Memo

Date:	Monday, September 30, 2019
Project:	Coastal Erosion Assessment of Sterling Highway Termini on Homer Spit
To:	Joselyn Biloon, Kenai Area Planner (DOT&PF)
From:	Ruth Carter, PE, Coastal Engineer (HDR)
Subject:	Analysis and Concept Alternative

The purpose of this technical memorandum is to provide a Coastal Erosion Assessment of Sterling Highway Termini on Homer Spit (herein referred to as the "Spit") as well as provide concepts for long-term solution to help reduce maintenance costs and extend the functional life of the highway.

Metocean Conditions and Sediment Transport

The following provides a brief description of the meteorological and oceanographic (metocean) conditions as well as sediment transport trends along the Spit.

Tide

Tide datums for the area were gathered from the NOAA tide station located at Seldovia, AK and are provided in Table 1. Although this station is located across Kachemak Bay, the tide datums provide a good representation of conditions along the Spit.

Table 1. Tidal Datums at Seldovia NOAA Tide Gauge (NOAA 2019)

	Elevation, FT (MLLW)	Elevation, FT (NAVD88)
Mean Higher High Water	18.1	12.7
Mean High Water	17.2	11.9
Mean Sea Level	9.6	4.3
Mean Low Water	1.7	-3.6
Mean Lower Low Water (MLLW)	0.0	-5.3
North American Datum of 1988 (NAVD88)*	5.3	0.0
NAVD88 conversion calculated using Alaska Department of Natural Resources – Alaska Tidal Datum Portal (DGGS 2019).		

Wind

Figure 1 provides a wind rose from data gathered at the Homer airport. The wind rose graphically shows the wind direction, magnitude, and frequency of occurrence. A silhouette of the Homer spit is also included in the figure in the background. This provides a graphical orientation of the Spit shoreline in relation to the wind trends. From the figure, it can be seen that annually wind predominantly blows in two primary directions: northeast and west southwest.

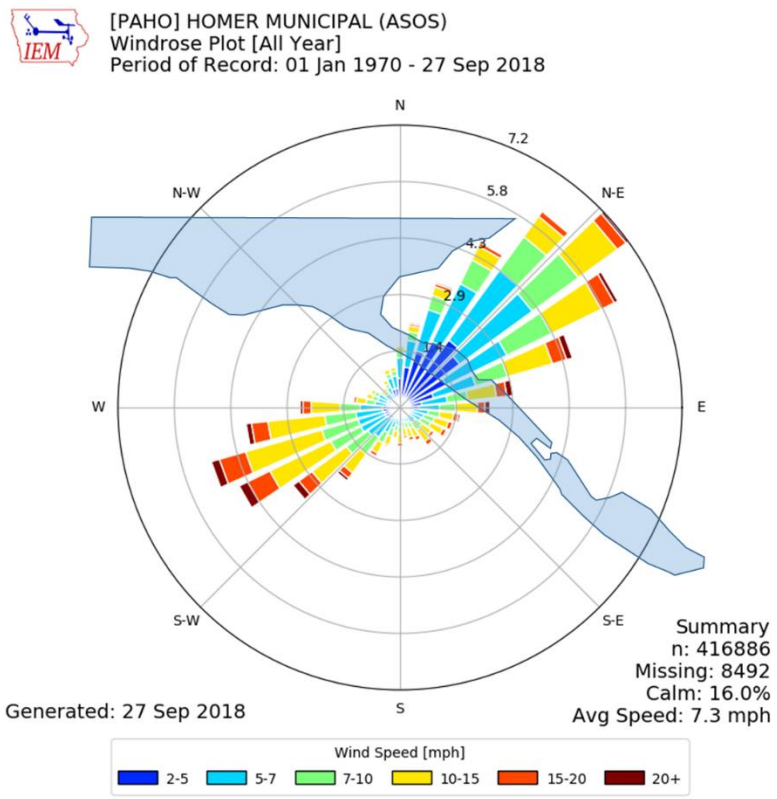

Figure 1. Wind rose showing predominant wind direction, freqency, and magnitude at Homer, AK (ISU 2019).

Waves

Kachekmak Bay is relatively shielded from open ocean swell coming from the Gulf of Alaska. Waves generated that impact the Spit are primarily wind-generated waves that have developed within the Kachekmak Bay/Cook Inlet water bodies. Because of this, wave directional trends will closely align with directional trends of the winds shown in Figure 1.

Homer Spit and the highway are partially protected by the Archimandritof Shoals, which forms off the terminus of the spit. The largest waves break offshore on the shoal. Nearshore, breaking waves form “offshore bars” that are visible at low tides; channels form on the beach from the strong return currents of these breaking waves.

Sediment Transport
For discussion purposes, sediment transport can be simplified as cross-shore transport and long shore transport.

Cross-shore transport is the movement of sediment up and down the beach profile. In typical open-ocean beaches, wave action from winter storms will cause cross-shore sediment transport to the lower part of the beach profile creating a skinner beach or lower beach elevations. During calmer summer periods, cross-shore transport will move this sediment back up into the higher portions of the beach profile creating a seasonally wider beach. This trend or some variation is likely occurring as seasonal variations of the Homer beach elevations are typical.

Long shore sediment transport is the movement of sediment parallel to the shoreline. Sediment will move along the shoreline as waves approach a shoreline from an oblique angle. The more oblique the angle and more wave energy, the more sediment is transported. Based on the wave directional trends and orientation along the Homer Spit, the beach experiences waves impacting the shoreline from a consistent oblique angle, thus a net sediment transport is southeastwardly as it moves around the tip of the Spit on incoming tides; outgoing tides send material westward off the end of the spit contributing to the Archimandritof Shoals. A 200 meter deep submarine trough at the end acts as a sediment trap limiting further spit extension.

Existing Observations

A site visit was conducted on September 17, 2019 with the Homer Port Administrator/ Harbormaster to observe the condition of the highway along the Spit. The state's Maintenance Superintendent also attended briefly while in the area. Photographs included represent the conditions present at the time of the site visit.

Background: The Homer Spit is a 4.5 mile long glacial spit composed of sands and gravel that offers recreational, commercial, industrial, and residential use. It is a valuable asset to the City of Homer and the State due to its economic and recreational opportunities. It is also a unique, coastal feature and a valuable environmental resource with its extensive bird and marine habitat.

While typically in equilibrium, it is apparent that the spit is undergoing a long period of erosion. This is evidenced by observing the piling structures located on the Spit, which are exposed an estimated ten feet more than three years ago, according to observations by the Harbormaster. Near Land's End, buried piling were exposed up to about 10-feet about three years ago, however only about one foot of piling was visible at the time of this site visit. Beach areas once used for camping and other recreation are now gone. Changes in storm patterns the past few years with milder summers and fewer strong southeasterly events may be affecting the sediment movement along the spit allowing greater erosion and less seasonal accretion (pers. comm. Bryan Hawkins, Homer Harbormaster).

The U.S. Army Corps of Engineers (USACE) rock revetment (Figure 2) appears exposed almost in its entirety (Figure 3), where in the past a greater portion of rock was buried. Originally, the Corps constructed 1000 feet of revetment in 1992, and extended it an additional 3700 feet in 1998. It is suspected that placement of the rock sections by the USACE affected the supply of

sediment, which impacted the overall littoral drift on the Spit. This caused beach lowering adjacent to the rock revetment and further south along the spit (i.e., down drift erosion).

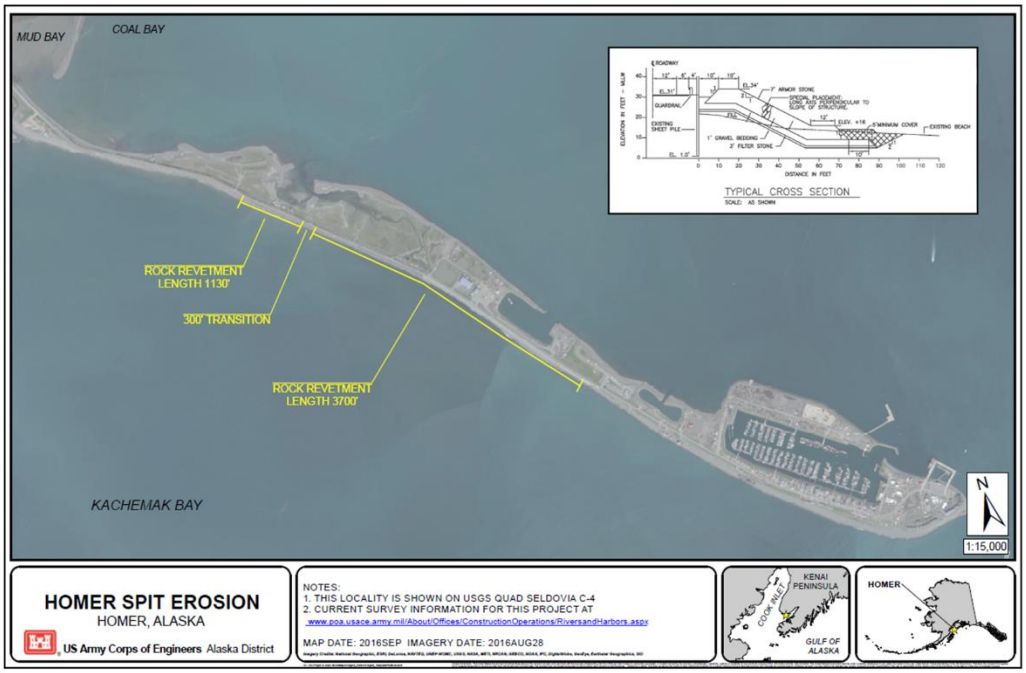

Figure 2. USACE rock revetment location maps (USACE 2019).

Figure 3. Condition of USACE revetment along the Spit.

Further to the south the Alaska Department of Transportation and Public Facilities (ADOT&PF) has armored the highway in two emergency projects. These areas are known to be subject to periodic overtopping; visible damage to the asphalt on the roadway shoulders was observed. The transition from USACE to the DOT&PF revetment projects is shown in Figure 4.

Figure 4. Transition of USACE and DOT&PF revetment projects.

A large lens of sand/gravel was noted near the DOT&PF revetment; it appears to be migrating southeast on the upper beach. The sand lens is shown in Figure 5.

Figure 5. Sand lens observed along DOT&PF revetment.

Dredged materials have been placed on the beach in various locations. This material was observed to be naturally sorted. Larger cobbles remain on the upper beach, while fines are washed out, migrate and are transported offshore or alongshore. This often leaves an escarpment that can be perceived as erosion, however it is a natural sorting effect that occurs when type of material is placed and exposed to wave/currents. Photograph of typical escarpment associated with eroding dredged material is shown in Figure 6.

Figure 6. Escarpment along Spit demonstrating natural sorting of placed dredged material.

Area between the boardwalk businesses near the end of the spit was damaged in a March 2019 storm, according to Bryan Hawkins. The City of Homer plans to place an estimated 40,000 cubic yards of dredged material from a privately-owned barge basin into this area to try to partially reclaim their city camping sites. Currently there is no camping area. It is expected that placement of this material will also provide a buffer for the highway embankment in this area. Figure 7 shows a former camping area; utility pole now exposed about 10-feet more than one year ago.

Figure 7. Former camping area along the Spit.

Near Land’s End, a perched beach was created by placing large boulders on the upper beach and back-filling with dredged material (Figure 8). Only the cobbles remain and provide a more stable beach profile. The large rocks also act as a small groin and have helped rebuild the upper beach in this area. It is estimated that 10 to 30 percent of the material in dredged spoils is cobbles; the remainder is fines that get moved offshore or alongshore. Photo perched beach concept.

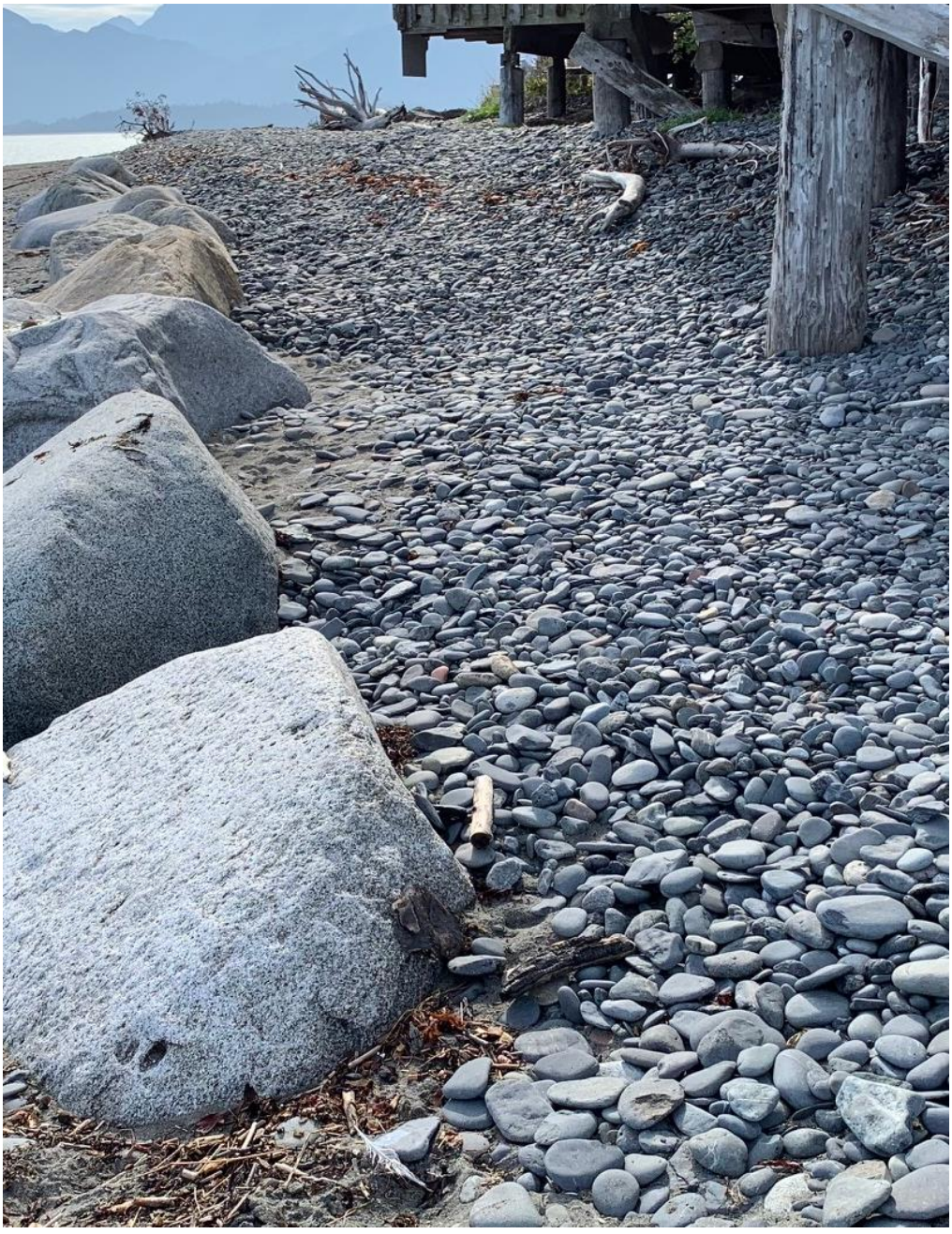

Figure 8. Boulders placed along Land's End.

Figure 9 provides an overall view of Homer Spit from the air with cruise ship at City of Homer dock.

Figure 9. Oblique aerial of the Homer Spit during the time of the site visit.

Coordination

State, federal and local agencies were contacted for this study. This included the DOT&PF Planning and Maintenance Sections, the U.S. Army Corps of Engineers Operations Branch, and the City of Homer Harbor Department. While this list is not extensive, sufficient information was gathered to address the needs herein.

In May of this year, there was a meeting held in Homer to address long term erosion concerns on Homer Spit; a copy of the meeting notes is attached. Overwhelmingly, the conclusion was

that a Long Term Management Plan is needed for material on the Spit and that there needs to be a Working Group involving state, federal and local agencies along with other interested parties.

Meeting on the Spit with the Homer Harbormaster and DOT&PF Maintenance Superintendent provided a view of city and state concerns. Additionally, efforts of both parties to address erosion were discussed onsite.

Highway Embankment Protection Concept

A number of concepts for improving the longevity of the existing roadway embankment were considered. Including a perched beach, a groin field, offshore breakwater, sediment management (beach nourishment), a traditional rock revetment and a combination of a revetment with sediment management.

Due to the importance of access on Homer Spit, a traditional revetment is recommended; however it is strongly encouraged to couple any rock project with a sediment management plan for long term viability of the spit. If the cost is similar, concrete armor units may be considered in lieu of rock to further reduce run-up and overtopping.

Armor Stone Revetment and Sediment Management

This concept is essentially a ‘belt and suspenders’ approach to protecting the department infrastructure and maintaining the recreational beach. This concept proposes to extend the existing armor stone revetment along the roadway and building the beach seaward of the larger rock.

The revetment would use at least two stone material classes: a filter stone and a primary armor stone. Filter stone would be placed between the primary armor stone and the road embankment. The larger primary armor stone would protect the roadway from large storm events; the beach nourishment would provide a buffer protecting the roadway from smaller events. A vertical cutoff wall would prevent undercutting of the asphalt on the shoulder of the road.

Figure 10 provides a schematic of this concept.

This concept include the following assumptions: Design High Water +18 feet, Design Low Water -3 feet, Design Wave Height 6 feet, Beach Slope 8H:1V, Highway Elevation +31 feet. 2H:1V revetment slope. Average weight armor stone 3,000 lb.; filter stone 300 lb.

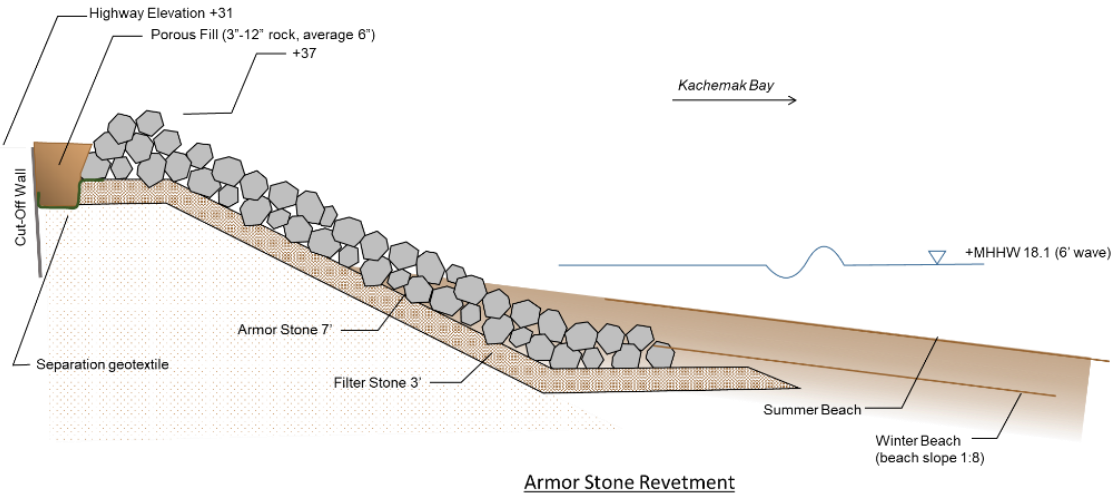

Figure 10. Armor stone revetment concept schematic.

Advantages

- Armor stone structures can be designed to have a long service life.
- Makes use of dredged materials; keeping them on the Spit.
- Reduce damage to edge pavement.

Disadvantages

- Armor stone can have a high construction cost.
- May require guardrail.
- Beach elevation will continue to lower in front of the rock revetments due to effect sediment cross-shore transport, so would need to be maintained.
- Down drift erosion will continue to occur due long-shore sediment transport.

Maintenance

- Conduct periodic surveys (every three to five years) to identify potential settlement of the structure and displaced stones.

Permits

Anticipated permits that would be required for this concept include: USACE 404/10, USACE 408, City of Homer, ADEC, U.S. Fish & Game Habitat, Endangered Species Act, Nation Marine Fisheries Service (NMFS)/Marine Mammal Compliance.

Rough Order Magnitude Costs

A rough order of magnitude (ROM) cost for this concept was developed. Quantities were determined through conceptual design and assumed rough unit rates were applied to develop the ROM costs. Note, no design has been performed to determine quantities, and comparable project costs were not reviewed. ROM costs should be used as a general "order of magnitude"

and not used for financial planning purposes. Costs associated with design and permitting of the concepts is include in the ROM cost values.

While in Homer there was a discussion with Bryan Hawkins, Homer Harbormaster, and Carl High, ADOT&PF Kenai Maintenance Superintendent, of rock availability and pricing briefly. Ouzinkie rock was used for a recently constructed Seward breakwater, according to Bryan Hawkins. Bryan also mentioned that there's a new quarry being tested in Kodiak. Carl stated that Dibble Creek out of Jakalof is producing crushed rock which is used to produce D-1 for highway projects. In addition, it was noted by both Bryan and Carl that there is the new Diamond Cape Quarry across the Inlet from Homer that may be able to provide armor rock.

The cost of this revetment would be roughly $1.1M to $1.5M per 100-foot station. Maintenance would be about 5% of cost of the revetment every three years.

Recommendations

The following provides some recommendations for advancing improvements to the Sterling Highway Terminus on Homer Spit.

- Due to the current state of erosion along the Spit, the roadway embankment should be protected with a hard structure. To develop an armor stone or concrete armor unit revetment, recommend advancing the project through a traditional design/bid/build or construction manager/general contractor (CM/GC) delivery project.
- The hard structure should be coupled with a Long Term Sediment Management Plan to improve the overall stability of the spit by keeping dredged materials in the system.
- Research and document historical and current studies to develop lessons learned prior to design.
- Work with City of Homer to establish a local observer network to install staffs to visibly measure the relative seasonal and annual changes in beach elevations. This could be as simple as a graduated staff attached to existing piling and was discussed with the Homer Harbormaster.
- Establish Working Group: City of Homer, DOT&PF, USACE, others, to meet annually and address immediate and long term needs.
- Develop a Long-Term Sediment Management Plan
    - Sediment Transport – determine where beach nourishment material is ending up and how long it takes to move from where it's placed.
    - Perform a Sediment Budget – determine how much material is needed to maintain the spit. Understand its origination. Determine the optimum placement and quantity for beach nourishment.
    - The Long-Term Sediment Management Plan should include extensive modeling and performance analyses to inform potential for erosion impacts. In addition, the plan should also include potential impacts/benefits of the Homer Harbor Expansion Project.

- Explore benefits of extending USACE revetment through a General Investigation as a Cooperative Project with state (ADOT&PF) and City of Homer as partners.

Attachments

- 2019-9-29 SUMMARY Homer Spit Erosion Tech Memo
- HOMER - May 21 Meeting Notes - USACE et al.
- 9-4-2019 Telephone Record-RCarter to JBiloon
- 9-16-2019 Telephone Record-RCarter to CHigh
- 9-16-2019 Teleconference Record-RCarter BHawkins JAnderson MTencza
- 9-17-2019 RAC Meeting Minutes - Field Observations-updated

References

DGGS, 2019. Alaska Department of Natural Resources, Division of Geological & Geophysical Surveys, Alaska Tidal Datum Port. Webpage, http://dggs.alaska.gov/sections/engineering/ak-tidal-datum-portal/calculator.php

ISU, 2019. Iowa State University, Iowa Environmental Mesonet. Webpage, http://mesonet.agron.iastate.edu/sites/locate.php

NOAA, 2019. Center for Operational Oceanographic Products and Services (CO-OPS), webpage, http://tidesandcurrents.noaa.gov/

USACE, 2019. United States Army Corps of Engineers, Alaska District. Webpage, https://www.poa.usace.army.mil/.