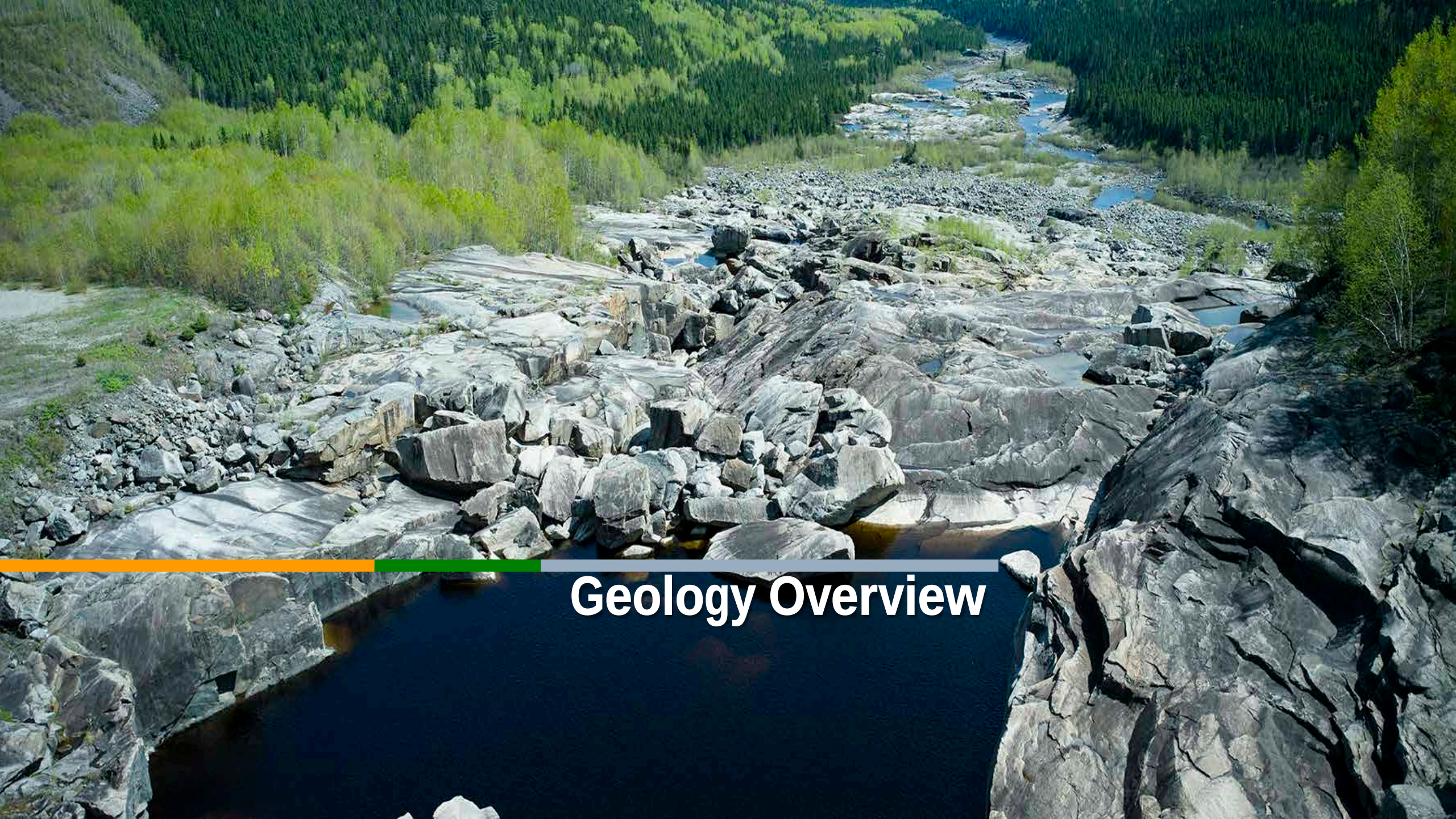
CONCRETE DAMS OVERTOPPING EROSION

Hydro-Québec Perspectives : Issues and Engineering Needs

Marco Quirion, P. Eng., Ph.D
Éric Mainville, P. Eng., M.Sc.A

Overview

- Quebec's geology overview
- Erosion downstream of Hydro-Québec spillways – Few examples
- Erodibility evaluation
- Some engineering issues



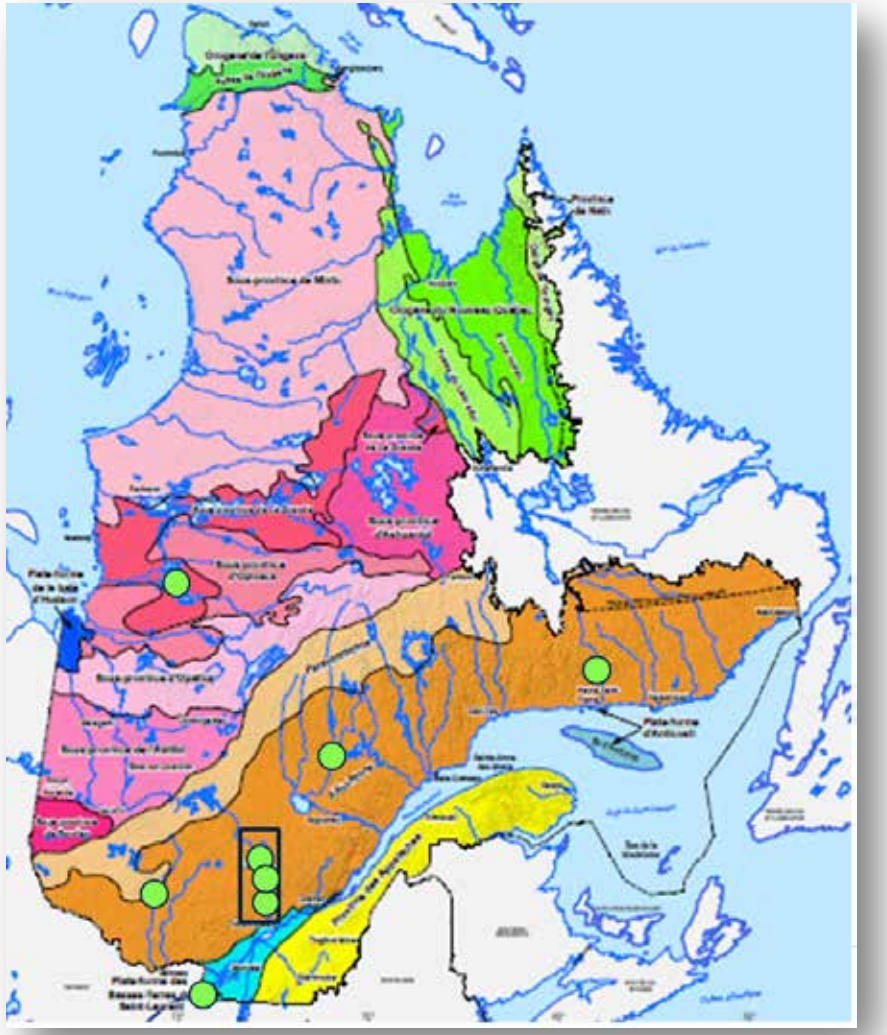
Geology Overview

Geological Provinces of Québec

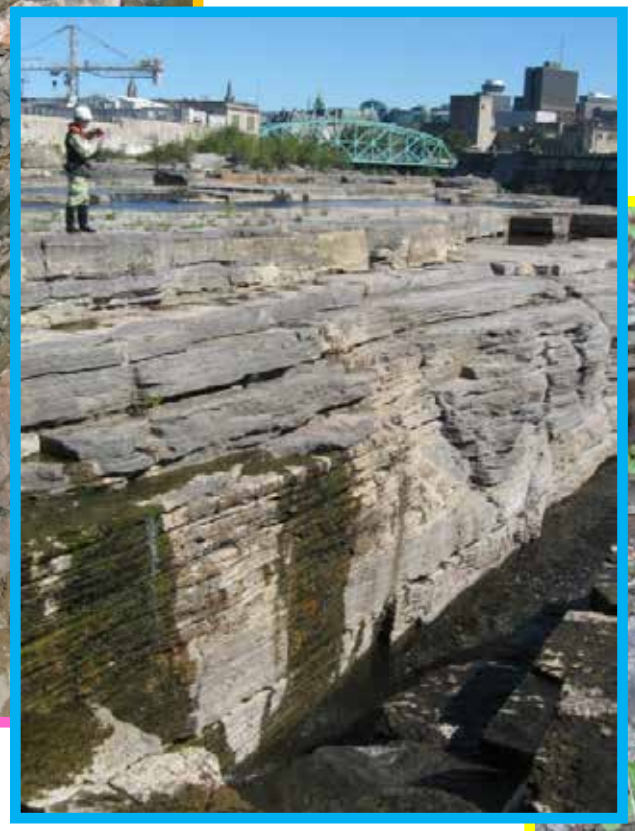
Crystalline Rocks
(Granite, gneiss)

Sedimentary Rocks
(Limestone, Shale)

Metamorphic Rocks
(Low Grade : Schist)



Rock Types



Typical Joints in Crystalline Rocks

Unlined Spillways Erosion: History Cases

Unlined Spillways Impacted by Erosion

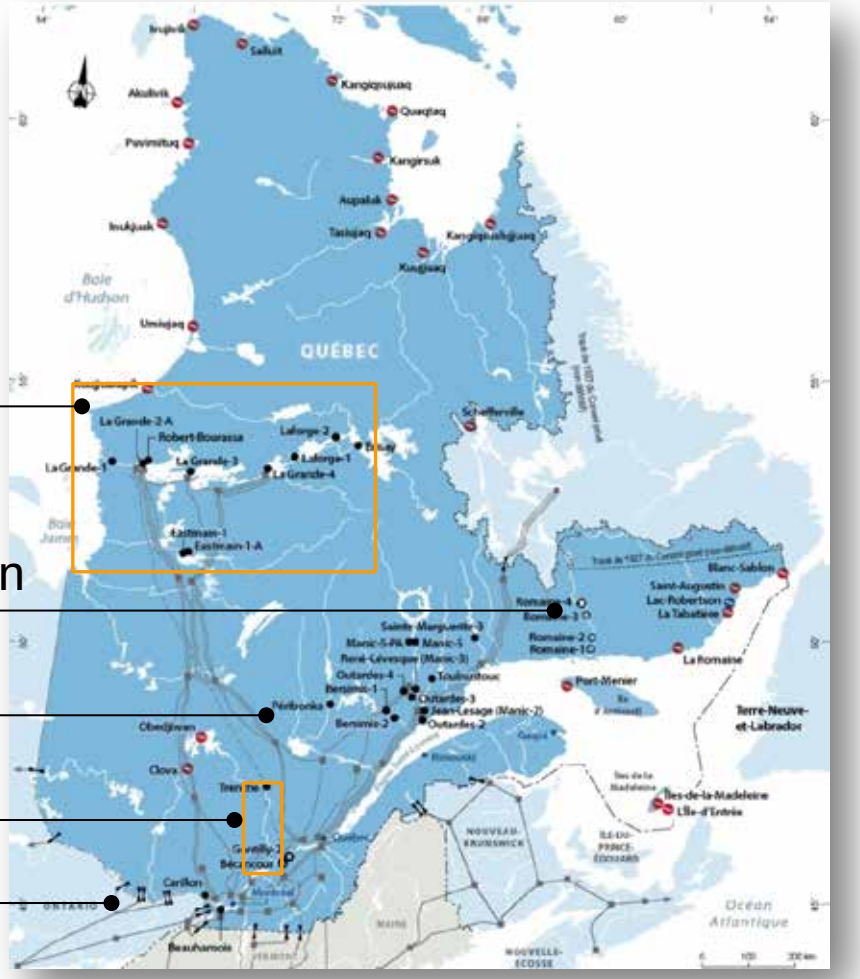
James Bay Region

Lower North Shore Region

Saguenay Region

St-Maurice River

Ottawa River



St-Maurice River [1] (2004)

- Rock erosion downstream of spillway channel
- Accumulation of sediments, gravel and blocks downstream of the powerhouse's tailrace
- Highlights
  - Underwater blasting
  - High Explosive loads
  - Significant subdrillings

St-Maurice River [2] (2008)

- During design, the rock downstream of the spillway was considered vulnerable (pegmatite)
- Highlights
  - Concrete protection at the foot of the sidewalls
  - 2008 Hydraulic Testing – Signs of erosion observed at the downstream end of the protection
  - 2010 Inspection indicates no further erosion

St-Maurice River [3] (2010)

- Autumn flood 2010 evacuated through one gate (VE4)
- Outflow of 470 m^3/s for 86 hours
- Significant damages at the spillway's apron
- Highlights
  - Construction in the 1940's
  - Low concrete thickness
  - Many concrete construction joints

Saguenay Region (2007)

Baskatong Reservoir (2007)

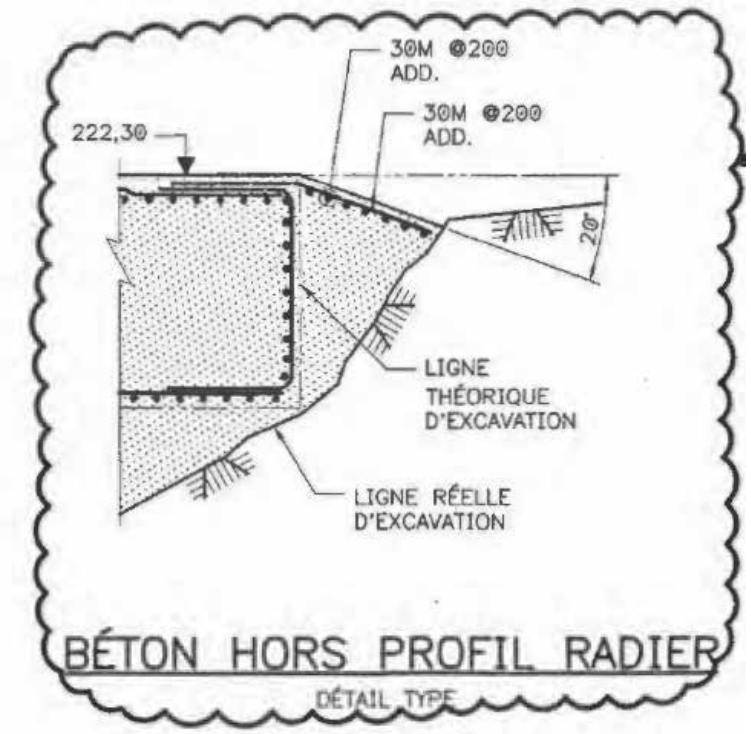
- Addition of a powerhouse starting in 2004
- Flood in 2007 evacuated by the bottom outlet during construction
- Boulders accumulation downstream
- Highlights
  - Outflow 400 m^3/s during 4 months
  - Velocities above 20 m/s
  - Described as exceptional

James-Bay Region (2008)

- About 2 m thick of rock eroded following the opening of the gates
- Corresponds to the thickness of rock affected by blasting
- Highlights
  - Shear zone
  - Significant subdrillings

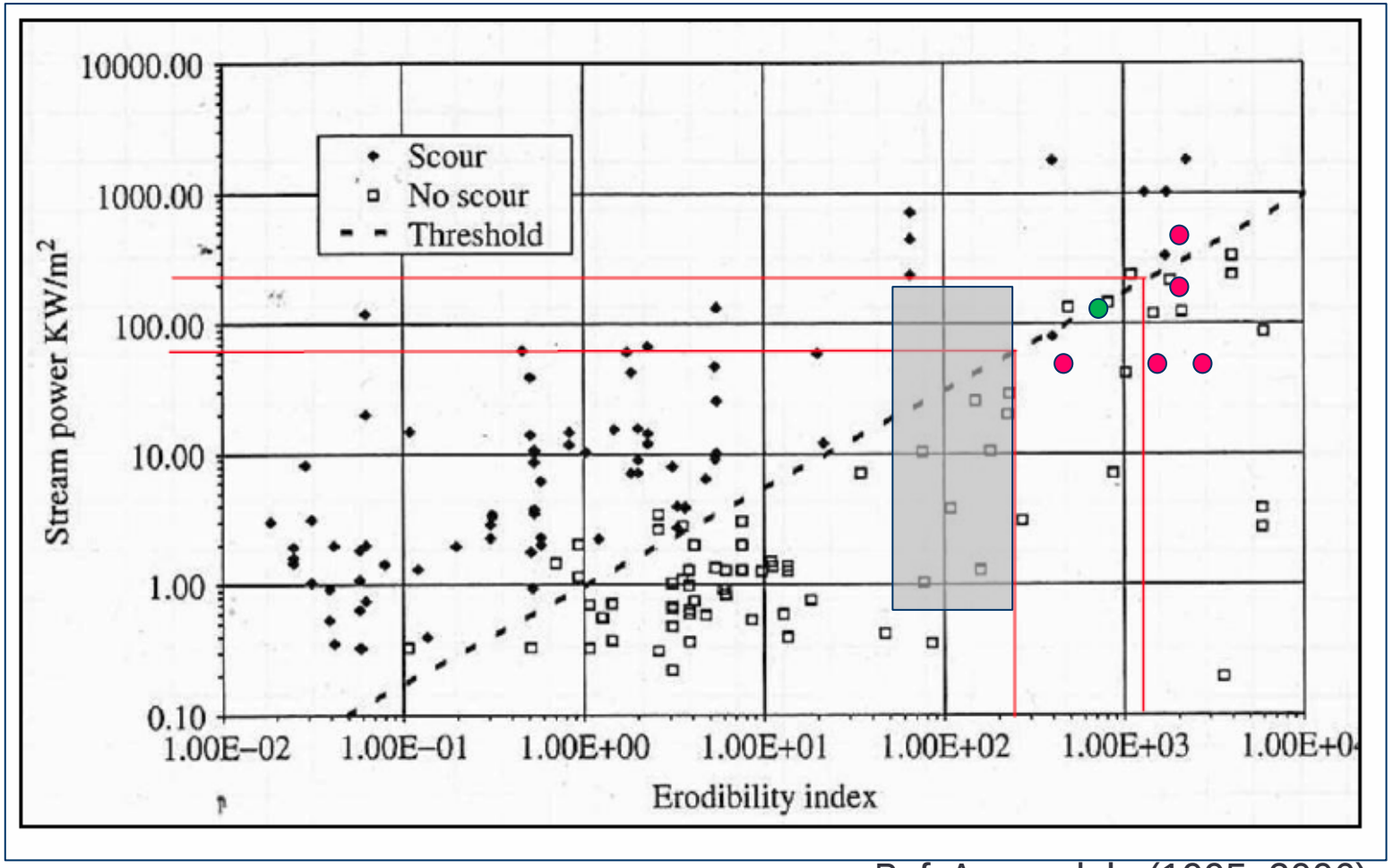
Lower North Shore Region

- Excavation profile not as planned
- Loss of reprofiling concrete



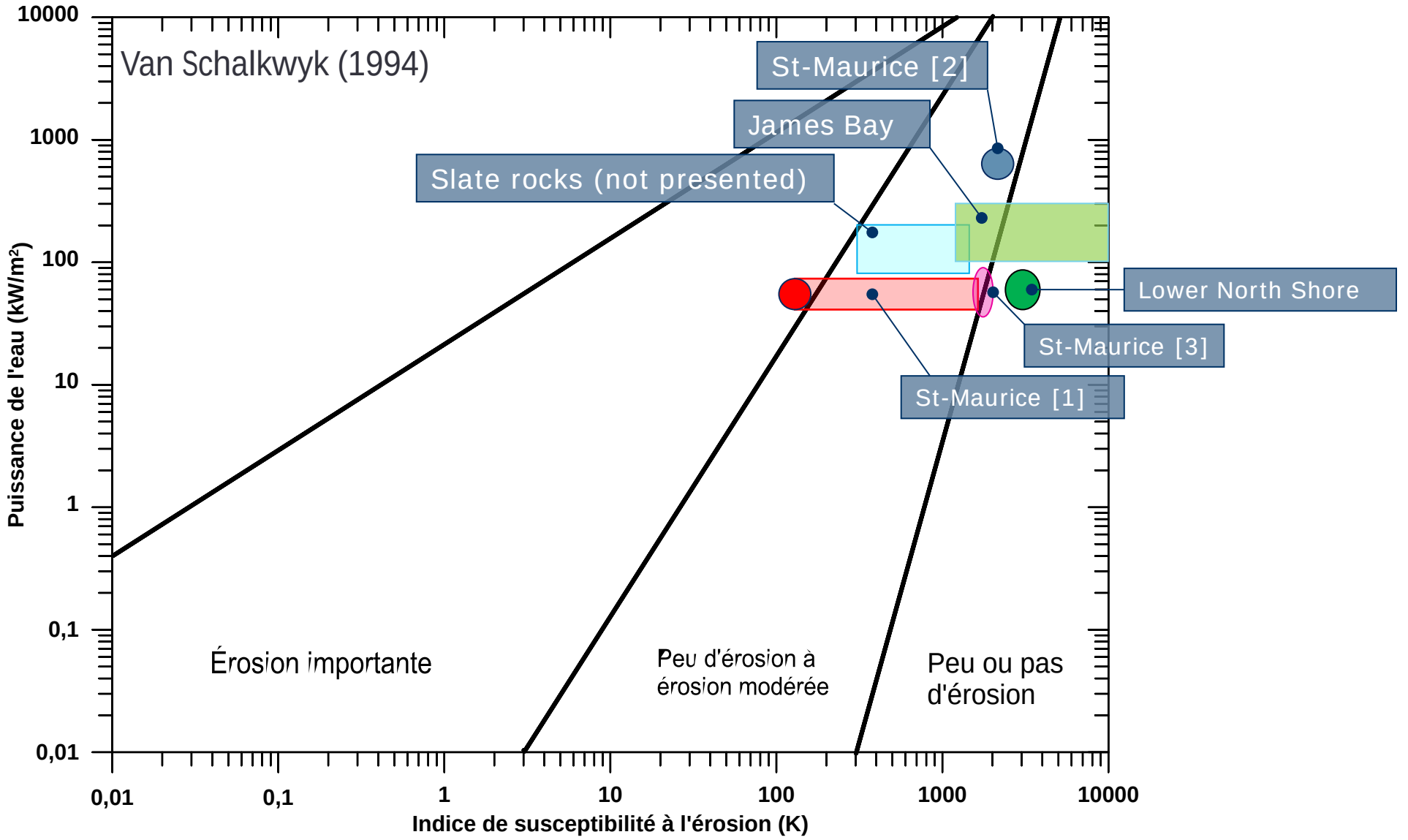
Erodibility Potential Evaluation

Erosion Potential – History Cases



Ref. Annandale (1995, 2006)

Erosion Potential – History Cases

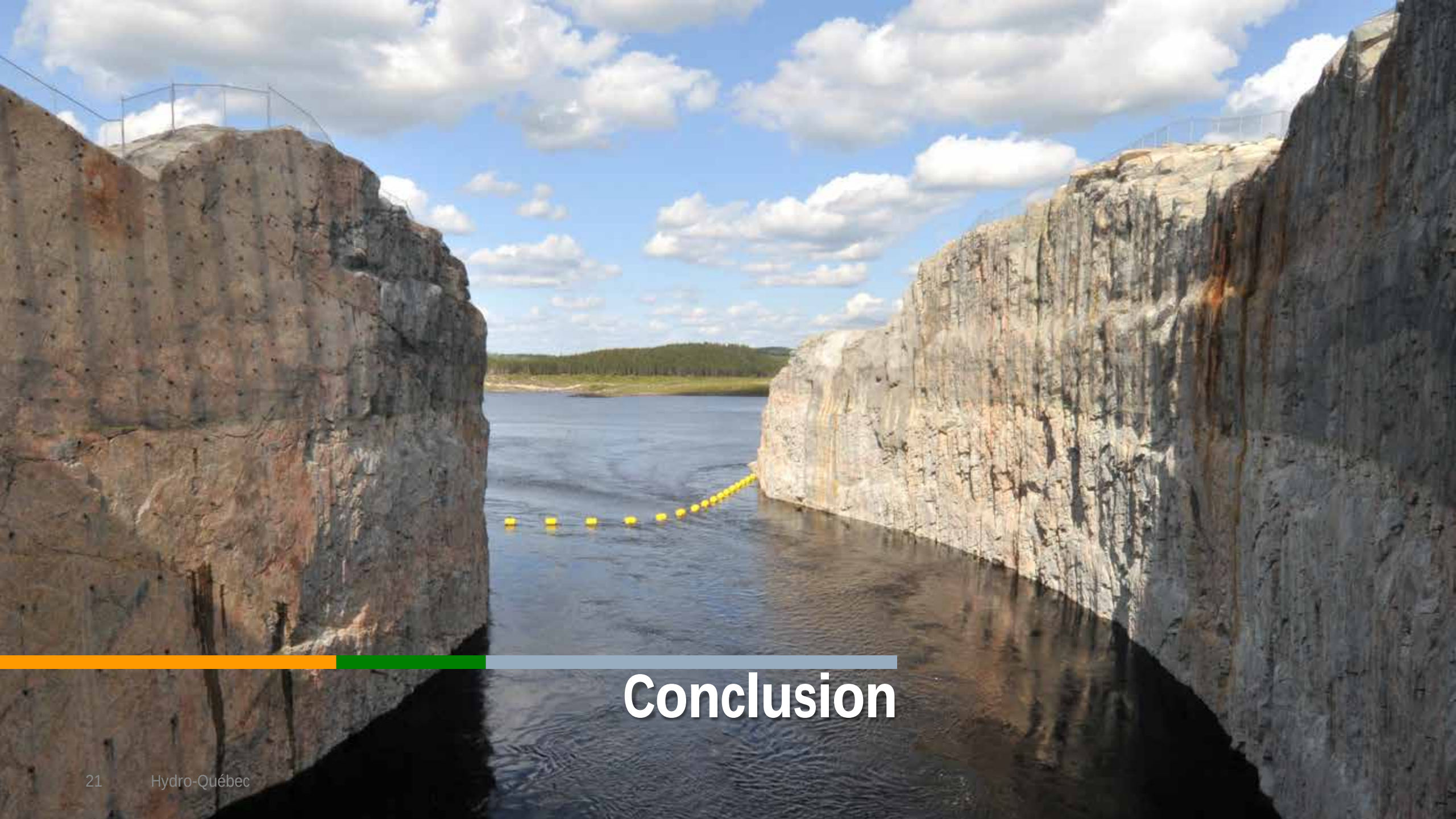


Erosive Capacity of Water

- Several equations for different flow situations
  - Straight reaches
  - Headcuts
  - Hydraulic jumps
- Is there a more general method to calculate the erosive capacity of water

Some Observations

- Hydro-Québec's erosion cases often involve excavation issues or the use of spillways in particular conditions
- Calculation of erosion capacity in design, or following a damage event, is solely based on the Annandale's concept
  - Are we doing things correctly ?
  - The possible extent of erosion is difficult to predict
  - Guidelines to calculate stream power would be beneficial



Conclusion

Issues and Engineering Needs

1. Rock damage caused by blasting activities;
    - Interest in existing technical provisions related to
        - Unlined spillway excavations
        - Design aspects of concrete-rock transition
2. Particular local geology
    - Is it possible to estimate the progression (or regression) of erosion towards the spillway structure?

Issues and Engineering Needs

3. Calculations related to the Erodibility Index

   § Needs of knowing better the fundamentals of Annandale's method
   - Provide sound values of Erodibility Index
   - Guidelines for stream power calculations
   - Better understanding of water action in joints to dislodge rock blocks

Erodibility Index: Collaborative effort with UQAC (Prof. Ali Saedi and Ph.D. Student Lamine Boumaiza)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