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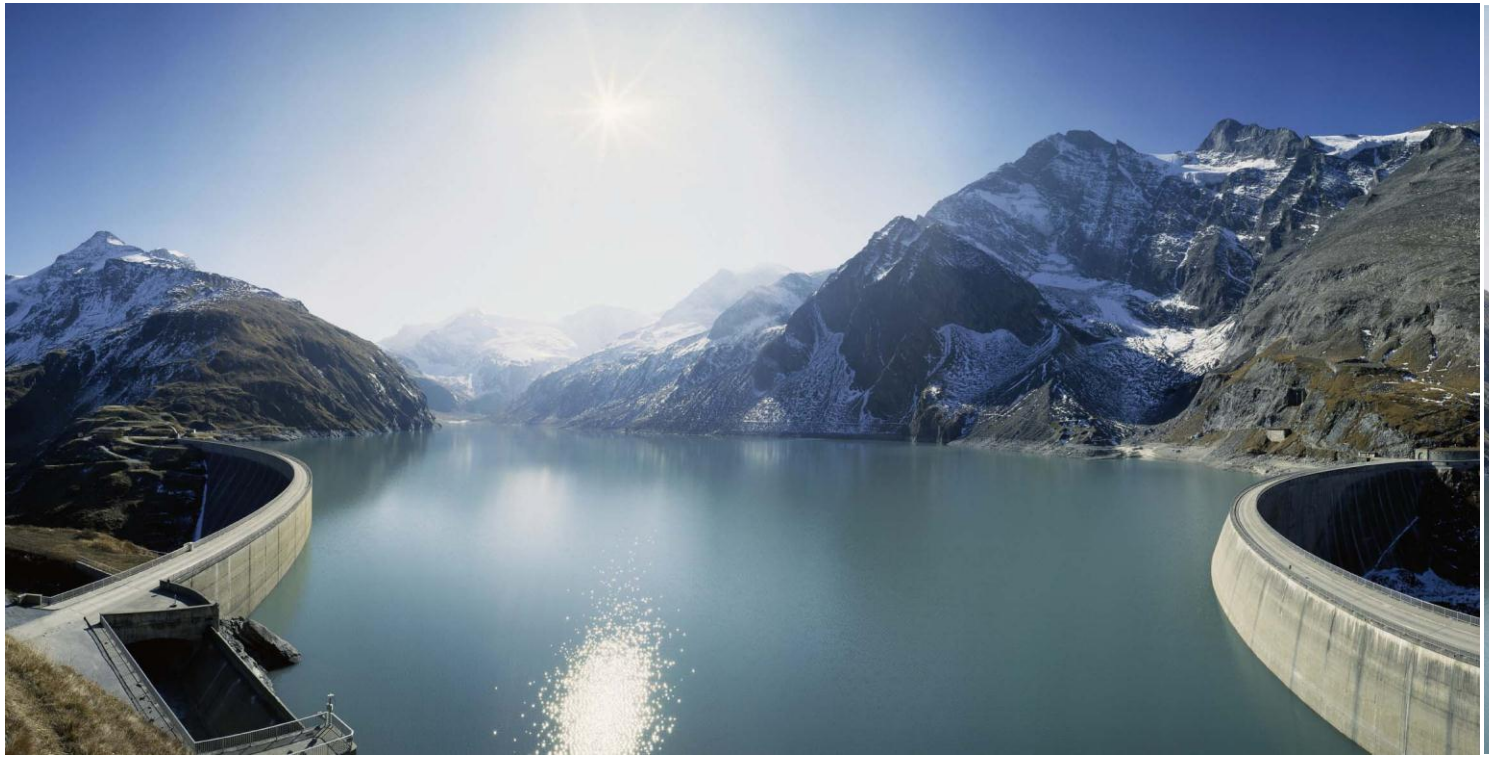

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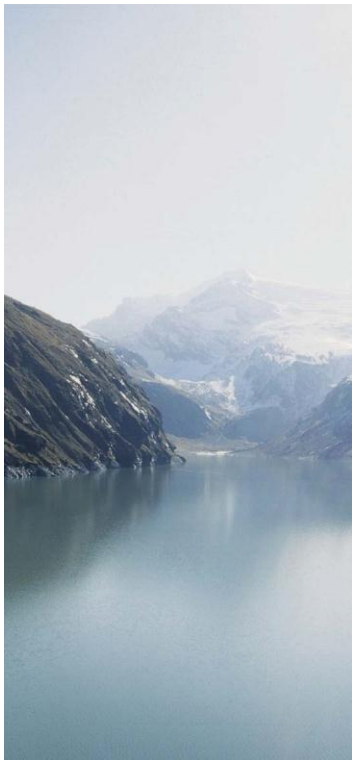
Overtopping Erosion
VERBUND Hydro Power
Perspective on Concrete Dams



Wagner, Kohler, Landstorfer
Aussois/France, 13.12.2017

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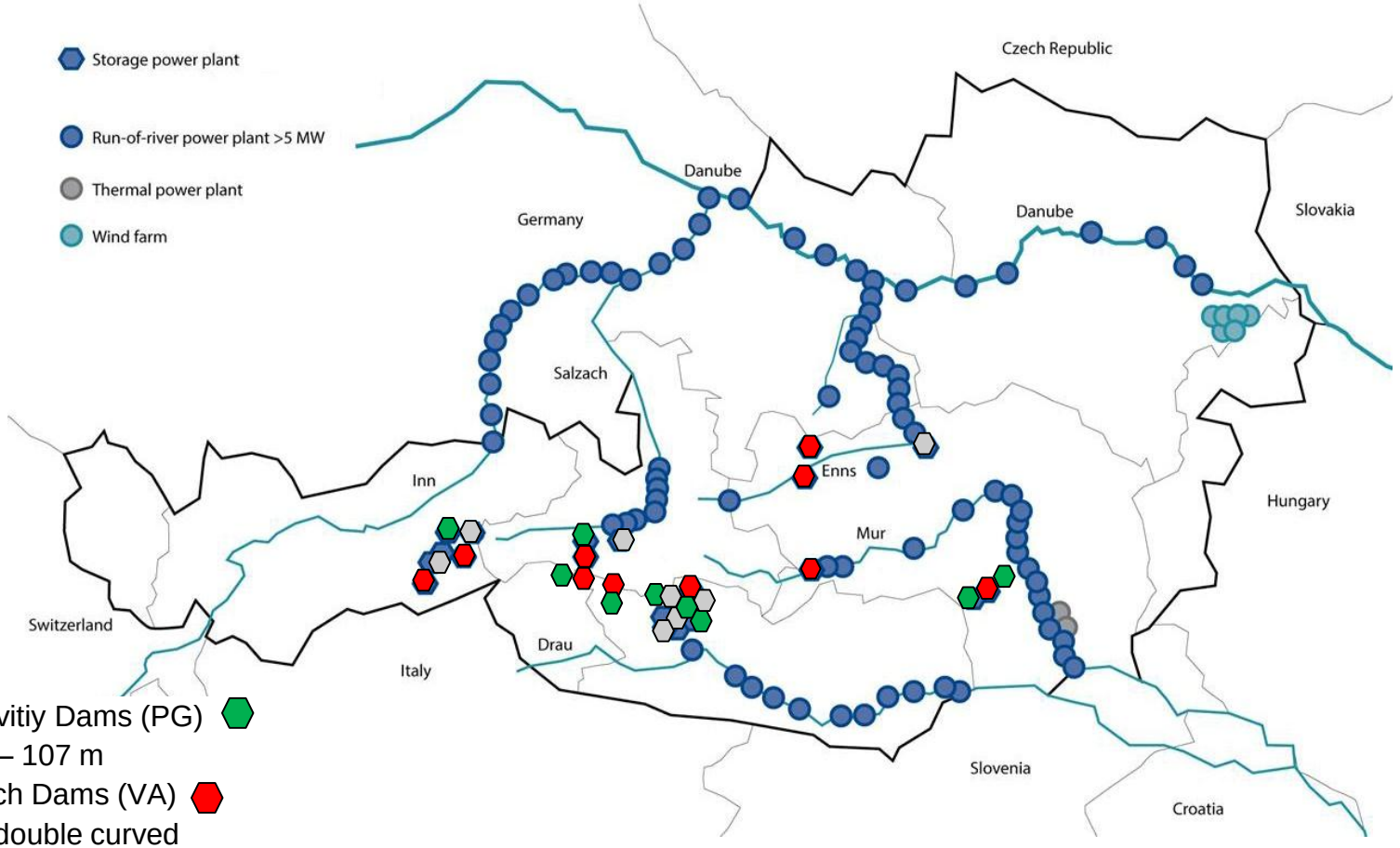
VERBUND Hydro Power – 28 Large Dams in Austria



- 9 Gravitiy Dams (PG)
  - 19 – 107 m
- 10 Arch Dams (VA)
  - all double curved
  - 37 - 200 m
- 9 Embankment Dams (TE)
  - 15 – 85 m

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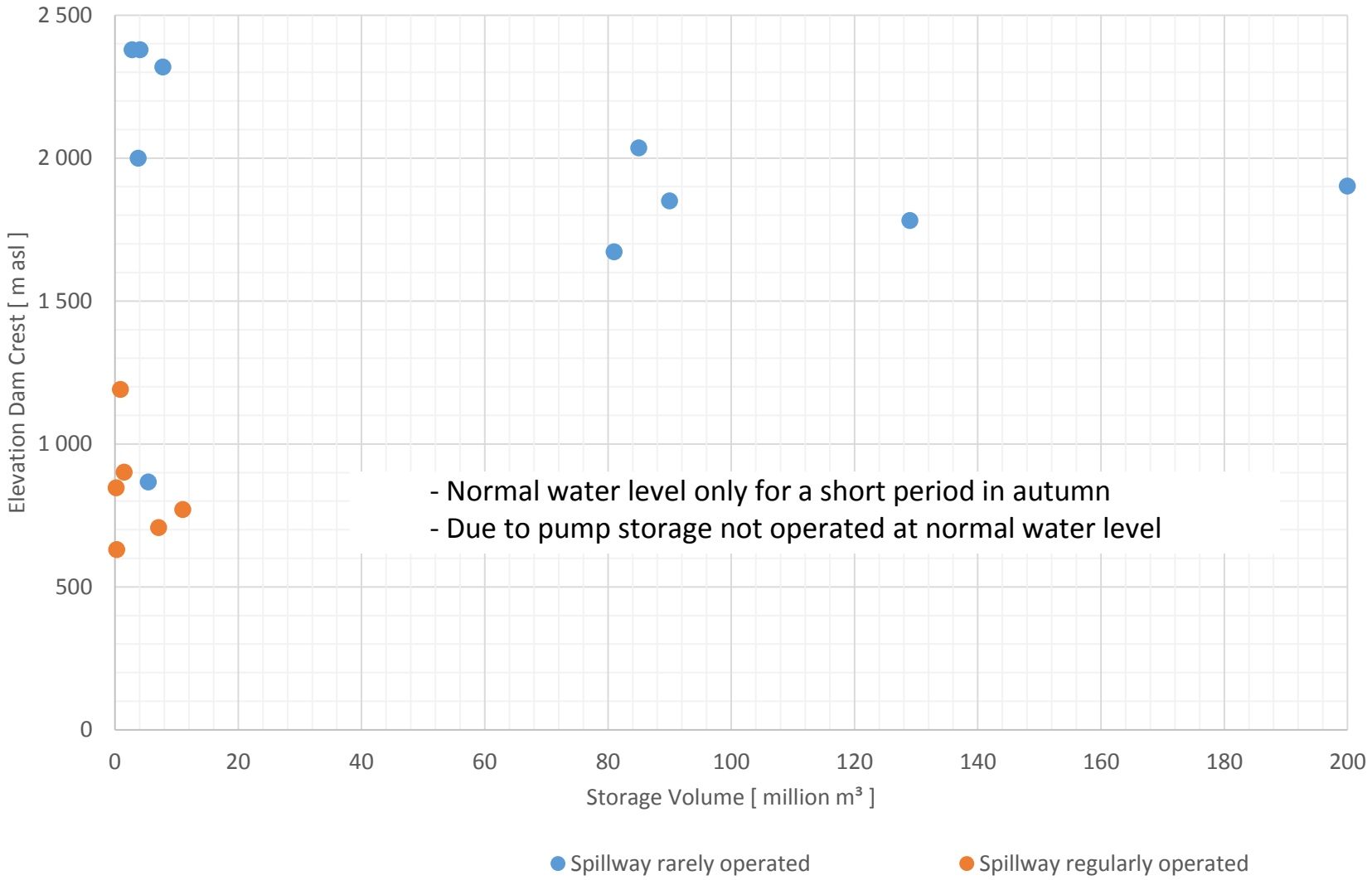
Spillways regularly in operation vs. rarely operated



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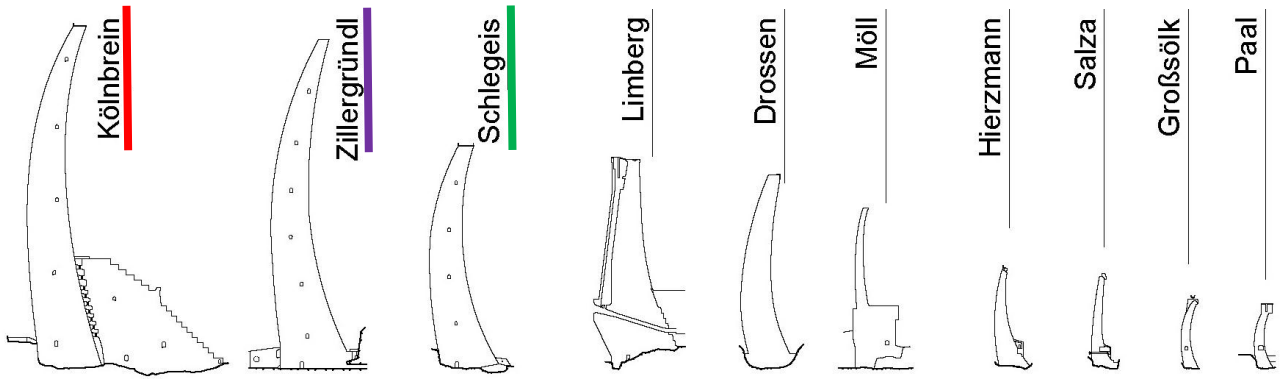
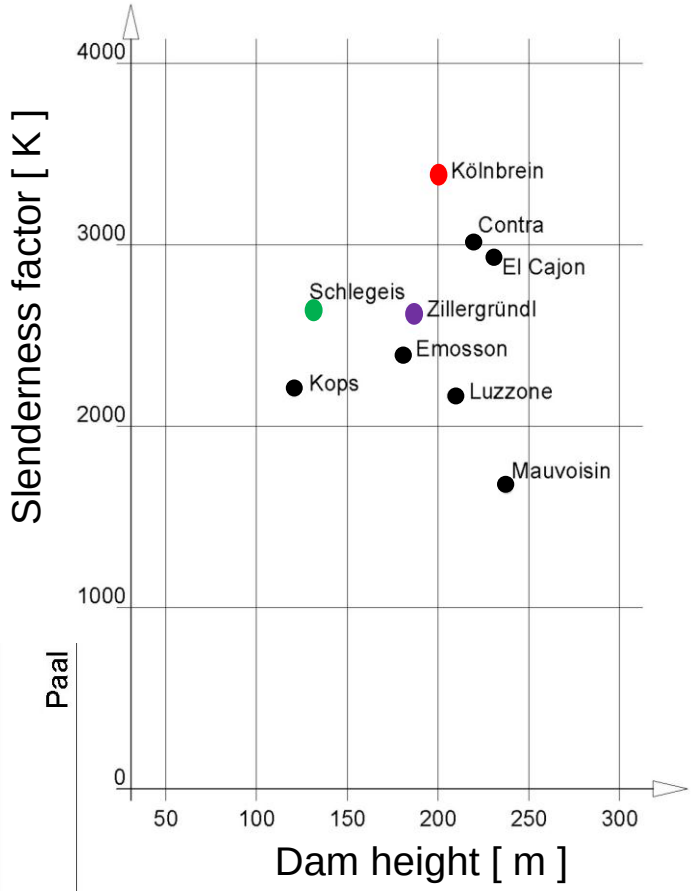
Slenderness factor according to Lombardi

- $K = A^2 / (V \times H)$
  - A = Area of dam
  - V = Volume of concrete
  - H = Height of dam





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Types of Spillways

- 12 – spillway on dam crest
  - 4 with an air flow
  - 8 with a chute on the dam, but no real skijump
- 5 – spillway with side weir
  - 2 with a tunnel
  - 3 with a chute on rock
  - Ending at the valley flank => water flow on unlined slope

- 3 gated spillway (1 x side weir, 2 x dam crest)
- 14 ungated spillways

- 10 with a stilling basin
  - all protected
  - 6 regularly in operation
- 7 with no stilling basin
  - 1 regularly in operation

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VERBUND‘s experience – Hierzmann 1

- 50 % of kinetic head strain/load the bedrock (plunge pool not deep enough)
- Q_{max} = 22 m³/s (average ~ 10 m³/s)
- Design flood > 300 m³/s
- Duration of flood ~ 3 days

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VERBUND‘s experience – Hierzmann 2

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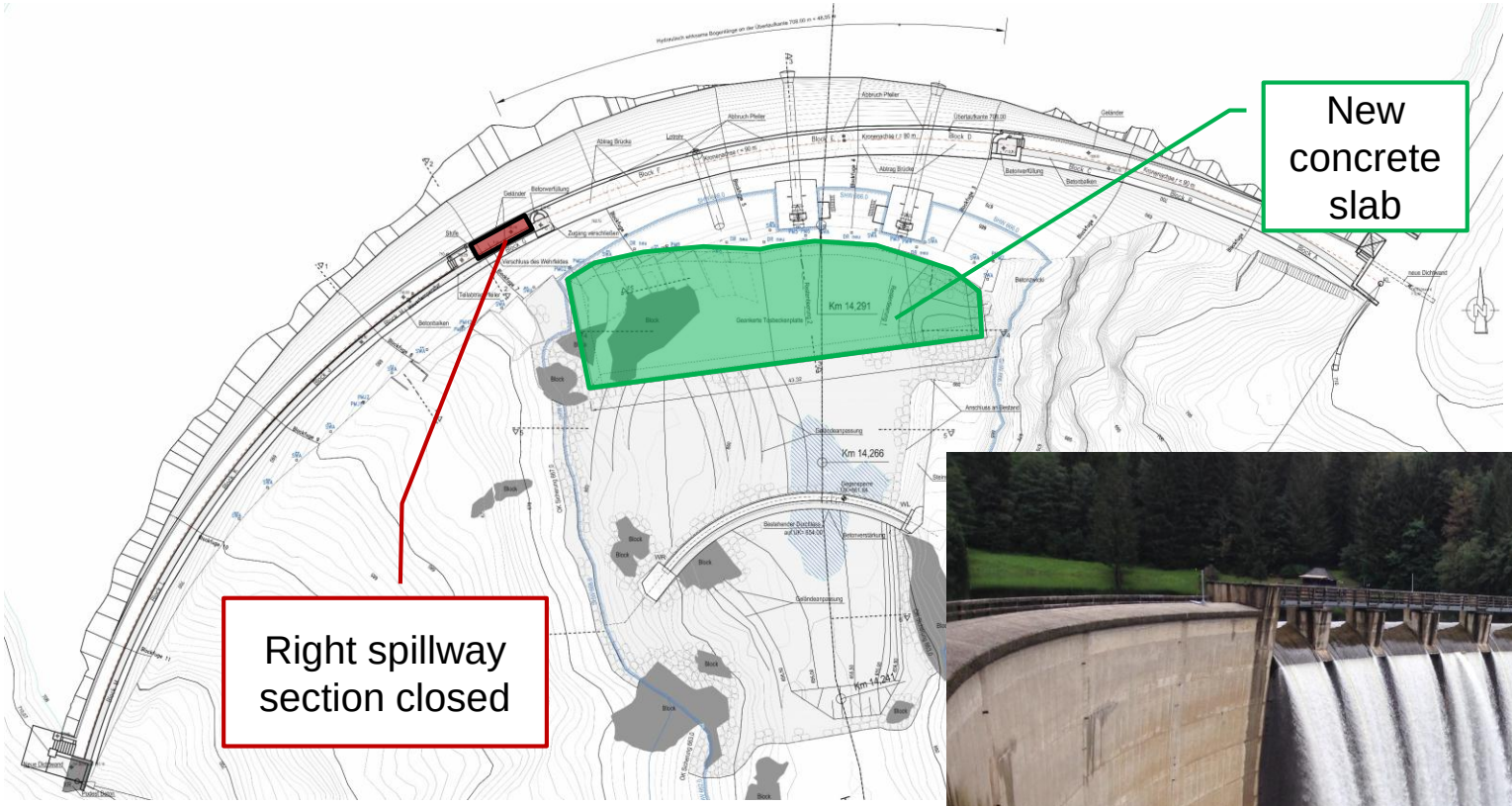
Hierzmann – upgrade of stilling basin



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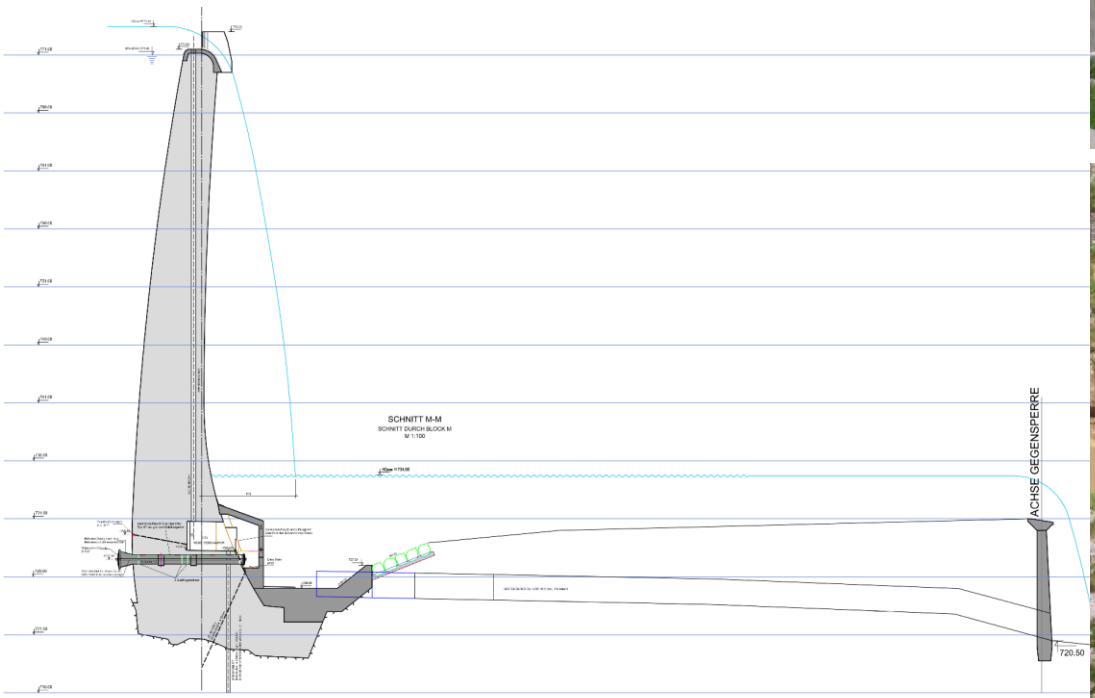
VERBUND‘s experience – Salza 1

- 02.06.2013 – Q_{max} = 76 m³/s

=> No damages downstream



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VERBUND‘s experience – Salza 2

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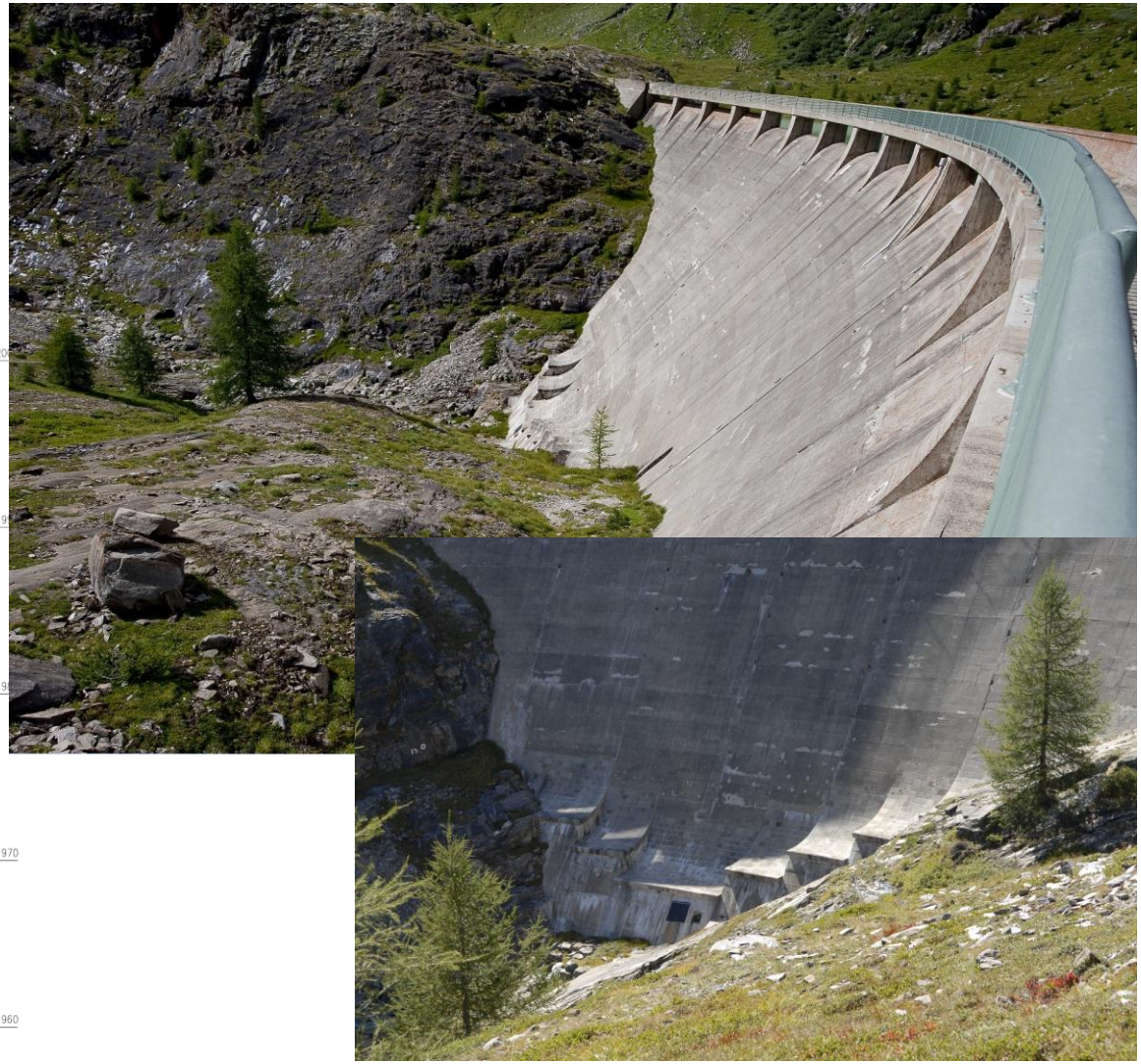
VERBUND‘s experience – Margaritze 1

Perspective of picture below

VERBUND‘s experience – Margaritze 2

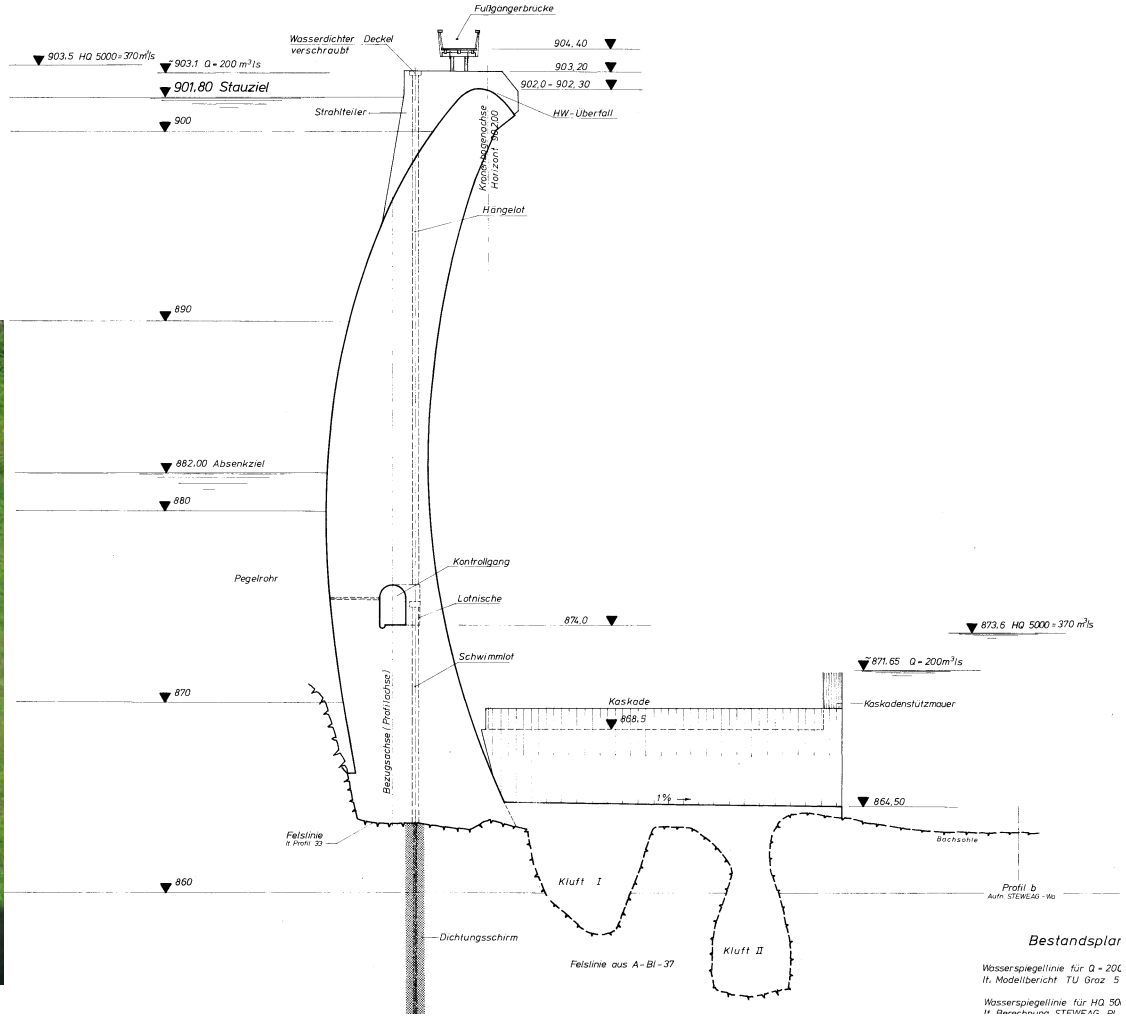
- 1966 – 4,7 million m³ in 6 days
- 1987 – max. 50 m³/s
- 2014 – max. 10 m³/s

=> No damages downstream



VERBUND‘s experience – Sölk

- 06.08.2017 – Q_{max} ~ 170 m³/s
  - > 100 year flood
  - No damages downstream



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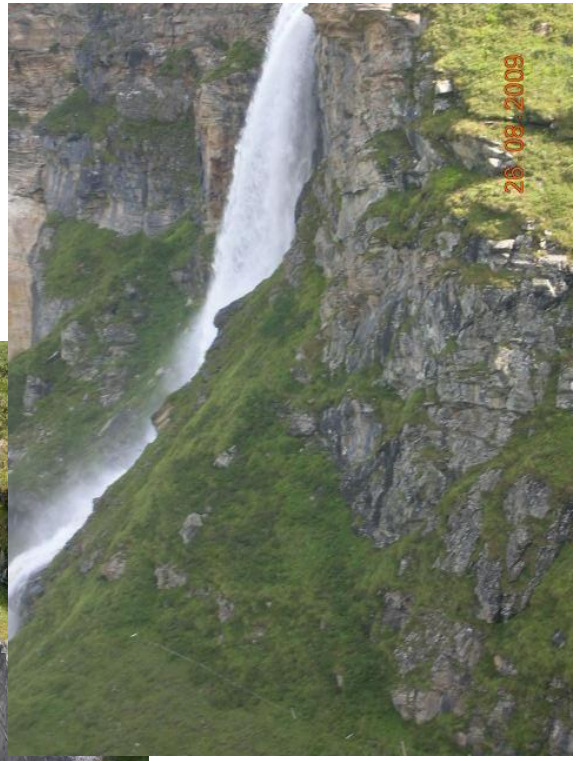
VERBUND‘s experience – Mooserboden

- Gated Spillway test in 2008



- Q = 10 m³/s
- Q_{max} > 100 m³/s

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Design requirements at time of construction

- Dams built between 1920s and 1980s

- Hydrology
  - No unified design criteria (between 100 and 5000 year flood)

- Geolocial Assessment
  - Valley flanks for side weirs with tunnel/chute
  - Influence of dip-direction of joints
  - Kind of rock mass
  - Degree of jointing
  - Exfoliation

- Statical layout
  - No uplift under stilling basins

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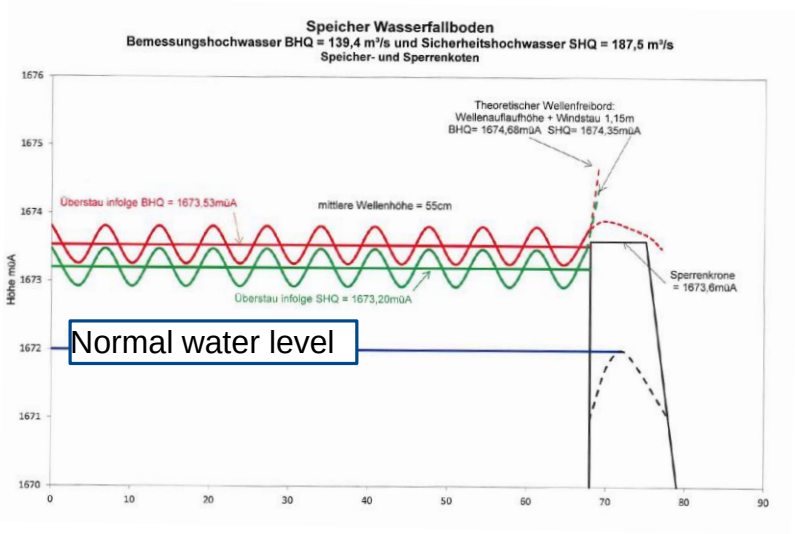
Update of hydrology or regulations

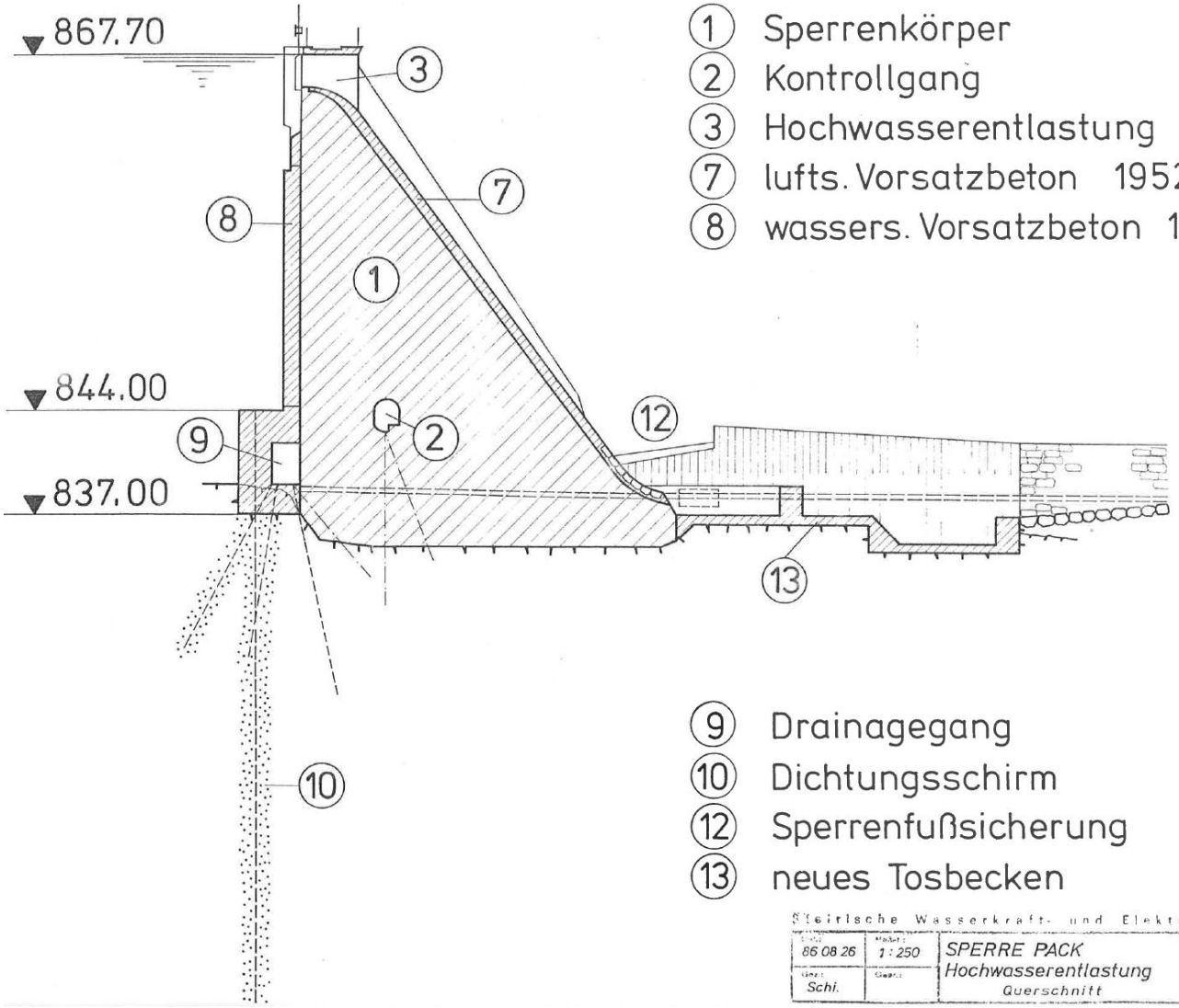
- Spillway guideline published in 2007
  by Austrian Commission on Dams/Federal Ministry for Agriculture

  - Unified hydrological design criteria
    - BHQ ~ 5000 year flood
      - Discharge only with spillway
    - SHQ = 1,3 * BHQ ~ PMF
      - Bottom outlet and headrace system can be used for discharge
  - Overtopping acceptable for exisiting dams in case of level raised by wind and waves

- Consequences of new guideline
  - Due to hydrological update (increased design flood), reconstruction of 3 spillways
  - 3 updates of debris control



Pack – new stilling basin due to increased design flood 1



1 Sperrenkörper
2 Kontrollgang
3 Hochwasserentlastung
7 lufts. Vorsatzbeton 1952/53
8 wassers. Vorsatzbeton 1982/83

9 Drainagegang
10 Dichtungsschirm
12 Sperrenfußsicherung
13 neues Tosbecken

Steirische Wasserkraft- und Elektrizitäts-A.G., Graz

86 08 26	1 : 250	SPERRE PACK Hochwasserentlastung Querschnitt	3.00.03.11 15.09112
Schi.			

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Pack – new stilling basin due to increased design flood 2

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Future research

- Numerical evaluation of stability of overflown unlined valley flank
  - Pore pressure propagation in jointed rock
  - Cavitation

- Energy dissipation of air-flow water jet
  - Pore pressure propagation in jointed rock
  - Numerical evaluation of development of scour holes
  - Stilling basin

- General research
  - Length of protection of riverbed downstream of stilling basin
  - Long term effects
    - Short term use (10 min) vs. Long term use (5 days)

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Thank you for your attention!

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