

MARSEILLE
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AU 3 JUIN
2022



ICOLD
27TH CONGRESS
90TH ANNUAL
MEETING



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27^{ÈME} CONGRÈS
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ANNUELLE



Special Sessions

Workshop «LANDSLIDE-GENERATED IMPULSE WAVES IN RESERVOIRS»

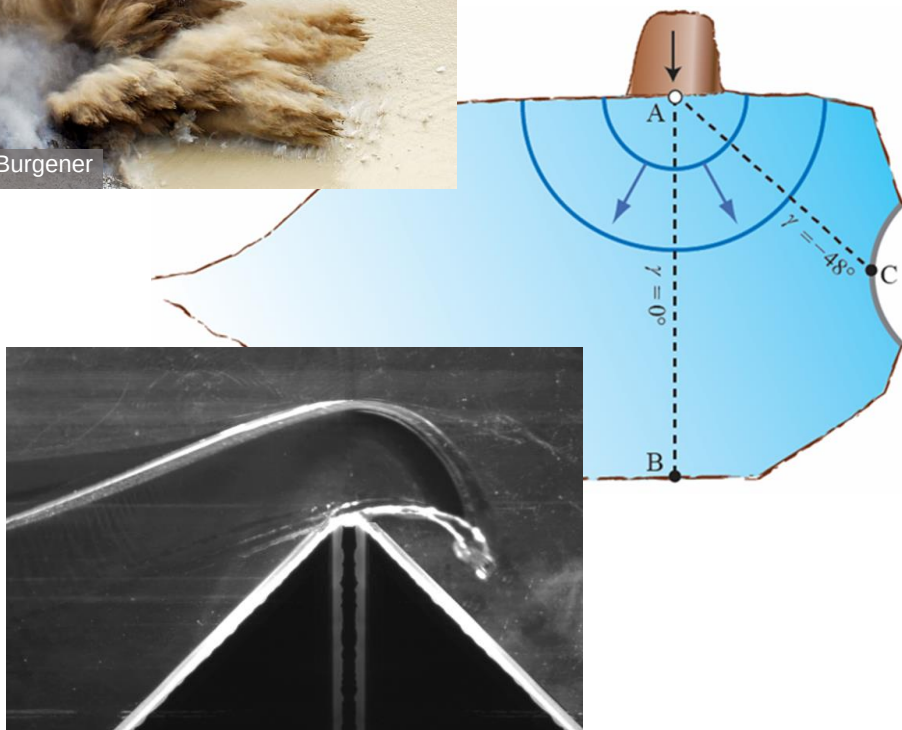
Introduction: Dam Safety and Updated Impulse Waves Manual

Robert Boes
Swiss Committee on Dams | ETH Zurich

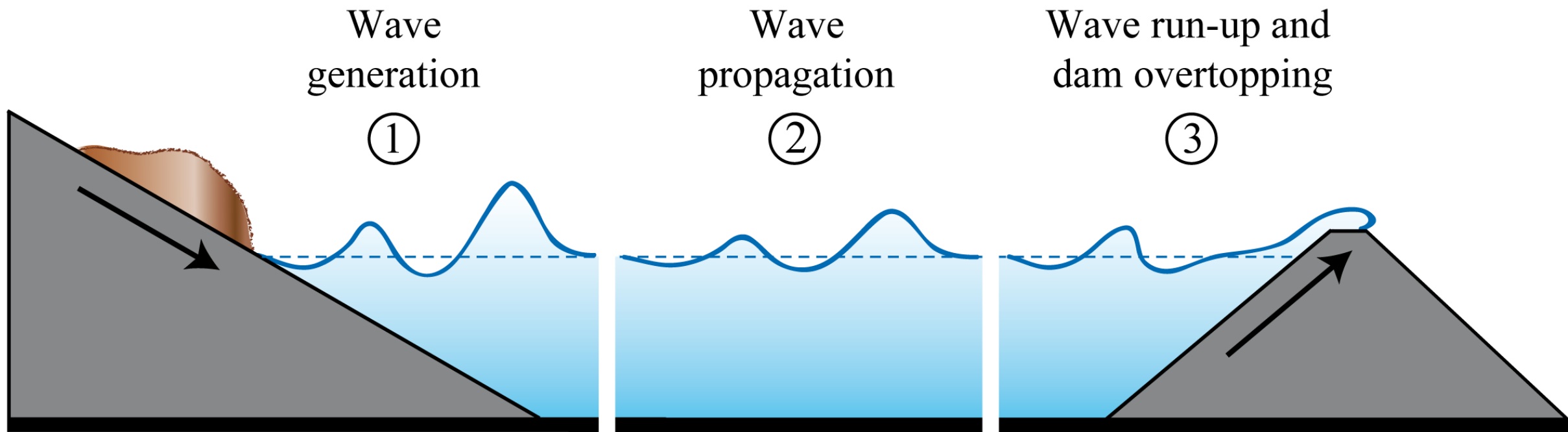


Outline

- Impulse Waves & Dam Safety
- Assessment Methods
- Research Advances (at VAW)
- Updated Impulse Waves Manual



Landslide-generated Impulse Waves



08-01-2022 10:30:05 Sat

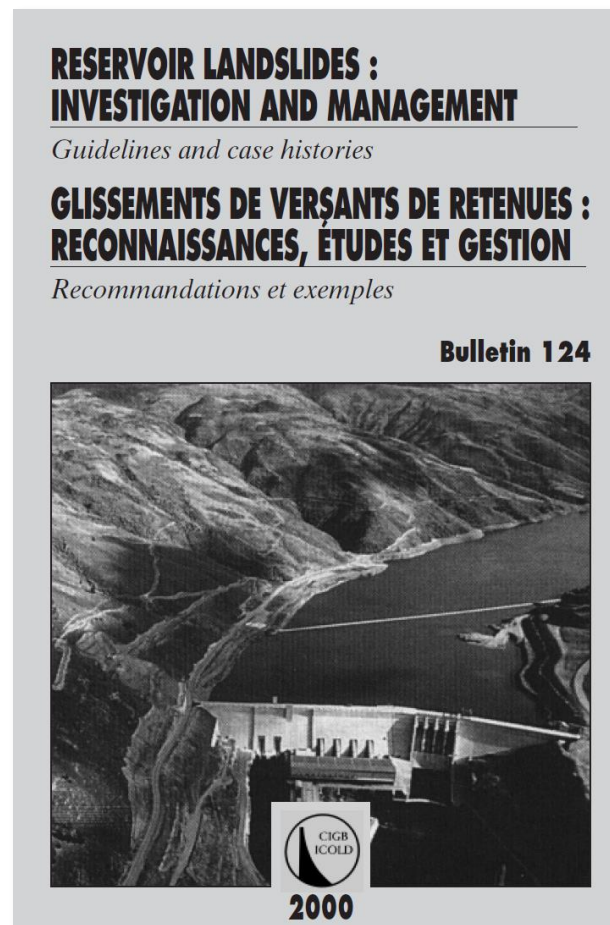


Pau Branco Mine, January 8, 2022



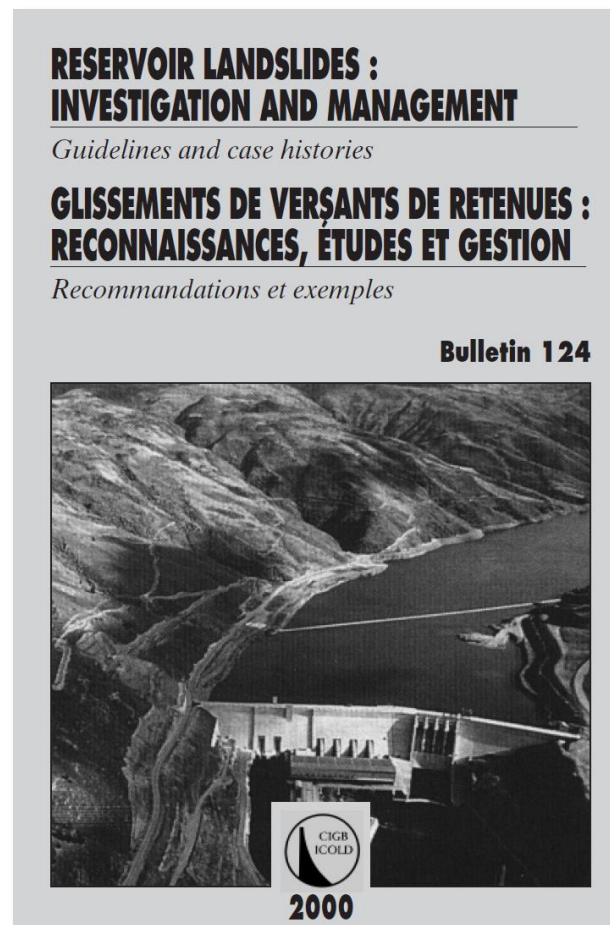
Bulletin 124 – Content (Selection)

- Geological and Geotechnical Investigation
- Slope Assessment and Analysis
- Impulse Waves and Valley Blockage
- Risk Management
- Risk Mitigation
- Monitoring



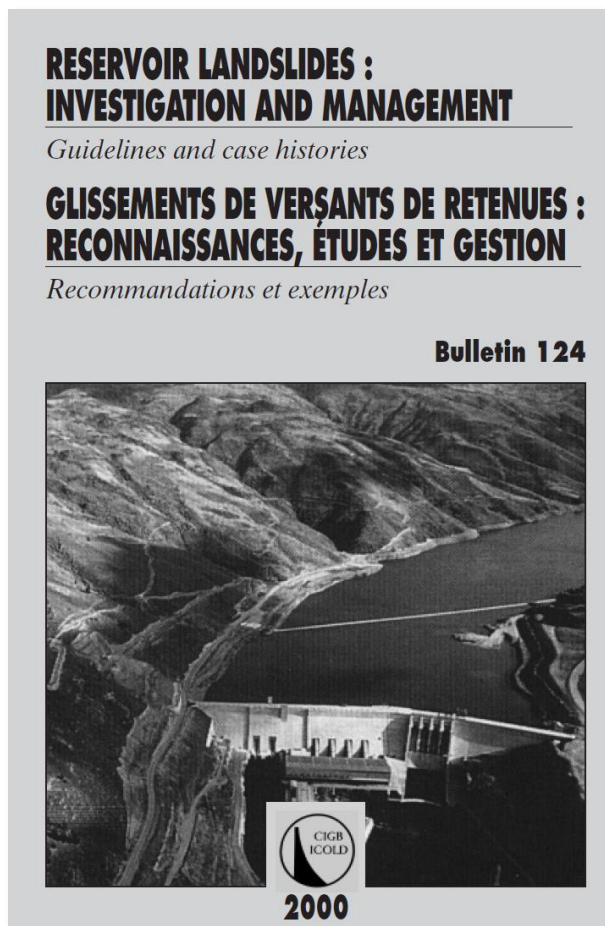
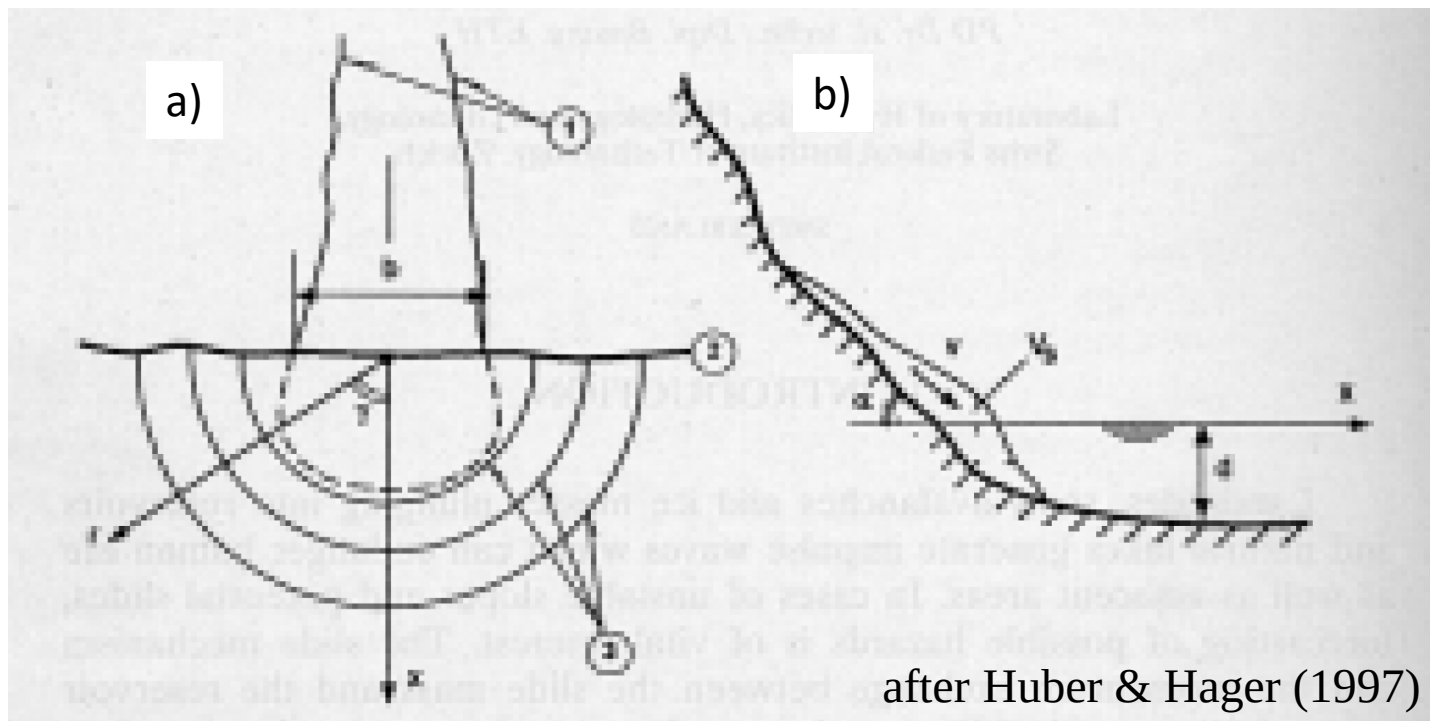
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Bulletin 124 – Content (Selection)

- Impulse Waves and Valley Blockage



Impulse Wave Assessment Methods

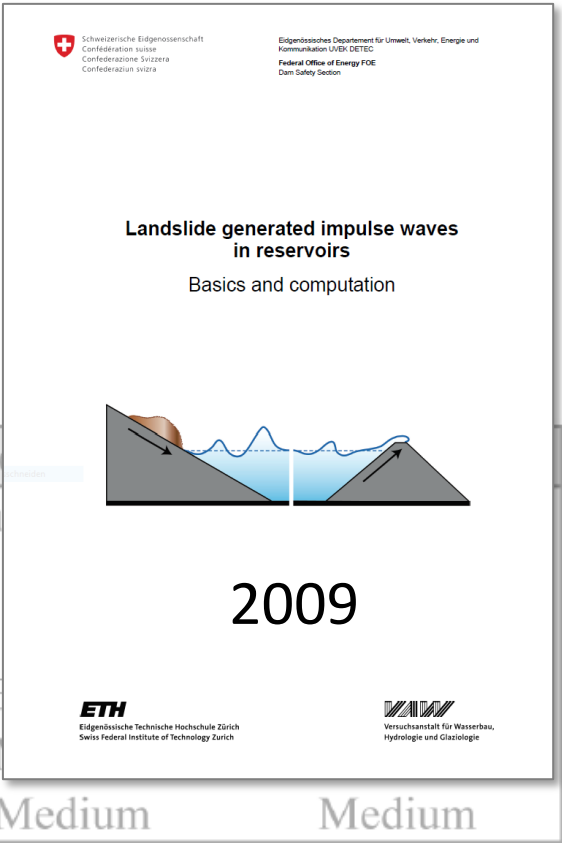
- (i) Generally applicable equations from model tests
- (ii) Prototype-specific model tests
- (iii) Numerical simulations
- (iv) Empirical equations from field data
- (v) Analytical investigations

Criterion	Method (i)	Method (ii)	Method (iii)	Method (iv)	Method (v)
Quality of results	Estimation	Exact	Estimation - exact	Rough estimate	Rough estimate
Time requirement	Low	Very high	High - very high	Low	Low
Cost	Low	Very high	High - very high	Low	Low
User	Engineer	Engineer	Expert	Engineer	Engineer
Clarity	Medium	High	Low	Medium	Low
Effort for governing parameters	Medium	High	High	Medium	Medium



Impulse Wave Assessment Methods

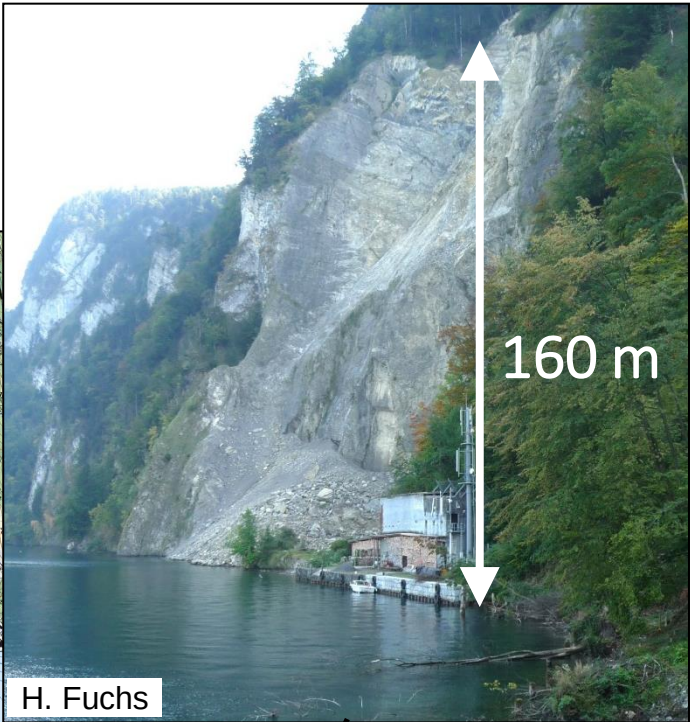
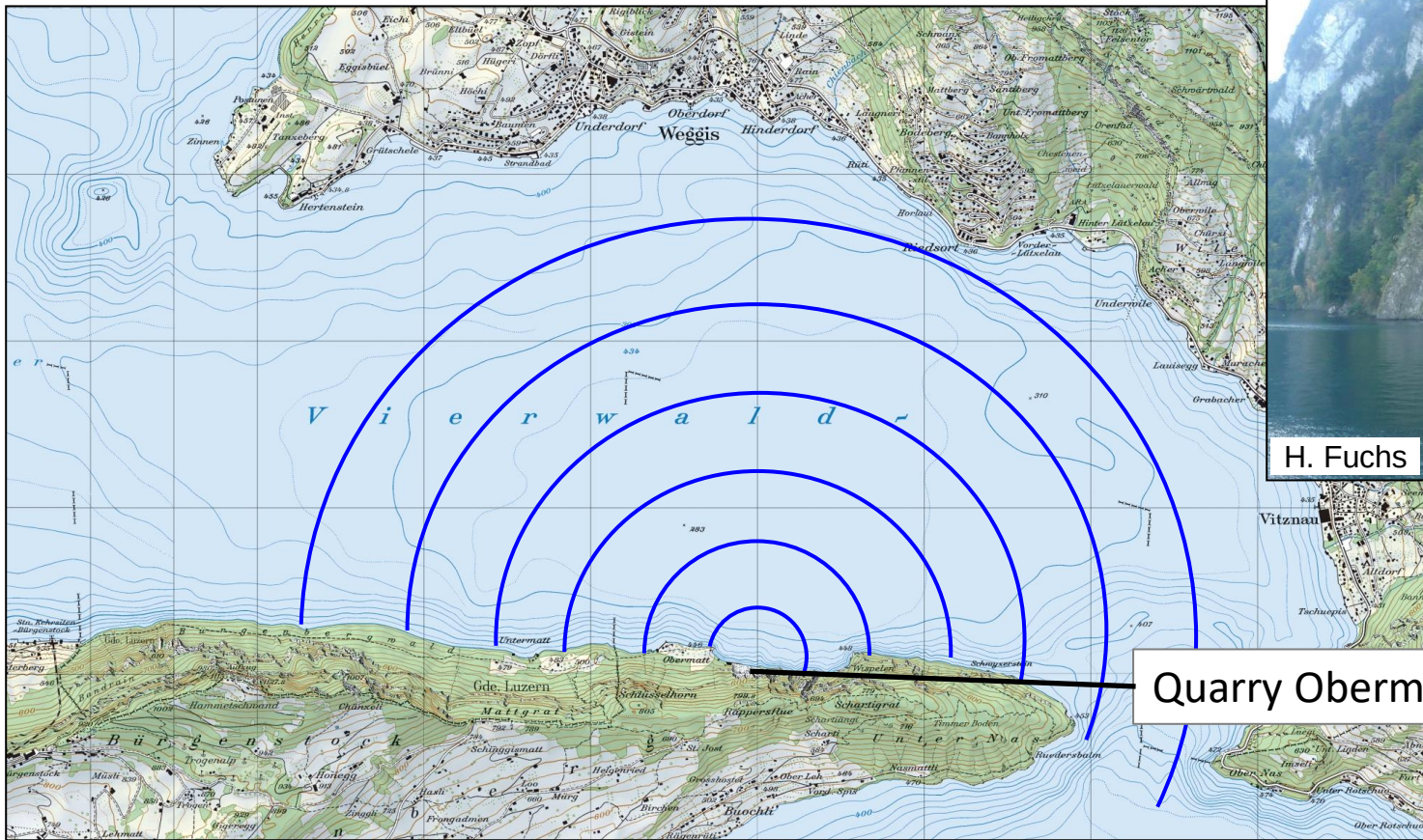
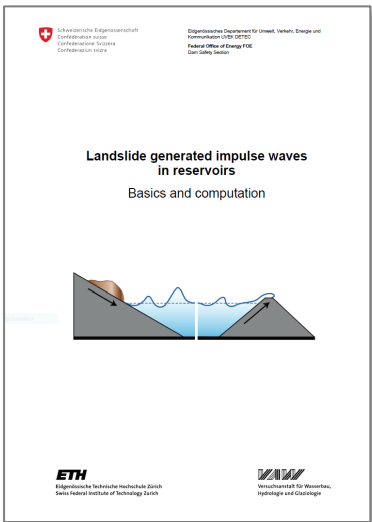
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Criterion	Method (i)	Method (ii)	Method (iii)	Method (iv)	Method (v)
Quality of results	Estimation	Exact	Estimation - exact	Estimation	Rough
Time requirement	Low	Very high	High - very high	High - very high	High - very high
Cost	Low	Very high	High - very high	High - very high	High - very high
User	Engineer	Engineer	Expert	Expert	Expert
Clarity	Medium	High	Low	Low	Low
Effort for governing parameters	Medium	High	High	Medium	Medium



Example: Lake Lucerne

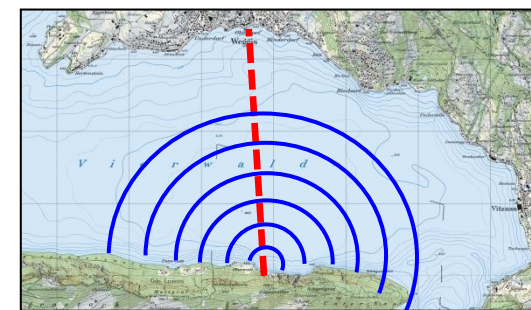


H. Fuchs

Quarry Obermatt

Impulse wave events:
1963, 1964, 2007





Example: Trift Reservoir

Hazards:

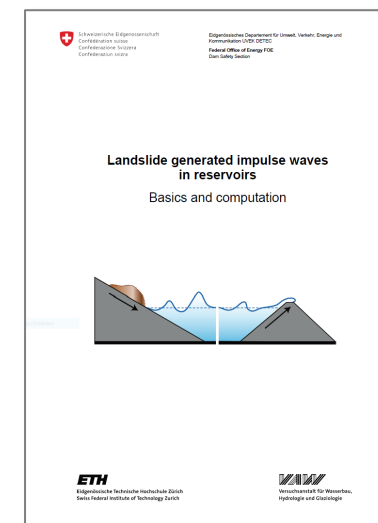
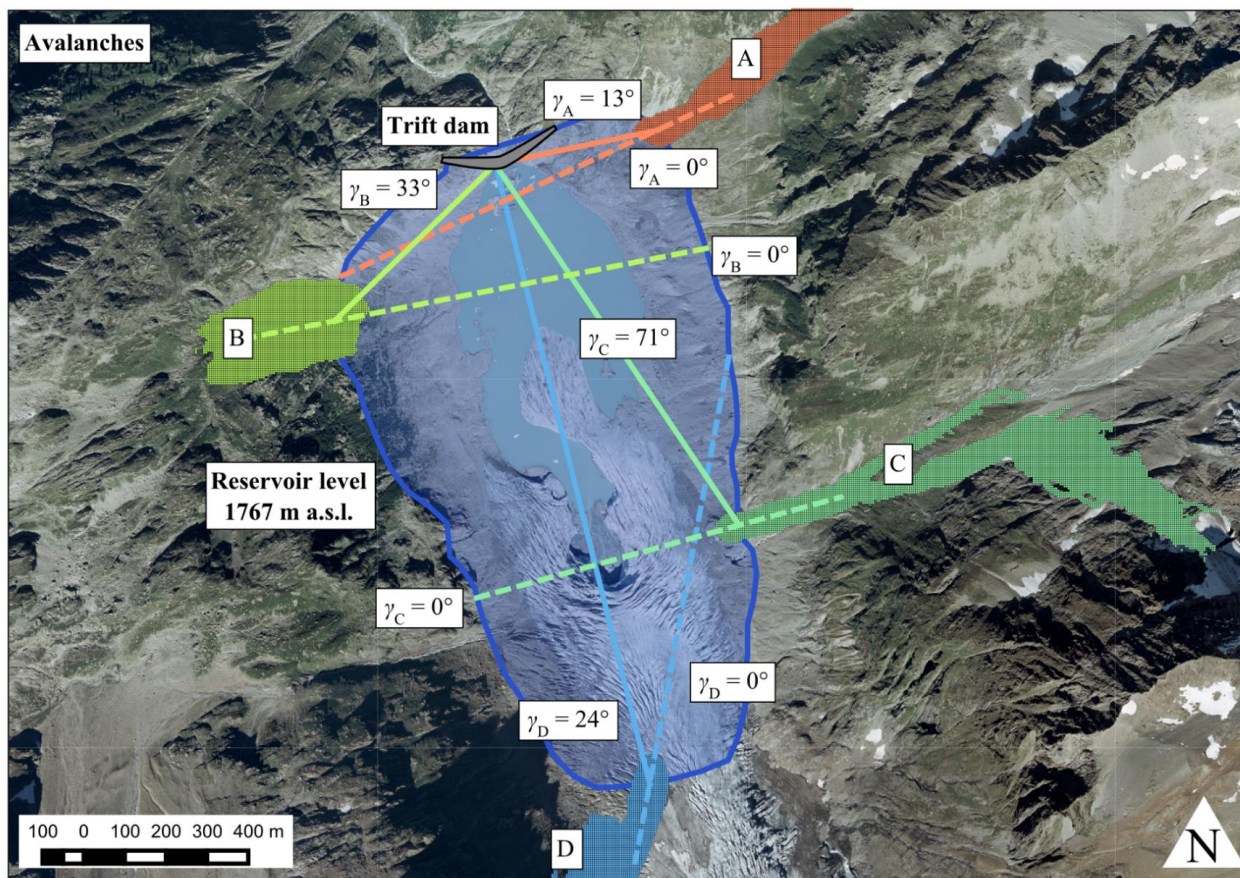
- (Rock avalanches)
- Snow avalanches
- Glacier break-offs

Avalanches/Glacier break-offs:

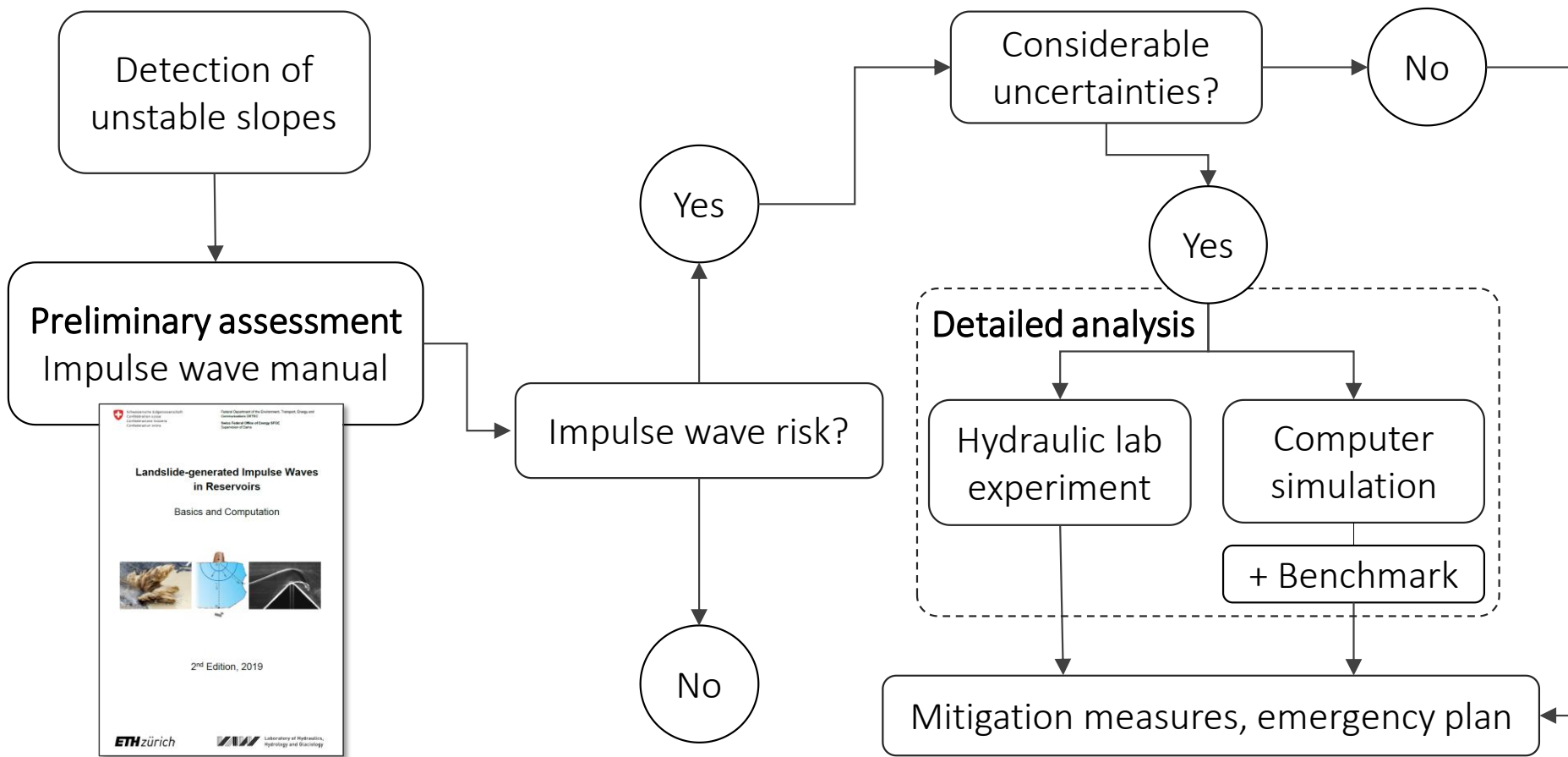
Numerical simulation

Impulse waves:

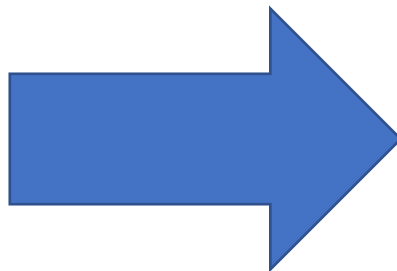
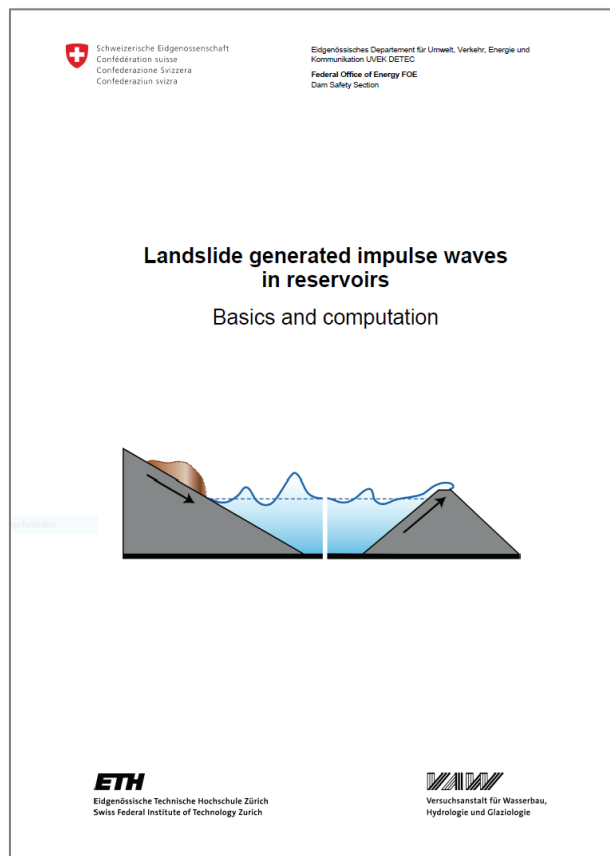
Generally applicable equations
(Manual 2009)



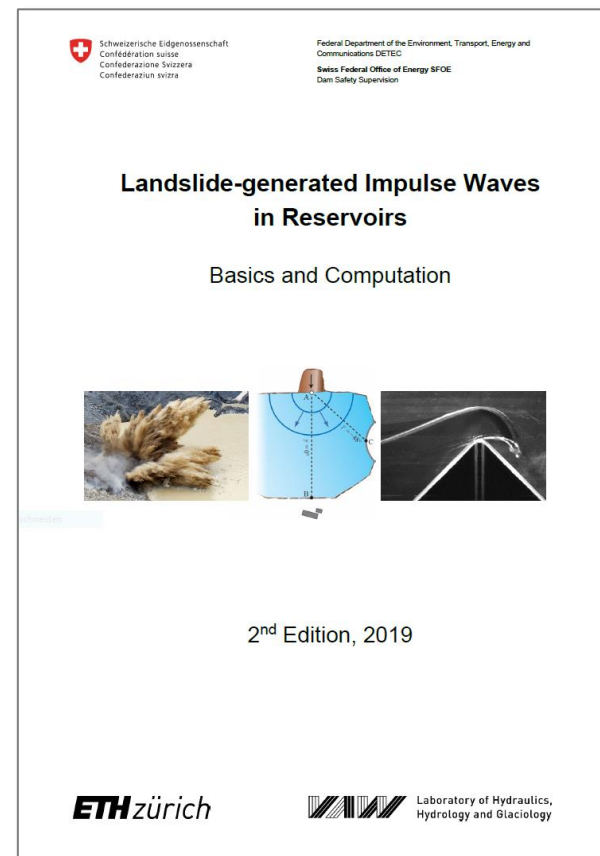
General Hazard Assessment Procedure



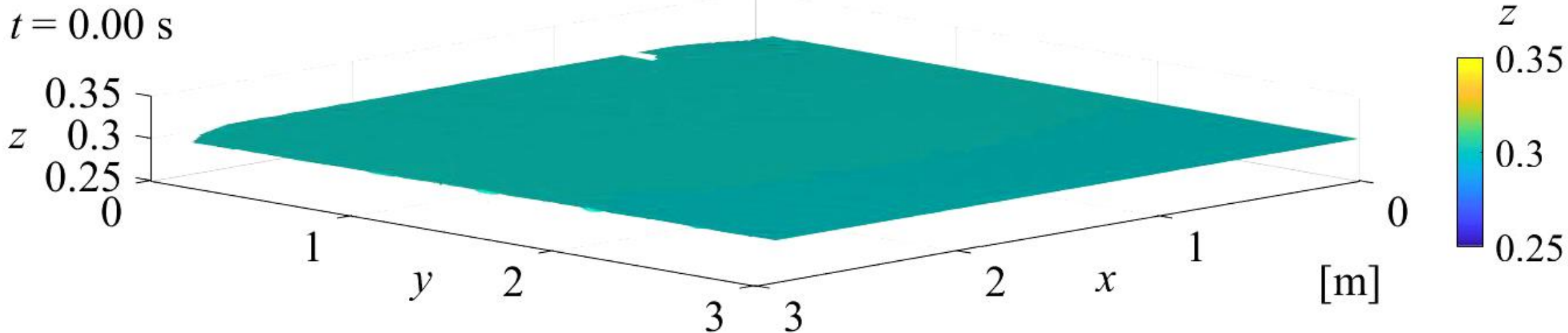
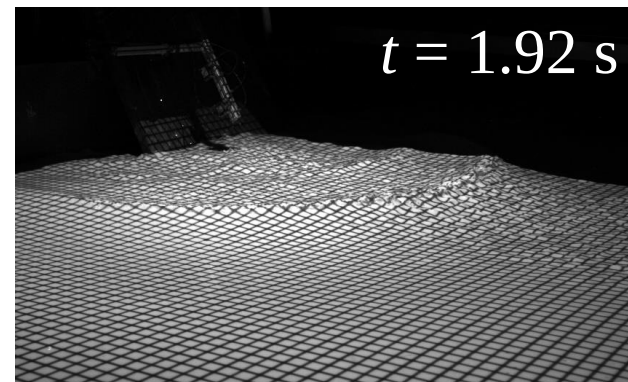
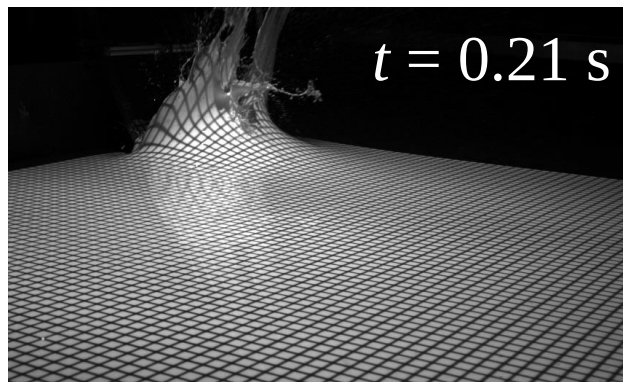
Impulse Wave Manual Update



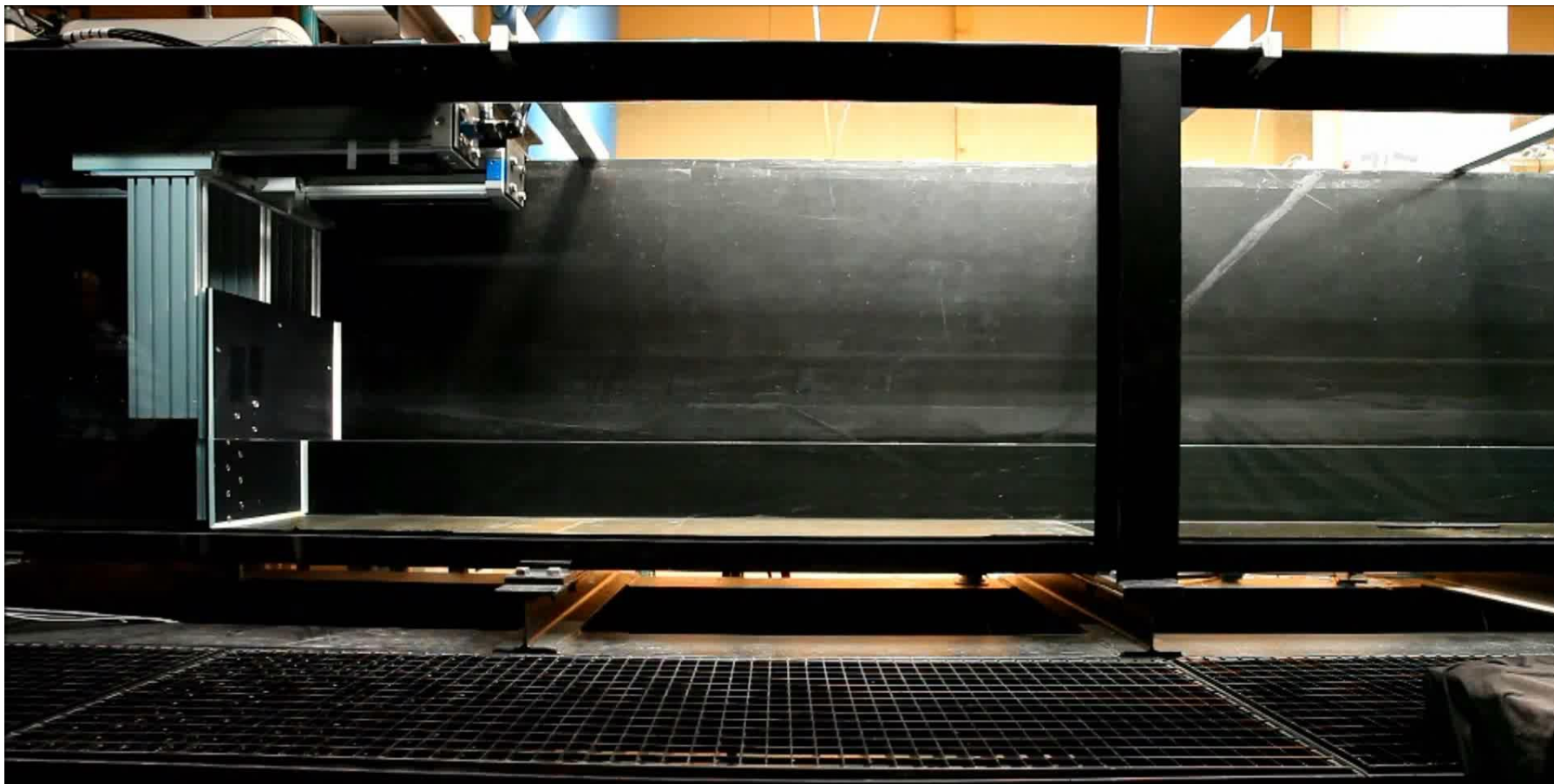
10 years



Research Advances: 3D Impulse Waves

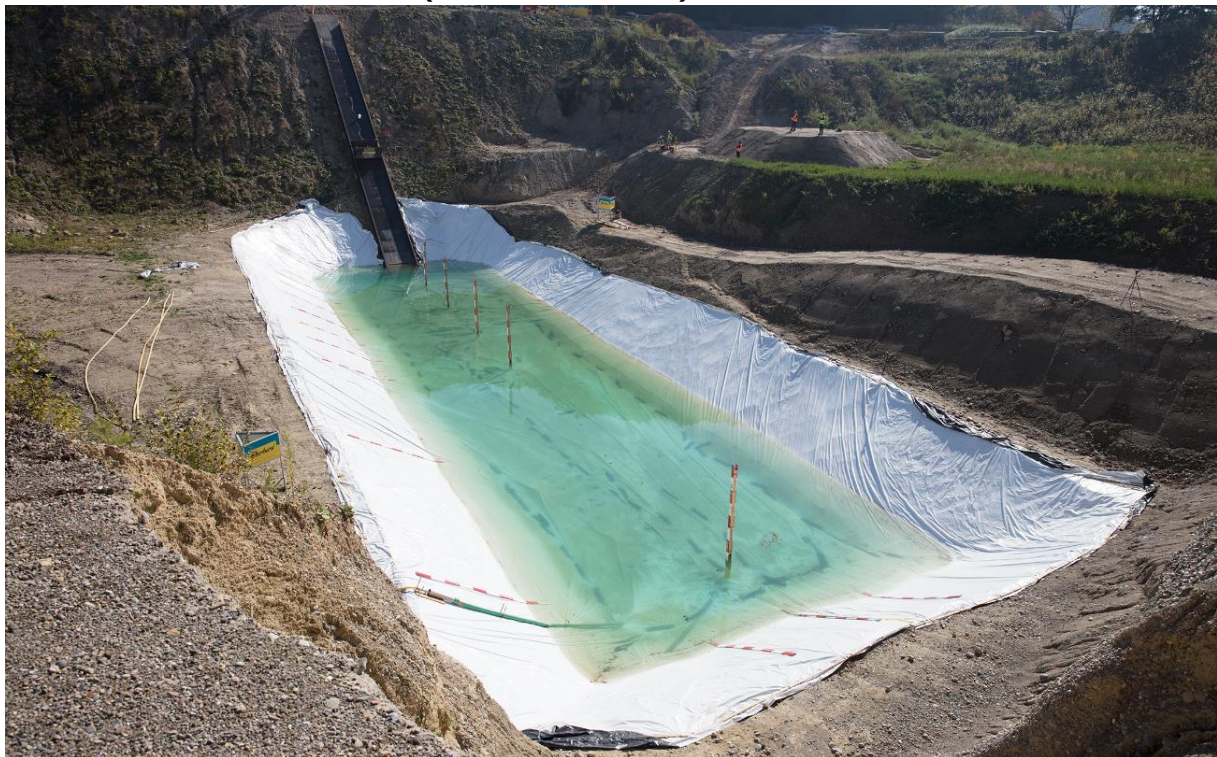


Research Advances: Overland Flow



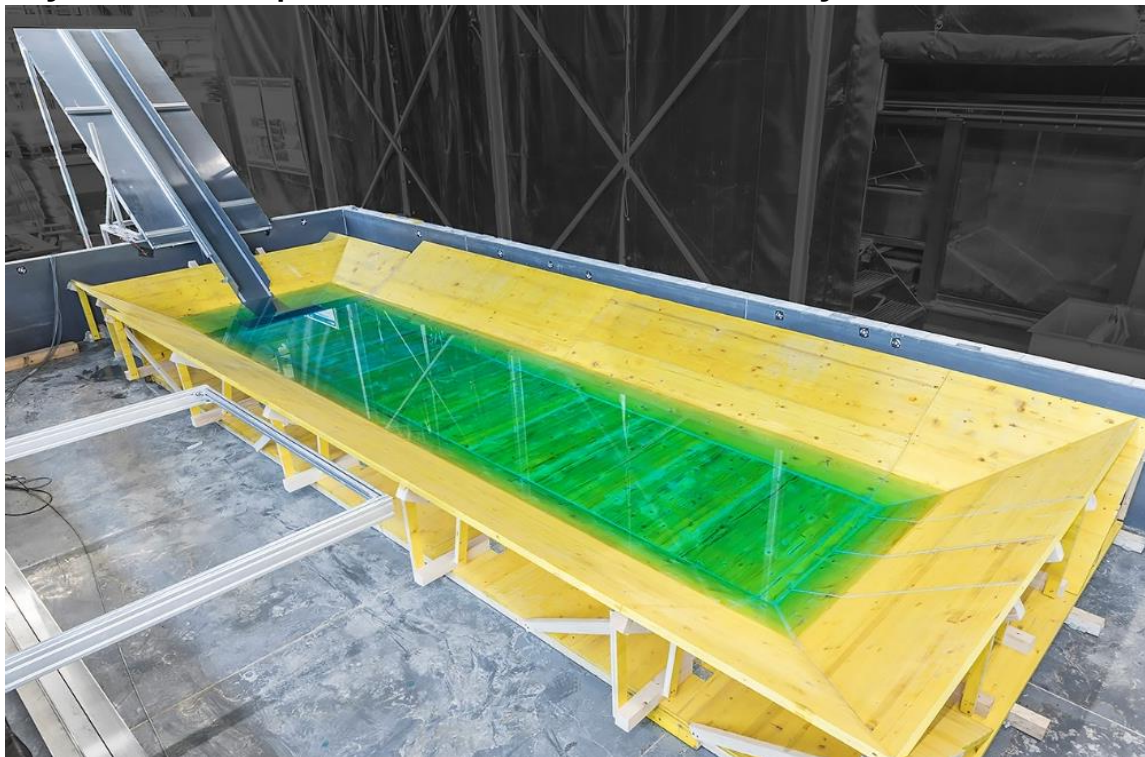
Research Advances: Scale Effects

Field tests, Bülach (Switzerland)



Dimensions: Wave basin 60 m x 15 m
Steel ramp 45 m

Hydraulic experiments, VAW laboratory

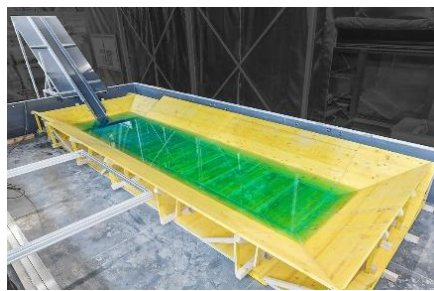
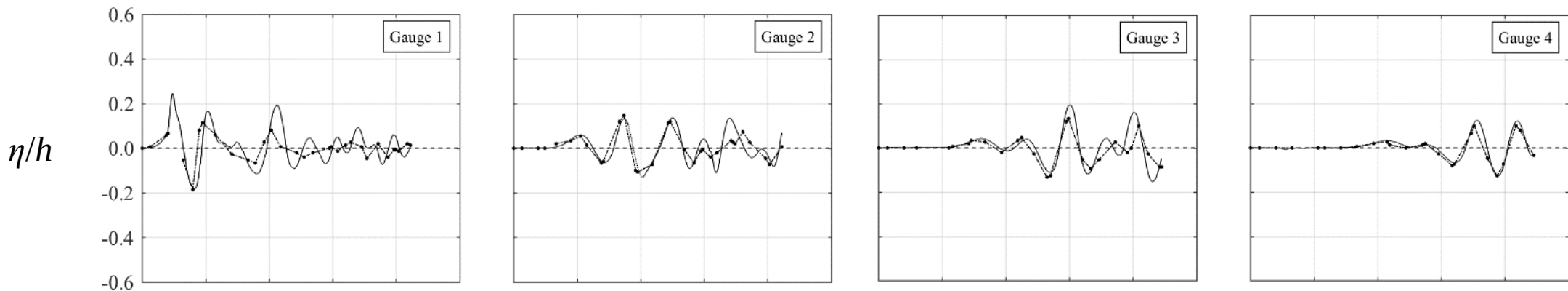


Model scale: 1:10



Impulse wave field and model tests

Research Advances: Scale Effects

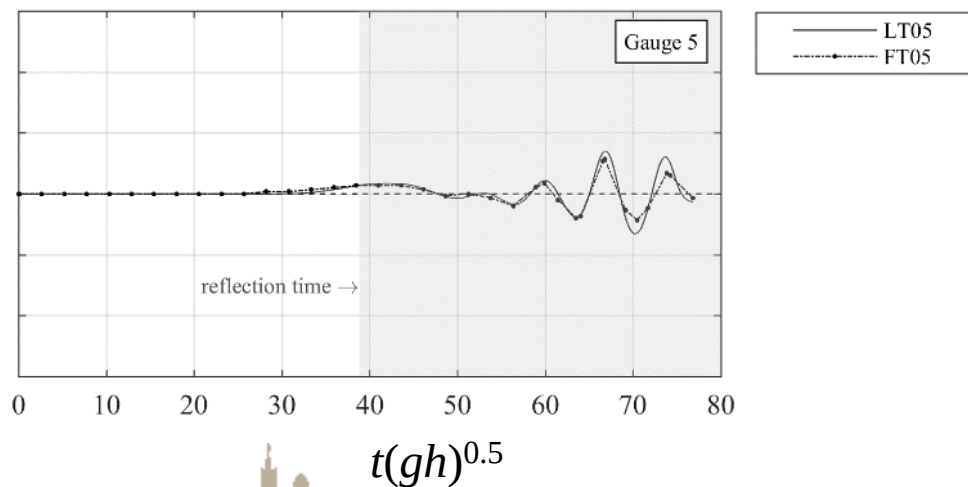


Slide mass: $m_s = 3.2 \text{ t}$

$m_s = 3.2 \text{ kg}$

Impact velocity: $V_s = 13.0 \text{ m/s}$

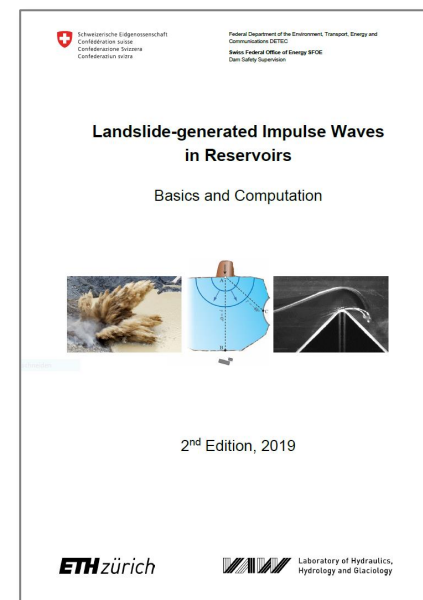
$V_s = 4.1 \text{ m/s}$



Updated Manual

Chapters and sections with **revised or extended** content:

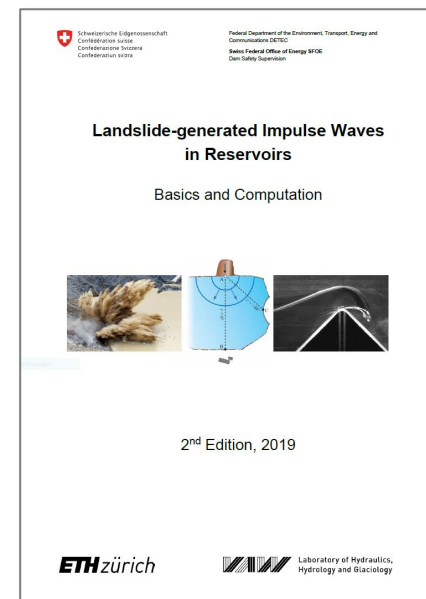
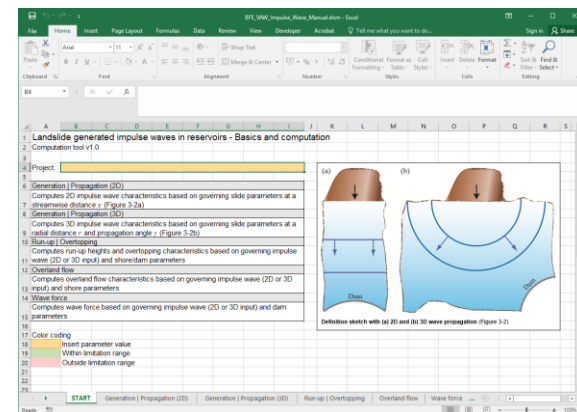
- Methods for predicting landslide-generated impulse waves (1.2)
- Water wave theory (2)
- Slide velocity at the point of impact (3.2.3)
- 3D impulse wave generation and propagation (3.2.4.3)
- Wave run-up and dam overtopping (3.3)
- Wave force on dams (3.5)
- Mass movement types (4.4)



Updated Manual

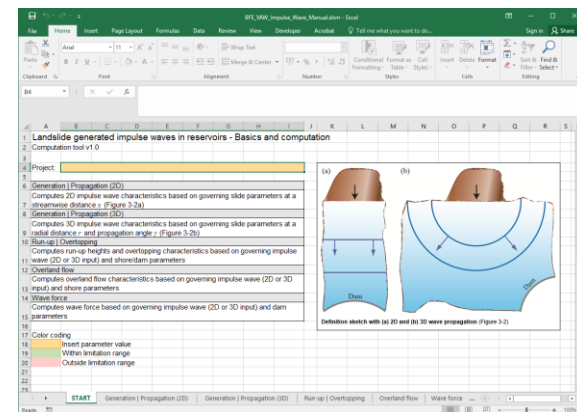
Chapters and sections with **new** content:

- Overland flow (3.4)
- Water body geometries between 2D and 3D (4.2.1)
- Edge waves (4.3)
- Underwater landslide deposits (4.5)
- New computational tool



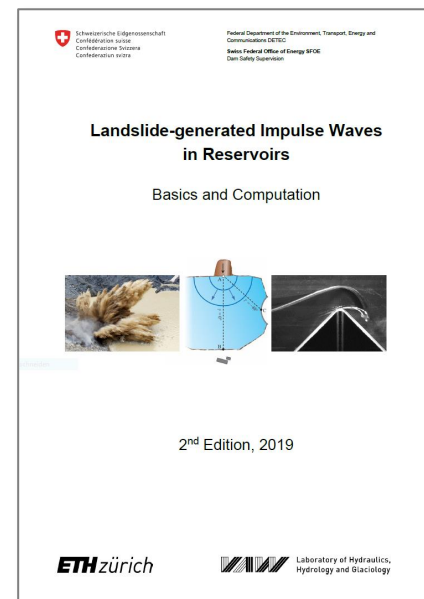
Updated Manual – Presentations

Manual Step 1: Computational procedure
Frederic Evers (VAW)



Exercise: Application of Step 1 (computational tool)
Helge Fuchs (SFOE)

Manual Step 2: Water body geometry, Edge waves, Sensitivity
Frederic Evers (VAW)



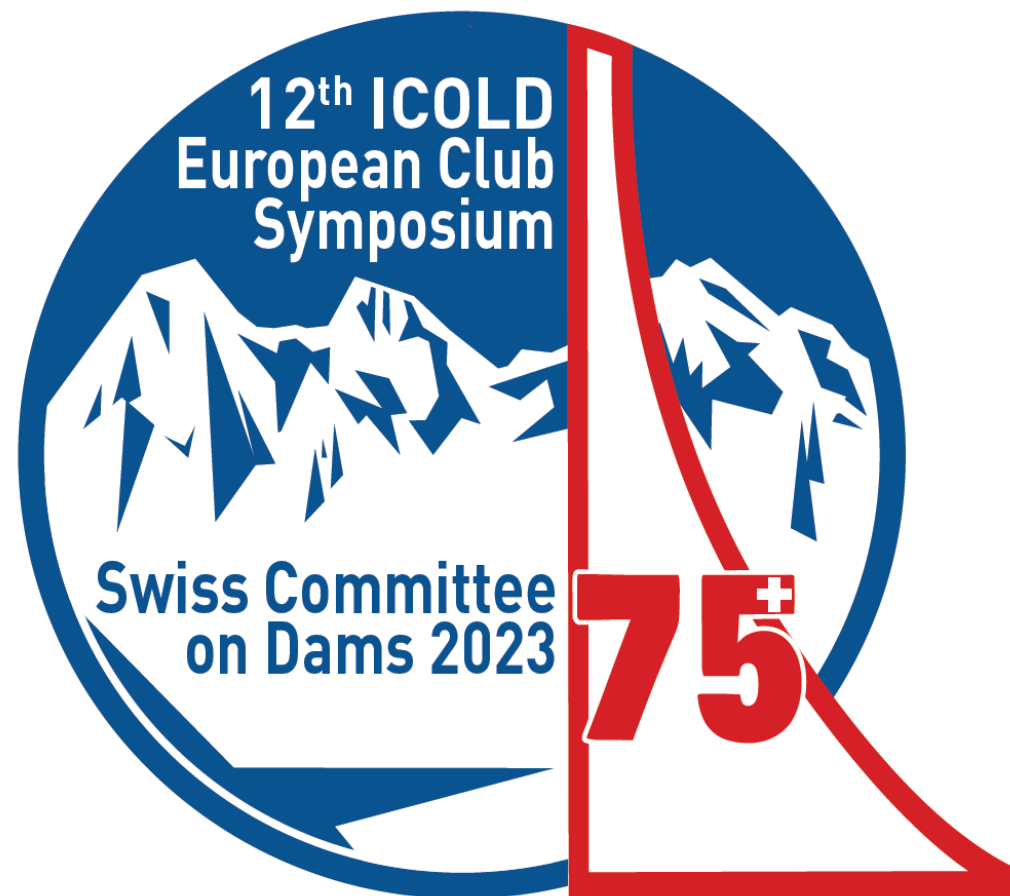


Thank you for your attention
Merci pour votre attention



Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

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