KLIMA 2050

RISK REDUCTION THROUGH CLIMATE ADAPTATION OF BUILDINGS AND INFRASTRUCTURE

Stormwater management – Systems to manage SW Close to the source of contamination

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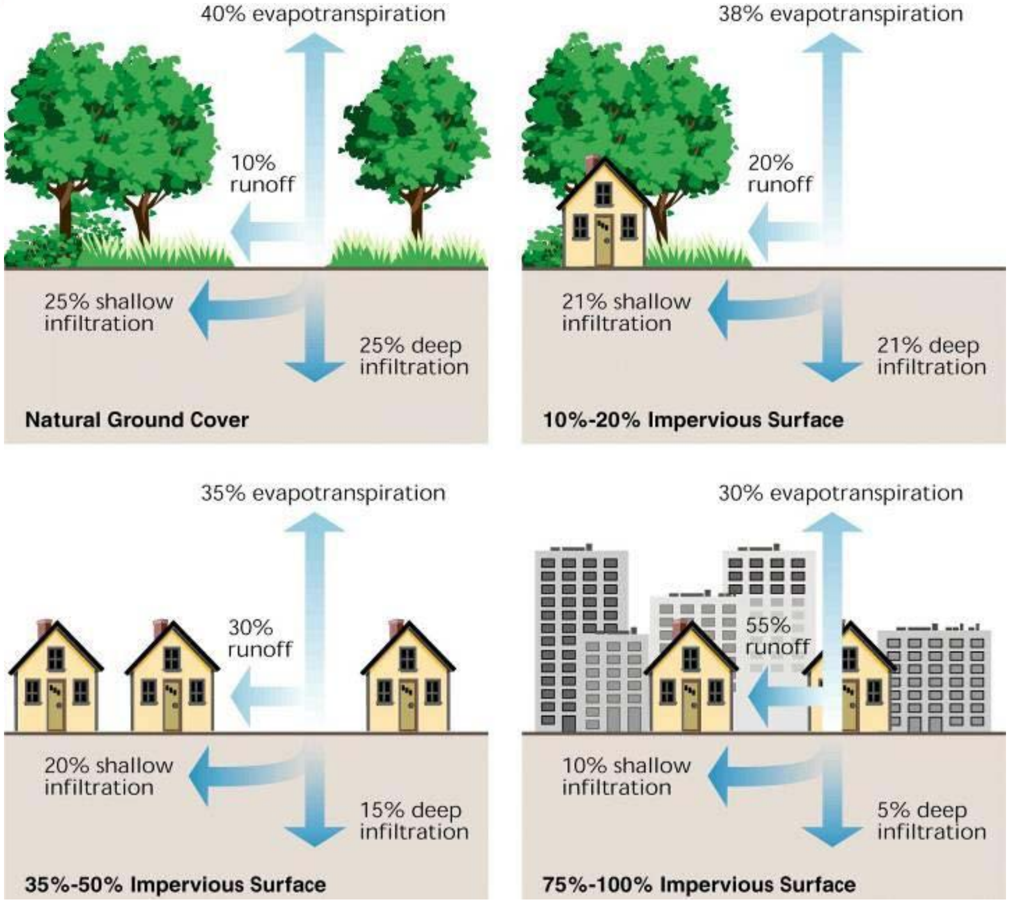
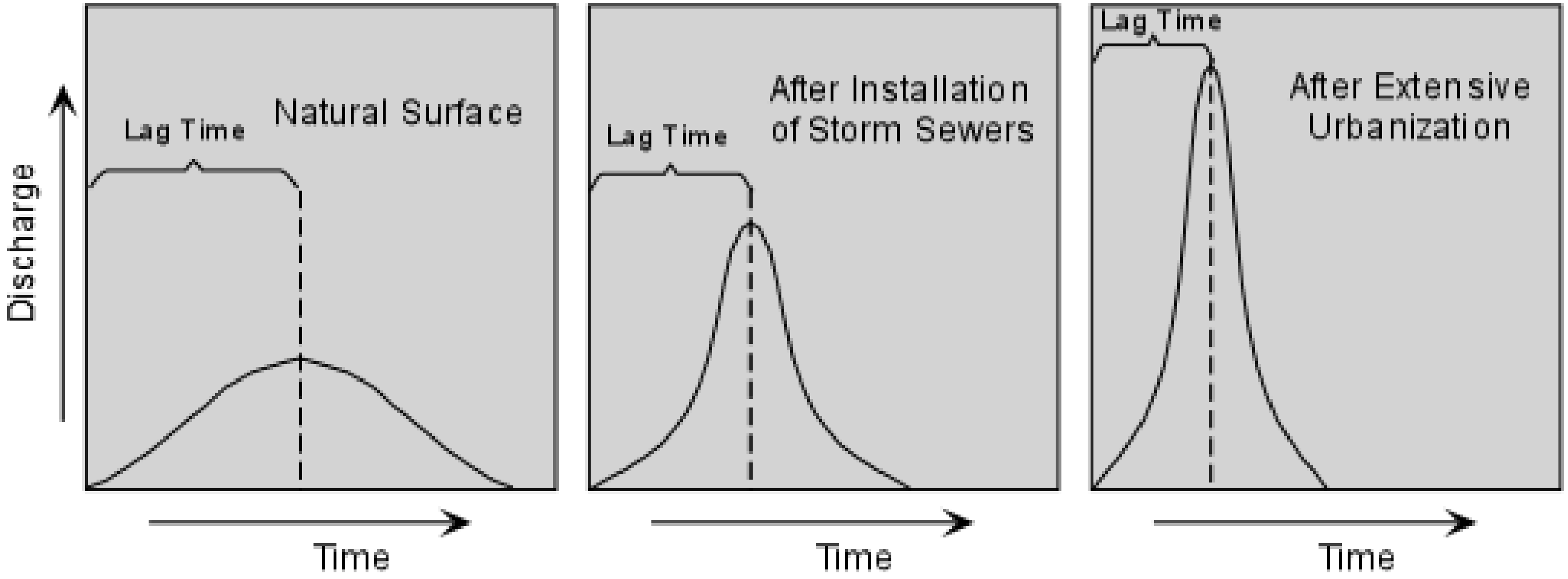
Modification of the watershed due to the urbanisation



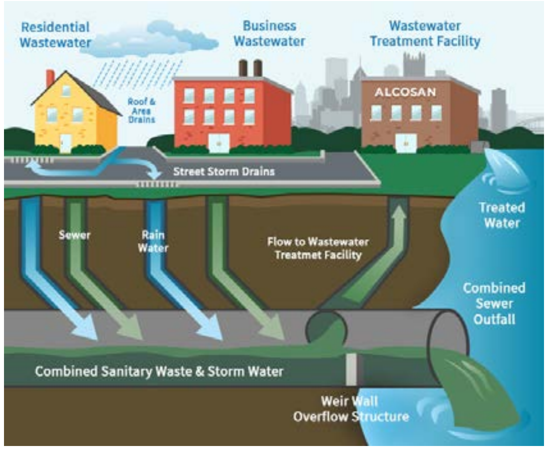
Source: FISRWG (2001)

Climate change → Increased precipitation and urban flooding

Effect of urbanisation on runoff hydrograph



Pollutant concentrations for different urban land use



Type of land use	Pb Average (min-max) µg/l	Zn Average (min-max) µg/l	Cu Average (min-max) µg/l	Cd Average (min-max) µg/l	COD Average (min-max) mg/l	TSS Average (min-max) mg/l	Tot-N Average (min-max) mg/l	Tot-P Average (min-max) mg/l
General urban areas	25 (15-60)	150 (80-300)	50 (25-100)	0.5 (0.3-0.9)	70 (40-120)	120 (50-200)	2.0 (1-2.5)	0.3 (0.2-0.4)
Residential district	15 (15-40)	120 (60-200)	35 (20-70)	0.3 (0.2-0.5)	60 (40-75)	70 (40-160)	1.5 (1-2)	0.3 (0.1-0.4)
Residential areas of block of flats	20 (15-60)	180 (90-300)	50 (25-100)	0.4 (0.3-0.6)	80 (60-110)	120 (60-200)	2.0 (1-3)	0.3 (0.2-0.5)
Residential and central areas	40 (20-70)	250 (120-400)	70 (25-110)	0.5 (0.3-0.7)	120 (90-150)	200 (100-260)	2.0 (1-3)	0.3 (0.2-0.6)
Citytraffic	40 (15-70)	240 (100-350)	75 (25-110)	0.5 (0.3-1.0)	160 (110-230)	200 (70-250)	2.0 (1-2.5)	0.3 (0.2-0.5)
Industry	40 (10-60)	250 (120-400)	70 (25-110)	0.5 (0.3-0.9)	90 (60-120)	170 (70-230)	2.0 (1-2.5)	0.3 (0.2-0.6)

Climate change → More frequent first flushes

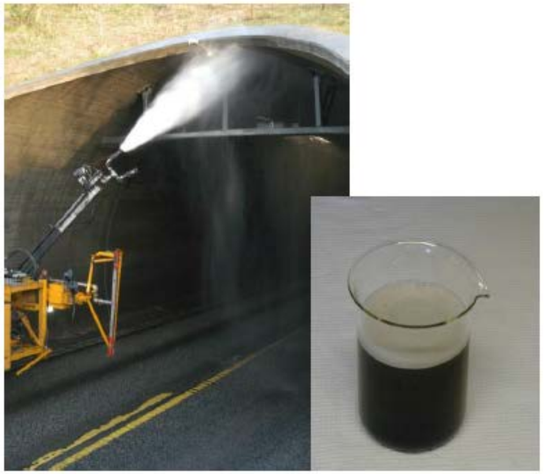
Source: Lindgren, A. (2001) Swedish Road Administration

Highway runoff constituents and their primary sources

Constituents	Primary Sources
Particulate	Pavement wear, vehicles, atmosphere, road maintenance (sanding in winter), tire wear, tire tread deposits
Nitrogen, phosphorus	Atmosphere, roadside fertilizer application
Lead	Tire wear (lead oxide filler material), lubricating oil and grease, bearing wear, metal deterioration
Zinc	Tire wear (filler materials), motor oil (stabilizing additive), grease, metal deterioration
Iron	Auto body rust, steel highway structures (guard rails, etc.), moving engine parts, metal deterioration
Copper	Metal plating, bearing and bushing wear, moving engine parts, brake lining wear, fungicides and insecticides, metal deterioration
Cadmium	Tire wear (filler material), insecticides, metal deterioration
Chromium	Metal plating, moving engine parts, break lining wear, metal deterioration
Nickel	Diesel fuel and gasoline exhaust, lubricating oil, metal plating, bushing wear, brake lining wear, asphalt paving, metal deterioration
Manganese	Moving engine parts
Cyanide	Anti-caking compound (ferric ferrocyanide, sodium ferrocyanide, yellow prussiate of soda) used to keep de-icing salt granular
Sodium, calcium, chloride	De-icing salts
Sulfate	Roadway beds, fuel, de-icing salts
Petroleum, oil and grease	Spills, leaks or blow-by of motor lubricants, antifreeze and hydraulic fluids, asphalt surface leachate, fuel and oil spills and leaks
Polycyclic aromatic hydrocarbon (PAH)	Asphalt, fuel and oil spills and leaks

Source: US EPA 1993

Special cases: tunnel wash water



- Tunnels are frequently washed
- Highly polluted and potentially acute toxic → a hot spot!
- Tunnel wash water is always treated in Austria and Switzerland, but not in Norway, Sweden and Italy.
- Treatment include:
  - Sedimentation basins
  - Sedimentation + chemicals/flocculants
  - Sedimentation + mobile treatment units (truck) for filtration and flocculation
  - Conveyed to public wastewater treatment plants

Source: Sondre Meland (Statensvegvesen, NORWAT Teknologidagene 2015)
Photo: Eilen Arctander Vik (Aquateam COWI, NORWAT Teknologidagene 2015)

Special cases: de-icing chemicals / road salt

- Sodium chloride (NaCl) has for decades been used to improve winter road conditions.
  - Poland: ~600 000 t salt/year
  - Norway/Sweden: > 200 000 t salt/year.
  - Ireland: ~ 50 000 t/year.
  - Austria ~ 100 000 t/year.

- Environmental concerns have been raised and chemical and ecological impacts are now documented.

- NaCl is highly mobile and will not be treated (only diluted) in treatment systems. It may, in fact, disturb the treatment processes.

EU Water Framework Directive (WFD)

WFD aims to achieve “good status” for all of Europe’s surface waters.

– Good status” implies “good ecological and chemical status” in terms of low levels of chemical pollutants as well as healthy ecosystems.

– Much effort has been done to meet the objectives in the WFD, but it is still a huge challenge.

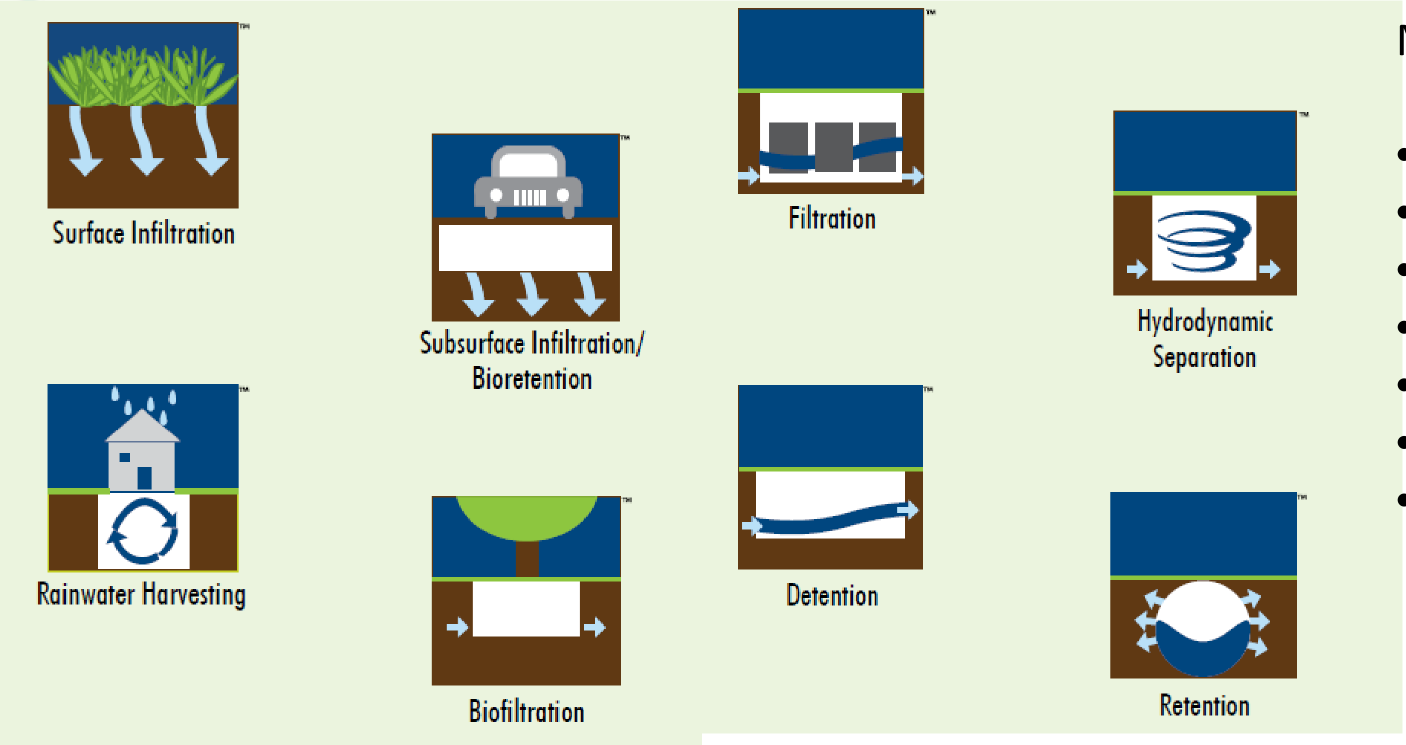
– 47 % of the EU surface waters will not have good ecological status by 2015.

Source: Sondre Meland (Statensvegvesen, NORWAT Teknologidagene 2015)

Mitigating peak runoff volumes as well as reducing pollution loadings and concentrations are now considered important and is often mandatory both from a regulatory perspective and for the National Road Administrations (NRAs) responsible for planning, building and maintenance of the road network

Source: Sondre Meland (Statensvegvesen, NORWAT Teknologidagene 2015)

How to treat stormwater (Quantity, Quality or both)

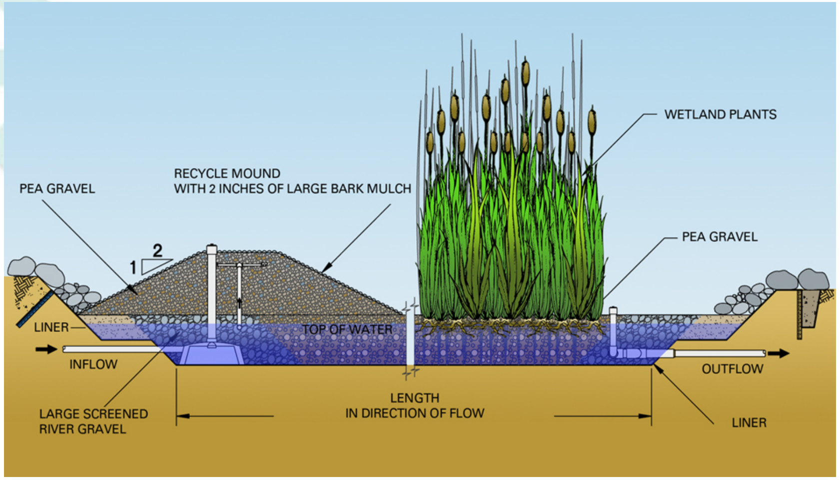


Mechanisms:

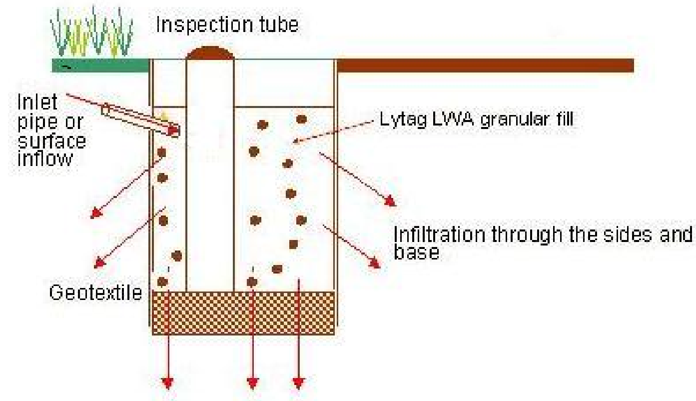
- Settling
- Coalescence
- Adsorption
- Ion exchange
- Biodegradation
- Bioaccumulation
- Retention

Source picture: Contech Engineered Solutions

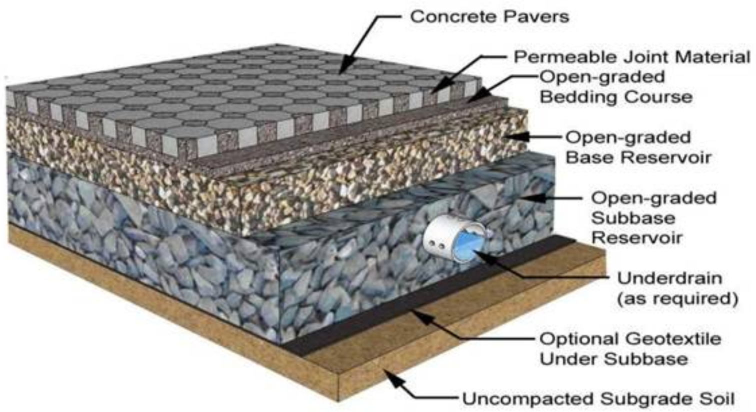
Some SUDS



Subsurface Constructed Wetlands
(source: www.natsys-inc.com)



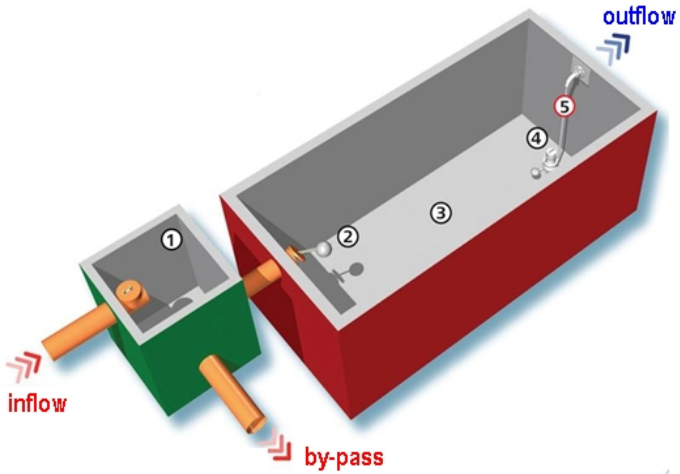
Cross-Section through a traditional soakaway
(source: www.lytag.co.uk)



Permeable paving
Source: Smith, 2009

Filterra Bioretention Systems
Source picture: Contech Engineered Solutions

How to treat polluted runoffs – European practices

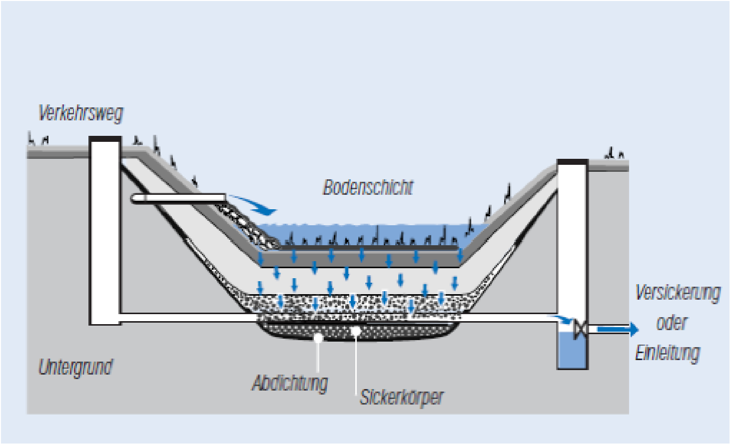


- Scandinavia, Ireland/UK, Poland:
  - Sedimentation / detention ponds.
  - Remove particle associated pollutants, but less effective on dissolved pollutants.

- Italy
  - Small treatment tanks (~40 m3).
  - Retain and treat “first-flush”.

Source: Sondre Meland (Statensvegvesen, NORWAT Teknologidagene 2015)

How to treat polluted runoffs – European practices

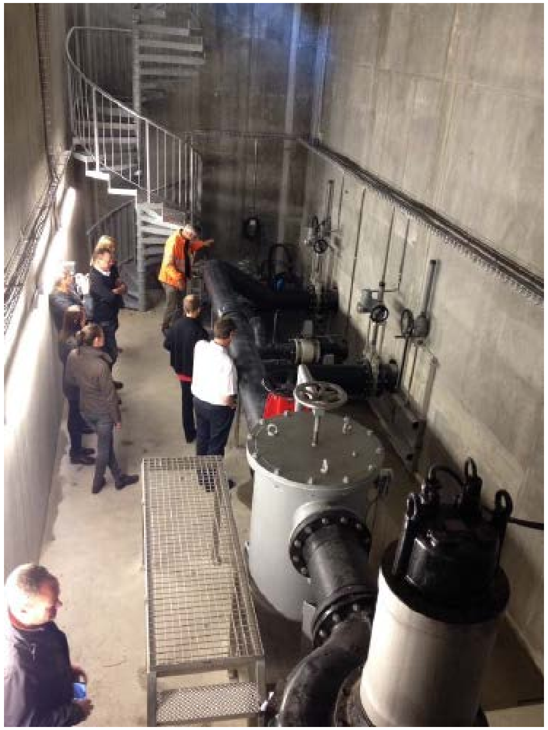


- Austria and Germany:
  - Sedimentation / detention ponds together with infiltration (humus material, ~30 years).
  - Require a lot of space.
  - Clogging may be a problem.
  - Austria is currently moving towards more compact solutions with commercial filter material.

- Switzerland
  - Various infiltration solutions.
  - Sedimentation ponds alone are not approved as adequate by the environmental authorities".

Source: Sondre Meland (Statensvegvesen, NORWAT Teknologidagene 2015)

New advanced treatment plant in Switzerland (opened summer 2015)

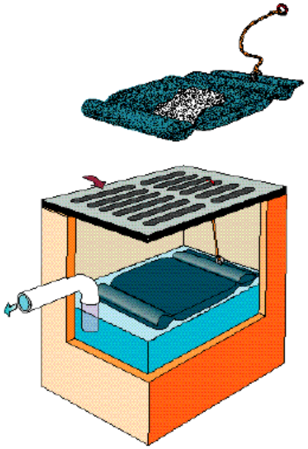


- Flow reduction, pumping, sedimentation, filtration ~6 mill. €
- Huge capacity, and cost effective i.e. cost per treated m2

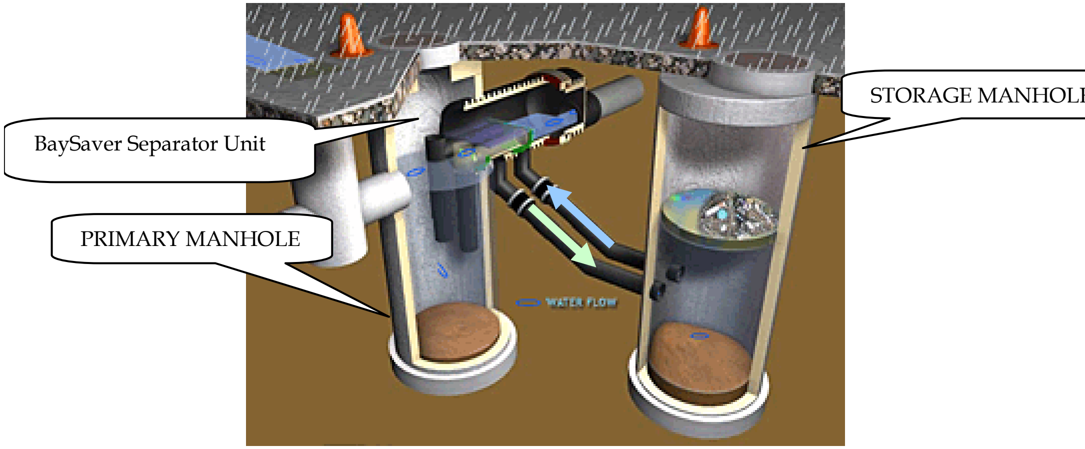
Source: Sondre Meland (Statensvegvesen, NORWAT Teknologidagene 2015)

Novel commercial units

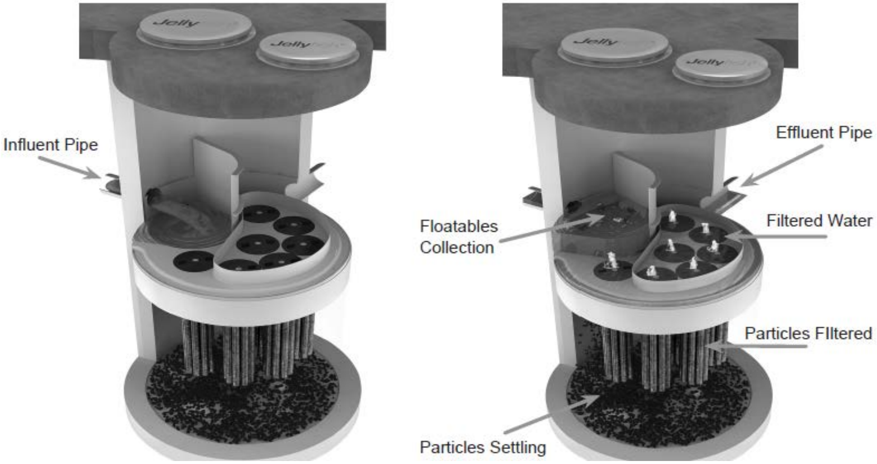
Ecol High efficiency coalescence separator ESK



oil separation by adsorbing pillow

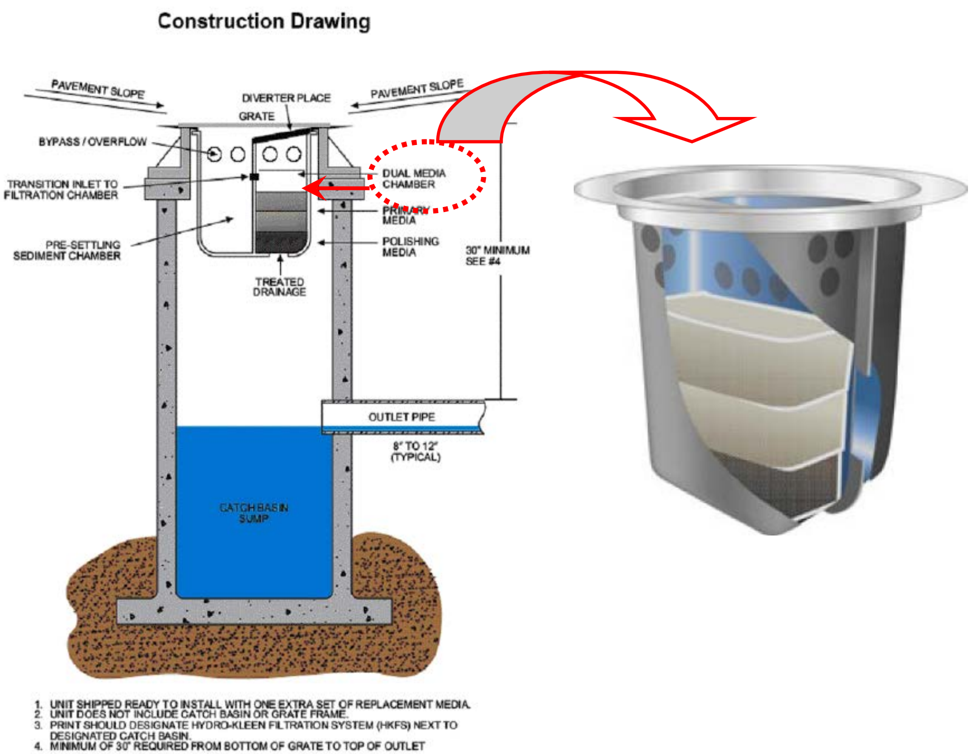


BaySaver® Separator



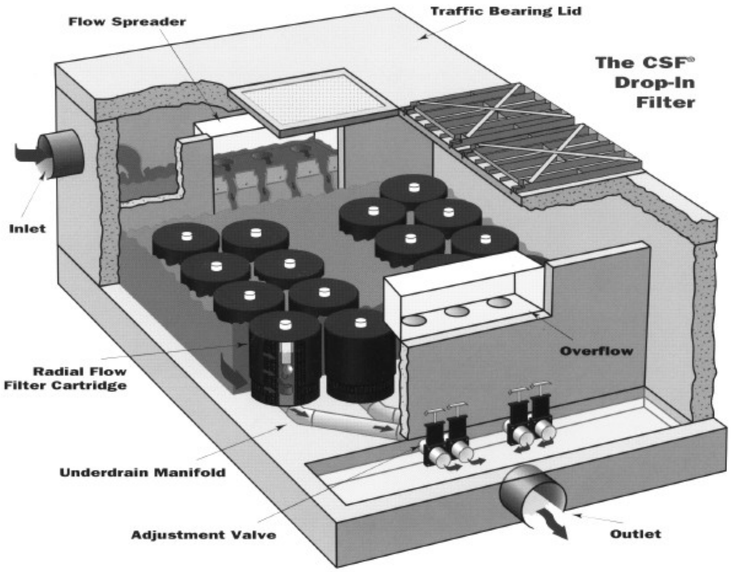
Jellyfish® Stormwater Treatment
Contech Engineered Solutions

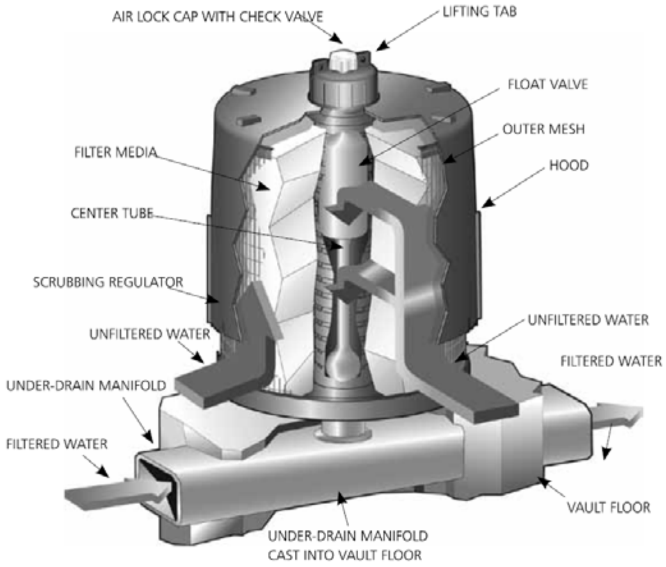
Media filtration



- Easy to be applied in prefabricated plastic boxes, also including pre-sedimentation
- Such systems do not require the application of sedimentation pre-treatment, which means reduced volumes and costs.
- Reported removal efficiencies are as high as 90% of TSS, 98% of Cu, 89% of Pb, and 99% of Zn and hydrocarbons.
- To avoid heavy maintenance, backwash systems have been introduced.
- These systems are made by one or more modules in cylindrical cartridges; each cartridge is made up by a cylinder of metal surface that contains the filter media, and by a layer of filter material (sand, perlite, GAC, compost or other adsorbing materials).

StormFilter® Stormwater Treatment





Filtering systems

- The three key properties of the bed are its surface area, depth, and profile, with the required surface area for a filter usually calculated based on the amount of impervious area treated and the media itself.

- Many key pollutant removal mechanisms associated with filters are related to the filter media. For example, filtration, adsorption, and microbial action are all influenced by the media type.

- New concept filtration systems consider the application of:
  - Different filler of loose material put in layers;
  - One or more layers of zeolite or GAC (granular activated carbon), or fibres from thermoplastic synthetic;
  - Tools in which the filter layer is placed into cartridges that allow backwash of filters.

Case study Avinor

Runway de-icing: PotassiumFormiate;

Aircraft de-icing: Propylen glycol

Requirement from the pollution authority:
- Not affect the ground water balance
- Not affect the ground water quality
- Not affect the natural erosion proceses in the ravine system
- Not affect the surrounding water resources

Environmental report 2013 Oslo Lufthavn:
"The greatest environmental challenges in the area of soil and water relate to traffic increase which, with an unchanged winter climate, will result in higher consumption of de-icing chemicals. This means that larger amounts of the chemicals must be degraded in the soil above the aquifer"

About 80% of aircraft de-icing fluid are collected, 10% remain on the plane and 10% are spread around

Biodegradation potential although significant is strongly dependent on retention time (Bente Wejden, & Jarl Øvstedal, 2006)

In addition, heavy metals, PAH and other contaminants common to roads

WP2.4 Innovative technical solutions for stormwater management - Detailed plan

Objectives: The main objective is to perform research to provide a basis for the development of innovative, efficient, and sustainable solutions to locally treat and control stormwater flows from roads and runways at airports.

The activities will consist in studying the efficiency of single or multiple media filters compared to soil (used here as a reference) in column tests. The clogging and performance of the filtration treatment system in removing de-icing chemicals, TSS, dissolved and particulate heavy metals, and PAHs from stormwater, will be evaluated.

Based on the findings, innovative stormwater systems using media filters, geotextiles and geo-membranes (from Isola) as well as strategies to recover clean and reuse the media filters (from Saint Gobain –Weber), will be discussed. Spin-off projects are expected to follow and to further develop and test these concepts.

Potential collaboration with a project that Christian Recker is running/devloping with German partners including the roads state department – Full scale test using the most successful media integrated in a geotextile/geomembrane system??

Work descriptions

Task 1. State of the art review

Task 2. Media filter test in laboratory column system

- Synthetic stormwater
- Room temperature and Thermostat-controlled climate room (4°C)
- Effect of temperature, salts and de-icing chemicals concentration
- Various media and combinations will be tested
- Assessment of clogging phenomena in granular filter media used for stormwater treatment
- Assessment of treatment performance

Picture: Tone M. Muthanna et al. (NORWAT Teknologidagene 2015)

Task 3. Design of innovative stormwater management systems

Deliverables

A report presenting the results from the experiments, a discussion and recommendation for treatment will be prepared.

Furthermore the following deliverable will also be included:

- A conference paper presenting the review of existing technologies emerging technologies.
- Peer-reviewed paper on the performance of the filter media for stormwater management.
- A Master thesis.
- An intermediate Workshop (in June 2016) with the Klima2050 partners.

Organisation

The task will be staffed and organized as shown below:

- Task leader: Kamal Azrague, Dr. Senior Research Scientist
- Participant: Gema Raspati, Dr. Research Scientist
- Participant: Tone Merete Muthanna, Dr. Associate Professor
- Participant: Julie Elisabeth Andersen, Master student
- Project Participant: Gøril Thorvaldsen, Research Engineer
- QA/QC: Edvard Sivertsen, Dr. Senior Research Scientist

Schedule

TASKS	2015				2016			
	1	2	3	4	1	2	3	4
Task 1: State of the art review			■	■				
Task 2: Media filter test in laboratory column system			■	■	■	■		
Task 3: Design of innovative stormwater management systems						■	■	■
Reporting			■	■	■	■	■	■
Dissemination				■	■	■	■	■

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