

RECENT DAM INCIDENTS AND FAILURES IN SWEDEN

Granö
Hästberga
(Kvistforsen)

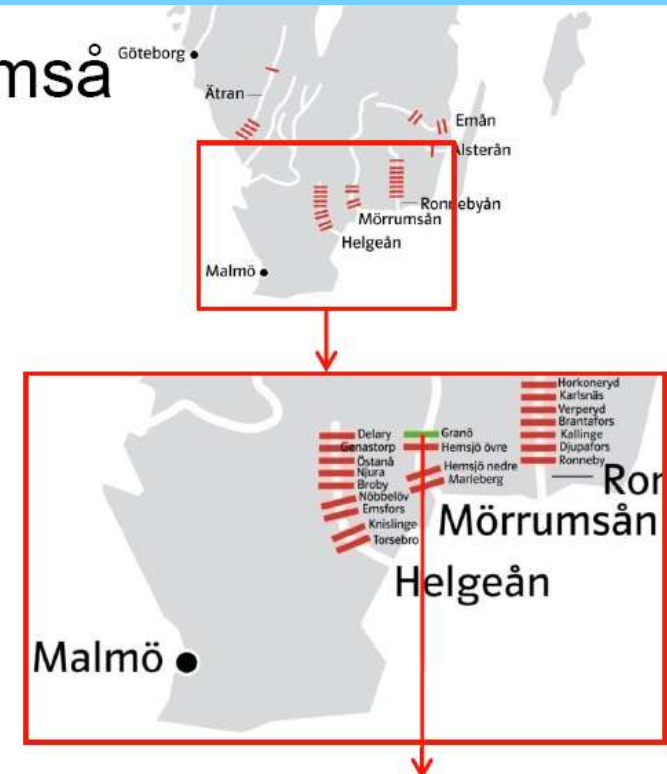
Ingvar Ekström

Sweco Infrastructure

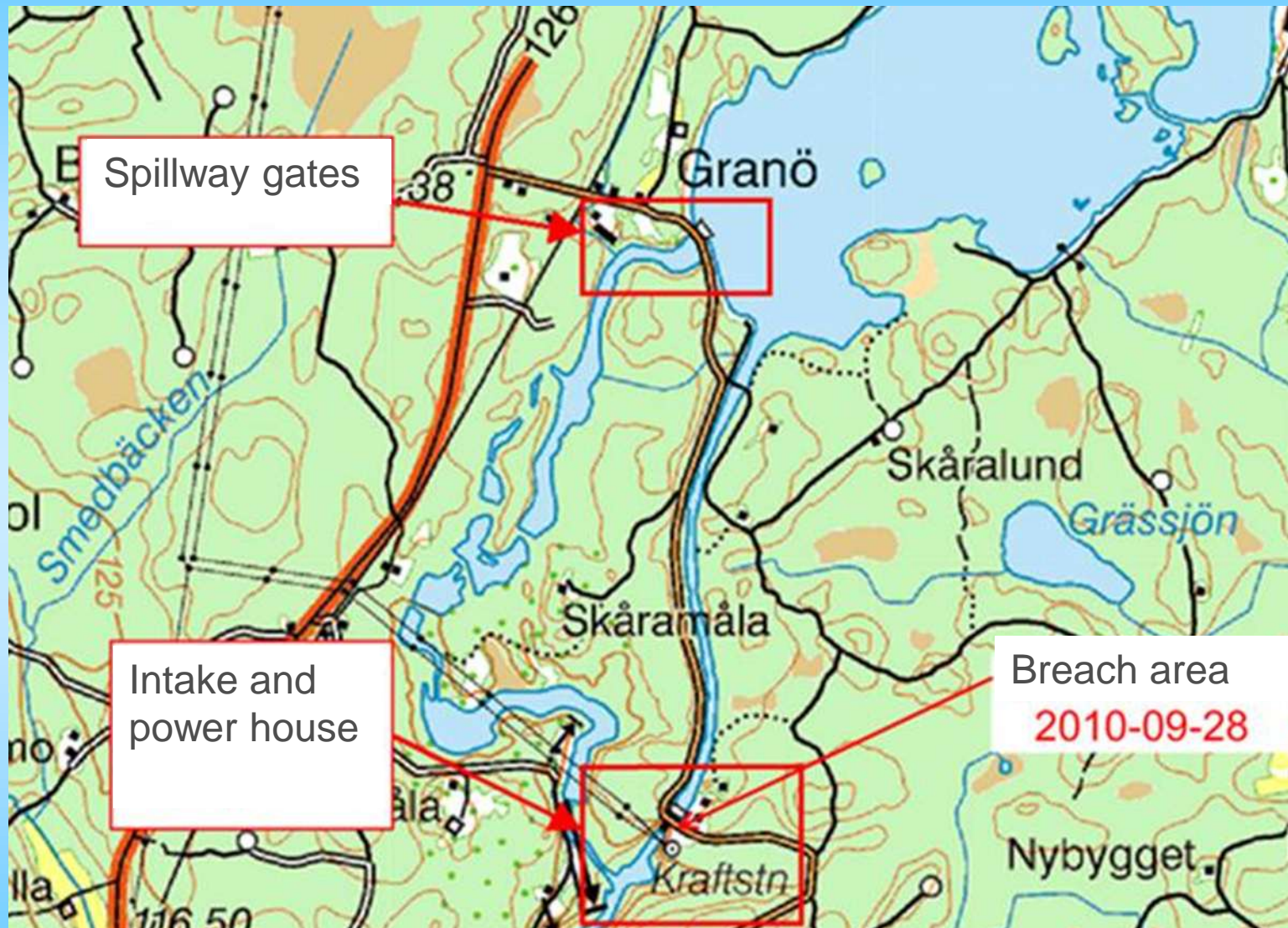


Granö Hydro Power Plant in Mörrumså

- Built in 1958 - 19 m high
- 2 units
- 9 MW
- 32 GWh/year
- 60 m³/s design flow
- Consequence class 1A



Granö power station





Failure zone





The outflow was stopped by filling coarse rock fill and till upstreams of the breach



Information from operational center

Monday morning automatic stop of right turbine. Left turbine is initiated.

Service personnel are contacted as it is assumed that the upstream eel rack is clogged. It is decided to clean the rack during Tuesday.

At 22:39 Monday evening the effect of the turbine is lower than expected.

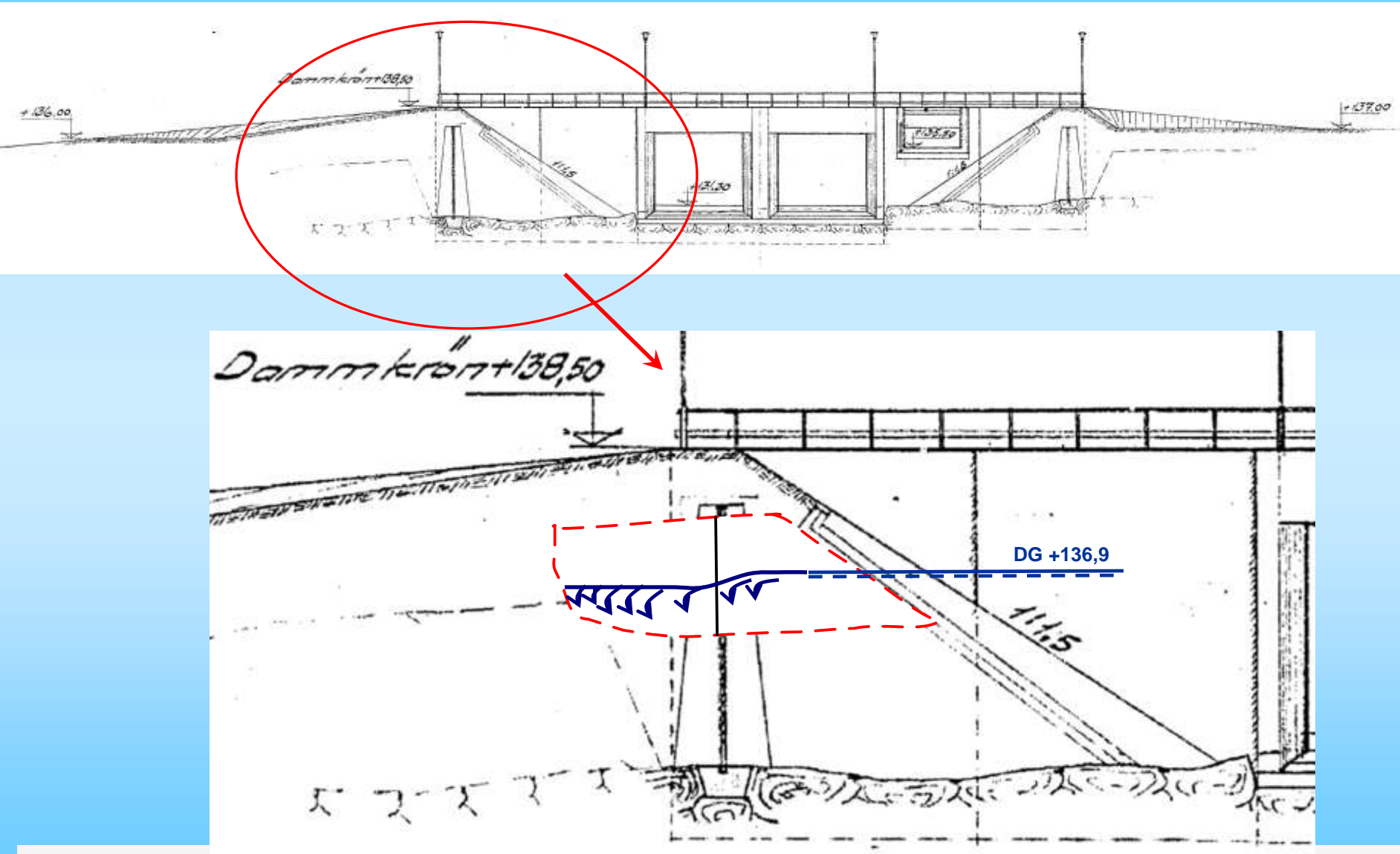
At 23:09 A-alarm is set off by the turbine which automatically shuts from 22 to 8 m³/s.

DC stops the turbine manually at 23:56 assuming the rack is clogged.

At 03:46 a multitude of alarms are set off from the power station and service personnel are dispatched.

Service personnel arrives at 04:45 and reports ongoing dam failure. Fortunately no complete breach due to coarse rocks in downstream fill

Upstream view of intake



No downstream filter

Loosely
compacted rock
fill with high
porosity

Till core



Connection core – "filter"





Wooden sheet pile found upstream in the canal

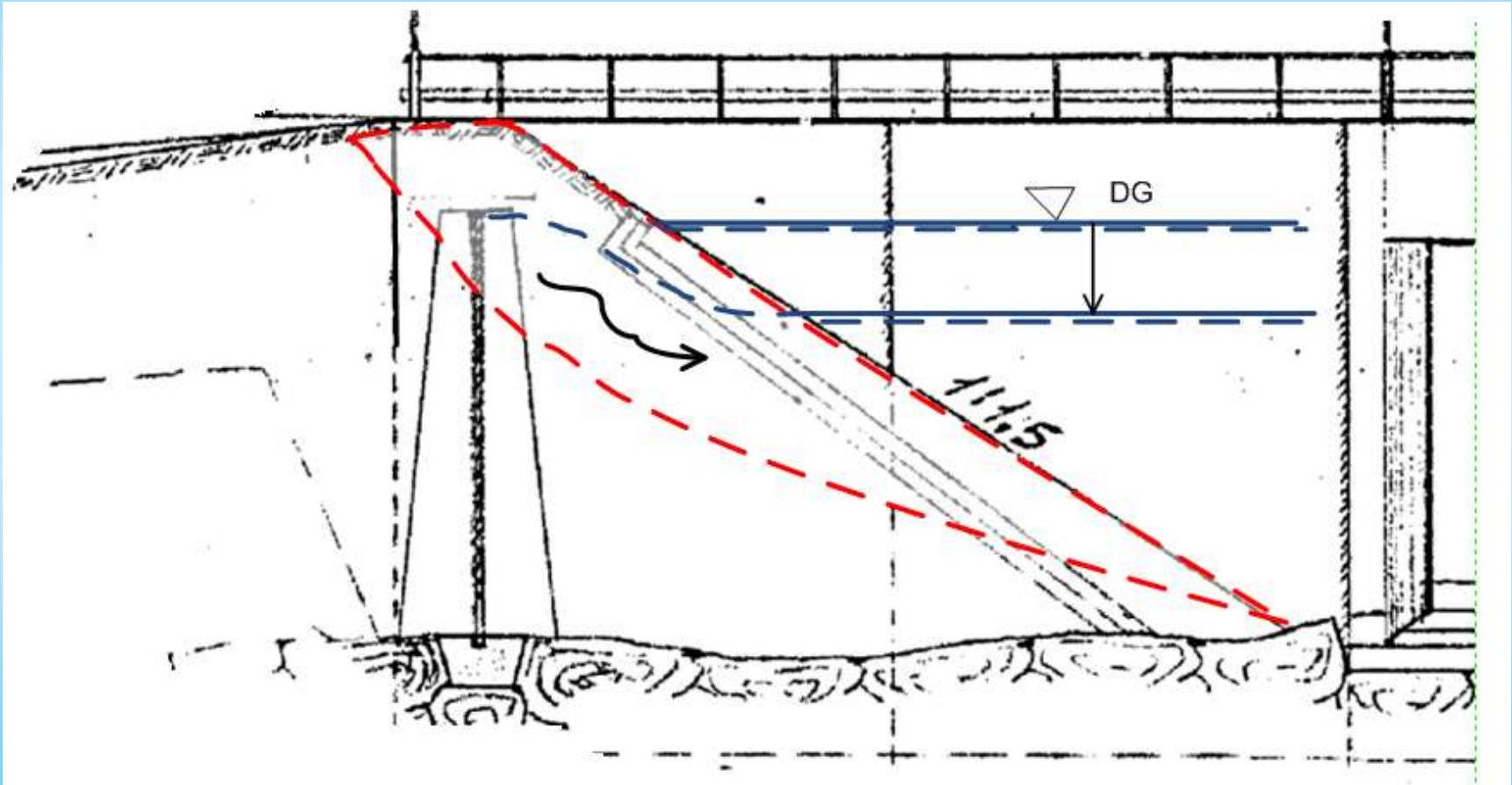




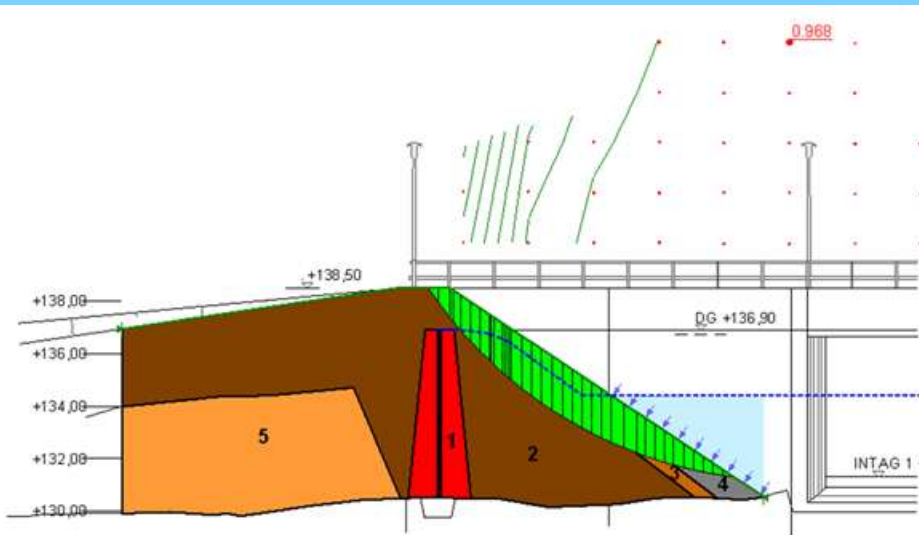
Displacement of sheet pile



Cause of failure, slide in upstream direction, followed by downstream erosion

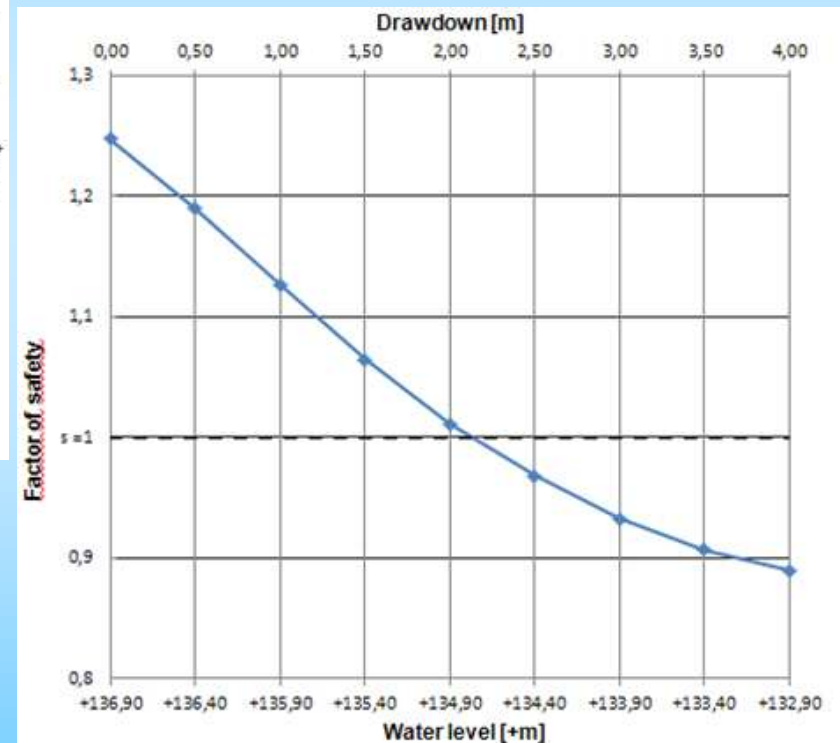


Stability in the upstream direction



2.5 m draw down $F = 0.97$

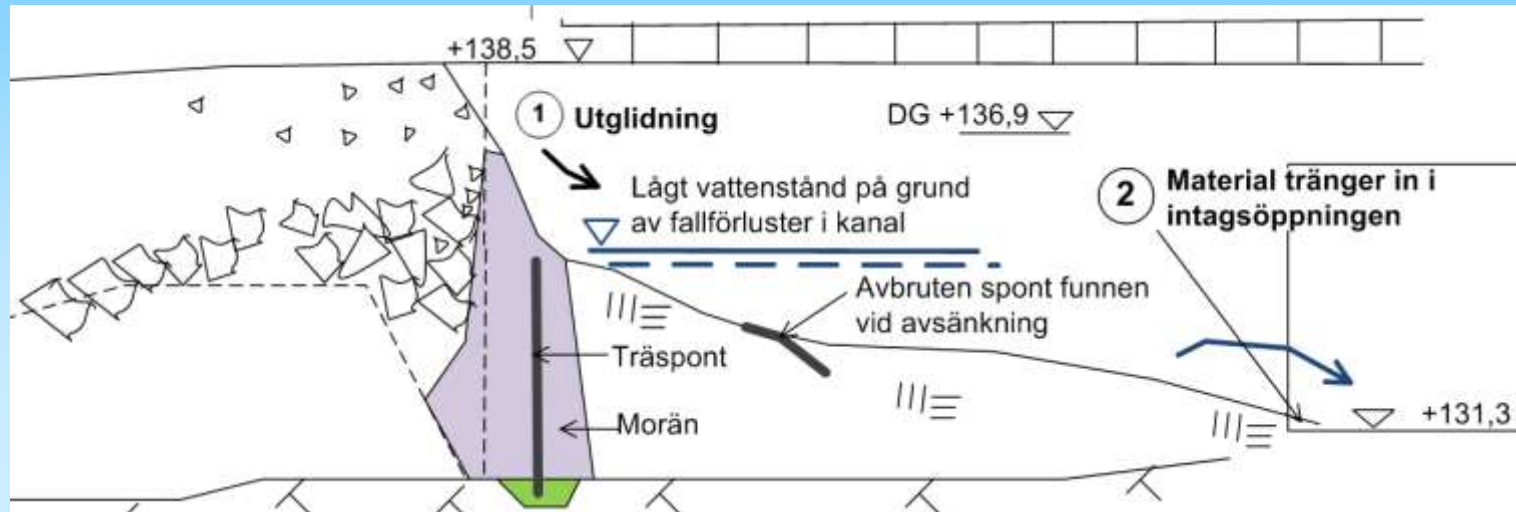
Fine grained fill resulting in high pore pressure uplift



Factor of safety as a function of drawdown

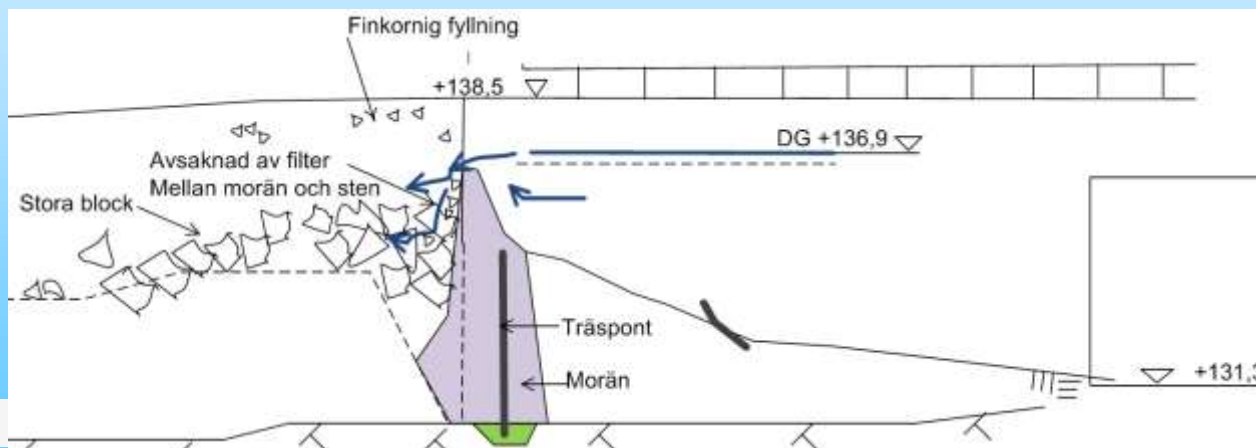
Breach scenario

1. Failure in the upstream direction caused by the sudden drawdown



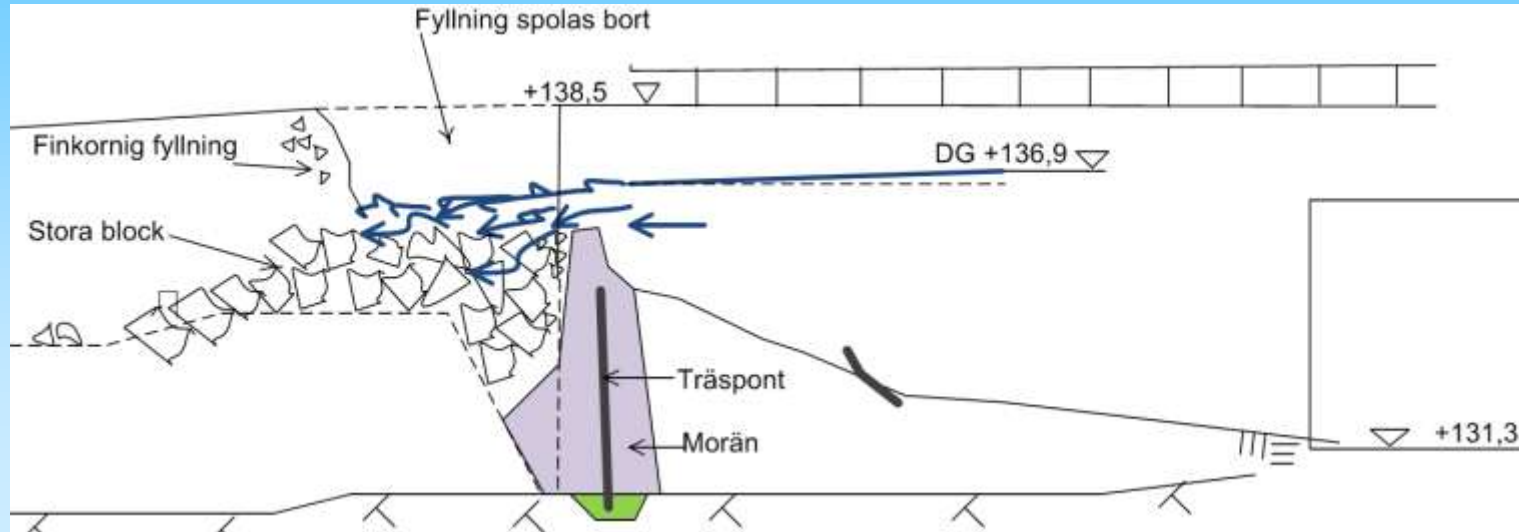
2.

The turbine effect decreases and the operational center shuts it down, causing a sudden raise of the water level to the maximum retention level and overflow the damaged section and erodes the remaining part of the core. 4 hours ...



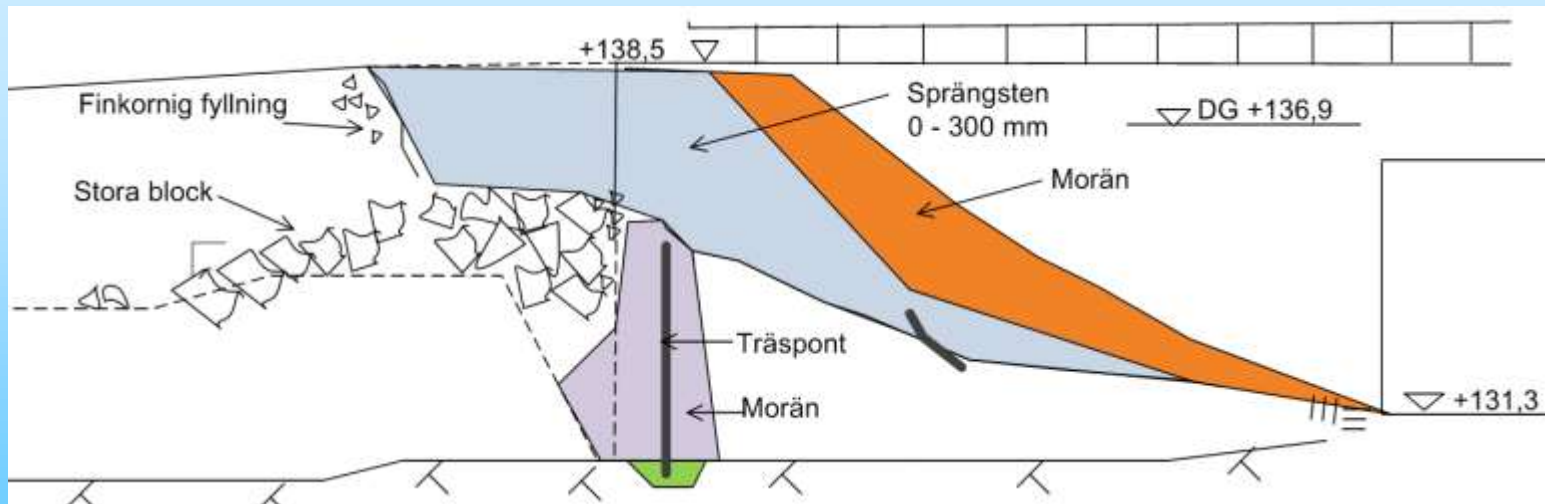
3.

Fine material from the core and remaining upper fill is washed into the coarse loosely compacted rock fill below.



4.

Sealing of the breach.



Some of the weaknesses in the construction

- 1. Wooden sheet pile 0.1 m below maximum retention level. Sheet pile rotten in several places.**
- 2. No downstream filter. Rock fill with voids in-between. Filter criteria not fulfilled at any part of the dam.**
- 3. Unfavorable geometry in the connection between dam and intake. Poor connection to concrete structure after raise of core.**
- 4. Steep upstream slope, dense and low permeable, partly fine-grained supporting fill.**
- 5. No instrumentation, lack of reservoir level reading in intake canal.**

Conclusion – this dam had so many in-built deficiencies that it eventually would have failed anyway.

Fortunately in this case only 5 m³ released.

Current state

Granö – completely reconstructed



Hästberga – still awaiting court decision. Will affect insurance case

