

Demonstrator 6: **SEDMIX**

Controlled fine sediment release through the power waterways by using a mixing device

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In cooperation with the CTI



Energy

Swiss Competence Centers for Energy Research



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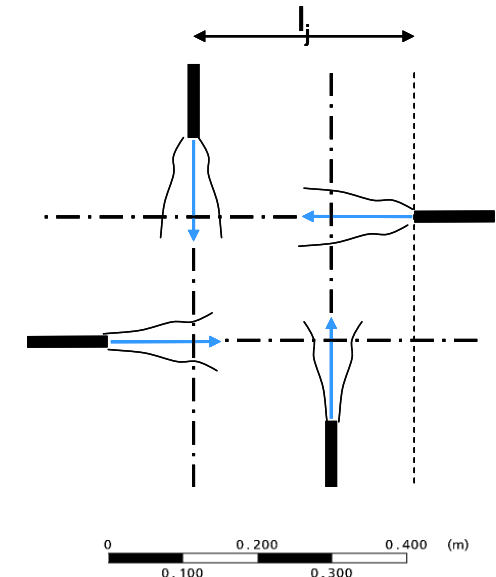
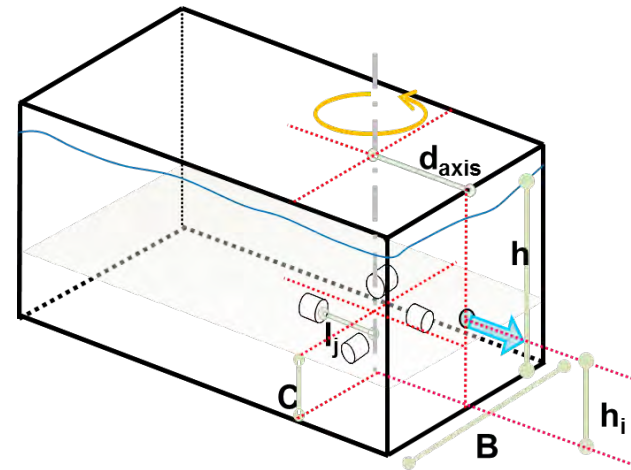
Reservoir sedimentation: *A problem of today*

SEDMIX: Innovative mitigation measure

(Thesis Jolanda Jenzer-Althaus, 2011)

Stirring device:

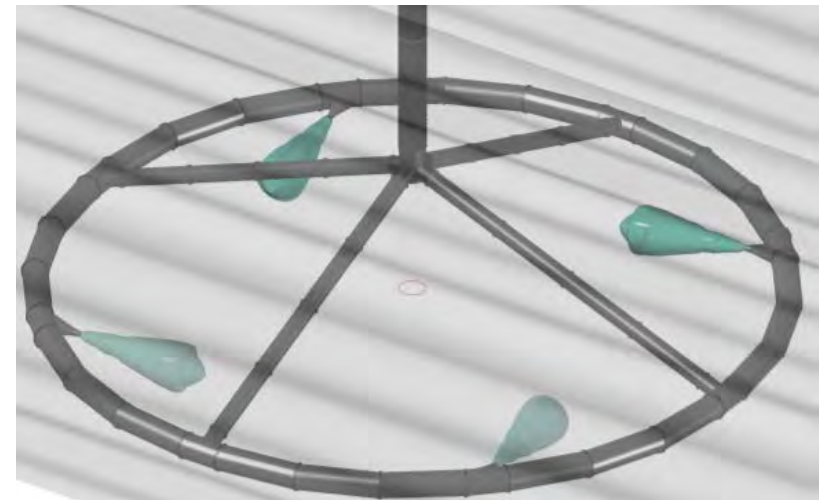
- 4 perpendicular water jets
- Induce sufficient up wind vortex
- During HPP operation



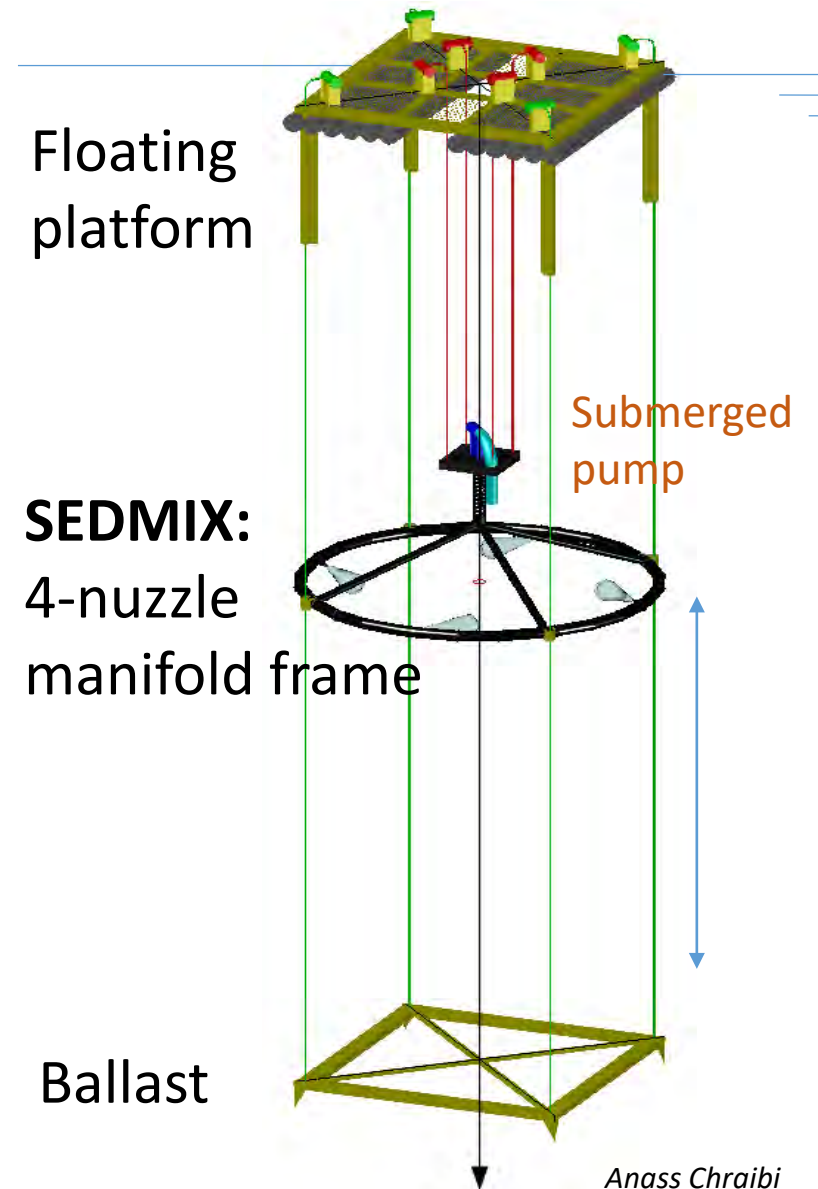
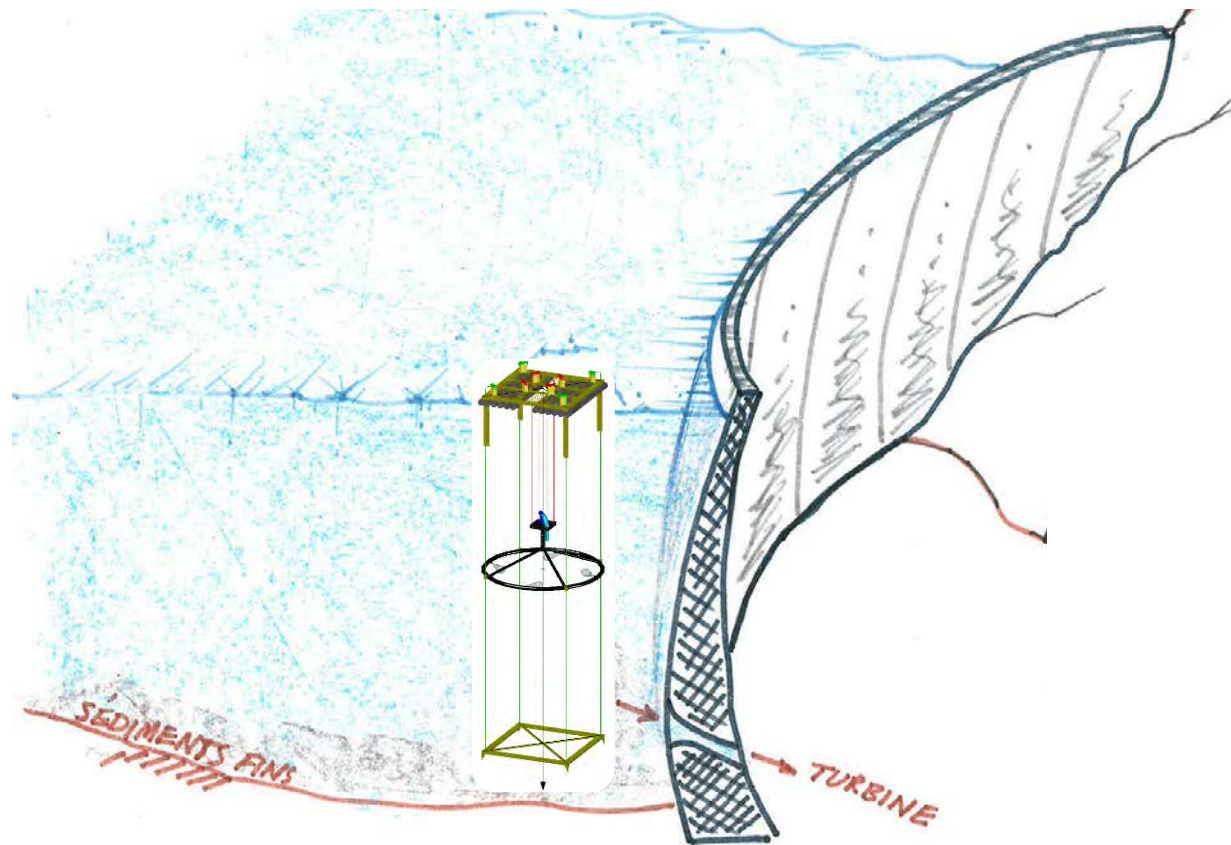
Test with a
model in the
laboratory



Tests with
prototype in
dam sites

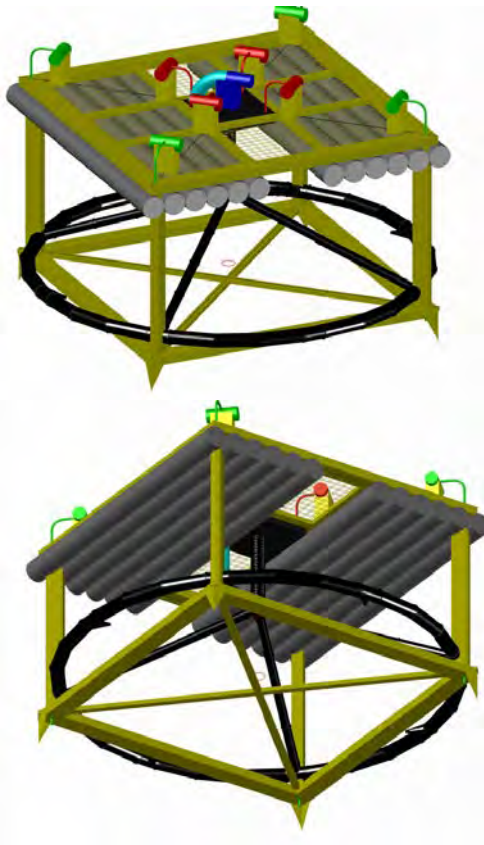


SEDMIX device: How does it function?

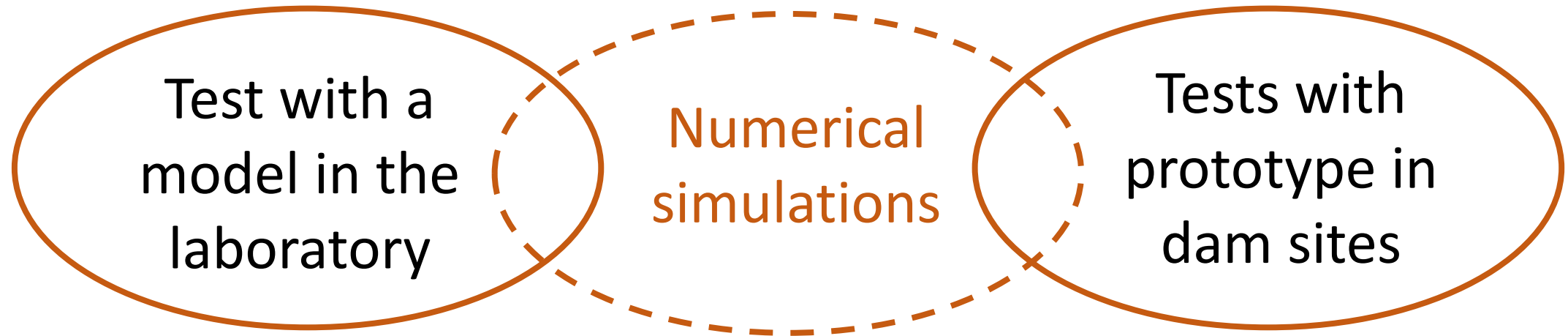


Anass Chraibi

SEDMIX device: How is it going to be installed?



SEDMIX device: Where to place it?



Numerical simulation of SEDMIX device



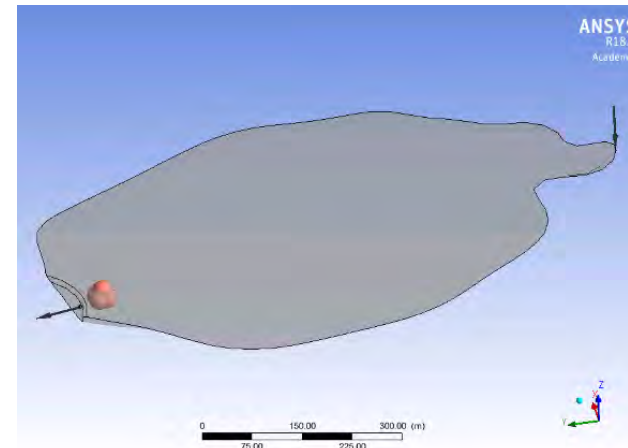
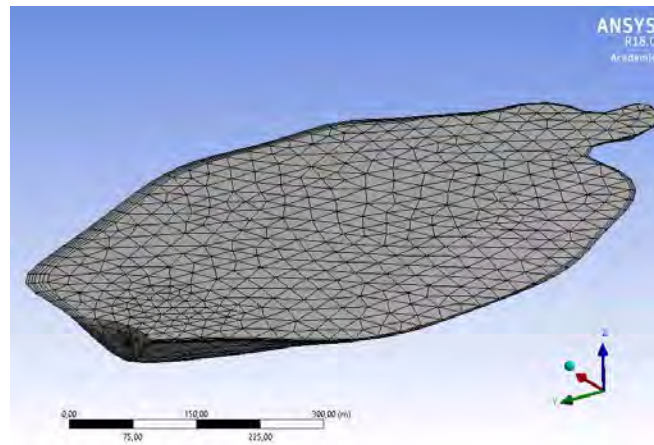
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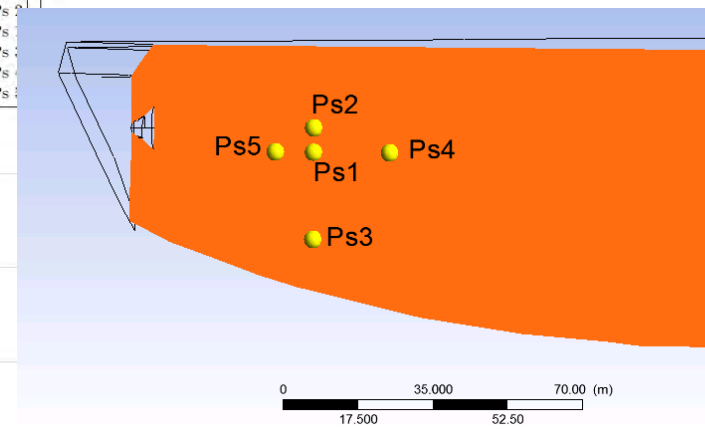
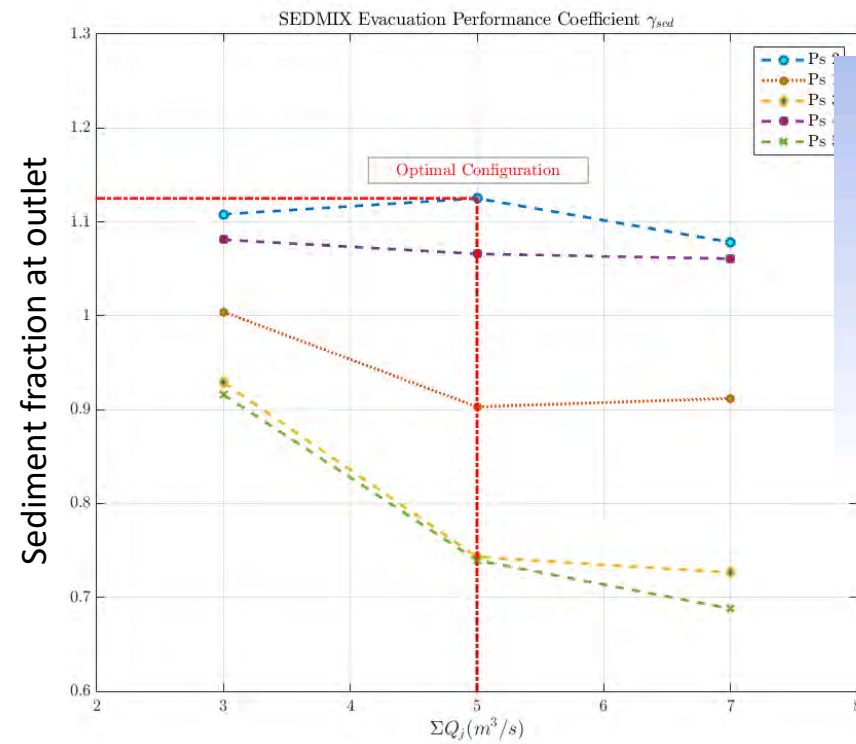
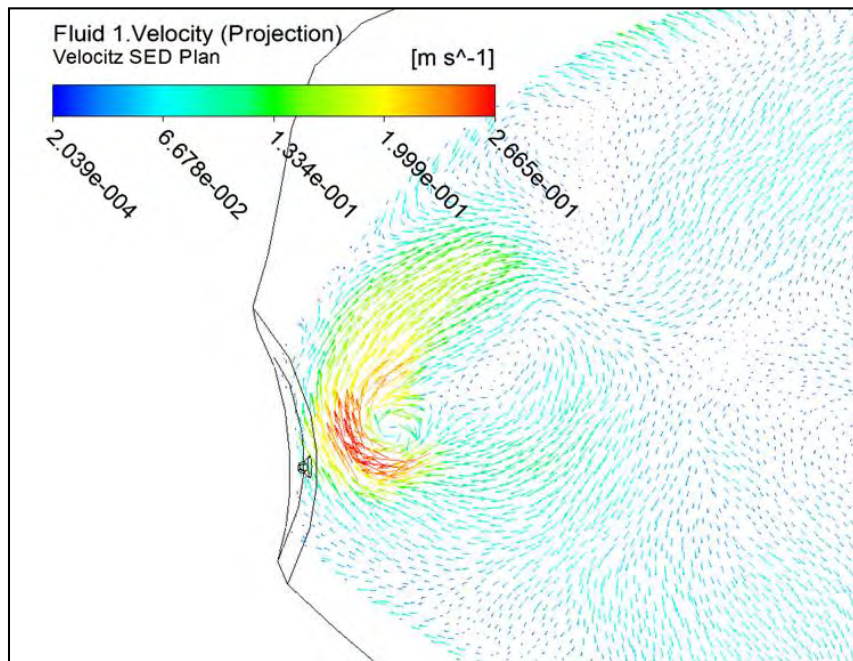
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202?

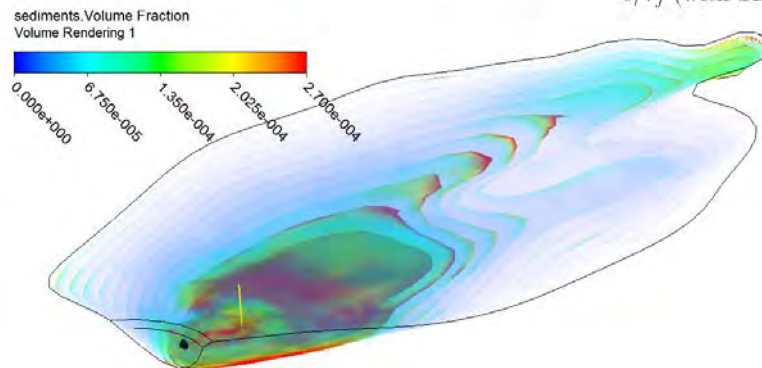
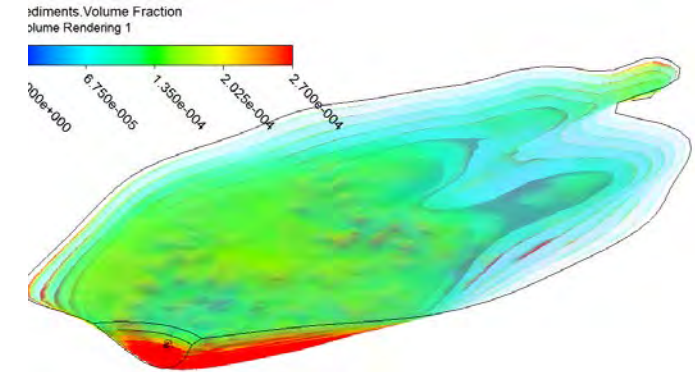
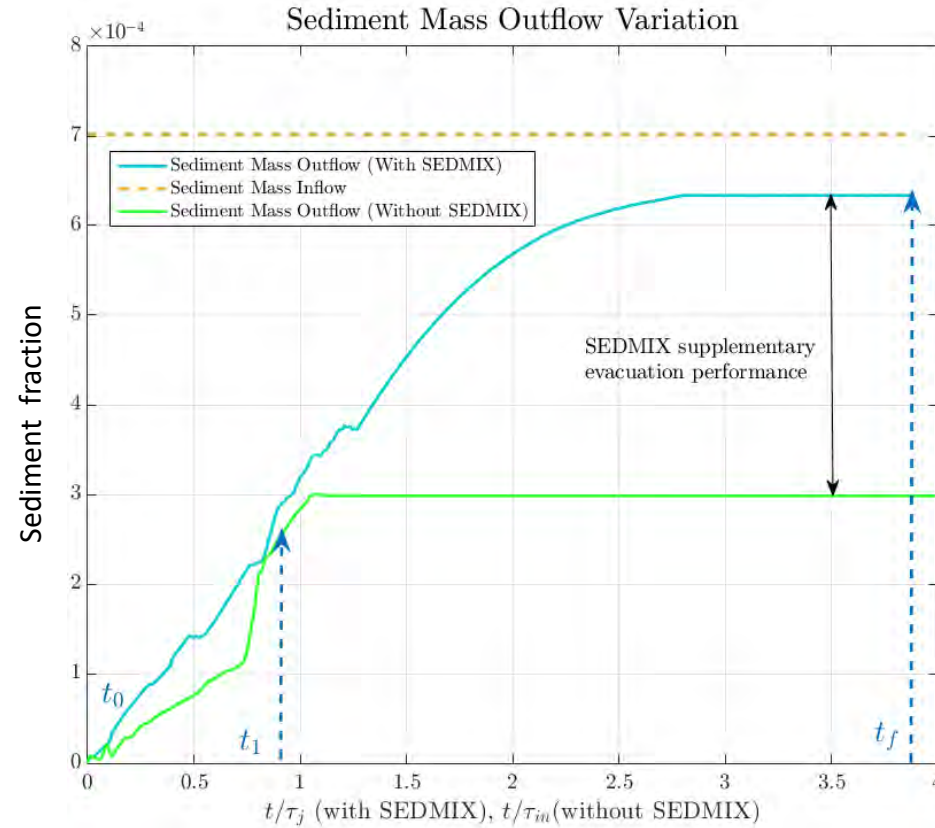


Selected results



Selected results

Q_{in} constant
 C_{in} constant
 Q_{out} constant



WP1: Design, operation and logistics of the demonstrator

WP2: Catchment area monitoring

WP3: Evaluation of reservoir hydrodynamics and **device performance**

WP4: Turbine monitoring

WP5: Ecologic & Ecomorphology monitoring

Current partners: EPFL-PL-LCH, HES-So Vallais, ETHZ-VAW, ETHZ-IF, HSLU, HES Wädenswil

Industrial partners: Hydropower Plant owners

THANK YOU!

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Scaling up and specifying a stirring device (SEDMIX) from laboratory to prototype

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Introduction

Sedimentation is a key challenge in reservoir management. A recent PhD study at EPFL (Jenzer-Althaus, 2011) proposed an innovative system called SEDMIX (Figure 1) allowing to keep in suspension or evacuate the fine particles near the dam. The current project's aim is to develop a real-scale prototype of SEDMIX device. It is equipped with 4-nozzle pressurized water jets inducing sufficient upward turbulence to maintain in sediments in suspension.

The work encompasses the following aspects:

- Hydraulic and structural design as well as technical specification of the device
- Installation procedure

Up-Scaling

- To quantify a similar efficiency as in the hydraulic model, the scaling factor (λ) used to design a mechanical SEDMIX should satisfy two conditions:
 - Friction similarity, expressed by a relationship between the jet discharge used in the test and those of the real case.
 - The propulsion velocity compared to the settling velocity should at least be the same as in test conditions.
- SEDMIX would be supplied either with a pump or directly connected to a water conveying tunnel which transfers water from a neighbouring catchment.
- For the presented prototype, a total jet discharge of 3 m³/s is considered. This leads to a scaling factor of $\lambda = 10$.

Design

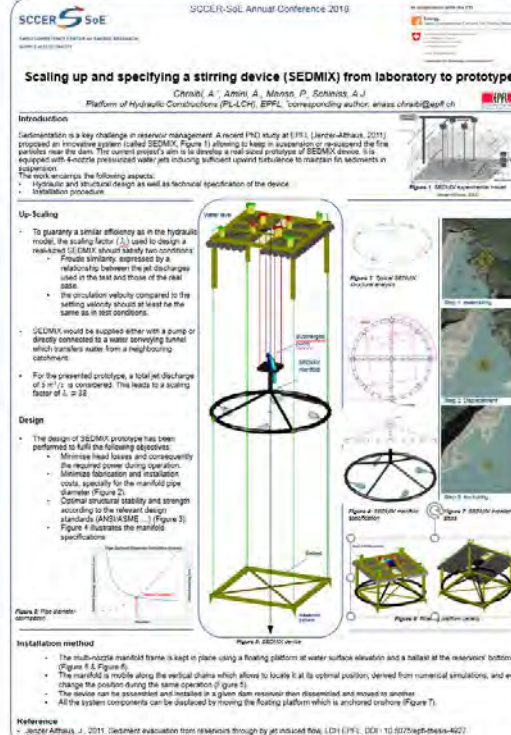
- The design of SEDMIX prototype has been performed to fulfil the following objectives:
 - Minimize head losses and consequently the required power during operation.
 - Minimize fabrication and installation costs, specially for the manifold pipe skimmer (Figure 2).
 - Optimal structural stability and strength according to the relevant design standards (ANSI/ASME - I) (Figure 3).
 - Figure 4 illustrates the manifold specifications.

Installation method

- The multi-nozzle manifold frame is kept in place using a floating platform at water surface elevation and a ballast at the reservoir's bottom (Figure 5 & Figure 6).
- The manifold is movable along the vertical plane which allows to locate it at its optimal position, derived from numerical simulations, and even change the position during the same operation (Figure 4).
- The device can be disassembled and reassembled in a given time reservoir when dismantled and moved to another.
- All the system components can be displaced by moving the floating platform which is anchored to the reservoir (Figure 7).

Reference

Jenzer-Althaus, J. (2011). Sediment evacuation from reservoirs through jet-induced flow. PhD (EPFL). DOI: 10.5075/epflthesis-4027



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Computational Modelling of an Innovative Water Stirring Device for Fine Sediment Release: The test case of the Future Trift Reservoir

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Introduction

- This work is part of a development project which aims to carry out an innovative system (SEDMIX) allowing to keep in suspension or evacuate the fine particles near the dam. With its 4-nozzle pressurized water jets, SEDMIX is expected to induce sufficient upward turbulence to maintain fine sediments in suspension.
- The aim of this part is to analyse the performance of a scaled SEDMIX operating in the future Trift reservoir (Figure 1) via numerical analyses. This study allows to validate or to improve SEDMIX optimal configuration experimentally determined in a recent PhD study at EPFL (Jenzer-Althaus, 2011).

Methodology

The numerical simulations were performed with ANSYS-CFX v15.0 on two different positions for the SEDMIX device (Figure 4). Steady state simulations as well as transient simulations were computed for the same boundary conditions, namely, the mass flow rate for the inlet ($Q_{in} = 22027 \text{ kg/s}$), the static pressure for the outlet ($p_{out} = 2 \text{ Pa}$) and 4 source points (SEDMIX jets) with specific discharge and directions (1 source point with negative discharge (downward SEDMIX jet) (Figure 1)). All the simulations are multiphase since they include sediment ($D_s = 0.1 \text{ mm}$, $\rho_s = 2650 \text{ kg/m}^3$, $C_s = 0.7 \text{ g/l}$). The chosen turbulence model was the $k-\epsilon$ model combined with inhomogeneous Boussinesq model. The performance of SEDMIX in each position has been evaluated and tested for different jet discharges.

Results

Analysis of the numerical simulation results has shown:

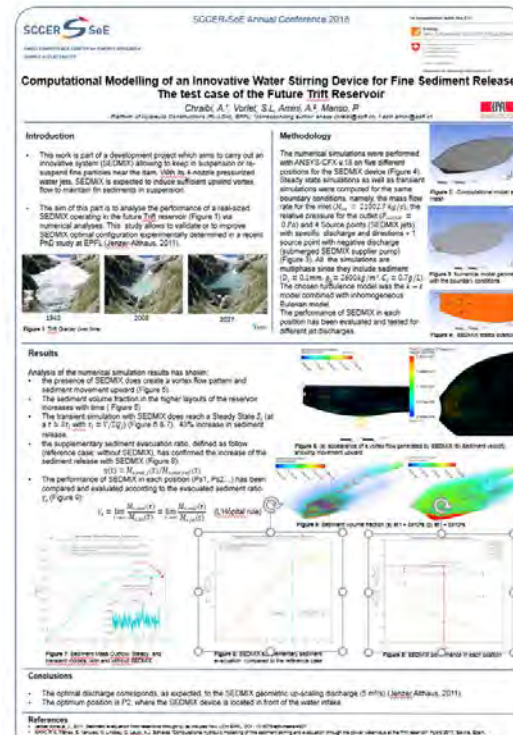
- The presence of SEDMIX jets create a vortex flow pattern and sediment movement upward (Figure 5).
- The sediment volume fraction at the higher layers of the reservoir increases with time (Figure 6).
- The transient simulation with SEDMIX does reach a Steady State 2, (at a t_{ss} with $t_{ss} = 1.7 \cdot (D_s^2 / g)$) (Figure 6 & 7). 40% increase in sediment release.
- The supplementary sediment evacuation ratio, defined as follow (reference case without SEDMIX (Figure 6))
- The performance of SEDMIX in each position (P1, P2...) has been compared and evaluated according to the expected sediment ratio r_s (Figure 8)

Conclusions

- The optimal discharge corresponds, as expected, to the SEDMIX geometric up-scaling discharge (5 m³/s) (Jenzer-Althaus, 2011).
- The optimum position is a P2, where the SEDMIX device is located in front of the water intake.

References

Jenzer-Althaus, J. (2011). Sediment evacuation from reservoirs through jet-induced flow. PhD (EPFL). DOI: 10.5075/epflthesis-4027



- Jenzer-Althaus J., De Cesare G., & Schleiss A. J. (2014). Sediment evacuation from reservoirs through intakes by jet-induced flow. Journal of Hydraulic Engineering, 141 (2)
- Jenzer-Althaus J., De Cesare G., & Schleiss A. J. (2016). Release of suspension particles from a prismatic tank by multiple jet arrangements. Chemical Engineering Science, 144, 153–164.
- Amini A., Manso P., Lindsey N., Venuelo S. & Schleiss A. J. (submitted to Hydro 2017 conference, Spain). Computational hydraulic modelling of the sediment stirring and evacuation through the power waterways at the Trift reservoir.