

From Sponge Forest to Sponge City

Why protecting a city from flooding means retaining, slowing, and cleaning water from the headwaters to the street.

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Floods often begin far from the city.

Some of the water may have fallen hours - or even days - earlier on forests, fields, wetlands, and roads upstream.

The watershed ignores municipal boundaries.

The rain may stop. The flood wave keeps moving.

Timing depends on slope, soils, wetlands, lakes, initial saturation, and how roads, ditches, and culverts speed water downstream.

A road network can also become a hydrological network.

57 %

of the studied road network
acted as a flow path

+46 %

peak-flow increase for
an older network near streams

<2 %

for a newer network
relocated away from streams

Same territory. Two layouts. Two very different effects on water speed and concentration.

These findings come from specific studied watersheds; they are not a universal rule.

Sources: Wemple et al. · Surfleet et al. / Caspar Creek

The “water surge” builds through accumulation.

01

Rain falls upstream

02

Roads and ditches speed transfer

03

Springs and small streams fill up

04

Tributaries join together

05

The flood wave moves downstream

06

Local rainfall may arrive at the same time

07

The city receives the sum of the system

A solution may work for the road itself and still shift risk toward the lowest part of the watershed.

A city cannot become a sponge if the upstream remains a funnel.

Forests · soils · peatlands · wetlands · lakes · floodplains · roads disconnected from streams

These landscapes temporarily store water, reduce some peak flows, and support streamflow during dry periods.

A city can receive two peaks at the same time.

FLOOD WAVE FROM UPSTREAM

Water that fell earlier
on the watershed

LOCAL RAINFALL ON THE CITY

Roofs · streets · parking lots
stormwater network

CITY AT PEAK LOAD

River already high + urban network saturated = higher risk

Exact timing varies by watershed - but overlapping peaks are a real risk to model.

Sponge forest or funnel city?

SPONGE FOREST

- Canopy intercepts
- Litter slows runoff
- Roots create pathways
- Living soil stores water
- Wetlands regulate flow

FUNNEL CITY

- Roofs concentrate water
- Asphalt seals the ground
- Curbs channel runoff
- Catch basins accelerate transfer
- Pipes shift risk downstream

The problem is not the city itself. It is a system that turns rainfall into discharge too quickly.

Every scale must manage its share of rainfall.

1

WATERSHED

Slow water before it
reaches the city

Forests · wetlands · roads

2

MUNICIPALITY

Plan for peak flows

Networks · parks ·
floodplains

3

NEIGHBOURHOOD

Do not transfer everything
downstream

Roofs · lots · parking areas

4

STREET

Retain, filter, infiltrate

Trees · media · safe
overflows

Evacuate only the excess - after retaining, slowing, reusing, or filtering what can be managed locally.

The street can become climate infrastructure.

Slow

Store

Filter

Infiltrate

**Evacuate the
excess**

A regenerative street does not blindly keep all water. It first gives time back to the territory.

Road water also carries road pollution.

Tire particles and microplastics

6PPD and 6PPD-quinone

Brake dust and metals

Hydrocarbons · oils · de-icing salts

The goal is not to move pollution from the river into the groundwater table.

Source treatment is possible.

>90 %

reduction in 6PPD-Q load
in most typical rainfall events

Mature bioretention cell

>96 %

retention of tire-particle
mass

Permeable pavement

68 %

average reduction in
6PPD-Q mass

Permeable pavement

These results come from specific experimental settings. Real performance depends on volume, media, maintenance, and overflow during extreme storms.

Sources: Environmental Science & Technology Letters · Science of the Total Environment

When water becomes scarce, the losses spread through the whole economy.

~1 %

of European Union GDP
in 2026

~€180B

estimated economic
loss

-1.4 pts

potential growth hit
for France

Agriculture · energy · transport · productivity · health · ecosystem services

These figures describe the cost of heat and drought - not a cost attributable to roads.

Source: Triodos Bank, Hot Summer Economics, 8 August 2026

A smart road should not only count cars.

TRAFFIC

Speed
Load
Vibration
Safety

WATER · HEAT · POLLUTION

Rainfall
Soil moisture
Water quality
Filter saturation

The sponge city begins in the forest, continues through every neighbourhood, and becomes measurable in every street.

For further reading

Full references and clickable links are included in the long article.

1. Roads and watersheds

roadsforwater.org

3. Urban flooding

epa.gov

5. Bioretention & 6PPD-Q

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commission.europa.eu

2. Caspar Creek

sciencedirect.com

4. Green streets

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6. Permeable pavements

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8. Hot Summer Economics

triodos.com

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