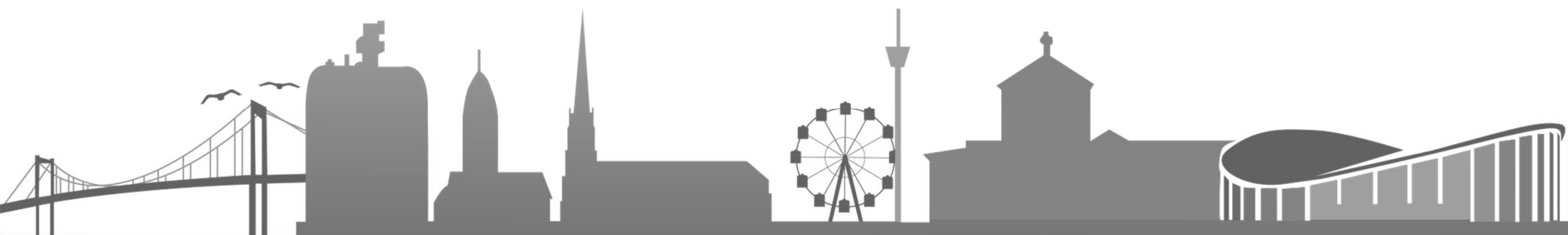




A Swedish perspective on extreme floods and adaption to climate change

Sten Bergström, professor, retired from the Swedish Meteorological and
Hydrological Institute, Sweden



ICOLD 2023 – 91st Annual Meeting – Symposium – Management for Safe Dams – Gothenburg – 13-14 June

Rivers in Sweden



Source: The Swedish Meteorological and Hydrological Institute

Most hydropower in the north



Photo: Sten Bergström

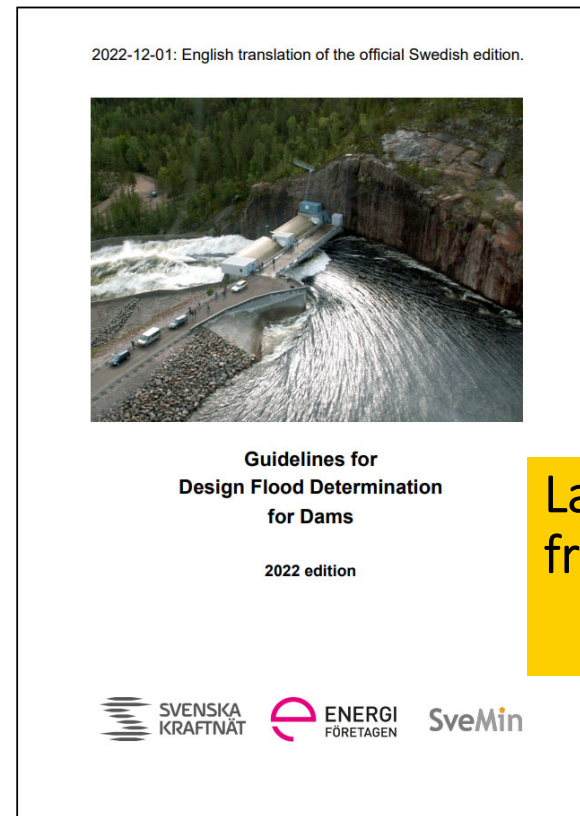
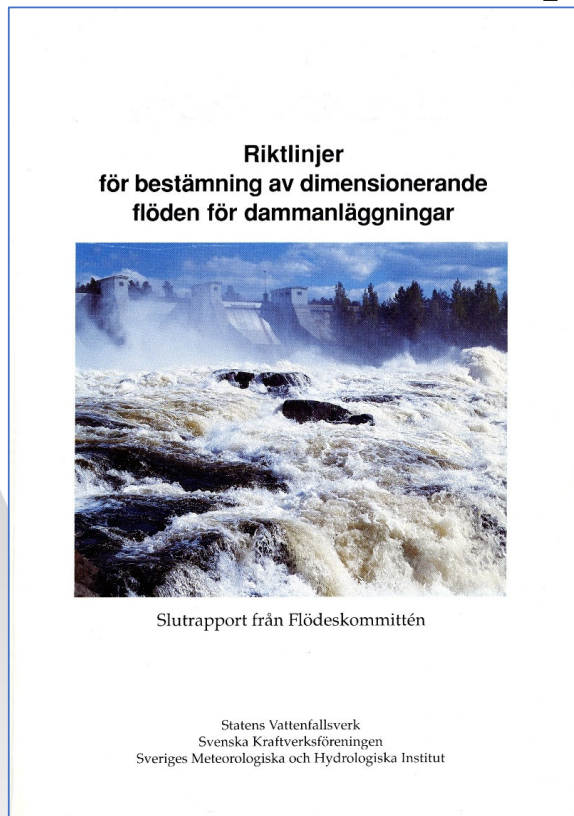
Dam safety concerns in the 1980-ies



Noppikoski dam failure in September 1985.

Source: Lantmäteriet

New guidelines on design floods were adopted in 1990

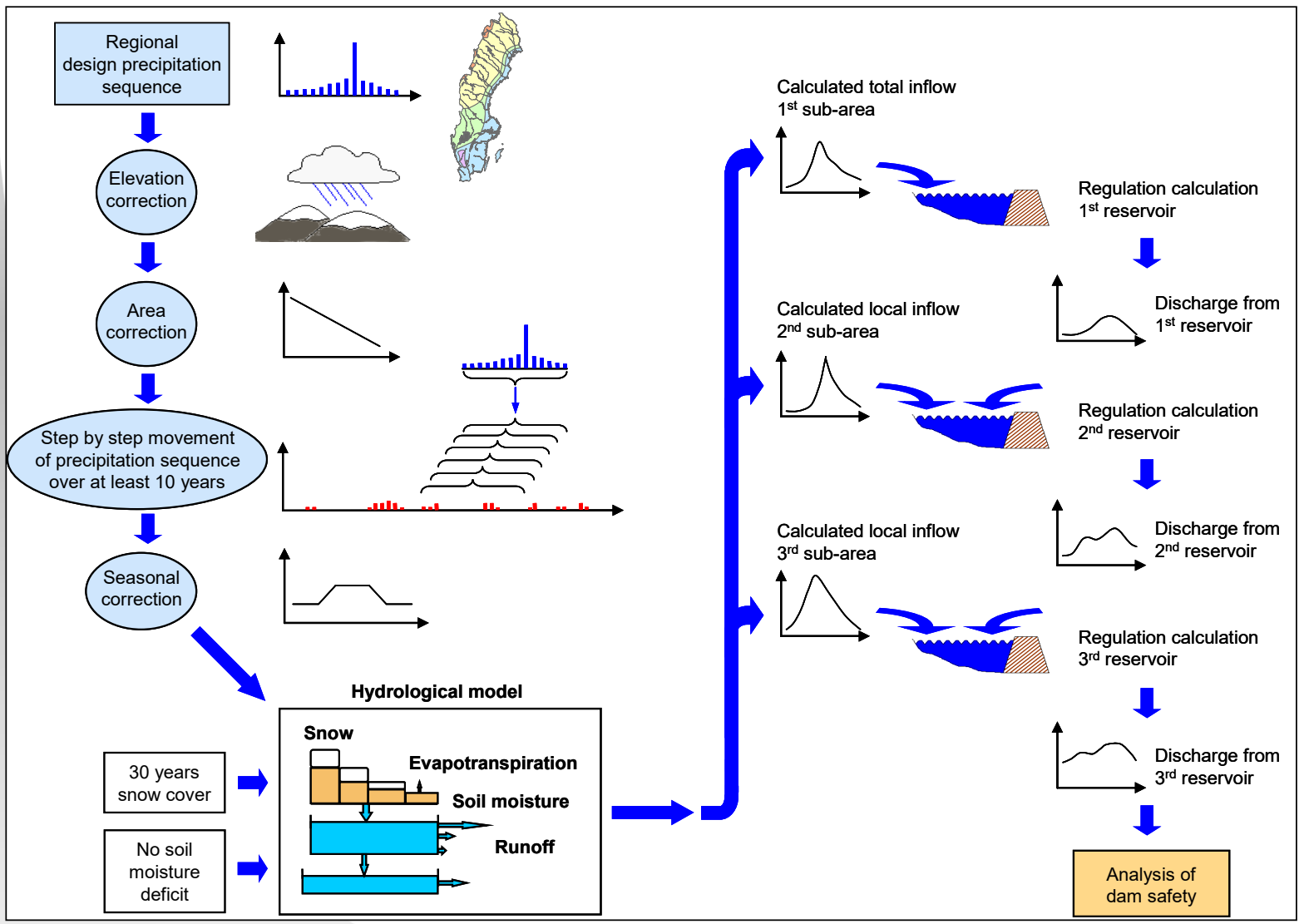


Latest edition
from 2022



Basic principles for high-hazard dams

- **Analysis of the whole river system**
- **Use of hydrological modelling to identify the most critical combination of flood generating factors (snowmelt and rainfall)**
- **River regulation is considered**



Principal drawing of the calculation of the design floods for high hazard dams in Sweden

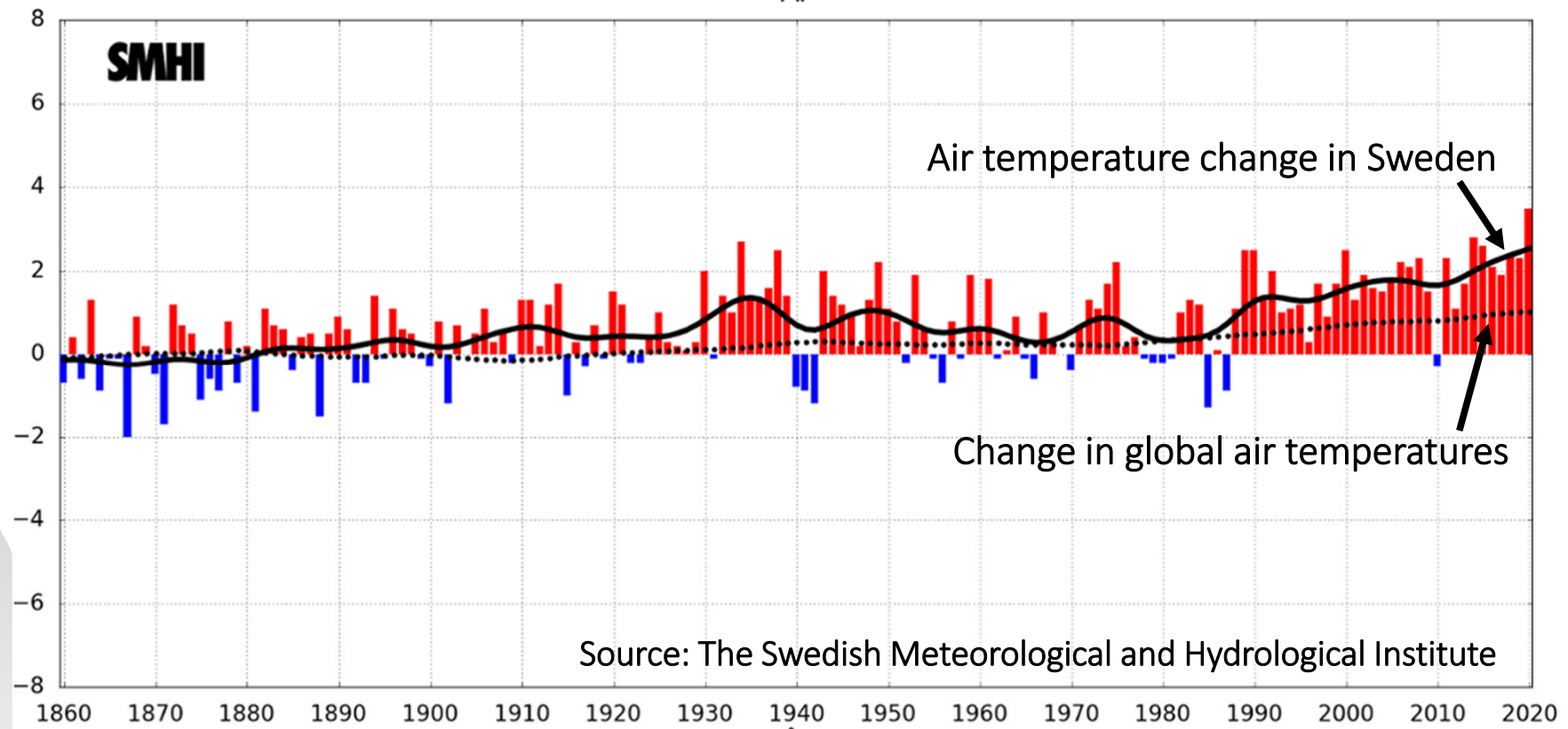
Re-assessment and upgrading



Häckren in River Indalsälven.

Photo: Vattenregleringsföretagen

Adaptation to climate change

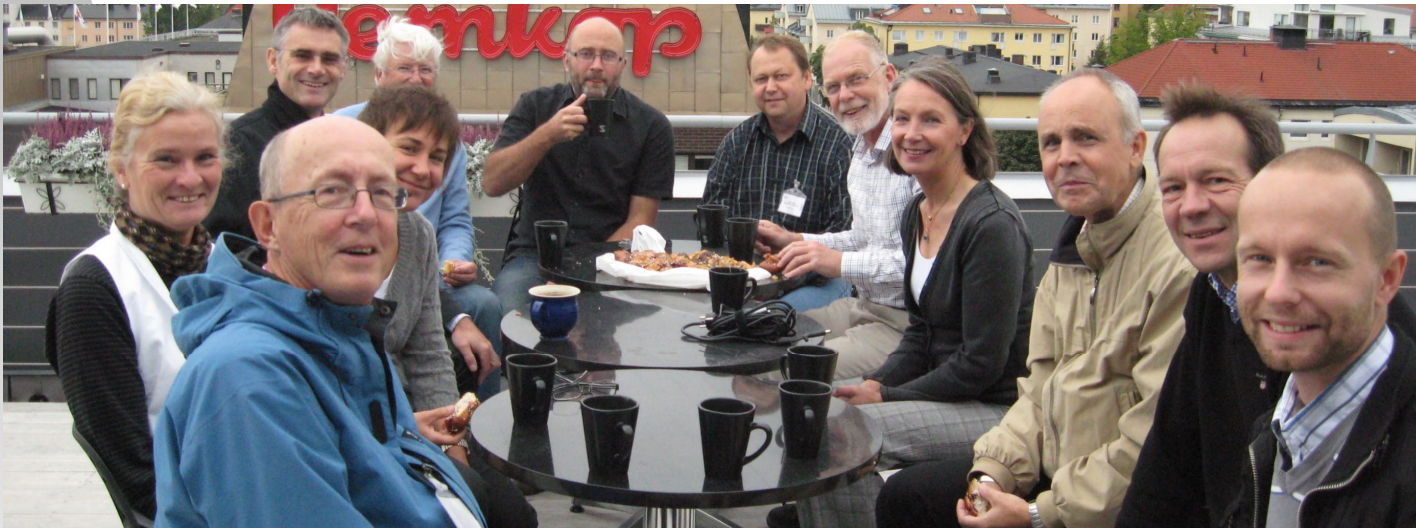


A climate committee was established in 2009



Members:

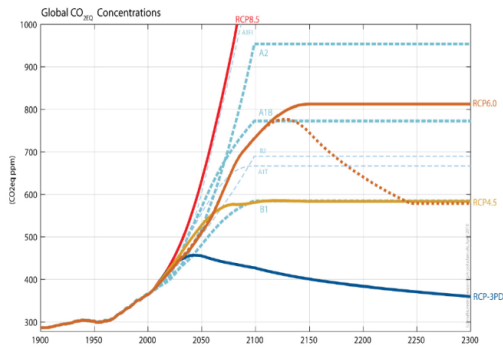
- Swedish Meteorological and Hydrological Institute
- Svensk Energi
- Svenska kraftnät
- Vattenfall
- Statkraft
- Vattenregleringsföretagen
- Fortum
- E.ON.
- SweMin



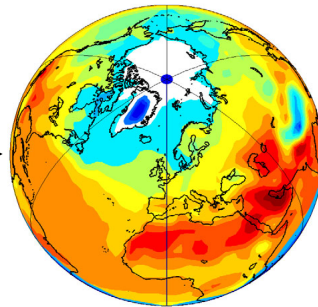
A method to account for climate change was developed



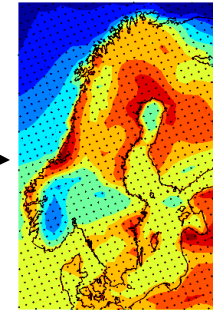
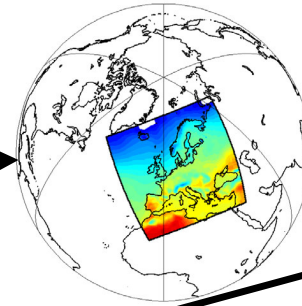
Future emissions



Global climate model

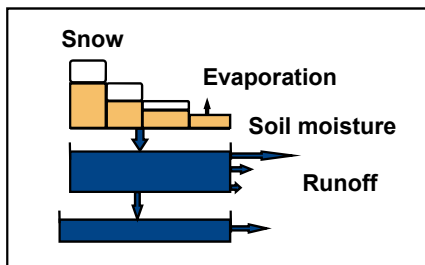


Regional climate model



Bias correction (scaling)

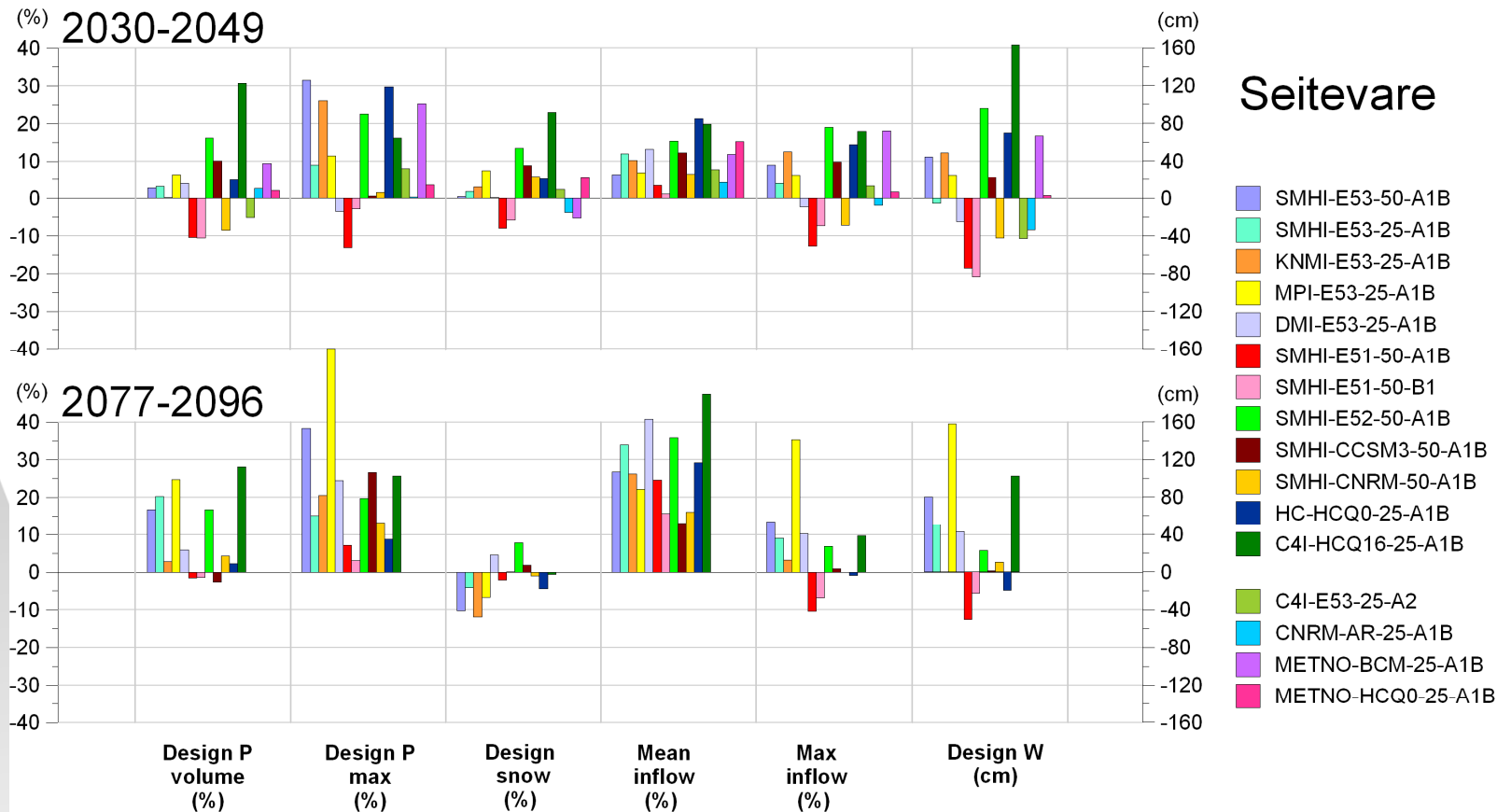
Hydrological model



Statistical treatment

Source: The Swedish Meteorological and Hydrological Institute

Results were analysed



Recommendations were formulated



2022-12-01: English translation of the official Swedish edition.



Guidelines for
Design Flood Determination
for Dams

2022 edition



SveMin

“The sensitivity of a river system to climate change should be analyzed by utilizing climate scenarios that describe both extensive and less extensive climate change (Hallberg et al., 2014). The methodology for this needs to be well documented and be supported by a scientific basis (Svenska kraftnät et al., 2011).

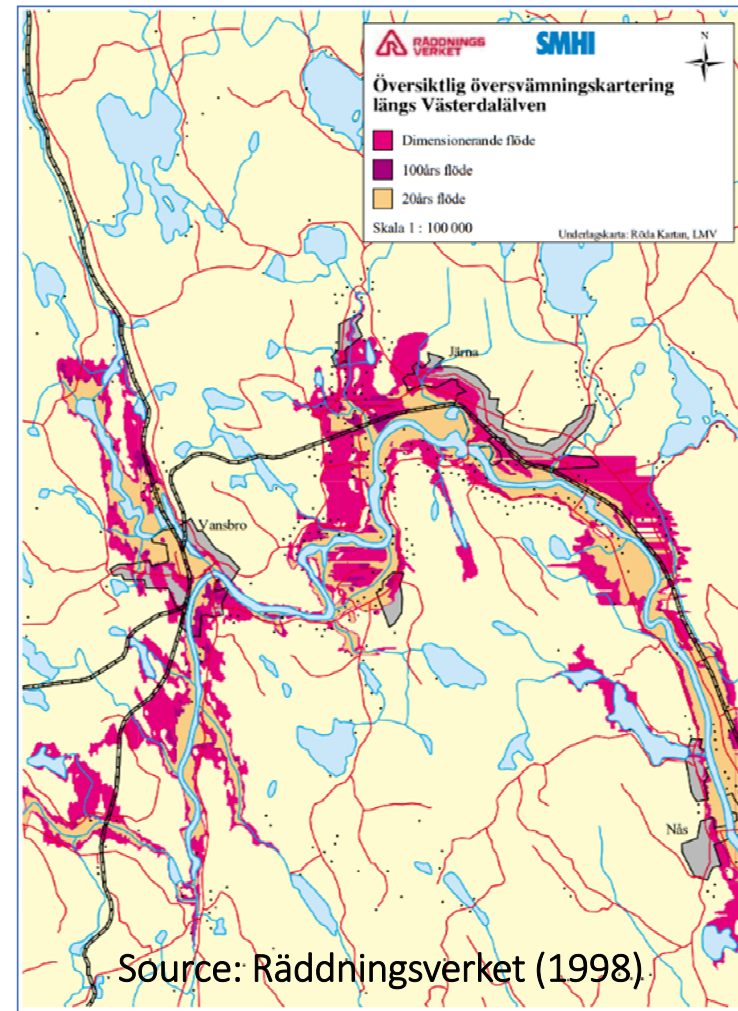
New conditions may lead to the need to revise design flood calculations. Uncertainties about how the climate is changing must however not hinder the implementation of measures necessary to enhance dam safety. Furthermore, these measures should where reasonable be designed so that flexibility and margins are created.”

Swedish community planning



The work on extreme floods, as carried out by the power and mining industries, has had far reaching impacts on Swedish community planning.

Flood risk mapping

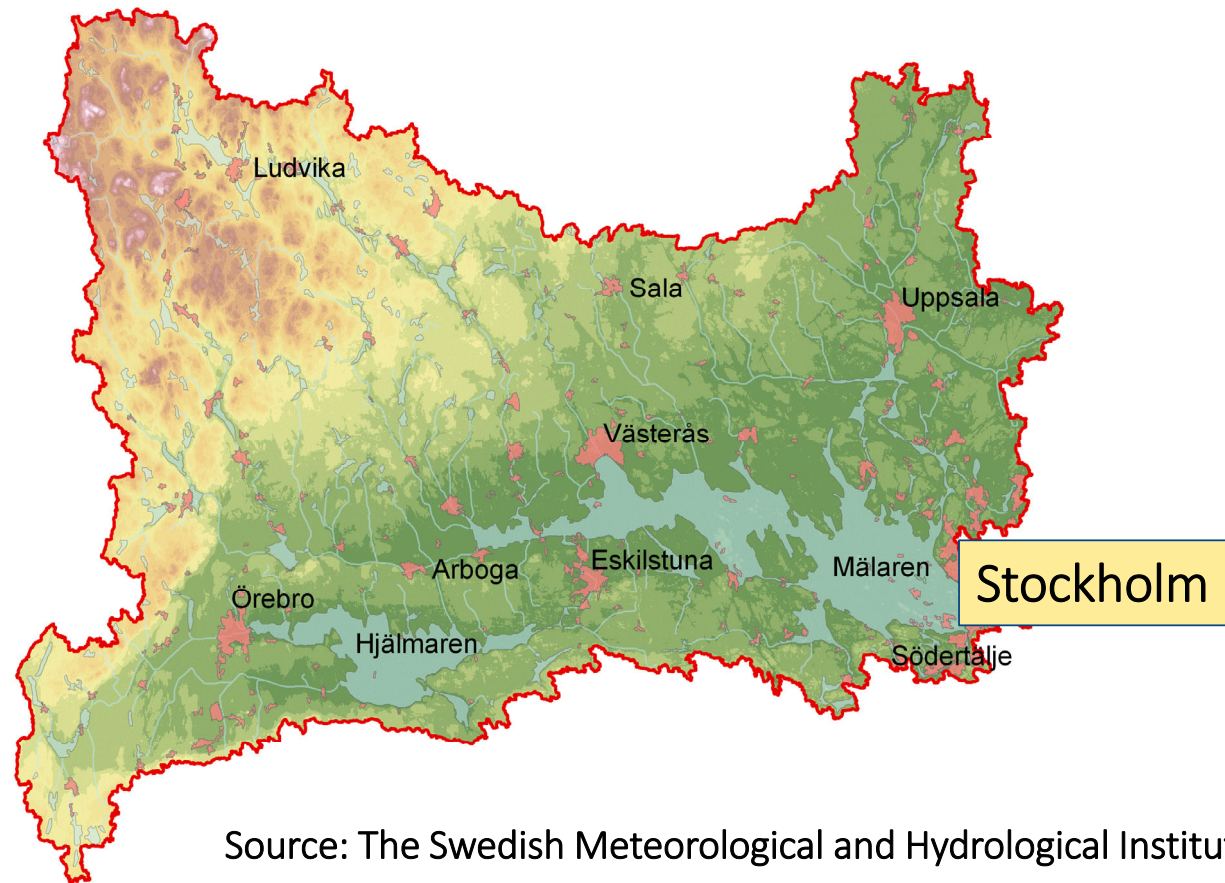




Stockholm and Lake Mälaren.

Photo: Sten Bergström

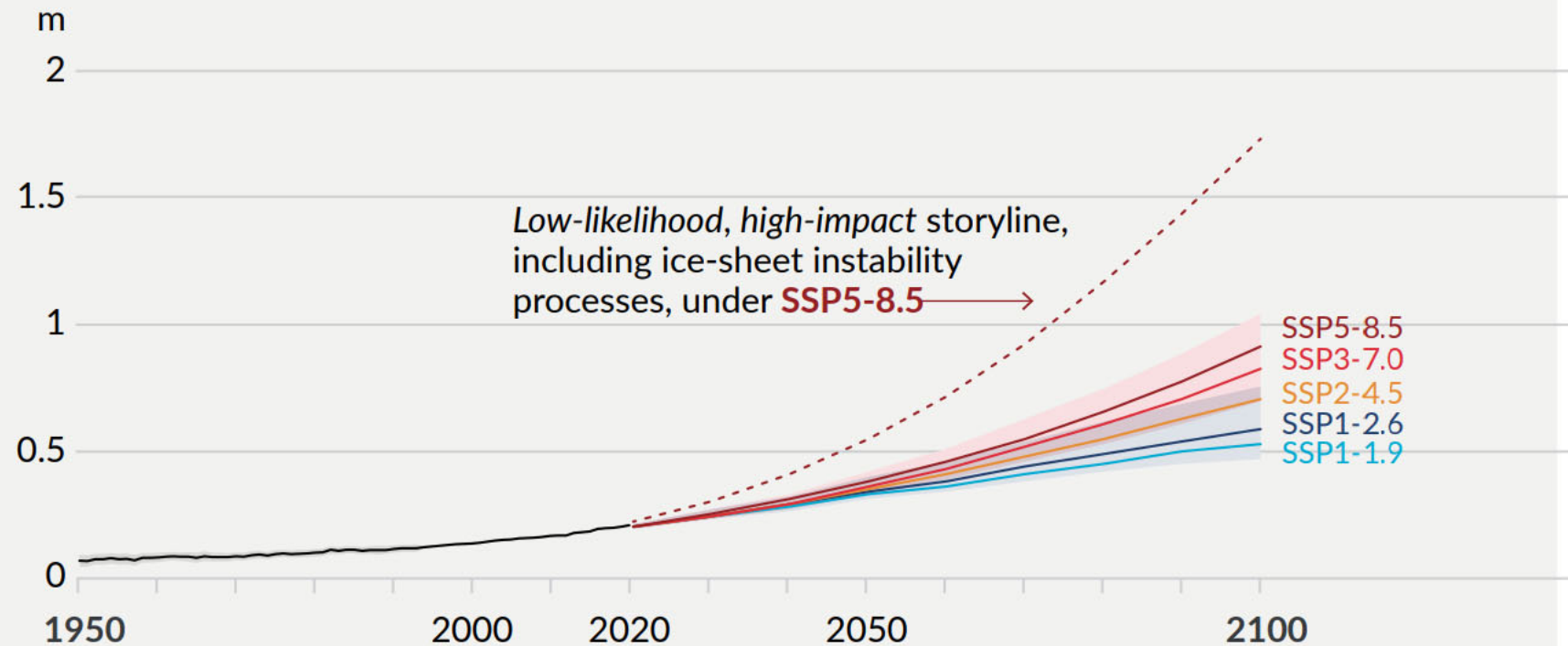
River flow is calculated according the guidelines



Source: The Swedish Meteorological and Hydrological Institute

Sea level rise is accounted for

(d) Global mean sea level change relative to 1900



Source: IPCC, 2021

Lake Vänern, River Göta älv and Gothenburg



Lake Vänern is the largest lake in EU
(area 5 650 square kilometers)

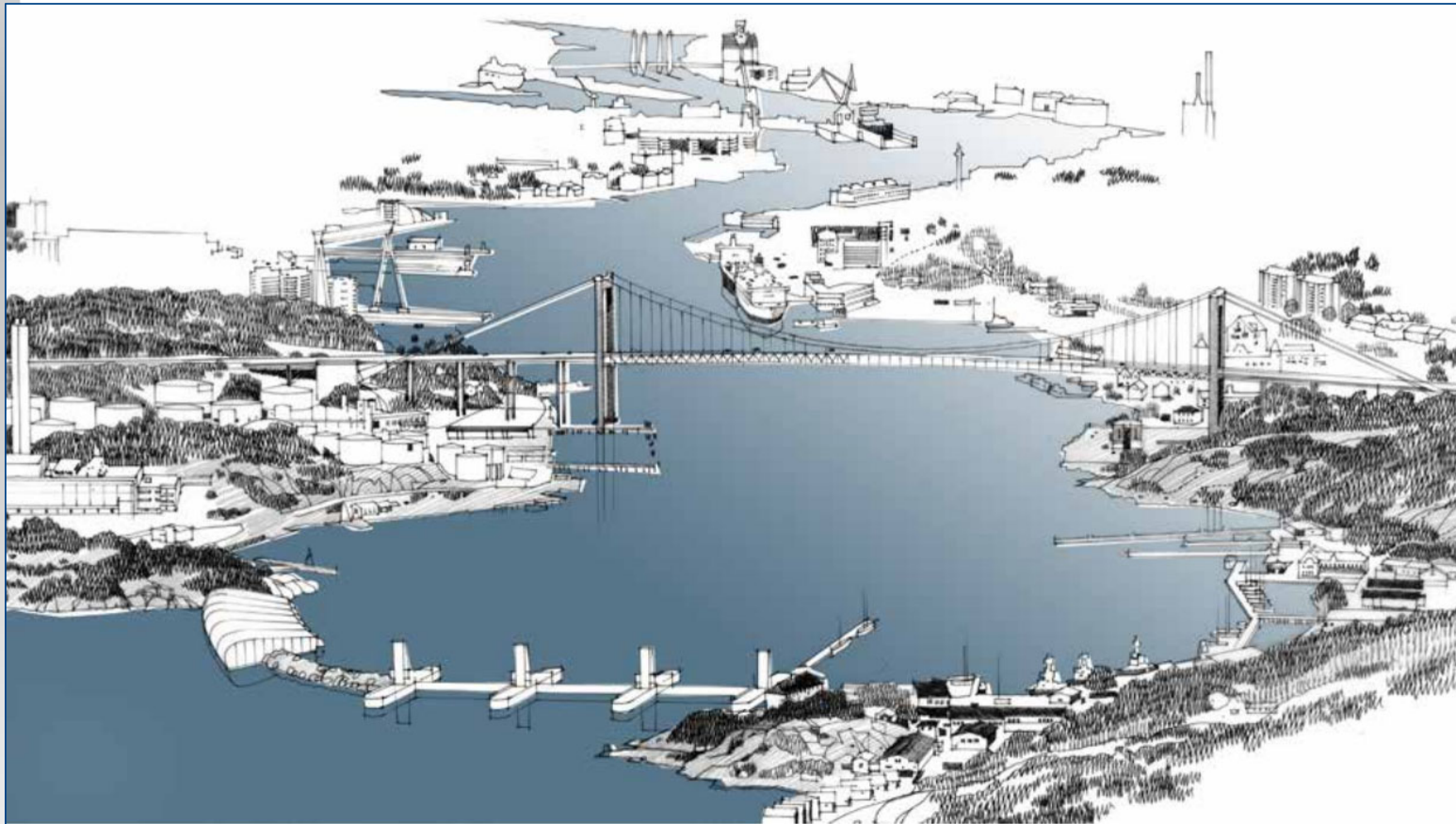
Göta älv is Swedens largest river
(mean annual flow 565 m³ /sec.)

Göta älv and Lake Vänern - a complex river system



- Hydropower production
- Shipping
- Water supply
- Agriculture
- Unstable geology (clay and landslides)
- Exploitation of the shoreline
- Vulnerable to climate change (river flows and sea level rise)

Gothenburg in the future?



Source: SWECO Architects, on contract from the city of Gothenburg

A new climate committee is in place



Adaptation to climate change requires long term co-operation between science, authorities and the industry!

Photo: Maria Bartsch



Thank you!