Sinclair Island Dock Replacement

Prepared for:

Skagit County Public Works

By:

PND ENGINEERS, INC.

Project Goals

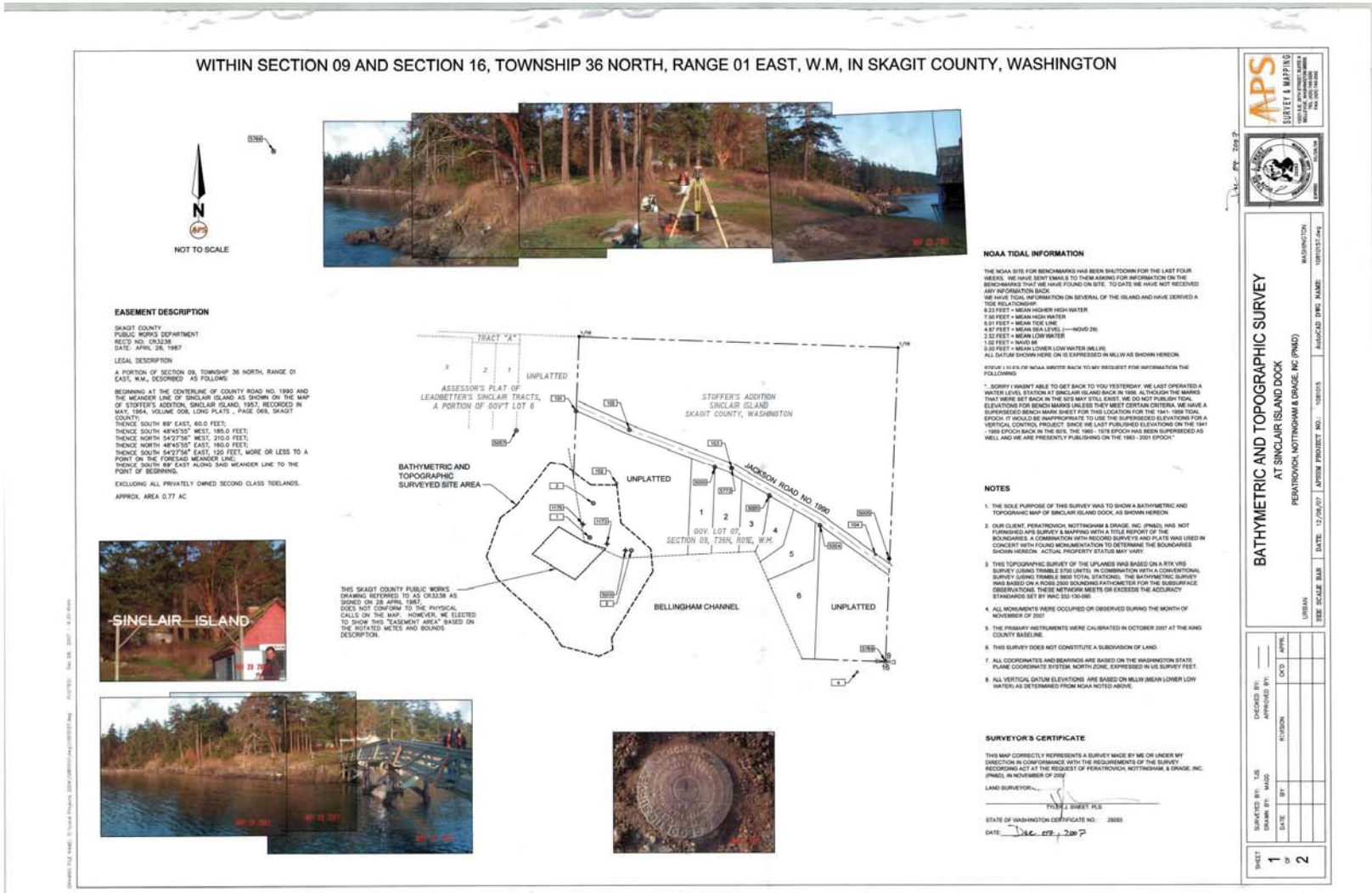
- Collect data and refine design criteria
  - Update wind and wave analysis
  - Collect geotechnical information
  - Conduct eelgrass/kelp survey
- Develop concept study and preferred design
- Suitable moorage in good to moderate conditions
- Structure survivability in all conditions
- Provide moorage for multiple vessels at a time
- Target construction of new facility by end of 2022

Condition Assessment

August 2007

October 2018

Surveys
(Property, Topographic, Bathymetric)



Surveys
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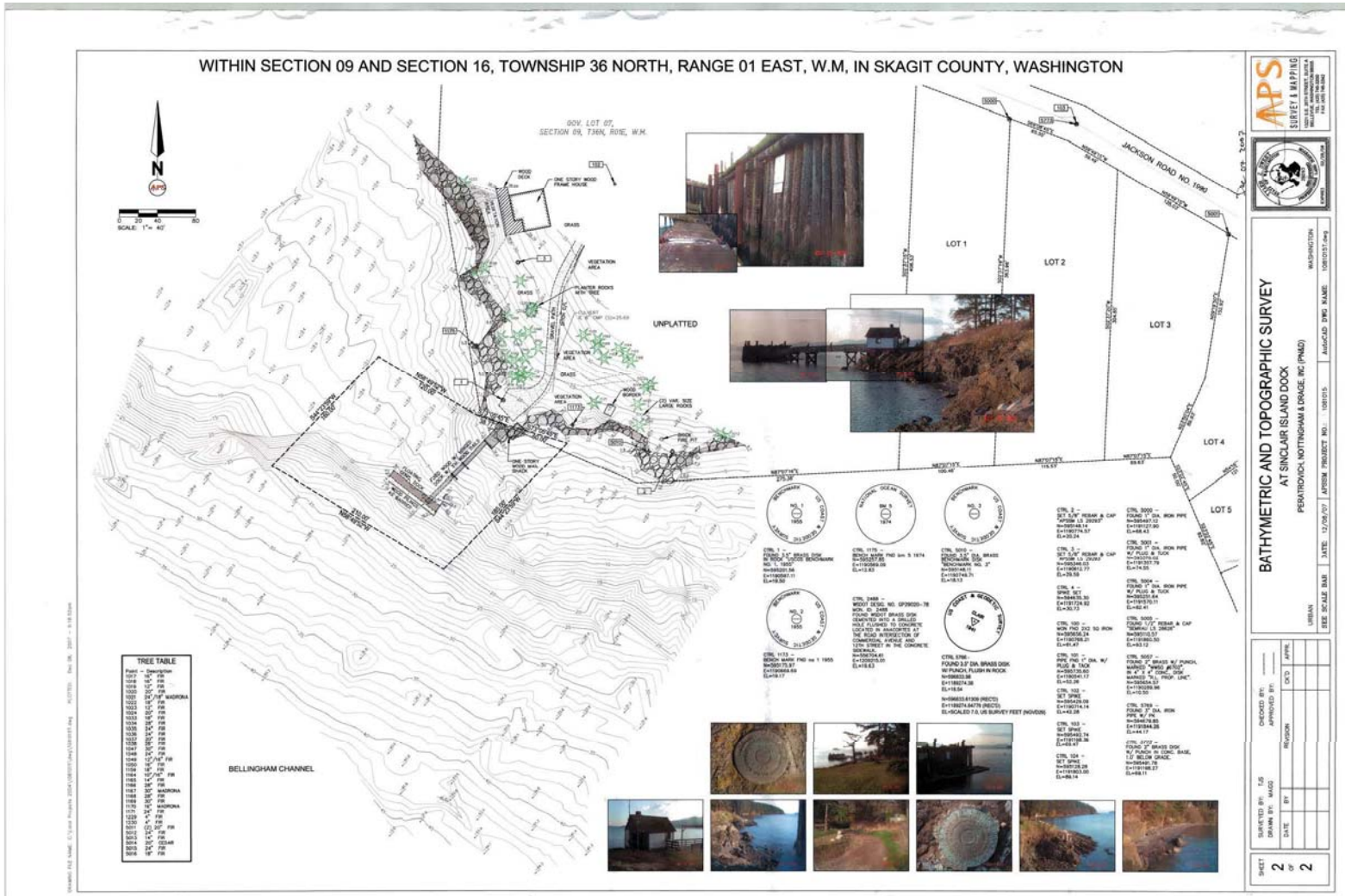
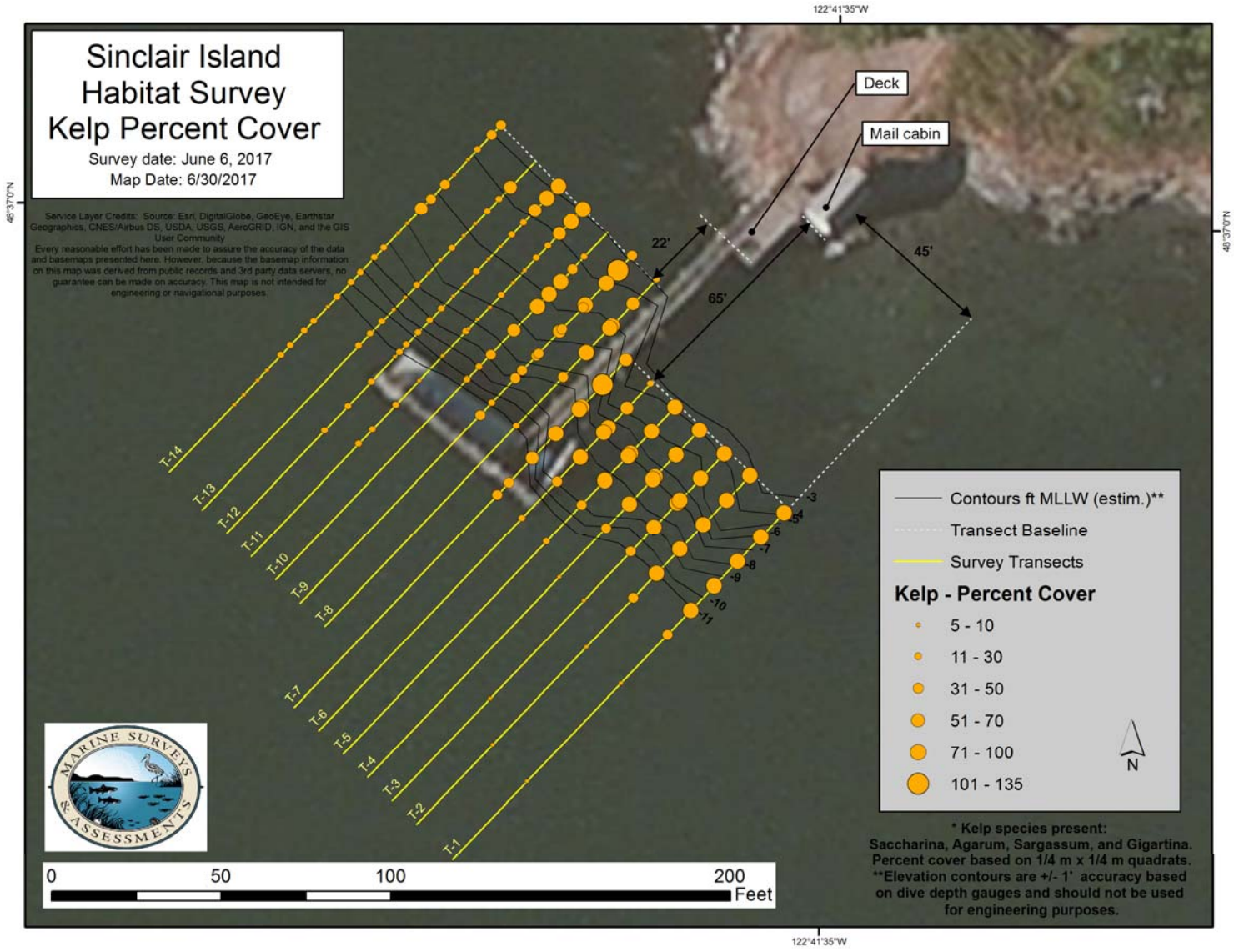


Eelgrass Density

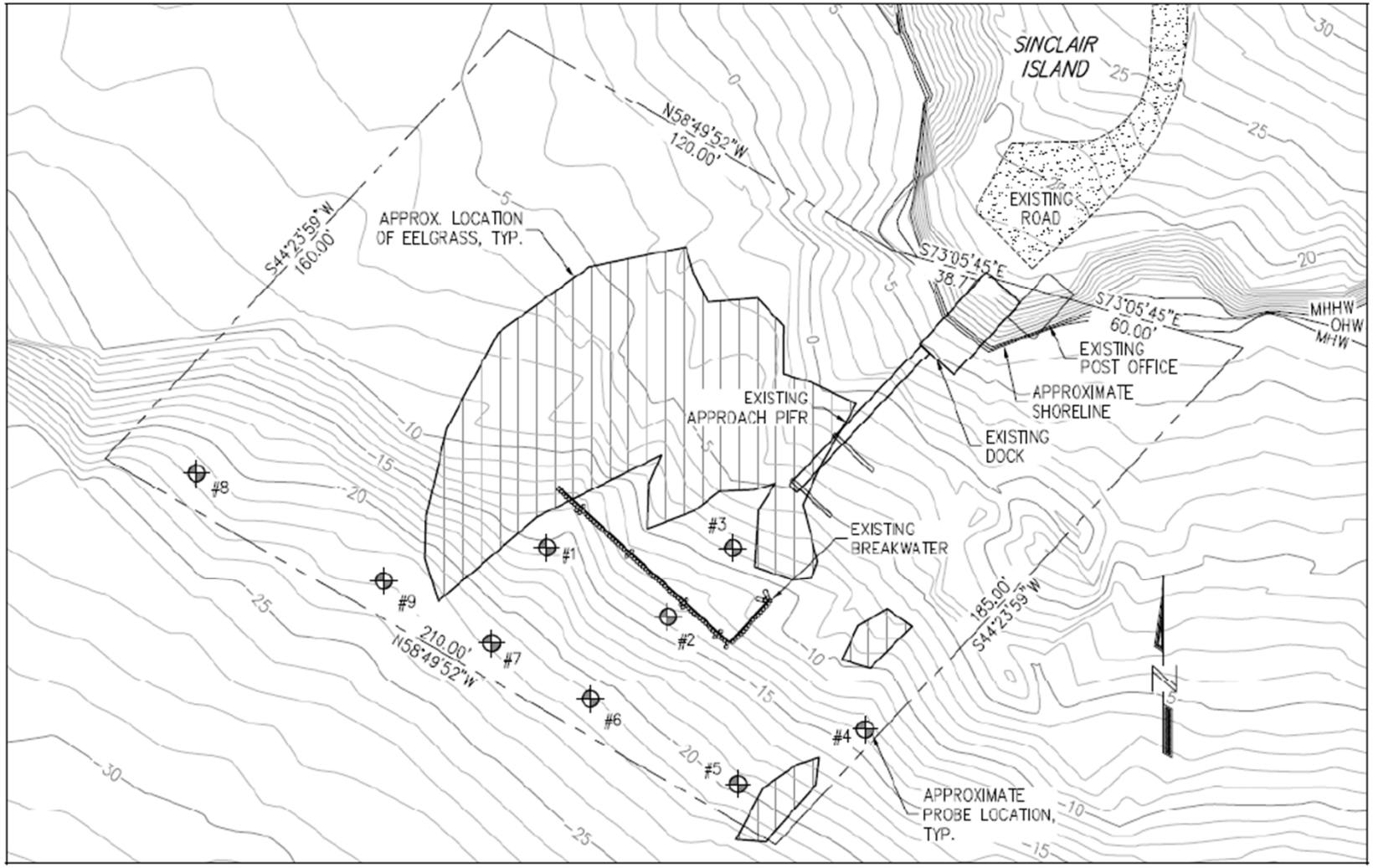
Kelp Percent Cover



Geotechnical Program

- Steel pipe pile probe
- Vibratory hammer and crane
- Measure overburden thickness

Pile Probe Locations



Pile Probe Results

Probe Location	Estimated Elev. (ft, MLLW)		Embedded Depth (ft)	Notes
	Mudline Elev.	Pile Tip Elev.		
#1	-15	-23	8	Vibratory Refusal
#2	-13	-20.5	7.5	Vibratory Refusal
#3	-9	-17	8	Vibratory Refusal
#4	-13	-14.5	1.5	Vibratory Refusal
#5	-20	-23.5	3.5	Vibratory Refusal
#6	-21	-22.25	1.25	Vibratory Refusal
#7	-22	-26.5	4.5	Vibratory Refusal
#8	-22	-27	5	Vibratory Refusal
#9	-23	-32.75	9.75	Vibratory Refusal

Pile Probe Summary

- Very little overburden on site
- Hard layer resists penetration with vibratory hammer
- Pile embedment requirements will require drilling
- May complicate other anchor types also

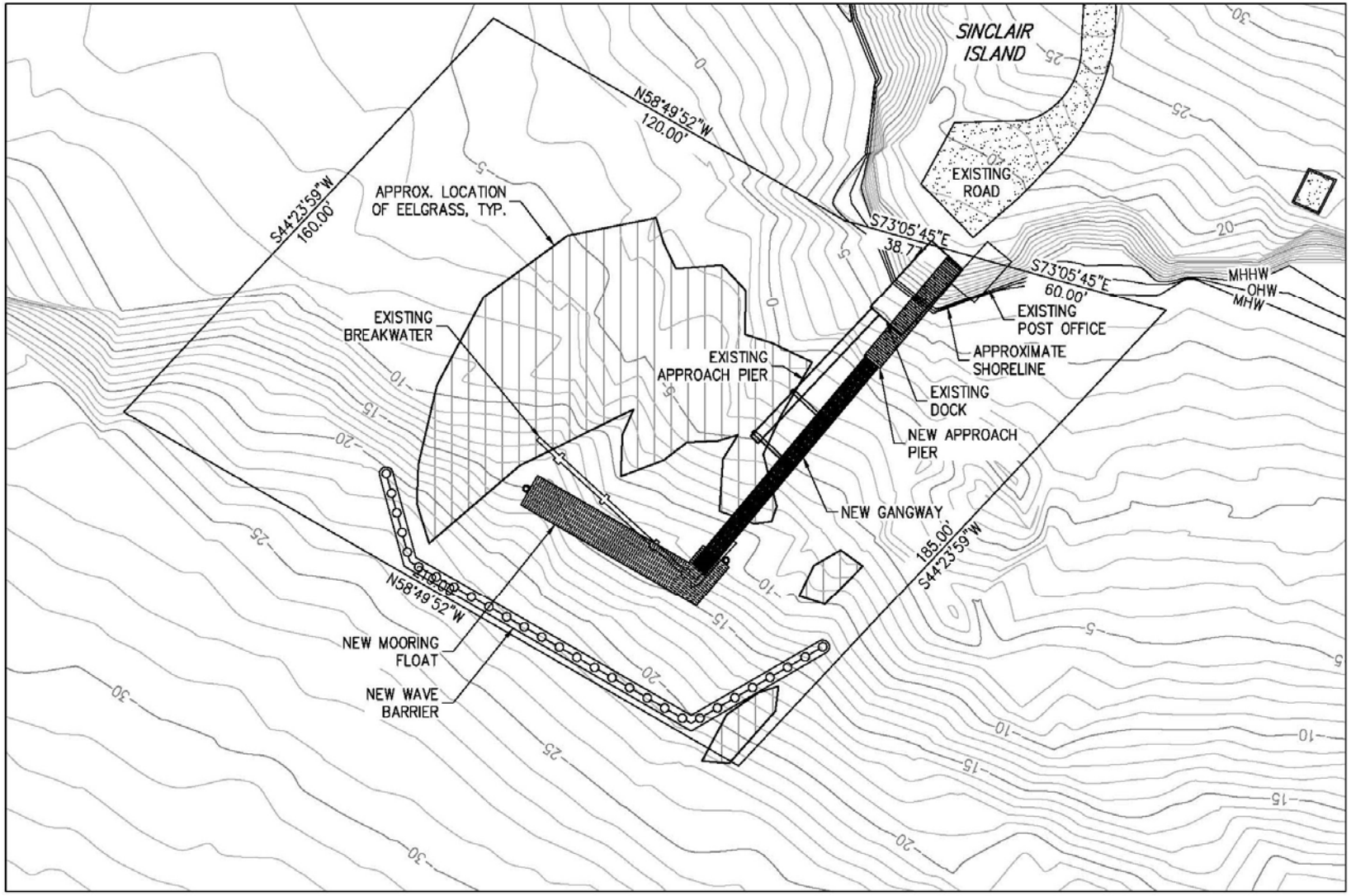
Original Met-Ocean Study

- March 2013
- Developed wave hindcast and met-ocean design criteria at existing location
- Baseline regional wave study
- Did not consider other types of structures
- Did not consider relocation of facility within the project site

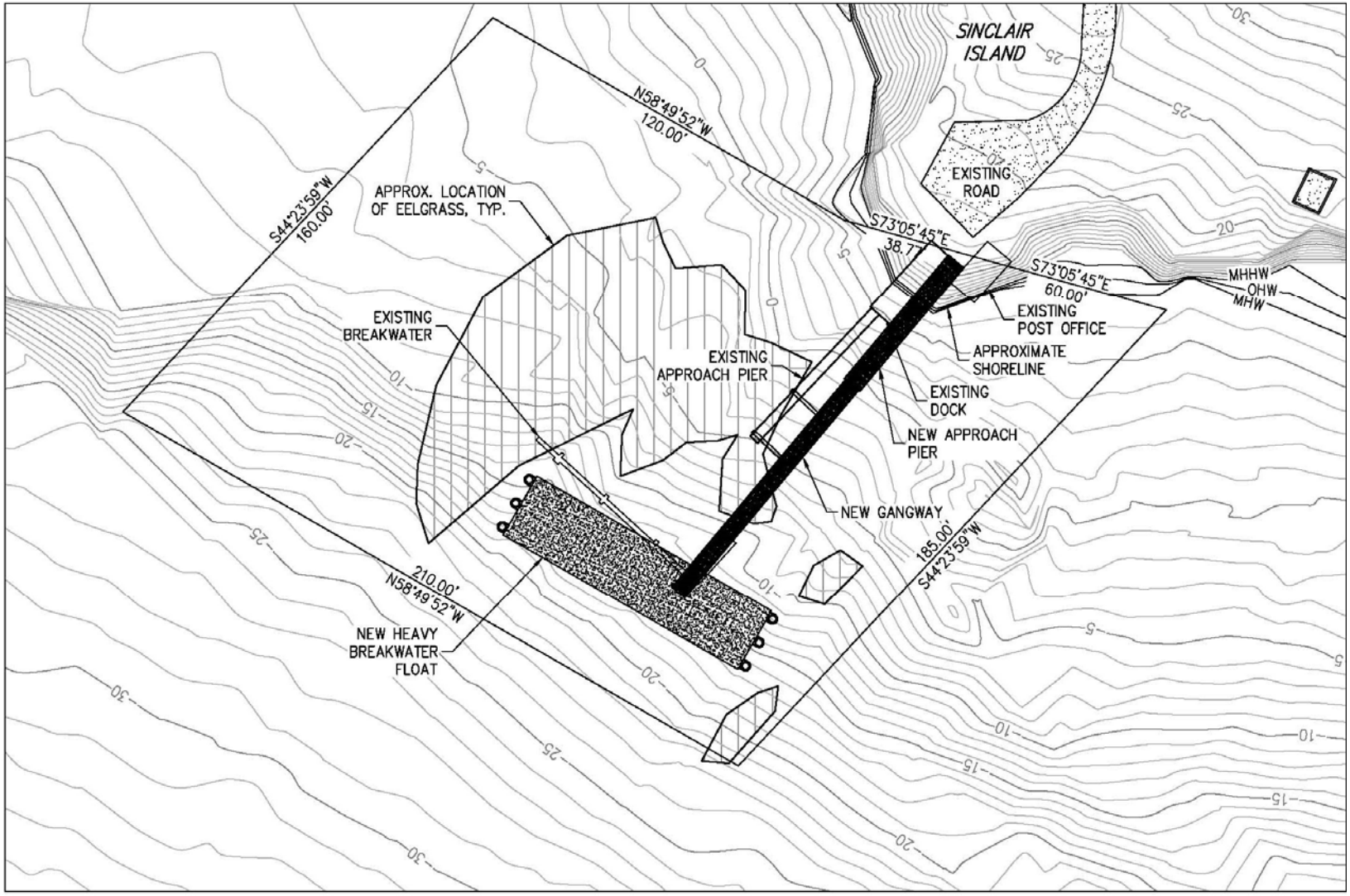
Structural Concept Analysis

- 3 Concepts Considered
  - Concept A – Vertical wave barrier with float
  - Concept B – Heavy breakwater float only
  - Concept C – Light duty float only
- Layout for Analysis
  - Rough sizing and structure layout developed for consideration in wave modeling
  - Layout minimizes coverage of vegetation
- Foundation Anchors
  - Anchor type depends on concept considered
  - Must consider geotechnical data collected and vegetation

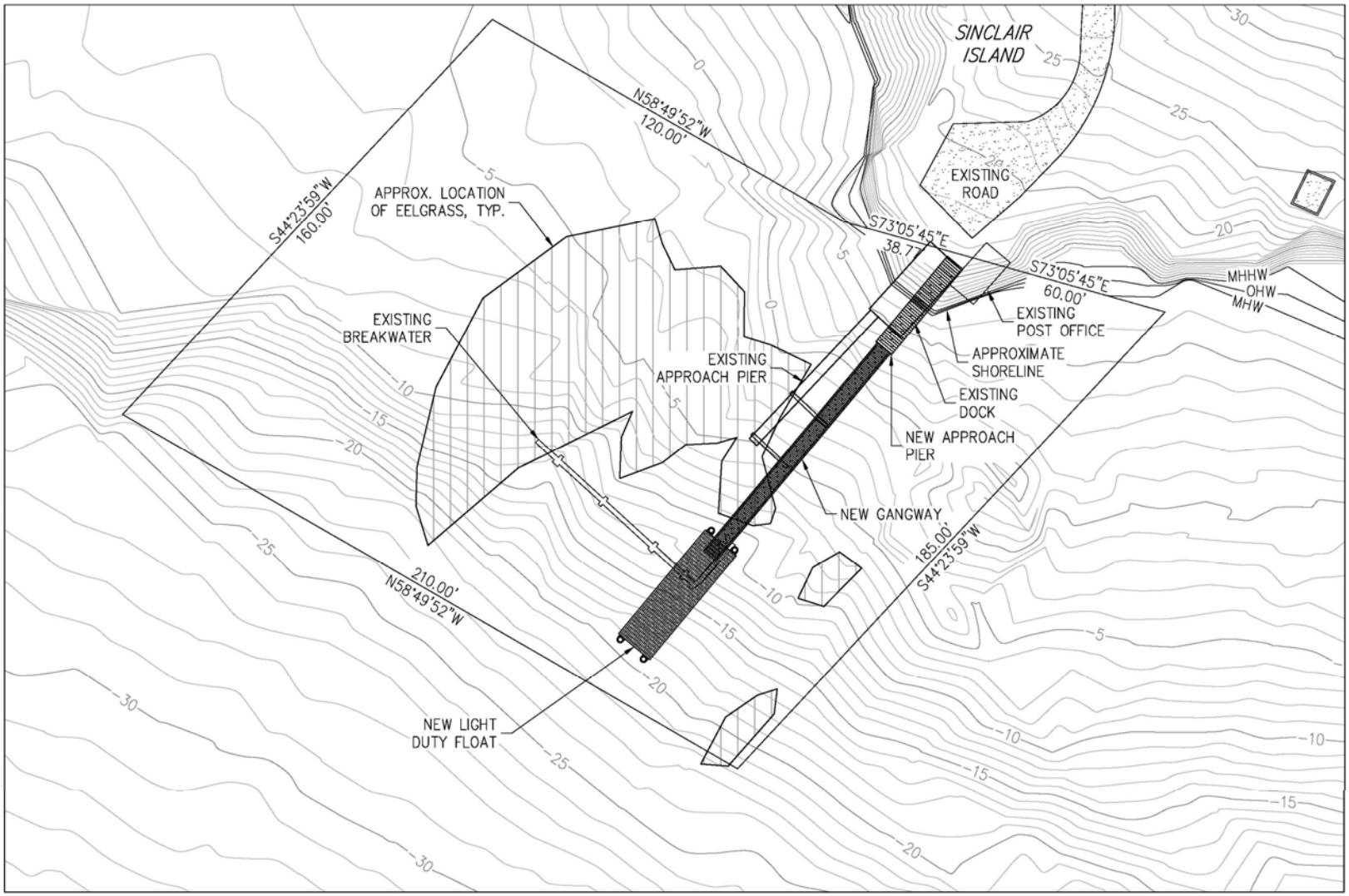
Concept A – Wave Barrier with Float



Concept B – Heavy Breakwater Float



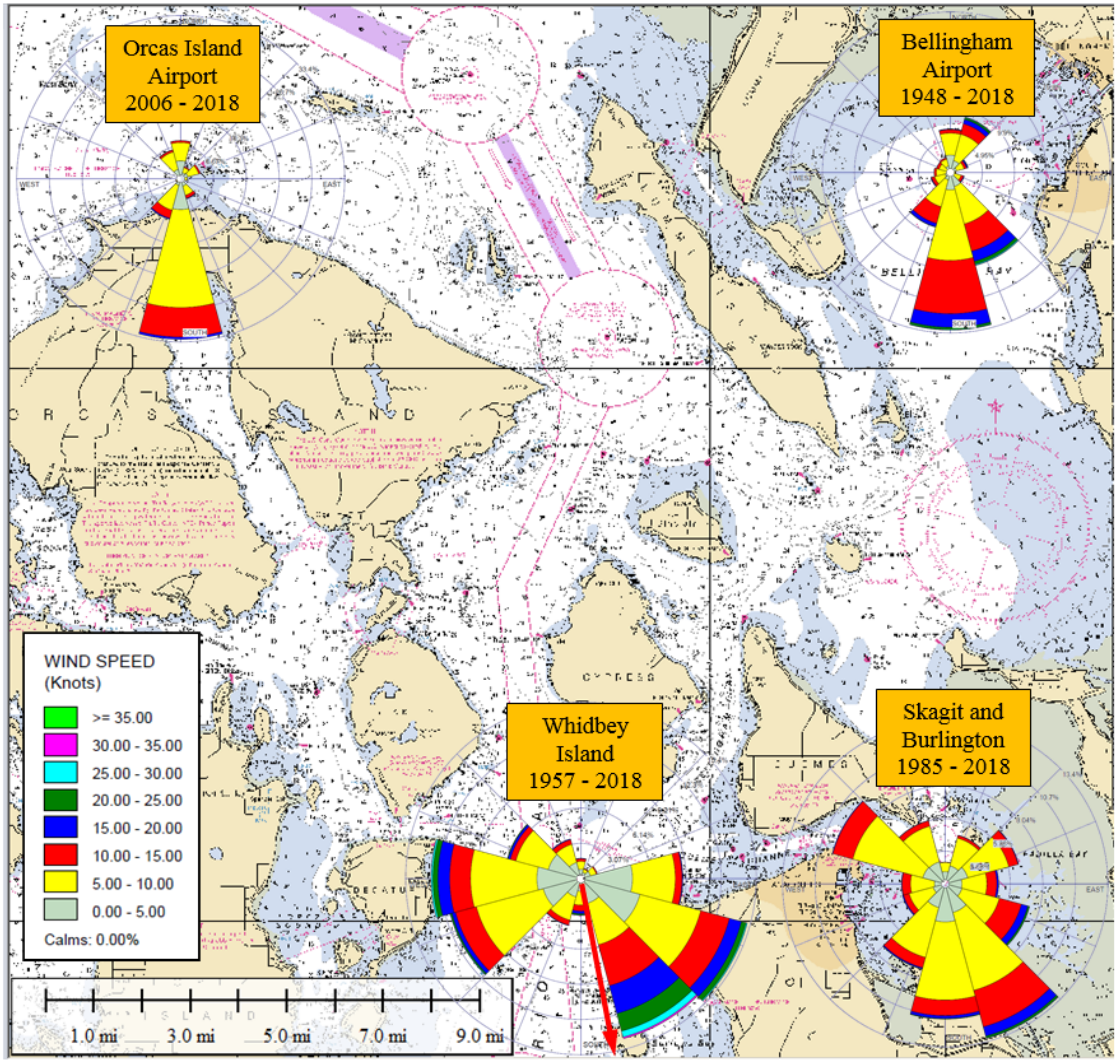
Concept C – Light Duty Float Only



Revised Met-Ocean Study

- Updated analysis March 2019
- Considered wave environment in deeper water, farther off shore
- Used model to approximate wave environment with different types of structure (concepts A, B, C)
  - Wave height
  - Wave period
- New wave models were used to estimate:
  - Wave transmission
  - Wave forces for structural design

Regional Wind Data Sources



Model Extraction Points

Resulting waves - for design wave environment outside any new structure

Floating Breakwater (Concept B) shown for location reference only

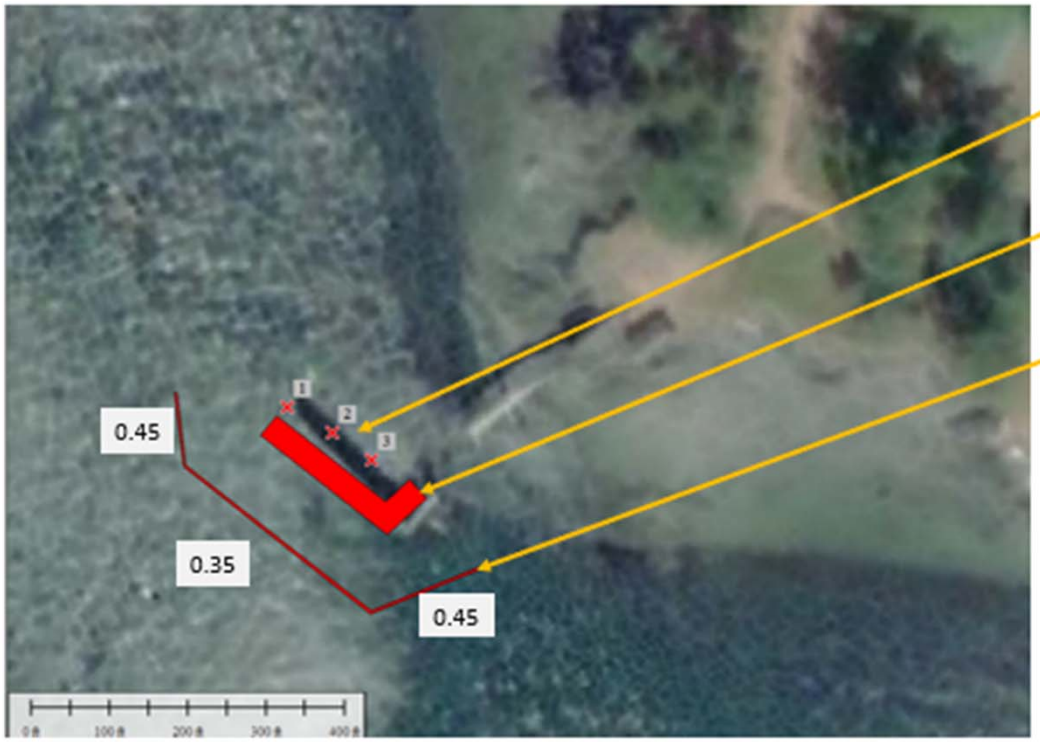
Model Results - Outside

These are the design waves just outside project area
These are the design waves against any new structure

Direction	Event	Wave Height (Hs)	Wave Period (Tp)
SE	50 yr	4.1 ft	3.2 sec
S	50 yr	5.8 ft	3.2 sec
W	50 yr	3.3 ft	2.5 sec
SE	2 yr	2.1 ft	2.5 sec
S	2 yr	3.4 ft	2.7 sec
W	2 yr	1.4 ft	2.2 sec

Concept A Layout

Partially Penetrating Wave Barrier
Moorage Float
3 Wave Extraction Points



Model Results Extraction Locations

Float

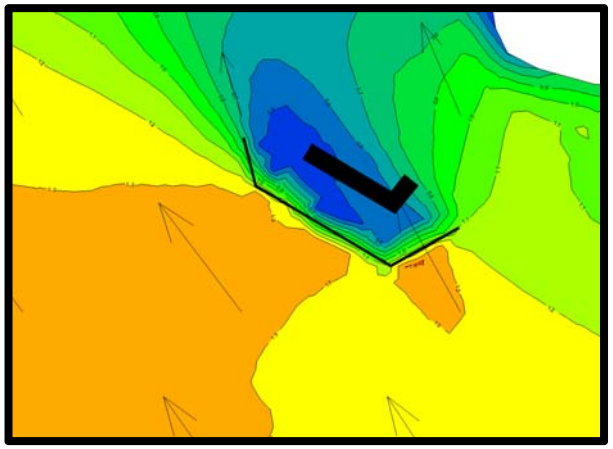
Partially Penetrating Wave Barrier with Various Wave Transmission Coefficient

West and Southeast section of the wall modeled with coefficient transmission = 0.45 (about -12 feet (MLLW) draft

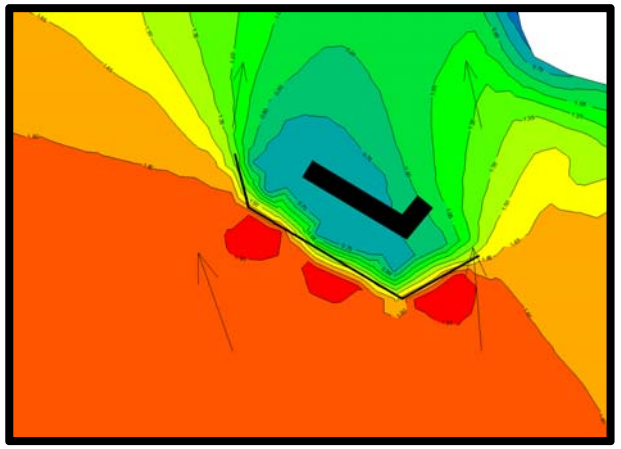
Southwest section of the wall modeled with coefficient transmission = 0.35 (about -16 feet (MLLW) draft

Concept A Wave Protection

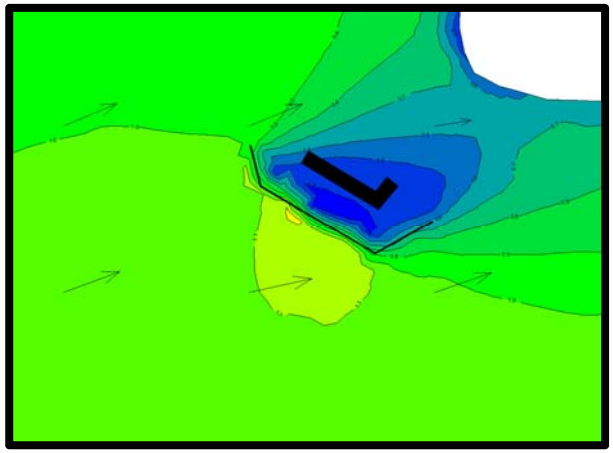
50 Year Return Period



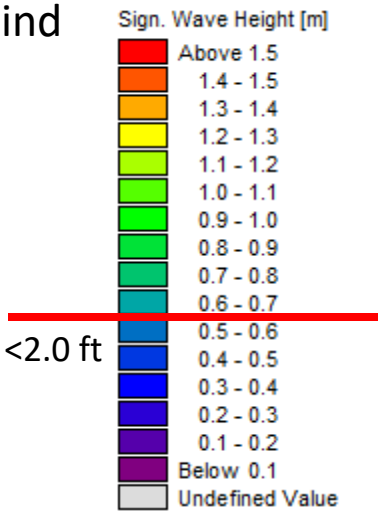
Southeast Wind



South Wind



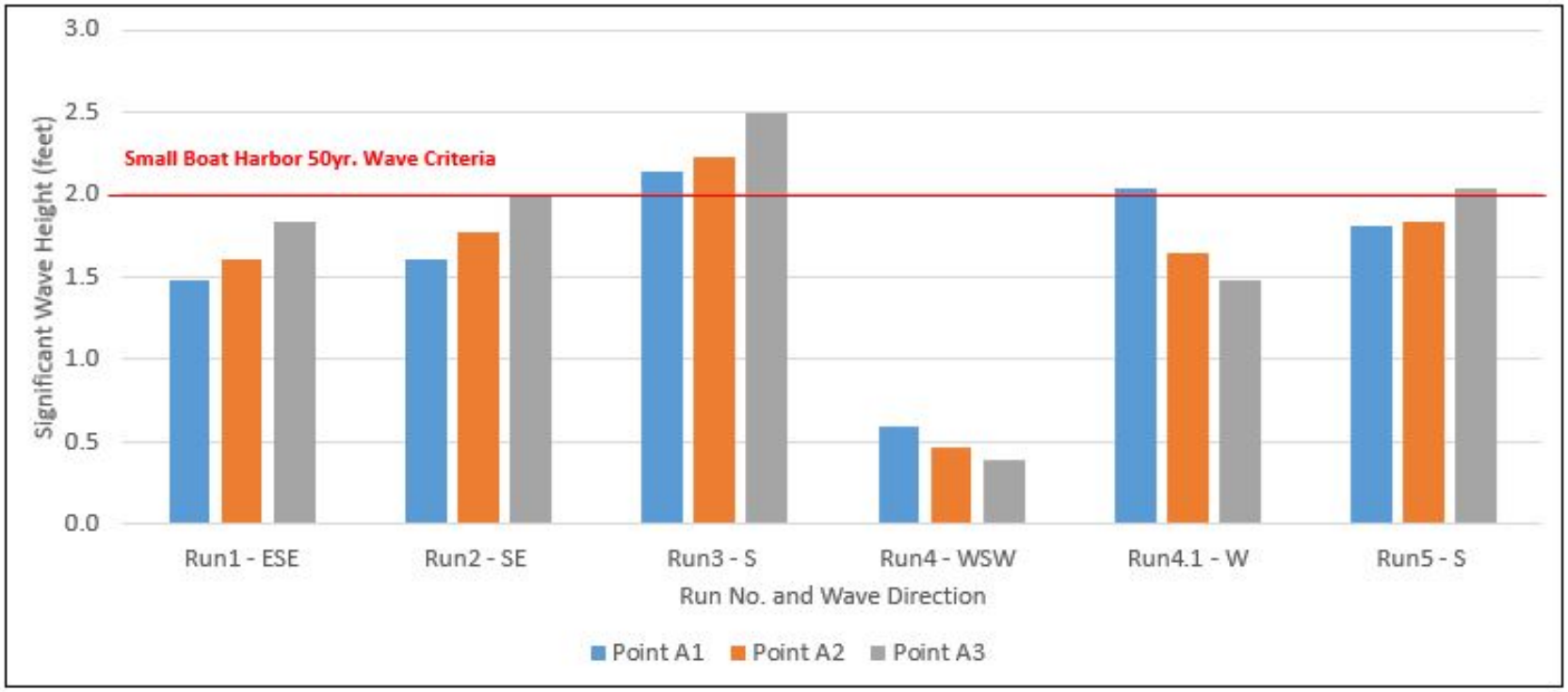
West Wind



<2.0 ft

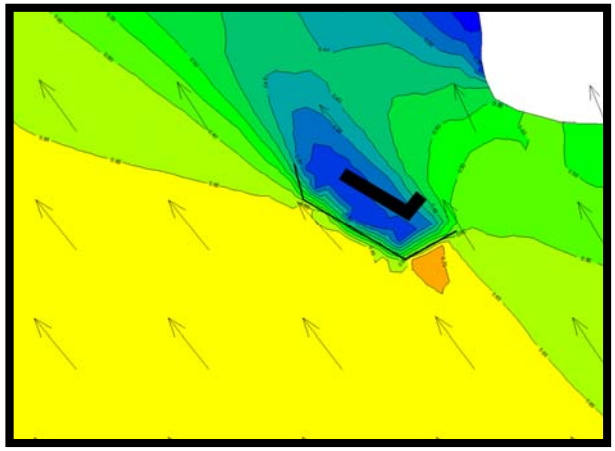
Concept A

50 Year Return Period Results Summary

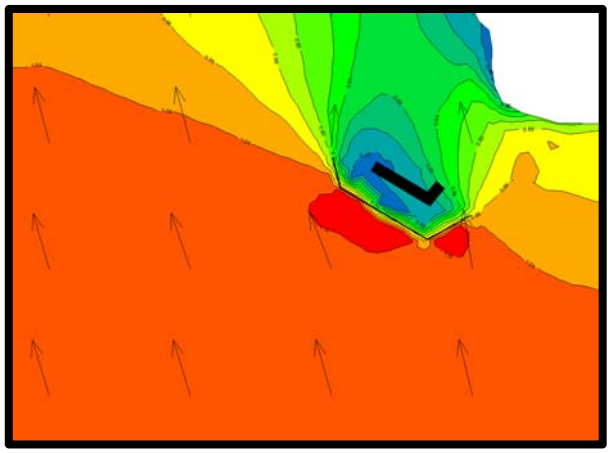


Concept A Wave Protection

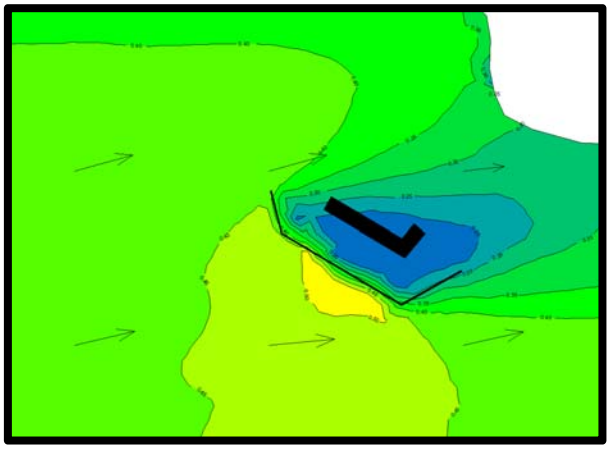
2 Year Return Period



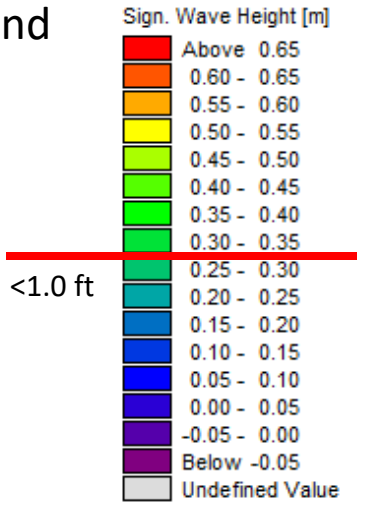
Southeast Wind



South Wind

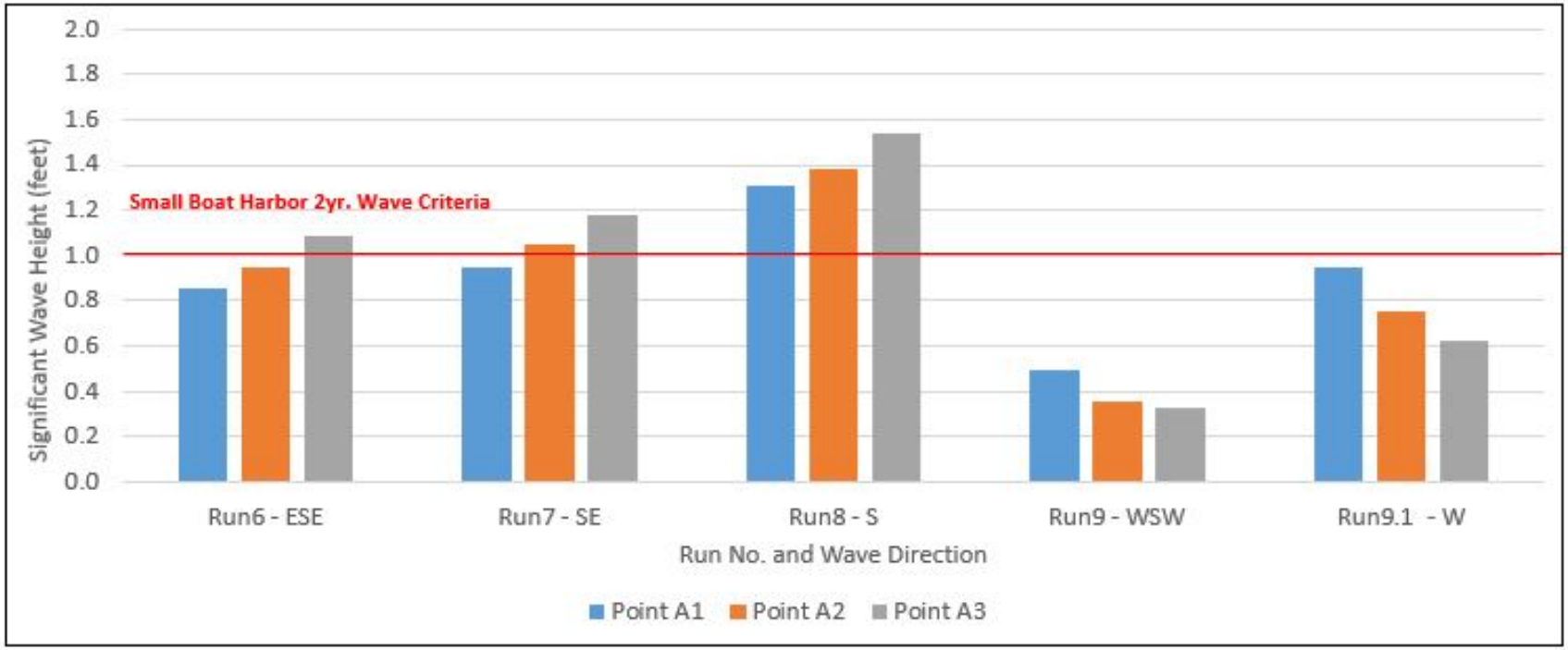


West Wind



Concept A

2 Year Return Period Results Summary



Concept B Layout

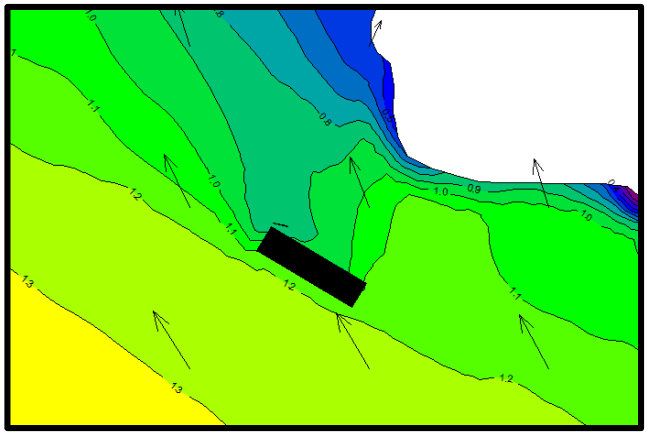
Large Breakwater Float
3 Wave Extraction Points

Model Results Extraction Locations

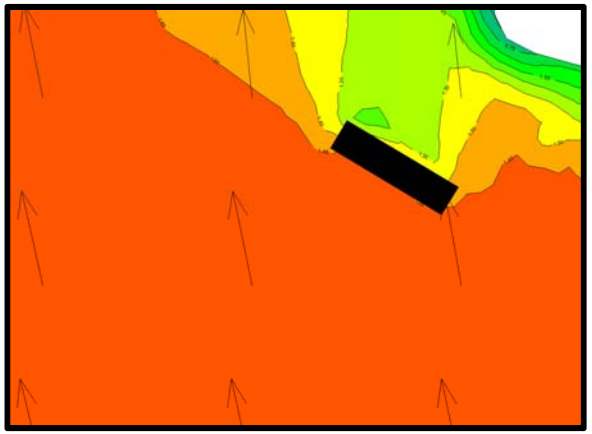
Floating Breakwater
Wave Transmission Coefficient = 0.7

Concept B Wave Protection

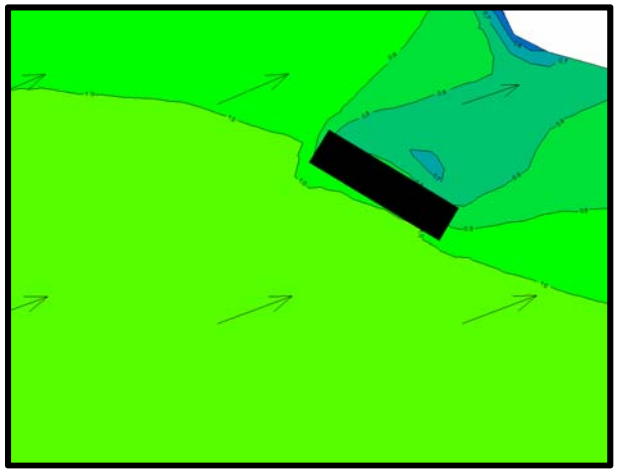
50 Year Return Period



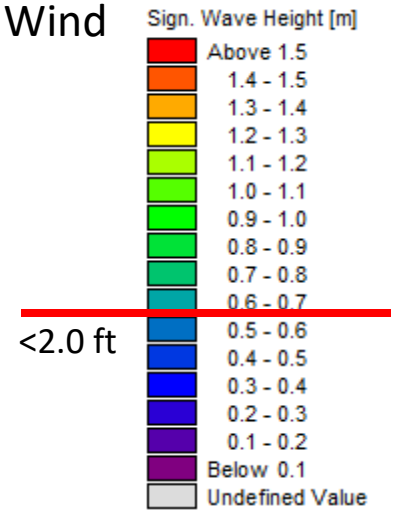
Southeast Wind



South Wind



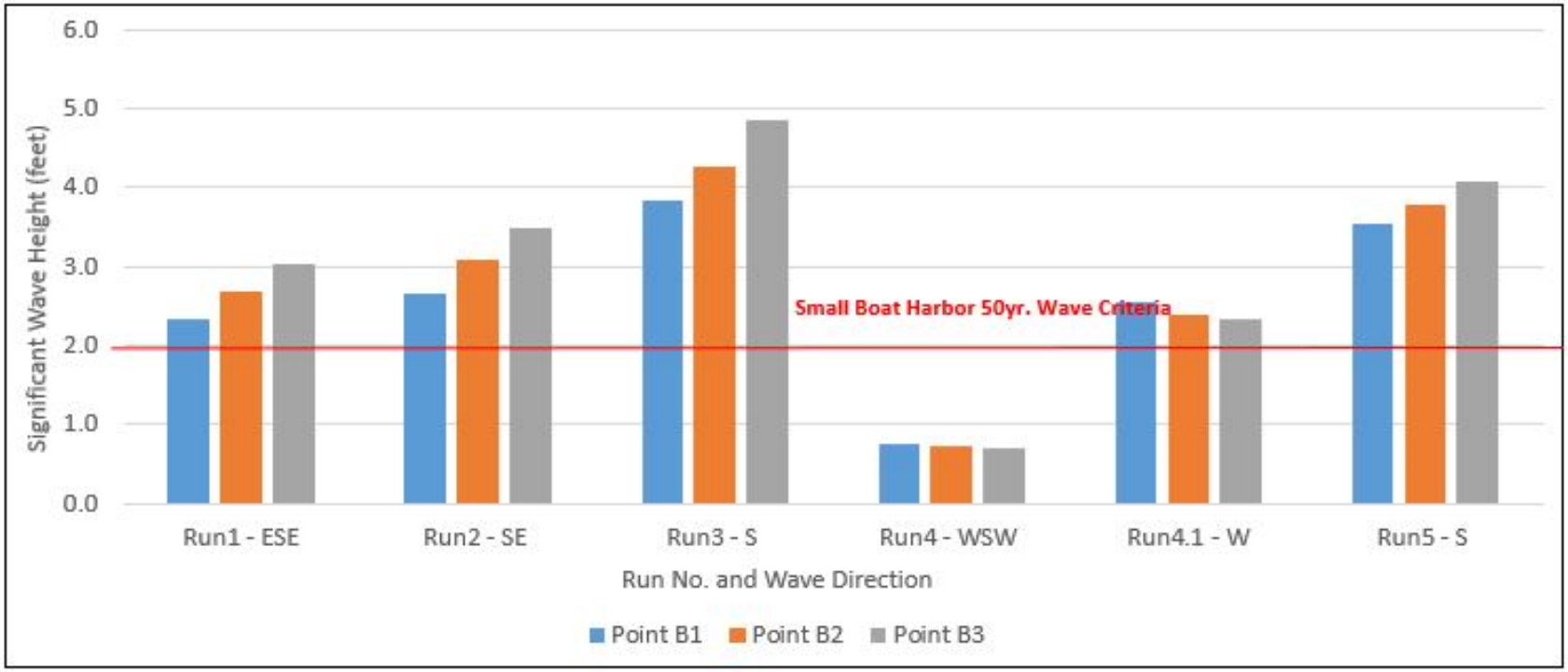
West Wind



<2.0 ft

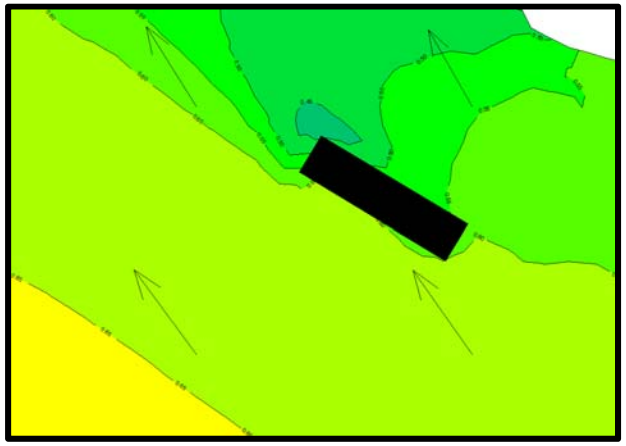
Concept B

50 Year Return Period Results Summary

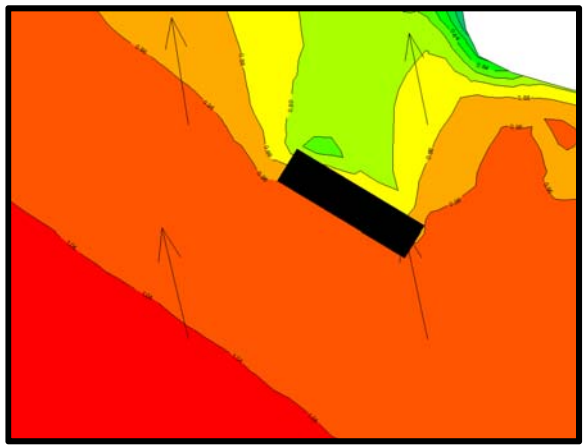


Concept B Wave Protection

2 Year Return Period



Southeast Wind



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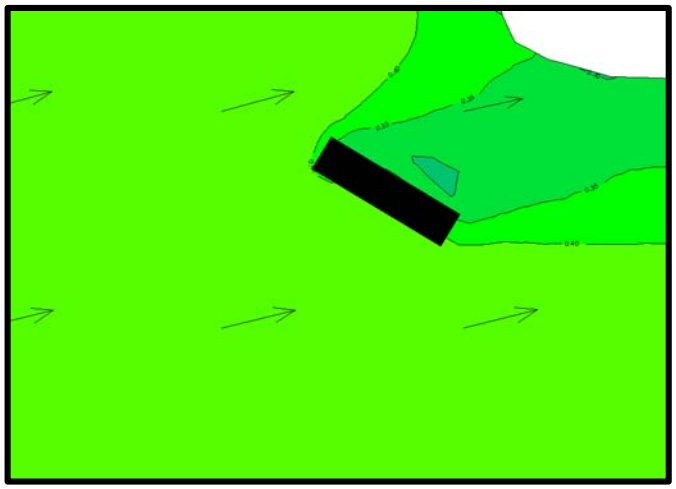
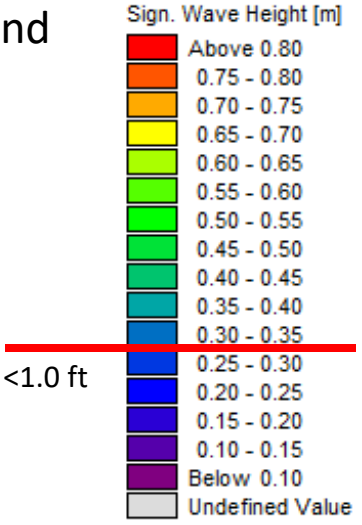


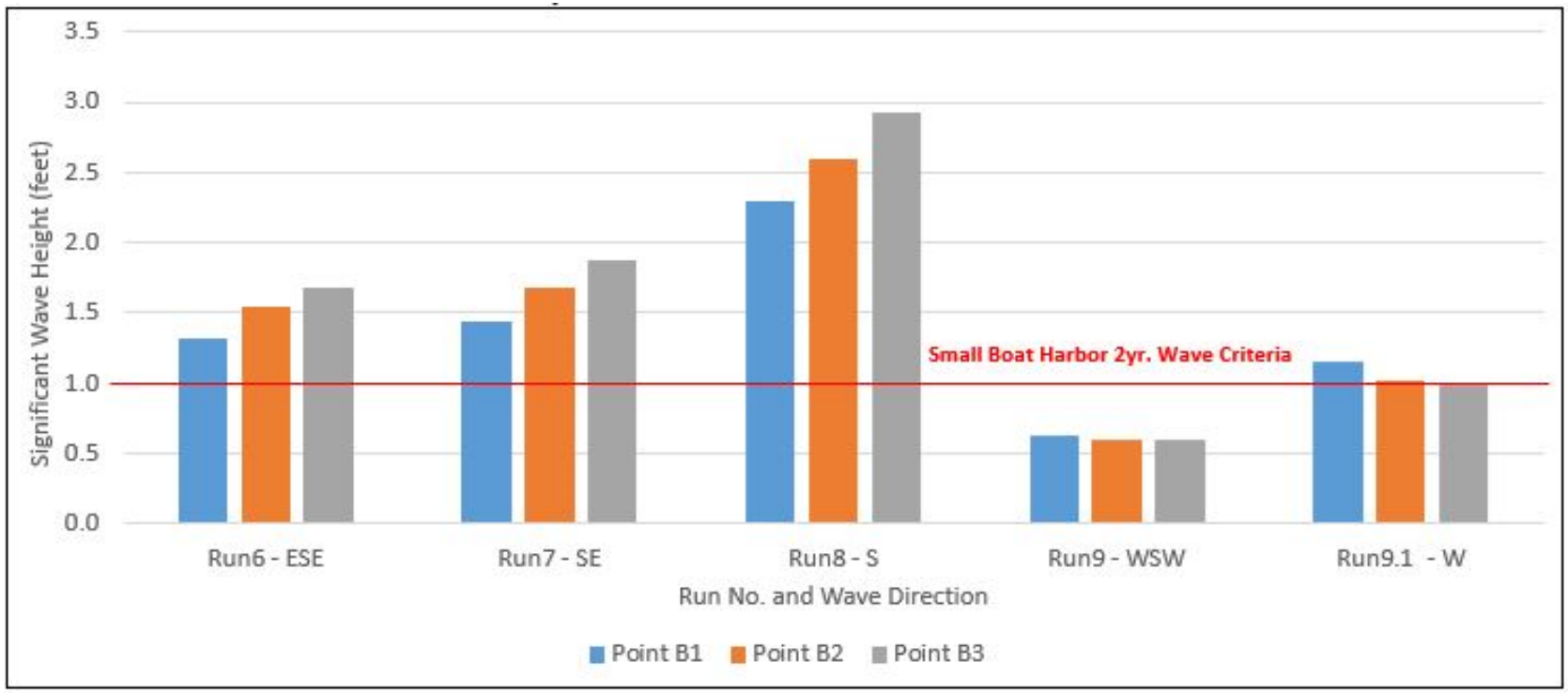
West Wind



<1.0 ft

Concept B

2 Year Return Period



Concept C Wave Protection

- This option offers no wave protection
- The external waves used for input in the model would be the exposure environment for the Concept C Float
- Float would be unusable as moorage during mild to moderate storm events
- The float design would need to be flexible yet rugged enough to resist damage during storm events

Met-Ocean Results Summary

- Maximum predicted wave height outside the structure is:
  - 5.8 feet for 50-year storm event
  - 3.4 feet for 2-year storm event
- Preferable wave environment for protected harbor is:
  - 2.0 feet for 50-year storm event
  - 1.0 feet for 2-year storm event
- Concept A - partially penetrating wall transmission coefficient is set to 0.35 (about 16 feet draft)
- Concept B - floating breakwater does not provide adequate wave protection behind the structure for storms from all directions
- Concept C - light float provides no wave protection

Anchor Type Analysis

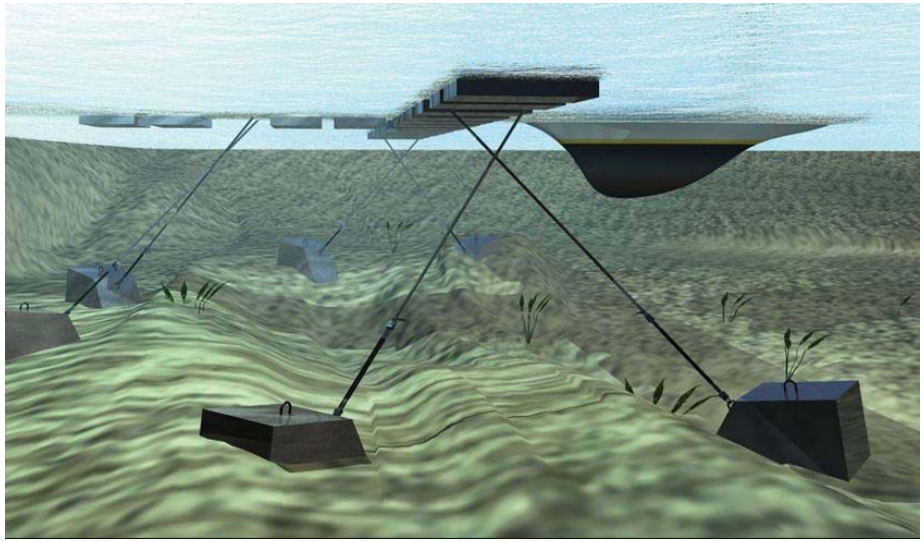
- Three types of anchor considered
  - Pile Drilled Socket
  - Elastic Lines with Helical or Weight Anchors
  - Drag Anchors
- Brief methodology and description
- Possible applications to this project
- Pros and Cons

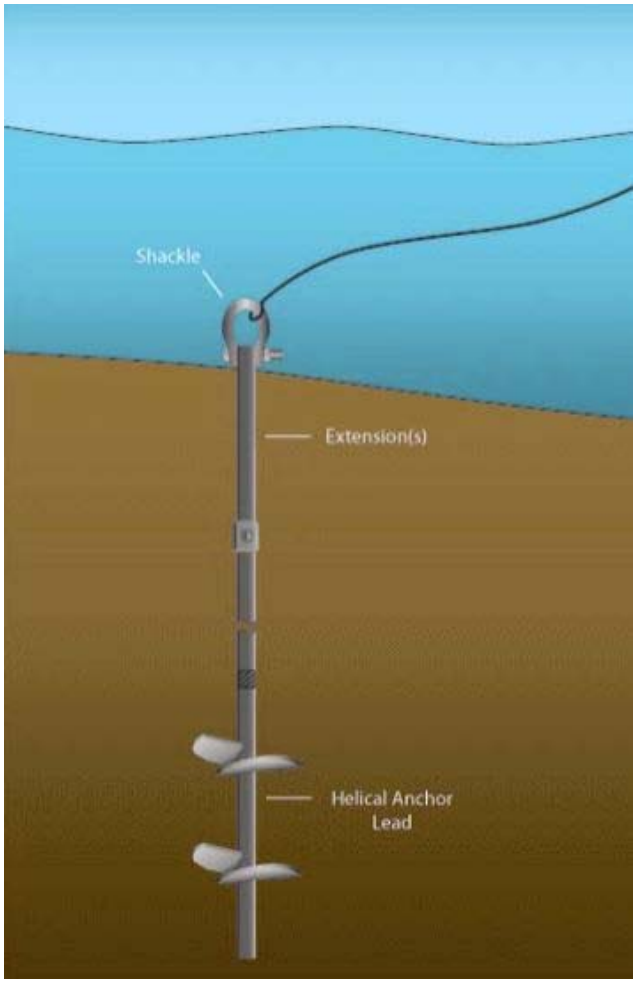
Anchor Type – Pile Drilled Socket

Pile Drilled Socket – Pros and Cons

- Most robust solution – Tried and true
- Vertical piles highly effective in all tide levels
- Consistent regardless of overburden depth
- Some structures require pile foundation regardless
- Low long term maintenance cost
- High initial expense
- Most environmental impact at initial installation

Anchor Type – Elastic (Seaflex®) Lines Helical and Weight Anchors

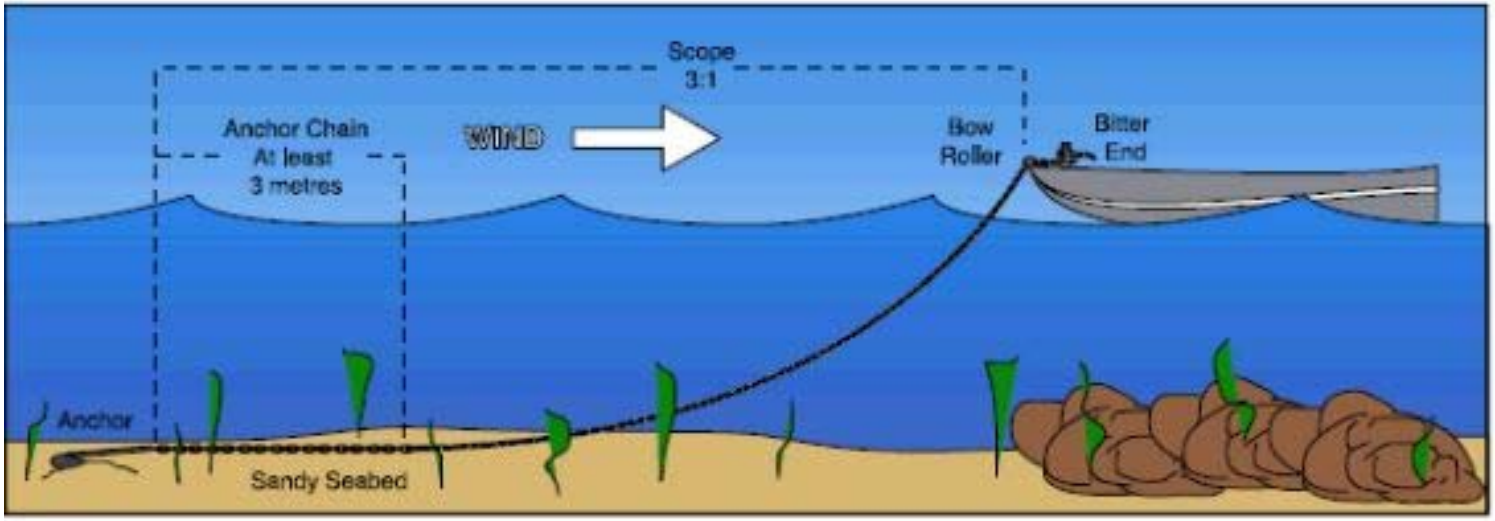




Elastic Lines with Helical and/or Weight Anchors – Pros and Cons

- Lowest environmental impact at initial installation and long term
- Low initial cost
- Questionable longevity of anchor lines – potentially high maintenance cost over time
- Helical anchors require specific install depth – depends on additional geotechnical information
- Elastic lines require specific balance between average water depth and high/low tide change
- Does not support wave barrier option, floats only

Anchor Type – Drag Anchors



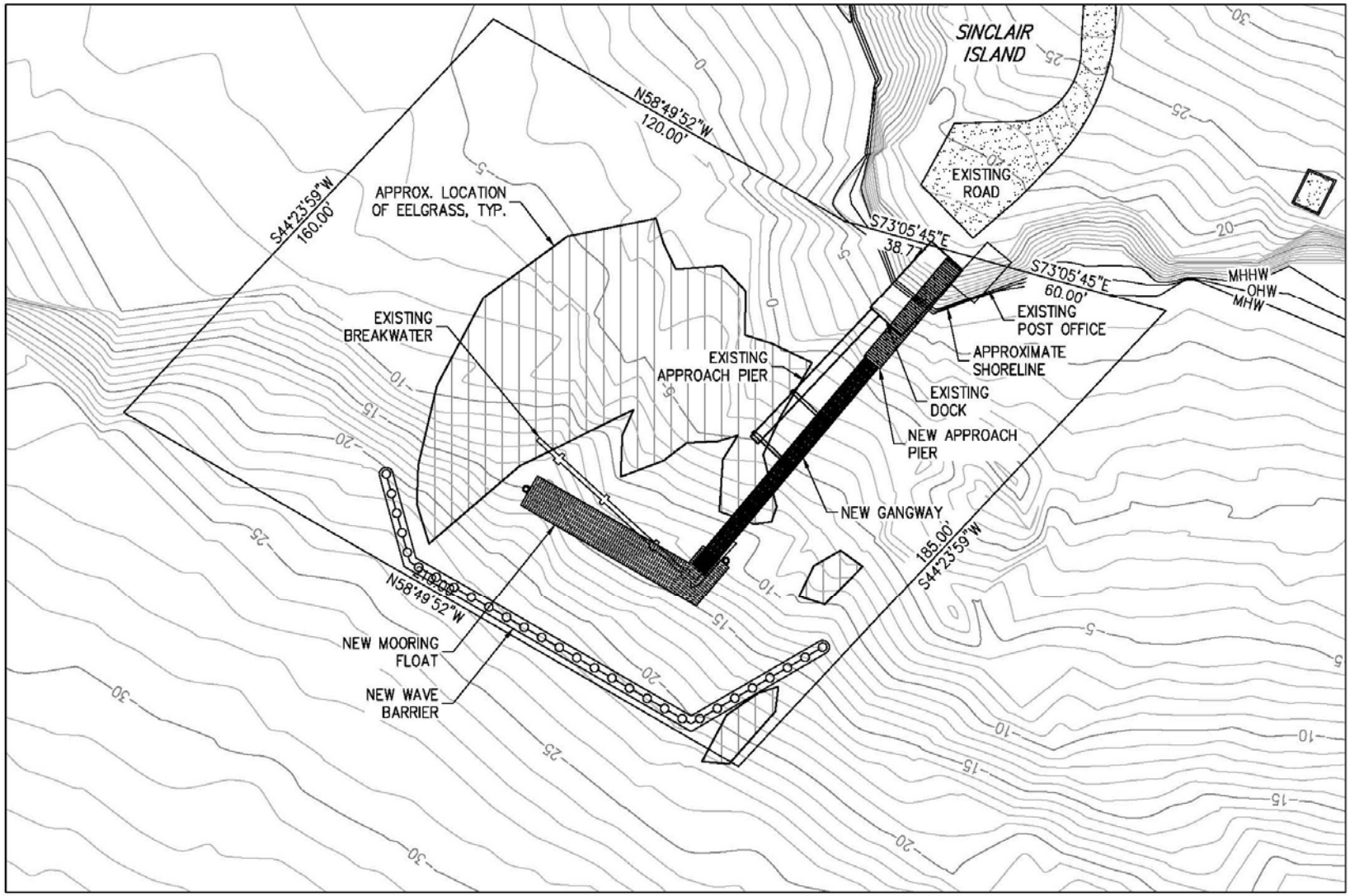
Drag Anchors – Pros and Cons

- Moderate environmental impact at initial installation
- Low initial cost
- Extreme environmental impact over long term
- Requires line scope and expansion of lease area to accommodate
- Drag anchor design depends on additional geotechnical information
- Does not support wave barrier option, floats only
- High maintenance cost over time

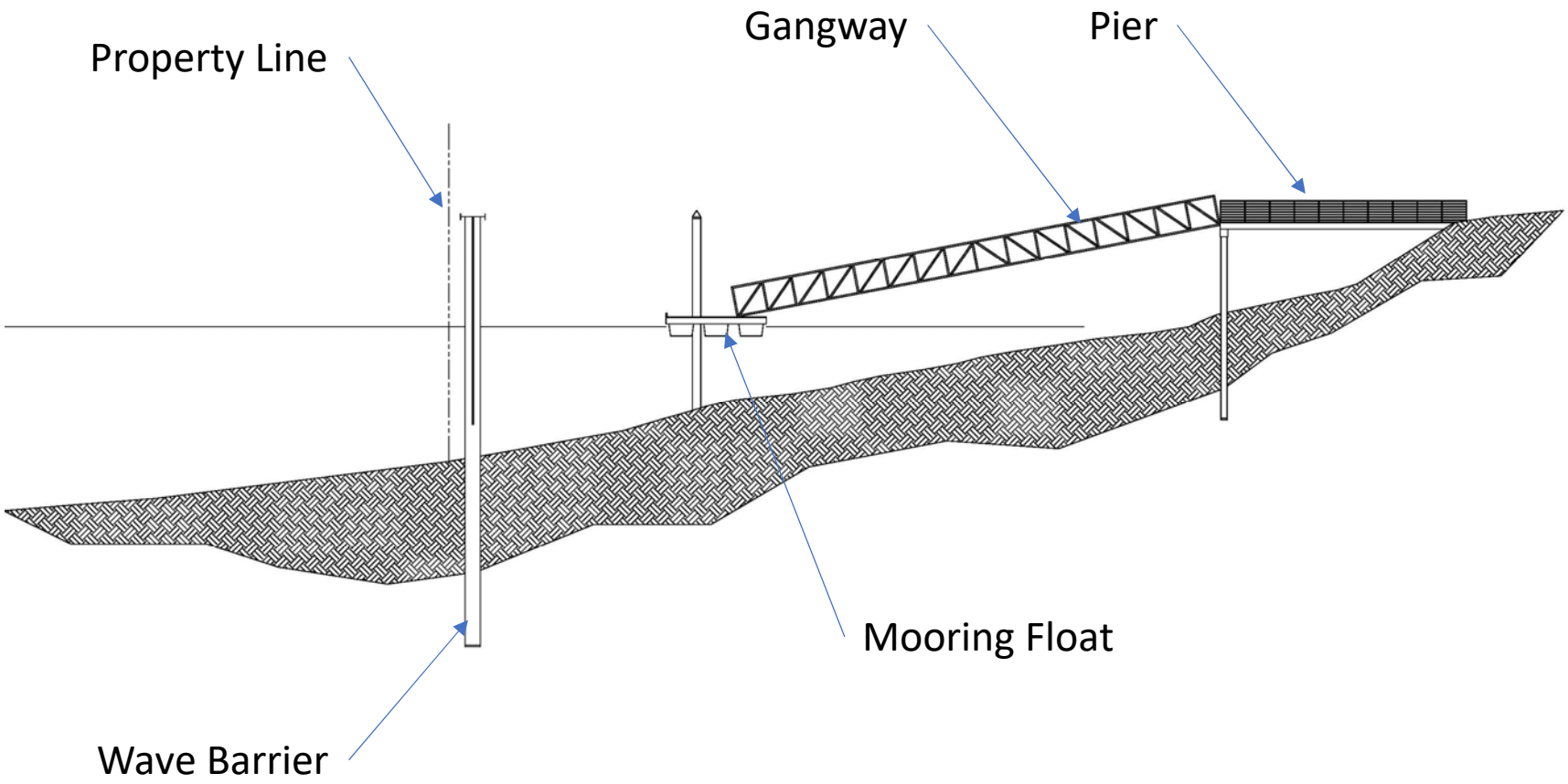
Recommendation – Drilled Piles

- Steel pipe piles can be used for all structure foundations
  - Float Piles
  - Wave Barrier
  - Pier Bearing Piles
- Drill and pile socket provides needed lateral capacity
- Low maintenance
- Low long term environmental impact

Concept A Plan

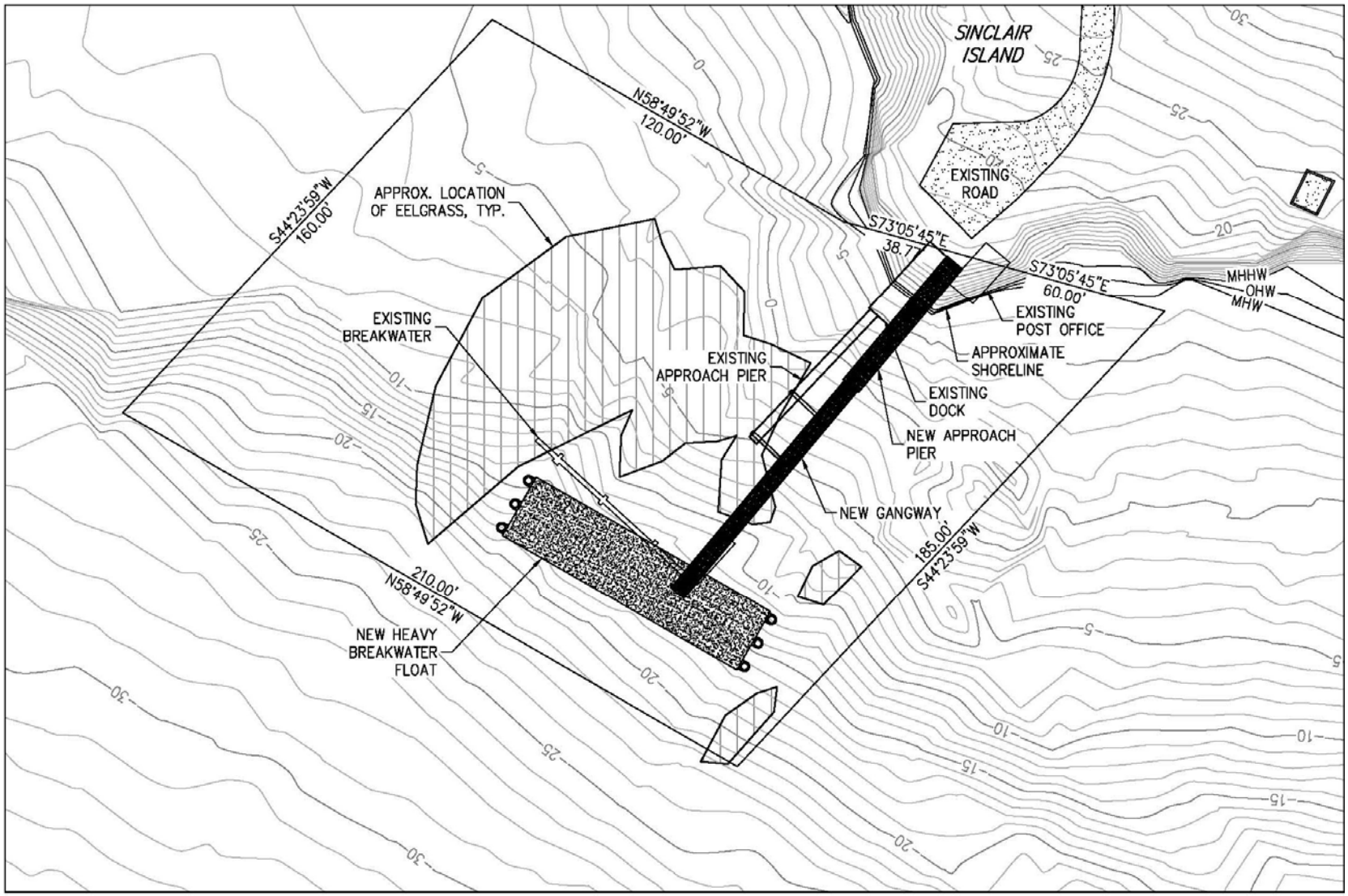


Concept A Section

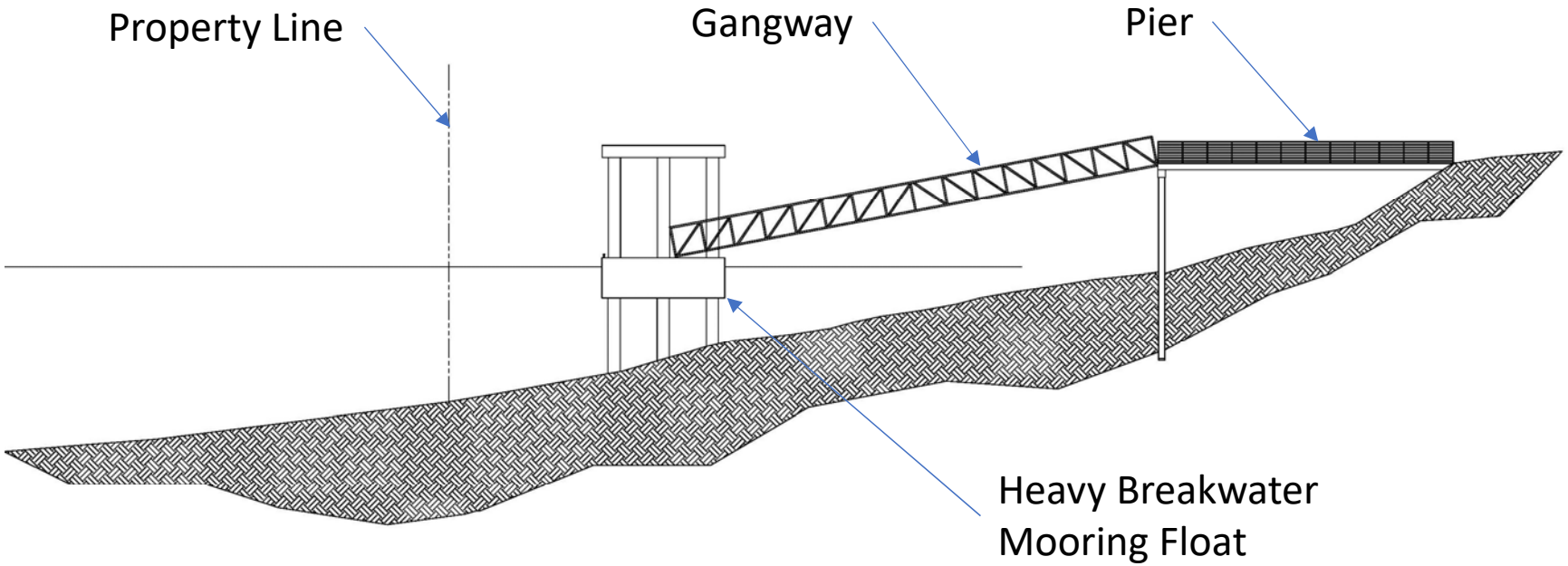


Cost Estimate: $3.3M

Concept B Plan

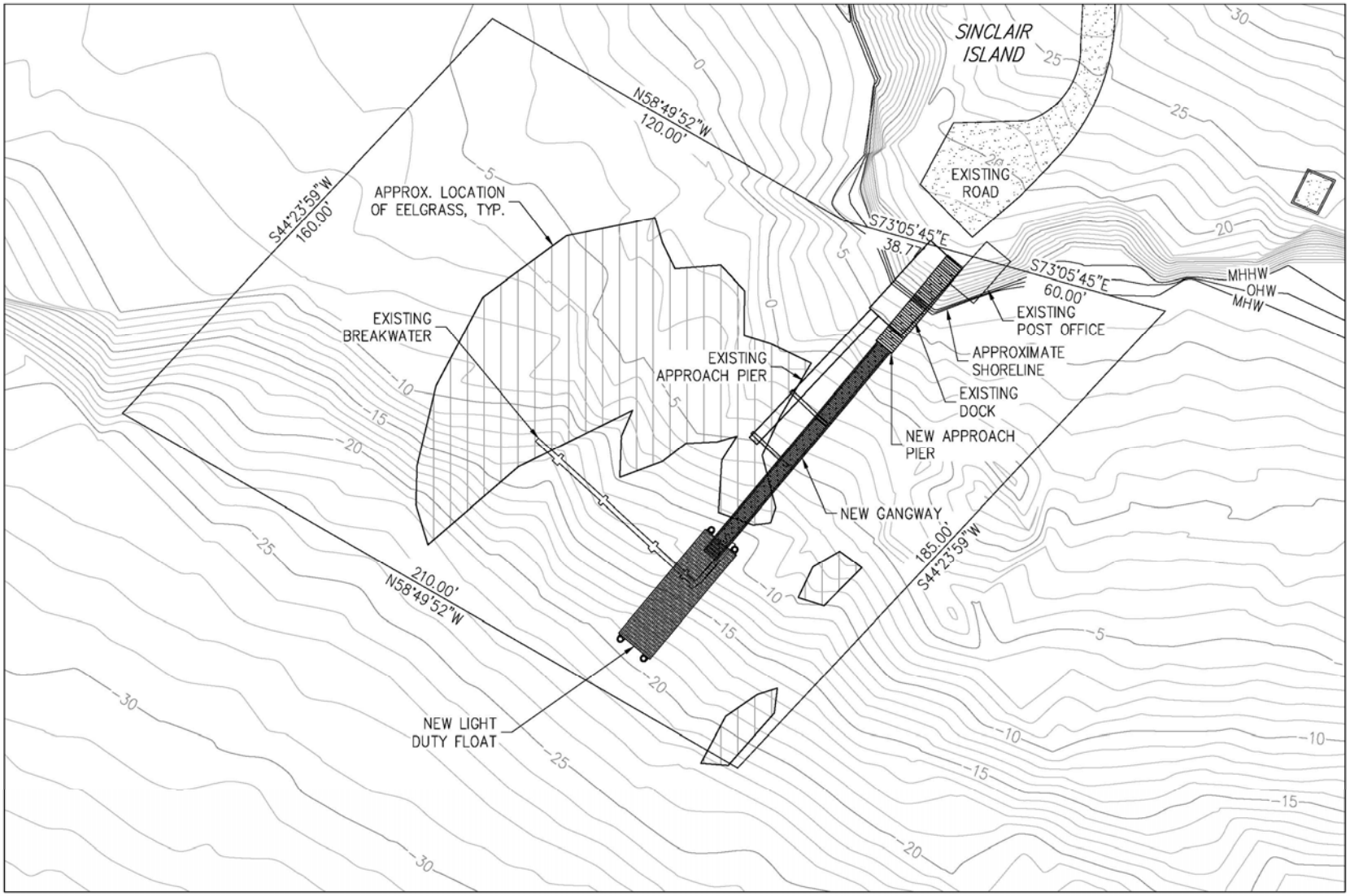


Concept B Section

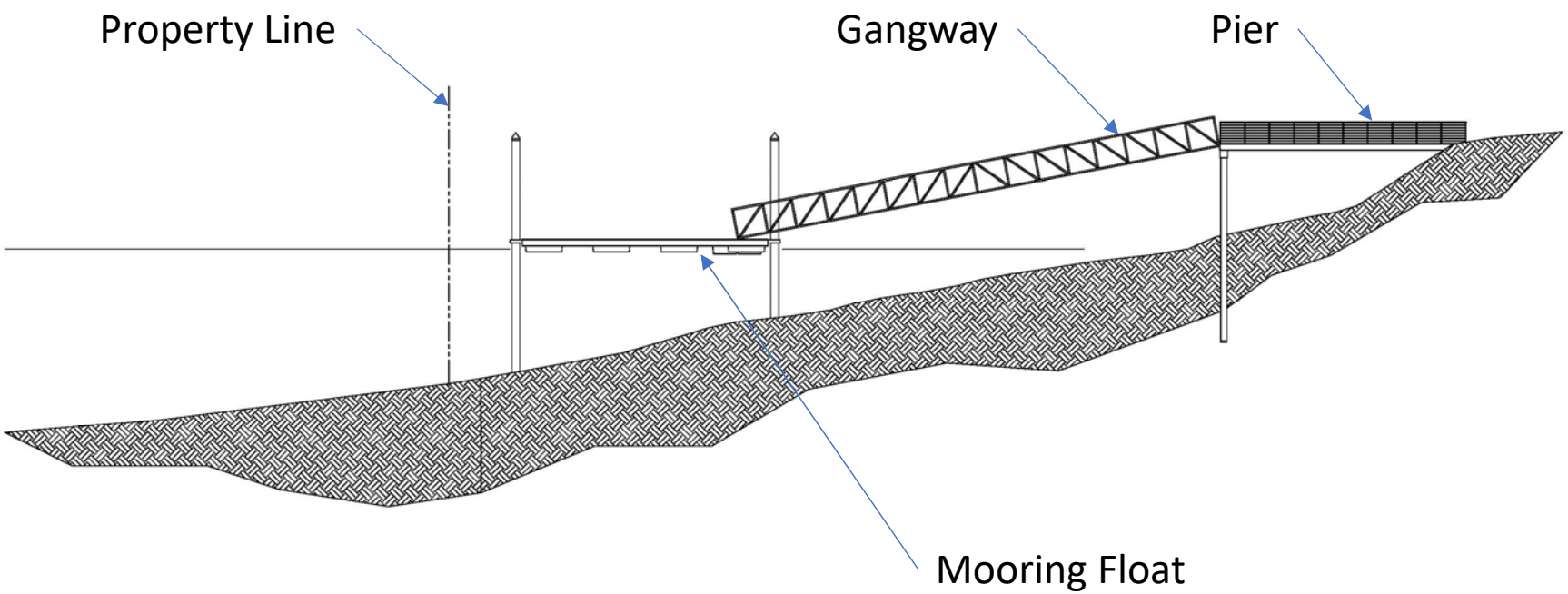


Cost Estimate: $1.6M

Concept C Plan



Concept C Section



Cost Estimate: $700k

Summary

- Concept A provides best protection and most moorage space for year round use. It also protects the facility from damage for the design life of the structure. Cost: $3.3M
- Concept B provides protection during moderate weather, on one side of the float. It leaves the facility exposed to damage during severe events. Cost: $1.6M
- Concept C provides no protection from storms and the facility is exposed to potential damage during storm events. Cost: $700k
- All feasible options depend on drilled/socketed piles.

Next Steps?

- Develop 30% Design
- Prepare permit documents and submit applications
- DNR negotiations
- Final Design Development
- Bid Solicitation
- Fabrication and Construction