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BREAKWATER RECONSTRUCTION AT CAP-DES-ROSIERS HARBOR

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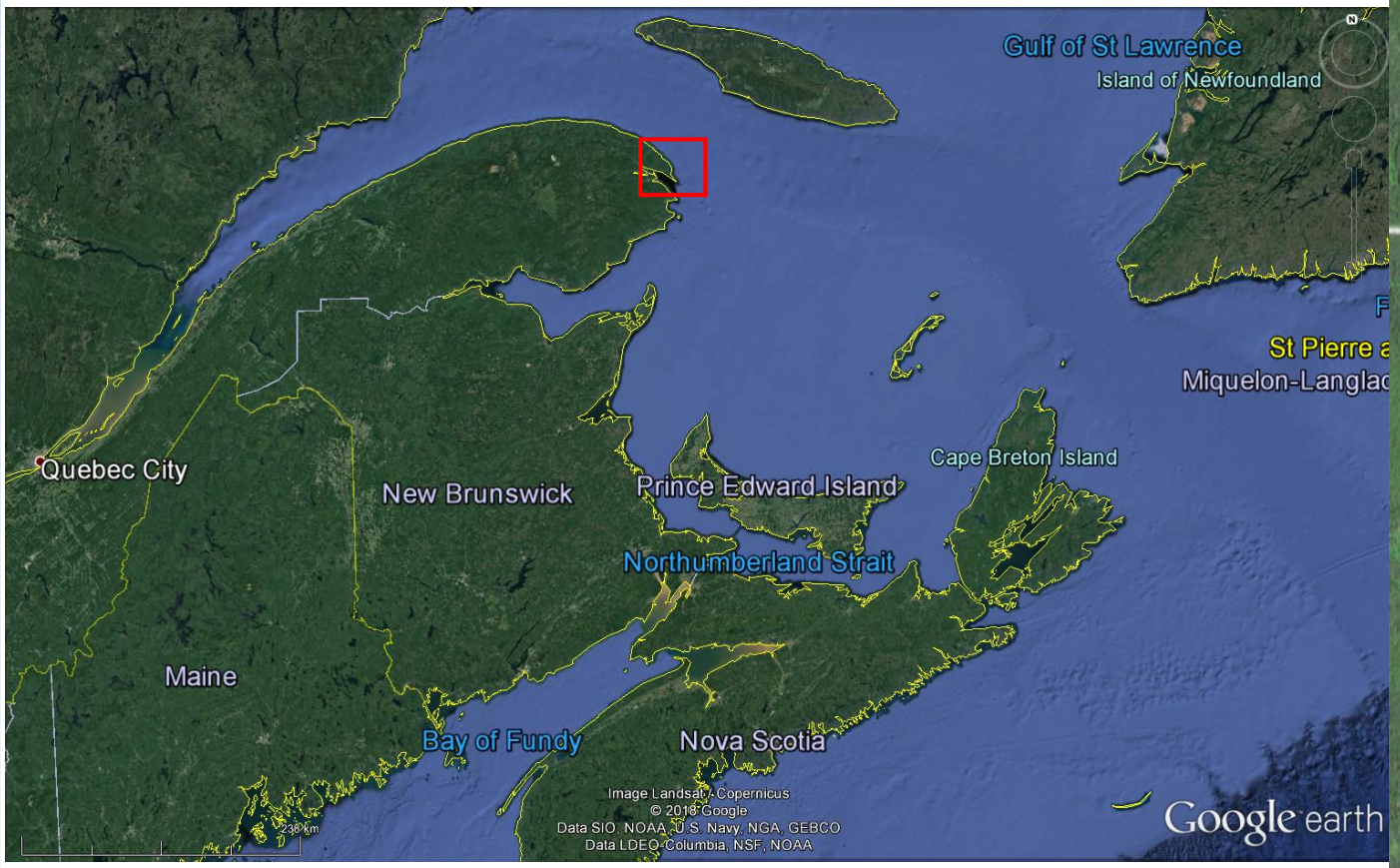
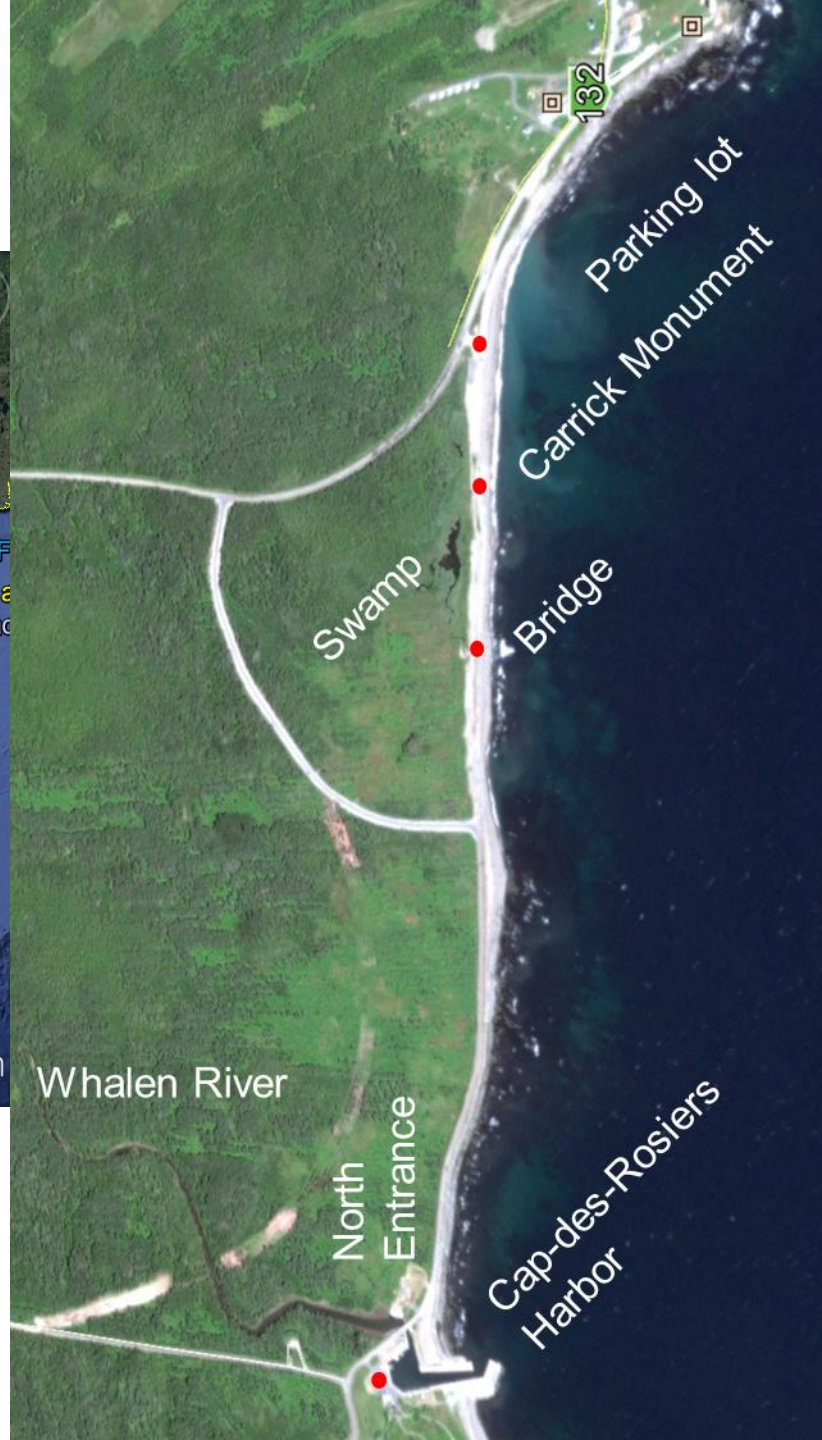
PRESENTATION OUTLINE

- Site Description
  - *Existing conditions*
  - *Proposed concept*
  - *Available data*
- Design Wave Height Modeling
- Wave Agitation Assessment
- Sediment Transport Assessment
- Conclusions and lessons learned

SITE DESCRIPTION





- 3 Main Concerns
  - *Damaged Berlin walls (structural)*
  - *Wave Agitation (Navigation)*
  - *Harbor Sedimentation (Dredging)*

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SITE DESCRIPTION

— Since 1980, repair works on the road or locally within the harbor were required every ~2 years

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SITE DESCRIPTION

Storm December 6th 2010

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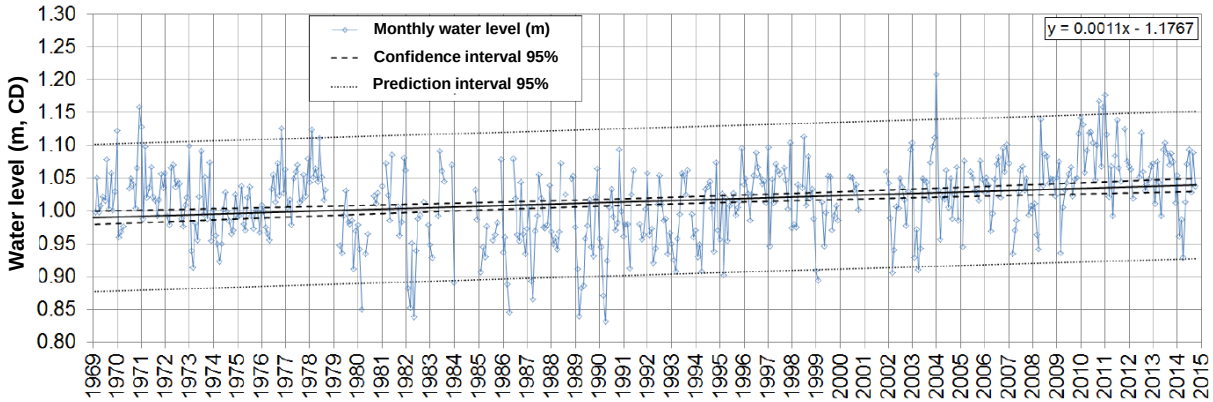
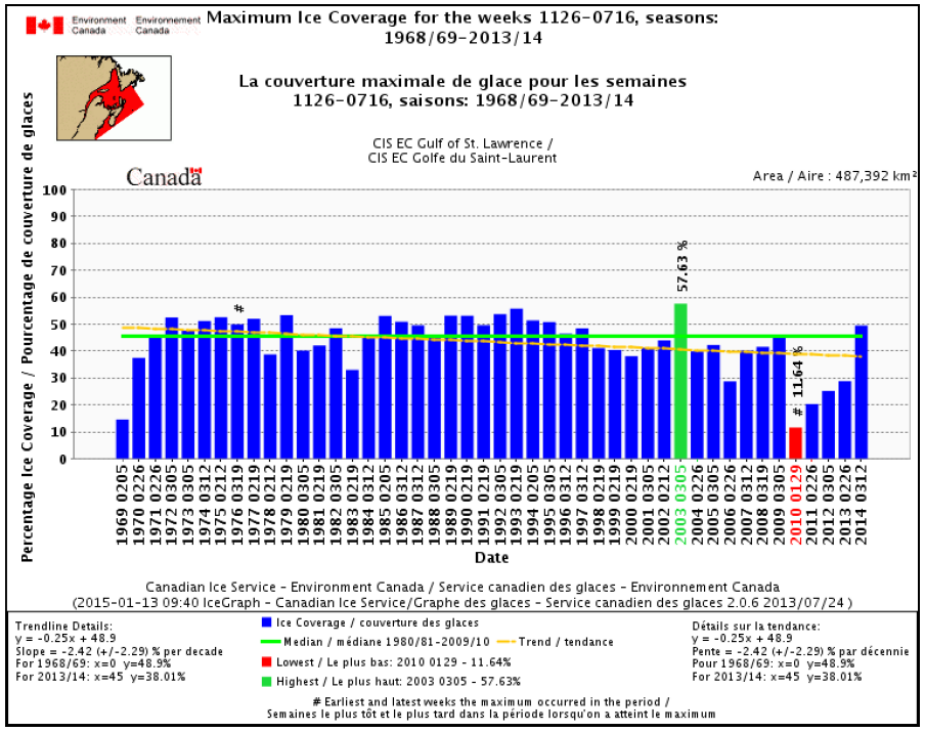
SITE DESCRIPTION

- Sea level rise :
  - *+1mm/yr felt at the nearest water level station*



- Reduction in ice cover
  - *Winter storms can now generate high waves that will reach the shoreline*



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SITE DESCRIPTION

Prior 2014 – Vertical wall

After 2014 – Rock revetment

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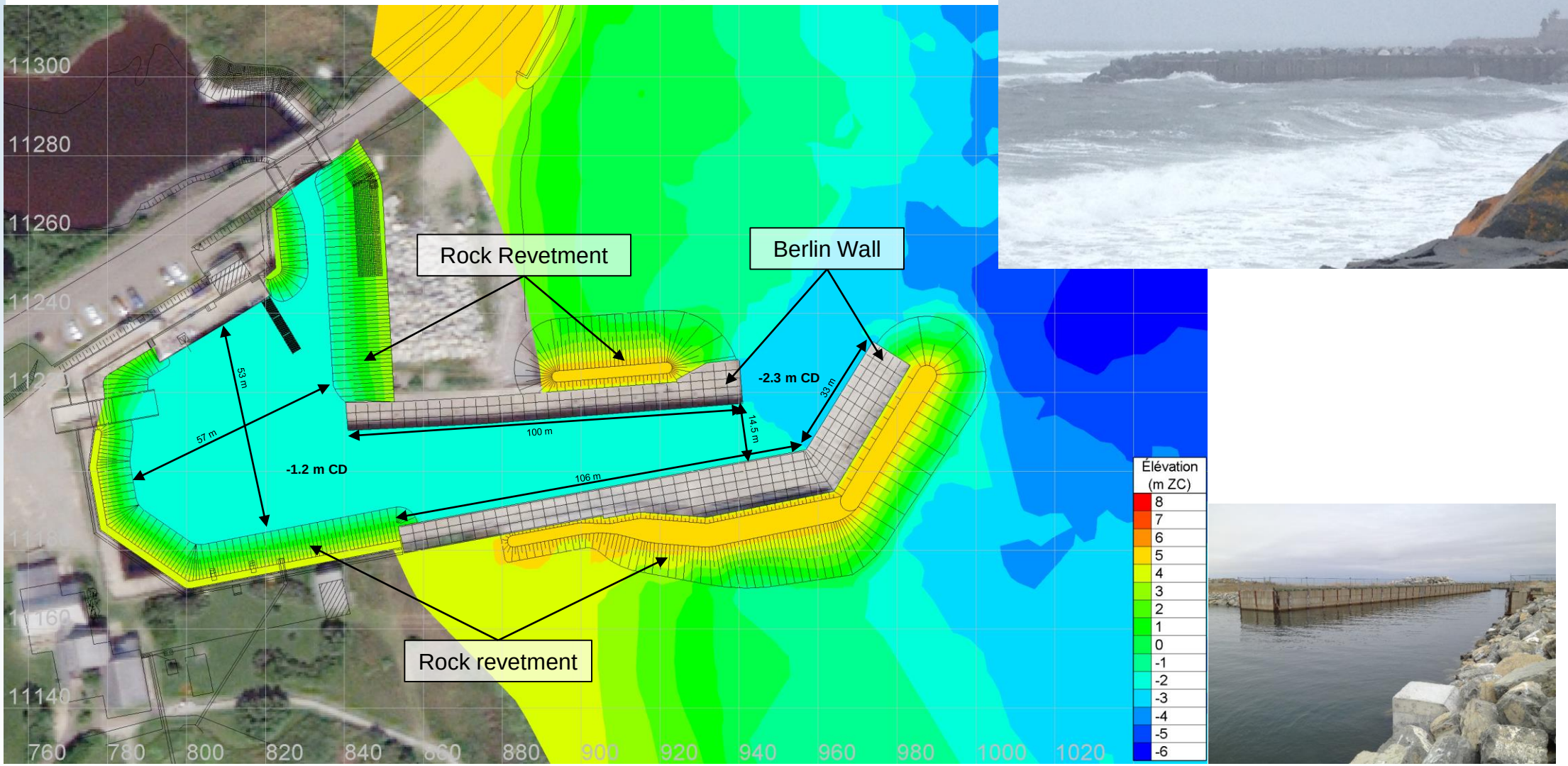
SITE DESCRIPTION

Existing Conditions (2016)



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SITE DESCRIPTION

- Typical boat
  - *3-4 m width*
  - *8 m length*
  - *1-1,5 m draught*

- Navigation (Harbor Entrance)
  - *North-North-East oriented entrance sheltered by lighthouse rocky cliff*
  - *South-West approach not possible due to multiple rock outcrops*
  - *East approach → exposition to large fetch and waves*
  - *Wave breaking at the entrance at low tide*

- Wave Agitation
  - *Wave reflection inside the entrance within the berlin wall and along the main navigation channel*

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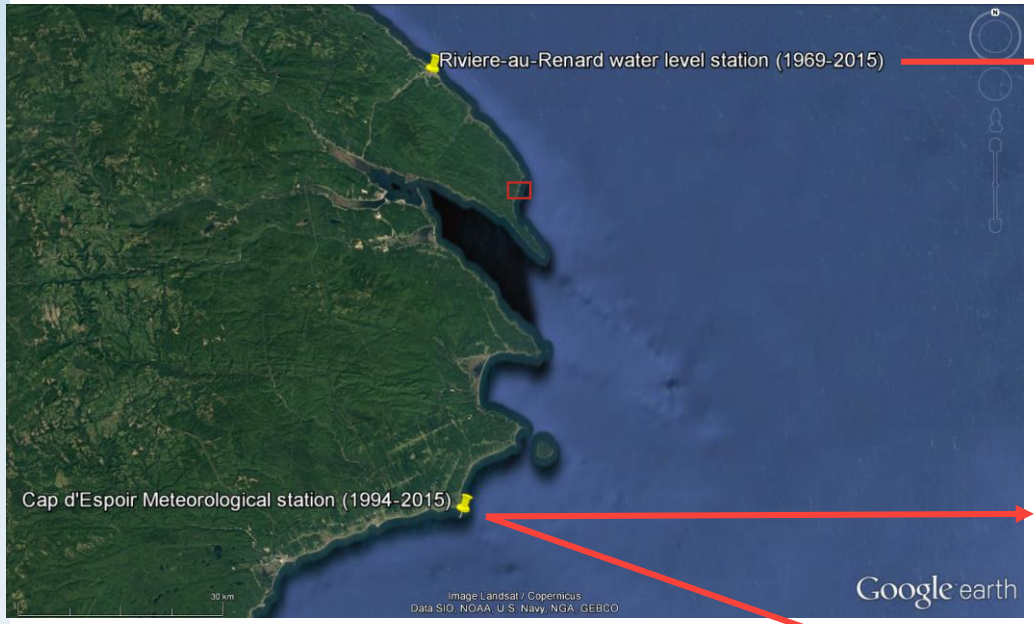
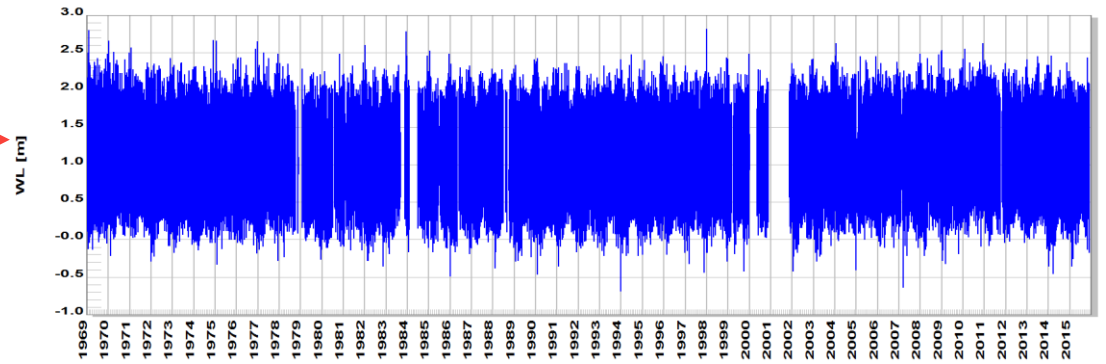
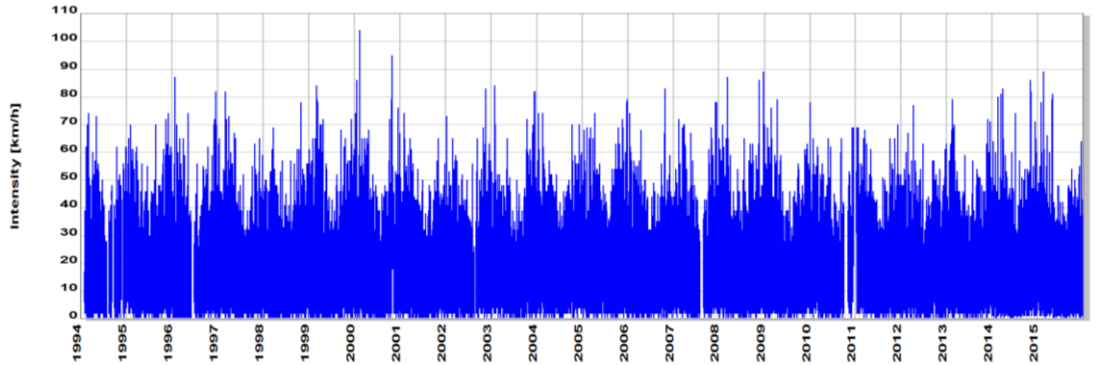
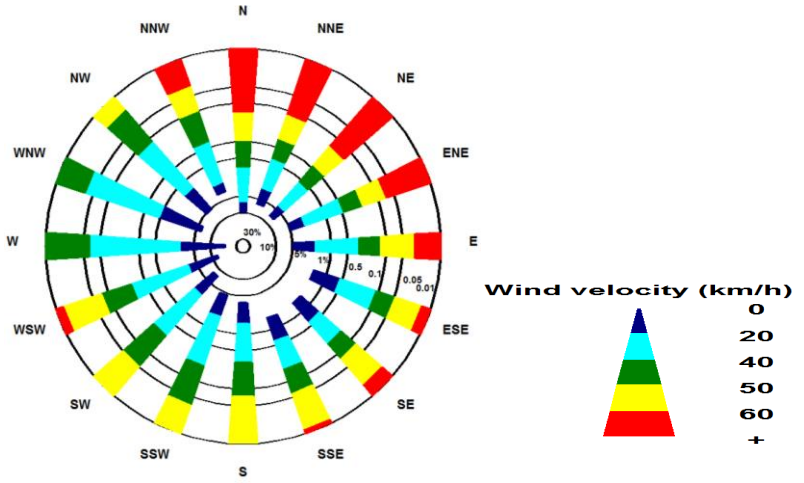
SITE DESCRIPTION









- Tidal range less than 3 m
- Wind velocity < 110 km/h
- Storm incoming directions from anywhere between N to SSE

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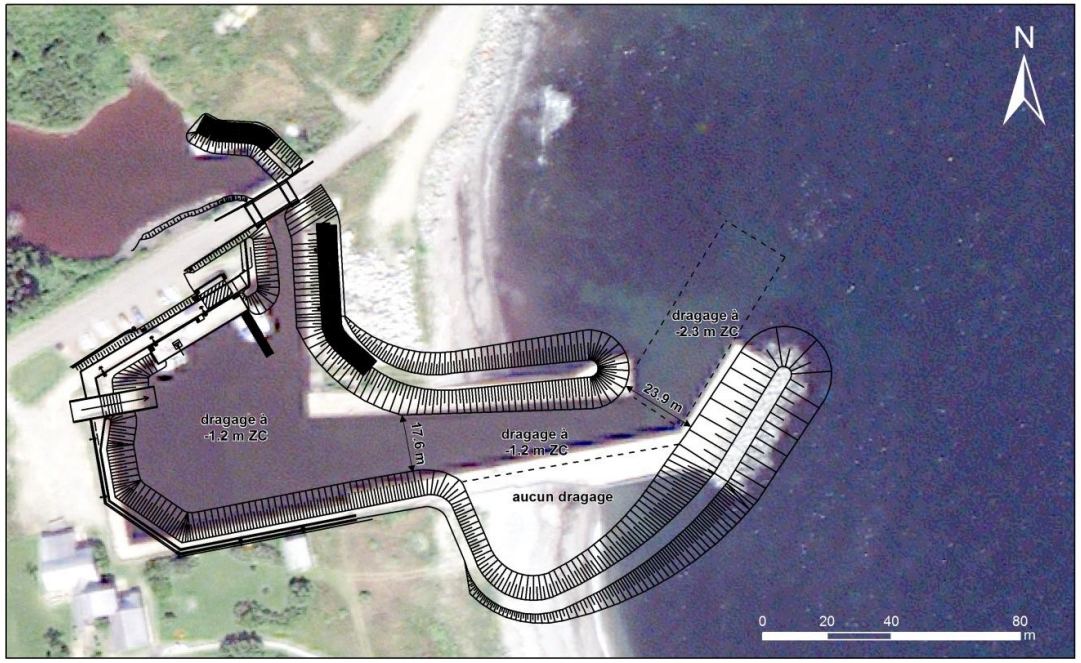
SITE DESCRIPTION

Existing Conditions

Proposed concept



— Key Features of Proposed Concept

- *Berlin walls replaced by breakwaters (Reduce agitation)*
- *Channel entrance width increased by 0,8 m (Navigation maneuvrability)*
- *Minimum channel width increased by 3,1 m (Navigation maneuvrability)*
- *Inner basin adjacent to southern breakwater to dissipate wave energy before it reaches the other end of the harbor (Reduce agitation & sedimentation)*

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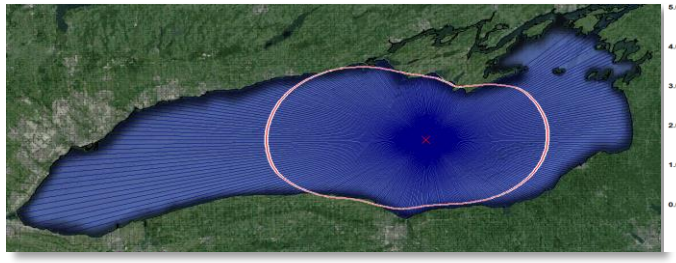
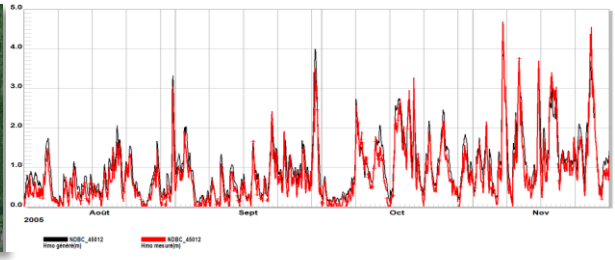
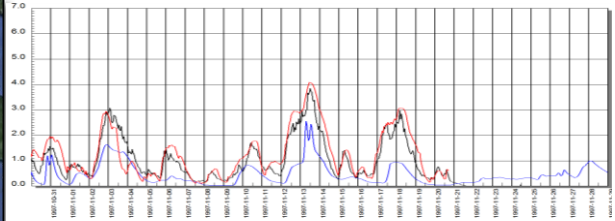
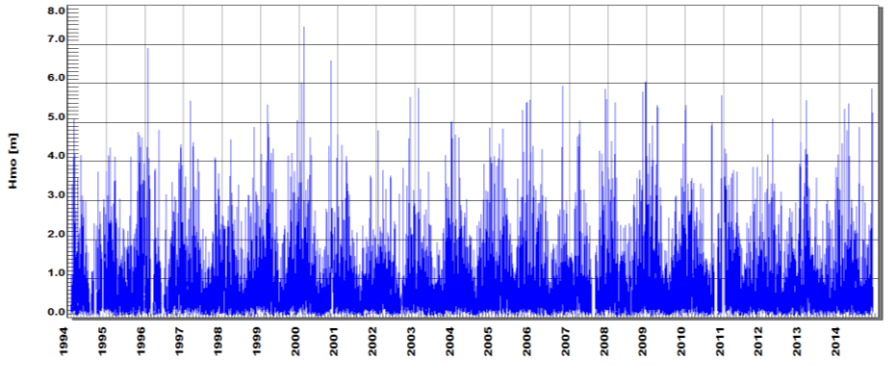
Design Wave Height Calculation Procedure

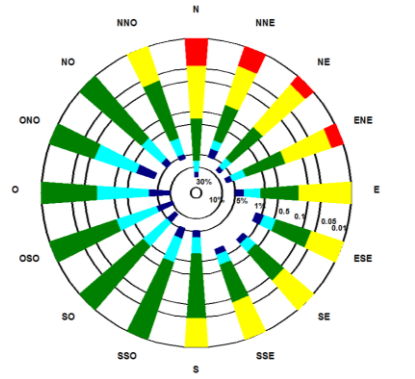
- Step 1 :
  - *Generation of a synthetic buoy offshore (deepwater) using local wind data*
  - *Use of wave hindcast model validated in Great Lakes and in Gulf of St-Lawrence*
  - *Hs max ~ 7,5 m*
  - *Dominant offshore wave direction = NE*

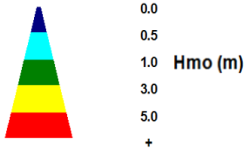












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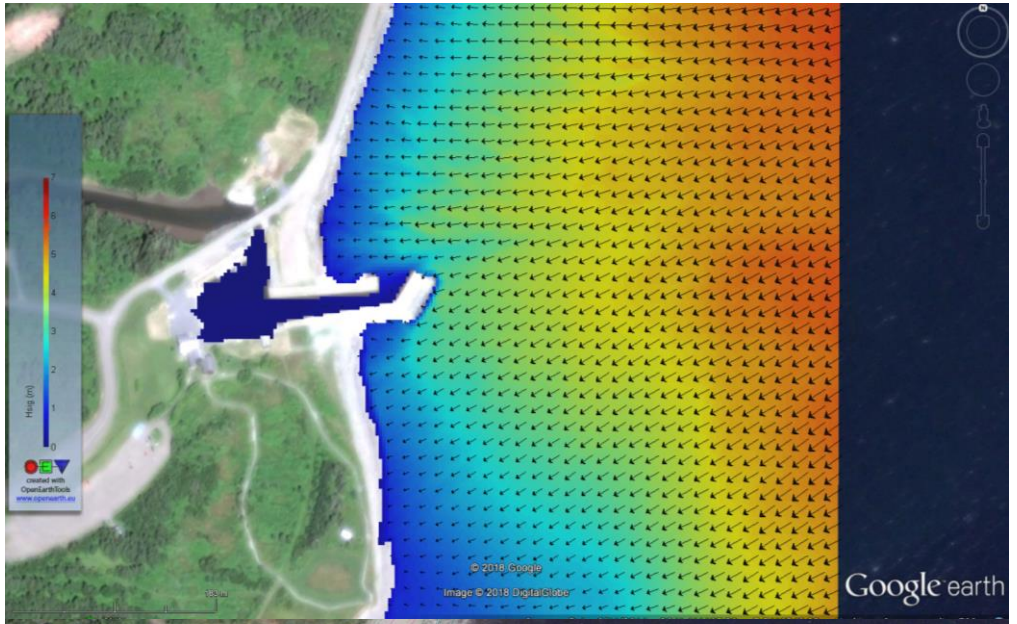
Design Wave Height Calculation Procedure

- Step 2 :
  - *Nearshore wave propagation using SWAN for hundreds of wave conditions (Hs, Tp, Dir) and water levels*



  - *Result extraction in zones adjacent to toe of proposed structures*

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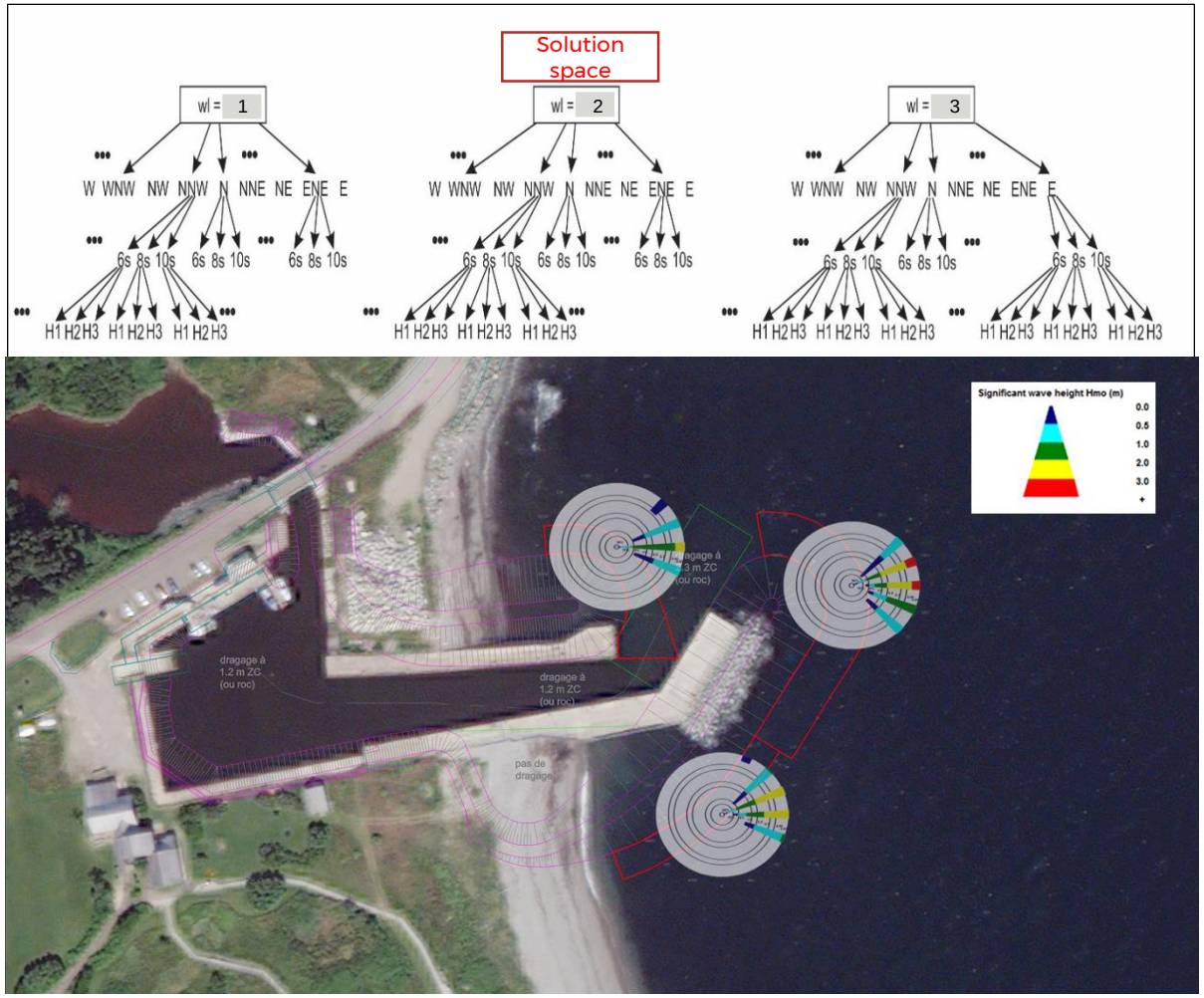
Design Wave Height Calculation Procedure

- Step 3 :
  - *Model result organized in solution space (multi-dimensional matrix)*
  - *4D linear interpolation using solution space, offshore wave and water level timeseries*
  - *Final result :*
    - **Hourly nearshore wave climate**



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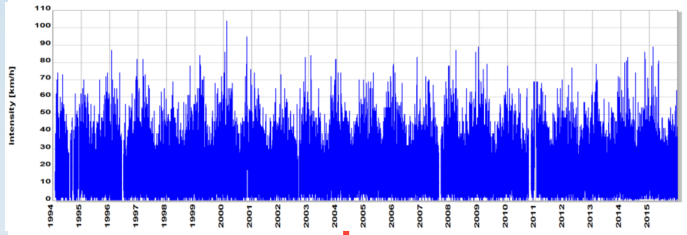
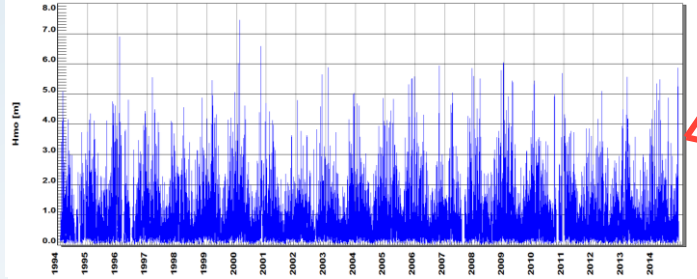
Design Wave Height Calculation Procedure

Measured hourly wind TimeSeries (TS)

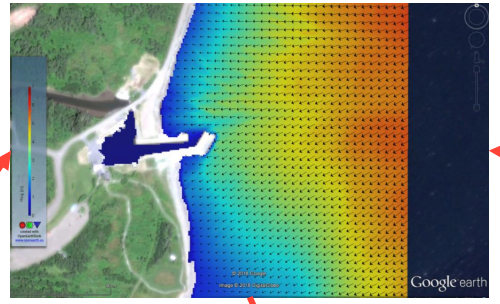


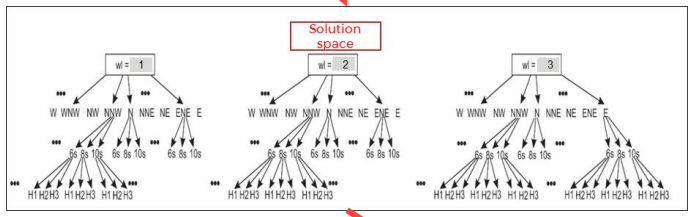
Hindcast model

Hourly offshore wave TS

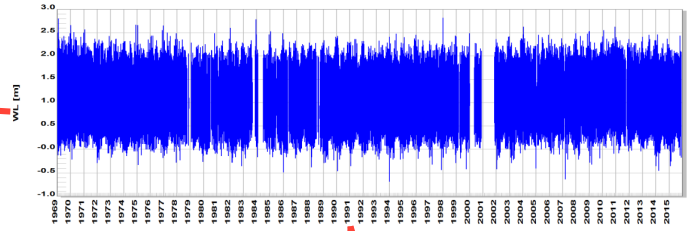


SWAN model results (hundreds of wave conditions)



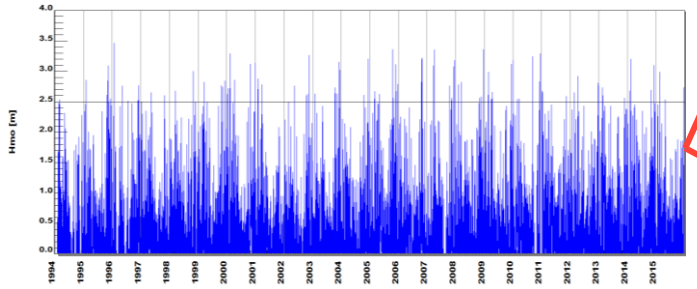


Measured hourly water level TS



Multi-dimensional interpolation

Hourly nearshore wave TS in zone



Hourly overtopping TS (Correlation with historical damages)

Extreme analysis (POT method etc.)

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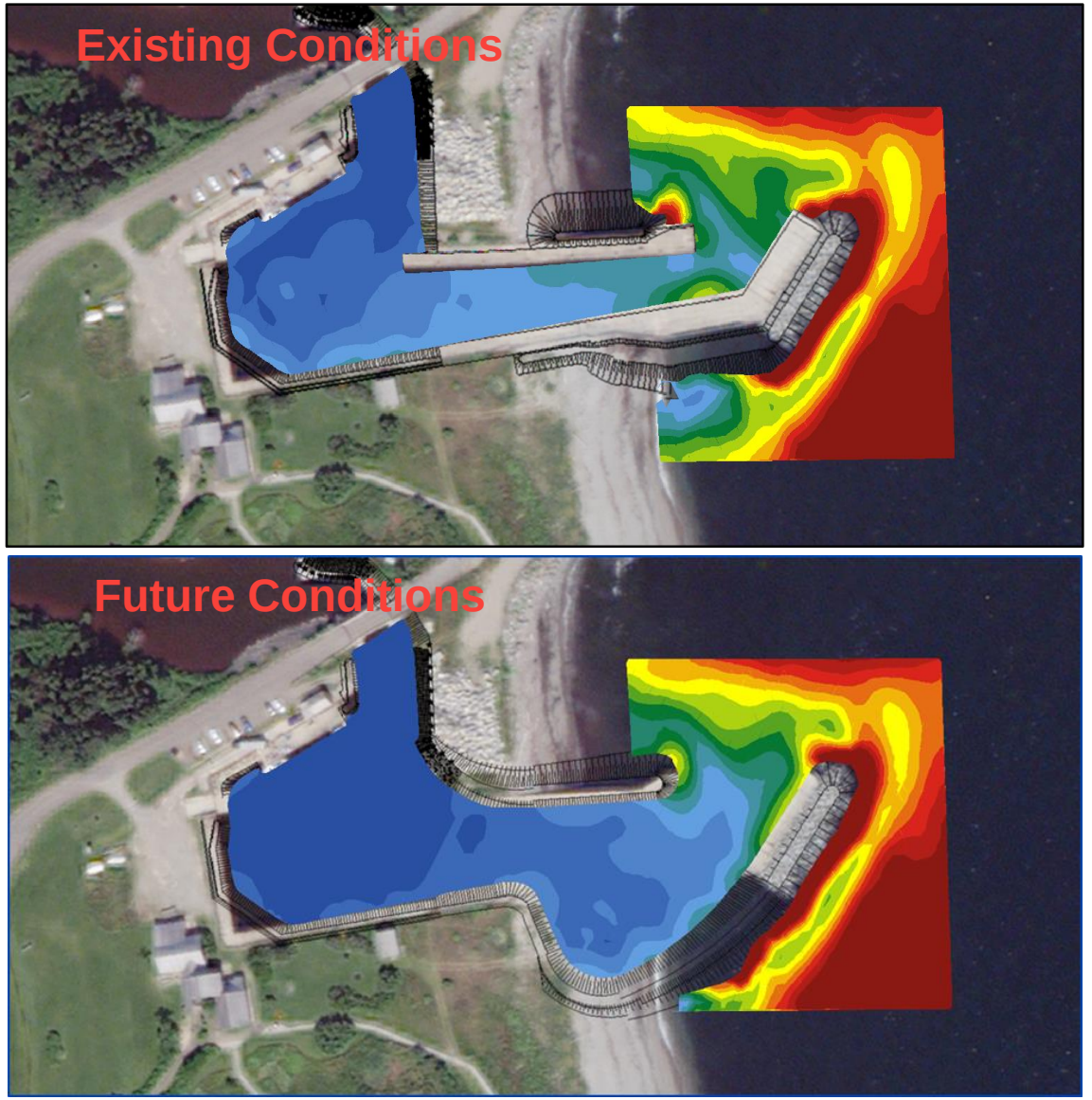
Wave agitation Assessment

— Steps 1–2-3 :

— *Wave propagation inside the harbor using CGWAVE*

— *Solution space and wave timeseries for each mesh calculation nodes inside the harbor*

— *Production of wave agitation chart for different probabilities*



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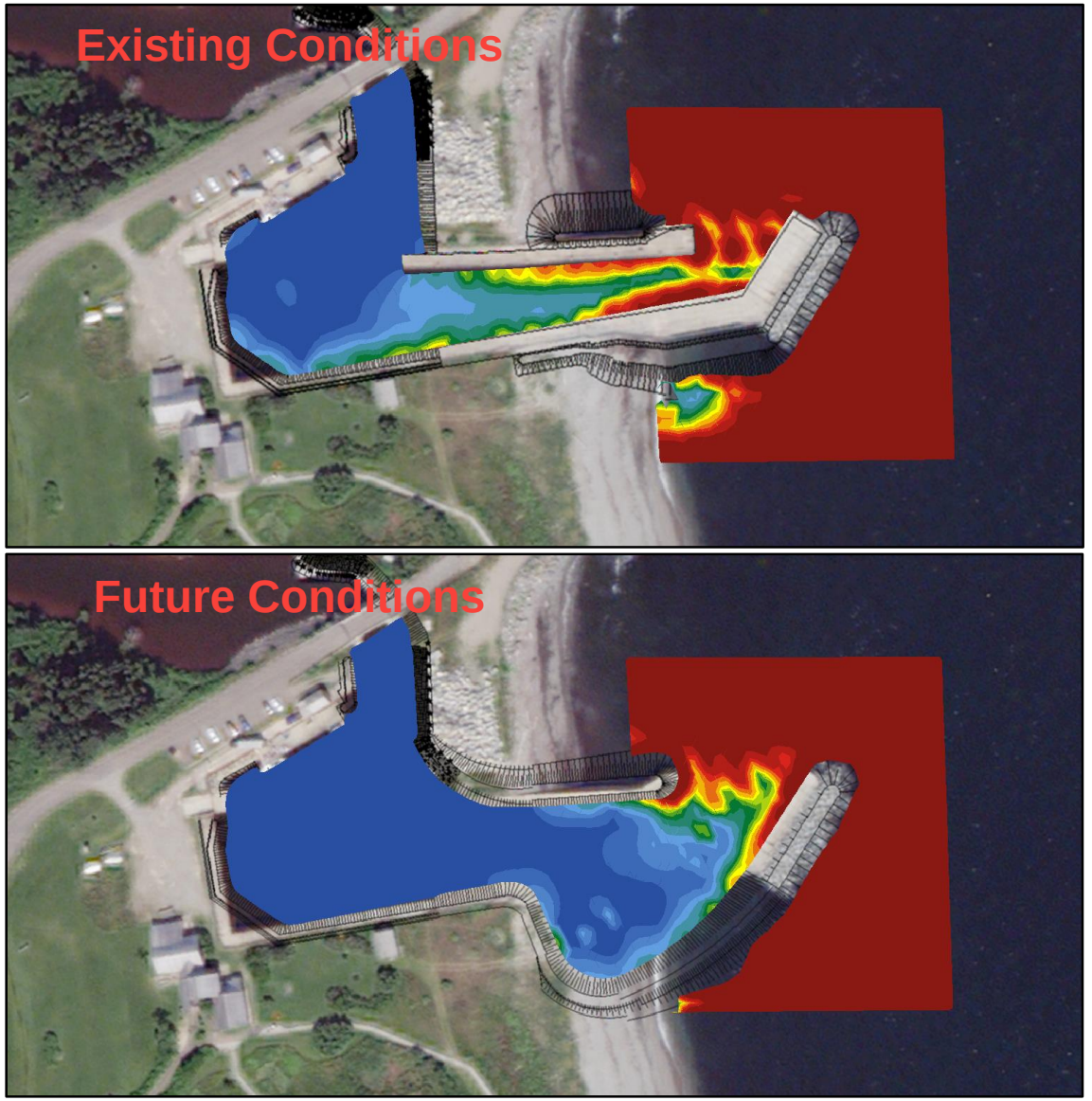

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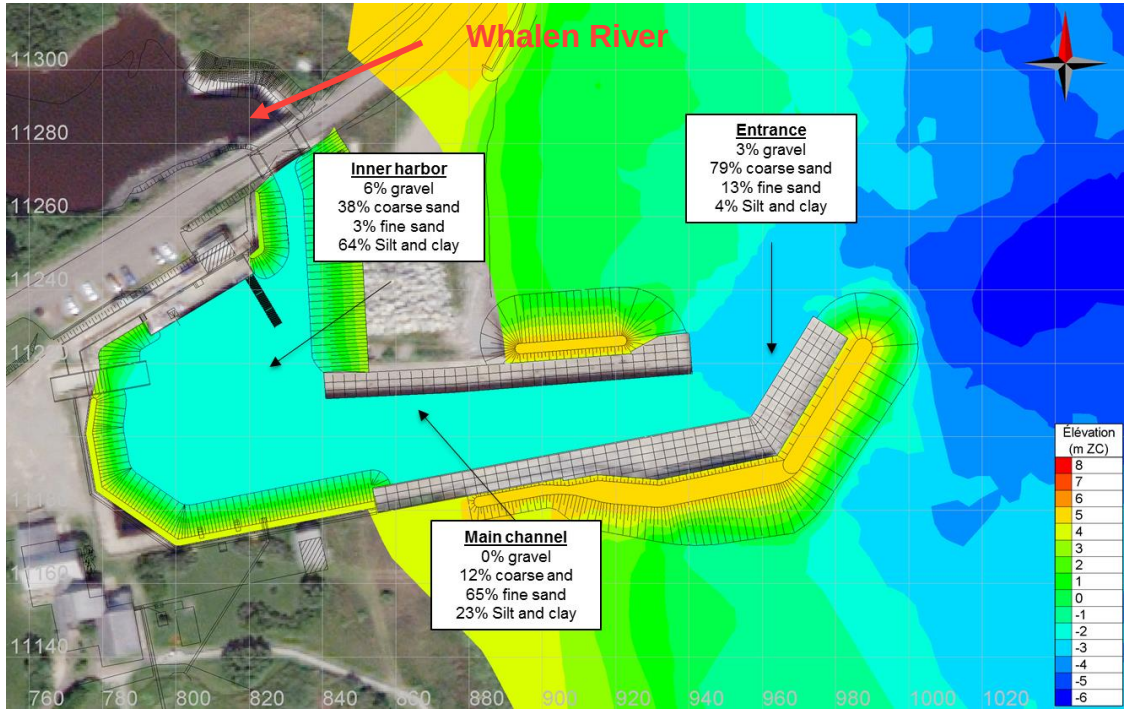
Sediment Transport Assessment

— Grain-size Classification

— *Sediment distribution indicates two transport mechanisms*

- — Sediment supply contribution from the Whalen River during flood
- — Contribution from the longitudinal drift during storms

	SAMPLINGS		
	INNER HARBOR	MAIN CHANNEL	ENTRANCE
Gravel	5.8%	0.0%	3.1%
Coarse sand	37.7%	12.2%	**79.4%**
Fine sand	2.9%	**64.8%**	13.0%
Silt and clay	**64.0%**	23.0%	4.5%



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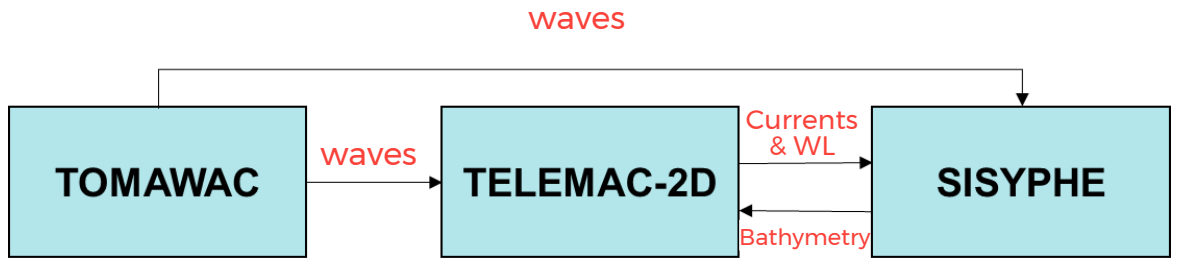
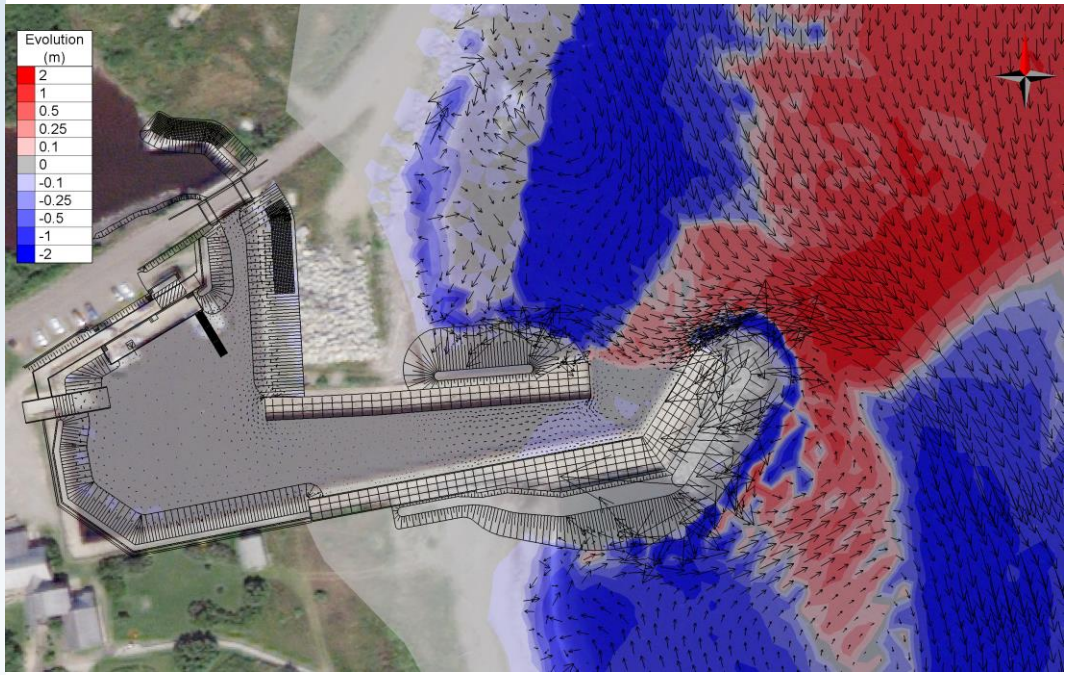
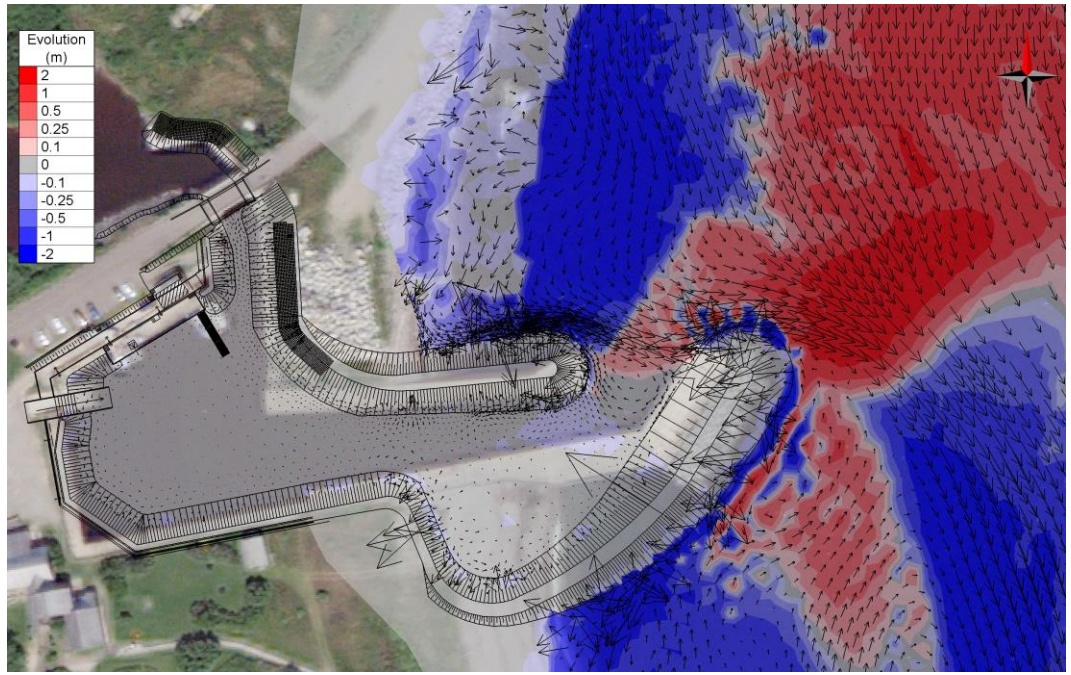
Sediment Transport Assessment

— Contribution from longitudinal drift







Northeastern storm, Hs ~= 4 m, Tp ~ = 9 s, Duration approx 24 hours

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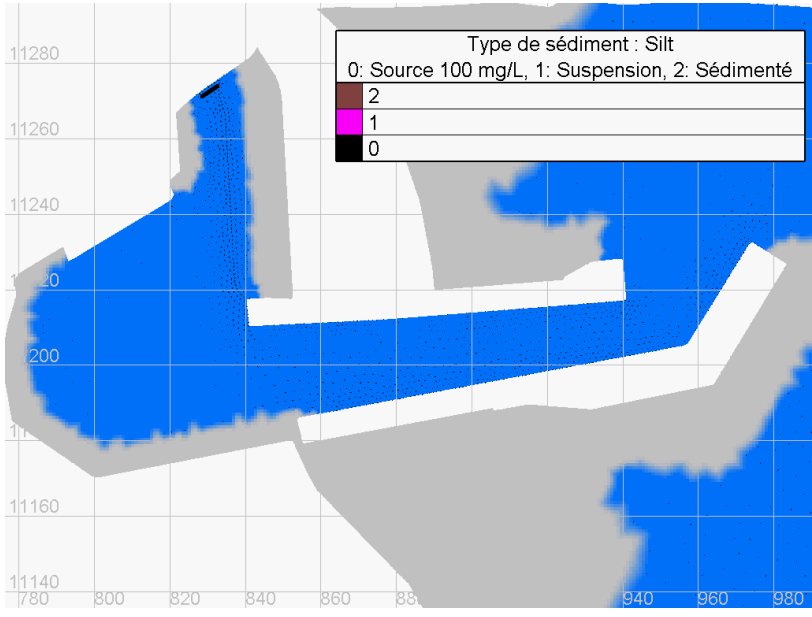
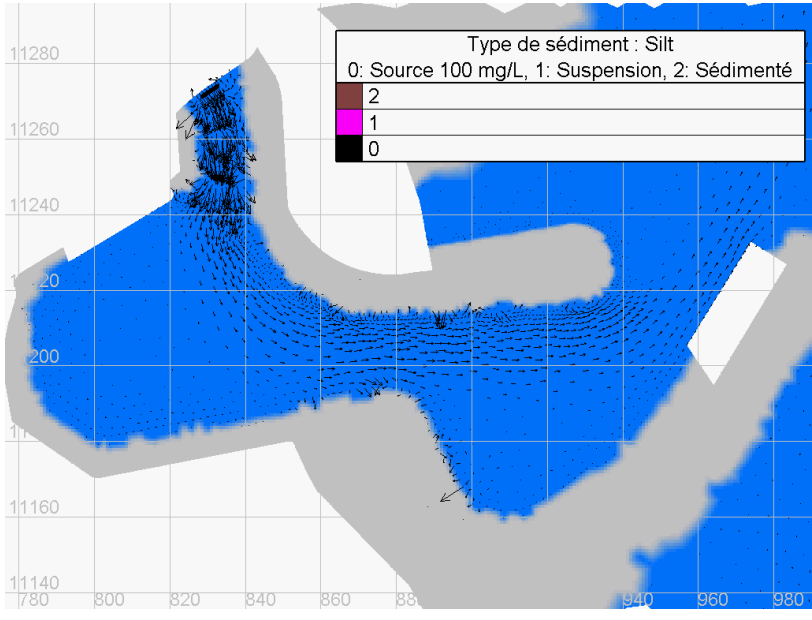
Sediment Transport Assessment

- Contribution from Whalen River
  - *PSed (Lagrangian particle-based sediment transport model)*
    - Hydrodynamics generated in Telemac-2d for multiple tidal cycle and including salinity gradient effects
    - Silt simulations show less accumulation in inner harbor in future conditions due to enhancement of the 90 deg bend

Silt Simulations





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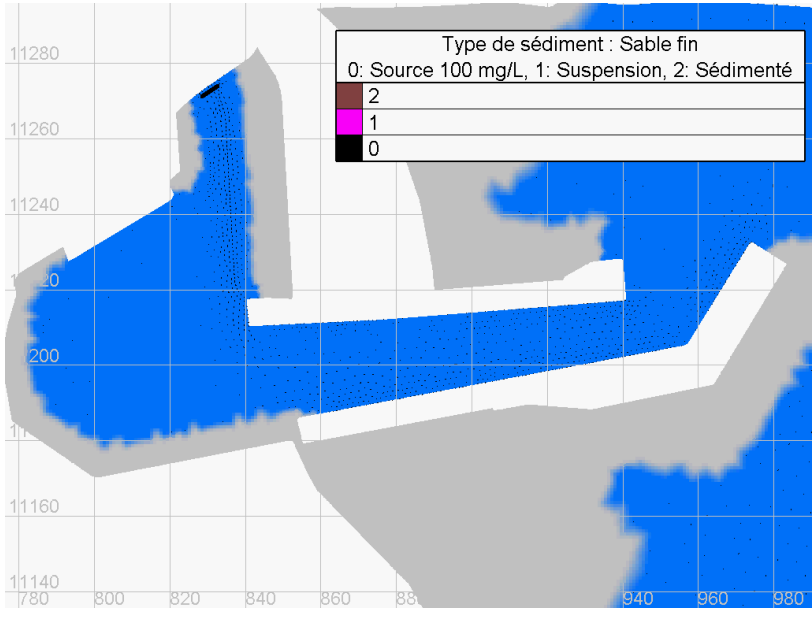
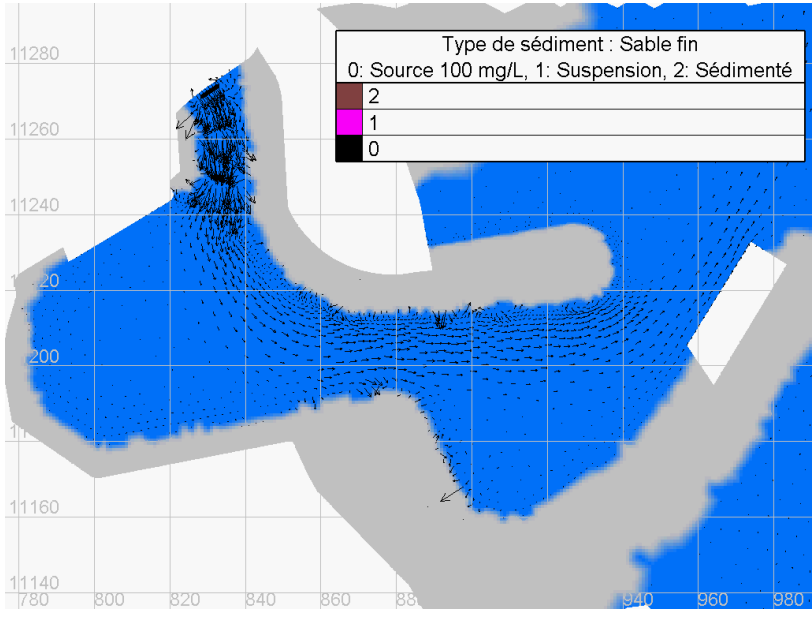
Sediment Transport Assessment

- Contribution from Whalen River
  - *PSed (Lagrangian particle-based sediment transport model)*
    - Hydrodynamics generated in Telemac-2d for multiple tidal cycle and including salinity gradient effects
    - Silt simulations show less accumulation in inner harbor in future conditions due to enhancement of the 90 deg bend
    - Fine sand simulations show loss of flushing capacity in future conditions due to widening of the main channel for navigation safety purposes

Fine Sand Simulations





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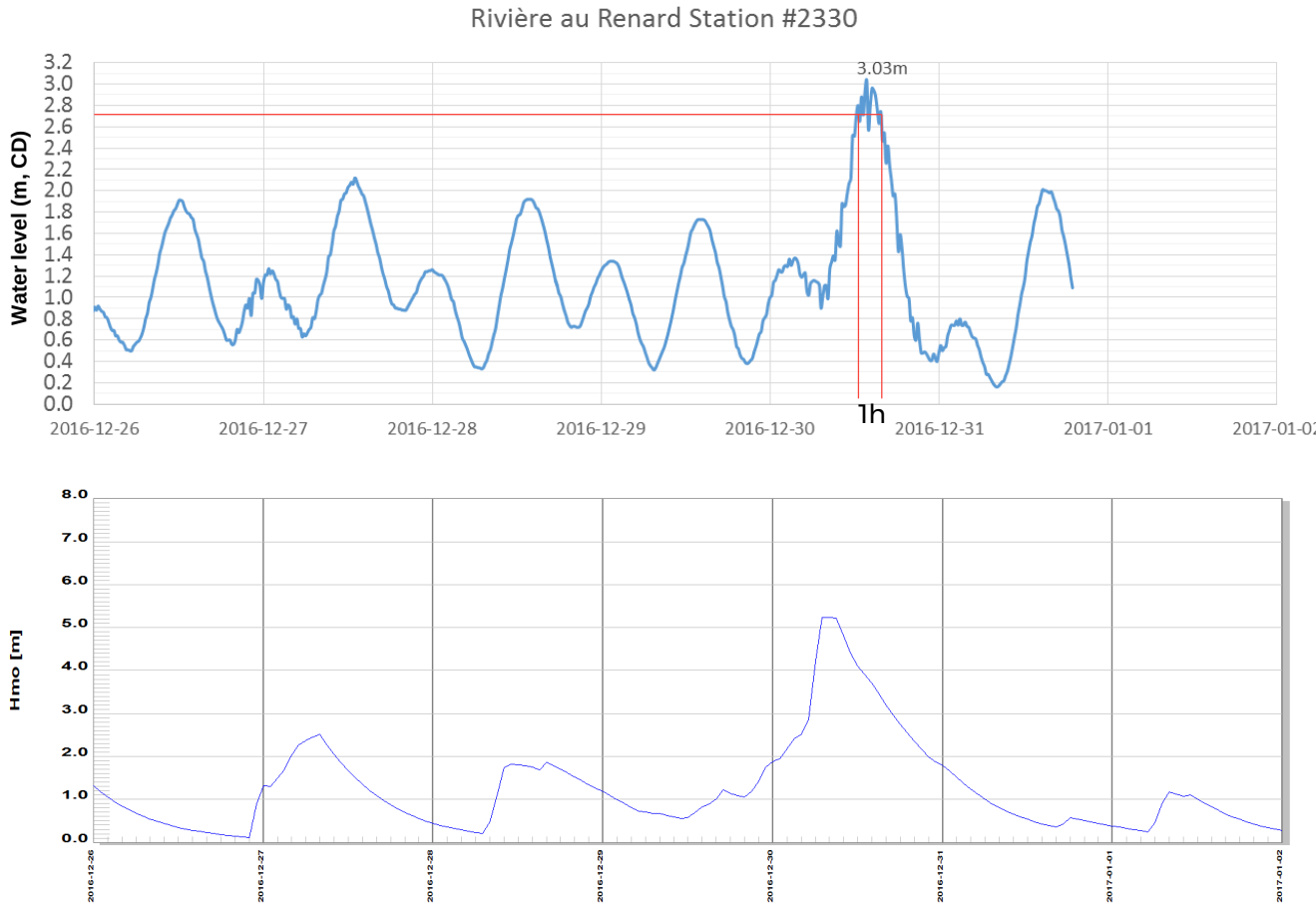
Lessons Learned

- Storm December 30th 2016
- Huge storm, lots of damage
- Maximum water level since 1969 in between two hours
- Importance of verifying high temporal resolution water level data when available!
  - *(1min to 6 min dataset)*



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CONCLUSIONS

- Different modeling strategies and simulation results allowed to :
  - *Provide key design parameters*
    - extreme water levels, wave heights and preliminary calculation for rock sizing
    - future wave agitation conditions to assess navigation conditions
    - Understand sediment transport mechanisms in future conditions
  - *Provide guidelines to support the decision-making process and future harbor design*
  - *Gain confidence in the proposed reconstruction option*

Thanks !

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