Evaluating the Equilibrated Toe of Fill at Key Biscayne Beach

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moffatt & nichol

Scope of Work

- Moffatt & Nichol was retained by the Village of Key Biscayne (Village) to procure permits authorizing future beach nourishment events on Key Biscayne Beach.
  - The Florida Department of Environmental Protection (FDEP) requires that the permittee conduct analyses demonstrating the proposed fill template does not directly, nor indirectly, impact the coastal ecosystem.

Project Area

- Key Biscayne Beach, Miami-Dade County, Florida
- Adjacent to Crandon Beach Park and Bill Baggs Cape Florida State Park
- Project Area is between R-101 and R-108 within Miami-Dade County
- Characterized by a mild beach slope and nearshore seagrasses

Nourishment History

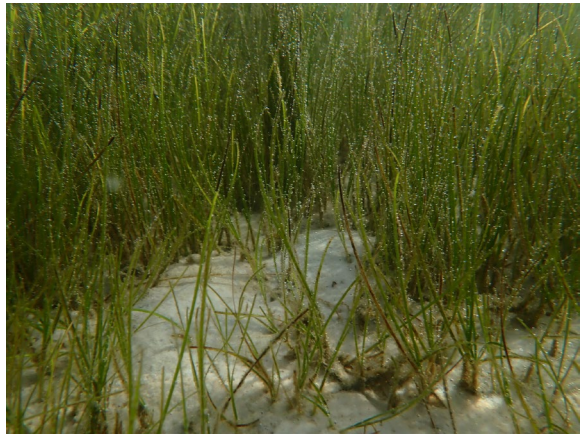
- Key Biscayne Beach has a long history of documented beach nourishment events, as outlined by the Florida Department of Environmental Protection (FDEP's) Strategic Beach Management Plan.

Date Completed	Volume (cy)	Borrow Source	Project Location	Length (ft)
1987	420,000	Offshore	R-101 to R-111 and R-112.3 to R-113.7	12,672
2002	121,100	Offshore	R-101 to R-108	6,864
2008[1]	2,400	Upland	R-103 to R-107	3,960
2012	37,500	Upland	R-101.3-R-107.6	6,336
May 2017	27,064	Upland	R-101.7-R-107.8	6,336
April 2021	31,000	Upland	R-102 to R-107.8	5,896

1. Dune only

Existing Seagrass Community

- Annual seagrass mapping in accordance with FDEP-approved Biological Monitoring Plan.
  - Delineation of Western Edge
  - Qualitative Seagrass Community Survey
- In general, western edge of seagrass is located in depths between -5 and -8 ft NAVD along project area shoreline, or within 150 feet from the shoreline.
- Presence of a persistent seagrass community.
  - Shoal grass (*Halodule wrightii*)
  - Turtle grass (*Thalassia testudinum*)
  - Manatee grass (*Syringodium filiforme*)
- All seagrasses in the Florida Waters are federally protected.



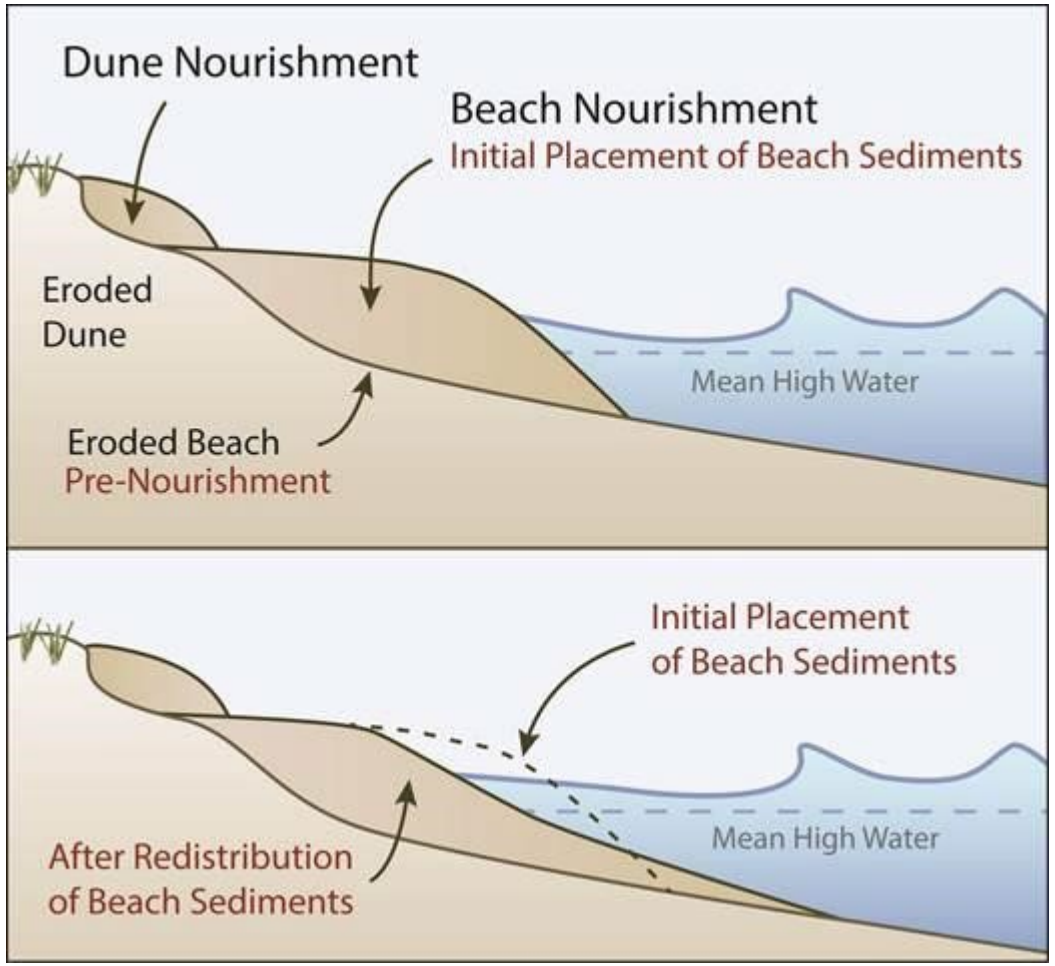
Shoal Grass

Turtle Grass

Manatee Grass

Beach Profile Equilibration

- Wave and current interaction following beach nourishment events cause beach profile equilibration.
  - The construction fill template volume is redistributed offshore, creating a milder beach slope.
- Fill material is expected to be redistributed anywhere landward of the depth of closure.
  - Based on methodology outlined by Dean & Grant (1989), the closure depth in the Miami area is approximately -14 feet relative to Mean Sea Level (MSL).
  - Closure depth is seaward of western edge of seagrass boundary!



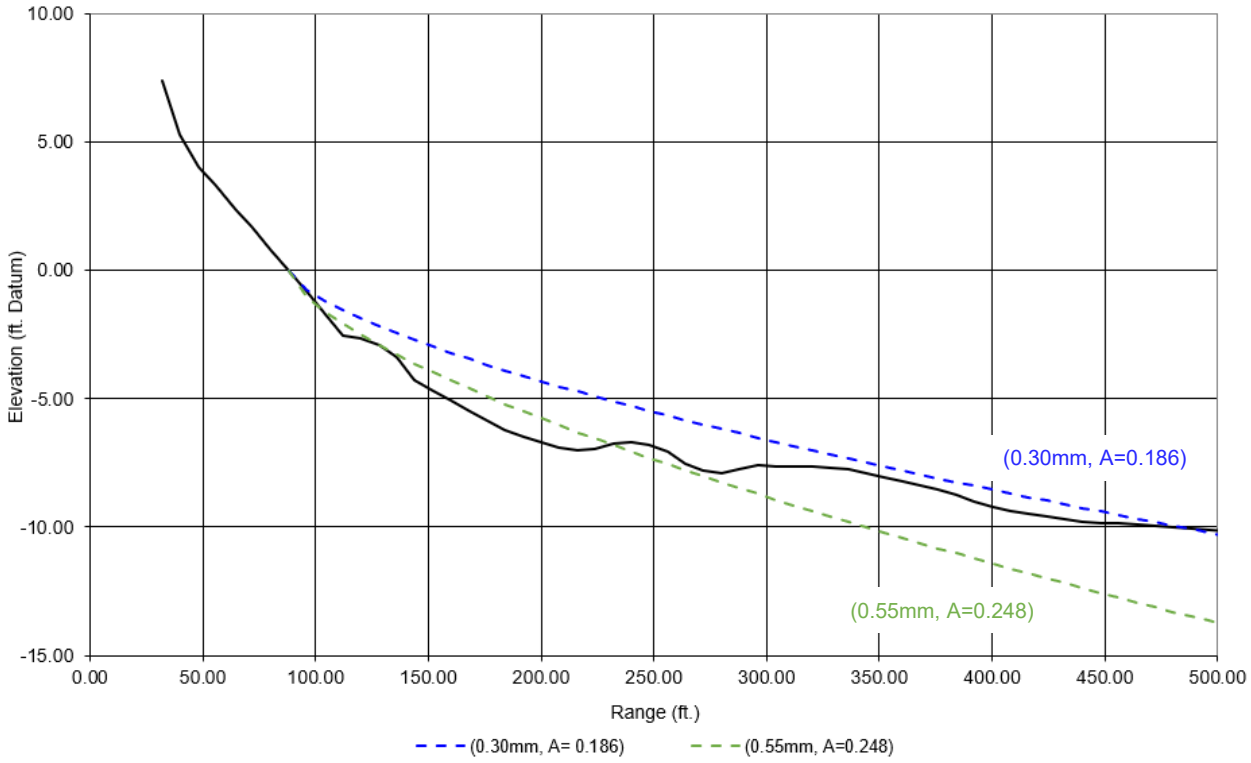
Dean Equilibrium Beach Profile

- Dean (1977) proposed that the equilibrium beach profile depends only on the sediment grain size.
- $h = A\, y^{2/3}$
  - h = Water depth
  - A = Sediment scale parameter
  - y = Cross-shore distance from shoreline

Table III-3-3
Summary of Recommended *A* Values (Units of *A* Parameter are $m^{1/3}$)

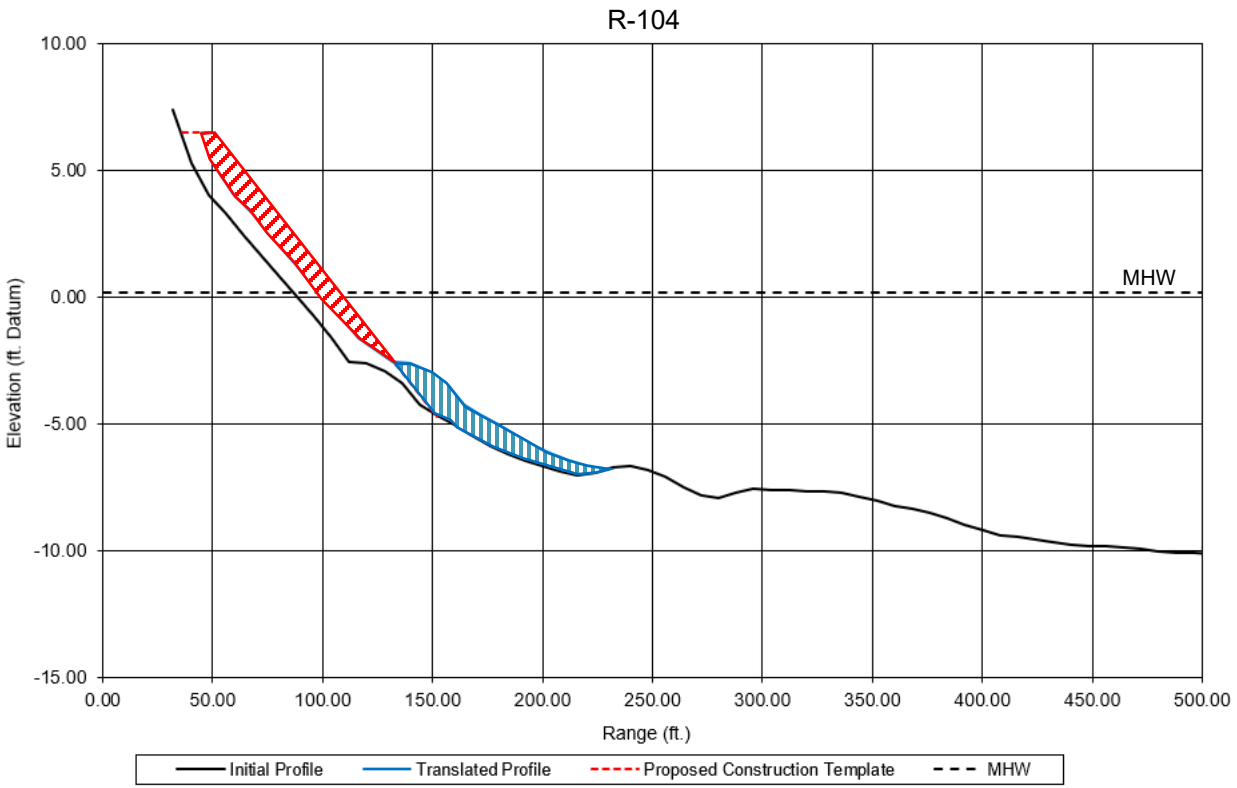
D(mm)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.1	0.063	0.0672	0.0714	0.0756	0.0798	0.084	0.0872	0.0904	0.0936	0.0968
0.2	0.100	0.103	0.106	0.109	0.112	0.115	0.117	0.119	0.121	0.123
0.3	0.125	0.127	0.129	0.131	0.133	0.135	0.137	0.139	0.141	0.143
0.4	0.145	0.1466	0.1482	0.1498	0.1514	0.153	0.1546	0.1562	0.1578	0.1594
0.5	0.161	0.1622	0.1634	0.1646	0.1658	0.167	0.1682	0.1694	0.1706	0.1718
0.6	0.173	0.1742	0.1754	0.1766	0.1778	0.179	0.1802	0.1814	0.1826	0.1838
0.7	0.185	0.1859	0.1868	0.1877	0.1886	0.1895	0.1904	0.1913	0.1922	0.1931
0.8	0.194	0.1948	0.1956	0.1964	0.1972	0.198	0.1988	0.1996	0.2004	0.2012
0.9	0.202	0.2028	0.2036	0.2044	0.2052	0.206	0.2068	0.2076	0.2084	0.2092
1.0	0.210	0.2108	0.2116	0.2124	0.2132	0.2140	0.2148	0.2156	0.2164	0.2172

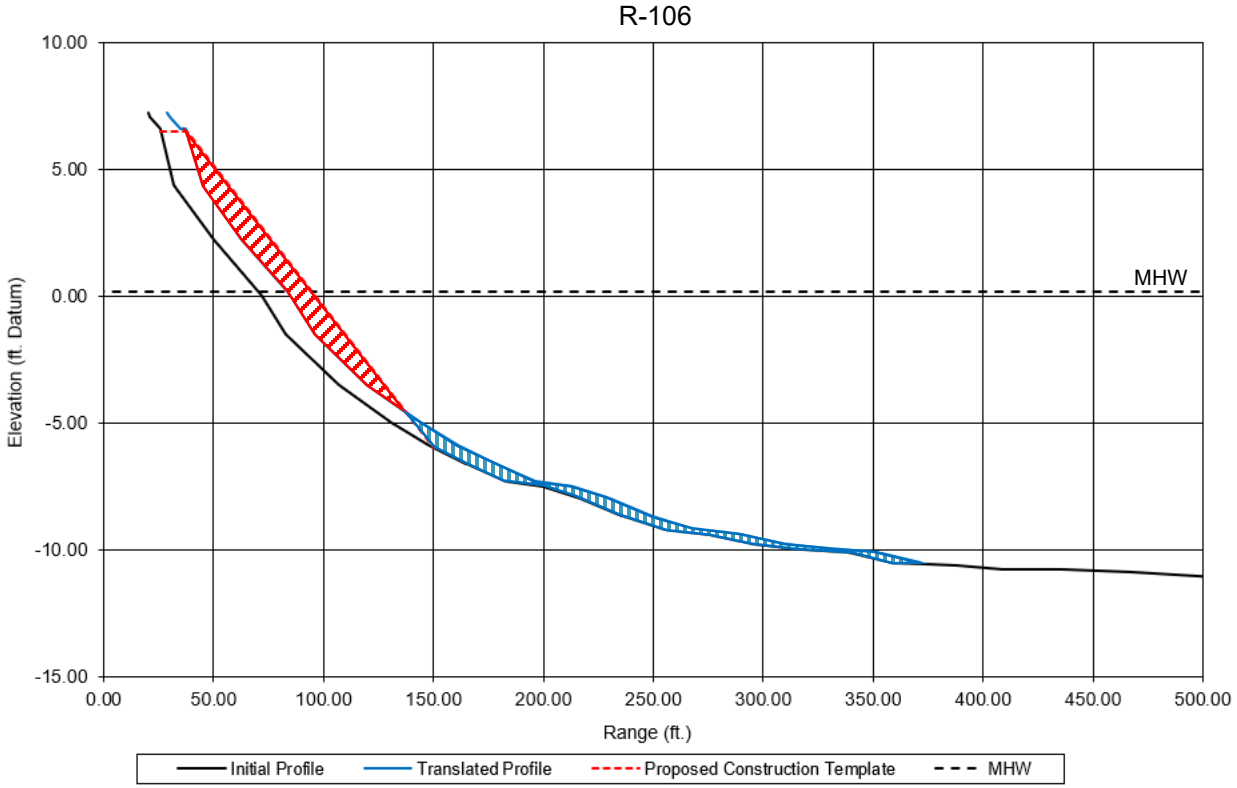
Notes:
(1) The *A* values above, some to four places, are not intended to suggest that they are known to that accuracy, but rather are presented for consistency and sensitivity tests of the effects of variation in grain size.
(2) As an example of use of the values in the table, the *A* value for a median sand size of 0.24 mm is: $A = 0.112\ m^{1/3}$. To convert *A* values to $feet^{1/3}$ units, multiply by $(3.28)^{1/3} = 1.49$.



Profile Translation

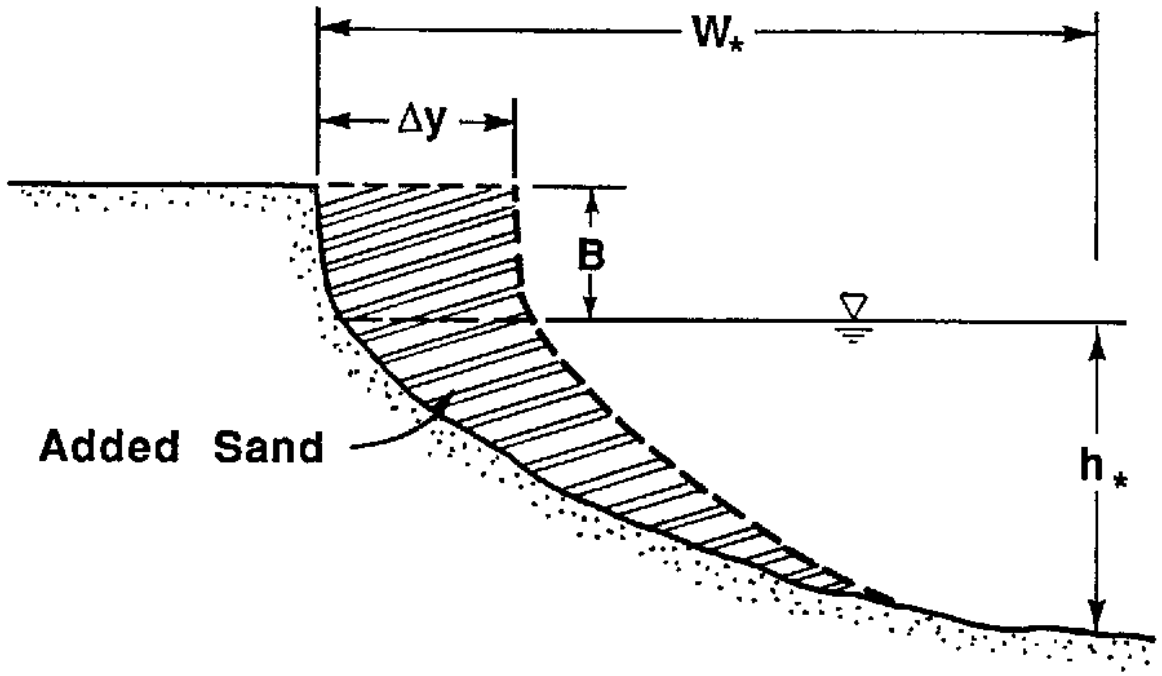
- This method involves translating the existing beach profile seaward and balancing volumetric losses from the proposed construction template with the equilibrated fill volume.





Modified Dean's Method

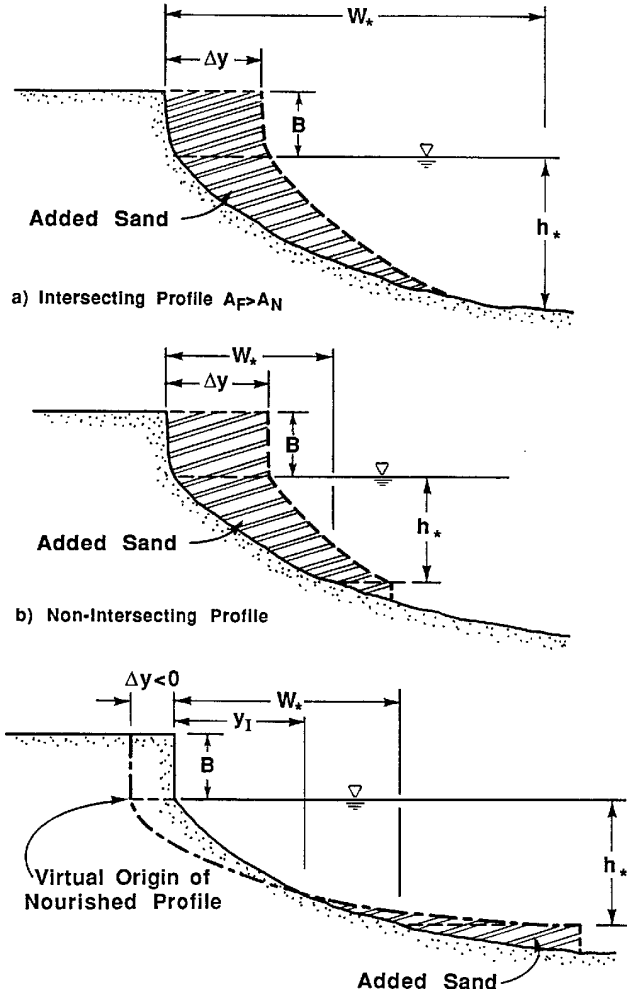
- Approach features elements from the Dean Equilibrium Profile and Translation Method
- Methodology accounts for the following:
  - Existing beach profile
  - Proposed construction template
    - Fill volume density (cy/ft)
    - Berm elevation (ft, MSL)
  - Fill and native sand grain size (A-value; $ft^{1/3}$)
    - Native sand grain size: 0.186 (0.30 mm)
    - Fill grain size: 0.248 (0.55 mm)
  - Depth of Closure (ft, MSL)



Modified Dean's Method

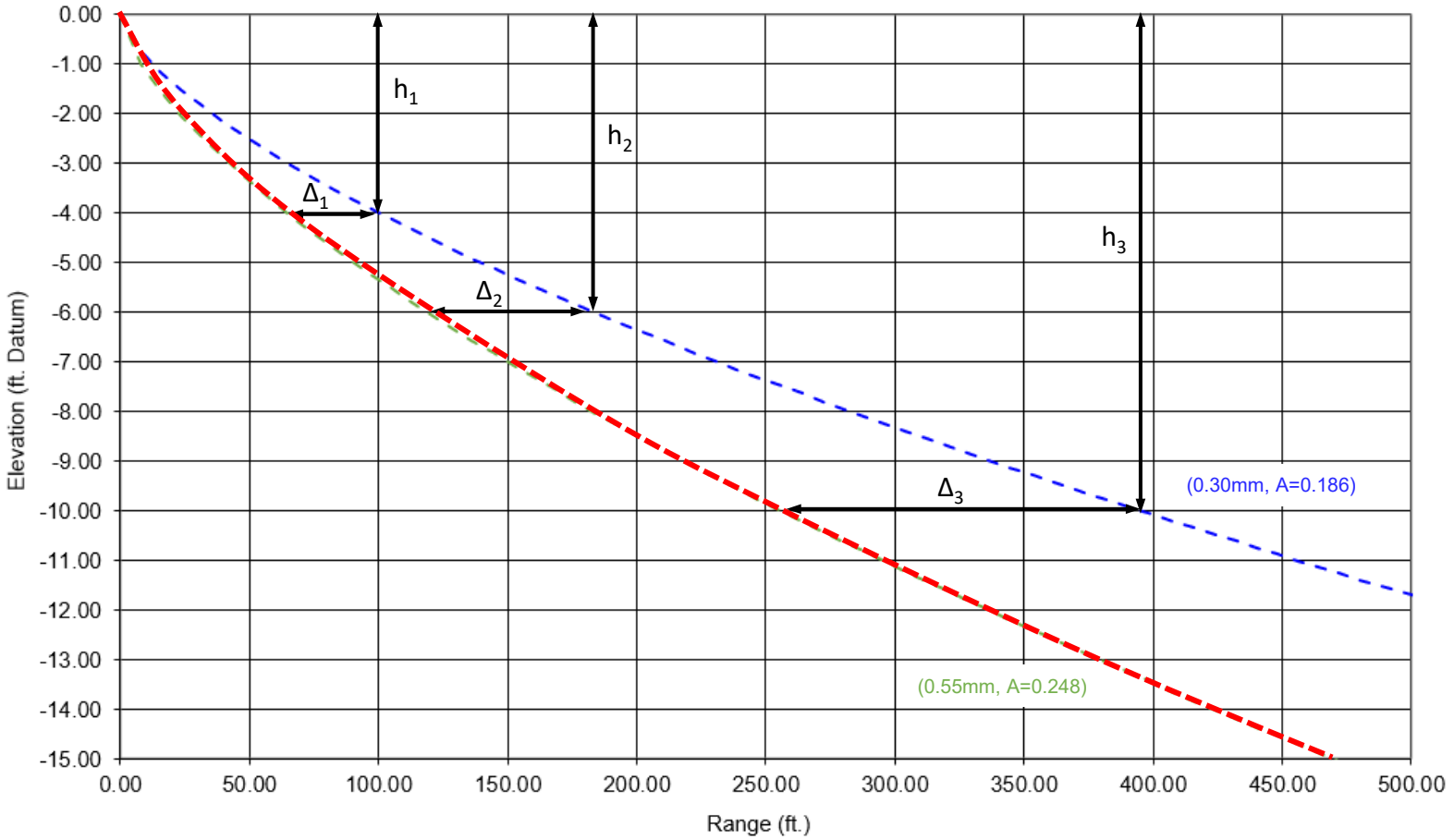
- Additional dry beach width (Δy_0) (ft)
  - $\forall$ = Fill volume density (cy/ft)
  - h_* = Depth of closure (ft, MSL)
  - B = Berm elevation, (ft, MSL)
- Beach Profile Types
  - Intersecting Profiles
    - Placed sand is coarser than native sand ($A_N < A_F$)
  - Non-Intersecting Profiles
    - Comparable grain sizes between placed and native sand ($A_N = A_F$)
  - Submerged Profiles
    - Placed sand is finer than native sand ($A_F < A_N$)

$$\Delta y_0 = \frac{\forall}{(h_* + B)}$$

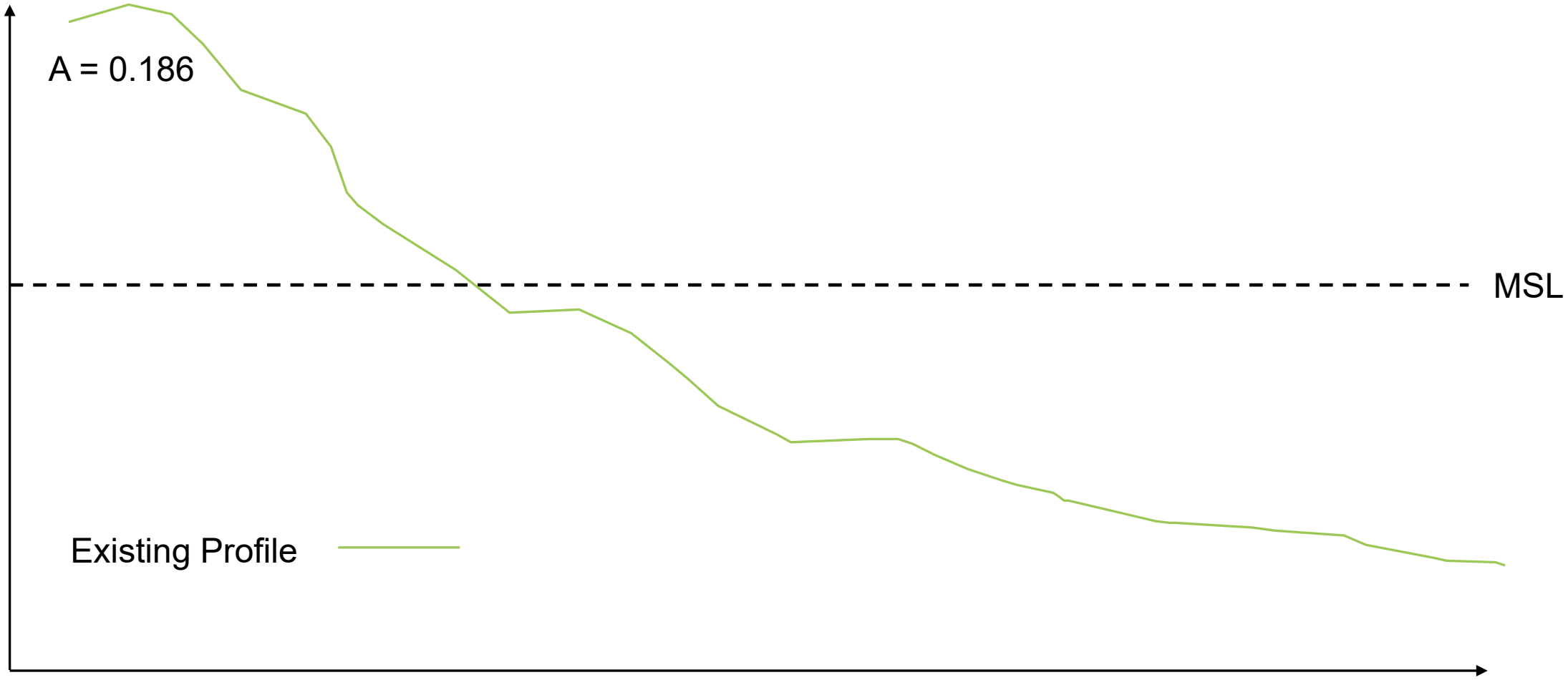


Modified Dean's Method

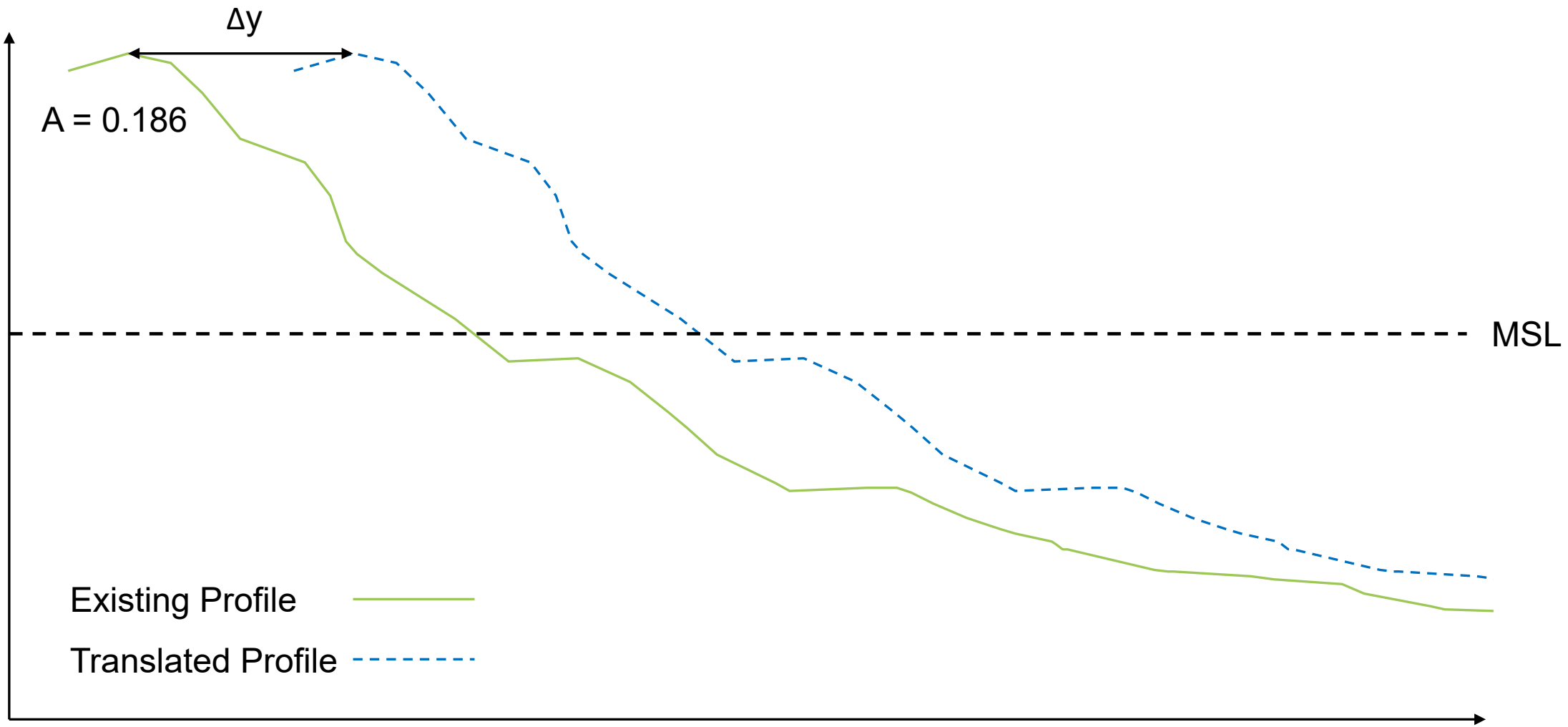
- Calculate difference in cross-shore distance ($y_F - y_N$) at a particular depth contour
  - $h_F = A_F\, y_F^{\,2/3}$ & $h_N = A_N\, y_N^{\,2/3}$
- Add calculated difference to the now translated "native" profile to estimate an equilibrated beach profile below MSL.



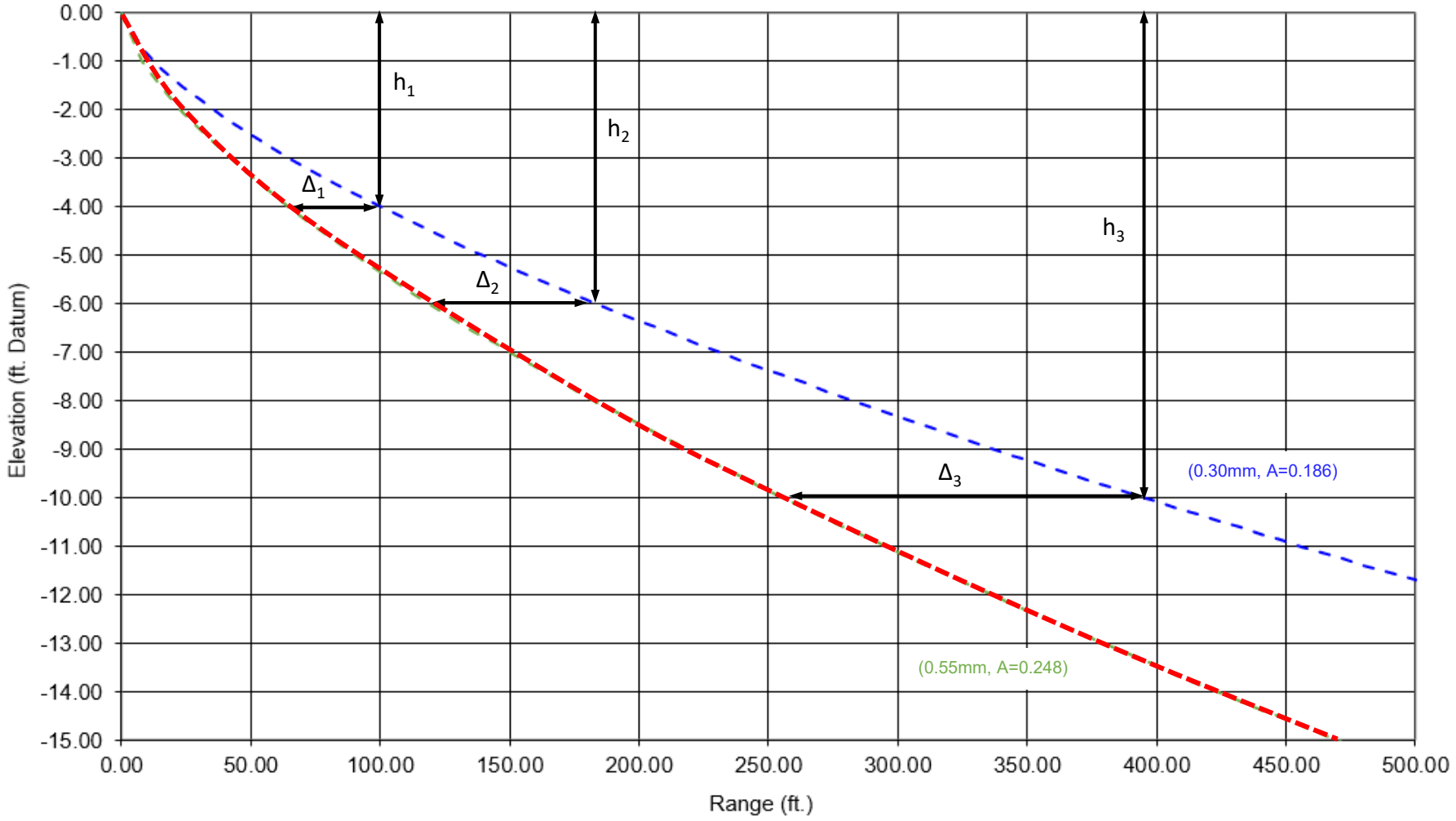
How it Works → Starting Beach Profile



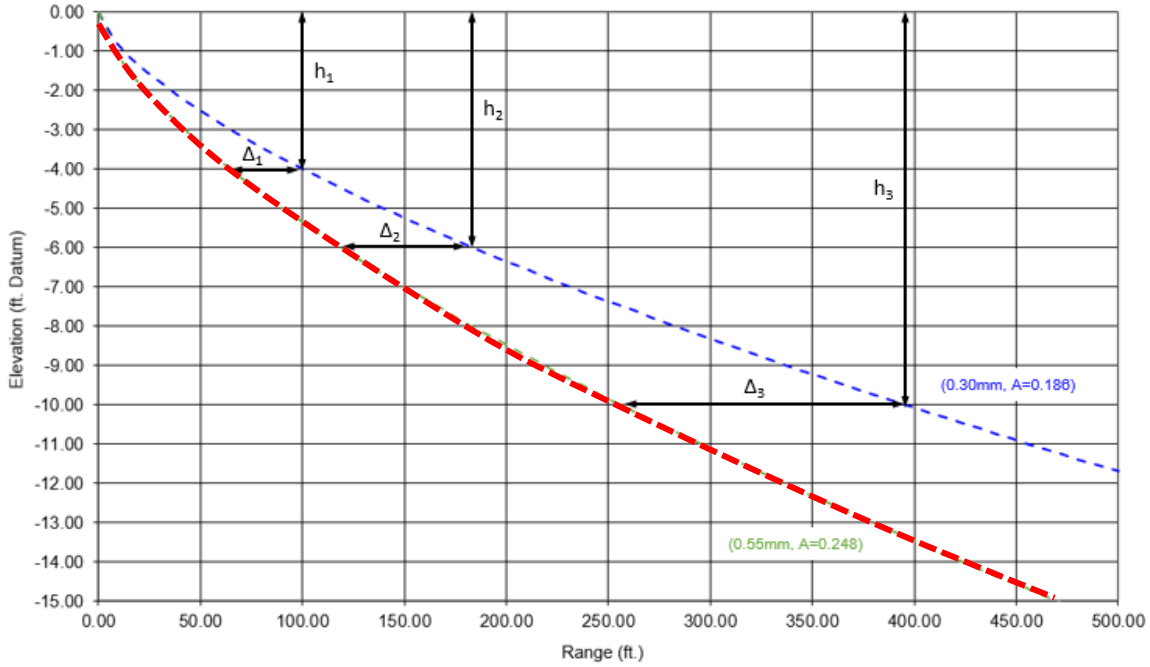
Apply Translation Method



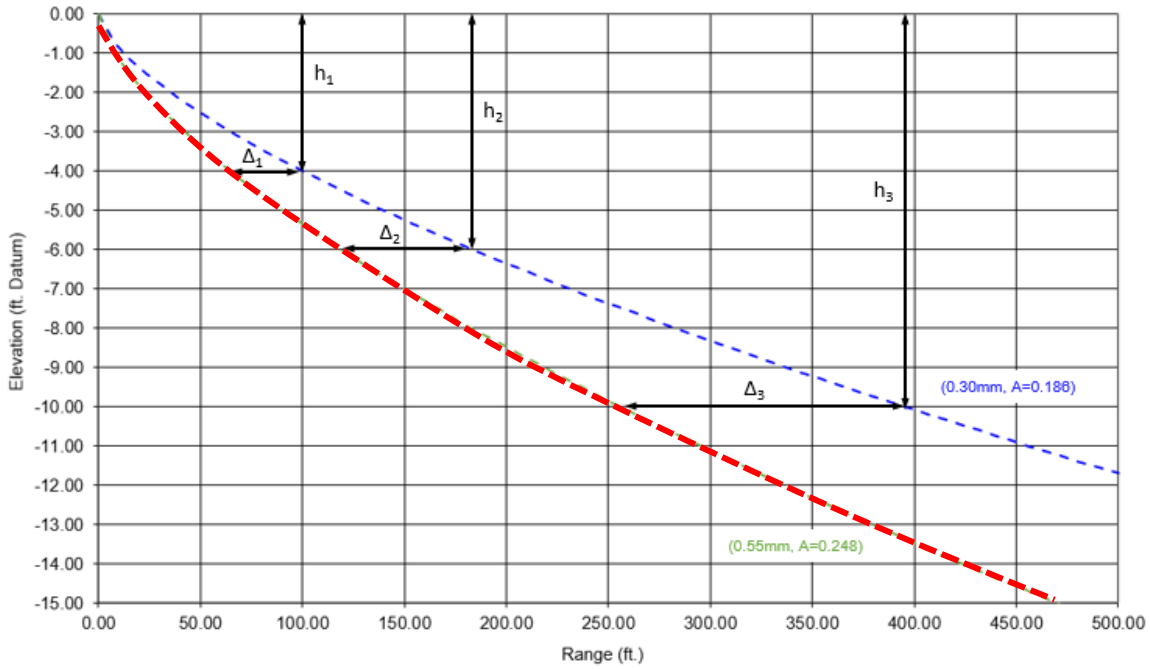
Calculate (Δ : h) Relationship



Apply (Δ : h) to Translated Profile



Apply below MSL



Δy

A = 0.186

MSL

A = 0.186

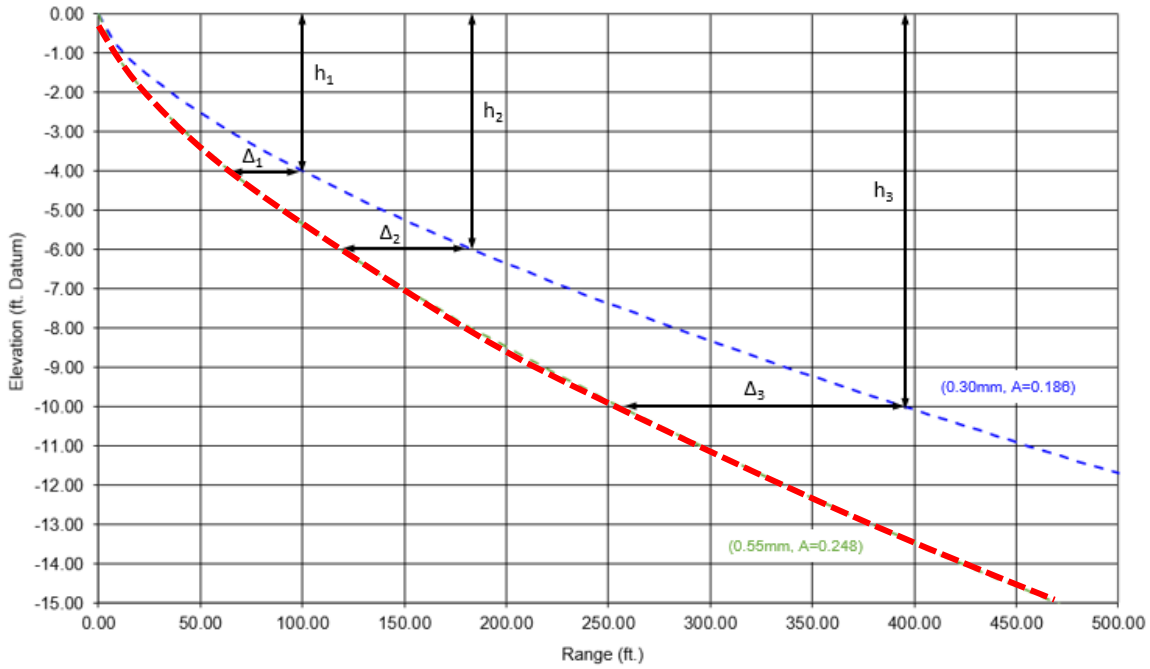
A = 0.248

Existing Profile

Translated Profile

Modified Profile

New ETOF Profile



Δy

A = 0.186

MSL

A = 0.186

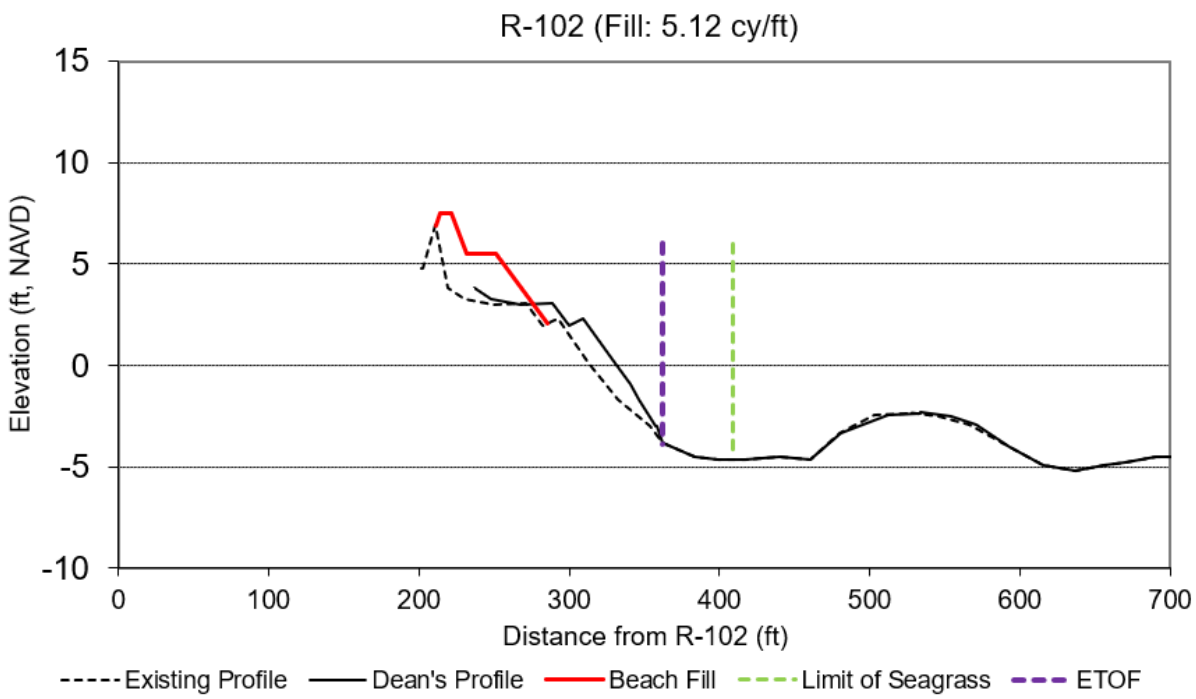
A = 0.248

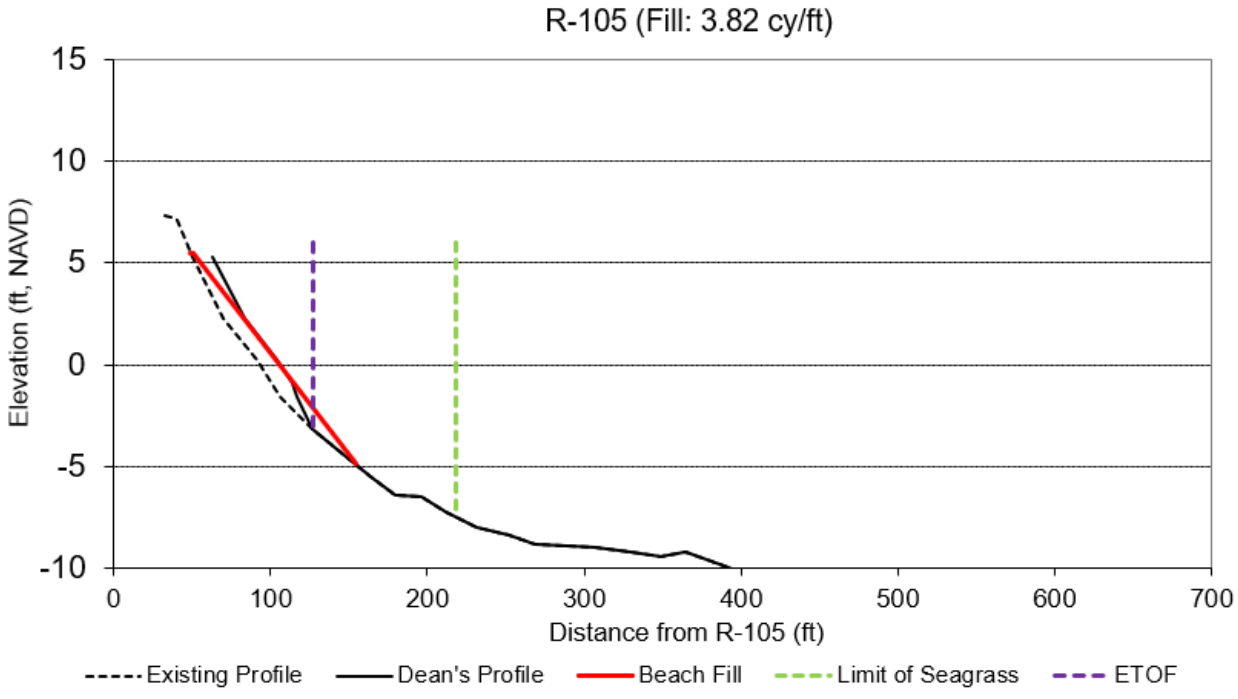
Existing Profile

Translated Profile

Modified Profile

Calculated ETOF at Key Biscayne Beach





Theory vs Actual

2023 Post-Construction Biological Monitoring Report

Village of Key Biscayne
Beach Renourishment Project
Village of Key Biscayne, Miami-Dade County, Florida

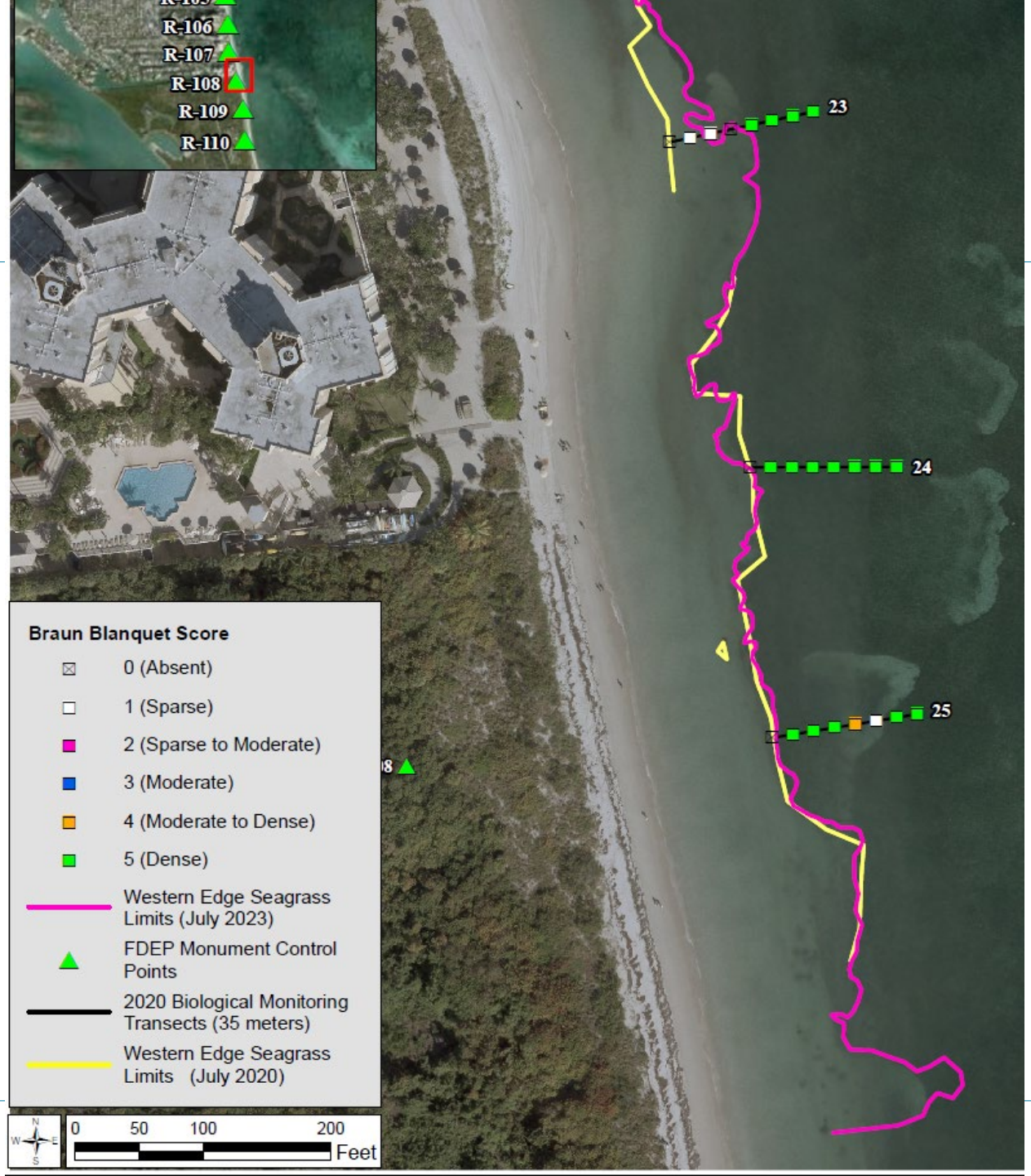
November 20, 2023

Prepared for:

Village of Key Biscayne
88 West McIntyre Street
Key Biscayne, FL 33149

Submitted to:

Florida Department of Environmental Protection—
Permit No. 0160846-001-JC - (Modification No. 0160846-021-JN)
U.S. Army Corps of Engineers—Permit No. SAJ-1999-04294 (IP-AG)
Miami-Dade County DERM—Permit No. 2010-CLI-PER-00088



Thank you

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