Urban Hydrology class 1: introduction

Luca Rossi

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Moodle website: urban hydrology

Verband Schweizer Abwasser- und Gewässerschutzfachleute

Association suisse des professionnels de la protection des eaux

Associazione svizzera dei professionisti della protezione delle acque

Swiss Water Association

VSA

Nous nous engageons au quotidien pour des eaux propres et vivantes

www.vsa.ch

VSA Young Professionals

VSA: domaines de compétence

Canalisation	Assainisse-ment urbain	Milieux récepteurs	Industrie et artisanat	Epuration des eaux

Plateformes

Qualité de l'eau

Techniques de traitement des micropolluants

1500 Membres
Actif depuis 80 ans dans toute la Suisse

DE FR IT

V S A Association suisse des professionnels de la protection des eaux

LOGIN GLOSSAIRE FAQ OFFRES D'EMPLOI MEDIA

FORMATIONS ET CONGRÈS PUBLICATIONS & PRODUITS DOMAINES / CC À PROPOS DU VSA

ACTUALITÉS DU VSA

13.01.2025

20.12.2024

NEWSLETTER

Restez informé! Entrez votre adresse e-mail dans la liste de SSIGE et VSA.

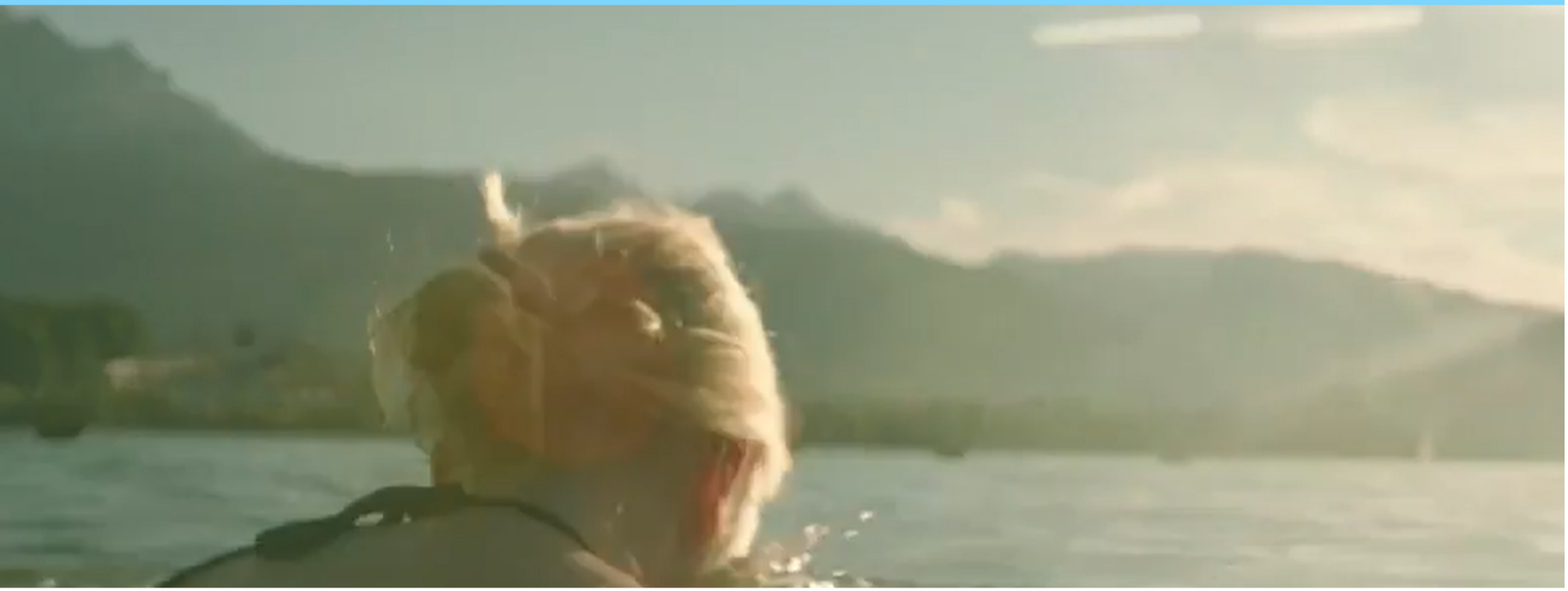
NOM

ADRESSE E-MAIL

SE CONNECTER

E-PAPER

se, LR 20.02.2025



DÉCOUVREZ LES MÉTIERS DE L'EAU

Qui fait en sorte que les cours d'eau soient propres, qui épure les eaux usées, qui assure le drainage et l'utilisation des eaux pluviales, qui aménage des zones urbaines adaptées au climat, qui veille à ce que l'eau potable soit propre ? Il y a dans le secteur de la gestion des eaux de nombreux métiers captivants et variés qui travaillent à des solutions pour notre avenir. Des spécialistes hautement qualifiés œuvrent au bien-être de notre population. Deviens toi aussi une professionnelle ou un professionnel de l'eau et informe-toi dès à présent.

CONTENUS

vsa.ch/YP

YOUNG PROFESSIONAL

Das junge Netzwerk
Le réseau jeune | La rete dei giovani

V S A

YOUNG PROFESSIONAL
Das junge Netzwerk
Le réseau jeune | La rete dei giovani

Goals of the course

- To know administrative / legal requirements in the field of urban hydrology
- To be able to identify an actual or future problem linked with urban hydrology
- To be able to understand, manage and plan urban water systems
- To be able to work with different mathematical tools
- To be able to select and to size technical solutions
- To be able to link different disciplines in order to promote sustainable development of cities regarding urban hydrology

Organisation of the class (provisional)

Date	Cours n°	Description	Exercices
20.02.2025	1	Introduction	Exercice 1
27.02.2025	2	Legislative aspects	Exercice 2
06.03.2025	3	Planning tools : PGEE	-
13.03.2025	4	Planning tools : PREE	Exercice 3
20.03.2025	5	Field trip (Lausanne wastewater system)	-
27.03.2025	6	Modeling tools	Exercice 4
03.04.2025	7	Deterministic modeling (Routing system 3)	Exercice 5
10.04.2025	8	Stochastic modeling (REBEKA)	Exercice 6
17.04.2025	9	Financial aspects	Exercice 7
24.04.2025		***Easter***	
01.05.2025	10	Technical solutions	-
08.05.2025	11	AG VSA Fribourg	-
15.05.2025	12	Field investigation (immission)	Exercice 8
22.05.2025	**13**	**Knowledge control (mandatory)**	
29.05.2025		***Ascension Day***	

Evaluation of the class

Evaluation :

- **continuous evaluation**: exercises during the semester
  → **60% of the final grade (8 exercices)**

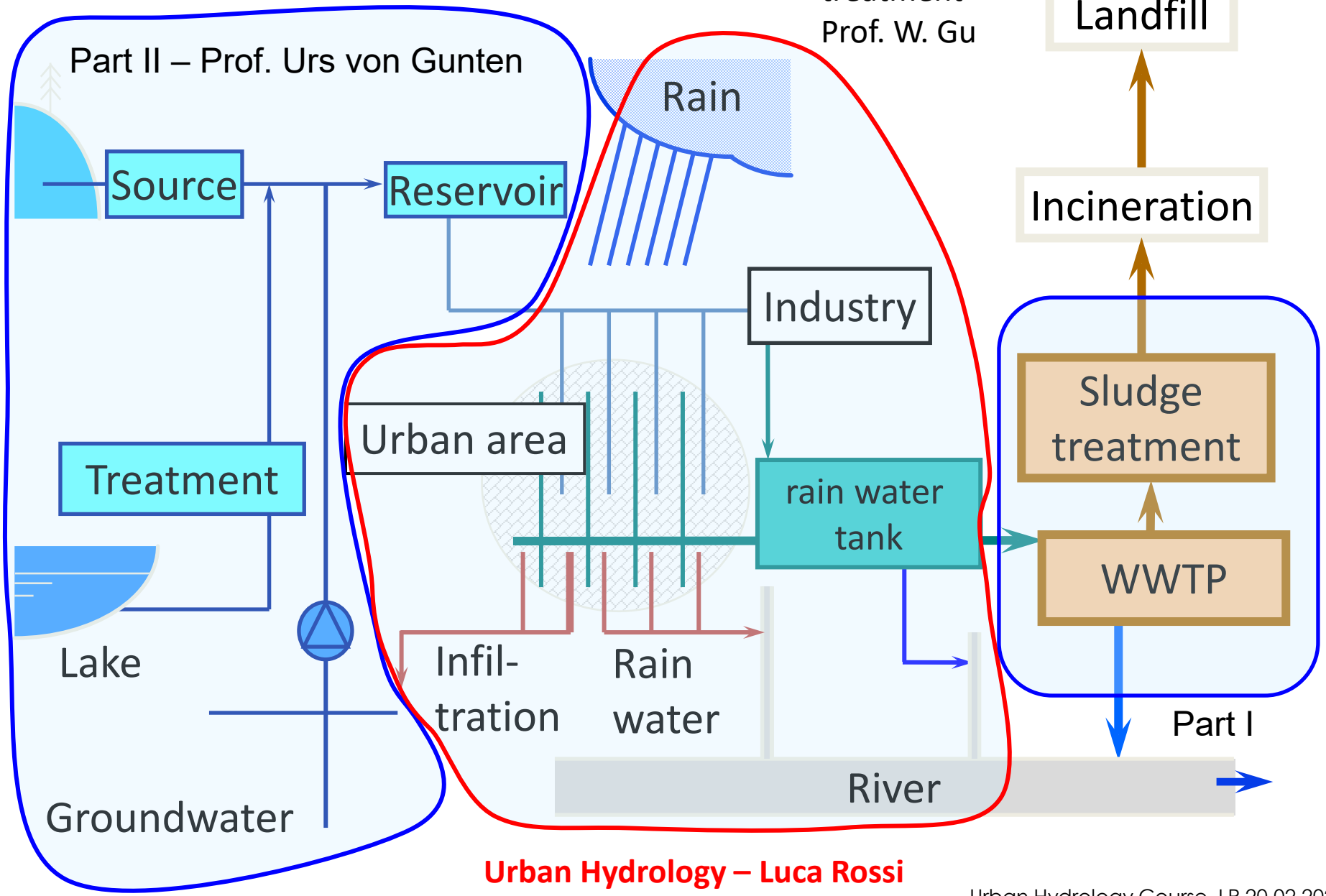
- Evaluation during one session (22/05/2025)
  → **40% of the final grade**

… your evaluation of the class is also conducted !

Companion lectures

Water and wastewater treatment – Prof. W. Gu

Part II – Prof. Urs von Gunten



Urban Hydrology – Luca Rossi

Companion lectures

LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

FICHE DE COURS

Climate and water sensitive urban design

ENV-526

Fiche de cours

Enseignant(s) :
Manoli Gabriele

Langue:
English

Summary
This project-based course introduces students to the field of urban climate and hydrology, with a focus on nature-based solutions for the design of climate and water resilient cities.

FICHE DE COURS

Hydraulique fluviale et aménagement de cours d'eau

CIVIL-410

Fiche de cours

Enseignant(s) :
Amini Azin
Arborino Antoine Maurice
De Cesare Giovanni

Langue:
Français

FICHE DE COURS

Urban Green&Blue infrastructure and global warming

ENV-462

Fiche de cours

Enseignant(s) :
Kazemi Yves

Langue:
English

Summary
The course introduces the concept of green and blue infrastructure in the context of global warming. It presents practical methods for planning, developing, and maintaining an efficient network of green and blue infrastructure in urban areas.

Urban hydraulic systems

CIVIL-413

Fiche de cours

Enseignant(s) :
Pfister Michael

Langue:
English

Summary
Sustainable freshwater and urban drainage system are considered. Fresh water: capture, reservoir and net. Drainage: hydrology, sponge city, individual conduit and manhole hydraulics. The integral rain water management and the legal frame are further key elements

Introduction part

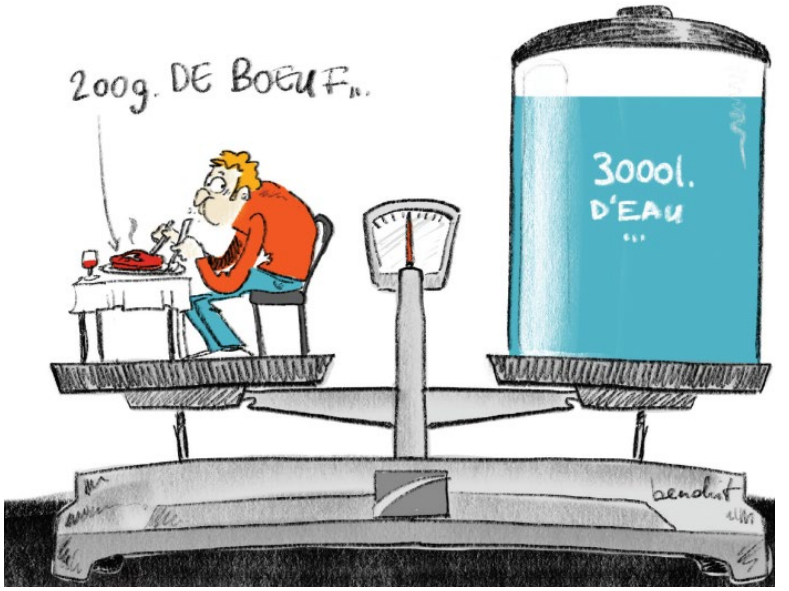
- Contemporary problems linked with urban hydrology
- Urban hydrology through history
- Immission approach: a new perspective in urban hydrology
- Movie: « Les lacs en dangers (1964)» and exercice n°1

https://www.rts.ch/play/tv/continents-sans-visa/video/les-lacs-en-danger?urn=urn:rts:video:13235317

Introduction to urban hydrology

1) How much water do you use every day [l/d]?
2) Where does your drinking water come from?
3) What is the price of drinking water [CHF/m^3]?
4) What is your annual water budget [CHF/inhab/year]?
5) What is the average rainfall per year [mm]?
6) How will this rainfall evolve with climate change?

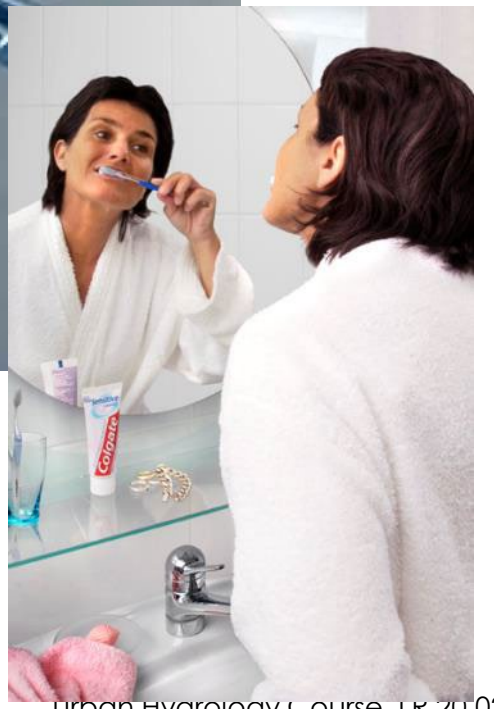
Water footprint

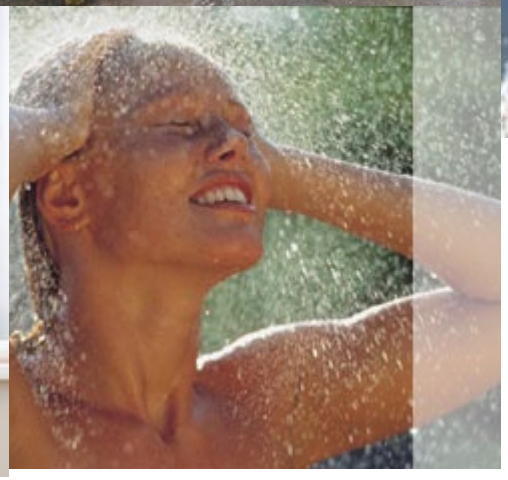


https://www.rts.ch/info/suisse/3852067-les-suisses-consomment-4200-litres-deau-par-jour.html

Drinking water

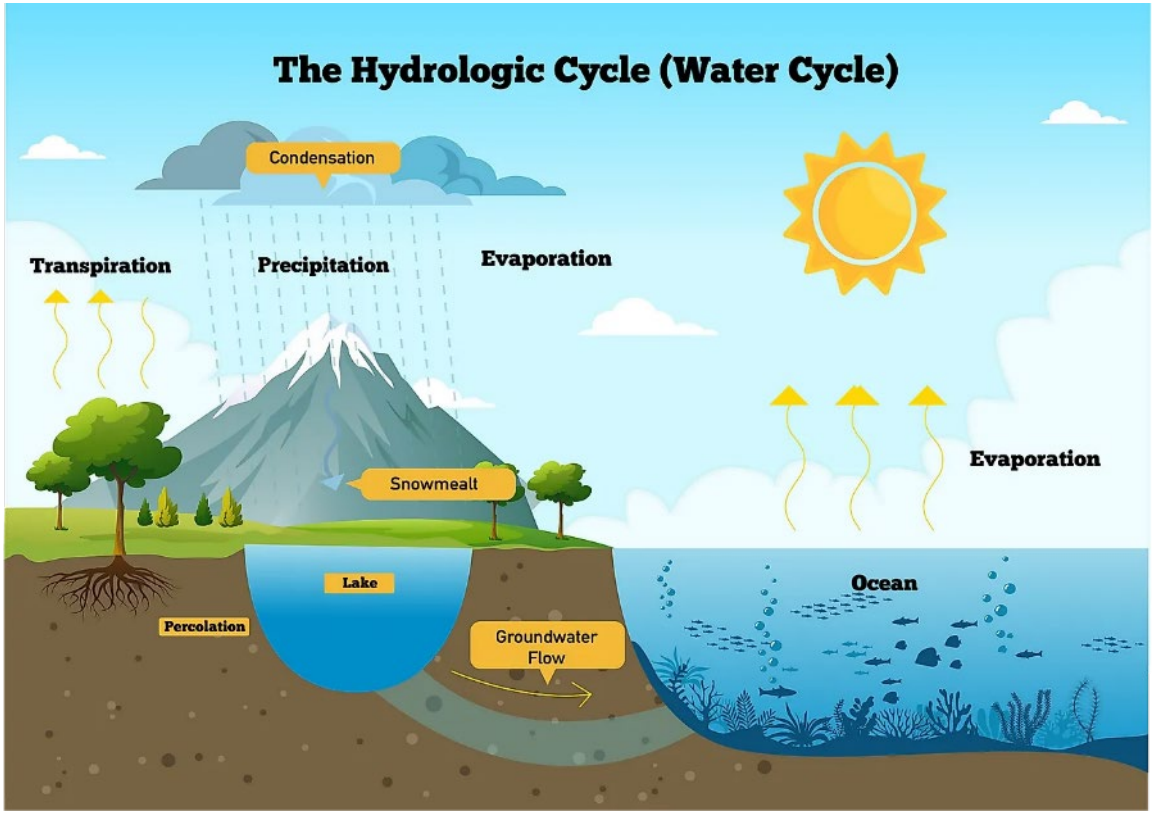
Hygiene





Fire-fighting

Contemporary issues linked with urban hydrology



The «natural» water cycle doesn't exist anymore ….

Article | Published: 03 March 2021

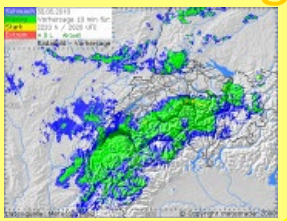
Human alteration of global surface water storage variability

Sarah W. Cooley, Jonathan C. Ryan & Laurence C. Smith

Nature **591**, 78–81 (2021) | Cite this article

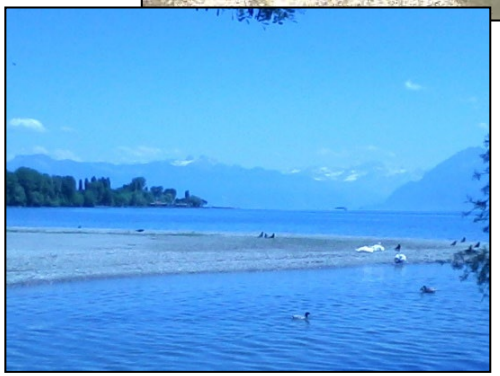
Contemporary issues linked with urban hydrology

Meteorology

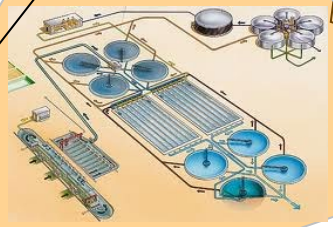


«natural» watershed

Receiving waters



Urban watershed



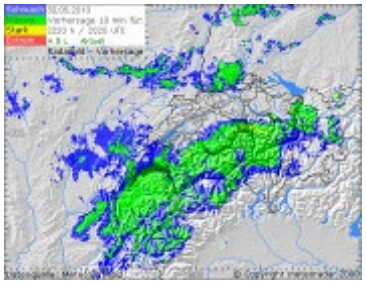
Wastewater treatment plants

Contemporary issues linked with urban hydrology

Climate change

Densification, urbanisation

Various territorial levels, regionalisation

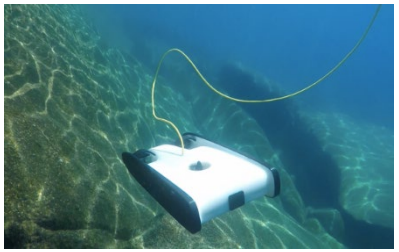


Water contamination

Funding of Infrastructure

Energy

Integration of new technologies



Contemporary issues linked with urban hydrology: Climate change

Sion (VS) 2018

Lausanne (VD) 2018

Lac des Brenets (NE) 2018

Suisse

16 octobre 2018 14:06; Act: 27.10.2018 07:11

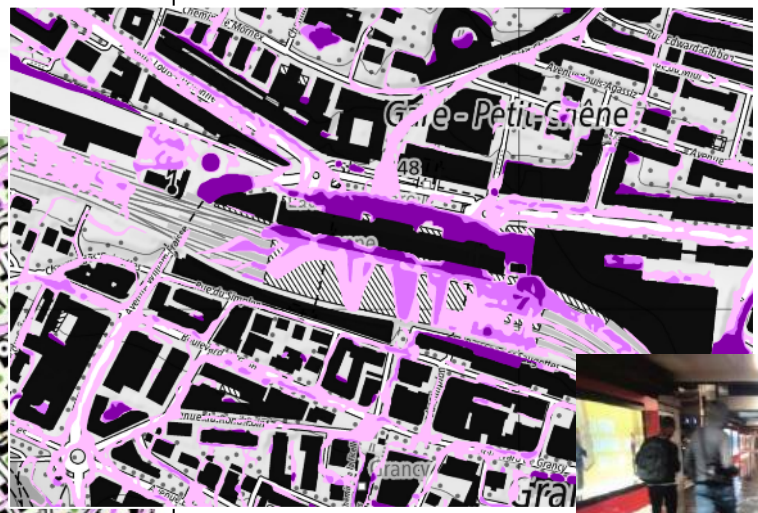
Carburants: Berne libère des réserves

Le faible niveau du Rhin ne permet plus d'importer du diesel et de l'essence. Les transports par train et par pipeline ne suffisent pas pour compenser la baisse.

Les transports sur le Rhin sont presque totalement interrompus entre Rotterdam et Bâle. (Photo: AFP)

Contemporary issues linked with urban hydrology: Climate change

Map available for the whole of Switzerland. Beware of calculation assumptions !!! (fiche d'information)



https://www.bafu.admin.ch/bafu/fr/home/themes/dangers-naturels/info-specialistes/donnees-de-base-et-utilisation-du-territoire/donnees-de-base-sur-les-dangers/alea-ruissellement.html

Contemporary issues linked with urban hydrology: Climate change

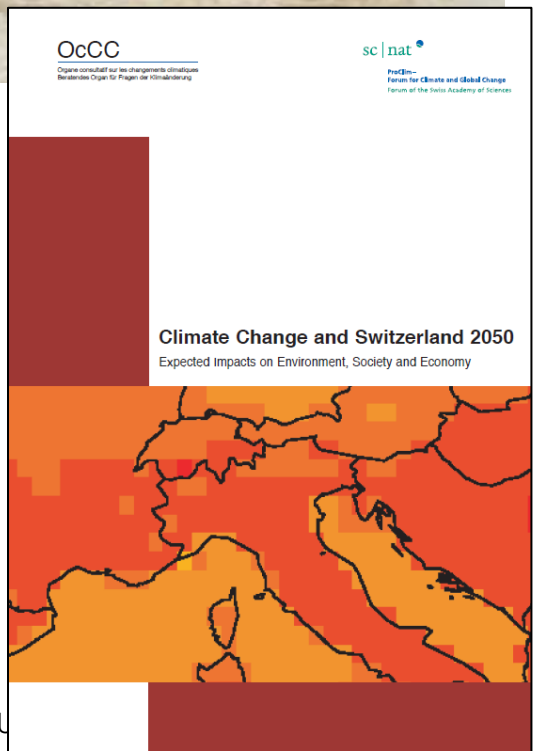
Evidence points to some form of climatic change in the future

Climate change is therefore among the main future concerns for urbanist and hydrologists

Goal: to anticipate these changes and develop resilient solutions at different scales, **but how?**

Example Sion

Precipitations: -10 mm



Contemporary issues linked with urban hydrology

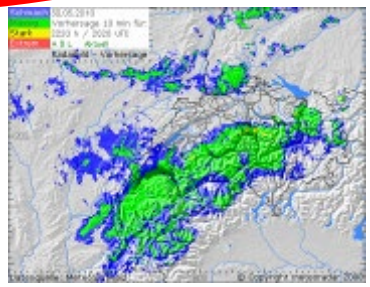
Climate change

Funding of Infrastructure

Densification, urbanisation

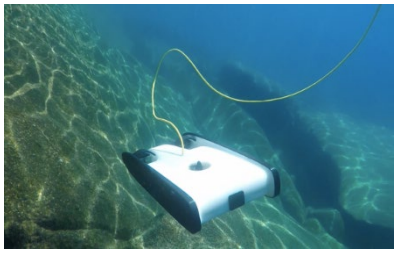
Energy

Various territorial levels, regionalisation

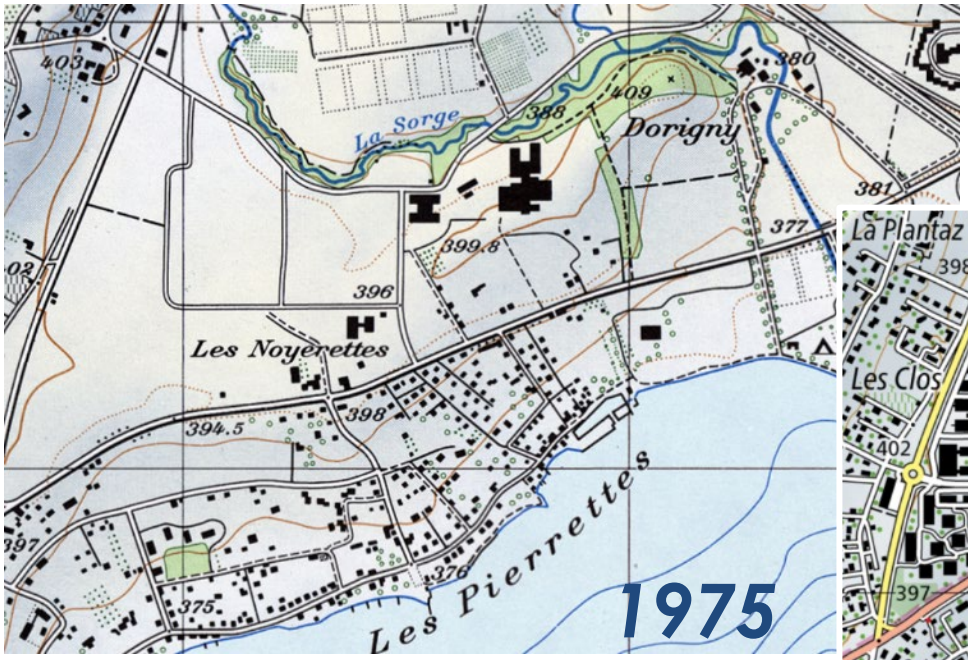


Water contamination

Integration of new technologies

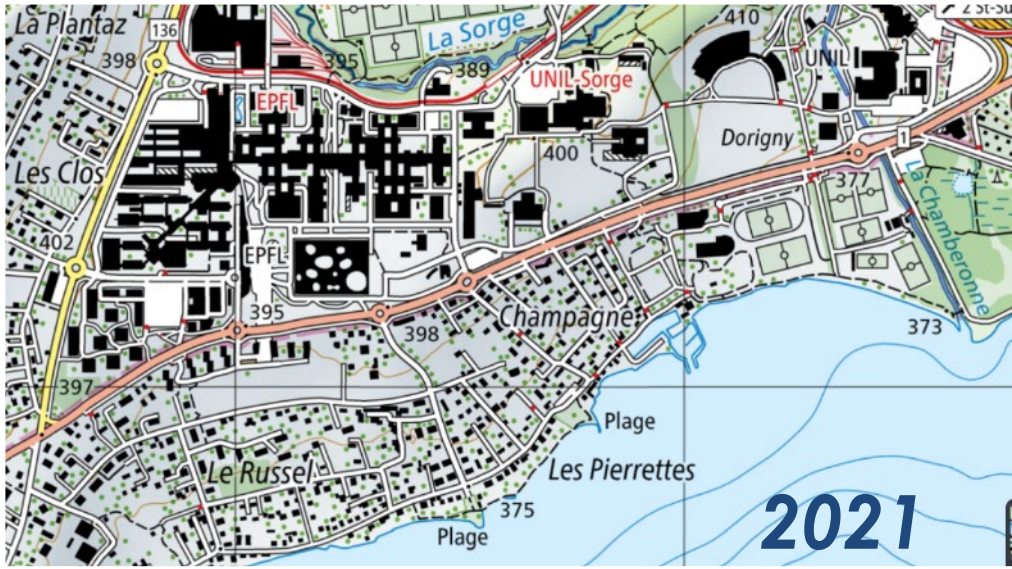


Contemporary issues linked with urban hydrology :Densification and urbanization



Land use evolution

[Tool "Time machine"]

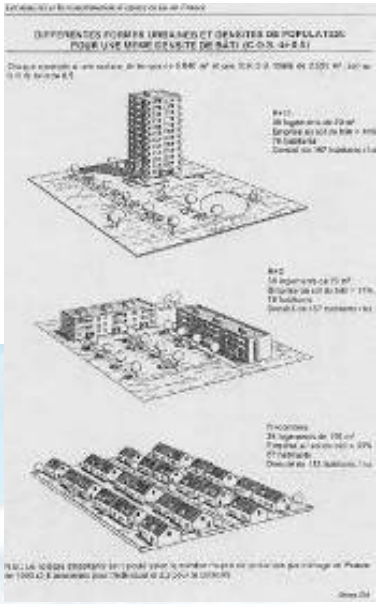


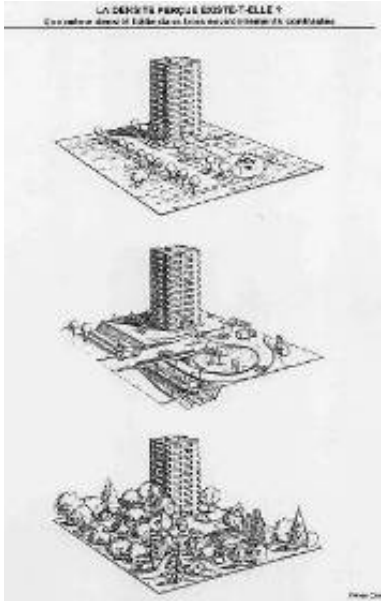
Construction rate: ca. 1 m^2/s

12 x  / day !

https://www.bfs.admin.ch/bfs/fr/home/statistiques/espace-environnement/utilisation-couverture-sol.html

Contemporary issues linked with urban hydrology :Densification and urbanization





Fouchier, 1997

www.laliberte.ch/info-regionale/urbanisme/une-foret-verticale-de-117-metres-aux-portes-de-lausanne-305423

Contemporary issues linked with urban hydrology

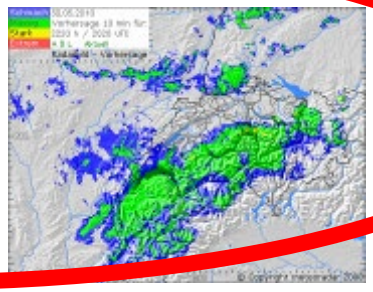
Climate change

Funding of Infrastructure

Densification, urbanisation

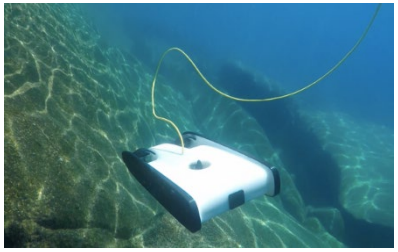
Energy

Various territorial levels, regionalisation

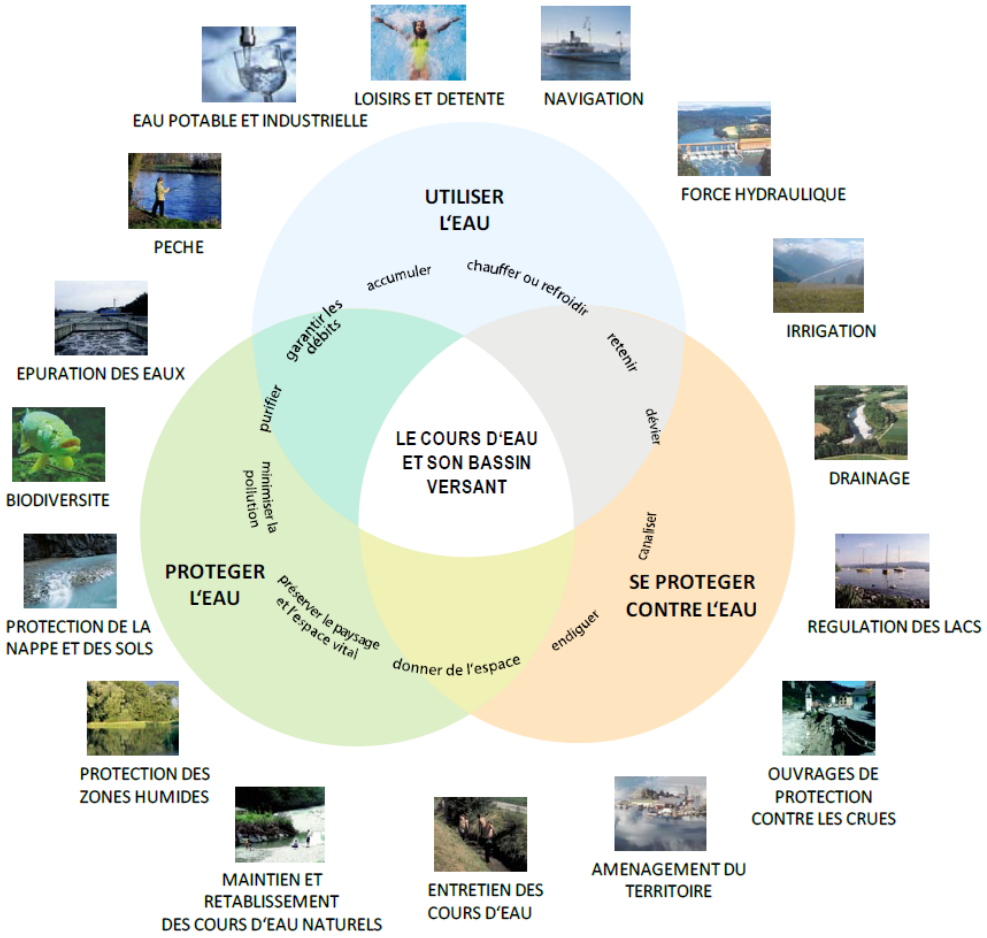


Water contamination

Integration of new technologies



Contemporary issues linked with urban hydrology :Various territorial levels, regionalisation



OFEV, 2013

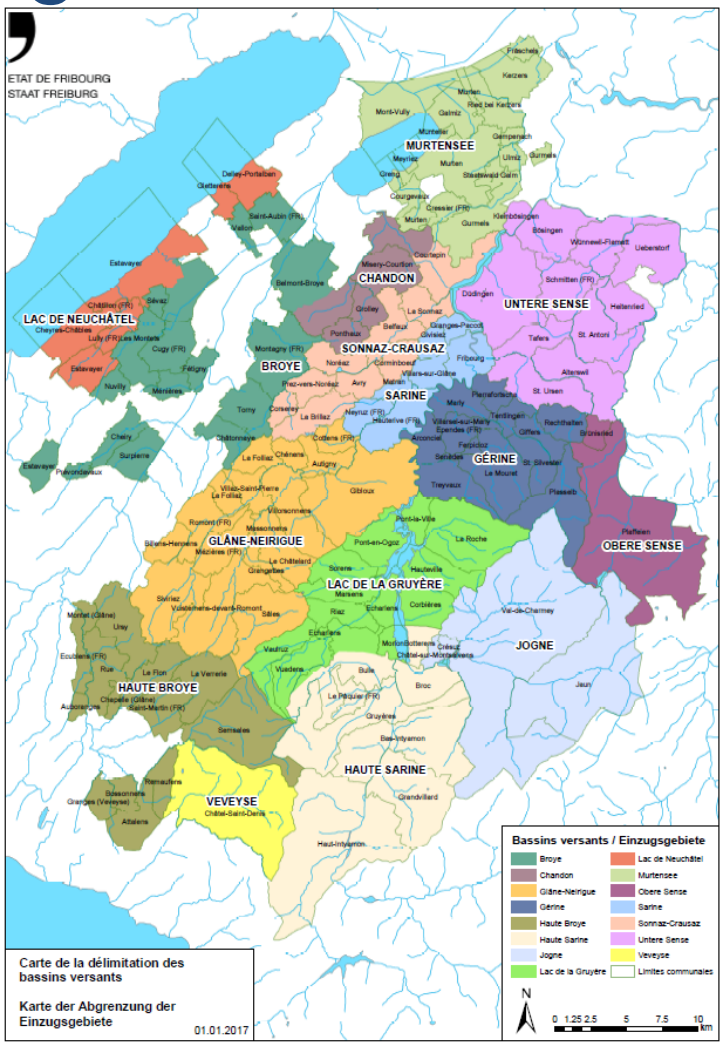
www.gwp.org, 2009

www.eau2013.ch/

OFEG 2003

Integrated water management

Contemporary issues linked with urban hydrology :Various territorial levels, regionalisation



Example Canton Fribourg:

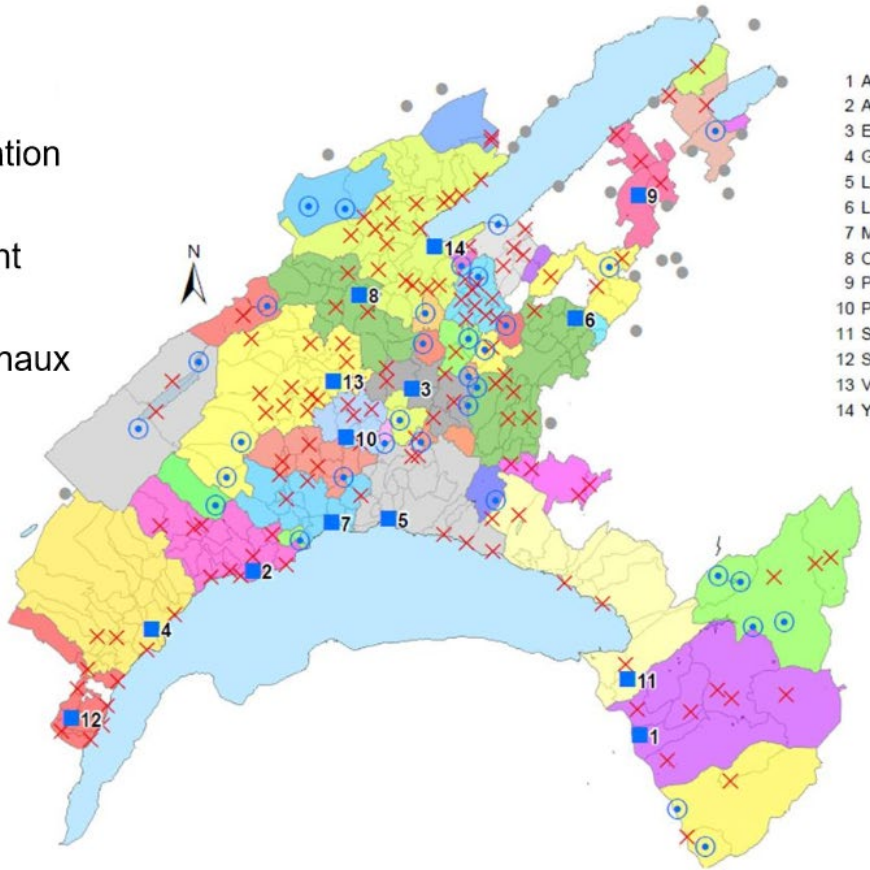
Water management at watershed level

Contemporary issues linked with urban hydrology :Various territorial levels, regionalisation

Plan Cantonal Micropolluants (PCM)

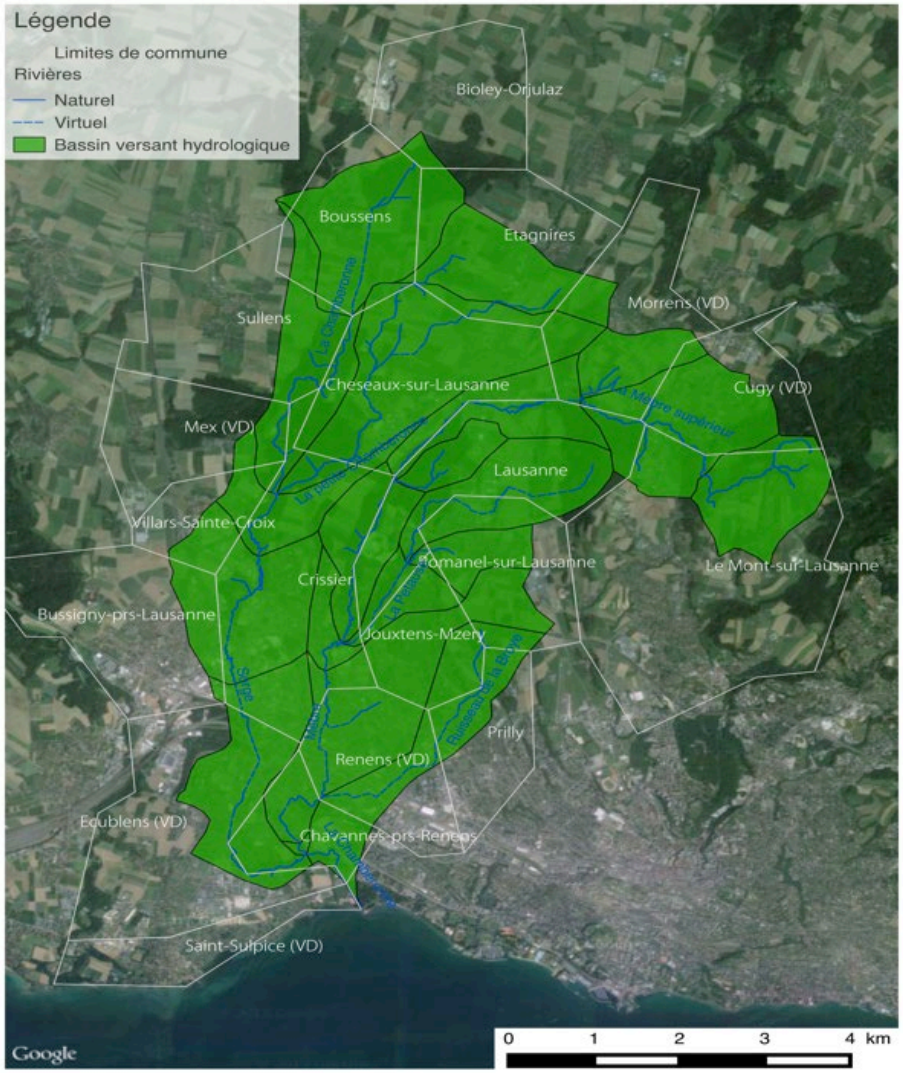
- **26** projets de régionalisation
- **14** projets avec traitement des micropolluants

  dont **3** projets intercantonaux



Canton Vaud: WWTPs regionalization

Contemporary issues linked with urban hydrology :Various territorial levels, regionalisation



Canton Vaud: 1st regional approach (Chamberonne PREE)

- Watershed: 41 km^2
- 21 municipalities
- ~77'000 inhabitants connected to the Vidy WWTP
- 19% impermeable areas

Contemporary issues linked with urban hydrology

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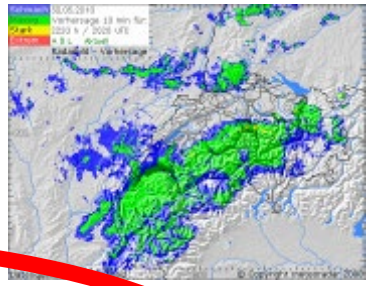
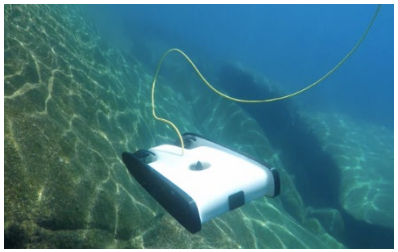


Water contamination

Integration of new technologies

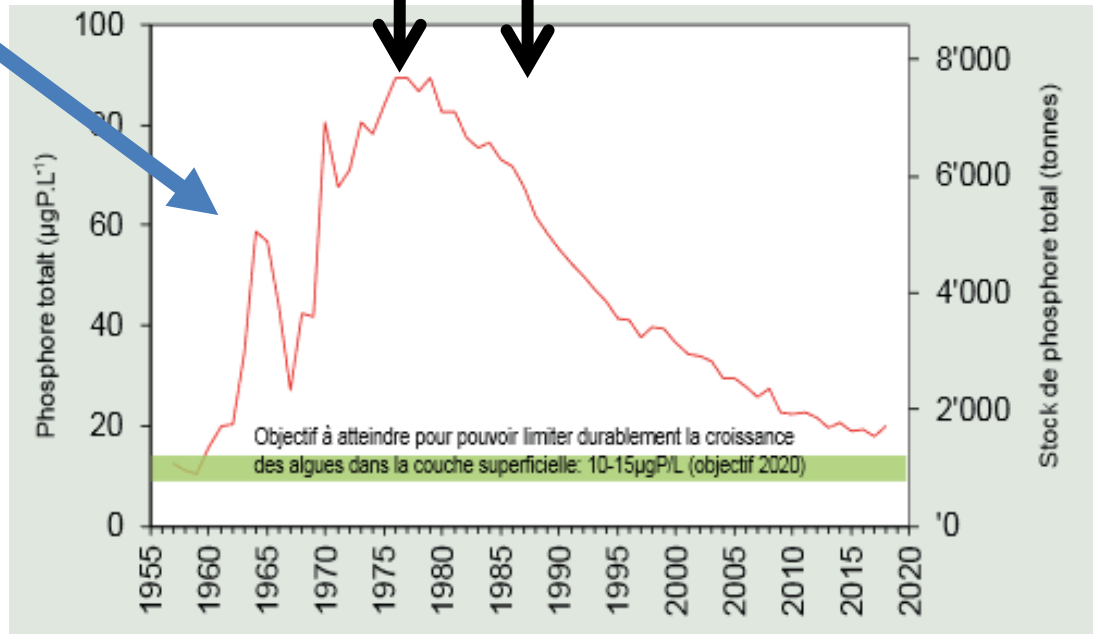


Contemporary issues linked with urban hydrology

www.rts.ch/archives/tv/information/continents-sans-visa/3436805-les-lacs-en-danger.html

Start of phosphorous elimination in WWTP

Ban of phosphates in wash powders in Switzerland and reduction of concentrations in France



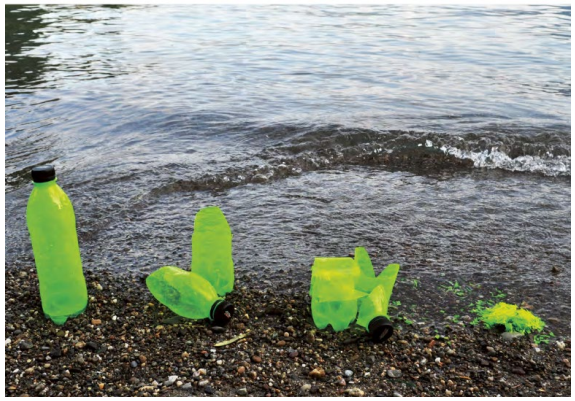
www.cipel.org, 2020

Evolution of phosphorus in Lake Geneva

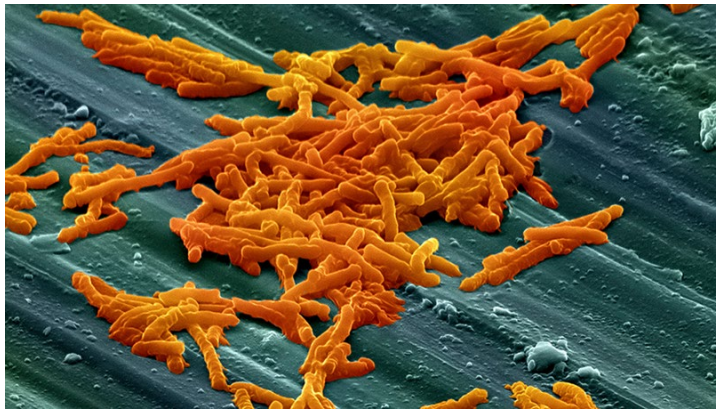
Contemporary issues linked with urban hydrology: Water contamination

Emerging pollutants found in ecotoxic concentrations in stormwater (biocides, nanoparticles, etc.) and in wastewater (pharmaceuticals , personal care products…) + "classical" problems (heavy metals, organic load, nutrients…) + antibiotic resistances + **PFAS + chlorothalonil + benzidine + pyréthroïdes + …**

Les microplastiques dans nos lacs et cours d'eau



Publication AQUAVIVA on the topic



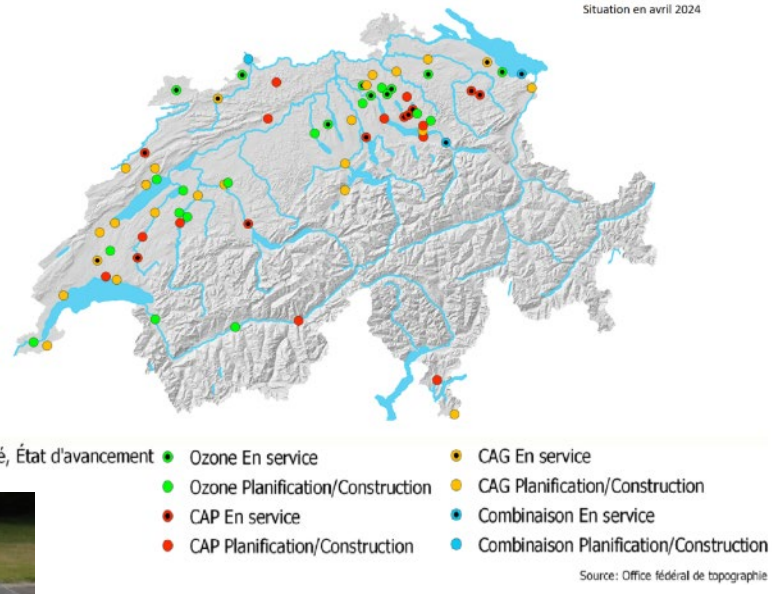
Spores bactériennes : un réservoir d'antibiorésistance
Information from OFEV

Contemporary issues linked with urban hydrology: Water contamination

Micropollutant elimination in selected WWTPs

[24] VAUD & RÉGIONS
06.07.2021

La conseillère d'État Béatrice Métraux en compagnie de René Devantay, de Penthaz et qui recueille les eaux usées de Cossonay, Penthalaz, Penti



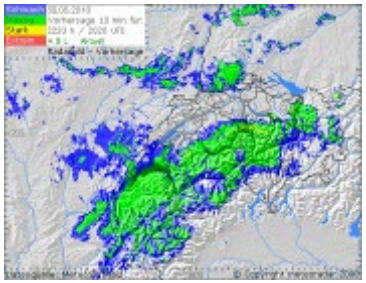
www.micropoll.ch

Contemporary issues linked with urban hydrology

Climate change

Densification, urbanisation

Various territorial levels, regionalisation

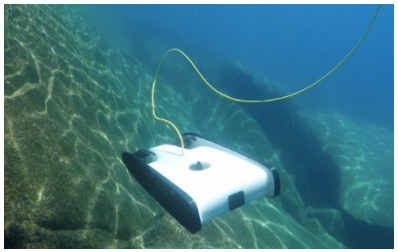


Water contamination

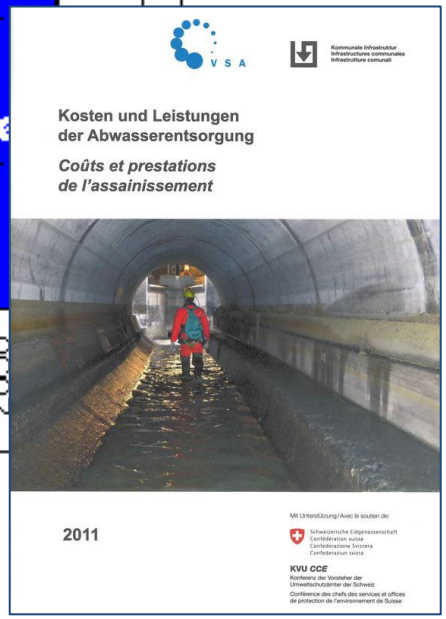
Funding of Infrastructure

Energy

Integration of new technologies



Funding of Infrastructure ?



Contemporary issues linked with urban hydrology

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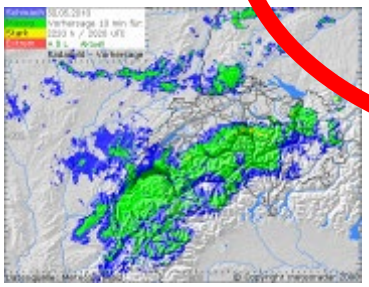

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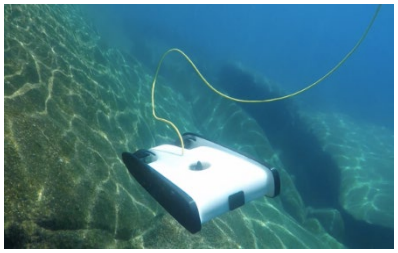
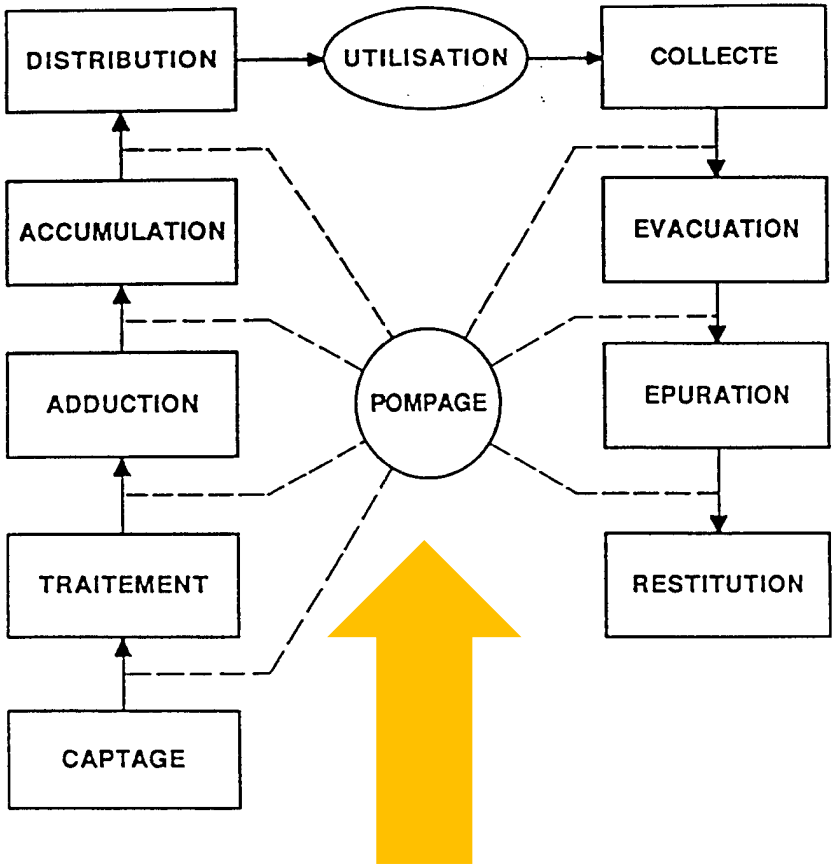


Contemporary issues linked with urban hydrology: energy



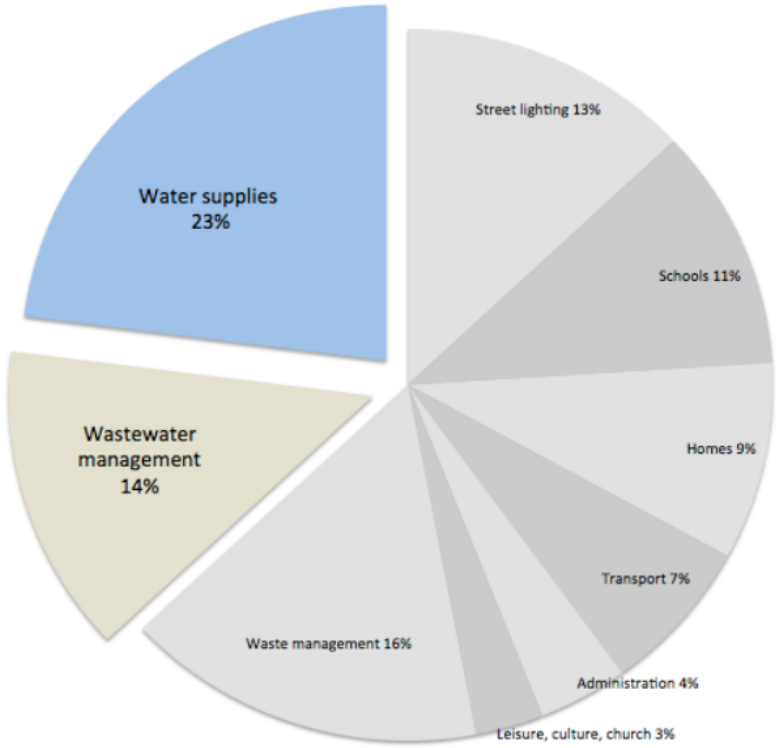


Figure 1.10: Electricity consumption in the public municipal sector in Switzerland (rough estimates).
Source: Factsheet Water and energy, EAWAG, 2011.

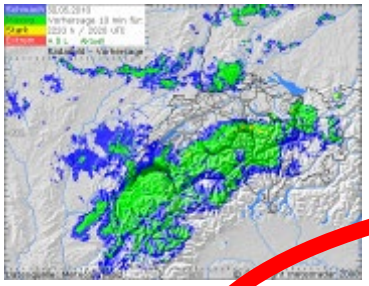
InfraWatt

Contemporary issues linked with urban hydrology

Climate change

Densification, urbanisation

Various territorial levels, regionalisation



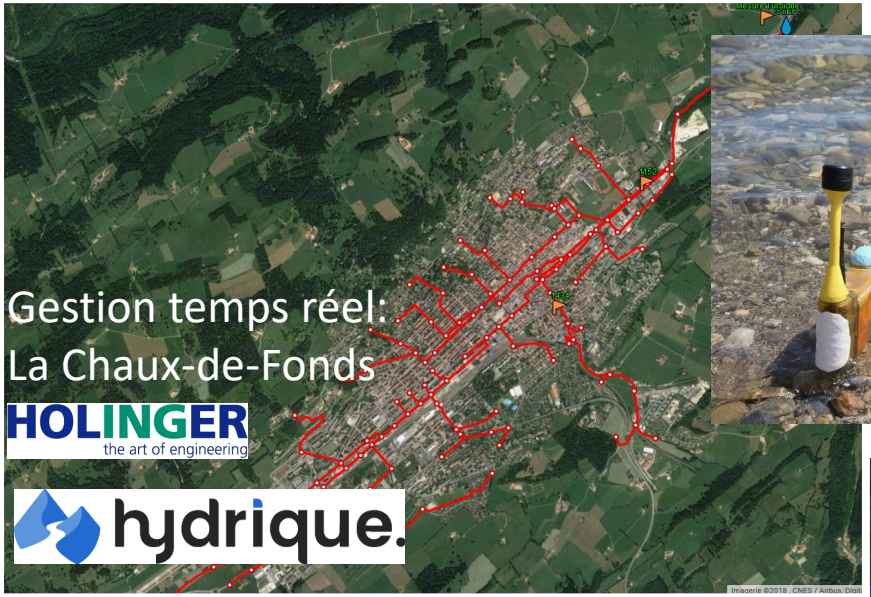
Water contamination

Funding of Infrastructure

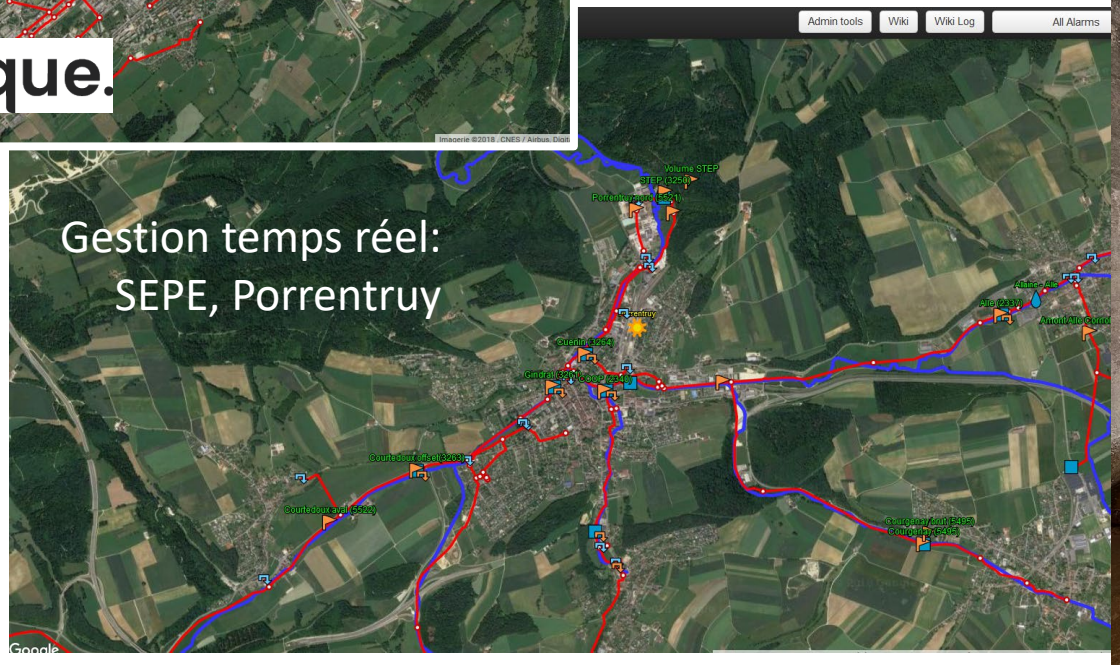
Energy

Integration of new technologies

Contemporary issues linked with urban hydrology : integration of new technologies



eawag
aquatic research



Introduction part

- Contemporary problems linked with urban hydrology
- **Urban hydrology through history**
- Immission approach: a new perspective in urban hydrology
- Movie

Water: an key factor for « urban quality »

www.kunsthofpassage.de/index.html

Place fédérale à Berne

Ur

Water: an important factor for « urban quality »

Structural Factor
Water and urbanization: Spatial identifications

Symbolic Factor
Water and Man; Emotional and physical wellbeing; Social factor

Environmental Factor
Water, Man and the environment Balance; Control of water; Territorial morphology; Architecture

Amnesia – Water throughout history

« Water is no longer valued, although historically it was once a structuring element. »

Place Navonna Allegrata, Rome par G. P. Pannini, 1756

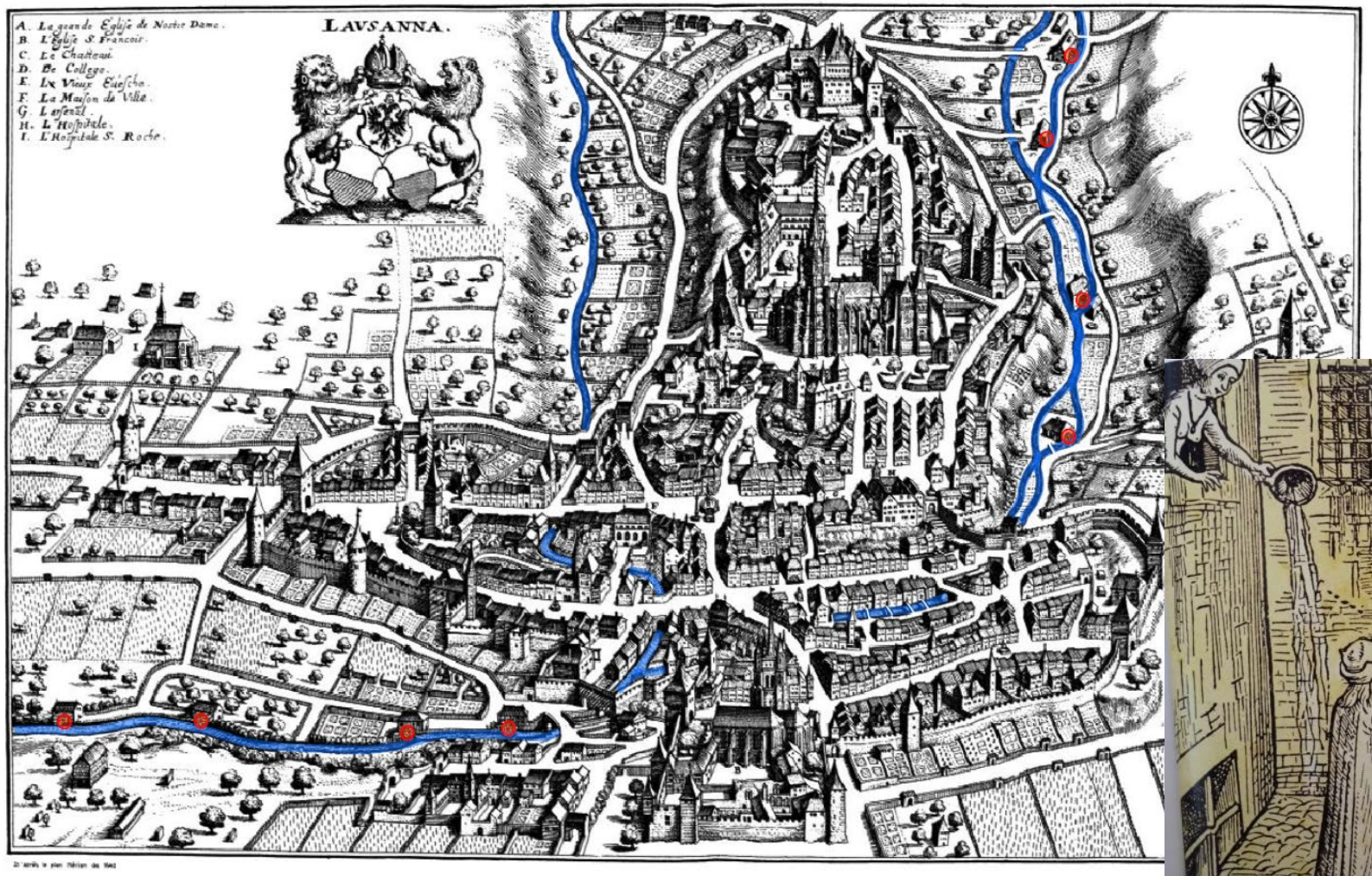
Canal at Su Zhou, China

Ducros_La Place de la Palud à Lausanne vers 1808

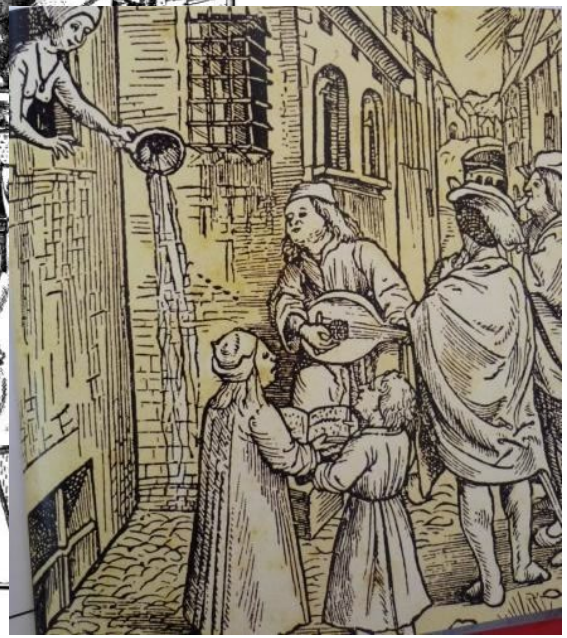
Les Grandes Forges de Vallorbe, http://www.eau21.ch/etude_32.html

www.iwapublishing.com/news/brief-history-water-and-health-ancient-civilizations-modern-times

Amnesia – Water throughout history



Lausanne, 1642



magenealogie.eklablog.com/histoire-de-wc-latrines-et-autres-lieux-d-aisance-a126523814


1700
LAUSANNA
LAUSANNE en 1673.


1740


1832


1870
PIANOS

Time machine Tool (from 1864)

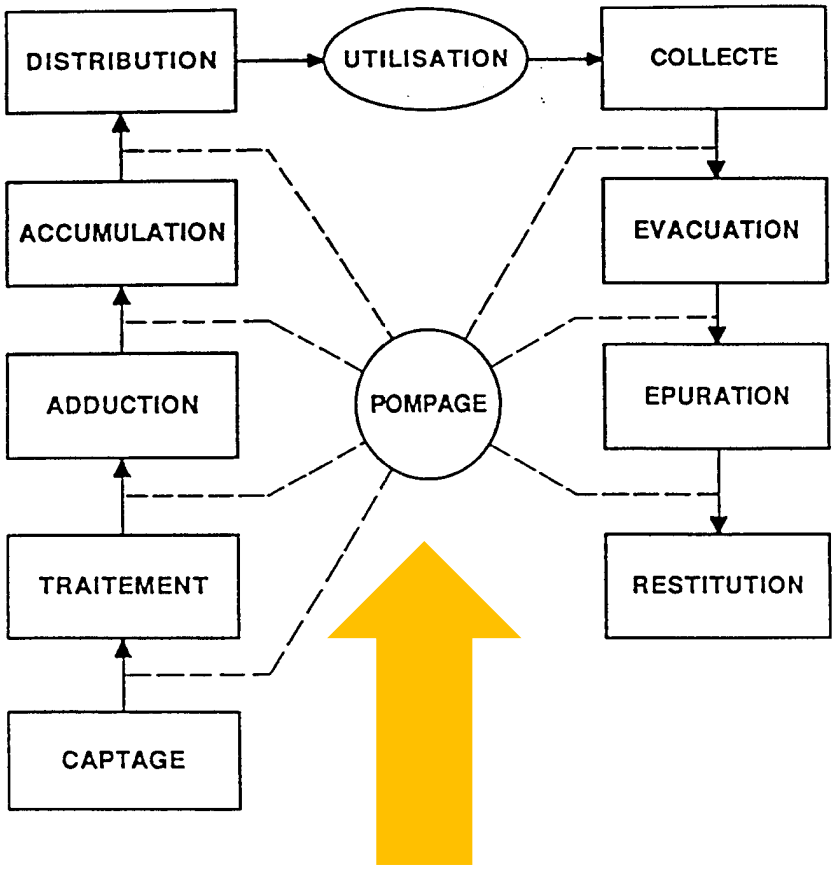
https://map.geo.admin.ch/

Water throughout history

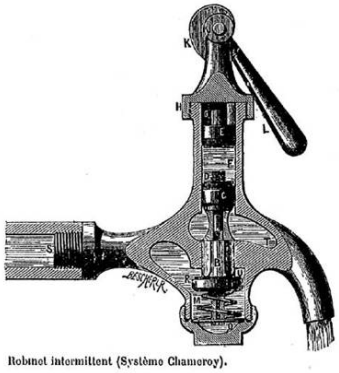
Toilettes Ephese, Ier siècle

www.julsa.fr/insolite-sega-invente-le-jeu-video-avec-le-pipi-au-japon/

Water throughout history



Everything changed with pumping possibilities !

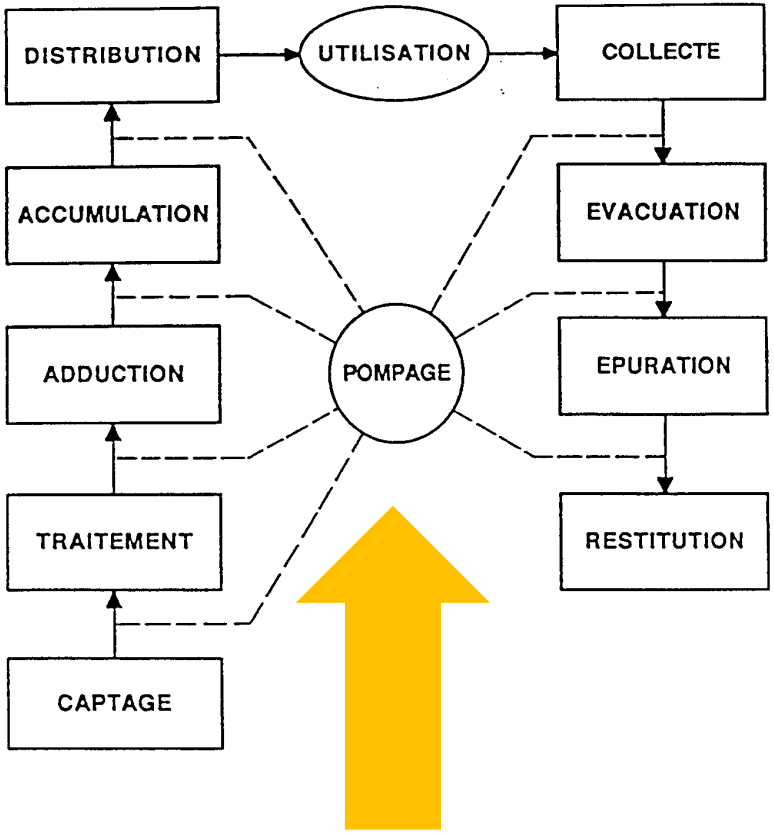


1870

www.histoire-vesinet.org/chameroy-inventeurs.htm

Toilet seat, Guise Familistère, 1890

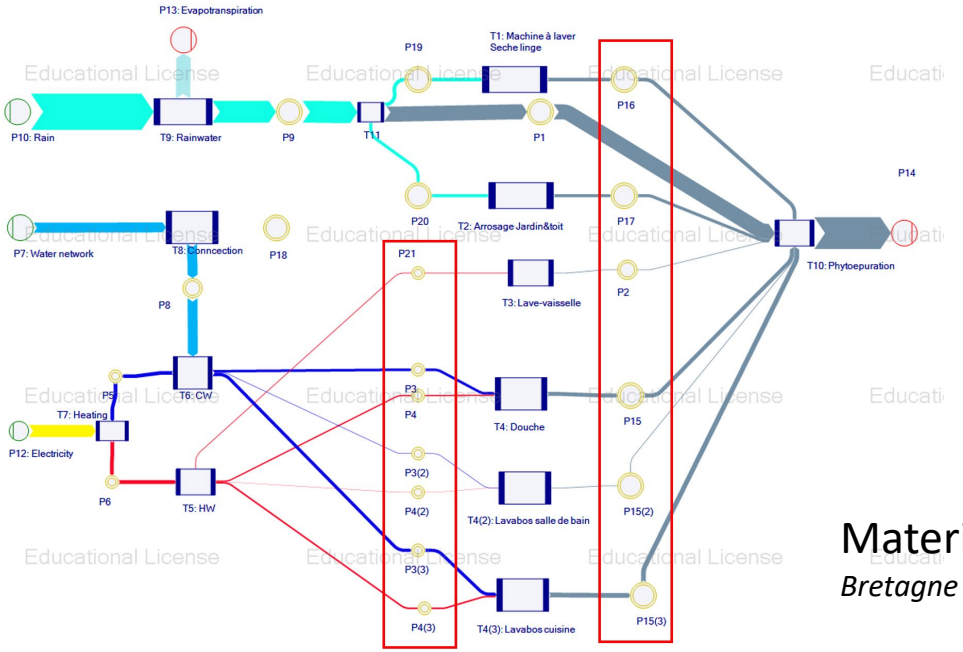
Contemporary issues linked with urban hydrology : energy



Water throughout history

Nebia Shower

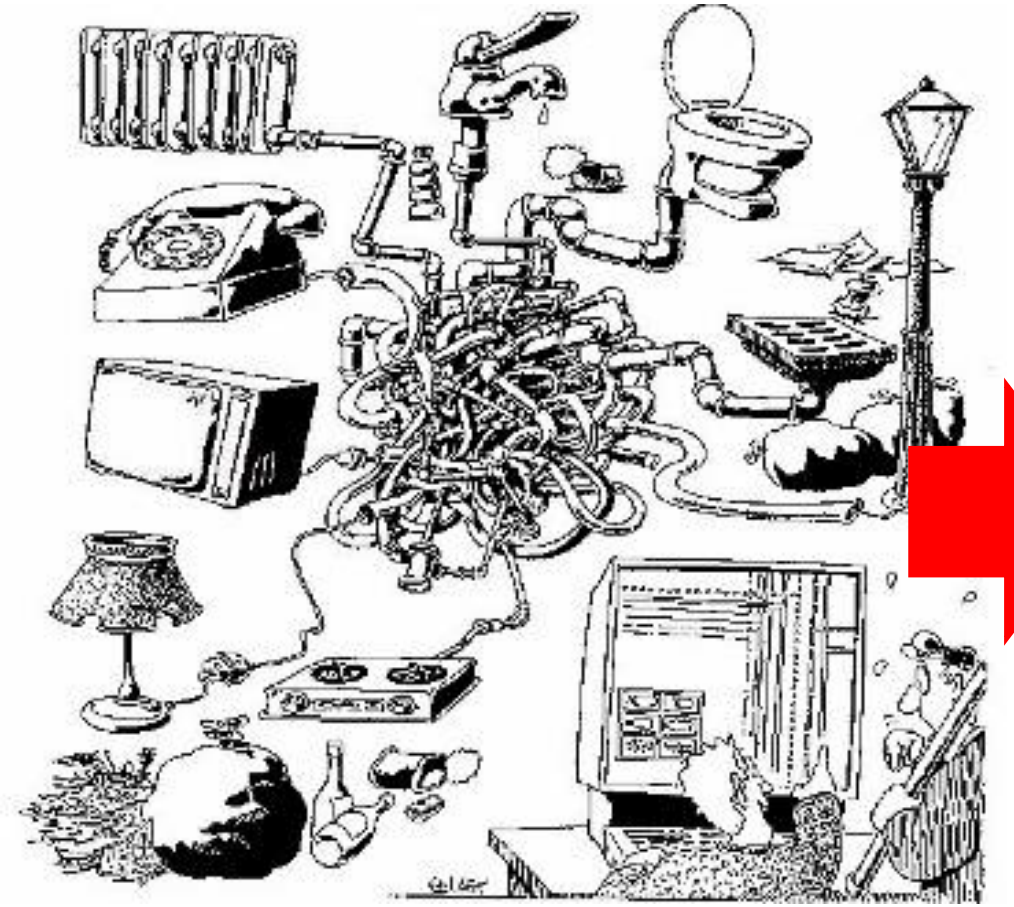
Smart Metering www.amphiro.com



Material and energy flow analysis

Bretagne et Landerer, 2016

Water throughout history: actual and future vision

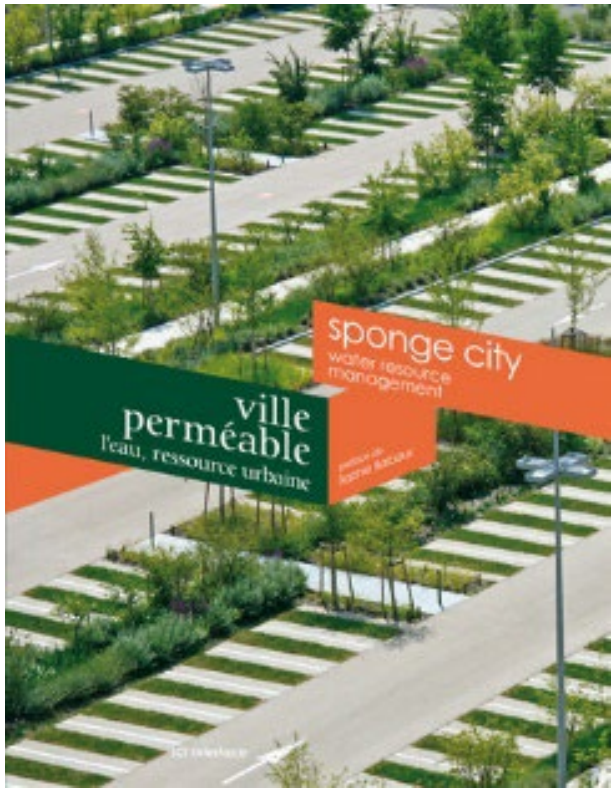


Global management of urban infrastructures

New concepts for urban water management:

- **Urban metabolism**
- **Resilient cities**
- **Sustainable urban development**
- **Zero Waste cities**
- **“Carrying capacity”**
- **Sponge cities**

Actual and future vision: «Sponge City»



ISBN 978-2-916977-35-5

- Retention/detention water reuse
- Flood control
- Reduction of the heat urban island effect
- Enhancement of biodiversity

Actual and future vision: «Sponge City»

www.bloomberg.com/news/articles/2017-08-18/berlin-is-becoming-a-sponge-city

http://www.dreiseitl.com/en

Example of solutions

«Eau de pluie dans l'espace urbain»

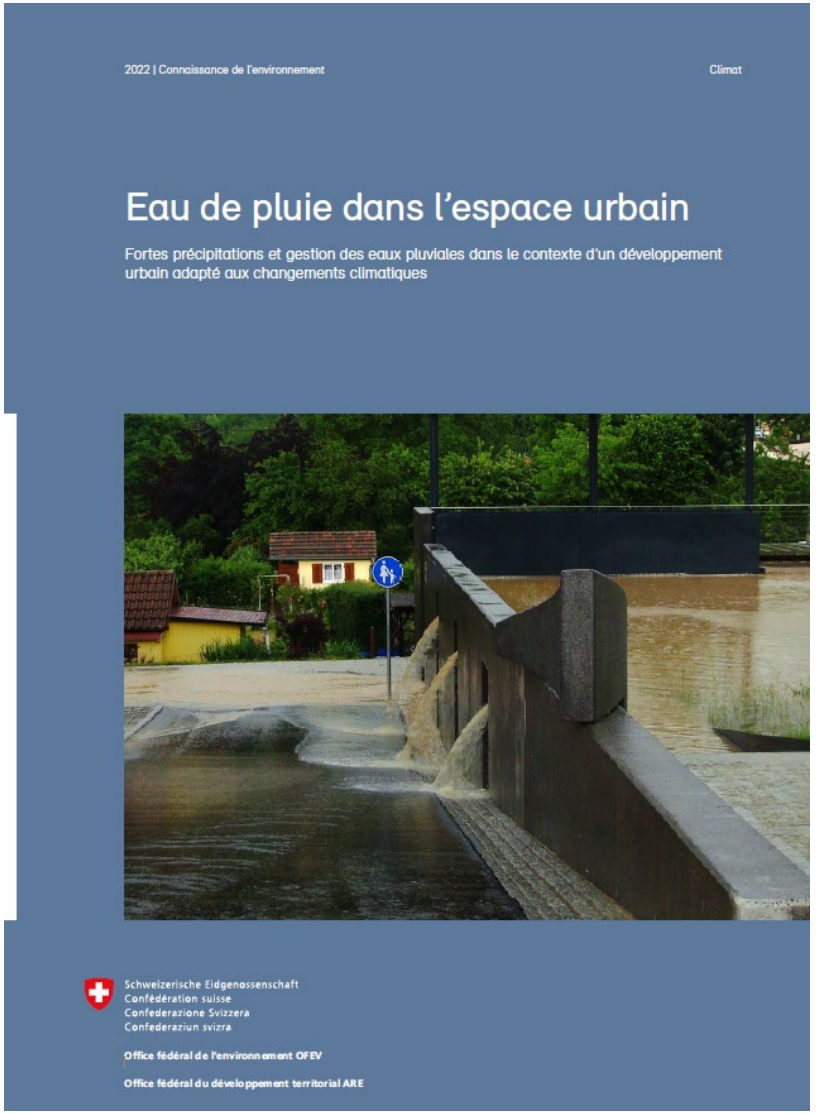
Swiss federal office of the environment

Fig. 85 : À Roskilde, le canal alimentant le bassin de rétention sert aussi de skatepark

Fig. 86 : Bassin de rétention aménagé comme un lac proche de l'état naturel

Fig. 87 : Bord de la place avec bordure de 3 cm de haut

Fig. 88 : La Vulkanplatz, un espace multifonctions



Example of solutions - Geneva

At-source runoff control

Office cantonal de l'eau
Service de la planification de l'eau

Eau en Ville

Gestion des eaux pluviales : vers un changement de pratiques ?

Version 1.0 – Avril 2020

REPUBLIQUE ET CANTON DE GENEVE

POST TENEBRAS LUX

https://www.ge.ch/eau-ville-changement-pratiques-applications

Example of solutions - VSA

plate-forme d'information ville éponge // sponge-city.info
pour une gestion de l'eau adaptée au climat en milieu urbain

DE FR IT

GLOSSAIRE CONTACT

BONS EXEMPLES OUTILS ÉVÉNEMENTS & FORMATIONS NOTRE RÉSEAU

AVEC LE CONCEPT VILLE ÉPONGE VERS UN ESPACE URBAIN DE QUALITÉ ET ADAPTÉ AU CLIMAT

Introduction part

- Contemporary problems linked with urban hydrology
- Urban hydrology through history
- **Immission approach: a new perspective in urban hydrology**
- Movie

New guidelines for urban hydrology: VSA approach

Base of support for this course…

VSA guidelines « STORM » Urban wet-weater management

Available through the Swiss Water Association VSA (www.vsa.ch)

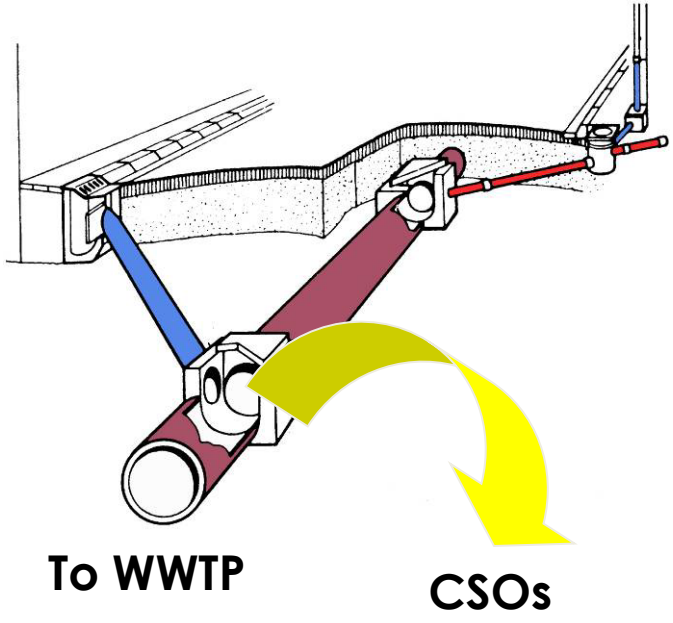
French, German and Italian versions, scientific papers in english

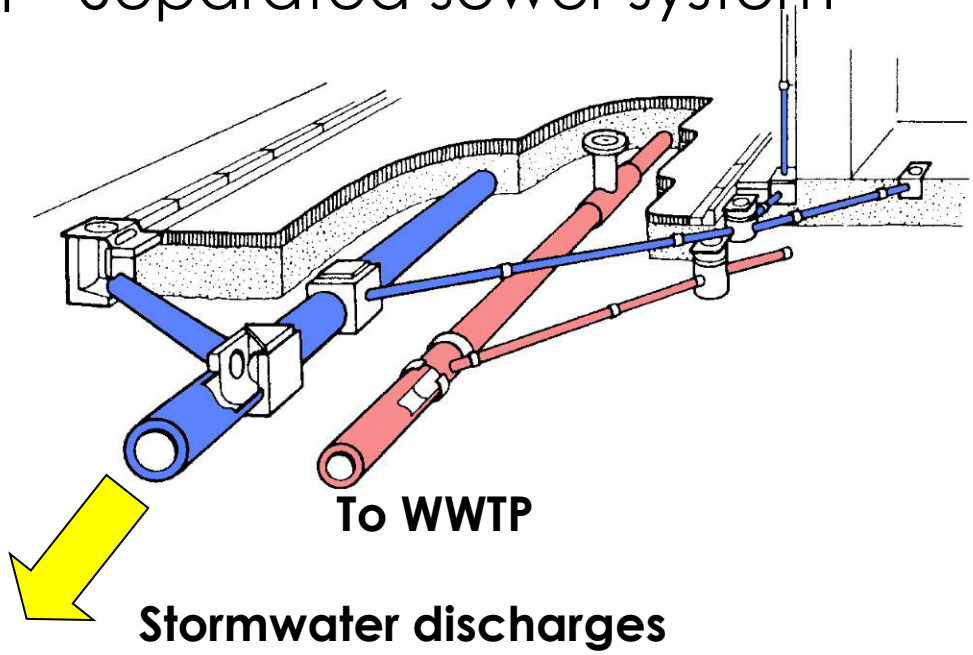
Available only for this class !!!

Urban wet-weather discharges: important source of problems

Combined sewer system

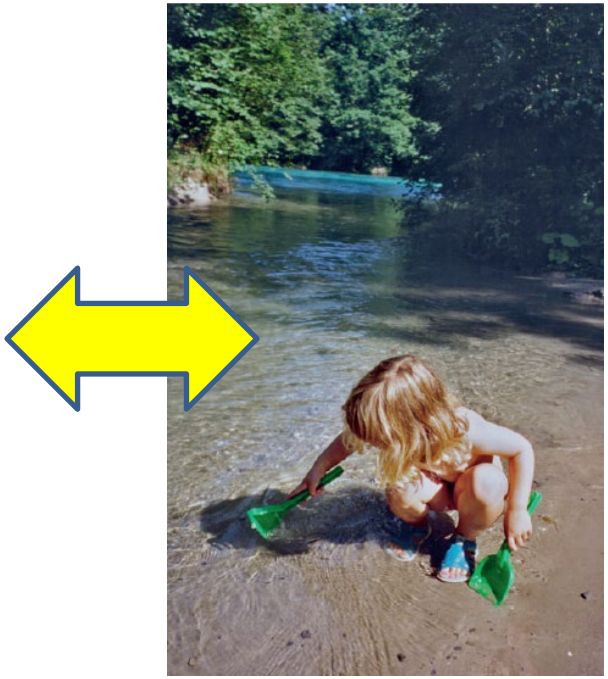
Separated sewer system



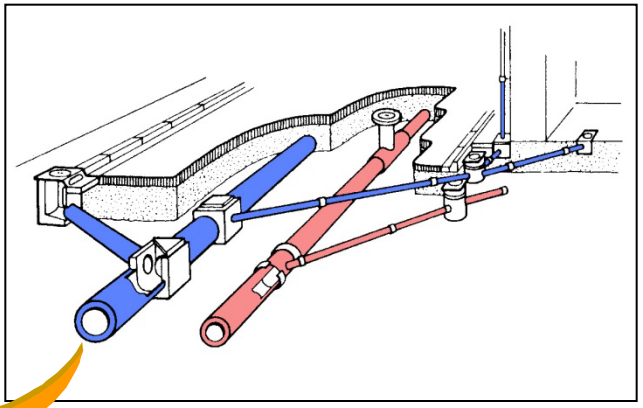


Combined sewer overflows (CSOs)

Important source of ***contamination*** (phosphorus, nitrogen, organic matter, bacteria and viruses, residues of pharmaceuticals …) and ***physical degradation*** (flooding, erosion…)



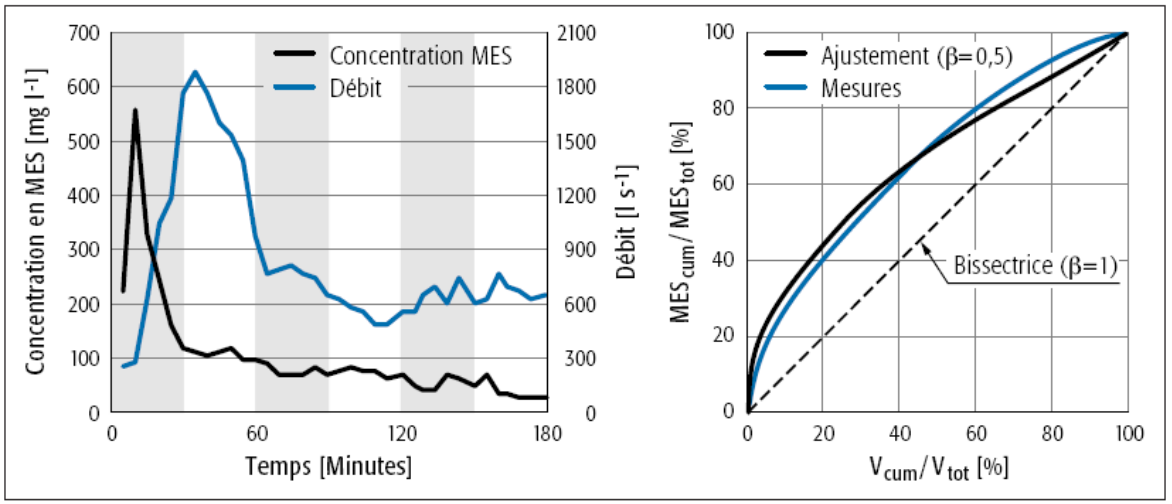
Numerous contaminants in stormwater

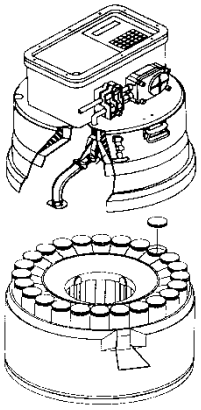


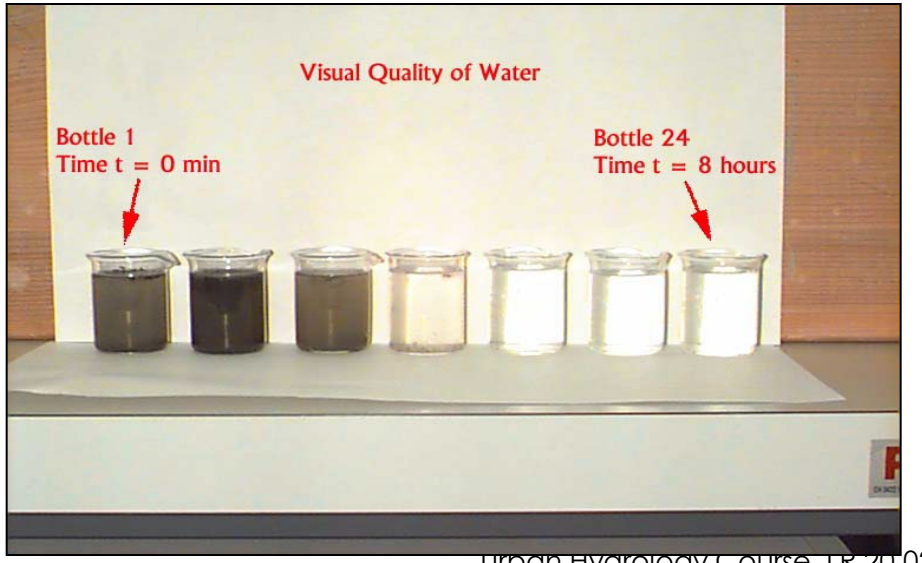
- **Heavy metals** (roofs, trafic…)
  Cu, Zn, Pb, Cd, Cr, Pt,…
- **PAHs** (trafic, industrial activities, heating systems…)
- **Biocides** (paints, wood protection…)
  diuron, mecoprop, microplastics…

Implicated processes ?

Example: dynamic of contamination during a rain event

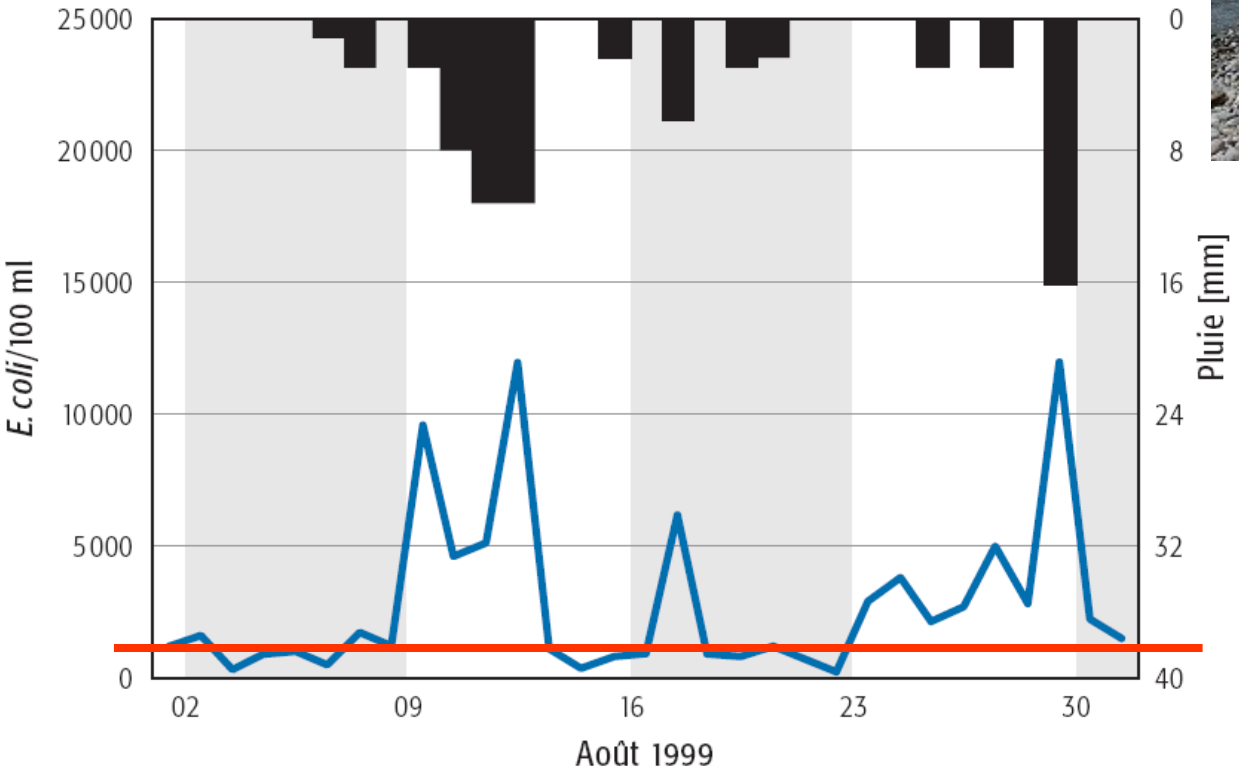






Bacteriological contamination

Salemer Aach,
Lac de Constance
(Baden-Wurtenberg)



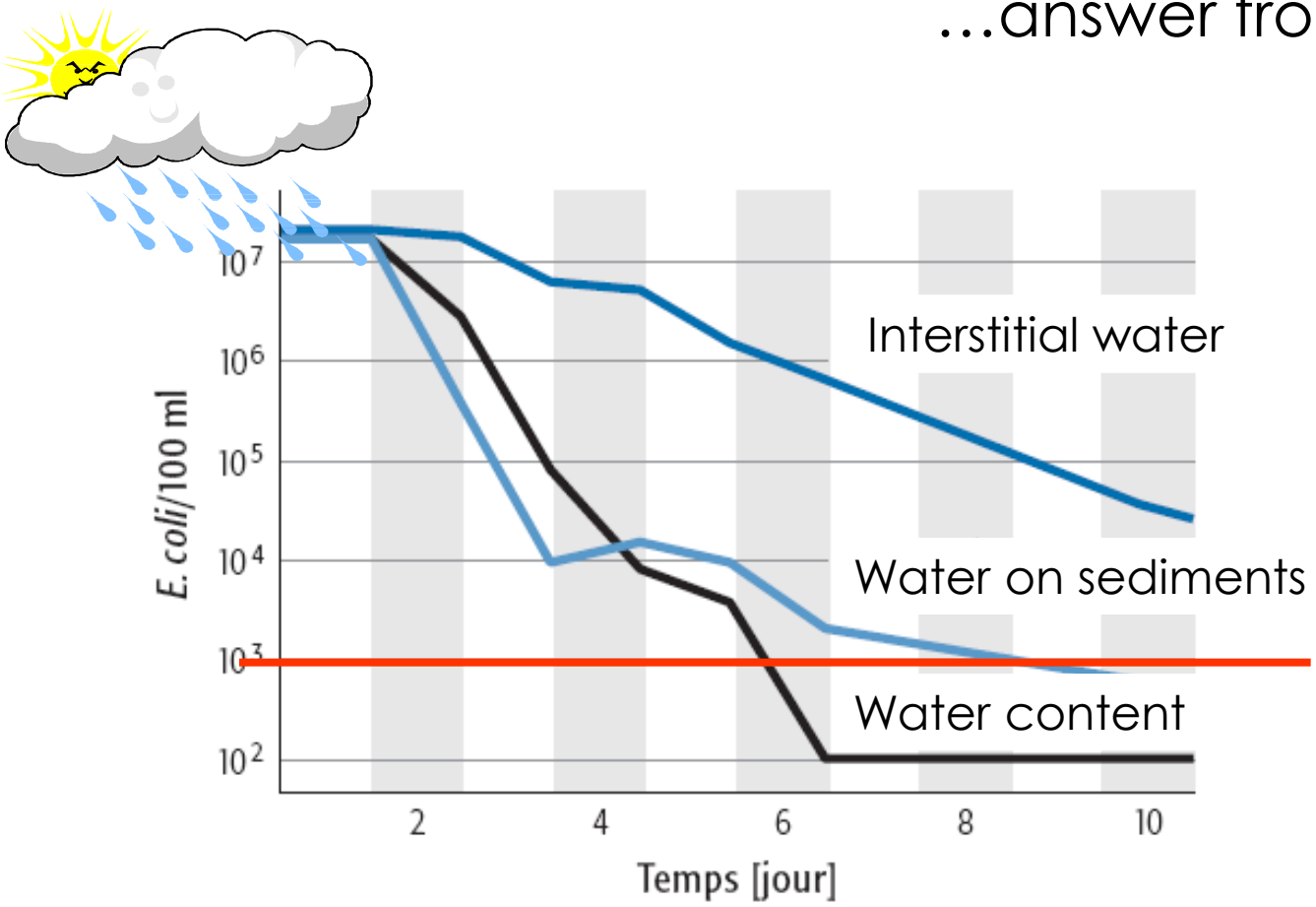
Class D, potential risks for human health (Swiss Guidelines)

Origin of the contamination: CSOs

Bacteriological contamination

« When it rains, nobody goes swimming… »

…answer from a Canton



Class D: potential risks for human health

Lac de Constance, Güde et al. 2003

Bacteriological contamination

TABLE 4.1. EXAMPLES OF PATHOGENS AND INDEX ORGANISM CONCENTRATIONS IN RAW SEWAGE[a]

Pathogen/index organism	Disease/role	Numbers per 100 ml
Bacteria		
Campylobacter spp.	Gastroenteritis	10^4–10^5
Clostridium perfringens spores	Index organism	$6 \times 10^4 - 8 \times 10^4$
Escherichia coli	Index organism (except specific strains)	10^6–10^7
Faecal streptococci/intestinal enterococci	Index organism	$4.7 \times 10^3 - 4 \times 10^5$
Salmonella spp.	Gastroenteritis	0.2–8000
Shigella spp.	Bacillary dysentery	0.1–1000
Viruses		
Polioviruses	Index organism (vaccine strains), poliomyelitis	180–500 000
Rotaviruses	Diarrhoea, vomiting	400–85 000
Adenoviruses	Respiratory disease, gastroenteritis	not enumerated[b]
Norwalk viruses	Diarrhoea, vomiting	not enumerated[b]
Hepatitis A	Hepatitis	not enumerated[b]
Parasitic protozoa[c]		
Cryptosporidium parvum oocysts	Diarrhoea	0.1–39
Entamoeba histolytica	Amoebic dysentery	0.4
Giardia lamblia cysts	Diarrhoea	12.5–20 000
Helminths[c] **(ova)**		
Ascaris spp.	Ascariasis	0.5–11
Ancylostoma spp. and *Necator* sp.	Anaemia	0.6–19
Trichuris spp.	Diarrhoea	1–4

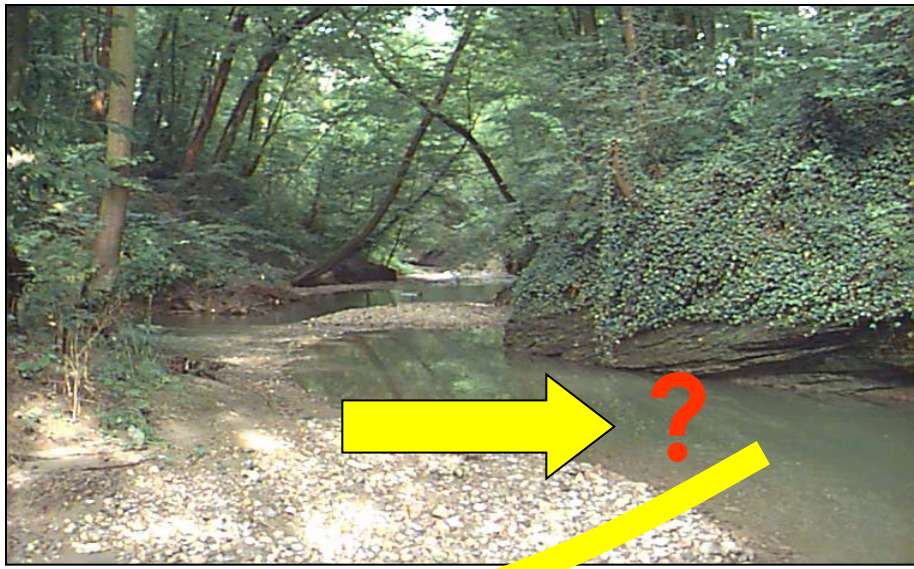
WHO: GUIDELINES FOR SAFE RECREATIONAL WATER ENVIRONMENTS

Goals of VSA guidelines

- New **concepts** in urban hydrology
- **Integrated approach** for water management
- Definition of specific **criteria**
- Management of **uncertainties and variability**
- Development of a **software** to support these concepts
- **Control** of technical solutions and impacts in receiving waters

From emission (end-of-pipe) to immission approach

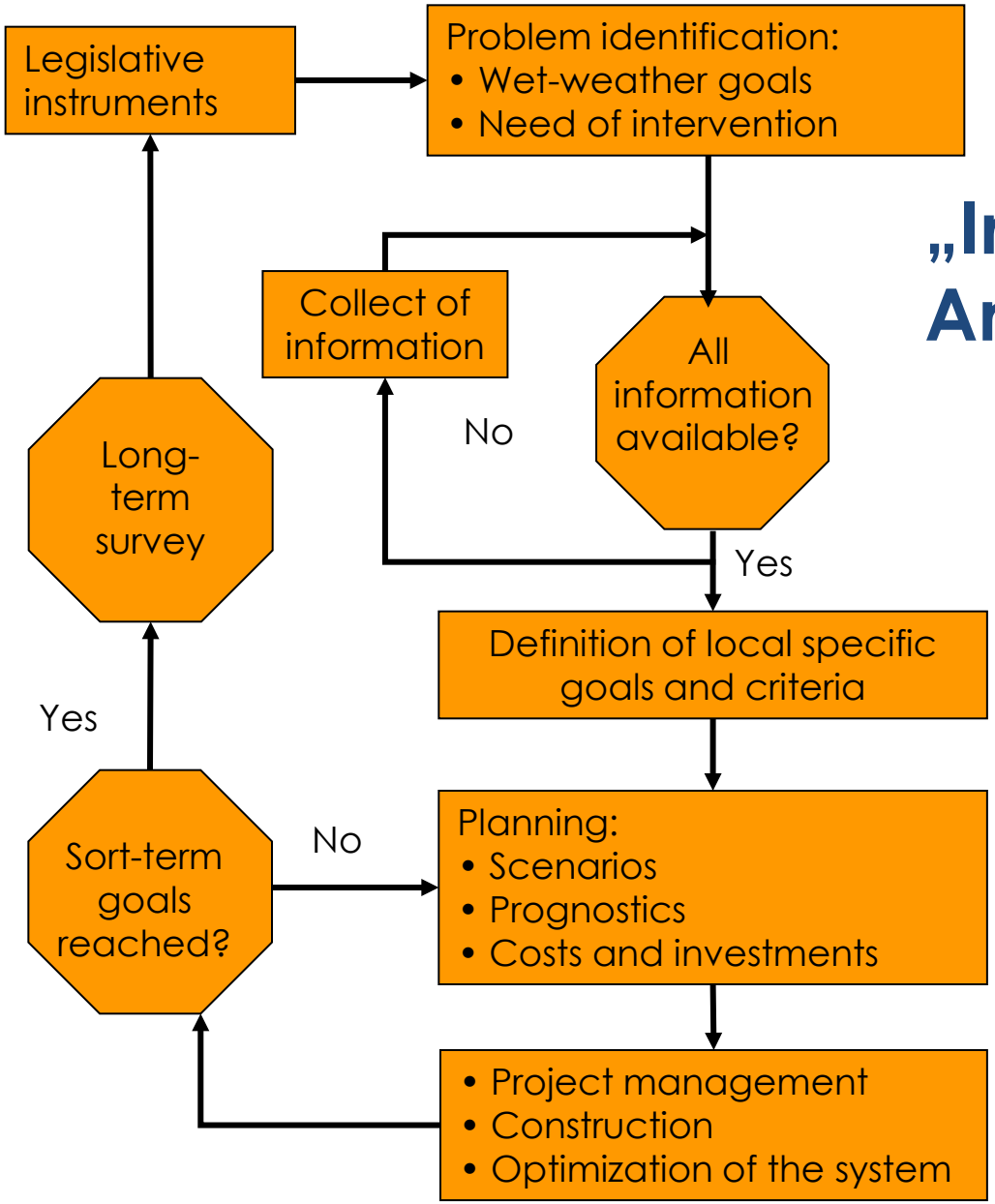
- Emissions: Discharge in the receiving waters, „end of pipe“ approach
- Immission: Effects of discharges in the receiving waters

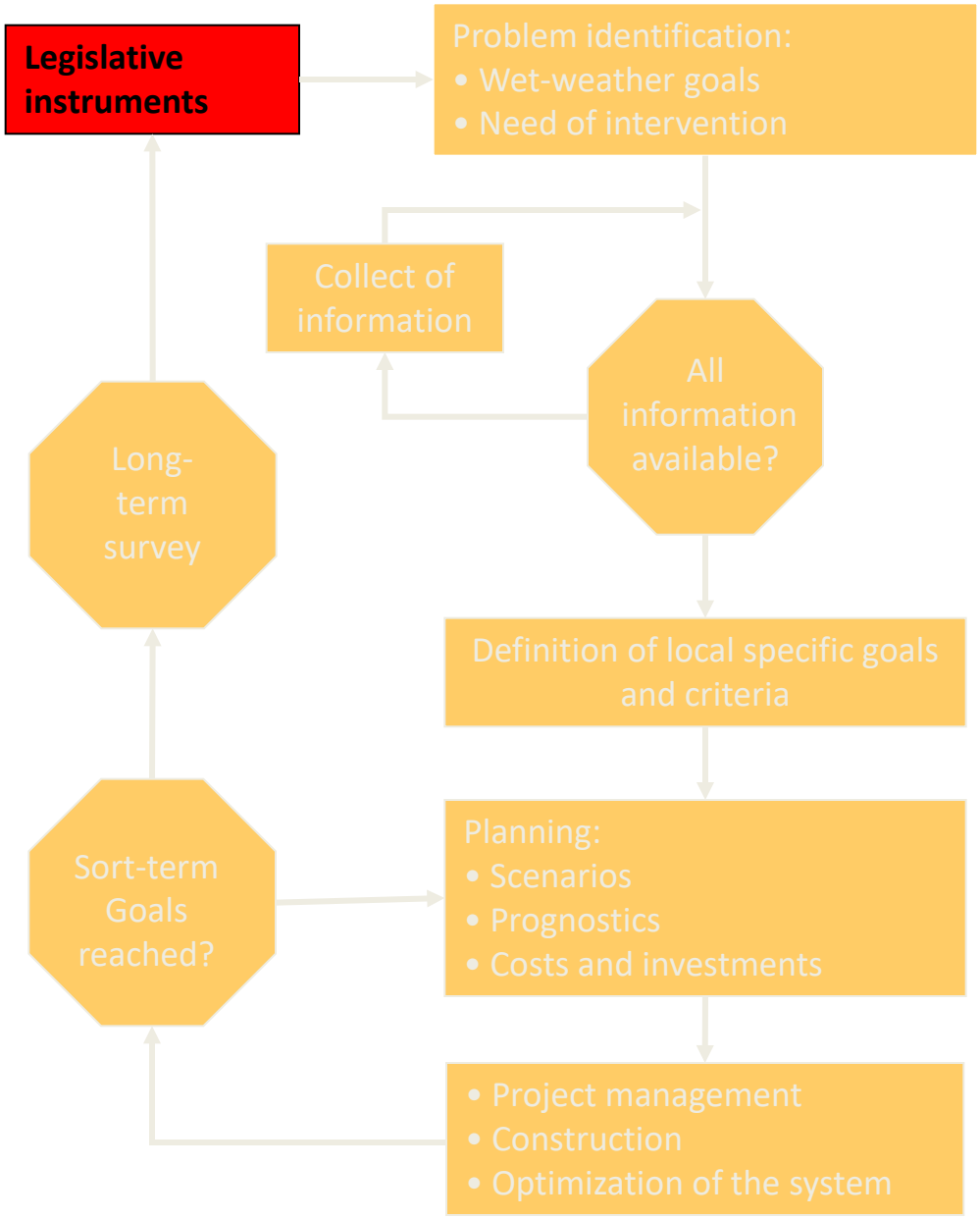


VSA guidelines

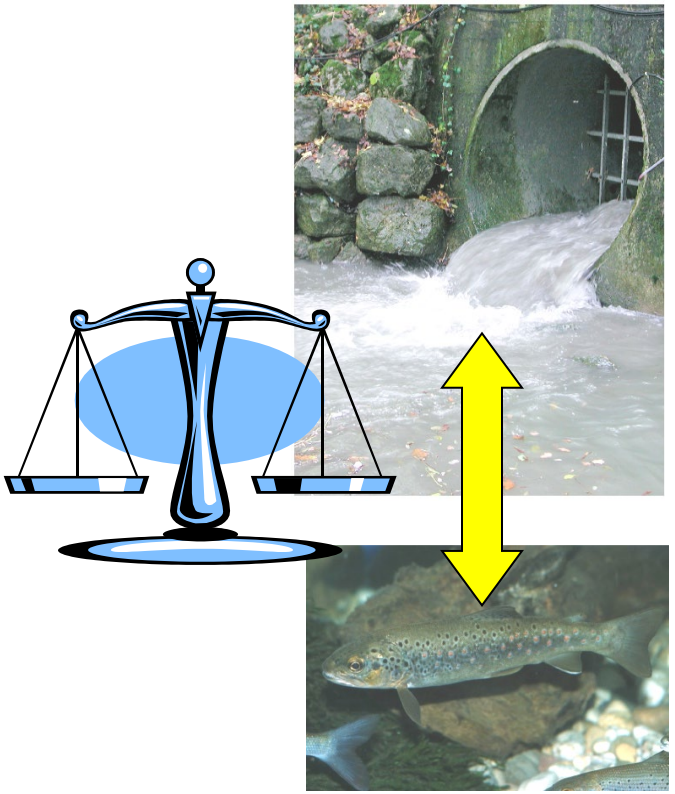
- Definition of the new approach for urban water management
- Take into account the administrative tools for water management in Switzerland and EU (PGEE, PREE, stepwise modular concept, other guidelines...)
- Impact based approach (emissions / immissions)
- Synthesis of numerous studies at international level
- Initiative from the Swiss Federal Office of the Environment / EAWAG
- Applied research project → guidelines

„Immision“ approach: An iterative procedure





Legal requirements: Specific for each country



Legislative instruments

Problem identification:
- **Wet-weather goals**
- **Need of intervention**

Function of local conditions in receiving waters and in sewer system

Collect of information

All information available?

Long-term survey

Definition of local specific goals and criteria

Sort-term Goals reached?

Planning:
- Scenarios
- Prognostics
- Costs and investments

- Project management
- Construction
- Optimization of the system

Legislative instruments

Problem identification:
- Wet-weather goals
- Need of intervention

Collect of information

All information available?

Long-term survey

Sort-term Goals reached?

Definition of local specific goals and criteria

Planning:
- Scenarios
- Prognostics
- Costs and investments

- Project management
- Construction
- Optimization of the system

wet-weather criteria

Time dependent criteria

Legislative instruments

Problem identification:
- Wet-weather goals
- Need of intervention

Collect of information

All information available?

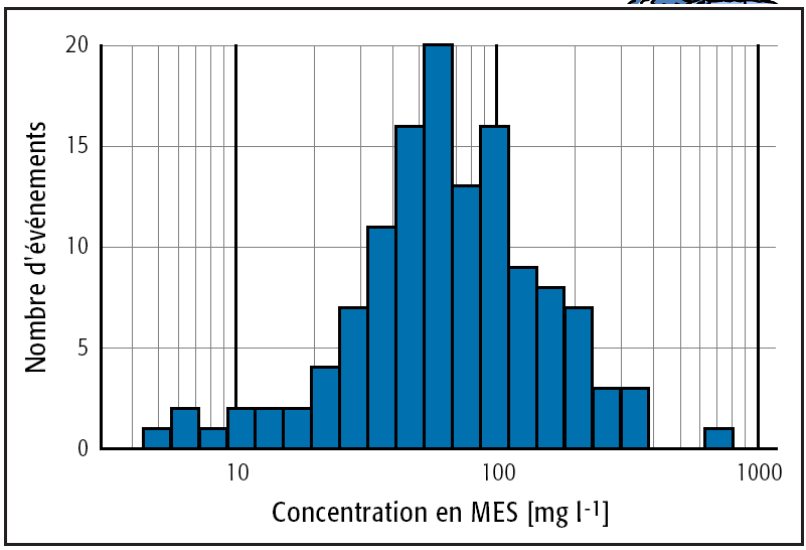
Long-term survey

Definition of local specific goals and criteria

Sort-term Goals reached?

Planning:
- **Scenarios**
- **Prognostics**
- **Costs and investments**

- Project management
- Construction
- Optimization of the system



TSS Concentration (EMCs) at the oulet of separated watersheds

Variability of rain events, uncertainties in parameters: Concentrations, watershed data (number of habitants, imperviousness…), impact assessment…

Stochastic – probabilistic approach

Legislative instruments

Problem identification:
- Wet-weather goals
- Need of intervention

Collect of information

All information available?

Long-term survey

Definition of local specific goals and criteria

Sort-term Goals reached?

Planning:
- Scenarios
- Prognostics
- Costs and investments

- **Project management**
- **Construction**
- **Optimization of the system**

Catalogue of technical solutions: source-control, detention tanks, receiving water management …

Receiving water and technical surveys integrated in the procedure

Legislative instruments

Problem identification:
- Wet-weather goals
- Need of intervention

Collect of information

All information available?

No

Yes

Definition of local specific goals and criteria

Planning:
- Scenarios
- Prognostics
- Costs and investments

- Project management
- Construction
- Optimization of the system

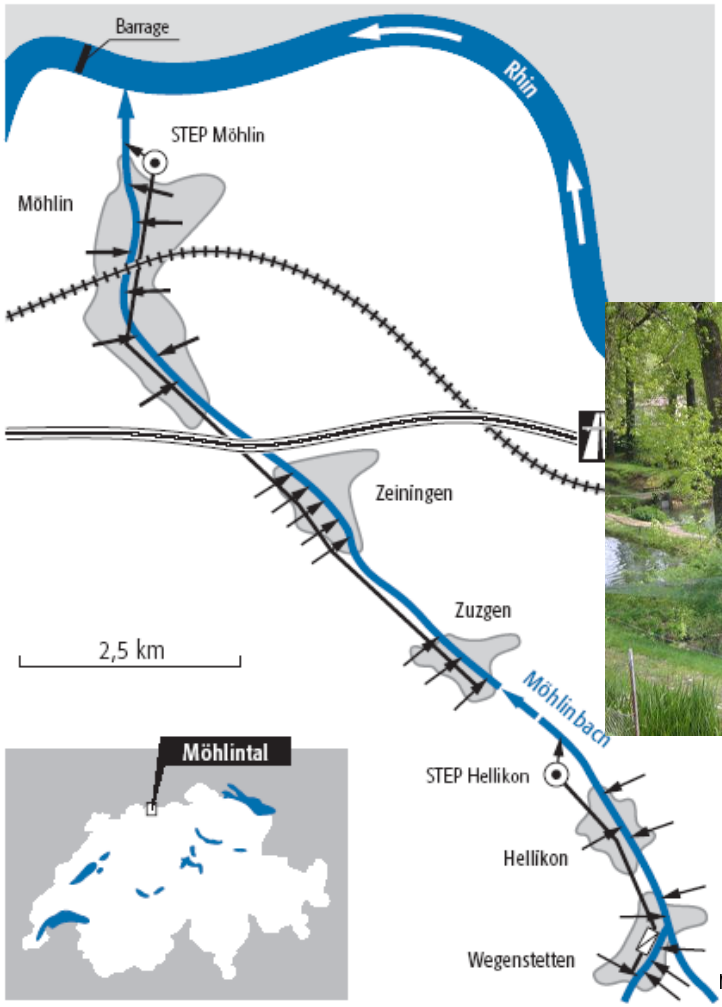
Long-term survey

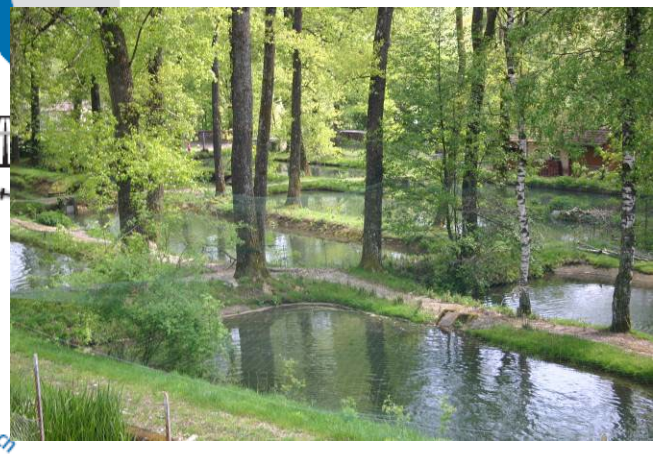
Sort-term Goals reached?

Tools :
VSA Module G / Modular Stepwise Procedure (Swiss) and EU / US approaches

Case studies, example „Möhlinbach“

- Immission approach for a small river
- Comparison old – new approach: ca. 0.8 Mio CHF economy



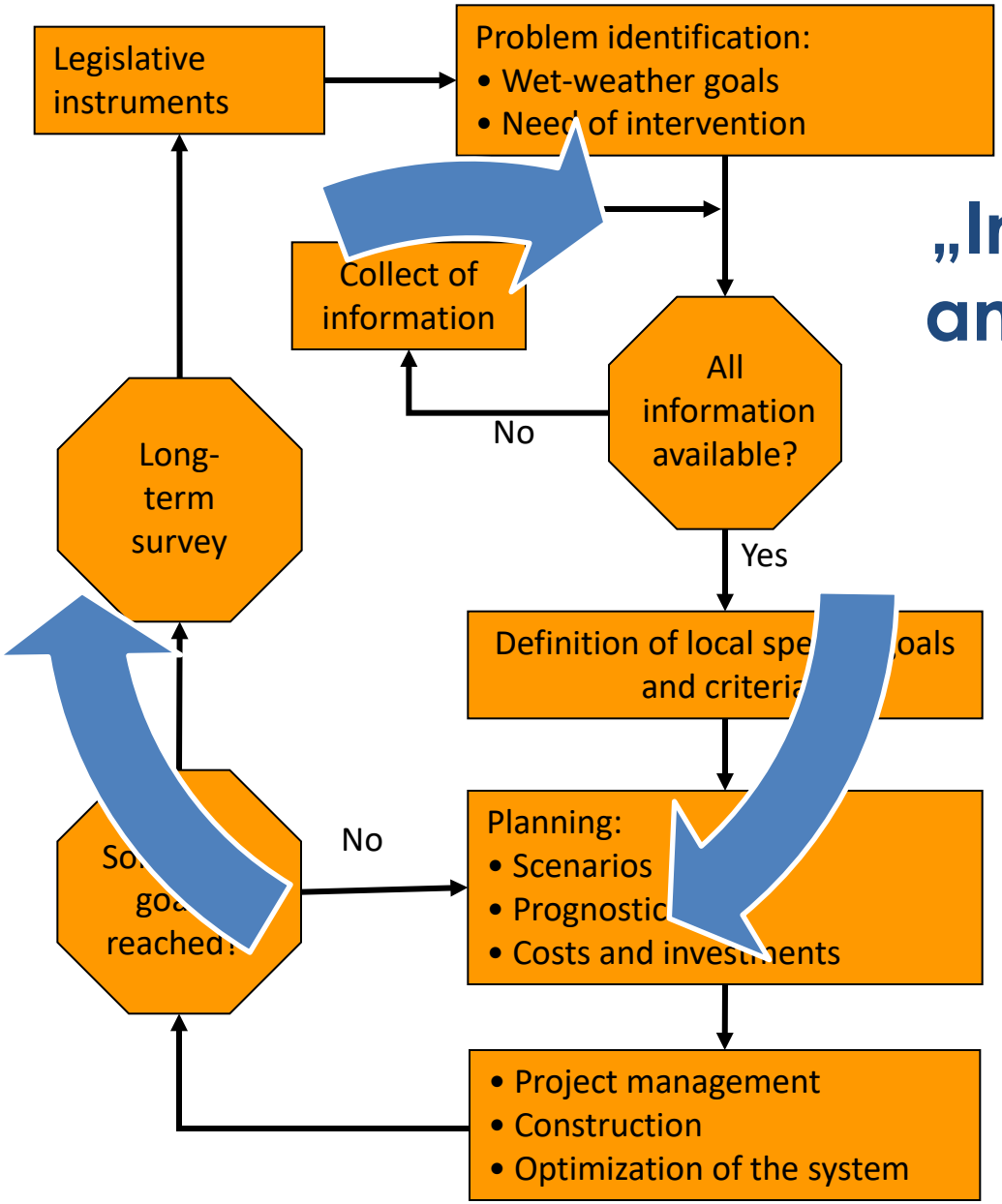


www.gire.ch

5 examples

Perspectives for this class:

- Integrated approach (urban hydrology and receiving water)
- "Immission" approach, link between "engineer" and "biologist" and ….
- New time dependent impact approaches (acute and chronic)
- Uncertainties and variability : new trends in urban hydrology
- Originality in setting up technical solutions
- Survey of projects realization
- New guidelines, inspired by international developments



„Immision“ approach: an iterative procedure

WE NEED YOU

Illustration of the problematic: « Les lacs en danger » 04.06.1964

Duration: 19 min

https://www.rts.ch/play/tv/continents-sans-visa/video/les-lacs-en-danger?urn=urn:rts:video:13235317