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Stofnfundur VAFRI

Kennslustofu nr. 158 VRII Háskóla Íslends

17. apríl 2009

Guest lecture on

Measures to control stormwater

by

Sveinn T. Thorolfsson

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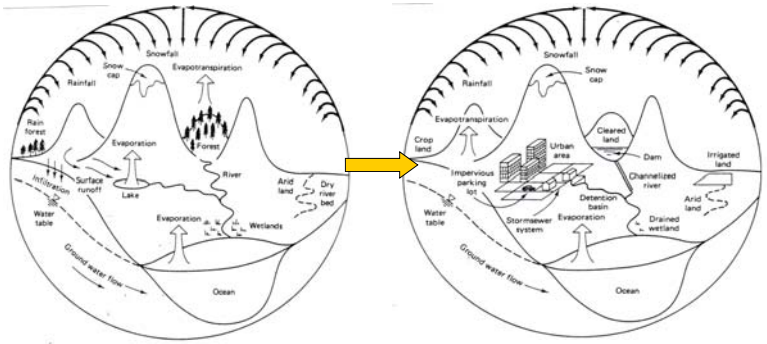
Urbanization

Urbanization leads to removal of the vegetation, more impervious surfaces, smoother surfaces, outlinded water ways etc. i.e. **quicker runoff**



Hydrologic cycle of the natural environment

Hydrologic cycle of the urban environment

McCUEN R.H. (1998)

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Global challenge

Refereeing to UN – UNESCO the people are facing:

1. Growth in population
2. Growth in urbanization
3. Growth in lack of water supply and wastewater services , mostly in developing countries
4. Climate changes

The population in the World passed in 6.5 billion in February 2006

People need:

- Clean water (Water Supply)
- Proper sanitary conditions (wastewater disposal)
- Protection against flooding (good stormwater management)

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Urbanization (U) and Urban Hydrology (UH)

Urbanization is one of the most important trends of the twenty-first century.

When a rural area is a subject to urbanization, changes in the flow regime will occur

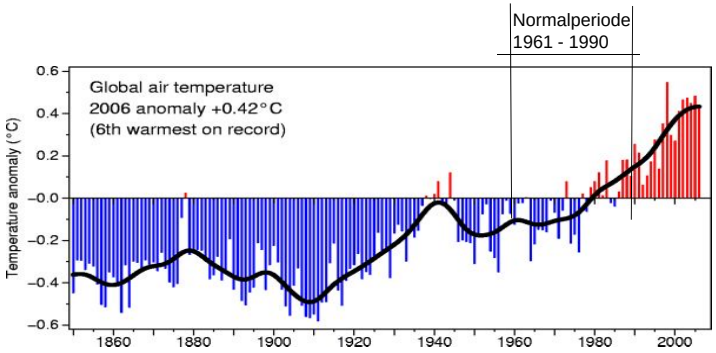
The urbanization seems to create two major hydrologic challenges to urban drainage:

Flood control i.e. the prevention of flooding within and downstream urban areas

Pollution control i.e. disposal of waterborne wastes from urban areas without impairing the quality of local watercourses.

Climate Change
Global warming

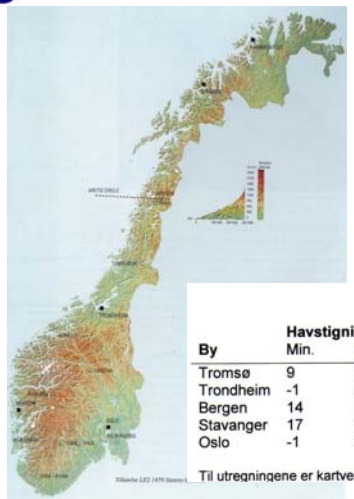
The trend since 1850 to day



Effects of increased air temperature

1. There will be wetter and wilder weather (at our latitude
   That gives higher depth of precipitation and higher intensities
2. Icecaps will melt
   The icecap on Greenland, in Antarctic, Himalaya, and glaciers in Iceland and Norway will disappear
3. The sea level will rise
   because of increased runoff from melt water and volume increase by higher temperature

Sea level rise in Norwegian Cities

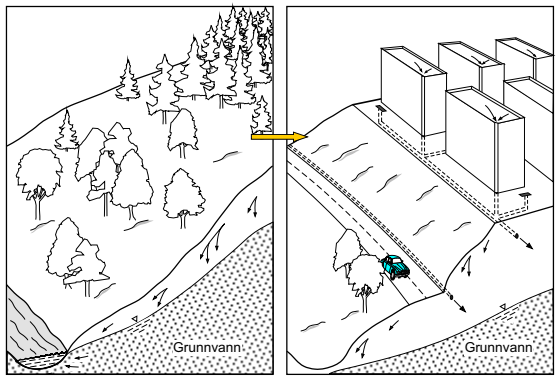


Up to date April 2008

	År 2050				År 2100			
	Havstigning (cm)		Stormflo (cm)		Havstigning (cm)		Stormflo (cm)	
By	Min.	Maks.	Min.	Maks.	Min.	Maks.	Min.	Maks.
Tromsø	9	31	214	236	43	98	253	308
Trondheim	-1	21	252	274	22	77	292	335
Bergen	14	36	171	193	53	108	215	270
Stavanger	17	39	138	160	57	112	183	238
Oslo	-1	21	184	206	21	76	211	266

Til utregningene er kartverkets digitale N50 kartserie brukt (fra Institutt for geovitenskap, UiB).

The effects of urbanization on urban runoff



Paving and construction of stormwater pipes and a quick conveyance of stormwater may lead to dramatic changes in the water circle

1. Removing vegetation and lining surfaces
2. Impervious areas (roads, streets, parking places etc.) are constructed
3. Quicker stormwater runoff and higher peaks
4. Groundwater table may be lowered and the vegetation will be degraded

Thorolfsson (1988)

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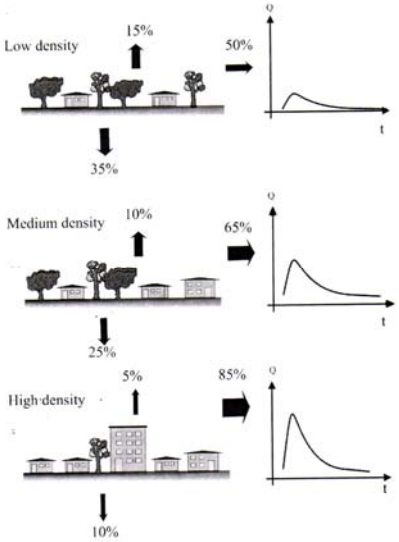
Effects of urbanization on runoff



Hydrograph I

Low peak – low volume

Hydrograph II

Higher peak – bigger volume

Hydrograph III

High peak – huge volume

Butler et.al (2004)

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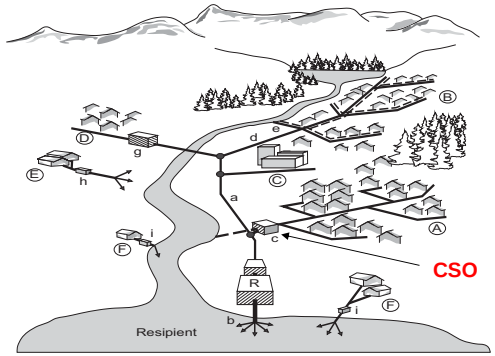
Conventional Urban Drainage Network from the 60s, 70s and 80s (90s). What now?



A) A combined sewer system area CSS)
B) A separate sewer system area (SSS)
C) An industrial area
D, E), F) Rural areas
c) CSO
R) A treatment plant

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The objective of the urban drainage system

The objective of urban drainage system (UDS) is to collect wastewater, stormwater, illegal water etc., where it is generated, dispose it locally or transport it away, treat it if required and finally discharge it into an appropriate and an approved recipient, without loss of pollutants.

And at acceptable costs

The total discharges from treatment plants and CSO including emergency CSO, leakages etc. is to be quantified, and the total amount of pollutants discharged from UDS to the nature is to know:

"Total discharges"

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The objective of the sewer system

The objective of the sewer system is to collect the all unwanted water (foul water and stormwater) where it is generated, dispose it locally or transport it away, treat it if it required and to discharge it to an approved recipient, with out loss of pollutants and at acceptable costs

It means optimizing of the system regarding hydraulic, pollution discharges and economy.

This require use of EDB based runoff models such as ***MOUSE, SWMM, NIVANETT*** etc.

Plus time data sets for long periods from urban hydrological measuring stations , GIS (or a map) and data communication.

From wastewater to stormwater oriented drainage plans

During the last 40 – 50 years we have been working on cleaning up regarding municipal sewage discharges

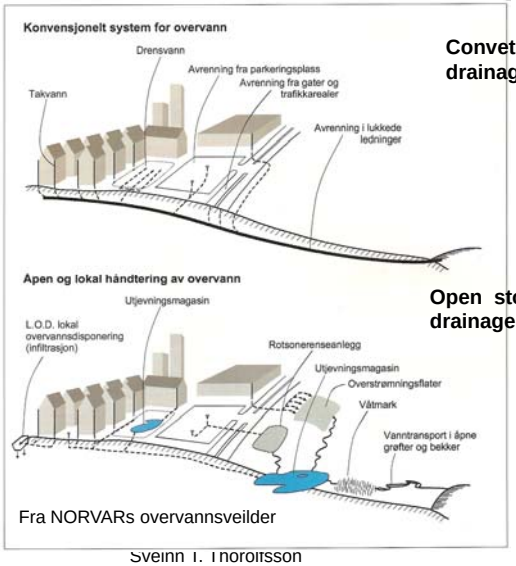
It has been especially the point discharges for foul water, that has been in focus because of hygienic considerations (bacteria viruses etc.).

Very costly facilities to collect, transport and treat foul water have been built

New it is turn for the stormwater

Stormwater is coming from precipitation i.e. rainfall snowmelt etc is much more difficult to handle because of it is stochastic processes and discharges are both point discharges and diffuse discharges

From piped to open stormwater management

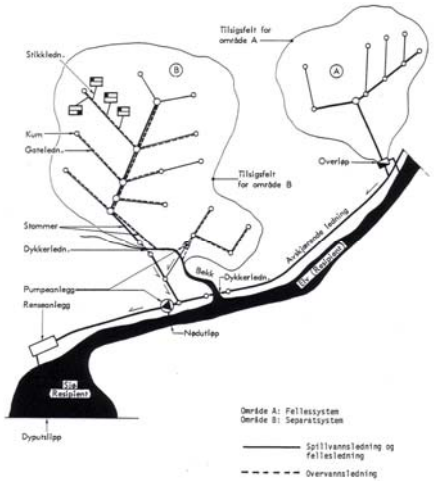


Convetional piped drainage system

Open stormwater drainage (OSD)

Fra NORVARs overvannsveilder

Conventional urban drainage plan with pipes
Wastewater oriented



The technical measurements to handle urban runoff and to deliver it to the nature in an acceptable way

- Collection system .
- System for transport to treatment plant
- Treatment plant
- Outlet

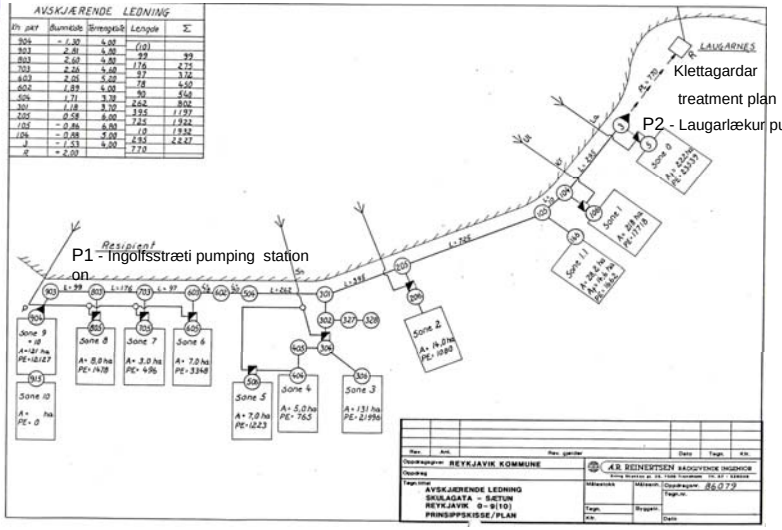
The transportation system

- Sewer pipes lines (free surface flow, but surcharge may occur)

  and pressured flow (siphons, pumping lines, discharge outlets etc)
- Sewer tunnels
- *CSO (Combined sewer overflows)*
- Detention facilities
- Pumping stations and pumping pipe lines
- Discharge arrangements (Outlets)

Planned interceptors in Reykjavik, Iceland (1984)

Modeling in NIVANETT (MOUSE)

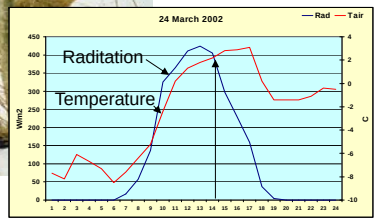


Exsamples on CSO

Raditation driven CSO

It is no rainfall

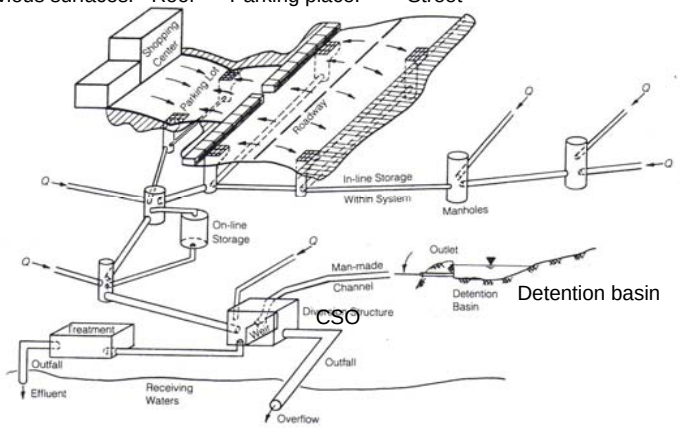
The CSO is caused by melting driven by positive temperature and radiation



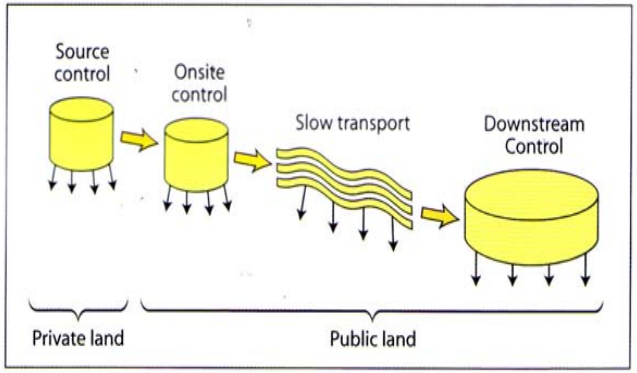
CSO discharge into Nidelva River from Fredlybekken basin (550ha) in Trondheim Sunday, March 24th 2002, PM 15:00

The urban stormwater system

Impervious surfaces: Roof Parking place. Street



Categorization of facilities for open storm drainage (OSD) (Stahre 2006)



Stahre (2006)

Examples on technical solutions within the four categories

Category	Examples of technical configuration
Source control (private land)	Roofs with vegetation cover (moss/sedum) Infiltration on lawns Permeable paving Infiltration in stone fillings (percolation) Local ponds Collection and recycling of roof runoff for irrigation, toilet flushing, etc.
Onsite control (public land)	Permeable paving Filter strips Temporary flooding onto especially prepared surfaces Ponds
Slow transport (public land)	Swales i.e. vegetated surfaces Greeks/ditches Channels
Downstream control (public land)	Large ponds Wetlands Lakes

Pollution in Stormwater

An example form a parking place near a shopping center in Seattle, USA

In addition to common water polluting matters, SS, COD etc, stormwater may content micro pollutants such as heavy metals; Pb, Cu, Cr, Hg, etc. and organic micro pollutants such as PAH, PCB etc.

That may be harmful to aquatic resources humans and other living beings

Photo; Thorolfsson 1997

Pollution in snow

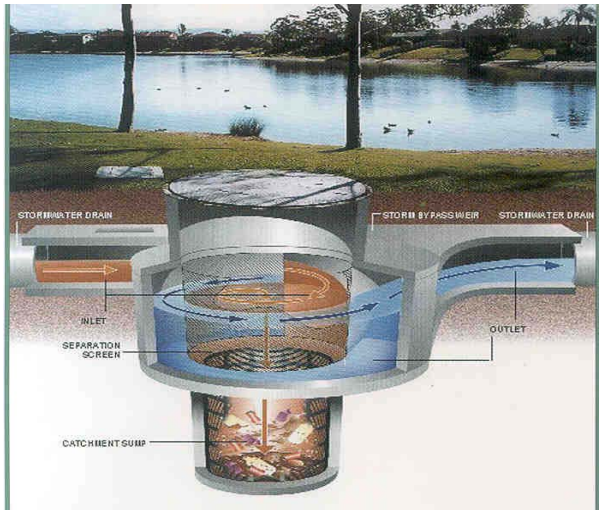
becomes stormwater pollution while melting

At Risvollan, Trondheim in April 1993

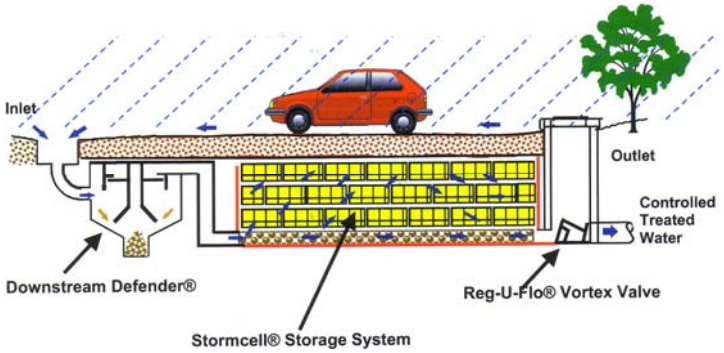
Snow dump at Byåsen in Trondheim

The snow may contain polluting matters as found in stormwater, also heavy metals as Pb, Cu, Cr, Zn, Hg, etc. and organic micro pollutants as PAH, PCB,.etc. Salt (NaCL) may be found in it too

Stormseptor



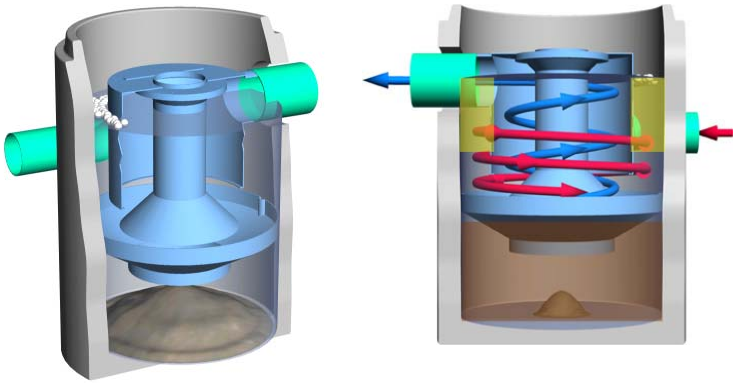
Hydro's integrated stormwater management system



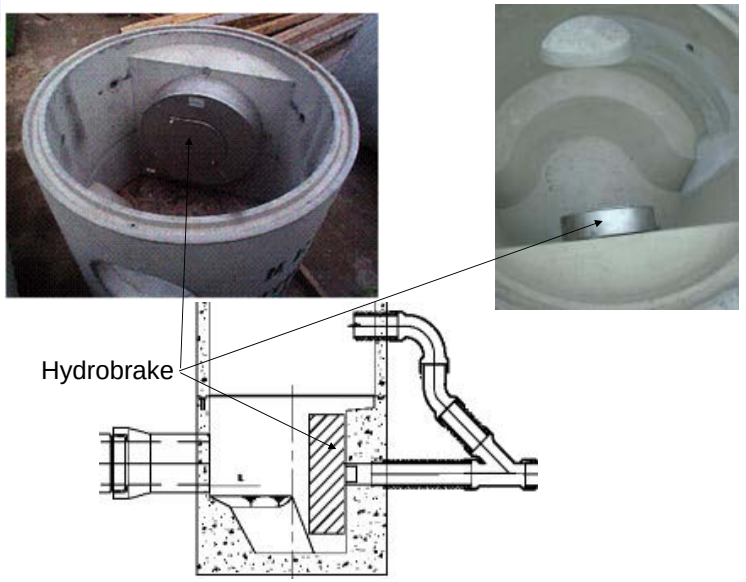
Deahl (2002)

Downstream defender

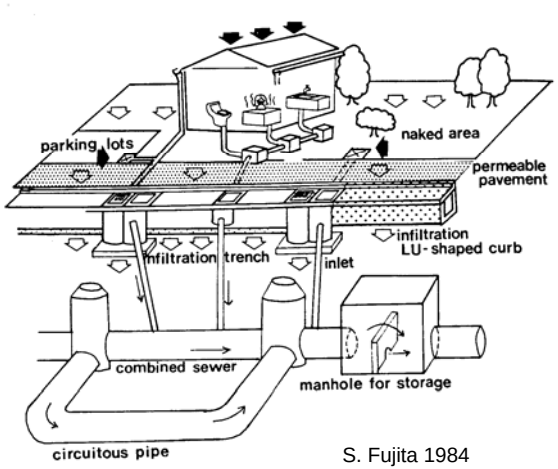
www.hydro-international-biz/us



Hydrobrake (Vortex valve)

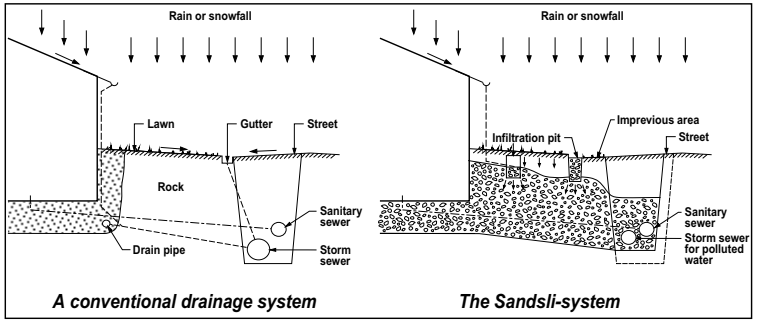


ESS - system in Tokyo
Infiltration system



S. Fujita 1984

Sandsli – system in Bergen, Norway



(Thorolfsson 1982)

Sandsli-system is reducing stormwater runoff by storing and infiltrating stormwater in the water and wastewater trenches

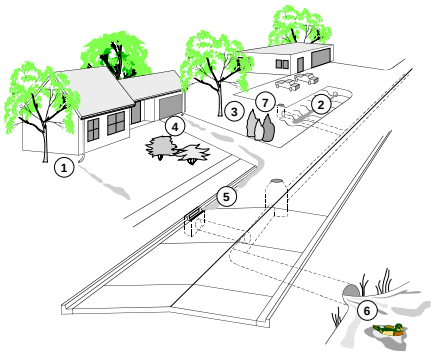
The LID - concept

LID-concept is developed in USA, originally to be used in temperate climate

LID-concept is an approach to stormwater management, where we by use of hydrology orientated area planning and sets of integrated management methods try to minimize the effect of man made efforts on the original hydrological situation.

LID-concept tries to mimic the conditions before urbanization by compensate for disappearance of natural water ways for the rain water, by maintain infiltration, evapotranspiration and depression storage, and in addition to increase the runoff time for stormwater and avoid storage of surplus water, PGDER (1999)

Open stormwater systems and vegetation



Raingarden

This Burnsville rain garden features a specially designed curb-cut that diverts and soaks up water from the street. (Photo courtesy Barr Engineering Co.)

LID – concept
Some examples from USA

Regnbed

Bjølsen student campus in Oslo
Open stormwater solution

Malmø Center, Sweden
Green roofs – open stormwater solutions

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Hybrid Stormwater Treatment Systems

www.modularwetlands.com/?video=1

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Stormwater Management along I5, Seattle, USA to Vancouver, Canada

Pollutant reduction

Detention

Photo Thorolfsson 1997

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Measures against pollutants

Høyballer rundt inntaket

Cloths in the gully pot catch the pollutants

Photo Thorolfsson 1997

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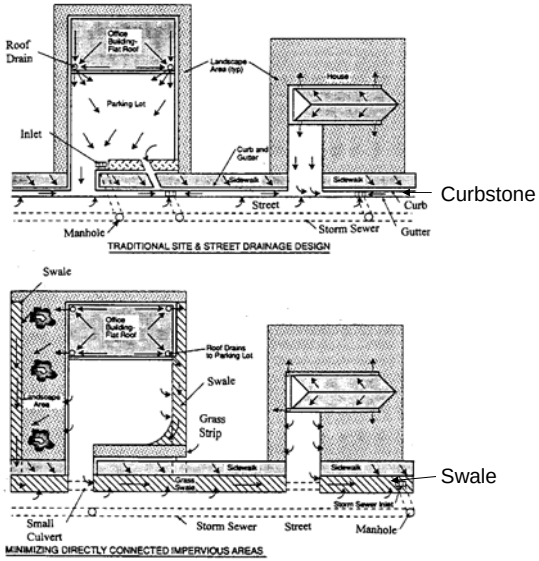
Measures against erosion

Halmballs on construction site

Plastic sheet on earth

Photo Thorolfsson 1997

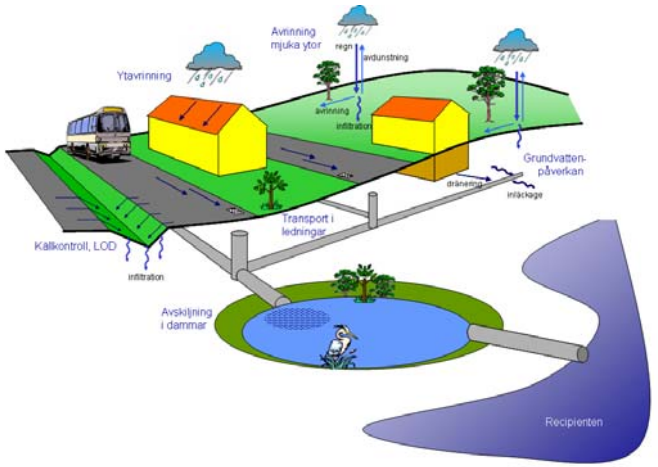
From curbstones to swales



Curbstone

Swale

Multiple stormwater system



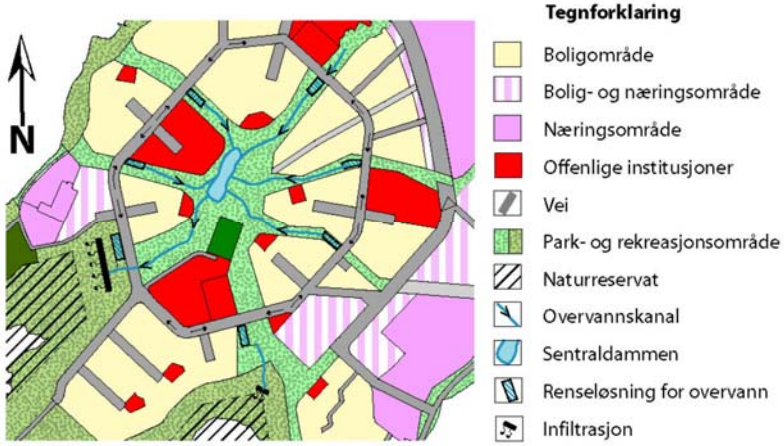
Airphoto on former Fornebu airport

Photo Fjellanger - Widerø 2001

New plans for Fornebu

Cowi 2004

The central park at Fornebu
Open stormwater solutions



Cowi 2004

Fornebu
Åpne overvannsløsninger

Cowi 2004

In the central park at Fornebu, autumn 2008

Sustainable Stormwater Management at Urridavatn in Gradabær in Iceland

The challenge:

The area around the shallow lake is to be urbanized

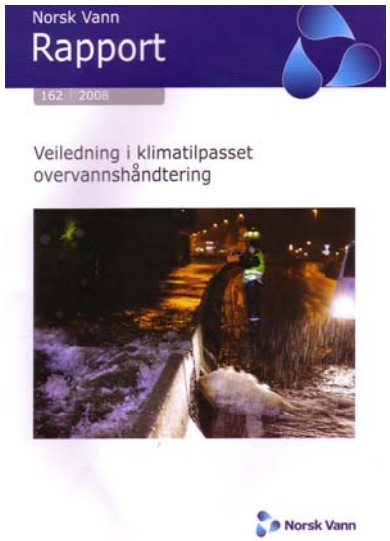
The task:

No pollution is to be discharges into Urridavatn

The developers focus on sustainable development

Utbyggingsplanen

Guidlines for climate adjusted stormwater management



The guideline focus on:

Climate changes, local stormwater disposal (LOD) and use of open stormwater solutions such as; constructed channels, ditches, dams and lakes, creeks and rivers in cities

Floodways for stormwater on urban surfaces to handle 100 yr storm

Dimensioning these facilities

See: www.norskvann.no

Measures affecting stormwater runoff

Pollutants in stormwater are often connected to particles
Following treatment methods are actual:

- Stormwater ponds
- Infiltration basins
- Infiltration on green surfaces
- Vegetated surfaces (swales)
- Percolation basins (f. examples underground stone basins),
- Percolation trenches
- Artificial wetlands
- Natural wetlands
- Detention basins
- Oil separation faculties

Thank you for your attention

Sveinn