**Existing Shoreline Protection**
**Performance Indicator Summary**

**Performance indicator:** Existing riparian shoreline protection structures on Lake Ontario and the Upper St. Lawrence River

**Technical Workgroup**: Coastal TWG

**Research by**: Baird & Associates

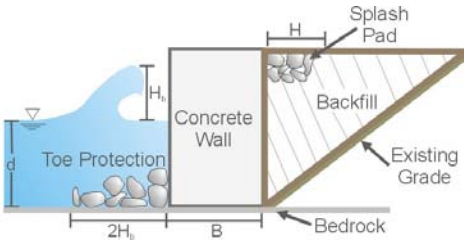
**Modeled by:** Complex algorithm in Flood and Erosion Prediction System (FEPS) linked directly to the Shared Vision Model

**Activity represented by this indicator:** Water level impacts on existing shoreline protection, such as structural failures or maintenance events, and the associated economic costs

**Link to water levels:** A significant number of riparian property on Lake Ontario and the Upper St. Lawrence River is already protected with engineered structures. For example, the property parcel database in the FEPS indicates that 6,175 of the front row parcels on Lake Ontario already feature protection, such as seawalls, armor stone revetments, and stacked armor stone walls (see example above). These structures are not designed or constructed to last indefinitely. They require maintenance and may ultimately need to be replaced. There are three principal modes of failure that will require significant maintenance or complete replacement:

- Age Failures – degradation of materials, such as concrete or quarried stone
- Overtopping Failures – wave overtopping during storms (event driven)
- Downcutting Failures – cumulative process at the toe of the structure

Age failures are independent of lake levels. However, the volume of water overtopping a structure during a storm is very sensitive to lake levels. In the sketch below, the crest of the concrete wall is a product of the design lake level and design wave height. If these levels are exceeded during a storm, in theory the wall may fail or require significant maintenance. The Existing Shore Protection PI evaluates a regulation plan by cycling through the hydrograph and looking for storm events that would cause failure or require maintenance of existing structures.




Lake bed downcutting is another common mode of failure for existing shoreline protection structures and it is sensitive to water levels. For example, if lake levels are low and the waterline is offshore of the structure toe, downcutting will not occur.

Conversely, if the water levels are very high, the majority of the wave energy will be dissipated on the structure face or will overtop the structure. Therefore, the amount of downcutting is very sensitive to lake levels. The picture at right, taken in the County of Prince Edward, Ontario, visually demonstrates the downcutting process. The concrete block wall was constructed directly on the shale lake bed. Over time, downcutting has eroded the shale at the structure toe and will eventually undermine the wall leading to a failure.

**Performance Indicator Metric:** Maximum monthly mean lake levels are the performance indicator metric for the Shore Protection PI on Lake Ontario. The table below summarizes the upper threshold for monthly lake levels (recommendations current as of spring 2004):

| Upper | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Meters | 74.70 | 74.70 | 74.87 | 75.04 | 75.20 | 75.20 | 75.20 | 75.20 | 75.04 | 74.87 | 74.7 | 74.7 |
| Feet | 245.1 | 245.1 | 245.6 | 246.2 | 246.7 | 246.7 | 246.7 | 246.7 | 246.2 | 245.6 | 245.1 | 245.1 |

Recommendations are in progress for the Upper St. Lawrence River. It is possible that a similar upper threshold will be recommended to minimize damage to existing shoreline protection structures.

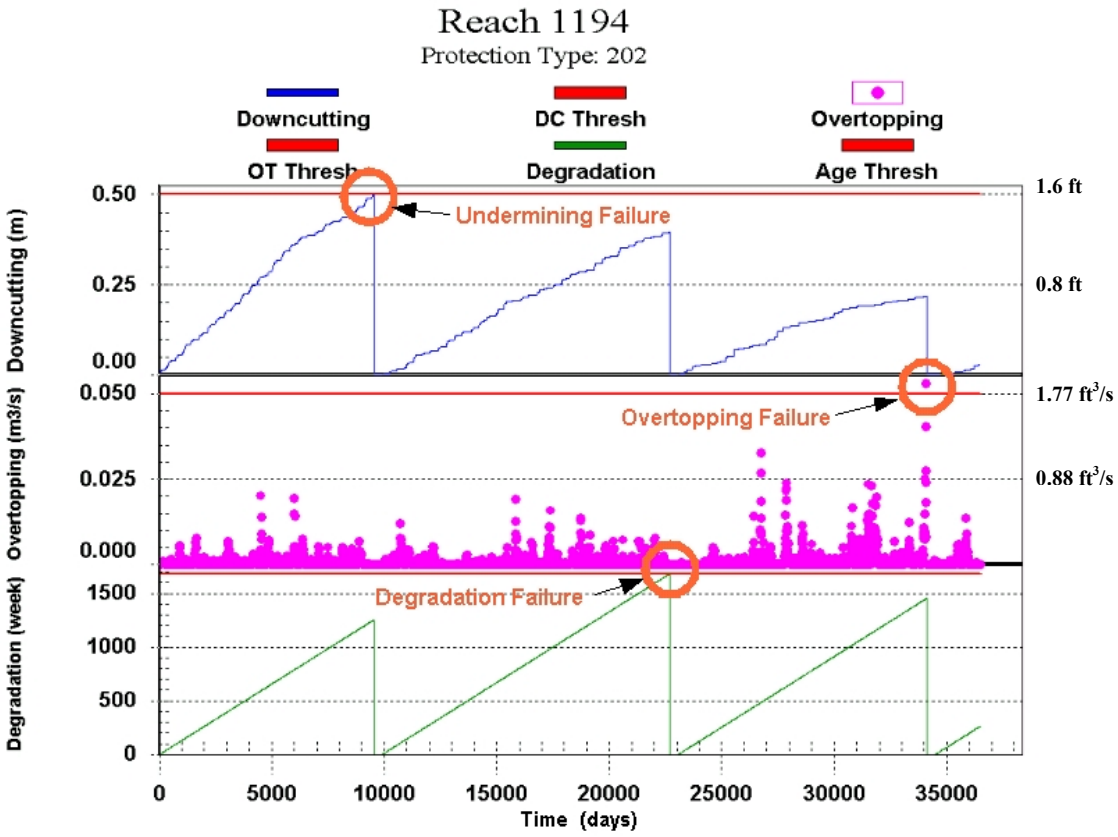
**Temporal validity:** The metric is valid throughout the year.

**Spatial validity:** The monthly water levels presented above are valid for Lake Ontario.

**Links with hydrology used to create the PI algorithm:** There are two direct links to hydrology. First, the algorithm evaluates potential structure failures every quarter month for a simulation based on the impact of lake levels. Second, the quarter month evaluation also includes storm surge, which is added to the static lake level.

**The Algorithm:** The Shore Protection PI algorithm was developed and tested in the FEPS. Refer to the February 2004 report for a complete reference (Baird, 2004c). The three modes of failure are evaluated simultaneously for a regulation plan, such as 1900 to 2000 water levels for the Pre-Project scenario. In any given quarter month, a structure can fail due to wave overtopping or lakebed downcutting. If the age threshold is passed for a given structure type, the function predicts a degradation failure. A visual summary of the resulting predictions for the function are plotted below for a Level 2 revetment

protecting a riparian property in Reach 1194, Niagara County, NY. Over the 101 year simulation, the structure first fails due to downcutting/undermining, then the time threshold is reached and a degradation failure is predicted. The third failure in the simulation is an overtopping event.




**Validation**: The criteria used to predict a failure in the algorithm are based on standard engineering techniques and published references. The frequency of failures in a given simulation was verified against reported events and our professional judgment.

**Documentation and References**:

Baird, (in preparation). *Lake Ontario and Upper St. Lawrence River Detailed Study Sites*. Prepared for the Coastal TWG.

Baird, 2004c. *Shore Protection Performance Indicator: Methodology and Shared Vision Model Application*. Prepared for the Coastal TWG, May 2004.

**Risk and uncertainty assessment:** Maintenance requirements and structural failures are well documented on Lake Ontario and the St. Lawrence River. The algorithm isolates the influence of lake levels for the purpose of comparing different regulation plans. There is some uncertainty in the frequency of the failures and thus overall magnitude of the economic damages. However, for the purpose of comparing the impacts of different regulation plans on this PI, this uncertainty will not influence the results.