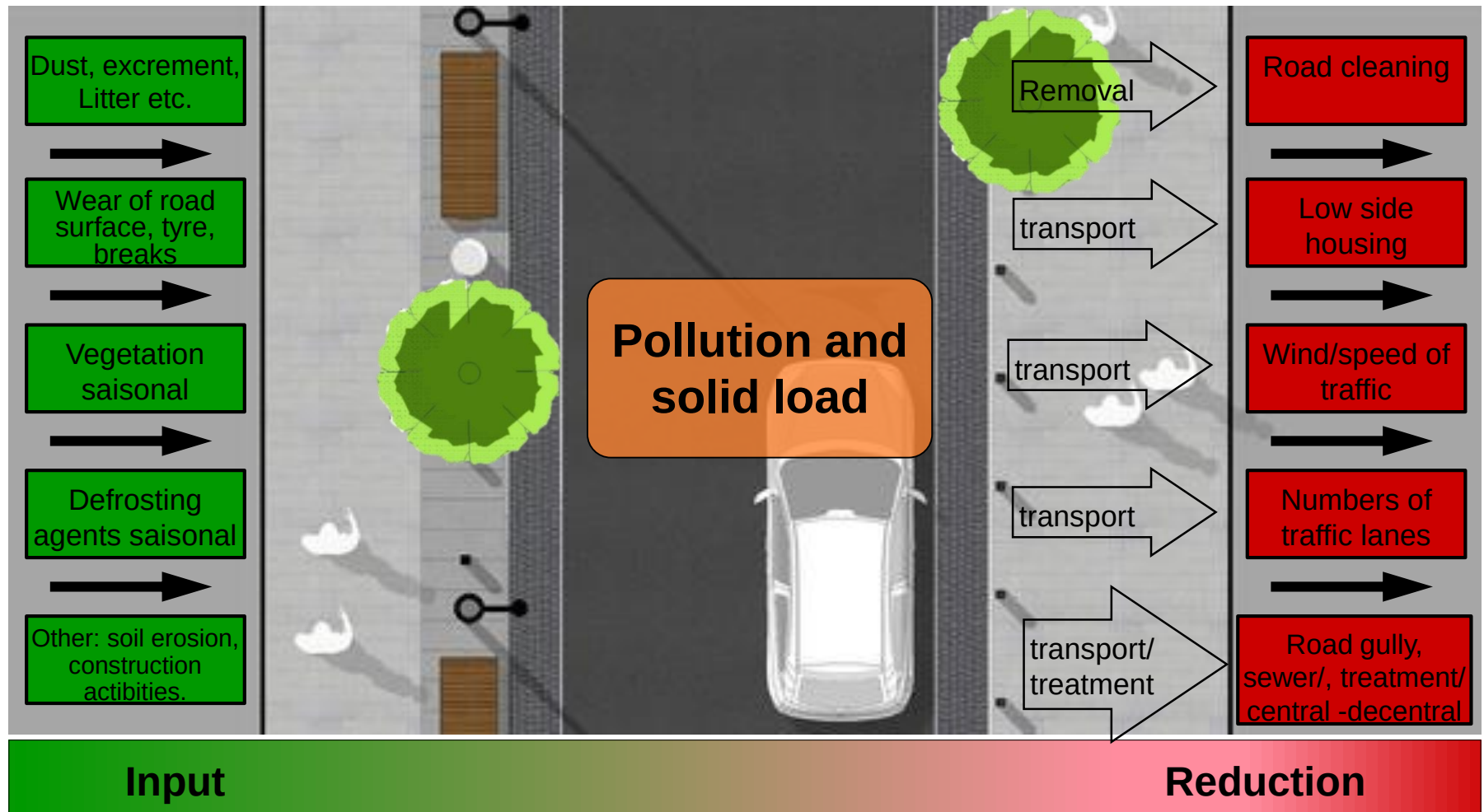
Water balance



Quelle: US-EPA, 2004 (angepasst)

- Objectives for the planning of new developments
 - ➔ Comparison of natural water balance with the planned status
 - ➔ Adjustment of the water balance in the planning area by new approaches
- Requirements for new development areas:
 - ➔ Single components of water balance must not differ larger than 10%.
 - ➔ Evapotranspiration should not vary more than 20 % from natural status.

Pollutions on the traffic area and in the road runoff



www.as-p.de (2019) & [Dierschke, 2014] verändert

Pesticides from walls,...

Typical values for road run off in siteu measurement in DSWT-Project



	AFS [mg/l]	AFS63 [mg/l]	CSB [mg/l]	P _{ges} [mg/l]	Zink [mg/l]	Kupfer [mg/l]	PAK [µg/l]
Verkehrsabfluss Schwerpunktwert (Vertrauensbereich) [DWA 2010]	200 (60-400)	100	100 (30-150)	0,5 (0,2-1,2)	0,44 (0,2-0,6)	0,08 (0,03-0,25)	2,5 (1,5-7,0)
Clayallee MW c_F n=15	223	125	267	0,92	0,81	0,31	-
Clayallee Median c_F n=15	181	71	299	0,79	0,62	0,25	-

[DWA 2010]: Schmitt, T. G.; Welker, A.; Dierschke, M.; Uhl, M.; Maus, C.; Remmler, F. (2010): Entwicklung von Prüfverfahren für Anlagen zur dezentralen Niederschlagswasserbehandlung im Trennverfahren. Schlussbericht an die Deutsche Bundesstiftung Umwelt, Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, Hennef, Juli 2010

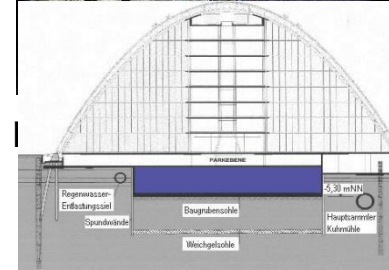
- Reference parameter:
 - ➔ Total suspended solids, fine particles TSS_{fine} ($< 63 \mu\text{m}$)
 - ➔ Indicator especially for heavy metals
- Approach: Pollution discharge $[\text{kg}/(\text{ha} \cdot \text{a})]$ emission concept

	Pollution discharge TSS_{fine} [kg/ha · a]	
Category I (low contaminated)	280	tolerabel
Category II (moderate contaminated)	530	↓ treatment necessary
Category I (high contaminated)	760	

Conventional stormwater discharge and treatment

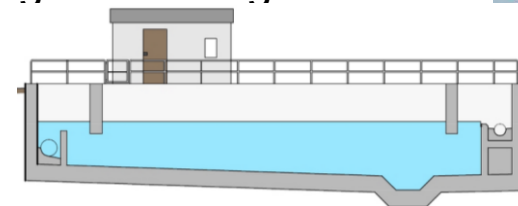
● Stormwater overflow discharge in combined sewers

- ➔ Combined sewer overflow (CSO)
- ➔ Stormwater tank with overflow (CST)
 - stormwater tank retaining the first flush
 - stormwater tank for settled combined sewage (run through)
 - compound tank
- ➔ Sewer storage capacity (SC)
- ➔ Stormwater holding tank



● Stormwater treatment in separate sewer systems

- ➔ Stormwater sedimentation tank; re-fitting of existing tanks (e.g. lamella separator)
- ➔ Stormwater holding tank
- ➔ Retention soil filter



635 l/inhabitant (2007)

658 l/inhabitant (2010)

703 l/inhabitant (2013)

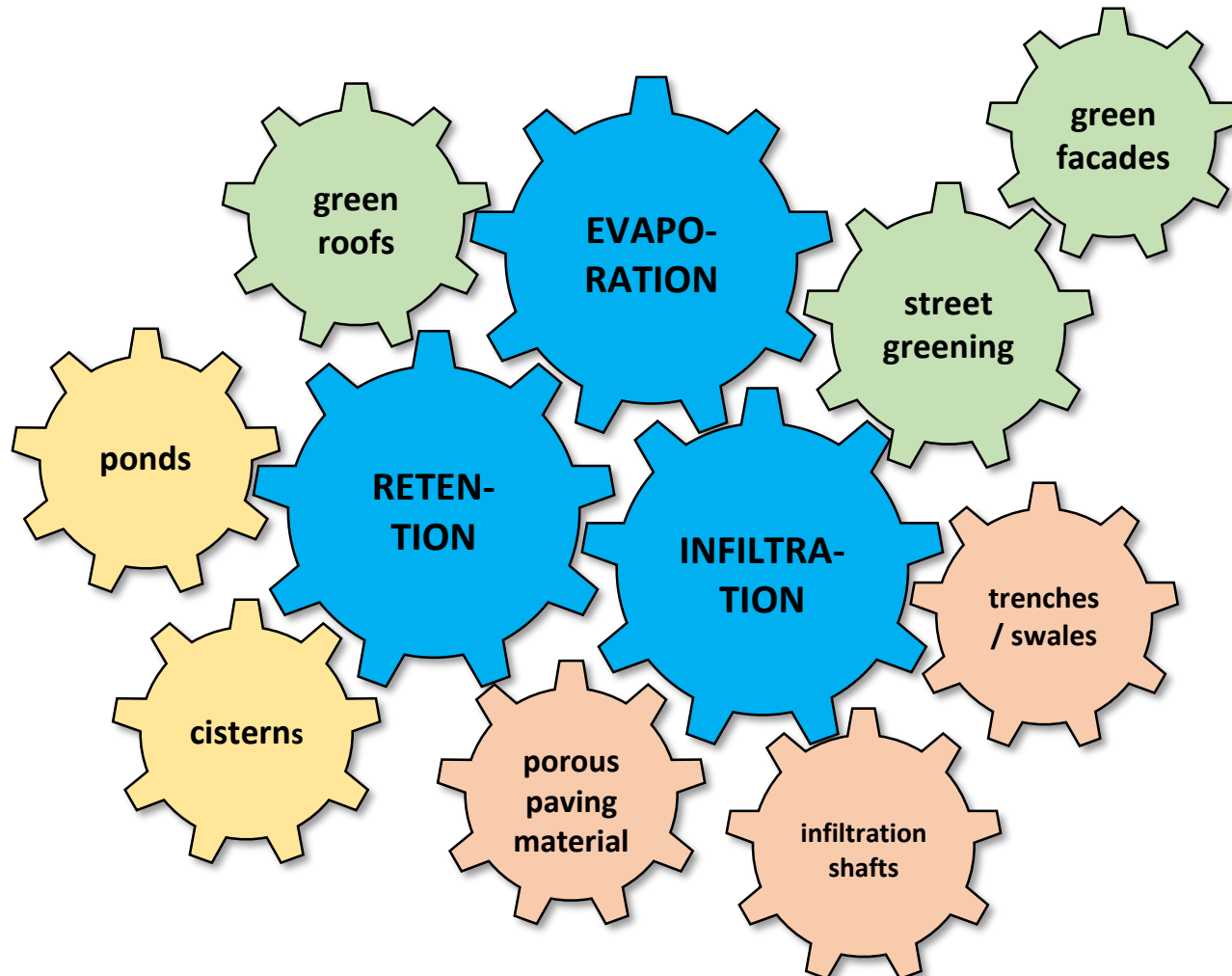
Retention soil filter

Efficiency

HAUPTWIRKUNG	WERT	ZUSATZWIRKUNG	WERT
Kappung Spitzenabfluss	●●●●○ ²	Verdunstung/ Mikroklima	●●●○○
Rückhalt fester Stoffe	●●●●●	Ökologisches Potenzial	Schilf-Landröhricht
Rückhalt gelöster Stoffe	●●●●○	Freiraumgestaltung	●●○○○
Grundwasserneubildung	○○○○○		
REINIGUNGSVERFAHREN		BEMESSUNG	
Sedimentation	ja	Maßgebliche Kriterien	AFS63 und Q_{krit}
Filtration	ja	Anschließbare Fläche	groß
Biologische Behandlung	ja	Spez. Fläche der Anlage	100 m ² /ha
Sorption	ja	Spez. Speichervolumen ³	bis 200 m ³ /ha
HYDRAULISCHE WIRKUNG		STOFFLICHE WIRKUNG	0% 50% 100%
Anteil behandeltes Wasser	Teilstrom/ Vollstrom min. $Q_{krit} > 94\%$	Anteil behandeltes Wasser	Teilstrom/Vollstrom min. $Q_{krit} > 94\%$
Retention	●●●●○	AFS	—————■
Abflusssdrosselung	ja	AFS63	—————■
		Phosphor ⁴	————■
		Schwermetalle	—————■
		Org. Summenparameter	—————■
		Ammonium	————■
		Keime ⁵	—————■
PLANUNG			
Bemessungsverfahren hydraulisch	DWA-A 178	Wissensstand	a.a.R.d.T.
Bemessungsverfahren stofflich	DWA-A 178	Regelwerk	ja ⁶



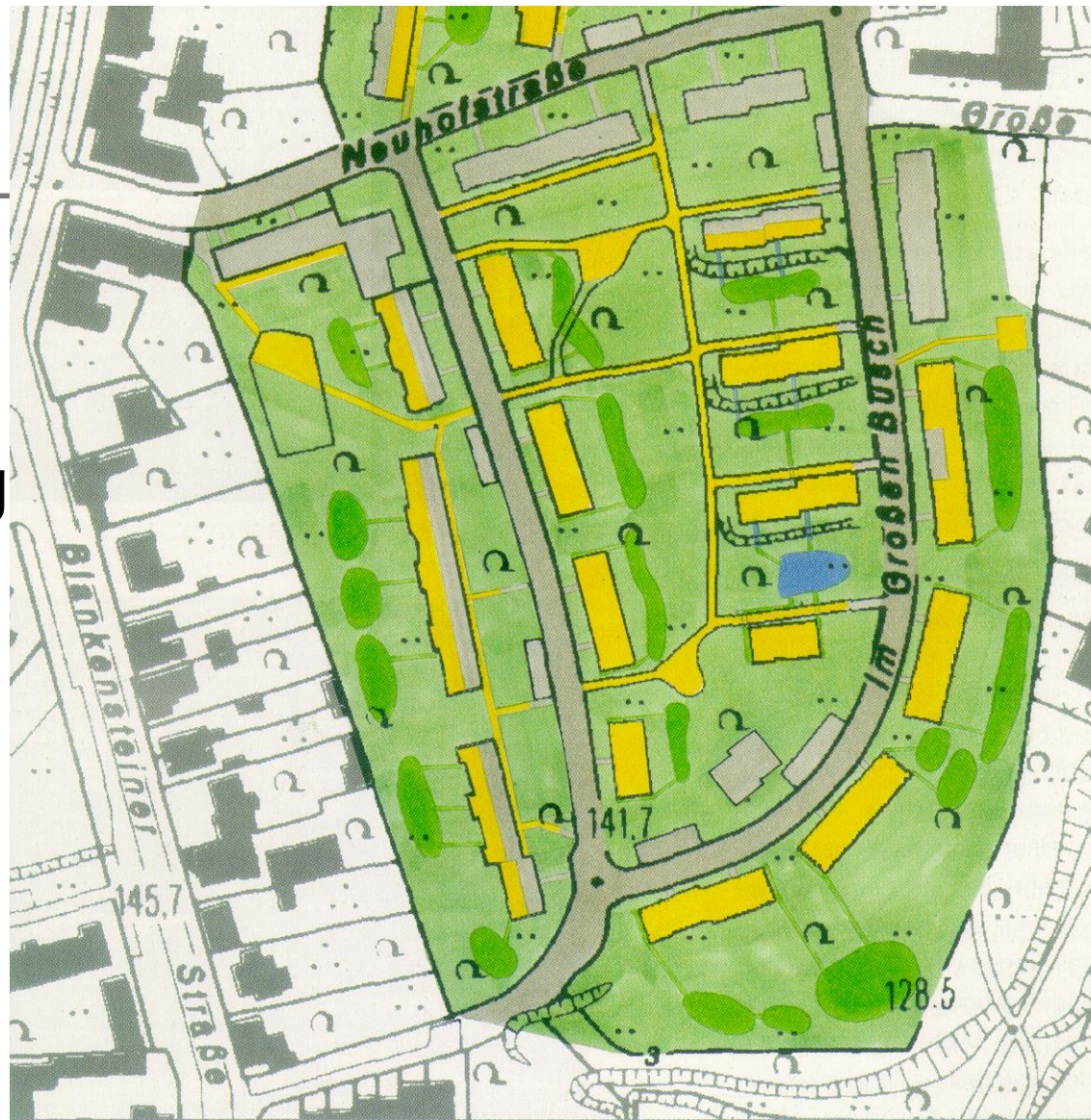
The new way out...decentralised



Elements of modern rainwater management

- Existing sites de-coupling space from sewers and create infiltration measures
- Porous surface of traffic layers
- Rainwater harvesting
- Rainwater infiltration with/without pre-treatment
 - ➔ decentralized or centralized
- Evapotranspiration
 - ➔ Ponds, lagoons
 - ➔ Roof and facade greening
 - ➔ Urban agriculture (multi function)
 - ➔ Street greening
- (Short-time) storage
 - ➔ Tree pits or tree drain
 - ➔ Intelligent cistern
- Decentralized stormwater treatment

De-coupling Residential area



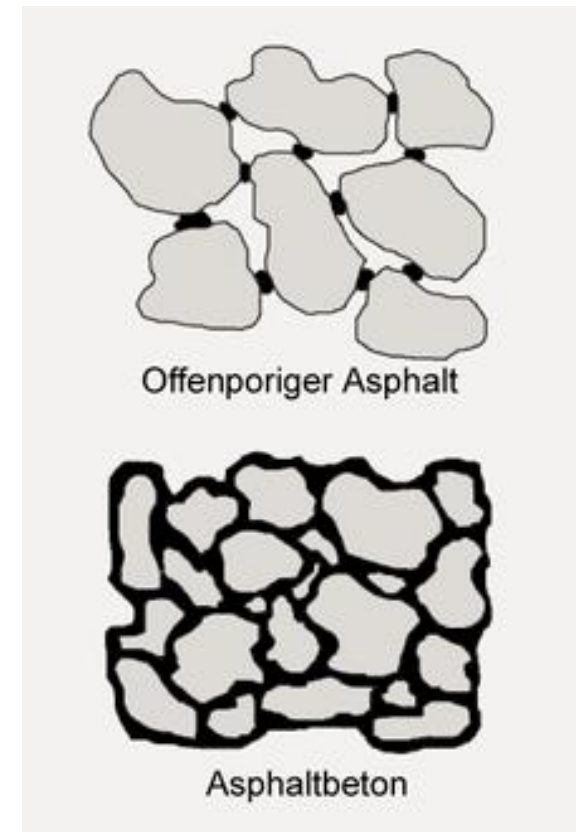
- | | | | |
|---|---------------------------------|---|---------------|
|  | abgekoppelte, befestigte Fläche |  | Grünfläche |
|  | Befestigte Fläche am Kanal |  | Dachbegrünung |
|  | Versickerung |  | Rigole |

Swale



Unsealed traffic layers

Drain asphalts – open porous



Rain water infiltration

Not requiring treatment

Favourable (vegetated, topsoil layer)

- Centralised infiltration on public land
- Decentralised infiltration on private land
- Pervious or unsealed spaces
- Swales and trenches
- Depression infiltration
- Shaft infiltration
- Retention soil filter
- ...

Availbilty of space
Infiltration capacity of the soil

Gras paver blocks from natural stone pavement with gaps



Depression infiltration

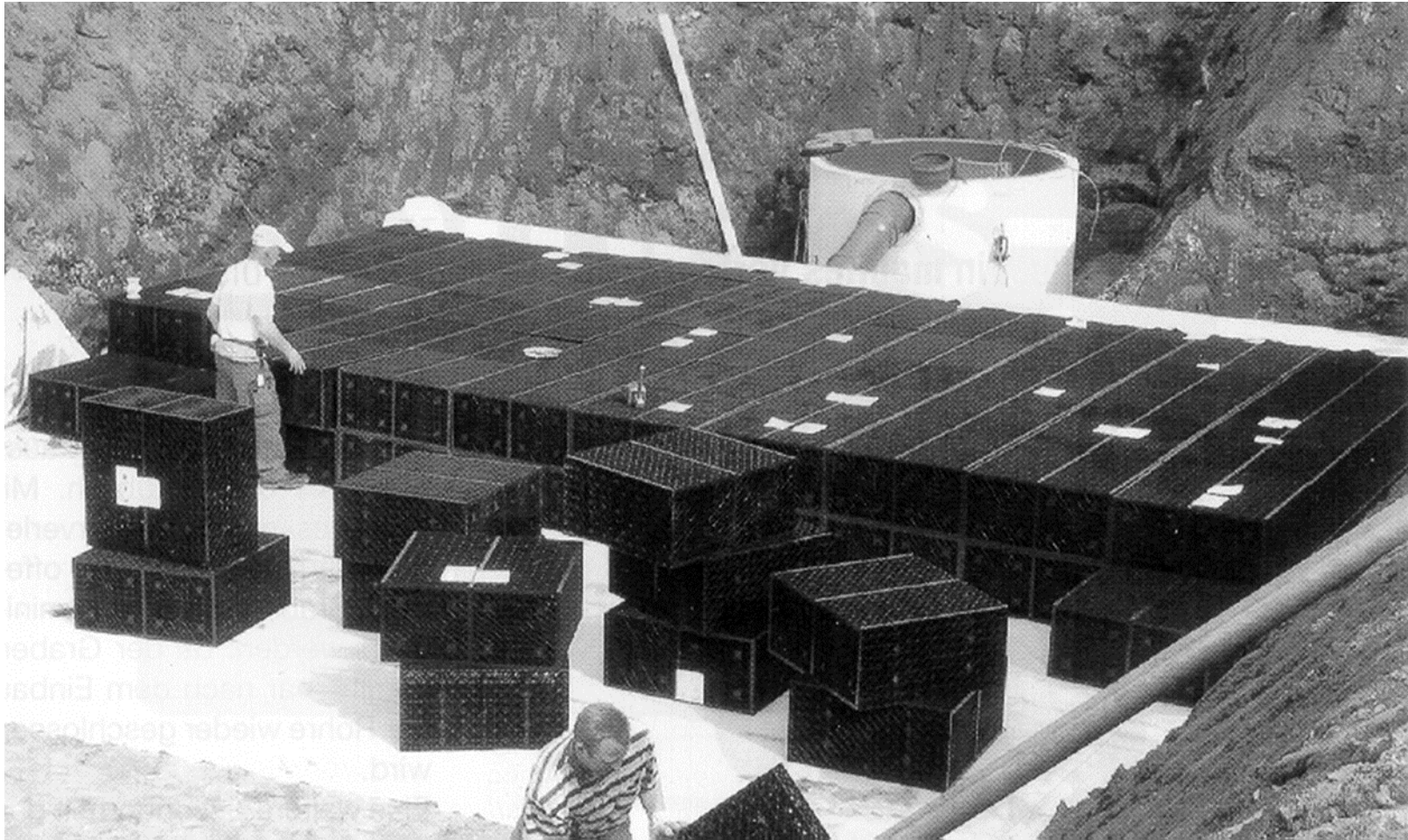
Example of swale and trench (laying)

temporary water storage possible

Berlin-Karow:
Swale in the courtyard at multi-
storey building

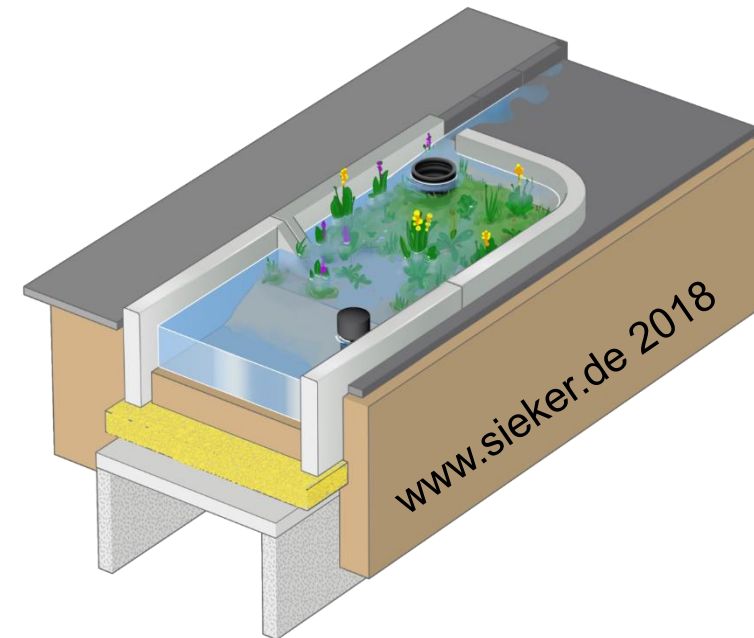


Trench infiltration system



Deep bed -Trench

- Combination of infiltration and retention run off system **with planted bed and trench out of plastic bodies**
- Treatment of road run off by upper soil layer
- Low space demand
- Additional traffic calming



Green roof



- Extensive green roofs

- ➔ of mosses, lichens, Sedum species and spontaneous vegetation
- ➔ no maintenance
- ➔ Improving micro climate
- ➔ better thermal isolation
- ➔ roof load $> 25 \text{ N/m}^2$

- Objective

- ➔ Buffering the effluent peak
- ➔ Increase of evaporation
- ➔ Habitat for organism

- Intensive green roofs

- ➔ roof pitch $< 3^\circ$
- ➔ Garden landscapes with trees, intensive care



Greening of facades



C.



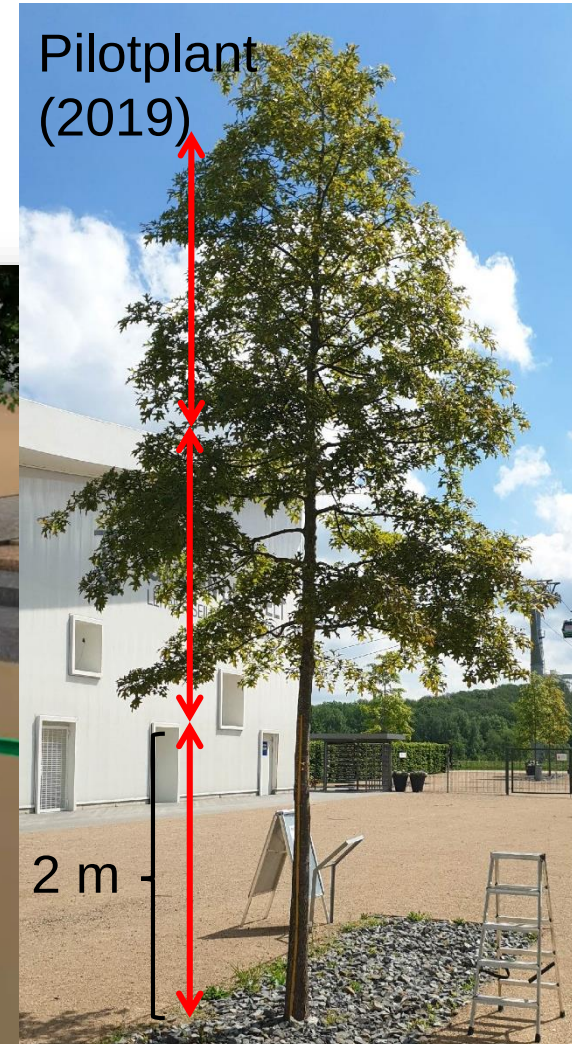
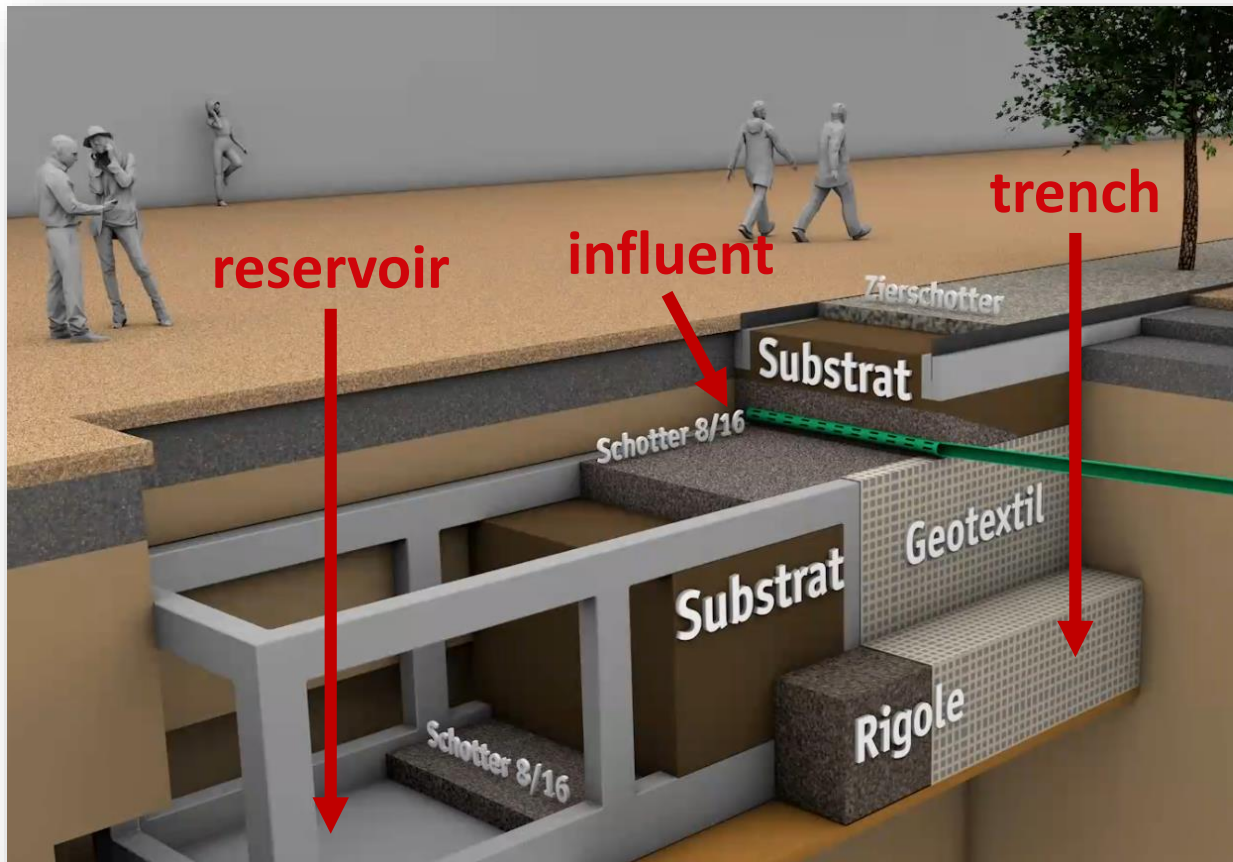
D.



TREEDRAIN – pilot plant

International garden exhibition in Berlin Marzahn

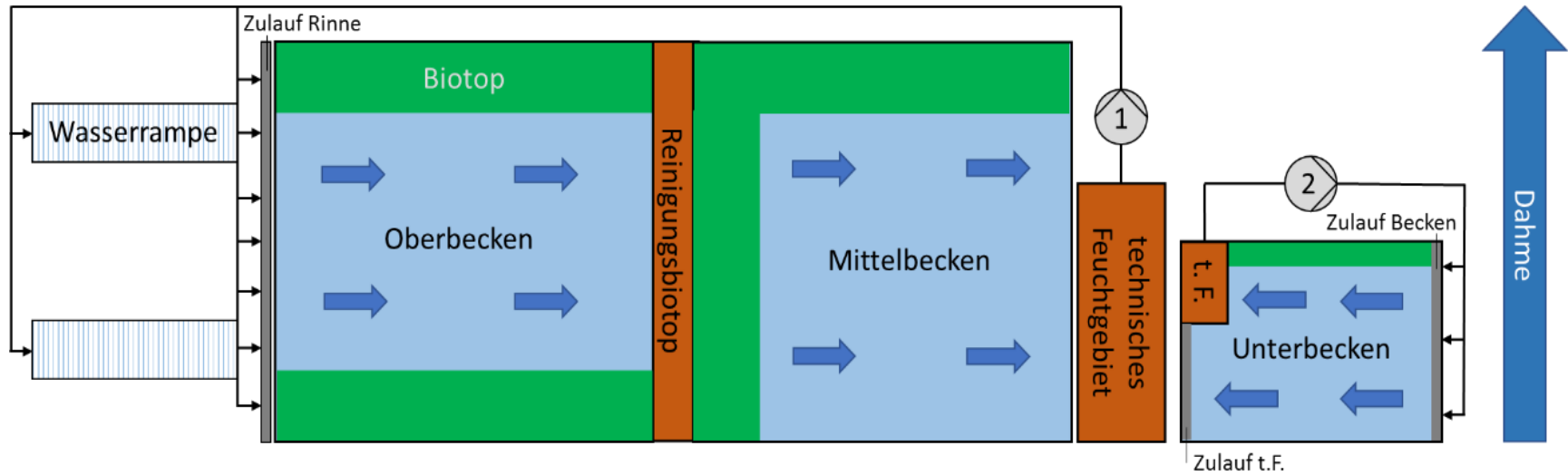
- Tree pits should storage rain water
- Rain water treatment
- Provide water in dry seasons
improvement of micro climate



Ingenieurgesellschaft Sieker (2017)

Rainwater pond, Berlin

Treatment and evaporation



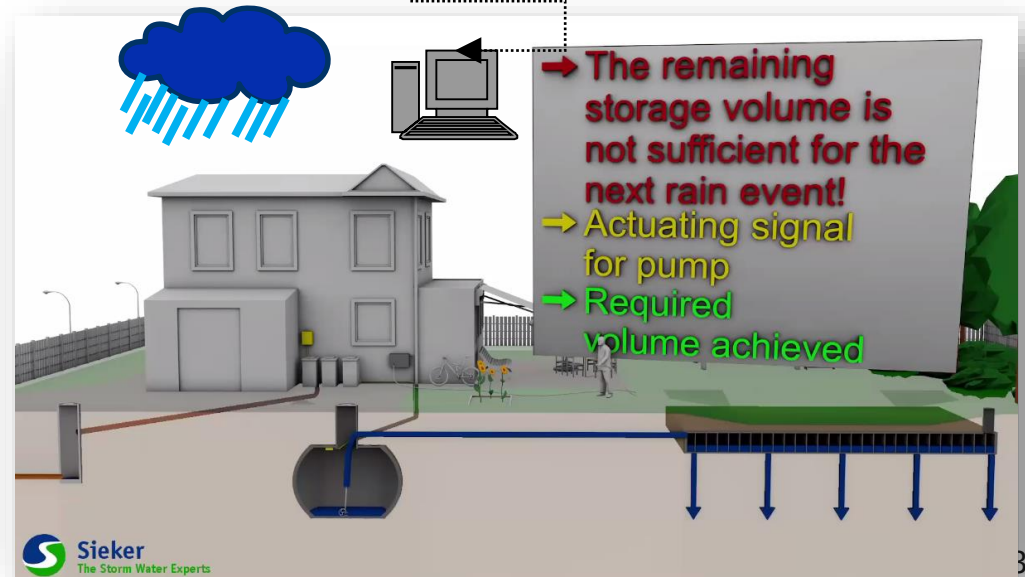
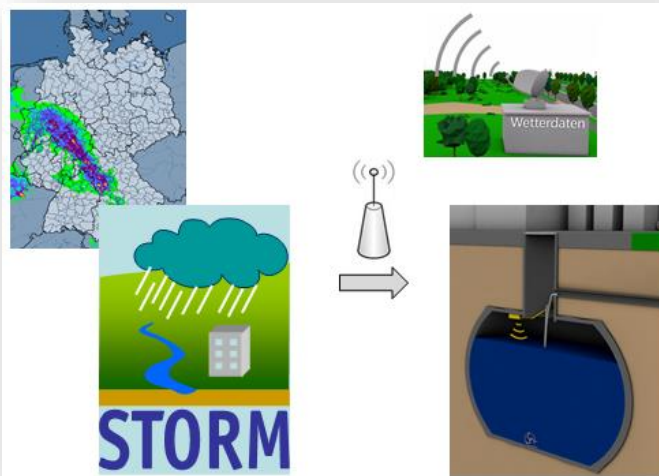
www.maps.de 2018



52grad-nord.de

Intelligent Cistern

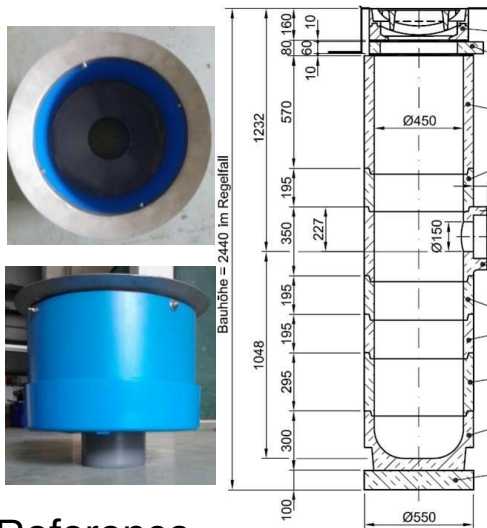
- Traditional technology, often used in Germany
 - ➔ 1.5 Mio. cisterns
 - ➔ 80,000 new cisterns per year (Source: Mall GmbH)
- Main objective: saving of drinking water → Ø price: 2.60 €/m³
- **Intelligent cistern**
 - ➔ Product allows the discharge of cisterns prior to forecast intense rain events



Decentralized Stormwater treatment

Selection of systems, Clayallee, Berlin

- Stormwater is treated directly, where it is produced
 - ➔ Near to run off building areas
 - ➔ No mixing of different kinds of rainwater.
- Advantage:
 - ➔ Higher concentration $\Rightarrow$ better treatment
 - ➔ Small space demand
 - ➔ High maintenance

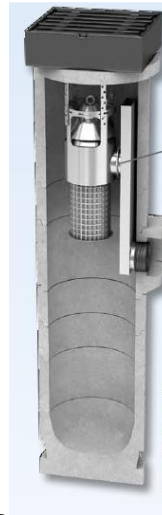


Reference

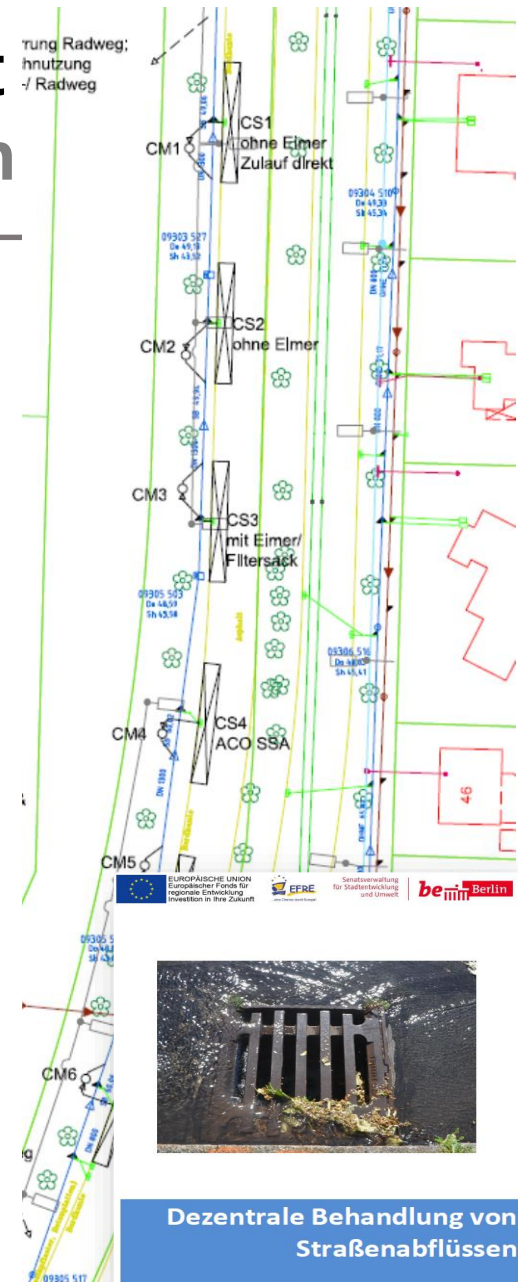
Wet gully with
sludge trap



Combipoint, ACO



INNOLET®-G, Budavinci Typ N
MeierGuss

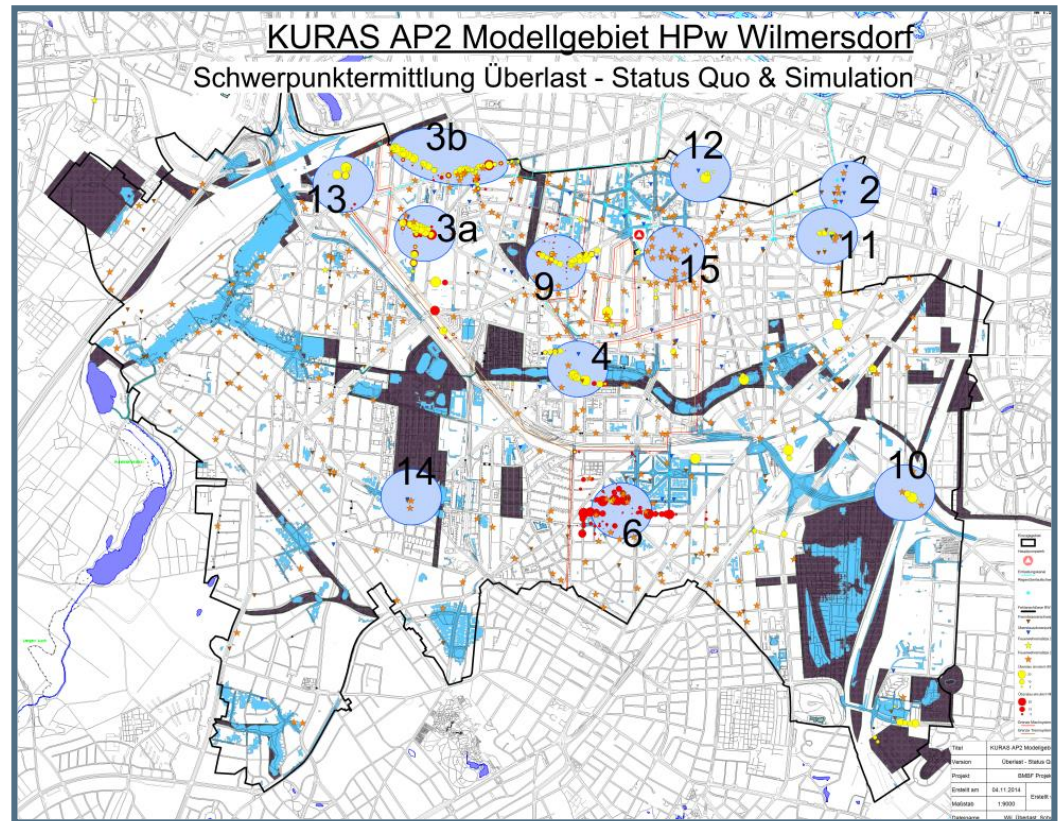


Dezentrale Behandlung von
Straßenabflüssen

Übersicht verfügbarer Anlagen
Stand 09/2015
3. überarbeitete Auflage

Technische
Universität
Berlin

Figure 10 is an aerial view of the University of Michigan campus. It displays various buildings, roads, and green spaces. Overlaid on the image are numerous small triangles representing depth data. A legend in the bottom right corner explains the color coding for these triangles: red for depth ≥ 0.5 m, orange for depth ≥ 0.3 m, and yellow for depth ≥ 0.1 m. The triangles are scattered across the campus, with a higher concentration in certain areas, particularly around the central buildings and along the roads.



Temporary retention space

Example children's play ground



Bild: De Urbanisten, 2011

Measures for urban flood protection

- Roads as a temporary retention element



Bilder: DWA/BWK, 2013



Angaben bezogen auf
240 m² Straßenraum
(L/B = 40 m / 6 m)

Bilder: DWA/BWK, 2013

Measures for urban flood protection

► Technical measures – Local measures at buildings

- Backwater protection, lifted entrance, waterproofed basement, bulkhead for garage

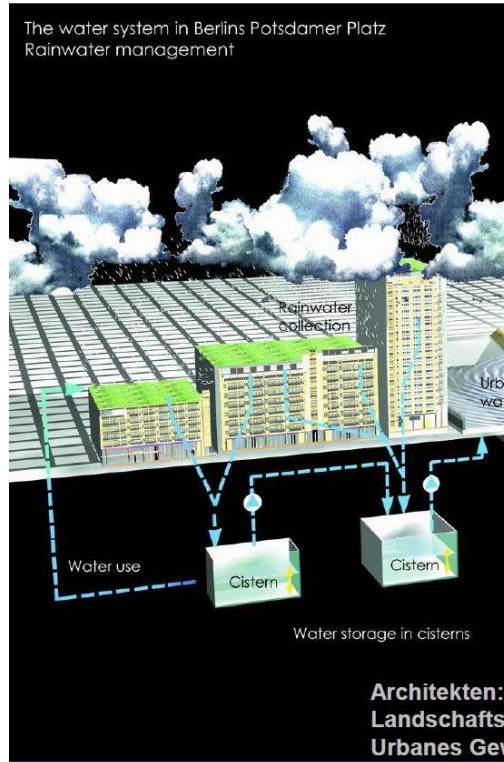


Bilder: DWA/BWK, 2013

Existing BG Solution

Potsdamer Platz

- Green roof , R



water spaces



Challenges for implementation of water sensitive city

- Improvement of knowledge of stakeholders and planers
 - ➔ Recent planning was focused only on drainage
 - ➔ Building up competences in the different authorities
 - ➔ Coordination with traffic-, spatial- and city planers
- Lack of regulations and incentives
 - ➔ Rules for flood protection
 - ➔ Creating open spaces, reducing sealed surface
 - ➔ Restrictions for real estate developers
 - ➔ Rain water fee for sealed space
- Integrated planning
 - ➔ Decrease of concentration of housing
 - ➔ Determination of spaces for infiltration and flood protection

The vision

- 
- From BlueGreen Dream
 - BlueGreen Street
 - Blue Green City
 - Water sensitive City