

PORT OF PORT TOWNSEND



Point Hudson Marina Entrance Breakwater Feasibility Assessment

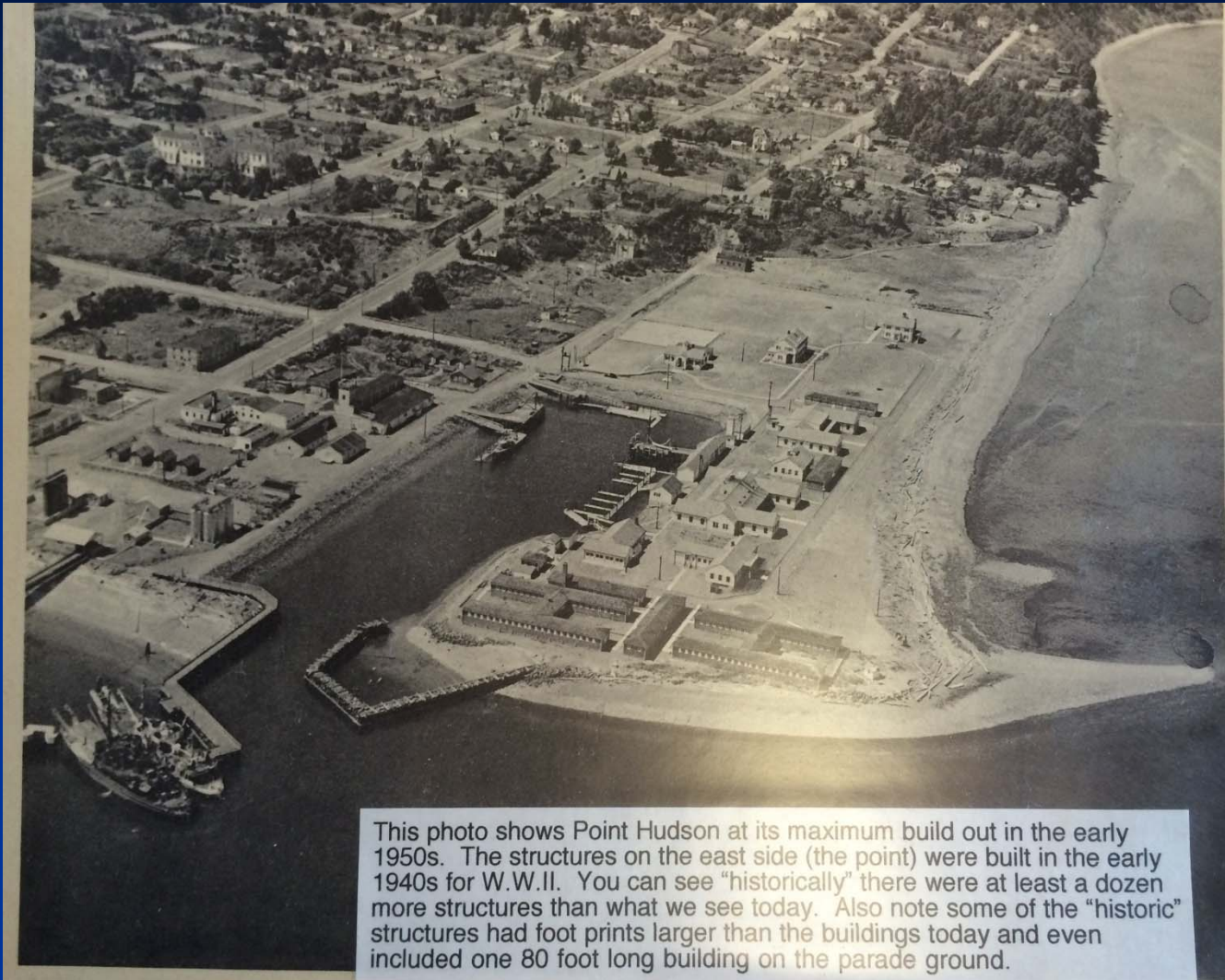


Outline

- Breakwater History
 - Facility
 - Materials
- Breakwater Condition
- Analysis
- Protecting the Marina – Options



Breakwater History



This photo shows Point Hudson at its maximum build out in the early 1950s. The structures on the east side (the point) were built in the early 1940s for W.W.II. You can see "historically" there were at least a dozen more structures than what we see today. Also note some of the "historic" structures had foot prints larger than the buildings today and even included one 80 foot long building on the parade ground.



Breakwater History - Facility

- Original 1934 Construction by Military
 - Creosote Treated Timber Piling
 - Creosote Treated Timber Walers (2 to 3 Rows)
 - Armor Rock
 - Steel Cable Tiebacks
- Major Rehabilitation in 1969
 - Conversion from Pier/Breakwater to Breakwater
 - New Outer Piles
 - New Center Cables Tied to Existing Piles
- Retrofit in 1996 - End 60' of S. Breakwater, Bend & End 12' of N. Breakwater
 - New ACZA Treated Timber Piling
 - Steel Cable Wrapped Around New Piling
 - Supplemental Armor Rock

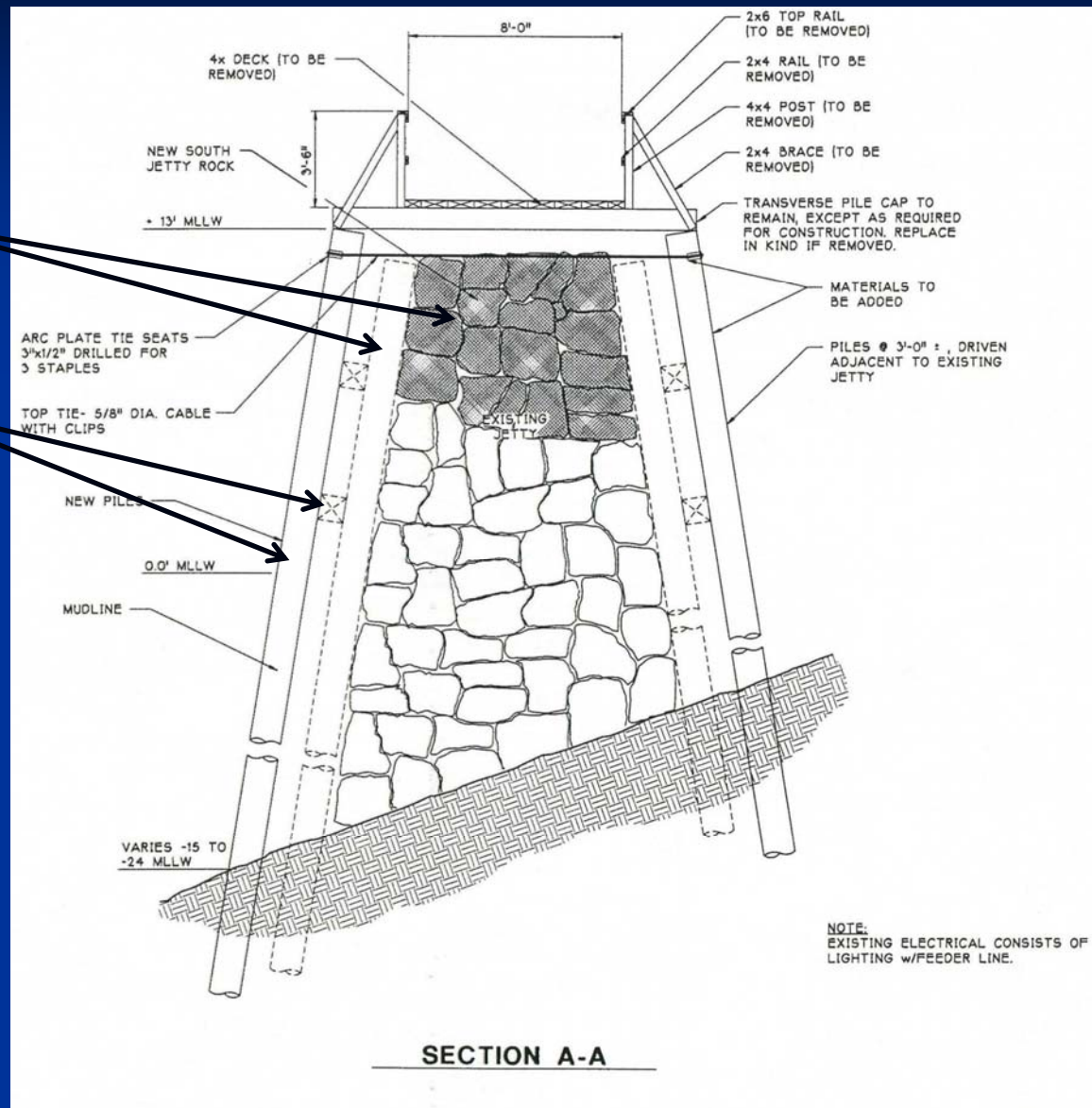


Breakwater History - Facility

1934

1969

Rehabilitation

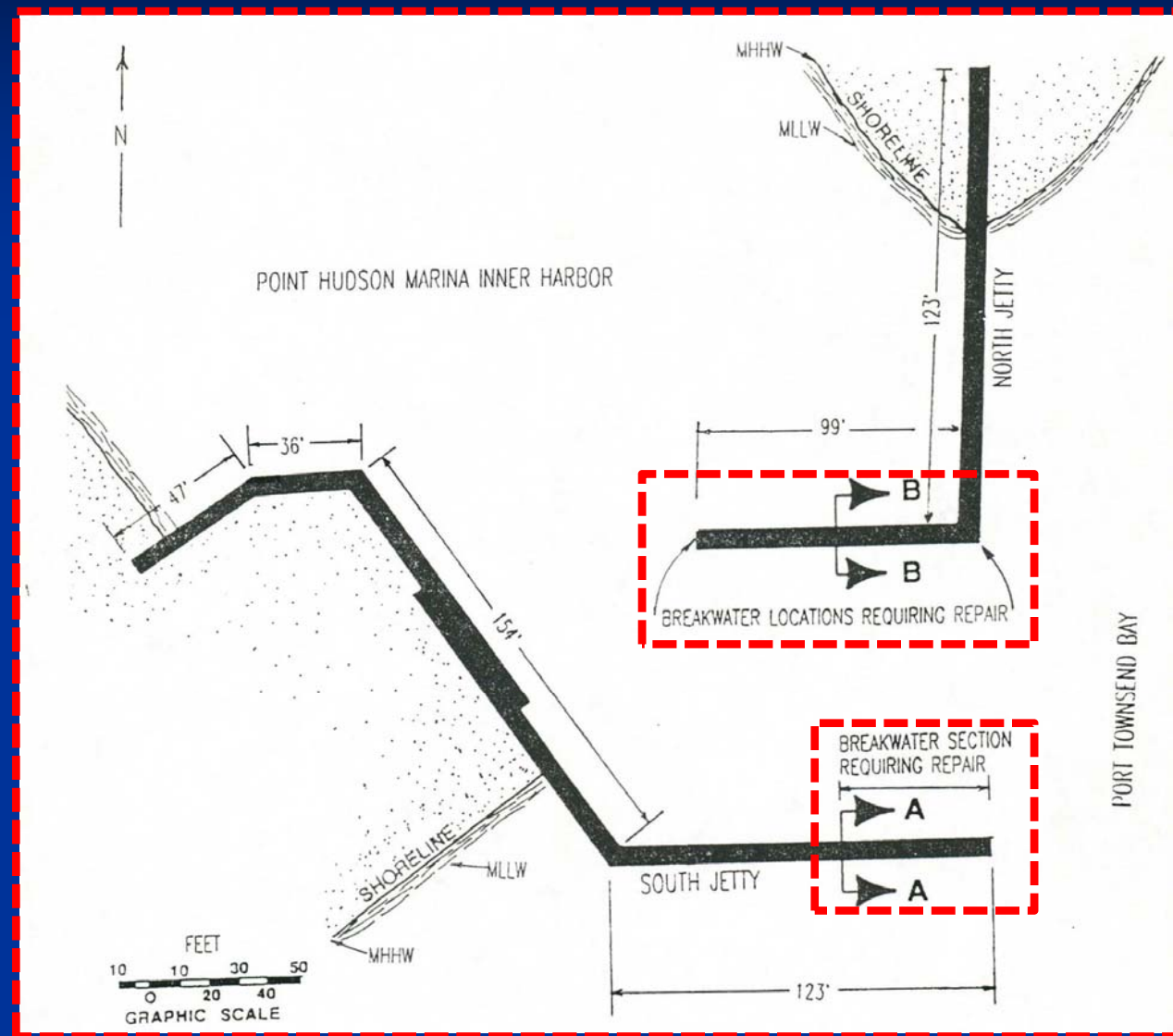


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Breakwater History - Facility



Breakwater History – Facility Improvements (1996)



Breakwater History - Materials

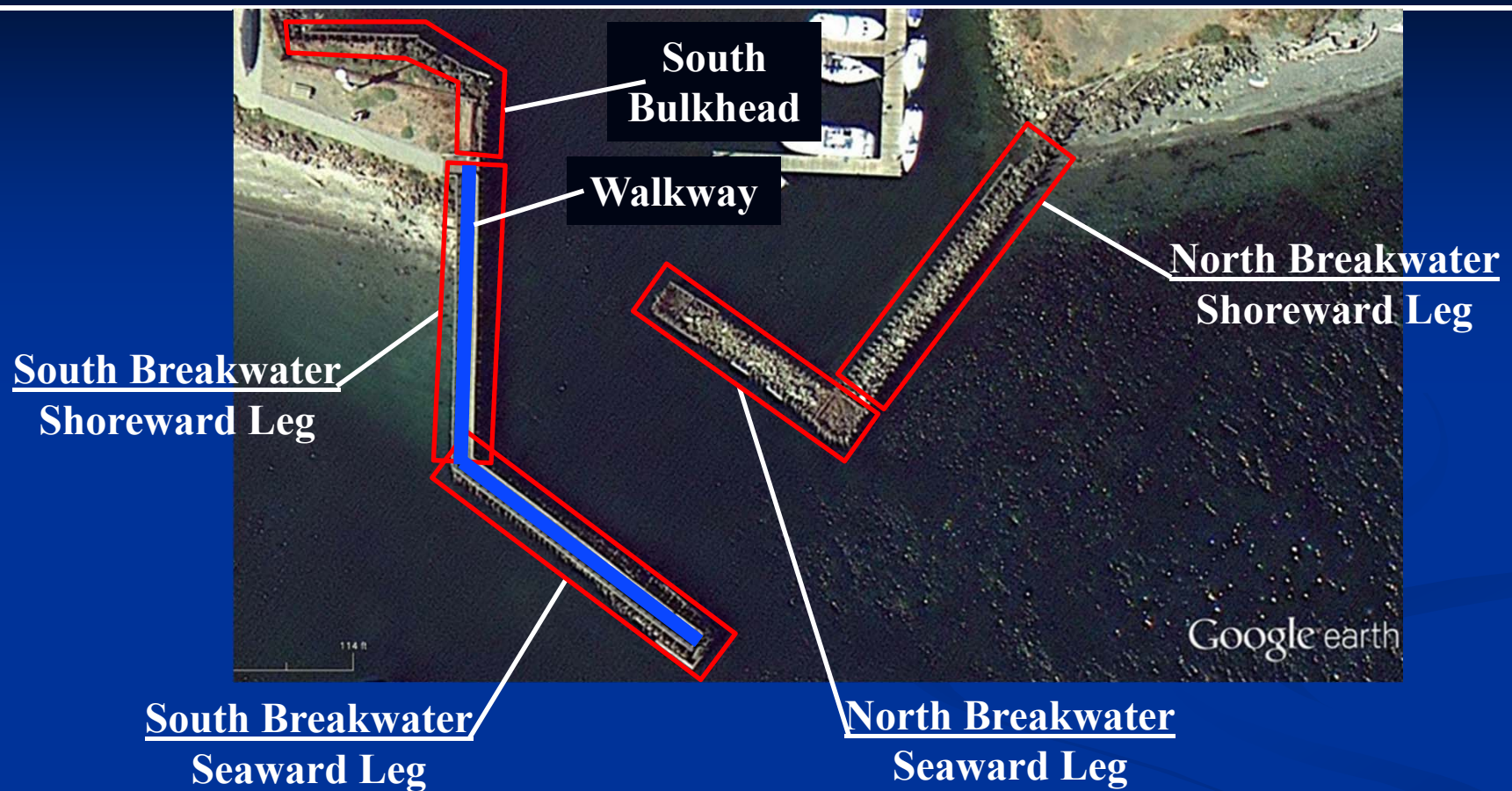
- Original Creosote Treated Timber Piling
 - Typical Life Expectancy of 35 to 80 Years
 - Excellent Quality Lumber
- Original Creosote Treated Timber Walers
 - Typical Life Expectancy of 35 to 50 Years
- Galvanized Steel Cable Tiebacks
 - Galvanizing Has Typical Life Expectancy of 20 - 30 Years in Marine Environments, Then Rapid Deterioration Begins
- ACZA Treated Timber Piling
 - Typical Life Expectancy Much Less Than Creosote Treated Timber Piling, Typically 20 to 35 Years
- Armor Rock
 - Marine Basalt – Low Quality. Typical Life Expectancy of 20 to 40 Years

Outline

- Breakwater History
- Breakwater Condition (Based on 2014 Site Visit)
 - System Components (Breakwater & Walkway)
 - Piles
 - Walers
 - Steel Cable Tiebacks
 - Armor Rock
 - S Breakwater End, Walkway
 - Conclusion
- Analysis
- Protecting the Marina - Options



Breakwater Condition – System Components



Breakwater Condition – Breakwater Components



Top Cable (1969)

Outer Pile (1969)

Upper Waler
(1934)

Center Cable
(1969)

Armor Rock
(1934)

Inner Pile (1934)

Lower Waler
(1934) (Not
Visible) ¹¹



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Note: >75% Inner Piles (1935) Observed to be Highly Deteriorated, Not Contributing to Structural Stability. Assessment Focused on Outer Piles.

Breakwater Condition – Walkway Components



Walkway

Stringer

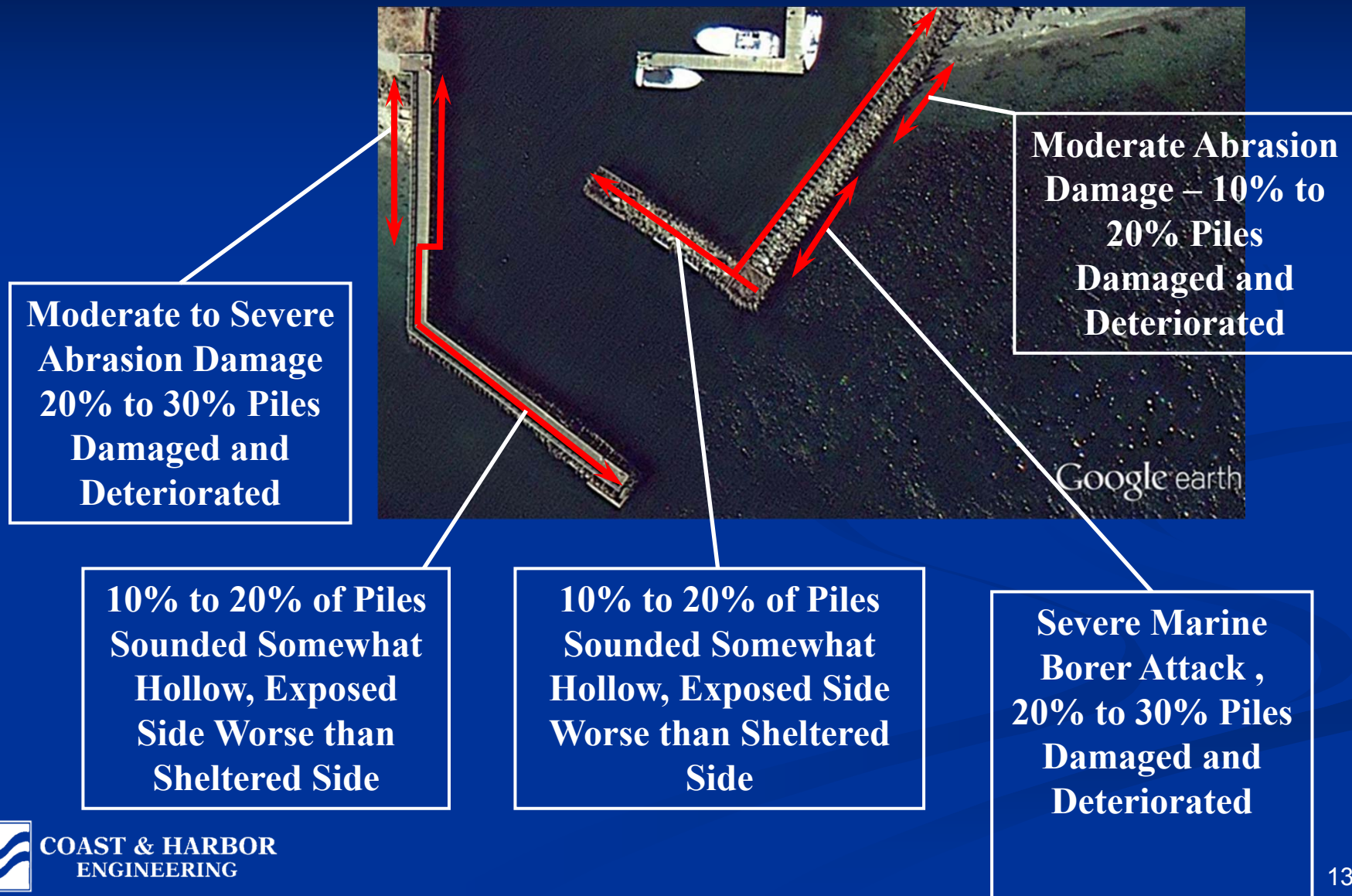
Pile Cap

**Stringer
Splice**



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Breakwater Condition – Outer Piles



Breakwater Condition – Outer Piles

- Varying Levels of Deterioration Depending on Exposure, Damage
- Likely Shallow Embedment – Highly Compacted Sand Layer 0.8ft to 2ft Below Mudline (Landau Biological Assessment/Evaluation, September 2005)
- Piles Beyond Useful Service Life



Piles in Poor Condition



Piles in Fair Condition

Breakwater Condition – Outer Piles

- Marine Borer Attack
- Varying Levels of Deterioration
- Decay Where Creosote Treatment Penetrated by Bolts, Thru Rods



**Inner Pile
(1934) :
Decay at
Penetration**

**Outer Pile
(1969):
Marine
Borer
Attack**



Breakwater Condition – Outer Piles

- Abrasion
Penetrated
Creosote
Protective
Treatment,
Subsequent
Decay/Marine
Borer Attack



**Inner Pile
(1934)
Abraded &
Decayed**

**Outer Pile (1969)
Abraded, Decaying
(Hollow Sounding)**



Current Condition – Upper & Lower Walers

**Walers Completely
Deteriorated –
Minimal Load
Carrying Capacity**



**Walers Completely
Deteriorated –
Minimal Load
Carrying Capacity**



Current Condition – Upper & Lower Walers

- Highly Deteriorated – Minimal Capacity
- Minimal Contribution to Structure Stability – Decreased System Capacity
- Loss of Stone Confinement
- Walers Beyond Useful Service Life



**Deteriorated
Waler**

**Loss of
Armor Rock**



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Current Condition – Steel Cable Tiebacks

**10% Cables Severed,
Remainder
Deteriorated, Areas
Exposed to Wave Splash
Worst**

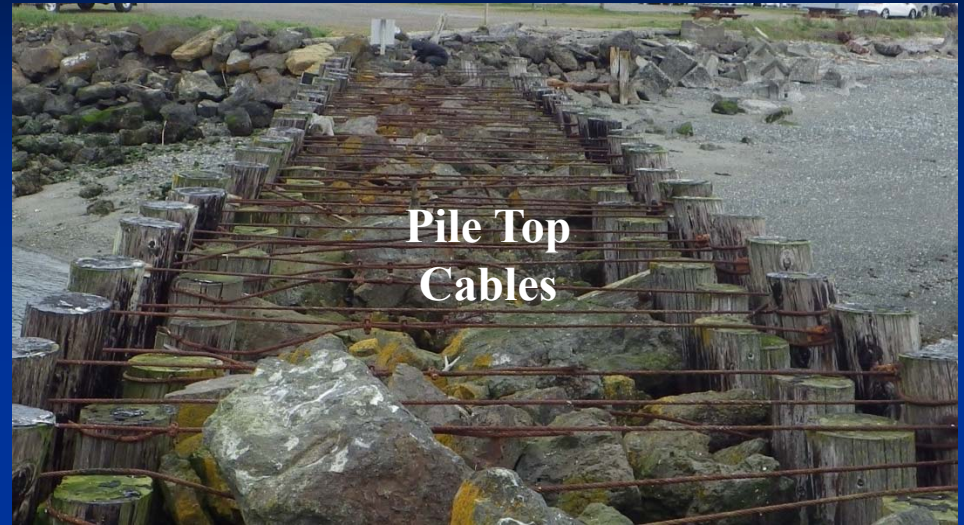
**10% to 20% of Cables
Severed, Remainder
Deteriorated, or
Highly Deteriorated**

**5% to 10% of
Cables Severed,
Remainder
Deteriorated**



Breakwater Condition – Steel Cable Tiebacks

- Pile Top – Cables Wrapped Around Pile Tops to Provided Lateral Support
- Intermediate – Cables Wrapped Between New and Old Piling – 90%+ Missing, Remainder Highly Deteriorated



Pile Top
Cables

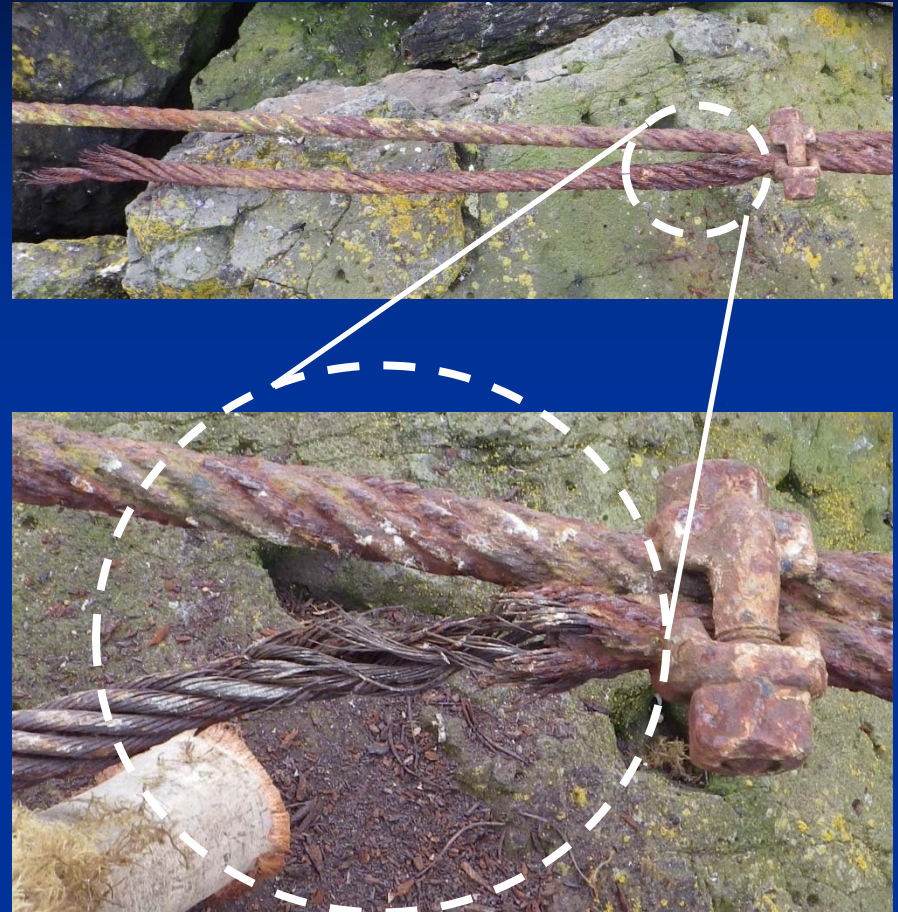


Intermediate Cables



Breakwater Condition – Steel Cable Tiebacks

- Level of Deterioration Difficult to Determine Visually
- Caked on Rust
- Cable End Examined, Estimated $<10\%$ Capacity Remaining
- Cable Beyond Useful Service Life

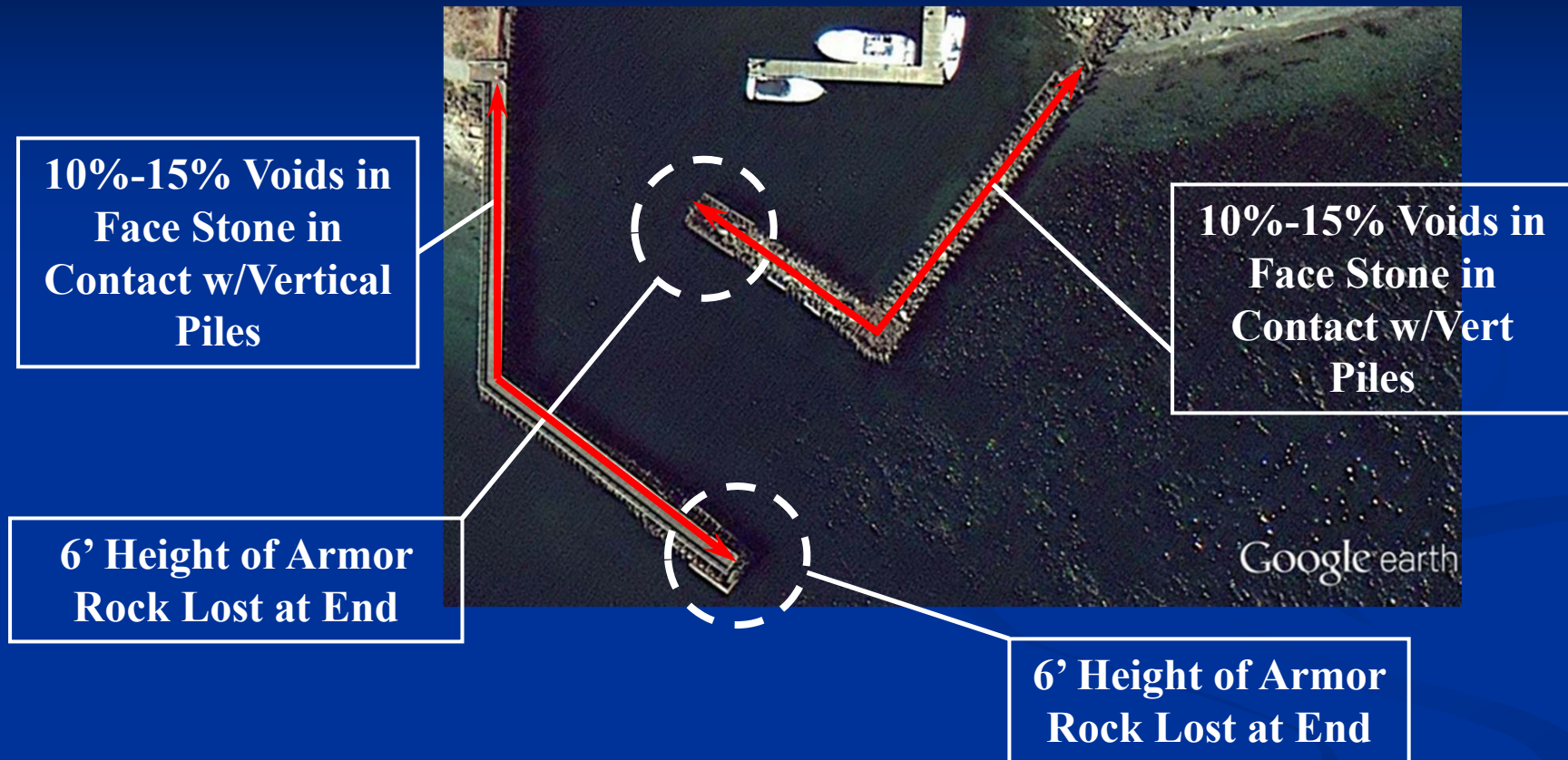


Breakwater Condition – Steel Cable Tiebacks

- Supplementary Armor Piled on Cables – Potentially Causing Damage



Current Condition – Armor Rock



Current Condition – Armor Rock

- Appears to be Matts Matts Sourced Marine Basalt – Low Quality Stone
- Highly Fractured
- >50% of Stone in Deteriorated to Highly Deteriorated State



Breakwater Condition – Armor Rock

- Armor Rock Spalls to 12" x 12" x 8" Pieces, Which are Being Pulled From Between Piles by Wave Action
- Loss of Waler Results in Decreased Confinement of Armor Rock



Breakwater Condition – Armor Rock

- Substantial Armor Rock Loss at Venerable Breakwater Ends – Approx. 6' Height of Material Lost
- 10% to 15% Voids in Face Stone in Contact With Vert. Pile
- Armor Rock Beyond Useful Service Life



Breakwater Condition – Outer Piles

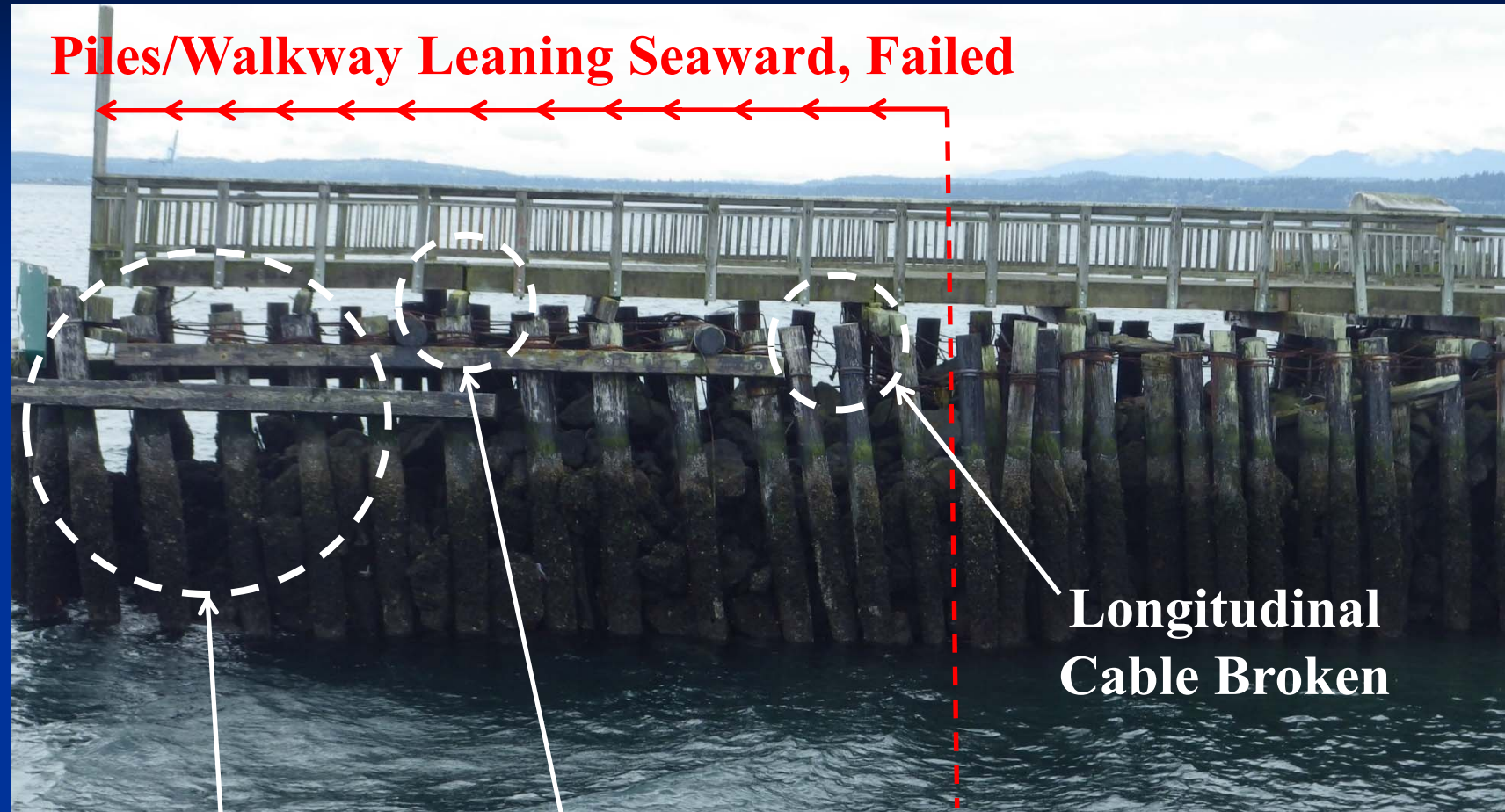
- Barge Impact Shows Consequences of Lost Pile: Armor Rock Falling Through Hole Gap in Piles Created by Pile Failure



Impact-Damaged Pile

Loss of Armor Rock

Breakwater Condition – S. Breakwater End, Walkway



Piles/Walkway Leaning Seaward, Failed

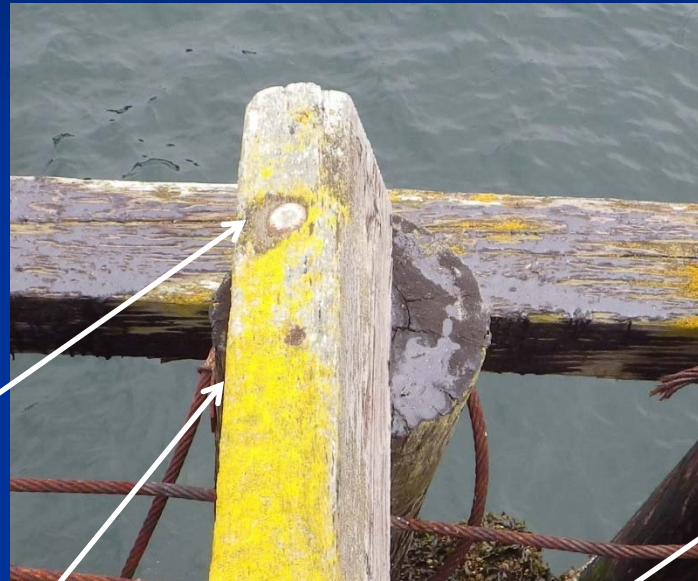
**Longitudinal
Cable Broken**

Lost Stone

**Stringer Nearly
Unseated, Pile
Cap Rotated**

Breakwater Condition – S. Breakwater End, Walkway

**Bent Shear
Pin**



Pile Cap

**Rail Recently
Modified for Lean**



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Breakwater Condition – S. Breakwater End

- Breakwater End Under Walkway Failing – Maintenance Staff Needs to Closely Monitor Condition.
- Further Failure/Shifting May be Grounds For Closure of Approx. 60' End Portion.
- Port Maintenance to Monitor Pile Caps, Stringer Splices for any Change in Condition.

Breakwater Condition – Assessment Summary

- Walers: *Highly Deteriorated, No Longer Functional*
- Steel Cable Tiebacks: *Deteriorated to Highly Deteriorated, Some Already Failed, At End of Useful Life.*
- Armor Rock: *At Age of Increasing Deterioration Rate, Beyond Useful Service Life*
- Piles: *Near End of Useful Life, Abrasion Damage, Marine Borer Attack Damage, Decaying*
- Overall Structural System: *Substantially Less Stable than Original Construction, Higher Stresses*
- S. Breakwater End: *Walkway Stringer Nearly Unseated, Entire 60' End Portion Failed, Leaning Seaward*
- Walkway: *End 60' Near End of Useful Life, Needs Monitoring. Remainder in Good/Moderate Condition*

Breakwater Condition – Assessment Summary

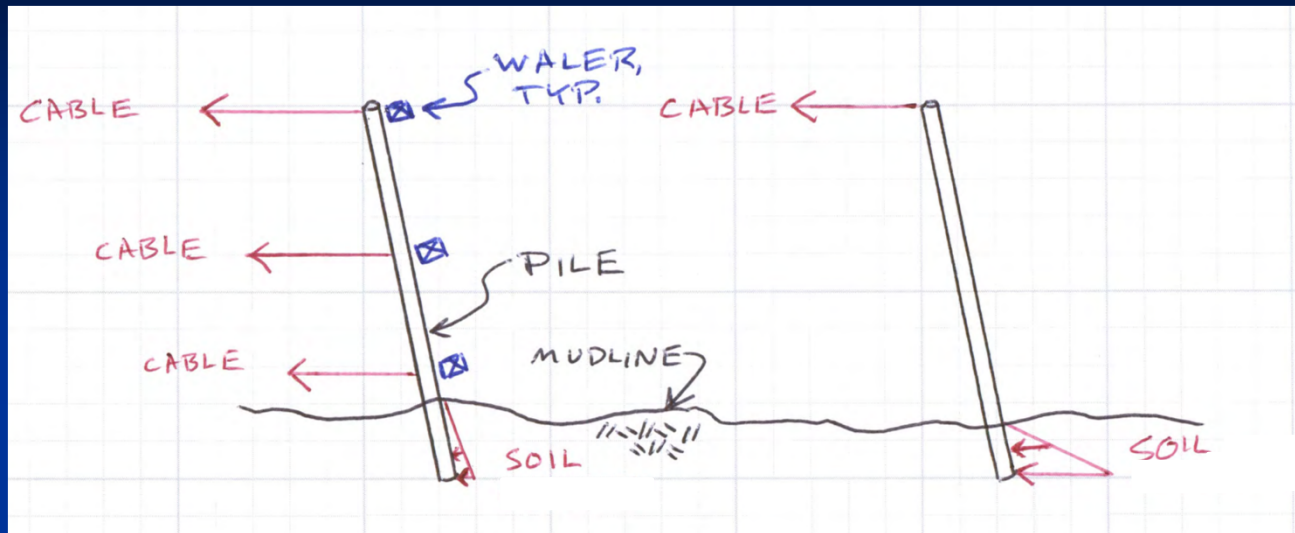
- Maintenance/Repair of Existing Structure is not a Viable Alternative for Intermediate to Long Term Solution
- Major Rehabilitation/Replacement Will Be Required

Outline

- Breakwater History
- Breakwater Condition (Based on 2014 Site Visit)
- Analysis
 - Overall Structural System
- Protecting the Marina - Options



Analysis – Overall Structural System



Original Construction

- Series of Cables Minimized Pile Stresses
- Minimal Reliance on Soil Capacity
- Minimal Reliance on Pile Capacity and Soil Capacity

Current Condition

- Only Top Cable Remaining
- Top Cable is Deteriorated – Reduced Capacity
- Stability Heavily Reliant on Pile Capacity and Soil Capacity



Breakwater Condition – Analysis Summary

- System Capacity Significantly Reduced due to Deterioration. System Degradation Leading to Increased Pile Loading
- Outer Pile Load Demand Increased Significantly due to
 - Failed Walers (2 Rows)
 - Failed Thru-Rods (2 Rows)
- Outer Piles are Deteriorated Relative to New Condition – Resulting in Reduced Capacity
- Conclusion: Replacement/Rehabilitation Recommended

Outline

- Breakwater History
- Breakwater Condition (Based on 2014 Site Visit)
- Analysis
- **Protecting the Marina**
 - Breakwater Replacement Options



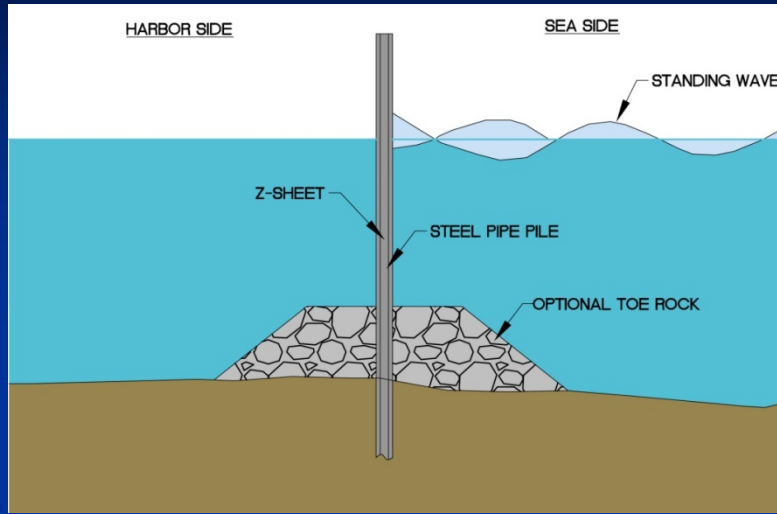
Breakwater Structure Type Alternatives

- Alternatives for Marina Protection
 - Vertical Pile Barrier
 - Braced Vertical Pile Barrier
 - Closed Cell Wall
 - Rubblemound
 - Exterior Soldier Pile

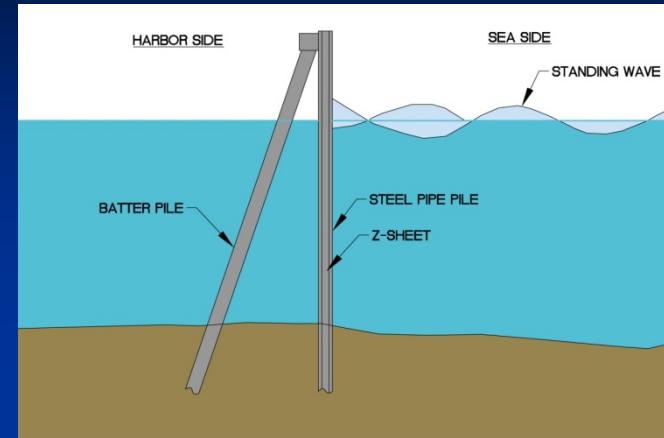
Considerations for Structure Type Selection

- Habitat – Eelgrass, Forage Fish
- Wave Reflection at entrance
- Wave Protection of Boat Basin
- Nearshore Sediment Processes
- Entrance Channel Width Requirement
- Structure Height (bottom elevation)
- Public Access Requirement
- Regulatory Requirements
- Construction Cost
- Maintenance

Protecting the Marina - Options



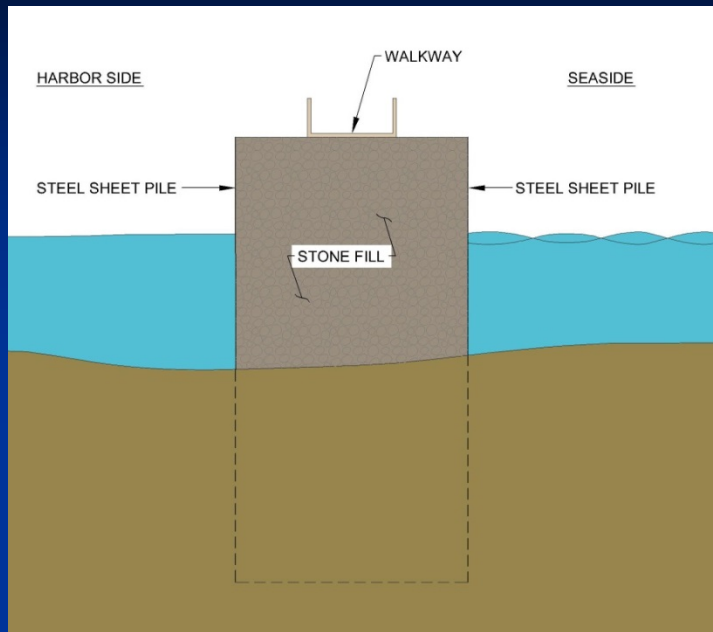
VERTICAL PILE (VP) BREAKWATER



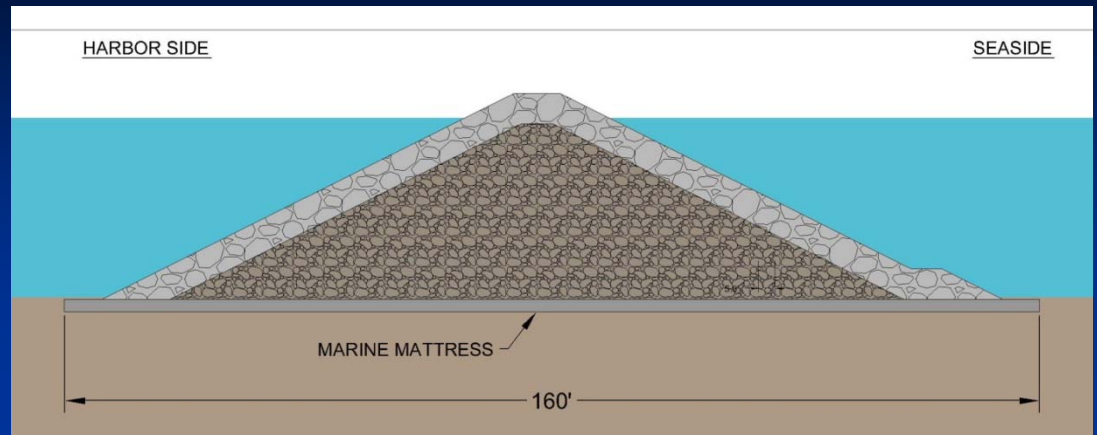
BRACED PILE (BP) BREAKWATER



Protecting the Marina - Options

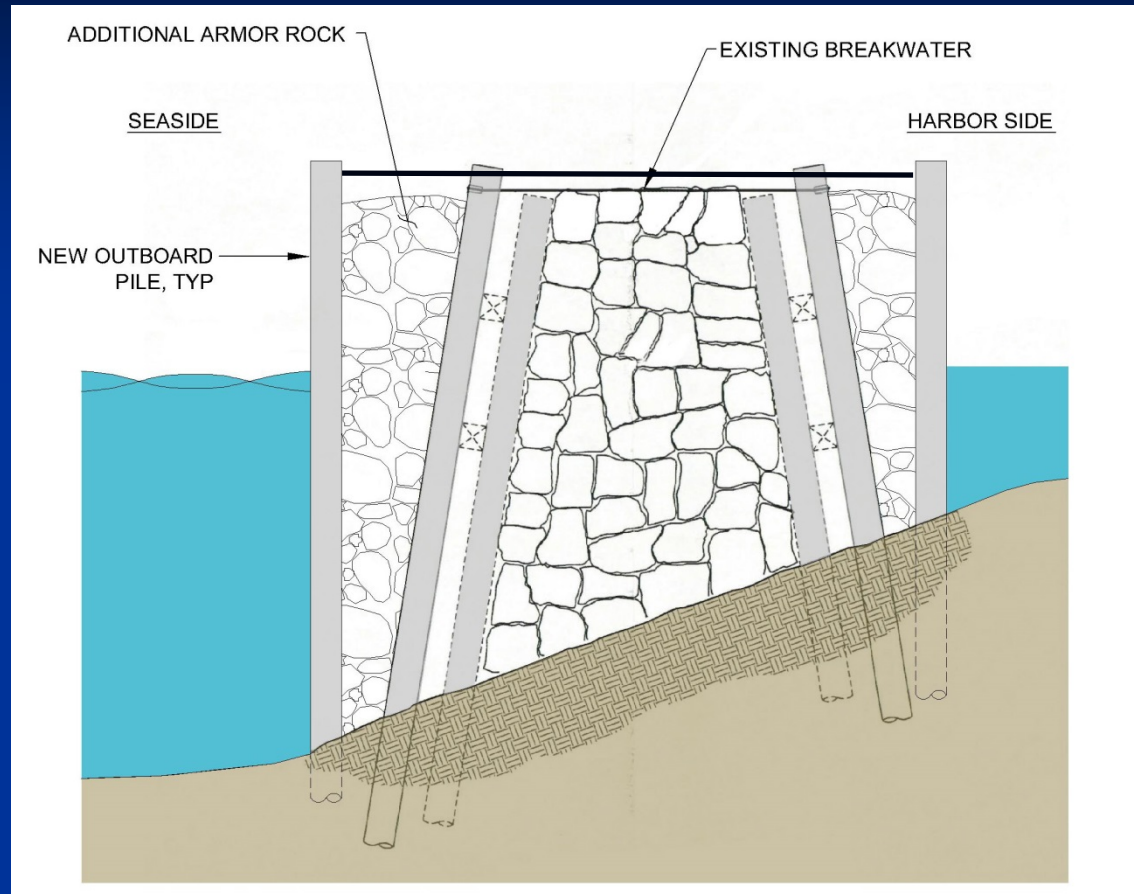


CLOSED CELL (CC) BREAKWATER



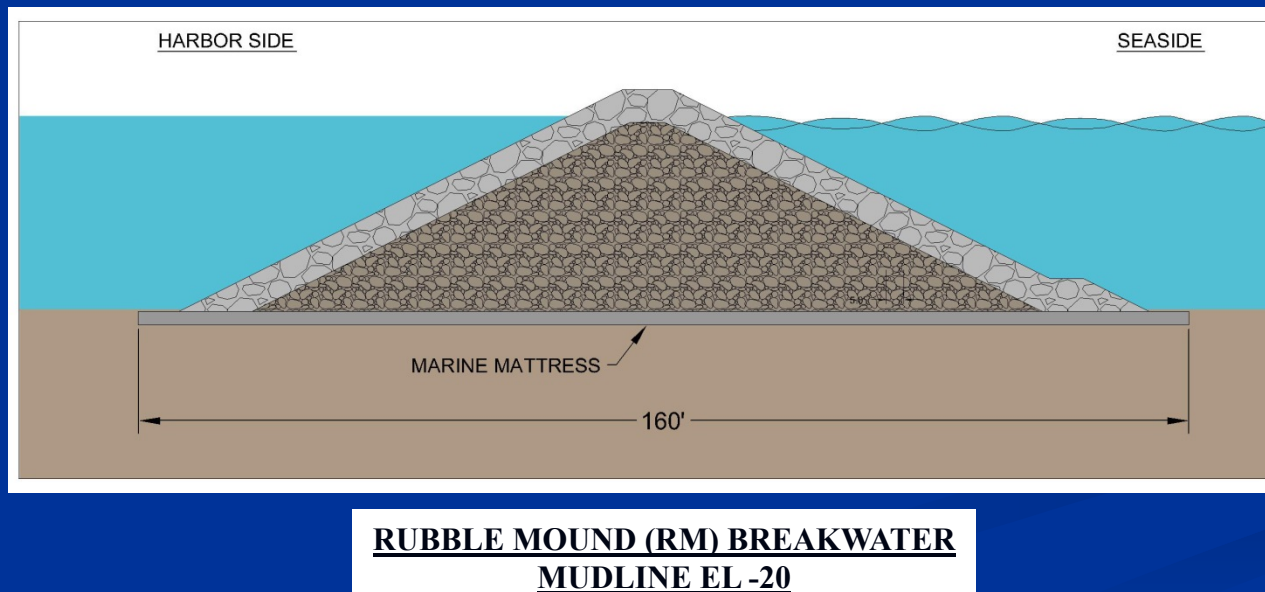
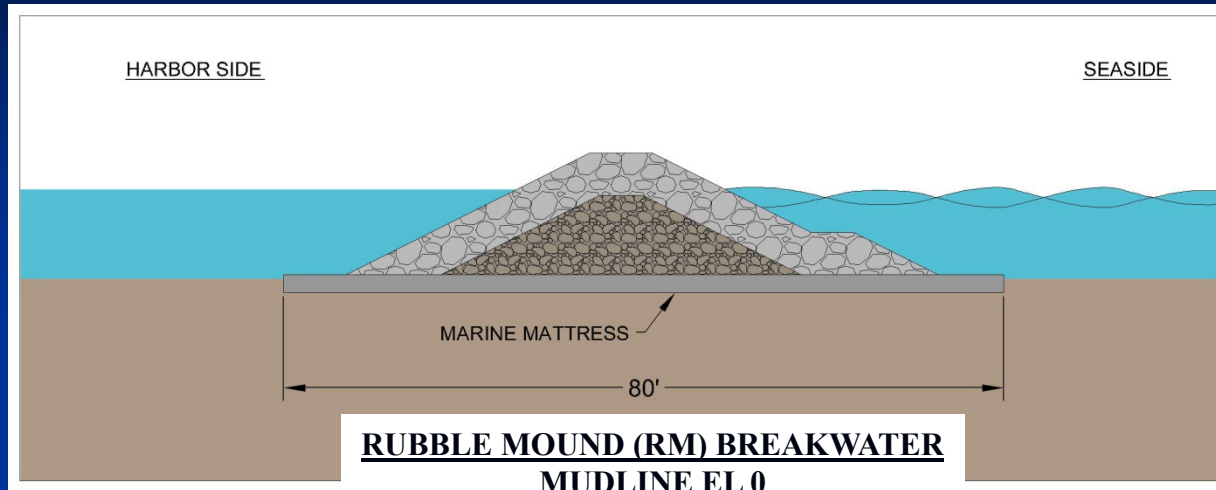
RUBBLE MOUND (RM) BREAKWATER

Protecting the Marina - Options



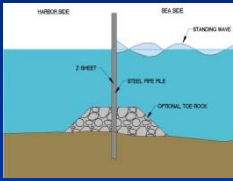
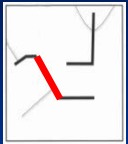
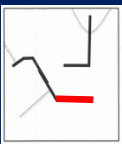
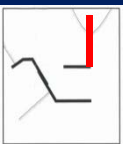
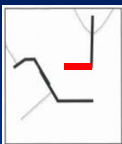
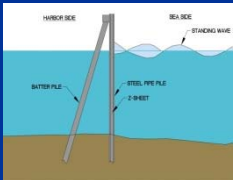




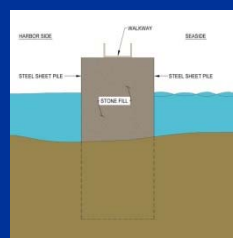




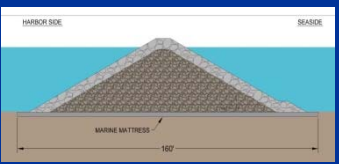




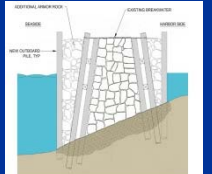




EXTERIOR SOLDIER PILE

Protecting the Marina - Options



Footprint too large
~ Not Feasible for
seaward
breakwater leg

Breakwater Alternatives Matrix

		South Breakwater		North Breakwater	
		Shore	Seaward	Shore	Seaward
Vertical Pile (VP)					
Braced Pile (BP)					
Closed Cell (CC)					
Rubblemound (RM)					
Exterior Soldier Pile (ESP)					

Pre-Feasibility Evaluation

- Evaluation Conducted Relative to the following:
 - Structural
 - Construction Cost
 - Material, Installation, Mobilization, etc...
 - Previous Similar Project Experience
 - Recent Puget Sound Areas Breakwater/Jetty Construction
 - Depths (Total Height of Structure)
 - Bottom Elevations
 - 0' MLLW, -5' MLLW, -10' MLLW, -20' MLLW
- Purpose:
 - Determine Range of Feasible Concepts and range of cost for project planning
 - Evaluation of breakwater configuration not conducted in this phase; next phase coastal engineering analysis to evaluate new configuration

Protecting the Marina - Options

Mudline EL 3.5, 129'

Vert. Pile Wall (\$6.5k/ft)
Braced Pile Wall (\$6.5k/ft)
Closed Cell (\$6.5k/ft)
Rubble Mound (\$4.8k/ft)
Exterior Soldier
Pile (\$8.8k/ft)

Mudline EL -13, 129'

Closed Cell (\$8.3k/ft)
Braced Pile Wall (\$6.9k/ft)

Mudline EL -7, 100'

Vert Pile Wall (\$6.9k/ft)
Braced Pile Wall (\$6.9k/ft)
Closed Cell (\$8.3k/ft)
Exterior Soldier Pile (\$10k/ft)

Mudline EL -1, 184'

Vertical Pile (\$6.5k/ft)
Closed Cell (\$6.5k/ft)
Rubble Mound (\$4.8k/ft)
Vert Pile Wall (\$6.5k/ft)



Order of Magnitude Upper Bound Cost Estimate

<u>Vertical Pile Wall</u>	Mudline	\$/LF		<u>Includes</u>
<u>Braced Pile Wall</u>	EL 0	\$	6,500.00	Demolition/Disposal
	EL -5	\$	6,700.00	New Materials
	EL -10	\$	6,900.00	Installation
	EL -20	\$	7,300.00	Mob/Demob (6%)
<u>Exterior Soldier Pile</u>	Mudline	\$/LF		Sales Tax (8.4%)
	EL 0	\$	8,800.00	Contingency (15%)
	EL -5	\$	9,400.00	
	EL -10	\$	10,000.00	
	EL -20	\$	11,100.00	<u>Excludes</u>
<u>Rubble Mound</u>	Mudline	\$/LF		Engineering Fees
	EL 0	\$	4,800.00	Permitting Assistance
	EL -5	\$	6,800.00	Construction Administration
	EL -10	\$	9,200.00	Walkway Construction
	EL -20	\$	16,000.00	South Bulkhead
<u>Closed Cell</u>	Mudline	\$/LF		
	EL 0	\$	6,500.00	
	EL -5	\$	7,400.00	
	EL -10	\$	8,300.00	
	EL -20	\$	10,000.00	

Order of Magnitude Cost Estimate

	Segment	Length [ft]	Potential System	Mudline [EL, MLLW]	Low Cost \$/ft	High Cost \$/ft	Low Cost	High Cost
N. Breakwater								
	Shore Leg	184	VP, BP, CC, RM	-1	4.8	6.5	\$ 880,000	\$ 1,200,000
	Seaward Leg	100	VP, BP, CC, ESP	-7	6.9	10	\$ 690,000	\$ 1,000,000
S. Breakwater								
	Shore Leg	129	VP, BP, CC, RM, ESP	3.5	4.8	8.8	\$ 620,000	\$ 1,140,000
	Seaward Leg	129	BP, CC	-13	6.9	8.3	\$ 890,000	\$ 1,070,000
	VP - Vertical Pile Wall					Total	\$ 3,080,000	\$ 4,410,000
	BP – Braced Pile Wall							
	CC- Closed Cell							
	RM - Rubble Mound							
	ESP – Exterior Soldier Pile							

Cost Evaluation Summary

- Estimated Construction Cost - Breakwater
 - \$3.25 Million to \$4.75 million
- Engineering, Data Collection, Permitting
 - Typically 15%
- Walkway?
 - To be determined

Next Steps

- Data Collection
 - Survey (Upland & Hydrographic)
 - Geotechnical borings
- Final Alternatives Evaluation
 - Coastal Engineering Analysis
 - Refine Entrance Channel & Breakwater Configuration
 - Reduce Construction Costs & Increase Entrance Safety & Maneuverability for Larger Vessels
 - Structural Engineering Analysis – Refine Design Concepts
 - Refine structure type, size, alignment
- Preliminary Engineering
 - Analysis, Design & Cost Estimates
- Permit Application Documents

Other Considerations

- Grant Funding
 - WA DNR - Creosote Treated Timber Pile Removal Program
 - RCO – Overwater Public Access Walkway
 - RCO – Breakwater for Marina Protection

PORT OF PORT TOWNSEND



Point Hudson Marina Entrance Breakwater Feasibility Assessment



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May 28, 2014