Bedrock Erosion
Storfinn & Ramsele HPP

Carl-Oscar Nilsson, +46 70 518 65 25, carl-oscar.nilsson@uniper.energy

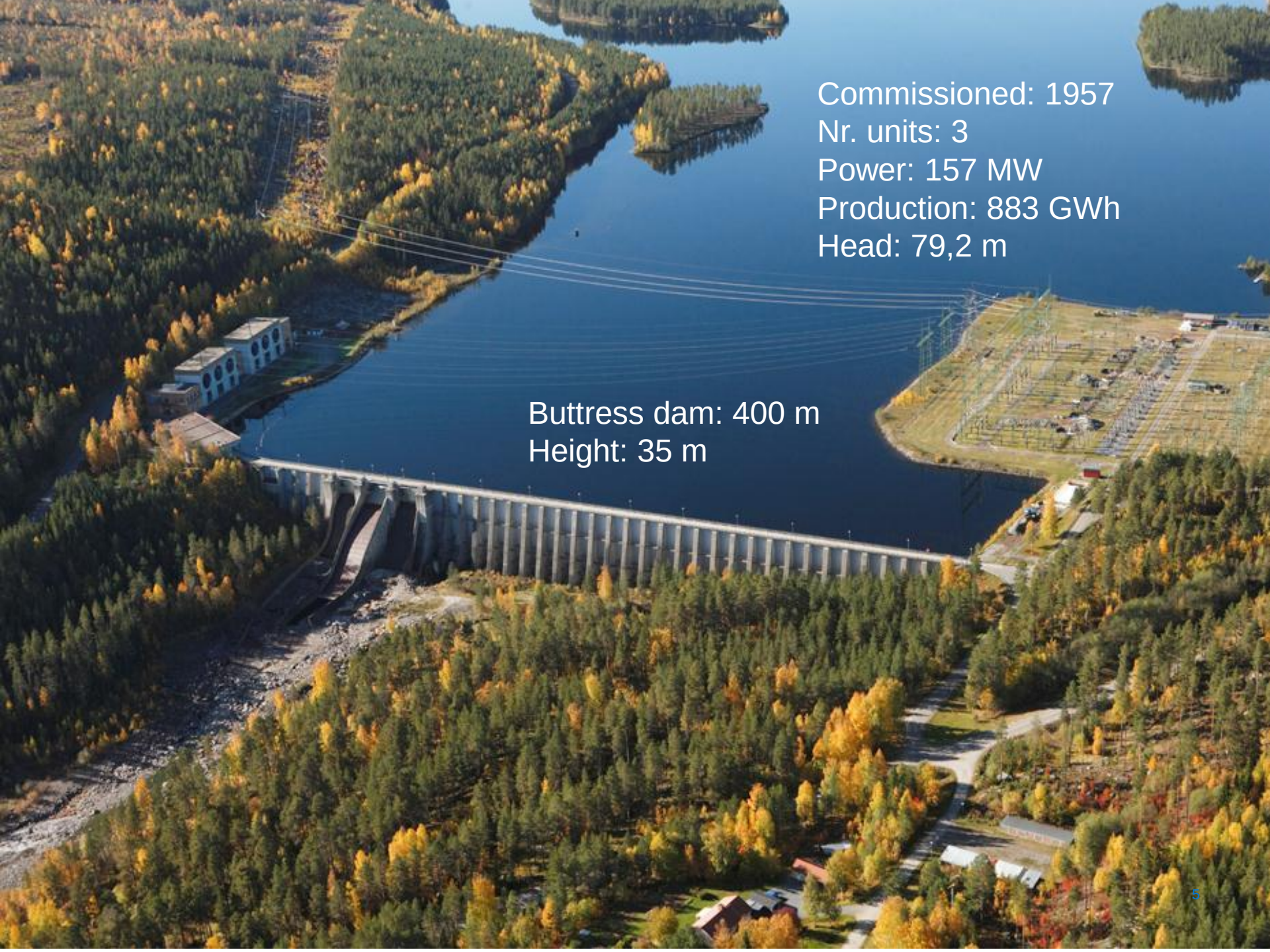
Orientation

- Faxälven, a branch of Ångermanälven

- 32 000 km^2 catchment area
- 500 m^3/s average water flow
- 12 TWh annually
- Approx 17% of total hydro production in Sweden


Bålforsen
Betsele
Hällforsen
Sippmikk
Blåsjön
Linvasselv
Fjällsjöälven
Umeälven
Faxälven
Borgforsen
Bodum
Åseleälven
Umeå
Stensjön
Kvarnfallet
Hällby
Gulsele
Degerforsen
Edensforsen
Fjällsjö
Lövön
Storfinnforsen
Uman
Moforsen
Lafssjö
Sollefteå
Ledinge
Graninge
Högfors
Forsse
Hjälta
Sollefteå
Ångermanälven
Indalsälven
Flåsjö
Rundbacken
Lagfors
Trångfors
Bergeforsen
Rätan
Turinge
Bursnäs
Ljungan
Sundsvall


Commissioned: 1954
Nr. units: 3
Power: 112 MW
Production: 536 GWh
Head: 49,5 m
Buttress dam: 900 m
Height: 40 m
Embankment dam: 300 m
Height: 25 m


Commissioned: 1957
Nr. units: 3
Power: 157 MW
Production: 883 GWh
Head: 79,2 m
Buttress dam: 400 m
Height: 35 m

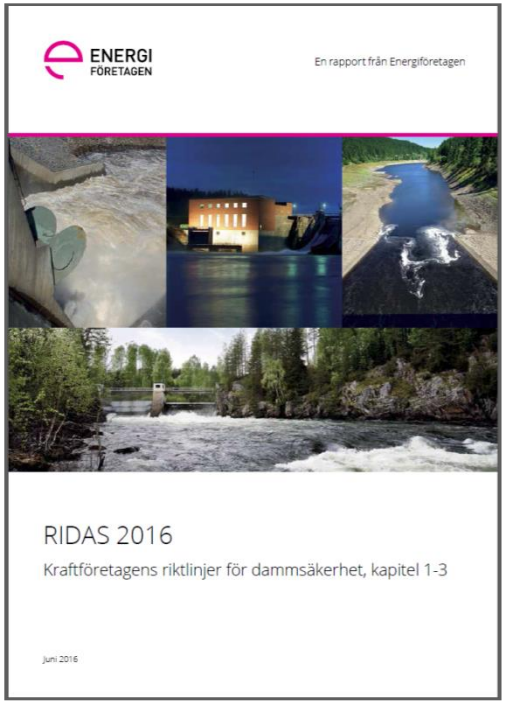
Owners question

Can the design flood can be safely discharged without dangerous rock scour?

Guideline - RIDAS

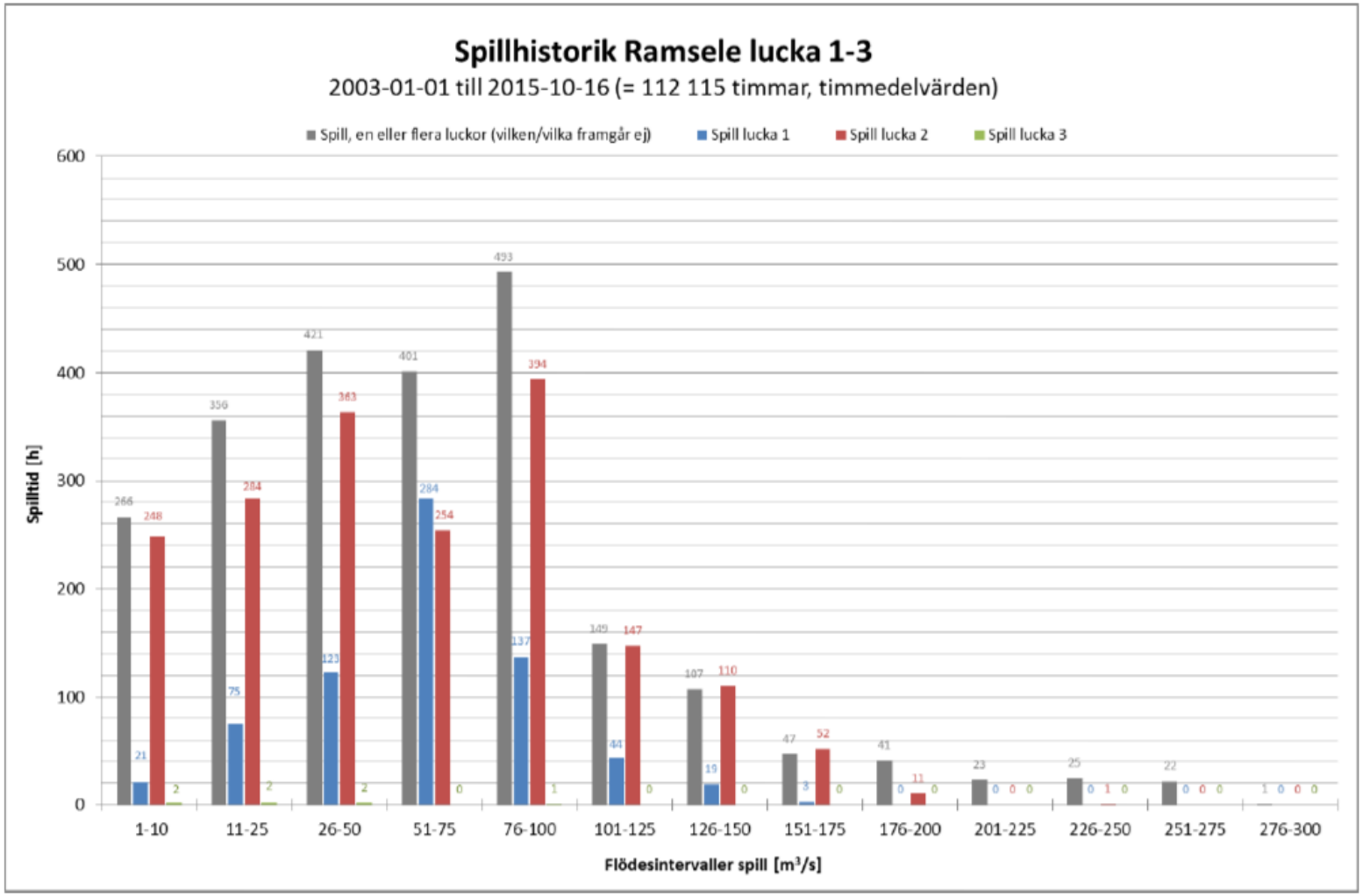
Only general descriptions like “Satisfactory energy dissipation to prevent undermining or other erosion that could threaten the dam at any flow up to the dimensional”

No detailed information



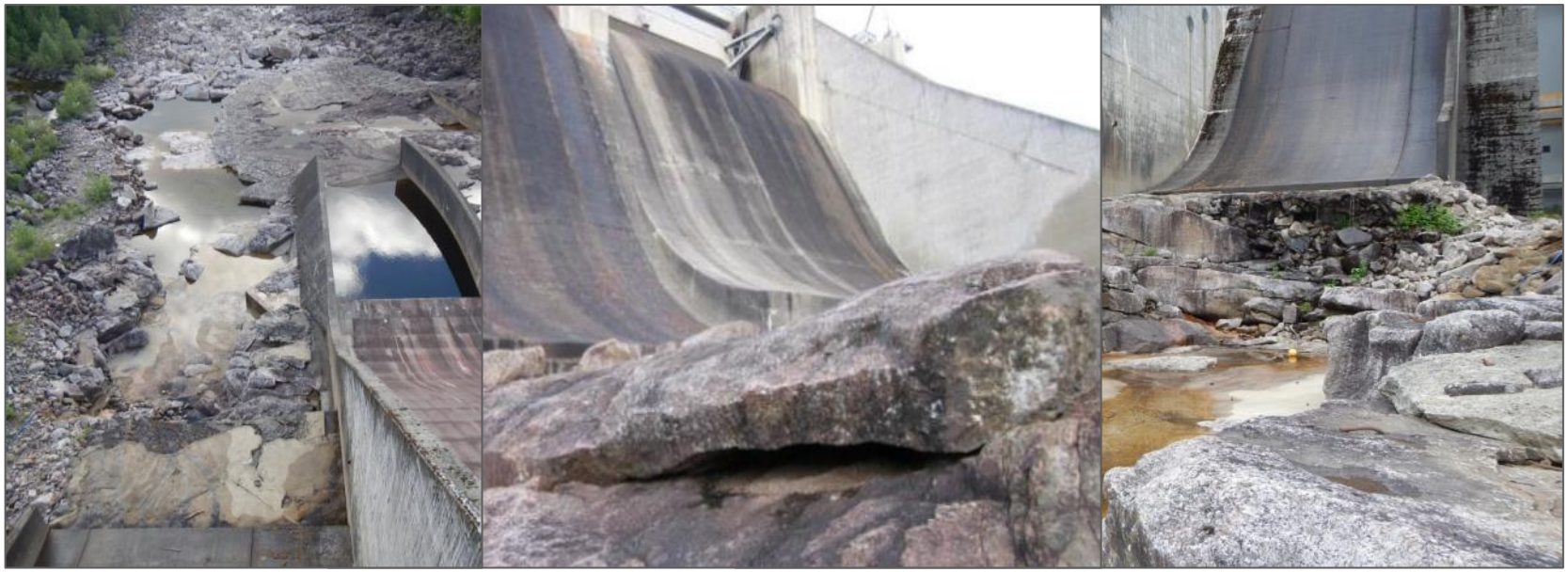
Experiences

- The spillways are seldom used, long time since last flood situation (1995)



Experiences

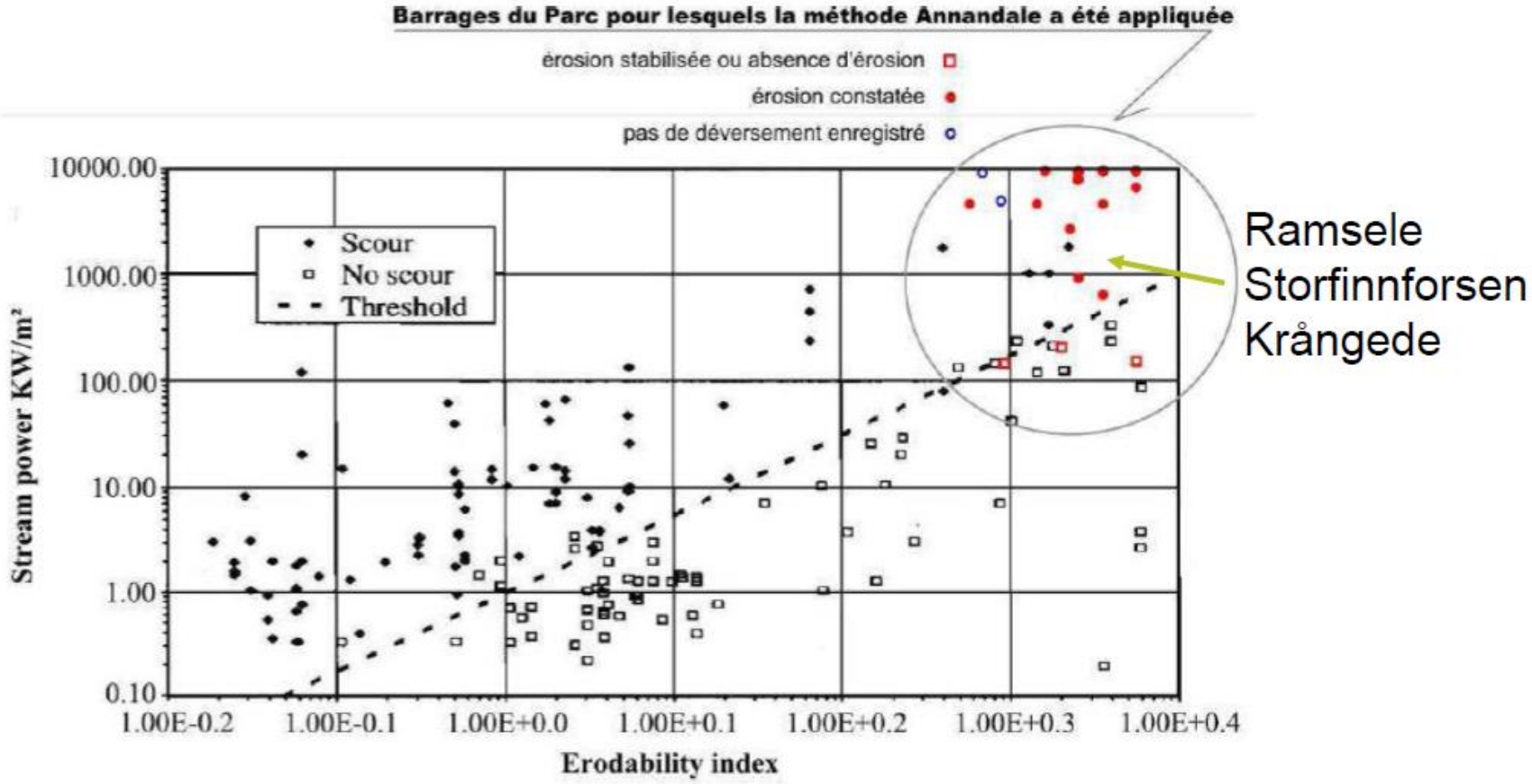
- Obvious scour downstream left spillway in Ramsele
- Minor scour at the other spillways
- Notes about scour in protocols from inspections and function testing



Left Spillway Ramsele

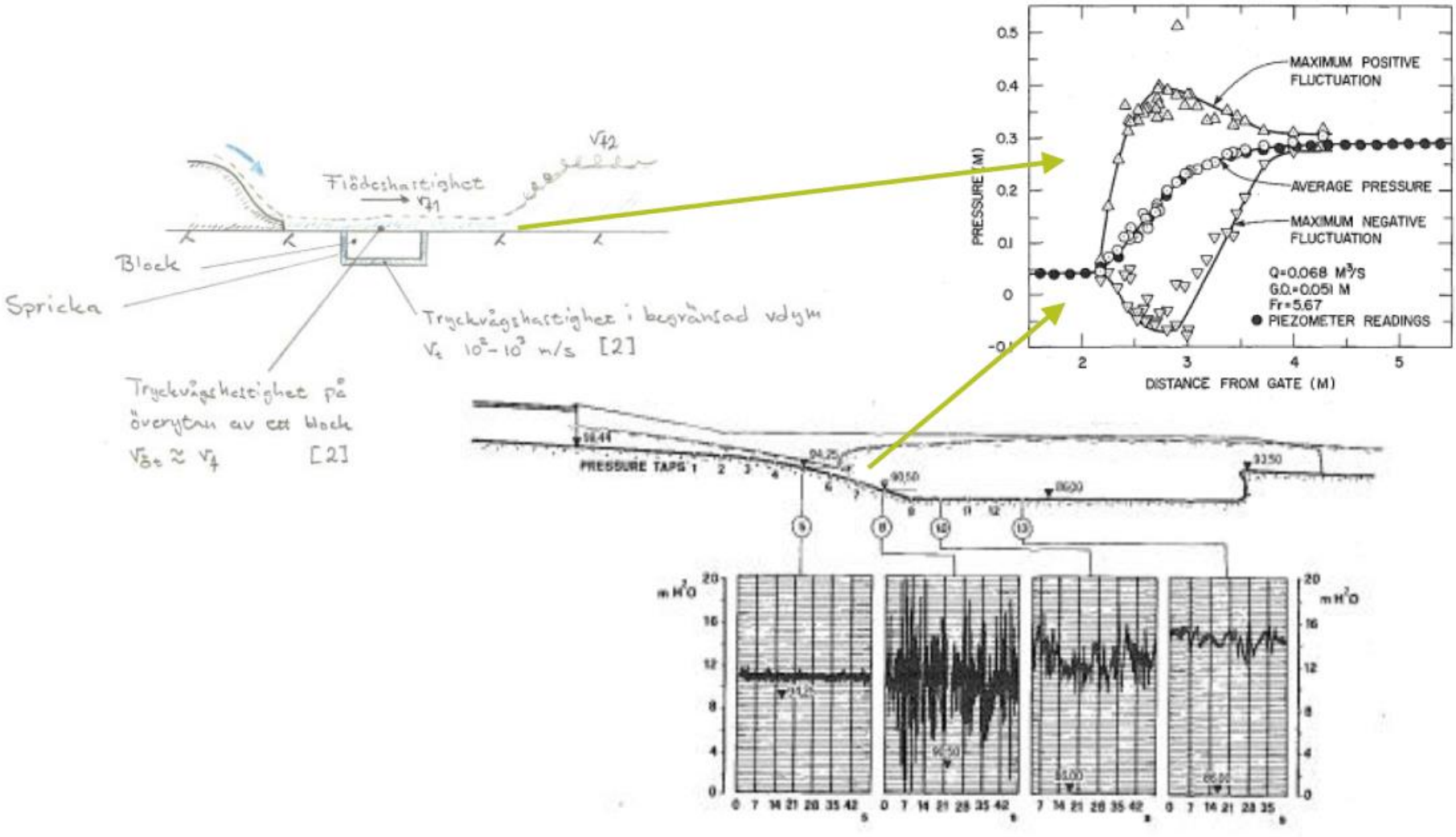
Erodability Index Method

G. Annandale

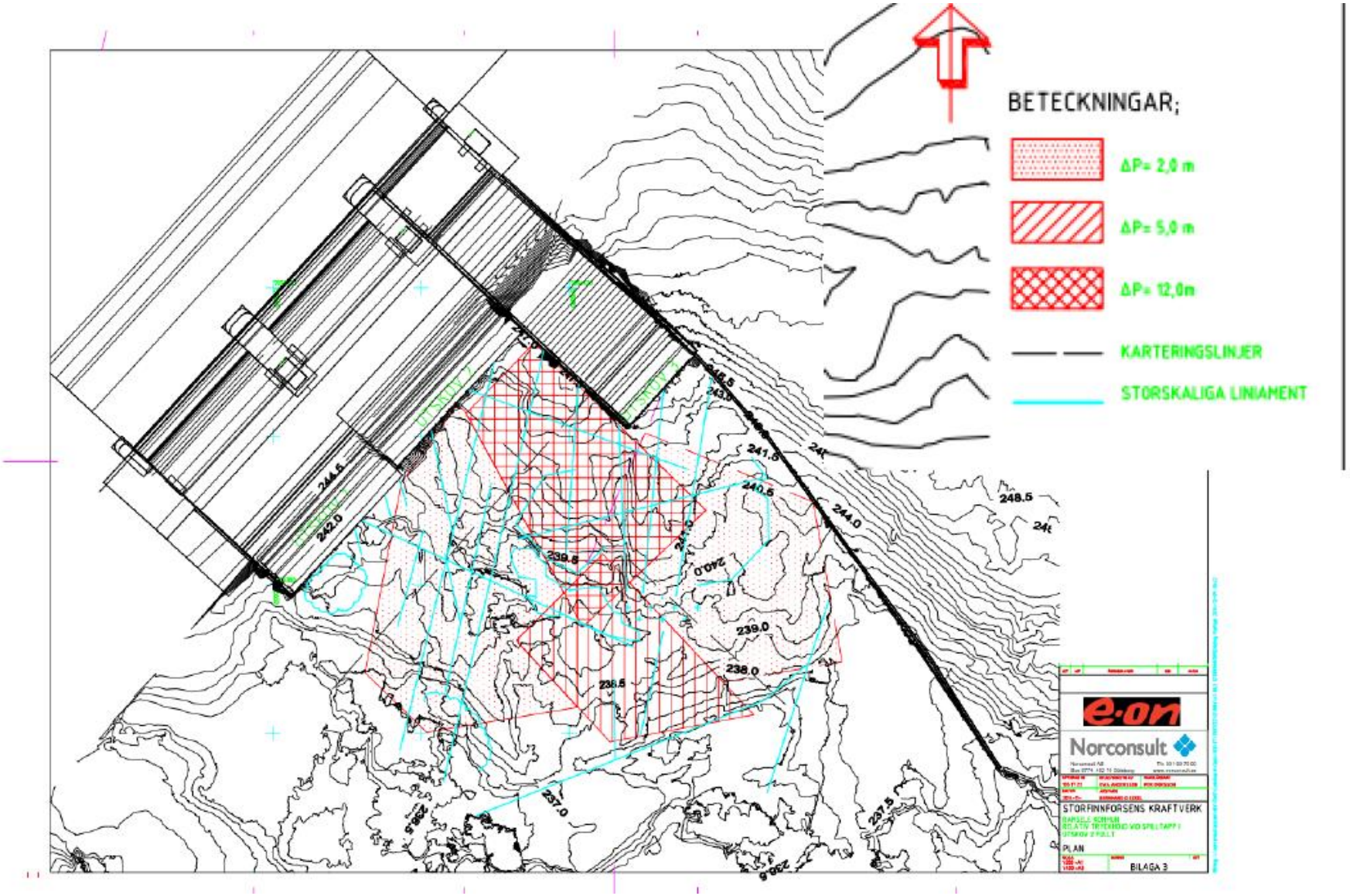


Calculations

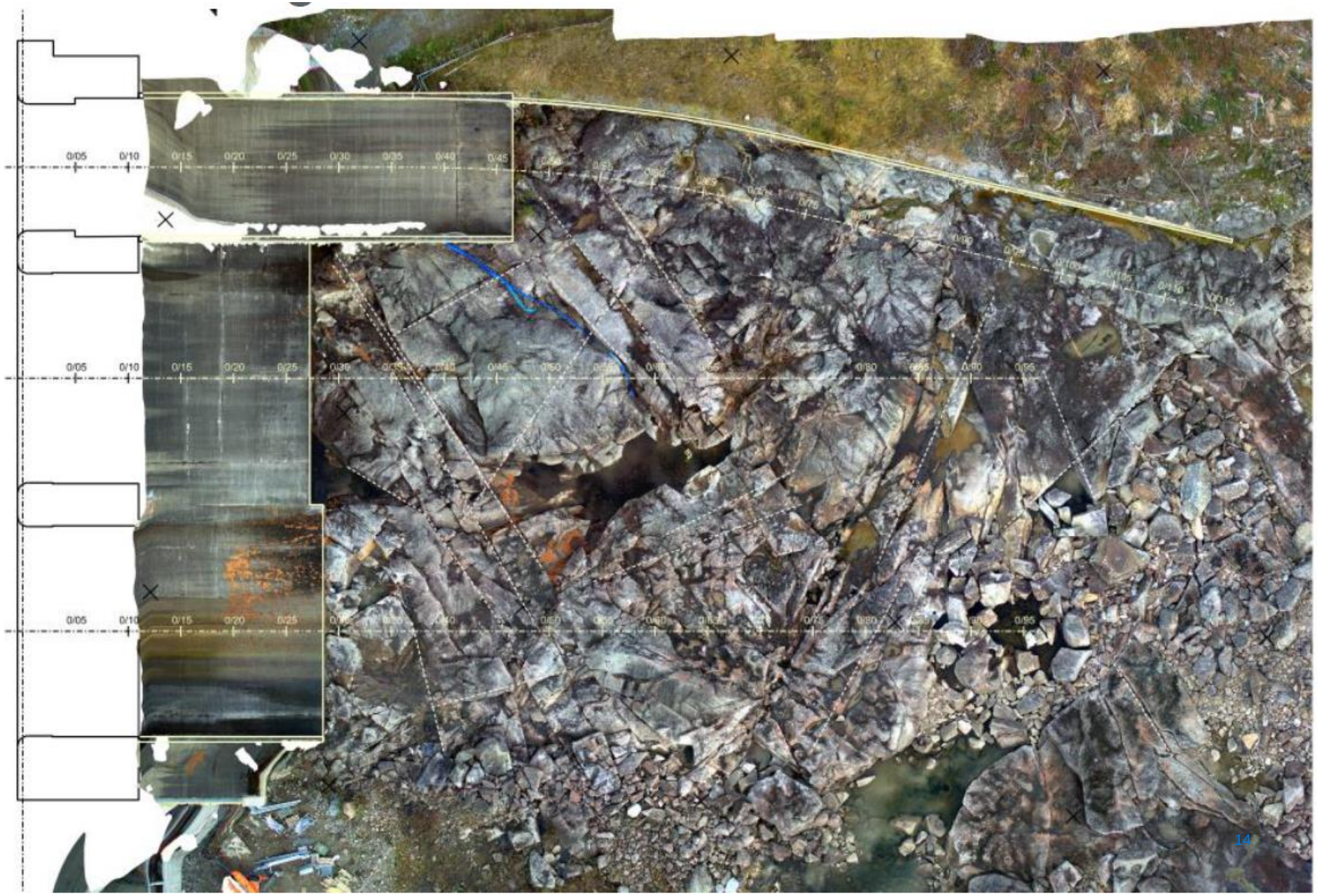
Large pressure fluctuations can evolve



Hydraulic Model



Geologic Model



Physical Modelling

“Indicators”

- Minor erosion has been reported during years of operation
- Obvious erosion in Ramsele left spillway
- Calculations shows that there are risk for erosion
- Laboratory tests confirms that
- Erodability index method also indicate potential problems

Q: Can the design flood can be safely discharged without dangerous rock scour?

A: Maybe, probably not, actions needs to be taken

Research in Sweden

- One minor project regarding Swedish data for the Erodibility Index Method with focus on site visits (Energiforsk, J. Persson, P. Eriksson et al.)
- Block erosion project, newly started, focus on why block erosion starts and main factors for it to become progressive (Luleå University of Technology, E. Nordlund, D. Saiang et al.)

Future work

- Advises in Swedish dam safety guideline for:
  - General estimation of risk for progressive rock erosion, during high flood and for extended time, for Swedish conditions
  - Identification of potential problems
  - How to judge the safety margin in a consisting (systematical) way for different sites
  - Good solutions for decreasing risk of rock erosion

- This will probably need a programme with a coordinator to collect knowledge and identify gaps. Cooperation between different research projects, domestic as well as international, are essential

What Did We Do?

Spillway extension with ski jump and rock bolting