

# Protection against Upland Erosion

The height and composition of the bluffs along New York's coast are highly variable. Addressing the erosion caused by groundwater seepage, surface water run-off and natural weathering is dependent on site conditions. The general guidelines presented here are intended to apply to the bluff and upland areas landward of a well-designed and constructed erosion control structure. The design of the upland erosion control features at a site should complement and work in concert with the proposed shore structure. Options for stabilizing the upland include:

## **1. Re-grade the existing slope to at least 2 horizontal to 1 vertical.**

This option applies where there is adequate distance between the shore structure top elevation and upland structures. Stabilization through re-grading and vegetating the bluff slope has been fairly successful along shores with bluffs composed of till and bluffs of medium elevation (less than about 40 feet).

## **2. Retain as much existing vegetation as possible.**

Native trees, shrubs, and perennials are the best means of limiting erosion from surface water run-off and naturally reducing flows from groundwater seeps. This is especially important along areas with medium to high till bluffs (40-60 feet). Tree and shrub roots are also extremely effective at stabilizing existing upper bluff soils.

## **3. Reduce or re-direct surface water sheet flow or collected surface water drainage.**

A slight swale at the top of the bluff, coupled with a well designed trench drain can eliminate most of the sheet flow down the bluff. Collected surface water should be diverted landward if at all possible; if not, the conveyance pipe should be run down the bluff to as close to the lake elevation as possible. Outlet protection should be placed at the down-slope end of the pipe to prevent erosion at that location.

As a general consideration, surface water is not to be conveyed over the edge of the bluff, even as limited sheet flow. For sites with unfavorable geology leading to perched water and seeps at the bluff face, the less upland surface water allowed to infiltrate into the groundwater the better.

If downspouts, other surface drainage or basement sumps are currently collected and conveyed over the bluff, discharge should be a pipe that extends the full distance to the toe of the bluff. Pipes suspended over the bluff allow the water to erode the bluff below it.

## **4. Terrace the upland.**

Low-height terracing can be a cost-effective means of stabilizing the upland bluff and can be designed to provide access pathways to the water. As a general consideration, multiple, 3 to 4-foot high terraces will be less prone to a large scale bluff failure, lower in initial cost, and easier

to repair than fewer, higher retaining walls. Terracing can also be effective in intercepting groundwater seeps and diverting the water along the terraces.

**Bulkheads:**

These are vertical retaining walls to hold or prevent soil from sliding seaward. Their main purpose is to reduce land erosion and loss to the sea, not to mitigate coastal flooding and wave damage. For eroding bluffs and cliffs, they increase stability by protecting the toe from undercutting. Bulkheads are either cantilevered or anchored sheet piles or gravity structures such as rock-filled timber cribs and gabions. Cantilever bulkheads derive their support from ground penetration; therefore, the effective embedment length must be sufficient to prevent overturning. Toe scour results in a loss of embedment length and could threaten the stability of such structures. Anchored bulkheads are similar to cantilevered bulkheads except they gain additional support from anchors embedded on the landward side or from structural piles placed at a batter on the seaward side. For anchored bulkheads, corrosion protection at the connectors is particularly important to prevent failures. Gravity structures eliminate the expense of pile driving and can often be used where subsurface conditions support their weight or bedrock is too close to the surface to allow pile driving. They require strong foundation soils to adequately support their weight, and they normally do not sufficiently penetrate the soil to develop reliable passive resisting forces on the offshore side. Therefore, they depend primarily on shearing resistance along the base of the structure to support the applied loads. Gravity bulkheads also cannot prevent rotational slides in materials where the failure surface passes beneath the structure.

**Pre-cast concrete block seawall design:**

There are many pre-cast concrete block configurations and sizes. The most common use a transverse tongue and groove to resist sliding forces of the stacked blocks. The specific sizes used will depend on factors such as the equipment available for installation, the pre-cast forms used by a manufacturer, the engineer’s or contractor’s familiarity with a specific type of block and the overall dimensions needed for the seawall.

Typical Pre-Cast Concrete Block Sizes			
Dimensions (ft)	Volume (ft <sup>3</sup> )	Weight (lbs)	Weight (tons)
3 x 3 x 3	27	3915	2.0
3 x 4 x 5	60	8700	4.4
4 x 4 x 4	64	9280	4.6
3 x 4 x 7	84	12180	6.1
NOTE: Based on 145 lb/ft <sup>3</sup> unit weight concrete			

As the table shows, pre-cast concrete block unit weights are in the same range as typical armor stone. There are also block seawalls that use large hollow pre-cast units. These are usually connected with reinforcing bars and the open space then filled with grout or concrete.

### **Block seawall general arrangement:**

The following guidelines reflect experience reviewing many designs and observing the performance of existing structures along the shore.

1. The layout of the seawall should match the plan of the shore. If the shore is curved, the seawall should be designed to match the shore plan.
2. A second row of block landward of the lower tier of block may provide additional stability and reduce the potential for sliding failure. The two blocks of the first tier should be structurally connected.
3. Designs that include a slight over-hang of the cap (with a chamfer) can help reduce overtopping by redirecting a portion of the wave energy lakeward.
4. Stepped block seawalls, with each tier slightly set back from the one below will generally result in a more stable structure with reduced run-up and overtopping.

### **Block seawall structural design:**

Structural design considerations include:

1. The first tier of block must be set on firm material with an appropriately design foundation and sufficient bearing capacity to resist settling. The conditions at each site should be verified, as there are numerous anomalous buried stream beds and discontinuities along the shore.
2. One of the most common reasons for the failure of block seawalls is the eventual undercutting of the nearshore, causing scour of the foundation material under the block. This is due to changing water levels and to the reflected wave energy from the seawall itself. To counter this common long-term threat to the structure the design can:
  - o Include entrenchment into the underlying material;
  - o Provide stone toe protection to reduce scour; or
  - o Locate the seawall as far landward as possible, which reduces the amount of wave energy at the structure's toe.
3. The importance of providing substantial interconnection of the blocks, cap, and any required tie-backs cannot be overstated. Although individual block units may have sufficient weight to resist wave forces, a unified structure is the best means of preventing significant failure of the seawall.