Documentation for TNC Restoration Explorer App

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To guide the user as to the most appropriate ecological shoreline restoration technique, the tidally influenced shoreline was first classified as to whether it is bordered by marsh (either salt, brackish or tidal freshwater) or uplands (which includes sand/gravel beach, armored shorelines, development or wooded wetlands). In situations where salt marshes are fronted by sand beach on the seaward edge, the shoreline was classified as upland. The NOAA *Environmental Sensitivity Index* (ESI; http://response.restoration.noaa.gov/maps-and-spatial-data/environmental-sensitivity-index-esi-maps.html) served as the basis for the classification of the shoreline type.

Using guidance provided by the Stevens Institute of Technology, thresholds were determined for various engineering criteria to determine whether different salt marsh edge enhancement or upland shoreline/beach restoration techniques were applicable. Geospatial models were developed to determine which of five techniques were applicable for marsh edge and four techniques for beach/upland shorelines. The engineering criteria thresholds for the various environmental parameters are the same whether for salt marsh edge or beach/upland shoreline. In the tables below, a 'YES' signifies that this technique is applicable under these environmental parameter values (i.e., for the environmental parameter *Tidal Range*, the Sill technique is applicable where the tidal range is <= 4.0 feet). A ' NO' signifies that the environmental parameter criteria has not been met. NA signifies that this environmental parameter is either not applicable for this technique or when a particular value is not applicable (i.e. for the environmental parameter *Shoreline Change*, where the shoreline is undergoing accretion, this parameter is not applicable in determining whether beach replenishment is appropriate). Where NA occurs, it is treated as a YES in determining the number of environmental conditions that have been satisfied.

The shoreline was then coded as to how many of the different shoreline enhancement/restoration techniques met approximately 85% or more of the seven environmental parameter criteria thresholds (i.e. a minimum of the 6 out of 7 parameters) .

Tidal Range (ft)

Tidal water surface layers, generated using the software program V-DATUM, were provided by the NOAA Coastal Services Center (CSC, NOAA CSC contact was William Brooks) for the coastal waters of New Jersey. Tidal range was defined as the vertical difference in water surface height between the MHHW (mean higher high water) layer and the MLLW (mean lower low water) (i.e. MHHW- MLLW). The data were rasterized to 10 m grid cells to match the spatial extent of the NOAA CSC New Jersey DEM. The original tidal range heights were given in meters but converted to feet for inclusion in the Restoration Explorer app.

***Tidal Range* engineering criteria for shoreline enhancement/restoration techniques**						
Tidal Range thresholds	**Nature-based living shoreline**	**Sill**	**Breakwater**	**Living Reef**	**Ecologically-enhanced Revetment**	**Beach replenishment**
0-2 ft	Yes	Yes	Yes	Yes	Yes	Yes
2.1-4.0 ft	Yes	Yes	Yes	Yes	Yes	Yes
4.1-6 ft	No	No	Yes	No	Yes	Yes
> 6 ft	No	No	Yes	No	Yes	Yes

Shoreline Change (Erosion vs. Accretion) (ft/yr)

NJDEP Tidelands GIS file was downloaded from NJGIN **(http://www.nj.gov/dep/gis/tidelandsshp.html).** The Tidelands claims line depicts areas now or formerly flowed at or below mean high tide as of 1977. The "Claimed" and "Unclaimed" tidelands were extracted and the individual map tile boundaries dissolved. The tidelands data were rasterized at a grid size of 10m to match the New Jersey DEM (provided by NOAA CSC) spatial extent.

The Mean Tide Level (MTL) water surface layer from NOAA CSC V-Datum water surface layers was differenced against the NOAA CSC NJ DEM (at 10 m grid size). Where this result = 0, the MTL shoreline was extracted. All areas of water were set as the NJ_water_mask (at MTL).

The Tidelands Claimed layer was buffered inland. The resulting buffer distance file was overlaid with the NJ_water_mask to determine those areas where the shoreline eroded (Tidelands Buffer and Water) vs. areas that have accreted (Not Tidelands and Not water) vs. No Change). Due to the 2010 baseline for the V-Datum MTL data and the 1977 year for the Tidelands data, there was a 33 year difference in time. Given a 10 m grid cell width, this equates to approximately 1 foot for year (10 m = approx. 33 feet; 33 ft/33 yr = 1 ft/yr).

***Shoreline Change* engineering criteria for shoreline enhancement/restoration techniques**						
Shoreline change thresholds	**Nature-based living shoreline**	**Sill**	**Breakwater**	**Living Reef**	**Ecologically-enhanced Revetment**	**Beach Replenishment**
Accretion	NA	NA	NA	NA	NA	NA
0-2 ft/yr	Yes	Yes	NA	Yes	NA	Yes
2.1-4.0 ft/yr	Yes	Yes	Yes	Yes	Yes	Yes
4.1-6 ft/yr	No	No	Yes	No	Yes	No
> 6.1 ft/yr	No	No	Yes	No	Yes	No

Coastal Ice Cover (frequency)

The USGS EarthExplorer Landsat 5-7-8 archive was examined for winter dates with substantial presence of ice on New Jersey's coastal waters. The objective was to map locations were ice forms and builds up during sufficiently cold winter periods. There were many winters were little if any ice formed on coastal waters or at least was not visible on available Landsat imagery dates either due to the fact that no ice was present or cloud cover obscured visual interpretation. Five images were selected to represent 5 different years. Landsat 5 and 7 Thematic Mapper Level 1 imagery downloaded from USGS EarthExplorer site http://earthexplorer.usgs.gov/. Following images were downloaded for Path/Row 14-31-33:

Landsat 7 ETM January 29, 2000
Landsat 5 TM February 1, 2004
Landsat 5 TM February 9, 2007
Landsat 5 TM January 29, 2009
Landsat 5 TM January 3, 2011.

A normalized snow index (NDSI) was computed [(Band 2 - Band 5)/(Band 5 + Band 2)] using the Level 1 imagery. The imagery data were taken "as is" without any additional processing (i.e. atmospheric or radiometric corrections). The NSDI data were thresholded using a digital number value of 210 to generate an "ice cover" layer (i.e., if NSDI > 210 → ice). The resulting ice cover for the 5 dates were composited using a rule where Output = 5, when all 5 dates were classified as ice cover; Output = 4, when 4 out of 5 dates were ice cover. It is estimated based on experience and anecdotal information that the ice thickness of those areas classified as ice cover were at least 2-3" inches thick. Areas of higher frequency ice cover were equated with ice thickness (inches). The resulting composite data were further qualitatively classed as:

Value 0 = No ice cover
1 = Low Ice cover (i.e. ice cover on 1 of 5 dates) (0-2" thick)
2 = Moderate ice cover (2.1-4" thick)
3 = High ice cover (4.1-6 " thick)
4&5 = Highest ice cover (> 6" thick)

***Ice Cover* engineering criteria for shoreline enhancement/restoration techniques**						
Ice Cover thresholds	**Nature-based living shoreline**	**Sill**	**Breakwater**	**Living Reef**	**Ecologically-enhanced Revetment**	**Beach Replenishment**
No ice cover	Yes	Yes	Yes	Yes	Yes	Yes
Low	Yes	Yes	Yes	Yes	Yes	Yes
Moderate	No	No	Yes	No	Yes	Yes
High	No	No	Yes	No	Yes	Yes
Highest	No	No	No	No	Yes	Yes

Wave Height (ft)

Wave data was provided by Natural Capital Project (http://www.naturalcapitalproject.org/). The data for any individual model point was averaged across the various compass point directions. Due to the spatial displacement of the rather coarse spatial scale individual model points and the finer scale MTL shoreline, the NAtCap data was resampled to match the finer scale shoreline data. The NatCap points were interpolated using the ArcGIS IDW (inverse distance weighted interpolation) algorithm with (1 neighbor selected, power = 1 and 1500 m search distance). A barrier poly line was used to help separate NatCap points in the ocean influencing interpolation on the bayside margin. The above approach basically is similar to a nearest neighbor resampling to assign the closest NatCap point value to each MTL shoreline grid cell. The original wave heights were given in meters but converted to feet for inclusion in the Restoration Explorer app.

Wave Height **engineering criteria for shoreline enhancement/restoration techniques**						
Wave Height thresholds	**Nature-based living shoreline**	**Sill**	**Breakwater**	**Living Reef**	**Ecologically-enhanced Revetment**	**Beach Replenishment**
< 1.0'	Yes	Yes	NA	Yes	NA	Yes
1.1-2.0'	No	Yes	NA	Yes	Yes	Yes
2.1-3.0'	No	Yes	NA	Yes	Yes	Yes
3.1-4'	No	No	Yes	No	Yes	Yes
> 4'	No	No	Yes	No	Yes	Yes

Slope (%)

The US Geological survey-provided a seamless topographic-bathymetric digital elevation model (at 1 m grid cell resolution) was used to derive slope (%) in ERDAS Imagine.

Shoreline slope was defined within the intertidal zone between MHHW (Mean Higher High Water) and MLLW (Mean Lower Low Water). Nearshore slope was defined as subtidal water (below MLLW) out to a depth of 5'. The nearshore slope was then projected to the MTL shoreline using ESRI ArcMap function EXPAND.

Shoreline Slope **engineering criteria for shoreline enhancement/restoration techniques**						
Shoreline Slope thresholds	**Nature-based living shoreline**	**Sill**	**Breakwater**	**Living Reef**	**Ecologically-enhanced Revetment**	**Beach Replenishment**
0-5.0%	Yes	Yes	Yes	Yes	Yes	Yes
5.1-10%	Yes	Yes	Yes	Yes	Yes	Yes
10.1%-15%	No	Yes	Yes	Yes	Yes	Yes
15.1-20%	No	Yes	Yes	Yes	Yes	Yes
>20%	No	No	Yes	No	Yes	No

Nearshore Slope **engineering criteria for shoreline enhancement/restoration techniques**						
Nearshore Slope thresholds	**Nature-based living shoreline**	**Sill**	**Breakwater**	**Living Reef**	**Ecologically-enhanced Revetment**	**Beach Replenishment**
0-5.0%	Yes	Yes	Yes	Yes	Yes	Yes
5.1-10%	Yes	Yes	Yes	Yes	Yes	Yes
10.1%-15%	No	No	No	No	Yes	No
15.1-20%	No	No	No	No	Yes	No
>20%	No	No	No	No	Yes	No

Salinity (ppt)

Sampling site locations and water quality samples were downloaded from the National Water Quality Monitoring Council's Water Quality Portal (WQP), located at http://www.waterqualitydata.us/portal.jsp.

Sampling site point data were imported into ESRI ArcGIS using Add XY Data, using GCS_North_American_1983 (lat/Long) as the coordinate system. The points were then projected into NAD 1983 New Jersey State Plane FIPS 2900 coordinate system. Min/Max/Average salinity values (in ppt) were calculated for the field ResultMeasureValue and then summarized for each sample location using the Summary Statistics tool.

Points that had values (NOT NULL) were then used as input into the IDW tool, using the appropriate field (Min/Max/Average) as the Z value. The cell resolution was set to 250 feet. After some preliminary review of the outputs, certain outlier sample points were dropped as input into the IDW tool, and the final IDW surfaces were created. The output surfaces were then masked by land boundaries up to the head of tide. The final step was to project the surfaces into the Web Mercator projection, using a 75 meter output cell size with cubic convolution, in order to be displayed as web maps.

***Salinity* engineering criteria for shoreline enhancement/restoration techniques**						
Salinity thresholds	**Nature-based living shoreline**	**Sill**	**Breakwater**	**Living Reef**	**Ecologically-enhanced Revetment**	**Beach Replenishment**
0-1 ppt	No	Yes	Yes	No	Yes	NA
1.1-3 ppt	No	Yes	Yes	No	Yes	NA
3.1-10 ppt	Yes	Yes	Yes	Yes	Yes	NA
10.1-30 ppt	Yes	Yes	Yes	Yes	Yes	NA
> 30 ppt	No	Yes	Yes	No	Yes	NA