Battling the Bering Sea:

St. George Island's Berm Breakwater

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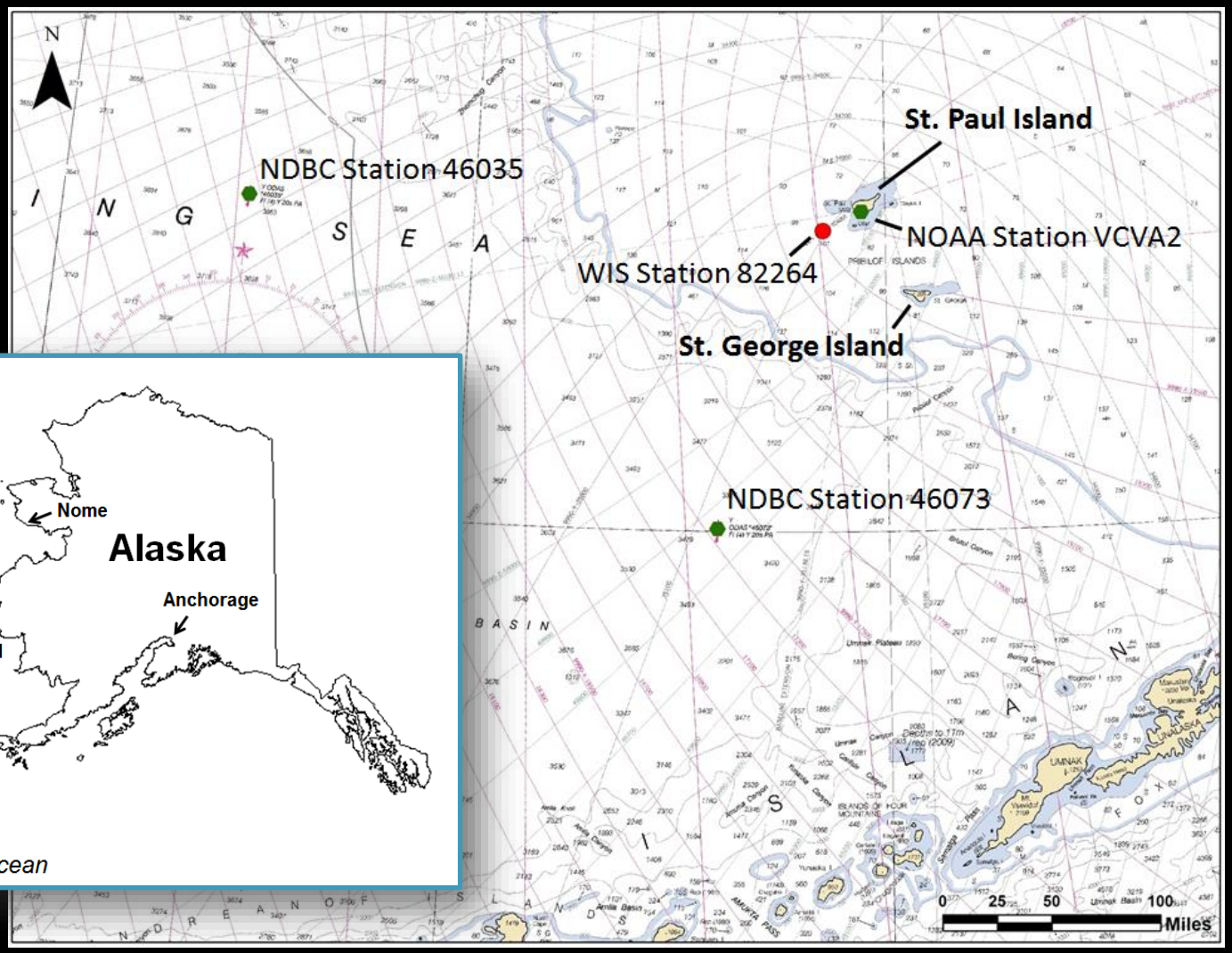
01 Introduction

Introduction
Site Location

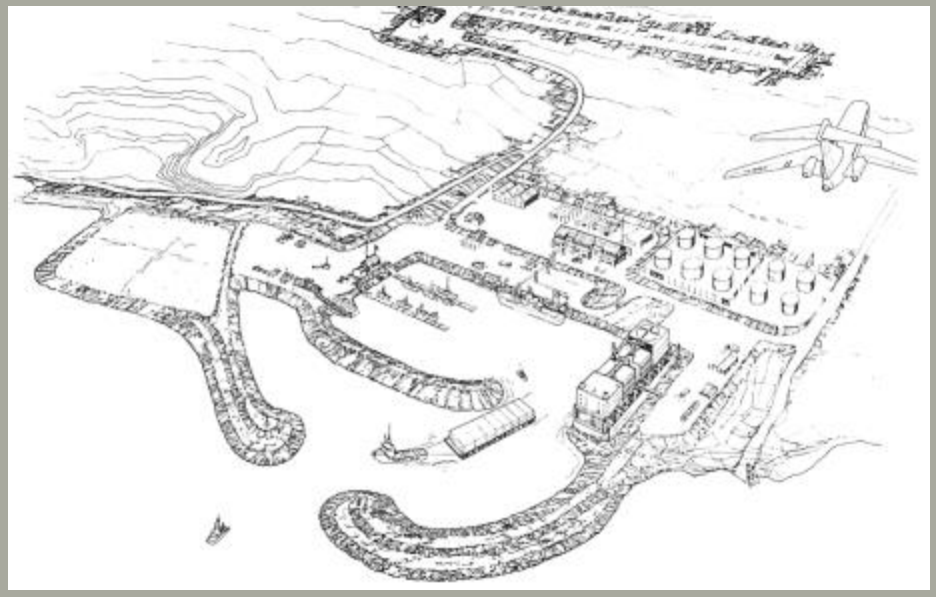


Introduction
Existing Harbor

02 Original Breakwater Design

Existing Harbor and Background Information

- State of Alaska began harbor design in 1982
  - Construction budget was not adequate
- The City hired a private engineering firm in 1984
  - Modified Design
  - Outer Breakwater Shallower Water
  - Reduced Construction Budget
- Deep water significant wave height of 34 ft at 18 seconds

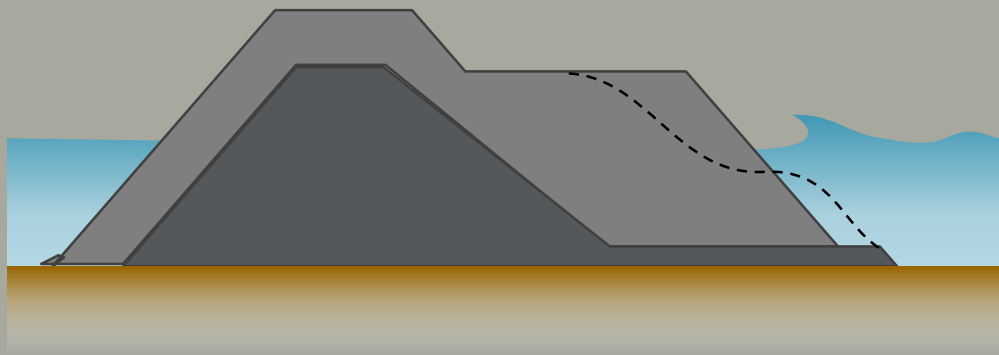


Existing Harbor and Background Information

- Major cost savings is contributed to use of a berm breakwater design
  - Berm breakwater design utilized the smaller basalt rock available on St. George Island
  - Higher yield from quarry
  - Less strict construction tolerances

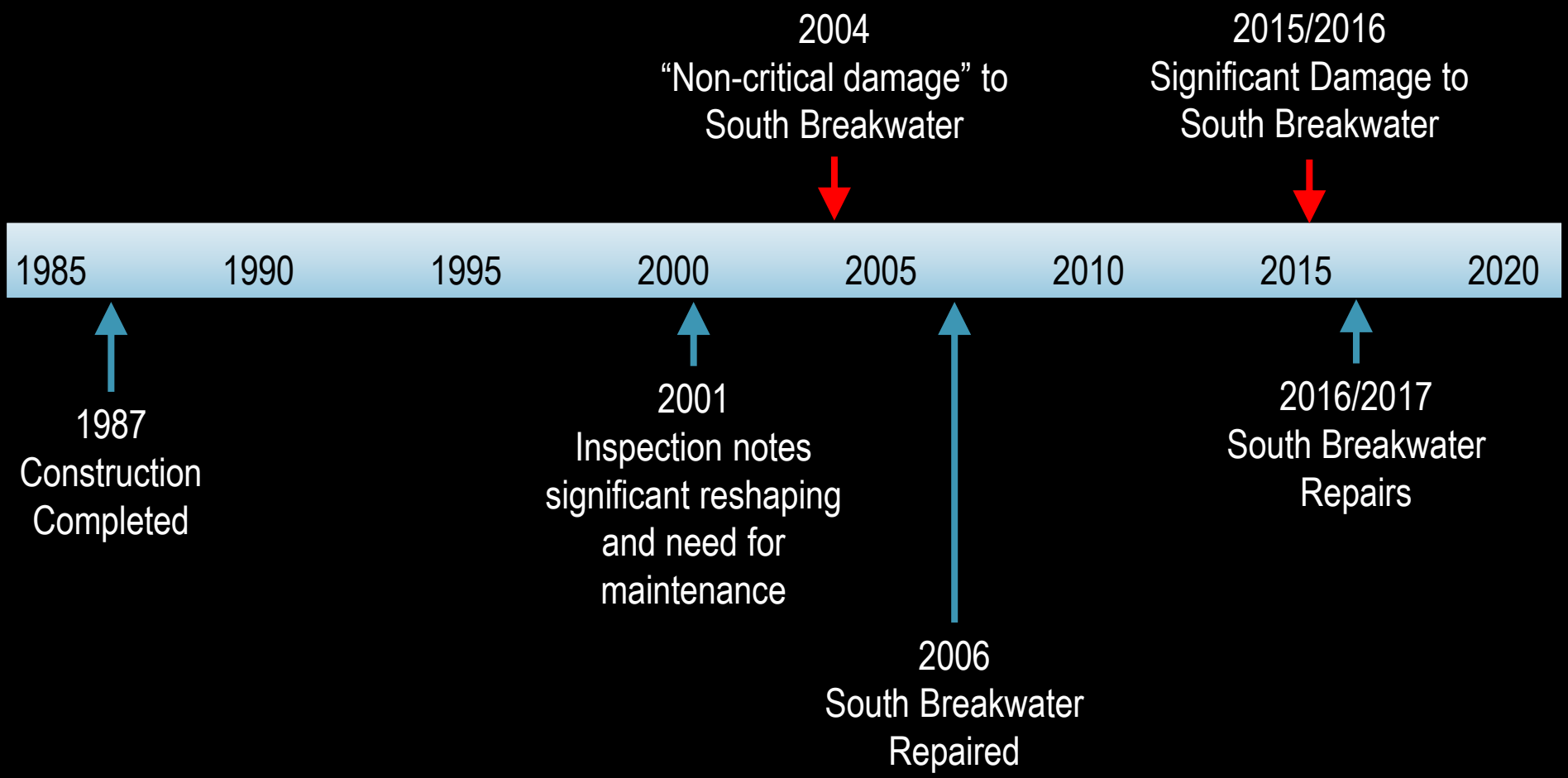
- “Under current contracts, the St. George Berm Breakwater is running less than one third of the per-linear foot cost of the St. Paul conventional breakwater.” –Alaska Construction & Oil, 1986

- The initial harbor was completed in 1987
  - Contractor partially built
  - City completed construction



03 Breakwater Performance

Breakwater Performance Timeline



Breakwater Cross-section Performance

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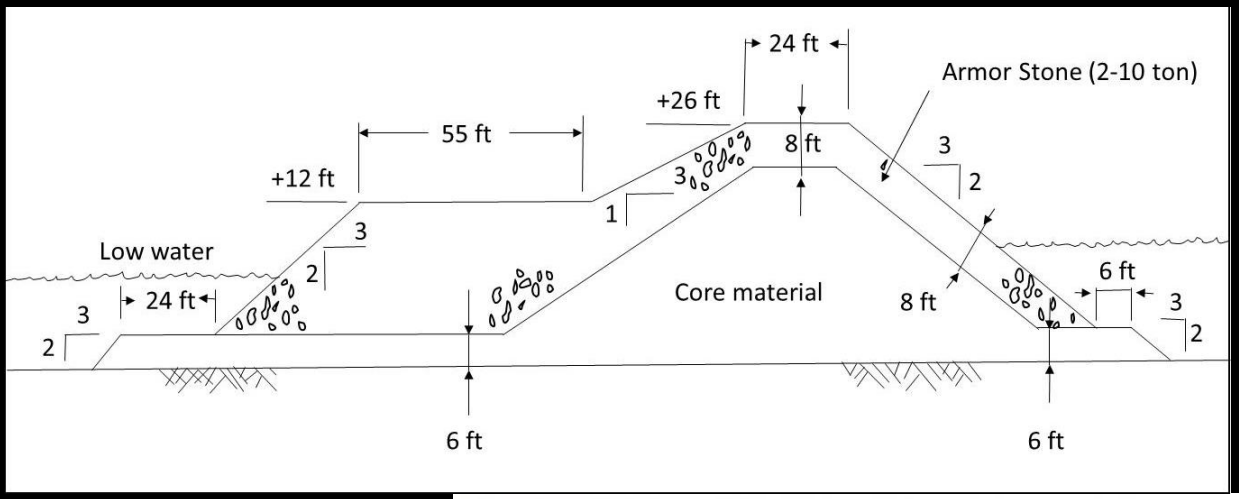
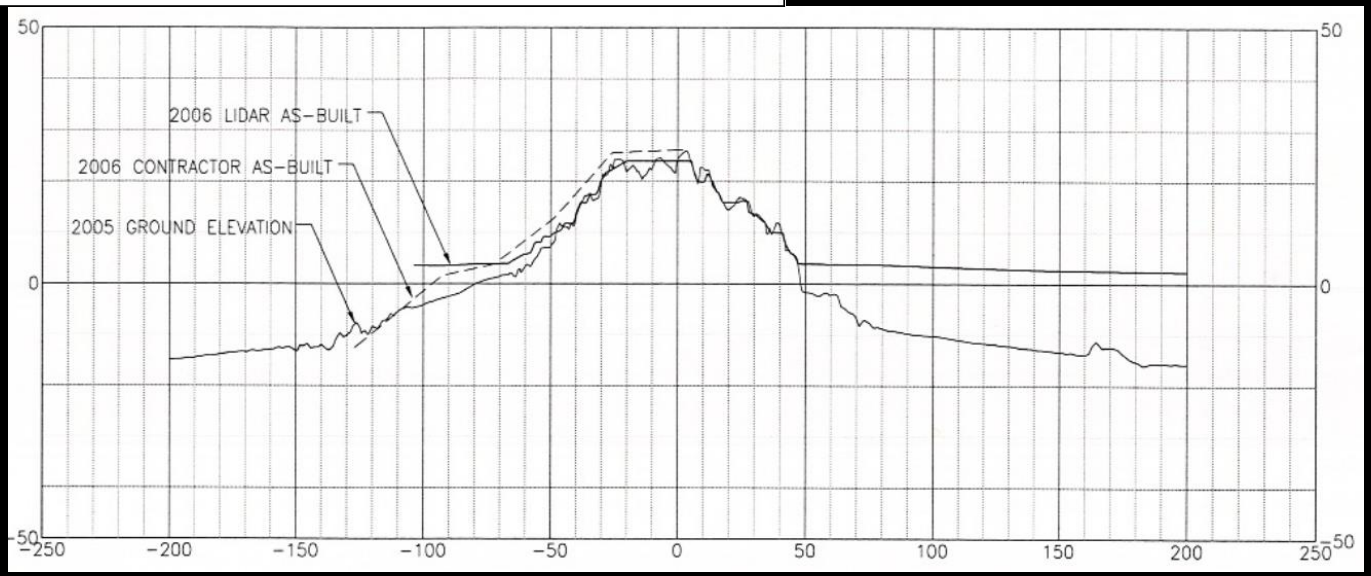


Original Design*

2005/2006



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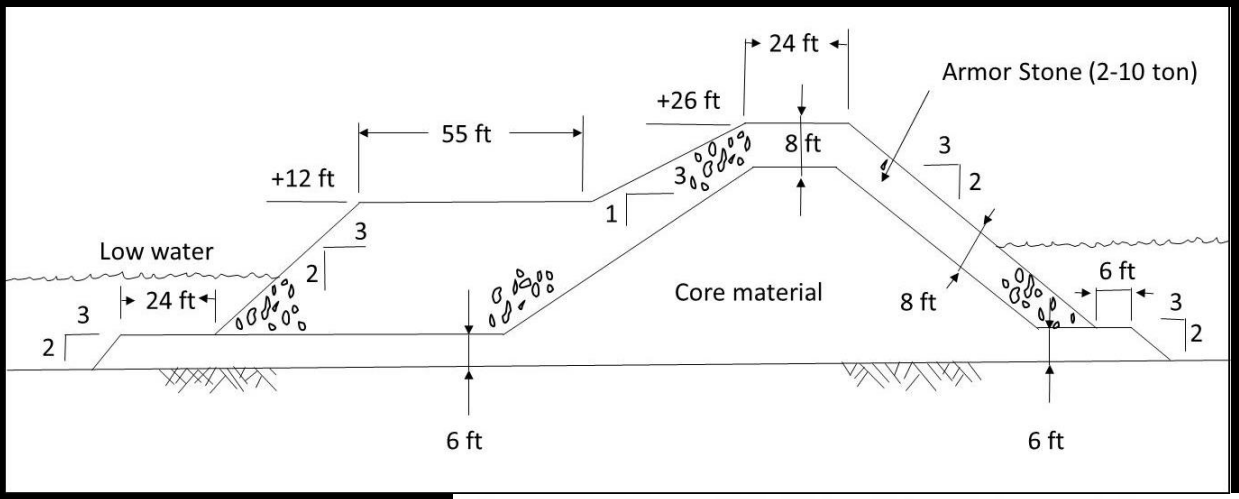

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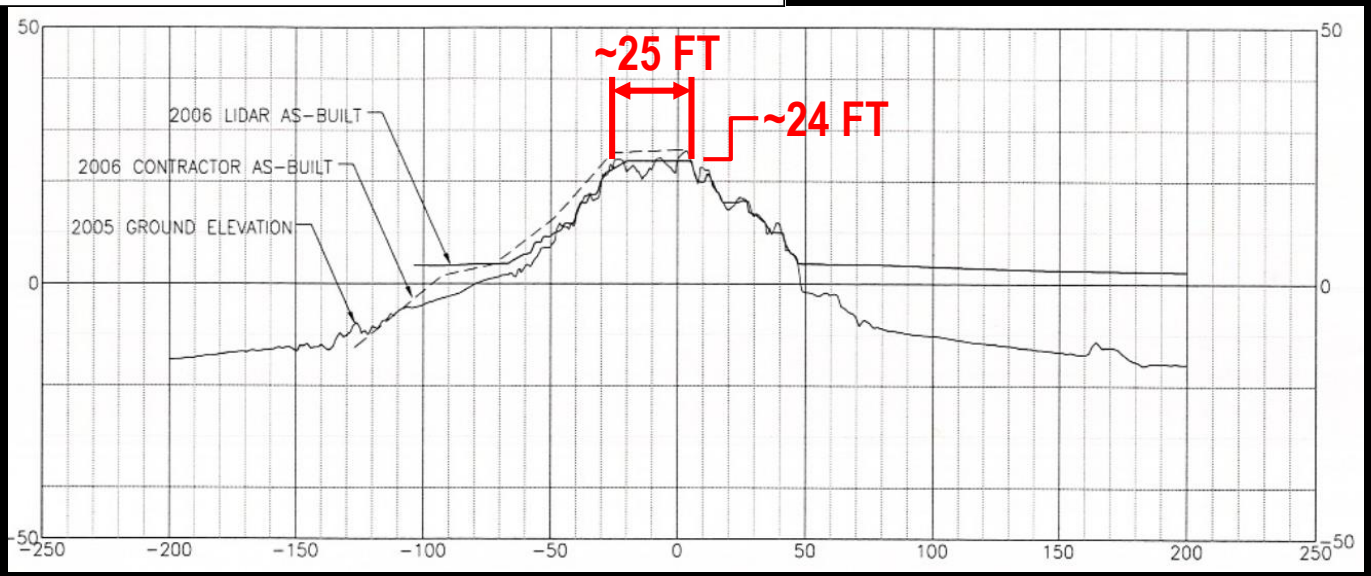

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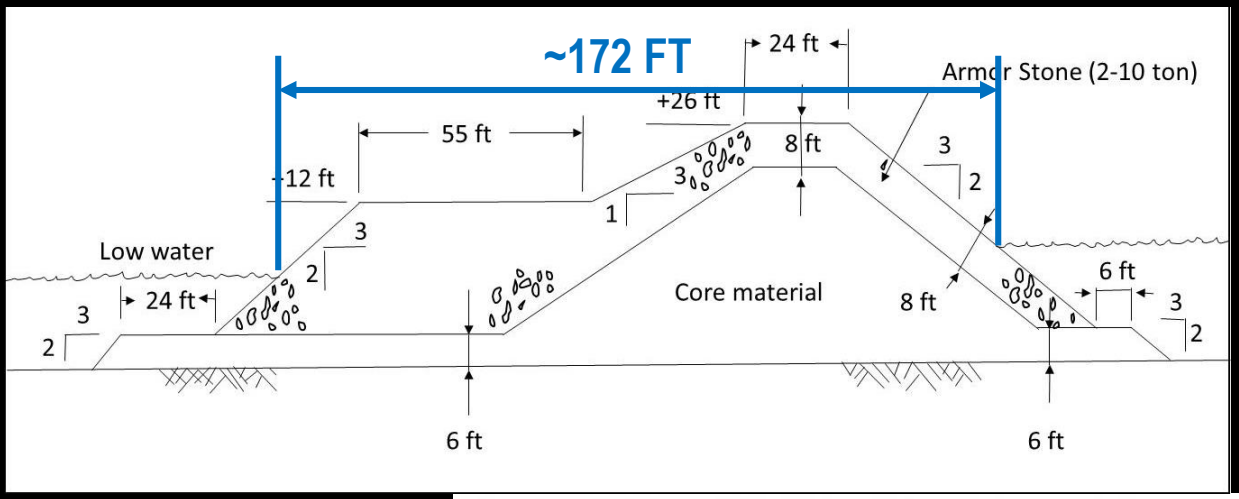

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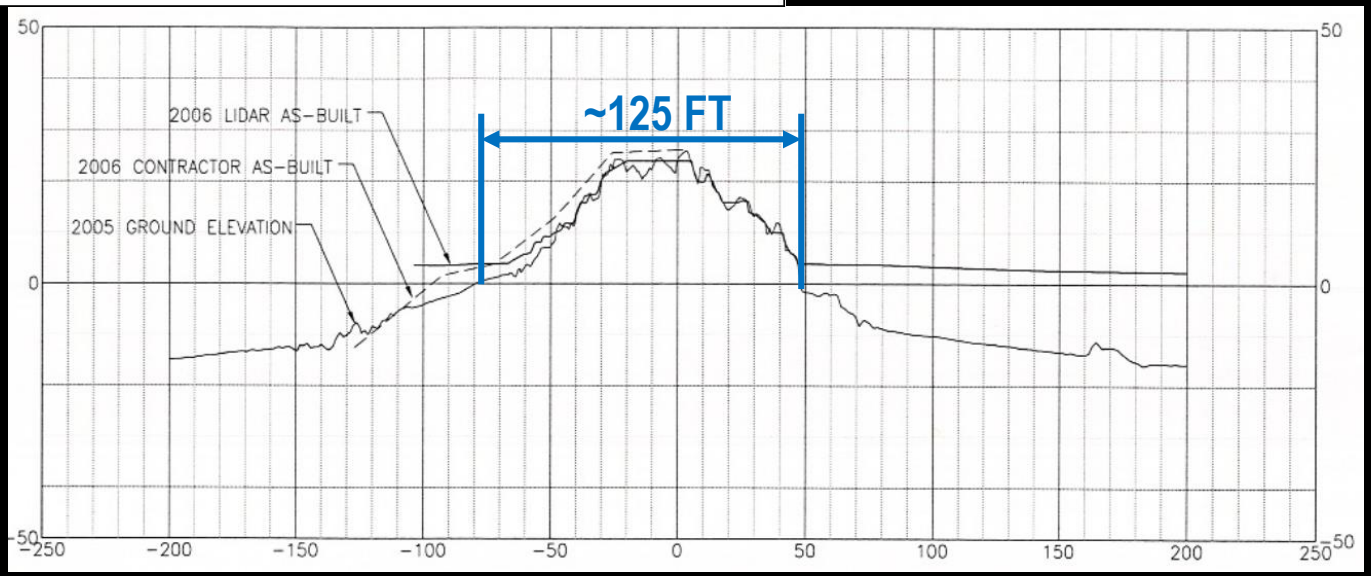

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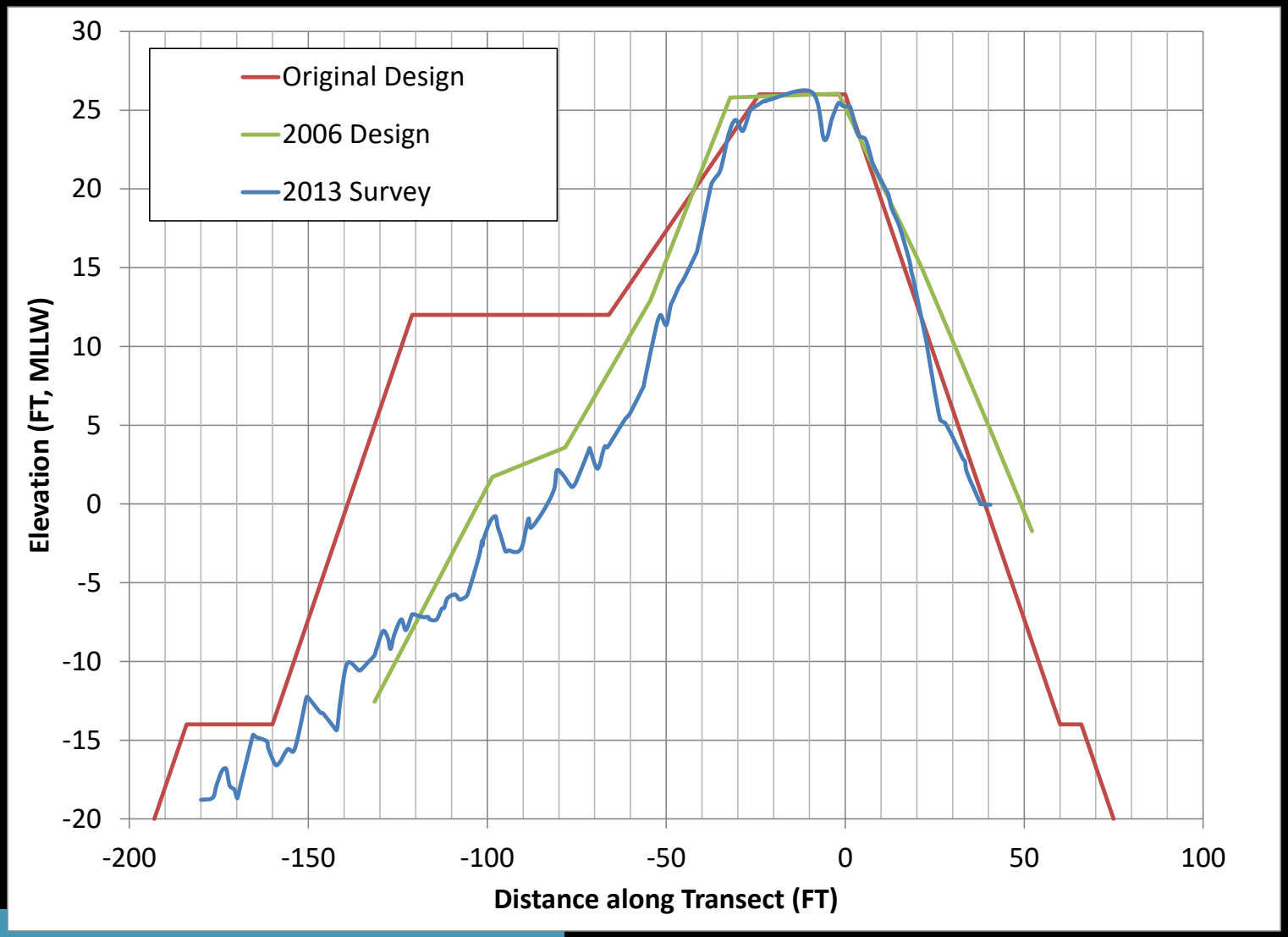

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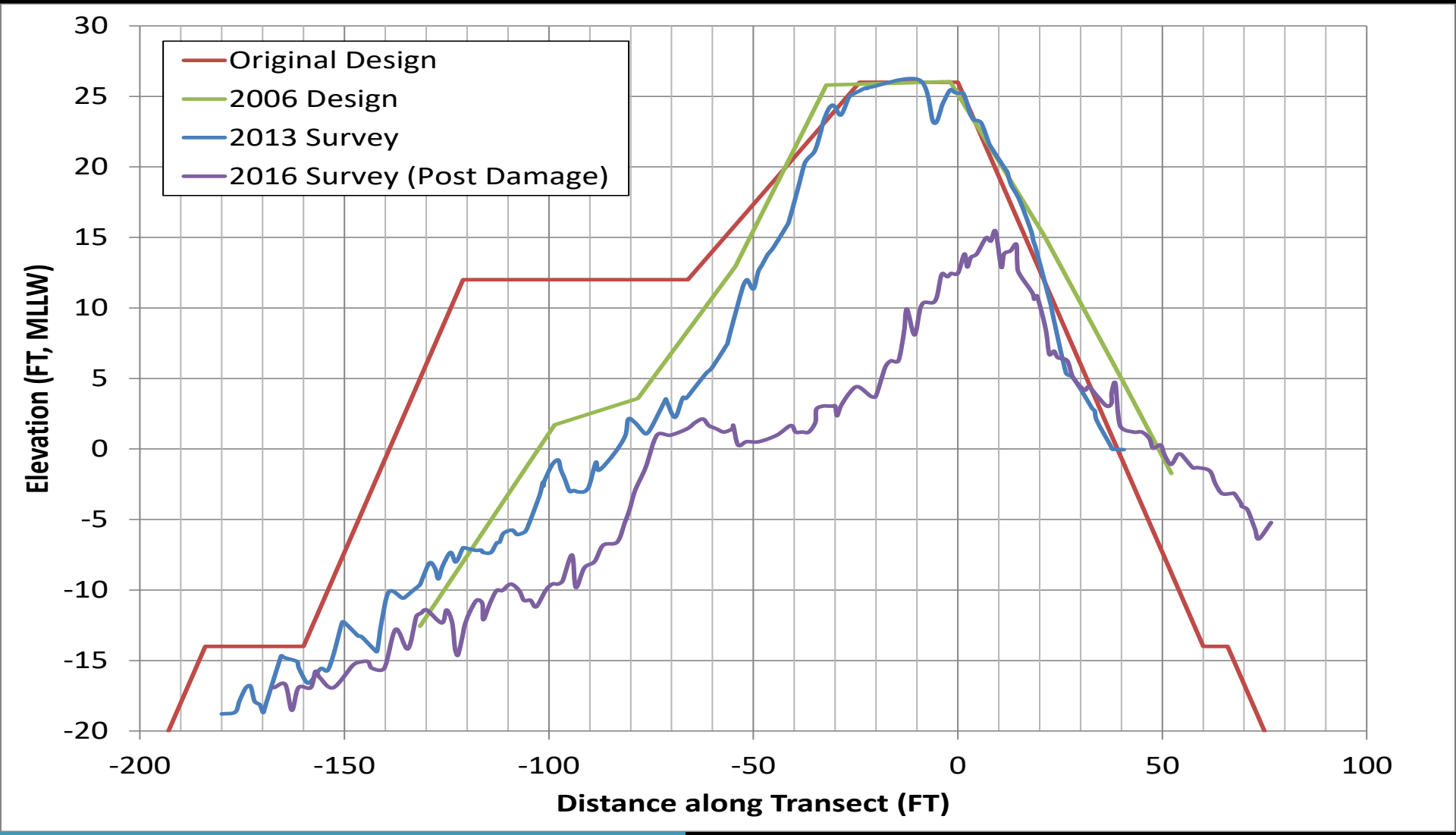


Berm Performance Discussion

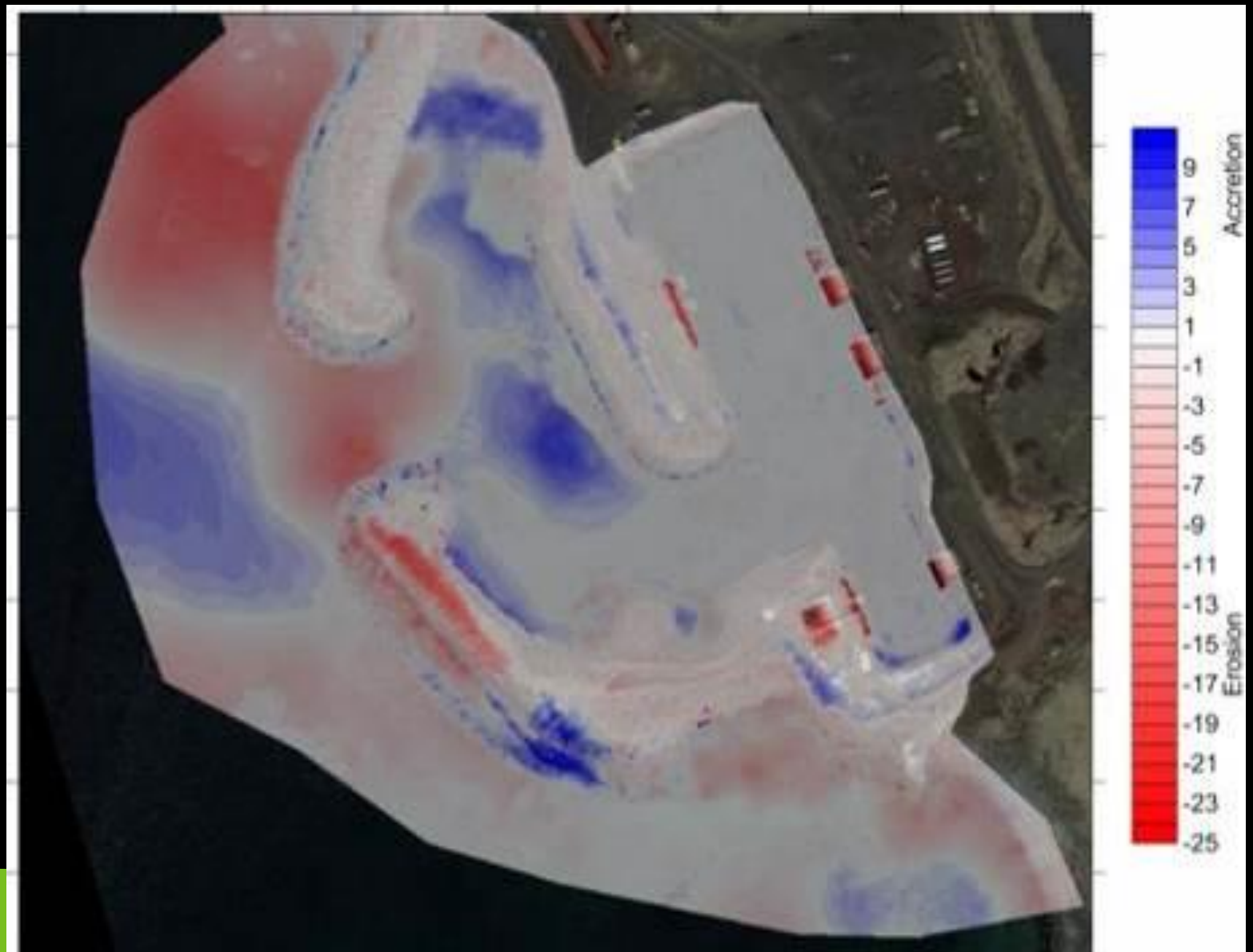
- Loss of berm material apparent in available survey data
  - Original design was considered dynamically stable
  - Armor stone used in original project was basalt rock with low durability
  - Potential lateral transport of berm stone

04 Storm Repair Design

Storm Repair Design
Location of damage

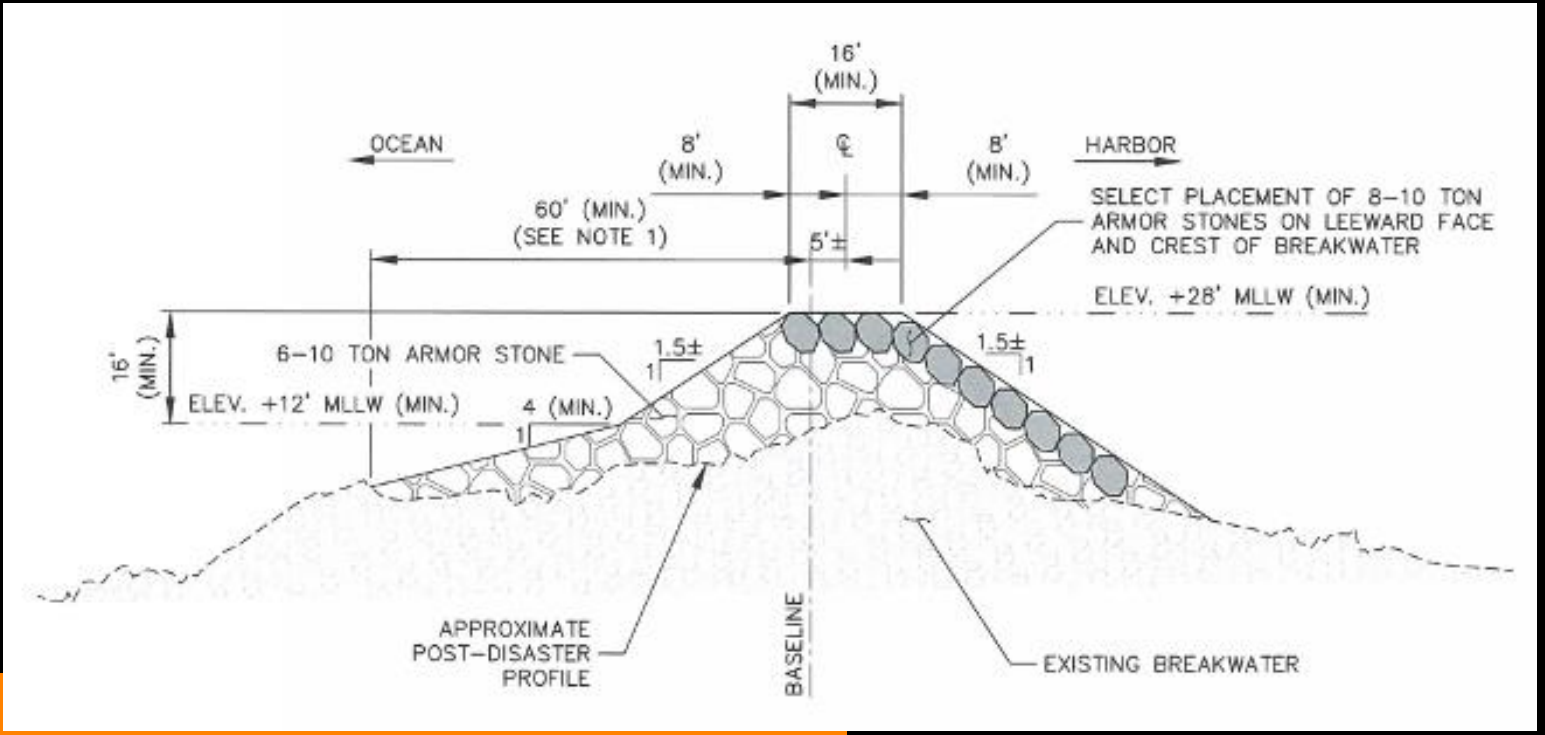
PHOTO COURTESY OF ALASKA DOT&PF

Storm Repair Design
Erosion/sedimentation Isopach Map



Storm Repair Design
Phase 1 Repair Design

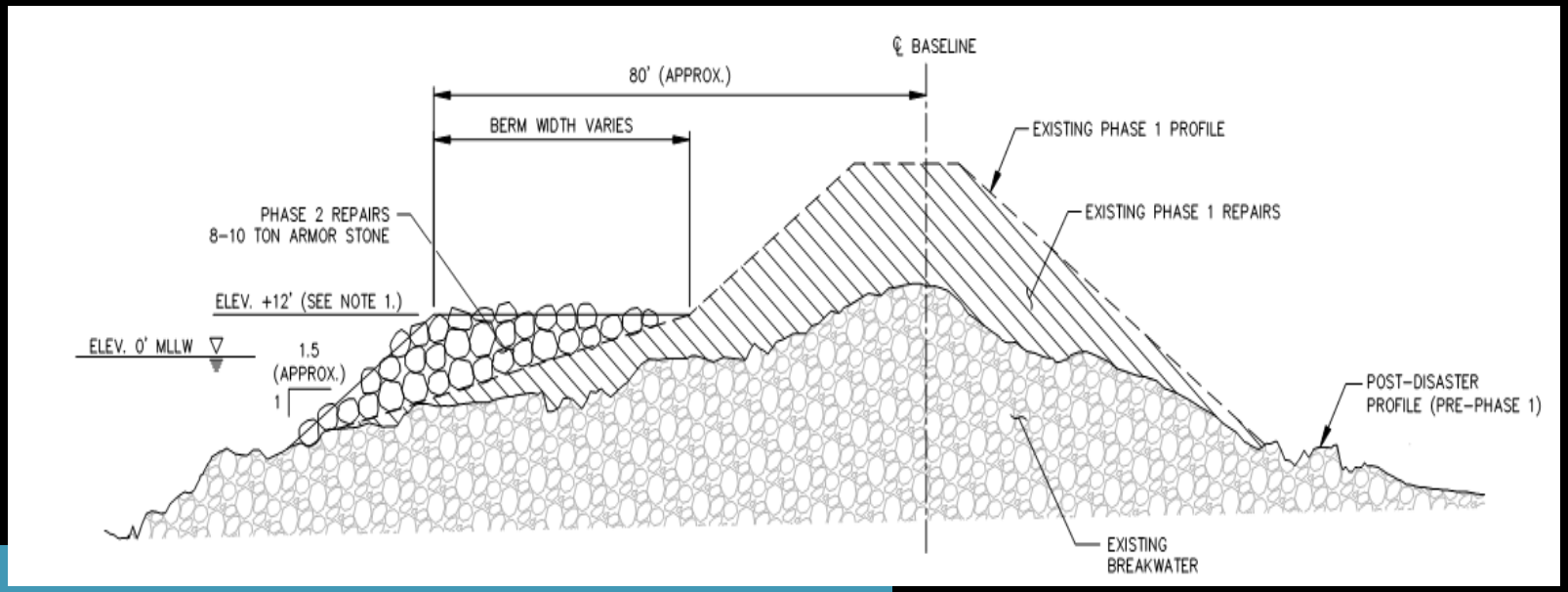
- Construction window from May to August
- Phase 1 designed by Alaska DOT&PF
- Performed without survey data
- Focused on re-building crest elevation and visible losses
- Higher quality and larger stone was transported for construction



Storm Repair Design
Phase 1 Repair Constructed

Storm Repair Design
Phase 2 Repair Design

- Phase 2 designed by Alaska DOT&PF and HDR
- Survey data collected in 2016 showed significantly more losses than originally anticipated
- Berm breakwater and composite slope breakwaters were considered
  - Berm breakwater was utilized
    - Previous success at St. George
    - Easier construction
- Higher quality and larger stone was transported for construction



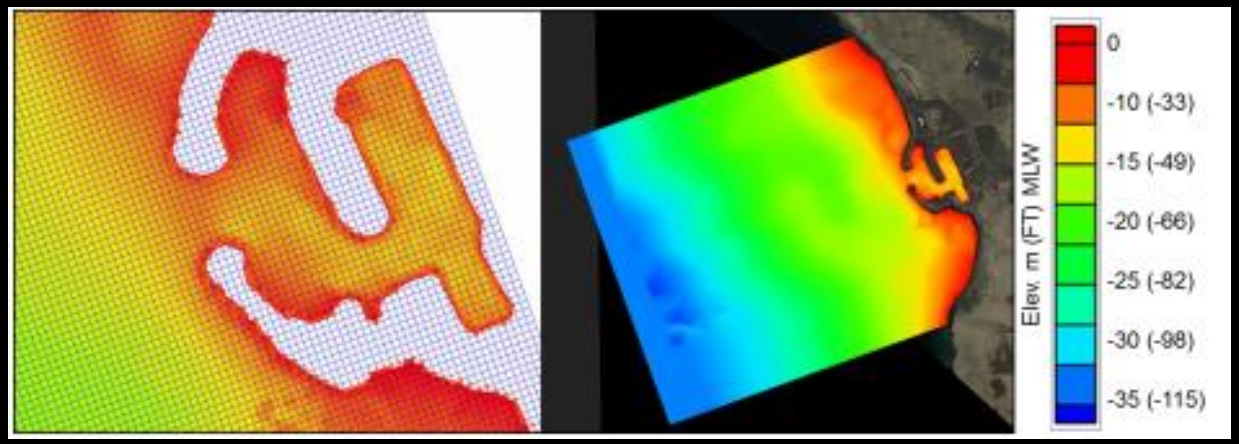
Storm Repair Design
Phase 2 Repair Constructed

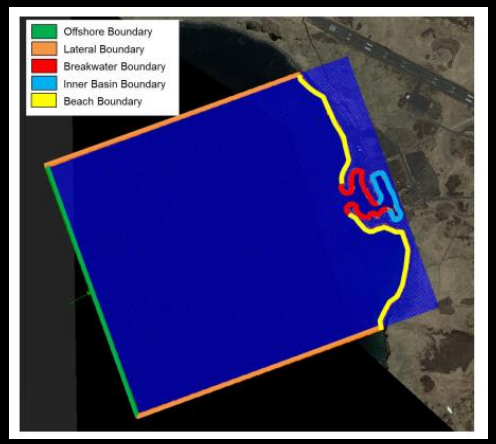
PHOTOS COURTESY OF BRICE CONSTRUCTION

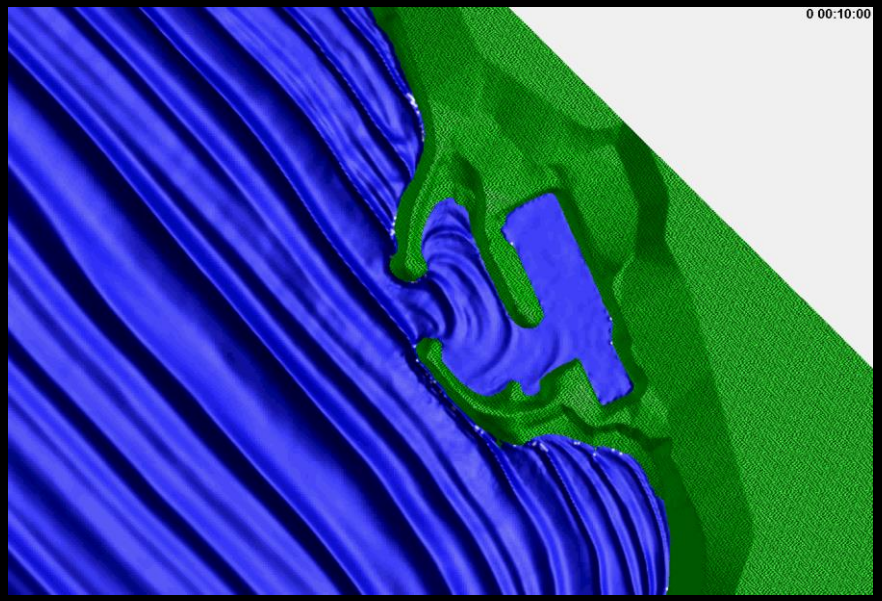
Summary

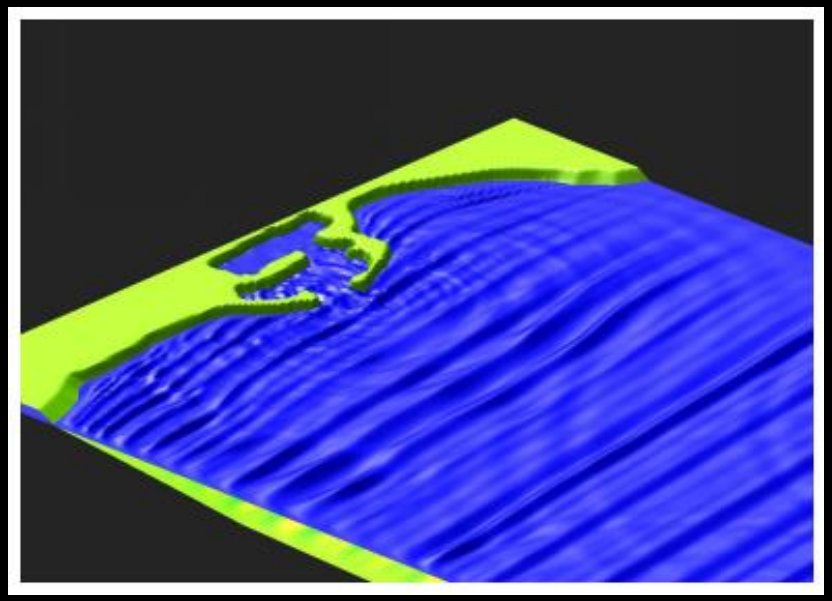
- Berm breakwater design made harbor construction at St. George Island feasible
- Breakwaters were successful
  - Functioned for nearly 20 years with no maintenance
- South breakwater suffered major damage in 2015/2016
  - Repairs utilized berm breakwater design
  - Larger higher quality stone
  - Repairs were constructed in 2 phases

Preliminary Harbor Design Evaluation
Boussinesq Wave Modeling

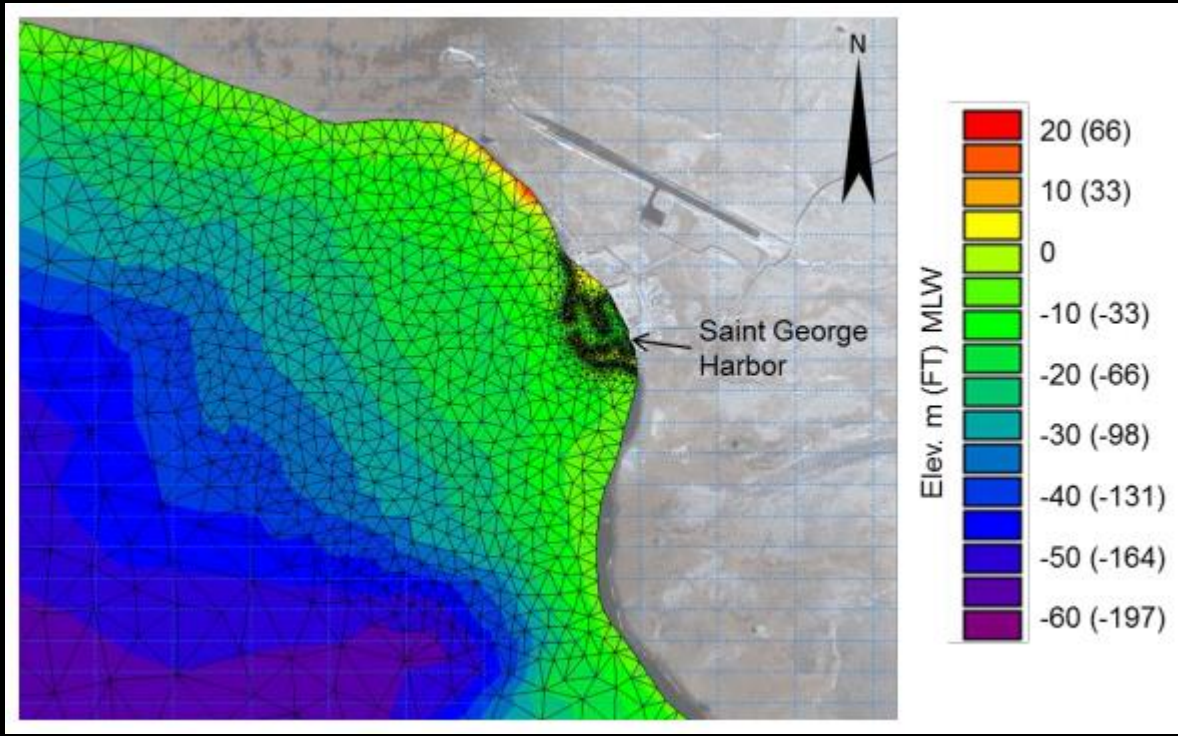


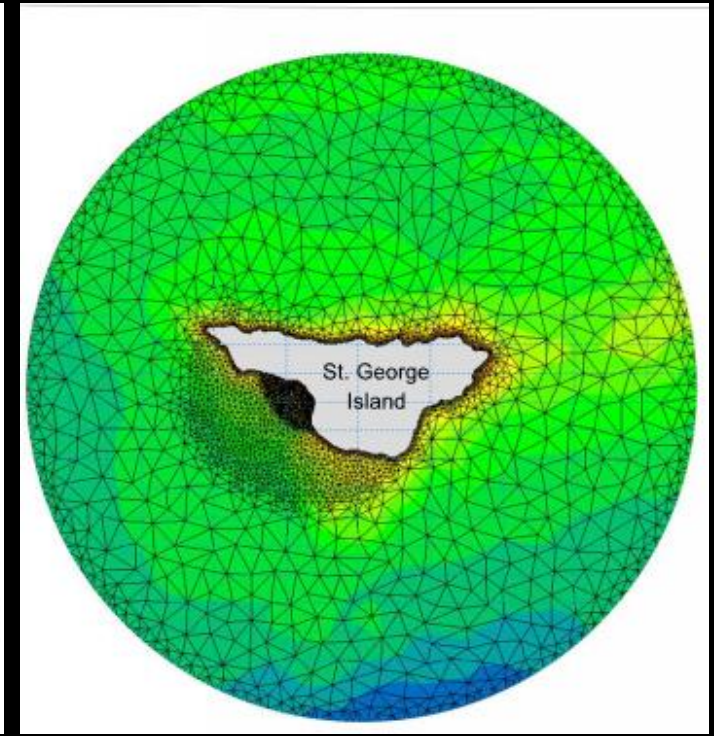






Preliminary Harbor Design Evaluation
Spectral Wave Modeling

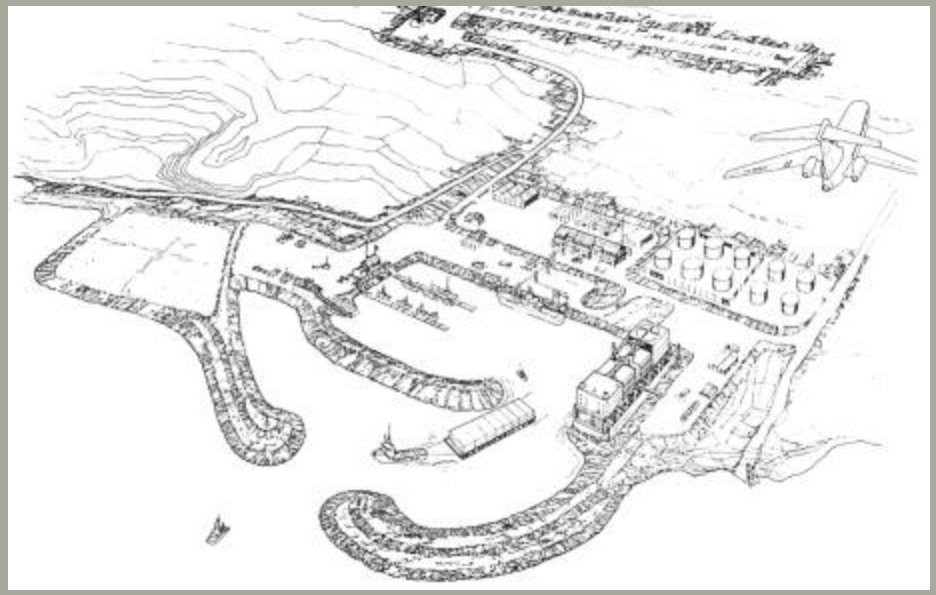




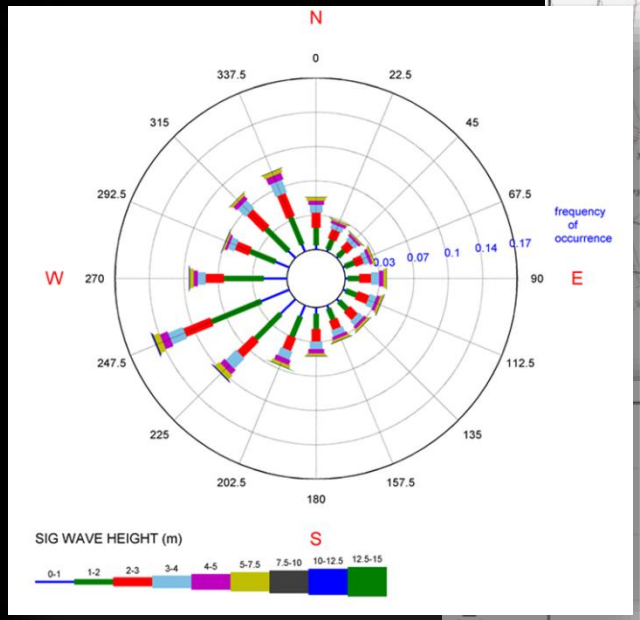
Add Results Figure

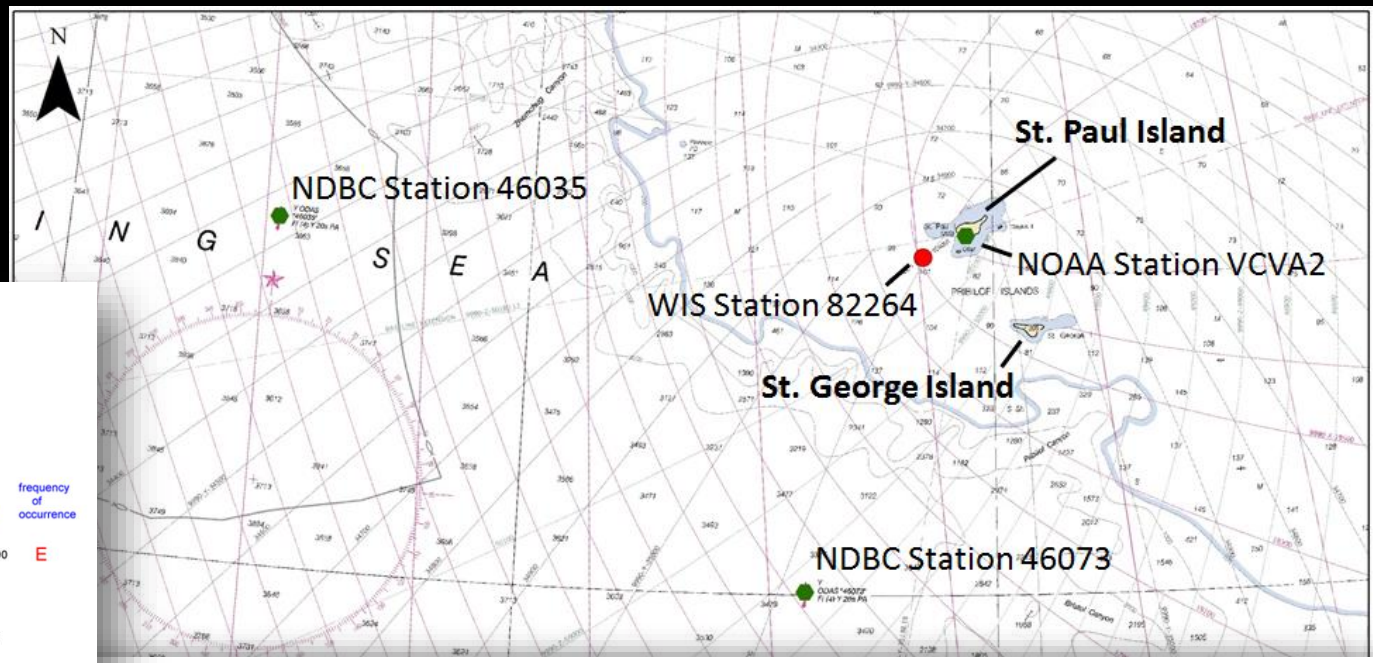
Existing Harbor and Background Information

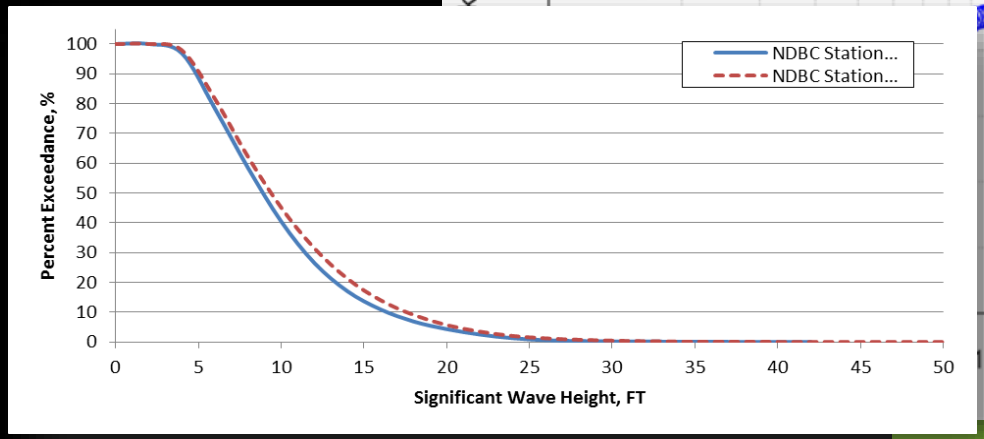
- Design consisted of two breakwater arms and an interior (“inner”) breakwater
- Construction budget was not adequate
- The City hired a private engineering firm
  - Modified Design
  - Outer Breakwater Shallower Water
  - Reduced Construction Budget



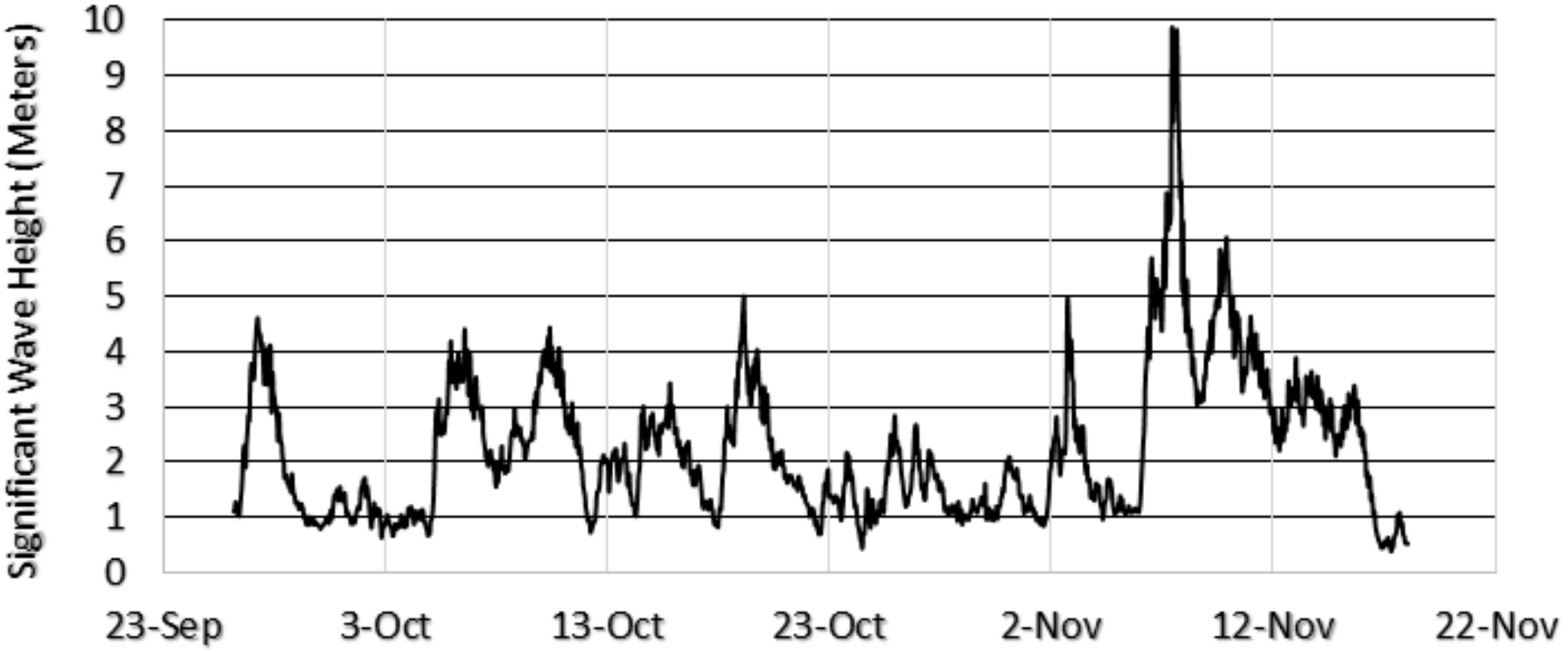
Wave Climate



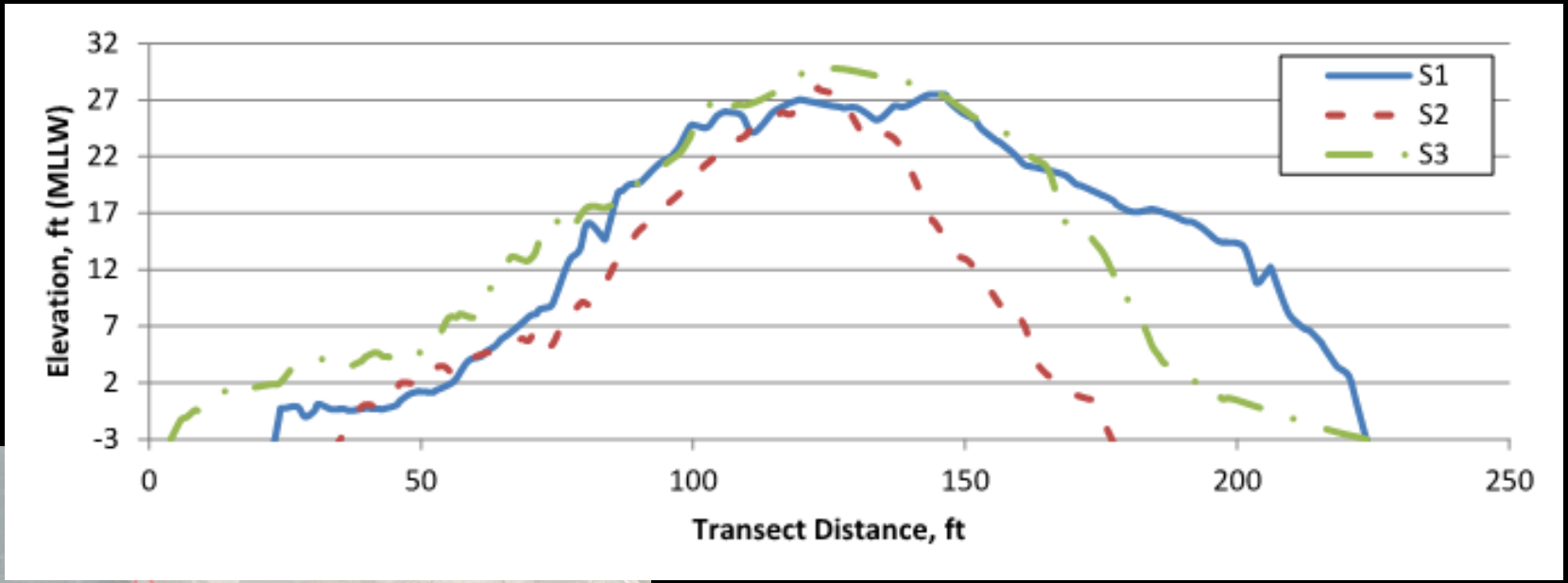


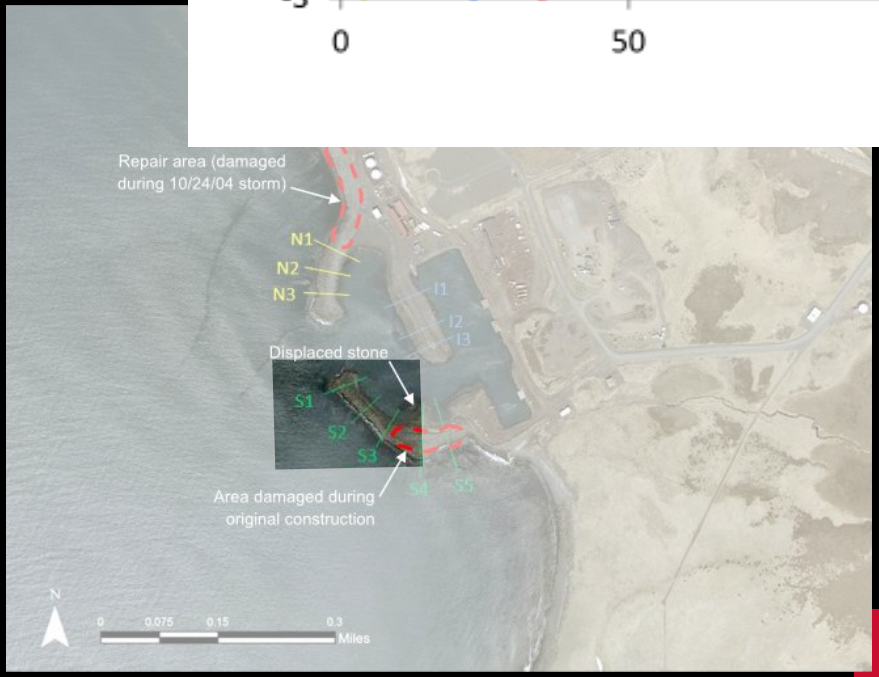


Measured Wave Heights



Existing Conditions and Coastal Processes
Breakwater Condition





Existing Conditions and Coastal Processes
Breakwater Condition