

Dickman Mill Pile Field Removal Coastal Engineering Assessment

Phase 2 Summary Memorandum

Project: Dickman Mill Sediment Transport Study

Our reference: 507101897 **Your reference:** AE 437

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Approved by: Scott Fenical **Checked by:** Scott Fenical

Subject: Phase 2 - Results Summary

1 Introduction

The Washington Department of Natural Resources (DNR) plans to remove approximately 1,000 timber piles from the intertidal and nearshore areas at the site of the old Dickman Mill (Figure 1-1). Dickman Mill is located along Ruston Way in Tacoma, Washington, on Commencement Bay in the Puget Sound. The mill operated from 1889 to 1977 and was located on a large wharf built over the water. The remaining creosote treated piles are suspected to be an ongoing source of contamination. Prior to removing the pile field, DNR is assessing the risk that pile field removal poses to additional erosion and release of contaminants of concern (COCs), and potential effects on nearby properties. DNR requested Mott MacDonald evaluate risks of pile removal following a two-step process: Phase 1 was a qualitative assessment completed in December 17, 2020, and Phase 2 was a quantitative modeling assessment which is the subject of this technical memo. The results of the Mott MacDonald analysis will be used to guide DNR on next steps and discussions with stakeholders, evaluate the need for additional field sampling and testing, the type of sampling required, and budgetary cost.

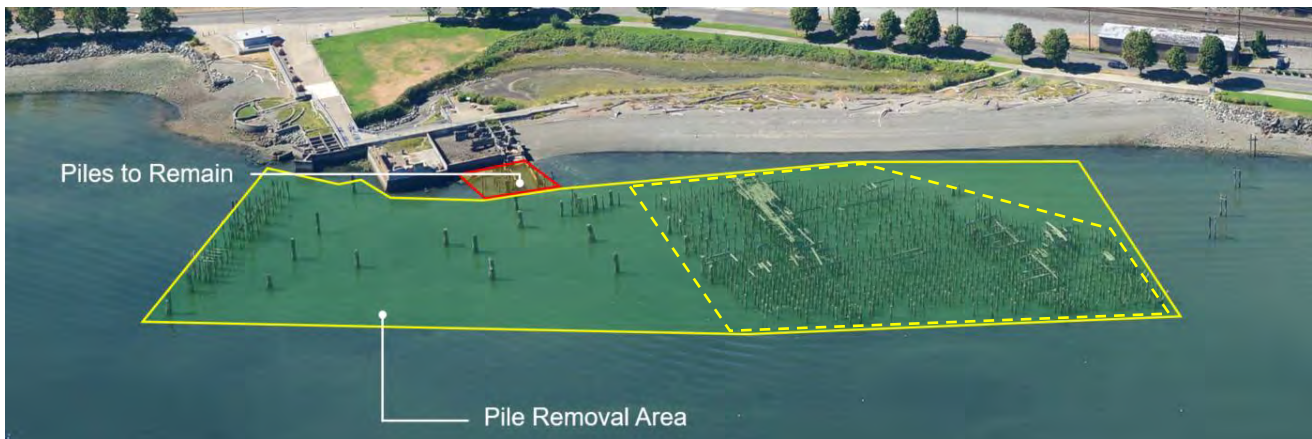


Figure 1-1 Pile Removal Areas – Focus of the analysis is on the dense pile field area within the dashed polygon.

The purpose of Phase 1 was to develop an initial opinion on the risk and level of potential contaminant spread outside the study area, and potential for impacts to the adjacent beach, due to pile field removal. Phase 2 was determined to be necessary following the results of Phase 1 and better quantifies potential movement of COC-

laden sediments and potential impacts to adjacent tideland and shoreline properties following pile field removal. DNR, Mott MacDonald, and GeoEngineers determined jointly that preliminary modeling should be conducted prior to additional field data collection so that the analysis could inform the sampling plan. Phase 2 analysis was performed to answer the following questions:

- Where in the pile field are the higher-risk areas of increased erosion and sediment mobilization after pile field removal¹?
- Does transport of sediments/COCs mobilized from the pile field result in off-site exceedances?
- Does pile field removal result in a higher risk of beach profile adjustment causing exposure of the existing wood under-layer on the beach?
- Based on the modeling results, where should DNR conduct sampling, what type of sampling should be performed, and how much might it cost?

Work conducted in Phase 2 included:

- Data review and analysis
- Coastal conditions analysis and modeling (winds, waves, currents)
- Hydrodynamic analysis and modeling
- Sediment transport analysis and modeling
- Evaluation of potential pile field removal impacts:
 - Mobilization of sediments/COCs from pile field to surrounding areas
 - Impacts to adjacent shoreline (beach profile modeling)
- Development of a sampling and analysis plan, and associated costs.

This technical memo summarizes the methodology, results, and conclusions of this analysis. Additional analysis details are included in an updated PowerPoint presentation provided to DNR on June 28, 2021 (see Appendix A). The Sampling and Analysis Plan is included as Appendix B.

2 Methodology

Numerical modeling tools were used to evaluate 1) potential movement of COC-laden sediments, and 2) potential impacts to adjacent properties following pile field removal. The physical processes and materials associated with these two distinct processes are different, requiring two different modeling efforts.

2.1 Methodology for Evaluating Potential Movement of COC-Laden Sediments

Two-dimensional hydrodynamic, wave and sediment transport model(s) were used to evaluate potential spread of COC-laden sediments eroded from the pile field area following pile field removal. Salish Sea hydrodynamic modeling was performed using MIKE21 FM (DHI 2021) covering the entire Salish Sea. The model was validated using tidal measurements throughout Puget Sound, including at Tacoma, and results compared favorably with similar modeling results produced by PNNL (2014). Nearshore sediment transport modeling was performed using a high-resolution nested MIKE21 model covering approximately 1.9 miles of shoreline at the project site. Storm conditions were developed using a 6-day long prototype storm with the peak wind speed scaled to 2-year winds (50% annual exceedance probability) and 50-year winds (2% annual exceedance probability) from NW, N, and NE directions. Southerly storms are not anticipated to mobilize site sediments and therefore were not considered. Typical tides and currents were taken from the Salish Sea

¹ Focus of the analysis is within the "dense" area of the pile field, outlined in Figure 1.

model and used to force the boundaries of the nested model. Additional details on model development, data sources and inputs can be found in Appendix A.

Site sediments were characterized using grain size measurements collected onsite by DNR. Site sediments are mixed, and estimated to be approximately 20% gravel, 60% sand, and 20% silt/clay. The bed content was estimated by averaging the measured levels of sand and mud content at sample locations within the central and north areas of the pile field. Sand grain sizes evaluated were *Very Coarse*, *Coarse*, *Medium*, *Fine* and *Very Fine Sand* (USGS Wentworth scale). Based on preliminary modeling, *Coarse Sand*, *Very Coarse Sand*, and *Gravel* were all determined to be immobile under extreme conditions and were not simulated. *Medium Sand*, *Fine Sand*, and *Very Fine Sand* were modeled as Type 1 Sand (0.088 mm), Type 2 Sand (0.177 mm), and Type 3 Sand (0.354 mm), respectively.

Mud (silt/clay) fractions were modeled separately from sand. Preliminary modeling showed that clay spreads over a very large area due to very low settling speeds and represents only a very small fraction of the bed; therefore, the clay fraction was included with the mud fractions in the modeling and was not modeled separately. *Fine to Very Fine Silt*, and *Coarse to Medium Silt*, were modeled separately as Type 1 Silt and Type 2 Silt, respectively. Sediment transport properties for the silts were taken from previous Puget Sound studies (USGS 2008, Lavelle & Davis 1987, Blake and Chadwick 2007). By modeling different sediment types separately, armoring² effects are not included, which is a conservative assumption resulting in significantly more predicted erosion. Additional details on sediment types near the pile field can be found in Appendix A.

Wave transmission through pile field (post-removal versus existing conditions) was estimated to assess the potential change in wave energy at the shoreline. Transmission was estimated using an empirical formula (Hayashi et al. 1966; Truitt & Herbich 1986), and also modeled in the MIKE21 FM spectral wave model using obstacle lines placed along each pile row. Both methods showed approximately 75% overall transmission (transmitted wave heights only 75% of incident offshore wave heights). These obstacle lines were removed from the MIKE21 FM wave model to simulate pile field removal. Results included hydrodynamics, waves, suspended sediment concentrations, and resulting bed changes. All resulting bed changes were weighted based on the fraction of each material within the bed in the eroded area.

2.2 Methodology for Evaluating Potential Impacts to Adjacent Properties

Potential impacts to adjacent properties following pile field removal focused on the adjacent gravel beach (part of Dickman Mill Park) which was nourished with a gravel layer around 2000. Potential changes to the gravel beach from pile field removal were evaluated using a 1-dimensional application of XBeach-G, which simulates beach profile adjustment for gravel beaches including groundwater interaction. Profile adjustment was simulated along a cross-shore transect taken through the center of the pile field.

Offshore boundary condition data (incident wave heights, water levels) were taken from the larger-scale models described in Section 2.1. For the simulations of future conditions (without pile field), the full computed offshore wave heights were used as input. For the existing conditions simulations, incident wave heights were reduced so as to represent the 75% transmission through the pile field. Beach material size is based on review of available design documents from the nourishment project and field verification. The assumed gradation includes a median diameter (D_{50}) of 1 inch, and 90 percentile diameter (D_{90}) of 2 inches. Sensitivity analysis was also performed assuming 25% coarser and 25% finer gradations. Results of the beach profile modeling included waves and resulting bed changes. Resulting beach profiles were evaluated for existing conditions (with pile field) and future conditions (without pile field).

² Armoring results following erosion of finer sediments which leaves a surface layer of coarser material less susceptible to erosion. Neglecting armoring effects in the analysis is conservative as it assumes the finer material below the armored surface layer can be mobilized.

3 Results

A brief summary of analysis results is included here with additional details provided in Appendix A.

3.1 Results - Potential Movement of COC-Laden Sediments

Movement of COC-laden sediments was analyzed under a range of storm conditions – some of those conditions indicating movement, and others indicating limited mobilization and movement. Erosion in the pile field is sensitive to the change in significant wave height due to the removal of the pile field. This sensitivity is due to a combination of wave heights, wave period and water depths at the time of the storm³. Modeling of the 2-year storm was conducted to characterize typical/recurring storm events, whereas the 50-year event was modeled to characterize more energetic extreme events. Sensitivity testing indicated the following:

- 2-year storm events induce minimal erosion for either existing conditions (with pile field) or future conditions (without pile field).
- Erosion and mobilization of sediment appears sensitive to wind direction, with Northerly winds mobilizing the greatest amount of sediment. Storms from other directions induce limited seabed erosion.
- The 50-year worst-case direction storm conditions cause relatively mild erosion in the pile field after pile removal (as shown in Figure 3-1) considering the low frequency of the event. The erosion shown in Figure 3-1 is total erosion, not the additional erosion that results from pile field removal.
- Limited erosion occurs in the deeper-water portions of the pile field as the wave-induced bottom velocities are not strong enough to mobilize the seabed. More sediment is mobilized in shallower water where the wave-induced bottom velocities are higher.
- **Pile field erosion appears to be measurably larger for post-removal conditions compared to existing conditions. Slide 32 of Appendix A shows the erosion in the pile field weighted by sediment type following the 50-year storm event from the worst-case direction.**

Results of the 50-year storm modeling indicate:

- Peak erosion is estimated to be approximately 0.9 feet and occurs in the shallowest water near the beach slope, both within DNR and City of Tacoma Metro Parks (Metro Parks) parcels.
- Eroded sand is anticipated to deposit locally within the project area, both within and just outside the pile field within primarily Metro Parks parcels.
- Eroded mud (silt/clay) is not anticipated to deposit locally; mud is anticipated to be transported down-drift to the southeast into deeper water where it is likely to become deposited in a thin veneer over a large area, primarily on DNR submerged lands. The deposition offsite following a 50-year storm after pile field removal is shown in Figure 3-2. The deposition shown in Figure 3-2 is total deposition, not the additional deposition that results from pile field removal.
- Maximum thickness of mud deposition anywhere outside the project area is approximately 0.1 inches.
- Calculation of resulting average surface layer concentrations is feasible but was not conducted at this time due to unknown conditions in the areas offsite where material may accrete. These calculations require prescriptive surface layer thickness and understanding of ambient COC concentrations in those off-site areas. If field sampling is performed, samples should also be collected in these off-site

³ In these simulations, water level at peak wave activity was approximately Mean Sea Level, though peak wave activity during storms could arrive at varying water levels, shifting the area of potential erosion to some degree

areas where deposition is predicted. Calculations are straightforward to perform at a later date and require no further modeling.

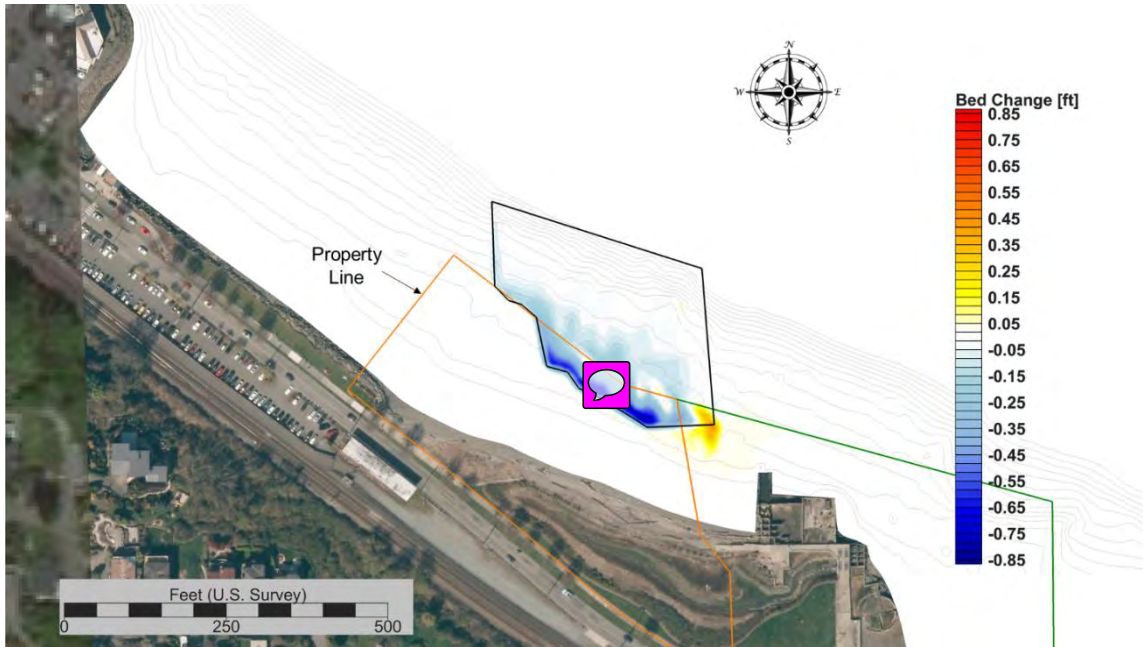


Figure 3-1 Erosion and deposition of sandy material caused by a Northerly 50-year storm event. Metro Parks parcel lines are shown in orange and green.

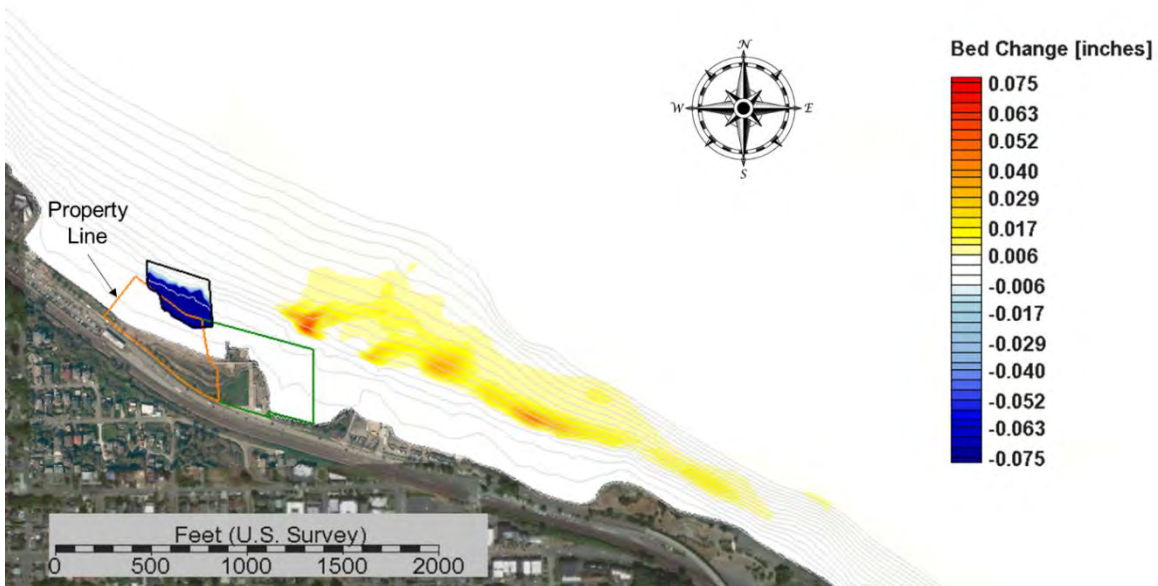


Figure 3-2 Erosion and deposition of mud (silt/clay) caused by a Northerly 50-year storm event. Metro Parks parcel lines are shown in orange and green.

3.2 Results – Potential Impacts to Adjacent Properties

Phase 1 analysis results indicated that the assessment of potential impacts to adjacent properties should focus on changes to the beach landward of the pile field. The existing beach above MLLW consists of a thin (1-2 foot) gravel/sand layer of material above a layer of wood waste. Since installation of this material in 2000 the beach appears to have adjusted in response to storms.

Beach profile adjustments result in localized vertical erosion, which at Dickman Mill could expose the wood waste layer under the beach. The magnitude of the profile adjustments depends on wave climate, the water level at the time of heavy wave activity, and the material on the beach. Existing thickness of this layer varies across the site, with limited hand dug explorations indicating the existing thickness of this layer to be ~6 inches near MLLW, and greater than 1.5 foot near MHHW. Analysis was conducted to estimate the risk of increased beach adjustment in response to storms that could increase the risk of exposure of the now buried layer of wood waste. An example of potential beach profile adjustment is shown in Figure 3-3, where the beach profile has adjusted in response to a set of storm waves and water level combinations.

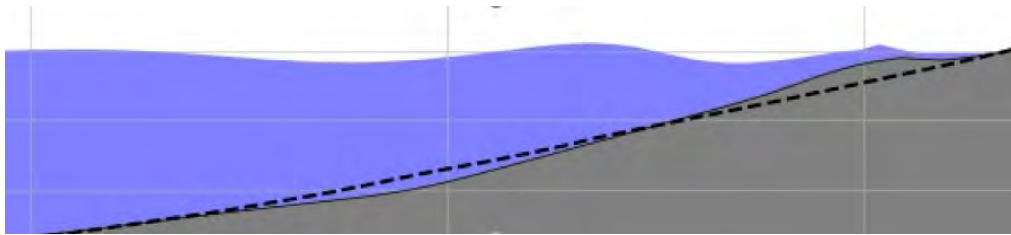


Figure 3-3 Example beach profile adjustment with original beach profile shown as a dashed line, and localized erosion below the dashed line.

The XBEACH-G model simulates beach profile evolution in response to storm conditions (water levels and waves) on gravel beaches, similar to the conditions found on site. Application of this model considering the site conditions indicates that due to the size of the beach gravel/sand mix found on site, smaller storms such as the 2-year event (~50% annual probability) appear to cause negligible differences in beach adjustment considering simulations with, and without, the pile field. However, in the larger storms, such as the 50-year storm, the differences in beach adjustment are likely non-negligible. Adjustment (or lowering) of localized areas of the beach due to storms could increase by approximately 4-8 inches due to removal of the pile field.

In summary, results of the beach profile modeling indicate that the increase in risk of exposing wood waste material under the gravel/sand beach due to pile removal is minimal except during major events. During major events (e.g. 50-year storm), localized erosion may increase on the order of 4-8 inches, exposing underlying wood waste material.

5 Conclusions

Phase 2 results provided a quantitative assessment of two potential pile field removal impacts that may occur during storm events: 1) transport of COC-laden sediments from the site and deposition offsite, and 2) impacts to adjacent properties (i.e. beach erosion). The analysis utilized validated numerical modeling tools and a conservative representation of site conditions and site physical processes. Modeling results and analysis indicate the following:

- COC movements outside the project area are only likely to occur for mud sediment fractions, which are mobilized far outside the pile field and are likely to deposit as a thin veneer on the seabed.
- Gravel and coarse sand are not anticipated to be significantly mobilized. Mobilized smaller sand material is anticipated to remain adjacent to the pile field.
- Pile field removal is anticipated to result in minimal changes to erosion in the pile field during more frequent events (e.g. 2-year storm); however, larger wave heights and increased localized erosion in the pile field (potentially on the order of 6 inches) are anticipated during rare extreme events (e.g. 50-year storm from the limiting-case direction).
- Mud spread to other areas is likely to be deposited as a thin veneer (less than 0.1 inches thick) that is unlikely to result in high local overall COC concentrations. For example, the thickest veneer of mud potentially deposited anywhere outside the project area (less than 0.1 inches) would only constitute ~2% of the top 10 cm of surface sediment.

Phase 2 questions posed by DNR are repeated in Table 1 and answered based on results of the analysis.

Table 1 - DNR Objectives Summary

Where in the pile field are the higher erosional risk areas?	What is the likely fate of mobilized sediments?	How will the adjacent beach adjust?	Where, and how should DNR conduct sampling?
<ul style="list-style-type: none"> • Shallow water areas are more erosive – erosion is likely to occur in Metro Parks property. • Erosion anticipated to be less than 1 foot during limiting-case 50-year event. • Analysis to be updated after site investigations to confirm initial modeling. 	<ul style="list-style-type: none"> • Fate depends on sediment size; mud is anticipated to leave the site, but sand is anticipated to remain nearby. • Mud (including sawdust) likely to be suspended and deposit in a thin veneer over primarily DNR submerged lands SE of the project site. 	<ul style="list-style-type: none"> • Beach is dynamic, adjustments already observed. • Increase in wave height due to pile field removal results in a higher risk of localized beach erosion in extreme storms. Negligible changes are expected for most storm conditions. 	<ul style="list-style-type: none"> • GeoEngineers developing SAP and cost estimate to implement. • Sampling is suggested in erosive area and far-field depositional area. • Surface sampling appears to be sufficient. No vibracoring is suggested. • Suggest limiting contaminant analysis COCs with high initial exceedances.

6 References

Blake & Chadwick (2007). User's Guide for Assessing Sediment Transport at Navy Facilities.

DHI (2021). MIKE21 Numerical modeling system.

Hayashi, T. et al. (1966). Hydraulic Research on Close Spaced Pile Breakwaters. Proceedings of the 10th Coastal Engineering Conference. Vol II, Chapter 50, pp 873-884.

Lavelle & Davis (1987). Measurements of Benthic Sediment Erodibility in Puget Sound, Washington. NOAA Technical Memorandum ERL PMEL-72. Pacific Marine Environmental Laboratory Seattle, Washington.

PNNL (2014). Salish Sea Model Data Portal. Solution files from past Salish Sea Model simulations. Website: <https://www.pnnl.gov/projects/salish-sea-model/data-portal>.

Truitt, CL & Herbich, JB (1986). Transmission of Random Waves Through Pile Breakwaters. Chapter 169. Coastal Engineering – 1986.

USGS (2008). Incorporation of Fine-Grained Sediment Erodibility Measurements into Sediment Transport Modeling, Capitol Lake, Washington. Open-File Report 2008-1340.

Appendix A: Final Results Meeting Slides (June 28, 2021)



WASHINGTON STATE DEPT OF
**NATURAL
RESOURCES**

Dickman Mill Pile Field Removal Coastal Engineering Assessment Final Results

June 28, 2021

Table of Contents

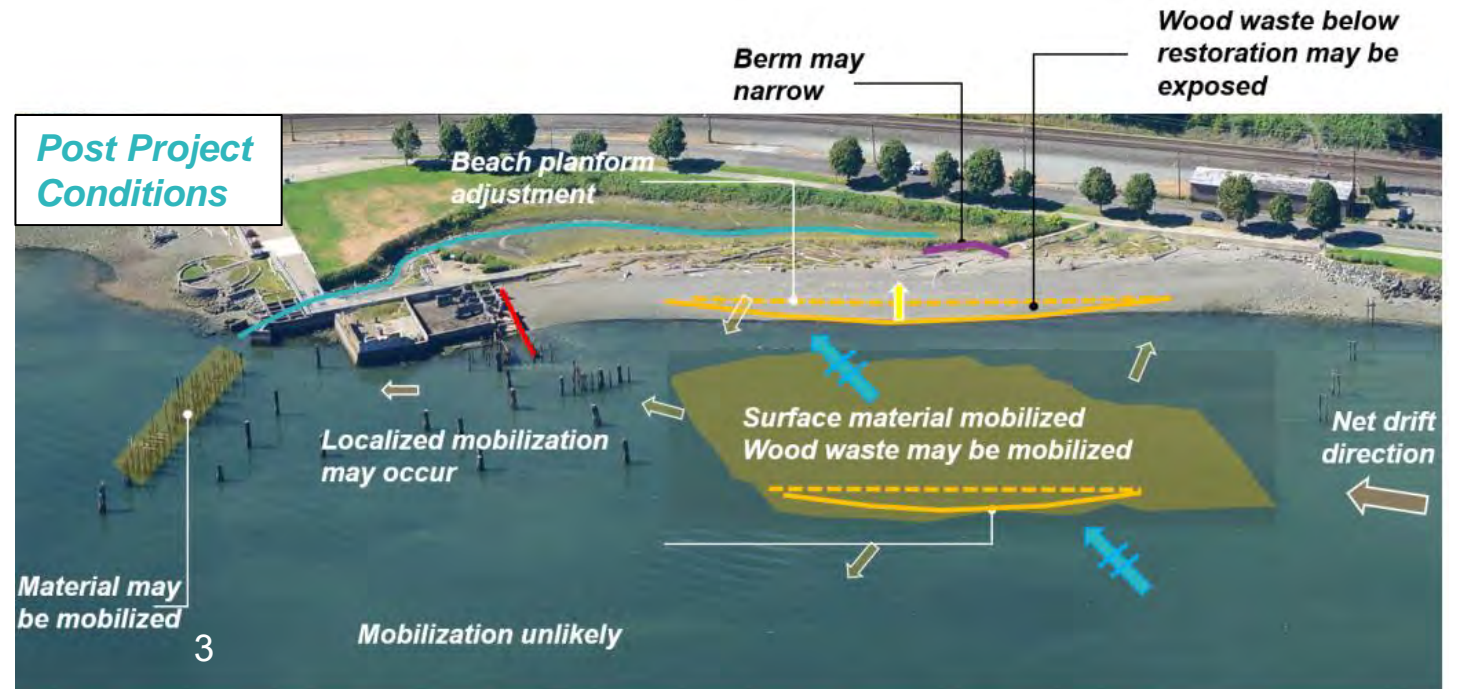
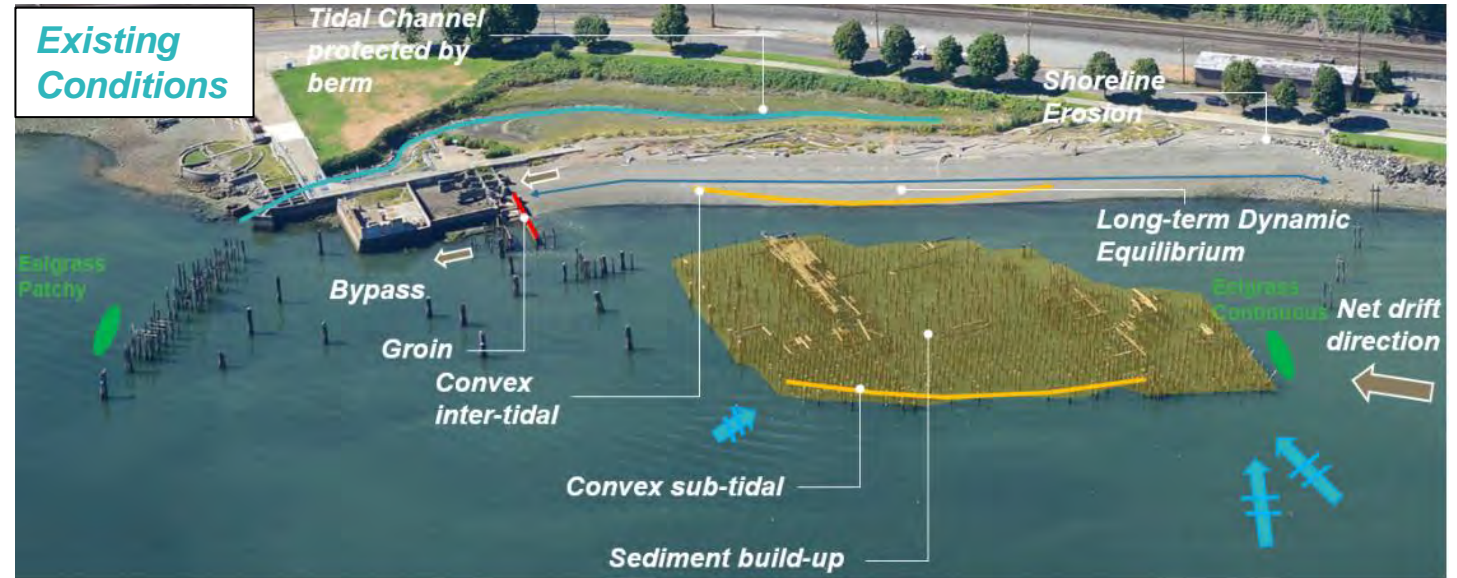
- Background and Phase 1 Review
- Site conditions (bathymetry, sediment data)
- Coastal conditions (winds, waves, currents, sediment transport)
- Sediment/COC transport from pile field area following removal
- Impacts to adjacent properties following removal
- Conclusions

Phase 1 Review

Previous phase of work by Mott MacDonald identified the potential risks associated with pile removal

- Mobilization and fate of sediments and associated COCs
- Beach profile adjustments

Conceptual Site Model



Phase 2 Questions

1

Where in the pile field are the higher risk areas for increased erosion and sediment mobilization after pile field removal?

2

Does transport of sediments mobilized from the pile field result in off-site exceedances?

3

Does pile field removal result in a higher risk of beach profile adjustment causing exposure of the wood under-layer?

4

Based on modeling results, where should DNR conduct sampling, what type, and how much might it cost?

Scope of Work

Phase 1

Data Collection, Compilation and Summary

- Data compilation
- New data
- Site visit
- Existing Structure Documentation
- Site contaminant background
- Existing study compilation
- Seabed profile and sediment evaluation (Qualitative)

Conceptual Site Model

Phase 2

Better quantify potential movement of sediment and related contaminants following removal of pile field

- Data review and analysis
- Coastal conditions analysis and modeling (winds, waves, currents)
 - Generate the near bed velocities that induced erosion due to waves and tidal currents
- Sediment transport analysis and modeling
 - How do the waves and currents mobilize material and transport the material and therefore contaminants?
- Evaluation of potential pile field removal impacts:
 - Mobilization of contaminants from pile field to surrounding areas
 - Impacts to adjacent properties
- Initial sampling plan recommendations and rough costs

Analysis Outline

1

**Site and coastal
conditions
development**

2

**Pile field removal
impact analysis**

- Mobilization of sediments
- Contaminant movement to surrounding areas
- Impacts to adjacent properties

3

Conclusions

Site and Coastal Conditions Development

Tasks Required

Develop site and coastal conditions to be used for hydrodynamic and sediment transport modeling.

Methodology:

1. Construct a site-wide unified elevation model.
2. Characterize sediments near pile field.
3. Analyze wind data sources and confirm storm statistics.
4. Refine MM's existing depth-averaged (2DH) Salish Sea-wide circulation model (MIKE21 FM).
5. Develop a large-scale wave growth and transformation model using SWAN.
6. Develop a refined, nested 2D circulation model with nearshore bathymetry.
7. Perform hydrodynamic modeling (tides, waves, currents) during storm conditions.

Site Conditions

Sediment Data

- All sediment sample locations shown here.
- Seven sample locations within and adjacent to pile field are considered for sediment transport analysis.
- Sediment samples near pile field show a mix of cohesive and non-cohesive sediments.



Summary of sediment distribution near pile field

Location ID	Mud (Silt/Clay) [%]*	Sand [%]	Gravel [%]
DMPR2015-01	26.6	68.2	5.3
DMPR2015-03	22.0	68.1	10.0
DMPR2015-08	34.3	57.9	7.8
DMPR2015-06	9.3	83.8	6.8
DMPR2015-D01	16.9	45.1	38.1
DMPR2015-D02	15.8	60.0	24.2
DMPR2015-D03	16.7	55.3	27.9

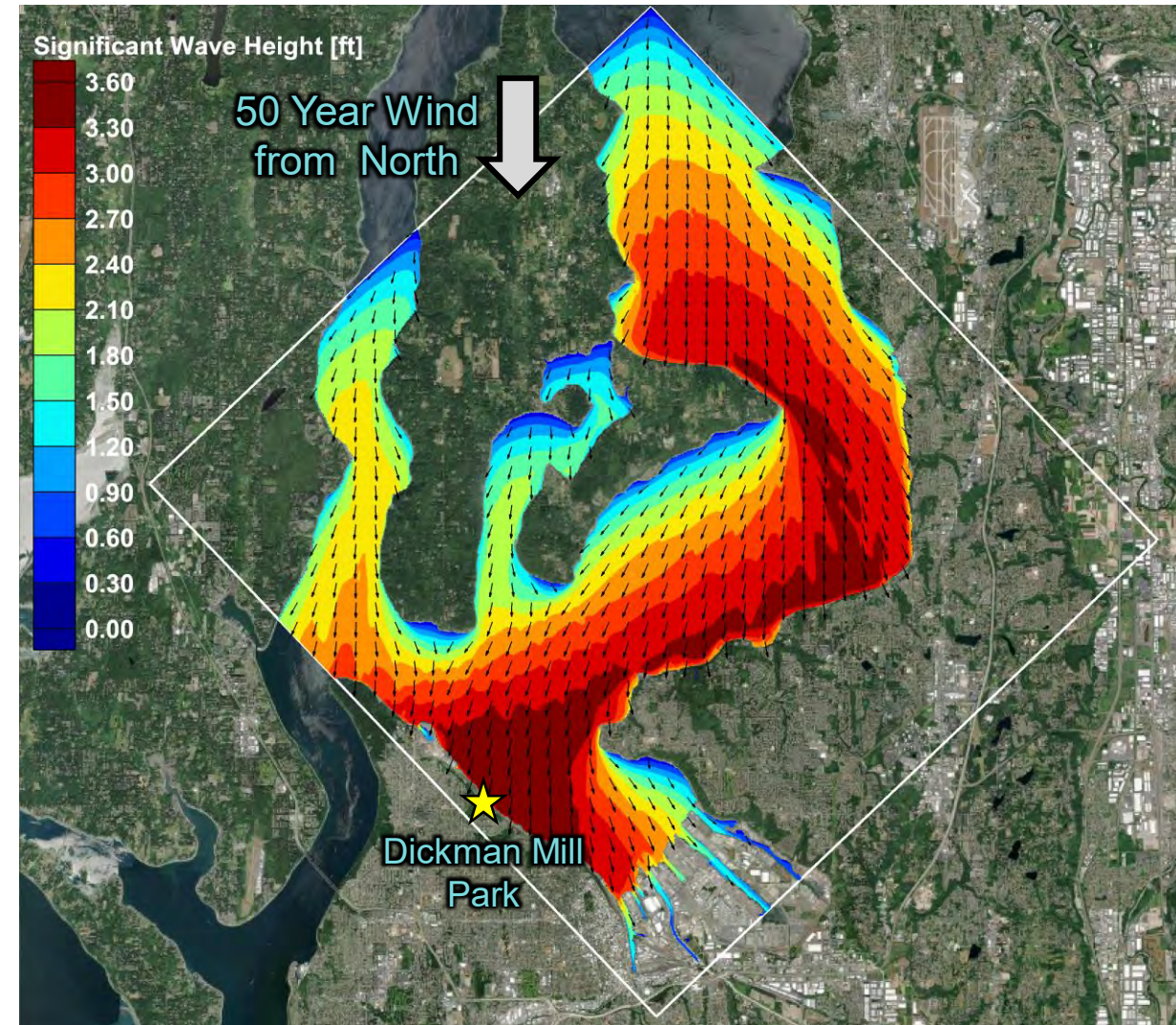
Coastal Conditions

Waves

- No wave measurements available near Project site.
- Wind-waves generated on a large-scale model grid.
- North 50-year wind-waves example shown here.
- Storms simulated ranging in magnitude from 1 to 50-year events, and all directions.

Long-term 2-min duration wind speeds [knots]

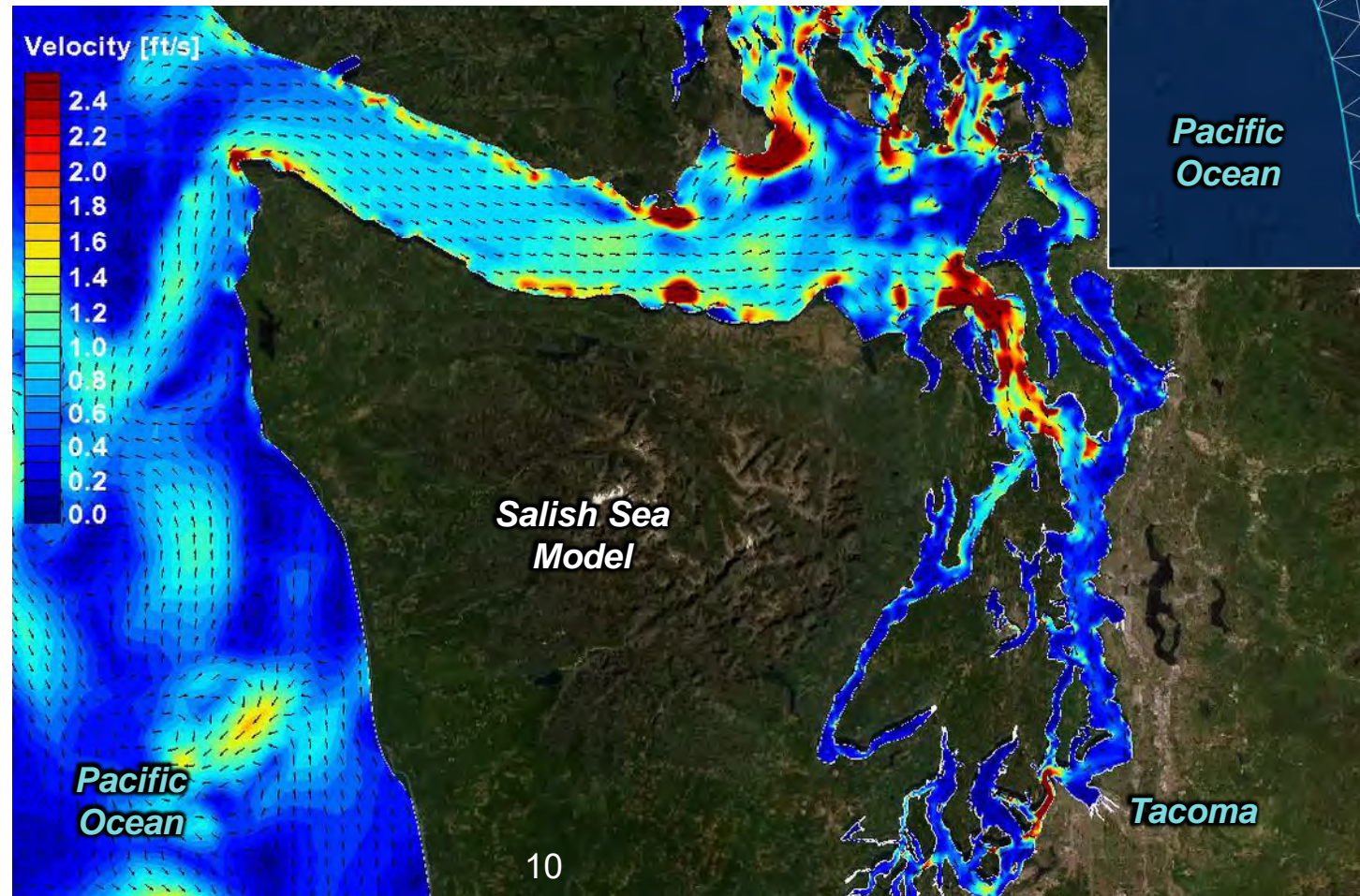
Return Period [year]	N	NE	E	SE	S	SW	W	NW
2	23.9	11.0	11.5	14.4	20.2	17.5	16.2	21.1
25	33.4	20.7	22.8	25.4	28.4	28.2	24.2	31.8
50	35.8	22.6	25.0	29.2	30.0	31.1	26.0	33.8
100	38.1	24.3	26.9	33.2	31.4	34.1	27.7	35.7



Coastal Conditions

Currents and Water Levels

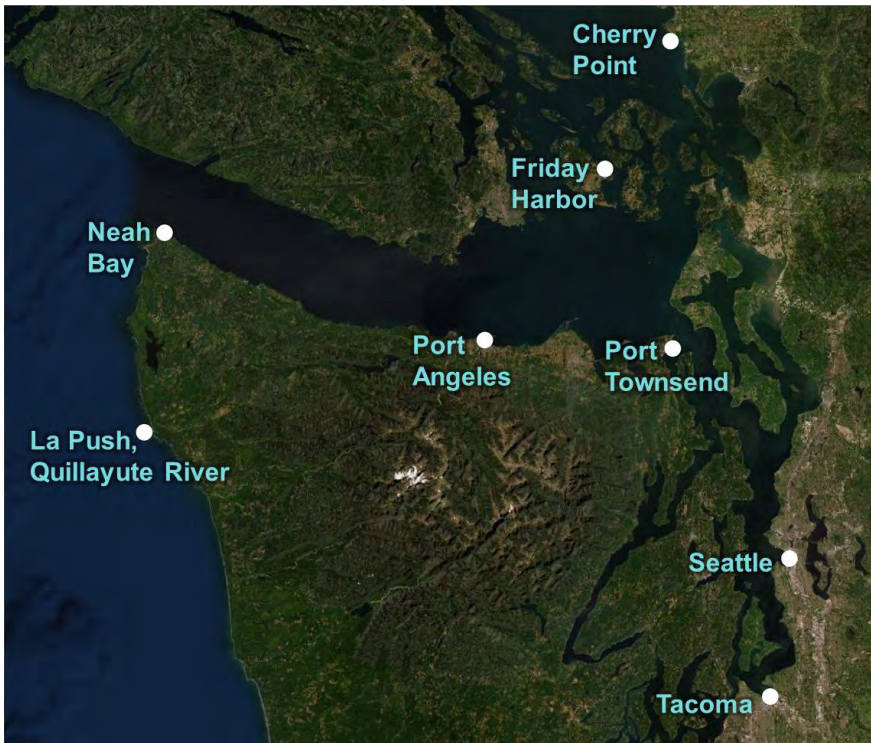
- Tidal hydrodynamics predicted using Salish Sea-wide modeling tools (MIKE21 FM).
- Model grid has been used successfully in other Mott MacDonald studies.
- Tide forcing in Pacific Ocean, rivers/creeks neglected.



Coastal Conditions

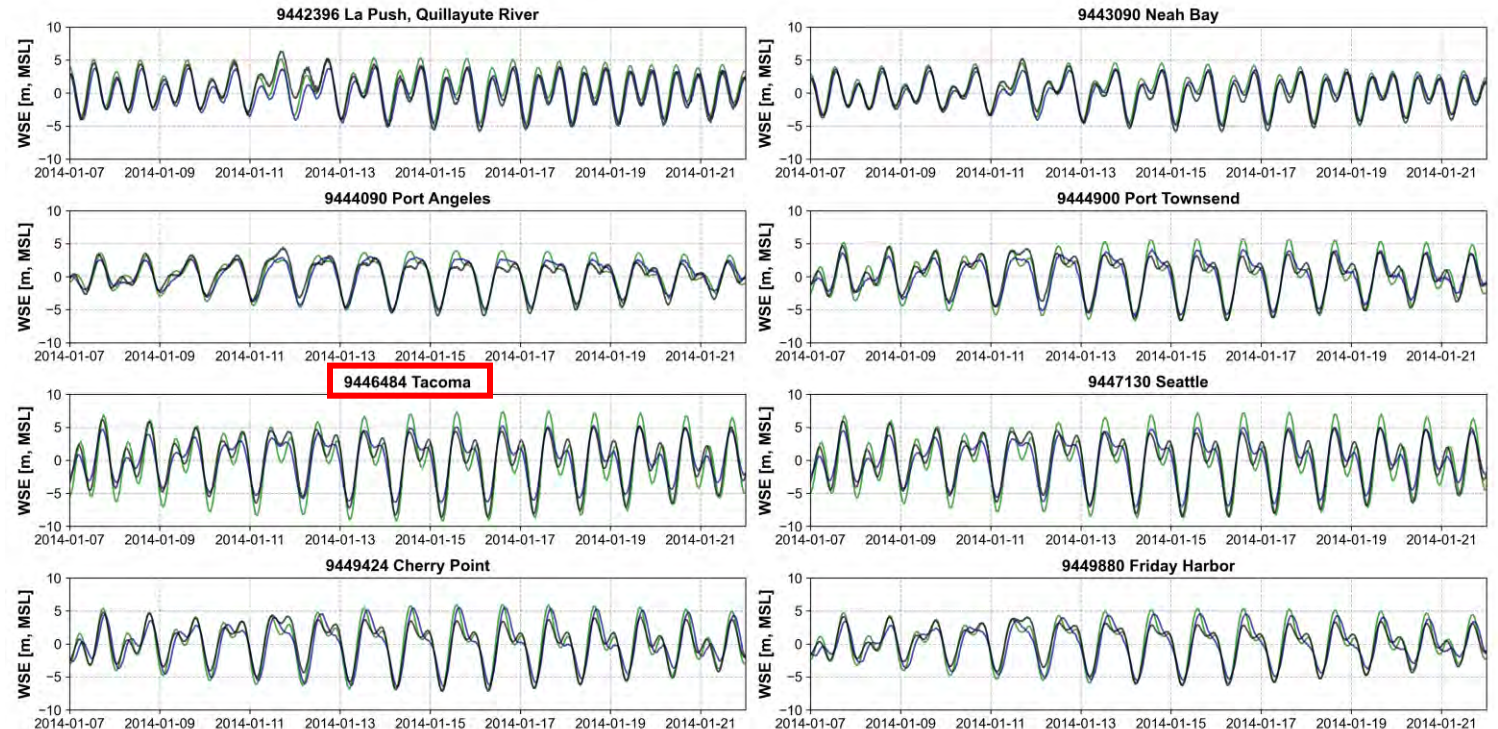
Currents and Water Levels

- Model validation: compared MIKE21 FM results with measured (NOAA) and PNNL Salish Sea study (2014).
- Full-year results available from PNNL Salish Sea study (2014).
- MIKE21 FM performs similar to PNNL model, better performance near Tacoma.



Mott MacDonald

NOAA Tide Stations

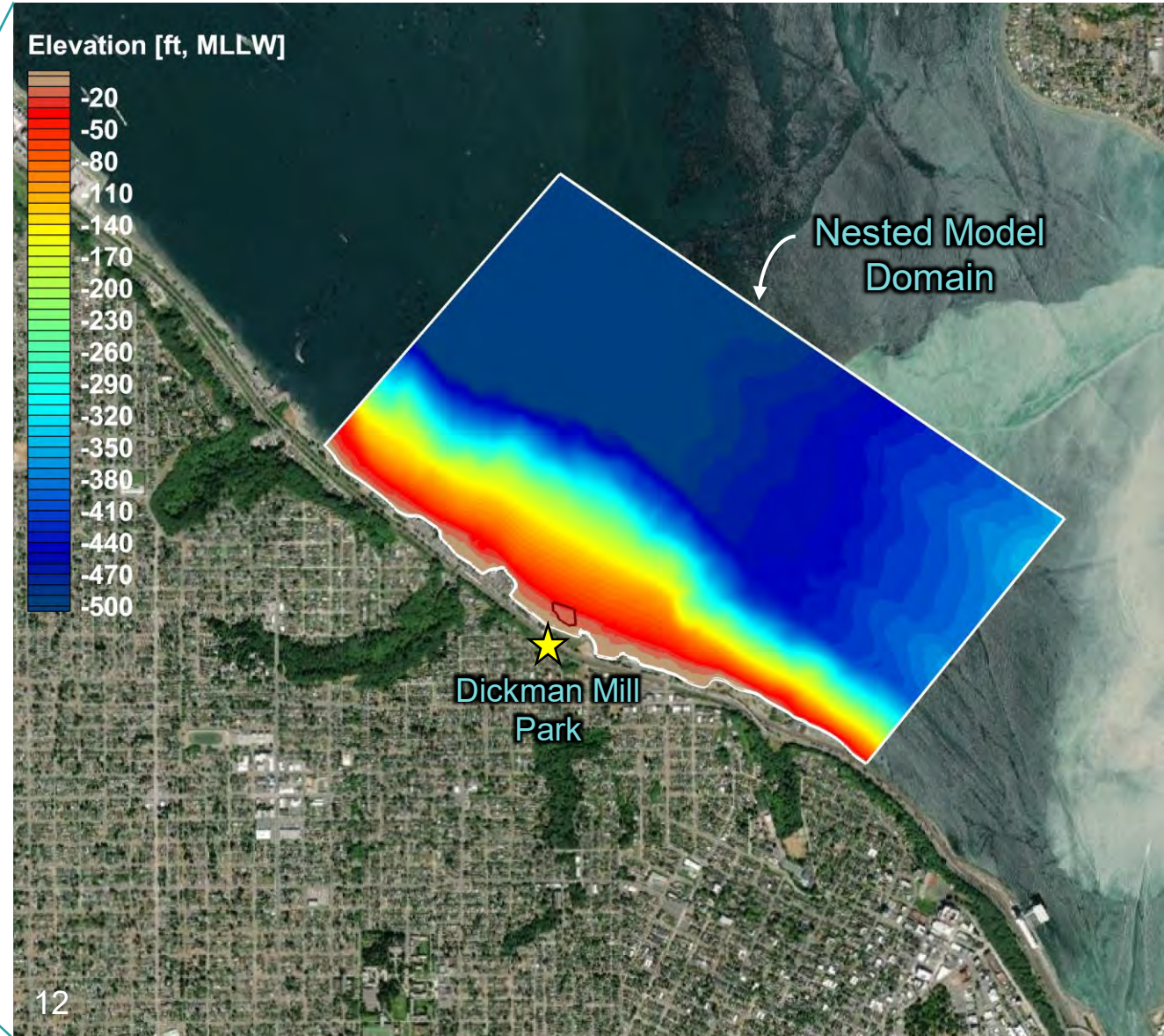


PNNL Salish Sea Model (Green), MIKE Modeled (Blue), NOAA Measured (Black)

Coastal Conditions

Currents and Water Levels

- Salish Sea-wide model results used to force a highly refined nested model, developed using MIKE21 FM.



Coastal Conditions

Currents and Water Levels

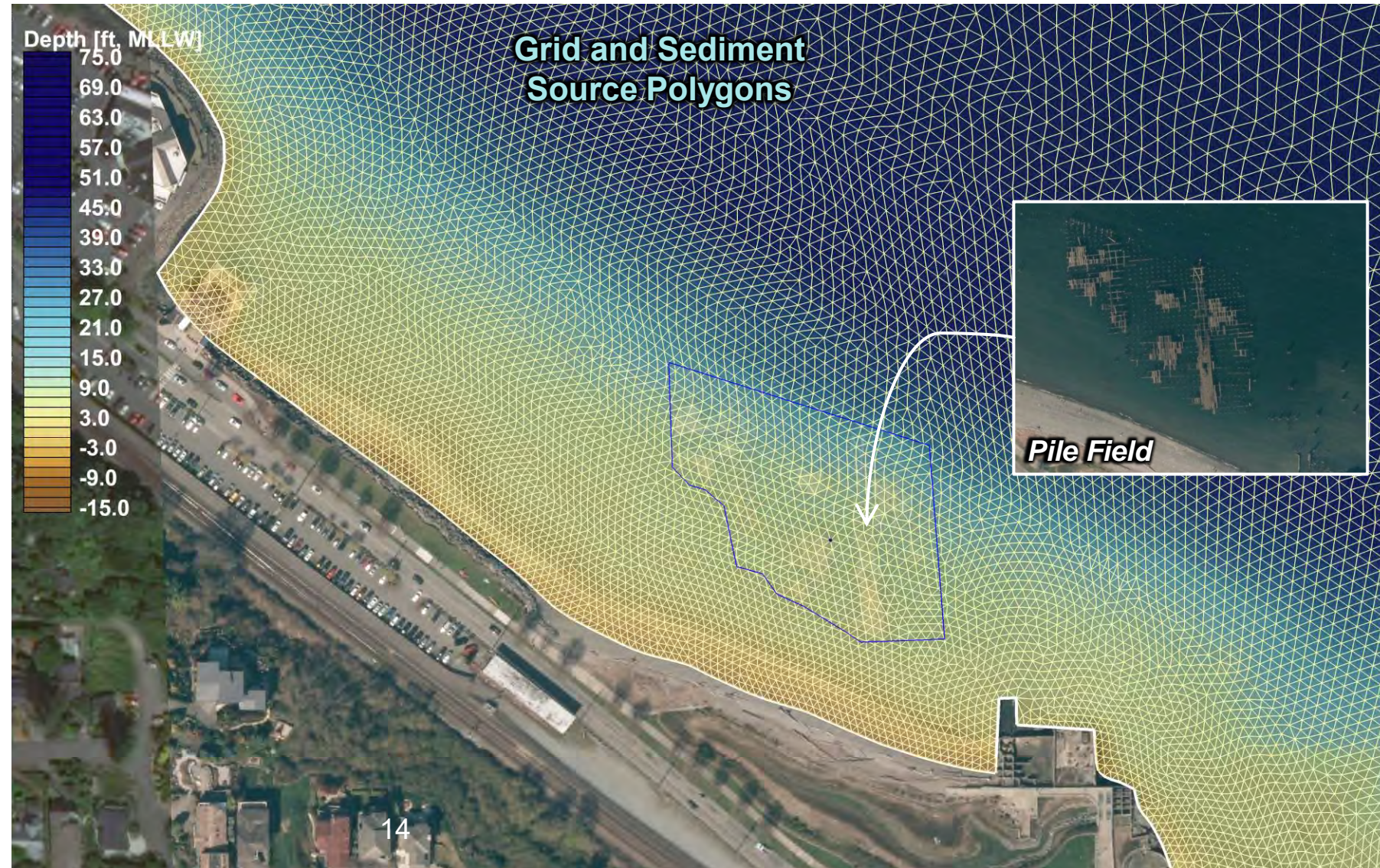
- Nested model mesh with variable mesh resolution shown here.
- Mesh resolution varies from 6 ft near shoreline to 150 ft offshore.



Coastal Conditions

Currents and Water Levels

- Modeling grid developed around pile field polygon with roughly 10-ft resolution.
- Modeling grid refined and fit to pile field polygon boundary.
- Shoreline features are resolved (e.g. groin).



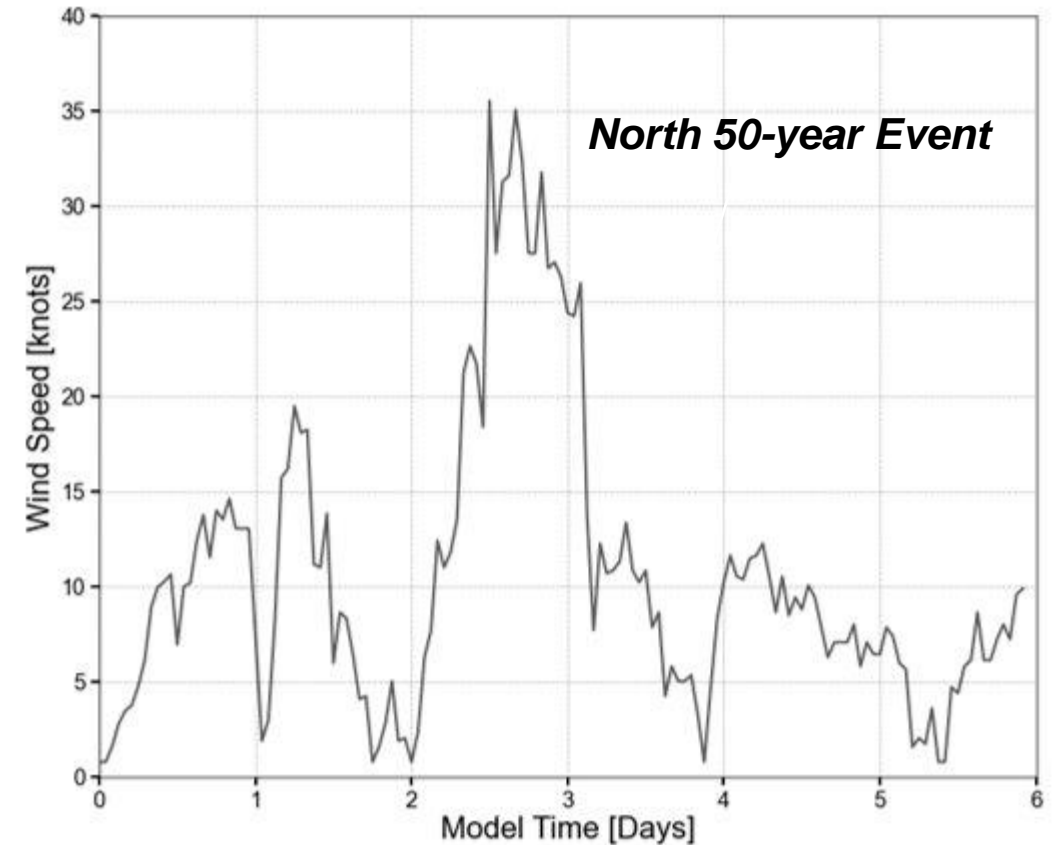
Coastal Conditions

Storms

- Prototype storm event extracted from wind records.
- Storm events constructed by scaling to desired peak wind.
- Each storm event consists of 6-day period with wind record scaled from real event.
- Storms are generally conservative in duration, i.e. large amounts of energy.

Long-term 2-min duration wind speeds [knots]

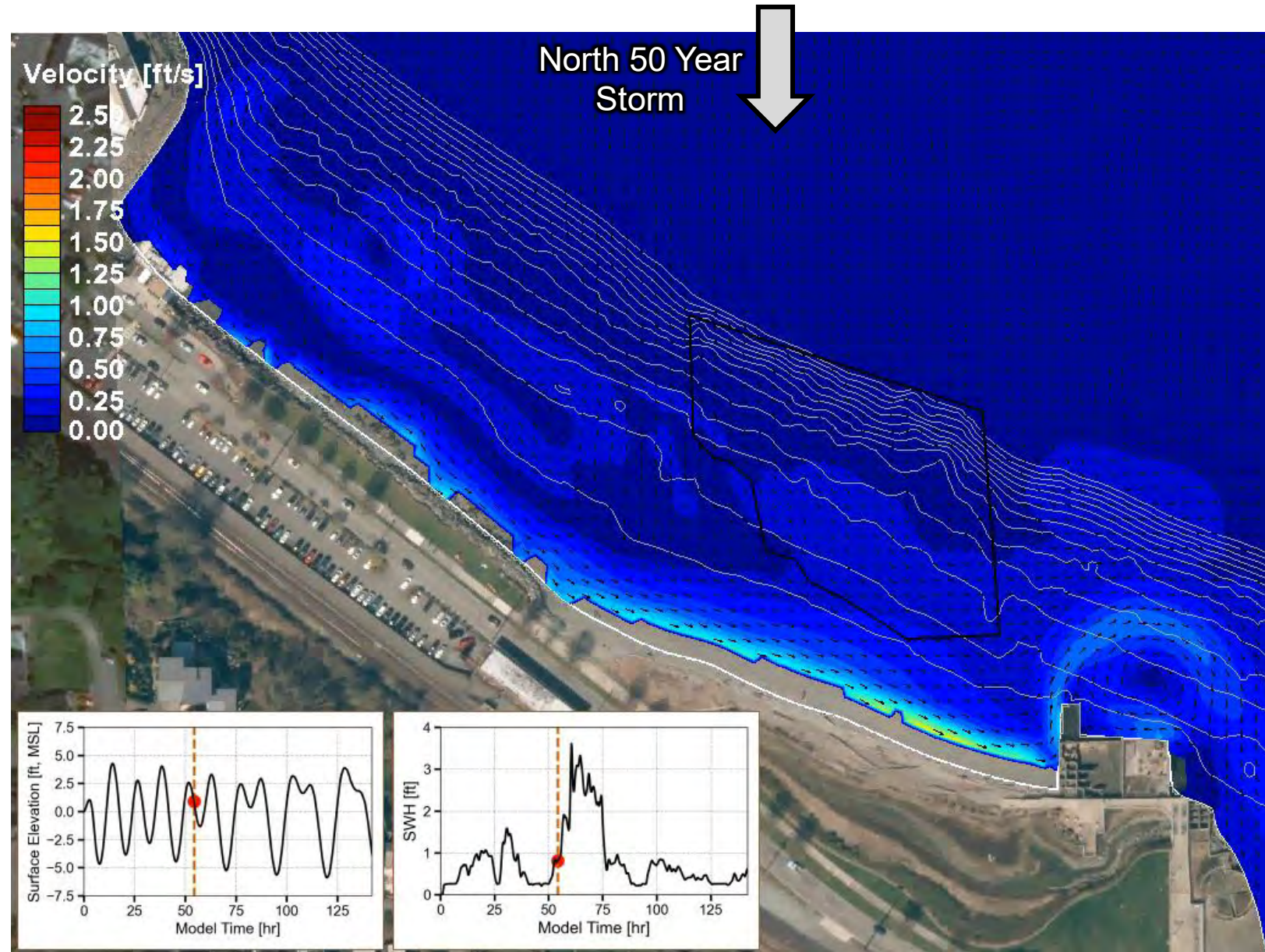
Return Period [year]	N	NE	E	SE	S	SW	W	NW
2	23.9	11.0	11.5	14.4	20.2	17.5	16.2	21.1
25	33.4	20.7	22.8	25.4	28.4	28.2	24.2	31.8
50	35.8	22.6	25.0	29.2	30.0	31.1	26.0	33.8
100	38.1	24.3	26.9	33.2	31.4	34.1	27.7	35.7



Coastal Conditions

Storm Results

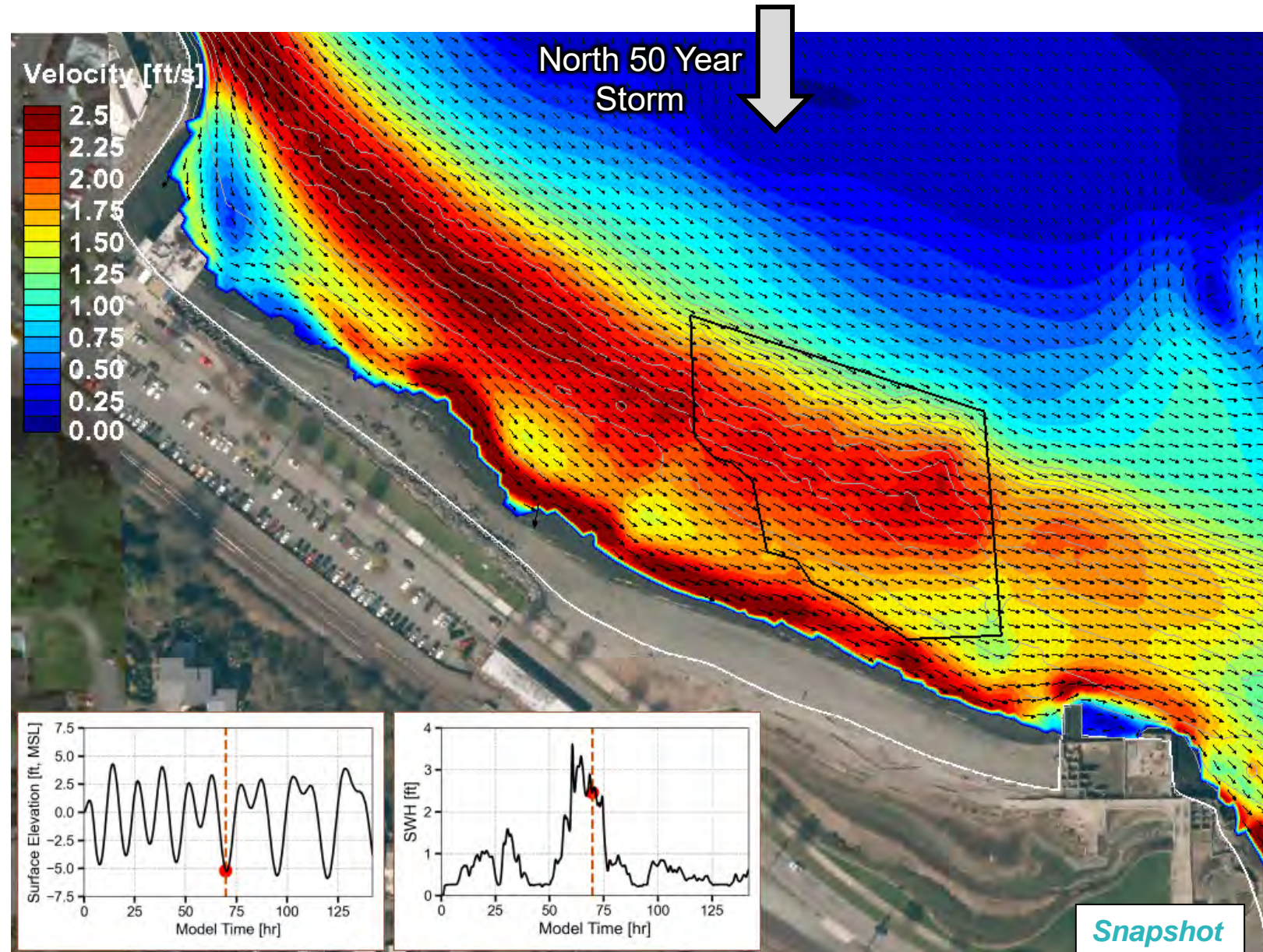
- 6-day storm simulations performed using typical spring tides/currents taken from large-scale models.
- North 50-year storm currents shown here.
- North storm waves generate SE-directed alongshore currents.



Coastal Conditions

Storm Results

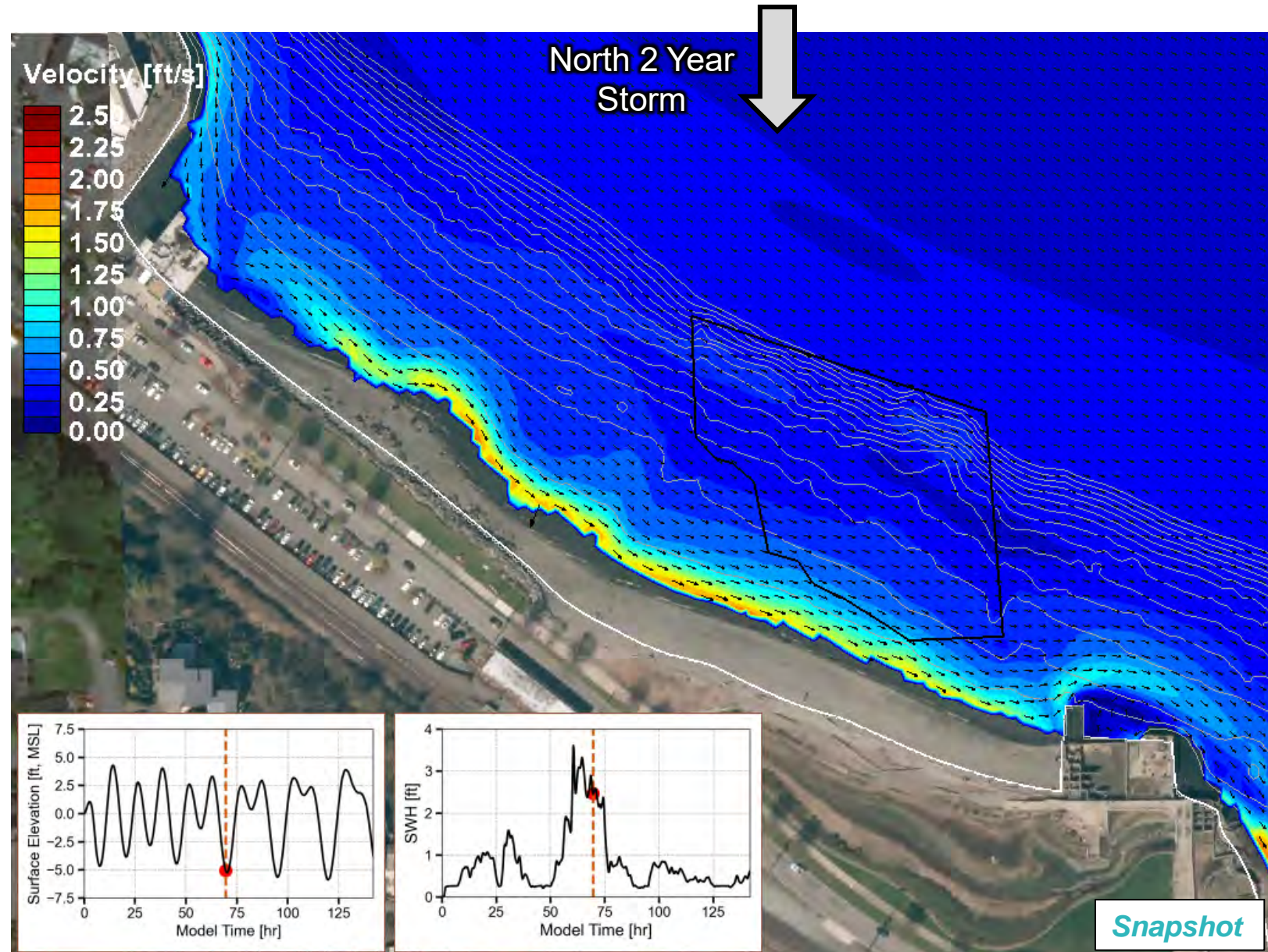
- Snapshot of peak North 50-year storm waves shown here.
- Current speeds reach 2.25 ft/s over pile field, sufficient to mobilize some types of sands.



Coastal Conditions

Storm Results

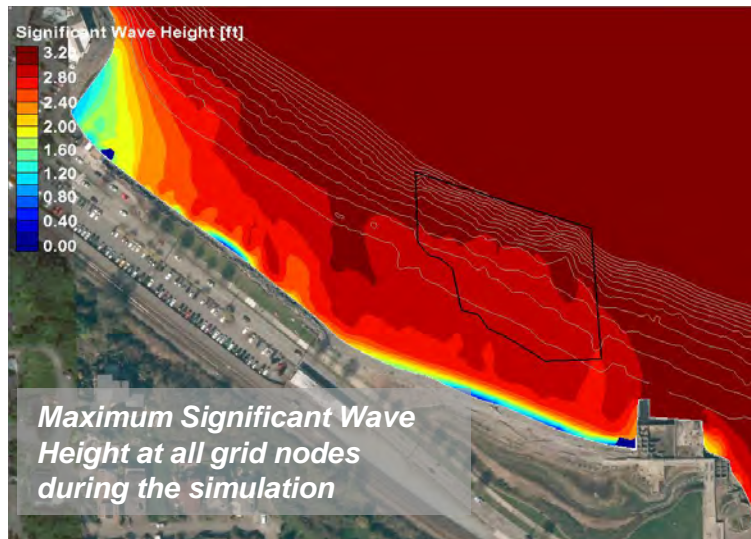
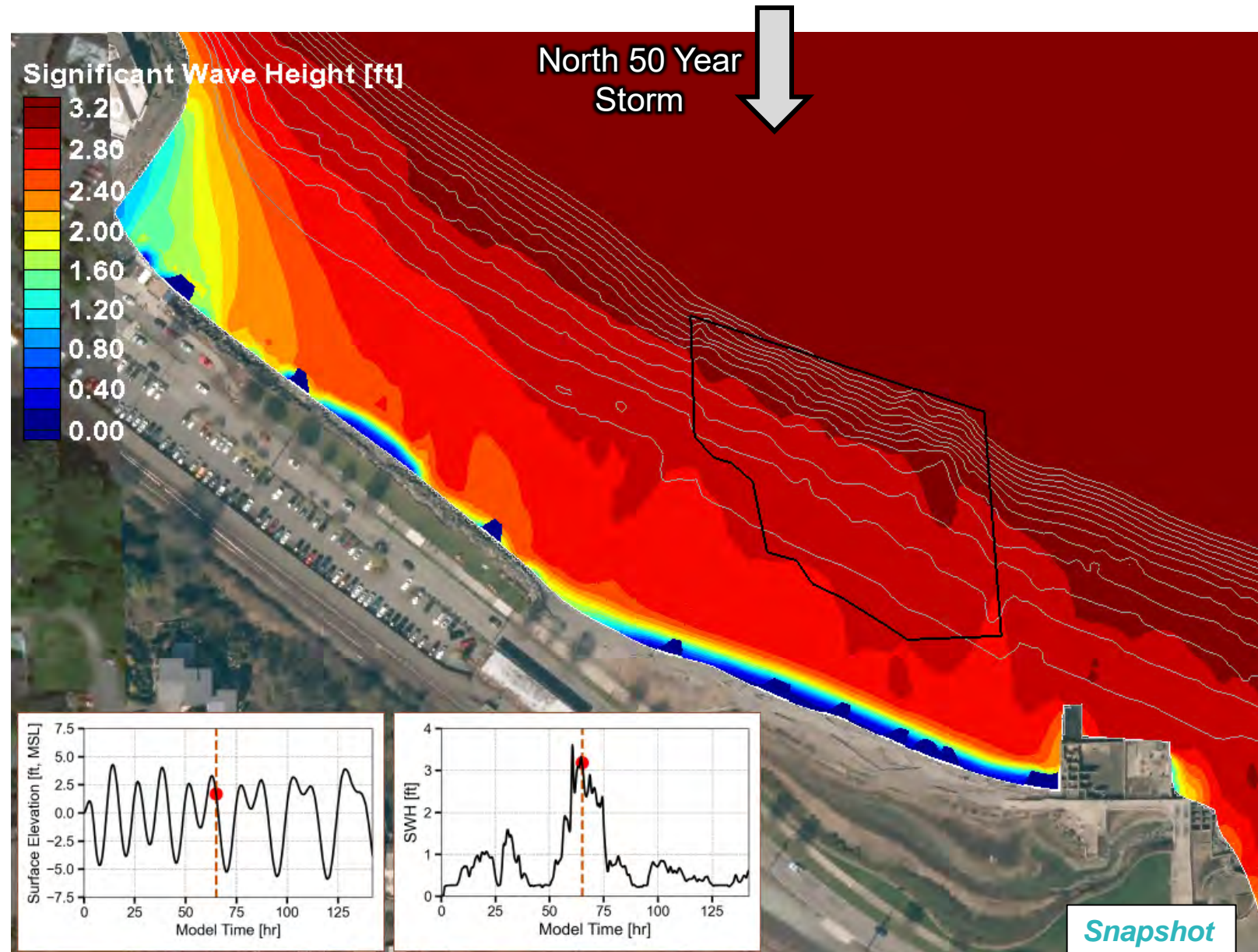
- Snapshot of peak North 2-year storm waves shown here.
- Current speeds reach only 0.6 ft/s over pile field, indicating little potential for sediment mobilization.
- Focus of the analysis moves to only the 50-yr event.



Coastal Conditions

Storm Results

- Snapshot from North 50-year storm example shown here, at time of storm peak.

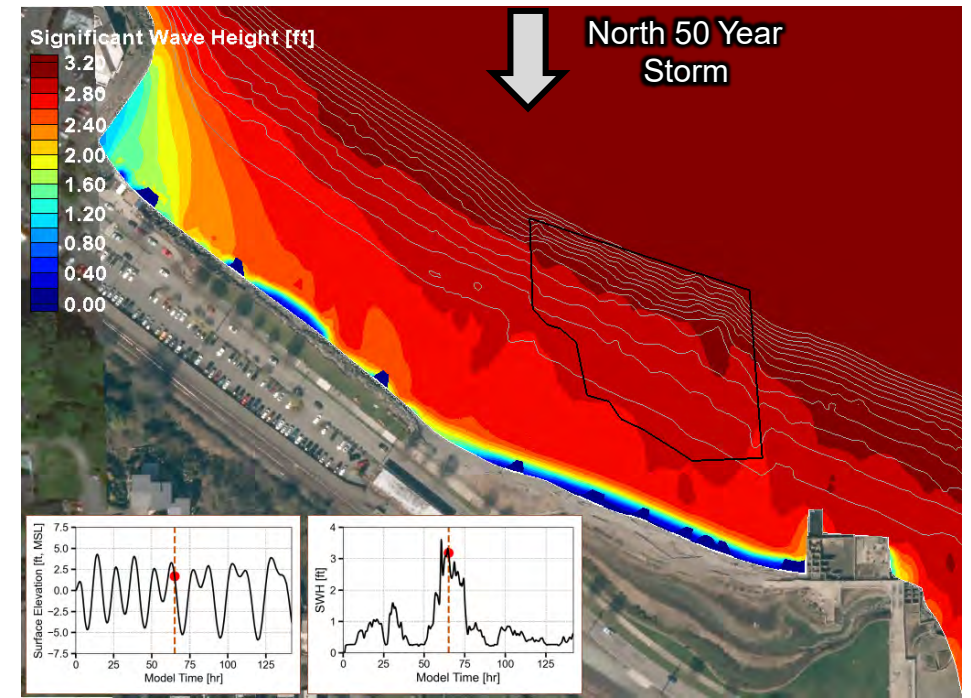


Coastal Conditions

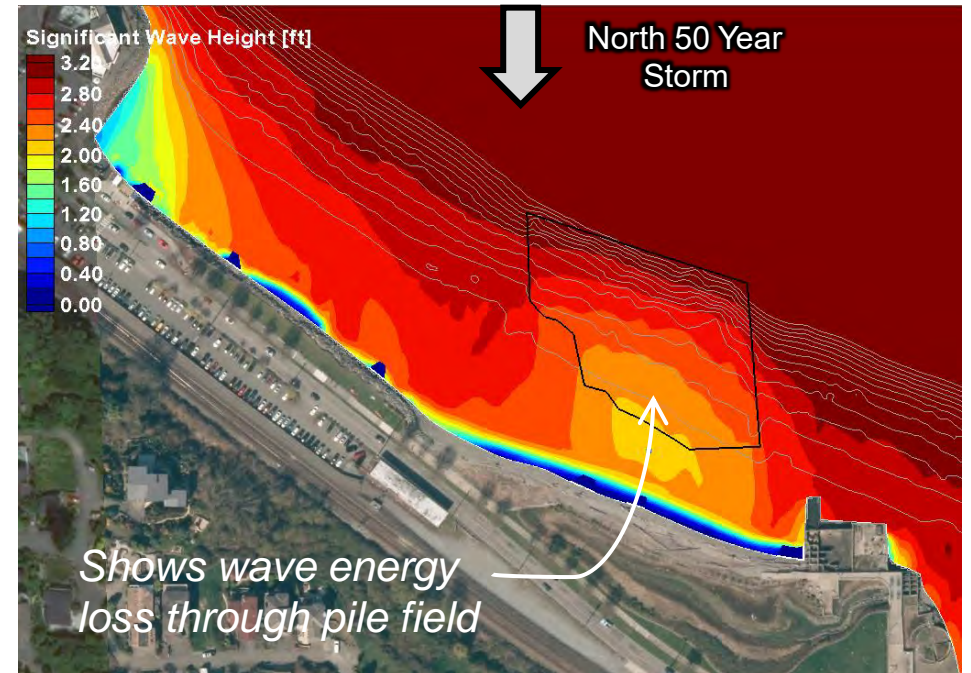
Storm Results – Post-Removal vs Existing Conditions

- Wave transmission through a pile array estimated using empirical formula (Hayashi et al. 1966; Truitt & Herbich 1986)
- Overall transmission through pile field is modeled in MIKE21 FM, ~75% transmission.

Post-removal



Existing



Analysis Outline

1

Site and Coastal
Conditions
Development

2

Pile field removal
impact analysis

- Mobilization of sediments
- Contaminant movement to surrounding areas
- Impacts to adjacent properties

3

Conclusions

Sediment Transport Analysis and Modeling

Sediment transport modeling for storm events to track contaminants and analyze risk of beach profile adjustment

Methodology:

- Perform separate sand and mud transport modeling due to material behavior
- Evaluate erosion in the pile field and change following pile field removal (mud and sand separate)
- Evaluate sediment/COC transport from pile field to surrounding areas
- Evaluate potential risk of beach adjustment due to pile field removal

Sediment Transport

Simulations Matrix

- Separate sediment transport simulations for sand and mud.
- Southerly storms do not mobilize sediments near the site, therefore not considered in the transport modeling.

- Type 1 Sand: Very Fine (0.088 mm)
- Type 2 Sand: Fine (0.177 mm)
- Type 3 Sand: Medium (0.354 mm).
- Type 1 Silt: Fine to Very Fine Silt
- Type 2 Silt: Coarse to Medium Silt

Mud Transport

Storm Return Period [years]	Mud Type	Storm Direction [deg, TN]
2	Type 1, 2	NW
2	Type 1, 2	N
2	Type 1, 2	NE
50	Type 1, 2	NW
50	Type 1, 2	N
50	Type 1, 2	NE

Note: Separate simulations were performed for each mud type

Sand Transport

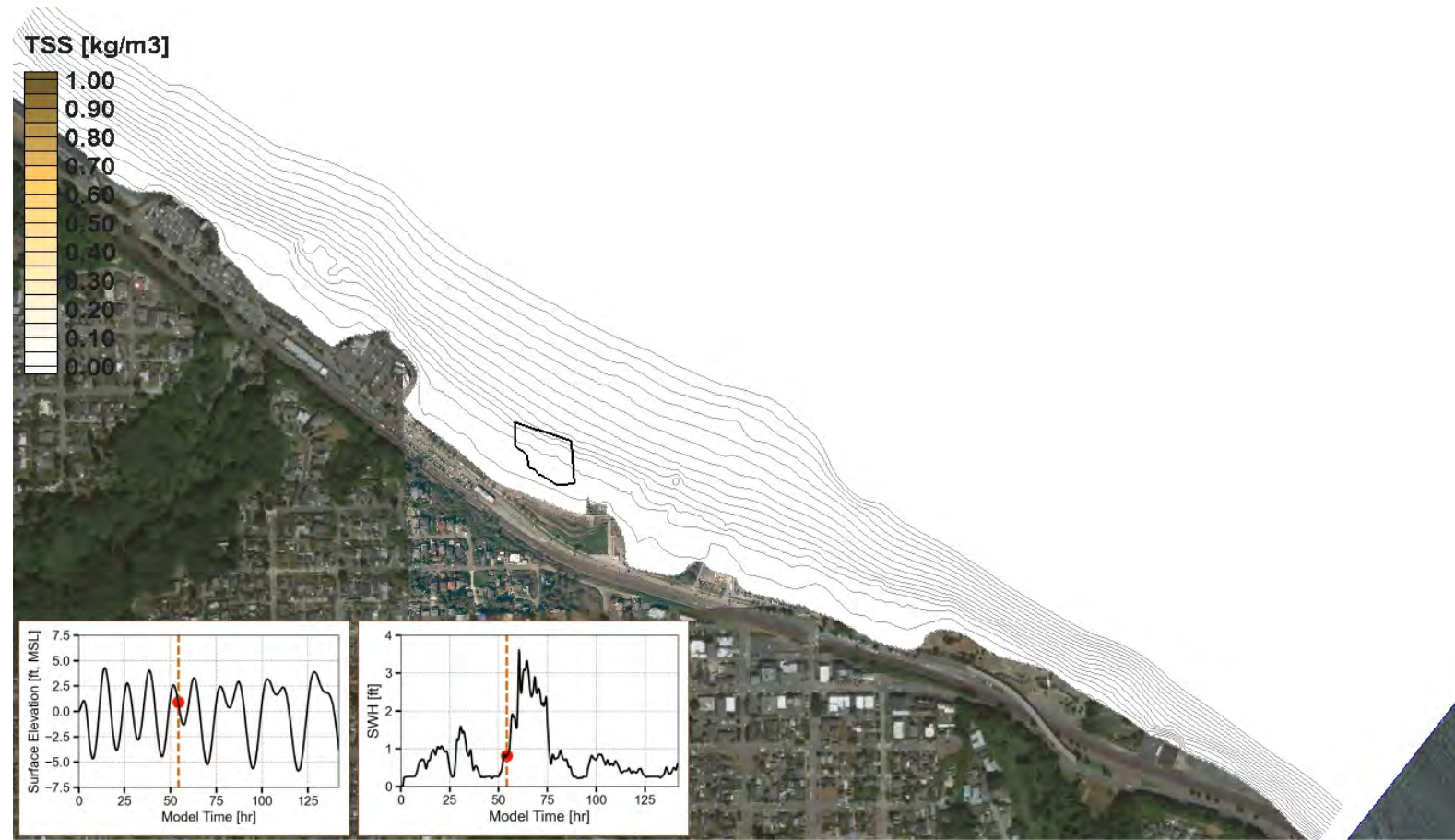
Storm Return Period [years]	Sand Type	Storm Direction [deg, TN]
2	Type 1, 2, 3	NW
2	Type 1, 2, 3	N
2	Type 1, 2, 3	NE
50	Type 1, 2, 3	NW
50	Type 1, 2, 3	N
50	Type 1, 2, 3	NE

Note: Separate simulations were performed for each sand type

Sediment Transport

Suspended Solids Movement – Example for Medium Silt

- Total Suspended Solids (TSS) concentrations as a result of mud transport (medium silt as an example)



Sediment Transport

Mud Results – Bed Change

- Weighted bed change computed assuming Type 1 and Type 2 Silt are each 10% of total sediments (conservative).
- Sediment movement observed during storms from N and NW, negligible bed changes occur during storms from all other directions.
- Northerly storms dominate erosion and transport (larger waves).
- Erosion is focused in shallower areas of the pile field.



Sediment Transport

Mud Results – Bed Change

- These are the same weighted bed change results as on previous slide, however using a zoomed-out view and a different color scale.
- Less than 0.10 inch of mud deposition is predicted elsewhere during more energetic N and NW 50-year storms.
- Negligible mud deposition elsewhere during storms from all other directions.

Note: Color range
-0.075 inches to
+0.075 inches



Sediment Transport

Mud Results – Bed Change

Effects of Pile Field Removal

50-year, N (Existing)



50-year, N (Post Removal)



Sediment Transport

Sawdust Transport

- Based on the grain size and bulk densities, sawdust should behave like medium/coarse silt, and we expect similar erosion/deposition.

Particle	Particle Size (microns)
Sand, very fine (0.0025 inch)	62
Sand, fine (0.005 inch)	125
Sand, medium (0.01 inch)	250
Sand, coarse (0.02 inch)	500
Sand, very coarse (0.02 inch)	500
Saw Dust	30 - 600
Sea Salt	0.035 - 0.5
Silt, coarse (0.0015)	37
Silt, medium (0.0006 - 0.0012 inche)	16 - 30
Silt, fine	8 - 13
Silt, very fine	4 - 8
Skin flakes	0.5 - 10
Smoke from Natural Materials	0.01 - 0.1
Smoke from Synthetic Materials	1 - 50
Smoldering or Flaming Cooking Oil	0.03 - 0.9
Spanish Moss Pollen	150 - 750

<https://www.osti.gov/pages/servlets/purl/1328338>



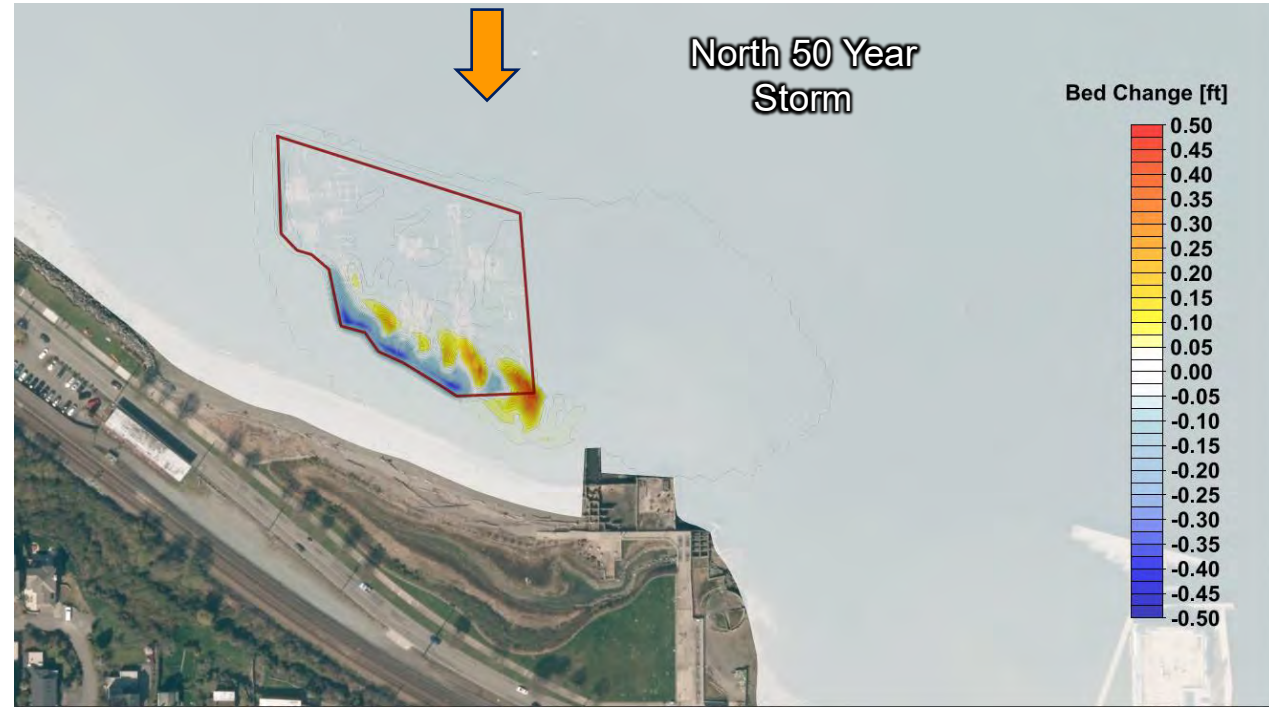
Table 2. Bulk densities of different types of wood [15].

Wood	Bulk density (ton/m ³) Dry ash free tonnes
Hardwood chips	0.23
Softwood chips	0.18–0.19
Sawdust	0.12
Planer Shavings	0.10

Sediment Transport

Sand Results – Bed Change

- Weighted bed change computed assuming Type 1, Type 2, Type 3 Sand are 15%, 20% and 20%, of total sediments, respectively (conservative).
- Sediment movement occurs during storms from N, negligible bed changes during storms from all other directions.

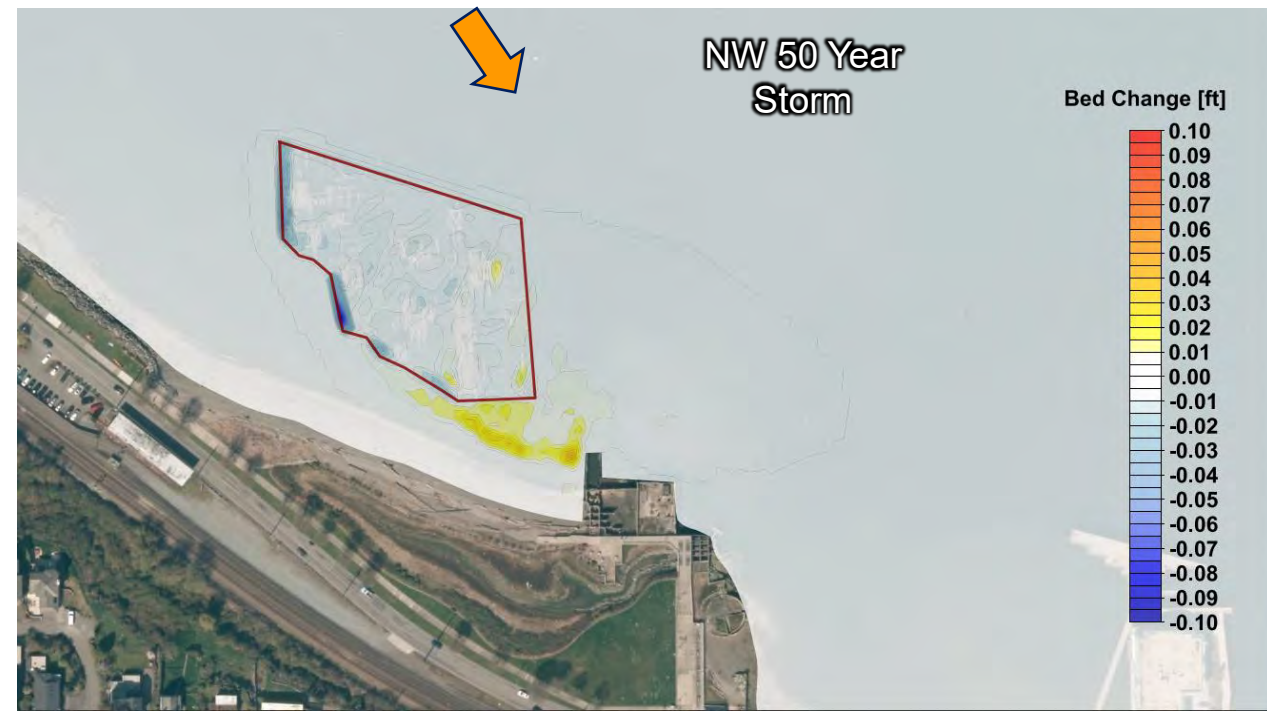
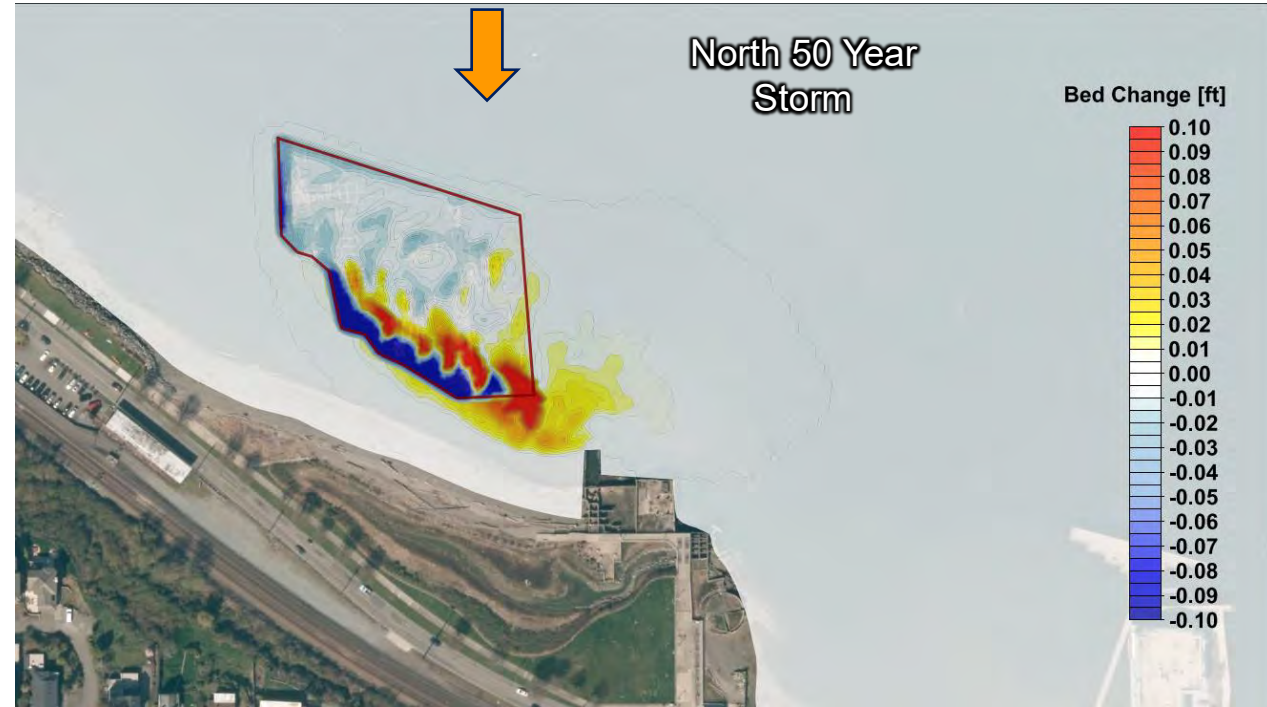


Sediment Transport

Sand Results – Bed Change

- These are the same weighted bed change results as on previous slide, however using a different color scale to show deposition.
- Sand mostly deposits within ~200 feet from pile field boundary.
- Less than 0.10 feet of sand deposition occurs outside pile field during NW storm.
- Negligible sand deposition occurs outside the pile field during storms from all other directions.

Note: Color range
-0.10 ft to +0.10 ft



Sediment Transport

Sand Results – Bed Change

Effects of Pile Field Removal

50-year, N (Existing)



50-year, N (Post Removal)



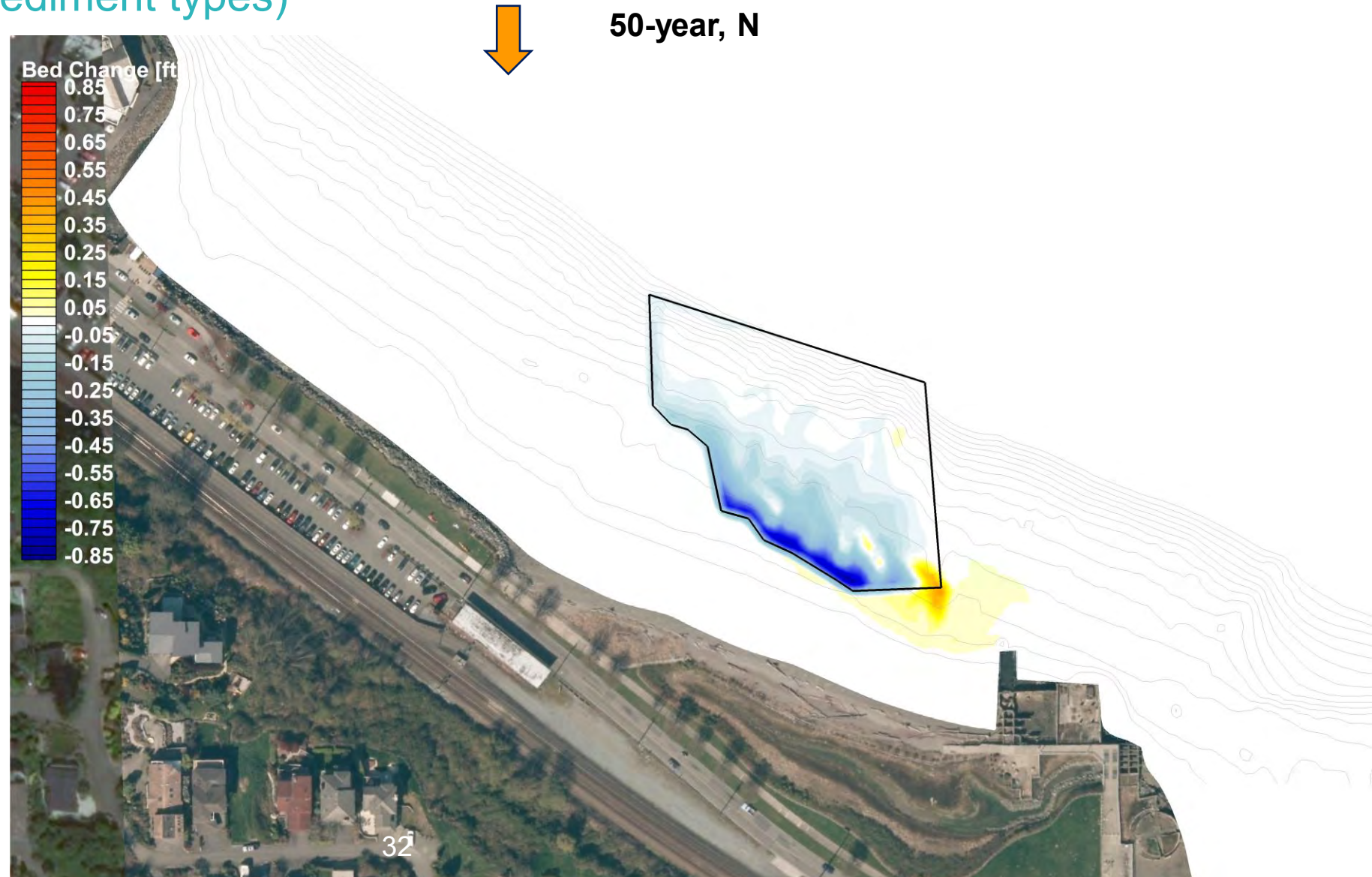
Sediment Transport

Total Bed Change (all sediment types)

Erosion: 0.85 ft (~1ft.)

Deposition: 0.40 ft (~0.5ft.)

Note: thin veneer of deposition outside project area (less than 0.1 inch thick) not shown here.



Analysis Outline

1

Site and coastal
Conditions
Development

2

**Pile field removal
impact analysis**

- Mobilization of sediments
- **Contaminant movement to surrounding areas**
- Impacts to adjacent properties

3

Conclusions

Future Sampling Areas

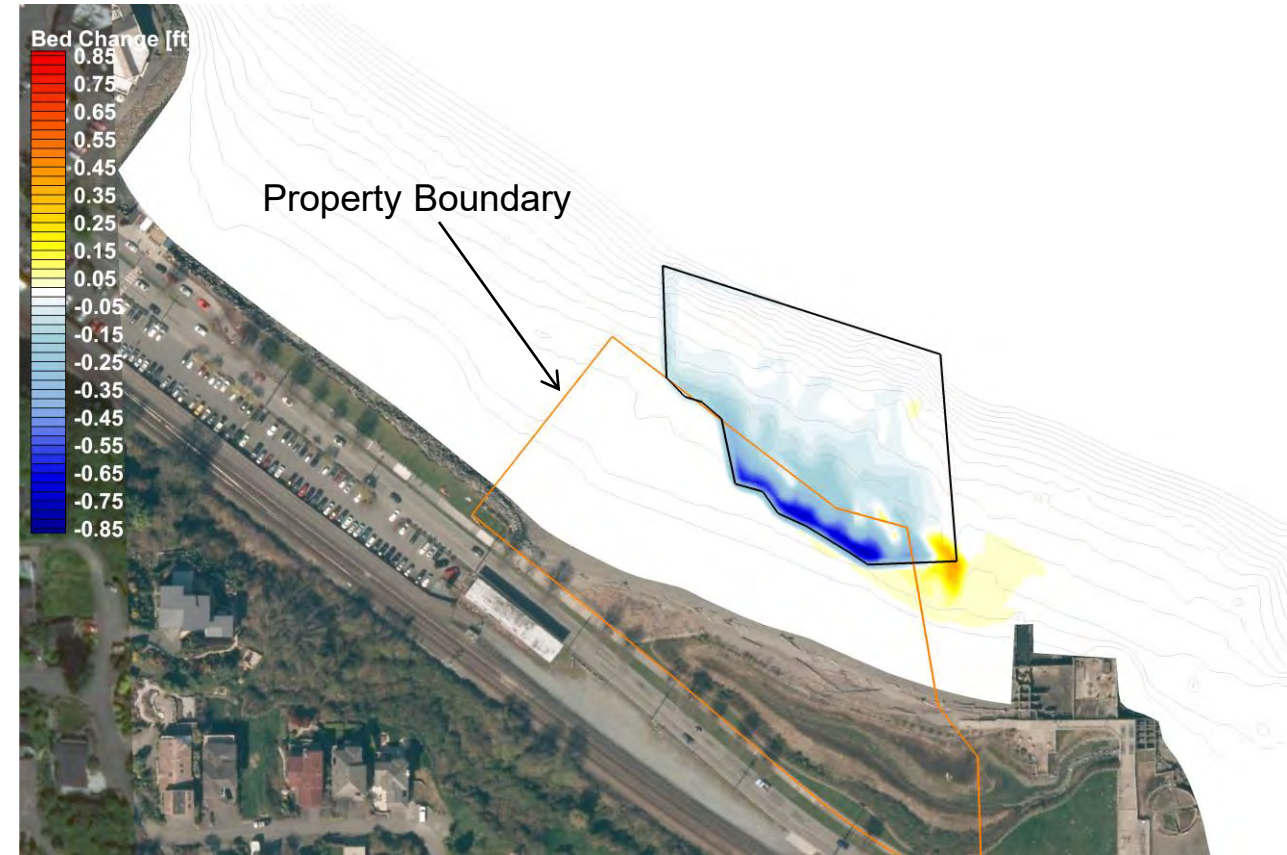
- Estimated erosion levels (which are likely conservative) indicate only surface sediment sampling is required.
- This conclusion is valid for sand alone, mud alone, and weighted material.
- Erosion potential should guide future sampling efforts (no. of samples and type of samples).

COC Summary

TABLE SUMMARY OF SWAC BY COC

SWAC = surface-area-weighted-average concentration, cPAH = carcinogenic polycyclic aromatic hydrocarbons, LPAH = low-molecular-weight polycyclic aromatic hydrocarbons, HPAH = high-molecular-weight polycyclic aromatic hydrocarbons

Contaminant of Concern (COC)	Units	SWAC Estimates	Criterion	Exceedance Factor
Dioxin TEQ	pg/g	21.7	19	1.1
cPAH TEQ	µg/Kg	5,285	78	68
Total LPAH	µg/Kg	21,766	5,200	4.2
Total HPAH	µg/Kg	233,751	12,000	13



Contaminant Movement/Mixing

- What does mud deposition of 0.1 inches or less mean to contamination elsewhere?
- If interested in top 10cm of sediment bed, this represents less than 2% contribution.
- Should we compute a resulting average COC concentration map, assuming a far-field ambient concentration and thickness (10cm)?
- Establishing baseline where deposition is predicted should be considered.

Mud Deposition

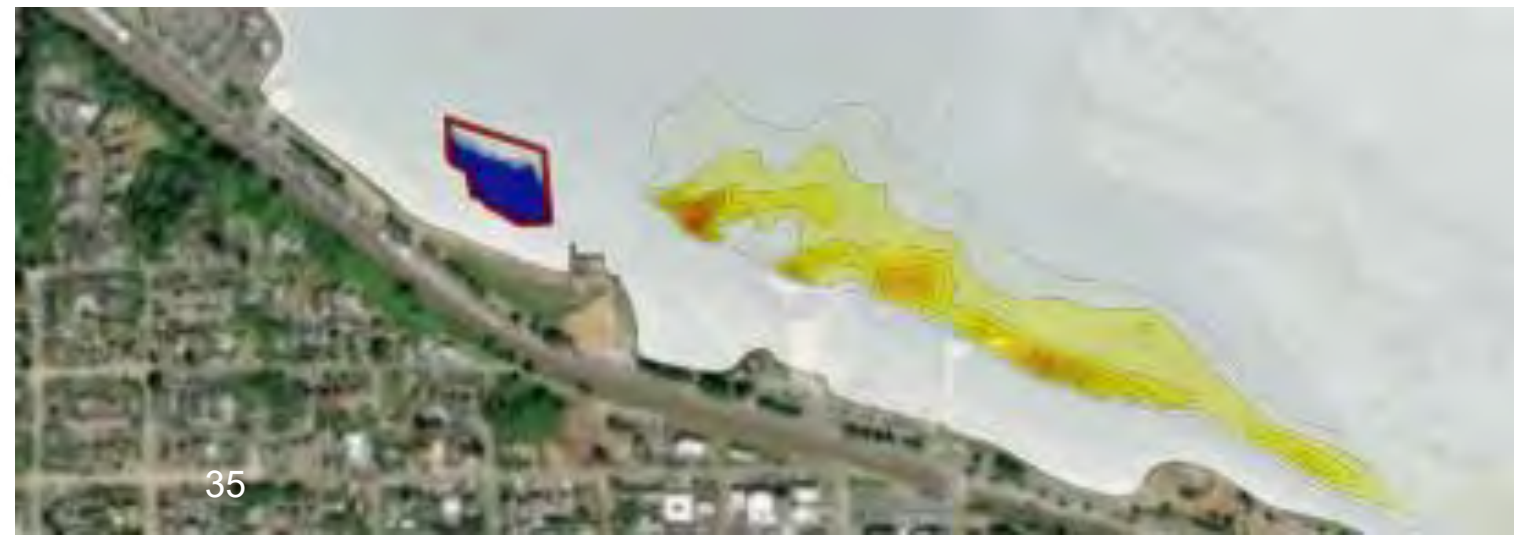


COC Summary

TABLE SUMMARY OF SWAC BY COC

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Total LPAH	µg/Kg	21,766	5,200	4.2
Total HPAH	µg/Kg	233,751	12,000	13



Analysis Outline

1

Site and Coastal
Conditions
Development

2

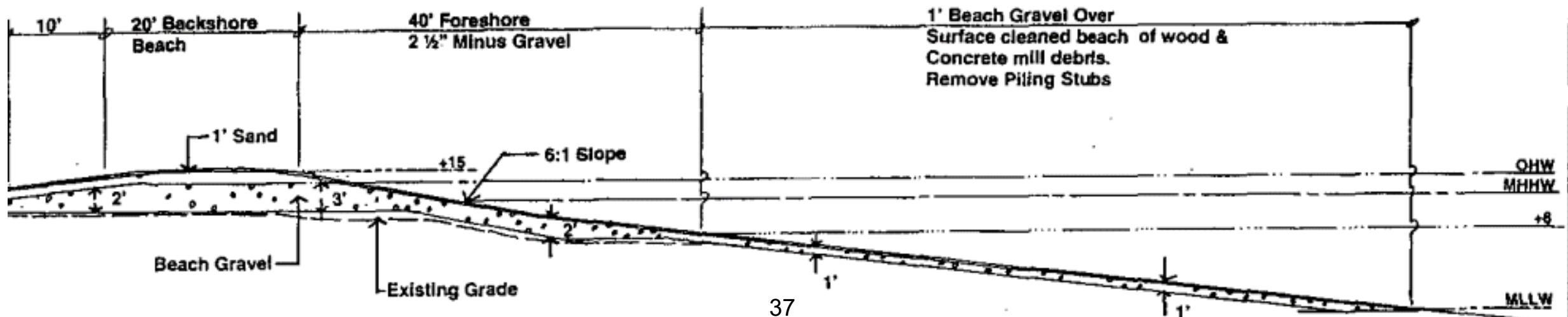
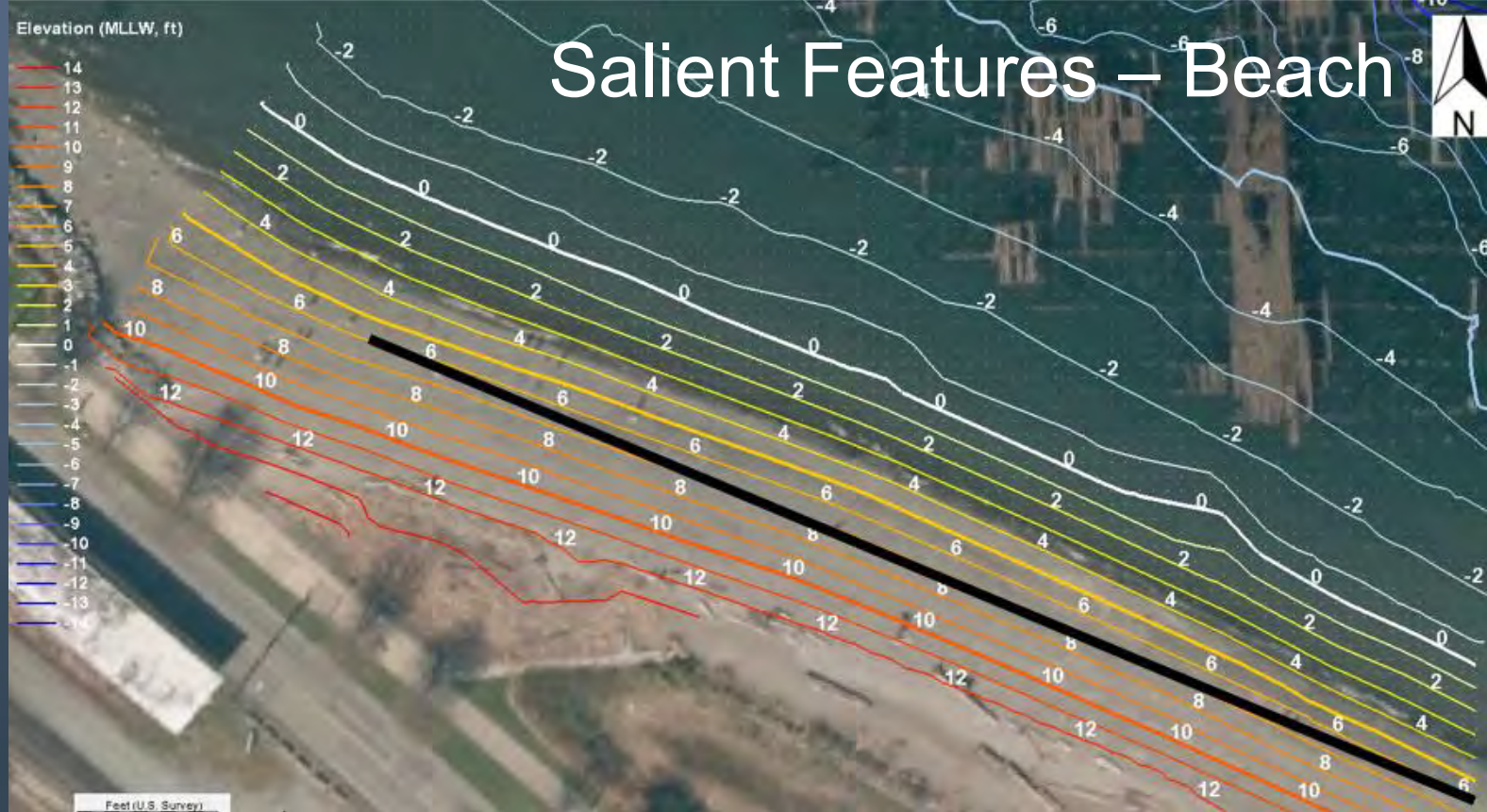
**Pile field removal
impact analysis**

- Mobilization of sediments
- Contaminant movement to surrounding areas
- **Impacts to adjacent properties**

3

Conclusions

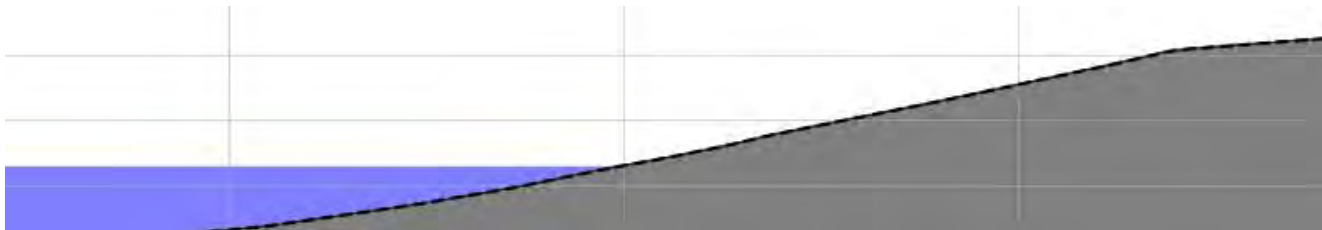
Salient Features – Beach



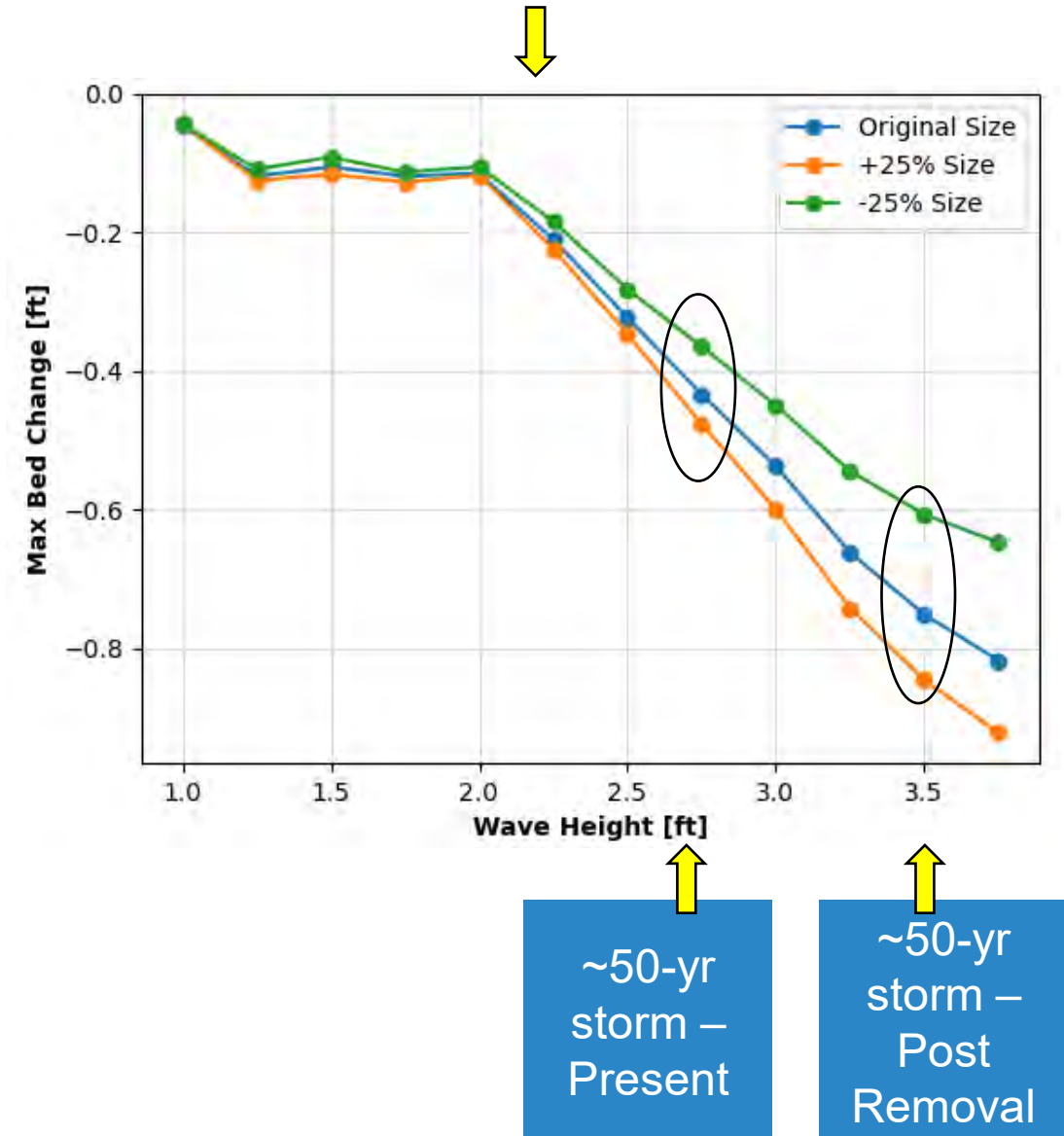
Beach Profile Change

Erosion Increases with Wave Height

- XBEACH-G used to predict gravel beach morphology under storm wave conditions, including effects of groundwater/infiltration.
- 1-D model with beach profile taken at center of the pile field.



Bed changes increase with significant wave heights over 2 feet



Analysis Outline

1

Site and Coastal
Conditions
Development

2

Evaluate potential pile
field removal impacts:

- Contaminant
movement to
surrounding areas
- Shoreline change

3

Conclusions

Conclusions

- Removal of the pile field results in minimal changes during more frequent events (e.g. 2yr storm); however, larger wave heights and measurably increased erosion in the pile field are anticipated during rare extreme events (e.g. 50yr event from worst-case direction).
- COC movements outside the project area are only likely to occur for mud sediment fractions; gravel in the pile field is immobile, and sand remains adjacent to the pile field.
- Mud spread to other areas becomes deposited in a very fine veneer (less than 0.1 inches) that is unlikely to result in high local COC concentrations. The thickest veneer of mud potentially deposited anywhere outside the project area (less than 0.1 inches) would only constitute ~2% of the top 10cm of surface sediment.
- Given the observed levels of erosion, subsurface sampling does not appear to be required. Surface samples are required in the more erosive shallower areas where samples do not exist. There may be a benefit to conducting sampling in the areas that the model simulations indicate accretion may occur.
- Removal of the pile field results in minimal changes to the adjacent beach profile during more frequent events (e.g. 2yr storm); however, increased localized beach profile adjustments are anticipated during rare extreme events (e.g. 50yr event from worst-case direction) as a result of the removal of the piles.

Answers to Phase 2 Questions

Where in the pile field are the higher risk areas?

Shallow water areas are more erosive – erosion is likely to occur in MetroParks property.

Erosion anticipated to be less than 1 foot during worst-case 50-year event.

Analysis to be updated after site investigations to confirm initial modeling.

Fate of sediments?

Fate depends on sediment size; mud leaves the site, but sand remains nearby.

Mud (including sawdust) likely to be suspended and deposit in a thin veneer over primarily DNR submerged lands SE of the project site.

Beach Adjustments?

Beach is dynamic, adjustments already observed.

Increase in wave height due to pile field removal results in a higher risk of localized beach erosion in extreme storms.

Negligible changes are expected for most storm conditions.

Where, how to sample?

GeoEngineers developing SAP and cost estimate to implement

Sampling is suggested in erosive area and far-field depositional area

Surface sampling appears to be sufficient. No vibracoring is suggested.

Suggest limiting contaminant analysis to COCs with high initial exceedances.



WASHINGTON STATE DEPT OF
**NATURAL
RESOURCES**

Dickman Mill Pile Field Removal Coastal Engineering Assessment Final Results

June 28, 2021

Appendix B: Sampling and Analysis Plan

Dickman Mill Pile Removal Project:

Pre-Removal Sediment Characterization Cost and Potential Scope to Complete

A Sampling and Analysis Plan (SAP) was developed that describes procedures that will be used to characterize sediment at the Dickman Mill Site (Site) related to the proposed piling removal. The Site is located along Ruston Way in Tacoma, Washington, on Commencement Bay in the Puget Sound. The objective of this document and associated costing spreadsheet is to capture the level of effort and potential cost for executing that SAP. Details such as sample numbers and chemical analyses are included in Appendix A, Table A-1 of the SAP and are not repeated here.

Estimated costs and level of effort to complete the scope of services outlined below are presented in the associated costing spreadsheet. These should only be used for planning purposes and do not constitute an executable proposal. The supplied costing spreadsheet includes estimated costs from GeoEngineers, RSS, and ARI serving in the roles of prime consultant (GeoEngineers) responsible for managing the effort and final deliverables, providing boat and diver support (RSS), and responsible for performing the sediment sample analysis (ARI). The spreadsheet presents estimated costs by task with labor hours by task and staff classification for GeoEngineers staff. There is also cost escalation presented in the spreadsheet to help inform how costs may increase if the work is deferred.

Task 1 - Quality assurance project plan (QAPP).

This quality assurance project plan (QAPP) provides the analytical quality assurance (QA)/quality control (QC) requirements for marine sediment samples associated with the Dickman Mill Pile Removal Project. The QAPP is applicable to the QA/QC aspects of field sampling and laboratory chemical analysis. The QAPP is a companion document to the SAP.

The QAPP seeks to demonstrate that field sampling, laboratory analysis and reporting, and data validation are within acceptable limits of variability by setting standards and implementing additional analyses to rule out paths for introduced variability in results that might be introduced by human or analytical errors. Part of this is the use of blanks and duplicate samples. The QAPP will dictate the frequency of QA (procedural blanks) and QC (field duplicates) samples to be taken as a part of the overall sampling effort. These will be used to verify precision and accuracy of field and laboratory procedures.

Task 2 - Permitting for In-Water Marine Work

Permitting for sediment sampling is required as it is considered in-water by Federal, State, and Local agencies and subject to their approval process. The effort for these activities fall under Task 2 of the costing spreadsheet. An application for all relevant Federal, State, and Local permits is required before implementation of the work. In Washington, these applications for shoreline or in-water work are consolidated in a single document – the Joint Aquatic Resource Permit Application (JARPA), which is reviewed by multiple agencies. The permit application and supporting documents will be prepared on behalf of DNR and submitted to the regulatory agencies following approval by DNR.

This scope of work assumes the JARPA and other related documents, as outlined below, will be completed prior to conducting sediment sampling to ensure that all procedural requirements are met.

- **Nationwide Permit 6 (NW6):** The NW6 incorporates requirements of the Clean Water Act (CWA) and the Rivers and Harbors Act as administered by federal agencies.
 - **“No Effects” Biological Evaluation (BE) Letter:** A requirement of the NW6 process would be an evaluation of potential effects on endangered species protected by the Endangered Species Act (ESA). A BE addresses the potential effects of the work on species protected under the Endangered Species Act (ESA) and critical habitat that may exist within the project area. This task assumes the proposed sediment sampling work will have no impacts on ESA-listed species and habitats and therefore a full BE report will not be required. GeoEngineers will prepare a “No Effects” BE letter to satisfy the Section 7 ESA requirements.
- **State Environmental Policy Act (SEPA) Environmental Checklist:** For the purposes of this effort, it is assumed that the sediment sampling work will not have significant adverse environmental impacts and would qualify for the Determination of Non-significance (DNS) and a SEPA exemption.
- **WDFW Hydraulic Project Approval:** Hydraulic Project Approval (HPA) permit from WA Department of Fish & Wildlife (review follows SEPA determination) is a necessary permission for all in water work. Application will be drafted using portions of the JARPA and BE utilized for the Corps application. All materials must be compiled and submitted through the WDFW APPS digital portal. WDFW will not commence review until issuance of a SEPA exemption.
- **City of Tacoma Shoreline Exemption:** It is expected that sediment sampling would be exempt from a Shoreline Substantial Development Permit under the Shoreline Management Program as administered by the Shoreline Management Act. Materials submitted for the checklist will be evaluated to determine if the project meets the requirements for exemption.
- **Coordination with DNR Land Management and Metro Parks:** It is expected that there will be coordination with these two entities to come to an understanding of the need of this sampling and the repercussions of the results prior to sampling.

If the Site becomes listed as a MTCA site under an Agreed Order, the Site will only require substantive compliance with State and Local permits but will still require Federal permits to be in place. This will result in a cost savings for the permitting effort related to the proposed sampling.

Task 3 - Field Characterization

The effort for these activities fall under Task 3 of the costing spreadsheet. The subtidal sediment investigation is being conducted to support pre-removal characterization of sediment affected by removing the substantial pile field located at the Site. The approach and assumptions regarding assumed sample numbers and chemical analyses are included in Table A-1 of Appendix A of the SAP generated for this project.

This scope assumes the subtidal investigation activities will include:

- Collect surface sediment samples at 13 locations using a combination of sampling gear as needed to reach target sample depth. The sampling will be conducted from a subcontracted marine research vessel and includes time for diver support.
- It is assumed that:

- Two days for sample collection will be needed with two environmental scientists to process and evaluate samples, on boat captain, one deck hand, and two divers.
- Divers may be needed is box corer cannot penetrate to prescribed sample depth.

Task 4 - Reporting and Analysis

This activity falls under Task 4 of the costing spreadsheet. The data report will synthesize the results of the investigation activities. In addition, the data report will describe the degree to which existing data gaps described in the sections above have been addressed and if further data gaps remain. The data report will also include conclusions regarding potential ramifications of movement of sediment offsite once the pile field is removed, if any, as proposed.

This scope of work assumes the following items and general sequence of work:

- Complete Analytical Results in the Data Report
 - Validate the sediment data and upload the analytical results to the Ecology Environmental Information Management (EIM) database as required.
 - Present analytical results (data tables and figures) for sediment including:
 - The extent of total and carcinogenic polycyclic aromatic hydrocarbon (cPAH) in shallow sediment in the erosional zone.
 - Chemical and geochemical data from the deposition area to serve as baseline information.
 - Analytical data for nearshore intertidal sediment and porewater conditions.
 - The extent of dioxin/furan contamination in subtidal surface sediment based on limited sampling.
 - A comparison of current data to previous data for the outlier sample location that was previously sampled.
 - Analytical costs are based on the following assumptions:
 - PAH and conventional analysis will be run for every sample.
 - Only two in samples will be run based on highest TVS values for samples within the pile field.
 - Costs for QAPP samples (e.g., field blanks, field duplicates) are not included in this cost.
 - Dioxin/furan samples archival costs for one year are included.

We appreciate the opportunity to support to DNR on the Dickman Mill project. Please contact us if you have questions regarding this scope and fee estimate.

Project Name: Dickman Mill
 Client: Mott Mac
 Date: 6/28/21
 Project No.: 0050302700

Project Summary	Estimated Budget (2021)	Estimated Budget (2022)	Estimated Budget (2023)	Phase
Task 1 - QAPP	\$7,297.04	\$7,515.95	\$7,779.01	Presampling
Task 2 - Permitting for Characterization	\$19,728.72	\$20,320.58	\$21,031.80	
Task 3 - Field Characterization	\$31,123.32	\$32,057.02	\$33,179.02	Sampling and Reporting
Task 4 - Analytical Costs and Reporting	\$31,256.02	\$32,193.70	\$33,320.48	
Total Budget	\$89,405.10	\$92,087.25	\$95,310.31	

Project Name: Dickman Mill
 Client: Mott Mac
 Date: 6/28/21
 Project No.: 0050302700

	Principal	Associate	Senior 2	Senior 1	Project 2	Project 1	Staff 3 Sci	Staff 2 Sci	Staff 1 Sci	Admin 3	Admin 2	Admin 1	Proj 1 GIS Analyst	CAD	Task Hours	Labor Fee
Personnel Rate	\$266.00	\$246.00	\$231.00	\$210.00	\$188.00	\$182.00	\$158.00	\$138.00	\$120.00	\$112.00	\$98.00	\$86.00	\$145.00	\$126.00		
Task 2 - Permitting for Characterization	3	0	18	0	0	66	0	0	0	5	0	0	4	4	100	\$18,612.00
Draft Permitting Documents	2		4			40				3			4	4	57	\$10,156.00
Final Permitting Documents	1		2			8				2					13	\$2,408.00
DNR Coordination (internal)			4												4	\$924.00
Submittal						6									6	\$1,092.00
Agency Coordination (external)			8			12									20	\$4,032.00
															0	\$0.00
															0	\$0.00
															0	\$0.00
															0	\$0.00
															0	\$0.00
															0	\$0.00
															0	\$0.00
Total Hours	3	0	18	0	0	66	0	0	0	5	0	0	4	4	100	\$18,612.00

NON-LABOR COST ESTIMATE*
 Item Description (these are estimates - will be billed based upon charges incurred)

Item Description	Units	Unit Cost	Item Total
Associated Project Costs (6% of Labor)	1	\$1,116.72	\$1,116.72
Vehicle Mileage		\$0.56	\$0.00
Ferry fee		\$35.00	\$0.00
Trimble GPS		\$115.00	\$0.00
Per Diem		\$60.00	\$0.00
Total Non-Labor Cost			\$1,116.72

GRAND TOTAL COST \$19,728.72

Project Name: Dickman Mill
 Client: Mott Mac
 Date: 6/28/21
 Project No.: 0050302700

	Personnel	Principal	Associate	Senior 2	Senior 1	Project 2	Project 1	Staff 3 Sci	Staff 2 Sci	Staff 1 Sci	Admin 3	Admin 2	Admin 1	roj 1 GIS Analy	CAD	Task Hours	Labor Fee
	Rate	\$266.00	\$246.00	\$231.00	\$210.00	\$188.00	\$182.00	\$158.00	\$138.00	\$120.00	\$112.00	\$98.00	\$86.00	\$145.00	\$126.00		
Task 4 - Analytical Costs and Reporting		2	14	11	0	0	48	0	22	0	4	0	0	6	0	107	\$19,607.00
Data QA/QC (data validation)				4			14				2					20	\$3,696.00
Data Analysis			8	2			2		12					3		27	\$4,885.00
Reporting		2	6	4			32			2				3		49	\$9,415.00
EIM submittal				1					10							11	\$1,611.00
																0	\$0.00
																0	\$0.00
																0	\$0.00
																0	\$0.00
																0	\$0.00
																0	\$0.00
																0	\$0.00
Total Hours		2	14	11	0	0	48	0	22	0	4	0	0	6	0	107	\$19,607.00

NON-LABOR COST ESTIMATE*
 Item Description (these are estimates - will be billed based upon charges incurred)

Item Description	Units	Unit Cost	Item Total	
Associated Project Costs (6% of Labor)	1	\$1,176.42	\$1,176.42	
Vehicle Mileage	60	\$0.56	\$33.60	
Analytical Cost Dioxin	2	\$775.00	\$1,550.00	
Analytical Cost PAH	13	\$255.00	\$3,315.00	
Analytical Cost Conventionals	13	\$250.00	\$3,250.00	Total Analytical
Analytical Storage Archived Samples (1 year)	5	\$275.00	\$1,375.00	\$9,490.00
10% markup on analytical services	1	10.00%	\$949.00	
Total Non-Labor Cost			\$11,649.02	

GRAND TOTAL COST **\$31,256.02**



**Dickman Mill Pile Removal Project
Pre-removal Sediment Characterization**

2423 Ruston Way
Tacoma, Washington

for
**Washington State Department of Natural
Resources *on behalf of* Mott MacDonald, LLC**

July 7, 2021

**Dickman Mill Pile Removal Project
Pre-removal Sediment Characterization**

2423 Ruston Way
Tacoma, Washington

for

**Washington State Department of Natural
Resources *on behalf of* Mott MacDonald, LLC**

July 7, 2021



2101 4th Avenue, Suite 950
Seattle, Washington 98121
206.728.2674

**Dickman Mill Pile Removal Project
Pre-removal Sediment Characterization**

**2423 Ruston Way
Tacoma, Washington**

File No. 0503-027-00

July 7, 2021

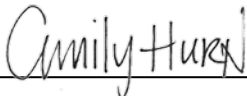
Prepared for:

Washington State Department of Natural Resources
Forest Practices
PO Box 47012
Olympia, WA 98504-7027

Attention: Monica Shoemaker

Prepared by:

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Project Environmental Scientist



Jason P. Stutes, PhD
Senior Marine Ecologist

ERH:JPS:tlm

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Table of Contents

1.0 INTRODUCTION	1
2.0 SITE CONTAMINANTS OF CONCERN	1
3.0 SAMPLING OBJECTIVES AND GENERAL APPROACH	1
4.0 PERSONNEL AND RESPONSIBILITIES	2
5.0 SAMPLING AND ANALYTICAL TESTING PROGRAM	4
5.1. Sampling Locations	4
5.2. Sample Positioning	4
5.3. Sediment Sample Designation	4
6.0 SAMPLING EQUIPMENT AND PROCEDURES	5
6.1. Sediment Sample Collection	5
6.2. Field Screening	7
6.2.1. Visual and Olfactory Screening.....	7
6.2.2. Water Sheen Screening	7
6.3. Equipment Decontamination Procedures	7
6.4. Field Documentation	8
6.5. Sample Containers	9
6.6. Sample Storage and Shipping.....	9
6.7. Disposal of Investigation Derived Waste (IDW).....	9
7.0 HEALTH AND SAFETY	9
8.0 LIMITATIONS	10
9.0 REFERENCES	10

LIST OF TABLES

Table A-1. Proposed Sample Locations, Objectives and List of Analyses

Table A-2. Sediment Analytical Methods, Sample Size, Containers, Preservation and Holding Times

LIST OF FIGURES

Figure 1. Vicinity Map

Figure 2. Sampling Overview

Figure 3. Proposed Sediment Sampling Locations – Erosional Area

Figure 4. Proposed Sediment Sampling Locations – Depositional Area

LIST OF ABBREVIATIONS AND ACRONYMS

ARI	Analytical Resources, Inc.
ASTM	ASTM International
bml	below mudline
CFR	Code of Federal Regulations
cm	centimeters
COCs	contaminants of concern
cPAHs	carcinogenic Polycyclic Aromatic Hydrocarbons
DM	Dickman Mill
DQOs	data quality objectives
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
fps	foot per second
GeoEngineers	GeoEngineers, Inc.
GPS	global positioning system
HASP	Health and Safety Plan
HPAH	high-molecular weight Polycyclic Aromatic Hydrocarbons
HS	heavy sheen
IDW	investigation derived waste
LPAHs	low-molecular weight Polycyclic Aromatic Hydrocarbons
MTCA	Model Toxics Control Act
MS	moderate sheen
NS	no sheen
OSHA	Occupational Safety and Health Act
PAHs	Polycyclic Aromatic Hydrocarbons
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RCW	Revised Code of Washington
SAP	Sampling and Analysis Plan
SMS	Sediment Management Standards
SS	slight sheen
TEQ	Toxic Equivalent Concentration

TOC	total organic carbon
TVS	total volatile solids
WAC	Washington Administrative Code
WDNR	Washington State Department of Natural Resources
WISHA	Washington Industrial Safety and Health Act

DICKMAN MILL PILE REMOVAL PROJECT: PRE-REMOVAL SEDIMENT CHARACTERIZATION

1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) describes procedures that will be used to characterize sediment at the Dickman Mill Site (Site) related to the proposed piling removal. The Site is located along Ruston Way in Tacoma, Washington, on Commencement Bay in the Puget Sound (Figure 1, Vicinity Map). The objective of the sampling investigation is to collect sediment information within areas modeled for erosion and deposition as a result of pile removal as described by Mott MacDonald in the “DRAFT Dickman Mill Pile Field Removal Coastal Engineering Assessment, Phase 2 Summary Memorandum” (Mott MacDonald 2021).

This SAP has been prepared in general accordance with requirements of the Washington State Model Toxics Control Act (MTCA; Chapter 173-340 Washington Administrative Code [WAC]) and Sediment Management Standards (SMS; Chapter 173-204 WAC).

2.0 SITE CONTAMINANTS OF CONCERN

Several environmental studies were performed at the Site by Washington State Department of Natural Resources (WDNR) in 2015. There is also a long-term monitoring sampling station located offsite. Results from the 2015 field investigations and the long-term monitoring data are summarized in a technical data review to evaluate the potential for transport of sediment-bound contamination during pile removal (GeoEngineers 2020). The review compared the maximum detected concentration for each analyte measured in sediment to its applicable criteria and identified the following contaminants of concern (COCs): dioxins (expressed as a toxic equivalent concentration or TEQ), carcinogenic polycyclic aromatic hydrocarbons (cPAHs; also expressed as a TEQ), low-molecular-weight PAHs (LPAHs) and high-molecular-weight PAHs (HPAHs).

3.0 SAMPLING OBJECTIVES AND GENERAL APPROACH

The SAP describes planned field methods, sample collection and handling, and analytical testing for sediment samples to be obtained during the sampling activities described. A Quality Assurance Project Plan (QAPP) has been proposed for the project and should be drafted prior to implementation of the SAP. However, GeoEngineers, Inc. (GeoEngineers) and the designated laboratory will ensure that the procedures, organization and specific quality assurance/quality control (QA/QC) activities are designed to achieve the data quality objectives (DQOs). The work will be conducted using appropriate protocols and procedures as described in this SAP to obtain additional site data needed to establish baseline conditions relevant to COCs in modeled erosional and depositional areas. These data could also be used in future cleanup coordination should the site be designated for cleanup.

An overview of the sampling locations proposed is shown on Figure 2, Sampling Overview and includes the following general tasks:

- Collect seven subtidal surface (0 to 30 centimeters [cm] below mudline [bml]) sediment samples to characterize material that is modeled to erode following pile removal activities proposed at the Site

(designated as sample type DM0). See Figure 3, Proposed Sediment Sampling Locations – Erosional Area for details on these locations.

- Collect five subtidal surface (0 to 2 cm bml) sediment samples to collect baseline sediment chemistry within the depositional area modeled post pile removal activities at the Site (designated as sample type DM1). See Figure 4, Proposed Sediment Sampling Locations – Depositional Area for details on these locations.
- Collect a reverification sample (designated as sample type DM2) at a location sampled during a previous sediment investigation (0 to 6 cm bml) to confirm concentrations within this area of the site (shown on Figures 3 and 4).

Contaminants identified in Site sediment during previous investigations that are to be further characterized using the procedures specified in this SAP include:

- Grain size
- Total Organic Carbon (TOC)
- Total Volatile Solids (TVS)
- Polycyclic aromatic hydrocarbons (PAHs)
 - LPAHs and HPAHs
 - cPAHs
- Dioxins/furans

All erosional samples will be analyzed for the analytes listed above with the exception dioxins/furans. Samples will be archived and analyzed for dioxins/furans based on results of TVS. The two samples with the highest TVS will be analyzed for dioxins/furans. TVS can be used as a proxy for characterizing extent of wood waste in a sample and since treated wood is thought to be a potential source of dioxin, analyzing the two samples with the most elevated TVS will correlate to the samples with the most elevated concentrations of dioxin/furans. Material from five erosional samples will be archived for future dioxin/furans analysis. Depositional samples and the reverification sample will be analyzed for all analytes with the exception of dioxin/furans, which will not be analyzed. Table A-1, Proposed Sample Locations, Objectives and List of analyses summarizes the proposed sample locations, objectives and list of analyses, as described above.

In addition, field QC samples will be collected and analyzed to monitor the consistency of sampling methods and potential influence of off-site factors on environmental samples. Field QC samples will consist of field duplicate(s) and field blank(s). Description of this type of QC will be developed in the proposed QAPP.

The sediment investigation will be conducted as a single field effort within and near the Site. Surface sediment samples will be collected using a combination of a box corer/push corer or Van Veen sampler deployed from a vessel.

4.0 PERSONNEL AND RESPONSIBILITIES

The following personnel will have key roles and responsibilities for future sediment sampling and analysis activities:

Project Management: The project manager will be responsible for the overall quality assurance for sediment sampling and analysis on this project to ensure that it meets technical requirements. The project manager will also oversee the tasks associated with the sediment sampling and analysis and will have responsibility for implementation of the sediment sampling and analysis program and data evaluation.

Field Coordinator: The Field Coordinator will be a qualified scientist (geologist, environmental scientist or engineer) who will be responsible for performing sediment sample collection in accordance with the methods and procedures. Duties will include coordination of field sampling efforts and sample delivery to the laboratory. Responsibilities will also include complying with the site-specific Health and Safety Plan (HASP).

Quality Assurance Leader: A Quality Assurance leader will be responsible for coordinating QA/QC for laboratory testing of field samples. Specific responsibilities include the following:

- Serve as the official contact for laboratory data QA questions and concerns.
- Confirm acceptability of the laboratory QA Plan.
- Respond to laboratory data QA needs, answer laboratory requests for guidance and assistance, and resolve issues.
- Monitor laboratory compliance with data quality requirements.
- Confirm that appropriate sampling, testing and analysis procedures are followed and that proper QC checks are implemented.
- Review the implementation of the QAPP and the overall quality of the analytical data generated.
- Implement or direct corrective actions if necessary.
- Review project policies, procedures and guidelines and review the project activities to verify that the QA program is being properly implemented.
- Provide oversight of the data development and review process and of subcontracting laboratories.
- Develop work scopes for the subcontracting laboratories that incorporate QAPP requirements.
- Conduct or delegate data review activities.
- Enter data into Washington State Department of Ecology's (Ecology's) Environmental Information Management (EIM) system.

Analytical Laboratory Manager (Subcontractor): The subcontracted laboratory(ies) conducting analytical testing for this project are required to confirm with the QA Leader that laboratory procedures are consistent with the project QA objectives. The Laboratory QA Coordinator administers the Laboratory QA Plan and is responsible for QC. Specific responsibilities of the Laboratory QA Coordinator include:

- Verify implementation of the Laboratory QA Plan.
- Serve as the laboratory point of contact.
- Activate corrective action as necessary when analytical control limits are exceeded.
- Issue the final laboratory QA/QC report.

- Comply with QAPP and contractual requirements for laboratory services.
- Participate in QA audits and compliance inspections if determined by GeoEngineers to be needed.

Analytical Resources, Inc. (ARI; Tukwila, Washington) is an Ecology-certified analytical laboratory and provided costing and information for the analysis of all analytes.

In addition to the above, we have assumed the field collection portion of this SAP would be implemented from a vessel with potential support from divers should remote sampling not meet sample acceptance criteria. Specific boat support needs include the following:

- Ability to position sampling devices or divers with sub-meter accuracy.
- Ability to deploy and retrieve sampling devices.
- Ability to decontaminate sampling gear and/or divers between sampling events.
- Enough deck space to process and manage sample processing.
- If divers are needed, provide equipment and divers compatible with sampling within a potentially contaminated sediment area (e.g. full face mask, impervious dry suits, trained in decontamination procedures)

Research Support Services was contacted for information on implementation and costing information for boat and diver support.

5.0 SAMPLING AND ANALYTICAL TESTING PROGRAM

Table A-1 presents a summary of the proposed sample locations, objectives and analyses. A summary of the proposed sample locations, positioning and sample designations is presented below.

5.1. Sampling Locations

Sediment sampling locations are focused within two main areas: erosional and depositional. The erosional area is the area that has been modeled to erode following pile removal. The depositional area is the area modeled to receive transported material from the Site. These areas are shown on Figures 2 and 3. The last location proposed for sampling is a reverification of a sample collected by WDNR in 2015.

5.2. Sample Positioning

The horizontal coordinates of exploration locations will be determined using a hand-held Trimble GeoXT® global positioning system (GPS) unit or similar equipment. GeoEngineers' field personnel will log the exploration location names and coordinates in the GPS unit for subsequent downloading to a computer. GPS data collected in the field will be processed in the office using measurements from the nearest reference station to each data collection point.

5.3. Sediment Sample Designation

Sediment samples collected from the intertidal and subtidal zones also will be assigned a unique sample alpha numeric identifier (DM***). The first two variables indicate site name (i.e. DM equates to Dickman

Mill) and are static for this sampling event. The following alpha numeric value corresponds to location and sampling technique and shall be assigned as follows:

- 0; erosional zone within pile field sampled with a box corer/push corer
- 1; depositional zone sampled with Van Veen
- 2; verification sample from previously sampled location using Van Veen

Remaining values are digits that indicate sample site (0 through 9). For example, the sample collected in the erosional zone would be identified at DM002 to indicate it was taken in the erosional zone (0) and it was the second sample location (02).

6.0 SAMPLING EQUIPMENT AND PROCEDURES

The following sections summarize sample collection procedures. Table A-1 provides supporting summary details for the planned sampling objectives and analytical program.

6.1. Sediment Sample Collection

Sediment samples will be collected using several methods depending on location. Erosional samples will be collected using a box corer sampler deployed from a vessel. In the event that samples collected using a box corer fail to meet sample acceptance criteria or other Site conditions preclude the use of a box corer, samples will be collected underwater via push corer using divers. Depositional samples and the reverification sample that do not require penetration beyond a few centimeters will be collected using a Van Veen sampler or modified Van Veen sediment sampler deployed from a vessel designed for such purposes. All equipment must be decontaminated before and after sampling.

The general procedure for collecting sediment samples via box corer or Van Veen is as follows:

1. Maneuver the sampling vessel to the proposed sampling location, steady the vessel and verify location control using the GPS.
2. Record the location of the sample.
3. Prepare the sampler for deployment.
4. Deploy the sampler through the water column to the mudline at approximately 1 foot per second (fps). Verify that the sampler cable is plumb.
5. Record the sampling time and the depth to mudline below the water surface (using the lead-line).
6. Release the sampler and raise it to the vessel at approximately 1 fps.
7. Place the sampler on the work surface of the vessel. Avoid jostling the sampler and/or disturbing the sample.
8. Examine the sample for the following sediment acceptance criteria:
 - The sampler is closed.
 - The sampler is not overfilled so that the sediment surface presses against the top of the sampler.
 - Minimal leakage has occurred, as evidenced by overlying water on the sediment surface.

- Minimal sample disturbance has occurred, as evidenced by limited turbidity in the overlying water.
 - For erosional samples, a penetration of at least 30 cm has been achieved. A depth of 30 cm shall be the target penetration depth in order to sample sediment that has not come into contact with the side of the sampler.
 - If penetration cannot be achieved with box corer, a diver will be used using push corer methods in order to achieve the target penetration depth.
 - For depositional samples, a penetration of at least 5 cm has been achieved. A depth of 5 cm shall be the target penetration depth in order to sample the top 2 cm of sediment that has not come into contact with the side of the sampler.
 - If any of the sediment acceptance criteria are not achieved, the sample will be rejected, and the location resampled. If the proposed sampling location cannot be achieved after four deployments, notify the Project Manager to determine an appropriate alternative location.
9. Siphon off standing water from the surface of the sediment using a hose primed with Site saltwater. Do not disturb the surface of the sediment.
 10. Visually classify sediment in accordance with ASTM International (ASTM) D 2488 methods and the Unified Soil Classification System (ASTM D 2487) and record on the field form. In addition to the visual classification, sediment samples shall be field screened (see Section 5.2 Sample Positioning). Qualitative descriptive parameters including biota, debris and presence of petroleum product/staining shall also be recorded.
 11. Photograph the sediment. Include in the camera's field of view a sheet of paper or white board with the sample name written in large black print; use care not to touch the sediment with the paper/whiteboard.
 12. For erosional samples, collect the upper 30 cm of sediment from the sampler using a decontaminated stainless-steel spoon. For depositional samples, collect the upper 2 cm of sediment from the sampler using a decontaminated stainless-steel spoon. For the reverification sample, collect the upper 6 cm of sediment from the sampler using a decontaminated stainless-steel spoon. For all samples, no sediment will be collected for analysis that has been in contact with the side of the sampler.
 13. Place the sediment into a decontaminated stainless-steel homogenization bowl. Cover the container with a new sheet of aluminum foil and dispose after use.
 14. Thoroughly rinse the interior of the sampler until all loose sediment has been washed off. Excess sediment will be returned to the water surface in the approximate location where the sample was collected.
 15. If sufficient sample volume was not collected, repeat the sampling process until sufficient volume is achieved. Successive deployments should be within an approximate 10-foot-radius of the initial deployment.
 16. Homogenize the sediment (from one deployment if adequate sediment volume was achieved, or from multiple deployments if multiple deployments were required) in the stainless-steel bowl using the stainless-steel spoon until the sediment appears generally uniform in color and texture.
 17. If large wood pieces (greater than 0.5-inch) are observed within the sample during homogenization, they will be removed prior to distribution into sample jars.

18. Distribute the sample to appropriate sample containers identified in Table A-2 and ensure that the samples are properly labeled and tightly closed.
19. Clean the exterior of the sample containers and store them in a cooler with ice.
20. Decontaminate all equipment as described in Section 5.3 Sediment Sample Designation.
21. Double check that field collection forms are completed.

6.2. Field Screening

As described in step 10 in the section above, field screening will be performed as part of sample collection. Results of field screening will be recorded on the field logs. The following field screening methods will be used: (1) visual screening; and (2) water sheen screening. These methods are described in detail below.

6.2.1. Visual and Olfactory Screening

Sediment will be observed for unusual color and stains and/or odor (e.g. hydrogen sulfide [rotten egg smell], petroleum hydrocarbons, etc.) indicative of possible contamination. Visual observation will also include presence of debris type, vegetation and biological activity. If wood debris is present, the type or types of wood debris (i.e., bark, chips, chunks, twigs, fibers, etc.) and the estimated quantity (i.e., observed percent by volume) of each type of wood debris will be recorded. Record size and quantity of wood material removed from homogenate prior to distribution into sample jars.

6.2.2. Water Sheen Screening

This is a qualitative field screening method that can help identify the presence or absence of petroleum hydrocarbons. A portion of the soil sample will be placed in a pan containing distilled water. The water surface will be observed for signs of sheen. The following sheen classifications will be used:

Classification	Identifier	Description
No Sheen	(NS)	No visible sheen on the water surface
Slight Sheen	(SS)	Light, colorless, dull sheen; spread is irregular, not rapid; sheen dissipates rapidly
Moderate Sheen	(MS)	Light to heavy sheen; may have some color/iridescence; spread is irregular to flowing, may be rapid; few remaining areas of no sheen on the water surface
Heavy Sheen	(HS)	Heavy sheen with color/iridescence; spread is rapid; entire water surface may be covered with sheen

6.3. Equipment Decontamination Procedures

Field sampling equipment, including the sediment samplers (i.e., Van Veen sampler, core barrel and drive head) as well as stainless-steel bowls and spoons, will be cleaned prior to sampling and between each sampling location. Equipment for reuse will be decontaminated according to the procedure below:

1. Seawater will be sprayed over equipment to dislodge and remove any sediment.
2. Surfaces of equipment contacting sample material will be scrubbed with a brush using an Alconox solution.
3. Scrubbed equipment will be rinsed and scrubbed with deionized water.

4. Equipment will undergo a final spray rinse of deionized water.

Field personnel will limit cross contamination by changing gloves between sampling events.

6.4. Field Documentation

Sample documentation will be recorded on sample forms. In addition, field reports will be completed on field report forms. Field sample forms and reports will become part of the project files at the conclusion of this field exploration.

At a minimum, the following information will be recorded during the collection of each sample:

- Sample location.
- Sampler's name(s).
- Date and time of sample collection.
- Water depth.
- Sampling equipment penetration, sample material recovery depth and sample interval.
- Gross characteristics of the sediment including:
 - Presence or absence of stratification
 - Texture
 - Color
 - Presence of biota or biological structures
 - Presence of debris including wood
 - Field screening results (see Section 5.2)
- Description of wood presence, type and quantity of wood, if observed, including:
 - Type of wood (e.g., sawdust, bark, processed lumber, stick)
 - Location of wood (e.g., on the surface, beneath the surface, in a layer, mixed throughout)
- Visually based volumetric estimate of wood (i.e., less than 25 percent, between 25 percent and 50 percent, and greater than 50 percent) in the sediment and/or in discernible sediment horizons (preferably using percentage diagrams available on soil classification charts).
- Gross characteristics of the vertical profile including:
 - Presence of a redox layer and redox layer thickness if present
 - Changes in material characteristics.

The following information also will be recorded in the field log for each day of sampling:

- Deviations from the SAP, HASP or QAPP.
- Decontamination procedures (i.e., whether solvents were used and where).
- Calibration readings for any equipment used.

The handling, use and maintenance of field logbooks are the field coordinator's responsibilities.

6.5. Sample Containers

Pre-cleaned sample bottles and jars will be supplied by the subcontracted analytical laboratory. The sample containers will be protected from contact with dust, dirt and other potential sources of cross-contamination. Sample containers will not be reused. The sample collection activities will be noted on the field forms. The Field Coordinator will monitor consistency between the SAP, sample containers/labels, field logbooks and the chain-of-custody. See Table A-2 for sample containers by analysis. Sample labels will be completed following the sample designation as described in Section 5.3.

6.6. Sample Storage and Shipping

Samples will be placed in a cooler with wet ice or “blue ice” immediately after they are collected. Holding times will be observed during sample storage. Holding times for the project analyses are summarized in Table A-2.

The samples will be transported and delivered to the analytical laboratories in coolers. Transport and delivery may be performed by one of the following methods:

- Field personnel may transport and deliver samples that are being submitted to a local laboratory for analysis.
- Field personnel may transfer the samples to a courier service. Custody seals will be attached to coolers.
- Field personnel may have the samples shipped to the laboratory via a commercial express mailing service. Custody seals will be attached to coolers.

Regardless of the transport method, the shipping containers (coolers) will be properly secured using ice, packaging material and clear plastic tape, as necessary.

6.7. Disposal of Investigation Derived Waste (IDW)

All disposable sampling material and personal protective equipment (i.e., disposable coveralls, gloves and paper towels) used in sample processing will be placed in garbage bags or other appropriate containers. Disposal supplies will be removed from the site by sampling personnel and placed in a normal refuse container for disposal at a solid waste landfill. Sediment remaining after surface sample collection will be returned to the water surface.

7.0 HEALTH AND SAFETY

Field activities will be performed in accordance with the requirements of the Washington Industrial Safety and Health Act (WISHA; Revised Code of Washington [RCW] 49.17) and the Federal Occupational Safety and Health Act (OSHA; 29 Code of Federal Regulations [CFR] 1910, 1926). These regulations include requirements that workers (including and especially divers) are to be protected from exposure to contaminants. Companies providing services for this project on a subcontracted basis (if applicable) will be responsible for developing and implementing their own HASP.

8.0 LIMITATIONS

This SAP has been prepared for the exclusive use of the Washington State Department of Natural Resources, their authorized agents and regulatory agencies in their evaluation of the Dickman Mill Site. No other party may rely on the product of our services unless we agree in advance and in writing to such reliance.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted environmental science practices in this area at the time this report was prepared. No warranty or other conditions, expressed or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

9.0 REFERENCES

American Society for Testing Materials (ASTM) “ASTM D 2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)” July 2017.

GeoEngineers, Inc. (GeoEngineers) 2020. Dickman Mill Coastal Engineering Assessment – Pile Study. Prepared for Mott MacDonald, LLC. December 14, 2020. GEI File No. 0503-027-00.

Mott MacDonald (Mott) 2021. DRAFT Dickman Mill Pile Field Removal Coastal Engineering Assessment, Phase 2 Summary Memorandum. June 28, 2021.

Occupational Safety and Health Act (OSHA) 29 USC Chapter 15; 29 CFR 1910, 1926.

Washington Industrial Safety and Health Act (WISHA) RCW 49.17, Chapter 296-62, 694-843.

Washington Administrative Code (WAC) 173, Chapter 173-340-820.

Table A-1
Proposed Sample Locations, Objectives and List of Analyses
 Sediment SAP, Dickman Mill Site
 Tacoma, Washington

Sample			Location ¹			Objectives	Analytes					
Identification	Collection Method	Sample Count Per Location	Coordinates ²		Depth Interval ³		Dioxin*	SVOCs		Conventional		
			Latitude	Longitude				cPAHs	PAHs	TOC	TVS	Grain Size
Sediment Samples												
DM0-01	Box corer/push corer	1	47.27833	-122.47175	0 to 30cm	Subtidal sediment sampling within the modeled erosional area to a depth of 0 to 30cm bgs.	X	X	X	X	X	X
DM0-02	Box corer/push corer	1	47.27824	-122.47160	0 to 30cm		X	X	X	X	X	X
DM0-03	Box corer/push corer	1	47.27832	-122.47156	0 to 30cm		X	X	X	X	X	X
DM0-04	Box corer/push corer	1	47.27816	-122.47138	0 to 30cm		X	X	X	X	X	X
DM0-05	Box corer/push corer	1	47.27806	-122.47119	0 to 30cm		X	X	X	X	X	X
DM0-06	Box corer/push corer	1	47.27822	-122.47123	0 to 30cm		X	X	X	X	X	X
DM0-07	Box corer/push corer	1	47.27816	-122.47105	0 to 30cm		X	X	X	X	X	X
DM1-01	Van Veen	1	47.27802	-122.46883	0 to 2cm	Subtidal sediment sampling within the modeled depositional area to a depth of 0 to 2cm bgs.		X	X	X	X	X
DM1-02	Van Veen	1	47.27825	-122.46883	0 to 2cm			X	X	X	X	X
DM1-03	Van Veen	1	47.27760	-122.46734	0 to 2cm			X	X	X	X	X
DM1-04	Van Veen	1	47.27744	-122.46599	0 to 2cm			X	X	X	X	X
DM1-05	Van Veen	1	47.27672	-122.46414	0 to 2cm			X	X	X	X	X
DM2-01	Van Veen	1	47.27879	-122.47052	0 to 6cm	Reverification of previously sampled location		X	X	X	X	X

Notes:

*Dioxin samples will be archived and analyzed based on results of TVS . The two samples with the highest TVS will be analyzed for dioxin.

¹ Approximate locations are shown on Figures 1 and 2

² Coordinates are presented in North American Datum (NAD) of 1983, Washington State Plane South.

³ Depth is presented in centimeter (cm) below mudline (bml) for sediment samples.

bgs = below ground surface

cPAHs = Carcinogenic Polycyclic Aromatic Hydrocarbons

PAHs = Polycyclic Aromatic Hydrocarbons

VOCs = Volatile Organic Compounds

SVOCs = Semi Volatile Organic Compounds

TVS = Total Volatile Sulfides

TOC = Total Organic Carbon

Table A-2
Sediment Analytical Methods, Sample Size, Containers, Preservation and Holding Times
Sediment SAP, Dickman Mill Site
Tacoma, Washington

Parameter	Method	Minimum Sample Size	Container Size and Type	Sample Preservation Technique	Holding Times ¹
Grain Size	PSEP 1997	300g	16 oz. HDPE or Plastic Bag	Cool, 6 °C	6 months
Total Organic Carbon (TOC)	Plumb 1981 (if TOC above 2%); Standard Method 5310B or SW846 Method 9060 (if TOC below 2%)	25g	8 oz. WM Glass with Teflon™- lined lid	Cool 0 to 6°C or Freeze -18 °C	14 days (fresh sample) or 6 months (frozen)
Total Volatile Solids	PSEP 1986	20g	4 oz. WM Glass with Teflon™- lined lid (no headspace)	Cool, 6 °C	14 days
PAHs	SW8270D-SIM	200 g	2 x 8 oz. or a 16 oz. WM Glass with Teflon™-lined lid	Cool, 4 °C	14 days
				Freeze, -18 °C	1 year until extraction
Dioxins/furans	EPA 1613B	100 g	8-oz WM Amber Glass with Teflon™-lined lid	Freeze -18 °C	1 year until extraction

Notes:

¹Holding times are based on elapsed time from date of sample collection.

EPA = Environmental Protection Agency

HDPE = High-density polyethylene

NA = Not Applicable

PAHs = Polycyclic Aromatic Hydrocarbons; LPAHs = Low Molecular Weight Polycyclic Aromatic Hydrocarbons; HPAHs = High Molecular Weight Polycyclic Aromatic Hydrocarbons.

PSEP = Puget Sound Estuary Program

SIM = Selective Ion Monitoring

SMS = Sediment Management Standards

SVOC = Semi-Volatile Organic Compound

TOC = Total Organic Carbon

TVS - Total Volatile Solids

WM = wide mouth

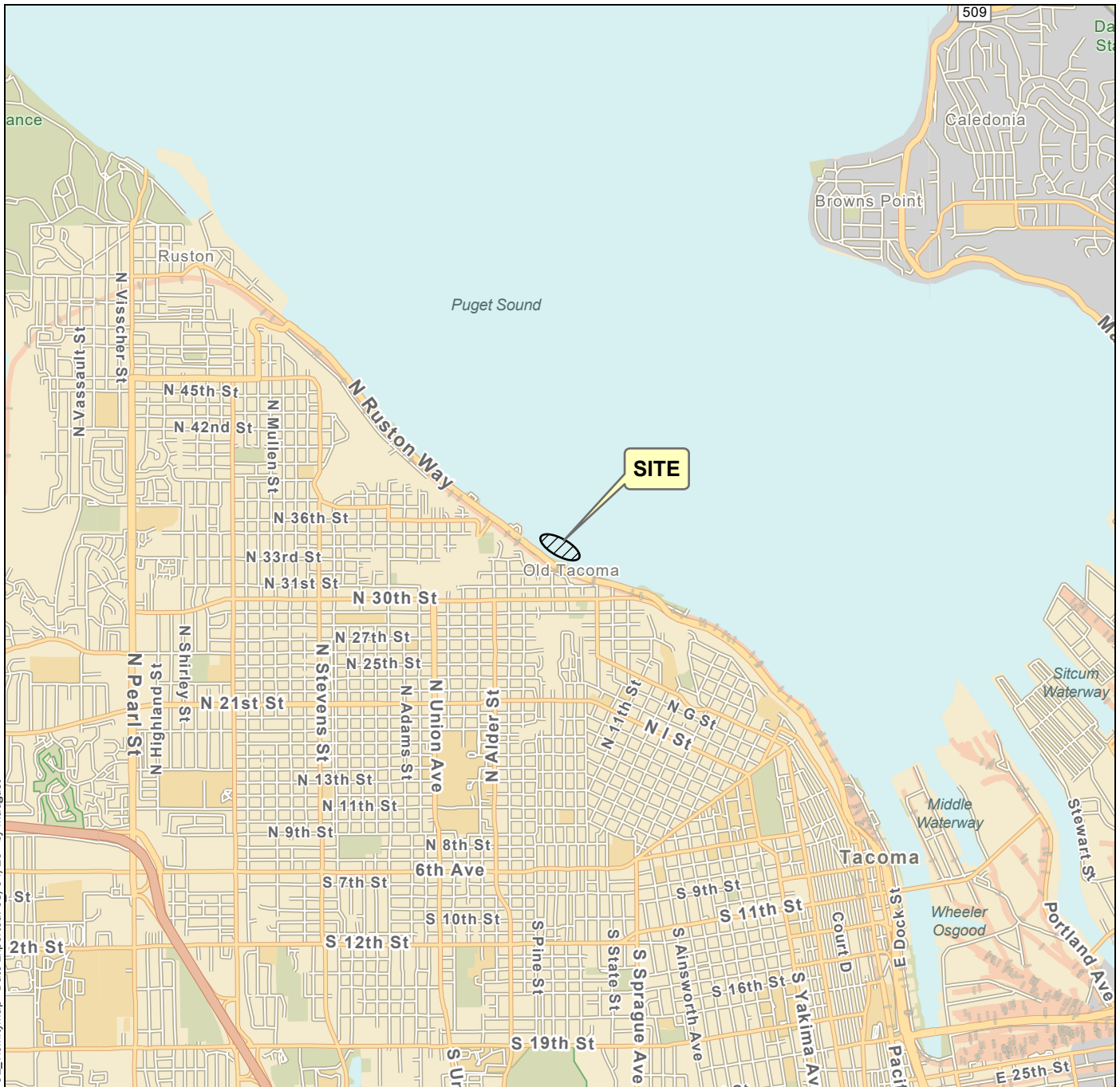
°C = degrees centigrade

g = gram

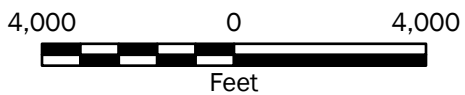
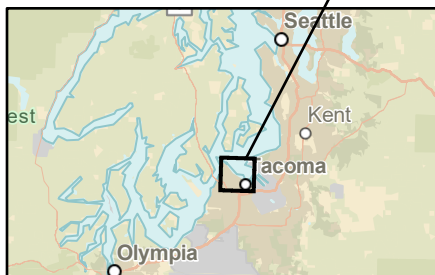
L = liter

ml = milliliter

oz =ounce



P:\0503027\GIS\050302700_Project\050302700_VicinityMap Date Exported: 08/04/20 by maugust



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: ESRI
 Projection: NAD 1983 UTM Zone 10N

Vicinity Map	
Dickman Mill Tacoma, Washington	
	Figure 1

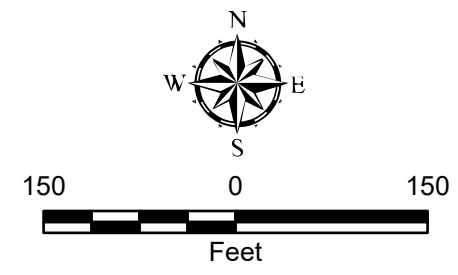
W:\Projects\0503027\GIS\050302700_Project\aprx\050302700_F02_SamplingOverview Date Exported: 06/29/21 by smahugh



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

- Legend
- Sample Locations
 - Reverification Sample Location
 - Approximate Inner Harbor Line

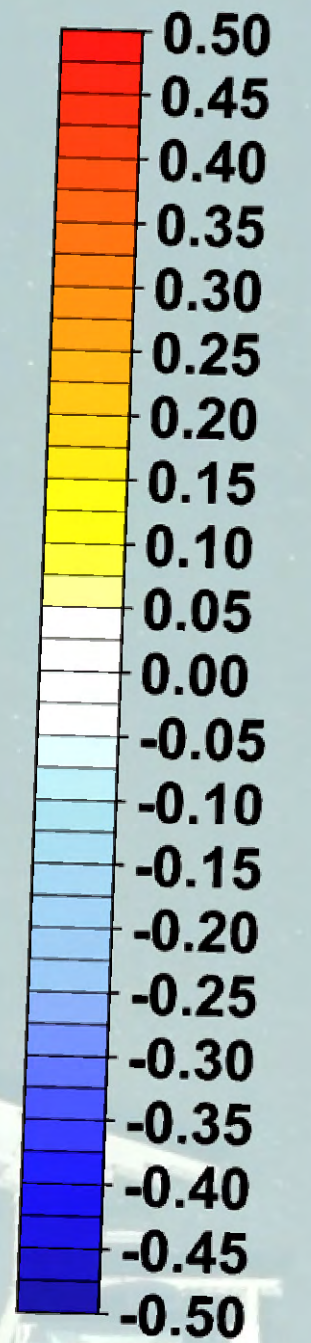
Data Source: ESRI 2021



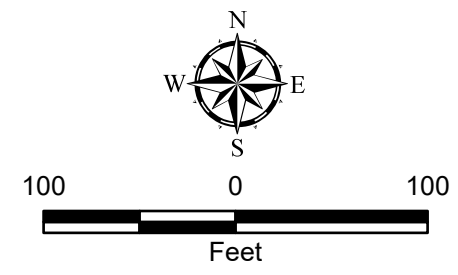
Sampling Overview	
Dickman Mill Tacoma, Washington	
	Figure 2



Bed Change [ft]



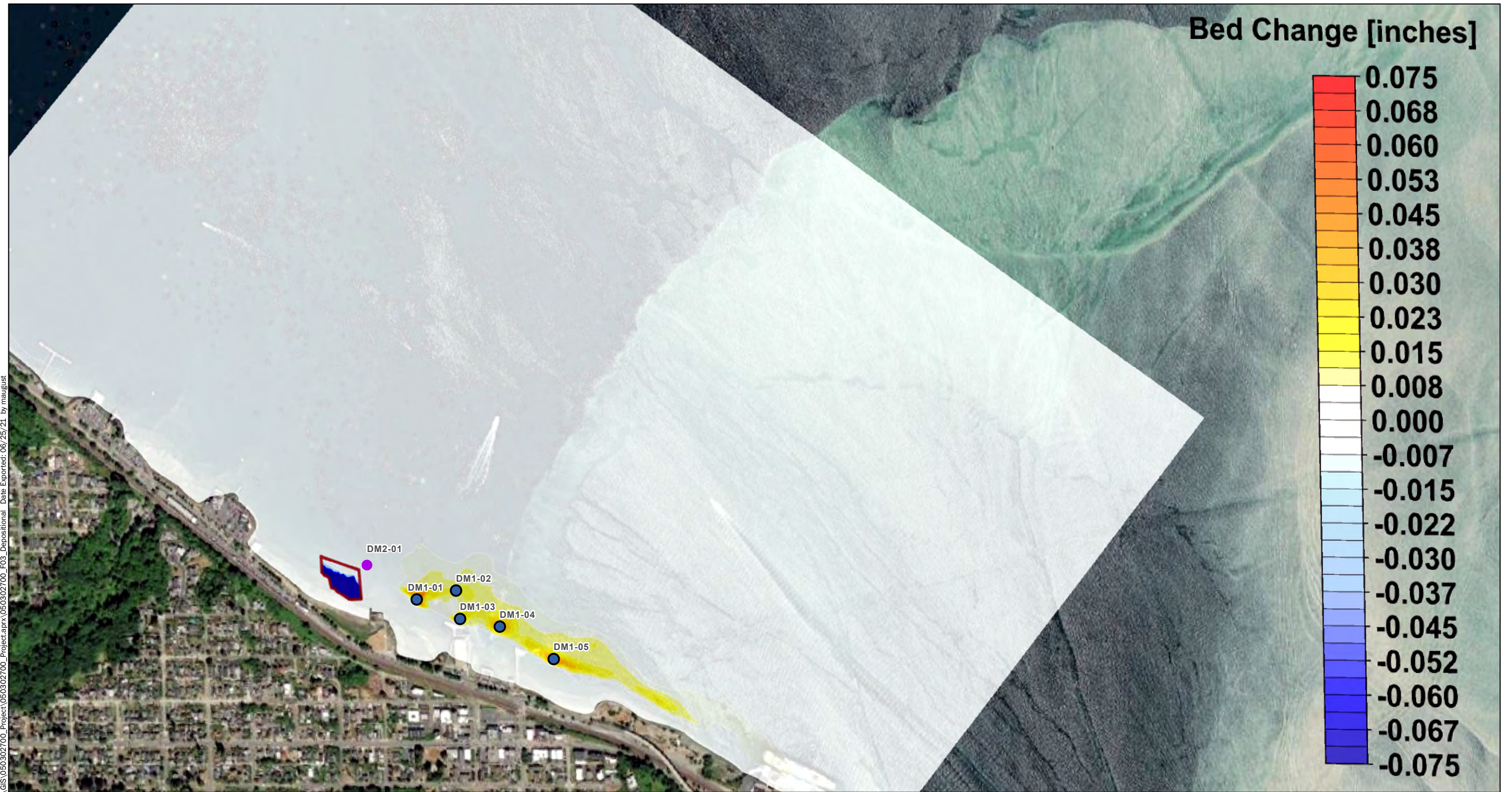
- Erosional Area within Pile Field Sampled with Box Corer/Push Corer (0 to 30cm bgs)
- Reverification Sample Location



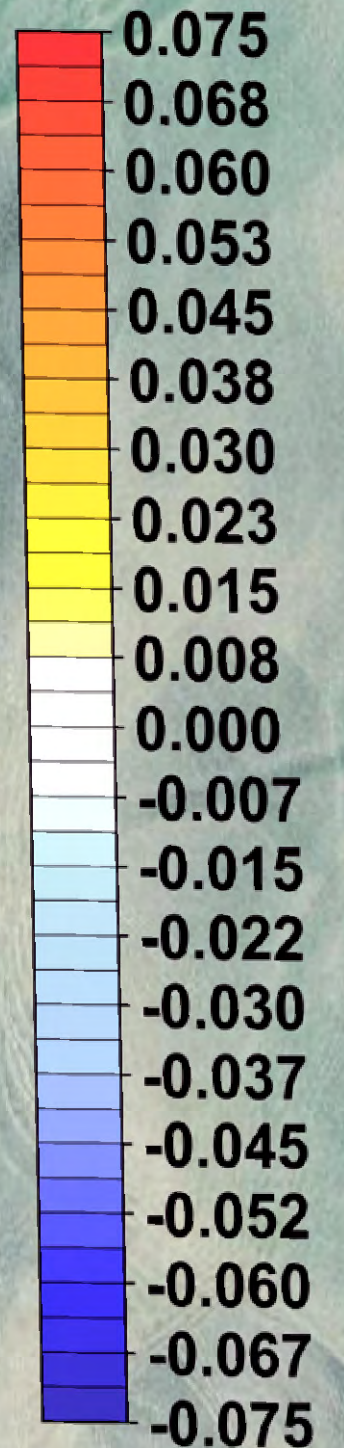
Proposed Sediment Sampling Locations - Erosional Area	
Dickman Mill Tacoma, Washington	
	Figure 3

Data Source: Dickman Mill Coastal Engineering Assessment— Pile Study, Mott Mac, 2021.

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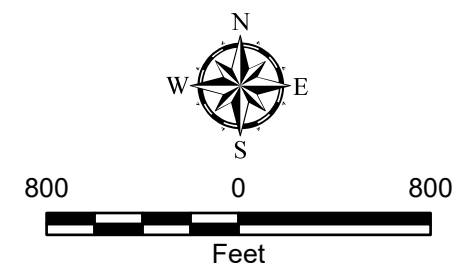


Bed Change [inches]



- Depositional Zone Sampled with a Van Veen (0 to 2 cm bgs)
- Reverification Sample Location

Data Source: Dickman Mill Coastal Engineering Assessment— Pile Study, Mott Mac, 2021.



Proposed Sediment Sampling Locations - Depositional Area	
Dickman Mill Tacoma, Washington	
	Figure 4

