Our Technical Toolkit

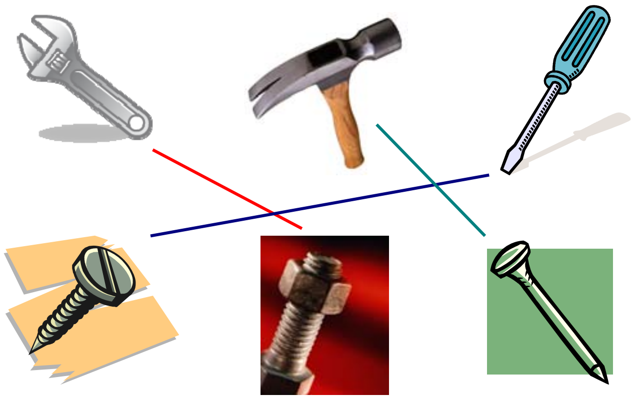
Prof. Janet G. Hering, Director

Eawag: Das Wasserforschungs-Institut des ETH-Bereichs

If you have a hammer,

everything looks like a nail.

Finding the right tool



Define the problem, then choose the tool.

Water and the water environment

ENGINEERED	HUMAN-DOMINATED	HUMAN-INFLUENCED	NATURAL

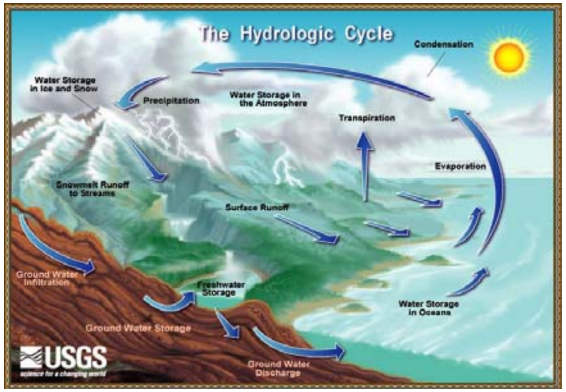
What are the critical issues facing society?

What problems need to be solved?

What are the critical gaps in our understanding of aquatic systems?

What tools are needed to improve our knowledge base and solve key problems?

The hydrologic cycle: greater than humankind?



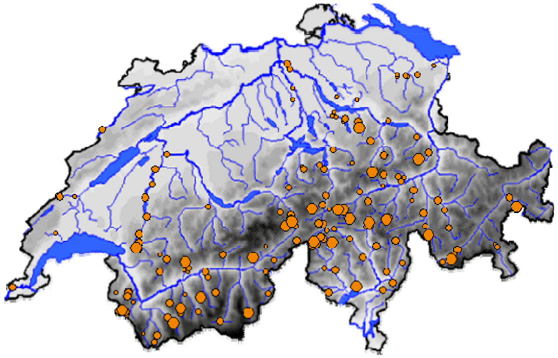
Water as a force of nature

BEFORE

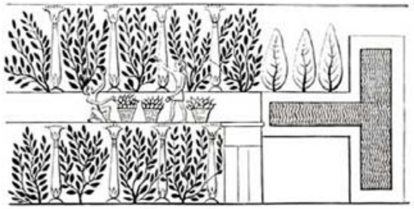
AFTER

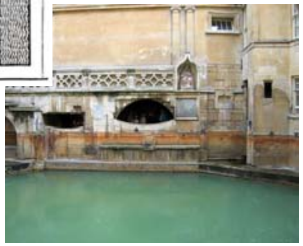
St. Francis Dam failure, March 12-13, 1928
Santa Clarita Valley, California

Human impacts on the waterscape



Water as a basis of civilization





Beneficial uses of water

Population Uses

municipal supply, agricultural supply, industrial process supply, industrial service supply, groundwater recharge, freshwater replenishment, navigation, hydropower generation

Recreation and Commercial Uses

water contact recreation, non-contact water recreation, commercial and sport fishing, aquaculture

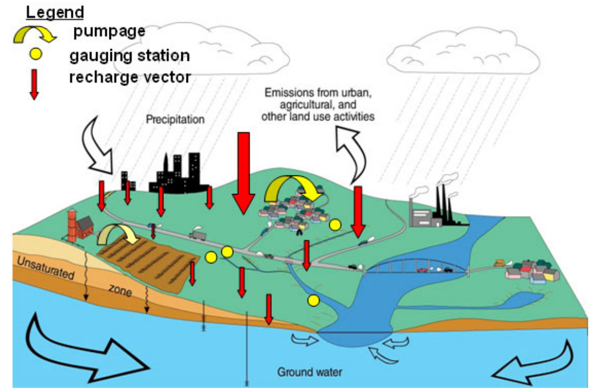
Habitat-Related Uses

warm freshwater, cold freshwater, inland saline water, estuarine, wetland, marine, preservation of biological habitat, rare, threatened or endangered species, migration of aquatic organisms, spawning, reproduction, and/or early development, shellfish harvesting

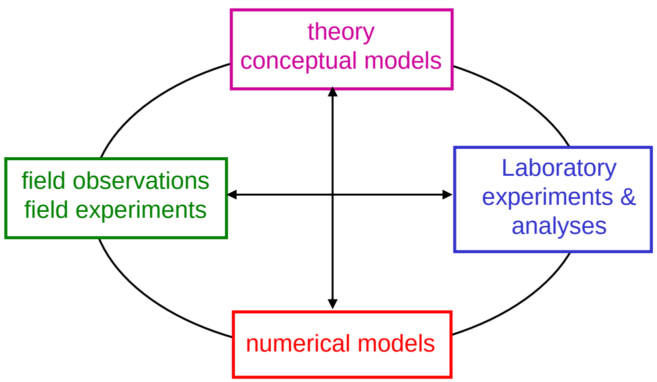
Not officially "beneficial uses"

waste assimilation, sewage conveyance

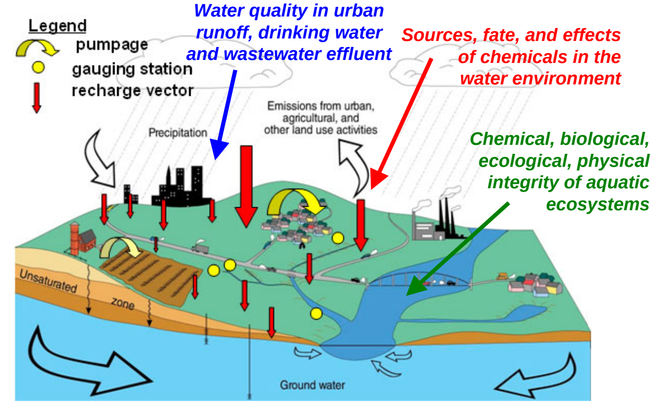
Intersection of human activities and the water environment



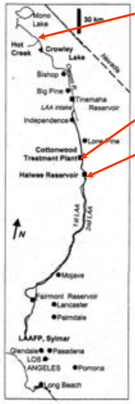
Meta-tools



What are key questions & problems?



Example: Biogeochemistry & engineering practice



Hot Creek: Geothermal source of arsenic
5% water volume, >60% As load

Cottonwood Treatment Plant:
$FeCl_3$ and cationic polymer added to LAA

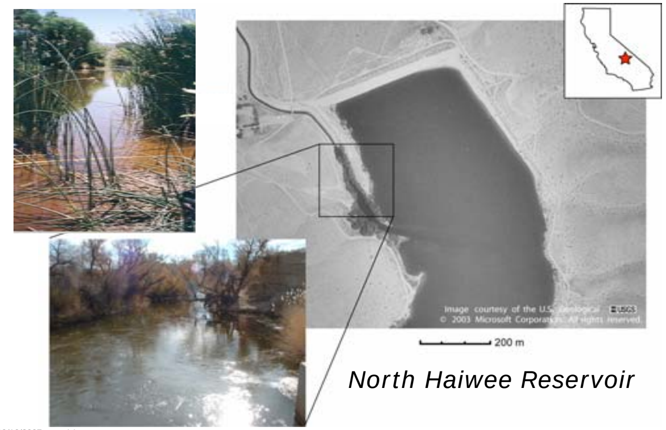
Haiwee Reservoir:
Iron floc removed from LAA by sedimentation

Average conc of As in LAA above Cottonwood:
22-25 µg/L

Average conc of As below Haiwee Reservoir:
5.1-8.3 µg/L

~67% of As deposited In Haiwee Reservoir

Site of arsenic deposition to sediments



Questions

How effectively is arsenic sequestered in the sediments? In what form does arsenic occur in the sediments?

What processes would allow remobilization of arsenic to the overlying water column? What controls the rates of these processes?

How might the sequestration of arsenic in the sediments change over time? What would be the effect of rare, extreme events (e.g., large earthquakes)?

What is the long-term sustainability of arsenic sequestration? How will the system respond if the ferric chloride dosing is discontinued?

Research approaches (i.e., tools)

Sediment and *in situ* porewater sampling

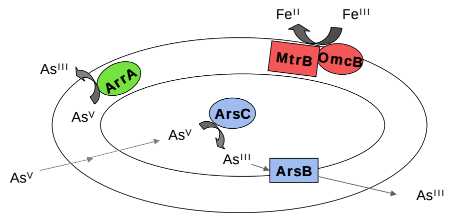
Spectroscopic examination of sediments

Laboratory studies of arsenic sorption

Laboratory studies of microbial As(V) and Fe(III) reduction

Identification of functional genes for As(V) reduction in environmental samples

As(V) and Fe(III) reduction by microbes

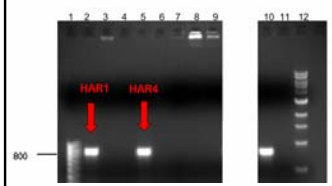


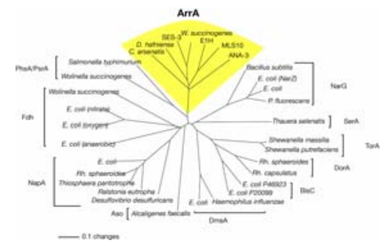
ArrA — **As Respiration**

ArsC / ArsB — **As Detoxification**

MtrB OmcB — **Fe Reduction**

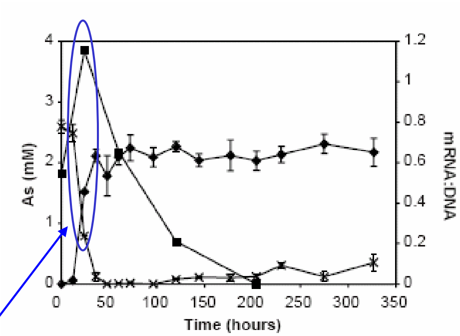
Detection of ArrA gene in the laboratory





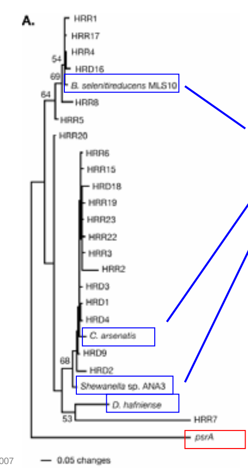
Detection of ArrA by PCR in isolate from Haiwee Reservoir

Expression of ArrA genes during As(V) reduction by *Shewanella* sp. strain ANA-3



Peak in ArrA expression corresponds to maximal As(V) reduction

Detection of ArrA gene in field samples

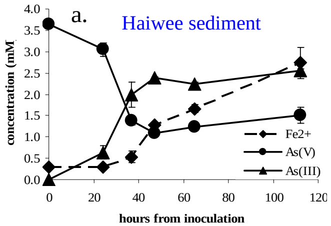


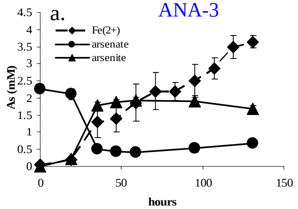
known functional sequences of ArrA

Presence of ArrA demonstrates respiratory As(V) reduction

polysulfide reductase

Preferential microbial reduction: As(V) vs. Fe(III)





HFO = 2 g/L, 0.002 mol As(V):mol Fe, pH =7.2, 19 mM lactate

HFO = 2.8 g/L, 0.001 mol As(V):mol Fe, pH =8.0, 14 mM lactate

In Haiwee sediments, As(V) reduction precedes Fe(III) reduction. With ANA-3, both proceed simultaneously.

Note: NO measurable dissolved As or Fe in these experiments.

Lessons learned

The ambient microbal community in the sediments is capable of As(V) reduction.

The ambient supply of organic carbon is sufficient to support this process.

As(V) reduction, *per se*, is insuficient to cause As mobilization (data not shown),

As mobilization is linked to Fe reduction and competition with phosphate for sorption sites on sediments (data not shown).

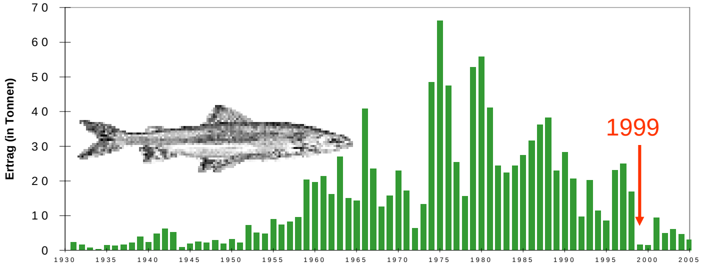
Example: Lake Brienz

Problem statement

- Collapse of (i) whitefish catches and (ii) *Daphnia* in 1999/2000
- Long standing conflicts over role of hydropower and pump-storage operations since 1980

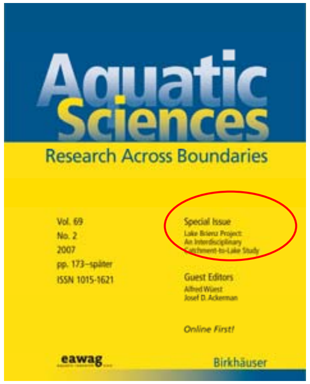
Objectives

- Determine causes of fisheries decline and possible management strategies to address problem



Lake Brienz: Conclusions

Oligotrophication plays a major role in fish decline



Example: Ecotoxicological test battery

Problem statement
>100‘000 organic micropollutants in surface waters and unknown mixture effects trigger need for effect-oriented sum parameters

Objectives
Development of a modular, low-cost, high-throughput and robust ecotoxicological test battery for water quality assessment and process monitoring (e.g. wastewater treatment efficiency)

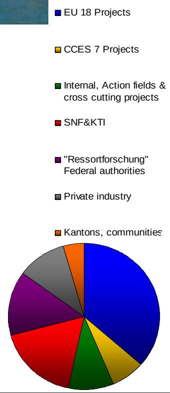
Outcomes
Test battery validated and ready for field applications

Statistics (2006)

Personnel
- 4 Full Professors (3 at ETHZ)
- 13 Adjunct Professors
- 155 Research Staff

Student supervision
- 107 PhD students
- 104 MS students

Publications, Spin-offs, External Funding
- publications: 194 ISI, 49 non-ISI
- 1 spin-off
- 13.5M CHF third-party funding



http://www.forumchriesbach.eawag.ch/dokumente/FC-Konzept_e.pdf

Organization and Focus Areas

Focus Areas

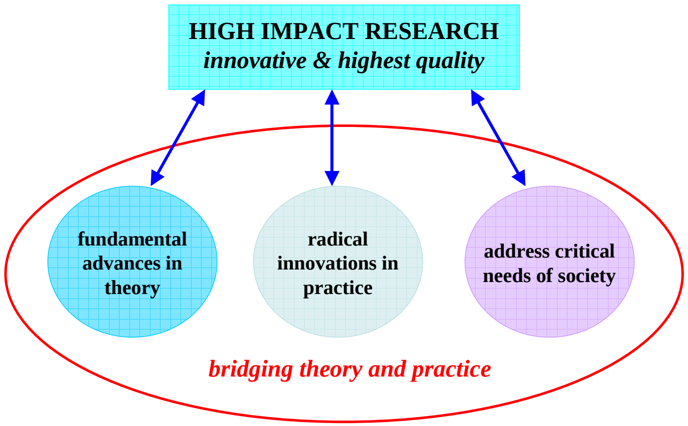
Aquatic ecosystems

Chemicals & effects

Urban water systems

Transdisciplinary activities

Bridging theory and practice



Come visit us!!!

Eawag, Überlandstrasse 133, 8600 Dübendorf, Phone 044 823 55 11, info@eawag.ch, www.eawag.ch