TETRA TECH, INC.

TRANSMITTAL

To:	U.S. Army Corps of Engineers Alaska District 2204 3rd Street Elmendorf AFB, AK 99506	Date: December 21, 2012
Attention:	Ronnie Barcak, Project Manager	
Project Name:	Design Services for Kenai Bluff Stabilization	

Description:

Electronic transmission via rmft upload, including:

- Quality Control Plan (Task 1 Deliverable)
- Updated Design Section (Task 3 Deliverable)
- Annotated Comments (Task 5 Deliverable)
- Cost Engineering Report (Task 6 Deliverable)
- Half-Size Drawings (Task 6 Deliverable)
- Initial Design Documentation Report (Task 7 Deliverable)
- Engineering Considerations and Instructions for Field Personnel (Task 8 Deliverable)

Remarks:

Please find the attached Initial Design Documentation Report (Initial DDR) for the Kenai Bluff Stabilization project. The cost engineering report, design drawings, annotated comments, and other supporting materials are provided as appendices to the Initial DDR. The enclosed design builds on the findings and recommendations of the 10/27/2008 Design Alternatives Report and replaces the 3/27/2009 Draft Design Report with updated wind and wave analyses. Please feel free to contact me with any questions. It has been a pleasure working with you on this project. Please feel free to contact me with any questions.

Signed: ____________________

Krey H. Price

TETRA TECH, INC.
1420 5th Ave.
Suite 550
Seattle, WA 98101
Tel: 206.728.9655
Fax: 206.728.9670

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U.S. Army Corps
of Engineers
Alaska District

Design Services for Kenai Bluff Stabilization

Initial Design Documentation Report

December 2012

Prepared By:

TETRA TECH, INC.
1420 5th Ave. Suite 550
Seattle, WA 98101

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EXECUTIVE SUMMARY

The City of Kenai, Alaska lies at the mouth of the Kenai River where it meets Cook Inlet. The ongoing erosion of a one-mile stretch of steep bluff along the north bank of the Kenai River has required the relocation of buildings, utilities, and other City of Kenai infrastructure. Engineering investigations have shown that as groundwater emerges along the bluff, it destabilizes the slope, carrying eroded material to the toe. River currents and wave action, in combination with high tides, carry the accumulated material into Cook Inlet, leaving the steep slope prone to further erosion. This report presents a recommended, long-term solution to halt the erosion of the bluff and stabilize the slope.

Previous conceptual designs presented alternatives for reducing or eliminating groundwater discharge from the bluff; these dewatering alternatives are not carried forward. The design presented in this report relies on the results of geotechnical investigations at the site, which concluded that in the absence of toe erosion resulting from wave action and river currents, a stable slope would allow the establishment of vegetation. In this design, groundwater discharge is conveyed through a subsurface filter layer of granular fill material or alluvial borrow material. Alternative configurations were developed and assessed, with individual alternatives varying in terms of their earthwork balance, the location of the revetment relative to the slope toe, and other configuration details.

The design earthwork balance considers the tradeoffs between additional the acquisition of real estate on the top of the bluff (required for the cut back slope) versus the impact of protruding the project footprint out into the river (required for placement of fill and rock at the toe of the slope). The affected bluff area was divided into zones in order to evaluate the relative costs and impacts of balancing cut and fill material against net excavation or placement of fill within each zone. This design generally balances earthwork within individual zones of the bluff, minimizing the net import or export of sediment to and from the site as well as between each zone.

The adopted solution was developed to effectively halt the erosion of the bluff, maintaining a stable slope under extreme conditions while minimizing impacts to the sensitive environmental habitat and cultural resources in the area. Long-term environmental impacts are not expected to be significant; however, these preliminary findings are to be revisited upon further environmental review of the proposed design.

The estimated construction cost is $30.8 million, with a total project cost of $41.4 million. The design and costs are based on a 50-year design life with a 4.5-foot design wave at the Kenai River mouth. The top of revetment is designed to accommodate the design wave runup occurring in conjunction with highest observed tide. Base mapping for the proposed design is based on aerial photography and detailed site topography acquired in September 2007. This report describes the project background, design criteria, engineering approach, and individual features of the design, with supporting documentation and previous studies included as attachments.

Design Services for Kenai Bluff Stabilization
Initial Design Documentation Report
December 2012

1.0 INTRODUCTION

1.1 Authorization

This work is authorized and funded under the Energy and Water Appropriations Act of 2002, Senate Report 107-039.

1.2 Problem Definition

For many years the City of Kenai has been concerned with the ongoing erosion of a one-mile portion of steep bluff along the north bank of the Kenai River. Over the past few decades the bluff has been significantly receding, requiring the relocation of privately owned buildings and public utilities. Unless measures to control the erosion and protect the bluff are implemented, bluff erosion is expected to continue, threatening additional cultural resources, public utilities, and residential, commercial, and public structures.

1.3 Project Purpose

This report documents the design criteria, alternative solutions, design analyses, design plans and cost estimates for a proposed bluff stabilization design. During the development of project alternatives, the costs of individual project components were compared against each other in the alternative formulation process in order to identify the least-cost option for addressing the project purpose while limiting environmental impacts. No economic analysis of without-project damages was performed as part of this study to quantify expected future damages to facilities and real estate if no action is taken. No with-project analysis of the potential increase in property values associated with a stabilized bluff was conducted as part of this study. These factors may be weighed separately during future project phases.

The data presented in this report are intended to assess and evaluate the causes and nature of the bluff erosion and to provide a basis of design for implementing a practicable, long-term solution. The primary objective in this endeavor is to stabilize the bluff against future erosion, utilizing a design approach that accounts for influences from wave action, river and tidal currents, overland flow, groundwater seepage, and other contributing forces. The design approach, as presented in the following chapters, recognizes the environmentally sensitive nature of the lower Kenai River Basin, particularly the fisheries resource and the marshlands habitat on the shore opposite the eroding bluff.

1.4 Project Location

The project is located in the City of Kenai, a home rule city within Alaska’s Kenai Peninsula Borough. The City of Kenai has a population of approximately 7,200 (U.S. Census Bureau 2011) and is situated where the Kenai River meets Cook Inlet. The eroding bluff is located along the north bank of the Kenai River, just upstream of the river mouth. Figures 1 and 2 show the project vicinity and location. The project area is divided into three zones referenced in this report. Zone A extends from the Kenai River mouth to Riverview Drive (Station 0+00 to 20+00 along the primary control line shown in Attachment G). Zone B extends from Riverview Drive to Ryan’s Creek (Station 20+00 to 36+00). Zone C extends from Ryan’s Creek to the Pacific Star Seafoods dock.

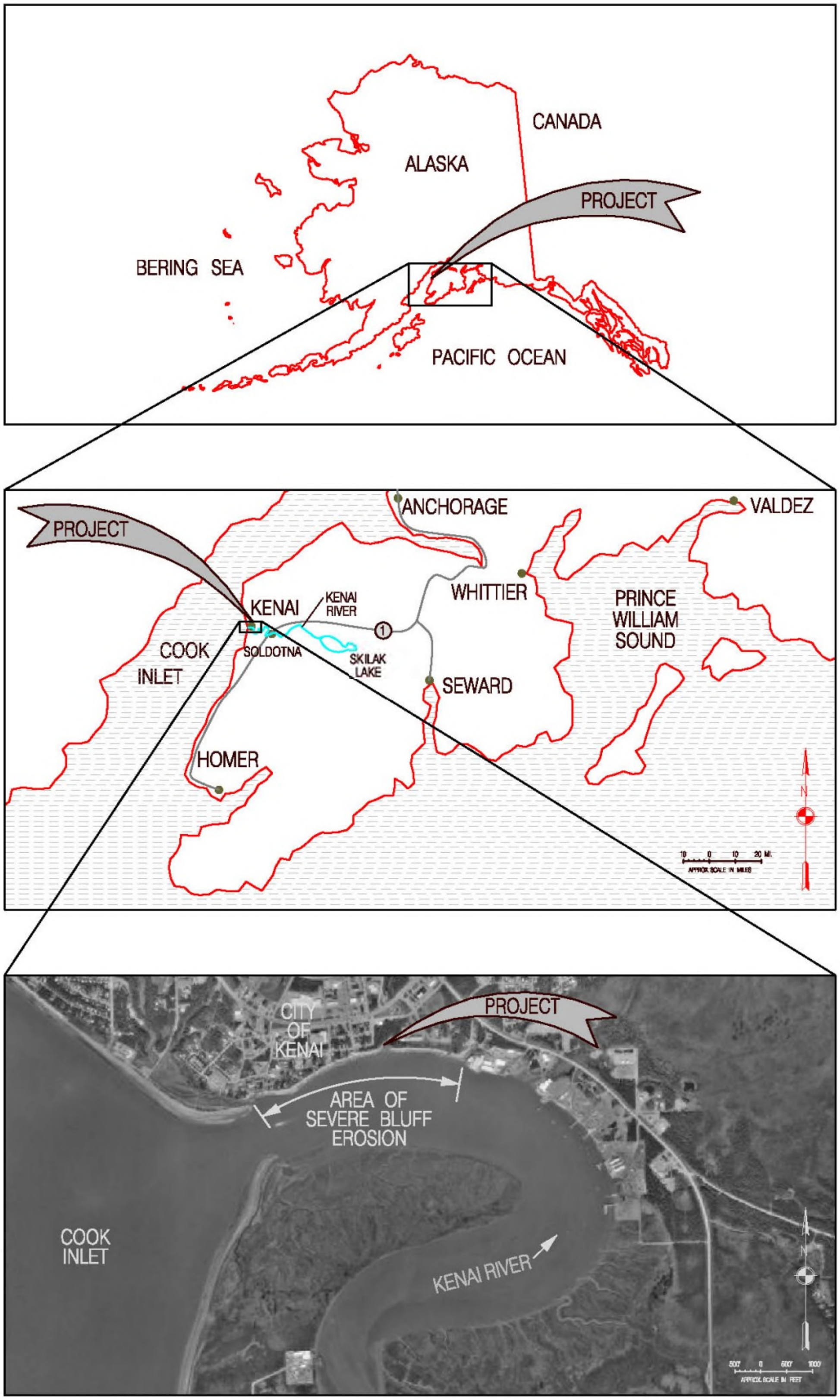


Figure 1. Project Vicinity

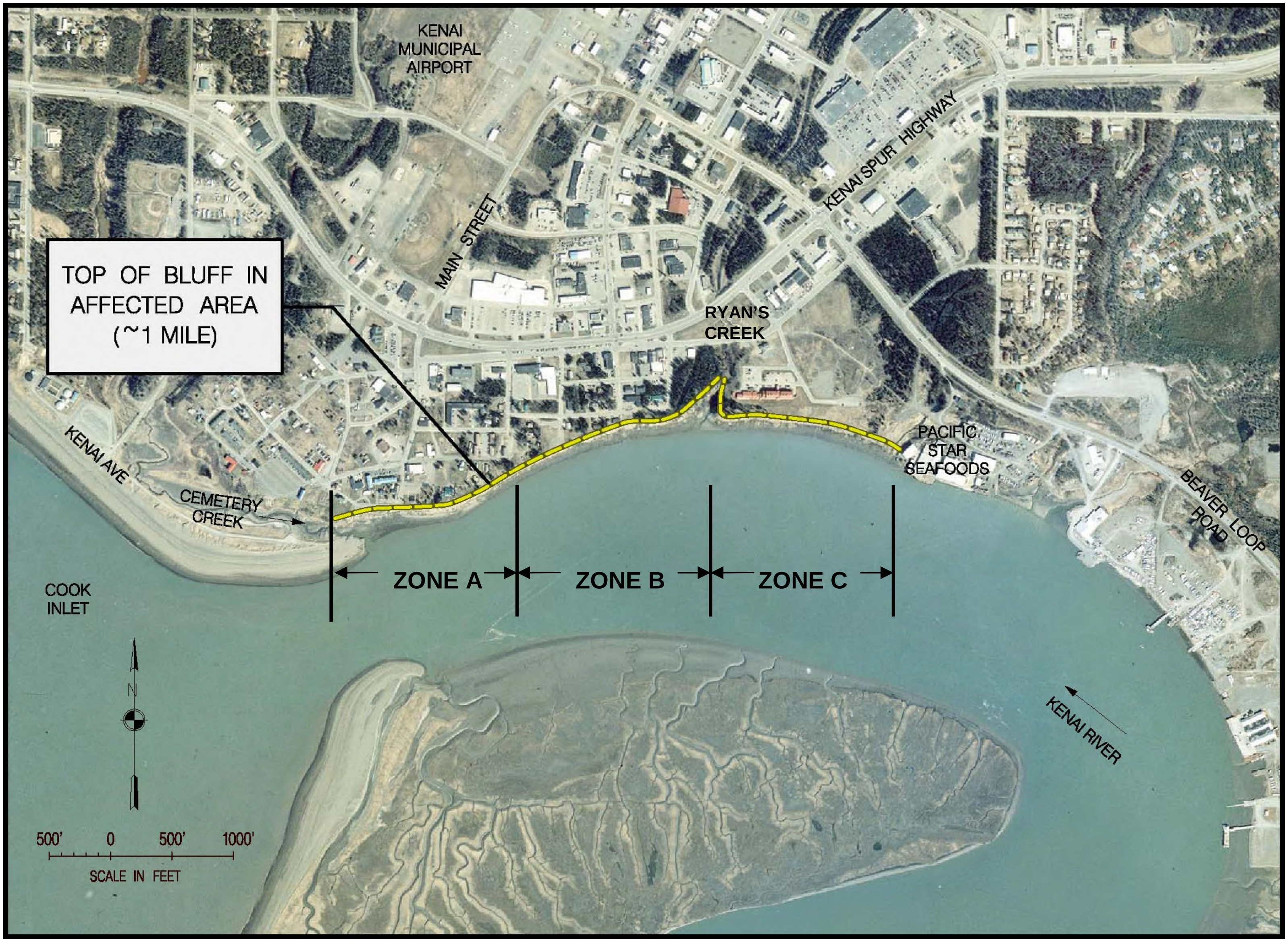


Figure 2. Project Location

Note: Background image provided by Kenai Peninsula Borough under limited use agreement

1.5 Previous Studies

Several previous studies have been conducted in the project area to document the existing condition, propose alternative solutions, and predict the potential effects of the proposed stabilization measures:

- TAMS Engineers conducted a Bluff Erosion Study in 1982 that developed alternative design solutions for stabilizing the bluff and presented the associated costs for comparison (TAMS 1982). Alternatives considered included bluff dewatering scenarios along with the construction of a sheet pile bulkhead or rock revetment incorporating a coastal trail.
- The Corps completed a navigation improvement study in 1997 that made recommendations regarding dredging of the Kenai River and use of the spoils in stabilizing the bluff (USACE 1997).
- PND Engineers presented a preliminary design of a rock revetment, coastal trail, and cut back slope in a 2002 Design Concept Report for the City of Kenai.
- The Corps completed a technical study of existing conditions, causes of erosion, potential solutions, and impacts of solution measures along the lower reach of the Kenai River. The results of the investigations are documented in the July 2006 Kenai River Bank Erosion Technical Report (USACE 2006b). Recommendations for obtaining data supplemental to the Technical Report were presented in an August 2006 Work Plan (Tetra Tech 2006).
- In February 2007 R&M Consultants completed a Geotechnical Investigations Report in accordance with the Work Plan recommendations (Attachment M, R&M Consultants 2007). The accompanying Groundwater Monitoring Report, summarizing the results of one year of groundwater monitoring efforts, was finalized in January 2008 (Attachment N, R&M Consultants 2008).
- Tetra Tech completed a Design Alternatives Report in 2008 resulting in the tentatively selected alternative that is refined further in this Initial Design Documentation Report (Tetra Tech 2008).

Attachment A includes a bibliography and summary of contents and results for these and other previous studies.

1.6 Contents of Document

This Initial Design Documentation Report is prepared by Tetra Tech for the Corps in accordance with the Scope of Work for Contract #W911KB-06-D-0010, Delivery Order #1, dated December 21, 2006. The findings in this report build upon the recommendations set forth in Tetra Tech (2006, 2008) and R&M Consultants (2007, 2008). This report summarizes the design criteria, design decisions, construction methods, and anticipated impacts of the bluff stabilization project. Supporting documentation is provided in attachments, including annotated comments, correspondence, meeting minutes, and trip reports.

2.0 EXISTING CONDITION

The existing condition of the project area has been described in several previous reports, including the Corps Kenai River Bank Erosion Technical Report (USACE 2006b). As documented in previous report and confirmed through supplemental field investigations, the primary, existing erosion mechanisms are shown schematically in Figure 3.

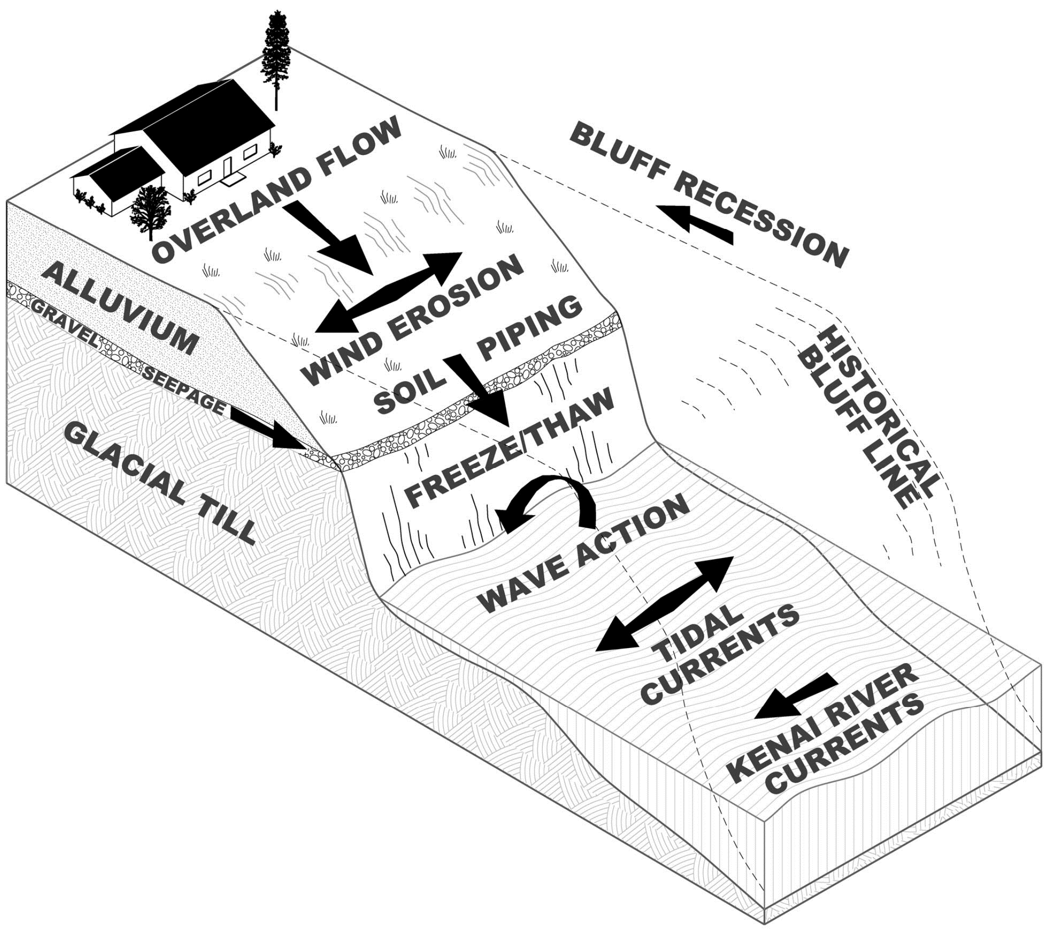


Figure 3. Erosion Mechanisms

The existing condition is described below for individual areas of study, including summaries of the findings of the Corps report and other previous reports.

2.1 Climate

Temperature, precipitation, and snowfall data are available for the Kenai FAA Airport gage dating to 1949. Climate data are compiled by the Western Regional Climate Center (WRCC). Extreme temperatures have ranged from -47ºF to 93ºF. Temperatures typically stay above freezing for approximately 100 days during the summer season. The area receives approximately 19 inches of precipitation annually. The mean annual total snowfall is approximately 61 inches, with an average of approximately 12 inches of snow depth during winter months. Summary climate data are presented graphically for selected parameters in Attachment B.

2.2 Tides and Currents

Tide elevations at Kenai typically fluctuate with a typical daily range of approximately twenty vertical feet. Figure 4 shows the bluff face at high and low tides.

Figure 4. Kenai River Bluff at High (left) and Low (right) Tides

The nearest measured tidal data are taken at Nikiski, approximately 10 miles north of Kenai. Mean Higher High Water (MHHW) at Nikiski is 20.42 ft above Mean Lower Low Water (MLLW), and Mean Sea Level (MSL) is 11.18 feet above MLLW. The toe of the Kenai Bluff is located at an elevation of approximately 22 to 23 feet MLLW, just above MHHW. Tide levels typically reach the toe of the bluff several times per month, as shown in further detail in Attachment B. Tidal predictions for the Kenai River are available from NOAA for the Kenai

City Pier and the Kenai River Entrance. Tidal predictions at Kenai apply correction factors to NOAA measurements at the reference site in Seldovia. Following are selected summary statistics for Kenai based on the tidal predictions.

Table 1. Tidal Data at Kenai

Station	Mean Range (ft)	Spring Range (ft)	Mean Tide (ft)
Kenai City Pier	17.5	19.8	10.4
Kenai River Entrance	17.7	20.7	11.0

An adjustment of -0.26 feet was made to the Kenai datum relative to the Nikiski gage in March 2008 and submitted to and approved by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). The adopted regulatory high tide elevation is 25.2 feet MLLW, and regulatory high water is 19.1 feet MLLW. Additional data related to the tidal records, including gage locations, hyperlinks to online data repositories, correction factors, datums, and tidal predictions, are presented in Attachment B.

Tidal currents in the project area are generally masked by the Kenai River currents. Tidal channels are present on the flatter slopes of the bank opposite the bluff; however, the bluff side does not exhibit typical tidal channels. Longshore currents were estimated in order to determine longshore sediment transport in conjunction with the ERDC Sediment Impact Analysis (USACE 2006b). The study determined that the project area does not appear to be subject to direct contact with longshore currents, since the longshore currents generally bypass the inlet area.

2.3 Wind and Waves

When storms coincide with high tide conditions, breaking waves attack the toe of the bluff directly. Figure 5 shows a breaking wave at the inlet.

Figure 5. Breaking Wave Conditions at Kenai River Mouth (USACE 2006b)

Wind data near the project site are collected at the Kenai Airport FAA station. Metadata for the station are presented in Attachment B. The Corps Navigational Study included directional wind speed data (USACE 1997). The University of Alaska, Anchorage conducted an hourly directional wind speed analysis on historical measurements taken at the Kenai Airport from 1973 to 2000 (UAA 2001).

The Corps Technical Report includes wave height estimates based on historical wind data, bathymetric cross sections collected by the Corps in 2003, and general observations of the bathymetry of the coastal zone adjacent to the project site (USACE 2006b). PND (2002) also includes estimates of the wave height and period. No direct wave height measurements or storm surge data are available at the Kenai River mouth other than visual observations. Oceanweather, Inc. developed a wave model and conducted continuous hindcast verification, with storm production based on 50-year conditions at Nikiski (Oceanweather 2009).

Although some Kenai Peninsula communities in Lower Cook Inlet experienced up to 40-foot high earthquake-generated tsunami waves in March 1964, the relatively shallow depth of Upper Cook Inlet with respect to the distance from Lower Cook Inlet substantially decreases the tsunami risk in Kenai.

2.4 Kenai River Hydrology

The stage of the Kenai River in the project area is influenced by both the discharge in the river and the tidal elevation in Cook Inlet. As a result, there is no direct stage-discharge relation at Kenai. The nearest stream flow gaging station is USGS Gage Number 15266300, located at the Sterling Highway Bridge in Soldotna, approximately twenty river miles upstream of the mouth. Daily discharge data for the Soldotna gage are available from 1965 to present. The maximum recorded instantaneous peak flow was 42,200 cubic feet per second (cfs). The historical average daily discharge for the entire period of record is shown graphically along with the station metadata in Attachment B. Historical USGS data for the Soldotna gage must be interpreted with caution, as some data are missing or estimated. The gage goes dry during certain periods of the summer, for example, and ice inhibits measurements during much of the winter.

Peak annual discharges were compiled and sorted to estimate the flow frequency using the Hydrologic Engineering Center’s Flood Frequency Analysis Software (HEC-FFA). Table 2 lists the top ten annual maximum daily average discharge rates in the Kenai River as measured at Soldotna using the entire period of record (43 years of data).

Table 2. Kenai River Maximum Annual Average Daily Flow, 1965-2007

Rank	Year	Discharge (cfs)
1	1995	41,400
2	1977	33,200
3	1969	29,600
4	1974	26,800
5	1989	26,800
6	1979	26,500
7	2002	25,100
8	1967	24,900
9	1966	24,000
10	1993	23,600

Using distribution factors from a USGS Regional Skew Analysis, the expected probability flows were computed as follows:

Table 3. Kenai River Expected Probability Flow

Flood Frequency>>	2-year	5-year	10-year	50-year	100-year	500-year
Discharge (cfs)>>	18,900	24,000	27,900	38,200	43,500	58,400

Additional statistical data, including confidence limits corresponding to the discharges in Table 3, are presented in Attachment B.

2.5 Kenai River Hydraulics

An HEC-RAS model of the project area was developed based on 2003 bathymetric survey data and FEMA river bed profiles. The HEC-FFA discharges were used as the flow rates. The results show that velocities and other hydraulic characteristics of the Kenai River in the project area are generally governed by tidal elevations rather than stream flow. The maximum Kenai River velocities occur during the lowest tidal levels. The project area river velocities associated with a 50-year discharge, for example, drop from approximately 6 feet per second at low tide to approximately 1 foot per second at high tide. At tide levels above mean higher high water (MHHW), even base flood flows in the Kenai River are almost completely masked by the tidal backwater; under these conditions (when Kenai River water surface elevations are governed by tidal conditions in Cook Inlet) flood flows generally do not introduce significantly higher velocities or higher water surface elevations near the river mouth than do typical daily flows. Table 4 shows the velocities, depths, and widths associated with various flows during extreme low and high tide events in the project area.

Table 4. Typical Kenai River Hydraulics in the Project Area

Profile	Discharge (cfs)	Tide Level	Tide Elevation (ft MLLW)	Water Surface El (ft)	Maximum Depth (ft)	Channel Velocity (fps)	Top Width (ft)
Minimum Flow	770	Low	-0.9	-0.9	12.8	0.2	530
Mean Flow	13,000	Low	-0.9	-0.3	13.4	3.5	725
10-year	27,900	Low	-0.9	1.2	14.9	5.9	1110
50-year	38,200	Low	-0.9	2.3	16.0	6.8	1175
100-year	43,500	Low	-0.9	2.8	16.5	7.2	1231
Minimum Flow	770	High	26.0	26.0	39.7	0.0	2206
Mean Flow	13,000	High	26.0	26.0	39.7	0.4	2206

Profile	Discharge (cfs)	Tide Level	Tide Elevation (ft MLLW)	Water Surface El (ft)	Maximum Depth (ft)	Channel Velocity (fps)	Top Width (ft)
10-year	27,900	High	26.0	26.0	39.7	0.9	2206
50-year	38,200	High	26.0	26.0	39.7	1.2	2206
100-year	43,500	High	26.0	26.0	39.7	1.4	2206

The flow characteristics in Table 4 correspond to bathymetric Cross Section #3 near the center of the project area (See Attachment C for section locations). Water surface elevations and velocities at other cross section locations are shown graphically in Attachment B.

The FEMA Flood Insurance Study for Kenai includes a Flood Insurance Rate Map (FIRM) with coastal wave zones (Community Panel Number 020012 2030 A, effective date May 19, 1981.) An excerpt of Panel 2030 is shown in Attachment B. The water surface profile is essentially flat in the project area; the base flood (100-year event) water surface elevations correspond to the Cook Inlet starting elevation for approximately ten river miles from the mouth at Kenai to near Soldotna. The mapped elevations on the FIRM are higher near the river mouth than at Soldotna due to the influence of coastal waves. The FEMA model includes two cross sections within the project area. The toe of the bluff in the project area lies in Zone V (Coastal Wave). The mapped water surface elevation for the project area is approximately 29.5 feet MLLW, approximately equal to the highest recorded water surface elevation in Kenai (29.0 ft MLLW, observed 12/26/1976).

2.6 Historical Bluff Erosion

As documented by the Corps, several sources have measured historical bluff retreat in Kenai (USACE 2006b). A UAA study (2002), for example, compared the top of bluff in 1976 and 1999. The geospatial data used in the UAA study were obtained as part of the draft design development along with additional historical aerial photography. 2006 aerial photography was overlaid to update the existing condition. A high-resolution scan of the bluff area in 1950 was acquired from USGS and georeferenced to expand the range of historical data. A comparison of the four bluff lines (1950, 1976, 1999, 2006) is shown in Attachment C. In the project area, the bluff retreated between 100 and 250 feet (approximately 2 to 4 feet per year) between 1950 and 2006.

With the exception of the project area, the upstream Kenai River banks have shown remarkably little change. Measurements along a 10-mile stretch upstream of the Kenai River mouth show that bluff retreat has been much more pronounced in the 1-mile project area than in the remaining area. Additional high-resolution orthophotography acquired in October 2010 indicate very little change in the top of bluff since 2006, particularly in Zone C. The historical thalweg and top of bluff location are shown in the figures in Attachment C. Hydrographic cross section data collected by the Corps in 2003 are also presented in Attachment C.

A Sediment Impact Analysis was conducted as part of the Corps technical studies in order to assess the relative contribution of the eroding bluff to the overall sediment load. According to the findings of the report, the bluff area supplies approximately 10,000 tons of sediment per year to the Kenai River and Cook Inlet, representing a relatively small percentage of the overall sand flux into the system (USACE 2006b).

2.7 Overland Flow

The two most significant local drainages in the project area are Cemetery Creek and Ryan’s Creek. Cemetery Creek enters the Kenai River at the mouth near Cook Inlet along the west side of the project area. Ryan’s Creek enters the Kenai River within the project area approximately 3,000 feet upstream of Cemetery Creek. Neither Cemetery Creek nor Ryan’s Creek appears to be affecting the bluff face directly, as the stream channels are not in contact with the bluff toe, and the adjacent slopes are heavily vegetated, limiting undercutting. Most of the local stormwater drainage from the top of the bluff is routed through the City of Kenai’s storm drain network. In some areas, such as along Mission Avenue, overland flows have been rerouted into drainage swales that convey runoff parallel to the slope. In other areas, surface drainage is directed overland toward the bluff, causing head cuts in several locations where the drainage flows over the edge of the bluff. Figure 6 shows one of the most pronounced head cuts near Broad Street.

Figure 6. Head Cut at the Top of the Bluff

A comparison of historical aerial photographs indicates that several large drainages along the bluff face have been filled in previous decades, with the runoff presumably routed through the City of Kenai storm drain network. The Kenai Watershed Forum developed a preliminary model of the storm drain network in the City of Kenai, including the top of bluff area. The model identifies components of the storm drain network, including properties of pipes, flow paths, and drainage delineations. Figure 7 shows the City of Kenai storm drain network, as mapped by the Kenai Watershed Forum (KWF 2008). The isolated points along the bluff in Figure 7 represent irrigation pipes protruding from the bluff face near the ground surface; these pipes convey small amounts of water that run directly down the bluff face.

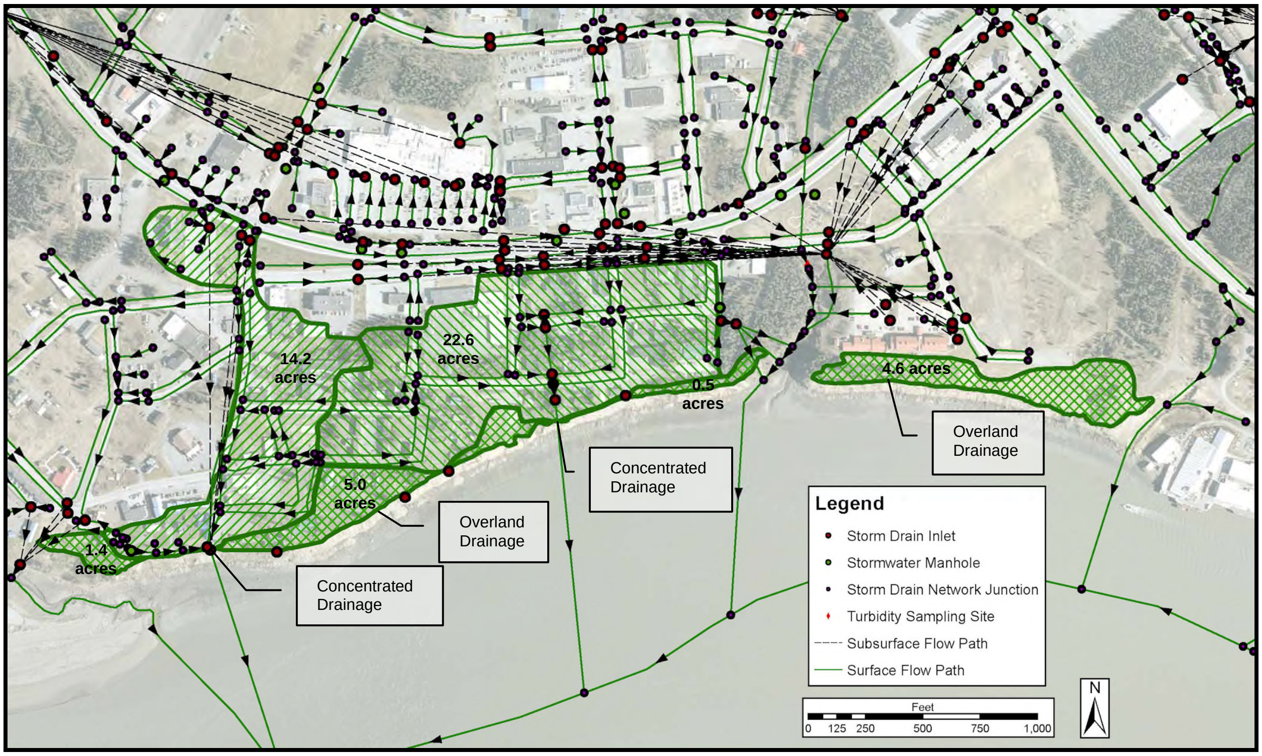


Figure 7. Local Drainage Patterns along the Bluff Face (KWF 2008)

The KWF drainage area delineations were refined based on the September 2007 topographic mapping. Topographic mapping and elevation measurements taken during supplemental site visits indicate that stormwater runoff accumulates in two primary concentration points along the top of the bluff. Approximately 14 acres of drainage concentrates along Mission Avenue, and approximately 23 acres of drainage accumulates in a basin near Bluff Street. An additional 7 acres drains to the bluff as overland flow west of Ryan's Creek. East of Ryan's Creek, approximately 5 acres of overland flow drains over the bluff face. The contributing areas are based on concentration points along the top of the bluff; the bluff face itself represents an additional 10 acres of drainage. The stormwater system delineations show additional drainage areas routed to Cemetery Creek just west of the project, Ryan's Creek just north of the project, and an unnamed drainage ditch within the commercial development just east of the project. Dye testing has been planned by KWF in order to verify flow paths, allowing the development of a storm drain model for the City; however, the implementation of the dye testing program is currently pending receipt of additional funding.

2.8 Ice

River ice is prominent in the Kenai River during winter months. Both sea ice and river ice collect at the toe of the bluff. Because of the large tidal range, most of the ice in Cook Inlet remains broken, and the formation of shorefast ice is inhibited. Figure 8 shows typical winter ice conditions along the toe of the bluff. Freeze-thaw action along the bluff face actively erodes the bluff, contributing to the bluff recession. The formation of river ice does not appear to contribute significantly to the bluff recession relative to freeze-thaw action on the bluff face.

Figure 8. Ice at the Toe of the Bluff

Glacier-dammed lakes are present upstream along the Kenai River. When the lakes begin releasing snowmelt, the rise in water levels can cause the ice cover to break up, forming ice jams and localized flooding. Some peak flows in the USGS gage records note a corresponding, upstream ice dam breach. Rapid water level increases and moving ice in the Kenai River have caused significant property damage in the Soldotna area. Figure 9 shows a shoreline access ramp damaged by an ice jam flood event that was triggered by the release of glacier-dammed Skilak Lake in 2007. No damage claims were filed in Kenai for the 2007 event. Under extreme circumstances, ice jam flood events could potentially damage facilities in the Kenai area, particularly the marine infrastructure just upstream of the project area; however, backwater conditions from Cook Inlet generally prevent the high velocities that would otherwise result in significant damage.

Figure 9. Ice Damage along the Kenai River in Soldotna (KWF 2007)

2.9 Geology and Soils

The Kenai area is generally designated as glacial lowland. Details on the regional geology are included in the Geotechnical Investigations Report (R&M Consultants 2007). The bluff itself generally consists of alluvial deposits over glacial till, separated by a layer of lag gravel. Bedrock is located at a considerable depth below the toe of the bluff.

Kenai is located in a seismically active area. Although the overall region sustained significant damage during the 1964 magnitude 9.2 Great Alaska Earthquake, long-time residents present at a 13 December 2008 public meeting at the City of Kenai did not recall any mass slope failures or any other visible damage to public infrastructure within the City of Kenai. According to the USGS, the 1964 earthquake produced marginal pressure ridges and cracks in the ice of small lakes on the Kenai Peninsula as well as some intense local fragmentation visible in surface ice in Skilak Lake, possibly indicating underwater landslides.

Figure 10 shows an oblique aerial photograph of the City of Kenai immediately following the 1964 earthquake along with an image from a similar vantage point four years later. In several areas along the bluff near Bluff Street and Mission Street (Areas 4 and 5 in Figure 10), the 1964 photo shows alluvial material at the toe of the bluff, where the 1968 photo shows a distinct layer of glacial till underlying the alluvial material. A 1950 aerial orthophoto likewise shows the underlying till exposed. Whether the sloughing of the alluvial material from the upper layer to the toe of the slope was a short-term result of the earthquake or part of the overall cycle of erosion and transport is unknown. In any case, the alluvial material present at the toe in 1964 was carried away, most likely by river and tidal currents, by 1968. Subsidence may have accelerated the toe erosion after the earthquake. The toe of the bluff near Riverview Drive (Area 3 in Figure 10) appears to be undercut in the 1964 photo but has a smooth slope in the 1964 photo.

As shown in Figure 10, fill has been placed along the bluff face in several locations, most prominently between Upland Street and Main Street (Areas 1 and 2) and at the end of Bluff Street (Area 4). Additional details on nearby faults, seismic activity, and other geologic conditions at the project site are covered in R&M Consultants (2007).

Figure 10. Kenai after the 1964 Earthquake (above) and in 1968 (below)

Note: Photographs courtesy of Anchorage Museum Archives

2.10 Hydrogeology

Groundwater conditions at the project site are documented in the Kenai Bluff Geotechnical Investigations Report (Attachment M, R&M Consultants 2007). A supplementary one-year monitoring program of groundwater levels concluded in December 2007 (Attachment N, R&M Consultants 2008). Monitoring efforts consisted of monthly readings at seventeen wells in the bluff area along with real-time readings in selected wells. The groundwater readings show aquifers at different elevations; the upper aquifers exhibit very little seasonal variation. The deep wells exhibit greater fluctuation due to tidal influence. Real-time pressure transducer readings taken in August 2007 from two of the wells are shown in Figure 11. The results show a dampened tidal effect on Well 614, the deeper of the two wells extending to a depth of 100 feet below ground surface (bgs). Well 614 exhibited a vertical range of approximately 5 feet and a lag of 2 to 3 hours. The shallower well (Well 615, 75 feet bgs) showed no tidal influence and exhibited only a 0.1 foot fluctuation during the entire month. Minor daily fluctuations on the order of a hundredth of a foot did occur; these fluctuations are potentially attributable to temperature changes in the piezometer casing or air pressure changes in the air trapped in the piezometer. Several rainfall events occurred during the one-month monitoring period, totaling approximately 2 inches of rainfall depth. The rainfall did not appear to affect the groundwater elevations significantly. Further details on vertical and lateral variation in the discharge rate are discussed in Attachment N.

The Corps estimated a total potential flow of approximately 7,000 gallons per minute (gpm) in the aquifer behind the bluff resulting from annual rainfall (USACE 2006b). The aquifer discharges along the Kenai River bluff, the coastal bluff to the west of Kenai, and in adjacent creek channels and local drainages. Within the project area along the Kenai River, most of the discharge from the bluff face occurs along a seepage plane in the lag gravel interface, which exhibits much higher conductivities than the underlying glacial till or overlying alluvial deposits. Surface discharge was quantified using physical measurements in 2006 and 2007. Measurements were taken in December 2006 just below the lag gravel layer in three areas of concentrated flow. Additional measurements were taken in July and August 2007 along the entire toe of the bluff. These measurements indicate a total surface discharge of approximately 100 to 200 gpm in three distinct zones of groundwater flow. The zones are described further in Attachment N. The measurements account for visible surface flow only; however, there are also signs of groundwater seepage entering the Kenai River just below the river's water surface.

As a comparison to measured rates, calculations of the rate of groundwater discharging from the bluff face were performed based on the soil's porosity and other parameters presented in the Geotechnical Investigations Report (R&M Consultants 2007). As described further in Attachment N, the calculations assume saturated conditions to 15 feet above the seepage plane. The calculated values for groundwater flux from the alluvial deposits and glacial till are approximately 300 to 400 gpm. These values are higher than the measured values, which might be expected due to the presence of unseen subsurface flows, particularly where granular sediments have been placed as fill or eroded to the toe of the bluff, covering the till layer.

In winter months, the flow paths are apparent from the formation of aufeis. As mentioned above, the preliminary groundwater monitoring results indicate very little seasonal variation in the upper aquifers. The lack of seasonal variation in the groundwater table measurements indicates that groundwater discharge from the bluff likewise remains relatively constant year-round, as a higher discharge rate would generally require a steeper groundwater gradient.

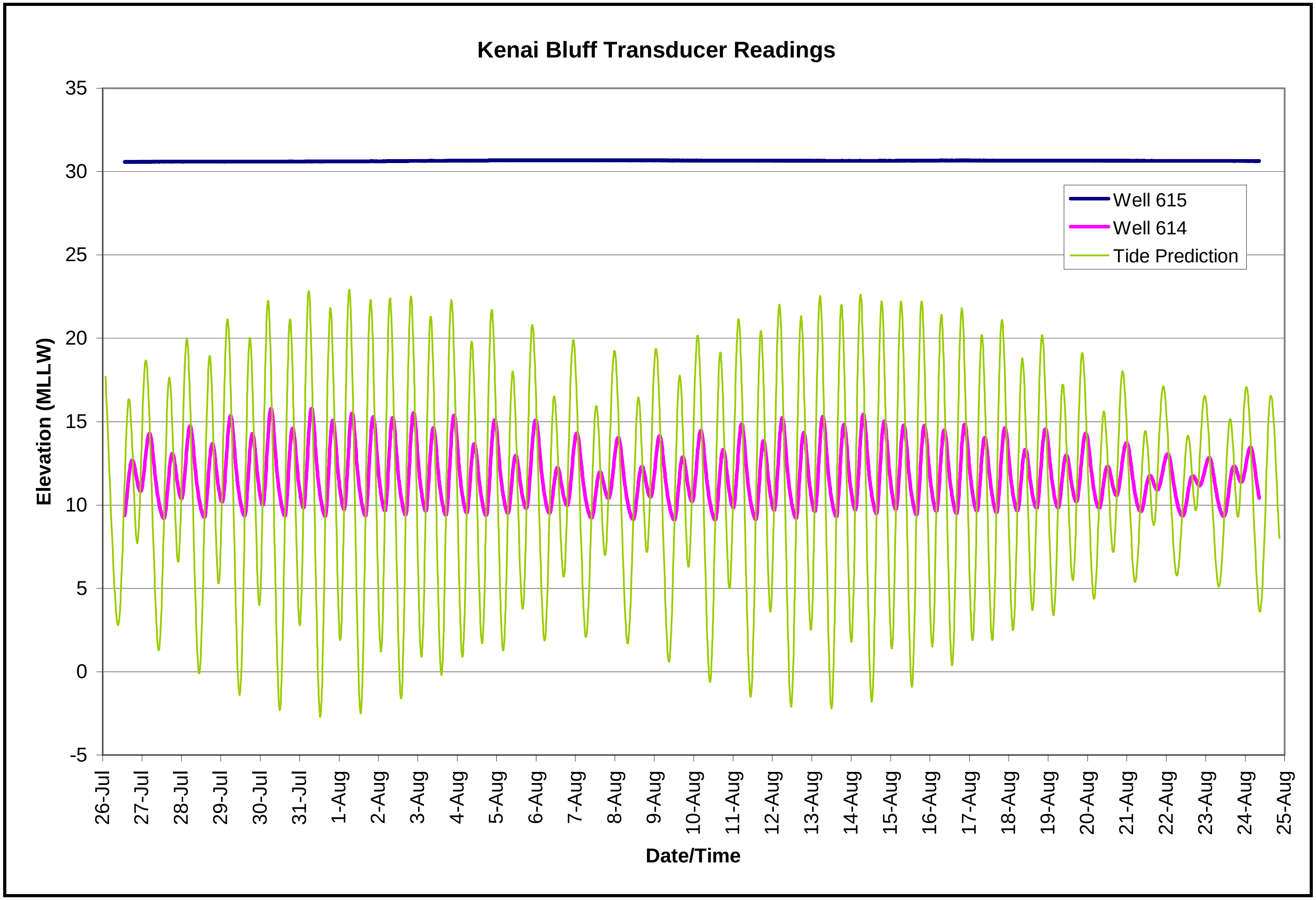


Figure 11. Real-Time Groundwater Readings at Kenai, August 2007

2.11 Water and Sediment Quality/HTRW

No sediment quality or HTRW data for the soils in the bluff face have been located for this study. The geotechnical investigations encountered construction debris throughout the surficial soils along the bluff crest. Asphalt, concrete, perforated steel matting, and other miscellaneous debris was observed at the toe of the bluff (R&M Consultants 2007).

No water quality data have been located for the groundwater discharging from the bluff or for urban runoff flowing over the edge of the bluff as part of this study. The Kenai Watershed Forum (KWF) conducts annual water quality sampling at index sites in the Kenai River from Cooper Landing to Cook Inlet. Testing is conducted in partnership with the Kenai Peninsula Borough and other agencies. Parameters tested include metals, nutrients, hydrocarbons, and bacteria. Monitoring equipment has been deployed on a permanent buoy near the river mouth, transmitting real-time water quality data for water temperature, dissolved oxygen, conductivity, turbidity, and pH. Historical daily water temperatures in the Kenai River are available from USGS for 1998-2003. Additional water quality data are cited in the Corps Technical Report (USACE 2006b), which notes that time series temperature and salinity data reflect the highly dynamic nature of the Kenai River estuary.

2.12 Wetlands and Riparian, Upland, and Aquatic Habitat

Undeveloped areas along the top of the bluff are characterized as Bottomland Spruce-Poplar forest. A wetland delineation of the project site has not been conducted but may be included in future project phases in preparation for permitting support. The bluff itself is largely unvegetated with the exception of the Ryan’s Creek canyon walls and the banks of Cemetery Creek. The shoreline and wetland habitat in the area support seasonal use for nesting, foraging, and staging. Additional data on the existing aquatic habitat and wetlands in the project area are included in the Corps Technical Report’s Environmental Appendix (USACE 2006b).

2.13 Fish and Wildlife

The Kenai area supports a wide array of fish and wildlife. The Kenai River is well known as a prime fishing location, and the tide flats on the bank opposite the bluff are particularly abundant in terms of wildlife. The Environmental Appendix of the Corps Technical Report includes sampling results for birds, mammals, fish, and benthic invertebrates. Benthic invertebrate samples were taken in the upper and lower intertidal zones near the toe of the bluff and on the opposite bank in 2003. Invertebrates including clams and marine polychaetes were found in one of twenty samples. Some sampling activities were limited due to hard substrates.

Monthly bird and marine mammal observations were recorded from April 2003 to March 2004, including spatial and seasonal distribution of gulls, bald eagles, mallards, goldeneyes and other birds. Beluga whales and harbor seals were also observed in the area. The Kenai River estuary is noted for supporting abundant fishery resources, including all 5 species of salmon. A baseline fisheries assessment documented the occurrence of 6 freshwater species, 11 anadromous species and 14 marine species of fish in three studies from 1986 to 1996. Species observed in the assessment included stickleback, lamprey, eulachon, rainbow trout, Dolly Varden, juvenile marine species such as walleye pollock, Pacific cod, tom cod, sole, Pacific herring, sand lance, Pacific sandfish, sculpins, snail fish, and shrimp species (USACE 2006b). Partial food webs were constructed for the estuary based on stomach content analyses. See the Environmental Appendix of the Corps Tehnical Report for additional details (USACE 2006b).

2.14 Threatened and Endangered Species

Existing environmental data are covered in the Corps Technical Report Environmental Appendix (USACE 2006b). Additional evaluation in terms of threatened and endangered species may be required under the Endangered Species Act. Further details regarding threatened and endangered species will accompany future design and permit submittals as appropriate.

2.15 Cultural Resources

The Kenai River bluff and the surrounding lands in the project area are rich in archaeological and historical resources. Russian settlers constructed Fort St. Nicholas in the area as early as 1791. The U.S. Military established Fort Kenai, named after the native tribes, in 1869 (Orth 1967). Three archeological sites have been documented in the project area (USACE 2006b). In order to minimize disturbance to these resources during development and implementation of a selected solution, additional cultural resources activities have been proposed. These activities include evaluating project area buildings for the National Register of Historic Places, examining and evaluating the log structures along the bluff face for eligibility in the National Registers, evaluating the Shk'ituk't (KEN-00020) and the two other archaeological sites for eligibility in the National Register, and surveying the project area for unreported archaeological sites. These efforts will also include consulting local people and elders to obtain information about cultural resources within the project area. Further details will accompany future design and permit submittals as appropriate.

2.16 Economy and Recreation

Oil and gas drilling and exploration, fishing, and tourism are the primary contributors to the economy of the Kenai area. Other important economic sectors include fish processing, timber, agriculture, transportation services, construction, and retail trade (USACE 2006b). The Kenai area is a popular tourist destination for both in-state and out-of-state visitors. Trophy King and Silver Salmon inhabit the Kenai River; dip-net fishing attracts approximately 20,000 visitors per year during the three week dip-net season, often with over 1,000 people concurrently accessing the dunes near the mouth of the Kenai River (Poynor 2008). The toe of the bluff is currently off limits for fishing and other public access due to safety concerns. Along the top of the bluff near the Kenai River mouth, Hansen Park provides recreational uses such as birdwatching. Hansen Park includes safety railing along the bluff edge, whereas other areas of the top of bluff are unprotected with warning signage posted. Near the Kenai Senior Center, the unobstructed views from the top of the bluff likewise provides birdwatching opportunities. A gravel parking area provides some public access for recreational use; however, safety concerns limit use of the bluff.

2.17 Land Use and Real Estate

Land use along the top of the bluff in the project area is primarily residential. Fish processing, boat storage, and other commercial facilities are located adjacent to the upstream extent of the project. The top of the bluff intersects approximately 46 parcels in the project area. Parcel numbers, appraised values, and other details included in Attachment D. Four areas with structures located in the immediate vicinity of the bluff line are also shown in Attachment D. According to the Kenai Peninsula Borough's GIS maps, several parcels that appear to have previously been located at the top of the bluff in the past are now entirely along the toe of the bluff or even beyond the Kenai River edge due to bluff recession.

3.0 DESIGN CRITERIA

This chapter presents the design criteria applied to the Kenai River Bluff stabilization project design by category. Table 5 summarizes the design criteria with details following by category.

Table 5. Summary of Design Criteria

Category	Design Criteria
Design Life	50 years
Design Wave	4.5’ in Zone A, 3.5’ in Zone B, 2.5’ in Zone C
Hydrologic and Hydraulic Design Criteria	Velocities based on 50-year event in Kenai River (38,200 cfs) with Cook Inlet at 0’ MLLW. Wetting and drying for revetment design based on full tidal cycle exchange (extreme tide to MLLW).
Top of Revetment Elevation	Highest observed tide + design wave runup (top of revetment at 34.5 feet elevation in Zone A, 33.0 feet in Zone B, and 31.5 feet in Zone C).
Toe of Revetment Elevation	Toe buried at 4.2 feet below existing ground in Zone A, 3.3 feet in Zones B and C. No increase for thalweg shift (to be monitored by periodic hydrographic survey and locally controlled if necessary.)
Ice Design	Use design wave for armor sizing, with minimum W_{50} of 600-lb stone size to resist ice.
Rate of Allowable Bluff Retreat	0 ft/year (design will effectively halt bluff erosion)
Lineal Project Extents	Mission Avenue to Pacific Seastar Foods
Design Storm	100-year, 24-hour local rainfall event (approximately 4 inches)
Geotechnical Design Criteria	Stable slope with seismic event at 10% probability of exceedance in 50 years, 475 year return period at 0.38 g: (1.5 horizontal to 1 vertical maximum slope)
Design Seepage Rate	400 gpm of flow, divided into three zones
Real Estate Constraints	Avoid impacts to non-residential physical facilities (senior center, Pacific Star Seafoods), minimize impacts to residential areas and infrastructure
Survey/CAD Standards	AK district standards, NAD83 horizontal control, MLLW vertical control
Environmental Constraints	To be adopted based on further input by the Corps and stakeholders
Public Use and Safety Criteria	Access to bluff slope restricted, toe of bluff access prohibited

3.1 Design Life

A 50-year design life is used in material specifications and in the calculation of costs. Estimated maintenance costs for the duration of the project life are amortized and included in the cost estimate as a present value. The cost of any material expected to need replacement within the project life is added to the project costs as operation and maintenance costs.

3.2 Design Wave

The design wave is used in determining the recommended top of revetment elevation, toe depth, and armor sizing. The design wave height was selected in coordination with the Corps of Engineers based on the results of the Extreme Wave Study (Oceanweather 2009). The selected design wave height varies along the bluff; a 4.5-foot wave height is applied to the 1,500 lineal feet of bluff nearest the Kenai River mouth (Zone A); a 3.5-foot wave height is applied to the remaining portion of the bluff extending upstream to Ryan’s Creek (Zone B); and a 2.5-foot design wave is applied from Ryan’s Creek to the Pacific Star Seafoods dock (Zone C).

The runup associated with the design wave is taken as 1.5 times the total wave height (6.8 feet in Zone A, 5.3 feet in Zone B, and 3.8 feet in Zone C.) This value assumes a sloping revetment. Figure 12 shows the approximate locations of the two design wave zones. Although Figure 12 shows a specific point at which the design wave height changes, the boundary indicates a transition zone. In the Cemetery Creek and Ryan’s Creek areas, the design wave is limited by the bathymetry and is adjusted accordingly.

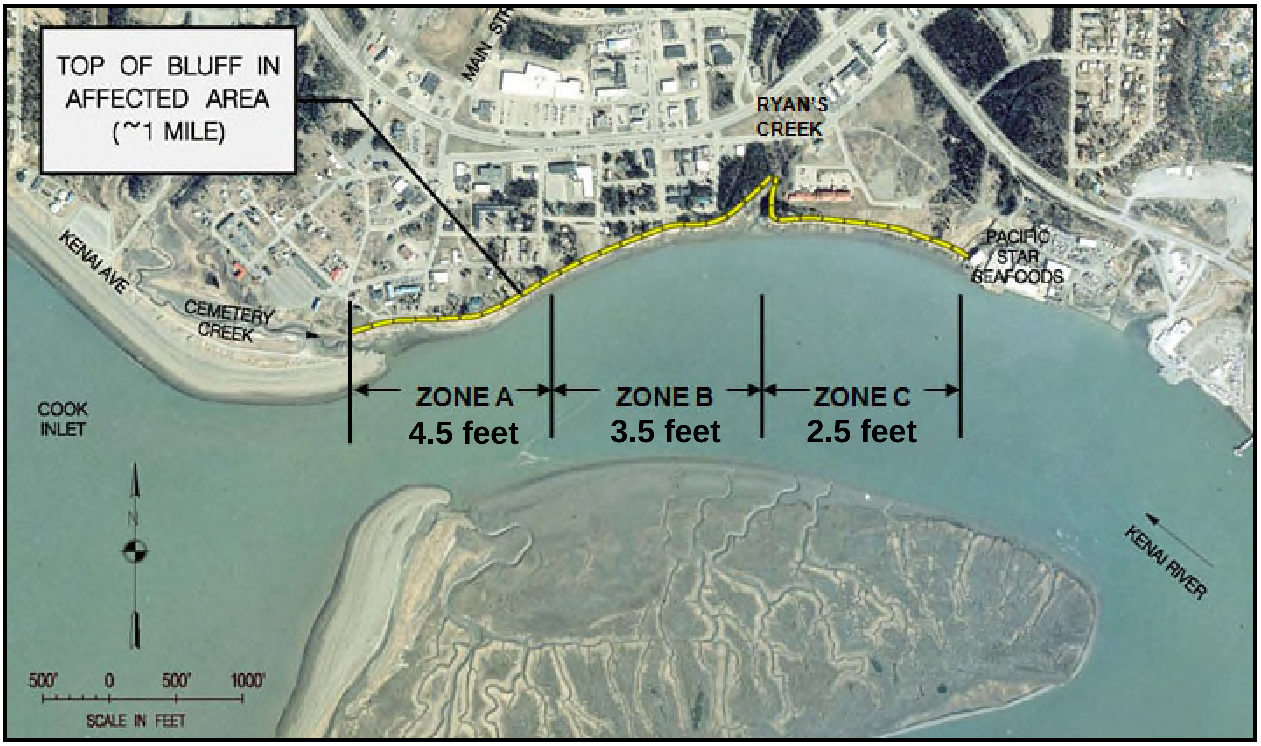


Figure 12. Design Wave

The PND Design Concept published in 2002 utilized a design wave 8 feet in height along the entire bluff line (PND 2002), and the Alternatives Analysis (Tetra Tech 2008) applied a 9-foot design wave at the river mouth, with a 6-foot design wave applied to the upstream areas. The reduction in wave height was made possible by results of the supplemental extreme wave study (Oceanweather 2009).

Although earthquake-generated tsunami waves are possible along the project site, Upper Cook Inlet is relatively shallow, limiting the tsunami risk. Because of the limited wave heights and low frequency of occurrence, tsunami conditions are not directly accounted for in the design wave height (KPB 2005). Although not a direct design constraint, the effect of a tsunami wave on any implemented project should be presented to local jurisdictional authorities in the development of emergency action plans.

3.3 Hydrologic and Hydraulic Design Criteria

Based on the current hydraulic model, river velocities under most tidal conditions appear to be negligible in comparison to the forces introduced by waves; any significant velocities occur when the Kenai River water surface is well below the proposed toe of the revetment. As provided by the Corps in the scope of work (USACE 2006a), the design accommodates the forces associated with a 50-year event in the Kenai River. The HEC-FFA 2% discharge, corresponding to the 50-year return period, is 38,200 cfs. Because the highest velocities occur at low tides, the 50-year Kenai River runoff event was modeled with tidal conditions in Cook Inlet at MLLW to determine the effect of river currents on the project area. As expected, the proposed project location remains dry under this scenario. In order to capture the maximum design condition, the 50-year event was modeled through a complete tidal cycle with 1-foot increments on the downstream boundary condition. These forces vary along the proposed project alignment. The maximum design condition encountered at the upstream end of the project differs significantly from the downstream end, where a different tidal elevation yields the highest velocities and shear stresses. The revetment system is designed to accommodate the wetting and drying corresponding to an extreme tidal cycle (reaching 26 ft MLLW and lowering to MLLW within 6 hours).

Longshore currents have an overall effect on the river mouth as material is transported along the shore; however, as described in Chapter 2, the project area does not appear to be subject to direct contact with longshore currents. Likewise, tidal currents are minimal in comparison to river currents, so the project design does not account for hydraulic forces resulting from longshore or tidal currents.

3.4 Top of Revetment Elevation

A combination of tidal, coastal wave, and river conditions is used in determining the top of revetment elevation and the depth of toe protection. The calculated heights and depths vary along the bluff. Tidal elevations at Kenai are based on calculated transformations of the Seldovia gage data rather than actual measurements, so a rise due to meteorological conditions is added to the calculated tidal elevations. The wind fetch, bathymetry, and coastal hydraulics of Cook Inlet and the Kenai River mouth area do not allow for significant storm surge due to wind action alone. In determining the top of revetment elevation for both waves, a storm surge of approximately 1.5 feet is added in both zones to account for lower barometric pressure. The design criteria for extreme tide, wave height, and river conditions are applied independently. The probability of a combination of all three conditions occurring simultaneously (the design wave occurring during the extreme tidal condition with a 50-year event in the Kenai River) is lower than practical for application to the revetment design. Several more reasonable combination events were investigated and compared to check their suitability as a design condition.

Potential combinations for establishing the top of revetment elevation were narrowed down to the four scenarios presented in Table 6. As shown in Table 6, Condition 4 is the most conservative of the scenarios and is adopted as the design criterion for the top of revetment. Despite this conservatism, the public risks of greater-than-design events should be presented to jurisdictional authorities for development of emergency action plans.

3.5 Toe of Revetment Elevation

The proposed depth of toe protection accommodates the greater of two-thirds of the design wave height or one armor stone plus the B-layer thickness. In accordance with the selected design wave, an apron or trenched toe design would thus accommodate an equivalent vertical scour depth of 4.2 feet in Zone A and 3.3 feet in Zones B and C. Sheet pile has previously been dismissed as an option. If it is introduced in specific areas, a reflective wave would need to be adopted and the design depth for scour adjusted according to the Shore Protection Manual guidance (Corps 1984).

In order to assess the adequacy of the toe scour depth, changes in the morphology of the Kenai River were considered over the design life of the project. A plan view plot of the thalweg location based on the hydrographic cross sections shows that in 2002, the thalweg was located at the approximate location of the 1950 top of bluff in some areas. If the rate of bluff retreat observed during the previous 50 years were to continue at its measured rate, the future thalweg could potentially reach the current location of the top of bluff in the next 50 years. The thalweg is an average of 200 to 300 feet seaward of the bluff toe and approximately twenty vertical feet below. If a project design were to account for a thalweg shift of that magnitude, the depth of scour protection would need to extend at least twenty vertical feet below the existing slope toe.

A review of the cross section plots (see Attachment C) indicates that at the locations in which the bluff is retreating most rapidly (Section 2 and Section 3) there is a slope of approximately 14% from the toe of the bluff to the point at which the slope flattens near the thalweg elevation. The limits of this slope correspond roughly to the elevation of the maximum and minimum extreme tides (with the Kenai River at mean flow) as computed in the Corps Technical Report (USACE 2006b). Where the bluff is retreating more slowly (Section 4) the slope is approximately 20%. At Section 5, where the bluff has not retreated, the slope is about 25%. The fastest-retreating areas have averaged a recession rate of 2.5 to 4 feet per year while the more slowly retreating areas are characterized by a rate of approximately one foot per year or less. The most rapidly retreating areas are on the portion of the bluff with the greatest exposure to wave action. The flat slopes of these sections are indicative of a wave and tidally influenced environment in contrast to the steep bank toe slope typically identified on the outside of a prominent bend. Based on these observations, it is likely that the material that is generated from the erosion of the bluff face is being predominantly conveyed away from the toe by wave action. The vertical extent and sizing of scour protection should therefore be based upon wave conditions rather than riverine conditions.

Review of the cross section geometry shows rather flat-bottom sections without a well-defined thalweg along the outside of the bend. This factor, along with the observation that transport of eroded material away from the toe of the bluff appears to be primarily the result of wave action, leads to the conclusion that designing the scour protection for the bluff stabilization measures to account for a thalweg shift against the bank would not be immediately warranted. Such a design would greatly increase the cost of construction. Continued migration toward the proposed stabilized bluff line is expected to occur as a steepening of the river's bank line within the river section rather than a wholesale shift in the river section. Because some of the protruding points have been smoothed by wave erosion and because of other constraints affecting the wave environment, the future migration is anticipated to be slower than the historical bluff erosion. Slope protection becomes more viable on the steeper slopes; therefore, it is recommended that potential scour from the channel migrating toward the bluff protection be addressed through a monitoring program that would identify any areas of excessive scour along the protected bluff. Additional toe protection could be applied to these localized areas as needed.

Table 6. Revetment Height and Toe Protection Depth

Parameter	**Zone A (Sta. 0+00 to 15+00)**	**Zone B (Sta. 15+00 to 45+00)**	**Zone C (Sta 45+00 to 70+00)**
MHHW	20.7 feet MLLW	20.7 feet MLLW	20.7 feet MLLW
Extreme Tide	26.0 feet MLLW	26.0 feet MLLW	26 feet.0 MLLW
Highest Observed	27.7 (6/14/95)	27.7 (6/14/95)	27.7 (6/14/95)
Design Wave	4.5 feet	3.5 feet	2.5 feet
Top of Revetment for Condition 1 (MHHW + design wave runup + storm surge)	29.0 feet MLLW	27.5 feet MLLW	26.0 feet MLLW
Top of Revetment for Condition 2 (extreme tide + nominal wave runup + storm surge)	32.0 feet MLLW	30.5 feet MLLW	29.8 feet MLLW
Top of Revetment for Condition 3 (highest observed tide + nominal wave runup)	32.2 feet MLLW	30.7 feet MLLW	30.0 feet MLLW
Top of Revetment for Condition 4 (highest observed tide + design wave runup)	**34.5 feet MLLW**	**33.0 feet MLLW**	**31.5 feet MLLW**
Effective Toe Depth (Greater of 2/3 wave height or 1 armor stone + B layer thickness)	4.2 feet	3.3 feet	3.3 feet

3.6 Ice Design

On similar projects designed by the Corps, armor designed to withstand wave action is sized sufficiently to resist transport or other damage by ice forces. Because Zone C is relatively protected from wave action, however, the computed armor size requirement warrants an increase. A 600-lb minimum W_{50} is recommended to withstand forces from river ice and sea ice, and the bluff face shall resist erosion from freeze-thaw cycles. All rock specifications were compared to ice design calculations based on recommendations by the Corps Cold Regions Research and Engineering Laboratory as set forth in the appropriate design manuals. Historical ice jams and the potential for flood waves from the breakup of ice jams were also considered in the minimum weight criteria.

3.7 Rate of Allowable Bluff Retreat

The intent of any project alternative considered in this report is to effectively stop bluff retreat. As such, the future with-project conditions erosion rate will be 0 feet per year along the entire project extent, in contrast to the existing historical rate of 2 to 4 feet per year. The design criterion of 0 feet per year is adopted regardless of any further analysis of the historical rate of recession along the bluff.

3.8 Lineal Project Extent

The historical bluff retreat analysis results (see Attachment C) were used to determine the necessary extent of revetment, establishing bounds for the lineal project extents. The Geotechnical Investigations Report (R&M Consultants 2007) includes a soil profile (SP-A) near Hansen Park. Historical aerial photographs indicate that fill was placed in this area in the 1960's. Although some of the fill areas have eroded, particularly at the toe of the slope, the historical aerial photographs indicate that the area around profile SP-A has remained stable for at least several decades. The geotechnical investigations likewise show a stable, vegetated slope with an absence of toe erosion. The Corps Technical Report (USACE 2006b) determined that large wave action in this area is generally limited due to protection afforded by coastal dunes, the wetlands to the south, and the shoal at the river mouth. This area marks the western extent of the proposed bluff stabilization measures.

As shown in Attachment C, the historical bluff retreat analysis indicates a rate of bluff retreat that is significantly less east of Ryan's Creek (Zone C) than in the near-mouth area (Zones A and B). In the vicinity of the existing Pacific Star Seafoods dock, historical aerial photographs show that fill was placed seaward of the historical bank line in conjunction with sheet pile and other marine structures. Although some erosion is apparent directly adjacent to the bulkheads, the bank line has been stable in this area since the structures were constructed in the 1940's. The waterfront development at the Pacific Star Seafoods dock marks the eastern extent of the project. The overall lineal project extent covers approximately 5,000 feet from Hansen Park to the Pacific Star Seafoods dock.

The rate of historical bluff retreat gradually decreases upstream along Ryan's Creek Canyon. Historical aerial photos show no discernible lateral erosion at a point measuring approximately 200 feet upstream of the mouth of Ryan's Creek.

3.9 Design Storm

The design accommodates the surface water runoff associated with a 100-year, 24-hour rainfall event as predicted by an analysis of data from the Kenai FAA gage site. As shown in the USGS isopluvial maps in Attachment B, the 100-year 24-hour rainfall depth in Kenai is approximately 4 inches. An analysis of 70 years of rainfall data spanning intermittently from 1899 to 2004 shows a 2-year, 24-hour rainfall depth (50% chance of exceedance in any given year) of approximately 1.1 inches. The maximum recorded rainfall event was October 10, 1986, when 4.3 inches of rain fell in a 24-hour period. As depicted in the design plans (Attachment G), all surface water runoff associated with the design event currently draining over the bluff face or through drainage pipes within the project area shall be diverted around the site, routed through surface or subsurface conveyance, or otherwise accommodated in the project design without adverse effects. Likewise, any irrigation pipes or other potential flow sources currently protruding from the bluff face will need to be intercepted and controlled under project conditions. The slope surface treatment is designed to prevent the formation of rills, gullies, and headcuts that could affect the integrity of the slope. See Attachment B for additional details regarding historical rainfall data. The effect of events exceeding the design event should be presented to jurisdictional authorities for use in preparation of emergency action plans.

3.10 Geotechnical Design Criteria

Slope stability calculations have been performed to supplement the findings of the Geotechnical Investigations Report (Attachment M, R&M Consultants 2007). The design earthquake used in the analyses has a 10% probability of exceedance in 50 years, or a 475-year return period. According to Wesson et al (1999), this results in a force of 0.38g. The stability of the bluff was evaluated both qualitatively by field observations, and quantitatively with analytical methods. The stability analysis was performed by limit-equilibrium methods using computer programs ReSAA(2.0), and PCSTABL4. Several models were set up, including global stability of the entire bluff, global stability of the upper alluvial soils, as well as global and surficial stability of the bluff regraded to various slope angles. Based on these analyses, it was concluded that the bluff regraded to 1.5 horizontal to 1 vertical (1.5H:1V) or flatter will be stable with respect to global failures, absent further erosion of the toe. The calculations indicate that the slope would be stable in both the alluvium and the glacial till soil. The lower till layer could accommodate a slightly steeper slope; however, because of the gravel lenses and other inconsistencies in the material, a uniform slope is recommended for the entire bluff face. The potential for slope failures in greater-than-design events should be presented to jurisdictional authorities for use in emergency action plans.

In previous conceptual designs, the TAMS study included a 1.25H:1V slope (TAMS 1983) and the PND concept included a 1.5H:1V slope. In light of the findings of the Geotechnical Investigations Report, the steeper slope as presented in the TAMS report is not recommended as it would not provide a sufficient safety factor without the application of significant supplemental bank stabilization and/or dewatering techniques.

A qualitative evaluation of the slope stability was initially conducted and was primarily based on observation of the existing areas of the bluff which are not currently subject to active toe erosion. Specifically the areas at the west end of the bluff in the vicinity of Cemetery Creek, and the slopes at the mouth of Ryan’s Creek were studied. These natural slopes appear to have stabilized and become vegetated at angles of about 1.5H:1V. The seepage from the base of the alluvial deposit is generally not visible in these areas, and appears to remain subsurface beneath the mantle of colluvium, except in the winter when aufeis becomes visible in these areas. This presence of ice on the slope in winter supports the conclusion that groundwater flow is present in these vegetated areas, but remains subsurface most of the year. R&M Consultants’ 2007 Geotechnical Investigations concluded that in the absence of river and tidal action, the slope would naturally flatten to an angle between 35 and 40 degrees (approximately 1.5H:1V) and become vegetated as was observed on the slopes around the bends near Cemetery Creek and Ryan's Creek (see Figure 13). Protecting the toe of the bluff would minimize the impact of water seepage on bluff erosion and may eliminate the need for a dewatering scheme.

Figure 13. Ryan's Creek Canyon

Based on these conclusions it is recommended that the slope be regraded to no steeper than 1.5H:1V. Benching is not considered to be necessary from a long-term slope stability standpoint.

3.11 Design Seepage Rate

The preliminary gradation and thickness of the filter layer is designed to accommodate a total groundwater discharge of up to 400 gpm. The gradation is also designed to prevent piping of the in-situ materials to the surface. The design is also intended to prevent the formation of aufeis on the bluff face. Supporting calculations of discharge rates and other hydrogeological parameters, including hydraulic conductivity and groundwater flux calculations, are presented in Attachment N. Filter designs follow procedures outlined in Forrester (2001) and Corps engineering manuals as appropriate. The proposed filter layer gradation is provided in Attachment E.

Measurements of the discharge along the toe indicate three separate zones of flow rates, as described and shown graphically in Attachment N. The design accommodates surfacing groundwater. Solutions for conveying discharged water down the slope and through the revetment account for the length of the zones with multiple discharge points to allow flows to equalize between each set of points. Icing likewise is considered at flow concentration points. Preliminary analyses indicate that local drainage from rainfall runoff during the design event (see Local Drainage above) exceeds groundwater flow by an order of magnitude. The conveyance system for the bluff face and revetment is therefore designed for local surface water runoff with a slight overdesign to account for the groundwater flux.

The groundwater data collected from the monitoring wells indicate that the groundwater flow from the alluvial deposit is quite uniform across the entire project area, and exhibits little seasonal variation. A comparison of water table gradients extrapolated in the direction of the bluff and toward the Ryan’s Creek canyon walls indicates that similar groundwater seepage conditions would be encountered along a cut slope. Although quantitative flow measurements are not available in this area, there is no reason to expect that the groundwater flow from the slopes at the west end of the project (Cemetery Creek), or slopes in Ryan’s Creek should be significantly different than along other portion of the bluff.

3.12 Real Estate Constraints

As tabulated in Attachment H, the top of bluff intersects approximately 46 parcels consisting of a combination of public, commercial, and private residential parcels. As such, all alternatives will involve temporary construction easements or permanent acquisition of some properties to accommodate the revetment and cut back slope. Parcel data, including values, are based on the latest assessor’s information provided by the Kenai Peninsula Borough. The design seeks to minimize impacts to non-residential physical facilities, such as the Kenai Senior Center and Pacific Star Seafoods dock.

3.13 Survey/CAD Standards

The base map for the current design is based on aerial photography acquired September 27, 2007 by AeroMetric, Inc. at a nominal scale of 1”=300’. Metadata and projection details for aerial photography are included in Attachment D. The design CAD files utilize the Alaska State Plane Zone 4 NAD 83 projection with units in U.S. Survey feet. The contour interval is 1 foot and maps are produced for output at a scale of 1”=100’. Topographic mapping complies with ASPRS Class II horizontal and vertical accuracy standards. Previous Corps hydrographic surveys utilize a NAD 83 projection; however, the Kenai Peninsula Borough maintains parcel maps and other layers in NAD 27. These layers have been reprojected for use in the CAD drawings using ArcMap software. River stationing is referenced according to the USGS river miles. The revetment is stationed from the downstream point of beginning separately from the river stationing. All vertical references are adjusted to the MLLW datum revised and approved by NOAA NGS in March 2008. Additional details regarding the datum adjustment are included in Attachment D. CAD plans for the selected alternative apply Alaska District CAD standards for AutoCAD 2008. Property lines, street rights-of-way, street names, and other geospatial data are taken from the Kenai Peninsula Borough (KPB) Geographical Information Systems (GIS) website.

3.14 Environmental Constraints

The design seeks to minimize adverse environmental impacts. Any construction debris or other materials that could contribute to possible contamination or instability of the bluff that are encountered during project excavation will be removed and replaced as necessary with clean backfill. Specific environmental design criteria, including target construction windows, will be developed by the Corps and documented in future reports under separate cover.

3.15 Public Use and Safety Criteria

Public access to the bluff slopes will be restricted by safety fencing except at controlled access areas along the bluff. Public access to the toe of the bluff will be restricted, with fishing and other activities prohibited along the entire extent of the bluff toe as at present

4.0 DESIGN ALTERNATIVES

In developing the project design, variations in individual project components were examined. The primary project components selected for variation included the approaches for controlling groundwater seepage, regrading the bluff face, and protecting the toe. Each component had several associated attributes that were varied in screening alternatives. The selected design configuration ultimately represents the optimal combination of individual components in terms of cost and effectiveness while limiting environmental impacts and balancing interdependencies. The development and refinement of design alternatives is covered in further detail in the Design Alternatives Report (Tetra Tech 2008.)

4.1 Groundwater Seepage Control

The following alternatives for addressing groundwater issues along the Kenai River Bluff were evaluated:

1) No action (allow present rate of groundwater seepage without water table modification or interception).
2) Construct a cutoff wall with a pump system that intercepts the groundwater landward of the bluff face.
3) Construct draw-down wells landward of the bluff face that lower the water table.
4) Construct a horizontal drain system on the bluff face that collects and diverts the groundwater.
5) Construct a network of drainage channels that alter the groundwater gradient.
6) Construct a free-draining retaining system that holds back the bank material while allowing free drainage of water from bluff face.

After consideration of the relative costs, maintenance requirements, and existing hydrogeological parameters, Option #6 (free-draining soil layer) was selected for the draft design.

4.2 Bluff Face Regrading

The following options for regrading the bluff face were evaluated:

1) No action (allow the bluff to reach a stable slope naturally).
2) Construct a stable slope by balancing the cut and fill areas along the bluff.
3) Construct a stable slope by cutting the bluff back from the existing slope toe.
4) Construct a stable slope by adding imported fill from the existing top of bluff.

A matrix of potential slope configurations was developed to represent combinations of the above options by zone. The balanced alternative (Option #2) was selected with local variation to protect public infrastructure along the top of the bluff and the sensitive riparian zones of Cemetery Creek and Ryan's Creek along the toe of the bluff.

4.3 Toe Protection

Various toe protection materials were considered along with potential variation in the location of the toe protection. A wide spectrum of toe protection applications was considered for use along the affected bluff area, ranging from "soft" solutions involving vegetation or soil treatment to "hard" solutions such as armor rock or sheet pile. Following is a sample of assessed options.

1) No action (leave existing bluff toe unprotected)
2) Bioengineering (combination of vegetation with geotextile, terracing, soil reinforcement, or other bank stabilization methods)
3) Articulated concrete revetment (Armorflex®, Petraflex®, Shoreblock®, or similar technology)
4) Flexible hydraulic fill containment (Geotube® or similar technology)
5) Rock (revetment or breakwater)
6) Precast concrete armor unit (Tetrapod or similar application such as Core-Loc®, Tribar, Accropode®, Ecopode®, Dolos, Stabit, Akmon, Seabee, A-jack, Xbloc®, Gassho®, Modified Cube, etc.)
7) Bulkhead (concrete seawall or sheet pile)

After consideration of the relative costs and engineering properties of each of the materials, armor rock (Option 5) was selected as the most practical toe protection material.

Variation in the configuration of the toe protection was also considered. Two potential locations for placing the armor rock toe protection are considered:

1) Construct a rock revetment at the toe of the slope (attached alternative).
2) Construct an offshore breakwater (detached alternative).

The detached alternative (Option #2) would protect the toe from wave action and allow the bluff to reach a stable slope naturally. Due to the uncertainty and concerns regarding environmental impacts and public safety, the detached alternative was dismissed in favor of Option #1.

4.4 Alternative Evaluation

Alternative combinations were developed with the revetment location and the balance of cut and fill varying within each of the three project zones (A, B, and C as shown in Figure 2). The previously proposed concept (PND 2002) included a coastal trail along the top of the revetment. The coastal trail component was not carried in the current design alternatives; however, multi-use applications for benches were considered. The design criteria outlined in Chapter 3 were held common to each alternative combination. As presented in the Design Alternatives Report (Tetra Tech 2008), four alternative combinations were selected from a matrix of 24 combinations. These alternatives were evaluated in terms of cost, engineering performance, and environmental impacts, with impacts of individual design features on cultural resources, real estate, recreation, and other areas of concern covered qualitatively.

4.5 Alternative Selection

The four proposed alternatives were presented to agencies and individuals in public meetings December 13, 2007. Feedback was collected on each alternative. Design refinements were further evaluated with the Corps, Tetra Tech, and R&M Consultants in meetings held December 14, 2007 and April 30, 2008. The tentatively selected alternative was presented at additional public and agency meetings on November 19, 2008. Agency representatives, residents, and the Corps favored proceeding with the proposed design development. The design presented in this report was refined from the adopted alternative that provides an optimal balance between costs, impacts, and performance.

5.0 DRAFT DESIGN

This chapter presents design details related to individual features comprising the draft design. The draft design is shown as a 24-sheet plan set in Attachment G.

5.1 Seepage Control

A typical cross section showing the seepage control approach is shown on Plate C-11 in Attachment G. The design applies a minimum 10-foot thick layer of free-draining soil to convey the groundwater seepage to the toe of the bluff. The layer thickness of this free-draining soil is sized to adequately convey the design seepage rate described in Chapter 3. In areas where this soil is less permeable than the underlying soils (where the lag gravel layer or gravel lenses are exposed, for instance) there may be a rise in the water table due to the damming effect. Geotechnical analyses of the in situ alluvial material indicate a permeability ranging from 0.00013 to 0.00018 ft/second. Assuming a hydraulic gradient of 0.55 (1.5H:1V) to 0.71 (1H:1V) and a 10-foot thick blanket of alluvium, the analysis yields an equivalent flow rate capacity of 0.3 to 0.6 gallons per minute per lineal foot of bluff. This capacity is adequate as an average; however, in isolated areas, there may be some risk of flow concentration surfacing. These flow concentration areas would be extremely difficult to predict and may require localized maintenance efforts involving the placement of a rock mattress or other erosion mitigation following construction. Mixing the native stockpiled soil with imported coarse-grained material or placement of a drainage geotextile could reduce the potential for future maintenance but would add significant project costs. These solutions would tend to result in an overdesigned system in most areas if applied project-wide; a localized maintenance approach is therefore recommended.

An additional factor that can decrease the permeability of the soil blanket and thus contribute toward potential damming issues is the frost depth. There are some uncertainties in the frost depth related to the exposed slope and the contribution of groundwater heat in melting ice below the surface. The maximum frost depth along the bluff face is estimated as four to five feet below the surface. The provision of a minimum blanket thickness of ten feet allows for a factor of safety against freezing within the layer.

In order to provide this minimum thickness, a bench is incorporated into the typical cross section. This allows the excavation of additional alluvial material from the top of the bluff while providing a free-draining layer of sufficient thickness for groundwater flow conveyance. Although the bench is similar in dimensions to the bench proposed in the PND concept (2003), the function differs. The bench in the PND concept was located below the lag gravel layer with the intent of concentrating and collecting groundwater seepage as surface water flow. The draft design approach places the bench above the lag gravel layer to prevent flows from surfacing. The bench also serves additional purposes for constructability and maintenance. The design includes security fencing to prevent public access except at designated overlook locations; however, some public use of the bench may be accommodated in the future with the construction of fencing and access points by local agencies.

In this concept, the groundwater is intended to surface within the armor rock zone. Some of the excess till material excavated from the slope is used at the toe of the slope. Some mixing with alluvial soil may be required for compaction in a recommended 60:40 alluvium:till mix. It is anticipated that this material would inhibit flow in the vertical direction and force the seepage out through the filter fabric behind the revetment. This would reduce the potential for piping below the revetment.

5.2 Revetment

The typical revetment section is shown on Plate C-12 in Attachment G. The draft design utilizes a layered armor rock armor design that varies by zone with the design wave. Armor sizing, layer thickness, and gradations are designed according to the Shore Protection Manual (Corps 1984) as presented in Attachment E. The armor section includes a buried toe. Geotechnical analyses indicated that trenching efforts may encounter difficulties in specific areas. In these areas, the equivalent toe depth might be provided as an apron of launch material. For an assumed foreslope of 2H:1V, the horizontal projection of the toe material would be twice the design depth. Any trenching from land-based equipment would have to be done at low tide and backfilled in sections prior to high tide. This would require construction of the entire cross section in lateral sections rather than vertical layers across the entire project site.

Preliminary bearing capacity analyses based on the results of borings at the toe of the slope indicate that no additional compaction would be required at the toe once the initial overexcavation for the bedding layer is completed. Settlement is anticipated to be on the order of several inches; therefore, a slight overbuild is recommended in terms of the top of revetment elevation. Filter fabric is recommended beneath the revetment bedding to prevent piping of material through the revetment while relieving the buildup of excessive pressure from the groundwater and/or tidal cycles. The revetment face and foreslope toe must remain continuous and smooth to avoid scour from incoming wave refraction; a transition zone (Station 19+50 to 21+50) is therefore applied to provide a gradual decrease in revetment height, armor size, and layer thickness between Zones A and B.

5.3 Earthwork

The typical cross section applied to the bluff is shown on Plate C-11 in Attachment G. In developing the typical section for the draft design, templates with varying side slopes were run along the primary control line using Bentley InRoads software, and the resulting earthwork quantities were tabulated. Templates were developed with slopes varying between 1.5H:1V (the steepest recommended slope based on the results of the geotechnical analysis) and 3H:1V. The template offset from the primary control line was also varied within each zone to determine the earthwork quantities associated with moving the typical section landward or seaward. Moving the typical template further seaward increases the amount of imported fill required at the toe along with the associated cost. Moving the typical template further landward decreases the required imported fill, but significantly increases the amount of excess glacial till that would have to be hauled offsite. The draft design is based on the offset that optimizes the costs by minimizing the net import or export of material.

The draft design resulting from this optimization procedure yields a typical section with a 2H:1V bluff face slope above the bench and a 1.5H:1V slope below the bench. The milder slope within the alluvial layer provides native borrow material for reuse onsite, reducing the amount of imported fill required. The milder slope also promotes better vegetation survivability in the areas most visible from the top of the bluff and from the bench. Applying the milder slope rather than maximizing the slope for geotechnical stability alone results in additional acquisition costs due to the larger footprint but optimizes the earthwork while simplifying maintenance procedures in the areas with the greatest aesthetic impact. An even milder slope, such as a 3H:1V slope, increases the factor of safety against localized erosion but would also significantly increase the volume of earthwork (construction costs) and the project footprint (acquisition costs) associated with the project if applied to the entire slope. A secondary disadvantage of a milder slope may also be an increase in unauthorized public access to the toe.

The slope stability analysis indicates an acceptable factor of safety for the design earthquake conditions as described in Chapter 3. Under this scenario, there is potential for some deformation up to about 25 feet back from the slope crest. Setback ordinances for future development along the top of the bluff are thus recommended to minimize structural losses during the design event or during earthquakes potentially exceeding the design events. To accommodate maintenance access and drainage requirements along the top of the bluff, a permanent easement measuring approximately 20 feet from the edge of the constructed bluff slope is recommended. According to the International Building Code (International Code Council 2006), a 40-foot minimum setback is recommended for foundations constructed near a descending slope. This easement would apply to new construction; existing structures located within the easement zone (between 20 and 40 feet from the bluff edge) would be treated on an individual basis and may be subject to further review by a structural engineer to assess the long-term stability.

Although a 1.5H:1V slope is considered stable from a long-term geotechnical standpoint, the height of the slope causes some concern for construction equipment during placement of the fill. Placement of a geogrid, as shown on Plate C-11 in Attachment G, is recommended to alleviate concerns regarding constructability. Geogrid placement is recommended at every second compaction lift (18-inch vertical spacing) with a minimum width of five feet. A list of potential products is included in Attachment E. For products manufactured in six-foot rolls, a six foot width would be recommended in favor of cutting the roll. Uniaxial products would need to be rolled with frequent cuts and excessive overlap requirements; a biaxial geogrid is therefore recommended. The opening size should be at least one inch square to accommodate roots from the vegetation planted along the bluff face. The geogrid should be flexible fabric rather than stiff plastic so that establishment of roots reinforces rather than destabilizes the slope.

The draft design also includes erosion control fabric, vegetation, and other measures to control erosion along the bluff face as shown in Plate C-11 in Attachment G; however, even with these measures, careful installation and ongoing monitoring and maintenance are required to promote vegetation survivability and to prevent local sloughing.

Excavation activities will most likely uncover some material unsuitable for reuse onsite that will have to be hauled for offsite disposal. Some reuse of the excess till material is assumed within the toe trench backfill in order to minimize voids and reduce the potential for fish stranding. During construction, any loose and/or saturated debris should be removed from the face of the bluff prior to placing the fill material. Benching into the bluff face is recommended to expose undisturbed material. Control of the seepage water will also be important during construction. The fill should not be allowed to become excessively wet prior to compaction. An open-graded gravel material against the bluff face is recommended to aid in drainage as necessary. The proposed gradation is provided in Attachment E. The gradation requirements are loosened somewhat beyond the ideal permeability in order to allow the inclusion of most of the existing alluvial material. A coarser material specification would allow for a thinner cover layer but would potentially preclude the use of existing alluvial deposits. To help facilitate drainage, a layer of coarser gravel is proposed in localized areas where the seepage is greatest. The localized improvements are part of ongoing monitoring and maintenance work (see OMRRR below). Further geotechnical analyses of slope stability and seismic design criteria are included in Attachment E.

5.4 Stormwater Management

In accordance with the design criteria, the draft design prevents overland runoff from flowing over the edge of the bluff in order to reduce the risk of head cuts and other associated drainage problems. As described in Chapter 2, runoff concentrates in three primary locations in the project area (one within each zone). A discussion of options considered for accommodating the runoff is included in Attachment E. These include the following:

1) Construct bioswales and vegetated basins to treat stormwater runoff and allow infiltration.
2) Route concentrated flows away from the bluff and into the City of Kenai storm drain network.
3) Construct rock V-ditch slope drain
4) Construct pipe slope drain

As shown in Plate C-11 in Attachment I, the draft design proposes a small berm approximately 6 inches in height along the edge of the bluff; the twelve-foot wide access route adjacent to the berm is graded with a reverse cross slope (sloping away from the bluff at 2-3%), and a small ditch varying from 1 foot to 2 feet in depth is proposed on the landward side of the road to collect sheet flow runoff. The ditch should be vegetated in order to act as a bioswale for filtering stormwater runoff. At the three key concentration points, vegetated settling basins are proposed. The swales route flow into the settling basins, which attenuate peak flows while allowing pollutants to settle, and the vegetation within the basins filters urban runoff from adjacent streets prior to being released. The bed of the ditches and basins should be lined with either a pond liner (impervious geomembrane) or bentonite seal to prevent infiltration that might otherwise surcharge the groundwater table.

As shown on Plate C-2 in Attachment G, a settling basin is proposed in Zone A near Mission Avenue. Approximately 18 acres of drainage area collects in the basin. An existing culvert that conveys stormwater runoff through the existing subsurface network to the bluff edge is redirected into the basin. A flashboard riser structure is proposed as a basin outlet to allow adaptive management of water levels and optimize detention times. The riser would preferably be connected to the portion of the City of Kenai storm drain network draining away from the bluff; however, additional analysis of the existing storm drain system is required to assess the feasibility of this option prior to further design. Routing flows away from the bluff through the City's storm drain network would most likely require additional infrastructure improvements outside of the project footprint. Development of a storm drain model by KWF is pending funding availability; in the interim, the proposed design routes flows from the riser pipe to a rip rap V-ditch that extends to the toe of the bluff, as shown on Plate C-13 in Attachment G. Infiltration basins may be incorporated if the basins are a minimum of 500 feet from the bluff face. Additional property acquisition or easements would be required to construct set-back infiltration basins.

As shown on Plate C-4 in Attachment G, an existing basin with a flashboard riser is present along Peninsula Avenue in Zone B. Regrading the basin is proposed to accommodate the access road, with the drainage swale flows routed into the basin for a total drainage area of approximately 25 acres. An existing corrugated metal pipe (CMP) culvert drains from the flashboard riser to the toe of the bluff. The existing culvert has failed in several locations, causing severe erosion along the slope. The proposed design removes the existing inlet and pipe and replaces them with measures similar to the Mission Avenue basin.

In Zone C, the drainage swale concentrates at the low spot along the top of the bluff with a total drainage area of approximately five acres. The approach for routing the flow to the toe of the bluff is similar to Zones A and B; however, a reduction in size and thickness of the rip rap is recommended as the design flows are significantly less. In addition, the armor rock at the eastern, upstream extent of the project near the Pacific Star Seafoods dock intercepts a ditch flowing along the edge of the bluff. A rip rap V-ditch is proposed in this location.

Additional details regarding the rip rap gradation and hydraulic characteristics are included in Attachment E. The risers, culverts, and V-ditches are sized to accommodate a 100-year rainfall event; however, a rain-on-snow event occurring while the culvert is blocked by ice or a design rainfall event occurring over frozen ground with highly limited infiltration may result in exceeding the system capacity. Should a greater-than-design event occur, immediate inspection is recommended to address potential erosion problems and prevent large-scale slope failure.

For runoff resulting from rainfall on the bluff face itself (approximately 10 acres), allowing sheet flow and preventing accumulation of erosive, concentrated flows down the face is recommended in favor of terracing and trenching the bluff face to accumulate and feed surface water into collector channels or slope drains. Several considerations regarding grading, compaction, layering, and special placement of geotextiles are required to prevent erosion prior to the establishment of vegetation. These recommendations are presented under the *Vegetation* section below. Other Best Management Practices (BMP's) may be implemented to address water quality issues pending analysis of the runoff source.

5.5 Vegetation

The existing bluff face is unvegetated, except in areas where material at the toe is not carried away by waves or currents (Cemetery Creek and Ryan's Creek). Groundwater seepage is present in these areas, and the draft design approach presumes that a stable bluff slope with a protected toe would allow the establishment of vegetation in similar manner. The establishment of vegetation on the slope face will reduce the risk of erosion of the slope face during heavy rainfall and during spring breakup. As determined in the geotechnical analyses, surficial stability and resistance to erosion will be greatly enhanced once vegetation is established on the regraded slope face. During the period immediately following construction, prior to the establishment of vegetation, the slope will be more susceptible to erosion, and the placement of topsoil and a high-performance erosion control mat is recommended in order to speed the greening process. Erosion control fabric is recommended for the entire bluff face above the armor rock. Replacement of some plants may be required during establishment, particularly if design-level or greater-than-design rainfall events occur during the establishment period.

A phased planting approach is recommended to maximize survivability. Grasses should be allowed to establish first as a mandatory construction item, with willow and alders plantings proposed after several seasons as an optional construction item. Following establishment of the alders, spruce trees would be planted on the upper slope, likewise as an optional construction item. Because of the high degree of exposure to wind and ice, spruce would have higher survivability if protected by other surrounding vegetation.

The planting plan for the project includes the following components:

- During Construction: Place, key in and stake erosion control fabric along entire bluff face.

- Phase I (Mandatory): Seed entire area with emergent native grasses, including beach wildrye (Elymus mollis), blue joint reed grass (Calamagrostis canadensis) at 5 lb/ac and tufted hairgrass (Deschampsia cespitosa) at 5 lb/acre.
- Phase II (Optional): Plant riparian vegetation. Plant willow stakes immediately uphill of the revetment 5 feet on center. Extend the willows 3 feet along the slope uphill from the revetment in the near mouth area and 4.5 feet in the remaining area. Plant one row of alders adjacent to willows spaced 10 feet on center.
- Phase III (Optional): Plant upland vegetation. Plant rows of spruce 15 feet on center to the top of the bluff.

Additional details regarding the recommended planting and seeding plan are included in Attachment E and on Plates L-1, L-2, and L-3 in Attachment G. The planting plan has been prepared in coordination with Mr. Stoney Wright at the Alaska Plant Materials Center. Preliminary discussions with Mr. Wright indicate that there has been some local success planting alders and/or spruce trees in a phased manner. Success has been site-dependent; however, forestry replantings have typically been successful and the forestry-focused sources may have plants available. Of the seed species, wildrye is best applied where there will be salt spray or tidal influences. For the Kenai Bluff, this zone would be at the base of the slope. The remaining proposed grass seeds (reed grass and tufted hair grass) can be mixed in and generally do well in wet situations. Upland grasses should be seeded in on the upper slope.

A layer of alluvial sand is recommended over the entire bluff face, including areas excavated into glacial till. The alluvial layer is recommended for groundwater seepage; care should be taken to ensure that the layer is not so porous as to leave the roots of the vegetation completely dry. The current proposed recommendation is to place a minimum of 10 feet of alluvial material, capped with 1 foot of topsoil. The top soil should be smoothly compacted and graded to allow a flush contact with the erosion control fabric.

A 100% biodegradable erosion control blanket is recommended. Woven coir erosion control mats have a functional life of 4-6 years, but often last longer. Specifications for the erosion control fabric recommended for this application by Rolanka are included in Attachment E. Any similar product may be applied, so long as it meets the ASTM testing standards. Due to the relatively harsh environment at Kenai, several considerations should be followed during installation to extend the life and functionality of the product. Because the bluff face is south-facing, UV exposure will be intense, particularly in the summer months. A heavy-grade fabric is recommended in order to resist degradation from UV exposure. Because of the steep slope, high winds, and freeze-thaw action, the standard spacing for stakes should be doubled (quadrupling the number of required stakes) from the standard vendor recommendations. Particular care must be taken to ensure the mat lies flush against the topsoil. Key-in and overlap requirements should also be strictly adhered to.

Wherever the fabric is sliced for planting (including phased planting in seasons following completion of construction), the flaps should be buried into the hole for the rootball as a key-in. Plantings should be mulched as needed above the fabric. Some seeding can be completed prior to installation. In some cases, plugs can be planted through the openings in the blanket without slicing. Prevention of rilling and gullying along the bluff face relies on the infiltration. The subsurface material is likewise designed to be a pervious layer. As such, irrigation may be required during the initial phases until root depth are sufficiently established to prevent dessication. The costs of vegetation, as described in the following chapter, assume replacement of plants as needed to establish specified survivability rates within the establishment period.

5.6 Real Estate

The draft design involves some easement acquisition as well as potential condemnation and removal of several structures located within the excavation footprint. Approximately 46 parcels, 34 of which are privately owned, are located within the anticipated project area. The real estate plan and additional details regarding the affected parcels are included in Attachment D.

5.7 Recreational Features

The draft design includes one overlook with signage in each zone. Additional recreational features are not included in the draft design; local entities may add features such as public trails at a later point. Safety fencing is included at the edge of the proposed easement to control public access. The bench that has been incorporated into the design to promote groundwater conveyance presents an opportunity for additional recreational use. Agencies and residents have expressed a preference to have a birding trail in place of the multi-use bicycle trail proposed in previous concepts. The trail surfacing, aesthetic fencing, signage, and other features would require additional coordination with the City of Kenai. Transitioning the trail to the top of the bluff at the ends may also require further coordination. As presently shown in Attachment G, the trail is separated by Ryan's Creek Canyon; if there is a future desire to connect the trails with a crossing over Ryan's Creek, further coordination would be required.

5.8 Construction Sequence

The draft design approach assumes that the bluff face is cut back a minimum of 10 feet below the proposed bluff face, with the alluvial material stockpiled for placement as backfill. The cut and fill process could be looped by providing two access ramps, one near Cemetery Creek and one near the Pacific Seastar dock. Staging could be in the open area at the top of the bluff just west of the dock. A partial ramp exists in this area. It may be beneficial to temporarily span Ryan's Creek with rock and temporary culverts to allow continuity of the operation. Material could then be scraped at the top, transported around the ramp and dropped below with compactors running behind in a continuous loop. Alternatively, material could be pushed down by equipment at the top of the bluff, with additional compaction and earthmoving equipment located at the toe to allow placement and compaction in layers. The existing bluff face in any proposed fill areas would be notched first to avoid a smooth interface between soil types. The proposed construction sequence does not include driving vehicles on the sloping bluff face but rather filling in horizontal layers with a bucket or other extension performing the final smoothing and compaction of the immediate face.

Rock could be imported through a combination of barging and land-based equipment with the barge placing apron material at high tide, and the land-based equipment placing the remaining armoring at low tide. It is anticipated that the material behind the revetment would be constructed as an access road first. Complete segments of the armor section would be completed during each low tide cycle to at least the elevation of the maximum tide lines. Additional details regarding the proposed construction equipment, sequence, and other assumptions are included in Attachment F.

5.9 Monitoring Plan

The implemented project would require ongoing monitoring of vegetation, armor rock, bluff face integrity, river thalweg location, and other aspects of the project throughout the project life. The planting plan utilizes a phased approach, with implementation of each phase dependent on the success of the previous phase. As such, an annual inspection of vegetation is required. Results of the annual inspection will drive the timing of subsequent phases, should they be required. The monitoring plan should also include periodic hydrographic surveys to determine whether the thalweg is migrating toward the bluff face.

5.10 Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRRR)

The implemented project would require ongoing maintenance of the bluff face, vegetation, and toe protection throughout the project life. OMRRR needs will be assessed, prioritized, and implemented based on the results of the monitoring plan. The proposed access routes along the top of the bluff and along the bench are vegetated with grasses that would need to be maintained to provide continued access. Depending on the required frequency of access and the type of access vehicles, additional stabilization of the access routes, such as an open-celled mat, may be warranted. Without a bench, the reach length is excessive from the top of the bluff, and the types of equipment that could be mobilized to implement maintenance activities would be limited; however, the location of the bench above the lag gravel layer leaves the bench higher than ideal for maintenance purposes. If concentrated groundwater flows were to surface and require a rock mattress over the slope, the placement would most likely need to be manual.

Specifications of maintenance equipment, including width requirements for extensions, would need to be coordinated in further detail prior to use of equipment on the bench. Placement of additional rock at the toe in areas threatened by a thalweg shift would be guided by the results of the hydrographic survey. The top of the armor layer is not suitable as a driving surface, and the reach length from the bench is excessive. In addition, rock protruding from the top layer is proposed to deter public access along the top of the armor rock, as shown in the typical section on Plate C-12 in Attachment G. Because of these constraints, maintenance of the rock may need to be provided with barge access at high tide. Additional details on estimated OMRRR activities are included in the cost notes in Attachment H.

5.11 Quantities

Details on quantity takeoffs are included in Attachment H. A summary of the primary line items is presented in Table 7.

Table 7. Summary of Quantities

Line Item	Quantity	Unit
Excavate and Backfill	159,000	Cubic yards
Excavate and Haul Offsite	74,000	Cubic yards
Import, Place, and Compact	8,900	Cubic yards
Place Filter Fabric	83,000	Square yards
Place Filter Rock	15,400	Tons
Place “B” Rock	17,200	Tons
Place Armor Rock	35,200	Tons
Place Geogrid	34,000	Square yards
Place Top Soil	27,000	Cubic yards
Place Erosion Control Fabric	83,000	Square yards

5.12 Costs

The accompanying cost engineering report is included as Attachment H. The costs are presented with a breakdown of equipment, labor, and materials using the Microcomputer-Aided Cost Engineering System Second Generation (MII) software and cost databases. Attachment J includes notes, assumptions, quotes, and contacts related to the cost estimate. Hauling costs and the availability of rock from nearby quarries vary significantly over time and should be revisited with any updates to the design. Innovative approaches to construction sequencing, rock transport and placement, or earthwork components may result in lowered costs as the project proceeds. In addition to the first costs shown in Attachment H, annual operation and maintenance costs for annual rock and vegetation inspections, hydrographic surveying, and vegetation, drainage swale, settling basin, recreational feature, and revetment maintenance are assumed. These costs amount to approximately $20,000 per year, yielding a present value of approximately $350,000 over the 50-year project life.

5.13 Schedule

Costs are based on May 2012 unit prices, with an assumed initiation of construction activities in the summer of 2013. A preliminary construction schedule is included in Attachment H. The dates are adopted as a point of reference and do not reflect actual anticipated construction dates. Because of uncertainties in the anticipated construction schedule, costs would need to be escalated to account for the actual construction period as future project design phases are refined. Construction of each zone could vary in terms of implementation schedule. Because of the anticipated amount of time and budget required for complete project installation, phasing may be desirable, with the initial phases used as a demonstration section to show the final configuration and allow actual testing of the slope stability and armor material. The optimal split point if two phases were implemented would be Ryan’s Creek between Zones B and C. The historical erosion rate has been significantly higher west of Ryan’s Creek; phasing the construction with Zones A and B implemented prior to Zone C would provide the most immediate benefits.

Table 8. Total Project Cost Summary

PROJECT: Kenai River Bluff Stabilization
LOCATION: Kenai, AK
This Estimate reflects the scope and schedule in report; Kenai Bluff Feasibility Report

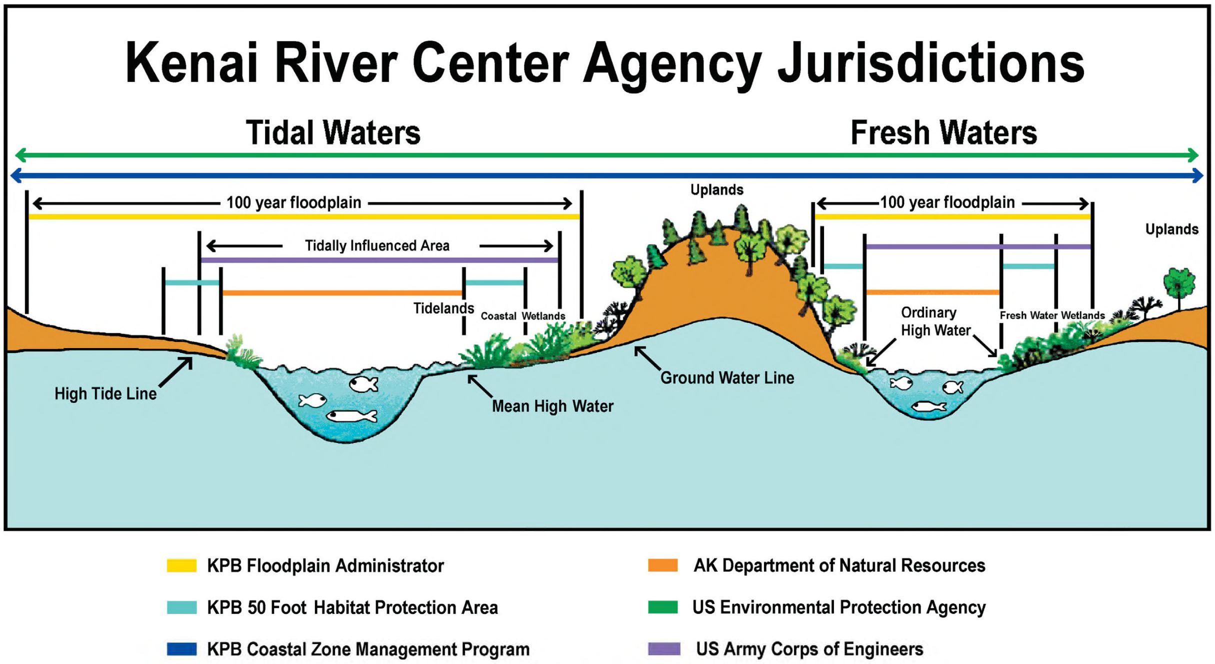
DISTRICT: Alaska District
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 5/8/2012

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Doller Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			8-May-12	Program Year (Budget EC):			2013					
		Effective Price Level:			8-May-12	Effective Price Level Date:			1 OCT 12					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	P	L	M	N	O
	PHASE 1 or CONTRACT 1													
04	DAMS	$651	$130	20%	$781	0.9%	$657	$131	$788	2014Q1	1.6%	$667	$133	$801
14	RECREATION FACILITIES	$530	$106	20%	$636	0.9%	$535	$107	$642	2014Q1	1.6%	$543	$109	$652
16	BANK STABILIZATION	$23,886	$4,777	20%	$28,663	0.9%	$24,100	$4,820	$28,920	2014Q1	1.6%	$24,480	$4,896	$29,376
	CONSTRUCTION ESTIMATE TOTALS:	$25,067	$5,013	20%	**$30,080**		$25,292	$5,058	$30,350			$25,690	$5,138	$30,828
01	LANDS AND DAMAGES	$3,000	$600	20%	$3,600	0.9%	$3,027	$605	$3,632	2013Q1		$3,027	$605	$3,632
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$376	$75	20%	$451	0.7%	$379	$76	$455	2013Q1		$379	$76	$455
1.5%	Planning & Environmental Compliance	$376	$75	20%	$451	0.7%	$379	$76	$455	2013Q1		$379	$76	$455
7.0%	Engineering & Design	$1,755	$351	20%	$2,106	0.7%	$1,768	$354	$2,122	2013Q1		$1,768	$354	$2,122
1.0%	Engineering Tech Review ITR & VE	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q1		$253	$51	$303
1.0%	Contracting & Reprographics	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q1		$253	$51	$303
1.0%	Engineering During Construction	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q2	0.4%	$254	$51	$305
1.0%	Planning During Construction	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q2	0.4%	$254	$51	$305
1.0%	Project Operations	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q1		$253	$51	$303
31	CONSTRUCTION MANAGEMENT													
4.0%	Construction Management	$1,003	$201	20%	$1,204	0.7%	$1,010	$202	$1,212	2013Q2	0.4%	$1,014	$203	$1,217
2.0%	Project Operation:	$501	$100	20%	$601	0.7%	$505	$101	$606	2013Q2	0.4%	$507	$101	$608
2.0%	Project Management	$501	$100	20%	$601	0.7%	$505	$101	$606	2013Q2	0.4%	$507	$101	$608
	CONTRACT COST TOTALS:	$33,834	$6,767		**$40,600**		$34,128	$6,826	$40,954			$34,536	$6,907	**$41,443**

6.0 POTENTIAL ENVIRONMENTAL EFFECTS

The Corps previously assessed potential effects associated with the proposed bluff stabilization project in the Technical Report (USACE 2006b). The findings of the Corps report are based on the potential effects of the PND concept design (PND 2003). The tentatively selected design concept has a smaller overall footprint than the PND concept due to the elimination of the trail on the revetment, so the potential effects are assumed to apply conservatively to the current design. The total project footprint below the regulatory high water elevation of 19.1 feet MLLW is 5.8 acres. An additional 3.4 acres of the total, permanent project footprint is below the regulatory high tide elevation of 25.2 feet MLLW. A temporary staging area of 12.2 acres is included along the toe of the bluff to allow for water-based rock placement.

The proposed construction sequence is provided as Attachment F, and the proposed schedule is presented in Appendix H. The proposed construction sequencing and schedule will be further coordinated with jurisdictional agencies to determine suitable construction windows to minimize adverse effects on marine mammals (e.g., whale migration), as well as on birds and other wildlife. Adjustments to the construction schedule are anticipated in order to comply with required windows. Table 9 summarizes anticipated potential effects of the draft design on each of the components described in Chapter 2 *Existing Environment*. Figure 14 shows the jurisdictional boundaries applicable to the Kenai River area (KRC 2009).



Areas of Regulatory Authority:

KPB Resource Planners: Lands within 50 feet of Ordinary High Water (OHW) (or within 50 feet of mean high tide in tidal areas) on streams covered by the KPB's Habitat Protection Area ordinance
KPB Floodplain Administrator: Lands within mapped floodplains and floodways in the Kenai Peninsula Borough
DNR DPOR: The area at and below OHW (or mean high tide in tidal areas) in the Kenai River Special Management Area and any structures projecting over the water; commercial activities on Alaska State Parks lands and waters
DNR OHMP: Areas at or below OHW (or mean high tide in tidal areas) of catalogued anadromous streams and streams supporting high value resident fish species
EPA: All activities which may result in discharge of pollutants to waters of the United States, including streams, rivers, lakes, ponds, marine waters and wetlands
KPB Coastal District: The borough's coastal district includes all areas out to the 3-mile off-shore limit, up to the 1000-foot elevation above sea level, and along the course of all documented streams important for salmon.
US ACE: Waters of the United States, including wetlands
City of Soldotna: Lands within 100 feet of OHW on the Kenai River inside Soldotna city limits

Figure 14. Agency Jurisdictions for Permitting (KRC 2009)

Table 9. Potential Effects of the Selected Alternative

Affected Environment Component	Potential Effects of Proposed Project
Climate	Negligible effect
Tides	Negligible effect
Coastal Currents	Negligible effect
Wind	Under proposed condition, the bluff area will include vegetation that, when fully established, will provide a wind buffer in the immediate vicinity of the edge of the bluff and potentially reduce wind erosion of bluff sediments. Larger-scale wind patterns are not likely to be affected.
Wave Climate	Some changes in the wave reflection patterns are anticipated due to the modified alignment of the revetment. The revetment face alignment is generally smoother than the existing bluff line, which reduces concentrated wave attacks that are caused by existing protruding points. The proposed armor gradation and revetment slope allow more wave energy dissipation (and thus less reflection) than the existing overconsolidated till layer. As a result, some reduction in wave and boat wake reflection would be anticipated as a result of the project.
Kenai River Hydrology	Negligible effect (see Overland Drainage for localized hydrological effects)
Kenai River Hydraulics	Negligible effect. The Corps Technical Report (USACE 2006b) found that the tidal backwater boundary condition masks any measurable effect of the project encroachment on Kenai River water surface elevations or river currents.
Kenai River Morphology	Bank migration to the north will be halted by the proposed design for approximately one river mile. The bluff retreat appears to be a function of localized erosion rather than large-scale bend widening or long-term adjustment of river meanders. As such, no significant effect on the river morphology is anticipated outside of the immediate project area.
Kenai River Sediment Transport	The sediment previously supplied to the Kenai River and Cook Inlet from the eroding bluff will be substantially eliminated under project conditions. The Sediment Impact Analysis in the Corps Technical Report found the effect of eliminating this sediment load to be minor relative to the overall sediment transport load in the Kenai River (USACE 2006b).
Longshore Sediment Transport	Negligible effect. The Corps Technical Report found that the dunes at the estuary mouth are primarily fed by longshore currents and wave action. Changes in longshore sediment

Affected Environment Component	Potential Effects of Proposed Project
	transport resulting from the project are not expected to be significant. Longshore sediment transport generally bypasses the inlet area, and the project would be unlikely to adversely affect the dunes at the river mouth, the intertidal zone in front of the dunes, or the water treatment plant (USACE 2006b).
Overland Drainage	Urban runoff that previously drained directly to the Kenai River over the bluff will be rerouted into the City storm drain network or concentrated and diverted into drainage swales. The rerouted flows will not significantly affect Kenai River hydrology or hydraulics.
Ice	Negligible effect
Geology/Soils	Negligible effect. Geotechnical analyses show the existing slope to be stable under normal conditions; the proposed slope will exhibit increased stability in seismic events.
Hydrogeology	No significant effect on the groundwater table elevation. The gradation of material proposed as fill against the till layer allows free drainage, preventing damming effects that would otherwise result from lower permeability material (raising the water table and pore pressures). The proposed project does not include mechanical dewatering or other features that would lower the water table. The discharge that currently seeps out of the bluff at the seepage interface in the lag gravel layer will remain subsurface along the bluff and seep through the filter under the revetment; although the flow paths will change, no significant effect is expected on the total discharge rate seeping out of the bluff.
Water Quality	Some additional groundwater filtering would occur due to the lengthened flow path under the proposed project configuration. Storm water runoff that currently drains directly to the Kenai River may receive supplemental treatment in settling basins or other BMP's associated with the project prior to discharge into the Kenai River, potentially improving the stormwater quality. Some coordination may be required under the Clean Water Act.
Sediment Quality	No significant effect on sediment quality. Any contaminated sediments encountered during excavation activities will be removed from the site and/or treated according to specifications for sediment quality.
HTRW	BMP's and other preventive measures will be implemented prior to, during and following construction to prevent adverse effects related to HTRW issues. Additional data collection is required to establish the baseline HTRW condition. The presence of HTRW materials would add costs to the project not currently accounted for.

Affected Environment Component	Potential Effects of Proposed Project
Aquatic Habitat and Wetlands	The Corps Technical Report assessed potential impacts to aquatic habitat and wetlands resulting from the project (USACE 2006b). Adverse impacts to the riparian zones adjacent to Ryan's Creek and Cemetery Creek are minimized with the selected project footprint; however, there will be some disturbance of these areas from construction equipment, particularly where the revetment is keyed into the toe of the existing hillside. There is also a potential for direct and indirect loss of habitat in the intertidal area from construction activities and placement of rock. A detailed wetland delineation is required to more accurately assess impacts; the Corps will be evaluating the potential effects. The analysis of impacts should account for the change in habitat use of the bluff face, particularly during establishment of vegetation, for species that currently use the bluff face or toe area. The analysis should also account for changes to aquatic habitats, including depths, velocities, and substrate types.
Fish and Wildlife	There is the potential for direct and indirect loss of habitat from stabilization of the bank. Direct habitat loss would occur by placing riprap in the intertidal area and also result in a loss of potential nesting habitat for swallows if the bank grade is altered. The Corps Technical Report assessed potential impacts to fish and wildlife resulting from the project (USACE 2006b). The report concluded that some short-term disturbance and displacement of birds is likely during certain construction phases, but that many adverse impacts could be avoided by setting construction windows with proper timing to avoid nesting or other critical periods. At low tides, gulls, eagles, shorebirds and ducks forage on the intertidal mudflats below the toe of the proposed project. Since most bird usage occurs outside the project footprint, the Corps' assessment concluded that the project is not expected to affect the dunes or opposite shoreline. The project may not negatively affect birds in the long term. Seals foraging in the river mouth may be disturbed by construction activities. Since the toe of the revetment will be above the water line except for high tides, the long-term effects to fish and aquatic species are likely to be minimal. Some spruce trees at the top of the bluff that bald eagles currently use for perching would be lost in the short term as the bank is cut back; however, in the long term, the project prevents further bluff erosion that would lead to the loss of additional trees. Because the existing slope is largely unvegetated, once vegetation has fully established under proposed conditions, an

Affected Environment Component	Potential Effects of Proposed Project
	increase in habitat value is anticipated for wildlife species in the area. Construction activities may have short-term effects on gull nesting or other uses on the opposite bank. Intertidal areas where shorebirds forage for prey to fuel their migration to breeding grounds may be affected. Eagles perching along the bank of the inside bend wetlands could also be disturbed by construction activities. Additional coordination may be required under the National Environmental Policy Act, Coastal Zone Management Act, and Fish and Wildlife Coordination Act.
Threatened and Endangered Species	Further evaluation of listed species is required to assess the affected environment and collect data that would support a Biological Assessment (BA). Additional coordination may be required under the Endangered Species Act
Cultural Resources	By stabilizing the bluff, the project preserves cultural resources that otherwise might be threatened by continued bluff erosion. The remains of two archaeological sites and four structures eligible for the National Register of Historic could be impacted by continued erosion during the project's period of analysis. Additional studies of other impacted structures (see Real Estate) may be warranted to determine historical significance. Additional data collection is required to document the existing cultural resources that fall inside the project footprint. Effects of the project on cultural resources will be minimized, but cannot be ascertained, quantified, or mitigated until further data collection is completed. The effects of the project on cultural resources in the area will be further analyzed pending additional documentation of the existing cultural resources within the project footprint, including documentation of coordination under the National Historic Preservation Act.
Economy	The project is expected to improve the economy of the area by removing an uncertainty for city planners. The stabilized slope is expected to result in increased property values for parcels along the bluff as well as additional parcels further inland that would benefit from increased stability. The Corps Technical Report (USACE 2006b) quantified economic impacts of the project. The Corps Reconnaissance Report documented groundings, collisions, delays, fish catch degradation, and other issues related to navigation. The proposed project is not expected to improve navigation.
Recreational Use	Recreational use may increase as a result of the project if recreational features are added to

Affected Environment Component	Potential Effects of Proposed Project
	the project configuration. Any increase in use must be accompanied by the appropriate infrastructure such as fencing, trash receptacles, and toilet facilities to minimize impacts of additional recreational traffic. It is difficult to predict the degree of disturbance that may arise from construction. In summer months, there is generally a large amount of boat traffic near the mouth of the Kenai from both commercial and recreational boaters. The degree of disturbance from construction is unknown. Disturbances may result from the type and duration of the noise produced from construction.
Land Use	Negligible effect. The project is not expected to affect overall land use in the area in terms of residential and commercial zoning. In coordination with the City of Kenai, zoning regulation may be developed to include an easement restricting future development within the immediate vicinity of the top of the bluff.
Real Estate	The project will involve acquisition of some parcels and condemnation, demolition, and removal of some structures. Approximately 16 structures are affected, including residential structures, sheds, detached garages, and bungalows. The configuration of the selected project seeks to minimize encroachment of the existing project on affected parcels. Though prediction of with-project condition land values is difficult, there is no doubt that the attractiveness of the land will increase dramatically resulting in additional value and added benefits to the project. The Corps Technical Report quantified the benefits to property nearby the bank. In addition to the affected structures, the projected without-project erosion rate shows approximately 30 structures susceptible to bluff erosion during the time period equivalent to the project life. The benefits from a project that stops the existing erosion problems are the increased value of land and resale ability and eliminating the elimiation of the need to relocate buildings and utility lines.

7.0 CONCLUSIONS

This report presents the design considerations for the Kenai Bluff Stabilization Project and summarizes the alternative development and selection process. The proposed design is based on the results of analyses of available information as documented in Attachment A.

7.1 Summary of Findings

The stability of the bluff was evaluated both qualitatively by field observations, and quantitatively with analytical methods. The qualitative evaluation of the slope stability was primarily based on observation of the existing areas of the bluff which are not currently subject to active toe erosion. Specifically the areas at the west end of the bluff in the vicinity of Cemetery Creek, and the slopes at the mouth of Ryan's Creek were studied. These natural slopes appear to have stabilized and become vegetated at angles of about 1.5:1 (H:V). Based on these observations and as confirmed by additional slope stability modeling, it was concluded that the bluff regraded to 1.5:1 (H:V) or flatter will be stable with respect to global failures, absent further erosion of the toe. Surficial stability and resistance to erosion is expected to be greatly enhanced once vegetation is established on the regraded slope face. The placement of topsoil and a high performance erosion control mat/fabric is included to speed the greening process.

A layer of granular soil covering the seepage area at the base of the alluvial deposit is expected to keep the groundwater in the subsurface for most of the year, and the establishment of vegetation on the slope face will reduce the risk of erosion of the slope face during heavy rainfall, and spring breakup.

The design approach presented in this report, with armor rock at the toe, earthwork balanced and groundwater runoff collected in the alluvial fill material, was identified as the optimal project configuration in terms of balancing costs against impacts while maintaining functionality. The Kenai Bluff Stabilization Project would effectively halt further erosion of the Kenai River bluff for an approximate construction cost of $31 million and a total implementation cost of $41 million. Additional benefits of the project are not quantified in this study. Adverse environmental impacts are not anticipated to be significant in the long-term; however, there will be some limited environmental impacts during construction activities. Further environmental coordination is required as the project design proceeds.

7.2 Recommendations

Supplemental information pertaining to the existing condition, the proposed solution, or associated impacts will allow further development of the design. It is anticipated that the following information will be needed to complete the Kenai Bluff Stabilization Project Final Design and Specifications, and to support future permit applications in preparation for construction:

- *Topographic Survey*. Updated topographic survey and aerial photography of the project area was acquired in November 2007, with additional orthophotography acquired in October 2010. Cultural resources, environmental resources, and other features that fall within the project footprint may be surveyed and added to the base mapping as the project proceeds and additional baseline data become available. Project topography and datums are suitable for construction-level documents; however, the top of the bluff should be resurveyed prior to any construction work to document ongoing bluff erosion.

- *Utility Inventory*. Locations of existing infrastructure, overhead lines, pipelines, and other buried utilities were estimated but not field-verified during the Design development. These utilities can be located in the field through the Alaska Dig Line one-call service at (907) 278-3121 and subsequently incorporated into the project survey data.

- *FEMA Coordination.* The hydraulic analysis has shown that the project is unlikely to have an effect on the flood elevations due to the coastal storm backwater boundary condition. As such, coordination efforts with FEMA should be simplified; however, project implementation will result in a permanent structure that affects the spatial extent of the floodplain boundary, and some coordination with FEMA is be required to provide the conditional delineation.

- *Storm Water Analysis*. Field investigations should be conducted to delineate sources of storm water runoff, quantify the anticipated runoff, document the baseline water quality, determine existing flow paths, and assess the feasibility of routing storm water from the top of the bluff into the City storm drain network. These efforts must be coordinated with the City of Kenai and the Kenai Watershed Forum.

- *Construction Sequence and Equipment List*. Future permitting will likely require analysis of the impacts from the proposed construction equipment. A proposed construction sequence is included in Attachment F with a construction schedule and equipment list provided in Attachment H; however, any changes to the proposed construction approach, including contractor recommendations, should be coordinated with permit submittals.

- *Permitting.* Federal participation in the project requires evaluation under the Clean Water Act, National Historic Preservation Act, National Environmental Policy Act, Coastal Zone Management Act, Essential Fish Habitat, Endangered Species Act, and Fish and Wildlife Coordination Act (USACE 2006b). Additional environmental data will be required to support these permitting processes, including determination of whether the project will require an Environmental Impact Statement (EIS) or an Environmental Assessment (EA). Agency jurisdictions are presented in Chapter 6.

- *Recreational Analysis*. Coordination will be required between stakeholders to prevent site access except in designated, fenced, accessible areas. Recreational features and access should be coordinated with any relevant City of Kenai master plan features. Any proposed recreational features should be evaluated for compatibility with proposed project purposes and for potential impacts to project performance and project life.

- *Real Estate Agreements*. Prior to construction a real estate agreement should be completed with all affected parcel owners identifying all rights of way, access points, temporary construction easements, and permanent easements related to the project.

- *Operation and Maintenance Agreement*. Prior to construction, agreement on responsibilities for monitoring and operation, maintenance, repair, replacement, and rehabilitation (OMRRR) activities should be reached between all stakeholders.

- *Archeological Survey*. Prior to construction, historical buildings and areas with archeological value should be identified. The effects of the project on these sites and the relocation potential of historical buildings and resources should be assessed.

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ATTACHMENTS

ATTACHMENT A: PREVIOUS STUDIES

ATTACHMENT B: HYDROLOGY AND HYDRAULICS

ATTACHMENT C: HISTORICAL BLUFF EROSION

ATTACHMENT D: REAL ESTATE AND GEOSPATIAL DATA SOURCES

ATTACHMENT E: DESIGN CALCULATIONS AND SPECIFICATION NOTES

ATTACHMENT F: PROPOSED CONSTRUCTION SEQUENCE

ATTACHMENT G: DESIGN PLANS

ATTACHMENT H: COST ENGINEERING REPORT

ATTACHMENT I: ENGINEERING CONSIDERATIONS AND INSTRUCTIONS FOR FIELD PERSONNEL

ATTACHMENT J: ANNOTATED COMMENTS AND ITR CERTIFICATION

ATTACHMENT K: TRIP REPORT AND MEETING MINUTES

ATTACHMENT L: HYDROGEOLOGY AND R&M GROUNDWATER MONITORING REPORT

ATTACHMENT M: R&M GEOTECHNICAL INVESTIGATIONS REPORT

ATTACHMENT N: OCEANWEATHER EXTREME WAVE STUDY

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ATTACHMENT A: PREVIOUS STUDIES

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Narrative Summary of Relevant Previous Studies

A number of studies and other efforts have been undertaken to investigate and assess the bluff erosion problem at Kenai, develop measures to protect the bluff from continuing erosion, and evaluate potential environmental effects from proposed protection measures. These previous studies span over 25 years and were conducted by the Corps of Engineers, the City of Kenai, the University of Alaska, and others. Results and recommendations are summarized below for relevant documents pertaining to studies in the Kenai area spanning the period from 1982 through 2007.

Estimated Bluff Erosion Rate and Effects

In a 2001 study, the University of Alaska Anchorage (UAA 2001) documented that between 50 and 100 feet of lateral erosion had occurred during the period 1976 to 1999, yielding an average annual bank retreat rate of approximately 3 feet per year. In a Corps study released in 2006 (USACE 2006b), the Corps concluded that the UAA estimate was conservative, and suggested that a more realistic estimate of the historical rate would be 1.2 feet per year. The Corps report reasoned that during the period of time analyzed in the UAA report, the study area experienced higher than normal erosion. An extrapolation of either rate into the future shows the top of bluff reaching several structures and utilities within the City of Kenai over the next decade.

- The 2001 UAA study reported that the bluffs contribute approximately 51,000 tons of sediment to the Kenai River each year, representing approximately 7% of the sediment load in the river.
- A Sediment Impact Assessment conducted by ERDC in 2004, as reported by the Corps, found that a total of approximately 21,000 tons of sediment was eroding from the bluff annually, representing approximately 5% of the total sediment load in the Kenai River (USACE 2006b).
- The Corps (2006b) also estimated that the average annual capital loss due to the bluff erosion was about $150,000.

Factors Contributing to the Bluff Erosion

All previous studies concurred that the factors contributing to the bluff erosion include: (a) wave action undermining the bluff toe; (b) groundwater from the surrounding area flowing through the bluff face; (c) overland or surface flow; (d) wind action eroding the face of the bluff; and (e) tidal and river currents carrying away sloughed and eroded material. There is no concurrence among previous studies, however, as to the relative importance of each of these factors. For example, the 2001 UAA study found the bluff erosion to be primarily associated with extreme high tides and wave action, and that the influence of river currents was less, and indirect (UAA 2001). The 2006 Corps study (USACE 2006b) pointed to additional findings by Scott (1982), Barrick (1984), Inghram (1985), Reckendorf (1989), and Reckendorf and Saele (1993) that documented anthropogenic (human) factors such as loss of bank vegetation, streamside use, boat wakes, and improperly designed erosion control practices as important contributing factors.

Several mechanisms of bank loss were noted in the Corps' Sediment Impact Assessment. Bank failure in the stiff clay in the lower layer was characterized by wave erosion retreat at the toe, freeze/thaw action, and block failures associated with poor internal drainage. The till soils in the upper layer are subject to dry soil fall, aeolian transport, freeze/thaw, rilling, and piping, which results in shallow translational failures and soil fall when the lower layer fails (USACE 2006b).

The 2002 PND concept report reported that the historical Kenai River thalweg appeared to remain relatively constant over time, and that a shifting river thalweg was, therefore, not a significant contributor to the bluff erosion.

Previously Proposed Solutions

A number of potential solutions to the bluff erosion at Kenai have been proposed in previous studies, as discussed below.

Tippetts, Abbett, McCarthy, Stratton (TAMS), 1982. A 1982 bluff erosion study by TAMS presented a range of alternative concept designs and preliminary cost estimates for addressing the bluff erosion. One proposed design involved installing a cutoff wall with wells and pumps, and excavating the slope to a 1.25H:1V vegetated slope with a collector pipe at the sand/silt interface. An alternative design involved constructing a vertical sheet pile bulkhead and layered rock armoring at a 1H:2V slope. Constructing a 24’ roadway with a 10’ walkway was also considered in the alternatives.

Peratrovich, Nottingham, & Drage (PN&D), 2002. PN&D proposed a design solution in their February 2002 report that involved cutting the upper slope of the bluff back to a 1.5H:1V vegetated slope, and constructing a layered armoring system at a 1.5H:1V slope along the lower portion of the bluff face, and constructing a 200’ span bridge across Cemetery Creek at the Kenai Dunes Park. The proposed design also included constructing a bench across the bluff face for seepage control that included a 12’ wide paved recreation trail.

In addition to the above two concept design solutions, other previous studies have proposed regulatory solutions such as limiting public access to the dunes, regulating land use in the vicinity of the top of the bluff, promoting vegetation for erosion control, and controlling surface water flows (USACE 2006b and UAA 2001).

Potential Effects of Previously Proposed Solutions

Local stakeholders and agencies commented on the PN&D concept design (City of Kenai 2002). In general, the stakeholders expressed the need to have further analysis of potential effects on the Kenai Flats area located across from the eroding bluff. Another major concern was the environmental effect associated with bringing a large number of people onto the proposed recreation trail along the bluff face.

The 2001 UAA erosion study evaluated longshore, river, tidal, and wave-induced sediment transport forces under existing conditions and conditions based on the 2000 PN&D draft concept design. The report found that the predicted effects on future erosion trends would likely be relatively minor. However, the trampling of dune vegetation by human visitors encouraged by the trail and bridge was likely to present a serious threat to the Kenai Dunes.

The Corps Technical Report (2006b) concluded that although stabilization of the Kenai Bluffs would affect the sediment dynamics in the estuary, the overall impact of the reduction in sediment load would likely be minor. A key finding of the report was that changes in the morphology of the tidal flats and dunes were not expected to result from bluff stabilization given the net surplus of sediment in the reach.

Table A-1: Summary of Previous Study Contents and Results

Title	Agency/author	Date	Contents/summary of results
City of Kenai Comprehensive Plan, Public Review Draft	City of Kenai (Kevin Waring Associates, Benson Planning Associates, Bechtol Planning and Development)	February 2003	Summary of existing city infrastructure and plans for future development, downloaded from City website http://www.ci.kenai.ak.us/. Includes GIS plates for existing land use, land ownership, wetlands, floodplains, zoning, roads, water, sewer, and aerial photography.
Draft Bluff Erosion Study, Kenai River Sedimentation Study	City of Kenai (TAMS Engineers)	November 1982	Preliminary costs and quantities for addressing erosion control problems. Includes site photos, topography, and typical sections. According to 905(b) this report identified groundwater seepage from the bluff face as the primary mechanism of bluff erosion and recommended control of this seepage as the first order of work towards bluff stabilization.
Erosion and Sedimentation in the Kenai River, Alaska. Geological Survey Professional Paper 1235	U.S. Geological Survey (Kevin Scott)	1982	Assessment of erosion and sedimentation of the entire Kenai River. Includes an overall assessment of the underlying regional geology and geological processes.
Erosion at the Mouth of the Kenai River, Alaska. Analysis of Sediment Budget with regard to the proposed Kenai Coastal Trail and Erosion Control Project	University of Alaska Anchorage (Orson Smith, William Lee, and Heike Merkel)	April 2001	Evaluation of PND design, including wind speed analysis, longshore transport capacity, streamflow statistics, and river sediment transport data. Report contains a sediment budget analysis with regard to the proposed "Kenai Coastal Trail and Erosion Control Project", PND January 2000 Draft.
Groundwater Monitoring Report. Kenai River Bluff Erosion	R&M Consultants	January 2008	Results of one year of monthly groundwater monitoring well readings.
Geotechnical Investigation and Site Conditions Report. Kenai River Bluff Erosion	R&M Consultants	February 2007	Laboratory results and summary geotechnical data from November 2006 site investigations and borings along the Kenai Bluff.
Kenai Agency Concerns and Technical Report Responses	USACE, Alaska District, Project Formulation Section	November 2007	Summarizes agency comments received on Draft Technical Report. Outlines responses to concerns based on additional studies.
Kenai Bluff Erosion Project Benthic Invertebrate Sampling Memorandum	USACE Alaska District (Christopher Hoffman)	July 3, 2003	Invertebrate sampling methods and results, includes sampling location map

Title	Agency/author	Date	Contents/summary of results
Kenai Bluff Erosion Project Bird and Marine Mammal Survey Memorandum	USACE Alaska District (Christopher Hoffman)	July 3, 2003	Bird and mammal survey methods and results, including maps of monthly survey results
Kenai Bluff Erosion Project Phase 2 Work Plan Report	Tetra Tech, Inc.	September 5, 2006	Presents recommendations for additional data collection and analyses in preparation for initiating design work.
Kenai Coastal Trail and Erosion Control Project Design Concept Report and Plan Set	City of Kenai (Peratrovich, Nottingham, and Drage, Inc.)	February 2002	This report provides a design concept of bluff stabilization and a pedestrian trail along the bluff. Report includes schematic design, preliminary costs and quantities, preliminary design assumptions for armor sizing, sand budget, slope stabilization, and drainage. Separate attachment includes 12-sheet plan set with plan/profiles, typical sections, typical bridge details, and right of way property plan. Plan set attachment obtained is from January 2000 draft (not obtained for February 2002 final)
Kenai Coastal Trail Memorandum, Summary of Agency Comments	City of Kenai (Keith Kornelis)	October 16 2001	Compilation of agency comments on 2000 PND concept design Includes comments from Corps (regulatory), EPA, DEC, USF&W, State DF&G, NOAA, KBP, State DOT/PF, State DGC, Central Peninsula Counseling
Kenai Coastal Trail Permitting Process, Letter to Keith Kornelis	PND (Dennis Nottingham)	November 15, 2001	Recommended tasks for project permitting process
Kenai River Bank Erosion Technical Report	USACE Alaska District	July 2006	According to 905(b) analysis, “this report assessed environmental resources at the lower Kenai River, identified the mechanisms for bluff erosion, and assessed environmental and hydrogeomorphic consequences of bluff stabilization.” Includes project summary, economic evaluation, and maps of affected parcels and utilities. Includes the following technical appendices: Appendix A: Environmental Studies - Invertebrate sampling - Bird and marine mammal survey - Cultural resources - ADF&G baseline fisheries assessment Appendix B: Hydraulics and Hydrology - Tidal datums - Mean daily discharge summary (Kenai River at Soldotna)

Title	Agency/author	Date	Contents/summary of results
			- Estimated design wave - Wind measurements - Estimated volume of eroded material - Estimated groundwater seepage - HEC-RAS results - Groundwater readings from October 2003 and April 2004 Appendix C: Sediment Impact Assessment - Erosion assessment - Sediment analysis Appendix D: Geotechnical Investigation - Laboratory results/gradation and water levels for four boreholes drilled Sep 2003
Kenai River Bluff Erosion Section 905(b) (WRDA 86) Analysis	USACE Alaska District (Colonel Timothy Gallagher)	July 28, 2005	Project summary, funding details, location maps, typical conceptual cross section
Kenai River Bluff Erosion Study Meeting Notes	USACE Alaska District (Patrick Fitzgerald)	July 29, 2002	Agency concerns and information requested
Kenai River Cultural Resources Memorandum	USACE Alaska District	unknown	Includes two maps from 1996 Kenai Townsite Historic District Survey Report. Shows 25 potential sites in project area.
Kenai River Estuary Baseline Fisheries Assessment Regional Information Report No. 2A04-13	Alaska Dept of Fish and Game (T. M. Willette, J. M. Edmundson, R. D. DeCino)	March 2004	Baseline fisheries assessment focused on documenting the fish assemblage and some predator-prey interactions occurring in the Kenai River estuary.
Kenai River Sedimentation Study	City of Kenai (TAMS Engineers)	September 1983	Primarily to support a study of for a proposed harbor upstream of the project site. Pebble counts, grain size distribution
Letter to Keith Kornelis, City Engineer, City of Kenai	Alaska Dept. Fish and Game (Gary Liepitz)	January 31, 2000	Referenced in 2001 Smith report (not obtained)
Reconnaissance Report for Navigation Improvements and Erosion Control, Lower Kenai River	USACE, Alaska District	1997	Discusses findings relative to dredging for navigation improvements and the use of dredge spoils behind a revetment for erosion control. Referenced in 2001 Smith report.

Title	Agency/author	Date	Contents/summary of results
Summary Trip Report	Tetra Tech, Inc.	March 24, 2006	Trip report, including meeting notes, site photos, and newspaper articles for March 2006 site visit and City Council meeting

ATTACHMENT B

HYDROLOGY AND HYDRAULICS

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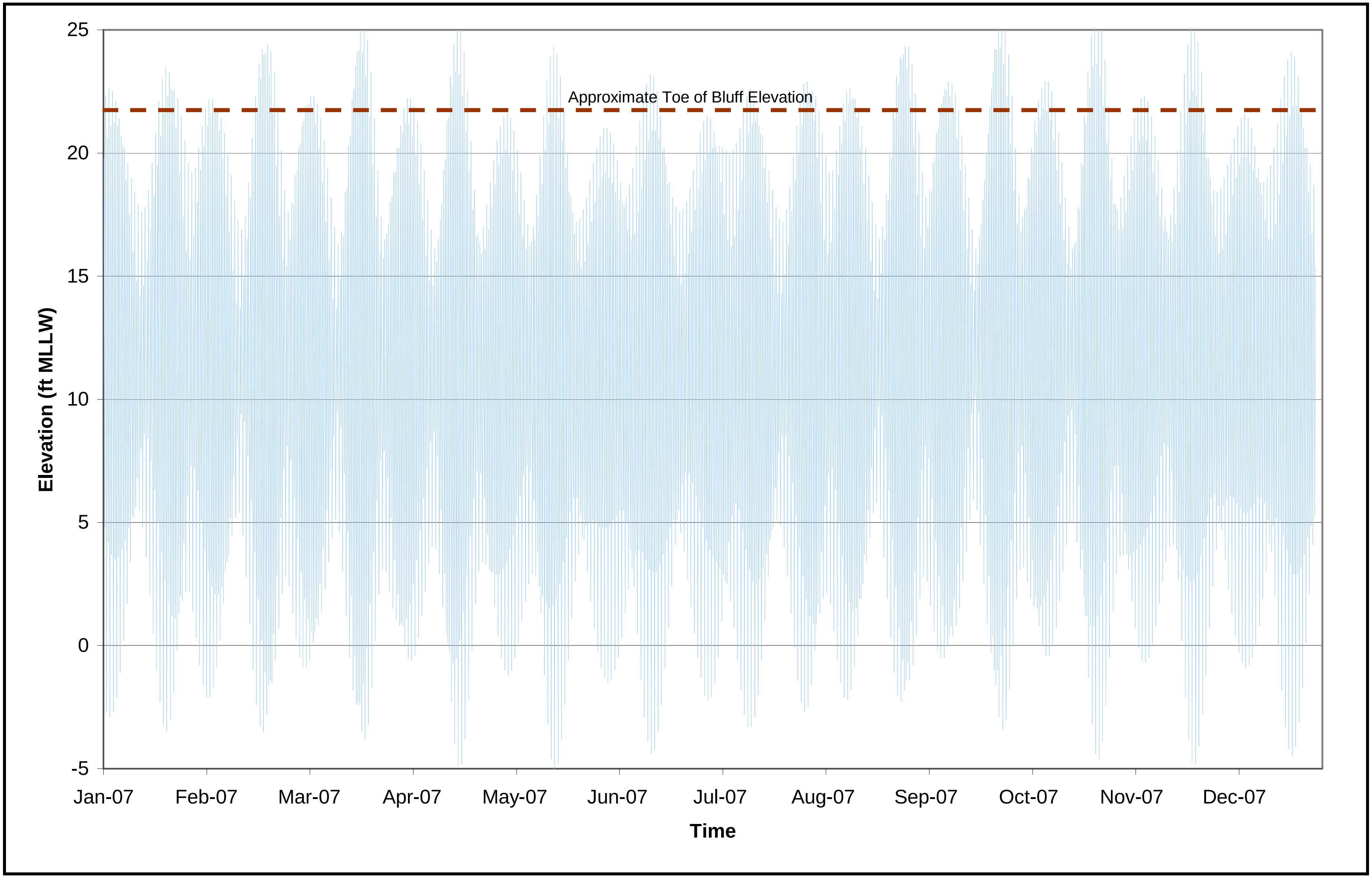

Figure B-1. 2007 Tide Predictions for Kenai River Entrance

Table B-1: Station Metadata for Tidal Data

Station	Lat	Long	Mean Range (ft)	Spring Range (ft)	Mean Tide (ft)	Reference Station	Time Correction	Height Correction
Kenai City Pier	60° 33'	151° 14'	17.5	19.8	10.4	Seldovia	High +1 hr 54 min Low +2 hr 55 min	High +1.9 Low +-0.1
http://tidesandcurrents.noaa.gov/get_predictions.shtml?year=2007&stn=1815+Seldovia&secstn=Kenai+City+Pier&thh=%2B1&thm=54&tlh=%2B2&tlm=55&hh=%2B1.9&hl=-0.1&footnote=								
Kenai River Entrance	60° 33'	151° 17'	17.7	20.7	11.0	Seldovia	High +1 hr 52 min Low +2 hr 18 min	High +2.7, Low +0.5
http://tidesandcurrents.noaa.gov/get_predictions.shtml?year=2007&stn=1815+Seldovia&secstn=Kenai+River+entrance&thh=%2b1&thm=52&tlh=%2b2&tlm=18&hh=%2b2.7&hl=%2b0.5&footnote=								

Table B-2: Tidal Datums for Nikiski (Station 9455760)

Tidal Datum	Elevation (ft MLLW)
Highest Observed Water Level (12/26/1976)	29.02
Mean Higher High Water	20.42
Mean High Water	19.68
Mean Sea Level	11.18
Mean Tide Level	10.86
NAVD 1988	6.76
Mean Low Water	2.05
Mean Lower Low Water	0.00
Lowest Observed Water Level (12/25/1999)	-6.37

Tidal Datum Notes: Nikiski data are based on 1983-2001 Tidal Epoch, with no NGVD29 orthometric height for AB7146. Kenai MLLW datum is based on 2003 data with US C&GS Kenai Cook Inlet Tidal Bench Mark 3 (1966) at Elevation 31.44 feet. The available datum information from NOAA is presented for the two Kenai tidal stations below. Additional corrections were applied to reference the tidal bench mark to the Nikiski Tidal Bench Mark in March 2008, resulting in a net correction factor of -0.26 feet. Project vertical datum is referenced to Mean Lower Low Water (MLLW) based on NOAA Tidal Station Nikiski, Station ID No. 945 5760, publication date 10/30/2003. Station Nikiski is referenced by BM No. 8, et al., which was held for all project elevations (BM No. 8 elevation was verified by measurements to BM Nos. 7 & 9). The official station designation for BM No. 8 is "945 5760 TIDAL 8" (see PID No. AB7150). NOAA MLLW elevation for BM No. 8 = 109.659 U.S. Survey Feet (33.424 meters).

NOS ID	1983	Name	Kenai River entrance, Cook Inlet, Alaska		
SEQ	0	Common Name			
Latitude	60 33.00 North	T. M.	135.00	T. M. Corr.	0.00 Hrs.
Longitude	151 17.00 West	T. Z.	9.00	Reference ID	9455500

Greenwich Int.		Time Diff.		Height Diff.		Levels (ft.)	
HWI	1307	HW	152	HW	2.70	HAT	
LWI	712	LW	218	LW	0.50	TcHHW	
HHWI		HHW		HHW		HHW	20.70
LLWI		LLW		LLW		HWS	
MRI	1010	Mean	205			HW	19.90
LI	1026	DR	555			HWN	
						MTL	11.00

Ratios

HW	0.00	Sp/Mn	0.00
LW	0.00	Np/Mn	0.00

Levels (ft.) (cont.)	
MSL	
DTL	10.30
LWN	
LW	2.20
LWS	
LLW	0.00
TcLLW	
LAT	

Local Int.

HWI	241
LWI	911
HHWI	
LLWI	

Ranges

Mean	17.70	Neap	
Spring		Gc	-100
Gt	20.70	DATUM	MLLW
DHQ	0.80	DLQ	2.20

Source Acc. values for Chinulna Pt. near Kenai R. entr. 159 H-158 L, 1910.

Benchmark Date		Source Year	1910
NGVD	(MLLW)	Source Length	0 Yr(s). 0 Month(s)
Estimated Low	-6 ft. below MLLW	Tide Table	WCTT

Remarks Name, Lat, long. changed in 1938. T.M. changed 10-30-83.

Epoch -

Ratio of Ranges						
Mn.	0.00	First used in T.T.		By:	WBZ	6/8/1936 00:00:00
Gt.	0.00	Last used in T.T.		Entered:	ML	2/22/1993 00:00:00
		Lastr revised in T.T.	1985	Verified:		

Table B-3: Station Metadata for Rainfall, Streamflow, and Climatological Data

Parameter	**Source**	**Metadata**
Tides		
Precipitation	http://www.wrci.dri.edu	NCDC Station Historical Listing for NWS Coop #504550-5 KENAI 9 N, ALASKA Lat 60 deg 40 min, Long 115 deg 19 min Elev. 130 ft Period of record 6/83 to present. NCDC Station Historical Listing for NWS Coop #504546-5 KENAI FAA AIRPORT, ALASKA Lat 60 deg 34 min, Long 115 deg 15 min Elev. 90 ft Period of record 9/49 to present
Runoff	http://waterdata.usgs.gov	USGS Gage 15266300 Kenai River at Soldotna. Hydrologic Unit 19020302 NAD27 Latitude 60°28'39" Longitude 151°04'46" Period of record 5/1/65 – present. Drainage area: 1,951 square miles Datum of gage: 35.34 feet above sea level NGVD29.
Temperature	http://www.wrci.dri.edu	NCDC Station Historical Listing for NWS Coop #504550-5 KENAI 9 N, ALASKA Lat 60 deg 40 min, Long 115 deg 19 min Elev. 130 ft Period of record 6/83 to present. NCDC Station Historical Listing for NWS Coop #504546-5 KENAI FAA AIRPORT, ALASKA Lat 60 deg 34 min, Long 115 deg 15 min Elev. 90 ft Period of record 9/49 to present
Wind Speed	http://weather.noaa.gov	ICAO Station ID PAEN. Latitude 60°34'23" N Longitude 151°14'42" W Elev. 99 ft ASOS Tower, Height 25 ft NCDC Data Set 702590

Note: Project measurements are based on Nikiski benchmark NO 8 1973 (NOAA designation 945 5760 TIDAL 8). Corrections were made was to Kenai BM No. 3 and any data that was based on Kenai BM No. 3.

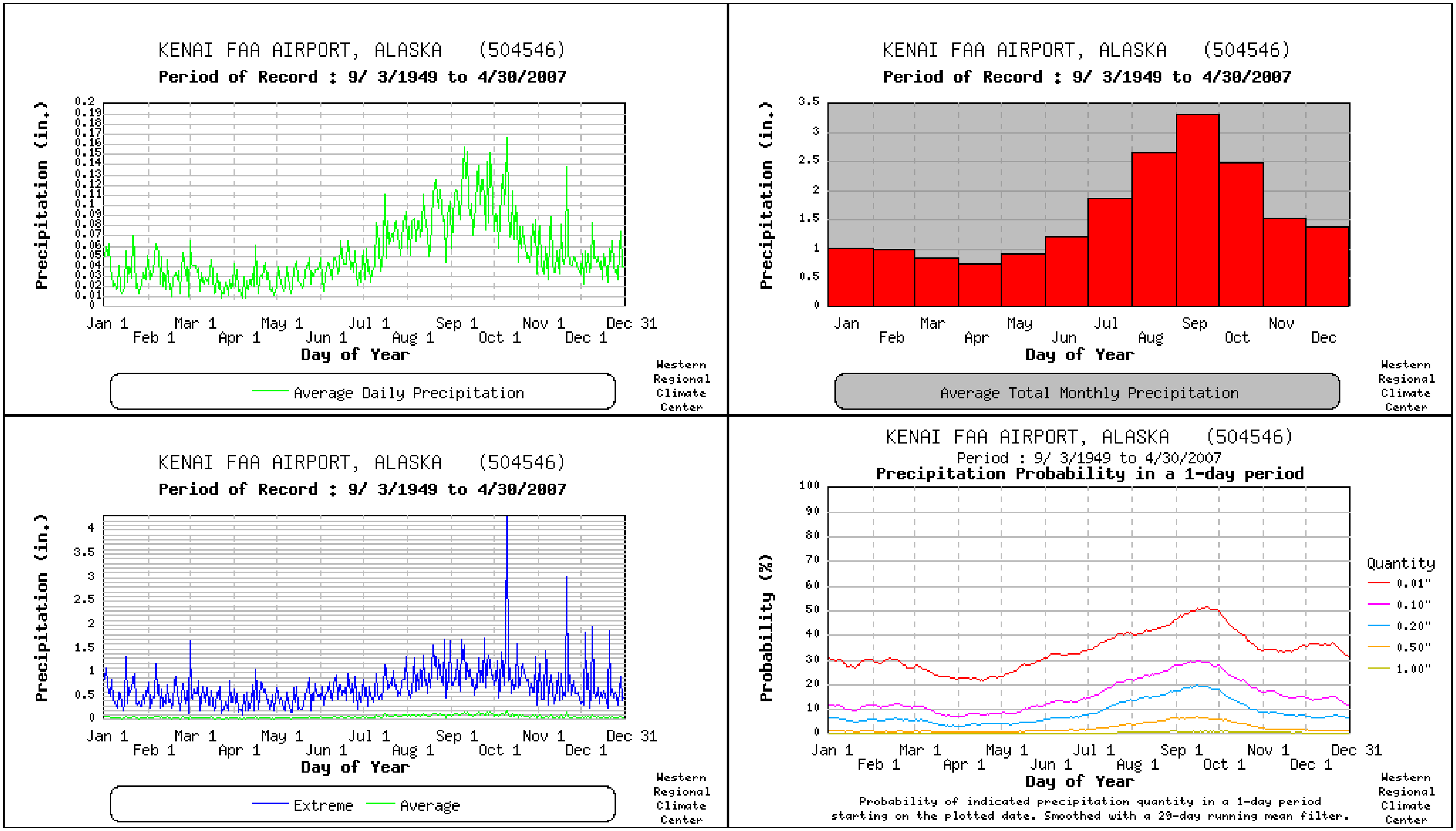

Figure B-2. Historical Precipitation Records and Statistics for Kenai Airport (WRCC 2007)

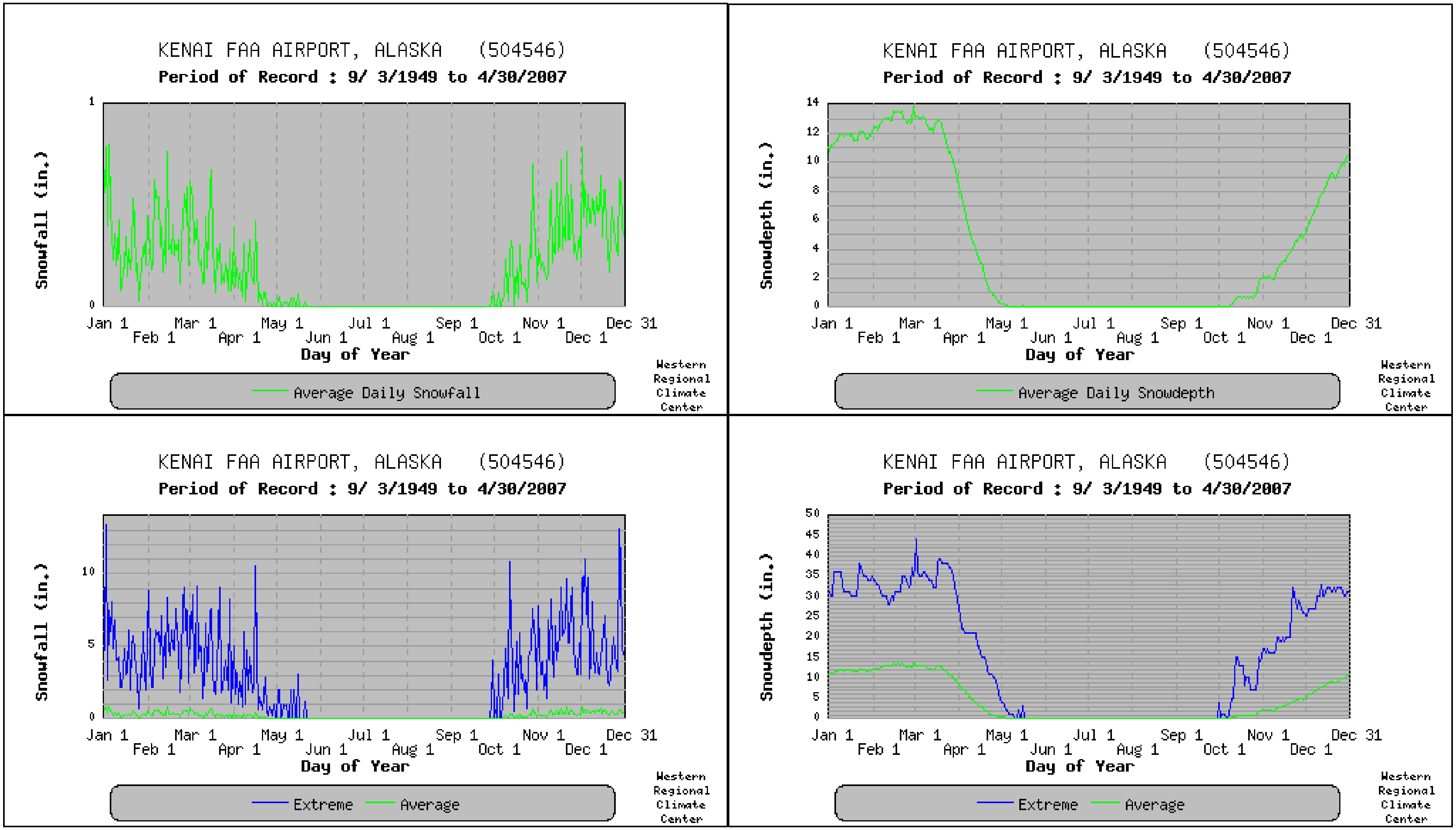

Figure B-3. Historical Snowfall Records and Statistics for Kenai Airport (WRCC 2007)

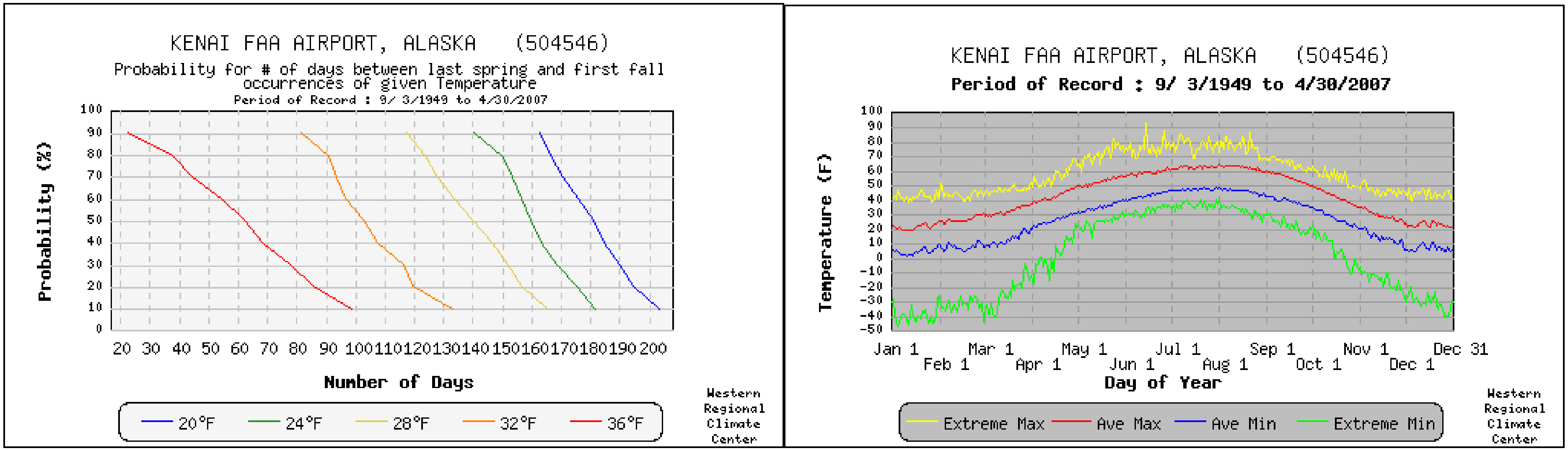

Figure B-4. Historical Temperature Records and Statistics for Kenai Airport (WRCC 2007)

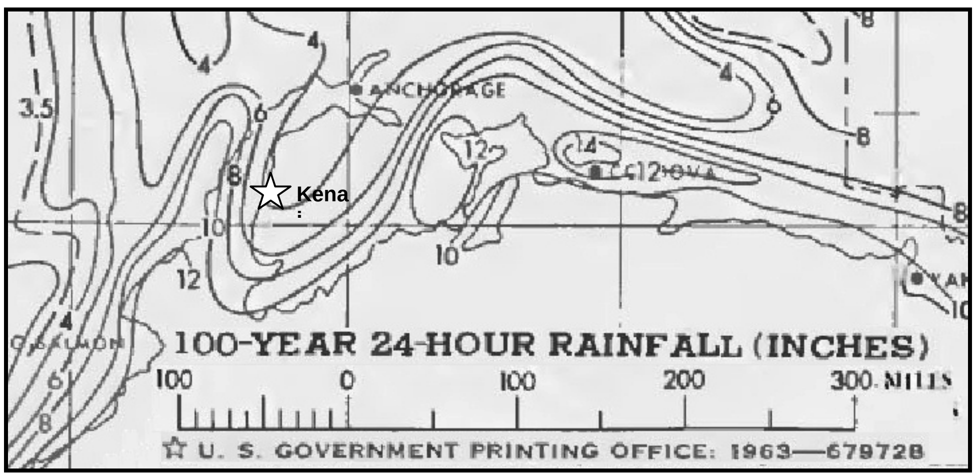

Figure B-5. Isopluvial Map (USGS 2003)

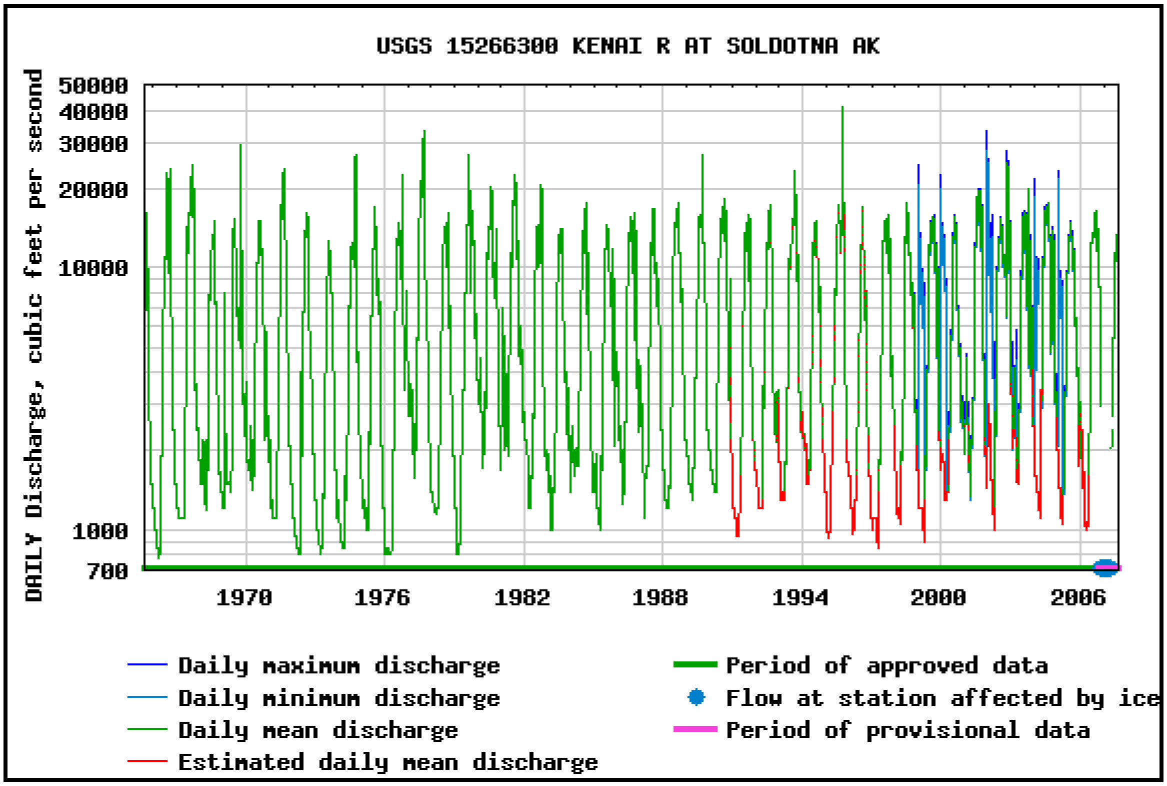

Figure B-6. Kenai River Historical Flow Records (USGS 2007)

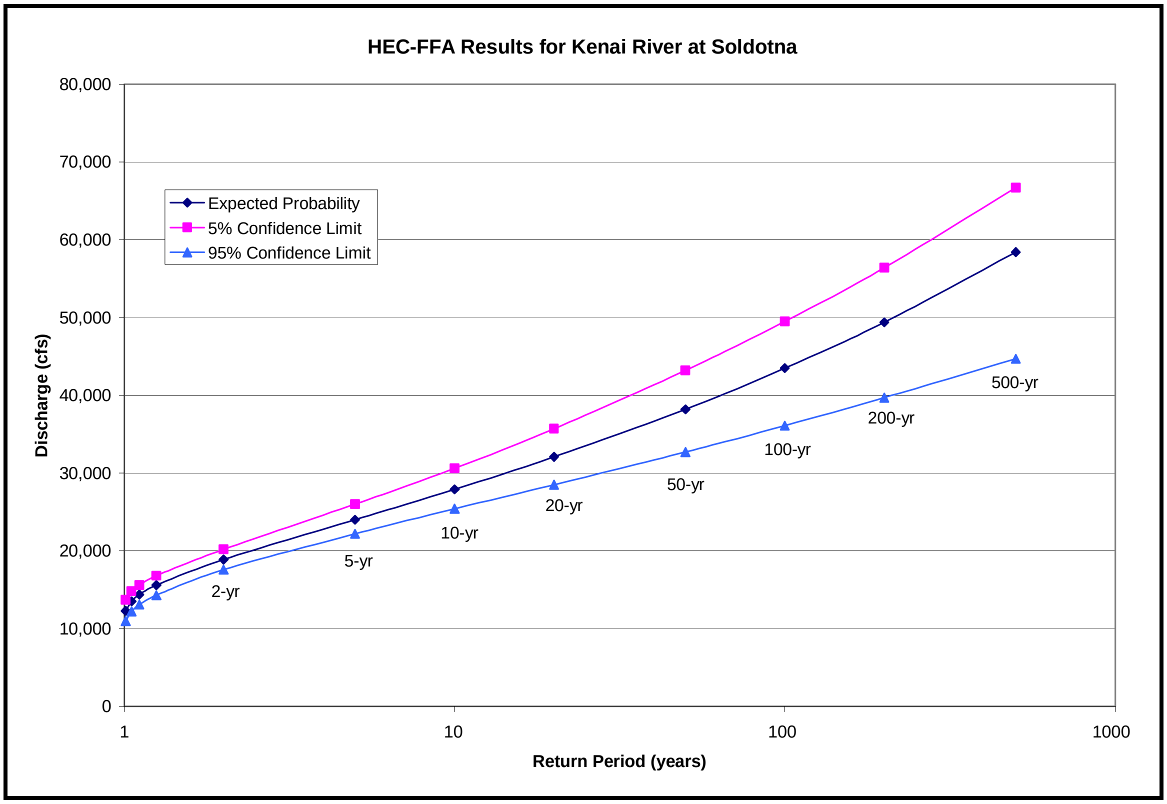

Figure B-7. Kenai River Flood Frequency Analysis (USGS 2007)

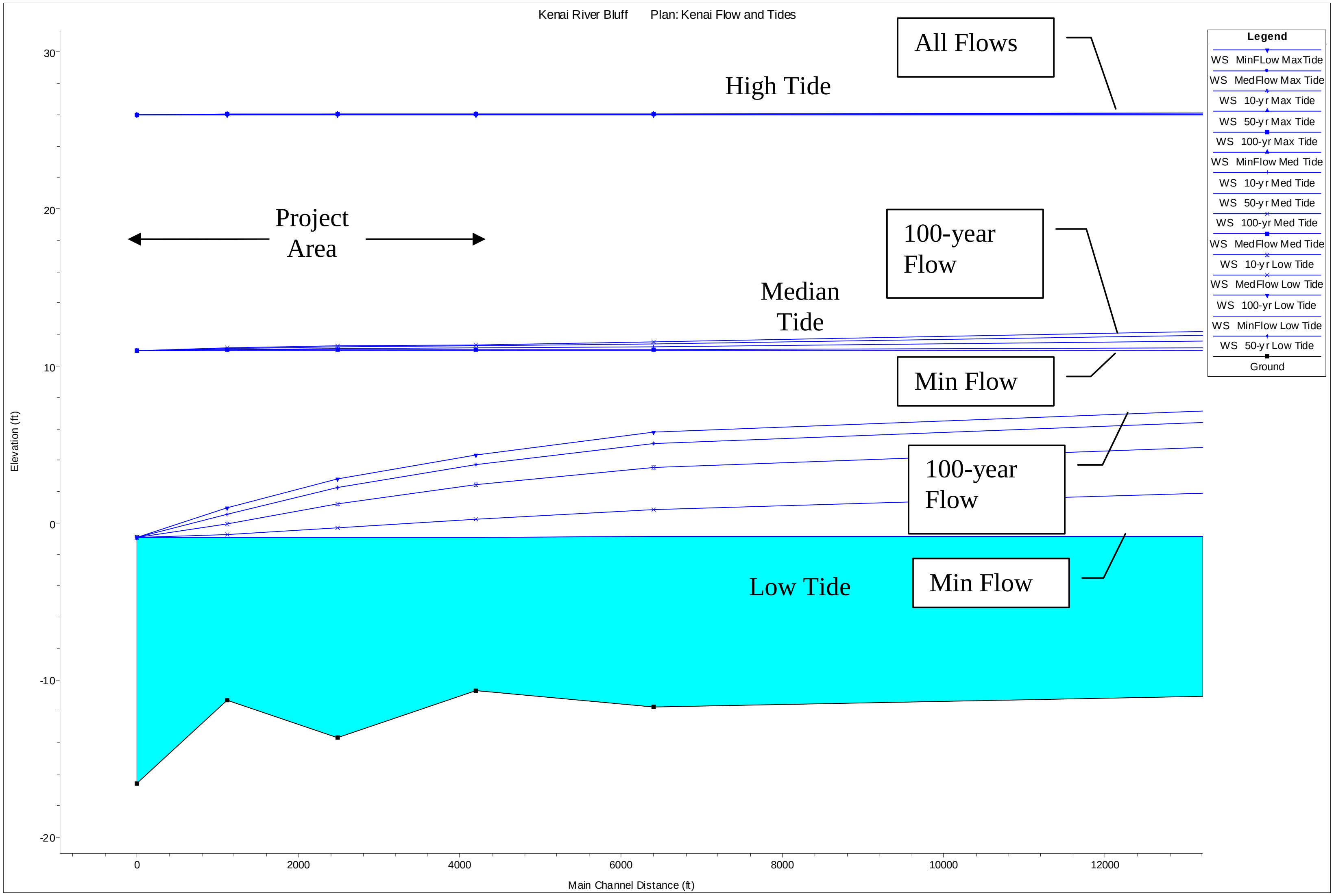

Figure B-8. HEC-RAS Profiles

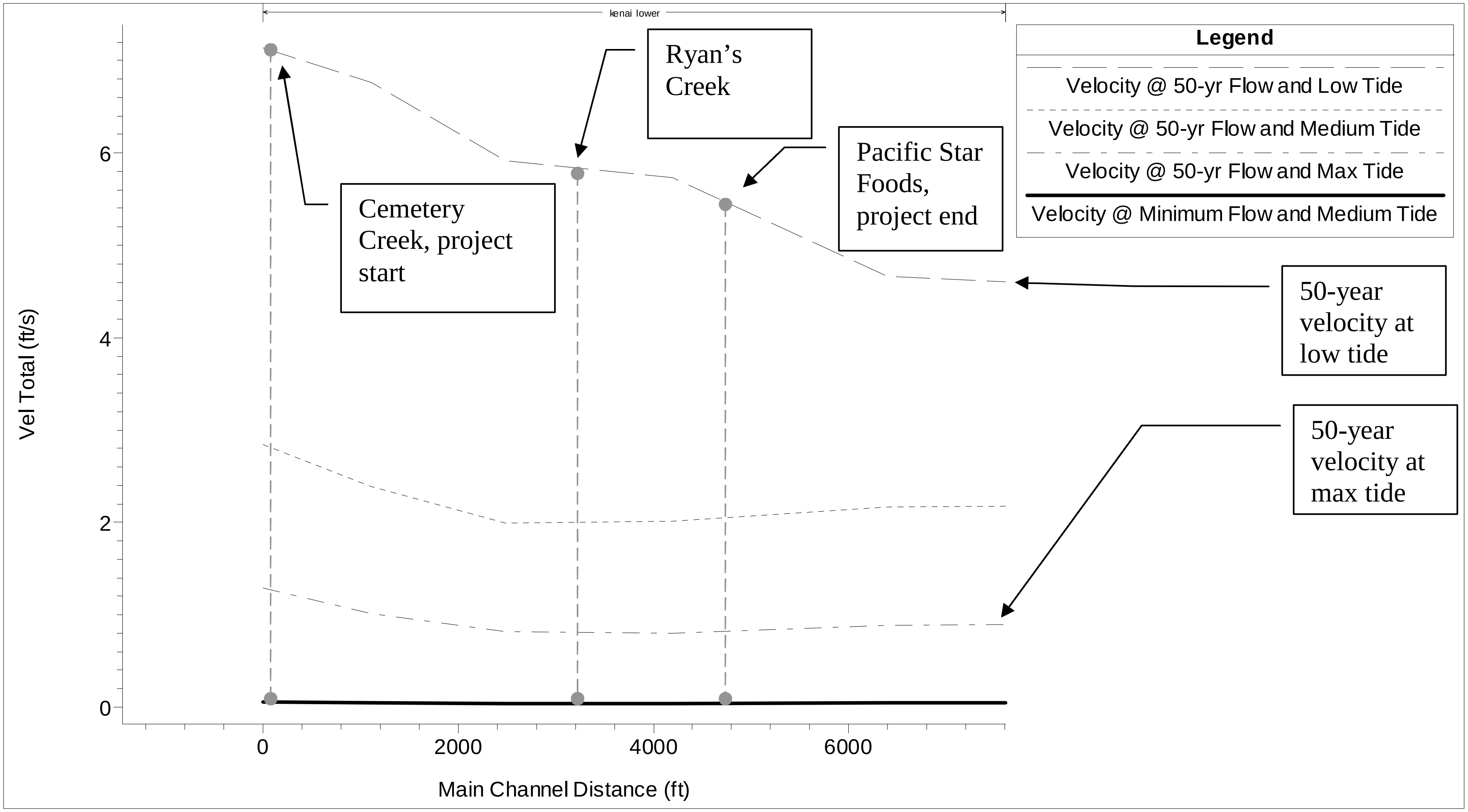

Figure B-9. Kenai River Velocity Profile

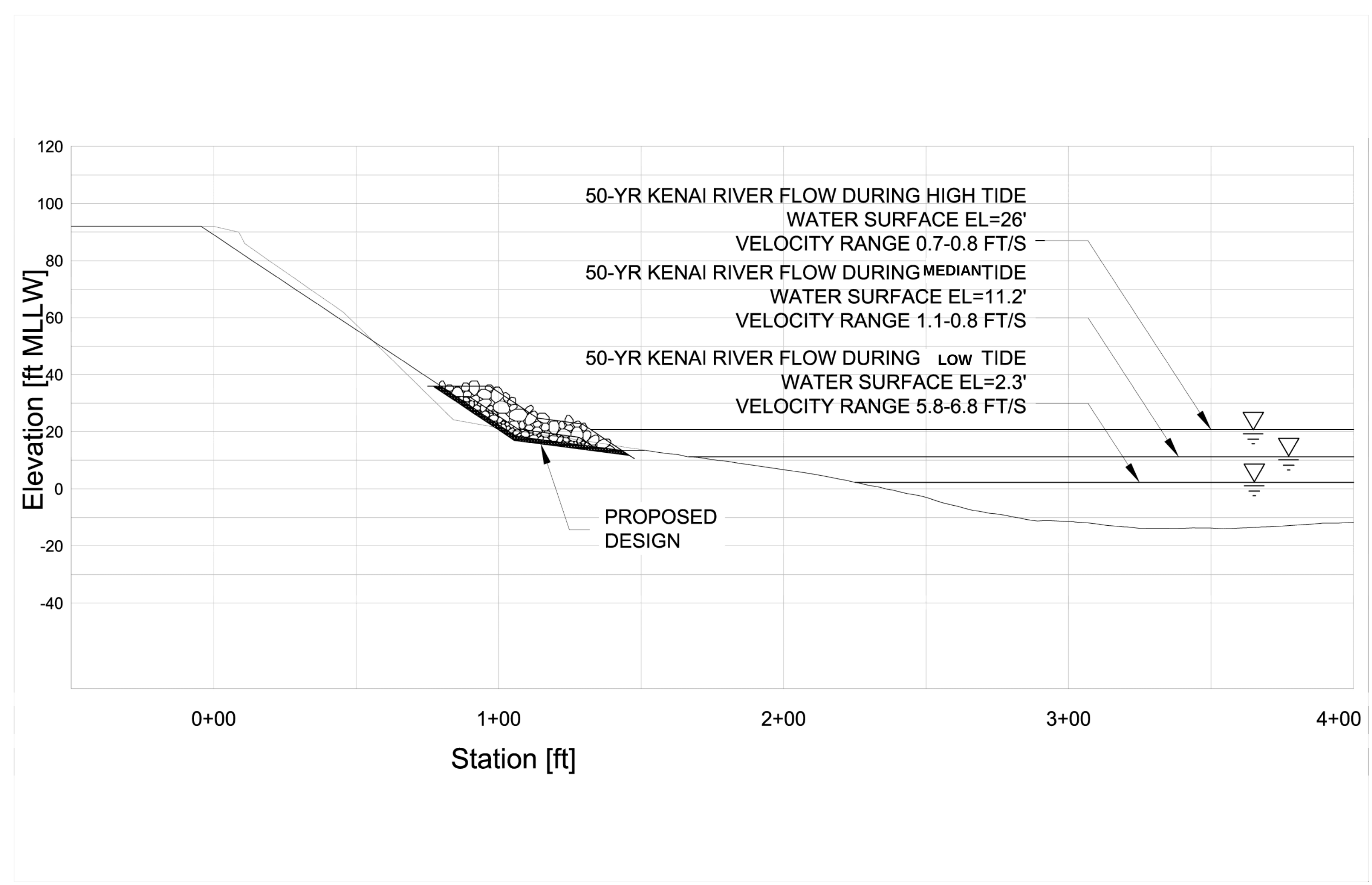

Figure B-10. Typical Kenai River Cross Section with Velocity Range by Tide Level

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Kenai River								
A	0	1,223[2]	26,200	1.5	13.5	9.0[3]	9.0[3]	0.0
B	3,380	1,901[2]	38,750	1.0	13.5	9.1[3]	9.1[3]	0.0
C	6,440	1,701[2]	34,746	1.1	13.5	9.1[3]	9.1[3]	0.0
D	9,840	1,821[2]	29,073	1.3	13.5	9.1[3]	9.1[3]	0.0
E PROJECT	13,030	1,343[2]	28,620	1.3	13.5	9.1[3]	9.1[3]	0.0
F	16,270	1,216[2]	24,083	1.6	13.5	9.2[3]	9.2[3]	0.0
G	19,460	1,248[2]	18,531	2.1	13.5	9.3[3]	9.3[3]	0.0
H	22,700	1,012[2]	21,076	1.8	13.5	9.4[3]	9.4[3]	0.0
I	25,460	873[2]	15,249	2.5	13.5	9.4[3]	9.4[3]	0.0
J	25,880	790[2]	15,604	2.5	13.5	9.5[3]	10.5[3]	1.0
K	29,430	751[2]	13,168	2.9	13.5	9.7[3]	10.7[3]	1.0
L	31,430	630[2]	10,073	3.8	13.5	9.8[3]	10.7[3]	0.9
M	33,370	603[2]	9,895	3.9	13.5	10.1[3]	11.0[3]	0.9
N	36,000	747[2]	12,739	3.0	13.5	10.6[3]	11.4[3]	0.8
O	38,765	758[2]	13,024	2.9	13.5	10.8[3]	11.6[3]	0.8
P	41,495	564[2]	10,559	3.6	13.5	11.0[3]	11.8[3]	0.8
Q	44,215	481[2]	8,959	4.3	13.5	11.3[3]	12.0[3]	0.7
R	46,980	770[2]	10,869	3.5	13.5	11.9[3]	12.6[3]	0.7
S	49,975	1,120[2]	20,287	1.9	13.5	12.3[3]	12.9[3]	0.6
T	52,835	440[2]	6,994	5.5	13.5	12.3[3]	12.9[3]	0.6
U	54,435	880[2]	13,379	2.8	13.5	12.8[3]	13.4[3]	0.6
V	55,915	450[2]	6,202	6.1	13.5	12.8[3]	13.4[3]	0.6
W	58,000	1,049	12,437	3.0	13.7	13.7	14.2	0.5
X	59,705	2,250	14,922	2.5	13.9	13.9	14.4	0.5
Y	62,640	1,210	6,842	5.5	14.6	14.6	15.0	0.4
Z	65,485	850	8,840	4.3	16.0	16.0	16.5	0.5

[1]Feet Above Cross Section A [2]Width Affected by Tidal Influences [3]Elevations Computed Without Consideration of Backwater Effects From Cook Inlet

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

KENAI PENINSULA BOROUGH, AK

FLOODWAY DATA

KENAI RIVER

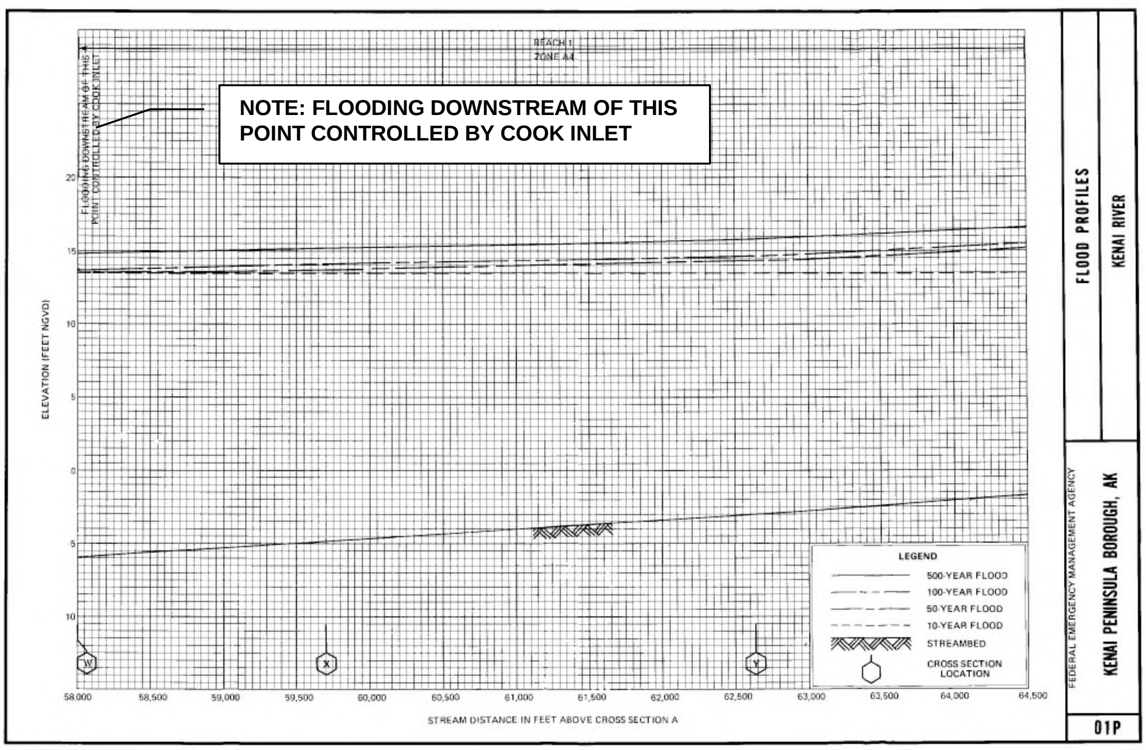

Figure B-11. Kenai River Flood Profile (FEMA 1981)

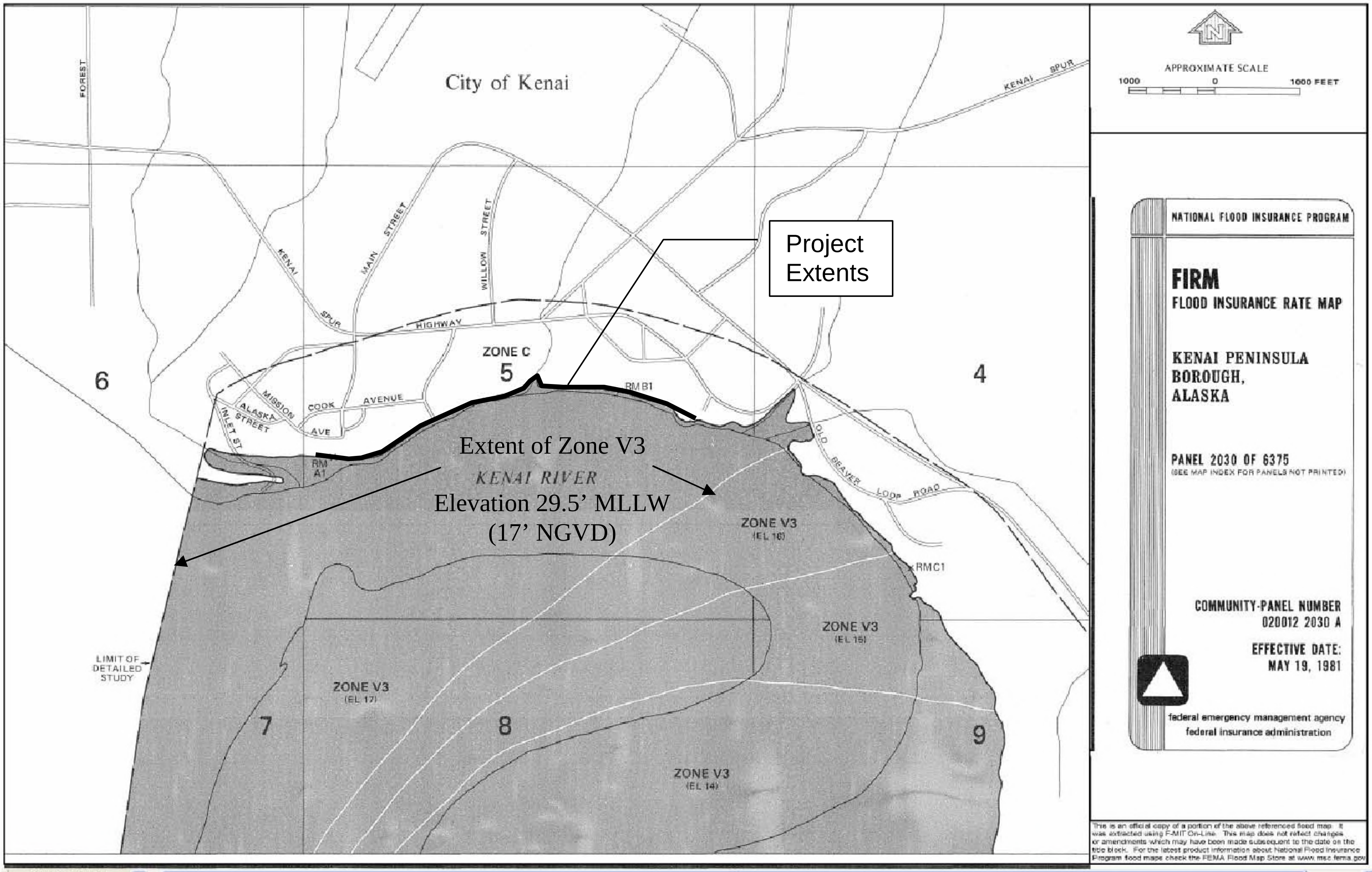

Figure B-12. FEMA FIRM Panel 2030 with V-Zone Designation

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ATTACHMENT C

HISTORICAL BLUFF EROSION

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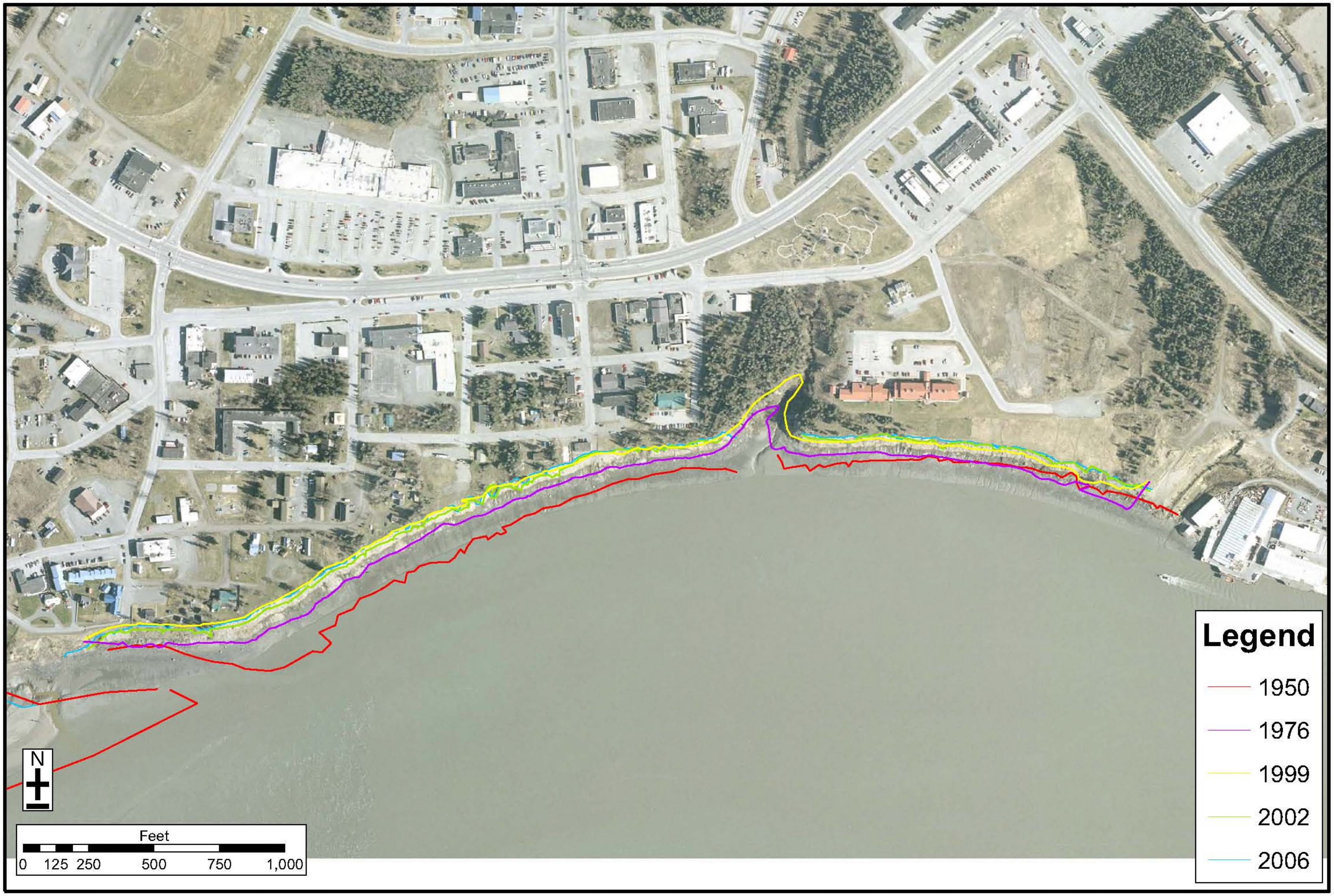

Figure C-1. Historical Bluff Retreat, 1950-2006

Figure C-2. Historical River Morphology, 1950-2006 (with 1950 aerial background)

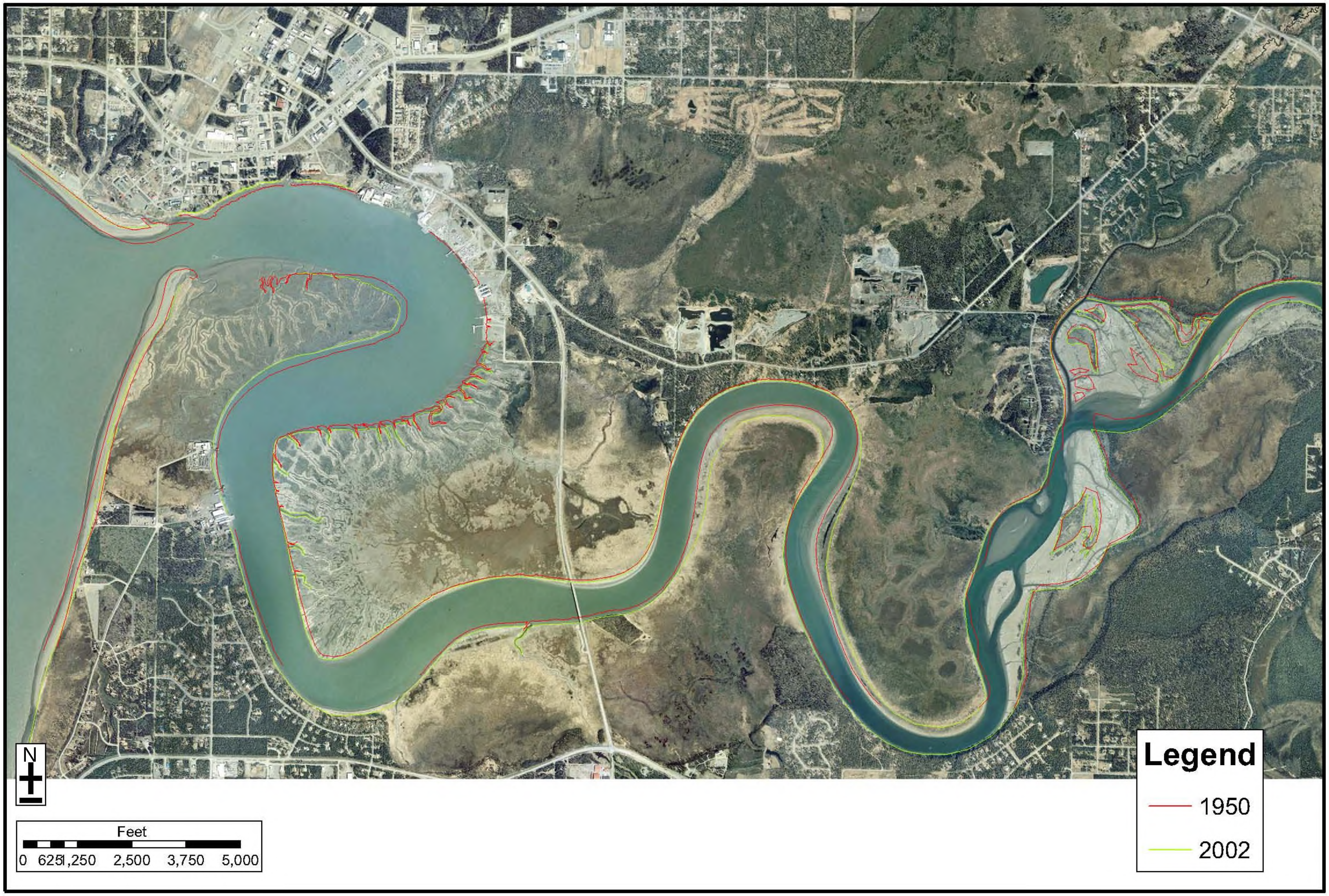

Figure C-3. Historical River Morphology, 1950-2006 (with 2002 aerial background)

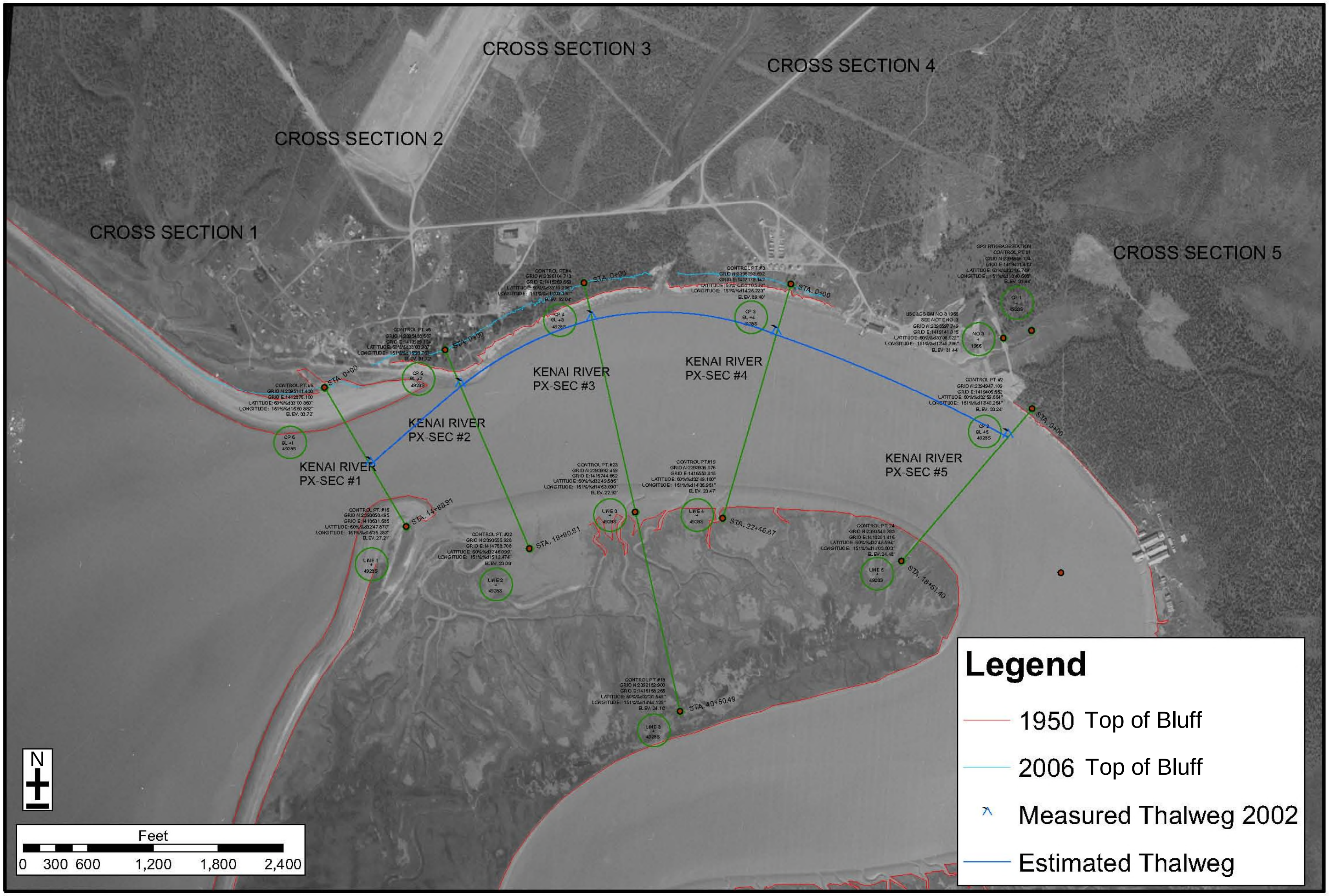

Figure C-4. 1950 Aerial Image with 2002 Thalweg and Bathymetric Section Locations

Figure C-5. 2002 Aerial Image and Thalweg with 1950 Top of Bluff Overlay

Table C-1: Aerial Photo Sources

Agency / Company	Website	Metadata			
		Acquisition Date	Image Type	Scale	Product
USGS	earthexplorer.usgs.gov	8/2/1950	BW	40000	Scanned
		6/25/1951	BW	40000	Medium Res/Scanned
		7/22/1972	BW / CIR	42893	Scanned
		6/23/1974	BW	444000	Scanned
		7/16/1977	CIR	124002	Scanned
		8/20/1980	BW	32000	Medium Res/Scanned
		8/3/1982	BW	119333	Scanned
		8/12/1984	CIR	61428	Scanned
		8/27/1996	BW	24000	Scanned
Aero-metric	www.aero-metric.com	1963, 1967, 1973, 1979, 1984, 1986, 1990, 1995, 1998, 2001, 2006, 2007, 2010. Additional details available from Aero-metric.			

Table C-2. Historical Bluff Retreat, 1950-2006

River Station from Corps XS #1	Bluff Retreat (ft)	Avg Annual (ft/yr)	Location
0	0	0.0	Cross Section #1
250	0	0.0	Coastal shore, no bluff discernible in historical aerials
500	0	0.0	Banks match in historical aerials
750	83	1.5	
1000	75	1.3	
1250	212	3.8	Cross Section #2
1500	245	4.4	Area demonstrating maximum historical bluff retreat
1750	150	2.7	
2000	163	2.9	
2250	134	2.4	
2500	136	2.4	
2750	140	2.5	Cross Section #3
3000	110	2.0	
3250	122	2.2	
3500	0	0.0	Ryan's Creek - no bluff
3750	100	1.8	
4000	84	1.5	
4250	79	1.4	
4500	65	1.2	
4750	67	1.2	Cross Section #4
5000	50	0.9	
5250	0	0.0	Developed shoreline, no retreat discernible
5500	0	0.0	Developed shoreline, no retreat discernible
5750	0	0.0	Developed shoreline, no retreat discernible
6000	0	0.0	Developed shoreline, no retreat discernible
6250	0	0.0	Developed shoreline, no retreat discernible
6500	0	0.0	Developed shoreline, no retreat discernible
6750	0	0.0	Developed shoreline, no retreat discernible
7000	0	0.0	Cross Section #5

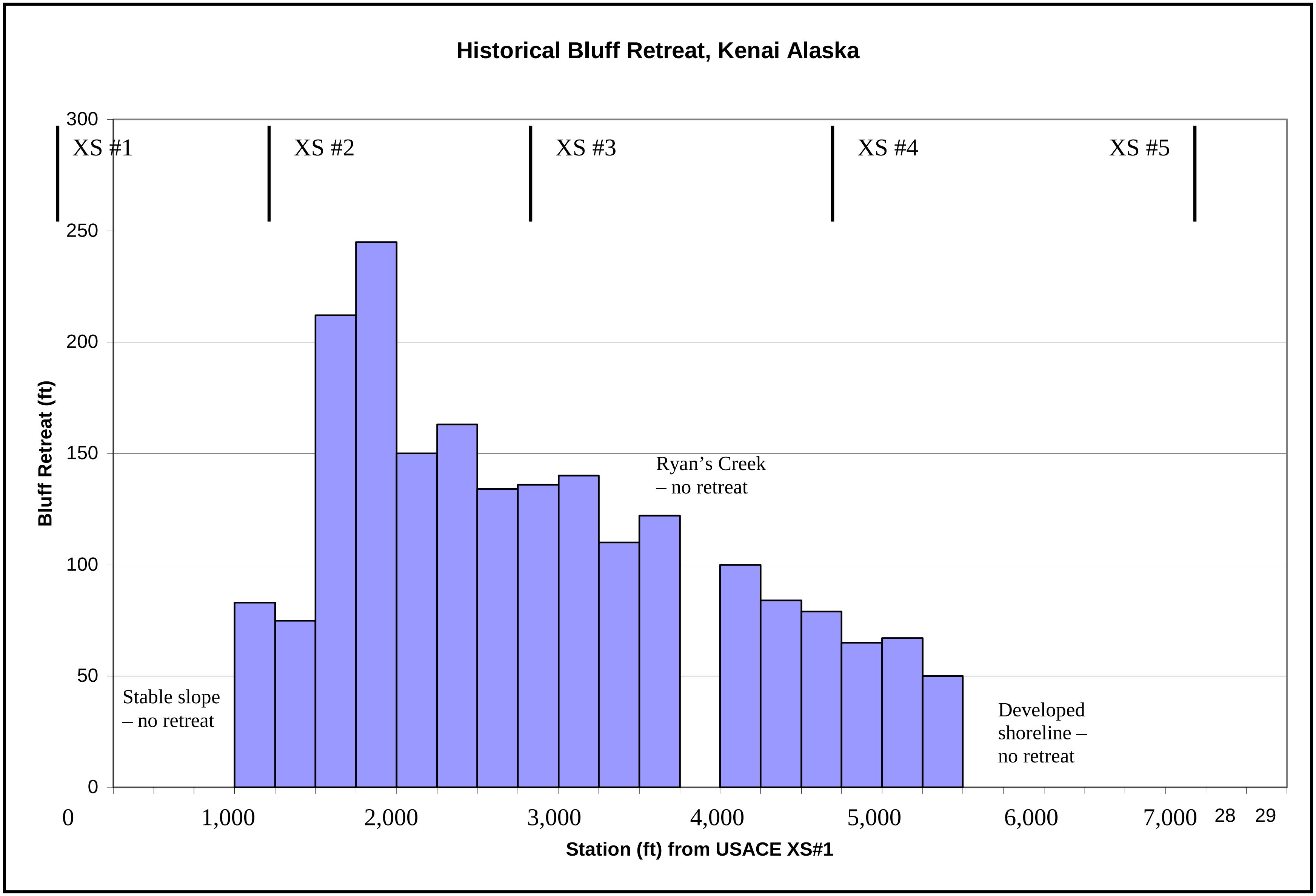

Figure C-6. Historical Bluff Retreat, 1950-2006

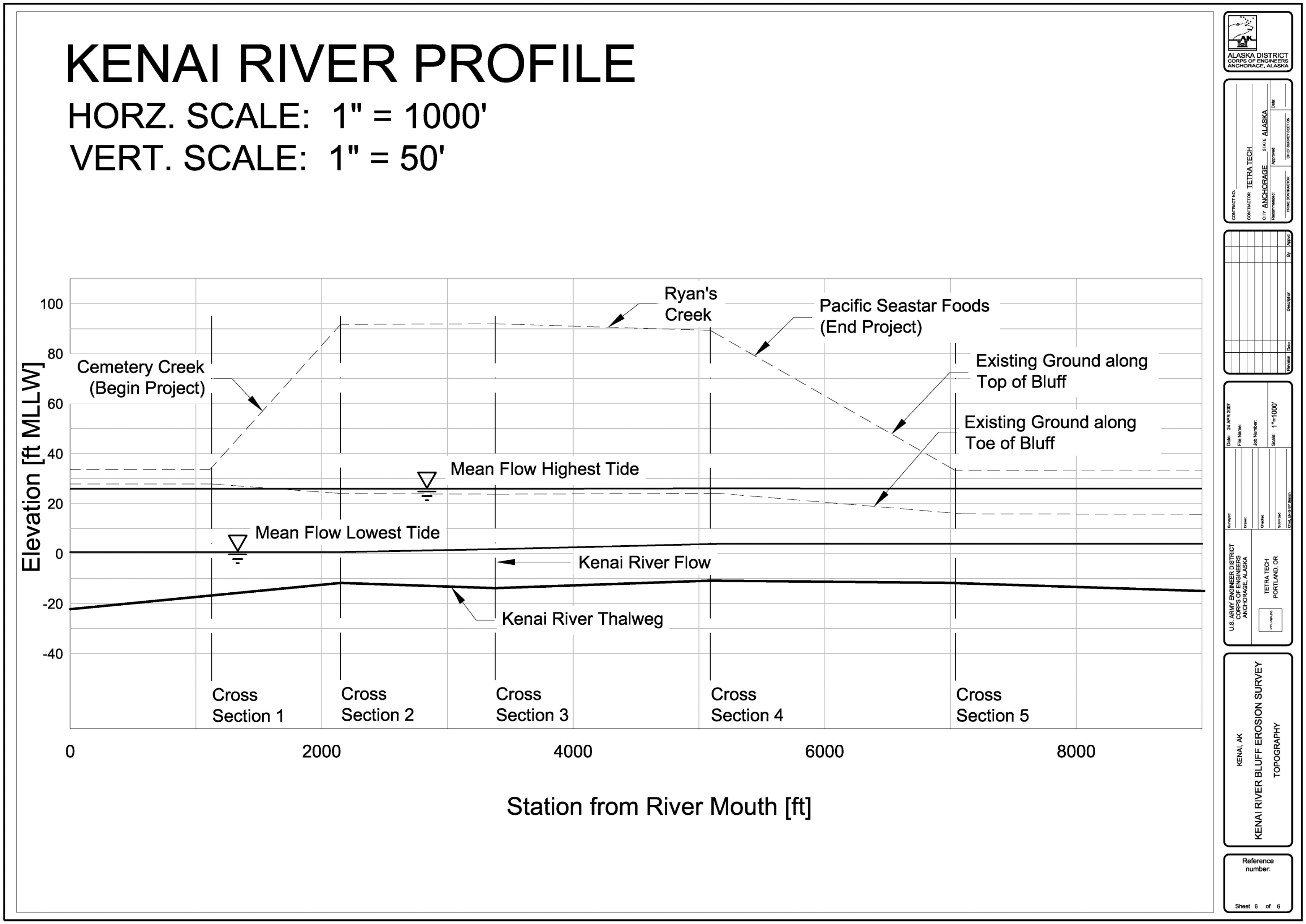

Figure C-7. Kenai River Profile, 2003

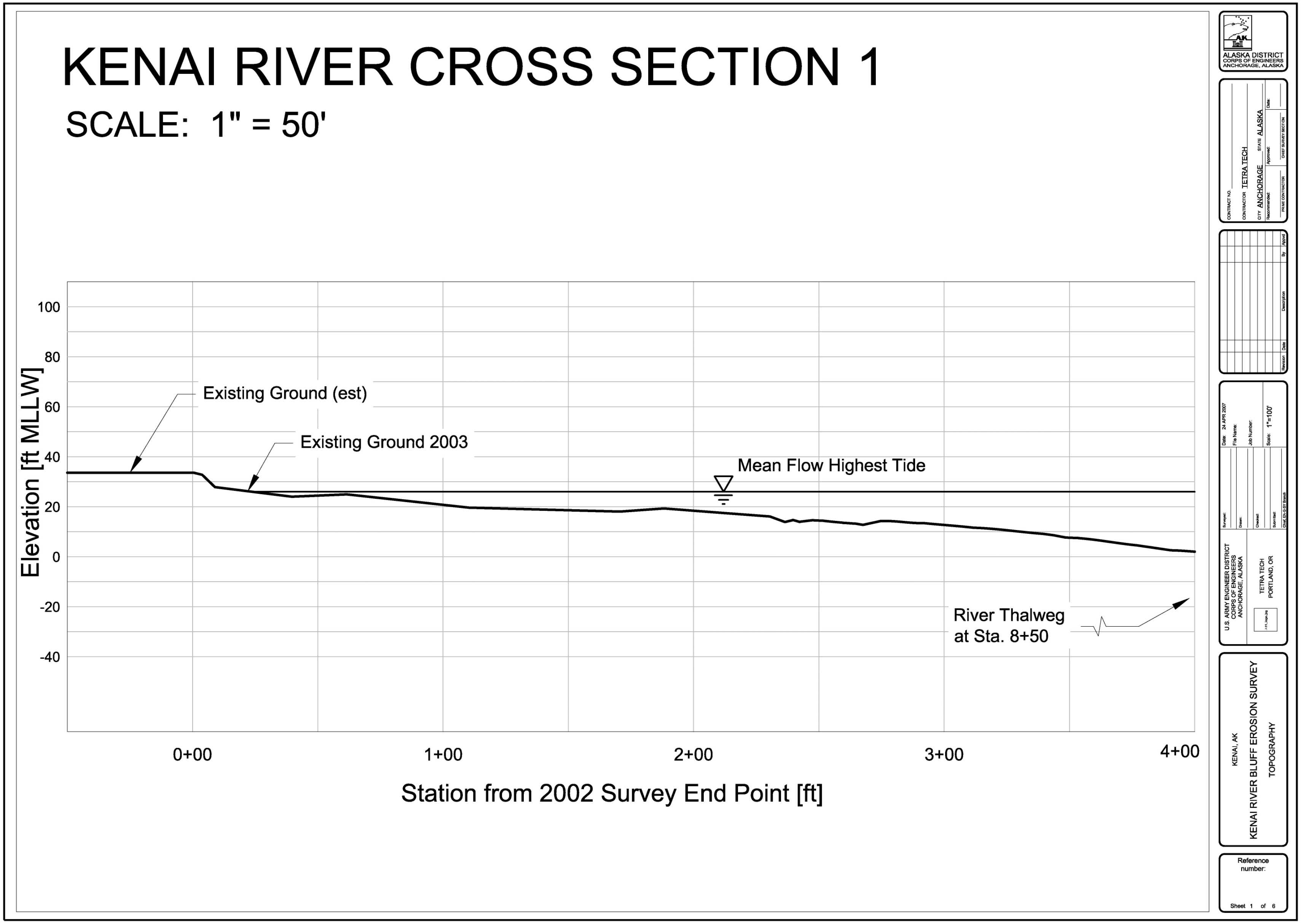

Figure C-8. USACE 2003 Hydrographic Cross Section #1

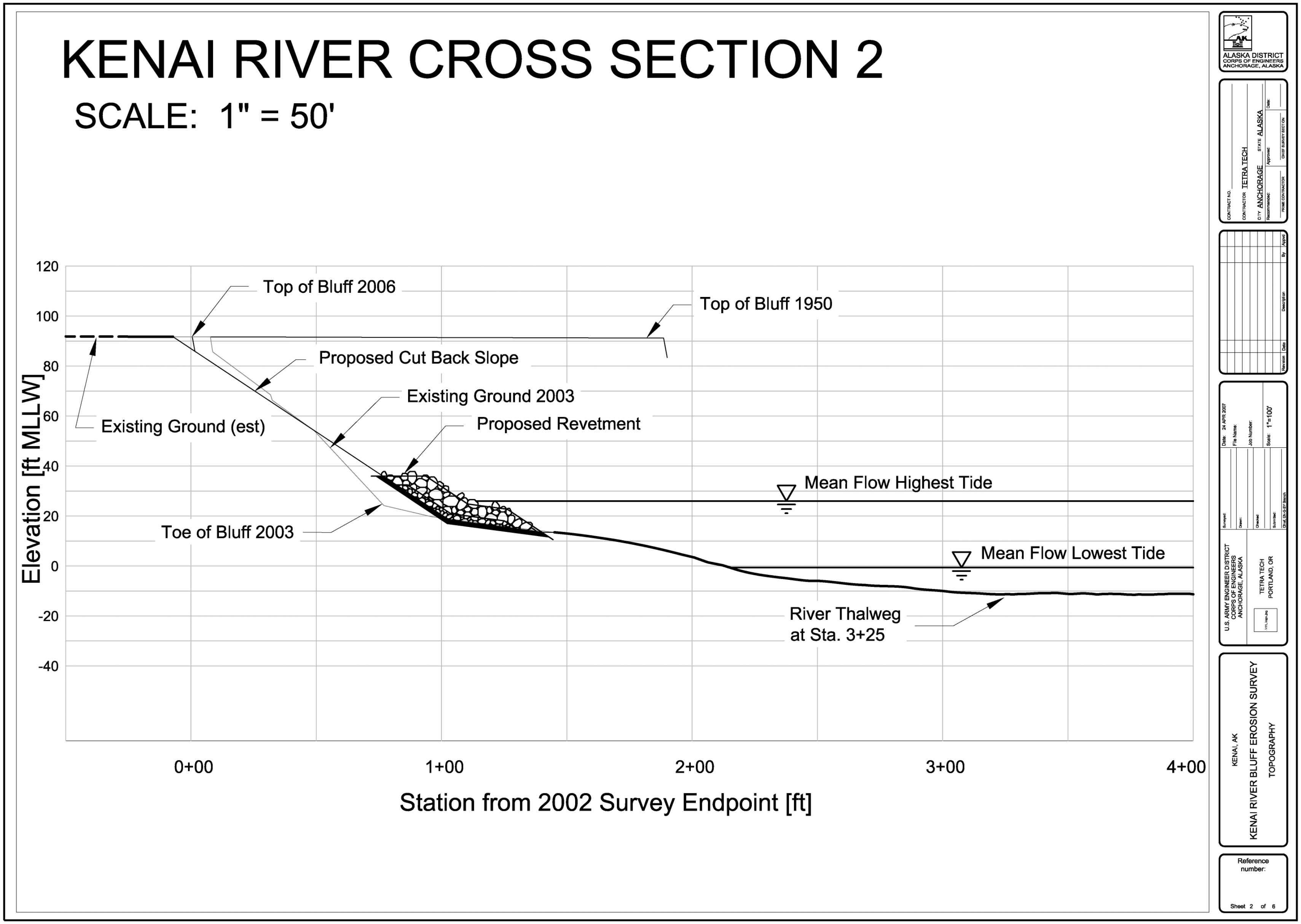

Figure C-9. USACE 2003 Hydrographic Cross Section #2 with Historical Top of Bluff

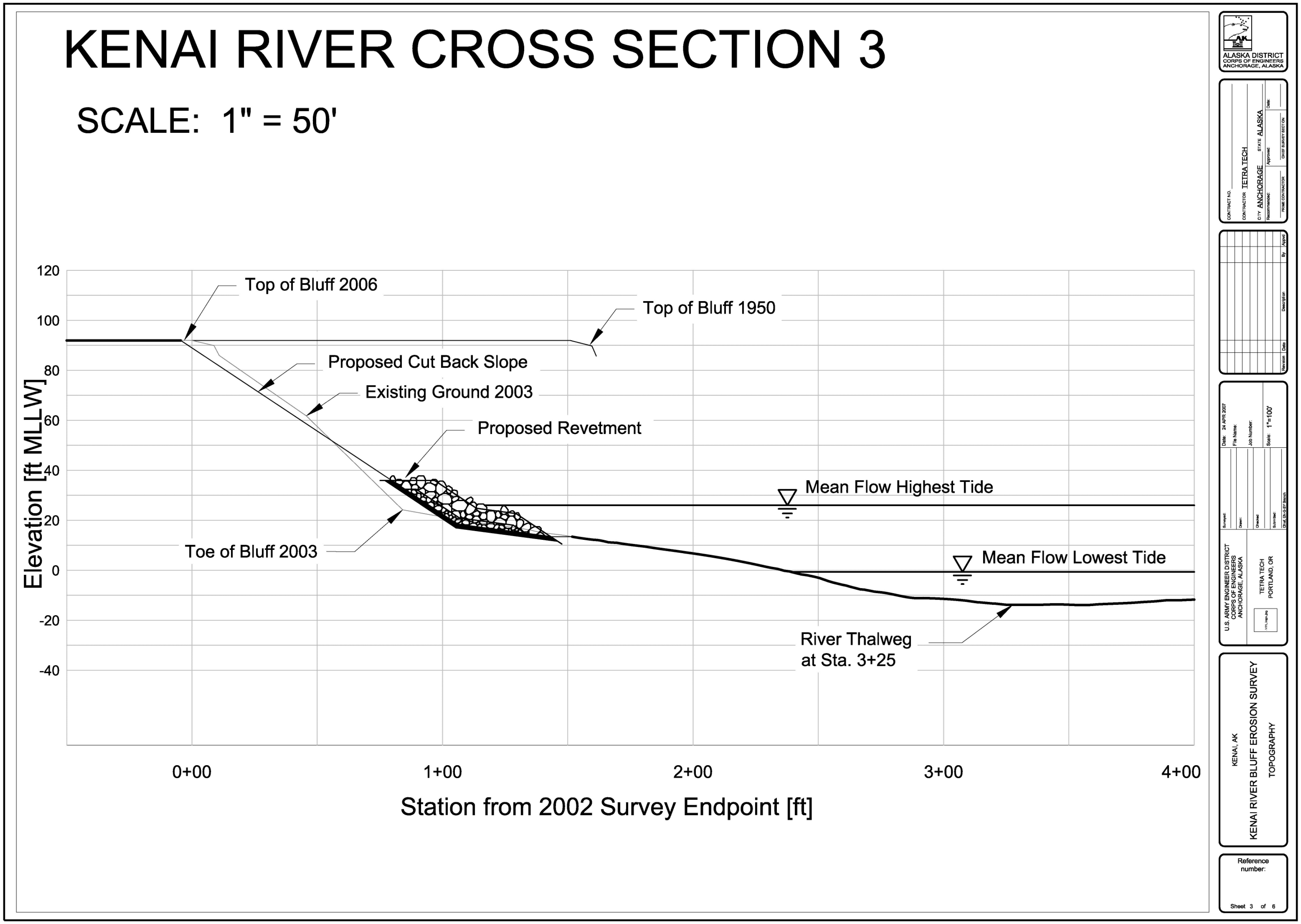

Figure C-10. USACE 2003 Hydrographic Cross Section #3 with Historical Top of Bluff

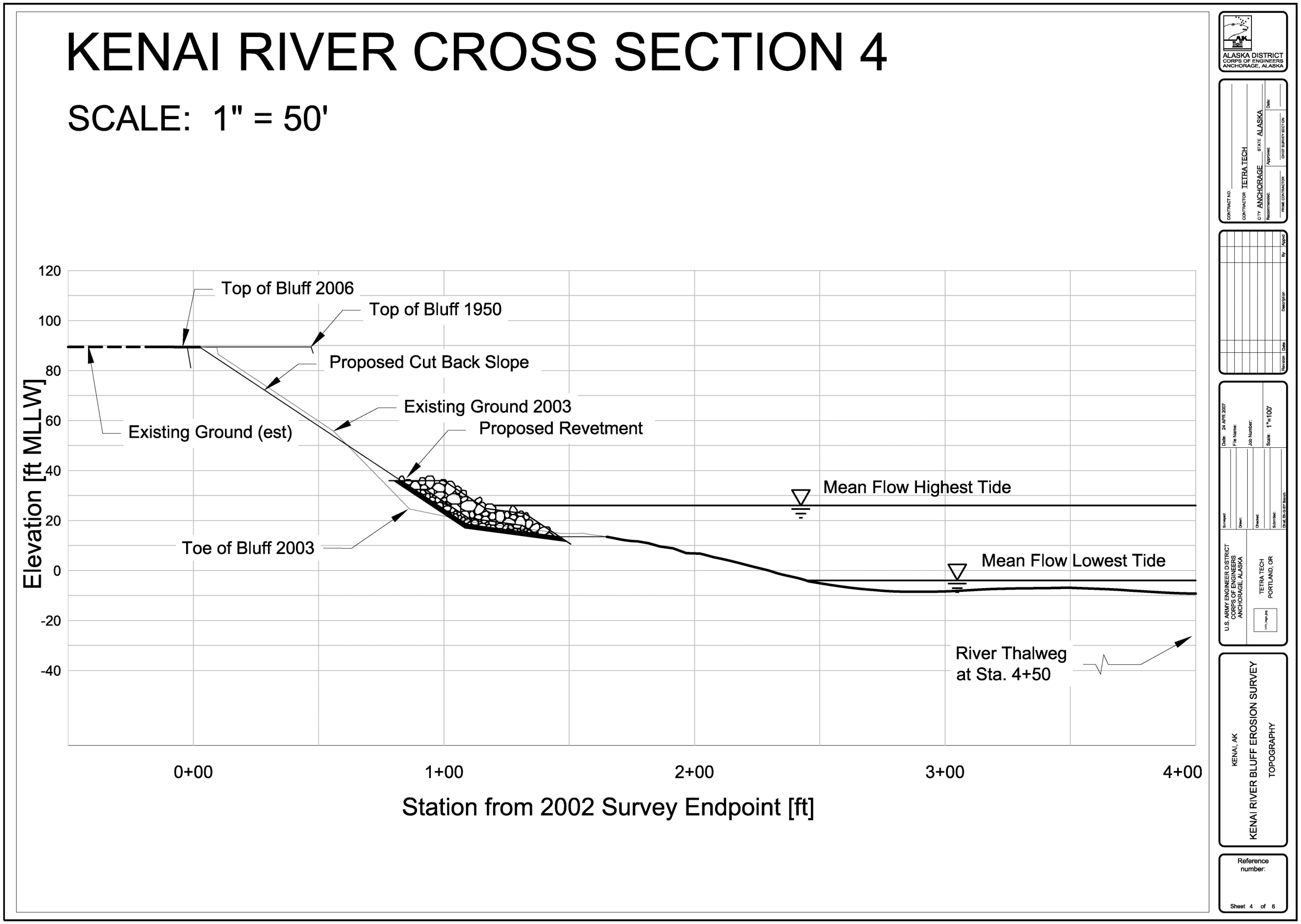

Figure C-11. USACE 2003 Hydrographic Cross Section #4 with Historical Top of Bluff

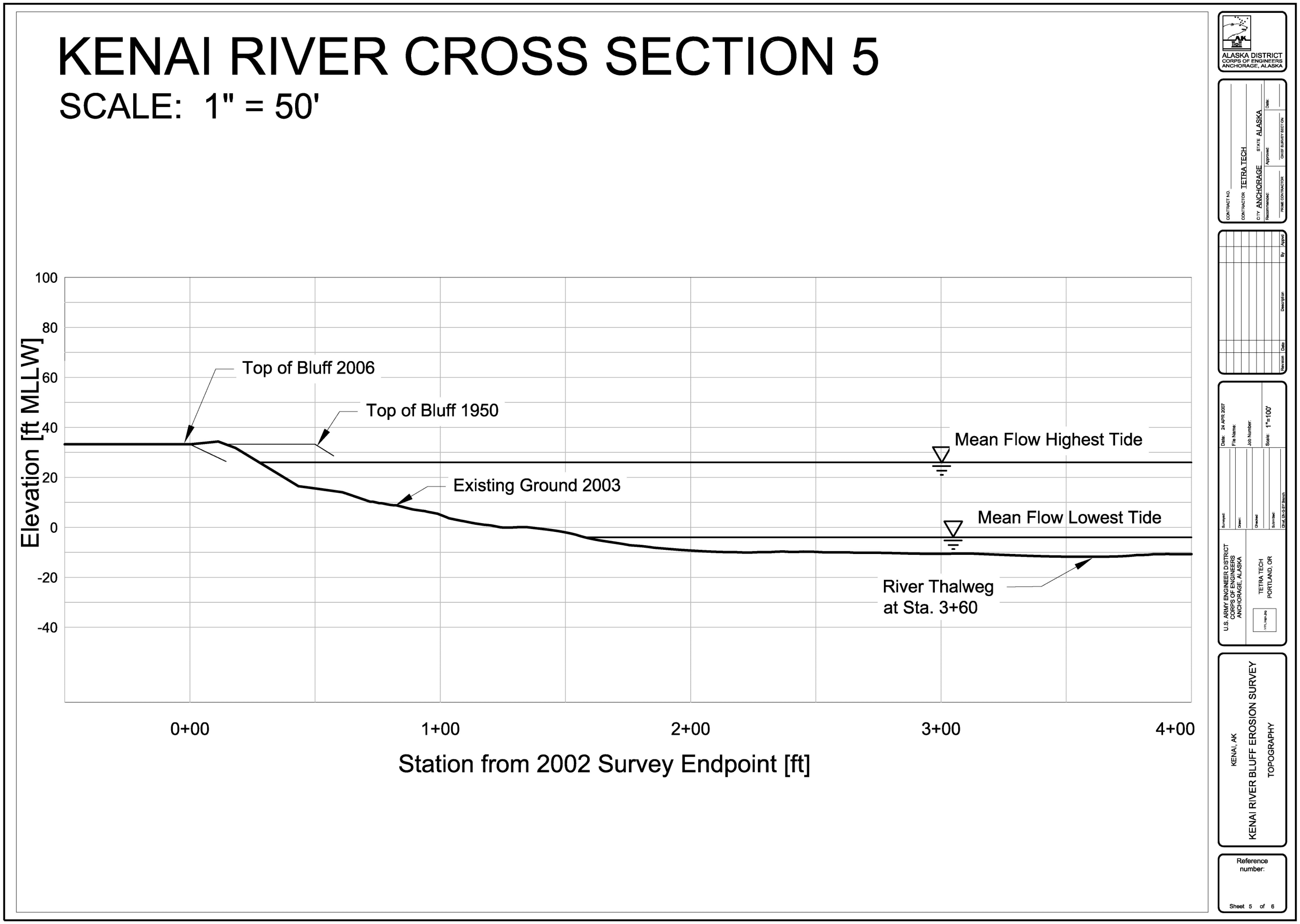

Figure C-12. USACE 2003 Hydrographic Cross Section #5 with Historical Top of Bluff

ATTACHMENT D

REAL ESTATE AND GEOSPATION DATA SOURCES

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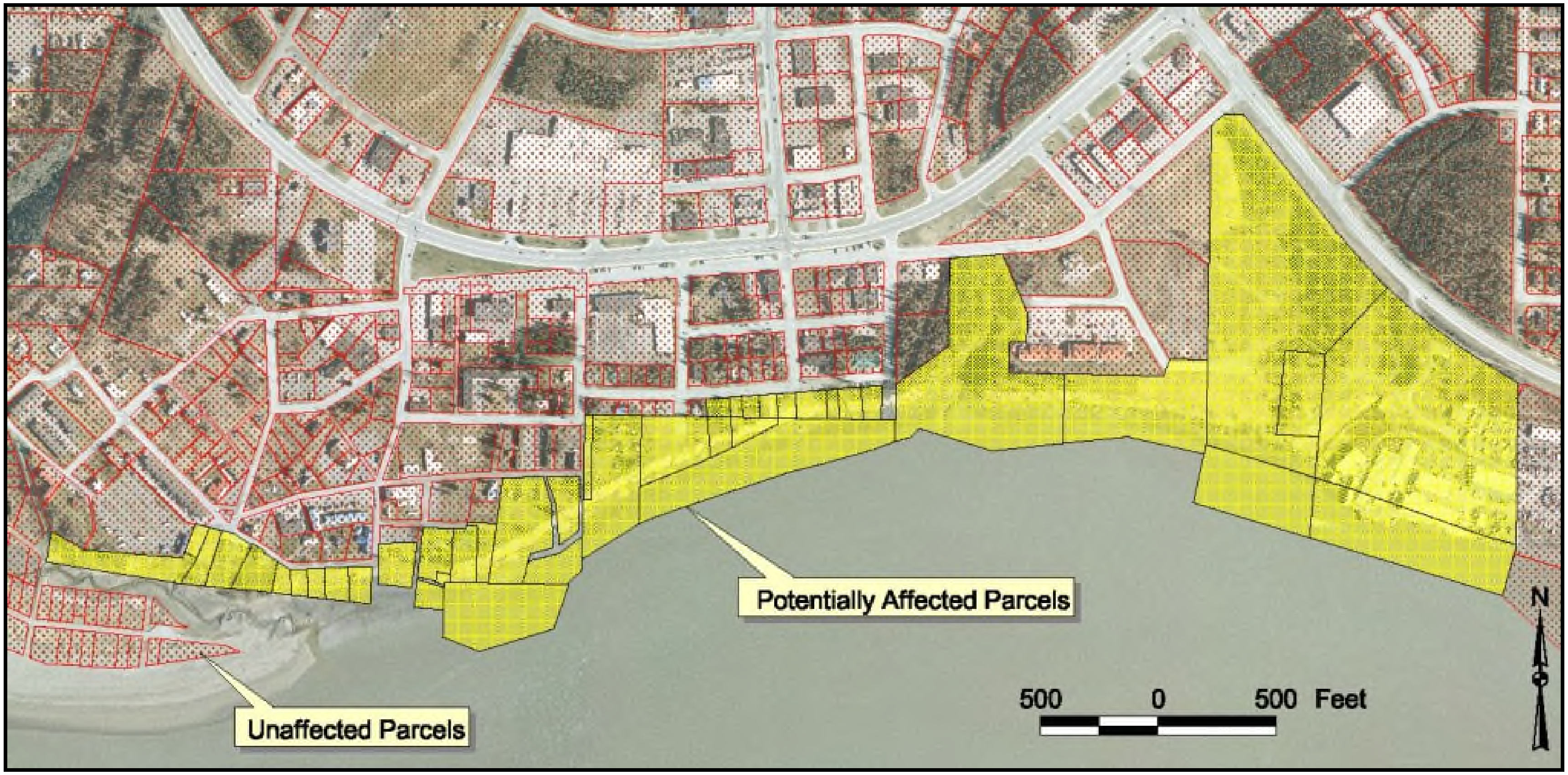

Figure D-1. Parcels Intersecting Top or Toe of Bluff

Table D-1: Potentially Affected Parcels

Note: Assessed values and ownership are from Kenai Peninsula Borough GIS. Some values in the GIS records are placeholders only. Updated information may be available. This information is presented for planning and informational purposes only.

Parcel ID	Ownership Type	Usage	Required Easement (Acres)	Total Lot Size (Acres)	Required Easement (% of Lot)	Affected Structures (square feet)	Total Assessed Value	Owner
4709308	PRV	VA	0.41	0.41	100%	0	$400	OCONNELL ROBERT D ET AL, SWARNER LINDA
4709307	PUB	VA	0.64	0.64	100%	0	$100	CITY OF KENAI
4709306	PRV	RS	0.44	0.58	76%	0	$119,900	SHOWALTER JENNIFER F
4709305	PUB	VA	0.19	0.19	100%	0	$100	KENAI CITY OF
4709304	PRV	VA	0.19	0.19	100%	0	$100	WEBBER CHARLES R
4709303	PRV	VA	0.21	0.21	100%	0	$100	KNIGHT KEITH K
4709302	PUB	VA	0.32	0.32	100%	0	$100	KENAI CITY OF
4709301	PRV	VA	0.33	0.33	100%	0	$100	KENAI BIBLE CHURCH
4709109	PRV	RS	0.00	0.37	1%	0	$172,000	ANDERSON HARRY K & NELLIE MAE
4709110	PRV	CH	0.02	0.35	7%	0	$434,300	KENAI BIBLE CHURCH
4710315	PRV	RS	0.63	0.63	100%	1314	$131,900	LOFSTEDT DIANA
4710308	PRV	VA	0.17	0.30	56%	0	$400	STERLING GLENDA A ET AL, MCCANN BILLY ESTATE
4710306	PRV	CM	0.63	0.63	100%	1938	$136,200	LOFSTEDT DIANA
4710307	PRV	VA	0.06	0.06	100%	0	$100	ERREA JULIAN & HILDERBRAND DAN L
4710311	PRV	VA	0.10	2.77	4%	0	$2,300	CLARK RUSSELL S
4710312	PRV	RS	0.43	0.57	76%	3137	$184,900	FOSTER GARY L & KATHLEEN
4710316	PRV	VA	0.30	0.33	91%	0	$5,300	SEELINGER DONALD P
4710219	PRV	RS	0.66	1.40	47%	0	$59,400	SEELINGER DONALD P
4710301	PUB	VA	0.03	0.69	4%	0	$100	KENAI CITY OF
4710201	PRV	VA	0.47	0.62	75%	0	$23,500	PETERKIN ROBERT T & BONNIE
4711907	PUB	VA	0.08	0.29	27%	0	$100	CITY OF KENAI
4711906	PRV	RS	1.13	2.67	42%	637	$126,400	KARAFFA PAUL P & CONSIEL ROGER D
4711904	PRV	VA	1.08	1.60	67%	0	$36,100	VANN RICKY L & CONNIE L TRUSTEES
4711901	PRV	VA	2.98	4.31	69%	0	$3,100	JOHNSON JAMES E, JOHNSON LANCET ANN ET AL

Parcel ID	Ownership Type	Usage	Required Easement (Acres)	Total Lot Size (Acres)	Required Easement (% of Lot)	Affected Structures (square feet)	Total Assessed Value	Owner
4711903	PRV	VA	0.35	0.35	100%	0	$1,400	COOPER DOROTHY M
4711902	PRV	VA	0.36	0.36	100%	0	$1,100	SANDS PATRICIA R TRUSTEE B B SANDS
4711603	PRV	AB	0.02	0.10	20%	0	$4,100	FREITAG HERBERT & JUDITH
4711602	PUB	VA	0.18	0.18	100%	0	$5,800	KENAI CITY OF
4711607	PRV	RS	0.07	0.16	42%	2369	$52,600	VANHORNE ALAN K & MARIAN F
4711606	PRV	VA	0.11	0.17	65%	0	$10,500	HANNAH TONEY A & LINDA M
4711605	PRV	CM	0.17	0.19	86%	2040	$35,400	HUTCHINGS STEPHEN PAUL SR CUST
4711501	PRV	VA	0.35	0.35	100%	0	$2,000	ALASKA LABORERS BUILDING CORP
4711502	PRV	VA	0.14	0.14	100%	0	$1,100	YOUNG WILLIAM C TRUSTEE
4711503	PRV	VA	0.30	0.30	100%	0	$2,100	CENTRAL PENINSULA MENTAL HEALTH
4711504	PRV	VA	0.27	0.27	100%	0	$2,000	LEDOUX CLARENCE E SR ESTATE OF
4705506	PUB	VA	3.14	8.22	38%	0	$281,500	CITY OF KENAI
4205502	PUB	VA	0.22	1.11	20%	0	243000	CITY OF KENAI
4705501	PRV	CH	0.02	1.14	2%	0	$109,800	SHELDON DENTON SHILLING
4705510	PUB	VA	0.14	3.43	4%	0	5508100	CITY OF KENAI
4705806	PUB	VA	3.13	3.37	93%	0	$193,700	CITY OF KENAI
4705602	PUB	VA	3.24	14.98	22%	0	$104,800	PACIFIC STAR SEAFOODS INC
4705601	PRV	CH	1.24	1.43	87%	0	$82,800	DIOCESE OF SITKA & ALASKA ORTHODOX
4705703	PRV	ID	0.32	14.50	2%	0	$1,351,800	PACIFIC STAR SEAFOODS INC

A total value of existing real estate of $2.75 million is assumed based on 11,400 square feet of existing structures and 1.09 million square feet of platted land within the project footprint. Structures are assigned a uniform value of $50 per square foot, with land valued at $2 per square foot. Most of the existing parcel land within the project footprint is not suitable for development and is thus assigned a relatively low unit price.

Table D-1: GIS Metadata for Parcel and Utility Layers

Parameter	Value
Projected Coordinate System	NAD 1927 State Plane Alaska 4 FIPS 5004
Projection	Transverse Mercator
Central_Meridian	-150.00000000
Scale_Factor	0.99990000
Latitude_Of_Origin	54.00000000
Linear Unit	U.S. Foot
Geographic Coordinate System	GCS North American 1927
Datum	D North American 1927
Prime Meridian	0
Angular Unit	Degree

Table D-2: GIS Data Layers Obtained for Kenai Bluff Erosion Study

Layer	Source	Comments
Aerial Photo	Peninsula Borough	Proprietary 2005 data – do not distribute
Sewers	City of Kenai	Includes relocated sewer near bluff
Storm Drains	City of Kenai	None near site
Street Lights	City of Kenai	Lights present within potential project footprint
Water Supply	City of Kenai	Pipes present within potential project footprint
Linked As-builts	City of Kenai	Raster scans of previous public works projects
Parcels	Peninsula Borough	Includes ownership data as of 2005

Table D-3: Metadata and Survey Notes for Aerial Photography and Topographic Mapping

- Mapping compiled to meet horizontal accuracy in accordance with ASPRS Class II Accuracy Standards.
- Mapping compiled to meet vertical accuracy in accordance with ASPRS Class II Accuracy Standards.
- Areas denoting vegetation cover on the ground should be considered less accurate and not used for engineering purposes until field checked in accordance with ASPRS Accuracy Standards.
- Projection is Alaska State Plane, Zone 4, NAD83 as expressed in U.S. Survey feet.
- Vertical data is referenced to MLLW based on NOAA Tidal Station "Nikiski".
- Mapping based on photography acquired 09-27-2007 at a nominal scale of 1"=300'.
- Mapping produced for output at a scale of 1"=100' with a contour interval of 1 foot.
- Information provided is based on Aerial Mapping produced by Aerometric and controlled by field surveys performed by R&M Consultants. The aerial photography was acquired September 27, 2007. R&M Control Surveys took place in 2007 and 2008.
- Primary horizontal control and aerial photo control was established using Static GPS techniques with Trimble duel frequency receivers. GPS vectors were adjusted using simultaneous least-squares methods.

- Project coordinates are referenced to the Alaska Coordinate System of 1983 (ACS83), Zone 4 values, reported in U.S. Survey Feet and are based on Survey Control Station "McLane CP 1" as shown on the DOWL Engineers drawing "Kenai River Bluff Erosion Survey Topography" dated July 16, 2003.
- McLane CP 1 zone 4 coordinates = N 2,395,666.774, E 1,419,401.413. Project bearings are NAD83 Zone 4 state plane grid bearings based on GPS adjusted measurements constrained at McLane CP 1.
- Primary vertical control was established with a combination of Trimble dual frequency GPS measurements and differential leveling. GPS measurements incorporated Geoid06. Differential levels were performed with a Leica DNA10 digital level and barcode rod.
- Project vertical datum is referenced to Mean Lower Low Water (MLLW) based on NOAA Tidal Station Nikiski, Station ID No. 945 5760, publication date 10/30/2003. Station Nikiski is referenced by BM No. 8, et al., which was held for all project elevations (BM No. 8 elevation was verified by measurements to BM Nos. 7 & 9). The official station designation for BM No. 8 is "945 5760 TIDAL 8" (see PID No. AB7150). NOAA MLLW elevation for BM No. 8 = 109.659 U.S. Survey Feet (33.424 meters). Elevations were transferred from BM No. 8 roughly 10 miles south to the project site using the following sequence:

BM No. 8 to nearby set point CP 51	Differential levels.
CP 51 to McLane CP 1	GPS & Geoid06
CP 1 to nearby Kenai BM No. 3	Differential levels.

- Note that CP 1 is vertically unstable and that Kenai BM No. 3 has been used to control and adjust the elevation of CP 1 at each visit for GPS observations. The most recent visit found CP 1 with aluminum cap lying nearby. The cap was reset and the elevation reestablished from Kenai BM No. 3. The elevation for Kenai BM No. 3, established from Nikiski, is 31.18 feet.
- Elevations of tidal datums referred to station Nikiski MLLW in feet:
- Aerial Mapping contours were ground-truthed using RTK GPS broadcasted from station McLane CP 1. Elevations fit well in areas without foliage and less well where trees and brush existed. No extreme discrepancies were discovered.
- Geotechnical borehole positions were located using RTK GPS together with differential levels.
- The contour interval shown is one foot.

Property lines, street rights-of-way, street names, etc. were taken from the Kenai Peninsula Borough (KPB) Geographical Information Systems (GIS) website. The KPB GIS was inserted and fit to physical features within the aerial mapping (street intersections, etc).

Originator: Aero-Metric, Anchorage
Title: Kenai 2006
Geospatial_Data_Presentation_Form: remote-sensing image
Publication_Place: Anchorage, Alaska, USA
Publisher: Aero-Metric, Anchorage
Online_Linkage: \\AM068\E$\6070103_Kenai\2client\kenai.tif
Abstract:
Digital Orthomosaic of Kenai based on 22 May 2006 aerial photography with a pixel ground resolution of 1.0 foot
Purpose: Provide visual backdrop for vector data
Calendar_Date: 20060522
Currentness_Reference: ground condition
Bounding_Coordinates:
West_Bounding_Coordinate: -151.275428
East_Bounding_Coordinate: -151.223419
North_Bounding_Coordinate: 60.557871
South_Bounding_Coordinate: 60.548427
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: Automated DEM
Source_Contribution:
The DEM was used in the construction of the orthomosaic to correct for terrain distortion.

Process_Description:
Aerial Photography Capture: A twin-engine aircraft with an on-board 6 (six) inch focal length film camera was used to capture 3 (three) exposures along 1 (one) flight line.

Scanning Process: The photographic negatives were scanned on a photogrammetric scanner at a resolution 16 microns to produce pixels with a nominal ground distance of about 0.9449 feet

Aerotriangulation Process: The aerotriangulation was performed using GPS/IMU data and was refined using conventional photogrammetric methods.

Orthorectification Process: The scanned images, aerotriangulation information, and DEM were processed using orthoimagery software to remove systematic and geographic distortions while georeferencing the scanned imagery. The resulting orthorectified images were then mosaicked and color balanced into a single image with a ground resolution of 1.0 foot

Raster_Object_Type: Pixel
Row_Count: 3276
Column_Count: 9301
Horizontal_Coordinate_System_Definition: Planar
Map_Projection_Name: Transverse Mercator

Scale_Factor_at_Central_Meridian: 0.999900
Longitude_of_Central_Meridian: -150.000000
Latitude_of_Projection_Origin: 54.000000
False_Easting: 1640416.666667
False_Northing: 0.000000
Planar_Coordinate_Encoding_Method: row and column
Abscissa_Resolution: 1.000000
Ordinate_Resolution: 1.000000
Planar_Distance_Units: survey feet
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222
Entity_and_Attribute_Overview:
The orthomosaic is a natural color image

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ATTACHMENT E

DESIGN CALCULATIONS AND SPECIFICATIONS

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Hydraulic Design and Armor Sizing

The design wave heights are derived from hindcasting efforts published in the Oceanweather report Cook Inlet Wave Extreme Storm Study (2009) and additional refinements made in coordination with the Alaska District Corps of Engineers. Figure E-1 shows the adopted design wave zones applied to the revetment design.

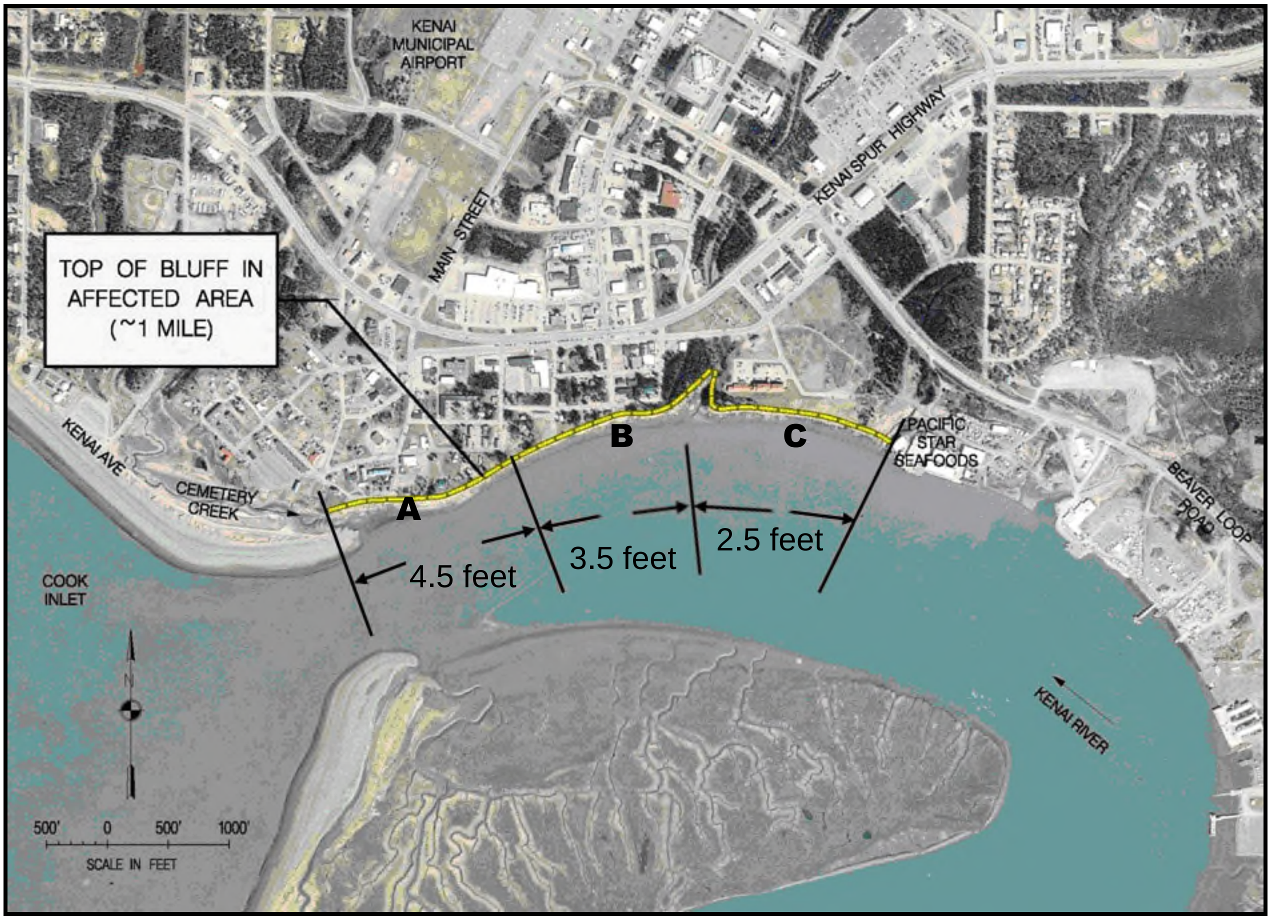


Figure E-1. Design Wave (USACE 2010)

The design wave height in Zone C utilizes a minimum median armor stone weight of 600 lbs to resist ice forces; the equivalent design wave matches that of Zone B. The top of revetment height is based on the design wave superimposed on the highest observed tide. The actual design wave for each zone is applied in determining the top of revetment with no adjustment for ice forces. A K_{rr} value of 2.0 is applied. An additional factor of safety may be attained by ensuring longitudinal placement in accordance with Shore Protection Manual guidelines; however, because this project may be constructed by other agencies rather than the Corps, the K_{rr} value for random placement is assumed. Additional design criteria for the top of revetment and the toe depth are included in Table E-1.

Table E-1. Revetment Height and Toe Protection Depth

Parameter	Zone A (Sta. 0+00 to 15+00)	Zone B (Sta. 15+00 to 45+00)	Zone C (Sta 45+00 to 70+00)
MHHW	20.7 feet MLLW	20.7 feet MLLW	20.7 feet MLLW
Extreme Tide	26.0 feet MLLW	26.0 feet MLLW	26 feet.0 MLLW
Highest Observed	27.7 (6/14/95)	27.7 (6/14/95)	27.7 (6/14/95)
Design Wave	4.5 feet	3.5 feet	2.5 feet
Computed Armor Stone W_{50}	1280 lbs	600 lbs	220 lbs
Applied Armor Stone W_{50}	1280 lbs	600 lbs	600 lbs
Applied Armor Stone D_{50}	2.5 feet	1.9 feet	1.9 feet
Applied Armor Layer Thickness (2 x D_{50})	5.0 feet	3.8 feet	3.8 feet
Computed B Layer W_{50}	128 lbs	60 lbs	22 lbs
Applied B Stone W_{50}	128 lbs	60 lbs	60 lbs
Aplied B Layer D_{50}	1.1 feet	0.9 feet	0.9 feet
Applied B Layer Thickness (1.5 x D_{50})	1.7 feet	1.4 feet	1.4 feet
Wave Runup	6.8 feet	5.3 feet	3.8 feet
Storm Surge / Barometric Pressure	1.5 feet	1.5 feet	1.5 feet
Nominal Wave Height	3.0 feet	2.0 feet	1.5 feet
Nominal Wave Runup	4.5 feet	3.0 feet	2.3 feet
Top of Revetment for Condition 1 (MHHW + design wave runup +	29.0 feet MLLW	27.5 feet MLLW	26.0 feet MLLW

Parameter	Zone A (Sta. 0+00 to 15+00)	Zone B (Sta. 15+00 to 45+00)	Zone C (Sta 45+00 to 70+00)
storm surge)			
Top of Revetment for Condition 2 (extreme tide + nominal wave runup + storm surge)	32.0 feet MLLW	30.5 feet MLLW	29.8 feet MLLW
Top of Revetment for Condition 3 (highest observed tide + nominal wave runup)	32.2 feet MLLW	30.7 feet MLLW	30.0 feet MLLW
Top of Revetment for Condition 4 (highest observed tide + design wave runup)	**34.5 feet MLLW**	**33.0 feet MLLW**	**31.5 feet MLLW**
Effective Toe Depth (Greater of 2/3 wave height or 1 armor stone + B layer thickness)	4.2 feet	3.3 feet	3.3 feet

A multilayer armor section is recommended for the revetment at the toe of the slope along the Kenai Bluff. The U.S. Army Engineer Waterways Experiment Station (WES) developed a formula to determine the stability of armor units on rubble structures. The stability formula is based on modeled test results. The formula for the weight of an individual armor unit in the primary layer is:

$$W = \frac{w_r H^3}{K_{RR}(s_r - 1)^3 \cot\theta}$$ (Equation 7-117, USACE, 1984)

Table E-2 lists the components of the equation along with values used in this study to verify the stability of the armor stone.

Table E-2: Design Assumptions and Armor Stone Weight Calculations

Variable (units)	Definition	Design Value
W (lbs)	Weight of individual armor unit (primary layer)	Calculated
w_r (lb/ft^3)	Unit weight of armor unit	165 lb/ft^3
H_1 (ft)	Design wave height, Zone A	4.5 feet
H_2 (ft)	Design wave height, Zones B and C	3.5 feet
S_r (unitless)	Specific gravity, computed as w_r/w_w	2.6
w_w (lb/ft^3)	Unit weight of water	64 lb/ft^3

Variable (units)	**Definition**	**Design Value**
theta (degrees)	Structure slope angle (from horizontal)	33.7 degrees
K_{RR} (unitless)	Angular graded riprap stability coefficient	2.0

The unit weight of the stone material is assumed to be 165 lb/ft^3, corresponding to a specific gravity of 2.6 relative to the unit weight of seawater. Although the salinity varies along the bluff with Kenai River flows, the effect on the unit weight of water is minimal relative to the armor sizing. The design wave heights provided by the Corps (4.5 feet for Zone A, 3.5 feet for Zone B, and 2.5 feet for Zone C) are used for this analysis. The angle of the revetment is derived from an armor face at a 1.5H:1V slope. As recommended in Table E-3 below, the assumed stability coefficient of 2.0 accounts for graded angular quarrystone subjected to a breaking wave. As recommended for use of the 2.0 stability factor, the armor layer is sized to approximately twice the diameter of the median rock with random placement. Special placement with the long axis of the stone placed perpendicular to the revetment face will increase the factor of safety.

Applying these assumptions to the stability equations gives a calculated W_{50} values presented in Table E-1. The SPM recommends a maximum individual stone weight of four times the W_{50} and a minimum of one-eighth of the W_{50} (USACE 1984). Placing armor stones in the maximum size range would be impractical, particularly for the near-mouth area (Zone A). According to the SPM, uniform-size armor units are generally more economical. The resulting cross sections are attached for review.

Placing armor stones in the maximum size range would be impractical, particularly for the near-mouth area (Zone A). According to the SPM, for waves higher than 5 feet, uniform-size armor units are generally more economical. Bedding layer gradations are designed according to Terzaghi's Equations and other design standards to prevent piping and accommodate the bearing loads. The armor rock and B rock sublayer gradations are tabulated in Table E-4, with layer dimensions shown on Plate C-12 in Attachment G.

Table E-3. Suggested K_D Values for use in determining Armor Unit Weight (Table 7-8, USACE, 1984)

No-Damage Criteria and Minor Overtopping

Armor Units	n[3]	Placement	Structure Trunk K_D[2] Breaking Wave	Structure Trunk K_D[2] Nonbreaking Wave	Structure Head K_D Breaking Wave	Structure Head K_D Nonbreaking Wave	Structure Head Slope Cot θ
Quarrystone							
Smooth rounded	2	Random	*1.2*	2.4	*1.1*	1.9	1.5 to 3.0
Smooth rounded	>3	Random	*1.6*	*3.2*	*1.4*	*2.3*	[5]
Rough angular	1	Random[4]	[4]	*2.9*	[4]	*2.3*	[5]
Rough angular	2	Random	2.0	4.0	*1.9* *1.6* 1.3	3.2 2.8 2.3	1.5 2.0 3.0
Rough angular	>3	Random	*2.2*	*4.5*	*2.1*	*4.2*	[5]
Rough angular	2	Special[6]	5.8	7.0	*5.3*	6.4	[5]
Parallelepiped[7]	2	Special[1]	7.0 – 20.0	*8.5 – 24.0*	—	—	
Tetrapod and Quadripod	2	Random	7.0	8.0	*5.0* *4.5* *3.5*	6.0 5.5 4.0	1.5 2.0 3.0
Tribar	2	Random	*9.0*	10.0	*8.3* *7.8* 6.0	9.0 8.5 6.5	1.5 2.0 3.0
Dolos	2	Random	15.8[8]	31.8[8]	*8.0* 7.0	*16.0* *14.0*	2.0[9] 3.0
Modified cube	2	Random	*6.5*	7.5	-----	*5.0*	[5]
Hexapod	2	Random	*8.0*	9.5	*5.0*	*7.0*	[5]
Toskane	2	Random	*11.0*	22.0	—	—	[5]
Tribar	1	Uniform	12.0	15.0	*7.5*	*9.5*	[5]
Quarrystone (K_{RR}) Graded angular	–	Random	2.2	2.5	—	—	

[1] CAUTION: Those K_D values shown in *italics* are unsupported by test results and are only provided for preliminary design purposes.

[2] Applicable to slopes ranging from 1 on 1.5 to 1 on 5.

[3] n is the number of units comprising the thickness of the armor layer.

[4] The use of single layer of quarrystone armor units is not recommended for structures subject to breaking waves, and only under special conditions for structures subject to nonbreaking waves. When it is used, the stone should be carefully placed.

[5] Until more information is available on the variation of K_D value with slope, the use of K_D should be limited to slopes ranging from 1 on 1.5 to 1 on 3. Some armor units tested on a structure head indicate a K_D-slope dependence.

[6] Special placement with long axis of stone placed perpendicular to structure face.

[7] Parallelepiped-shaped stone: long slab-like stone with the long dimension about 3 times the shortest dimension (Markle and Davidson, 1979).

[8] Refers to no-damage criteria (<5 percent displacement, rocking, etc.); if no rocking (<2 percent) is desired, reduce K_D 50 percent (Zwamborn and Van Niekerk, 1982).

[9] Stability of dolosse on slopes steeper than 1 on 2 should be substantiated by site-specific model tests.

Table E-4. Idealized Multilayer Gradation

Kenai Armor Stone Gradation Calculations

Variable (units)	Definition	Design Value	
W (lbs)	Weight of individual armor unit (primary layer)	Calculated	
w_r (lb/ft^3)	Unit weight of armor unit	165	lb/ft^3
H_1 (ft)	Design wave height, near-mouth area	4.5	feet
$H_{2,3}$ (ft)	Design wave height, remaining area	3.5	feet
s_r (unitless)	Specific gravity, computed as w_r/w_w	2.58	
w_w (lb/ft^3)	Unit weight of water	64	lb/ft^3
θ (degrees)	Structure slope angle (from horizontal)	33.7	deg
K_{rr} (unitless)	Angular graded riprap stability coefficient	2.0	

$s_r = w_r/w_w$

$W=(w_rH^3)/(K_{rr}(s_r-1)^3\cot\theta)$

W (for H_1): **1276** lbs

W (for H_2): **600** lbs

Diameter=((W*6)/(π*w_r))^(1/3)

Rock Size Gradation

Rock Size	Layer	Denominator	Gradation		Gradation for H_1 (lbs)					
			from	to	W_0	D_0	W_{50}	D_{50}	W_{100}	D_{100}
W	Primary Cover Layer	1	75%	125%	957	2.2	1276	2.5	1595	2.6
W/10	First Underlayer	10	30%	130%	38	0.8	128	1.1	166	1.2
W/15	Secondary Cover Layer Toe	15	75%	125%	64	0.9	85	1.0	106	1.1
W/200	Second Underlayer	200	50%	150%	3.2	0.3	6	0.4	10	0.5
W/6000	Core and Bedding Layer	6000	30%	170%	0.1	0.1	0.2	0.1	0.4	0.2

Rock Size	Layer	Denominator	Gradation		Gradation for H_2 (lbs)					
			from	to	W_0	D_0	W_{50}	D_{50}	W_{100}	D_{100}
W	Primary Cover Layer	1	75%	125%	450	1.7	600	1.9	750	2.1
W/10	First Underlayer	10	30%	130%	18	0.6	60	0.9	78	1.0
W/15	Secondary Cover Layer Toe	15	75%	125%	30	0.7	40	0.8	50	0.8
W/200	Second Underlayer	200	50%	150%	1.5	0.3	3.0	0.3	4.5	0.4
W/6000	Core and Bedding Layer	6000	30%	170%	0.0	0.1	0.1	0.1	0.2	0.1

Filter Layer Gradation

In the design provided in Attachment G, groundwater that currently emerges from the bluff face continues to flow along the seepage plane but remains subsurface within a layer of alluvial fill material. The alluvial material placed at the toe acts as a filter layer to prevent piping of soil, and the groundwater emerges through geotechnical fabric underlying the rock revetment. The fabric allows groundwater seepage while preventing piping of the granular material. Benching into the bluff face is recommended to expose undisturbed material. Control of the seepage water will also be important during construction. The fill should not be allowed to become excessively wet prior to compaction. An open-graded gravel material against the bluff face is recommended to aide in drainage as necessary.

Contacts at various Alaska agencies have provided examples of successes as well as slope failures, vegetation desiccation, or other issues encountered on projects with slopes of similar scale and/or materials, including some with similarities in climate zone, soil types and other parameters. The applicability of reference sites or other details may be revisited upon receipt of additional monitoring data.

Table E-5 presents a recommended filter layer gradation. The recommended gradation is held relatively loose with overlapping bounds to prevent the exclusion of most of the alluvial borrow material. A coarser material would potentially preclude the use of existing alluvial deposits and potentially drain the soils below the establishing roots of the vegetation on the bluff face. To help facilitate drainage, a layer of coarser gravel in areas where the seepage is greatest may be beneficial. Placement of localized gravel lenses would require import or sorting, and the coarse material would require an intermediate filter layer as bedding to prevent piping. The soil used as granular fill material should contain no muck, frozen material, roots, sod, or other delirious matter. The plasticity shall not exceed 6. In some locations, the existing bluff sediments include fines exceeding the maximum allowable percentage specified in Table E-5. Some sieving of these materials from the stockpile may be required.

Table E-5. Filter Layer Gradation

Sieve	% Passing
3"	100%
#4	20-100%
#60	0-50%
#200	0-6%

Slope Drain or V-Ditch for Stormwater Management

The schematic illustration in Figure E-2 shows a typical solution for routing flows from a collection basin to the toe of the bluff in a slope drain configuration. Slope drains are commonly used on roadway fills. The berm in the illustration can be constructed of earthen fill, concrete, asphalt, or other materials. The inlet can be horizontal or vertical, with or without grating, or apply other configurations. The drain itself can be open channel (earthen, geotextile, rock, asphalt, or concrete V-ditch) piped (anchored surface pipe or buried pipe), or a combination (French drain, half-round corrugated metal). Dissipation at the outlet is typically provided with rock, concrete baffles, or other solution.

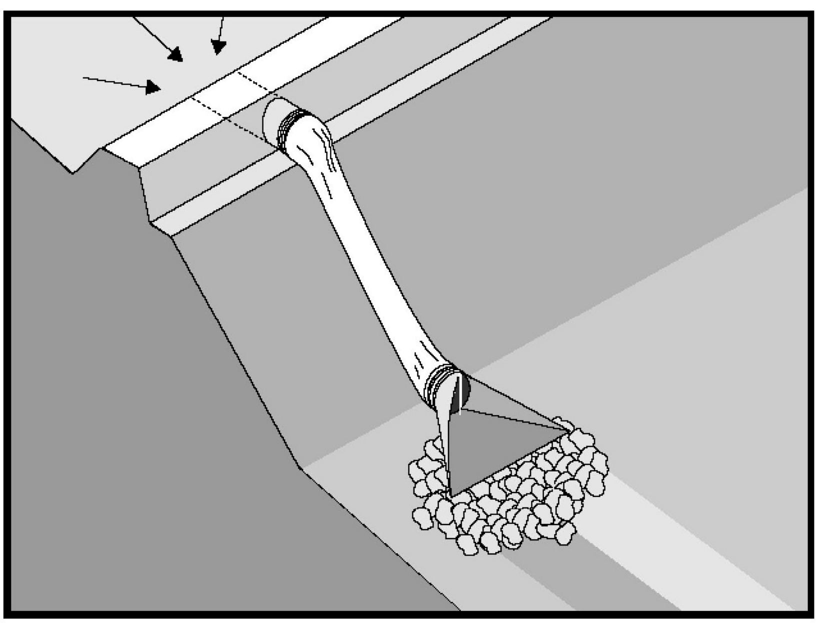


Figure E-2. Typical Slope Drain (Source: CASQA)

For a pipe solution in Kenai, freezing conditions would cause concerns. Local building codes utilize a design frostline depth of 42 inches, with pipes commonly placed 1 foot below the frostline. Blockage of the outlet by ice could present a safety hazard because of the substantial head that could build up behind the ice. Maintenance of the pipe could also present concerns. Alternatives including geotextile liners, rock, asphalt, concrete, and vegetated swales, anchored surface pipes, a grid or hardened trenches, french drains, and other solutions were presented to the Corps in a meeting held 4/30/2008. In light of potential maintenance, safety, aesthetic, and other concerns, all parties were in favor of infiltration basins and bioswales at the top of the bluff, rerouting flows to the City's storm drain network, and handling excess flows through an open channel, rip rap V-ditch rather than a buried pipe or other solution.

Additional details on the City's storm drain network are not expected to become available during the current study period; a combination of these alternatives is therefore proposed as an interim solution in the draft design. The vegetated swales and basins serve to attentuate peak flows. Connection to the City's storm drain network is supplemented by a flashboard riser which feeds into a culvert across the maintenance road and a rip rap V-ditch 10 feet wide and 1 foot deep. Applying the rational method and HEC-RAS to the infiltration basin, culvert and ditch under a conservative 100-year rainfall intensity of 2 inches per hour yields the following results:

Table E-5 Stormwater Parameters

Zone	Drainage Area (ac)	Impervious Area (%)	Rational Coefficient	Peak Discharge (cfs)	Channel Velocity (fps)	Channel Shear (psf)
A	18	40	0.6	22	12	11
B	25	30	0.5	25	13	12
C	5	0	0.2	2	7	5

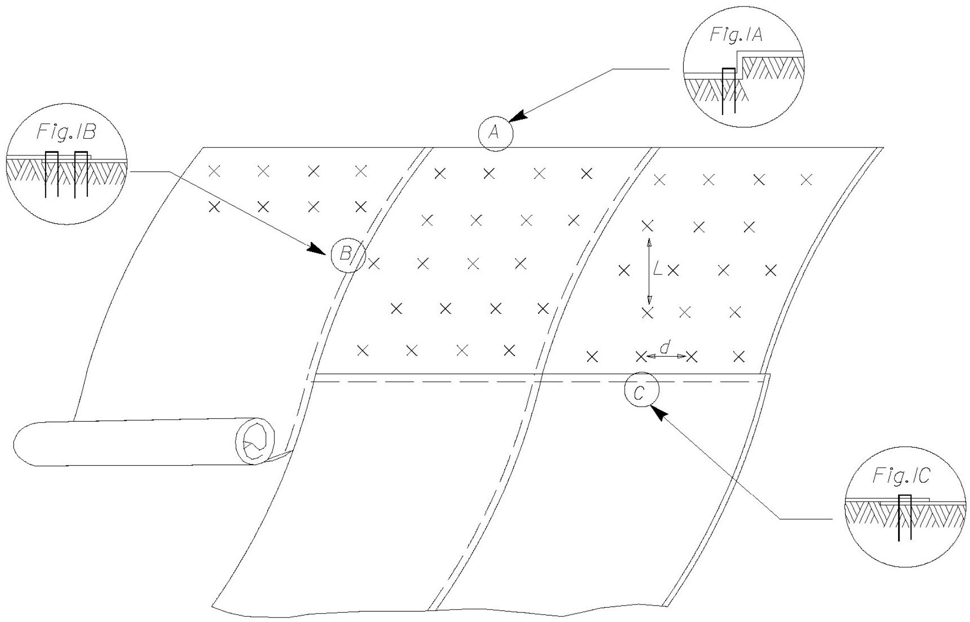
The proposed rip rap thickness is 2.5 feet, with a D_{50} of 12 inches and a D_{100} of 18 inches. The rip rap should be well-graded and compacted with void spaces filled. The larger rock should project from the surface, generating enough turbulence to prevent sustained supercritical flows. A rip rap geotextile should underlie the V-ditch. The V-ditch is intended for emergency overflows only. Rock and other debris may be mobilized down the slope during freeze-thaw cycles. Localized maintenance activities may be required after severe events. As more detailed stormwater discharge details become available, design parameters should be verified using rock chute design programs such as those available through NRCS (ASAE 1998), USBR, or in Corps Engineering Manuals such as EM 1110-2-1601.

Filter Fabric Recommendations

Filter Fabric recommendations:

- Filter fabric with an Apparent Opening Size (AOS) <0.3mm
- Permittivity >0.1 sec-1
- Strong and stiff fabric
- Grab strength >700 N
- Elongation 15%
- Burst Strength >1300 kPa
- Trapezoidal Tear >250 N.
- Examples include Mirafi FW500 and FW700.

http://www.usfabricsinc.com/



General Installation Instructions for TRM and Blanket in Slopes

1. Prepare soil, including grading, application of lime, fertilizer, and seeds. The surface of the soil should be smooth and free of rocks, roots and other obstructions.
2. Start at the top of the slope by anchoring blankets in a 6" deep and 6" wide anchor trench. place blankets, staple (8" staples recommended), backfill and compact. (Fig. 1A)
3. Roll the blankets down the slope (recommended for steep slopes) or across the slope. Staple the open blanket edge using one row of staples at 1.5 - 2 feet intervals. The middle of the blankets should be stapled using a preferred staple pattern (Table 1). Be sure to lay blankets loosely on the ground allowing a good contact between soil and blankets.
4. When blanket splicing is necessary, use an 8 inch overlap. Use two rows of staples to anchor blankets. A twelve inch staple spacing with a staggered pattern is recommended. Overlap sides of blankets at least 6" and use staples along the overlap at 12" spacing (Fig. 1C).
5. Provide a 6" deep and 6" wide anchor trench at the toe of the slope or streambank or shoreline. This anchor trench in streambanks and shorelines may be replaced with BioD-Roll coir rolls.
6. Use wire staples of gauge 11 or lower and a minimum length of 8". If wooden pegs are used, the minimum length is 12 inches. Anchors should be long enough to provide a strong bond between the blanket and the ground. Require anchor length may vary depending on the soil conditions.
7. This procedure could be altered at the discretion of the site engineer / architect.

TABLE 1

STAPLE PATTERN		
SLOPE	L	D
> 1:1 Slopes	3.0'	2.0'
2:1 Slopes	4.0'	2.0'
3:1 Slopes	6.0'	3.0'
4:1 Slopes	8.0'	3.0'

Figure E-3. Typical Erosion Control Installation Details (Source: www.rolanka.com)

Table E-6 General Specifications for Erosion Control Fabric

Following are minimum design criteria for erosion control fabric. Equivalent products shall meet the properties shown. The blankets shall be woven from coir twines. Coir twines shall be made of bristle coir obtained from freshwater cured coconut husks which shall be machine spun to a uniform diameter. The blanket shall also conform to the following properties.

Property	Test Method	BioD-Mat 90
Weight	ASTM D 3776	29 oz/SY
		(980 g / m^2)
Tensile Strength **Dry**	ASTM D 4595	
Machine direction		2024 lbs/ft
		(29.6 kN/m)
Cross direction		1160 lbs/ft
		(17.0 kN/m)
Tensile Strength **Wet**	ASTM D 4595	
Machine direction		1776 lbs/ft
		(26 kN/m)
Cross direction		936 lbs/ft
		(13.7 kN/m)
Open area	Calculated	38%
Thickness	ASTM D1777	0.35 inch
		(9 mm)
Number of twines in the mat		
Machine direction		117 / yard (128 / m)
Cross direction		55 / yard (60 / m)
Recommended slope		>1:1
Recommended flow		16 fps
		(4.9 m/s)
Recommended shear stress		5 lbs /ft^2
		(240 N/m^2)
"C" factor		0.002

(Source of specifications www.rolanka.com)

Table E-7 Equivalent Geogrid Products

Manufacturer	Product	LTDS
Huesker Inc	Fortrac 20/13-20	780
Strata Systems	Stratagrid 150	1008
Mirafi	Miragrid 2XT	1082
Synteen Technical Fabrics	SF 20	1099
Huesker Inc	Fortrac 35	1322
Tensar Earth Technologies	UX1100HS	1450*
Tensar Earth Technologies	UX1400HS	1760*
Synteen Technical Fabrics	SF 35	1787
Mirafi	Miragrid 3XT	1705
Strata Systems	Stratagrid 200	1918
Huesker Inc	Fortrac 55	2027
Mirafi	Miragrid 5XT	2327
Synteen Technical Fabrics	SF 55	2361
Strata Systems	Stratagrid 350	2685
Tensar Earth Technologies	UX1500HS	2860*
Mirafi	Miragrid 7XT	3084
Huesker Inc	Fortrac 80	3117
Strata Systems	Stratagrid 500	3507
Tensar Earth Technologies	UX1600HS	3620*
Mirafi	Miragrid 8XT	3788
Huesker Inc	Fortrac 110	4130
Synteen Technical Fabrics	SF 80	4133
Tensar Earth Technologies	UX1700HS	4390*
Strata Systems	Stratagrid 550	4466
Synteen Technical Fabrics	SF 90	4747
Strata Systems	Stratagrid 600	4987
Tensar Earth Technologies	UX1800HS	5080*
Mirafi	Miragrid 10XT	5141
Huesker Inc	Fortrac 150	5535
Synteen	SF 110	5700
Mirafi	Miragrid 20XT	6252
Strata Systems	Stratagrid 700	6411

Source: www.usfabrics.com

Table E-8 General Specifications for Geogrid

Ultimate and Creep Limited Strengths

			Microgrid[1,2]	SG 150[1]	SG 200	SG 350	SG 500	SG 550	SG 600	SG 700
Ultimate Strength[2,3]	ASTM D-6637 METHOD A	lbs/ft (kN/m)	2000 (29.2)	1875 (27.4)	3500 (51.1)	4900 (71.5)	6400 (93.4)	8150 (118.9)	9100 (132.8)	11700 (170.7)
Creep Limited Strength	ASTM D-5262	lbs/ft (kN/m)	1266 (18.5)	1165 (17.0)	2215 (32.3)	3101 (45.3)	4051 (59.1)	5158 (75.3)	5759 (84.1)	7405 (108.1)

	Microgrid	SG 150	SG 200	SG 350	SG 500	SG 550	SG 600	SG 700
RF $_{installation\ damage}$ (Sand, Silt & Clay, D_{50} < 0.6mm)	1.20	1.05	1.05	1.05	1.05	1.05	1.05	1.05
RF $_{installation\ damage}$ (3/4" minus angular aggregate, D_{50} < 6mm)	1.30	1.10	1.10	1.10	1.10	1.10	1.10	1.10
RF $_{installation\ damage}$ (1.5" minus angular aggregate, D_{50} < 20mm)	1.40	1.20	1.20	1.20	1.20	1.20	1.20	1.20
RF $_{durability}$	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10

Long-Term Design Strength (LTDS or T_{al})[4]

		Microgrid[1]	SG 150[1]	SG 200	SG 350	SG 500	SG 550	SG 600	SG 700
For Sand, Silt & Clay	lbs/ft (kN/m)	959 (14.0)	1008 (14.7)	1918 (28.0)	2685 (39.2)	3507 (51.2)	4466 (65.2)	4987 (72.8)	6411 (93.6)
For ¾" minus angular aggregate	lbs/ft (kN/m)	885 (12.9)	962 (14.0)	1813 (26.7)	2563 (37.4)	3348 (48.9)	4263 (62.2)	4760 (69.5)	6120 (89.3)
For 1.5" minus angular aggregate	lbs/ft (kN/m)	822 (12.0)	882 (12.9)	1678 (24.5)	2349 (34.3)	3069 (44.8)	3908 (57.0)	4363 (63.7)	5610 (81.9)

Soil Interaction Coefficients for Pullout (C_i) and Direct Sliding (C_{ds})

Sand/Clay (ML, CL)	0.6 - 0.7
Sandy Silts & Clay (SC, GC)	0.7 - 0.8
Uniformly-Graded Sands, Silty Sand (SP, SM)	0.8 – 0.9
Gravel, Sand Gravel Mix, Well-Graded Sand (SW, GP, GW)	0.9 – 1.0

Molecular Properties

Item	Unit	Spec.
Molecular Weight (min.)	g/mol	25000
Carboxyl End Group (CEG) Count (max.)	Meq/kg	60

Physical Properties

			Microgrid	SG 150	SG 200	SG 350	SG 500	SG 550	SG 600	SG 700
Roll Dimensions	Width x Length	feet (m)	10 x 225 (3.05 x 68.6)	6 x 150 (1.83 x 45.7)	6 x 300 (1.83 x 91.4)	6 x 300 (1.83 x 91.4)	6 x 300 (1.83 x 91.4)	6 x 300 (1.83 x 91.4)	6 x 300 (1.83 x 91.4)	6 x 300 (1.83 x 91.4)
Area		Sq. Yds. Sq. m.	250 (209)	100 (83.6)	200 (167.2)	200 (167.2)	200 (167.2)	200 (167.2)	200 (167.2)	200 (167.2)
Weight Per Roll		lbs (kg)	105 (47.6)	45 (20.4)	110 (49.9)	130 (59.0)	155 (70.3)	170 (77.1)	180 (81.6)	210 (95.3)

[1]Bi-Axial (strength in both directions) / [2]Microgrid Ultimate Tensile per ASTM D-4595 / [3]Values shown are Minimum Average Roll Values

[4]LTDS or T_{al} = Tult (RFcreep x RFinstallation damage x RFdurability) as per FHWA NHI-00-043

Source: www.usfabrics.com
Additional info: http://www.gxgeogrids.com/

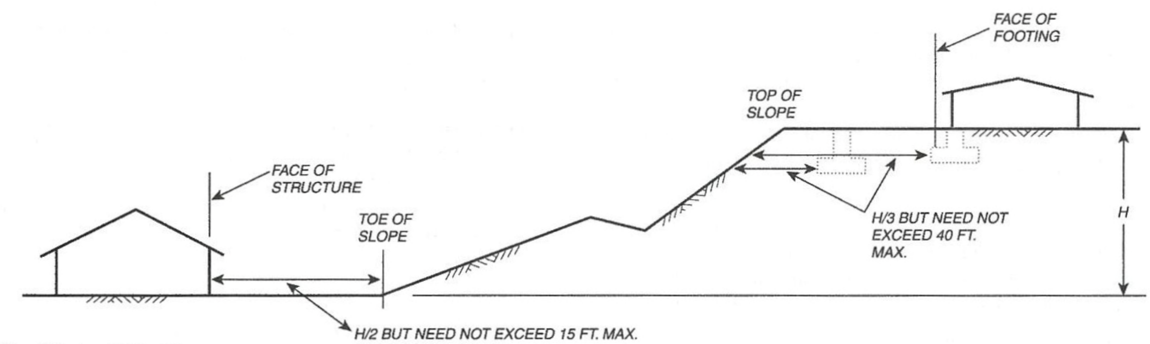
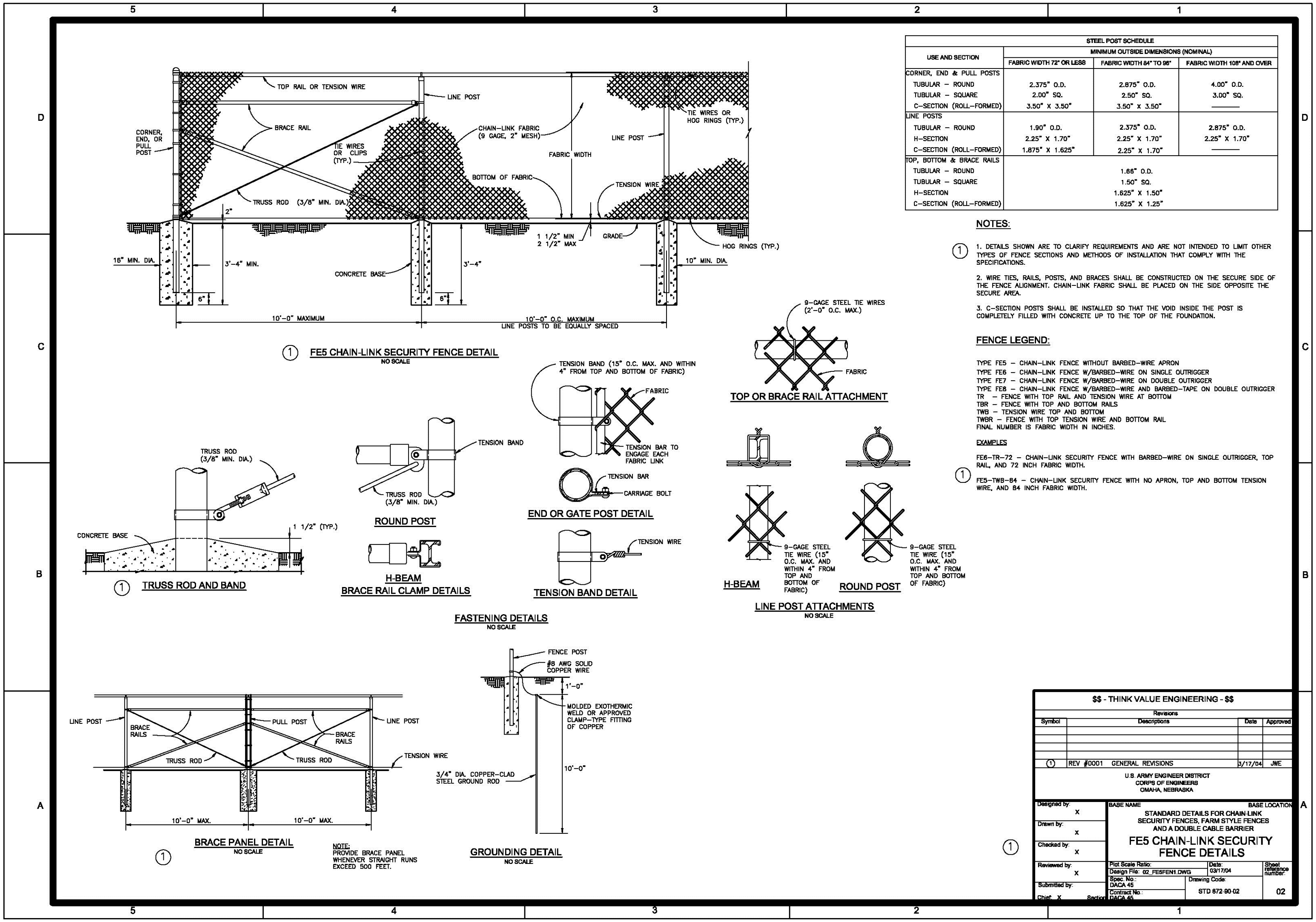


Figure E-4. Typical Setback Recommendations (ICC 2006)

Security Fencing

The Draft Design Plans in Attachment I show a wood plank fence along the project boundary. Wood plank fencing generally provides preferable aesthetics to chain link fencing; however, it also may present obstruction of views for parcels along the top of the bluff. The following figures show Corps standard plans for chain link and woven wire fencing and access gates that may be preferred by residents.



STEEL POST SCHEDULE

USE AND SECTION	MINIMUM OUTSIDE DIMENSIONS (NOMINAL) FABRIC WIDTH 72" OR LESS	FABRIC WIDTH 84" TO 96"	FABRIC WIDTH 108" AND OVER
CORNER, END & PULL POSTS			
TUBULAR – ROUND	2.375" O.D.	2.875" O.D.	4.00" O.D.
TUBULAR – SQUARE	2.00" SQ.	2.50" SQ.	3.00" SQ.
C–SECTION (ROLL–FORMED)	3.50" X 3.50"	3.50" X 3.50"	———
LINE POSTS			
TUBULAR – ROUND	1.90" O.D.	2.375" O.D.	2.875" O.D.
H–SECTION	2.25" X 1.70"	2.25" X 1.70"	2.25" X 1.70"
C–SECTION (ROLL–FORMED)	1.875" X 1.625"	2.25" X 1.70"	———
TOP, BOTTOM & BRACE RAILS			
TUBULAR – ROUND	1.66" O.D.		
TUBULAR – SQUARE	1.50" SQ.		
H–SECTION	1.625" X 1.50"		
C–SECTION (ROLL–FORMED)	1.625" X 1.25"		

NOTES:

1 1. DETAILS SHOWN ARE TO CLARIFY REQUIREMENTS AND ARE NOT INTENDED TO LIMIT OTHER TYPES OF FENCE SECTIONS AND METHODS OF INSTALLATION THAT COMPLY WITH THE SPECIFICATIONS.

2. WIRE TIES, RAILS, POSTS, AND BRACES SHALL BE CONSTRUCTED ON THE SECURE SIDE OF THE FENCE ALIGNMENT. CHAIN–LINK FABRIC SHALL BE PLACED ON THE SIDE OPPOSITE THE SECURE AREA.

3. C–SECTION POSTS SHALL BE INSTALLED SO THAT THE VOID INSIDE THE POST IS COMPLETELY FILLED WITH CONCRETE UP TO THE TOP OF THE FOUNDATION.

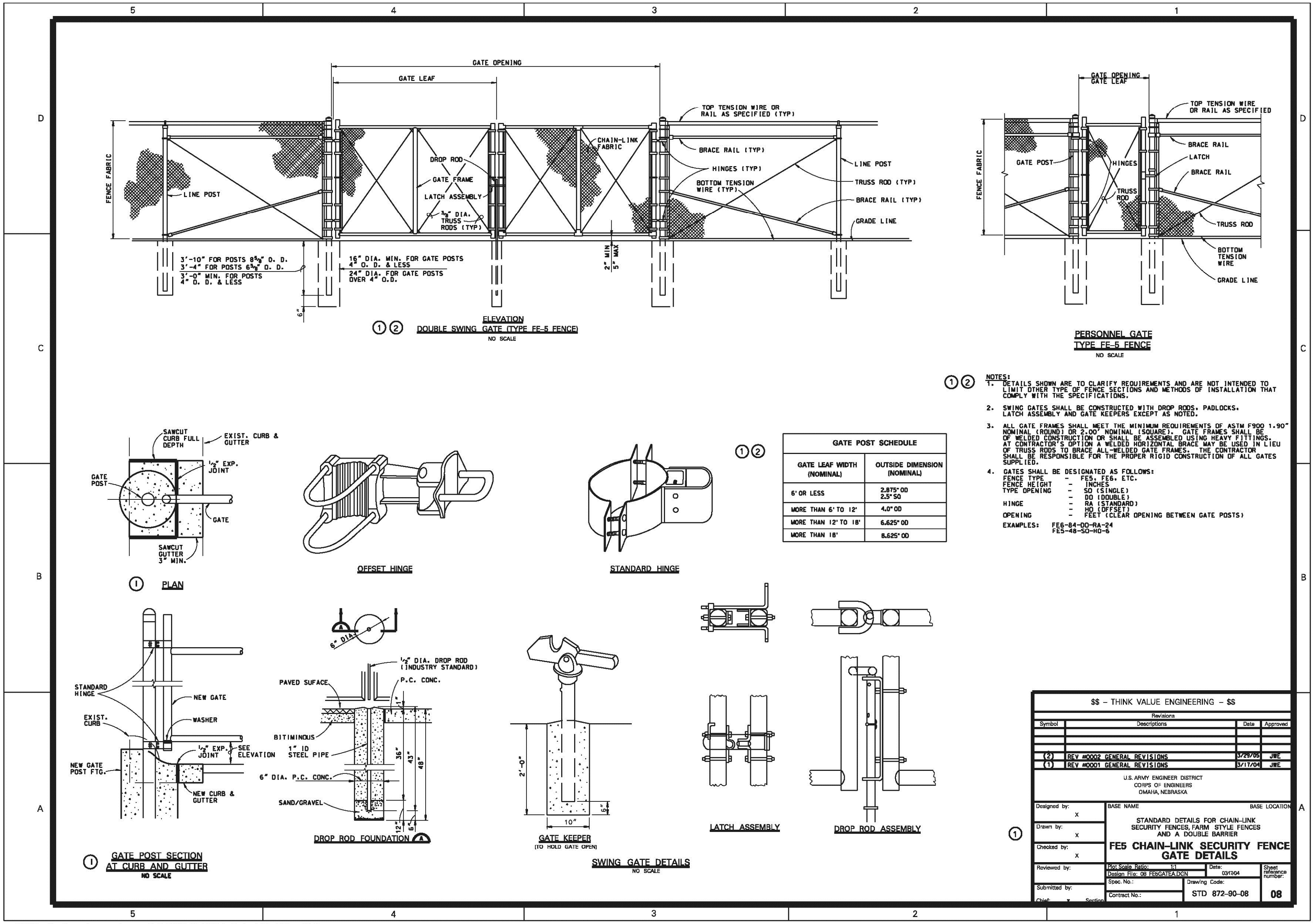
FENCE LEGEND:

TYPE FE5 – CHAIN–LINK FENCE WITHOUT BARBED–WIRE APRON
TYPE FE6 – CHAIN–LINK FENCE W/BARBED–WIRE ON SINGLE OUTRIGGER
TYPE FE7 – CHAIN–LINK FENCE W/BARBED–WIRE ON DOUBLE OUTRIGGER
TYPE FE8 – CHAIN–LINK FENCE W/BARBED–WIRE AND BARBED–TAPE ON DOUBLE OUTRIGGER
TR – FENCE WITH TOP RAIL AND TENSION WIRE AT BOTTOM
TBR – FENCE WITH TOP AND BOTTOM RAILS
TWB – TENSION WIRE TOP AND BOTTOM
TWBR – FENCE WITH TOP TENSION WIRE AND BOTTOM RAIL
FINAL NUMBER IS FABRIC WIDTH IN INCHES.

EXAMPLES

FE6–TR–72 – CHAIN–LINK SECURITY FENCE WITH BARBED–WIRE ON SINGLE OUTRIGGER, TOP RAIL, AND 72 INCH FABRIC WIDTH.

1 FE5–TWB–84 – CHAIN–LINK SECURITY FENCE WITH NO APRON, TOP AND BOTTOM TENSION WIRE, AND 84 INCH FABRIC WIDTH.



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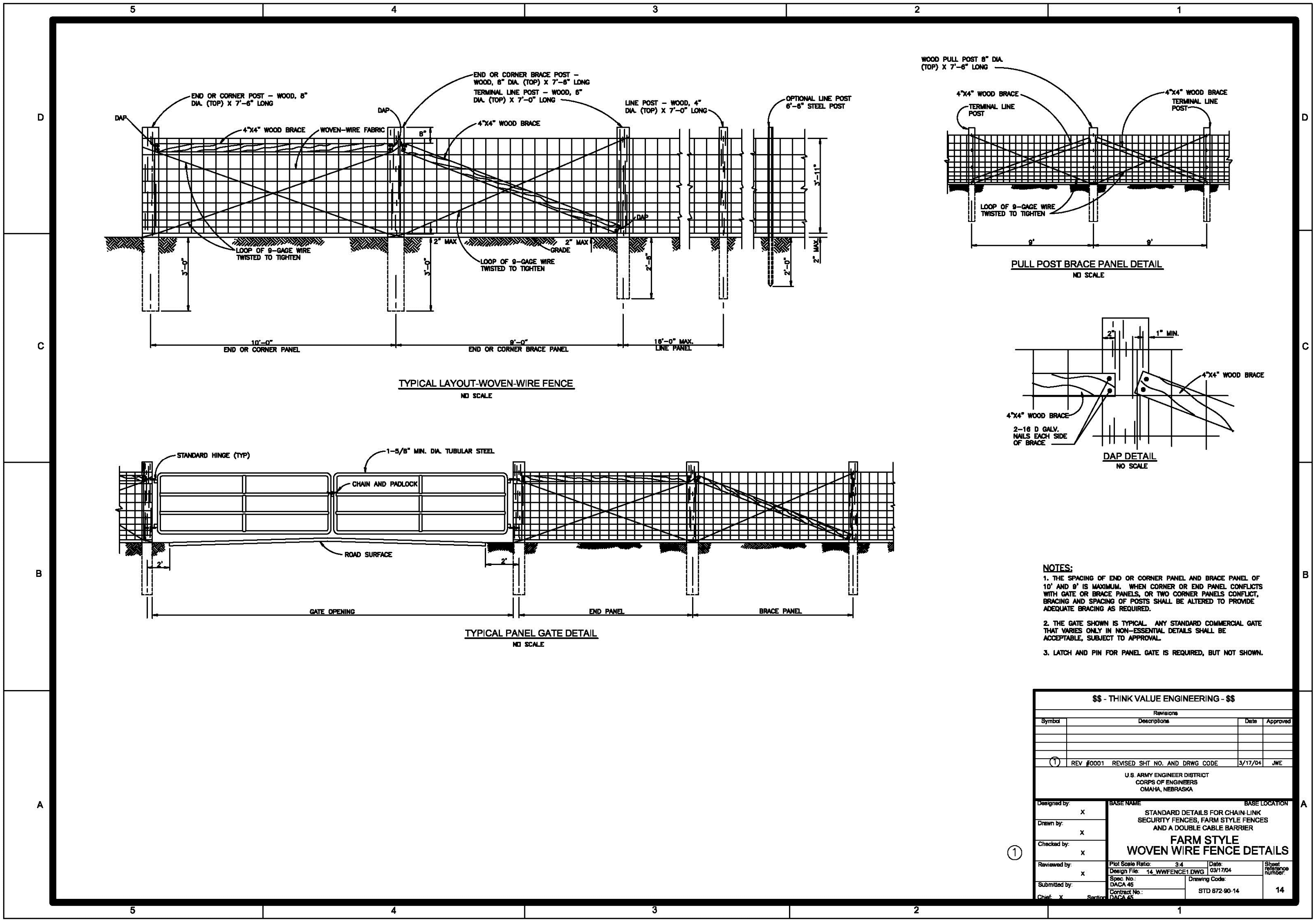

END OR CORNER POST – WOOD, 8" DIA. (TOP) X 7'-6" LONG
DAP
4"X4" WOOD BRACE
WOVEN-WIRE FABRIC
END OR CORNER BRACE POST – WOOD, 8" DIA. (TOP) X 7'-6" LONG
TERMINAL LINE POST – WOOD, 8" DIA. (TOP) X 7'-0" LONG
LINE POST – WOOD, 4" DIA. (TOP) X 7'-0" LONG
OPTIONAL LINE POST 6'-6" STEEL POST
LOOP OF 9-GAGE WIRE TWISTED TO TIGHTEN
GRADE
2" MAX
3'-11"
10'-0" END OR CORNER PANEL
9'-0" END OR CORNER BRACE PANEL
16'-0" MAX. LINE PANEL
TYPICAL LAYOUT-WOVEN-WIRE FENCE
NO SCALE
WOOD PULL POST 8" DIA. (TOP) X 7'-6" LONG
TERMINAL LINE POST
PULL POST BRACE PANEL DETAIL
NO SCALE
1" MIN.
2-16 D GALV. NAILS EACH SIDE OF BRACE
DAP DETAIL
NO SCALE
STANDARD HINGE (TYP)
1-5/8" MIN. DIA. TUBULAR STEEL
CHAIN AND PADLOCK
ROAD SURFACE
GATE OPENING
END PANEL
BRACE PANEL
TYPICAL PANEL GATE DETAIL
NO SCALE
NOTES:
1. THE SPACING OF END OR CORNER PANEL AND BRACE PANEL OF 10' AND 9' IS MAXIMUM. WHEN CORNER OR END PANEL CONFLICTS WITH GATE OR BRACE PANELS, OR TWO CORNER PANELS CONFLICT, BRACING AND SPACING OF POSTS SHALL BE ALTERED TO PROVIDE ADEQUATE BRACING AS REQUIRED.
2. THE GATE SHOWN IS TYPICAL. ANY STANDARD COMMERCIAL GATE THAT VARIES ONLY IN NON-ESSENTIAL DETAILS SHALL BE ACCEPTABLE, SUBJECT TO APPROVAL.
3. LATCH AND PIN FOR PANEL GATE IS REQUIRED, BUT NOT SHOWN.
$$ - THINK VALUE ENGINEERING - $$
Revisions
Symbol Descriptions Date Approved
1 REV #0001 REVISED SHT NO. AND DRWG CODE 3/17/04 JWE
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
OMAHA, NEBRASKA
Designed by: X
Drawn by: X
Checked by: X
Reviewed by: X
Submitted by:
Chief: X Section
BASE NAME
BASE LOCATION
STANDARD DETAILS FOR CHAIN-LINK SECURITY FENCES, FARM STYLE FENCES AND A DOUBLE CABLE BARRIER
FARM STYLE
WOVEN WIRE FENCE DETAILS
Plot Scale Ratio: 3:4
Design File: 14_WWFENCE1.DWG
Date: 03/17/04
Sheet reference number: 14
Spec. No.: DACA 45
Contract No.: DACA 45
Drawing Code: STD 872-90-14

ATTACHMENT F

PROPOSED CONSTRUCTION SEQUENCE

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The following sequence is proposed for constructing the Kenai Bluff Stabilization Project:

1. Mobilize equipment and prepare site

The temporary staging areas and permanent construction zones along the top of the bluff would initially be cleared and grubbed of vegetation and debris, with the materials stockpiled on site or removed for off-site disposal. The trees lining the top of the bluff within the project footprint would also be removed. Affected utilities located within the construction area would be rerouted as needed. Some small structures would be demolished and resulting debris would be hauled off-site. In addition, all abandoned concrete and timber foundations located within the construction area would be removed and hauled to the selected disposal area. Temporary stormwater and erosion control measures would be implemented according to the adopted SWPPP. Temporary security fencing would be installed along the bluff above the construction area according to the fencing details in the plans.

2. Construct four access ramps from top of bluff to toe of bluff
    a. Cemetery Creek
    b. Ryan's Creek (west)
    c. Ryan's Creek (east)
    d. Pacific Seastar

Figure F-1. Ramps and Stockpile/Staging Areas

The ramps would follow the alignment of the control line in the design plans from the top of bluff to the proposed bench elevation and would then proceed to the toe of the bluff along the same alignment. Materials excavated for the construction of the access ramps would need to be sorted and temporarily stored. Four temporary stockpile or staging areas are shown in Figure F-1. A partial ramp already exists near ramp *d*. While small amounts of material could be stored in the two westernmost staging areas, due to space limitations, the bulk of the material would need to be stored in the outlined areas near the senior center, requiring road transport for the materials excavated for ramps *a* and *b*. Organics and topsoil would need to be separated and stored separately for later disposal or reuse.

3. Construct temporary haul road from ramp *d* to *c*

Granular material suitable for construction of a haul road would be sorted from the stockpile near the senior center. After some preliminary grading of the haul road alignment, this material would be placed from *d* to *c* to construct a temporary haul road. Due to the nature of the tide flat, the preliminary grading, material placement and compaction would be done with equipment from each constructed reach of the haul road itself. Where possible, the elevation and alignment of the haul road would match the proposed top of the alluvium/till mix ("CF" zone) shown in the individual cross sections (10 vertical feet below the top of revetment). The haul road fill could then be used as backing for the geotextile underlying the rock. An example is shown as the cross-hatched pattern in Figure F-2 for Section 12+00. This section is used as a representative cross section throughout this document. Other cross sections vary in their balance of cuts and fills and the zones outlined in the figures would be reduced or increased accordingly; the proposed grading plan attempts to balance the cuts and fills with the reuse of suitable material for the overall project. 6-wheel drive articulated trucks with a 30 cy capacity are assumed for hauling.

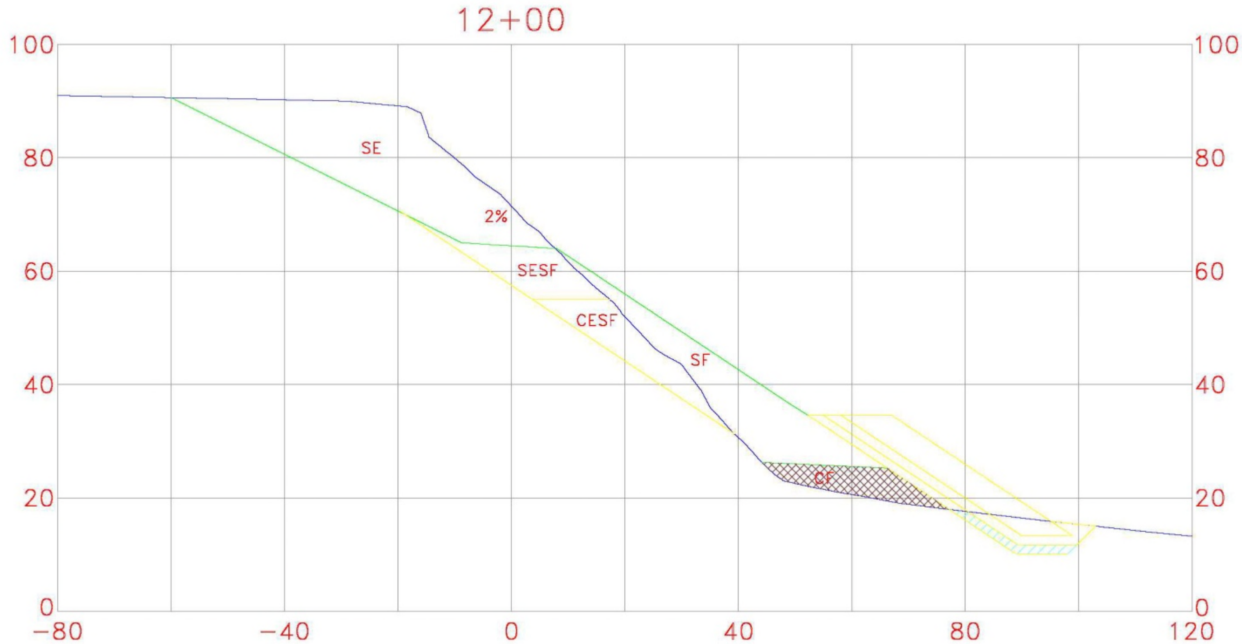

Figure F-2. Haul Road Location in Section View

4. Construct temporary bridge over Ryan's Creek

As shown in Figure F-3, a temporary bridge would need to be constructed over Ryan's Creek to connect the construction zones between ramps *c* and *b*. Placement of culverts with rock cover would allow for scour protection and vehicle access; however, a wider opening may be desirable. The bridge could be a set of flatbed trailers or could utilize a similar approach. The bridge would be placed at the haul road elevation or above. During limited time periods in extreme high tide conditions, the haul road would become submerged, and placement of the bridge at a higher elevation may be warranted to prevent submersion. The Ryan's Creek area is a highly sensitive environment, and the proposed bridge would need to be coordinated with the relevant jurisdictional authorities to avoid adverse impacts.

5. Construct temporary haul road from ramp *b* to *a*

The sorted material would be hauled from the senior center stockpile along ramp *d* and then over the temporary bridge to be used to construct a haul road from ramp *b* to *a*. The haul road would need to be extended past each ramp to facilitate the placement of rock to the tie-in point with the hillside. Because the project footprint does not extend through these areas (particularly due to the sensitive habitat at Cemetery Creek and Ryan's Creek) trucks and other construction equipment would need to back in or out of these areas rather than operating in a loop. A second bridge over Ryan's Creek was considered to connect the endpoints of the haul road; however the radius would limit the equipment capable of making the turn. Construction of a turnaround with sufficient radius does not appear to be feasible along the toe of the bluff. Some efficiency may be lost in having to back vehicles to the nearest access ramp during construction of the haul road, and this has been accounted for in the cost estimate.

Figure F-3. Haul Road Location in Plan View

6. Excavate material from top of bluff

Several passes with a scraper would be needed to remove organics and the upper silt layer. The excavation equipment would need to be located a sufficient distance from the edge of bluff to avoid the risk of bank failure caused by the equipment. As shown in Figures F-4 and F-5, the initial passes would extend along the proposed bluff face, leaving sufficient distance to the bluff edge. Material close to the edge of the bluff could be excavated with excavators, draglines, or other equipment once the scraper passes have reached their maximum extent. The excavated material between ramps *a* and *b* would be transported along city streets to the stockpile area while excavated material between ramps *c* and *d* could be transported directly to the stockpile without on-road vehicle limitations. The granular material that meets the specification for use as the filter layer would be separated and stockpiled for placement. The proposed haul routes and initial excavation passes are shown as dashed lines below. The cross section below shows in the hatched pattern where excavation could commence with scrapers and other heavy equipment. Some material may be collected from the haul road at the toe of the bluff, either by equipment pushing it down from above or pulling it down from below, particularly where the excavation depth along the bluff would not allow for a sufficiently wide bench on which to locate excavation equipment. In some areas, such as along Mission Avenue, only minimal excavation would occur as most of the cross section is in fill. The exposed bluff face would be notched or scarified to prepare for the placement of the filter layer or topsoil backfill.

Figure F-4. Schematic Excavation and Haul Routes

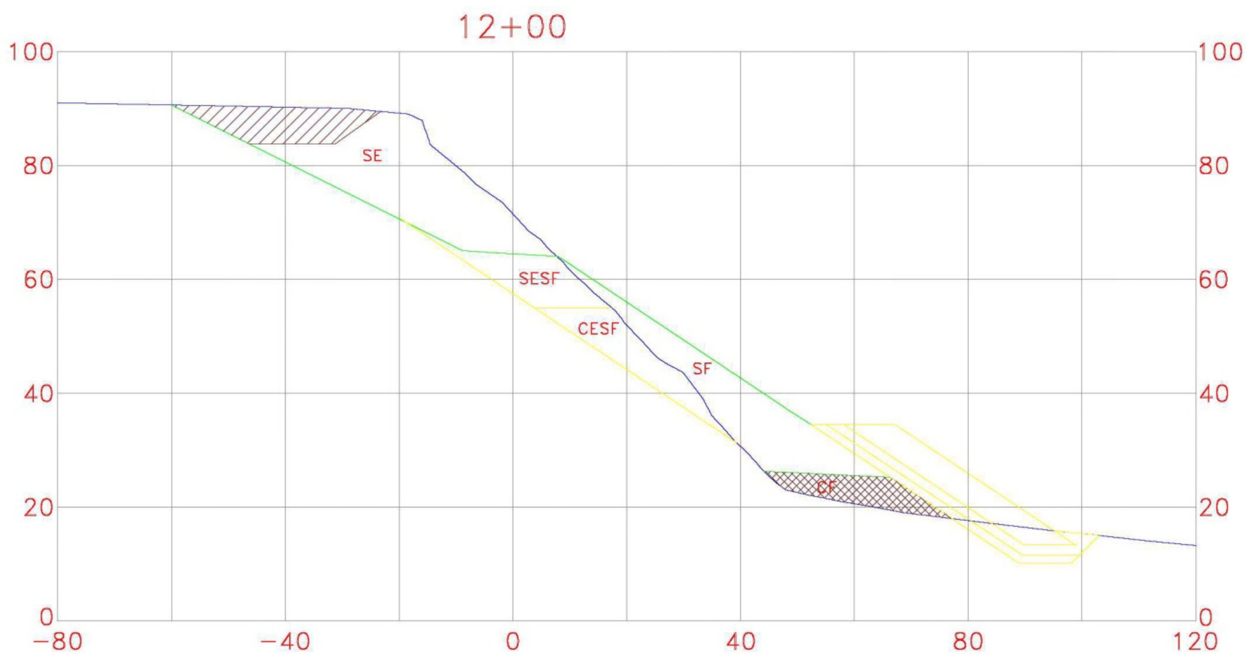

Figure F-5. Initial Excavation in Section View

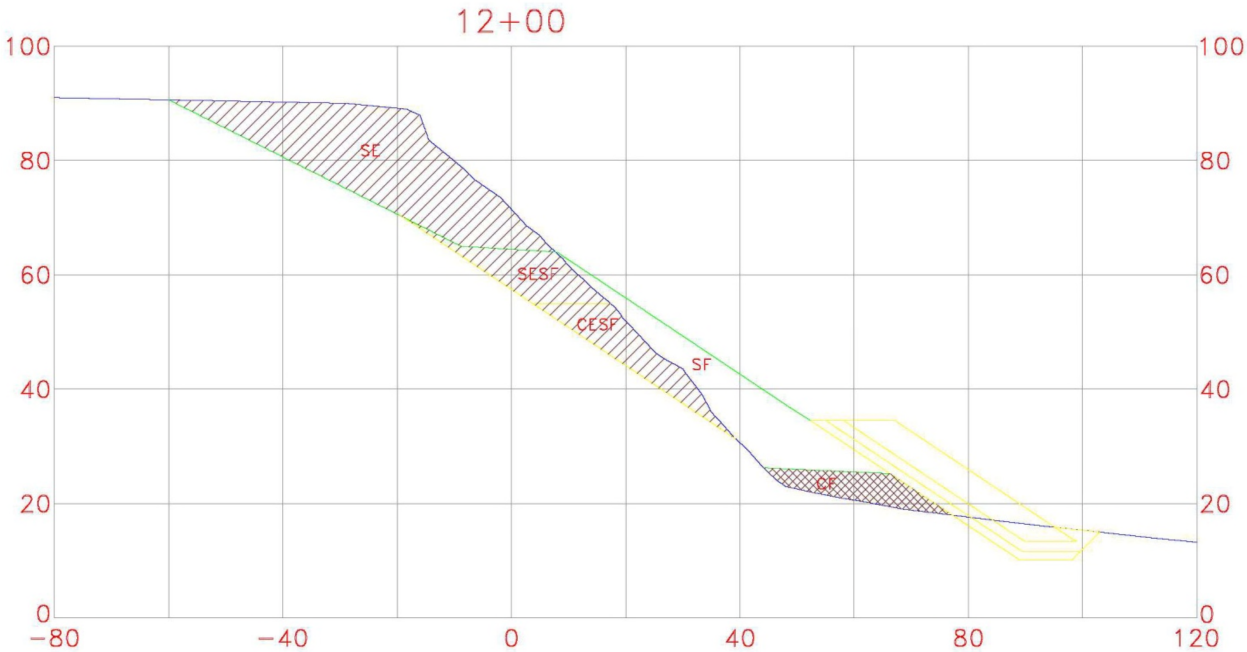

Figure F-6. Total Excavation in Section View

7. Sort material for use in filter layer

Most of the material located above the lag gravel layer would be suitable for use in backfilling the filter layer. This material would be sorted at the stockpile site, while additional material sourced from below the lag gravel layer will likely be unsuitable. This additional material (primarily glacial till) will be mixed with alluvium as necessary to meet requirements for fill zones outside of the filter layer, with the remainder hauled offsite for disposal. The stockpile areas may include piles up to 20 feet high to accommodate the amount of material being handled.

8. Place and compact backfill filter layer

The suitable material would be taken from the stockpile for placement in the filter layer above the haul road. Placement and compaction equipment could be operated on each successive layer of fill; the installation of a geogrid is proposed at every other compaction lift to improve the slope stability. Revised quantity estimates for suitable and unsuitable material are included in the MII cost report. The schematic location of the initial fill zone is shown in Figures F-7 and F-8.

Figure F-7. Fill Zones in Plan View

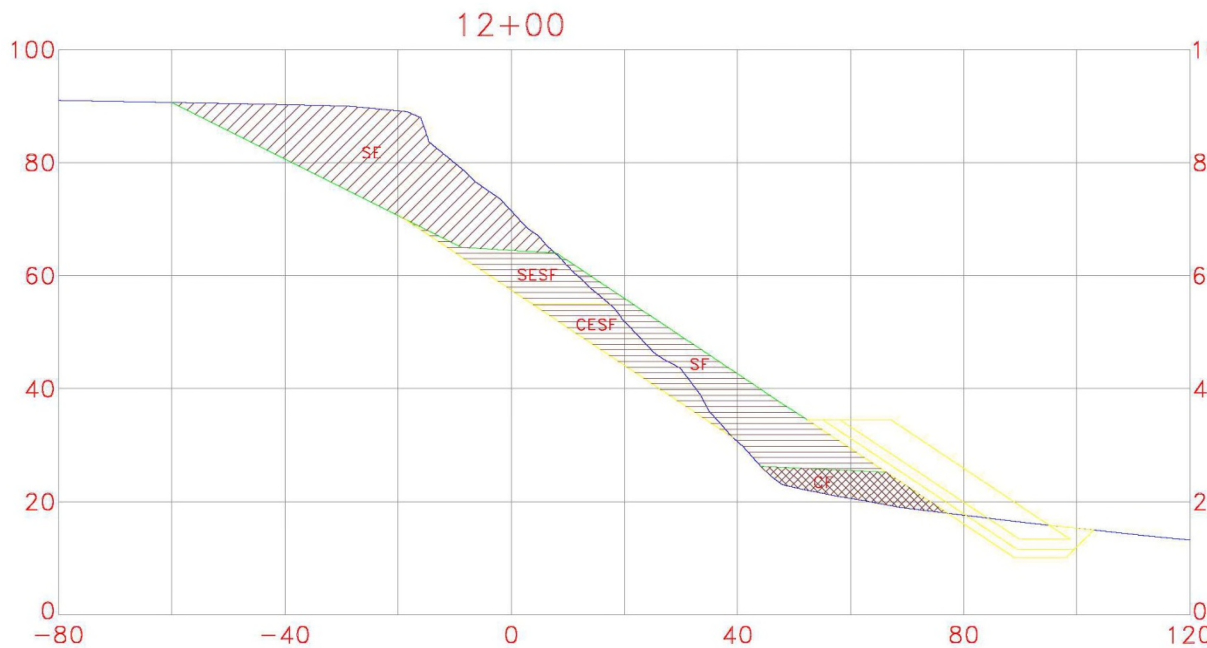

Figure F-8. Fill Zones in Section View

The exposed bluff face in any proposed fill areas would be notched to avoid a smooth interface between soil types. The proposed construction sequence does not include driving vehicles on the sloping bluff face but rather filling in horizontal layers with a bucket or other extension performing the final smoothing and compaction of the immediate face. The topsoil layer would be placed in several increments so as not to exceed the reach of the construction equipment.

9. Place rock

The geotextile fabric, sublayers, and armor rock would need to be placed while the haul road is at a sufficient elevation to allow equipment access. Rock is therefore likely to be placed in several stages as the backfill is placed on the haul road. Rock could be imported through a combination of barging and land-based equipment with the barge placing apron material at high tide, and the land-based equipment placing the remaining armoring at low tide. Complete segments of the armor section would be completed during each low tide cycle to at least the elevation of the maximum tide lines. It is assumed the land based equipment would operate for half of the shift and the water based equipment would operate the other half. Hauling has been assumed to be done entirely by land in the current estimate; barging the rock over water is also presented as an alternative in the design report to facilitate future agency coordination that may be required to leave that option open to the contractor. Placement of the rock is assumed to be by hydraulic excavator.

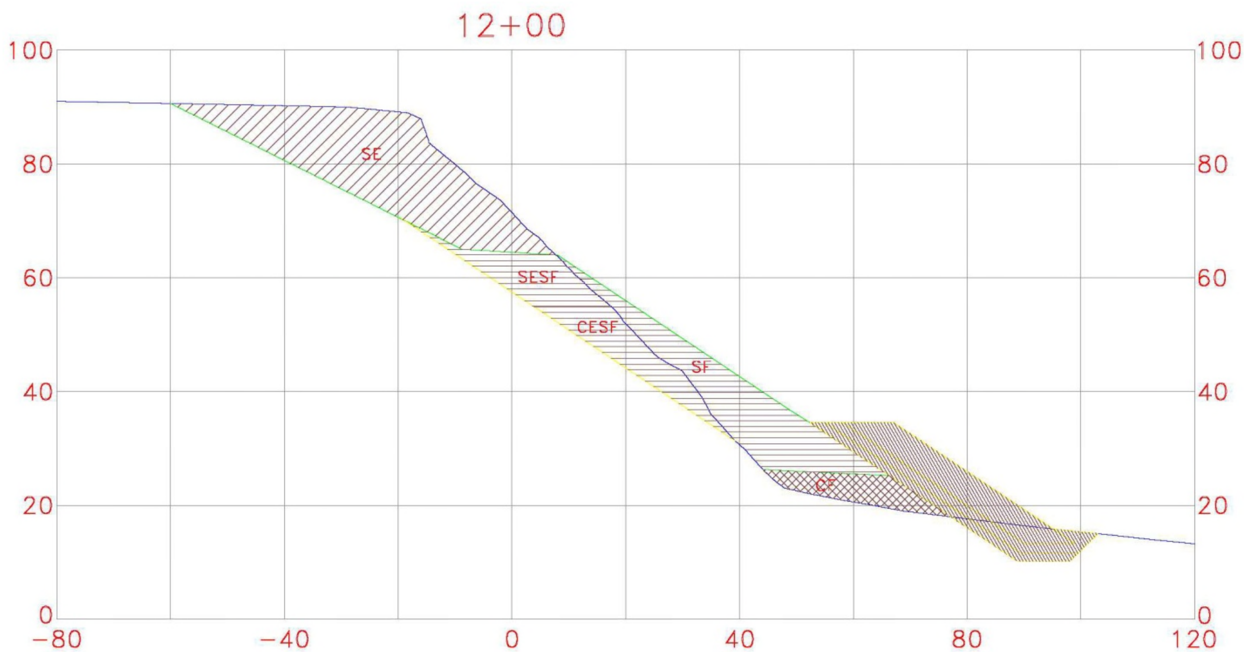

Figure F-9. Rock Placement in Section View

10. Place geotextile

Erosion control fabric is proposed along the entire bluff face due to the relatively steep slope. The fabric would be pinned to the compacted material below, with the spacing of the stakes doubled to provide an additional safety factor against the adverse conditions. Fabric staking would likely occur with hand placement and potentially ATV-mounted transport of materials to the bench area.

11. Additional features

Construction of the rock drainage chutes, stormwater basins, and other ancillary features will take place throughout the construction window. Road works, including the installation of a guardrail system and repaving disturbed areas will occur in keeping with the traffic control plan prepared by the contractor and adopted by the owner.

12. Initiate phased planting approach

Planting will commence following construction activities. The schedule for each phase will depend on the successful establishment of each previous phase. Placement would be manual, with limited equipment access along the bench.

13. Construct recreational features

Interpretive signage kiosks are proposed in three locations along the bench. Timber platforms are to be constructed along the top of the bluff, with stairs leading to the platforms where necessary. Three-seat benches are to be placed at each overlook along the top of the bluff.

14. Demobilization

The construction laborers, equipment and other personnel are assumed to come from Anchorage. It is estimated that overall construction would take approximately 15 months to construct. This duration has been used in the estimate to determine costs for the contractor to maintain field facilities and construction supervision. The overall schedule is based on a construction crew (1 shift) working 12hrs per day and 6 days per week. A tentative project schedule of the overall project is presented along with crews, equipment, and additional details in the cost engineering report.

ATTACHMENT G

DESIGN PLANS

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Figure G-1. Conceptual Plan View, Zone A

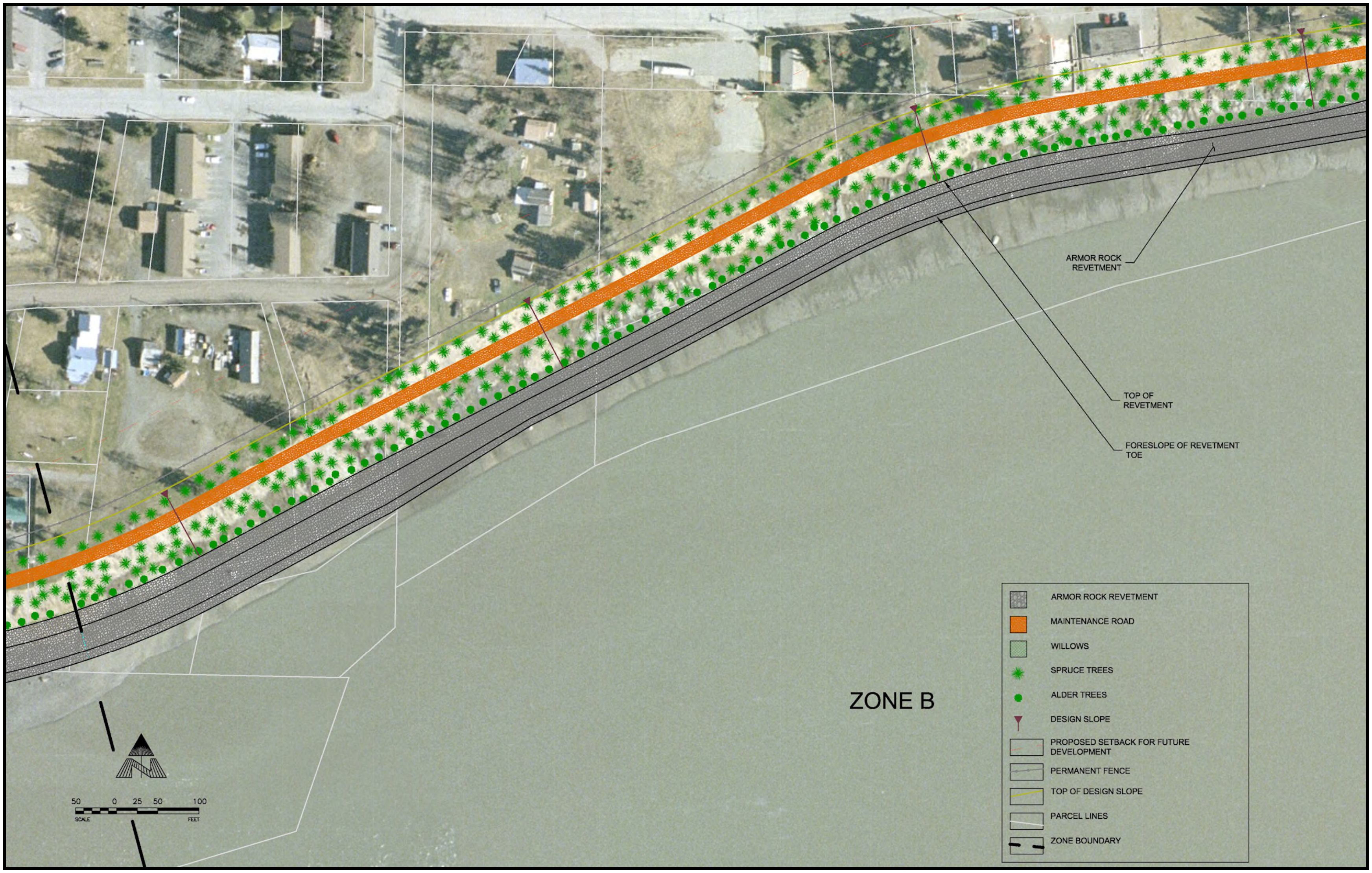


Figure G-2. Conceptual Plan View, Zone B

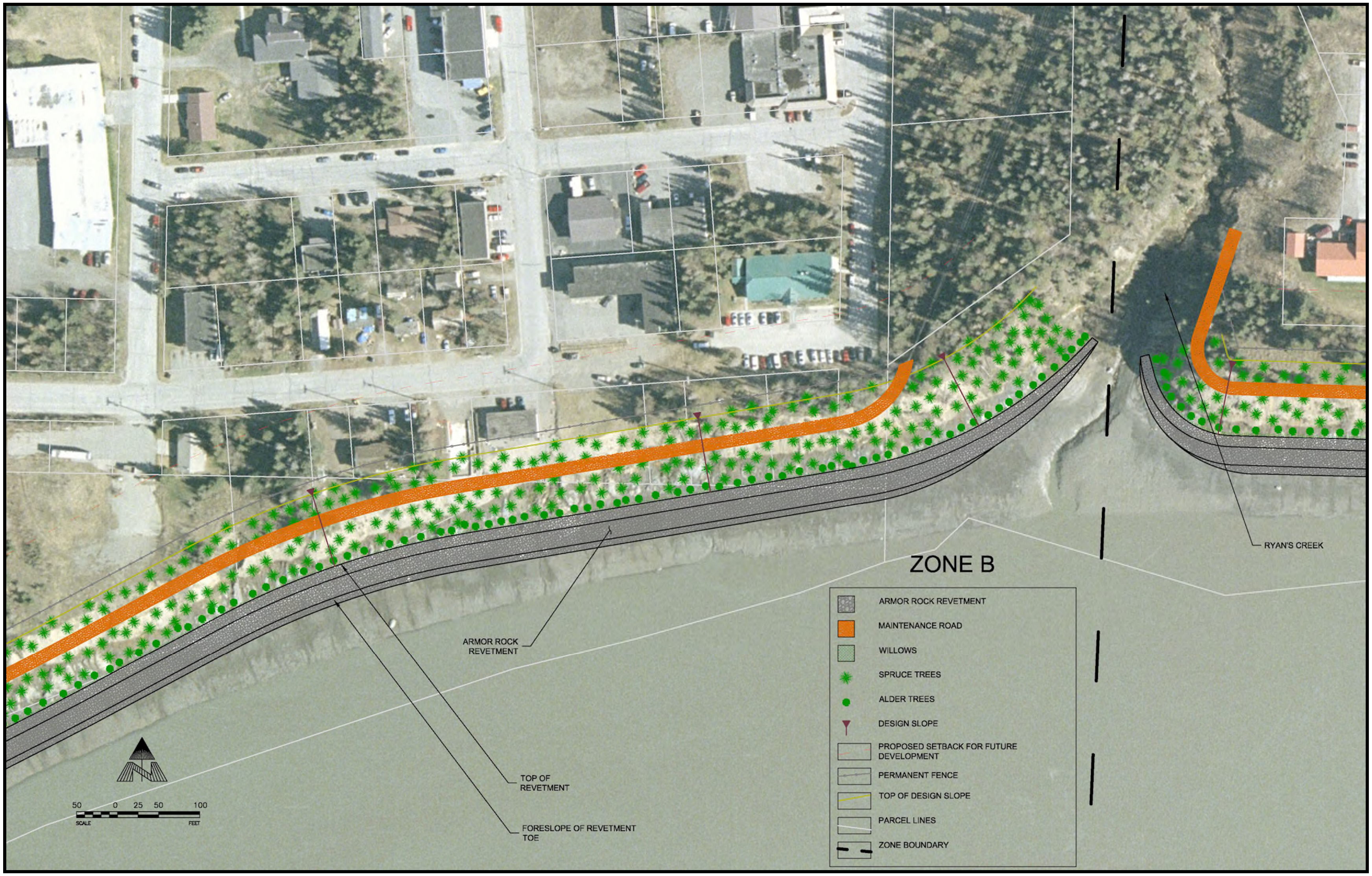


Figure G-3. Conceptual Plan View, Zone B (cont)

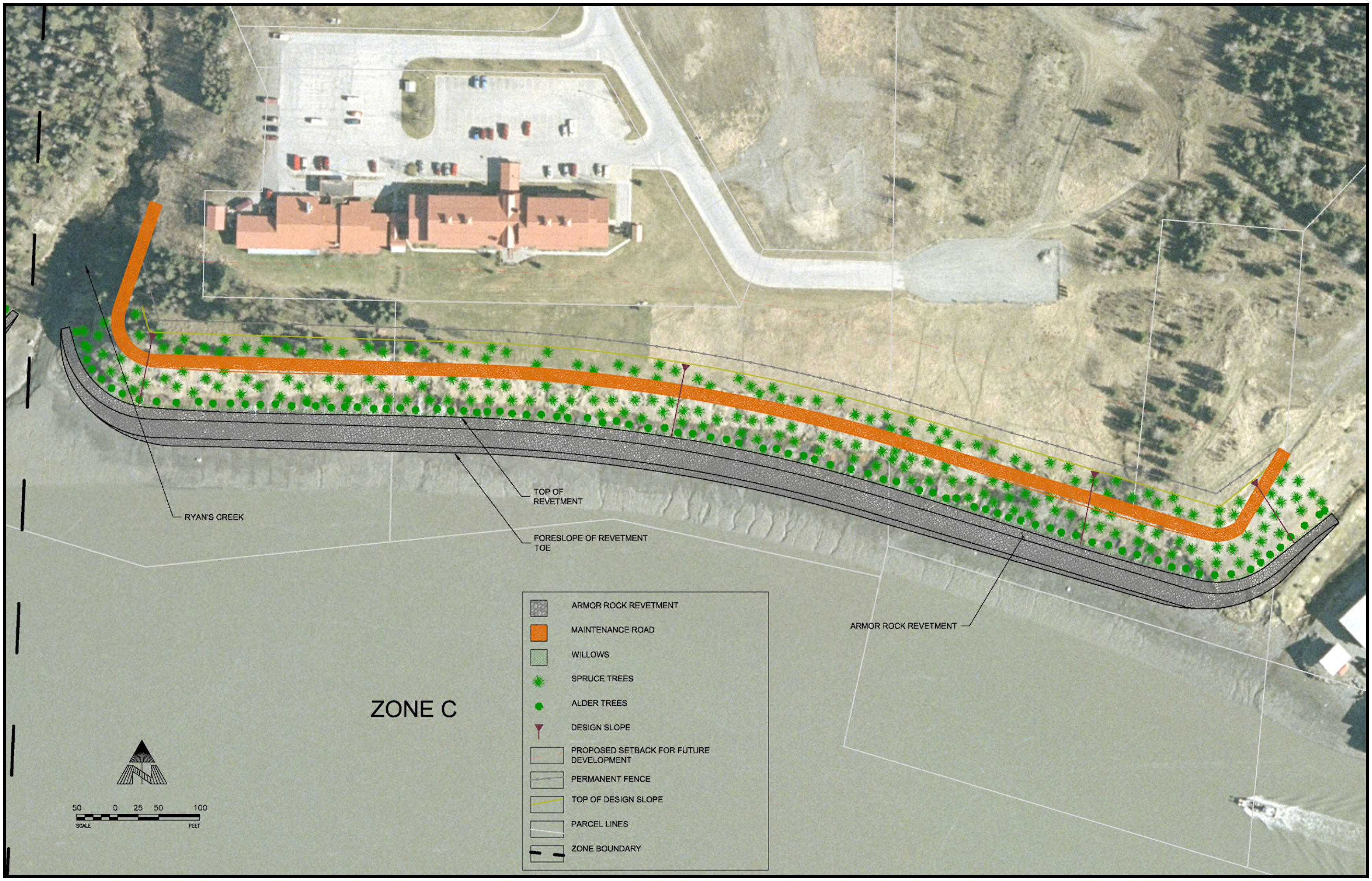
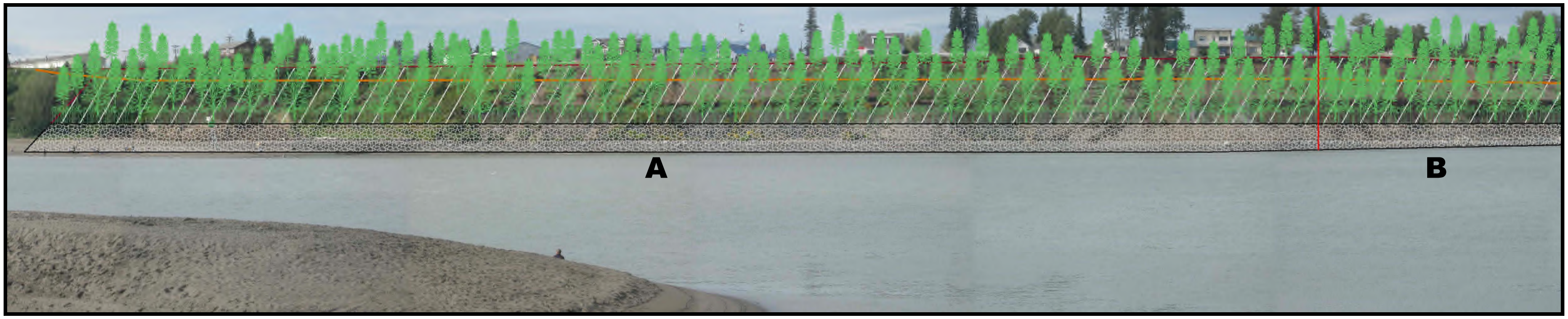


Figure G-4. Conceptual Plan View, Zone C



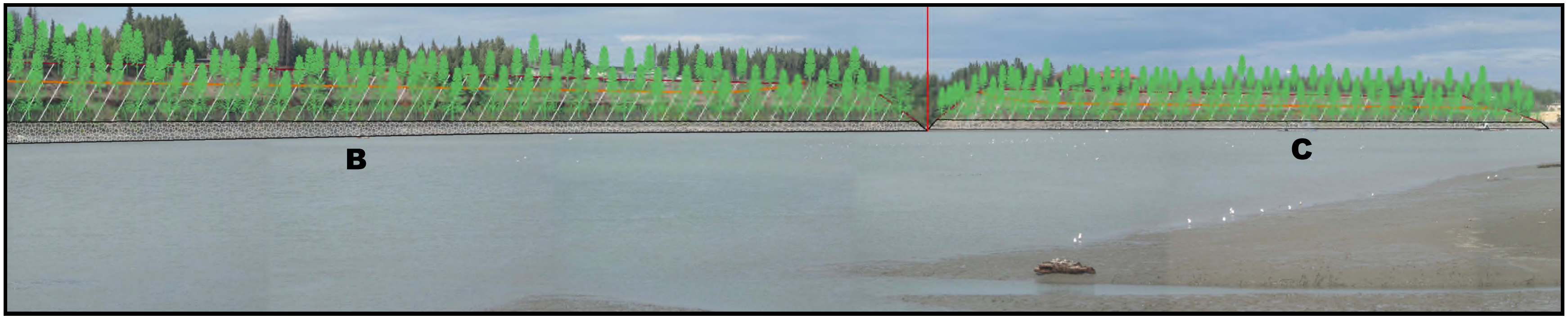


Figure G-5. Conceptual Bluff Elevation, Zone A (Top), Zone B and Zone C (bottom)

Table G-1: Design Sheet List

Kenai Bluff Stabilization		
Sheet List		
Sheet	Plate	Title
1	G-1	Cover, Vicinity, and Location
2	G-2	Sheet Index
3	G-3	Legend, Notes, and Abbreviations
4	G-4	Survey Control
5	G-5	Real Estate, Access and Staging
6	G-6	Erosion Control and Wetlands I
7	G-7	Erosion Control and Wetlands II
8	C-1	Civil Plan/Profile I
9	C-2	Civil Plan/Profile II
10	C-3	Civil Plan/Profile III
11	C-4	Civil Plan/Profile IV
12	C-5	Civil Plan/Profile V
13	C-6	Civil Plan/Profile VI
14	C-7	Civil Plan/Profile VII
15	C-8	Grading Cross Sections I
16	C-9	Grading Cross Sections II
17	C-10	Grading Cross Sections III
18	C-11	Typical Sections
19	C-12	Rock Revetment Details
20	C-13	Drainage Details
21	C-14	Miscellaneous Details
22	L-1	Planting Plan I
23	L-2	Planting Plan II
24	L-3	Planting Table and Details

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US Army Corps
of Engineers
Alaska District

KENAI BLUFF STABILIZATION

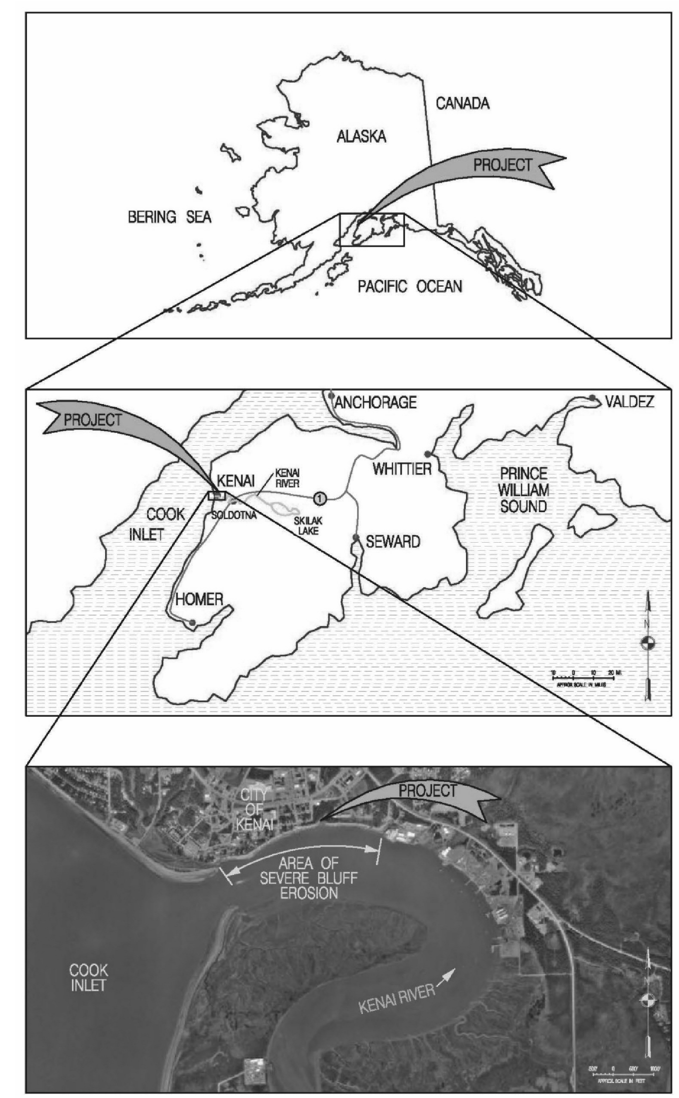
KENAI, ALASKA

PRELIMINARY DESIGN
02JUL2012

KENXXX

PN XXXXX

INV. NO. DACW85-03-D-0002



KENAI BLUFF STABILIZATION

KENAI, ALASKA

PRELIMINARY DESIGN - KENXXX/PN xxxxx, 02JUL2012
INV. NO. DACW85-03-D-0002

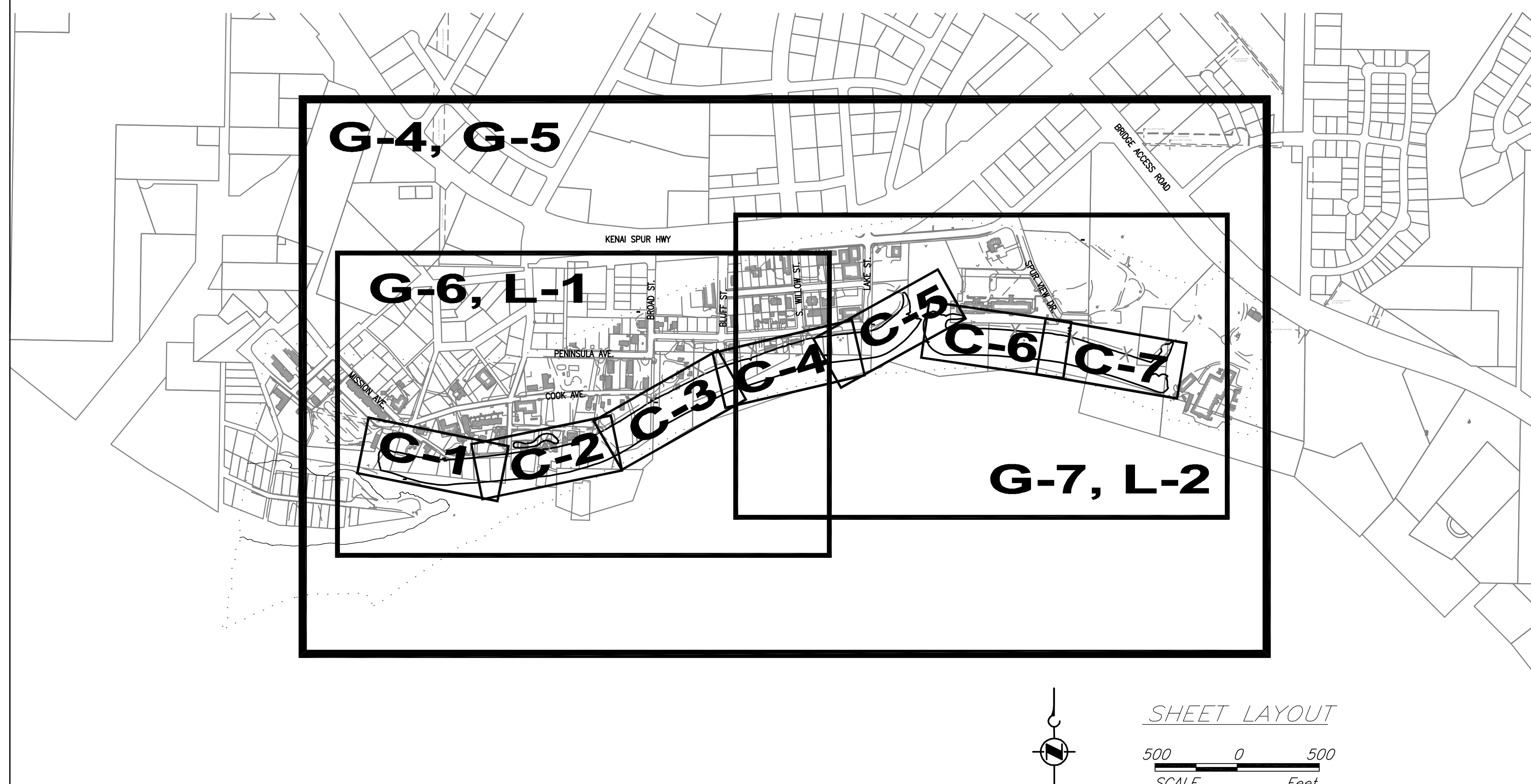
ALASKA DISTRICT U.S. ARMY CORPS OF ENGINEERS

SCHEDULE OF DRAWINGS

SHT	REF. NUM.	SHEET TITLE
		GENERAL
1	G-1	COVER, VICINITY, AND LOCATION
2	G-2	SHEET INDEX
3	G-3	LEGEND, NOTES, AND ABBREVIATIONS
4	G-4	SURVEY CONTROL
5	G-5	REAL ESTATE, ACCESS AND STAGING
6	G-6	EROSION CONTROL AND WETLANDS I
7	G-7	EROSION CONTROL AND WETLANDS II
		CIVIL
8	C-1	PROJECT PLAN AND SITE MAP
9	C-2	PROJECT PLAN AND SITE MAP
10	C-3	PROJECT PLAN AND SITE MAP
11	C-4	PROJECT PLAN AND SITE MAP
12	C-5	PROJECT PLAN AND SITE MAP
13	C-6	PROJECT PLAN AND SITE MAP
14	C-7	PROJECT PLAN AND SITE MAP
15	C-8	GRADING CROSS SECTIONS I
16	C-9	GRADING CROSS SECTIONS II
17	C-10	GRADING CROSS SECTIONS III
18	C-11	TYPICAL SECTIONS
19	C-12	ROCK REVETMENT DETAILS
20	C-13	DRAINAGE DETAILS
21	C-14	MISCELLANEOUS DETAILS
		LANDSCAPING PLANS
22	L-1	PLANTING PLAN I
23	L-2	PLANTING PLAN II
24	L-3	PLANTING TABLE AND DETAILS

SHT	REF. NUM.	SHEET TITLE

SHEET LAYOUT



Drawing C:\Projects\Kenai\GIS\dwg\2012\Kenai_G-2.dwg was plotted by Price, Krey on 06/16/11

LEGEND

EXISTING		PROPOSED
HV-312 93.57	AERIAL PANEL POINTS	DESIGN ELEVATION
	ANCHOR	GRADING LIMITS
	ANTENNA	5' MAJOR CONTOUR
AP-25	AUGER POINT	MINOR CONTOUR
	CATCH BASIN	CENTERLINE
	CATCH BASIN MANHOLE	FLOW PATH
	CLEANOUT	REG HIGH TIDE
	COMMUNICATION PED	REG HIGH WATER
EM	ELECTRIC METER	GEOTEXTILE
	ELECTRIC PEDESTAL	X WOOD FENCE
	FIRE HYDRANT	CUT AREA
	GUARD POST/BOLLARD	DEMOLITION AREA
	LIGHT POLE	COMPACTED FILL/ PIT-RUN GRAVEL
	MANHOLE	ARMOR "A" ROCK
MW	MONITORING WELL	SECONDARY "B" ROCK
	NATURAL GAS METER	CORE "C" ROCK
	POWER POLE	RIPRAP
	ROCK / BOULDER	SECONDARY RIPRAP
	SIGN	CRUSHED ROAD SFC
123.4	SPOT ELEVATION	
	TREE / BUSH	
	VENT PIPE	
	WATER VALVE	
	BUILDING	
	CONCRETE	
	CULVERT	
	CURB AND GUTTER	
	EDGE OF GRAVEL / DIRT	
	EDGE OF PAVEMENT	
	EDGE OF VEGETATION	
X	FENCE LINE	
	GUARD RAIL	
	REGULATORY HIGH TIDE (25.5 MLLW)	
	REGULATORY HIGH TIDE (19.1 MLLW)	
100	MAJOR CONTOUR	
	MINOR CONTOUR	

DISCLAIMER

THESE DOCUMENTS HAVE BEEN PREPARED FOR A SPECIFIC PROJECT AND SHALL NEITHER BE ALTERED NOR REUSED FOR ANY OTHER PURPOSE. ALSO, THESE DOCUMENTS DO NOT REPRESENT AS-BUILT CONDITIONS. IF THESE DOCUMENTS ARE ALTERED INTENTIONALLY OR UNINTENTIONALLY, OR REUSED WITHOUT THE DESIGN ENGINEER'S WRITTEN APPROVAL, IT WILL BE AT THE SOLE RISK AND RESPONSIBILITY OF THE USER. THE ACT OF ALTERING OR REUSING IS CONSTRUED AS INDEMNIFYING AND HOLDING THE DESIGN ENGINEERING FIRM AND ITS EMPLOYEES HARMLESS FROM ALL CLAIMS, DAMAGES, AND EXPENSES, INCLUDING ATTORNEY FEES, ARISING OUT OF SUCH ACT.

GENERAL NOTES

PROJECT LIMITS
ALL CONSTRUCTION ACTIVITY SHALL BE CONFINED TO THE PROJECT LIMITS (FOOTPRINT) INCLUDING THE STAGING/STOCKPILE AREA, DESIGNATED HAUL ROUTES AND PROJECT FEATURES AS SHOWN ON THE DRAWINGS, DO NOT DISTURB, EXCAVATE OR WORK BEYOND PROJECT LIMITS WITHOUT PERMISSION FROM CONTRACTING OFFICER OR REPRESENTATIVE.

SITE MAPPING
REPRESENTATIONS OF TRUE NORTH SHALL NOT BE USED TO IDENTIFY OR ESTABLISH THE BEARING OF TRUE NORTH AT THE JOB SITE. VERIFICATION OF MAPPING IS THE RESPONSIBILITY OF THE CONTRACTOR. CONTRACTOR IS RESPONSIBLE FOR ESTABLISHING AND MAINTAINING REQUIRED DATUM, BENCHMARKS, CONTROL LINES AND LEVELS.

SURVEY STAKING
SURVEY STAKING IS THE RESPONSIBILITY OF THE CONTRACTOR. SURVEY CONTROL POINTS EXISTS ON SITE, BUT SURVEY CONTROL LINES NEED FIELD LAYOUT.

PERMITS
THE CONTRACTOR SHALL COMPLY WITH ALL APPLICABLE REQUIREMENTS SET FORTH IN ALL PERMITS OBTAINED FOR THIS PROJECT. THE CONTRACTOR IS REQUIRED TO COMPLY WITH ALL CONSTRUCTION RELATED REQUIREMENTS IN EACH PERMIT.

UTILITIES
UTILITY LOCATIONS HAVE NOT BEEN SURVEYED. IT IS THE RESPONSIBILITY OF CONTRACTOR TO PERFORM ALL UTILITY LOCATIONS 48 HOURS PRIOR TO EXCAVATION, CALL (907) 278-3121. IT IS THE RESPONSIBILITY OF CONTRACTOR TO PROTECT ALL EXISTING SEWER, WATER, GAS AND ELECTRIC UTILITIES ENCOUNTERED IN THE WORK. ANY RELOCATION OR IMPROVEMENTS OF UTILITIES SHALL BE ACCURATELY NOTED ON AS-BUILT DRAWINGS AND ISSUED TO THE CONTRACTING OFFICER AT THE COMPLETION OF THE CONSTRUCTION.

TEMPORARY CONSTRUCTION FACILITIES
ALL TEMPORARY UTILITIES AND FACILITIES WILL BE THE RESPONSIBILITY OF THE CONTRACTOR. A CONSTRUCTION TRAILER IS NOT REQUIRED. POTABLE WATER AND ELECTRICITY ARE NOT AVAILABLE ON SITE AND SHALL BE PROVIDED BY CONTRACTOR. A CHEMICAL TOILET OF SUITABLE TYPE SHALL BE PROVIDED AND MAINTAINED BY THE CONTRACTOR AT ALL TIMES. THE CONTRACTOR IS RESPONSIBLE FOR JOB SITE CONDITIONS AND THE SAFETY OF HUMAN LIFE, DURING THE COURSE OF CONSTRUCTION. THIS REQUIREMENT SHALL APPLY CONTINUOUSLY DURING THE PERIOD OF CONSTRUCTION AND NOT LIMITED TO NORMAL WORKING HOURS. THE CONTRACTOR SHALL PROVIDE SIGNAGE AND BARRIERS NECESSARY TO PROVIDE SECURITY AND SAFETY TO WORKERS AND THE PUBLIC DURING THE ENTIRETY OF THE CONSTRUCTION PERIOD.

THE CONTRACTOR SHALL KEEP JOB SITE AREA CLEAN, HAZARD FREE AND DISPOSE OF ALL DEBRIS, RUBBISH AND CONSTRUCTION WASTE, AND REMOVE ALL MATERIALS FROM THE SITE. ALL DISTURBED STAGING AND ACCESS AREAS ARE TO BE REHABILITATED TO PRE-CONSTRUCTION CONDITION. THE CONTRACTOR IS RESPONSIBLE TO RECLAIM (REGRADE AND SEED) CONSTRUCTION FEATURES NOT SPECIFIED AS REMAINING ON THE SITE AND CLEAN UP ALL AREAS AT THE COMPLETION OF THE CONSTRUCTION.

ENVIRONMENTAL PROTECTION
ENVIRONMENTAL PROTECTION IS THE PREVENTION/CONTROL OF POLLUTION AND HABITAT DISRUPTION THAT MAY OCCUR TO THE ENVIRONMENT DURING CONSTRUCTION. THE CONTROL OF ENVIRONMENTAL POLLUTION AND DAMAGE REQUIRES CONSIDERATION OF LAND, WATER, AND AIR; BIOLOGICAL AND CULTURAL RESOURCES; AND INCLUDES MANAGEMENT OF VISUAL AESTHETICS; NOISE; SOLID, CHEMICAL, GASEOUS, AND LIQUID WASTE; RADIANT ENERGY AND RADIOACTIVE MATERIAL AS WELL AS OTHER POLLUTANTS. THE CONTRACTOR SHALL MINIMIZE ENVIRONMENTAL POLLUTION AND DAMAGE THAT MAY OCCUR AS THE RESULT OF CONSTRUCTION OPERATIONS. THE ENVIRONMENTAL RESOURCES WITHIN THE PROJECT BOUNDARIES AND THOSE AFFECTED OUTSIDE THE LIMITS OF PERMANENT WORK SHALL BE PROTECTED DURING THE ENTIRE DURATION OF THIS CONTRACT. THE CONTRACTOR SHALL COMPLY WITH ALL APPLICABLE ENVIRONMENTAL FEDERAL, STATE, AND LOCAL LAWS AND REGULATIONS.

THE CONTRACTOR IS RESPONSIBLE FOR IMPLEMENTING AND UTILIZING BEST MANAGEMENT PRACTICES (BMPS) TO PREVENT STORMWATER RUNOFF AND WATER POLLUTION DURING CONSTRUCTION ACTIVITIES. CONTRACTOR SHALL PROVIDE COR WITH STORMWATER POLLUTION PREVENTION PLAN (SWPPP) FOR APPROVAL PRIOR TO CONSTRUCTION. THE CONTRACTOR SHOULD USE CAUTION WHEN WORKING IN AND AROUND LOCAL DUMPING AREAS. IF POTENTIAL HAZARDOUS MATERIALS ARE ENCOUNTERED, THE CONTRACTING OFFICE SHOULD BE CONTACTED IMMEDIATELY.

CONSTRUCTION SPOILS AND WASTE HANDLING
ALL CONSTRUCTION SPOILS AND WASTE SHALL BE DISPOSED OF AT AN APPROVED DISPOSAL SITE AND/OR LANDFILL FACILITY.

CLEARING AND GRUBBING
EXISTING ON-SITE MATERIALS SHALL BE CAREFULLY REMOVED AND STORED, OR DISPOSED OF. COMPLETELY REMOVE STUMPS, ROOTS, WILLOWS, SHRUBS, WEEDS, AND OTHER DEBRIS PROTRUDING FROM THE GROUND IN AREAS TO BE EXCAVATED. ALL CLEARED AND GRUBBED STUMPS, ROOTS, WILLOWS, SHRUBS, WEEDS, AND LIMBS SHALL BE DISPOSED PER CONSTRUCTION WASTE HANDLING SPECIFICATIONS. TREES DESIGNATED TO BE CLEARED, SHALL BE DISPOSED OF BY THE CONTRACTOR.

SITE EARTHWORK AND GRADING
THE CONTRACTOR IS RESPONSIBLE FOR ALL SITE EARTHWORK AND GRADING ACTIVITIES TO MEET DESIGNS IDENTIFIED IN PLANS AND DETAILS, WHICH ARE INTENDED TO SHOW FINAL RESULT OF DESIGN. MODIFICATIONS MAY BE REQUIRED TO SUIT JOB SITE CONDITIONS AND SHALL BE INCLUDED IN AS-BUILT DRAWINGS PROVIDED TO CONTRACTING OFFICER AT COMPLETION OF CONSTRUCTION. AT THE END OF EACH DAY OF WORK THE CONTRACTOR SHALL MAINTAIN ALL EXPOSED AREAS AS ACCEPTABLE TO COR AND PERMIT REQUIREMENTS.

BACKFILL MATERIAL SHALL BE IN ACCORDANCE WITH THE SPECIFICATIONS. ADDITIONAL IMPORTED FILL MATERIAL MAY BE REQUIRED FOR CONSTRUCTION ALONG THE LANDWARD SIDE OF THE ARMORED EMBANKMENT IF THE OPTION IS EXERCISED. ALL MATERIAL SHALL BE FREE FROM ORGANIC MATTER, SILTS, CLAYBALLS AND OTHER DELETERIOUS MATERIALS EXCEPT WHERE EXPLICITLY STATED.

ABBREVIATIONS

AC	ACRE
APPROX	APPROXIMATE
BDY	BOUNDARY
BOB	BASIS OF BEARING
BM	BENCH MARK
BMP	BEST MANAGEMENT PRACTICES
CLR	CLEARANCE
CMP	CORRUGATED METAL PIPE
CONC	CONCRETE
CONT	CONTINUE
COR	CONTRACTING OFFICER'S REPRESENTATIVE
DIA	DIAMETER
DET	DETAIL
D/S	DOWNSTREAM
E	EAST, EASTING
EA	EACH
EL	ELEVATION
EG	EXISTING GRADE
EP	EDGE OF PAVEMENT
EXIST	EXISTING
FG	FINISH GRADE
G1	ENTRANCE GRADE
G2	EXIT GRADE
GB	GRADE BREAK
GRND	GROUND
H, HORIZ	HORIZONTAL
HGL	HYDRAULIC GRADE LINE
IE	INVERT ELEVATION
INV	INVERT
LF	LINEAR FOOT
MAX	MAXIMUM
MIN	MINIMUM
N	NORTH, NORTHING
N/A	NOT APPLICABLE
NTS	NOT TO SCALE
OC	ON CENTER
OD	OUTSIDE DIAMETER
PERM	PERMANENT
PCL	PRIMARY CONTROL LINE
PC	POINT OF CURVATURE
POC	POINT ON CURVE
POB	POINT OF BEGINNING
POE	POINT OF END
PI	POINT OF INTERSECTION
PRV	PRIVATE
PVI	POINT OF VERTICAL INTERCEPT
PVT	POINT OF VERTICAL TANGENCY
PT	POINT OF TANGENCY
POT	POINT ON TANGENT
PROP	PROPOSED
PUB	PUBLIC
Q	FLOW
R	RADIUS
R/W	RIGHT OF WAY
REINF	REINFORCED
REG	REGULATORY
S	SOUTH
SCL	SECONDARY CONTROL LINE
SF	SQUARE FEET
SS	SANITARY SEWER
SPEC	SPECIFICATION
STA	STATION
SW	SIDEWALK
SWPPP	STORMWATER POLLUTION PREVENTION PLAN
SY	SQUARE YARD
TBD	TO BE DETERMINED
TOB	TOP OF BANK
TOE	TOE OF BANK
TYP	TYPICAL
ULT	UNDER GROUND
VERT	VERTICAL
W	WEST
WSEL	WATER SURFACE ELEVATION

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_G-3

Designed: KHP
Drawn: MRG
Reviewed: YHC

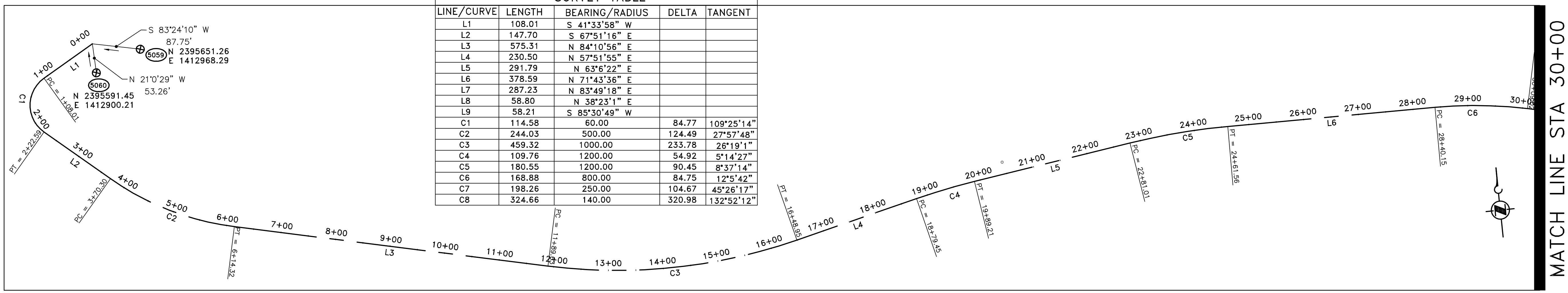
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

TETRA TECH, INC.

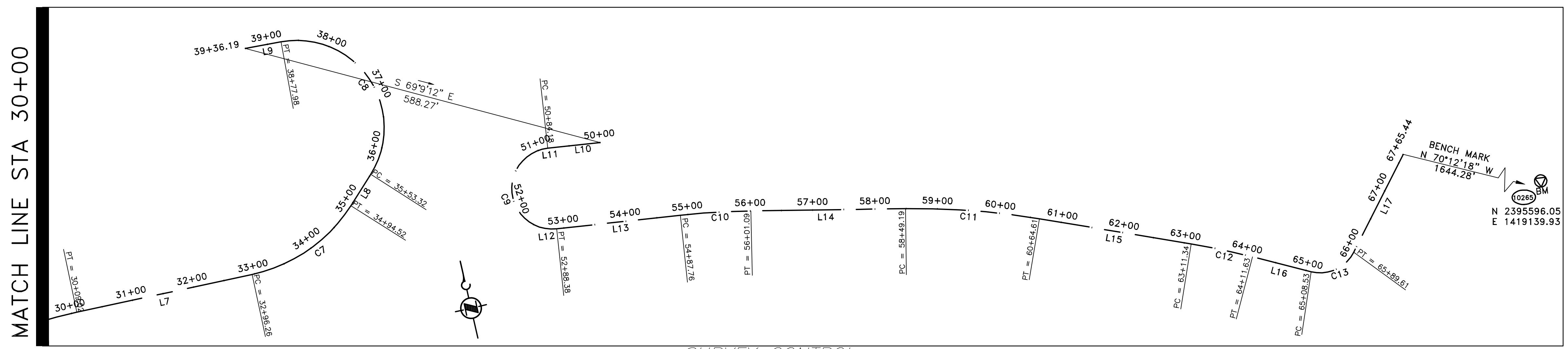
KENAI BLUFF STABILIZATION
KENAI, ALASKA

LEGEND, NOTES, AND ABBREVIATIONS

Reference number:
G-3
Sheet 3 of 24



LINE/CURVE	LENGTH	BEARING/RADIUS	DELTA	TANGENT
L1	108.01	S 41°33'58" W		
L2	147.70	S 67°51'16" E		
L3	575.31	N 84°10'56" E		
L4	230.50	N 57°51'55" E		
L5	291.79	N 63°6'22" E		
L6	378.59	N 71°43'36" E		
L7	287.23	N 83°49'18" E		
L8	58.80	N 38°23'1" E		
L9	58.21	S 85°30'49" W		
C1	114.58	60.00	84.77	109°25'14"
C2	244.03	500.00	124.49	27°57'48"
C3	459.32	1000.00	233.78	26°19'1"
C4	109.76	1200.00	54.92	5°14'27"
C5	180.55	1200.00	90.45	8°37'14"
C6	168.88	800.00	84.75	12°5'42"
C7	198.26	250.00	104.67	45°26'17"
C8	324.66	140.00	320.98	132°52'12"



SURVEY CONTROL

100 0 100
SCALE Feet

AEROMETRIC AERIAL MAPPING NOTES

1. This map was compiled to meet horizontal accuracy in accordance with ASPRS Class II Accuracy Standards.
2. This map was compiled to meet vertical accuracy in accordance with ASPRS Class II Accuracy Standards.
3. Areas denoting vegetation cover on the ground should be considered less accurate and not used for engineering purposes until field checked in accordance with ASPRS Accuracy Standards.
4. The map projection is Alaska State Plane, Zone 4, NAD83 as expressed in U.S. Survey Feet.
5. Vertical data is referenced to MLLW based on NOAA Tidal Station "Nikiski".
6. This map is based on photography acquired 09-27-2007 at a nominal scale of 1"=300'.
7. This map produced for output at a scale of 1"=100' with a contour interval of 1 foot.

PHOTO CONTROL SURVEY NOTES

1. The information provided here is based on Aerial Mapping produced by Aerometric and controlled by field surveys performed by R&M Consultants. The aerial photography was acquired September 9th, 2007. R&M Control Surveys took place in 2007 and 2008.
2. Primary horizontal control and aerial photo control was established using Static GPS techniques with Trimble duel frequency receivers. GPS vectors were adjusted using simultaneous least-squares methods.
3. Project coordinates are referenced to the Alaska Coordinate System of 1983 (ACS83), Zone 4 values, reported in U.S. Survey Feet and are based on Survey Control Station "McLane CP 1" as shown on the DOWL Engineers drawing "Kenai River Bluff Erosion Survey Topography" dated July 16, 2003. McLane CP 1 zone 4 coordinates = N 2,395,666.774, E 1,419,401.413.
4. Project bearings are NAD83 Zone 4 state plane grid bearings based on GPS adjusted measurements constrained at McLane CP 1.
5. Primary vertical control was established with a combination of Trimble dual frequency GPS measurements and differential leveling. GPS measurements incorporated Geoid06. Differential levels were performed with a Leica DNA10 digital level and barcode rod.
6. Project vertical datum is referenced to Mean Lower Low Water (MLLW) based on NOAA Tidal Station Nikiski, Station ID No. 945 5760, publication date 10/30/2003. Station Nikiski is referenced by BM No. 8, et al., which was held for all project elevations (BM No. 8 elevation was verified by measurements to BM Nos. 7 & 9). The official station designation for BM No. 8 is "945 5760 TIDAL 8" (see PID No. AB7150). NOAA MLLW elevation for BM No. 8 = 109.659 U.S. Survey Feet (33.424 meters).

   Elevations were transferred from BM No. 8 roughly 10 miles south to the project site using the following sequence:

BM No. 8 to nearby set point CP 51	Differential levels.
CP 51 to McLane CP 1	GPS & Geoid06
CP 1 to nearby Kenai BM No. 3	Differential levels.

   Note that CP 1 is vertically unstable and that Kenai BM No. 3 has been used to control and adjust the elevation of CP 1 at each visit for GPS observations. The most recent visit found CP 1 with aluminum cap lying nearby. The cap was reset and the elevation reestablished from Kenai BM No. 3. The elevation for Kenai BM No. 3, established from Nikiski, is 31.18 feet.

   Elevations of tidal datums referred to station Nikiski MLLW in feet:

Highest Observed Water Level (12/26/1976)	= 29.02
Mean Higher High Water (MHHW)	= 20.42
Mean High Water (MHW)	= 19.68
Mean Sea Level (MSL)	= 11.18
North American Vertical Datum-1988 (NAVD88)	= 6.76
Mean Low Water (MLW)	= 2.05
Mean Lower Low Water (MLLW)	= 0.00
Lowest Observed Water Level (12/25/1899)	= -6.37

7. Aerial Mapping contours were ground-truthed using RTK GPS broadcasted from station McLane CP 1. Elevations fit well in areas without foliage and less well where trees and brush existed. No extreme discrepancies were discovered.
8. Geotechnical borehole positions were located using RTK GPS together with differential levels.
9. The contour interval shown is one foot.
10. Property lines, street rights-of-way, street names, etc. were taken from the Kenai Peninsula Borough (KPB) Geographical Information Systems (GIS) website. The KPB GIS was inserted and fit to physical features within the aerial mapping (street intersections, etc).

LINE	LENGTH	BEARING	DELTA	TANGENT
L10	84.18	S 89°45'1" W		
L11	0.00	N 89°45'1" E		
L12	0.00	S 89°45'1" W		
L13	199.38	N 89°45'1" E		
L14	248.09	S 84°50'18" E		
L15	246.73	S 74°33'10" E		
L16	96.90	S 69°45'50" E		
L17	175.83	N 32°48'54" E		
C9	204.20	65.00	180°0'2"	INFINITE
C10	113.34	1200.00	5°24'41"	56.71
C11	215.42	1200.00	10°17'8"	108.00
C12	100.30	1200.00	4°47'20"	50.18
C13	81.08	60.00	77°25'16"	48.09

MONUMENT LEGEND

- RECOVERED BLM MONUMENT
- RECOVERED PRIMARY MONUMENT (BRASS CAP)
- RECOVERED PRIMARY MONUMENT (ALCAP)
- RECOVERED SECONDARY MONUMENT
- SET PRIMARY SURVEY CONTROL POINT
- BENCH MARK
- TEMPORARY BENCH MARK
- 123 SURVEY POINT NUMBER

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_G-4
Designed: KHP
Drawn: MRG
Reviewed: YHC

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

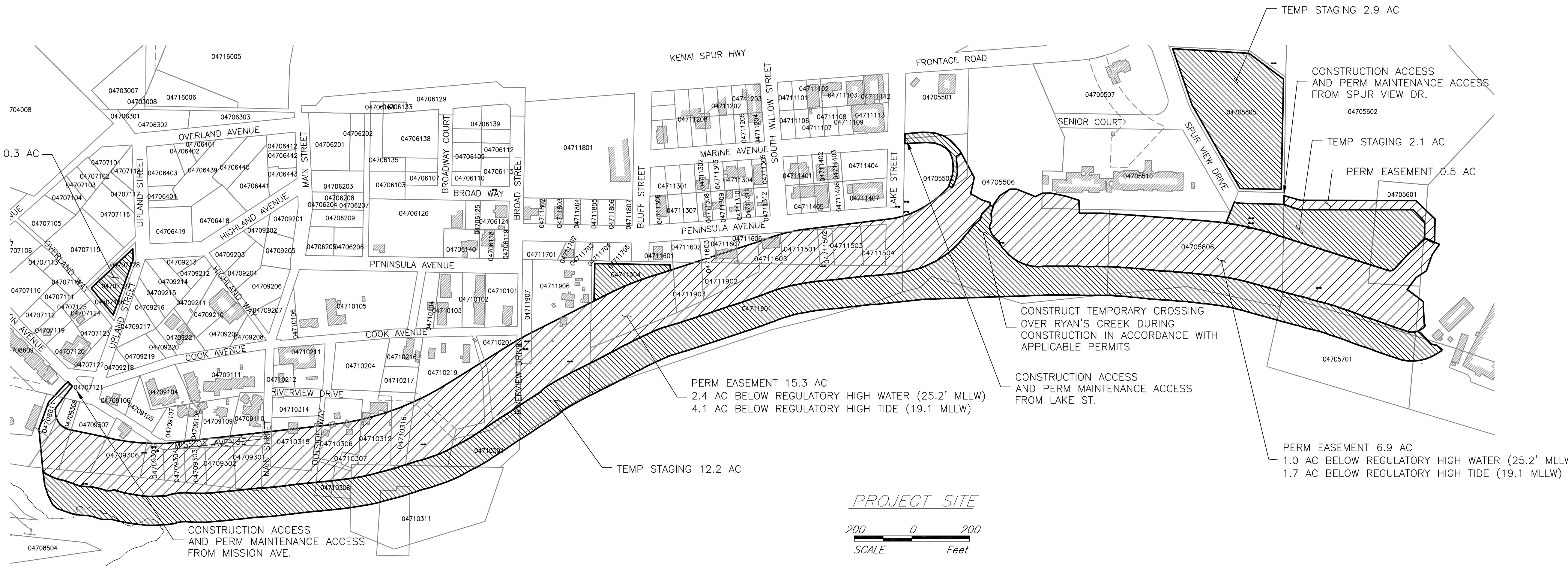
TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA

SURVEY CONTROLS

Reference number:
G-4

Sheet 4 of 24



KEY

PERMENANT EASEMENT

TEMPORARY EASEMENT

PROJECT EASEMENT AREAS BY PARCEL

Parcel ID	Ownership Type	Usage	Required Easement (Acres)	Total Lot Size (Acres)	Required Easement (% of Lot)	Affected Structures (square feet)	Owner
4709308	PRV	VA	0.41	0.41	100%	0	OCONNELL ROBERT D ET AL, SWARNER LINDA
4709307	PUB	VA	0.64	0.64	100%	0	CITY OF KENAI
4709306	PRV	RS	0.44	0.58	76%	0	SHOWALTER JENNIFER F
4709305	PUB	VA	0.19	0.19	100%	0	KENAI CITY OF
4709304	PRV	VA	0.19	0.19	100%	0	WEBBER CHARLES R
4709303	PRV	VA	0.21	0.21	100%	0	KNIGHT KEITH K
4709302	PUB	VA	0.32	0.32	100%	0	KENAI CITY OF
4709301	PRV	VA	0.33	0.33	100%	0	KENAI BIBLE CHURCH
4709109	PRV	RS	0.004	0.37	1%	0	ANDERSON HARRY K & NELLIE MAE
4709110	PRV	CH	0.02	0.35	7%	0	KENAI BIBLE CHURCH
4710315	PRV	RS	0.63	0.63	100%	1314	LOFSTEDT DIANA
4710308	PRV	VA	0.17	0.30	56%	0	STERLING GLENDA A ET AL, MCCANN BILLY ESTATE
4710306	PRV	CM	0.63	0.63	100%	1938	LOFSTEDT DIANA
4710307	PRV	VA	0.06	0.06	100%	0	ERREA JULIAN & HILDERBRAND DAN L
4710311	PRV	VA	0.10	2.77	4%	0	CLARK RUSSELL S
4710312	PRV	RS	0.43	0.57	76%	3137	FOSTER GARY L & KATHLEEN
4710316	PRV	VA	0.30	0.33	91%	0	SEELINGER DONALD P
4710219	PRV	RS	0.66	1.40	47%	0	SEELINGER DONALD P
4710301	PUB	VA	0.03	0.69	4%	0	KENAI CITY OF
4710201	PRV	VA	0.47	0.62	75%	0	PETERKIN ROBERT T & BONNIE
4711907	PUB	VA	0.08	0.29	27%	0	CITY OF KENAI
4711906	PRV	RS	1.13	2.67	42%	637	KARAFFA PAUL P & CONSIEL ROGER D

Parcel ID	Ownership Type	Usage	Required Easement (Acres)	Total Lot Size (Acres)	Required Easement (% of Lot)	Affected Structures (square feet)	Owner
4711904	PRV	VA	1.08	1.60	67%	0	VANN RICKY L & CONNIE L TRUSTEES
4711901	PRV	VA	2.98	4.31	69%	0	JOHNSON JAMES E, JOHNSON LANCET ANN ET AL
4711903	PRV	VA	0.35	0.35	100%	0	COOPER DOROTHY M
4711902	PRV	VA	0.36	0.36	100%	0	SANDS PATRICIA R TRUSTEE B B SANDS
4711603	PRV	AB	0.02	0.10	20%	0	FREITAG HERBERT & JUDITH
4711602	PUB	VA	0.18	0.18	100%	0	KENAI CITY OF
4711607	PRV	RS	0.07	0.16	42%	2369	VANHORNE ALAN K & MARIAN F
4711606	PRV	VA	0.11	0.17	65%	0	HANNAH TONEY A & LINDA M
4711605	PRV	CM	0.17	0.19	86%	2040	HUTCHINGS STEPHEN PAUL SR CUST
4711501	PRV	VA	0.35	0.35	100%	0	ALASKA LABORERS BUILDING CORP
4711502	PRV	VA	0.14	0.14	100%	0	YOUNG WILLIAM C TRUSTEE
4711503	PRV	VA	0.30	0.30	100%	0	CENTRAL PENINSULA MENTAL HEALTH
4711504	PRV	VA	0.27	0.27	100%	0	LEDOUX CLARENCE E SR ESTATE OF
4705506	PUB	VA	3.14	8.22	38%	0	CITY OF KENAI
4205502	PUB	VA	0.22	1.11	20%	0	CITY OF KENAI
4705501	PRV	CH	0.02	1.14	2%	0	SHELDON DENTON SHILLING
4705510	PUB	VA	0.14	3.43	4%	0	CITY OF KENAI
4705806	PUB	VA	3.13	3.37	93%	0	CITY OF KENAI
4705602	PUB	VA	3.24	14.98	22%	0	PACIFIC STAR SEAFOODS INC
4705601	PRV	CH	1.24	1.43	87%	0	DIOCESE OF SITKA & ALASKA ORTHODOX
4705703	PRV	ID	0.32	14.50	2%	0	PACIFIC STAR SEAFOODS INC

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

TETRA TECH, INC.

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_G-5

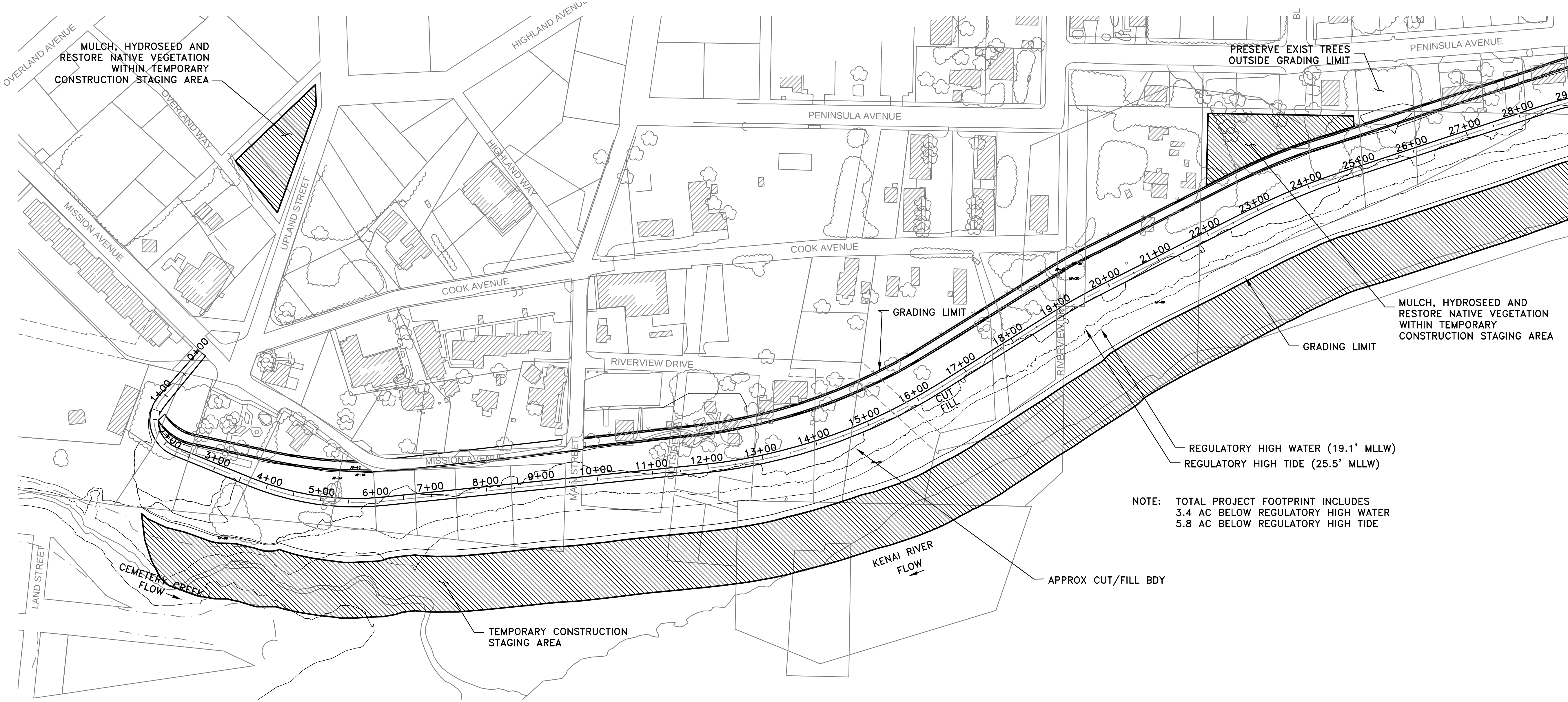
Designed: KHP
Drawn: MRG
Reviewed: YHC

KENAI BLUFF STABILIZATION
KENAI, ALASKA

REAL ESTATE, ACCESS AND STAGING

Reference number:
G-5

Sheet 5 of 24



MATCH LINE SEE SHEET G-7

NOTE:
CONTRACTOR SHALL SUBMIT STORMWATER POLLUTION PREVENTION PLAN (SWPPP) FOR APPROVAL PRIOR TO CONSTRUCTION. SWPPP MAY INCLUDE TEMPORARY SILT FENCES, TURBIDITY CURTAINS, STRAW BALES, OR OTHER BMPS AND SHALL DEMONSTRATE ADHERENCE WITH ALL APPLICABLE ENVIRONMENTAL GUIDELINES.

EROSION CONTROL AND WETLAND PLAN

100 0 100
SCALE Feet

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

CONTRACT NO.
CONTRACTOR
CITY STATE
Recommended: PRIME CONTRACTOR
Approved: RESIDENT ENGINEER
Date:

Sym | Action | Description | Date | Appr

Date: JULY 2012
Dwg Scale: AS NOTED
Plot Scale:
File: Kenai_G-6
Drawing #:

Designed: KHP
Drawn: MRG
Reviewed: YHC
Submitted:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

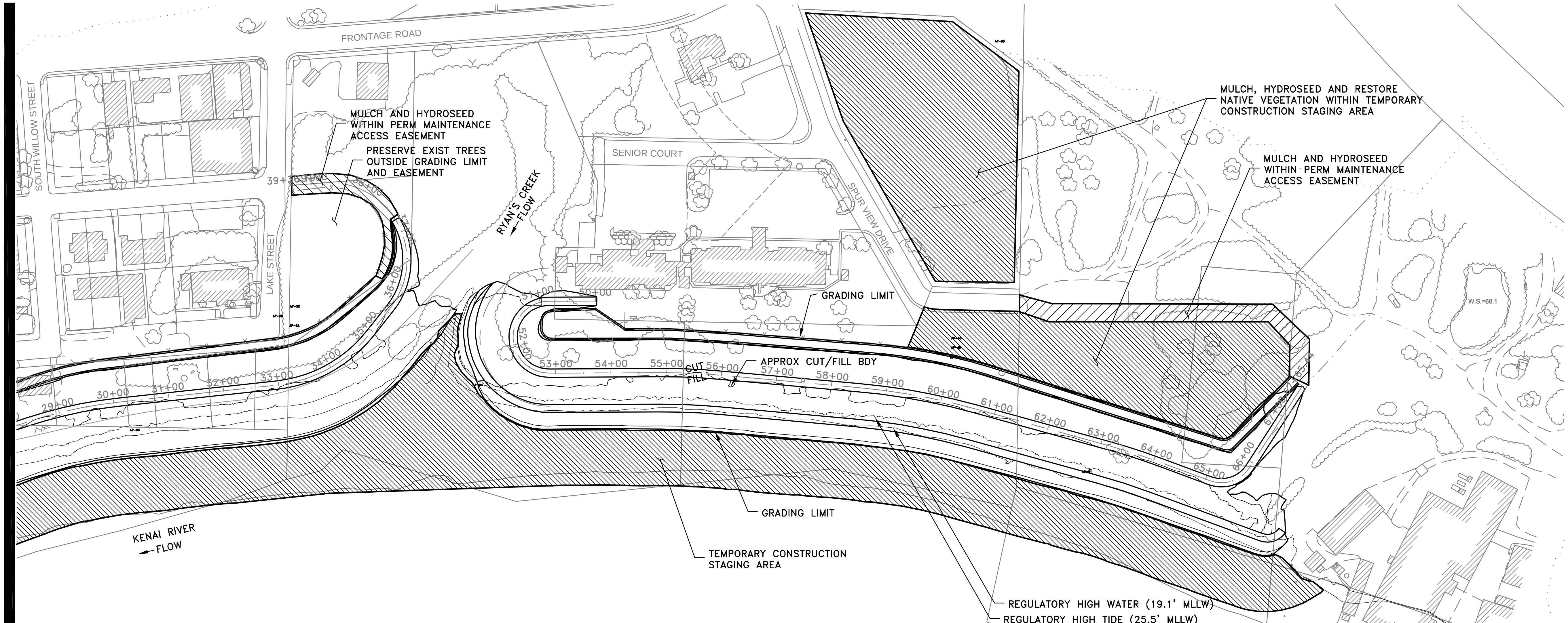
TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA
GENERAL
EROSION CONTROL AND WETLANDS I

PRELIMINARY DESIGN

Reference number:
G-6
Sheet 6 of 24

MATCH LINE SEE SHEET G-6



EROSION CONTROL AND WETLAND PLAN

100 0 100
SCALE Feet

NOTE:
CONTRACTOR SHALL SUBMIT STORMWATER POLLUTION PREVENTION PLAN (SWPPP) FOR APPROVAL PRIOR TO CONSTRUCTION. SWPPP MAY INCLUDE TEMPORARY SILT FENCES, TURBIDITY CURTAINS, STRAW BALES, OR OTHER BMPS AND SHALL DEMONSTRATE ADHERENCE WITH ALL APPLICABLE ENVIRONMENTAL GUIDELINES.

NOTE: TOTAL PROJECT FOOTPRINT INCLUDES
3.4 AC BELOW REGULATORY HIGH WATER
5.8 AC BELOW REGULATORY HIGH TIDE

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

CONTRACT NO.
CONTRACTOR
CITY STATE
Recommended: Approved: Date:
PRIME CONTRACTOR RESIDENT ENGINEER

Sym	Action	Description	Date	Approval

Date: JULY 2012
Dwg Scale: AS NOTED
Plot Scale:
File: Kenai_G-7
Drawing #:

Designed: KHP
Drawn: MRG
Reviewed: YHC
Submitted:

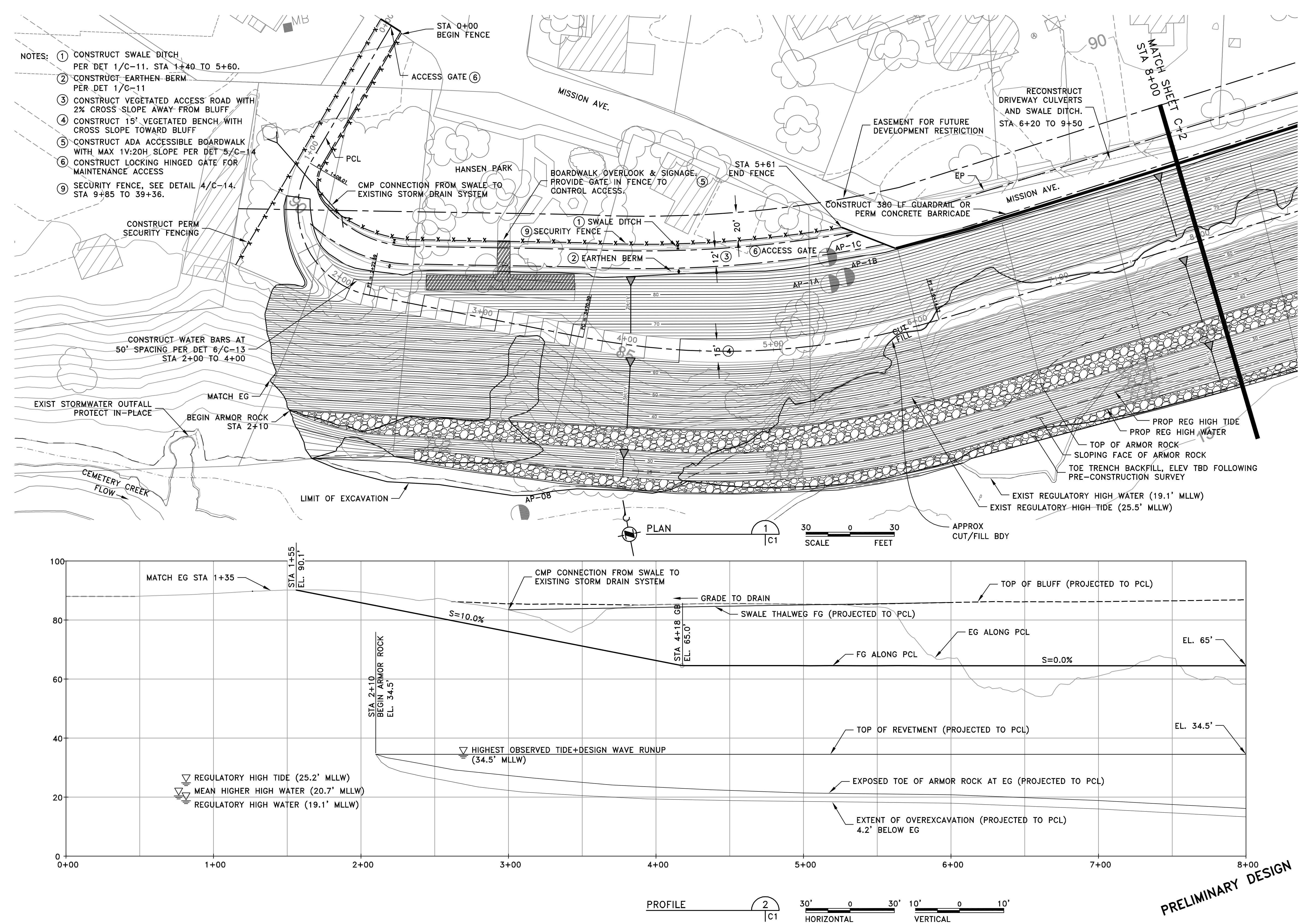
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA
GENERAL
EROSION CONTROL AND WETLANDS II

Reference number:
G-7

Sheet 7 of 24



US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_C-1

Designed: KHP
Drawn: MRG
Reviewed: YHC

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA

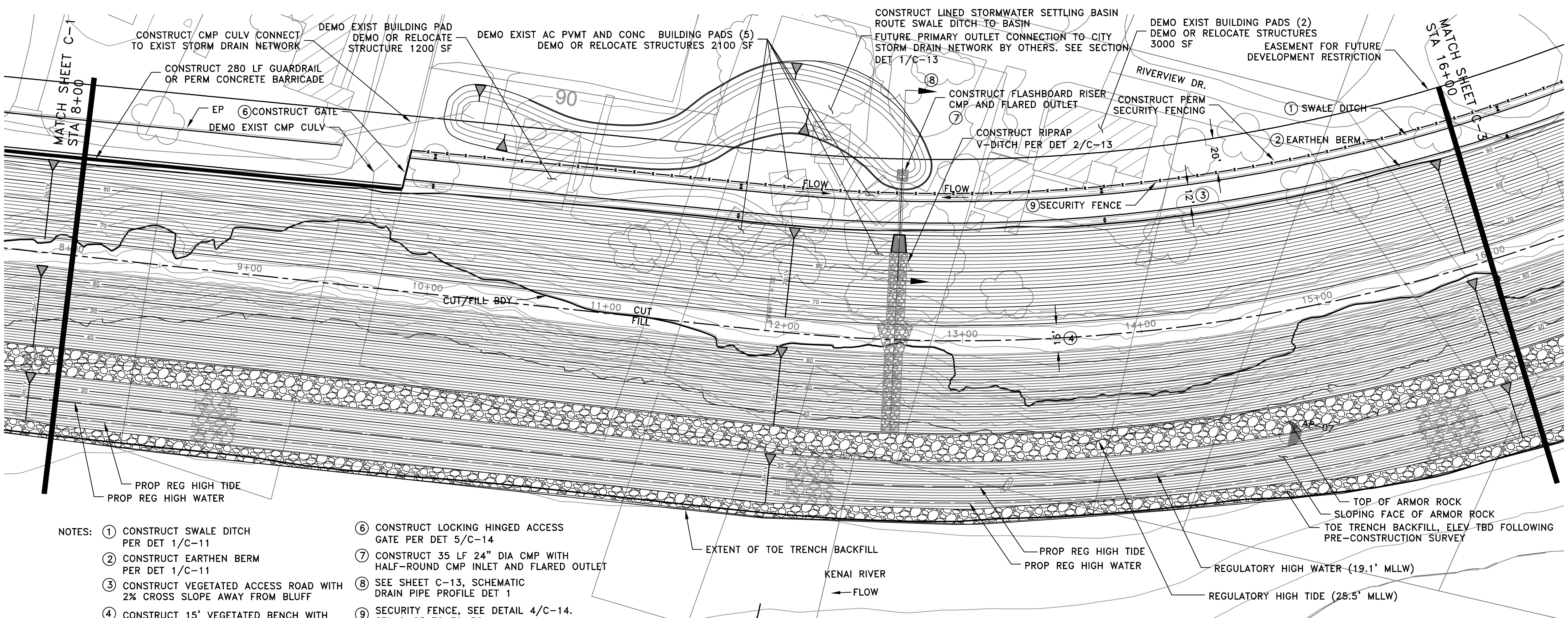
TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA

PROJECT PLAN AND SITE MAP

Reference number:
C-1

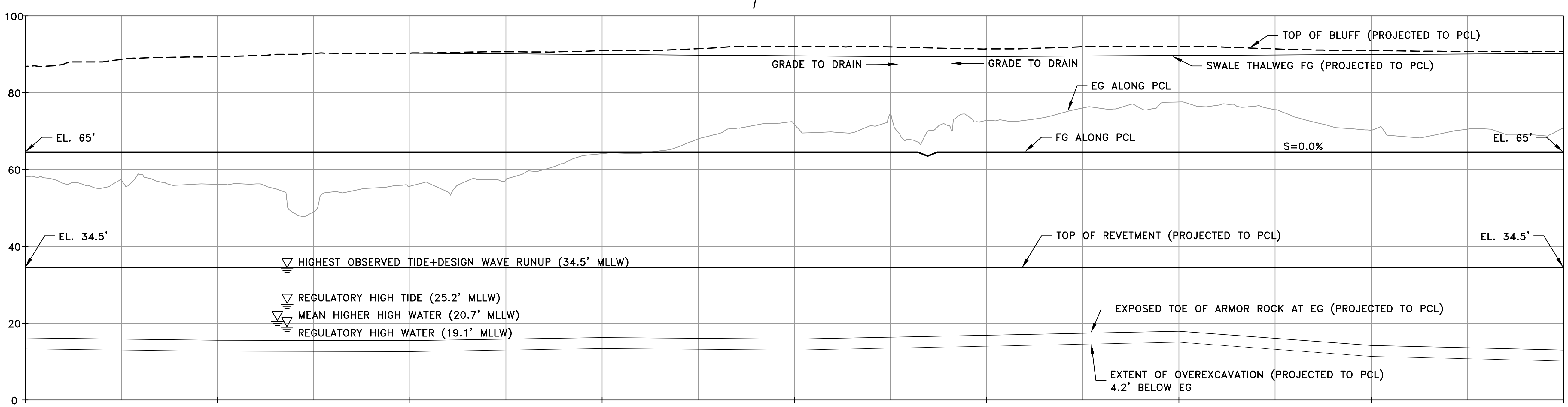
Sheet 8 of 24



NOTES:
1. CONSTRUCT SWALE DITCH PER DET 1/C-11
2. CONSTRUCT EARTHEN BERM PER DET 1/C-11
3. CONSTRUCT VEGETATED ACCESS ROAD WITH 2% CROSS SLOPE AWAY FROM BLUFF
4. CONSTRUCT 15' VEGETATED BENCH WITH 2% CROSS SLOPE TOWARD BLUFF
6. CONSTRUCT LOCKING HINGED ACCESS GATE PER DET 5/C-14
7. CONSTRUCT 35 LF 24" DIA CMP WITH HALF-ROUND CMP INLET AND FLARED OUTLET
8. SEE SHEET C-13, SCHEMATIC DRAIN PIPE PROFILE DET 1
9. SECURITY FENCE, SEE DETAIL 4/C-14. STA 9+85 TO 39+36.

PLAN 1 / C2

SCALE 30 0 30 FEET



PROFILE 2 / C2

30' 0 30' HORIZONTAL

10' 0 10' VERTICAL

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

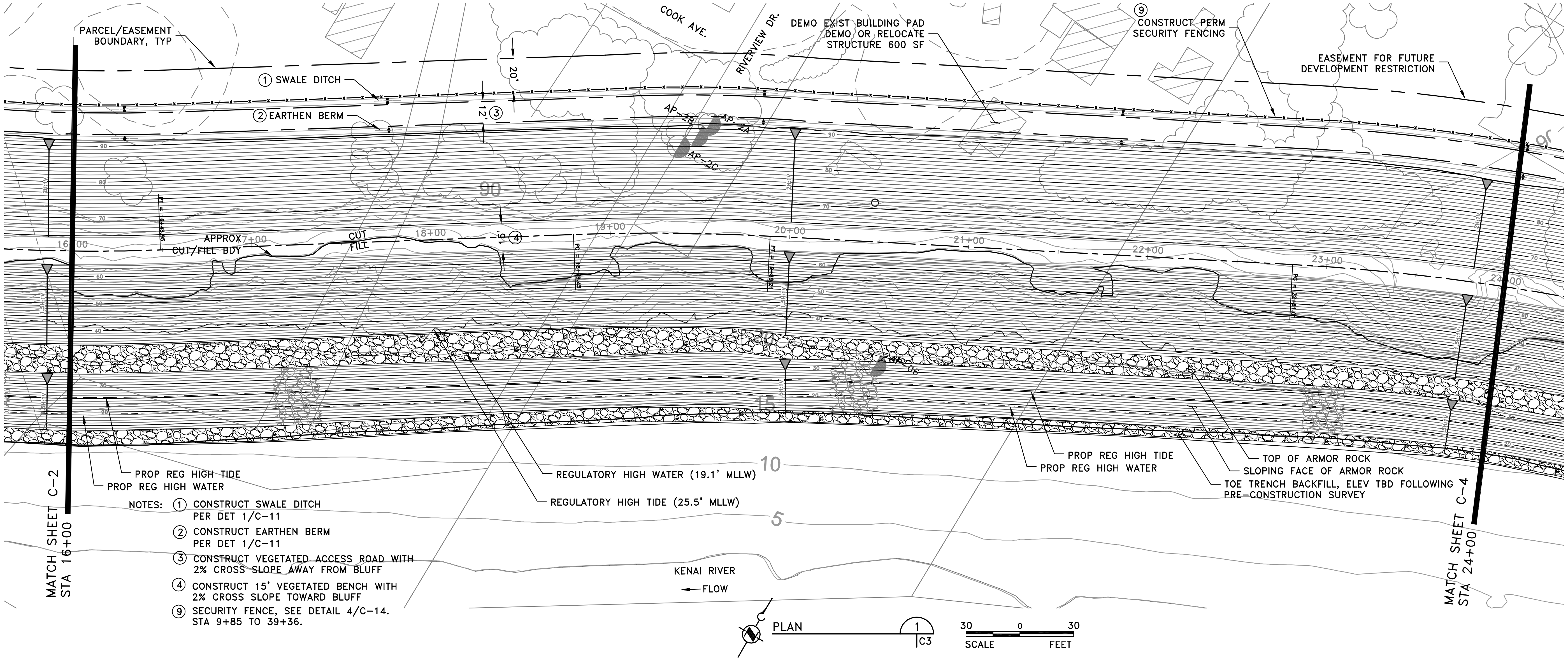
Designed: KHP
Drawn: MRG
Reviewed: YHC
Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_C-2

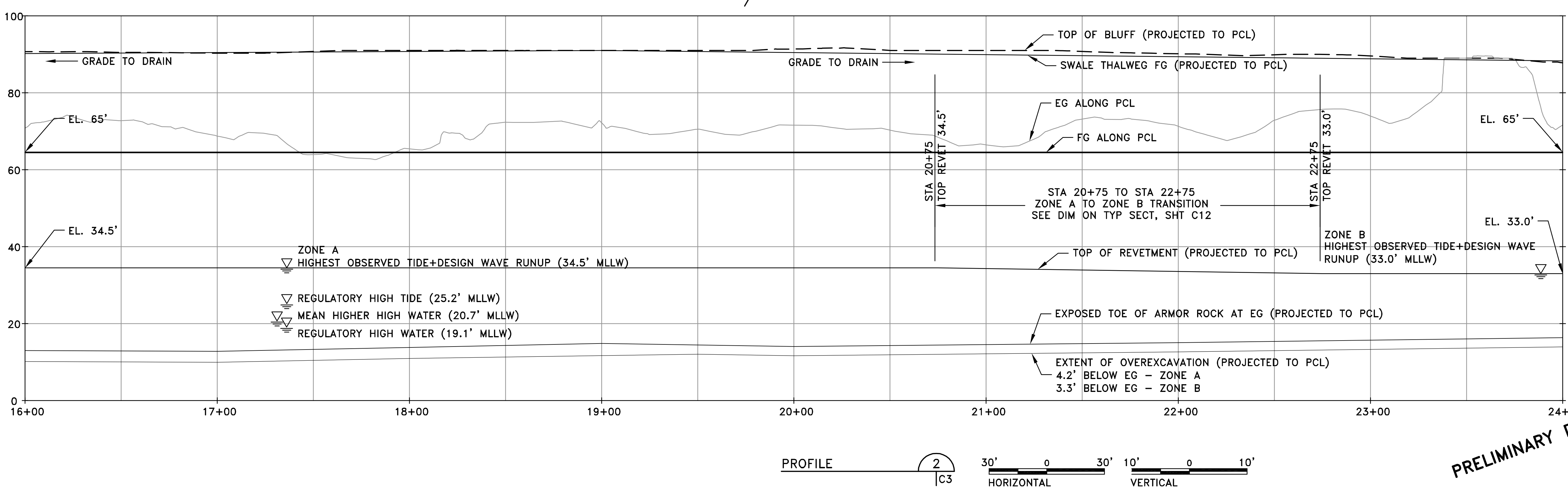
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA

TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA
CIVIL
PROJECT PLAN AND SITE MAP

Reference number:
C-2
Sheet 9 of 24





PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_C-3

Designed: KHP
Drawn: MRG
Reviewed: YHC

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA

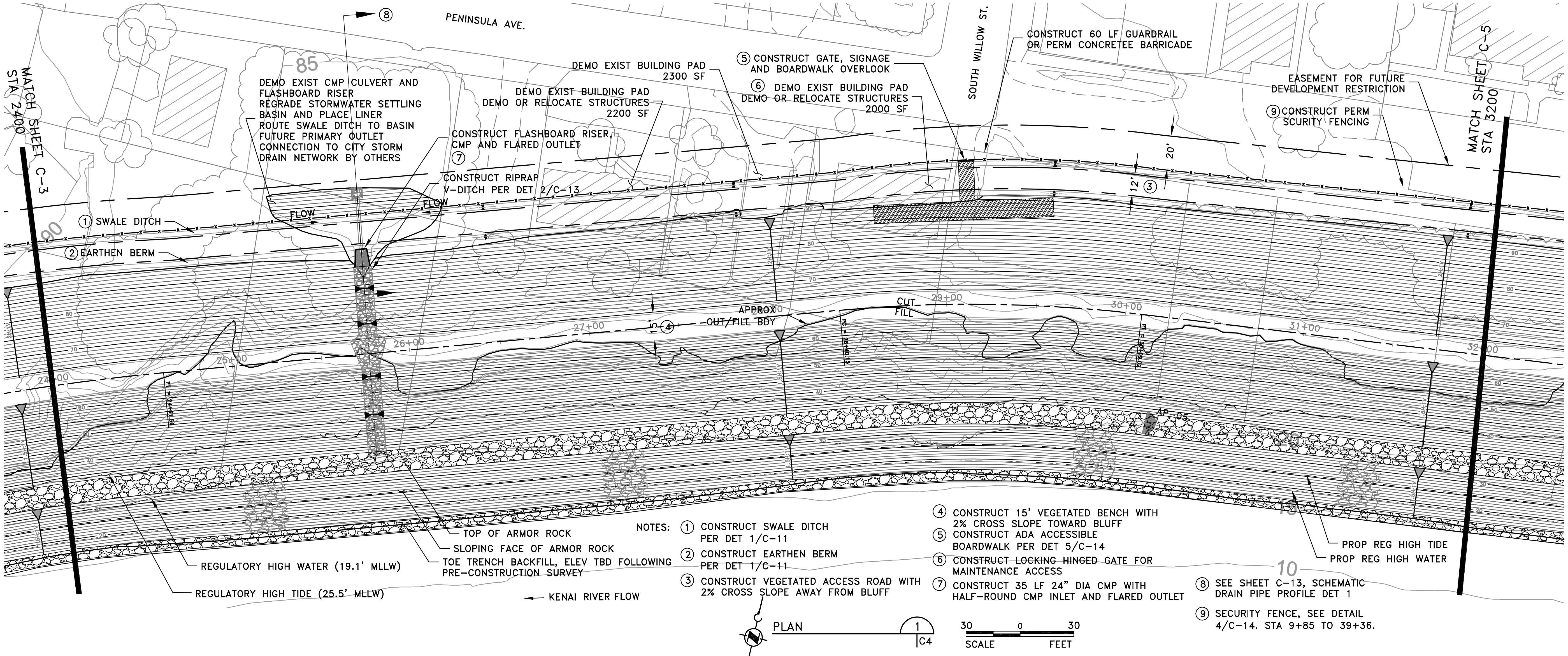
TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA

PROJECT PLAN AND SITE MAP

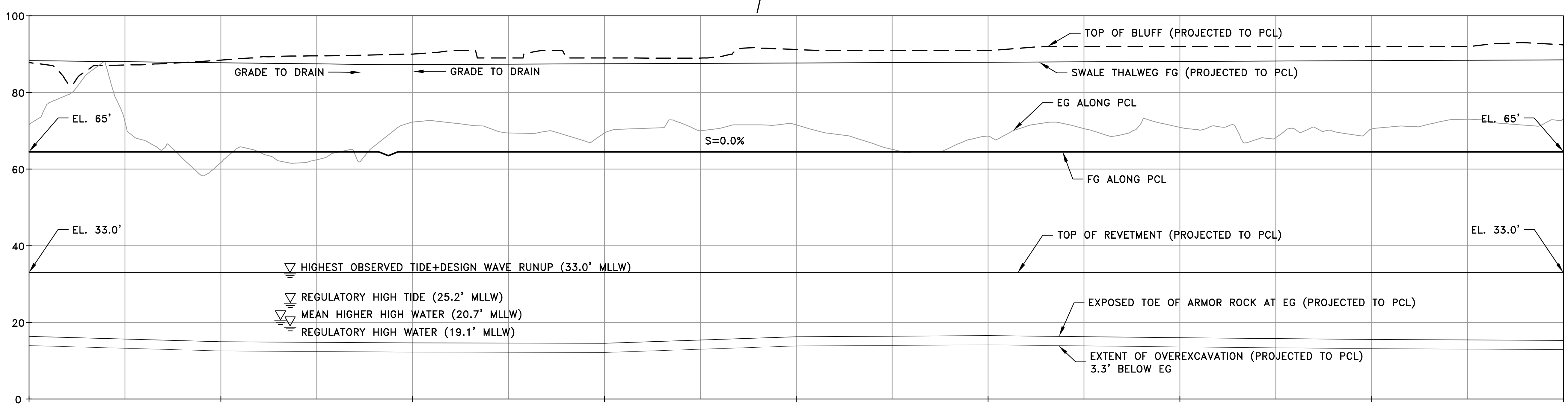
Reference number:
C-3

Sheet 10 of 24



PLAN 1/C4

30 0 30 SCALE FEET



PROFILE 2/C4

30' 0 30' HORIZONTAL

10' 0 10' VERTICAL

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

CONTRACT NO. | CONTRACTOR | CITY | STATE
Recommended: PRIME CONTRACTOR | Approved: RESIDENT ENGINEER | Date:

Sym	Action	Description	Date	Appvd

Date: JULY 2012
Dwg Scale: AS NOTED
Plot Scale:
File: Kenai_C-4
Drawing #:

Designed: KHP
Drawn: MRG
Reviewed: YHC
Submitted:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

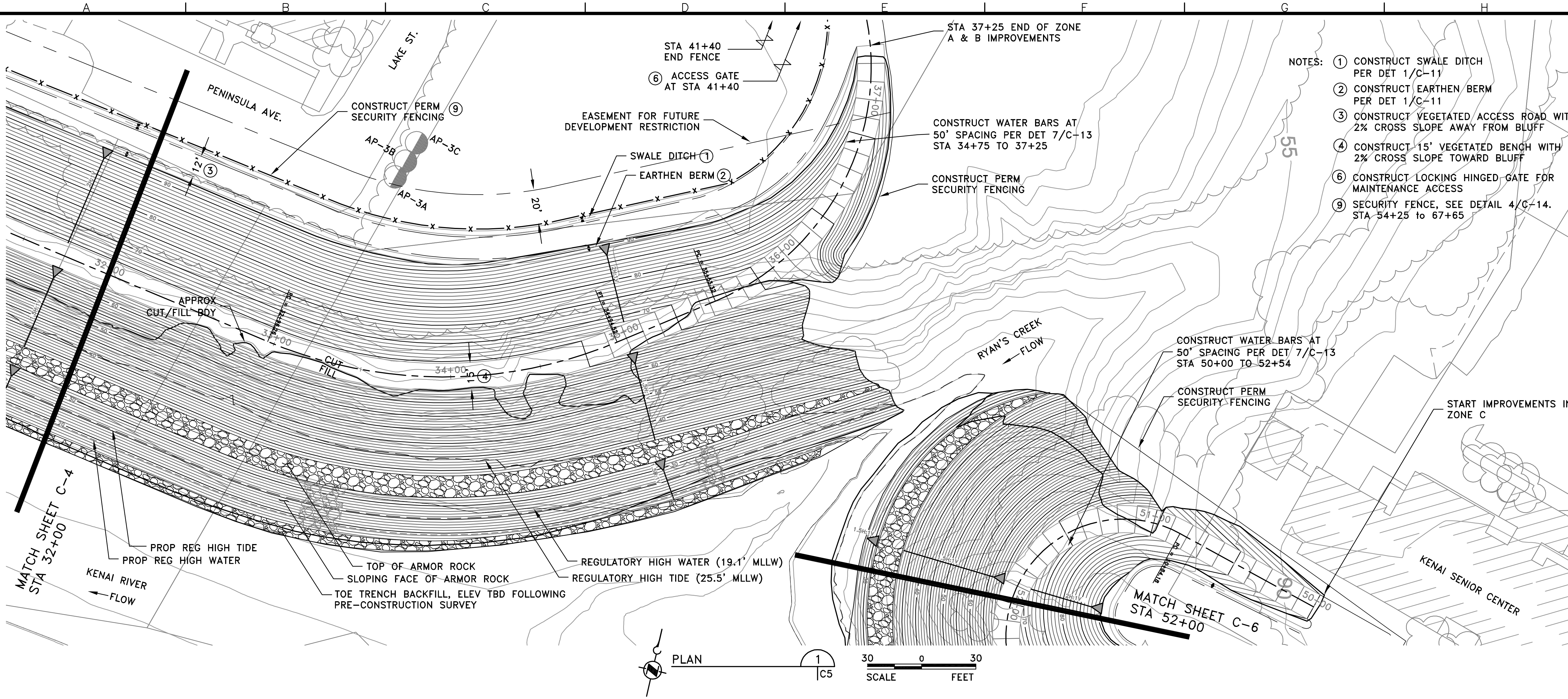
TETRA TECH, INC.

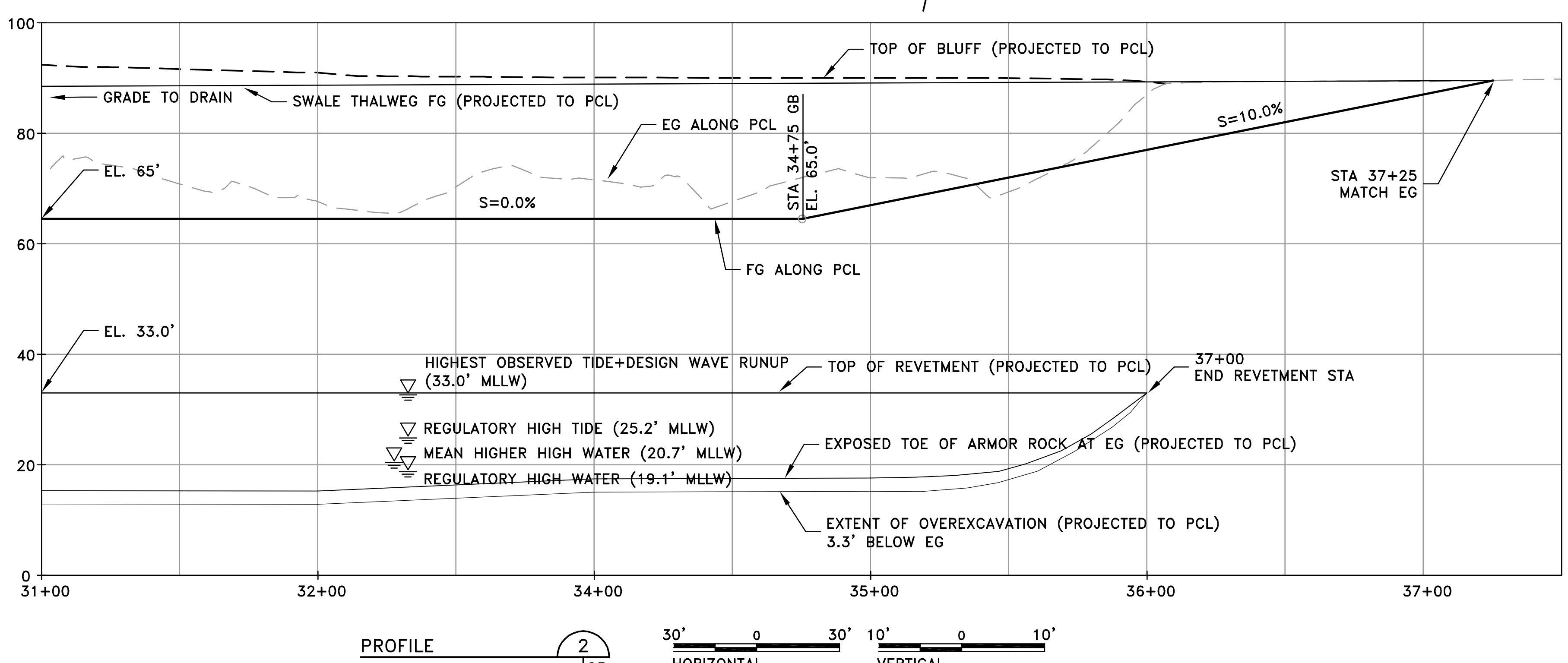
KENAI BLUFF STABILIZATION
KENAI, ALASKA

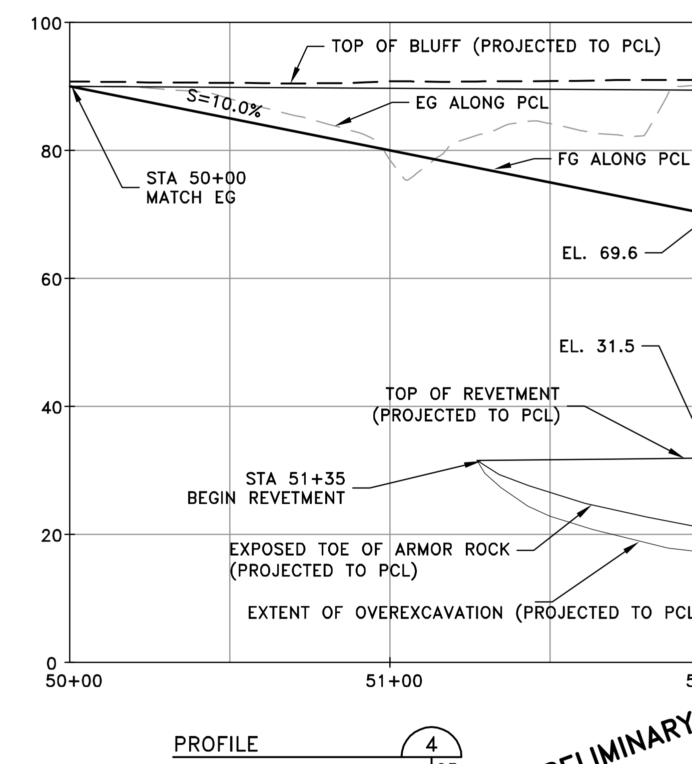
PROJECT PLAN
AND SITE MAP

Reference number:
C-4

Sheet 11 of 24







PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

CONTRACT NO. / CONTRACTOR / CITY / STATE / Recommended: PRIME CONTRACTOR / Approved: RESIDENT ENGINEER / Date:

Sym | Action | Description | Date | Approval

Date: JULY 2012
Dwg Scale: AS NOTED
Plot Scale:
File: Kenai_C-5
Drawing #:

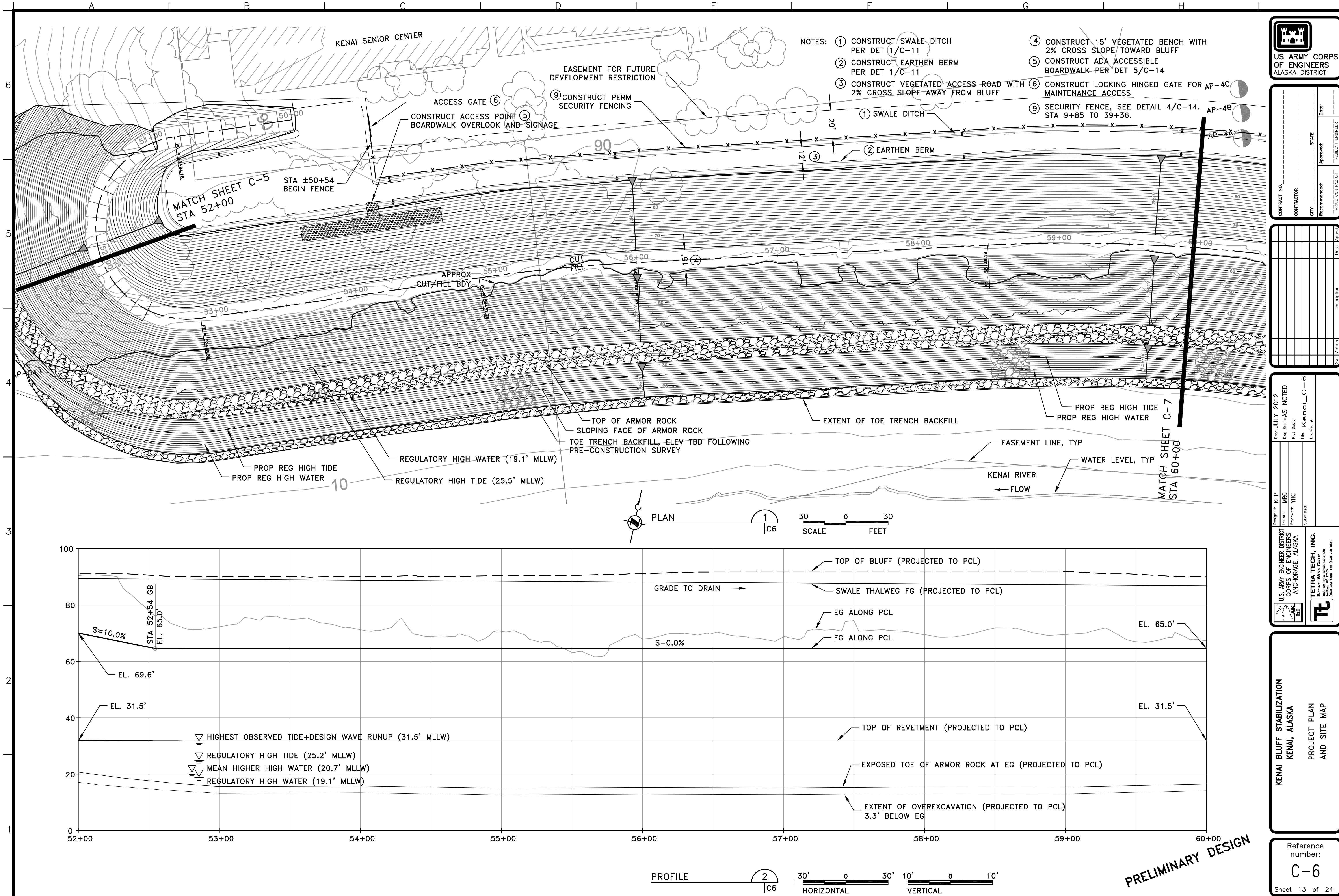
Designed: KHP
Drawn: MRG
Reviewed: YHC
Submitted:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

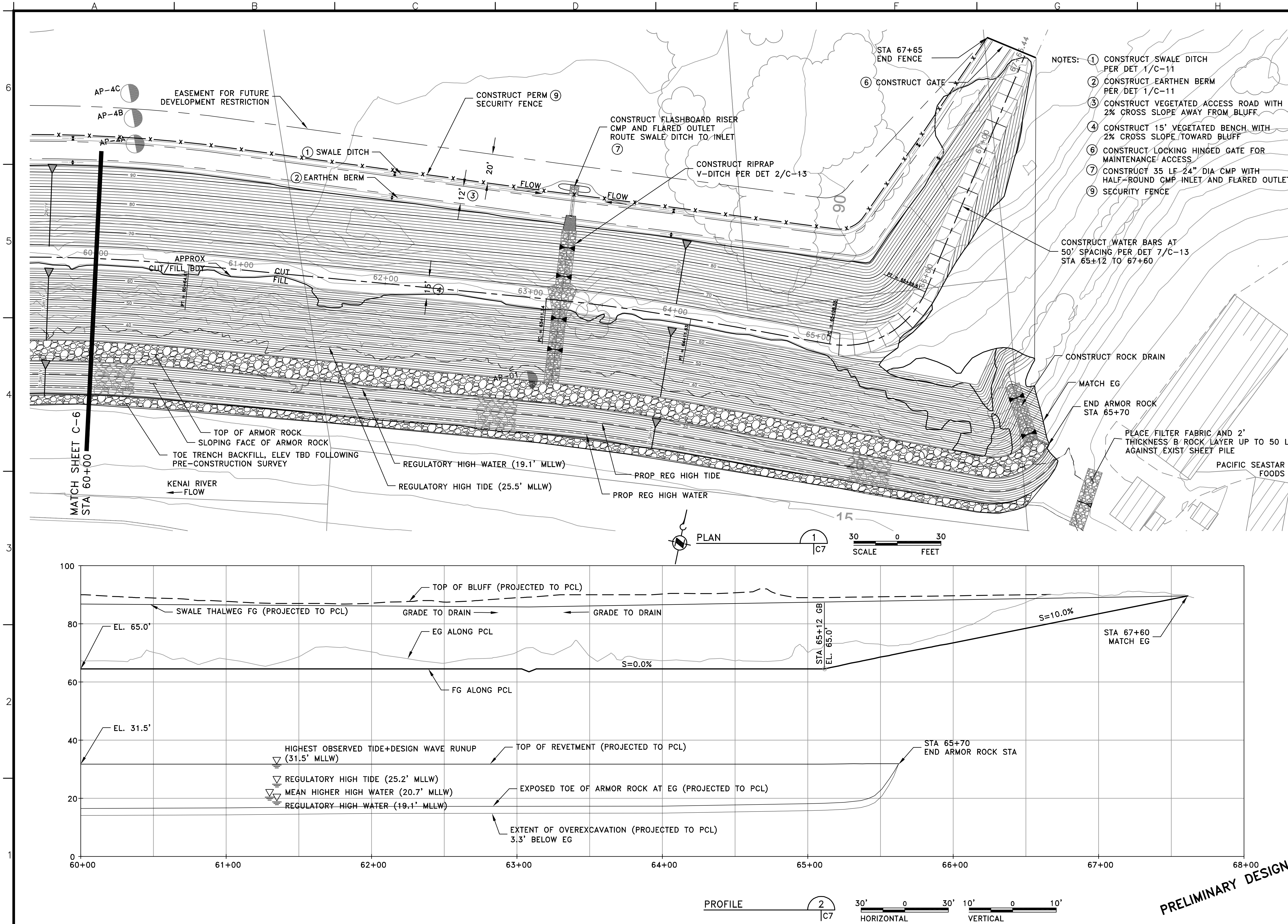
TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA
CIVIL
PROJECT PLAN
AND SITE MAP

Reference number:
C-5
Sheet 12 of 24



KENAI SENIOR CENTER
NOTES:
1 CONSTRUCT SWALE DITCH PER DET 1/C-11
2 CONSTRUCT EARTHEN BERM PER DET 1/C-11
3 CONSTRUCT VEGETATED ACCESS ROAD WITH 2% CROSS SLOPE AWAY FROM BLUFF
4 CONSTRUCT 15' VEGETATED BENCH WITH 2% CROSS SLOPE TOWARD BLUFF
5 CONSTRUCT ADA ACCESSIBLE BOARDWALK PER DET 5/C-14
6 CONSTRUCT LOCKING HINGED GATE FOR MAINTENANCE ACCESS
9 SECURITY FENCE, SEE DETAIL 4/C-14. STA 9+85 TO 39+36.
EASEMENT FOR FUTURE DEVELOPMENT RESTRICTION
9 CONSTRUCT PERM SECURITY FENCING
ACCESS GATE 6
CONSTRUCT ACCESS POINT 5 BOARDWALK OVERLOOK AND SIGNAGE
1 SWALE DITCH
2 EARTHEN BERM
MATCH SHEET C-5 STA 52+00
STA ±50+54 BEGIN FENCE
APPROX CUT/FILL BDY
CUT
FILL
TOP OF ARMOR ROCK
SLOPING FACE OF ARMOR ROCK
TOE TRENCH BACKFILL, ELEV TBD FOLLOWING PRE-CONSTRUCTION SURVEY
EXTENT OF TOE TRENCH BACKFILL
PROP REG HIGH TIDE
PROP REG HIGH WATER
REGULATORY HIGH WATER (19.1' MLLW)
REGULATORY HIGH TIDE (25.5' MLLW)
EASEMENT LINE, TYP
WATER LEVEL, TYP
KENAI RIVER
FLOW
MATCH SHEET C-7 STA 60+00
AP-4C
AP-4B
AP-4A
PLAN 1 C6
SCALE 30 0 30 FEET
TOP OF BLUFF (PROJECTED TO PCL)
GRADE TO DRAIN
SWALE THALWEG FG (PROJECTED TO PCL)
EG ALONG PCL
FG ALONG PCL
S=10.0%
S=0.0%
STA 52+54 GB EL. 65.0'
EL. 69.6'
EL. 65.0'
EL. 31.5'
EL. 31.5'
TOP OF REVETMENT (PROJECTED TO PCL)
HIGHEST OBSERVED TIDE+DESIGN WAVE RUNUP (31.5' MLLW)
REGULATORY HIGH TIDE (25.2' MLLW)
MEAN HIGHER HIGH WATER (20.7' MLLW)
REGULATORY HIGH WATER (19.1' MLLW)
EXPOSED TOE OF ARMOR ROCK AT EG (PROJECTED TO PCL)
EXTENT OF OVEREXCAVATION (PROJECTED TO PCL) 3.3' BELOW EG
52+00 53+00 54+00 55+00 56+00 57+00 58+00 59+00 60+00
PROFILE 2 C6
30' 0 30' HORIZONTAL
10' 0 10' VERTICAL
PRELIMINARY DESIGN
US ARMY CORPS OF ENGINEERS ALASKA DISTRICT
Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_C-6
Designed: KHP
Drawn: MRG
Reviewed: YHC
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
TETRA TECH, INC.
KENAI BLUFF STABILIZATION KENAI, ALASKA
PROJECT PLAN AND SITE MAP
Reference number: C-6
Sheet 13 of 24



US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

CONTRACT NO.	CONTRACTOR	CITY	STATE
Recommended: PRIME CONTRACTOR	Approved: RESIDENT ENGINEER	Date:	

Sym	Action	Description	Date	Approval

Date: JULY 2012
Dwg Scale: AS NOTED
Plot Scale:
File: Kenai_C-7
Drawing #:

Designed: KHP
Drawn: MRG
Reviewed: YHC
Submitted:

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA

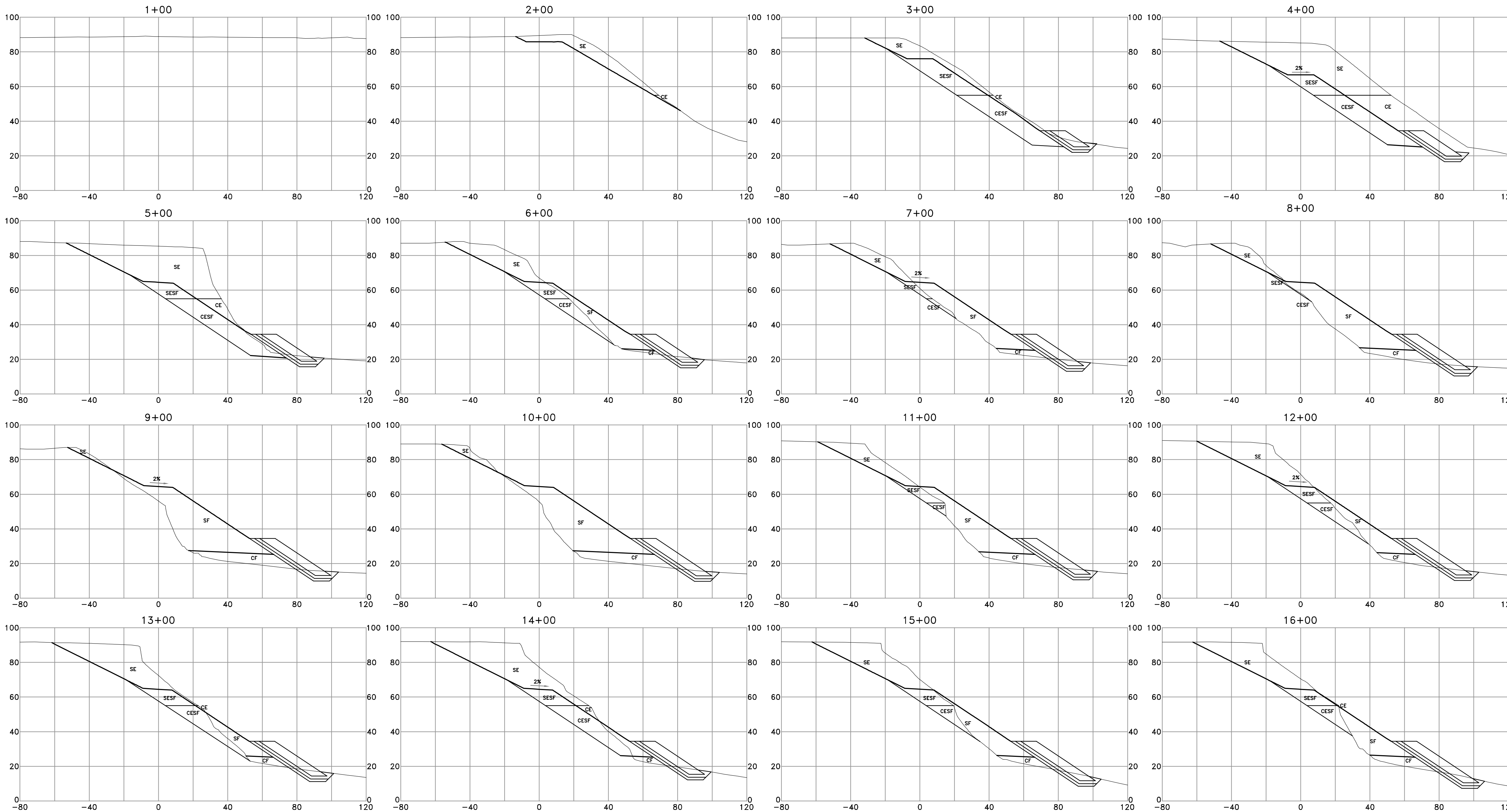
TETRA TECH, INC.

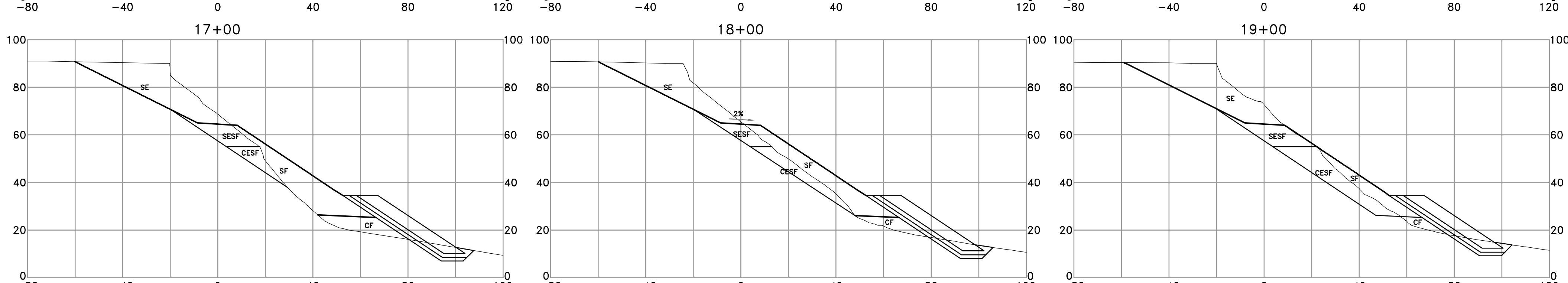
KENAI BLUFF STABILIZATION
KENAI, ALASKA

PROJECT PLAN AND SITE MAP

Reference number:
C-7

Sheet 14 of 24





KEY

SE	EXCAVATE ALLUVIUM
SESF	EXCAVATE ALLUVIUM BACKFILL ALLUVIUM
CESF	EXCAVATE TILL BACKFILL ALLUVIUM
CE	EXCAVATE TILL
SF	FILL ALLUVIUM
CF	FILL ALLUVIUM/TILL MIX

NOTE: EXISTING GROUND SHOWN IN CROSS SECTIONS BASED ON 2006 TOPOGRAPHY. CONTRACTOR SHALL CONDUCT TOPOGRAPHIC SURVEY PRIOR TO CONSTRUCTION TO VERIFY CHANGES TO THE EXISTING CONDITIONS.

PRELIMINARY DESIGN

CROSS SECTIONS 1/C8
SCALE: 1"=30'

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

CONTRACT NO. / CONTRACTOR / CITY / STATE
Recommended: PRIME CONTRACTOR / Approved: RESIDENT ENGINEER / Date:

Sym | Action | Description | Date | Appvd

Date: JULY 2012
Dwg Scale: AS NOTED
Plot Scale:
File: Kenai_C-8
Drawing #:

Designed: KHP
Drawn: MRG
Reviewed: YHC
Submitted:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

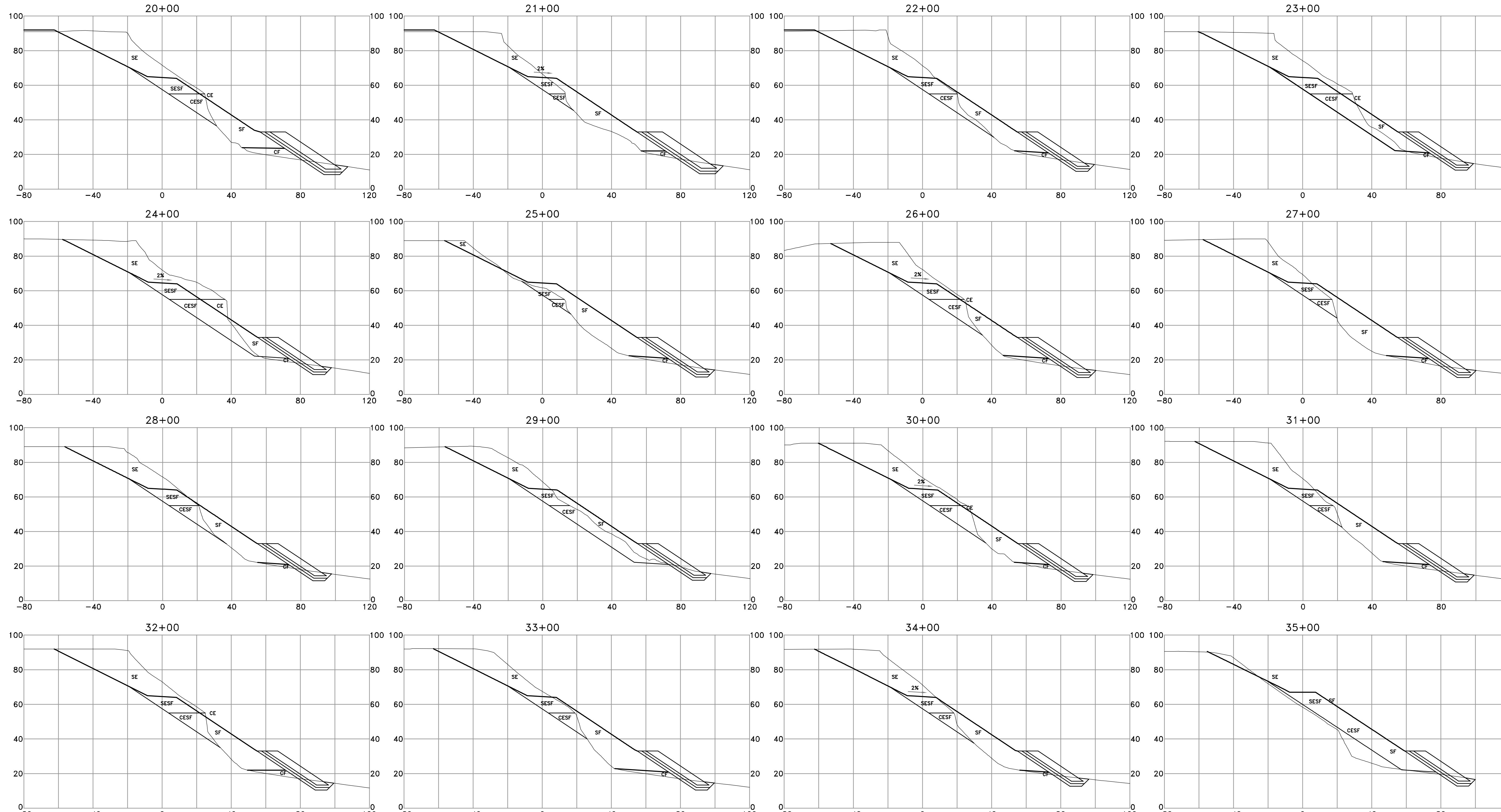
TETRA TECH, INC.

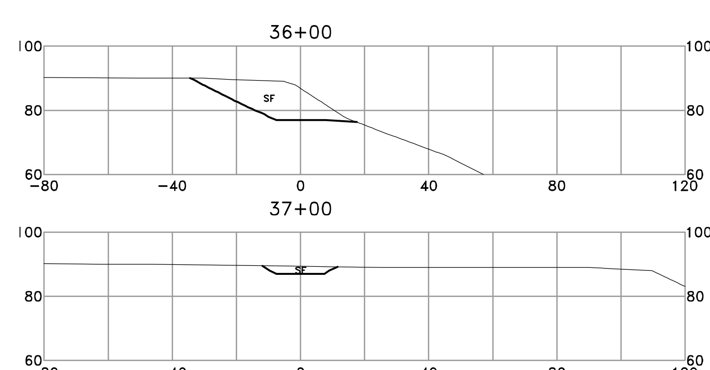
KENAI BLUFF STABILIZATION
KENAI, ALASKA

GRADING CROSS SECTIONS I

Reference number:
C-8

Sheet 15 of 24





KEY

SE	EXCAVATE SAND
SESF	EXCAVATE SAND BACKFILL SAND
CESF	EXCAVATE CLAY BACKFILL SAND
CE	EXCAVATE CLAY
SF	FILL SAND
CF	FILL SAND/CLAY MIX

NOTE: EXISTING GROUND SHOWN IN CROSS SECTIONS BASED ON 2006 TOPOGRAPHY. CONTRACTOR SHALL CONDUCT TOPOGRAPHIC SURVEY PRIOR TO CONSTRUCTION TO VERIFY CHANGES TO THE EXISTING CONDITIONS.

CROSS SECTIONS 1 C9
SCALE: 1"=30'

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_C-9
Designed: KHP
Drawn: MRG
Reviewed: KHP

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

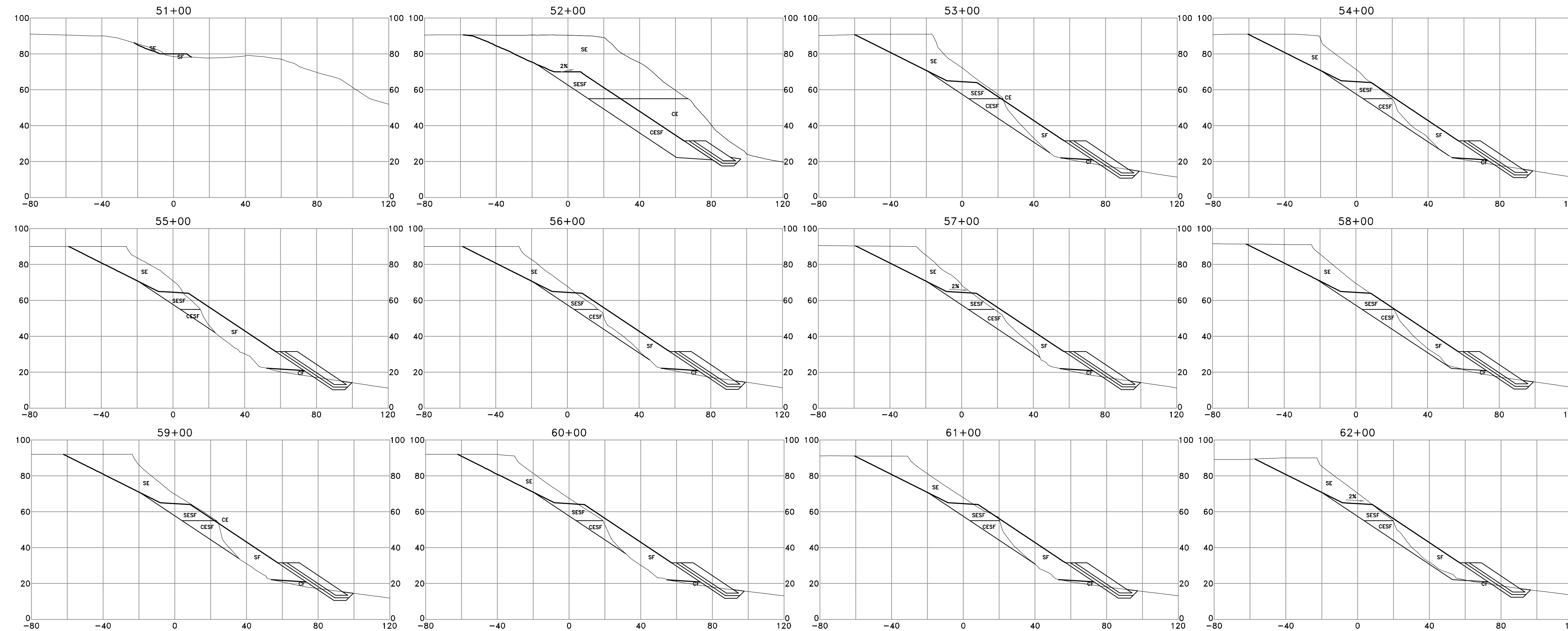
TETRA TECH, INC.

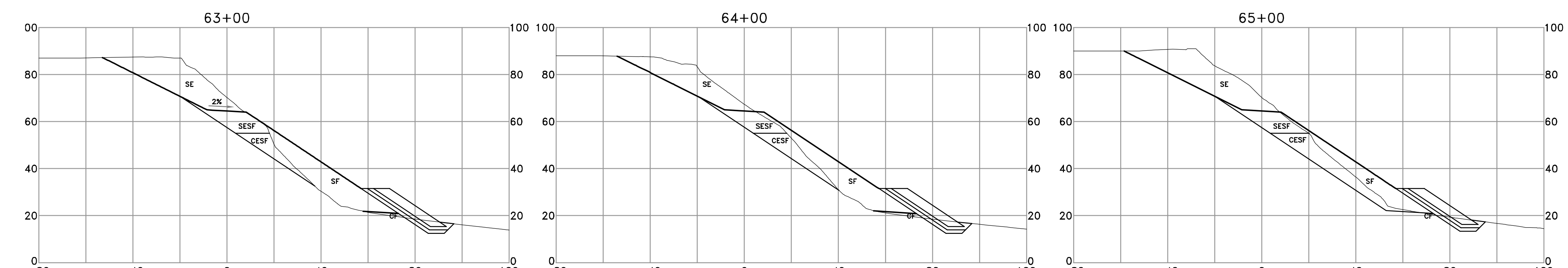
KENAI BLUFF STABILIZATION
KENAI, ALASKA

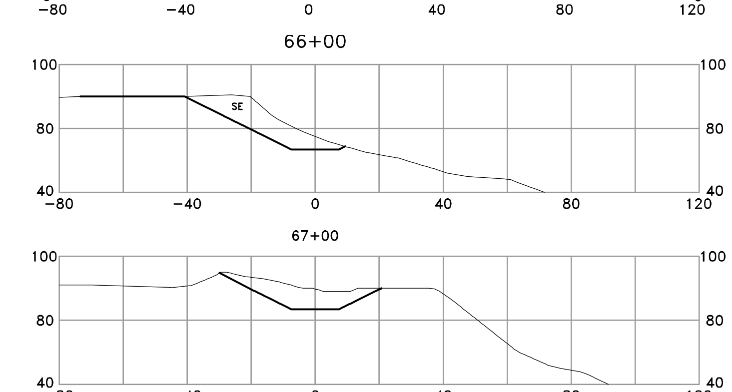
GRADING CROSS SECTIONS II

Reference number:
C-9

Sheet 16 of 24





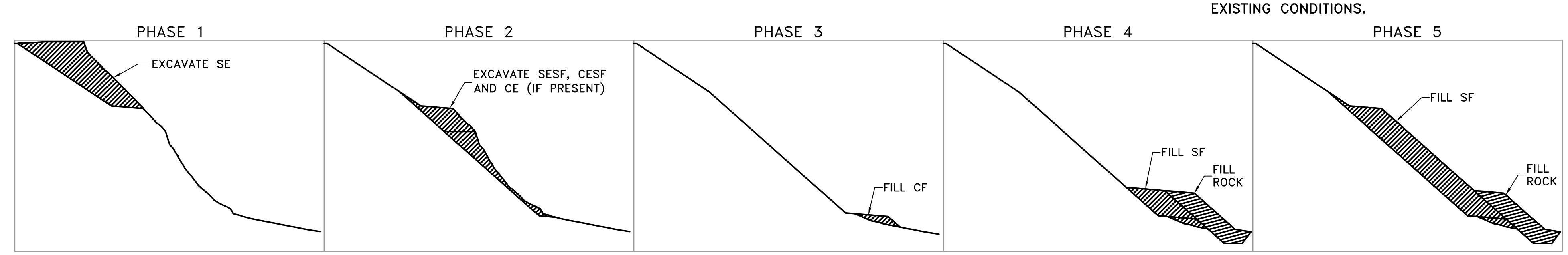


KEY

SE	EXCAVATE SAND
SESF	EXCAVATE SAND BACKFILL SAND
CESF	EXCAVATE CLAY BACKFILL SAND
CE	EXCAVATE CLAY
SF	FILL SAND
CF	FILL SAND/CLAY MIX

CROSS SECTIONS 1
SCALE: 1"=30' C10

NOTE: EXISTING GROUND SHOWN IN CROSS SECTIONS BASED ON 2006 TOPOGRAPHY. CONTRACTOR SHALL CONDUCT TOPOGRAPHIC SURVEY PRIOR TO CONSTRUCTION TO VERIFY CHANGES TO THE EXISTING CONDITIONS.



CONST. PHASING 2
SCALE: NTS C10

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

CONTRACT NO.
CONTRACTOR
CITY
STATE
Recommended: PRIME CONTRACTOR
Approved: RESIDENT ENGINEER
Date:

Sym | Action | Description | Date | Approval

Date: JULY 2012
Dwg Scale: AS NOTED
Plot Scale:
File: Kenai_C-10
Drawing #:
Designed: KHP
Drawn: MRG
Reviewed: YHC
Submitted:

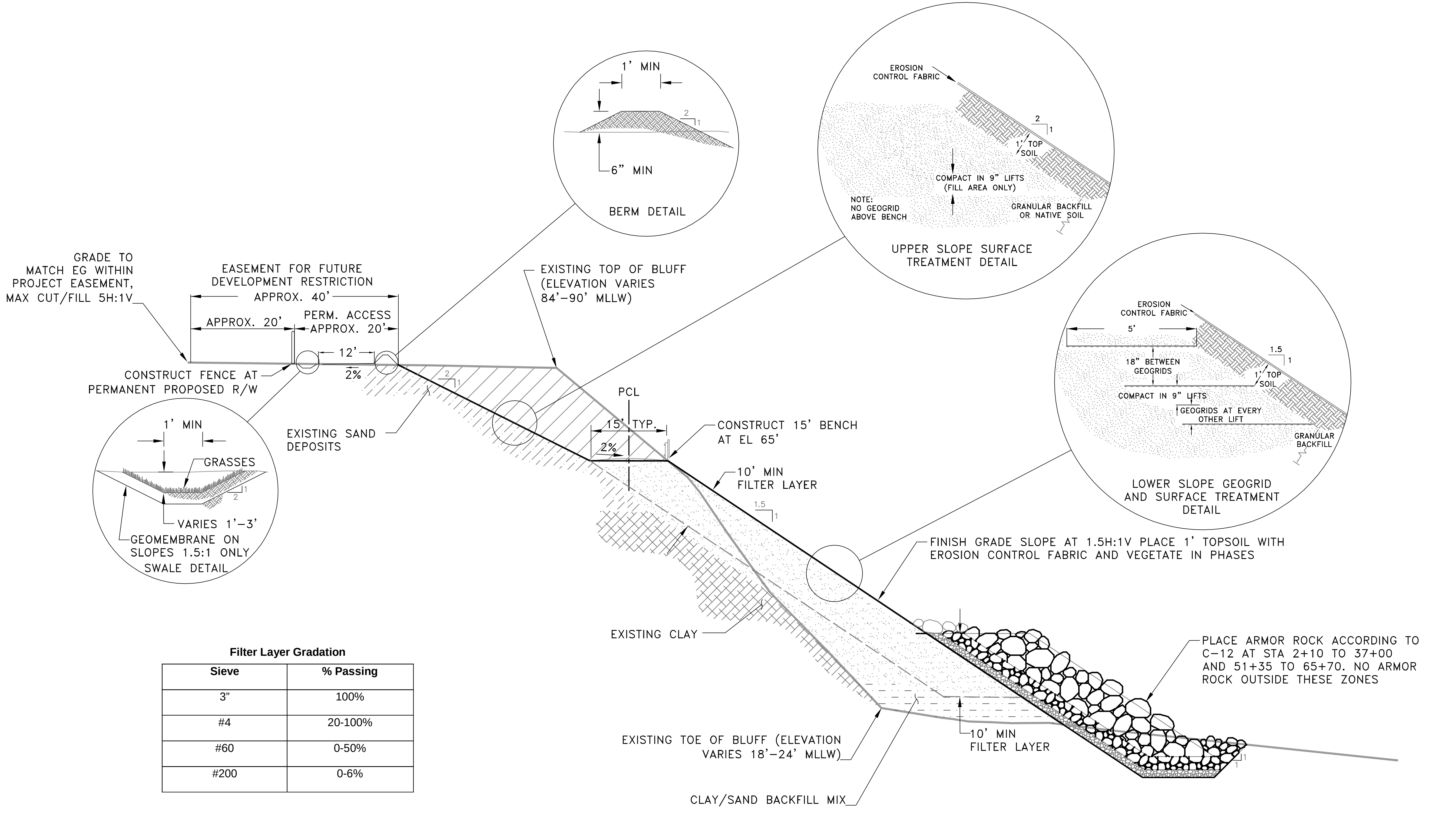
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA

GRADING CROSS SECTIONS III

Reference number:
C-10
Sheet 17 of 24



Filter Layer Gradation

Sieve	% Passing
3"	100%
#4	20-100%
#60	0-50%
#200	0-6%

STA 2+10 TO 37+00 AND STA 51+35 TO 65+70

TYPICAL SECTION 1 / C11

SCALE: NTS

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA

TETRA TECH, INC.

Designed: KHP
Drawn: MRG
Reviewed: YHC

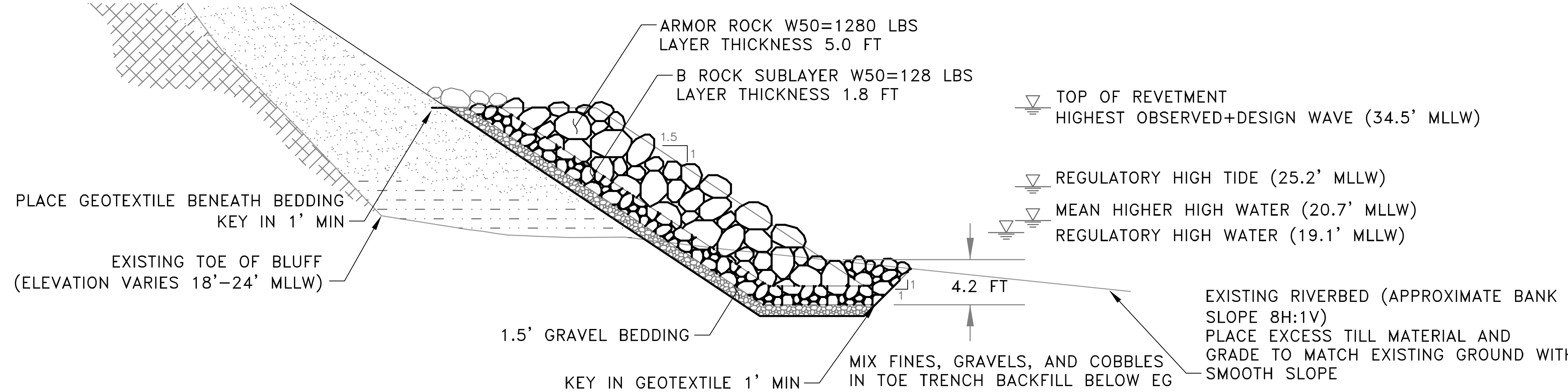
Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_C-11 rev

KENAI BLUFF STABILIZATION
KENAI, ALASKA

TYPICAL SECTIONS

Reference number:
C-11

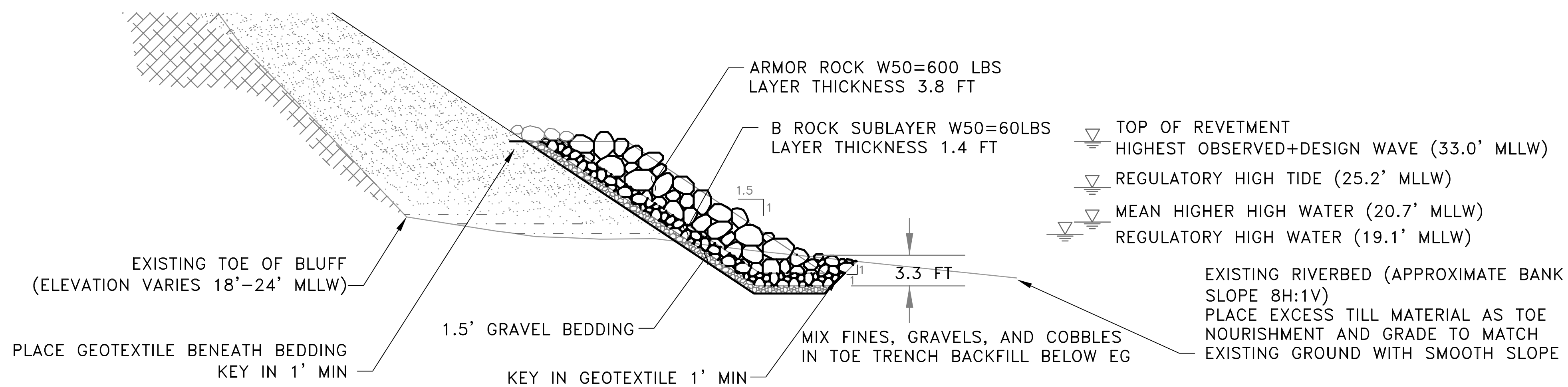
Sheet 18 of 24



STA 0+00 TO STA 21+75

TYPICAL SECTION A C12

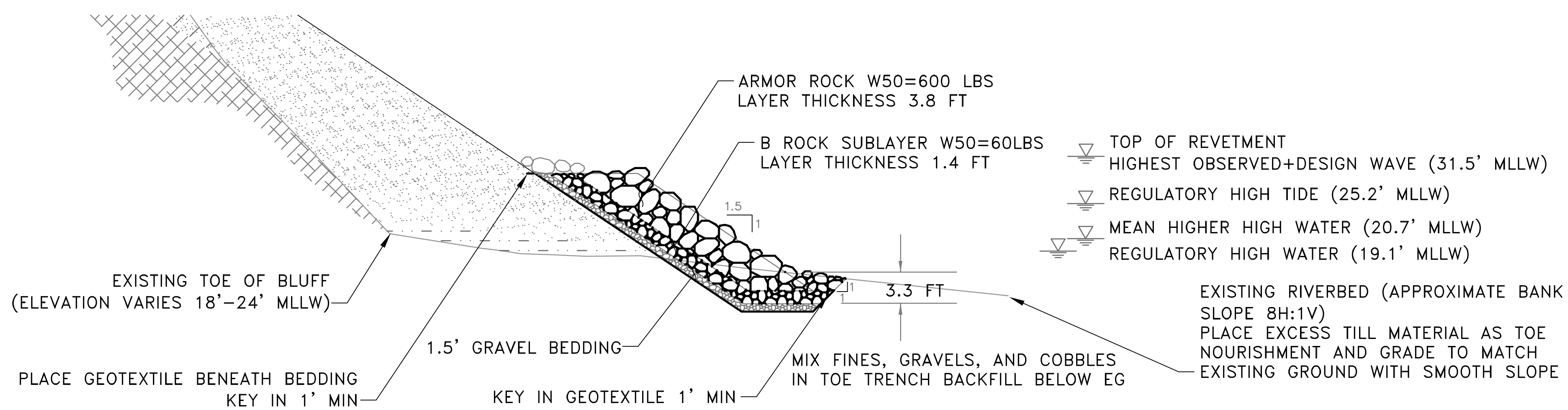
SCALE: NTS



STA 21+75 TO STA 37+00

TYPICAL SECTION B C12

SCALE: NTS



STA 51+35 TO 65+70

TYPICAL SECTION C C12

SCALE: NTS

NOTE: ROCK SHALL BE UNIFORM IN SIZE AND SELECTIVELY PLACED, ADHERING TO PLACEMENT AND GRADATION REQUIREMENTS AND PROJECT SPECIFICATIONS

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_C-12

Designed: KHP
Drawn: MRG
Reviewed: YHC

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

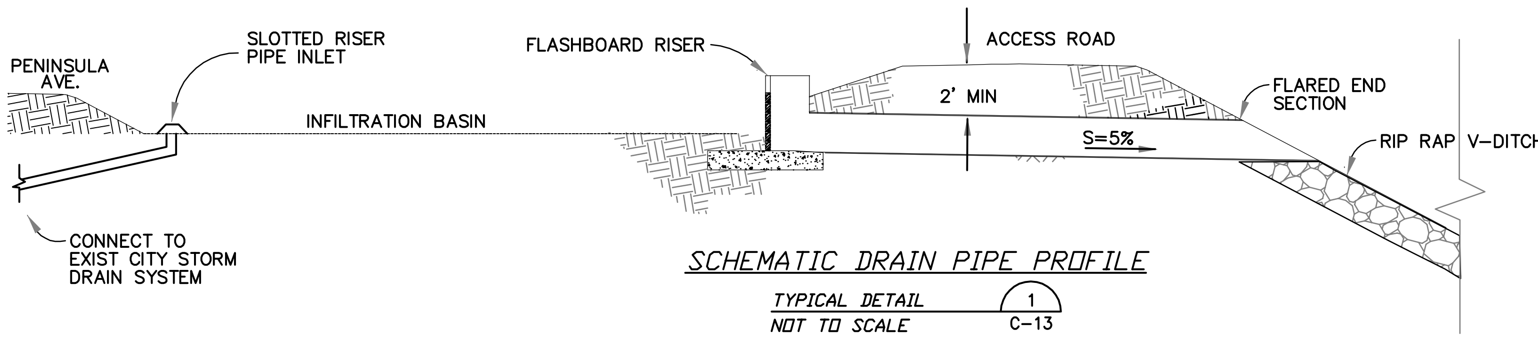
TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA

ROCK REVETMENT DETAILS

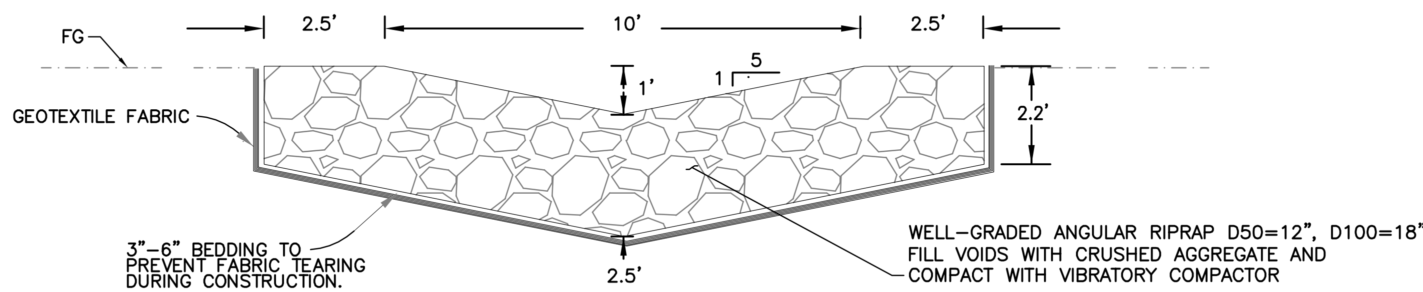
Reference number:
C-12

NOTE: PRIMARY BASIN OUTLET CONNECTED TO CITY STORM DRAIN NETWORK TBD. FLASHBOARD RISER AND V-DITCH ACT AS SECONDARY OUTLET FOR EMERGENCY OVERFLOW ONLY.



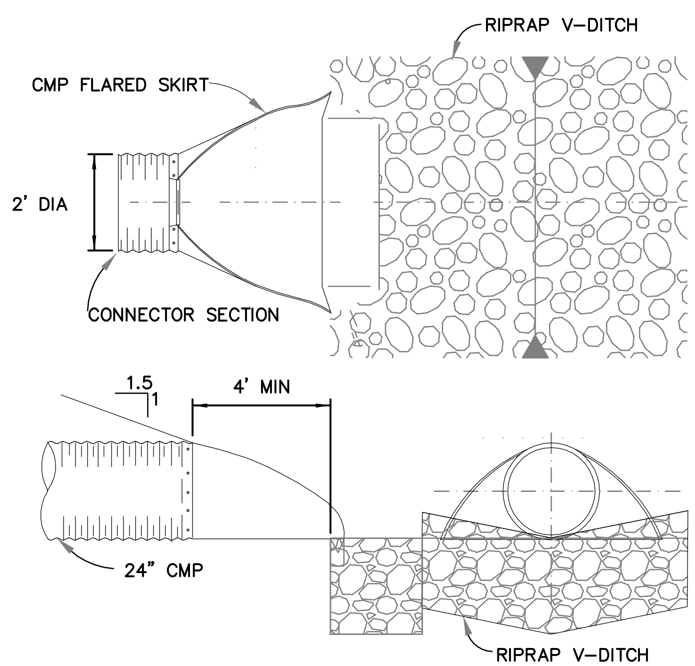
SCHEMATIC DRAIN PIPE PROFILE

TYPICAL DETAIL 1
NOT TO SCALE C-13



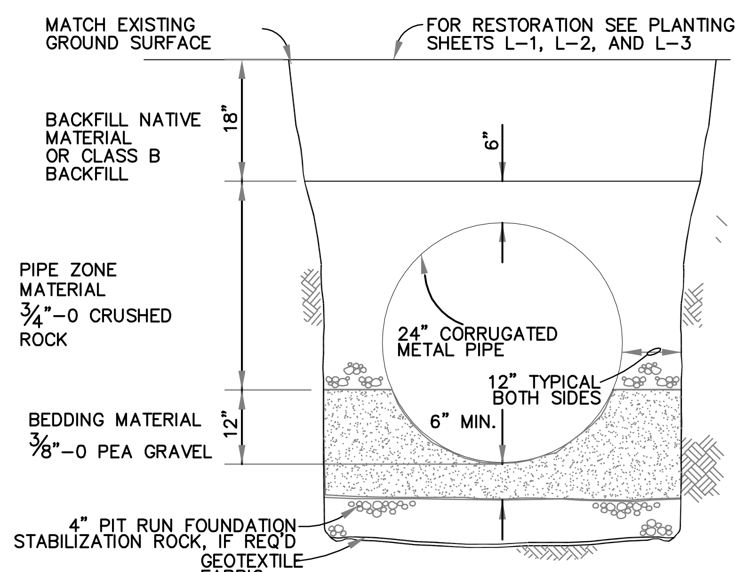
RIPRAP V-DITCH

TYPICAL DETAIL 2
NOT TO SCALE C-13



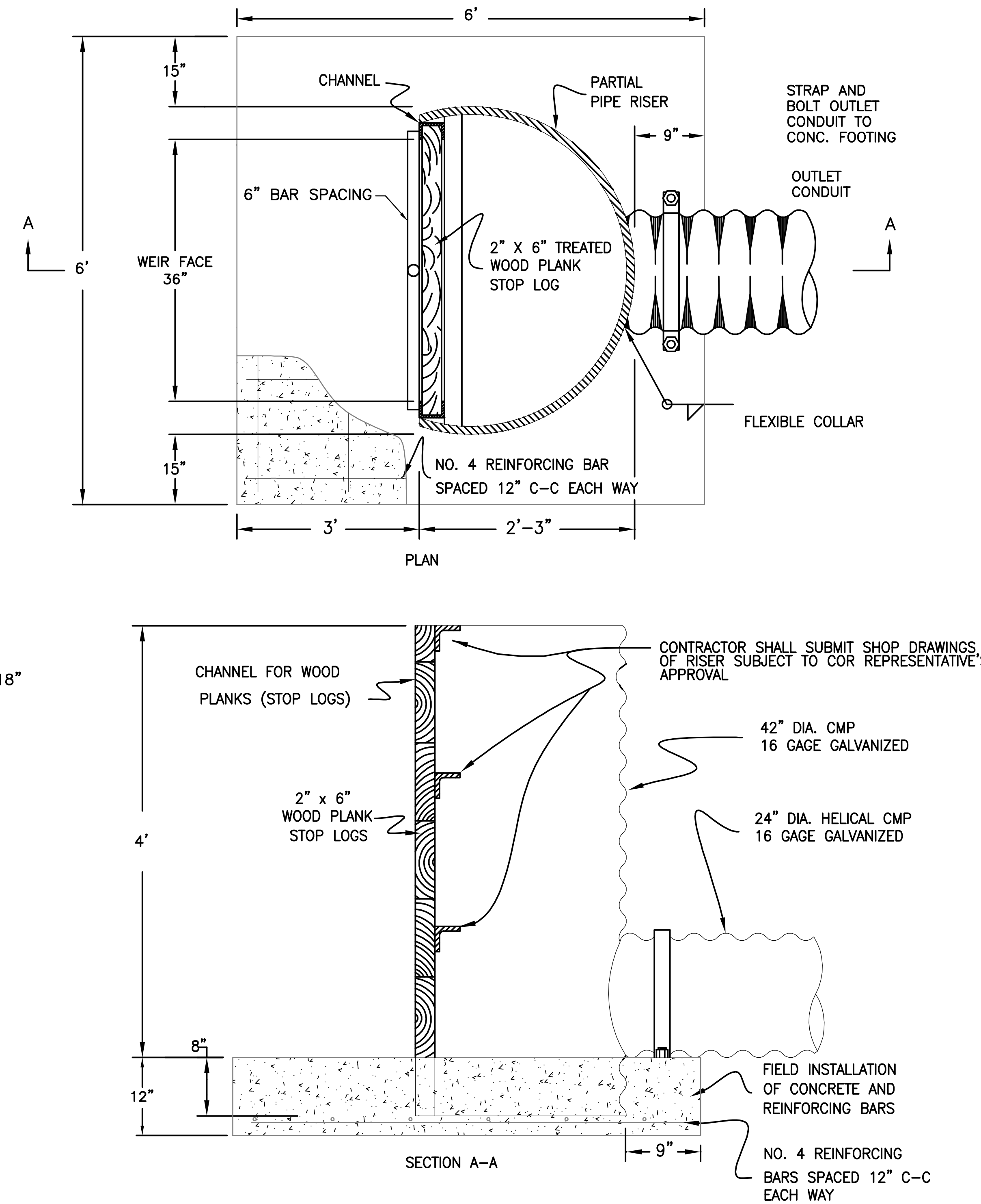
FLARED END SECTION

TYPICAL DETAIL 3
NOT TO SCALE C-13



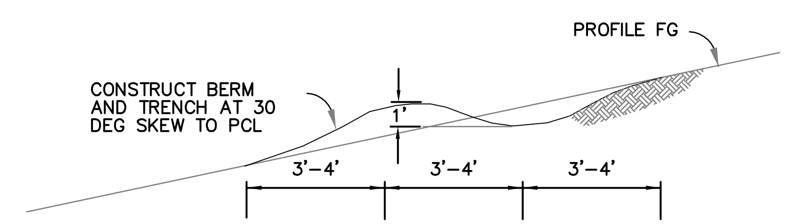
TRENCH DETAIL

TYPICAL DETAIL 4
NOT TO SCALE C-13



FLASHBOARD RISER PLAN AND SECTION

TYPICAL DETAIL 5
NOT TO SCALE C-13



WATER BAR

TYPICAL DETAIL 6
NOT TO SCALE C-13

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Symbol	Description	Date	Approval

Date: JULY 2012
Dwg Scale: AS NOTED
Plot Scale:
File: Kenai_C-13
Drawing #:

Designed: KHP
Drawn: MRG
Reviewed: YHC
Submitted:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA
GENERAL

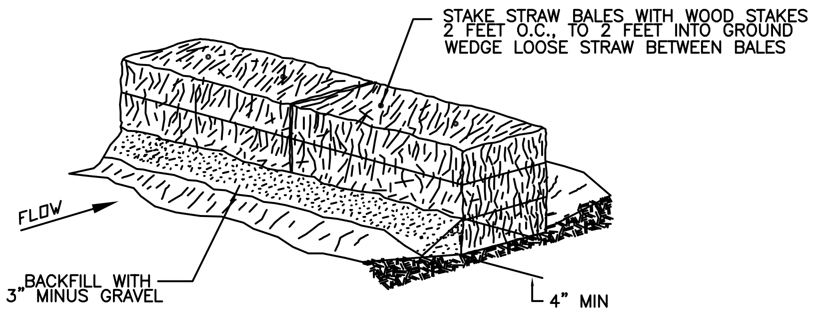
DRAINAGE DETAILS

Reference number:
C-13

Sheet 22 of 24

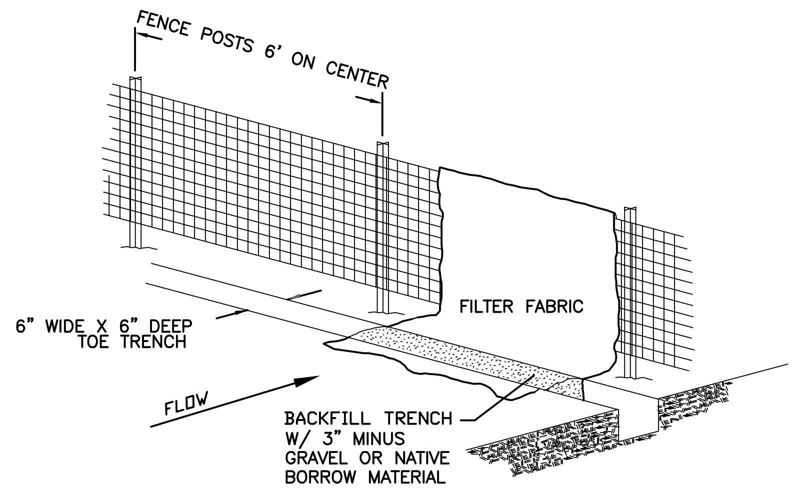
NOTE:

CONTRACTOR SHALL SUBMIT STORMWATER POLLUTION PREVENTION PLAN (SWPPP) FOR APPROVAL PRIOR TO CONSTRUCTION. SWPPP MAY INCLUDE TEMPORARY SILT FENCES, TURBIDITY CURTAINS, STRAW BALES, OR OTHER BMPS AND SHALL DEMONSTRATE ADHERENCE WITH ALL APPLICABLE ENVIRONMENTAL GUIDELINES. DETAILS SHOWN HEREIN ARE PROVIDED AS EXAMPLES ONLY.



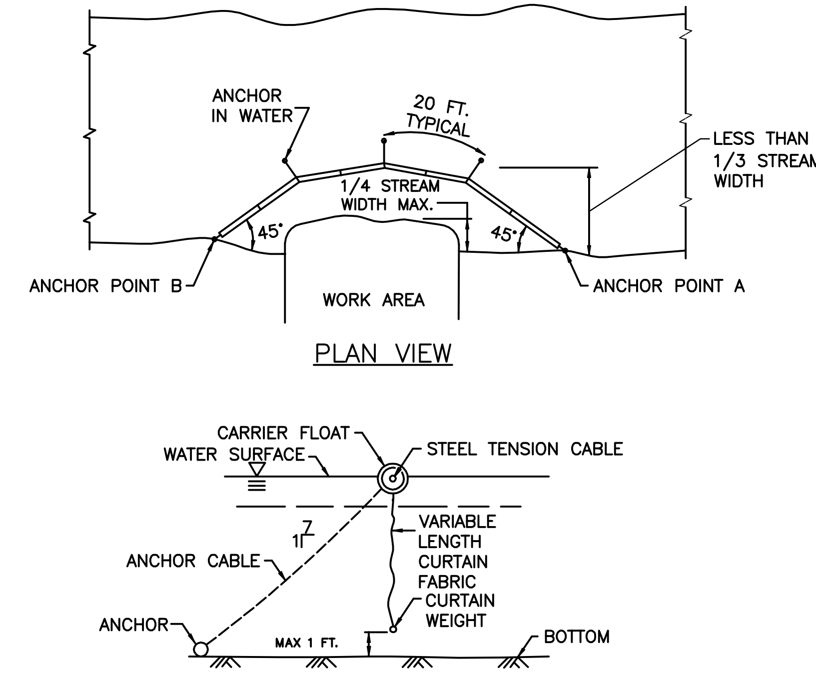
STRAW BALE

TYPICAL DETAIL 1
SCALE: NOT TO SCALE TYP



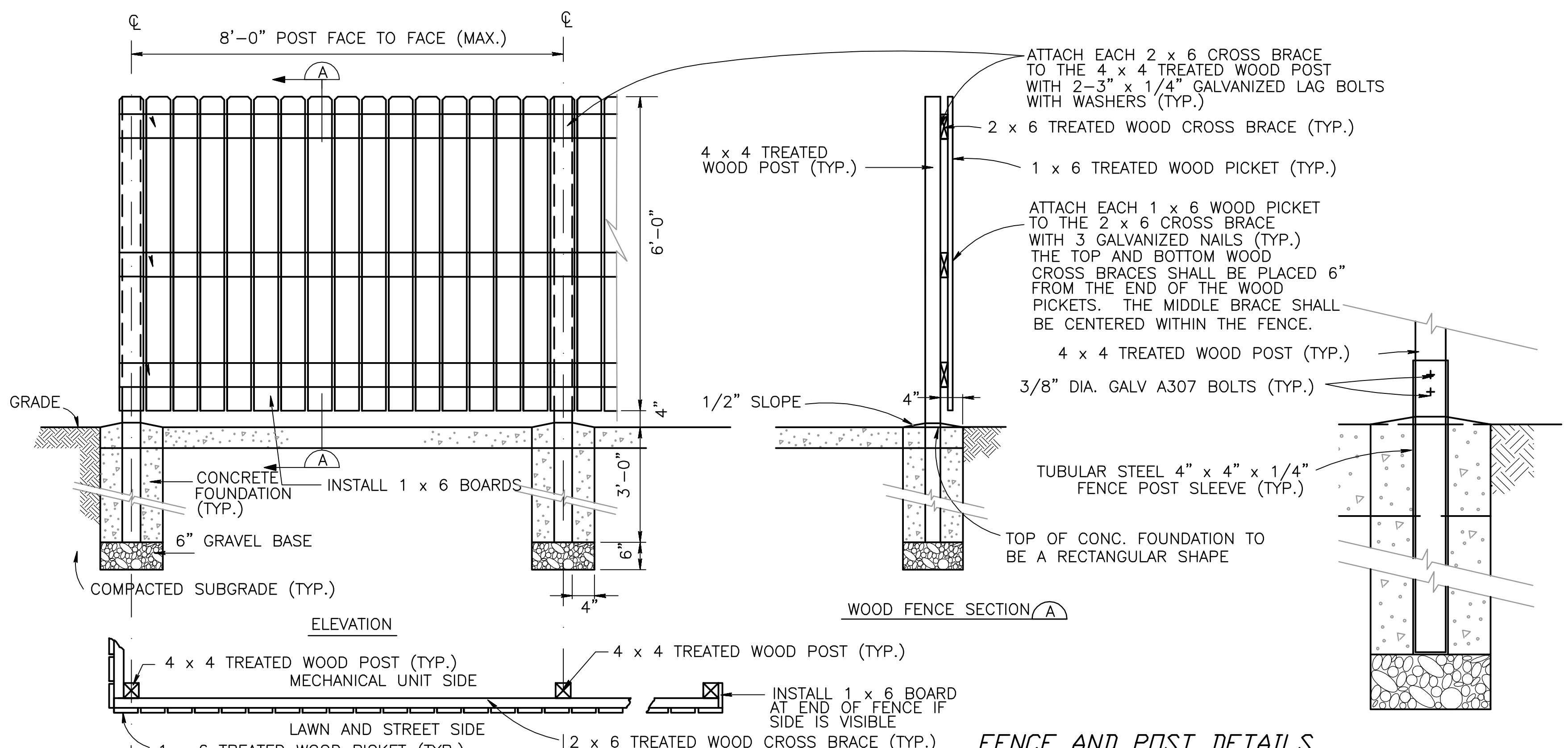
SILT FENCE

TYPICAL DETAIL 2
SCALE: NOT TO SCALE TYP



TURBIDITY CURTAIN

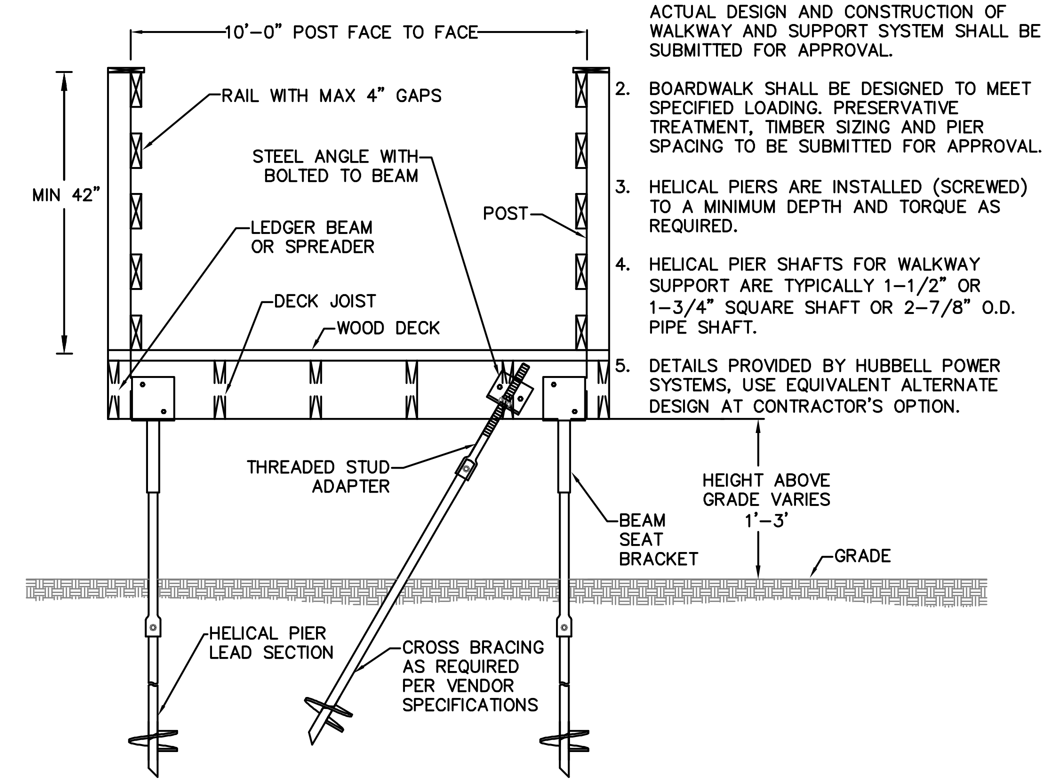
TYPICAL DETAIL 3
SCALE: NOT TO SCALE TYP



FENCE AND POST DETAILS

TYPICAL DETAIL 4
SCALE: NOT TO SCALE TYP

NOTES
1. THIS IS A CONCEPT DRAWING ONLY. ACTUAL DESIGN AND CONSTRUCTION OF WALKWAY AND SUPPORT SYSTEM SHALL BE SUBMITTED FOR APPROVAL.
2. BOARDWALK SHALL BE DESIGNED TO MEET SPECIFIED LOADING. PRESERVATIVE TREATMENT, TIMBER SIZING AND PIER SPACING TO BE SUBMITTED FOR APPROVAL.
3. HELICAL PIERS ARE INSTALLED (SCREWED) TO A MINIMUM DEPTH AND TORQUE AS REQUIRED.
4. HELICAL PIER SHAFTS FOR WALKWAY SUPPORT ARE TYPICALLY 1-1/2" OR 1-3/4" SQUARE SHAFT OR 2-7/8" O.D. PIPE SHAFT.
5. DETAILS PROVIDED BY HUBBELL POWER SYSTEMS, USE EQUIVALENT ALTERNATE DESIGN AT CONTRACTOR'S OPTION.



BOARDWALK DETAILS

TYPICAL DETAIL 5
SCALE: NOT TO SCALE TYP

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_C-14

Designed: KHP
Drawn: MRG
Reviewed: YHC

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA

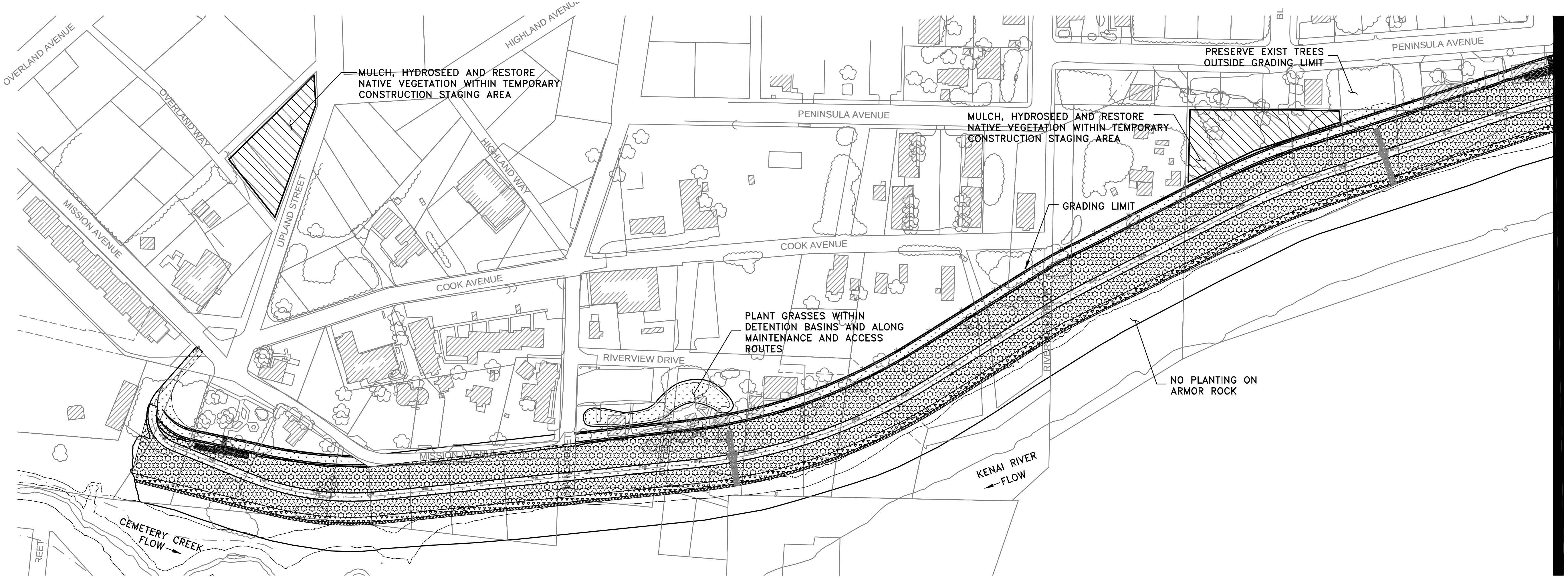
TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA
GENERAL

MISCELLANEOUS DETAILS

Reference number:
C-14

Sheet 21 of 24



MATCH LINE SEE SHEET L-2

PLANTING PLAN

100 0 100
SCALE Feet

LEGEND

- WILLOW
- ALDERS
- CONIFER
- GRASS

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

CONTRACT NO.
CONTRACTOR
CITY STATE
Recommended: Approved: Date:
PRIME CONTRACTOR RESIDENT ENGINEER

Sym	Action	Description	Date	Approval

Designed: KHP
Drawn: MRG
Reviewed: YHC
Submitted:
Date: JULY 2012
Dwg Scale: AS NOTED
Plot Scale:
File: Kenai_L-1
Drawing #:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

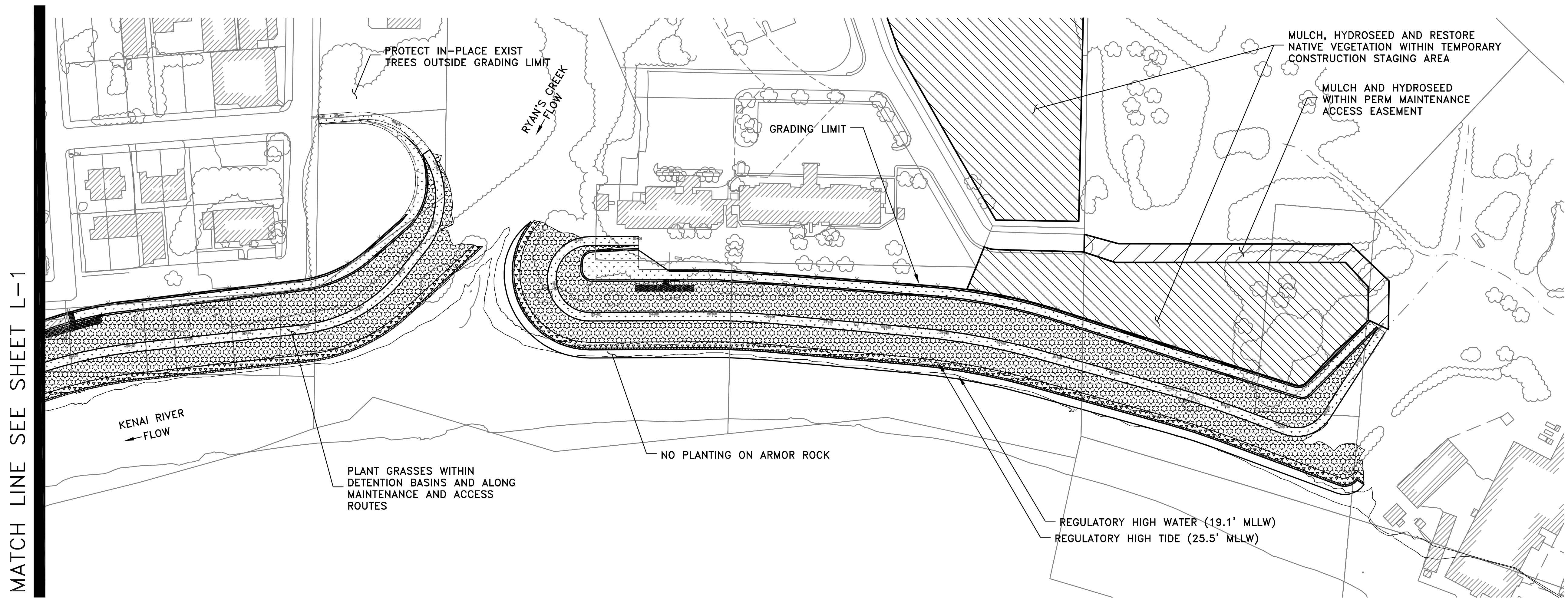
TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA
GENERAL

PLANTING PLAN I

Reference number:
L-1
Sheet 22 of 24

MATCH LINE SEE SHEET L-1



PLANTING PLAN

100 0 100
SCALE Feet

LEGEND

- WILLOW
- ALDERS
- CONIFER
- GRASS

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_L-2
Designed: KHP
Drawn: MRG
Reviewed: YHC

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

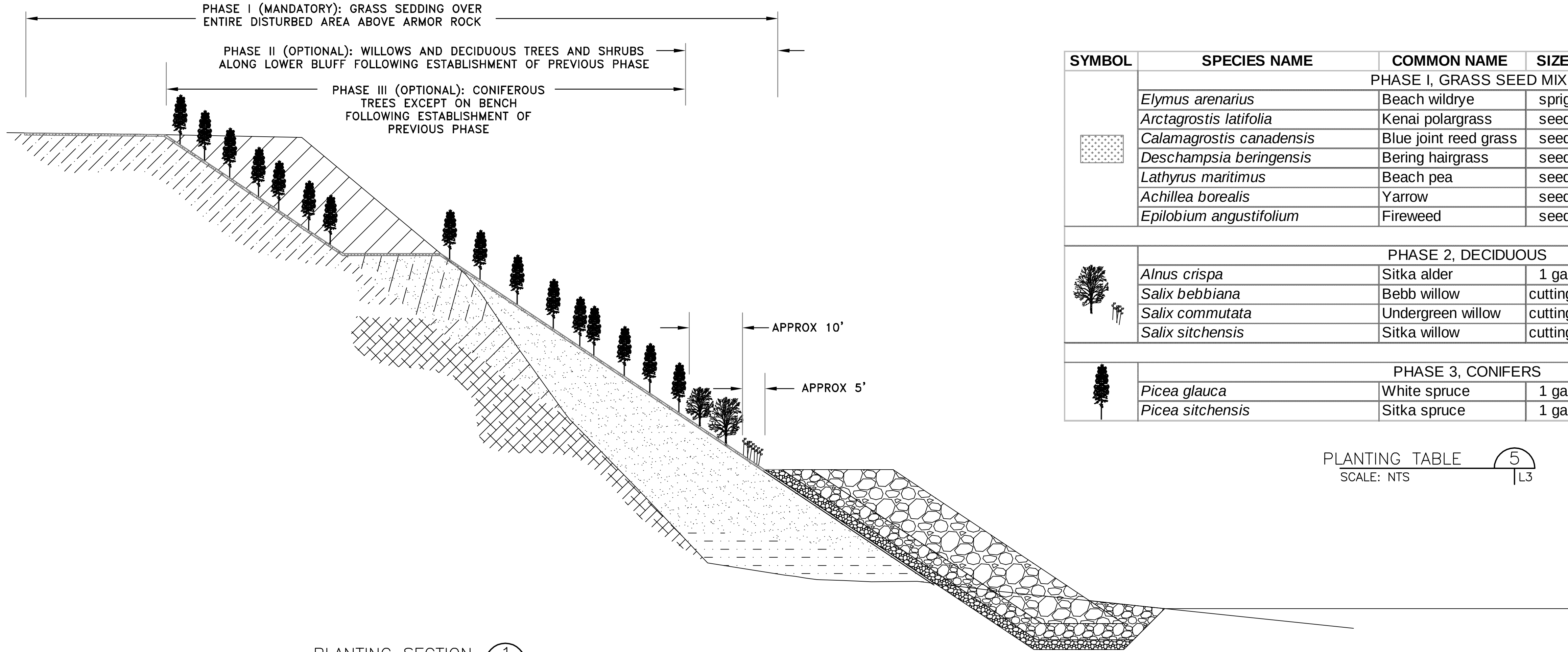
TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA
GENERAL

PLANTING PLAN II

Reference number:
L-2

Sheet 23 of 24



PLANTING SECTION 1 / L3
SCALE: NTS

SYMBOL	SPECIES NAME	COMMON NAME	SIZE	DENSITY	QUANTITY/acre
	PHASE I, GRASS SEED MIX				
	Elymus arenarius	Beach wildrye	sprig	2' o.c.	10,000
	Arctagrostis latifolia	Kenai polargrass	seed		5 lbs/ac
	Calamagrostis canadensis	Blue joint reed grass	seed		10 lbs/ac
	Deschampsia beringensis	Bering hairgrass	seed		3 lbs/ac
	Lathyrus maritimus	Beach pea	seed		1 lb/ac
	Achillea borealis	Yarrow	seed		2 lbs/ac
	Epilobium angustifolium	Fireweed	seed		1 lb/ac
	PHASE 2, DECIDUOUS				
	Alnus crispa	Sitka alder	1 gal	10' o.c.	435
	Salix bebbiana	Bebb willow	cuttings	5' o.c.	580
	Salix commutata	Undergreen willow	cuttings	5' o.c.	580
	Salix sitchensis	Sitka willow	cuttings	5' o.c.	580
	PHASE 3, CONIFERS				
	Picea glauca	White spruce	1 gal	15' o.c.	190
	Picea sitchensis	Sitka spruce	1 gal	25' o.c.	70

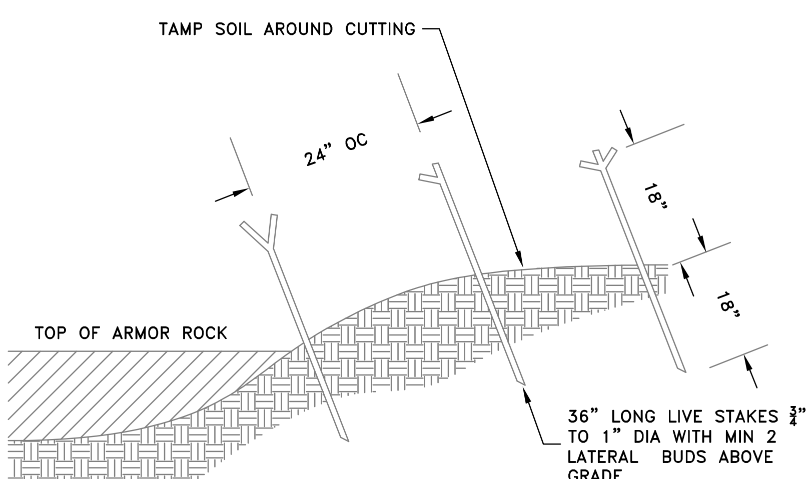
PLANTING TABLE 5 / L3
SCALE: NTS

NOTES:

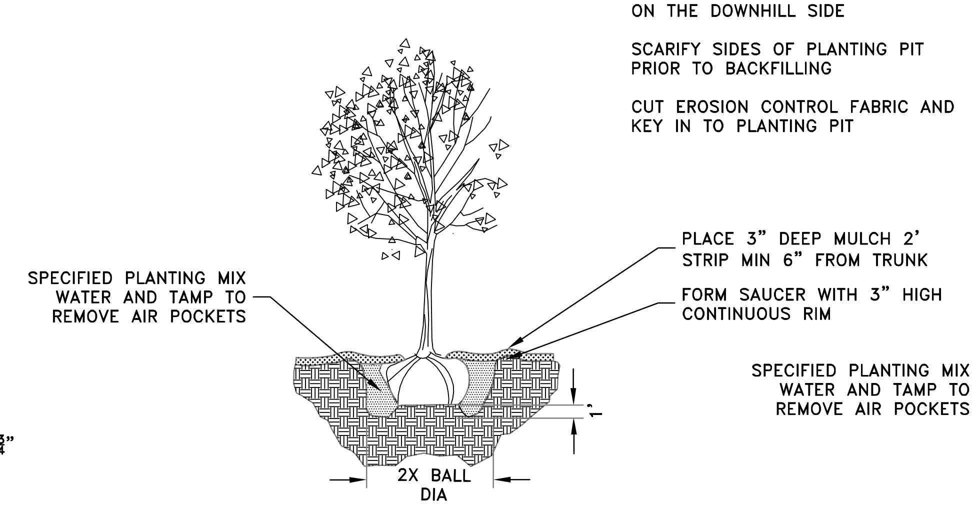
PLANT DECIDUOUS AND CONIFEROUS TREES SO THAT TOP OF ROOT BALL IS EVEN WITH THE FINISHED GRADE ON THE DOWNHILL SIDE

SCARIFY SIDES OF PLANTING PIT PRIOR TO BACKFILLING

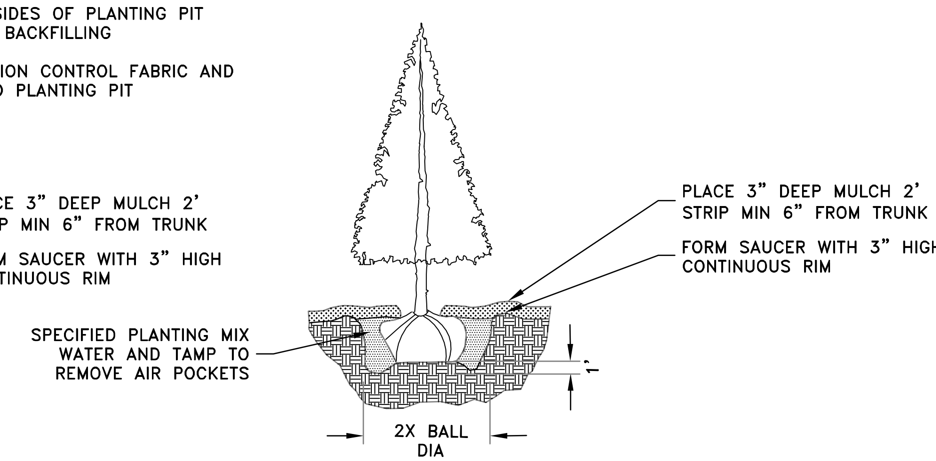
CUT EROSION CONTROL FABRIC AND KEY IN TO PLANTING PIT



WILLOW DETAIL 2 / L3
SCALE: NTS



DECIDUOUS TREE DETAIL 3 / L3
SCALE: NTS



CONIFER TREE DETAIL 4 / L3
SCALE: NTS

PRELIMINARY DESIGN

US ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

Date: JULY 2012
Dwg Scale: AS NOTED
File: Kenai_L-3

Designed: KHP
Drawn: MRG
Reviewed: YHC

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

TETRA TECH, INC.

KENAI BLUFF STABILIZATION
KENAI, ALASKA
GENERAL

PLANTING TABLE AND DETAILS

Reference number:
L-3

Sheet 24 of 24

ATTACHMENT H

COST ENGINEERING REPORT

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US Army Corps of Engineers
Alaska District

Kenai River Bluff Stabilization
Kenai, Alaska

COST ENGINEERING REPORT

May 2012

TETRA TECH

TABLE OF CONTENTS

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Kenai River Bluff Stabilization
LOCATION: Kenai, AK

DISTRICT: Alaska District PREPARED: 5/8/2012
POC: CHIEF, COST ENGINEERING, xxx

This Estimate reflects the scope and schedule in report; Kenai Bluff Feasibility Report

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Doller Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
						Program Year (Budget EC): 2013 Effective Price Level Date: 1 OCT 12				Spent Thru:				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	8-May-12 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
04	DAMS	$651	$130	20%	$781	0.9%	$657	$131	$788			$667	$133	$801
14	RECREATION FACILITIES	$530	$106	20%	$636	0.9%	$535	$107	$642			$543	$109	$652
16	BANK STABILIZATION	$23,886	$4,777	20%	$28,663	0.9%	$24,100	$4,820	$28,920			$24,480	$4,896	$29,376
	CONSTRUCTION ESTIMATE TOTALS:	$25,067	$5,013		$30,080	0.9%	$25,292	$5,058	$30,350			$25,690	$5,138	$30,828
01	LANDS AND DAMAGES	$3,000	$600	20%	$3,600	0.9%	$3,027	$605	$3,632			$3,027	$605	$3,632
30	PLANNING, ENGINEERING & DESIGN	$3,762	$752	20%	$4,514	0.7%	$3,790	$758	$4,548			$3,792	$758	$4,550
31	CONSTRUCTION MANAGEMENT	$2,005	$401	20%	$2,879	0.7%	$2,020	$404	$2,901			$2,027	$405	$2,433
	PROJECT COST TOTALS:	$33,834	$6,767	20%	$40,600		$34,128	$6,826	**$40,954**			$34,536	$6,907	$41,443

______________________ CHIEF, COST ENGINEERING, xxx

______________________ PROJECT MANAGER, xxx

______________________ CHIEF, REAL ESTATE, xxx

______________________ CHIEF, PLANNING,xxx

______________________ CHIEF, ENGINEERING, xxx

______________________ CHIEF, OPERATIONS, xxx

______________________ CHIEF, CONSTRUCTION, xxx

______________________ CHIEF, CONTRACTING,xxx

______________________ CHIEF, PM-PB, xxxx

______________________ CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:
ESTIMATED NON-FEDERAL COST:

ESTIMATED TOTAL PROJECT COST: $41,443

O&M OUTSIDE OF TOTAL PROJECT COST:

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Kenai River Bluff Stabilization
LOCATION: Kenai, AK
This Estimate reflects the scope and schedule in report; Kenai Bluff Feasibility Report

DISTRICT: Alaska District PREPARED: 5/8/2012
POC: CHIEF, COST ENGINEERING, xxx

WBS Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Doller Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			8-May-12	Program Year (Budget EC):			2013					
		Effective Price Level:			8-May-12	Effective Price Level Date:			1 OCT 12					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	PHASE 1 or CONTRACT 1													
04	DAMS	$651	$130	20%	$781	0.9%	$657	$131	$788	2014Q1	1.6%	$667	$133	$801
14	RECREATION FACILITIES	$530	$106	20%	$636	0.9%	$535	$107	$642	2014Q1	1.6%	$543	$109	$652
16	BANK STABILIZATION	$23,886	$4,777	20%	$28,663	0.9%	$24,100	$4,820	$28,920	2014Q1	1.6%	$24,480	$4,896	$29,376
	CONSTRUCTION ESTIMATE TOTALS:	$25,067	$5,013	20%	**$30,080**		$25,292	$5,058	$30,350			$25,690	$5,138	$30,828
01	LANDS AND DAMAGES	$3,000	$600	20%	$3,600	0.9%	$3,027	$605	$3,632	2013Q1		$3,027	$605	$3,632
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$376	$75	20%	$451	0.7%	$379	$76	$455	2013Q1		$379	$76	$455
1.5%	Planning & Environmental Compliance	$376	$75	20%	$451	0.7%	$379	$76	$455	2013Q1		$379	$76	$455
7.0%	Engineering & Design	$1,755	$351	20%	$2,106	0.7%	$1,768	$354	$2,122	2013Q1		$1,768	$354	$2,122
1.0%	Engineering Tech Review ITR & VE	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q1		$253	$51	$303
1.0%	Contracting & Reprographics	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q1		$253	$51	$303
1.0%	Engineering During Construction	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q2	0.4%	$254	$51	$305
1.0%	Planning During Construction	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q2	0.4%	$254	$51	$305
1.0%	Project Operations	$251	$50	20%	$301	0.7%	$253	$51	$303	2013Q1		$253	$51	$303
31	CONSTRUCTION MANAGEMENT													
4.0%	Construction Management	$1,003	$201	20%	$1,204	0.7%	$1,010	$202	$1,212	2013Q2	0.4%	$1,014	$203	$1,217
2.0%	Project Operation:	$501	$100	20%	$601	0.7%	$505	$101	$606	2013Q2	0.4%	$507	$101	$608
2.0%	Project Management	$501	$100	20%	$601	0.7%	$505	$101	$606	2013Q2	0.4%	$507	$101	$608
	CONTRACT COST TOTALS:	$33,834	$6,767		**$40,600**		$34,128	$6,826	$40,954			$34,536	$6,907	**$41,443**

KENAI RIVER BLUFF STABILIZATION

COST ESTIMATE NARRATIVE

1. Project Description

A. General: The bluffs located where the Kenai River intersects the Cook Inlet are eroding. The design solutions for the proposed bluff stabilization have been developed to a feasibility design level

B. Purpose: The purpose of this work is to develop detailed cost estimates – consistent to the level of design – for the cost and quantities of the construction features using Micro-Computer Aided Cost Estimating System (MCACES).

C. Design Features: Features include the excavation of bluff material, placement of excavated as well as imported soil, installation of armor rock, B rock, filter rock, erosion control fabric; seeding, planting, and construction of a trail with benches, overlooks and access stairs.

2. Basis of Estimate

A Basis of Design: Available design documents of the project elements are listed below. The project site plan is presented in Appendix A.

- Kenai River Bluff Erosion, Bluff Stabilization Design Alternatives, Design Alternatives Report.

B Basis of Quantities: The cost estimate is based on project quantity take-offs that have been calculated from the documents listed above. A quantity summary along with detailed quantity take-offs are presented in Appendix B. The detailed quantities include waste/loss factors for the project materials as listed below:

Soil Swell/Shrinkage Factor	25%
Armor Rock Overplace/Loss Factor	5%
B Rock Overplace/Loss Factor	5%
Filter Rock Overplace/Loss Factor	20%

3. Construction Schedule

It is estimated that overall construction would take approximately 15 months to construct. This duration has been used in the estimate to determine costs for the contractor to maintain field facilities and construction supervision. A simplified tentative project schedule of the overall project is presented in Appendix C. The overall schedule is based on the following reasoning and assumptions:

- Typical construction, crew (1 shift) working 12hrs per day and 6 days per week.

4. Acquisition Plan

The cost estimate is based on a single contract being awarded to the Prime Contractor with subcontractors for the vegetative aspects. The prime contractor would be responsible for the preparatory work, earthwork, and rock placement, as well as overseeing the subcontractor's vegetation work.

5. Project Construction

A. Staging and Site Access: Staging would be in the open area at the top of the bluff just west of the dock. A partial ramp exists in this area. The cut and fill process would be looped by providing two access ramps, one near Cemetery Creek and one near the Pacific Seastar dock.

B. Borrow/Disposal Areas and Materials: The rock required is assumed to be blasted, stockpiled and hauled from Seward Quarry which is located approximately 102-miles from Kenai. Delivering the rock is assumed to be performed entirely by land based equipment. Fill is assumed to be locally available and imported entirely by land based equipment.

   Price quotes of the various borrow materials, taken from phone calls and emails, can be found in Appendix F.

C. Construction Methodology:

   1) Site Preparation: The construction laborers, equipment and other personnel are assumed to come from Anchorage. The site would initially be cleared and grubbed of vegetation and debris. The trees lining the top of the bluff would also be removed. All utilities located within the construction area would be excavated, and rerouted. Some small structures would be demolished and resulting debris would be hauled off-site. In addition, all abandoned foundations located within the construction area would be removed and hauled to the nearest disposal area. Temporary stormwater and groundwater diversion and dewatering systems would be installed. A temporary gravel haul road would be constructed to allow for access to the toe of the bluff, and a temporary bridge crossing would be placed across Ryan's Creek. Temporary security, and silt fencing would be installed along the bluff above the construction area.

   2) Earthwork: The bluff would be excavated and laid back at a specified slope. The excavated material would be hauled to the designated stockpile area, and later used as backfill in the construction of the new stabilized bluff. Material unsuitable for reuse would be hauled offsite for disposal. The stockpiled material, and imported fill, would be placed and compacted in lifts. Geogrid fabric would be installed at every other lift on the lower half of the bluff. The top of the bluff would be rough graded.

   3) Erosion Protection: Rock would be placed at the toe of the bluff on top of geotextile fabric. The rock would consist of a 1.5-foot thick base layer of filter rock, a 1.4-foot to 1.7-foot thick layer of B rock on top of the filter rock, and a 3.8-foot to 5.0-foot thick layer of armor rock on top of the B rock. Rock placement was assumed to be performed by land and water based equipment. Rock would be placed by land based equipment at low tide and by water based equipment at high tide. It was assumed the

land based equipment would operate for half of the shift and the water based equipment would operate the other half. Hauling was assumed to be done entirely by land in the estimate. Barging the rock over water is also an alternative, but no costs were included for this method of hauling in the estimate.

4) Recreational Features: An overland drainage system is needed also. Timber platforms are to be constructed along the top of the bluff, with stairs leading to the platforms where necessary. Three-seat benches are to be placed at each overlook along the top of the bluff.

5) Vegetation: Erosion control fabric would be used prior to the import and placement of a layer of top soil. The banks of the bluffs would be seeded with native grasses to a density of 10 lb/acre. Wouldow stakes and other shrub plantings would be set in place along the bluff. Along the top of the bluff one row of alders would be planted along with rows of spruce trees.

6) Additional Project Features: Asphalt would be placed to repair roads along the top of the bluff that were damaged during construction. Guardrails would also be installed along Mission Avenue where it parallels the bluff.

D. <u>Unusual Conditions</u>: (Soil, Water, Weather, Traffic). Wet saturated soils can be expected during excavation of soils along the bluff below the water table. Extreme tidal fluctuations are likely to be encountered. Extreme cold weather, turbulent waters, and ice within the river are likely to be encountered at the project site during winter construction.

E. <u>Unique Construction Techniques</u>: Approximately half of the rock placement would be in water work with specialty equipment.

F. <u>Equipment/Labor Availability and Distance Traveled</u>: All equipment and labor should be available in the Anchorage area.

6. Environmental Concerns

Construction activities would likely increase turbidity in the river. There is a potential for construction equipment to leak or spill contaminates into the river and or damage existing sensitive plant and wildlife.

7. Effective Dates for Labor, Equipment and Material Pricing

The labor, equipment, and material pricing were developed using the MCACES 2010 English Unit Cost Library, 2012 Kenai Labor Library, and the 2009 Equipment Library (Region IX) for the base cost estimates. The index pricing data has been prepared in May 2012 dollars.

The base cost estimates have been updated with current quoted fuel prices of $4.67/gal for off-road diesel, $4.95/gal for on-road diesel and $4.55/gal for gasoline in the Kenai area.

8. Productivity Index and Estimated Production Rates

The base estimate includes an overall Production Index of 70% which is based on anticipated project difficulty, method of construction, labor availability, supervision, job conditions, weather and expected delays.

The construction of this project would require many types of specialty equipment and crews due to the in-river work. See Appendix E for the Production Index calculation and notes and the Estimated Production Rates.

9. Project Markups

A. Escalation: Escalation has been calculated within the TPCS. Price levels have been escalated from index price levels of the construction cost estimate for May 2012 to the mid-point of construction, which is estimated to be November 2013.

B. Contingency: Contingencies represent allowances to cover unknowns, uncertainties and/or unanticipated conditions that are not possible to adequately evaluate from the data on hand at the time the cost estimate is prepared but must be represented by a sufficient cost to cover the identified risks. An overall contingency of 20% has been used for construction to cover design changes and uncertainties in quantities and unit prices.

10. Functional Costs

Functional costs associated with this work were provided by the Project Manager, as follows:

A. 01 Account – Lands and Damages**:** Costs for this account were estimated at $100,000 per acre for 30-acres.

B. 30 Account – Planning, Engineering, and Design: Costs for this account were estimated at 15% of the construction cost. This account covers the preparation of plans and specifications.

C. 31 Account – Construction Management: Costs for this account were estimated to be 8% of the construction cost. This account covers construction management during construction.

11. MCACES Construction Cost Estimate:

The construction cost estimate was developed using MCACES (MII) version 4.1 (Build 4) cost estimating software in accordance with guidance contained in ER 1110-2-1302, Civil Works Cost Engineering. See Appendix G for the MCACES construction cost estimate output report.

12. References

U.S. Army Corps of Engineers, 1993, *Engineering and Design Cost Engineering Policy and General Requirements*, *Engineering Regulation 1110-1-1300,* Department of the Army, Washington D.C., 26 March 1993.

U.S. Army Corps of Engineers, 1999, *Engineering and Design For Civil Works Projects, Engineering Regulation 1110-2-1150,* Department of the Army, Washington D.C., 31 August 1999.

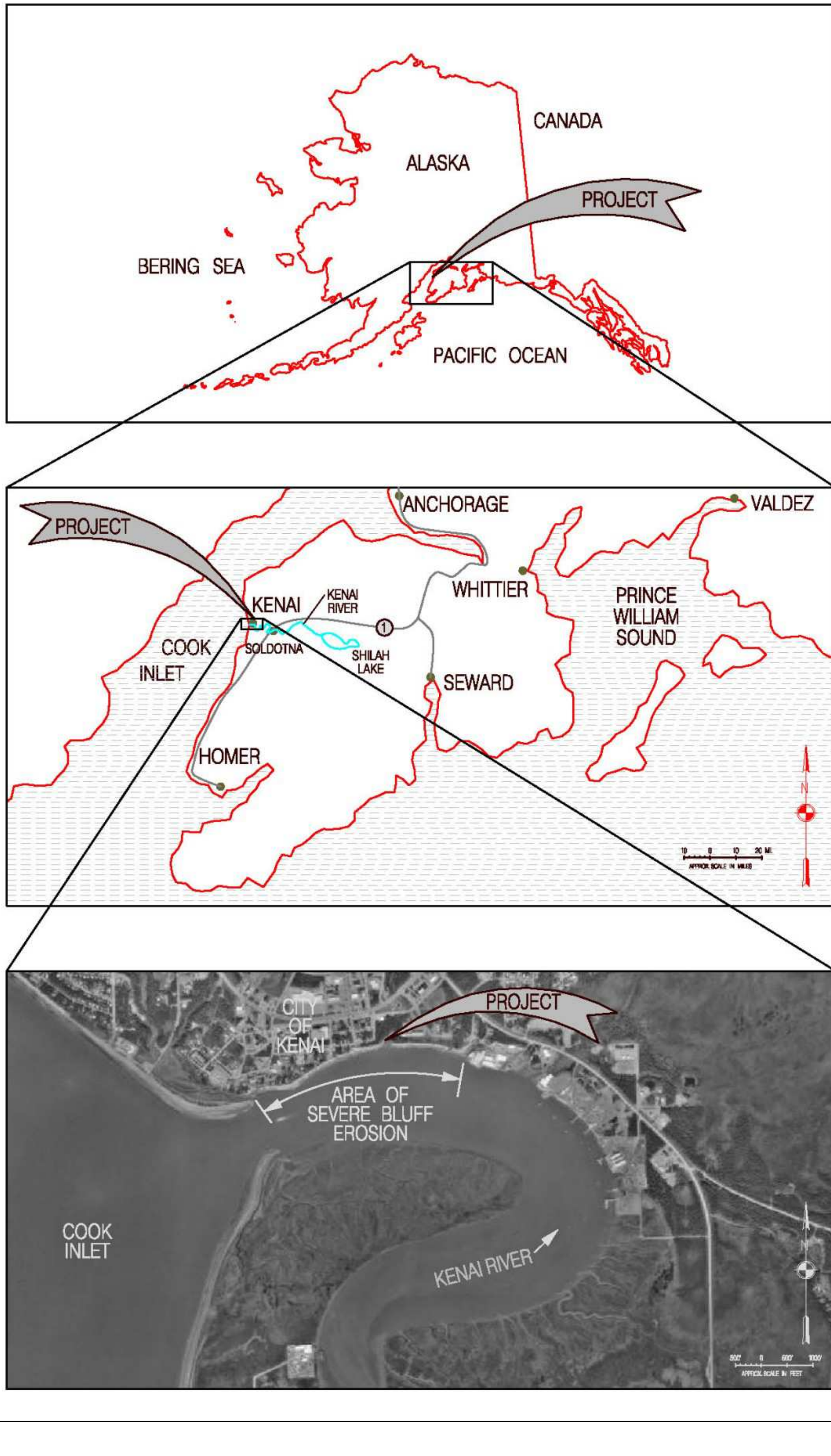
U.S. Army Corps of Engineers, 2008a, *Civil Works Cost Engineering, Engineering Regulation 1110-2-1302*, Department of the Army, Washington D.C., 15 September 2008.

U.S. Army Corps of Engineers, 2008b, *Construction Cost Estimating Guide For Civil Works, Engineering Technical Letter 1110-2-573,* Department of the Army, Washington D.C., 30 September 2008.

U.S. Army Corps of Engineers, 2010, *Civil Works Construction Cost Index System, Engineering Manual 1110-2-1304,* Department of the Army, Washington D.C., 31 March 2011.

APPENDIX A

Site Plan


CANADA
ALASKA
PROJECT
BERING SEA
PACIFIC OCEAN
ANCHORAGE
VALDEZ
PROJECT
WHITTIER
KENAI
KENAI RIVER
PRINCE WILLIAM SOUND
COOK INLET
SOLDOTNA
SHILAH LAKE
SEWARD
HOMER
APPROX SCALE IN MILES
CITY OF KENAI
PROJECT
AREA OF SEVERE BLUFF EROSION
COOK INLET
KENAI RIVER
APPROX SCALE IN FEET

APPENDIX B

Project Quantities and Detailed Quantity Take-Offs

Kenai River Bluff Stabilization Quantities

MCACES Source Tag	Item	Waste/Loss Factor (%)	Unit of Measure	Quantity
[02]	**RELOCATIONS**	**-**	**LS**	**1**
[02.01]	**Relcoations**	**-**	**LS**	**1**
[02.01.01]	**Pipe Demolition**	**-**	**LF**	**850**
[02.01.01.01]	**24" CMP Demolition**	**-**	**LF**	**200**
	Excavation	-	CY	178
	Demo 24" CMP	-	LF	200
	Backfill	-	CY	214
	Compaction	-	CY	214
[02.01.01.02]	**3/4" and 6" PVC Demolition**	**-**	**LF**	**650**
	Excavation	-	CY	433
	Demo 6" Pipe	-	LF	100
	Demo 3/4" to 4" Pipe	-	LF	550
	Demo 24" CMP Riser	-	EA	1
	Backfill	-	CY	520
	Compaction	-	CY	520
[02.01.02]	**Building and Pad Demolition**	**-**	**LS**	**1**
	Demo Building	-	SF	11,435
	Demo Foundation	-	SF	14,875
	Hauling	-	CY	661
	Disposal Fee	-	TON	1,227
[02.01.03]	**Overlook Demolition**	**-**	**LS**	**1**
	Demo Benches	-	EA	2
	Demo Retaining Wall	-	SF	360
	Hauling	-	CY	6.4
	Disposal Fee	-	TON	8
[02.01.04]	**Roadway Demolition**	**-**	**LS**	**1**
	Demo Pavement	-	SF	7,893
	Hauling	-	CY	117
	Tipping Fee	-	TON	195
[14]	**RECREATIONAL FACILITIES**	**-**	**LS**	**1**
[14.01]	**Recreational Facilities**	**-**	**LS**	**1**
[14.01.01]	**Overlook**	**-**	**EA**	**3**
[14.01.01.01]	**Overlook Boardwalk**	**-**	**LF**	**390**
	Lumber 2"x4"	-	LF	2,340
	Lumber 2"x6"	-	LF	2,340
	Lumber 4"x4"	-	LF	780
	Concrete Stairs	-	LF	100
	Lumber 2"x4"	-	SF	3,900
[14.01.01.02]	**Benches and Signs**	**-**	**LS**	**1**
	Benches	-	EA	15
	Signs	-	EA	40
[14.01.02]	**Roadway**	**-**	**LS**	**1**
	Asphalt Paving	-	TON	2,000
	Guide Rails	-	LF	400
[14.01.03]	**Surface Drainage**	**-**	**LS**	**1**
[14.01.03.01]	**24-inch CMP**	**-**	**LF**	**390**
	24" CMP	-	LF	205
	Excavation	-	CY	187
	Backfill	-	CY	144
	Bedding	-	CY	21
	Compaction	-	CY	165
	Hauling	-	CY	80
	Tipping Fee	-	TON	159
[14.01.03.02]	**Concrete Culverts**	**-**	**EA**	**3**
	Concrete Culverts	-	EA	3
[14.01.03.03]	**24-inch Gates**	**-**	**EA**	**3**
	24" Canal Gates	-	EA	3
[14.01.03.04]	**Riprap**	**-**	**CY**	**304**
	Riprap Placement	-	CY	304
[16]	**BANK STABILIZATION**	**-**	**LS**	**1**
[16.01]	**Bank Stabilization**	**-**	**LS**	**1**
[16.01.01]	**Site Preparation**	**-**	**LS**	**1**
[16.01.01.01]	**Silt Fence**	**-**	**LF**	**2,230**
	Silt Fence	-	LF	2,230

[16.01.01.02]	**Temporary Road**	**-**	**LF**	**5,225**
	Gravel Base	-	SY	5,806
	Stone Roadway	-	CY	968
[16.01.01.03]	**Pumping**	**-**	**LS**	**1**
	Dewatering Pumping	-	DAY	1,440
[16.01.01.04]	**Clearing and Grubbing**	**-**	**ACRE**	**10.3**
	Clearing and Grubbing	-	ACRE	10.3
	Tree Removal	-	EA	35
	Hauling	-	CY	5,609
	Tipping Fee	-	TON	38
[16.01.01.05]	**Fencing**	**-**	**LF**	**5,225**
	Fence	-	LF	5,225
[16.01.01.06]	**Temporary Fencing**	**-**	**LF**	**2,000**
	Temporary Fence	-	LF	2,000
[16.01.01.07]	**Temporary Bridge Crossing**	**-**	**EA**	**1**
	Temporary Bridge Crossing	-	SF	600
[16.01.02]	**Earthwork**	**-**	**LS**	**1**
[16.01.02.01]	**Alluvial Deposits**	**-**	**BCY**	**140,944**
[16.01.02.01.01]	**Excavation**	**-**	**BCY**	**140,944**
	Excavation	-	BCY	140,944
	Hauling	10%	LCY	155,038
[16.01.02.01.02]	**Backfill**	**-**	**CY**	**144,274**
	Transport From Stockpile	10%	LCY	158,701
	Spread Fill	10%	LCY	158,701
	Compaction	-	CY	144,274
[16.01.02.01.03]	**Dispose of Unusable Material**	**-**	**CY**	**23,256**
	Excavate and Load	10%	LCY	25,581
	Hauling	10%	LCY	25,581
	Tipping Fee	-	TON	37,674
[16.01.02.02]	**Glacial Till**	**-**	**BCY**	**67,006**
[16.01.02.02.01]	**Excavation**	**-**	**BCY**	**67,006**
	Excavation	-	BCY	67,006
	Hauling	25%	LCY	83,758
[16.01.02.02.02]	**Backfill**	**-**	**CY**	**15,078**
	Transport From Stockpile	25%	LCY	18,848
	Spread Fill	25%	LCY	18,848
	Compaction	-	CY	15,078
[16.01.02.02.03]	**Dispose of Unused Material**	**-**	**CY**	**51,928**
	Excavate and Load	25%	LCY	64,910
	Hauling	25%	LCY	64,910
	Tipping Fee	-	TON	84,123
[16.01.02.03]	**Borrow Fill**	**-**	**BCY**	**8,900**
	Borrow Fill	-	LCY	8,900
	Delivery Fee	-	TON	14,418
	Compaction	-	TON	8,900
[16.01.02.04]	**Soil Stabilization**	**-**	**LS**	**1**
	Geotextile Fabric	-	SY	83,000
	Grading	-	BCY	1,275
[16.01.03]	**Erosion Protection**	**-**	**LCY**	**56,307**
[16.01.03.01]	**Land Based Placement**	**-**	**LCY**	**26,878**
	Filter Rock	20%	LCY	6,878
	B Rock	5%	LCY	6,788
	Armor Rock	5%	LCY	13,212
[16.01.03.02]	**Water Based Placement**	**-**	**LCY**	**26,878**
	Filter Rock	20%	LCY	6,878
	B Rock	5%	LCY	6,788
	Armor Rock	5%	LCY	13,212
[16.01.03.03]	**Rock Loading on Barge**	**-**	**LCY**	**26,878**
	Filter Rock	-	LCY	6,878
	B Rock	-	LCY	6,788
	Armor Rock	-	LCY	13,212
[16.01.03.04]	**Geotextile Fabric**	**-**	**SY**	**34,433**
	Geotextile Fabric	-	SY	34,433
[16.01.04]	**Vegetation**	**-**	**LS**	**1**
	Geofabric	-	SY	62,700
	Soil Preparation	-	CY	26,851
	Seeding	-	ACRE	13
	Willow Tree	-	EA	3,660
	Willow Tree Planting	-	EA	3,660
	Spruce Trees	-	EA	5,362
	Spruce Tree Planting	-	EA	5,362

[02] RELOCATIONS
[02.01] Relocations
[02.01.01] Pipe Demolition
24" CMP Demolition

Excavating

Trench Length = 200 ft
Trench Depth = 6.0 ft
Trench Width = 4.0 ft

Volume = **178 BCY**

Backfill

Bank Volume = 178 BCY
Swell/Shrinkage Factor = 20%

Loose Volume = **214 LCY**

Compaction

Volume = **214 ECY**

3/4" - 6" PVC Demolition

Excavating

Trench Length = 650 ft
Trench Depth = 6.0 ft
Trench Width = 3.0 ft

Volume = **433 BCY**

Backfill

Bank Volume = 433 BCY
Swell/Shrinkage Factor = 20%

Loose Volume = **520 LCY**

Compaction

Volume = **520 ECY**

[02.01.02] Building and Pad Demolition

Hauling and Dumping

Area = 14,875 SF
Thickness = 1.0 ft
Swell/Shrinkage Factor = 20%
Density = 165 PCF

Loose Volume =	**661 LCY**
Weight =	**1,227 Tons**

[02.01.04] Roadway Demolition

Hauling and Dumping

Area = 7893 SF
Thickness = 4 in.
Swell/Shrinkage Factor = 20%
Density = 148 PCF

Loose Volume =	**117 LCY**
Weight =	**195 Tons**

[14] RECREATION FACILITIES
[14.01] Recreation Facilities

[14.01.03] Surface Drainage

Excavating

Bank Volume = 187 BCY

Loose Volume = **187 BCY**

Backfill

Bank Volume = 120 BCY
Swell/Shrinkage Factor = 20%

Loose Volume = **144 LCY**

Bedding

Bank Volume = 18 BCY
Swell/Shrinkage Factor = 20%

Loose Volume = **21 LCY**

Compaction

Volume = **165 ECY**

Hauling and Dumping

Bank Volume = 66 BCY
Swell/Shrinkage Factor = 20%
Density = 148 PCF

Loose Volume = **80 LCY**
Weight = **159 Tons**

Rock V-Ditch

Weight = 500 TONS
Density = 140 PCF
Overplace/Loss Factor = 15%

Volume = **304 LCY**

[16] BANK STABILIZATION
[16.01] Bank Stabilization
[16.01.01] Site Preparation

Clearing and Grubbing

Hauling and Dumping	
Area =	10.3 AC
Thickness =	4 in.
Density =	55 PCF

Loose Volume =	**5,539 LCY**
Weight =	**4,113 Tons**

Tree Removal

Hauling and Dumping	
No. of Trees =	35 EA
Chipped Volume =	2 CY
Density =	40 PCF

Loose Volume =	**70 LCY**
Weight =	**38 Tons**

[16] BANK STABILIZATION
[16.01] Bank Stabilization
[16.01.02] Earthwork
[16.01.02.01] Alluvial Deposits

Alluvial Material to Haul & Stockpile Onsite

Bank Volume = 140,944 BCY
Swell/Shrinkage Factor = 10%

Loose Volume = **155,039 LCY**

Unsuitable Alluvial Material to Haul Offsite & Dump

Unusable Percent = 15%
Unusable Volume = 23256 BCY
Swell/Shrinkage Factor = 10%
Density = 120 PCF

Loose Volume = **25,581 LCY**
Weight = **37,674 Tons**

Place & Compact Stockpiled Alluvial Material

Bank Volume = 144,274 BCY
Swell/Shrinkage Factor = 10%

Loose Volume = **158,701 LCY**

TETRA TECH, INC.

PROJECT: Kenai River Bluff Stabilization | JOB NO.: T17688
DETAIL: Detailed Quantity Take-Offs | DATE: 6/2/2011
COMPUTED BY: NSS
CHECKED BY: IGP

[16.01.02.02] Glacial Till

Glacial Till to Haul & Stockpile Onsite

Bank Volume = 67,006 BCY
Swell/Shrinkage Factor = 25%

Loose Volume = **83,757 LCY**

Unsuitable Glacial Till Material to Haul Offsite & Dump

Bank Volume = 51,928 BCY
Swell/Shrinkage Factor = 25%
Density = 120 PCF

Loose Volume = **64,910 LCY**
Weight = **84,123 Tons**

Place & Compact Stockpiled Glacial Till

Bank Volume = 15,078 BCY
Swell/Shrinkage Factor = 25%

Loose Volume = **18,847 LCY**

[16.01.02.03] Borrow Material

Import, Place & Compact Borrow Material

Bank Volume = 8,900 BCY
Density = 130 PCF

Weight = **15,619 Tons**

TETRA TECH, INC.

PROJECT: Kenai River Bluff Stabilization	JOB NO.: T17688
DETAIL: Detailed Quantity Take-Offs	DATE: 6/2/2011
COMPUTED BY: NSS	
CHECKED BY: IGP	

[16] BANK STABILIZATION
[16.01] Bank Stabilization
[16.01.03] Erosion Protection
[16.01.03.01] Land Based Placement

Filter Rock Placement

Weight =	7,680 TONS
Tonnage Factor =	1.34 TONS/CY
Bank Volume =	5,731 CY
Overplace/Loss Factor =	20%

Loose Volume = **6,878 LCY**

B Rock Placement

Weight =	8,663 TONS
Tonnage Factor =	1.34 TONS/CY
Bank Volume =	6,465 CY
Overplace/Loss Factor =	5%

Loose Volume = **6,788 LCY**

Armor Rock Placement

Weight =	17,616 TONS
Tonnage Factor =	1.4 TONS/CY
Bank Volume =	12,583 CY
Overplace/Loss Factor =	5%

Loose Volume = **13,212 LCY**

[16.01.03.02] Water Based Placement

Filter Rock Placement

Weight =	7,680 TONS
Tonnage Factor =	1.34 TONS/CY
Bank Volume =	5,731 CY
Overplace/Loss Factor =	20%

Loose Volume = **6,878 LCY**

B Rock Placement

Weight =	8,663 TONS
Tonnage Factor =	1.34 TONS/CY
Bank Volume =	6,465 CY
Overplace/Loss Factor =	5%

Loose Volume = **6,788 LCY**

Armor Rock Placement

Weight =	17,616 TONS
Tonnage Factor =	1.4 TONS/CY
Bank Volume =	12,583 CY
Overplace/Loss Factor =	5%

Loose Volume = **13,212 LCY**

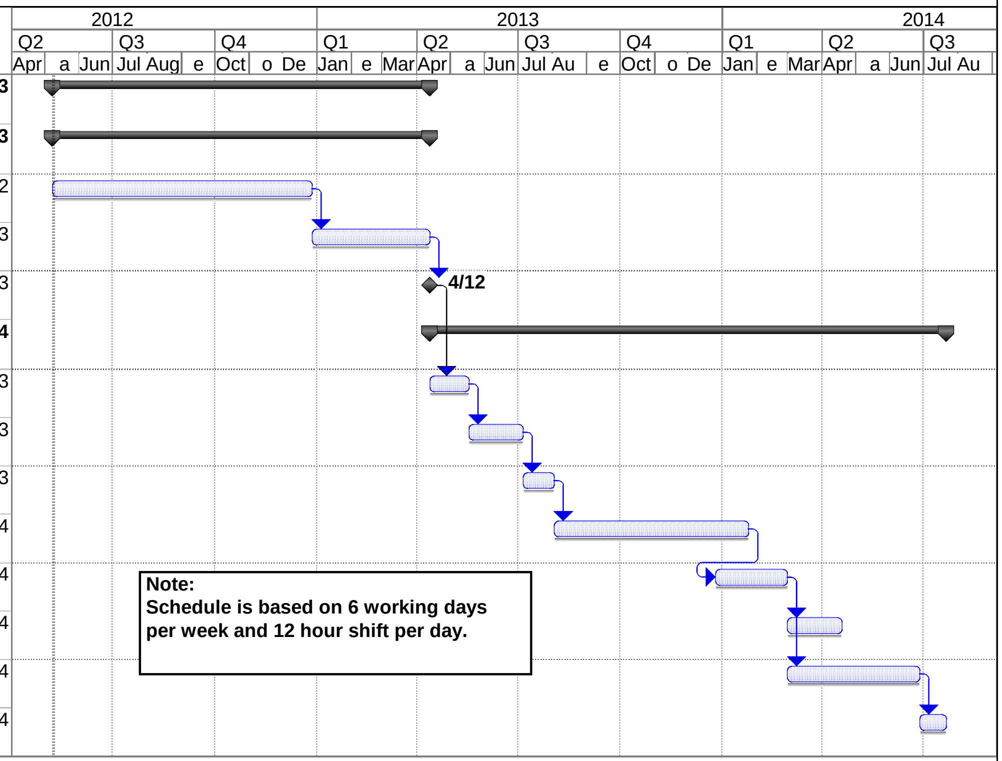
APPENDIX C

Tentative Project Schedule

Kenai River Bluff Stabilization
Tentative Project Schedule

Tue 5/8/12

ID	Task Name	Duration	Start	Finish
1	**Pre Construction Award**	**292 days**	**Tue 5/8/12**	**Fri 4/12/13**
2	**Planning and Design**	**292 days**	**Tue 5/8/12**	**Fri 4/12/13**
3	Plans, Specifications and Estimate	201 days	Tue 5/8/12	Thu 12/27/12
4	Contract Advertising	91 days	Fri 12/28/12	Fri 4/12/13
5	Construction Contract Award	0 days	Fri 4/12/13	Fri 4/12/13
6	**Post Construction Award**	**398 days**	**Sat 4/13/13**	**Mon 7/21/14**
7	Mobilization	30 days	Sat 4/13/13	Fri 5/17/13
8	Relocations	42 days	Sat 5/18/13	Fri 7/5/13
9	Site Preparation	24 days	Sat 7/6/13	Fri 8/2/13
10	Earthwork	150 days	Sat 8/3/13	Fri 1/24/14
11	Rock Placement	56 days	Thu 12/26/13	Fri 2/28/14
12	Recreational Facilities	42 days	Sat 3/1/14	Fri 4/18/14
13	Vegetative Planting	102 days	Sat 3/1/14	Fri 6/27/14
14	Demobilization	20 days	Sat 6/28/14	Mon 7/21/14



Task		Milestone		External Tasks	
Split		Summary		External MileTask	
Progress		Project Summary		Split	

APPENDIX D

Local Market Labor Rates

General Decision Number: AK120001 04/20/2012 AK1

Superseded General Decision Number: AK20100001

State: Alaska

Construction Types: Building and Heavy

Counties: Alaska Statewide.

BUILDING AND HEAVY CONSTRUCTION PROJECTS (does not include residential construction consisting of single family homes and apartments up to and including 4 stories)

Modification Number	Publication Date
0	01/06/2012
1	01/20/2012
2	02/03/2012
3	02/10/2012
4	02/17/2012
5	04/13/2012
6	04/20/2012

ASBE0097-001 01/01/2011

	Rates	Fringes
Asbestos Workers/Insulator (includes application of all insulating materials protective coverings, coatings and finishings to all types of mechanical systems)........................	$ 36.11	15.26

ASBE0097-002 01/01/2011

	Rates	Fringes
HAZARDOUS MATERIAL HANDLER (includes preparation, wetting, stripping, removal scrapping, vacuming, bagging, and disposing of all insulation materials, whether they contain asbestos or not, from mechanical systems).........	$ 36.11	15326

BOIL0502-002 07/01/2011

	Rates	Fringes
BOILERMAKER......................	$ 42.70	24.86

BRAK0001-002 07/01/2011

	Rates	Fringes
Bricklayer, Blocklayer,		

```
Stonemason, Marble Mason,
Tile Setter, Terrazzo Worker.....$ 37.39            17.60
Tile & Terrazzo Finisher.........$ 31.78            17.60
----------------------------------------------------------------
 CARP1501-001 09/01/2011

                                  Rates          Fringes

MILLWRIGHT.......................$ 33.89            18.23
----------------------------------------------------------------
 CARP2520-003 07/01/2010

                                  Rates          Fringes

Diver
     Stand-by....................$ 39.80            18.73
     Tender......................$ 38.80            18.73
     Working.....................$ 79.60            18.73
Piledriver
     Carpenter...................$ 35.49            18.73
     Piledriver; Skiff Operator
     and Rigger..................$ 34.49            18.73
     Sheet Stabber...............$ 35.49            18.73
     Welder......................$ 41.05            18.73

DEPTH PAY PREMIUM FOR DIVERS BELOW WATER SURFACE:
50-100 feet                  $1.00 per foot
101 feet and deeper          $2.00 per foot

ENCLOSURE PAY PREMIUM WITH NO VERTICAL ASCENT:
5-50 FEET                    $1.00 PER FOOT/DAY
51-100 FEET                  $2.00 PER FOOT/DAY
101 FEET AND ABOVE           $3.00 PER FOOT/DAY

SATURATION DIVING:
  The standby rate applies until saturation starts. The
  saturation diving rate applies when divers are under
  pressure continuously until work task and decompression are
  complete. the diver rate shall be paid for all saturation
  hours.

WORK IN COMBINATION OF CLASSIFICATIONS:
  Employees working in any combination of classifications
  within the diving crew (except dive supervisor) in a shift
  are paid in the classification with the highest rate for
  that shift.
----------------------------------------------------------------
 CARP4059-001 09/01/2011

                                  Rates          Fringes

CARPENTER
     Carpenter...................$ 35.49            20.38
     Lather/Drywall Applicator...$ 35.49            20.38
----------------------------------------------------------------
 ELEC1547-004 04/01/2012

                                  Rates          Fringes

CABLE SPLICER....................$ 39.77         3%+$21.93
```

```
Electrician;Technician...........$ 38.02        3%+$21.93
----------------------------------------------------------------
 ELEC1547-005 04/01/2012

Line Construction

                                  Rates          Fringes

CABLE SPLICER....................$ 49.92        3%+$24.08
Linemen (Including Equipment
Operators, Technician)...........$ 48.17         3%+24.08
Powderman........................$ 46.17        3%+$24.08
TREE TRIMMER.....................$ 33.62        3%+$18.58
----------------------------------------------------------------
 ELEV0019-002 01/01/2012

                                  Rates          Fringes

ELEVATOR MECHANIC................$ 49.035      23.535+a+b

FOOTNOTE: a.  Employer contributes 8% of the basic hourly rate
    for over 5 year's service and 6% of the basic
    hourly rate for 6 months to 5 years' of service
    as vacation paid credit.   b. Eight paid holidays:
    New Year's Day; Memorial Day; Independence Day;
    Labor Day; Veteran's Day; Thanksgiving Day; Friday after
    Thanksgiving and Christmas Day
----------------------------------------------------------------
 ENGI0302-002 01/01/2012

                                  Rates          Fringes

Power equipment operators:
     GROUP 1.....................$ 37.43            19.00
     GROUP 1A....................$ 39.19            19.00
     GROUP 2.....................$ 36.66            19.00
     GROUP 3.....................$ 35.94            19.00
     GROUP 4.....................$ 29.73            19.00
     TUNNEL WORK
      GROUP 1....................$ 41.17            19.00
      GROUP 1A...................$ 43.11            19.00
      GROUP 2....................$ 40.33            19.00
      GROUP 3....................$ 39.53            19.00
      GROUP 4....................$ 32.70            19.00

POWER EQUIPMENT OPERATOR CLASSIFICATIONS

  GROUP 1:  Asphalt Roller; Back Filler; Barrier Machine
  (Zipper); Batch Plant Operator: Batch and Mixer over 200
  yds.; Beltcrete with power pack and similar conveyors;
  Bending Machine; Boat Coxwains; Bulldozers; Cableways,
  Highlines and Cablecars; Cleaning Machine; Coating Machine;
  Concrete Hydro Blaster; Cranes-45 tons and under or 150
  foot boom and under (including jib and attachments): (a)
  Shovels, Backhoes, excavators with all attachments,
  Draglines, Clamshells; Gradalls-3 yards and under; (b)
  Hydralifts or Transporters, all track or truck type,(c)
  Derricks; Crushers; Deck Winches-Double Drum; Ditching or
  Trenching Machine (16 inch or over); Drilling Machines,
  core, cable, rotary and exploration; Finishing Machine
```

Operator, concrete paving, Laser Screed, sidewalk, curb and gutter machine; Helicopters; Hover Craft, Flex Craft, Loadmaster, Air Cushion, All Terrain Vehicle, Rollagon, Bargecable, Nodwell Sno Cat; Hydro Ax: Feller Buncher and similar; Loaders: Forklifts with power boom and swing attachment, Overhead and front end, 2 1/2 yards through 5 yards, Loaders with forks or pipe clamps, Loaders, elevating belt type, Euclid and similar types; Mechanics, Bodyman; Micro Tunneling Machine; Mixers: Mobile type w/hoist combination; Motor Patrol Grader; Mucking Machines: Mole, Tunnel Drill, Horizontal/Directional Drill Operator, and/or Shield; Operator on Dredges; Piledriver Engineers, L. B. Foster, Puller or similar Paving Breaker; Power Plant, Turbine Operator, 200 k.w. and over (power plants or combination of power units over 300 k.w.); Sauerman-Bagley; Scrapers-through 40 yards; Service Oiler/Service Engineer; Sidebooms-under 45 tons; Shot Blast Machine; Spreaders, Blaw Knox, Cedarapids, Barber Greene, Slurry Machine; Sub-grader (Gurries, C.M.I. and C.M.I. Roto Mills and similar types); Tack tractor; Truck mounted Concrete Pumps, Conveyor, Creter; Water Kote Machine; Unlicensed off road hauler; Welder; Electrical Mechanic, Camp Maintenance Engineer

GROUP 1A: Cranes-over 45 tons or 150 foot (including jib and attachments): (a) Shovels, backhoes,excavators with all attachments, draglines, clamshells-over 3 yards, (b) Tower cranes;Licensed Water/Waste Water Treatment Operator; Loaders over 5 yds.;Certified Welder, Electrical Mechanic, Camp Maintenance Engineer, Mechanic (over 10,000 hours); Motor Patrol Grader, Dozer, Grade Tractor (finish: when finishing to final grade and/or to hubs, or for asphalt); Power Plants: 1000 k.w. and over; Quad; Screed; Sidebooms over 45 tons; Slip Form Paver C.M.I. and similar types; Scrapers over 40 yards; Camera/Tool/Video Operator (Slipline).

GROUP 2: Batch Plant Operators: Batch and Mixer 200 yds. per hour and under; Boiler-fireman; Cement Hog and Concrete Pump Operator; Conveyors (except as listed in group 1); Hoist on steel erection; Towermobiles and Air Tuggers; Horizontal/Directional Drill Locator;Licensed Grade Technician; Loaders, Elevating Grader, Dumor and similar; Locomotives: rod and geared engines; Mixers; Screening, Washing Plant; Sideboom (cradling rock drill regardless of size); Skidder; Trencing Machine under 16 inches; Waste/ Waste Water Treatment Operator.

GROUP 3: "A" Frame Trucks, Deck Winches: single power drum; Bombardier (tack or tow rig); Boring Machine; Brooms-power; Bump Cutter; Compressor; Farm tractor; Forklift, industrial type; Gin Truck or Winch Truck with poles when used for hoisting; Grade Checker and Stake Hopper; Hoist, Air Tuggers, Elevators; Loaders: (a) Elevating-Athey, Barber Green and similar types (b) Forklifts or Lumber Carrier (on construction job site) (c) Forklifts with Tower (d) Overhead and Front-end, under 2 1/2 yds. Locomotives:Dinkey (air, steam, gas and electric) Speeders; Mechanics (light duty); Mixers: Concrete Mixers and Batch 200 yds. per hour and under; Oil, Blower Distribution; Post Hole Diggers, mechanical; Pot Fireman (power agitated); Power Plant, Turbine Operator, under 300 k.w.; Pumps-water; Roller-other than Plantmix; Saws, concrete; Skid Steer with all attachments; Straightening Machine; Tow Tractor

GROUP 4: Rig Oiler/Assistant Engineer (if over 85 tons or 100 ft. boom);Parts and Equipment Coordinator; Swamper (on trenching machines or shovel type equipment); Spotter; Steam Cleaner; Drill Helper.

FOOTNOTE: Groups 1-4 receive 10% premium while performing tunnel or underground work. Rig Oiler/Assistant Engineer shall be required on cranes over 85 tons or over 100 feet of boom.

IRON0751-003 08/01/2011

	Rates	Fringes
Ironworkers:		
BRIDGE, STRUCTURAL, ORNAMENTAL, REINFORCING MACHINERY MOVER, RIGGER, SHEETER, STAGE RIGGER, BENDER OPERATOR	$ 33.40	23.16
FENCE, BARRIER AND GUARDRAIL INSTALLERS	$ 29.90	23.16
GUARDRAIL LAYOUT MAN	$ 30.64	23.16
HELICOPTER, TOWER	$ 34.40	23.16

LABO0341-005 07/01/2011

	Rates	Fringes
Laborers: North of the 63rd Parallel & East of Longitude 138 Degrees		
GROUP 1	$ 29.00	20.02
GROUP 2	$ 30.00	20.02
GROUP 3	$ 30.90	20.02
GROUP 3A	$ 34.18	20.02
GROUP 3B	$ 35.01	20.02
GROUP 4	$ 18.57	20.02
TUNNELS, SHAFTS, AND RAISES		
GROUP 1	$ 31.90	20.02
GROUP 2	$ 33.00	20.02
GROUP 3	$ 33.99	20.02
GROUP 3A	$ 37.60	20.02
GROUP 3B	$ 38.51	20.02
Laborers: South of the 63rd Parallel & West of Longitude 138 Degrees		
GROUP 1	$ 29.00	20.02
GROUP 2	$ 30.00	20.02
GROUP 3	$ 30.90	20.02
GROUP 3A	$ 34.18	20.02
GROUP 3B	$ 35.01	20.02
GROUP 4	$ 18.57	20.02
TUNNELS, SHAFTS, AND RAISES		
GROUP 1	$ 31.90	20.02

GROUP 2	$ 33.00	20.02
GROUP 3	$ 33.99	20.02
GROUP 3A	$ 37.60	20.02
GROUP 3B	$ 38.51	20.02

LABORERS CLASSIFICATIONS

GROUP 1: Asphalt Workers (shovelman, plant crew); Brush Cutters; Camp Maintenance Laborer; Carpenter Tenders; Choke Setters, Hook Tender, Rigger, Signalman; Concrete Laborer(curb and gutter, chute handler, grouting, curing, screeding); Crusher Plant Laborer; Demolition Laborer; Ditch Diggers; Dump Man; Environmental Laborer (asbestos (limited to nonmechanical systems), hazardous and toxic waste, oil spill); Fence Installer; Fire Watch Laborer; Flagman; Form Strippers; General Laborer; Guardrail Laborer, Bridge Rail Installers; Hydro-Seeder Nozzleman; Laborers (building); Landscape or Planter; Laying of Decorative Block (retaining walls, flowered decorative block 4 feet and below); Material Handlers; Pneumatic or Power Tools; Portable or Chemical Toilet Serviceman; Pump Man or Mixer Man; Railroad Track Laborer; Sandblast, Pot Tender; Saw Tenders; Scaffold Building and Erecting; Slurry Work; Stake Hopper; Steam Point or Water Jet Operator; Steam Cleaner Operator; Tank Cleaning; Utiliwalk, Utilidor Laborer and Conduit Installer; Watchman (construction projects); Window Cleaner

GROUP 2: Burning and Cutting Torch; Cement or Lime Dumper or Handler (sack or bulk); Choker Splicer; Chucktender (wagon, airtrack and hydraulic drills); Concrete Laborers (power buggy, concrete saws, pumpcrete nozzleman, vibratorman); Culvert Pipe Laborer; Cured in place Pipelayer; Environmental Laborer (marine work, oil spill skimmer operator, small boat operator); Foam Gun or Foam Machine Operator; Green Cutter (dam work); Gunnite Operator; Hod Carriers; Jackhammer or Pavement Breakers (more than 45 pounds);Laying of Decorative Block (retaining walls, flowered decorative block above 4 feet); Mason Tender and Mud Mixer (sewer work); Pilot Car; Plasterer, Bricklayer and Cement Finisher Tenders; Power Saw Operator; Railroad Switch Layout Laborer; Sandblaster; Sewer Caulkers; Sewer Plant Maintenance Man; Thermal Plastic Applicator; Timber Faller, chain saw operator, filer; Timberman

GROUP 3: Alarm Installer; Bit Grinder; Guardrail Machine Operator; High Rigger and tree topper; High Scaler; Multiplate; Slurry Seal Squeegee Man

GROUP 3A: Asphalt Raker, Asphalt Belly dump lay down; Drill Doctor (in the field); Drillers (including, but not limited to, wagon drills, air track drills; hydraulic drills); Powderman; Pioneer Drilling and Drilling Off Tugger (all type drills); Pipelayers

GROUP 3B: Grade checker (setting or transfering of grade marks, line and grade)

GROUP 4: Final Building Cleanup

TUNNELS, SHAFTS, AND RAISES CLASSIFICATIONS

GROUP 1: Brakeman; Muckers; Nippers; Topman and Bull Gang; Tunnel Track Laborer

GROUP 2: Burning and Cutting Torch; Concrete Laborers; Jackhammers; Nozzleman, Pumpcrete or Shotcrete.

GROUP 3: Miner; Retimberman

GROUP 3A: Asphalt Raker, Asphalt Belly dump lay down; Drill Doctor (in the field); Drillers (including, but not limited to, wagon drills, air track drills; hydraulic drills); Powderman; Pioneer Drilling and Drilling Off Tugger (all type drills); Pipelayers.

GROUP 3B: Grade checker (setting or transfering of grade marks, line and grade)

Tunnel shaft and raise rates only apply to workers regularly employed inside a tunnel portal or shaft collar.

PAIN1959-001 07/01/2011

NORTH OF THE 63RD PARALLEL

	Rates	Fringes
PAINTER		
BRUSH/ROLLER PAINT OR WALL COVERER	$ 29.17	18.47
TAPING, TEXTURING, STRUCTURAL PAINTING, SANDBLASTING, POT TENDER, FINISH METAL, SPRAY, BUFFER OPERATOR, RADON MITIGATION, LEAD BASED PAINT ABATEMENT, HAZARDOUS MATERIAL HANDLER	$ 29.67	18.47

PAIN1959-002 07/01/2011

SOUTH OF THE 63RD PARALLEL

	Rates	Fringes
Painters:		
Brush, Roller, Sign, Paper and Vinyl, Swing Stage, Hand Taper/Drywall, Structural Steel, and Commercial Spray	$ 26.98	18.22
Machine Taper/Drywall	$ 28.18	18.22
Spray-Sand/Blast, Epoxy and Tar Applicator	$ 29.48	16.22

PAIN1959-003 07/01/2011

NORTH OF THE 63RD PARALLEL

	Rates	Fringes
GLAZIER	$ 34.09	17.28

PAIN1959-004 07/01/2011

	Rates	Fringes
FLOOR LAYER: Carpet	$ 30.52	12.39

PAIN1959-006 07/01/2011

SOUTH OF THE 63RD PARALLEL

	Rates	Fringes
GLAZIER	$ 34.09	17.23

PLAS0867-001 02/01/2012

	Rates	Fringes
PLASTERER		
North of the 63rd parallel	$ 33.93	19.07
South of the 63rd parallel	$ 33.68	19.07

PLAS0867-004 02/01/2012

	Rates	Fringes
CEMENT MASON/CONCRETE FINISHER		
North of the 63rd parallel	$ 33.68	19.07
South of the 63rd parallel	$ 33.43	19.07

PLUM0262-002 01/01/2012

East of the 141st Meridian

	Rates	Fringes
Plumber; Steamfitter	$ 36.02	23.82

PLUM0367-002 07/01/2011

South of the 63rd Parallel

	Rates	Fringes
Plumber; Steamfitter	$ 36.98	18.72

PLUM0375-002 07/01/2011

North of the 63rd Parallel

	Rates	Fringes
Plumber; Steamfitter	$ 39.71	18.45

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* PLUM0669-002 04/01/2012

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                                  Rates          Fringes

SPRINKLER FITTER.................$ 41.23           21.52
----------------------------------------------------------------
 ROOF0190-002 06/01/2011

                                  Rates          Fringes

ROOFER
     NORTH OF THE 63RD PARALLEL..$ 28.50         2.44 + a
     SOUTH OF THE 63RD PARALLEL..$ 28.50         2.44 + a

FOOTNOTE:
  a. Employers are to supply employees with comprehensive
  medical insurance.  Employer is  responsible to cover, at
  minimum one-half (1/2) of the individual premium.  The
  individual will be responsible for the remaining premium.
----------------------------------------------------------------
 SHEE0023-003 06/01/2010

South of the 63rd Parallel

                                  Rates          Fringes

Sheet Metal Worker...............$ 38.84           18.35
----------------------------------------------------------------
 SHEE0023-004 07/02/2010

North of the 63rd Parallel

                                  Rates          Fringes

Sheet Metal Worker...............$ 42.98           18.56
----------------------------------------------------------------
 TEAM0959-003 09/01/2011

                                  Rates          Fringes

TRUCK DRIVER
     GROUP 1.....................$ 37.77           16.43
     GROUP 1A....................$ 39.04           16.43
     GROUP 2.....................$ 36.51           16.43
     GROUP 3.....................$ 35.69           16.43
     GROUP 4.....................$ 35.11           16.43
     GROUP 5.....................$ 34.35           16.43

  GROUP 1:  Semi with Double Box Mixer; Dump Trucks (including
  rockbuggy and trucks with pups) over 40 yards up to and
  including 60 yards; Deltas, Commanders, Rollogans and
  similar equipment when pulling sleds, trailers or similar
  equipment; Boat Coxswain; Lowboys including attached
  trailers and jeeps, up to and including 12 axles; Ready-mix
  over 12 yards up to and including 15 yards); Water Wagon
  (250 Bbls and above); Tireman, Heavy Duty/Fueler

  GROUP 1A:  Dump Trucks (including Rockbuggy and Trucks with
  pups) over 60 yards up to and including 100 yards; Jeeps
  (driver under load)

  GROUP 2: Turn-O-Wagon or DW-10 not self-loading; All Deltas,
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Commanders, Rollogans, and similar equipment; Mechanics; Dump Trucks (including Rockbuggy and Trucks with pups) over 20 yards up to and including 40 yards; Lowboys including attached trailers and jeeps up to and including 8 axles; Super vac truck/cacasco truck/heat stress truck; Ready-mix over 7 yards up to and including 12 yards;

GROUP 3: Dump Trucks (including Rockbuggy and Trucks with pups) over 10 yards up to and including 20 yards; batch trucks 8 yards and up; Oil distributor drivers; Partsman; Oil Distributor Drivers; Trucks/Jeeps (push or pull); Traffic Control Technician

GROUP 4: Buggymobile; Semi or Truck and trailer; Dumpster; Tireman (light duty); Dump Trucks (including Rockbuggy and Truck with pups) up to and including 10 yards; Track Truck Equipment; Stringing Truck; Grease Truck; Flat Beds, dual rear axle; Hyster Operators (handling bulk aggregate); Lumber Carrier; Water Wagon, semi; Water Truck, dual axle; Gin Pole Truck, Winch Truck, Wrecker, Truck Mounted "A" Frame manufactured rating over 5 tons; Bull Lifts and Fork Lifts with Power Boom and Swing attachments, over 5 tons; Front End Loader with Forks; Bus Operator over 30 passengers; All Terrain Vehicles; Boom Truck/Knuckle Truck over 5 tons; Foam Distributor Truck/dual axle; Hydro-seeders, dual axle; Vacuum Trucks, Truck Vacuum Sweepers; Loadmaster (air and water); Air Cushion or similar type vehicle; Fire Truck/Ambulance Driver; Combination Truck-fuel and grease; Compactor (when pulled by rubber tired equipment); Rigger (air/water/oilfield); Ready Mix, up to and including 7 yards;

GROUP 5: Gravel Spreader Box Operator on Truck; Flat Beds, single rear axle; Boom Truck/Knuckle Truck up to and including 5 tons; Pickups (Pilot Cars and all light duty vehicles); Water Wagon (Below 250 Bbls); Gin Pole Truck, Winch Truck, Wrecker, Truck Mounted "A" Frame, manufactured rating 5 tons and under; Bull Lifts and Fork Lifts (fork lifts with power broom and swing attachments up to and including 5 tons); Buffer Truck; Tack Truck; Farm type Rubber Tired Tractor (when material handling or pulling wagons on a construction project); Foam Distributor, single axle; Hydro-Seeders, single axle; Team Drivers (horses, mules and similar equipment); Fuel Handler (station/bulk attendant); Batch Truck, up to and including 7 yards; Gear/Supply Truck; Bus Operator, Up to 30 Passengers; Rigger/Swamper

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WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

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Unlisted classifications needed for work not included within the scope of the classifications listed may be added after award only as provided in the labor standards contract clauses (29CFR 5.5 (a) (1) (ii)).

The body of each wage determination lists the classification and wage rates that have been found to be prevailing for the cited type(s) of construction in the area covered by the wage determination. The classifications are listed in alphabetical order of "identifiers" that indicate whether the particular rate is union or non-union.

Union Identifiers

An identifier enclosed in dotted lines beginning with characters other than "SU" denotes that the union classification and rate have found to be prevailing for that classification. Example: PLUM0198-005 07/01/2011. The first four letters , PLUM, indicate the international union and the four-digit number, 0198, that follows indicates the local union number or district council number where applicable , i.e., Plumbers Local 0198. The next number, 005 in the example, is an internal number used in processing the wage determination. The date, 07/01/2011, following these characters is the effective date of the most current negotiated rate/collective bargaining agreement which would be July 1, 2011 in the above example.

Union prevailing wage rates will be updated to reflect any changes in the collective bargaining agreements governing the rate.

Non-Union Identifiers

Classifications listed under an "SU" identifier were derived from survey data by computing average rates and are not union rates; however, the data used in computing these rates may include both union and non-union data. Example: SULA2004-007 5/13/2010. SU indicates the rates are not union rates, LA indicates the State of Louisiana; 2004 is the year of the survey; and 007 is an internal number used in producing the wage determination. A 1993 or later date, 5/13/2010, indicates the classifications and rates under that identifier were issued as a General Wage Determination on that date.

Survey wage rates will remain in effect and will not change until a new survey is conducted.

WAGE DETERMINATION APPEALS PROCESS

1.) Has there been an initial decision in the matter? This can be:

* an existing published wage determination
* a survey underlying a wage determination
* a Wage and Hour Division letter setting forth a position on a wage determination matter
* a conformance (additional classification and rate) ruling

On survey related matters, initial contact, including requests for summaries of surveys, should be with the Wage and Hour Regional Office for the area in which the survey was conducted because those Regional Offices have responsibility for the Davis-Bacon survey program. If the response from this initial contact is not satisfactory, then the process described in 2.) and 3.) should be followed.

With regard to any other matter not yet ripe for the formal process described here, initial contact should be with the Branch of Construction Wage Determinations. Write to:

Branch of Construction Wage Determinations
Wage and Hour Division
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

2.) If the answer to the question in 1.) is yes, then an interested party (those affected by the action) can request review and reconsideration from the Wage and Hour Administrator (See 29 CFR Part 1.8 and 29 CFR Part 7). Write to:

Wage and Hour Administrator
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

The request should be accompanied by a full statement of the interested party's position and by any information (wage payment data, project description, area practice material, etc.) that the requestor considers relevant to the issue.

3.) If the decision of the Administrator is not favorable, an interested party may appeal directly to the Administrative Review Board (formerly the Wage Appeals Board). Write to:

Administrative Review Board
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

4.) All decisions by the Administrative Review Board are final.

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END OF GENERAL DECISION

APPENDIX E

Productivity Index and Notes and Estimated Production Rates

PRODUCTION INDEX

NOTES. Enter percentage values in the yellow cells only. If a condition does not apply or it is already applied in the project then enter 100%.

PRODUCTION ELEMENTS	CONDITION	STATE	Production Efficiency Percent (%) Range		COMMENTS
1. Project Difficulty	**complicated**	One of a kind, hard to reach areas, overly congested, tunnel work.	*55%-85%*	80%	- Careful not to duplicate Project Difficulty. Enter 100% if Project Difficulty is already considered in the production rate of each individual cost item in the estimate.
	normal	Nature of work is common. Straightforward design. Normal site access.	*85%-100%*		
	Production efficiency resulting from project difficulty:			**80%**	
2. Method of Construction	**Low Equip - High Labor**	Unfavorable terrain, labor intensive, limited heavy equipment use	*25%-55%*		
	Medium Equip - Medium Labor	Average terrain, normal equipment and labor use	*55%-85%*		
	High Equip - Low Labor	Favorable terrain, extensive heavy equipment operation	*85%-100%*	90%	
	Production efficiency resulting from method of construction:			**90%**	
3. Labor	**shortage**	Remote area, poor training, low pay, scarce supply	*25%-55%*		- Availability of drug-free construction workers is an issue on many areas. - Shortage of labor forces in remote and specific geographic areas could be a problem.
	average	Suburban area, average training, average pay, normal supply	*55%-85%*	80%	
	surplus	Urban area, good training, good pay, surplus skilled labor supply	*85%-100%*		
	Production efficiency resulting from labor:			**80%**	
4. Supervision	**poor**	Inexperienced, low pay, 8(a) and HUB Zone Contracts	*25%-55%*		- We should not compensate contractors for having poor managers on their staff, however recognize that small contractors working on Govt projects have less experience and construction alliances.
	average	Average experience and training, average pay	*55%-85%*		
	good	Experienced, good pay, IFB Contracts	*85%-100%*	90%	
	Production efficiency resulting from supervision:			**90%**	
5. Job Conditions	**poor**	Emergency work, required first rate workmanship, short length of operations	*25%-55%*		
	average	Average site, regular workmanship required, average length of operations	*55%-85%*	55%	
	good	Favorable site, passable workmanship required, long length of operations	*85%-100%*		
	Production efficiency resulting from job conditions:			**55%**	
6. Weather	**bad**	Much precipitation, bitter cold, oppressive heat	*25%-55%*	30%	- Time extension for unusually severe weather and anticipated weather delays are covered under the Contract Clauses. This factor accounts for "normal" weather at the project site (i.e. Alaska, Las Vegas)
	fair	Some precipitation, moderate cold, moderate heat	*55%-85%*		
	good	Occasional precipitation, occasional cold, occasional heat	*85%-100%*		
	Production efficiency resulting from weather:			**30%**	
7. Expected Delays	**numerous**	Security restrictions (military bases), HTRW, Poor job flexibility, slow delivery, poor expediting	*25%-55%*		
	some	Limited number of work hours (residential proximity), normal delivery, average expediting	*55%-85%*	65%	
	minimum	Job flexibility, prompt delivery, good expediting	*85%-100%*		
	Production efficiency resulting from delays:			**65%**	

AVERAGE PRODUCTION EFFICIENCY PERCENT: **70%** ◄ **Enter in (MCACES) Mii**

* Each production element (8) carries equal weight.
* Apply to Direct Bare labor and equipment cost.

LABOR AND EQUIPMENT COST INCREASE: **43%** ◄ **For information only**

* Apply to Direct Bare labor and equipment cost.

(1 / Production Eff.) -1: MCACES (Mii) calculation method.

*** Average production efficiency percent of 70% represents 43% increase in direct labor and equipment costs.**

Production Index Notes.

For some time now, economic conditions and other factors have drastically affected the way estimates are computed in the industry. Consequently, I tabulated known economic information, applied productivity range factors based on my judgment, averaged them out and called it Production Index.

The Production Index encompass general factors affecting Government Estimates (GE) such as project difficulty, method of construction, labor availability, supervision, job conditions, weather and expected delays.

The Production Index is computed by adding the production efficiencies of each element and dividing the sum by the number of elements (i.e. arithmetic mean). Once the Production Index is calculated in EXCEL, it is applied to the labor and equipment costs at the bare cost level in the Mii estimate.

The Production Index does not account for objective construction costs, contingency and inflation. Direct construction costs such as fuel, material prices and overtime should be considered as usual. The Production Index is based on known factors and therefore it is not a contingency factor or a risk analysis tool, since it does not measure uncertainty.

In developing the Production Index care was taken to abide by our Regulations.
EI 01D010 (1 September 1997), paragraph 13-2 quotes: "Each Government estimate for procurement will reflect the fair and reasonable cost to a prudent contractor for performing the scope specified. Although contractor bids will reflect the anticipated competitiveness, the Government estimate must remain the "yardstick" against which cost reasonableness is judged. Therefore, Government estimates can contain adjustments due to quotations on direct and indirect costs, but no separate adjustment due to competitiveness or bid strategies."

Estimators are encouraged to implement the Production Index on all civil and military estimates, except projects under construction (modifications) or dredging projects. If the estimator chooses to use the Production Index then detailed comments must be included in the MCACES (Mii) notes.

Finally, particular care should be taken with on-going project estimates.

TITLE: KENAI RIVER BLUFF STABILIZATION
SUBJECT: LAND BASED ROCK PLACEMENT OUTPUT RATE

MADE BY:	NSS	JOB NO.:	T17688
CHECKED BY:	IGP	DATE:	3/19/2009

FILTER ROCK PLACEMENT

CREW:

B-57 - Modified
1 Dragline Cranes on Crawler w/ Clamshell Bucket
1 Equip. Oper. (crane)
1 Equip. Oper. (oiler)
1 Labor Foreman (outside)
1 Articulated Front End Loaders
1 Equip. Oper. (light)

PRODUCTION:

5	CY bucket/ Crane
0.85	% fill
45	min/hr
0.75	cycle/min

Output: 143 CY/hr

OVERTIME
1,721 CY/ 12 hr shift

B ROCK PLACEMENT

CREW:

B-57 - Modified
Dragline Crane on Crawler w/ Clamshell Bucket
Articulated Front End Loader
4 - Crew Members

PRODUCTION:

5	CY bucket/ Crane
0.6	% fill
45	min/hr
0.65	cycle/min

Output: 88 CY/hr

OVERTIME
1,053 CY/ 12 hr shift

ARMOR ROCK PLACEMENT

CREW:

B-57 - Modified
Dragline Crane on Crawler w/ Clamshell Bucket
Articulated Front End Loader
4 - Crew Members

PRODUCTION:

5	CY bucket/ Crane
0.45	% fill
45	min/hr
0.6	cycle/min

Output: 61 CY/hr

OVERTIME
729 CY/ 12 hr shift

FILTER ROCK PLACEMENT

CREW:

B-57 - Modified
1 Crane w/ Clamshell Bucket
1 Equip. Oper. (crane)
1 Equip. Oper. (light)
1 Equip. Oper. Oiler
1 Labor Foreman (outside)
2 Laborers
0.5 Tugboat
0.5 Tugboat Captain
0.5 Tugboat Hand
1 Barge

PRODUCTION:

5	CY bucket/Crane
0.85	% fill
45	min/hr
0.75	cycle/min

Output: 143 CY/hr

OVERTIME 1,721 CY/ 12 hr shift

B ROCK PLACEMENT

CREW:

B-57 - Modified
Crane w/ Clamshell Bucket
5 - Crew Members

PRODUCTION:

5	CY bucket
0.6	% fill
45	min/hr
0.65	cycle/min

Output: 88 CY/hr

OVERTIME 1,053 CY/ 12 hr shift

ARMOR ROCK PLACEMENT

CREW:

B-57 - Modified
Crane w/ Clamshell Bucket
5 - Crew Members

PRODUCTION:

5	CY bucket
0.45	% fill
45	min/hr
0.6	cycle/min

Output: 61 CY/hr

OVERTIME 729 CY/ 12 hr shift

FILTER ROCK LOADING

CREW:

B-57 - Modified
1 Barge Mounted Crane w/ Skip Box
3 Trucks with End Dump Trailers
7 - Crew Members

PRODUCTION:

15	CY skip box
0.85	% fill
45	min/hr
0.75	cycle/min

Output: 430 CY/hr

OVERTIME 5,164 CY/ 12 hr shift

B ROCK LOADING

CREW:

B-57 - Modified
1 Barge Mounted Crane w/ Skip Box
3 Trucks with End Dump Trailers
7 - Crew Members

PRODUCTION:

15	CY skip box
0.6	% fill
45	min/hr
0.65	cycle/min

Output: 263 CY/hr

OVERTIME 3,159 CY/ 12 hr shift

ARMOR ROCK LOADING

CREW:

B-57 - Modified
1 Barge Mounted Crane w/ Skip Box
3 Trucks with End Dump Trailers
7 - Crew Members

PRODUCTION:

15	CY skip box
0.45	% fill
45	min/hr
0.6	cycle/min

Output: 182 CY/hr

OVERTIME 2,187 CY/ 12 hr shift

ROCK HAULING FROM SEWARD QUARRY

CREW:

Z - Haul Crew From Quarry
1 Truck Driver
1 Truck
1 28cy Dump Trailer

PRODUCTION:

28	Truck Size (CY)
10%	Waste Factor
210	mi/roundtrip
280	min/roundtrip

Output: 5.40 CY/hr

OVERTIME 64.80 CY/ 12 hr shift

TITLE: KENAI RIVER BLUFF STABILIZATION			
SUBJECT: HAULING OUTPUT RATES			
MADE BY:	SKV	JOB NO.:	T17688
CHECKED BY:	IGP	DATE:	2/2/2012

ROCK HAULING FROM SEWARD QUARRY

CREW:	Z - Haul Crew From Quarry 1 Truck Driver 1 Truck 1 28cy Dump Trailer		
PRODUCTION:	30	cy truck	
	0.95	% fill	
	6.7	min. for loading	
	0.5	mi. to disposal location	
	20	mph haul speed	
	3.3	min. dump time	
	55	min/hr	
	28.5	cy/truck	
	0.24	hr	
			OVERTIME
Output:	120.6	cy/hr per truck	1,446.92 CY/ 12 hr shift
	2.00	Number of truck crews required to have little or no back up on route	
			OVERTIME
Total Output:	228.0	cy/hr	2,736.00 CY/ 12 hr shift

APPENDIX F

Phone Logs and Emails

NOTE: QUOTES ARE NON-BINDING ESTIMATES TO BE USED FOR INFORMATIONAL PURPOSES ONLY

Additional Notes on Earthwork:

Terry at West Construction Company estimated excavation costs, including mixing and dewatering of stockpile material, were at $20/yd. The cost of hauling excess material was estimated at $0.50 per cubic yard mile. Tel (907) 561-9811. Cost of rock for the project is estimated to be $60/ton, including transportation.

Additional Notes on Rock

Rock Alaska LLC estimated the price for 4' armor rock at $32.50/ton, not including transportation cost. Rock Alaska rents a side dump truck at $120/hr and an end dump truck at $95/hr. The quarry is located in Chugiak, Alaska, 180 miles (approximately 3hr 40 min) by land from the city of Kenai. There may be potential to ship the rock to the site on a barge. This price does not include placement cost of the rock. (907) 688-3500

Skookum Rock Quarry estimated the combined price of material and haul for 3' armor rock at $75/ton, with approximately half of that cost going to material and the other half to haul. Initially estimate based on December 2007 quote (non-binding). Fuel costs add 30% to haul costs as of June 2008 for a total delivered price of $89/ton. This estimate was based on a previous job involving shipping of 4,000 tons of 3' rock to Kenai for the State of Alaska, and the cost of the rock may be less with larger quantities. This price does not include placement cost. Skookum Rock Quarry is located in Chugiak, Alaska, 180 miles (approximately 3hr 40 min) by land from the city of Kenai. (907) 688-9700

Marcus Muler of the Seward Rock Quarry explained that the quarry, located in Seward, Alaska, (102 miles from Kenai, about 2hr 20 min by land) is not being actively quarried. Plans to reopen the quarry in the next year are underway. The quarry only has a limited amount of larger rock but would be able to produce more if reopened. The cost of 2'-3' rock is $45/ton and does not include transport or placement cost. (907) 714-2204.

According to Dick Miller at Amco Paving, current pricing for angular armor rock is approximately $35/ton for the material, and $20/ton for truck transportation from Girdwood, for a total of $55/ton. Prices are based on December 2007 quotes (non-binding). Escalation to current price level is assumed. (907) 440-1512. The price is a non-binding quote used for reference only. Due to the quantities involved, additional quotes should be obtained.

Contractor Contact info:

Rock Alaska LLC
PO Box 670249
Chugiak AK 99567

(907) 688-3500
Fax: (907) 696-2752
Cellular: 227-7448 or 229-0823

Skookum Rock Quarry
1010 Pack Horse Cir, Chugiak, AK
(907) 688-9700
State of Alaska Job: used West Construction—Bryce Ericson
Karl_High@dot.state.ak.us
May 25th to June 22nd
Rock & Haul—$75/ ton (half for haul, half for rock)
3’ rock, 4,000 tons—class III rock

Seward Rock Quarry

Kenai Peninsula Borough
Land Management Division
144 N Binkley Street
Soldotna, AK 99669
Phone 907-714-2200

Alaska Interstate Construction LLC
601 West 5th Avenue, Suite 400
Anchorage AK 99501
Tel: 907-562-2792
Fax: 907-562-4179
Email: info@aicllc.com
http://www.aicllc.com/servlet/content/7.html

Brian Forbes: brian.forbes@aicllc.com
Bristol Construction Services, LLC
111 W. 16th Avenue - Third Floor

Bristol Environmental & Engineering Services Corporation
Anchorage, AK 99501
Phone: (907) 563-0013
Steve Johnson— sjohnson@bristol-companies.com

West Construction Company
6120 A Street, Anchorage, AK 99518
Phone: 907 561 9811
Bryce Erickson—chief estimator, VP
http://bwcc.us/

Northstar Paving & ConstructionAddress:

APPENDIX G

MCACES Construction Cost Estimate

Kenai River Bluff Stabilization Cost Estimate

Estimated by	Tetra Tech
Designed by	Tetra Tech
Prepared by	Tetra Tech
Preparation Date	5/8/2012
Effective Date of Pricing	5/8/2012
Estimated Construction Time	464 Days

Description	Page

Description	Page

Designed by		Design Document	Kenai Bluff Stabilization Design Alternative Rpt.
Tetra Tech		Document Date	1/1/2012
Estimated by		District	Alaska
Tetra Tech		Contact	Pat Fitzgerald
Prepared by		Budget Year	2012
Tetra Tech		UOM System	Original

Direct Costs

LaborCost
EQCost
MatlCost
SubBidCost
Travel/PerDiem
Shipping
Fees

Timeline/Currency

Preparation Date	5/8/2012
Escalation Date	5/8/2012
Eff. Pricing Date	5/8/2012
Estimated Duration	464 Day(s)
Currency	US dollars
Exchange Rate	1.000000

Costbook CB10EB: MII English Cost Book 2010

Labor 01LA2011: Labor_Kenai_AK (2011)

tes. Fringes paid to the laborers may be fully or partially taxable. In a NON-UNION job, all the fringe benefits are taxable. In a UNION job, the vacation pay fringes is taxable an

Labor Rates

LaborCost1
LaborCost2
LaborCost3
LaborCost4

Equipment EP09R09: MII Equipment Region 9 2009

09 ALASKA

Sales Tax	3.00
Working Hours per Year	1,040
Labor Adjustment Factor	1.19
Cost of Money	4.88
Cost of Money Discount	25.00
Tire Recap Cost Factor	1.50
Tire Recap Wear Factor	1.80
Tire Repair Factor	0.15
Equipment Cost Factor	1.10
Standby Depreciation Factor	0.50

Fuel

Electricity	0.132
Gas	4.550
Diesel Off-Road	4.670
Diesel On-Road	4.950

Shipping Rates

Over 0 CWT	44.02
Over 240 CWT	41.59
Over 300 CWT	38.40
Over 400 CWT	35.48
Over 500 CWT	27.35
Over 700 CWT	25.43
Over 800 CWT	22.10

Direct Cost Markups	**Category**	**Method**
Productivity	Productivity	Productivity
Overtime	Overtime	Overtime

	Days/Week	*Hours/Shift*	*Shifts/Day*	*1st Shift*	*2nd Shift*	*3rd Shift*
Standard	*5.00*	*8.00*	*1.00*	*8.00*	*0.00*	*0.00*
Actual	*6.00*	*8.00*	*1.00*	*12.00*	*0.00*	*0.00*

Day	*OT Factor*	*Working*	*OT Percent*	*FCCM Percent*
Monday	*1.50*	*Yes*	*22.22*	*(44.44)*
Tuesday	*1.50*	*Yes*		
Wednesday	*1.50*	*Yes*		
Thursday	*1.50*	*Yes*		
Friday	*1.50*	*Yes*		
Saturday	*1.50*	*Yes*		
Sunday	*2.00*	*No*		

Sales Tax	TaxAdj	Running % on Selected Costs
MatlCost		

Contractor Markups	**Category**	**Method**
JOOH Prime (Small Tools)	Allowance	% of Labor
JOOH Prime	JOOH	JOOH (Calculated)
JOOH Sub	JOOH	Running %
HOOH	HOOH	Running %
Profit Prime	Profit	Profit Weighted Guidelines

Guideline	*Value*	*Weight*	*Percentage*
Risk	*0.100*	*20*	*2.00*
Difficulty	*0.100*	*15*	*1.50*
Size	*0.030*	*15*	*0.45*
Period	*0.075*	*15*	*1.13*
Invest (Contractor's)	*0.100*	*5*	*0.50*
Assist (Assistance by)	*0.070*	*5*	*0.35*
SubContracting	*0.118*	*25*	*2.95*
Total		*100*	*8.87*

Profit Sub	Profit	Direct %
Bond	Bond	Bond Table

Class B, Tiered, 24 months, 1.00% Surcharge

Contract Price	*Bond Rate*
500,000	*15.84*
2,000,000	*9.57*
2,500,000	*7.59*
2,500,000	*6.93*
100,000,000,000	*6.34*

Insurance	MiscContract	Direct %
Excise Tax	Excise	Running %

HOOH Sub	Allowance	Running %

Owner Markups	**Category**	**Method**
Contingency	Contingency	Contract %
SIOH	SIOH	Running %
Escalation	Escalation	Escalation

StartDate	*StartIndex*	*EndDate*	*EndIndex*	*Escalation*
2/18/2009	*689.38*	*11/1/2011*	*718.30*	*4.20*

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
Project Cost Summary Report			**25,066,620**	**25,066,620**	
02 RELOCATIONS	**1.00**	**LS**	**650,996**	**650,996**	
02.01 Relocations	**1.00**	**LS**	**650,996**	**650,996**	
02.01.01 Pipe Demolition	**850.00**	**LF**	*30.26* **25,723**	*30.26* **25,723**	
02.01.01.01 24" CMP Demolition	**200.00**	**LF**	*54.58* **10,917**	*54.58* **10,917**	
02.01.01.02 3/4" and 6" PVC Demolition	**650.00**	**LF**	*22.78* **14,806**	*22.78* **14,806**	
02.01.02 Building and Pad Demolition	**1.00**	**LS**	**576,518**	**576,518**	
02.01.03 Overlook Demolition	**1.00**	**LS**	**3,450**	**3,450**	
02.01.04 Roadway Demolition	**1.00**	**LS**	**45,305**	**45,305**	
14 RECREATIONAL FACILITIES	**1.00**	**LS**	**529,992**	**529,992**	
14.01 Recreational Facilities	**1.00**	**LS**	**529,992**	**529,992**	
14.01.01 Overlook	**3.00**	**EA**	*37,633.12* **112,899**	*37,633.12* **112,899**	
14.01.01.01 Overlook Boardwalk	**390.00**	**LF**	*169.58* **66,136**	*169.58* **66,136**	
14.01.01.02 Benches and Signs	**1.00**	**LS**	**46,763**	**46,763**	
14.01.02 Roadway	**1.00**	**LS**	**284,494**	**284,494**	
14.01.03 Surface Drainage	**1.00**	**LS**	**132,599**	**132,599**	
14.01.03.01 24-inch CMP	**205.00**	**LF**	*128.39* **26,319**	*128.39* **26,319**	
14.01.03.02 Concrete Culverts	**3.00**	**EA**	*5,399.41* **16,198**	*5,399.41* **16,198**	
14.01.03.03 24-inch Gate	**3.00**	**EA**	*5,820.19* **17,461**	*5,820.19* **17,461**	
14.01.03.04 Riprap	**304.00**	**CY**	*238.88* **72,621**	*238.88* **72,621**	
16 BANK STABILIZATION	**1.00**	**LS**	**23,885,631**	**23,885,631**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
16.01 Bank Stabilization	**1.00**	**LS**	**23,885,631**	**23,885,631**	
16.01.01 Site Preparation	**1.00**	**LS**	**1,565,263**	**1,565,263**	
16.01.01.01 Silt Fence	**2,230.00**	**LF**	*8.00* **17,846**	*8.00* **17,846**	
16.01.01.02 Temporary Road	**5,225.00**	**LF**	*41.13* **214,916**	*41.13* **214,916**	
16.01.01.03 Pumping	**1.00**	**LS**	**743,065**	**743,065**	
16.01.01.04 Clearing and Grubbing	**10.30**	**ACR**	*23,625.55* **243,343**	*23,625.55* **243,343**	
16.01.01.05 Fencing	**5,225.00**	**LF**	*44.27* **231,306**	*44.27* **231,306**	
16.01.01.06 Temporary Fencing	**2,000.00**	**LF**	*12.80* **25,594**	*12.80* **25,594**	
16.01.01.07 Temporary Bridge Crossing	**1.00**	**EA**	*89,192.51* **89,193**	*89,192.51* **89,193**	
16.01.02 Earthwork	**1.00**	**LS**	**7,990,220**	**7,990,220**	
16.01.02.01 Alluvial Deposits	**140,944.00**	**BCY**	*26.56* **3,743,400**	*26.56* **3,743,400**	
16.01.02.01.01 Excavation	**140,944.00**	**CY**	*10.77* **1,518,562**	*10.77* **1,518,562**	
16.01.02.01.02 Backfill	**144,274.00**	**CY**	*10.80* **1,558,311**	*10.80* **1,558,311**	
16.01.02.01.03 Dispose of Unusable Material	**23,256.00**	**CY**	*28.66* **666,527**	*28.66* **666,527**	
16.01.02.02 Glacial Till	**67,006.00**	**BCY**	*38.22* **2,560,949**	*38.22* **2,560,949**	
16.01.02.02.01 Excavation	**67,006.00**	**CY**	*11.65* **780,298**	*11.65* **780,298**	
16.01.02.02.02 Backfill	**15,078.00**	**CY**	*11.88* **179,198**	*11.88* **179,198**	
16.01.02.02.03 Dispose of Unused Material	**51,928.00**	**CY**	*30.84* **1,601,453**	*30.84* **1,601,453**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
			60.57	*60.57*	
16.01.02.03 Borrow Material	**8,900.00**	**BCY**	**539,041**	**539,041**	
16.01.02.04 Soil Stabilization	**1.00**	**LS**	**1,146,830**	**1,146,830**	
			200.16	*200.16*	
16.01.03 Erosion Protection	**56,307.00**	**LCY**	**11,270,551**	**11,270,551**	
			180.65	*180.65*	
16.01.03.01 Land Based Placement	**26,878.00**	**LCY**	**4,855,595**	**4,855,595**	
			212.52	*212.52*	
16.01.03.02 Water Based Placement	**26,878.00**	**LCY**	**5,712,200**	**5,712,200**	
			17.19	*17.19*	
16.01.03.03 Rock Loading on Barge	**26,878.00**	**LCY**	**461,949**	**461,949**	
			6.99	*6.99*	
16.01.03.04 Geotextile Fabric	**34,433.00**	**SY**	**240,807**	**240,807**	
16.01.04 Vegetation	**1.00**	**LS**	**3,059,597**	**3,059,597**	

Description	Quantity	UOM	Contractor	DirectCost	SubCMU	CostToPrime	PrimeCMU	ContractCost	C/O
Contract Cost Summary Report				**15,650,986**	**507,847**	**16,158,832**	**8,907,787**	**25,066,620**	
02 RELOCATIONS	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**416,030**	**0**	**416,030**	**234,966**	**650,996**	
02.01 Relocations	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**416,030**	**0**	**416,030**	**234,966**	**650,996**	
02.01.01 Pipe Demolition	**850.00**	**LF**	**AA PRIME CONTRACTOR**	*19.34* **16,439**	**0**	*19.34* **16,439**	**9,284**	*30.26* **25,723**	
02.01.02 Building and Pad Demolition	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**368,434**	**0**	**368,434**	**208,084**	**576,518**	
02.01.03 Overlook Demolition	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**2,205**	**0**	**2,205**	**1,245**	**3,450**	
02.01.04 Roadway Demolition	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**28,953**	**0**	**28,953**	**16,352**	**45,305**	
14 RECREATIONAL FACILITIES	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**338,701**	**0**	**338,701**	**191,292**	**529,992**	
14.01 Recreational Facilities	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**338,701**	**0**	**338,701**	**191,292**	**529,992**	
14.01.01 Overlook	**3.00**	**EA**	**AA PRIME CONTRACTOR**	*24,050.09* **72,150**	**0**	*24,050.09* **72,150**	**40,749**	*37,633.12* **112,899**	
14.01.02 Roadway	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**181,811**	**0**	**181,811**	**102,683**	**284,494**	
14.01.03 Surface Drainage	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**84,740**	**0**	**84,740**	**47,859**	**132,599**	
16 BANK STABILIZATION	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**14,896,255**	**507,847**	**15,404,101**	**8,481,530**	**23,885,631**	
16.01 Bank Stabilization	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**14,896,255**	**507,847**	**15,404,101**	**8,481,530**	**23,885,631**	
16.01.01 Site Preparation	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**1,000,308**	**0**	**1,000,308**	**564,955**	**1,565,263**	
16.01.02 Earthwork	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**5,106,287**	**0**	**5,106,287**	**2,883,933**	**7,990,220**	

Description	Quantity	UOM	Contractor	DirectCost	SubCMU	CostToPrime	PrimeCMU	ContractCost	C/O
				127.92		*127.92*		*200.16*	
16.01.03 Erosion Protection	**56,307.00**	**LCY**	**AA PRIME CONTRACTOR**	**7,202,638**	**0**	**7,202,638**	**4,067,913**	**11,270,551**	
16.01.04 Vegetation	**1.00**	**LS**	**LANDSCAPE SUBCONTRACTOR**	**1,587,021**	**507,847**	**2,094,868**	**964,729**	**3,059,597**	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
Project Direct Costs Report				**3,656,934**	**3,636,112**	**5,620,906**	**2,737,033**	**0**	**15,650,986**	
02 RELOCATIONS	**1.00**	**LS**	**AA PRIME CONTRACTO R**	**219,827**	**29,282**	**126,670**	**40,251**	**0**	**416,030**	
02.01 Relocations	**1.00**	**LS**	**AA PRIME CONTRACTO R**	**219,827**	**29,282**	**126,670**	**40,251**	**0**	**416,030**	
				15.37	*3.97*	*0.00*	*0.00*		*19.34*	
02.01.01 Pipe Demolition	**850.00**	**LF**	**AA PRIME CONTRACTO R**	**13,064**	**3,375**	**0**	**0**	**0**	**16,439**	
				28.24	*6.64*	*0.00*	*0.00*		*34.88*	
02.01.01.01 24" CMP Demolition	**200.00**	**LF**	**AA PRIME CONTRACTO R**	**5,648**	**1,329**	**0**	**0**	**0**	**6,976**	
				6.53	*2.15*	*0.00*	*0.00*		*8.68*	
RSM 312316130100 Excavating, trench or continuous footing, common earth, 5/8 C.Y. excavator, 4' to 6' deep, excludes sheeting or dewatering	178.00	BCY	AA PRIME CONTRACTOR	1,162	383	0	0	0	1,545	
				18.06	*2.49*	*0.00*	*0.00*		*20.54*	
RSM 024113400170 Selective demolition, metal drainage piping, CMP, steel, 24", diameter, excludes excavation	200.00	LF	AA PRIME CONTRACTOR	3,611	497	0	0	0	4,109	
(Note: 100-LF of Existing 24" CMP + 100-LF of 24" CMP storm drain = 200-LF)										
				2.07	*1.93*	*0.00*	*0.00*		*4.00*	
RSM 312323170170 Fill, from stockpile, 130 H.P., 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	214.00	LCY	AA PRIME CONTRACTOR	442	413	0	0	0	855	
				2.02	*0.17*	*0.00*	*0.00*		*2.19*	
RSM 023153107220 Compaction, 3 passes, 18" wide, 12" lifts, walk behind, vibrating plate	214.00	ECY	AA PRIME CONTRACTOR	432	36	0	0	0	468	
				11.41	*3.15*	*0.00*	*0.00*		*14.56*	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
02.01.01.02 3/4" and 6" PVC Demolition	**650.00**	**LF**	**AA PRIME CONTRACTOR**	**7,416**	**2,046**	**0**	**0**	**0**	**9,462**	
(Note: 100-LF of 6" pipe and 550-LF of 3/4" pipe.)										
				6.53	*2.15*	*0.00*	*0.00*		*8.68*	
RSM 312316130100 Excavating, trench or continuous footing, common earth, 5/8 C.Y. excavator, 4' to 6' deep, excludes sheeting or dewatering	433.00	BCY	AA PRIME CONTRACTOR	2,827	931	0	0	0	3,758	
				4.63	*0.00*	*0.00*	*0.00*		*4.63*	
RSM 024113381700 Selective demolition, water & sewer piping & fittings, plastic Pipe, 6"-8", diameter, excludes excavation	100.00	LF	AA PRIME CONTRACTOR	463	0	0	0	0	463	
				3.31	*0.00*	*0.00*	*0.00*		*3.31*	
RSM 024113381600 Selective demolition, water & sewer piping & fittings, plastic Pipe, 3/4" - 4", diameter, excludes excavation	550.00	LF	AA PRIME CONTRACTOR	1,821	0	0	0	0	1,821	
				180.57	*24.85*	*0.00*	*0.00*		*205.43*	
RSM 024113400220 Selective demolition, metal drainage piping, CMP end sections, steel, 24"-36", diameter, excludes excavation	1.00	EA	AA PRIME CONTRACTOR	181	25	0	0	0	205	
				2.07	*1.93*	*0.00*	*0.00*		*4.00*	
RSM 312323170170 Fill, from stockpile, 130 H.P., 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	520.00	LCY	AA PRIME CONTRACTOR	1,075	1,003	0	0	0	2,078	
				2.02	*0.17*	*0.00*	*0.00*		*2.19*	
RSM 023153107220 Compaction, 3 passes, 18" wide, 12" lifts, walk behind, vibrating plate	520.00	ECY	AA PRIME CONTRACTOR	1,049	87	0	0	0	1,137	
02.01.02 Building and Pad Demolition	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**195,705**	**22,048**	**110,430**	**40,251**	**0**	**368,434**	
				0.00	*0.00*	*0.00*	*3.52*		*3.52*	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
RSM 024116131020 Building demolition, single family, one story house, wood, includes 20 mile haul, excludes foundation demolition, dump fees, maximum	11,435.00	SF	AA PRIME CONTRACTOR	0	0	0	40,251	0	40,251	
(Note: Assuming single family homes are on average 1500-SF, the unit cost in SF to demolish a home is $5275-EA (per MCACES CSI Task 022201101020) /1500-SF per home = $3.52/SF.)										
				12.67	*1.11*	*0.00*	*0.00*		*13.78*	
RSM 024116170440 Bldg. footings and foundations demolition, floors, concrete slab on grade, concrete, rod reinforced, 6" thick, excludes disposal costs and dump fees	14,875.00	SF	AA PRIME CONTRACTOR	188,484	16,484	0	0	0	204,968	
				10.92	*8.42*	*0.00*	*0.00*		*19.34*	
RSM 023154901255 Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	661.00	LCY	AA PRIME CONTRACTOR	7,221	5,563	0	0	0	12,785	
				0.00	*0.00*	*90.00*	*0.00*		*90.00*	
RSM 024119190100 Selective demolition, dump charges, typical urban city, building construction materials, includes tipping fees only	1,227.00	TON	AA PRIME CONTRACTOR	0	0	110,430	0	0	110,430	
02.01.03 Overlook Demolition	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**1,429**	**136**	**640**	**0**	**0**	**2,205**	
				147.84	*0.00*	*0.00*	*0.00*		*147.84*	
RSM 024113930100 Selective demolition, site furnishings, benches, all types	2.00	EA	AA PRIME CONTRACTOR	296	0	0	0	0	296	
				2.95	*0.23*	*0.00*	*0.00*		*3.18*	
RSM 024113900900 Selective demolition, retaining walls, interlocking segmental retaining wall	360.00	SF	AA PRIME CONTRACTOR	1,063	82	0	0	0	1,145	
				10.92	*8.42*	*0.00*	*0.00*		*19.34*	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
RSM 023154901255 Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	6.40	LCY	AA PRIME CONTRACTOR	70	54	0	0	0	124	
				0.00	*0.00*	*80.00*	*0.00*		*80.00*	
RSM 024119190300 Selective demolition, dump charges, typical urban city, rubbish only, includes tipping fees only	8.00	TON	AA PRIME CONTRACTOR	0	0	640	0	0	640	
02.01.04 Roadway Demolition	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**9,629**	**3,724**	**15,600**	**0**	**0**	**28,953**	
				1.06	*0.35*	*0.00*	*0.00*		*1.41*	
RSM 024113175050 Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	7,893.00	SF	AA PRIME CONTRACTOR	8,351	2,739	0	0	0	11,090	
				10.92	*8.42*	*0.00*	*0.00*		*19.34*	
RSM 023154901255 Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	117.00	LCY	AA PRIME CONTRACTOR	1,278	985	0	0	0	2,263	
				0.00	*0.00*	*80.00*	*0.00*		*80.00*	
RSM 024119190300 Selective demolition, dump charges, typical urban city, rubbish only, includes tipping fees only	195.00	TON	AA PRIME CONTRACTOR	0	0	15,600	0	0	15,600	
14 RECREATIONAL FACILITIES	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**89,149**	**18,505**	**218,958**	**12,089**	**0**	**338,701**	
14.01 Recreational Facilities	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**89,149**	**18,505**	**218,958**	**12,089**	**0**	**338,701**	
				11,633.27	*113.75*	*12,303.07*	*0.00*		*24,050.09*	
14.01.01 Overlook	**3.00**	**EA**	**AA PRIME CONTRACTOR**	**34,900**	**341**	**36,909**	**0**	**0**	**72,150**	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				76.68	*0.11*	*31.59*	*0.00*		*108.37*	
14.01.01.01 Overlook Boardwalk	**390.00**	**LF**	**AA PRIME CONTRACTOR**	**29,905**	**42**	**12,319**	**0**	**0**	**42,266**	
				2.79	*0.00*	*0.35*	*0.00*		*3.14*	
RSM 061110280380 Porch or deck framing, treated lumber, railings and trim, 2" x 4"	2,340.00	LF	AA PRIME CONTRACTOR	6,539	0	819	0	0	7,358	
(Note: Per the designer, the total length of all the boardwalks is approximately 390'. Rails will be located on both sides of the boardwalk. There will be three rows of rails per designer's detail. Therefore, the total length is 390' x 2 x 3 = 2340'.)										
				1.34	*0.00*	*0.58*	*0.00*		*1.92*	
RSM 061110280320 Porch or deck framing, treated lumber, joists, 2" x 6"	2,340.00	LF	AA PRIME CONTRACTOR	3,139	0	1,357	0	0	4,496	
(Note: Per the designer, the total length of all the boardwalks is approximately 390'. 6 joists will run below the deck for the entire length per designer's detail. Therefore, the total length is 390' x 6 = 2340'.)										
				4.30	*0.00*	*6.40*	*0.00*		*10.70*	
RSM 061110280980 Porch or deck framing, redwood, posts or columns, 4" x 4"	780.00	LF	AA PRIME CONTRACTOR	3,354	0	4,992	0	0	8,346	
(Note: Per the designer, the total length of all the boardwalks is approximately 390'. Posts will be located on both sides of the boardwalk per designer's detail. Therefore, the total length is 390' x 2 = 780'.)										
				59.74	*0.42*	*5.10*	*0.00*		*65.26*	
RSM 033053406800 Structural concrete, in place, stairs (3500 psi), 3'-6" wide, free standing, includes forms(4 uses), reinforcing steel, concrete, placing and finishing, excludes safety treads	100.00	LF	AA PRIME CONTRACTOR	5,974	42	510	0	0	6,526	
				2.79	*0.00*	*1.19*	*0.00*		*3.98*	
RSM 061110280410 Porch or deck framing, treated lumber, decking, 2" x 4"	3,900.00	SF	AA PRIME CONTRACTOR	10,899	0	4,641	0	0	15,540	
(Note: The boardwalks are 10' wide per designer's detail and will have an approximate total length of 390'.)										
14.01.01.02 Benches and Signs	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**4,995**	**300**	**24,590**	**0**	**0**	**29,885**	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				211.20	*0.00*	*1,250.00*	*0.00*		*1,461.20*	
RSM 129343130510 Site seating, park benches, steel barstock pedestals with backs, 2 x 3 wood rails, 8' long	15.00	EA	AA PRIME CONTRACTOR	3,168	0	18,750	0	0	21,918	
				45.68	*7.49*	*146.00*	*0.00*		*199.17*	
RSM 101453200300 Signs, stock, aluminum, reflectorized, .080" aluminum, 30" x 30", excludes posts	40.00	EA	AA PRIME CONTRACTOR	1,827	300	5,840	0	0	7,967	
14.01.02 Roadway	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**26,043**	**7,168**	**148,600**	**0**	**0**	**181,811**	
				11.90	*3.40*	*68.00*	*0.00*		*83.30*	
RSM 321216130854 Plant-mix asphalt paving, for highways and large paved areas, wearing course, alternate method for developing paving costs, 3" thick, no hauling included	2,000.00	TON	AA PRIME CONTRACTOR	23,799	6,800	136,000	0	0	166,599	
				5.61	*0.92*	*31.50*	*0.00*		*38.03*	
RSM 347113260100 Vehicle guide rails, corrugated steel, galvanized steel posts, install metal guide/guard rail, double face, wood posts 6'-3" O.C., 6" x 8" posts	400.00	LF	AA PRIME CONTRACTOR	2,244	368	12,600	0	0	15,212	
14.01.03 Surface Drainage	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**28,206**	**10,996**	**33,449**	**12,089**	**0**	**84,740**	
				38.70	*6.41*	*33.06*	*3.88*		*82.05*	
14.01.03.01 24-inch CMP	**205.00**	**LF**	**AA PRIME CONTRACTOR**	**7,933**	**1,314**	**6,778**	**795**	**0**	**16,820**	
				26.58	*1.76*	*30.50*	*0.00*		*58.84*	
RSM 334113402620 Public Storm Utility Drainage Piping, corrugated metal pipe, galvanized uncoated, 20' lengths, 14 ga., 24" diameter, excludes excavation and backfill	205.00	LF	AA PRIME CONTRACTOR	5,448	361	6,253	0	0	12,062	
				6.53	*2.15*	*0.00*	*0.00*		*8.68*	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
RSM 312316130100 Excavating, trench or continuous footing, common earth, 5/8 C.Y. excavator, 4' to 6' deep, excludes sheeting or dewatering	187.00	BCY	AA PRIME CONTRACTOR	1,221	402	0	0	0	1,623	
				2.07	*1.93*	*0.00*	*0.00*		*4.00*	
RSM 312323170170 Fill, from stockpile, 130 H.P., 2-1/2 C.Y., 300' haul, spread fill, with front-end loader, excludes compaction	144.00	LCY	AA PRIME CONTRACTOR	298	278	0	0	0	576	
				15.75	*2.06*	*25.00*	*0.00*		*42.81*	
RSM 312323160050 Fill by borrow and utility bedding, for pipe and conduit, crushed or screened bank run gravel, excludes compaction	21.00	LCY	AA PRIME CONTRACTOR	331	43	525	0	0	899	
				2.02	*0.17*	*0.00*	*0.00*		*2.19*	
RSM 023153107220 Compaction, 3 passes, 18" wide, 12" lifts, walk behind, vibrating plate	165.00	ECY	AA PRIME CONTRACTOR	333	28	0	0	0	361	
				3.79	*2.52*	*0.00*	*0.00*		*6.31*	
HNC 312323180470 Hauling, excavated or borrow material, loose cubic yards, 4 mile round trip @ base wide rate, 12 C.Y. truck, highway haulers, excludes loading	80.00	LCY	AA PRIME CONTRACTOR	303	202	0	0	0	505	
				0.00	*0.00*	*0.00*	*5.00*		*5.00*	
RSM 024119190200 Selective demolition, dump charges, typical urban city, trees, brush, lumber, includes tipping fees only	159.00	TON	AA PRIME CONTRACTOR	0	0	0	795	0	795	
				3,099.01	*21.57*	*330.00*	*0.00*		*3,450.58*	
14.01.03.02 Concrete Culverts	**3.00**	**EA**	**AA PRIME CONTRACTO R**	**9,297**	**65**	**990**	**0**	**0**	**10,352**	
				3,099.01	*21.57*	*330.00*	*0.00*		*3,450.58*	
RSM 334213130120 Concrete Culverts, headwall concrete, cast in place, 30 degree skewed wingwall, 24" diameter pipe	3.00	EA	AA PRIME CONTRACTOR	9,297	65	990	0	0	10,352	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				990.74	*278.75*	*2,450.00*	*0.00*		*3,719.49*	
14.01.03.03 24-inch Gate	**3.00**	**EA**	**AA PRIME CONTRACTOR**	**2,972**	**836**	**7,350**	**0**	**0**	**11,158**	
				990.74	*278.75*	*2,450.00*	*0.00*		*3,719.49*	
RSM 352016630120 Canal gates, hydraulic structures, cast iron body, fabricated frame, 24" diameter	3.00	EA	AA PRIME CONTRACTOR	2,972	836	7,350	0	0	11,158	
				26.33	*28.89*	*60.30*	*37.15*		*152.66*	
14.01.03.04 Riprap	**304.00**	**CY**	**AA PRIME CONTRACTOR**	**8,003**	**8,781**	**18,331**	**11,294**	**0**	**46,410**	
				26.33	*28.89*	*60.30*	*37.15*		*152.66*	
RSM 313713100100 Rip-rap and rock lining, random, broken stone, machine placed for slope protection	304.00	LCY	AA PRIME CONTRACTOR	8,003	8,781	18,331	11,294	0	46,410	

(Note: Material: based on quote for blasting, sorting, and stockpiling rock at Seward Quarry provided by Advanced Blasting Services (Mikel Saunders, 907-243-1811); Sub Bid: based on quote for hauling the rock from Seward Quarry to Kenai provided by RL Trucking (Cal Watts, 907-351-6124);)

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
16 BANK STABILIZATION	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**3,347,959**	**3,588,324**	**5,275,278**	**2,684,693**	**0**	**14,896,255**	
16.01 Bank Stabilization	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**3,347,959**	**3,588,324**	**5,275,278**	**2,684,693**	**0**	**14,896,255**	
16.01.01 Site Preparation	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**678,889**	**118,117**	**146,302**	**57,000**	**0**	**1,000,308**	

(Note: The temporary staging areas and permanent construction zones along the top of the bluff would initially be cleared and grubbed of vegetation and debris, with the materials stockpiled on site or removed for off-site disposal. The trees lining the top of the bluff within the project footprint would also be removed. Affected utilities located within the construction area would be rerouted as needed. Some small structures would be demolished and resulting debris would be hauled off-site (see 02 Account). In addition, all abandoned concrete and timber foundations located within the construction area would be removed and hauled to the selected disposal area (see 02 Account). Temporary stormwater and erosion control measures would be implemented according to the adopted SWPPP. Temporary security fencing would be installed along the bluff above the construction area according to the fencing details in the plans.)

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				4.32	*0.00*	*0.79*	*0.00*		*5.11*	
16.01.01.01 Silt Fence	**2,230.00**	**LF**	**AA PRIME CONTRACTOR**	**9,643**	**0**	**1,762**	**0**	**0**	**11,405**	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				4.32	*0.00*	*0.79*	*0.00*		*5.11*	
HNC 023707001120 Erosion control, silt fence, polypropylene, 3' high, includes 7.5' posts	2,230.00	LF	AA PRIME CONTRACTOR	9,643	0	1,762	0	0	11,405	
				9.31	*1.60*	*15.37*	*0.00*		*26.29*	
16.01.01.02 Temporary Road	**5,225.00**	**LF**	**AA PRIME CONTRACTOR**	**48,656**	**8,361**	**80,328**	**0**	**0**	**137,346**	
				7.56	*0.50*	*8.00*	*0.00*		*16.06*	
RSM 015523500100 Temporary, roads, gravel fill, 8" gravel depth, excl surfacing	5,806.00	SY	AA PRIME CONTRACTOR	43,906	2,911	46,448	0	0	93,265	
(Note: Accounts for base of temporary road. Assumes the access road is 10' wide. The length is 5,225-LF per the designer.)										
				4.91	*5.63*	*35.00*	*0.00*		*45.54*	
RSM 310516100300 Aggregate for earthwork, crushed stone, 1.40 tons per C.Y., 1-1/2", spread with 200 H.P. dozer, includes load at pit and haul, 2 miles round trip, excludes compaction	968.00	CY	AA PRIME CONTRACTOR	4,751	5,450	33,880	0	0	44,081	
(Note: Accounts for extra stone required to support equipment on roadway. Assumes the access road is 10' wide and 6" thick. The length is 5,225-LF per the designer.)										
16.01.01.03 Pumping	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**446,538**	**28,331**	**0**	**0**	**0**	**474,869**	
				310.10	*19.67*	*0.00*	*0.00*		*329.77*	
RSM 312319200650 Dewatering, pumping, 8 hr., attended 2 hours per day, 4" discharge pump used for 8 hours, includes 20 L.F. of suction hose and 100 L.F. of discharge hose	1,440.00	DAY	AA PRIME CONTRACTOR	446,538	28,331	0	0	0	474,869	
(Note: 4-pumps are operating at 24-hrs per day for 4 months. 4-pumps * 3 8-hr shifts * 30-days * 4-months = 1440-days.)										
				8,552.76	*6,268.86*	*276.70*	*0.00*		*15,098.31*	
16.01.01.04 Clearing and Grubbing	**10.30**	**ACR**	**AA PRIME CONTRACTOR**	**88,093**	**64,569**	**2,850**	**0**	**0**	**155,513**	
				1,283.12	*1,331.11*	*0.00*	*0.00*		*2,614.22*	
RSM 311110100150 Clearing & grubbing, grub stumps	10.30	ACR	AA PRIME CONTRACTOR	13,216	13,710	0	0	0	26,927	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				388.61	*104.27*	*0.00*	*0.00*		*492.88*	
HNC 022301007320 Tree removal, congested area, 12" to 24" diameter, tree removal, cutting and chipping	35.00	EA	AA PRIME CONTRACTOR	13,601	3,649	0	0	0	17,251	
				10.92	*8.42*	*0.00*	*0.00*		*19.34*	
RSM 023154901255 Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	5,609.00	LCY	AA PRIME CONTRACTOR	61,276	47,209	0	0	0	108,485	
(Note: Clearing and Grubbing Haul Volume (5,539-LCY) + Tree Removal Haul Volume (70-LCY) = 5,609-LCY.)										
				0.00	*0.00*	*75.00*	*0.00*		*75.00*	
RSM 024119190200 Selective demolition, dump charges, typical urban city, trees, brush, lumber, includes tipping fees only	38.00	TON	AA PRIME CONTRACTOR	0	0	2,850	0	0	2,850	
(Note: Tree Removal Dumping Volume (38-Tons))										
				14.56	*3.23*	*10.50*	*0.00*		*28.29*	
16.01.01.05 Fencing	**5,225.00**	**LF**	**AA PRIME CONTRACTOR**	**76,101**	**16,857**	**54,863**	**0**	**0**	**147,820**	
				14.56	*3.23*	*10.50*	*0.00*		*28.29*	
RSM 323129101300 Wood fences & gates, no. 2 cedar, treated wood rails, 6' high, includes post and post hole	5,225.00	LF	AA PRIME CONTRACTOR	76,101	16,857	54,863	0	0	147,820	
				4.93	*0.00*	*3.25*	*0.00*		*8.18*	
16.01.01.06 Temporary Fencing	**2,000.00**	**LF**	**AA PRIME CONTRACTOR**	**9,856**	**0**	**6,500**	**0**	**0**	**16,356**	
				4.93	*0.00*	*3.25*	*0.00*		*8.18*	
RSM 015626500100 Temporary Fencing, chain link, 6' high, 11 ga	2,000.00	LF	AA PRIME CONTRACTOR	9,856	0	6,500	0	0	16,356	
				0.00	*0.00*	*0.00*	*57,000.00*		*57,000.00*	
16.01.01.07 Temporary Bridge Crossing	**1.00**	**EA**	**AA PRIME CONTRACTOR**	**0**	**0**	**0**	**57,000**	**0**	**57,000**	

(Note: A temporary bridge would need to be constructed over Ryan's Creek to connect the construction zones.)

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				0.00	*0.00*	*0.00*	*95.00*		*95.00*	
USR Z Temporary Bridge Crossing	600.00	SF	AA PRIME CONTRACTOR	0	0	0	57,000	0	57,000	
(Note: Quantity: Assumes bridge would need to be 40' long by 15' wide; Sub Bid: Based on CalTrans estimate of temporary bridge crossings to be between $45-95 per square foot.)										
16.01.02 Earthwork	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**1,856,570**	**2,125,592**	**515,135**	**608,990**	**0**	**5,106,287**	
(Note: Several passes with a scraper would be needed to remove oranics and the upper silt layer. The excavation equipment would need to be located a sufficient distance from the edge of the bluff to avoid the risk of bank failure caused by the equipment. Material close to the edge of the bluff could be excavated with excavators. The excavated material would be transported to the stockpile locations. Much of the excavated material could be used as backfill for the new bluff.)										
				6.46	*9.18*	*0.00*	*1.34*		*16.97*	
16.01.02.01 Alluvial Deposits	**140,944.00**	**BCY**	**AA PRIME CONTRACTOR**	**910,044**	**1,293,864**	**0**	**188,375**	**0**	**2,392,284**	
				2.59	*4.29*	*0.00*	*0.00*		*6.89*	
16.01.02.01.01 Excavation	**140,944.00**	**CY**	**AA PRIME CONTRACTOR**	**365,744**	**604,719**	**0**	**0**	**0**	**970,463**	
(Note: Assumes half of excavation would be performed by scrapers and the other half by hydraulic excavators.)										
				0.85	*1.78*	*0.00*	*0.00*		*2.63*	
HNC 312316503140 Excavation, bulk, bank measure, 9 cycles/hour, 25 C.Y., push loaded self propelled scraper	70,472.00	BCY	AA PRIME CONTRACTOR	60,021	125,449	0	0	0	185,470	
				1.24	*1.73*	*0.00*	*0.00*		*2.98*	
HNC 023154260160 Excavate and load, bank measure, medium material, 3-1/2 C.Y. bucket, hydraulic excavator	70,472.00	BCY	AA PRIME CONTRACTOR	87,596	122,132	0	0	0	209,728	
				1.41	*2.30*	*0.00*	*0.00*		*3.71*	
USR Z15 Transport Fill to/from Stockpile Site	155,038.00	LCY	AA PRIME CONTRACTOR	218,127	357,138	0	0	0	575,265	
(Note: Quantity: Based on designer provided quantities of fill; Productivity: Based on calculations provided in the cost engineering report for fill transport.)										
				2.88	*4.02*	*0.00*	*0.00*		*6.90*	
16.01.02.01.02 Backfill	**144,274.00**	**CY**	**AA PRIME CONTRACTOR**	**415,619**	**580,246**	**0**	**0**	**0**	**995,865**	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				1.41	*2.30*	*0.00*	*0.00*		*3.71*	
USR Z15 Transport Fill to/from Stockpile Site	158,701.00	LCY	AA PRIME CONTRACTOR	223,281	365,576	0	0	0	588,857	
(Note: Quantity: Based on designer provided quantities of fill; Productivity: Based on calculations provided in the cost engineering report for fill transport.)										
				0.34	*0.56*	*0.00*	*0.00*		*0.91*	
HNC 312323132360 Backfill, dumped gravel or fill, 6" layers, spread, dozer	158,701.00	LCY	AA PRIME CONTRACTOR	54,681	89,018	0	0	0	143,699	
				0.95	*0.87*	*0.00*	*0.00*		*1.83*	
RSM 312323235640 Compaction, 4 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	144,274.00	ECY	AA PRIME CONTRACTOR	137,658	125,652	0	0	0	263,309	
				5.53	*4.68*	*0.00*	*8.10*		*18.32*	
16.01.02.01.03 Dispose of Unusable Material	**23,256.00**	**CY**	**AA PRIME CONTRACTOR**	**128,682**	**108,899**	**0**	**188,375**	**0**	**425,956**	
				1.24	*1.73*	*0.00*	*0.00*		*2.98*	
HNC 023154260160 Excavate and load, bank measure, medium material, 3-1/2 C.Y. bucket, hydraulic excavator	25,582.00	BCY	AA PRIME CONTRACTOR	31,798	44,335	0	0	0	76,133	
				3.79	*2.52*	*0.00*	*0.00*		*6.31*	
HNC 312323180470 Hauling, excavated or borrow material, loose cubic yards, 4 mile round trip @ base wide rate, 12 C.Y. truck, highway haulers, excludes loading	25,582.00	LCY	AA PRIME CONTRACTOR	96,884	64,564	0	0	0	161,447	
				0.00	*0.00*	*0.00*	*5.00*		*5.00*	
RSM 024119190200 Selective demolition, dump charges, typical urban city, trees, brush, lumber, includes tipping fees only	37,675.00	TON	AA PRIME CONTRACTOR	0	0	0	188,375	0	188,375	
				8.39	*9.76*	*0.00*	*6.28*		*24.42*	
16.01.02.02 Glacial Till	**67,006.00**	**BCY**	**AA PRIME CONTRACTOR**	**561,926**	**654,077**	**0**	**420,615**	**0**	**1,636,618**	
				2.81	*4.64*	*0.00*	*0.00*		*7.44*	
16.01.02.02.01 Excavation	**67,006.00**	**CY**	**AA PRIME CONTRACTOR**	**188,020**	**310,643**	**0**	**0**	**0**	**498,663**	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
(Note: Assumes half of excavation would be performed by scrapers and the other half by hydraulic excavators.)										
				0.85	*1.78*	*0.00*	*0.00*		*2.63*	
HNC 312316503140 Excavation, bulk, bank measure, 9 cycles/hour, 25 C.Y., push loaded self propelled scraper	33,503.00	BCY	AA PRIME CONTRACTOR	28,534	59,640	0	0	0	88,174	
				1.24	*1.73*	*0.00*	*0.00*		*2.98*	
HNC 023154260160 Excavate and load, bank measure, medium material, 3-1/2 C.Y. bucket, hydraulic excavator	33,503.00	BCY	AA PRIME CONTRACTOR	41,644	58,063	0	0	0	99,707	
				1.41	*2.30*	*0.00*	*0.00*		*3.71*	
USR Z15 Transport Fill to/from Stockpile Site	83,758.00	LCY	AA PRIME CONTRACTOR	117,841	192,941	0	0	0	310,782	
(Note: Quantity: Based on designer provided quantities of fill; Productivity: Based on calculations provided in the cost engineering report for fill transport.)										
				3.14	*4.45*	*0.00*	*0.00*		*7.60*	
16.01.02.02.02 Backfill	**15,078.00**	**CY**	**AA PRIME CONTRACTOR**	**47,398**	**67,121**	**0**	**0**	**0**	**114,520**	
				1.41	*2.30*	*0.00*	*0.00*		*3.71*	
USR Z15 Transport Fill to/from Stockpile Site	18,848.00	LCY	AA PRIME CONTRACTOR	26,518	43,417	0	0	0	69,935	
(Note: Quantity: Based on designer provided quantities of fill; Productivity: Based on calculations provided in the cost engineering report for fill transport.)										
				0.34	*0.56*	*0.00*	*0.00*		*0.91*	
HNC 312323132360 Backfill, dumped gravel or fill, 6" layers, spread, dozer	18,848.00	LCY	AA PRIME CONTRACTOR	6,494	10,572	0	0	0	17,066	
				0.95	*0.87*	*0.00*	*0.00*		*1.83*	
RSM 312323235640 Compaction, 4 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	15,078.00	ECY	AA PRIME CONTRACTOR	14,387	13,132	0	0	0	27,518	
				6.29	*5.32*	*0.00*	*8.10*		*19.71*	
16.01.02.02.03 Dispose of Unused Material	**51,928.00**	**CY**	**AA PRIME CONTRACTOR**	**326,508**	**276,313**	**0**	**420,615**	**0**	**1,023,436**	
				1.24	*1.73*	*0.00*	*0.00*		*2.98*	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
HNC 023154260160 Excavate and load, bank measure, medium material, 3-1/2 C.Y. bucket, hydraulic excavator	64,910.00	BCY	AA PRIME CONTRACTOR	80,682	112,493	0	0	0	193,175	
				3.79	*2.52*	*0.00*	*0.00*		*6.31*	
HNC 312323180470 Hauling, excavated or borrow material, loose cubic yards, 4 mile round trip @ base wide rate, 12 C.Y. truck, highway haulers, excludes loading	64,910.00	LCY	AA PRIME CONTRACTOR	245,826	163,820	0	0	0	409,645	
				0.00	*0.00*	*0.00*	*5.00*		*5.00*	
RSM 024119190200 Selective demolition, dump charges, typical urban city, trees, brush, lumber, includes tipping fees only	84,123.00	TON	AA PRIME CONTRACTOR	0	0	0	420,615	0	420,615	
				12.89	*13.16*	*12.65*	*0.00*		*38.71*	
16.01.02.03 Borrow Material	**8,900.00**	**BCY**	**AA PRIME CONTRACTOR**	**114,750**	**117,148**	**112,585**	**0**	**0**	**344,483**	
				0.44	*0.52*	*12.65*	*0.00*		*13.61*	
RSM 312323155080 Borrow, select granular fill, 5 C.Y. bucket, loading and/or spreading, front end loader, wheel mounted	8,900.00	BCY	AA PRIME CONTRACTOR	3,873	4,672	112,585	0	0	121,130	
				6.55	*6.70*	*0.00*	*0.00*		*13.26*	
RSM 312323151800 Borrow, delivery charge, minimum 20 tons, 1 hour round trip, add	15,620.00	TON	AA PRIME CONTRACTOR	102,385	104,725	0	0	0	207,110	
				0.95	*0.87*	*0.00*	*0.00*		*1.83*	
RSM 312323235640 Compaction, 4 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	8,900.00	ECY	AA PRIME CONTRACTOR	8,492	7,751	0	0	0	16,243	
16.01.02.04 Soil Stabilization	**1.00**	**LS**	**AA PRIME CONTRACTOR**	**269,849**	**60,502**	**402,550**	**0**	**0**	**732,901**	
				3.24	*0.71*	*4.85*	*0.00*		*8.81*	
RSM 312513100060 Synthetic erosion control, nylon, 3 dimensional geomatrix, 9 mil thick	83,000.00	SY	AA PRIME CONTRACTOR	269,190	59,161	402,550	0	0	730,901	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				0.52	*1.05*	*0.00*	*0.00*		*1.57*	
HNC 023103303020 Rough grading, open site, large area, 300 H.P., dozer	1,275.00	BCY	AA PRIME CONTRACTOR	659	1,341	0	0	0	2,000	
				9.68	*22.42*	*59.97*	*35.85*		*127.92*	
16.01.03 Erosion Protection	**56,307.00**	**LCY**	**AA PRIME CONTRACTOR**	**544,995**	**1,262,408**	**3,376,533**	**2,018,703**	**0**	**7,202,638**	

(Note: The geotextile fabric, sublayers, and armor rock would need to be placed while the haul road is at a sufficient elevation to allow equipment access. Rock is therefore likely to be placed in several stages as the backfill is placed on the haul road. Rock could be imported through a combination of barging and land-based equipment with the barge placing apron material at high tide, and the land-based equipment placing the remaining armoring at low tide. Complete segments of the armor section would be completed during each low tide cycle to at least the elevation of the maximum tide lines. It is assumed the land based equipment would operate for half of the shift and the water based equipment would operate the other half. Hauling has been assumed to be done entirely by land in the current estimate; barging the rock over water is also presented as an alternative in the design report to facilitate future agency coordination that may be required to leave that option open to the contractor. Placement of the rock is assumed to be by hydraulic excavator.)

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				5.15	*11.12*	*61.63*	*37.55*		*115.45*	
16.01.03.01 Land Based Placement	**26,878.00**	**LCY**	**AA PRIME CONTRACTOR**	**138,352**	**298,931**	**1,656,416**	**1,009,352**	**0**	**3,103,051**	
				2.82	*6.10*	*60.30*	*37.15*		*106.37*	
USR Z10 Land Based Rock Placement (Filter Rock)	6,878.00	LCY	AA PRIME CONTRACTOR	19,409	41,936	414,743	255,518	0	731,607	

(Note: Material: based on quote for blasting, sorting, and stockpiling rock at Seward Quarry provided by Advanced Blasting Services (Mikel Saunders, 907-243-1811); Sub Bid: based on quote for hauling the rock from Seward Quarry to Kenai provided by RL Trucking (Cal Watts, 907-351-6124); Productivity: 143.5-cy/hr is based on calculations provided in the cost engineering report for land based placement of filter rock.)

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				4.60	*9.94*	*60.30*	*37.15*		*111.99*	
USR Z10 Land Based Rock Placement (B Rock)	6,788.00	LCY	AA PRIME CONTRACTOR	31,236	67,490	409,316	252,174	0	760,217	

(Note: Material: based on quote for blasting, sorting, and stockpiling rock at Seward Quarry provided by Advanced Blasting Services (Mikel Saunders, 907-243-1811); Sub Bid: based on quote for hauling the rock from Seward Quarry to Kenai provided by RL Trucking (Cal Watts, 907-351-6124); Productivity: 88-cy/hr is based on calculations provided in the cost engineering report for land based placement of B rock.)

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				6.64	*14.34*	*63.00*	*37.97*		*121.95*	
USR Z10 Land Based Rock Placement (Armor Rock)	13,212.00	LCY	AA PRIME CONTRACTOR	87,707	189,505	832,356	501,660	0	1,611,228	

(Note: Material: based on quote for blasting, sorting, and stockpiling rock at Seward Quarry provided by Advanced Blasting Services (Mikel Saunders, 907-243-1811); Sub Bid: based on quote for hauling the rock from Seward Quarry to Kenai provided by RL Trucking (Cal Watts, 907-351-6124); Productivity: 61-cy/hr is based on calculations provided in the cost engineering report for land based placement of armor rock.)

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				8.84	*27.80*	*61.63*	*37.55*		*135.82*	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
16.01.03.02 Water Based Placement	**26,878.00**	**LCY**	**AA PRIME CONTRACTOR**	**237,557**	**747,155**	**1,656,416**	**1,009,352**	**0**	**3,650,479**	
				4.85	*15.24*	*60.30*	*37.15*		*117.53*	
USR Z03 Breakwater Placement (Filter Rock)	6,878.00	LCY	AA PRIME CONTRACTOR	33,326	104,817	414,743	255,518	0	808,404	
(Note: Material: based on quote for blasting, sorting, and stockpiling rock at Seward Quarry provided by Advanced Blasting Services (Mikel Saunders, 907-243-1811); Sub Bid: based on quote for hauling the rock from Seward Quarry to Kenai provided by RL Trucking (Cal Watts, 907-351-6124); Productivity: 143.5-cy/hr is based on calculations provided in the cost engineering report for water based placement of filter rock.)										
				7.90	*24.85*	*60.30*	*37.15*		*130.20*	
USR Z03 Breakwater Placement (B Rock)	6,788.00	LCY	AA PRIME CONTRACTOR	53,634	168,686	409,316	252,174	0	883,810	
(Note: Material: based on quote for blasting, sorting, and stockpiling rock at Seward Quarry provided by Advanced Blasting Services (Mikel Saunders, 907-243-1811); Sub Bid: based on quote for hauling the rock from Seward Quarry to Kenai provided by RL Trucking (Cal Watts, 907-351-6124); Productivity: 88-cy/hr is based on calculations provided in the cost engineering report for water based placement of B rock.)										
				11.40	*35.85*	*63.00*	*37.97*		*148.22*	
USR Z03 Breakwater Placement (Armor Rock)	13,212.00	LCY	AA PRIME CONTRACTOR	150,597	473,652	832,356	501,660	0	1,958,265	
(Note: Material: based on quote for blasting, sorting, and stockpiling rock at Seward Quarry provided by Advanced Blasting Services (Mikel Saunders, 907-243-1811); Sub Bid: based on quote for hauling the rock from Seward Quarry to Kenai provided by RL Trucking (Cal Watts, 907-351-6124); Productivity: 61-cy/hr is based on calculations provided in the cost engineering report for water based placement of armor rock.)										
				3.03	*7.95*	*0.00*	*0.00*		*10.98*	
16.01.03.03 Rock Loading on Barge	**26,878.00**	**LCY**	**AA PRIME CONTRACTOR**	**81,556**	**213,660**	**0**	**0**	**0**	**295,216**	
				1.66	*4.34*	*0.00*	*0.00*		*6.00*	
USR Z01 Breakwater Loading (Filter Rock)	6,878.00	LCY	AA PRIME CONTRACTOR	11,403	29,874	0	0	0	41,277	
(Note: The loading quantity is the same as the water based placement quantity.)										
				2.71	*7.10*	*0.00*	*0.00*		*9.81*	
USR Z01 Breakwater Loading (B Rock)	6,788.00	LCY	AA PRIME CONTRACTOR	18,400	48,205	0	0	0	66,605	
(Note: The loading quantity is the same as the water based placement quantity.)										
				3.92	*10.26*	*0.00*	*0.00*		*14.18*	
USR Z01 Breakwater Loading (Armor Rock)	13,212.00	LCY	AA PRIME CONTRACTOR	51,753	135,581	0	0	0	187,334	
(Note: The loading quantity is the same as the water based placement quantity.)										

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
				2.54	*0.08*	*1.85*	*0.00*		*4.47*	
16.01.03.04 Geotextile Fabric	**34,433.00**	**SY**	**AA PRIME CONTRACTOR**	**87,530**	**2,661**	**63,701**	**0**	**0**	**153,892**	
				2.54	*0.08*	*1.85*	*0.00*		*4.47*	
HTW 334626100114 Geotextile Fabric, 170 Mil Thick Non-Woven Polypropylene	34,433.00	SY	AA PRIME CONTRACTOR	87,530	2,661	63,701	0	0	153,892	
16.01.04 Vegetation	**1.00**	**LS**	**LANDSCAPE SUBCONTRACTOR**	**267,505**	**82,208**	**1,237,309**	**0**	**0**	**1,587,021**	
				1.05	*0.09*	*6.30*	*0.00*		*7.44*	
HTW 025613102415 Secure burial cell construction, liner and dike support, geogrids, uniaxial, tnsl mod. = 50KSF, 4.3' x 98' roll	62,700.00	SY	LANDSCAPE SUBCONTRACTOR	65,923	5,631	395,010	0	0	466,564	
				3.69	*2.85*	*23.00*	*0.00*		*29.55*	
RSM 329113235100 Soil preparation, structural soil mixing, spread topsoil, articulated loader and hand dress	26,851.00	CY	LANDSCAPE SUBCONTRACTOR	99,183	76,576	617,573	0	0	793,332	
				414.49	*0.00*	*3.46*	*0.00*		*417.95*	
RSM 029203207060 Seeding, mechanical spread	12.60	ACR	LANDSCAPE SUBCONTRACTOR	5,223	0	44	0	0	5,266	
				0.00	*0.00*	*6.45*	*0.00*		*6.45*	
RSM 329343407351 Conifer trees, pinus sylvestris, (Scotch Pine), container/B&B, zone 3, seedlings	3,660.00	EA	LANDSCAPE SUBCONTRACTOR	0	0	23,607	0	0	23,607	
(Note: This item covers the willow material cost.)										
				1.91	*0.00*	*0.00*	*0.00*		*1.91*	
RSM 329343100130 Planting, trees, shrubs and ground cover, light soil, bare root seedlings, 11" to 16", includes planting only	3,660.00	EA	LANDSCAPE SUBCONTRACTOR	6,988	0	0	0	0	6,988	
				0.00	*0.00*	*37.50*	*0.00*		*37.50*	
RSM 329343405651 Conifer trees, picea glauca, (White or Canadian Spruce), container/B&B, zone 3, 3' to 4'	5,362.00	EA	LANDSCAPE SUBCONTRACTOR	0	0	201,075	0	0	201,075	

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost	C/O
(Note: 547 Alder Trees + 4,815 Spruce Trees = 5,362 Trees. This item covers the spruce tree material cost.)										
				16.82	*0.00*	*0.00*	*0.00*		*16.82*	
RSM 329343100300 Planting, trees, shrubs and ground cover, light soil, container, 1 gallon, includes planting only	5,362.00	EA	LANDSCAPE SUBCONTRACTOR	90,189	0	0	0	0	90,189	

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
Crews (Bare Costs) by Contractor, Report		**28,604.77**			**55,226.80**	**2,880,276.94**	**54,532.72**	**4,792,092.59**	**7,672,369.53**
AA PRIME CONTRACTOR	**LaborCost1**	**28,604.77**		**0.00**	**55,226.80**	**2,880,276.94**	**54,532.72**	**4,792,092.59**	**7,672,369.53**
					1.00	*18.94*	*0.00*	*0.00*	*18.94*
CIV UFLDB 1 janitor	LaborCost1	900.62			900.62	17,057.76	0.00	0.00	17,057.76
FOP FB-JANTR Janitors			*Journeyman*	*18.94*	*1.00*	*18.94*			
					2.25	*122.40*	*0.00*	*0.00*	*122.40*
GOV ACARD 2 carpnters	LaborCost1	44.29			99.64	5,420.35	0.00	0.00	5,420.35
MIL B-CARPNTER Carpenters			*Foreman*	*55.82*	*0.25*	*13.96*			
MIL B-CARPNTER Carpenters			*Journeyman*	*54.22*	*2.00*	*108.44*			
					2.00	*100.04*	*0.00*	*0.00*	*100.04*
GOV ALABCLAB2 2 laborers	LaborCost1	72.82			145.63	7,284.55	0.00	0.00	7,284.55
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*2.00*	*100.04*			
					2.00	*105.16*	*1.00*	*207.92*	*313.08*
GOV CODEB12D 1 eqoprcrn + 1 hydr excavator, crawler, 3.70 CY	LaborCost1	1,709.60			3,419.20	179,781.54	1,709.60	355,463.52	535,245.05
MIL B-EQOPRCRN Equip. Operators, Heavy			*Journeyman*	*56.43*	*1.00*	*56.43*			
MIL B-EQOPROIL Equip. Operators, Oilers / Grade Checker			*Journeyman*	*48.73*	*1.00*	*48.73*			
GEN H25Z3210 HYDRAULIC EXCAVATOR, CRAWLER, 140,000 LB (63,503 KG), 3.50 CY (2.7 M3) BUCKET, 31.4' (9.6 M) MAX DIGGING DEPTH			*EP / Average*	*207.92*			*1.00*	*207.92*	
					6.00	*306.76*	*3.00*	*112.77*	*419.53*
GOV CODFB7 2 eqoprmed + 1 loader, F/E, crawler, 2.60 CY	LaborCost1	33.33			200.00	10,225.33	100.00	3,759.14	13,984.48
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*4.00*	*200.08*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
GEN C05Z1210 CHAINSAW, 24" - 42" (610-1,067 MM) BAR			*EP / Average*	*4.10*			*2.00*	*8.20*	
GEN L35Z4260 LOADER, FRONT END, CRAWLER, 2.60 CY (2.0 M3) BUCKET			*EP / Average*	*104.57*			*1.00*	*104.57*	
					1.80	*97.37*	*1.30*	*286.15*	*383.52*
GOV CODSB33E 1 eqoprmed + 1 scraper, self propelled, 21-31 CY	LaborCost1	675.16			1,215.29	65,739.21	877.71	193,197.09	258,936.29
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.30*	*72.36*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*0.50*	*25.01*			

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
PTC S15Z5980 SCRAPER, CONVENTIONAL, STANDARD LOADING, 21-31 CY (16-24 M3), 37.5 TON (34.0 MT), 4X2 - SINGLE POWERED			*EP / Average*	*217.50*			*1.00*	*217.50*	
GEN T15Z6600 TRACTOR, CRAWLER (DOZER), 341-440 HP (254-328 KW), POWERSHIFT, W/UNIVERSAL BLADE			*EP / Average*	*228.85*			*0.30*	*68.65*	
					1.50	*80.67*	*1.00*	*182.18*	*262.85*
GOV CODTB10BS 1 eqoprmed + 1 dozer, crawler, 181-250 HP (severe)	LaborCost1	563.65			845.47	45,469.45	563.65	102,686.83	148,156.28
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*0.50*	*25.01*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE			*EP / Severe*	*182.18*			*1.00*	*182.18*	
					1.50	*80.67*	*1.00*	*228.85*	*309.52*
GOV CODTB10M 1 eqoprmed + 1 dozer, crawler, 341-440 HP	LaborCost1	6.07			9.11	489.78	6.07	1,389.42	1,879.20
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*0.50*	*25.01*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
GEN T15Z6600 TRACTOR, CRAWLER (DOZER), 341-440 HP (254-328 KW), POWERSHIFT, W/UNIVERSAL BLADE			*EP / Average*	*228.85*			*1.00*	*228.85*	
					1.00	*54.20*	*1.00*	*50.95*	*105.15*
GOV COEIB34B 1 trkdvrhv + 1 truck, dump, 16-23.5 CY	LaborCost1	4,600.48			4,600.48	249,346.15	4,600.48	234,378.58	483,724.73
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*1.00*	*54.20*			
GEN T50Z7420 TRUCK, HIGHWAY, 45,000 LB (20,412 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)			*EP / Average*	*50.95*			*1.00*	*50.95*	
					1.30	*65.33*	*0.00*	*0.00*	*65.33*
GOV ULABA 1 laborer	LaborCost1	739.80			961.73	48,327.91	0.00	0.00	48,327.91
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*0.30*	*15.31*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*1.00*	*50.02*			
					3.00	*151.06*	*0.40*	*6.19*	*157.25*
GOV ULABJ 3 laborers + 1 pickup truck, 8,8000 GVW	LaborCost1	437.24			1,311.73	66,050.15	174.90	2,707.91	68,758.05
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*2.00*	*100.04*			
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
GEN T50Z7320 TRUCK, HIGHWAY, CONVENTIONAL, 8,800 LB (3,992 KG) GVW, 4X4, 2 AXLE, 3/4 TON (0.68 MT) - PICKUP			*EP / Average*	*15.48*			*0.40*	*6.19*	
					1.00	*50.02*	*1.00*	*5.55*	*55.57*
RSM A1E A1E	LaborCost1	27.40			27.40	1,370.45	27.40	152.16	1,522.62
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*1.00*	*50.02*			
GEN C10Z1400 COMPACTOR, VIBROPLATE, 21" (534 MM) WIDE x 24" (610 MM) PLATE			*EP / Average*	*5.55*			*1.00*	*5.55*	
					1.50	*80.67*	*1.00*	*101.42*	*182.09*
RSM B10G B10G	LaborCost1	1,479.14			2,218.71	119,322.10	1,479.14	150,015.16	269,337.26
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*0.50*	*25.01*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
GEN R45Z5580 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, PADDED DRUM, 13 TON (11.8 MT), 84" (2.1 M) WIDE, SOIL COMPACTOR			*EP / Average*	*101.42*			*1.00*	*101.42*	
					1.50	*80.67*	*4.00*	*7.07*	*87.74*
RSM B10I B10I	LaborCost1	4,114.29			6,171.43	331,899.43	16,457.14	29,070.56	360,969.98
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*0.50*	*25.01*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
GEN P50Z5090 PUMP, WATER, CENTRIFUGAL, TRASH, HOSE, SUCTION/DISCH, 4" (102 MM) DIA x 20' (6.1 M)LENGTH, W/COUPLING/SECTION			*EP / Average*	*0.41*			*1.00*	*0.41*	
GEN P50Z5098 PUMP, WATER, CENTRIFUGAL, TRASH, HOSE, SUCTION/DISCH, 4" (100 MM) DIA X 50' (15 M) WITH COUPLING (PER SECTION)			*EP / Average*	*0.97*			*2.00*	*1.94*	
GEN P65Z5490 PUMP, WATER, DIAPHRAGM, WHEEL, ENGINE DRIVE, 4" (102 MM) DIA, 4,440 GPH (16,807 LPH) @ 25' (7.6 M) HEAD (ADD HOSES)			*EP / Average*	*4.71*			*1.00*	*4.71*	
					1.50	*80.67*	*1.00*	*104.57*	*185.24*
RSM B10P B10P	LaborCost1	16.72			25.09	1,349.11	16.72	1,748.86	3,097.97
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*0.50*	*25.01*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
GEN L35Z4260 LOADER, FRONT END, CRAWLER, 2.60 CY (2.0 M3) BUCKET			*EP / Average*	*104.57*			*1.00*	*104.57*	

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
					1.50	*80.67*	*1.00*	*136.31*	*216.98*
RSM B10U B10U	LaborCost1	35.69			53.53	2,879.05	35.69	4,864.97	7,744.02
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*0.50*	*25.01*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
GEN L40Z4420 LOADER, FRONT END, WHEEL, ARTICULATED, 5.50 CY (4.2 M3) BUCKET, 4X4			*EP / Average*	*136.31*			*1.00*	*136.31*	
					2.00	*106.45*	*2.00*	*166.12*	*272.57*
RSM B12G B12G	LaborCost1	56.04			112.07	5,965.12	112.07	9,308.74	15,273.86
MIL B-EQOPRCRN Equip. Operators, Heavy			*Journeyman*	*56.43*	*1.00*	*56.43*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*1.00*	*50.02*			
GEN B25Z1040 BUCKET, CLAMSHELL, 0.6 CY (0.5 M3) GENERAL PURPOSE, SQUARE NOSE (ADD TEETH WEAR COST)			*EP / Average*	*5.09*			*1.00*	*5.09*	
GEN C85Z2370 CRANE, MECHANICAL, LATTICE BOOM, CRAWLER, DRAGLINE/CLAMSHELL, 0.50 CY (0.4 M3), 17 TON (15 MT), 100' (30.5 M) BOOM (ADD BUCKET)			*EP / Average*	*161.03*			*1.00*	*161.03*	
					2.00	*106.45*	*1.00*	*48.76*	*155.21*
RSM B12Q B12Q	LaborCost1	36.48			72.96	3,883.30	36.48	1,778.70	5,661.99
MIL B-EQOPRCRN Equip. Operators, Heavy			*Journeyman*	*56.43*	*1.00*	*56.43*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*1.00*	*50.02*			
GEN H25Z3165 HYDRAULIC EXCAVATOR, CRAWLER, 27,000 LB (12,247 KG), 0.625 CY (0.5 M3) BUCKET, 18.1' (5.5 M) MAX DIGGING DEPTH			*EP / Average*	*48.76*			*1.00*	*48.76*	
					7.00	*356.26*	*1.00*	*68.40*	*424.66*
RSM B13 B13	LaborCost1	8.00			56.00	2,850.08	8.00	547.21	3,397.29
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
MIL B-EQOPRCRN Equip. Operators, Heavy			*Journeyman*	*56.43*	*1.00*	*56.43*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*4.00*	*200.08*			
MIL B-EQOPROIL Equip. Operators, Oilers / Grade Checker			*Journeyman*	*48.73*	*1.00*	*48.73*			
GEN C80Z2260 CRANE, HYDRAULIC, TRUCK MOUNTED, 25 TON (22.7 MT), 80' (24.4 M) BOOM, 6X4			*EP / Average*	*68.40*			*1.00*	*68.40*	
					6.00	*306.04*	*1.00*	*27.85*	*333.89*
RSM B14 B14	LaborCost1	121.28			727.69	37,116.81	121.28	3,377.94	40,494.74
MIL B-EQOPRLT Equip. Operators, Light			*Journeyman*	*54.94*	*1.00*	*54.94*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*4.00*	*200.08*			

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
GEN L50Z4640 LOADER/BACKHOE, WHEEL, 0.80 CY (0.6 M3) FRONT END BUCKET, 9.8' (3.0 M) DEPTH OF HOE, 24" (0.61 M) DIPPER, 4X4			*EP / Average*	*27.85*			*1.00*	*27.85*	
					3.50	*189.07*	*3.00*	*304.04*	*493.11*
RSM B15 B15	LaborCost1	18.44			64.53	3,486.09	55.31	5,605.91	9,092.01
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*0.50*	*25.01*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*2.00*	*108.40*			
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE			*EP / Average*	*148.49*			*1.00*	*148.49*	
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4			*EP / Average*	*77.77*			*2.00*	*155.55*	
					3.00	*149.57*	*0.00*	*0.00*	*149.57*
RSM B20 B20	LaborCost1	11.27			33.80	1,684.95	0.00	0.00	1,684.95
MIL B-SKILLWKR Skilled Workers			*Journeyman*	*48.53*	*1.00*	*48.53*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*1.00*	*50.02*			
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
					12.00	*623.80*	*4.00*	*244.72*	*868.52*
RSM B25B B25B	LaborCost1	28.57			342.86	17,822.86	114.29	6,992.06	24,814.91
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*4.00*	*222.64*			
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*7.00*	*350.14*			
GEN A30Z0640 ASPHALT PAVER, 10.0' (3.1 M) WIDE, SELF PROPELLED, W/19' (5.8 M) SCREED EXTENSION, WHEEL			*EP / Average*	*155.71*			*1.00*	*155.71*	
GEN R30Z5640 ROLLER, STATIC, SELF-PROPELLED, PNEUMATIC, 9 TIRES, 14 TON (12.7 MT), 68" (1.7 M) WIDE			*EP / Average*	*36.68*			*1.00*	*36.68*	
GEN R45Z5670 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, SMOOTH, 2.7 TON (2.5 MT), 47"(3.8 M) WIDE, ASPHALT COMPACTOR			*EP / Average*	*26.17*			*2.00*	*52.33*	
					3.00	*164.06*	*3.00*	*239.42*	*403.48*
RSM B30 B30	LaborCost1	58.86			176.57	9,656.10	176.57	14,091.37	23,747.48
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*2.00*	*108.40*			

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
GEN H25Z3185 HYDRAULIC EXCAVATOR, CRAWLER, 55,000 LB (24,948 KG), 1.50 CY (1.2 M3) BUCKET, 23.3' (7.1 M) MAX DIGGING DEPTH			*EP / Average*	*83.87*			*1.00*	*83.87*	
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4			*EP / Average*	*77.77*			*2.00*	*155.55*	
					1.00	*54.20*	*1.00*	*77.77*	*131.97*
RSM B34B B34B	LaborCost1	1,373.19			1,373.19	74,426.73	1,373.19	106,797.28	181,224.01
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*1.00*	*54.20*			
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4			*EP / Average*	*77.77*			*1.00*	*77.77*	
					1.00	*54.20*	*2.00*	*80.46*	*134.66*
RSM B34K B34K	LaborCost1	114.29			114.29	6,194.29	228.57	9,195.81	15,390.09
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*1.00*	*54.20*			
GEN T45Z7245 TRUCK TRAILER, LOWBOY, 120 TON (108.9 MT), 4 AXLE (ADD TOWING TRUCK)			*EP / Average*	*20.08*			*1.00*	*20.08*	
GEN T50Z7600 TRUCK, HIGHWAY, 50,000 LB (22,680 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)			*EP / Average*	*60.39*			*1.00*	*60.39*	
					1.00	*54.20*	*2.00*	*64.62*	*118.82*
RSM B34N B34N	LaborCost1	57.14			57.14	3,097.14	114.29	3,692.43	6,789.57
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*1.00*	*54.20*			
GEN T45Z7120 TRUCK TRAILER, FLATBED, 40 TON (36.3 MT), 48' (14.6 M) LENGTH, 2 AXLE (ADD TOWING TRUCK)			*EP / Average*	*7.43*			*1.00*	*7.43*	
GEN T50Z7700 DUMP TRUCK, HIGHWAY, 10 - 13 CY (7.6 - 9.9 M3) DUMP BODY, 35,000 LBS (15,900 KG) GVW, 2 AXLE, 4X2			*EP / Average*	*57.18*			*1.00*	*57.18*	
					5.00	*261.66*	*4.00*	*118.32*	*379.98*
RSM B38 B38	LaborCost1	23.86			119.32	6,244.24	95.46	2,823.64	9,067.88
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*2.00*	*100.04*			
MIL B-EQOPRLT Equip. Operators, Light			*Journeyman*	*54.94*	*1.00*	*54.94*			
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
GEN H25Z3680 HYDRAULIC EXCAVATOR, ATTACHMENT, MATERIAL HANDLING, BUCKET, 36" (914 MM) PAVEMENT REMOVAL (ADD TO 75,000 LB (34,019 KG) HYDRAULIC EXCAVATOR)			*EP / Average*	*2.76*			*1.00*	*2.76*	
GEN H25Z3685 HYDRAULIC EXCAVATOR, ATTACHMENT, CONCRETE PULVERIZER, 3,000 LB (1360 KG) W/POINT (ADD TO 26,000-36,000 LB (11,793-16,329 KG) HYDRAULIC EXCAVATOR)			*EP / Average*	*17.14*			*1.00*	*17.14*	
GEN L40Z4400 LOADER, FRONT END, WHEEL, ARTICULATED, 3.50 CY (2.7 M3) BUCKET, 4X4			*EP / Average*	*70.57*			*1.00*	*70.57*	
GEN L50Z4640 LOADER/BACKHOE, WHEEL, 0.80 CY (0.6 M3) FRONT END BUCKET, 9.8' (3.0 M) DEPTH OF HOE, 24" (0.61 M) DIPPER, 4X4			*EP / Average*	*27.85*			*1.00*	*27.85*	
					3.00	*154.98*	*1.00*	*27.85*	*182.83*
RSM B6 B6	LaborCost1	1.60			4.80	247.97	1.60	44.56	292.53
MIL B-EQOPRLT Equip. Operators, Light			*Journeyman*	*54.94*	*1.00*	*54.94*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*2.00*	*100.04*			
GEN L50Z4640 LOADER/BACKHOE, WHEEL, 0.80 CY (0.6 M3) FRONT END BUCKET, 9.8' (3.0 M) DEPTH OF HOE, 24" (0.61 M) DIPPER, 4X4			*EP / Average*	*27.85*			*1.00*	*27.85*	
					3.00	*154.98*	*1.00*	*16.27*	*171.25*
RSM B62 B62	LaborCost1	5.14			15.43	797.04	5.14	83.68	880.72
MIL B-EQOPRLT Equip. Operators, Light			*Journeyman*	*54.94*	*1.00*	*54.94*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*2.00*	*100.04*			
GEN L40Z4610 LOADER, FRONT END, WHEEL, SKID-STEER, 9-11 CF (0.2-0.3 M3), 60" (1.5 M) BUCKET {BOBCAT}, 13 CWT (590 KG)			*EP / Average*	*16.27*			*1.00*	*16.27*	
					4.00	*208.52*	*3.00*	*46.37*	*254.89*
RSM B80 B80	LaborCost1	14.55			58.20	3,034.10	43.65	674.73	3,708.83
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
MIL B-EQOPRLT Equip. Operators, Light			*Journeyman*	*54.94*	*1.00*	*54.94*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*1.00*	*50.02*			
MIL B-TRKDVRLT Truck Drivers, Light			*Journeyman*	*52.54*	*1.00*	*52.54*			
GEN T40Z7010 TRUCK OPTION, FLATBED, 8' (2.4 M) x 16' (4.9 M) (ADD 25,000 LB (11,340 KG) GVW TRUCK)			*EP / Average*	*1.31*			*1.00*	*1.31*	
GEN T50Z7400 TRUCK, HIGHWAY, 25,000 LB (11,340 KG) GVW, 4X2, 2 AXLE (ADD ACCESSORIES)			*EP / Average*	*42.83*			*1.00*	*42.83*	

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
GEN XMEZ9120 POST DRIVER, 8" (203 MM) MAX DIA POST, 30,000 LB (13,608 KG) IMPACT (ADD 20,000-35,000 LB (9,072-15,876 KG) GVW TRUCK)			*Non-EP / Average*	*2.23*			*1.00*	*2.23*	
					3.00	*150.06*	*2.00*	*44.14*	*194.20*
RSM B80A B80A	LaborCost1	1,355.10			4,065.31	203,346.61	2,710.20	59,815.29	263,161.90
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*3.00*	*150.06*			
GEN T40Z7010 TRUCK OPTION, FLATBED, 8' (2.4 M) x 16' (4.9 M) (ADD 25,000 LB (11,340 KG) GVW TRUCK)			*EP / Average*	*1.31*			*1.00*	*1.31*	
GEN T50Z7400 TRUCK, HIGHWAY, 25,000 LB (11,340 KG) GVW, 4X2, 2 AXLE (ADD ACCESSORIES)			*EP / Average*	*42.83*			*1.00*	*42.83*	
					3.00	*152.58*	*3.00*	*45.66*	*198.24*
RSM B80C B80C	LaborCost1	373.21			1,119.64	56,945.04	1,119.64	17,040.48	73,985.52
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*2.00*	*100.04*			
MIL B-TRKDVRLT Truck Drivers, Light			*Journeyman*	*52.54*	*1.00*	*52.54*			
MAP L15HZ001 POST HOLE DRILL, UP TO 8" DIA, 30" DEEP, ONE MAN OPERATION			*EP / Average*	*1.52*			*1.00*	*1.52*	
GEN T40Z7010 TRUCK OPTION, FLATBED, 8' (2.4 M) x 16' (4.9 M) (ADD 25,000 LB (11,340 KG) GVW TRUCK)			*EP / Average*	*1.31*			*1.00*	*1.31*	
GEN T50Z7400 TRUCK, HIGHWAY, 25,000 LB (11,340 KG) GVW, 4X2, 2 AXLE (ADD ACCESSORIES)			*EP / Average*	*42.83*			*1.00*	*42.83*	
					5.00	*251.10*	*5.00*	*29.54*	*280.64*
RSM B9 B9	LaborCost1	566.67			2,833.33	142,290.00	2,833.33	16,741.25	159,031.25
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*4.00*	*200.08*			
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
GEN A15Z0140 AIR COMPRESSOR, 250 CFM (7 CMM), 100 PSI (689 KPA) (ADD HOSE)			*EP / Average*	*23.50*			*1.00*	*23.50*	
GEN A20Z0400 PAVING BREAKER, 66 LB (30 KG) (ADD 100 CFM (2.8 CMM) COMPRESSOR)			*EP / Average*	*0.66*			*2.00*	*1.32*	
GEN A20Z0480 AIR HOSE, 1.5" (38 MM) DIA x 100' (31 M) LENGTH, HARDROCK (USE AS DRILLING ACCESSORY)			*EP / Average*	*2.36*			*2.00*	*4.72*	
					6.00	*323.34*	*1.00*	*3.02*	*326.36*
RSM C14H C14H	LaborCost1	35.20			211.19	11,380.90	35.20	106.30	11,487.20
MIL B-RODMAN Rodmen (Reinforcing)			*Journeyman*	*56.56*	*1.00*	*56.56*			
MIL B-CARPNTER Carpenters			*Journeyman*	*54.22*	*2.00*	*108.44*			
MIL B-CARPNTER Carpenters			*Foreman*	*55.82*	*1.00*	*55.82*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*1.00*	*50.02*			
MIL B-CEMTFINR Cement Finishers			*Journeyman*	*52.50*	*1.00*	*52.50*			

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
GEN XMEZ9520 CONCRETE VIBRATOR, 2.5" (63.5 MM) DIA, W/7.5 HP (5.6 KW) GENERATOR			*Non-EP / Average*	*3.02*			*1.00*	*3.02*	
					1.00	*54.22*	*0.00*	*0.00*	*54.22*
RSM CARP CARP	LaborCost1	326.22			326.22	17,687.49	0.00	0.00	17,687.49
MIL B-CARPNTER Carpenters			*Journeyman*	*54.22*	*1.00*	*54.22*			
					1.00	*49.02*	*0.00*	*0.00*	*49.02*
RSM CLAB CLAB	LaborCost1	205.93			205.93	10,094.79	0.00	0.00	10,094.79
MIL B-LABORERG Laborers, General			*Journeyman*	*49.02*	*1.00*	*49.02*			
					1.00	*59.95*	*0.00*	*0.00*	*59.95*
RSM ELEC ELEC	LaborCost1	5.71			5.71	342.57	0.00	0.00	342.57
MIL B-ELECTRN Electricians			*Journeyman*	*59.95*	*1.00*	*59.95*			
					4.00	*228.11*	*1.00*	*88.67*	*316.78*
RSM L5A L5A	LaborCost1	9.80			39.18	2,234.55	9.80	868.59	3,103.13
MIL B-STRSTEEL Structural Steel Workers			*Journeyman*	*56.56*	*2.00*	*113.12*			
MIL B-STRSTEEL Structural Steel Workers			*Foreman*	*58.56*	*1.00*	*58.56*			
MIL B-EQOPRCRN Equip. Operators, Heavy			*Journeyman*	*56.43*	*1.00*	*56.43*			
GEN C75Z2000 CRANE, HYDRAULIC, SELF-PROPELLED, ROUGH TERRAIN, 30 TON (27 MT), 80' (24.4 M) BOOM, 4X4			*EP / Average*	*88.67*			*1.00*	*88.67*	
					1.00	*54.20*	*2.00*	*59.07*	*113.27*
USR B34D B34D	LaborCost1	936.76			936.76	50,772.50	1,873.52	55,337.34	106,109.84
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*1.00*	*54.20*			
GEN T45Z7200 TRUCK TRAILER, END DUMP, 20 CY (15 M3), 24 TON (21.8 MT) (ADD TOWING TRUCK)			*EP / Average*	*8.13*			*1.00*	*8.13*	
GEN T50Z7580 TRUCK, HIGHWAY, 45,000 LB (20,412 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)			*EP / Average*	*50.95*			*1.00*	*50.95*	
					7.00	*368.80*	*7.00*	*1,312.30*	*1,681.10*
USR Z01 Loading Crew	LaborCost1	163.43			1,143.99	60,271.74	1,143.99	214,464.18	274,735.92
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
MIL B-EQOPROIL Equip. Operators, Oilers / Grade Checker			*Journeyman*	*48.73*	*1.00*	*48.73*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*1.00*	*50.02*			
MIL B-EQOPRCRN Equip. Operators, Heavy			*Journeyman*	*56.43*	*1.00*	*56.43*			
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*3.00*	*162.60*			
USR XX0XX430 BARGE MTD CLAMSHELL, 54CY NON DREDGE,350T,200'B,250'X75X15			*Non-EP / Average*	*1,134.10*			*1.00*	*1,134.10*	

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
GEN T45Z7080 TRUCK TRAILER, END DUMP, 17 CY (13 CM), 22 TON (20.0 MT) (ADD TOWING TRUCK)			*EP / Average*	*8.45*			*3.00*	*25.36*	
GEN T50Z7580 TRUCK, HIGHWAY, 45,000 LB (20,412 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)			*EP / Average*	*50.95*			*3.00*	*152.84*	
					4.00	*213.62*	*7.00*	*1,312.30*	*1,525.92*
USR Z01 Mob/Demob Loading Crew	LaborCost1	114.29			457.14	24,413.71	800.00	149,976.73	174,390.44
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*3.00*	*162.60*			
USR XX0XX430 BARGE MTD CLAMSHELL, 54CY NON DREDGE,350T,200'B,250'X75X15			*Non-EP / Average*	*1,134.10*			*1.00*	*1,134.10*	
GEN T45Z7080 TRUCK TRAILER, END DUMP, 17 CY (13 CM), 22 TON (20.0 MT) (ADD TOWING TRUCK)			*EP / Average*	*8.45*			*3.00*	*25.36*	
GEN T50Z7580 TRUCK, HIGHWAY, 45,000 LB (20,412 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)			*EP / Average*	*50.95*			*3.00*	*152.84*	
					0.00	*0.00*	*7.00*	*1,312.30*	*1,312.30*
USR Z01 Standby Loading Crew	LaborCost1	114.29			0.00	0.00	800.00	149,976.73	149,976.73
USR XX0XX430 BARGE MTD CLAMSHELL, 54CY NON DREDGE,350T,200'B,250'X75X15			*Non-EP / Average*	*1,134.10*			*1.00*	*1,134.10*	
GEN T45Z7080 TRUCK TRAILER, END DUMP, 17 CY (13 CM), 22 TON (20.0 MT) (ADD TOWING TRUCK)			*EP / Average*	*8.45*			*3.00*	*25.36*	
GEN T50Z7580 TRUCK, HIGHWAY, 45,000 LB (20,412 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)			*EP / Average*	*50.95*			*3.00*	*152.84*	
					2.50	*127.58*	*4.50*	*1,531.60*	*1,659.18*
USR Z03 Mob/Demob Water Based Rock Placement Crew	LaborCost1	228.57			571.43	29,161.14	1,028.57	350,081.11	379,242.25
MIL B-EQOPROIL Equip. Operators, Oilers / Grade Checker			*Journeyman*	*48.73*	*1.00*	*48.73*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*0.50*	*27.83*			
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
USR XX0XX800 DUMP SCOW BARGE, 1,500 CY APPROX. 200'x 50' x 15'			*Non-EP / Average*	*118.32*			*1.00*	*118.32*	
USR XX0Z9720 TUG BOAT, 150-400 HP (112-298 KW)			*Non-EP / Average*	*371.75*			*0.50*	*185.88*	
USR XX0XX430 BARGE MTD CLAMSHELL, 54CY NON DREDGE,350T,200'B,250'X75X15			*Non-EP / Average*	*1,134.10*			*1.00*	*1,134.10*	

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
USR XX0XX730 WORK BARGE, FLAT DECK , 3000 TON APPROX. 200'x 60'x 15',WOOD DECK			*Non-EP / Average*	*73.88*			*1.00*	*73.88*	
EP B25HB013 BUCKET, CLAMSHELL, 5.0 CY, HEAVY DUTY/DIGGING			*EP / Average*	*19.43*			*1.00*	*19.43*	
					7.00	*364.00*	*4.50*	*1,531.60*	*1,895.60*
USR Z03 Removal/Placement Crew	LaborCost1	488.08			3,416.57	177,661.56	2,196.37	747,547.54	925,209.10
MIL B-EQOPRLT Equip. Operators, Light			*Journeyman*	*54.94*	*1.00*	*54.94*			
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
MIL B-EQOPRCRN Equip. Operators, Heavy			*Journeyman*	*56.43*	*1.00*	*56.43*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*0.50*	*27.83*			
MIL B-EQOPROIL Equip. Operators, Oilers / Grade Checker			*Journeyman*	*48.73*	*1.00*	*48.73*			
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*2.50*	*125.05*			
USR XX0XX800 DUMP SCOW BARGE, 1,500 CY APPROX. 200'x 50' x 15'			*Non-EP / Average*	*118.32*			*1.00*	*118.32*	
USR XX0Z9720 TUG BOAT, 150-400 HP (112-298 KW)			*Non-EP / Average*	*371.75*			*0.50*	*185.88*	
USR XX0XX430 BARGE MTD CLAMSHELL, 54CY NON DREDGE,350T,200'B,250'X75X15			*Non-EP / Average*	*1,134.10*			*1.00*	*1,134.10*	
USR XX0XX730 WORK BARGE, FLAT DECK , 3000 TON APPROX. 200'x 60'x 15',WOOD DECK			*Non-EP / Average*	*73.88*			*1.00*	*73.88*	
EP B25HB013 BUCKET, CLAMSHELL, 5.0 CY, HEAVY DUTY/DIGGING			*EP / Average*	*19.43*			*1.00*	*19.43*	
					0.00	*0.00*	*4.50*	*1,531.60*	*1,531.60*
USR Z03 Standby Removal/Placement Crew	LaborCost1	114.29			0.00	0.00	514.29	175,040.56	175,040.56
USR XX0XX800 DUMP SCOW BARGE, 1,500 CY APPROX. 200'x 50' x 15'			*Non-EP / Average*	*118.32*			*1.00*	*118.32*	
USR XX0Z9720 TUG BOAT, 150-400 HP (112-298 KW)			*Non-EP / Average*	*371.75*			*0.50*	*185.88*	
USR XX0XX430 BARGE MTD CLAMSHELL, 54CY NON DREDGE,350T,200'B,250'X75X15			*Non-EP / Average*	*1,134.10*			*1.00*	*1,134.10*	
USR XX0XX730 WORK BARGE, FLAT DECK , 3000 TON APPROX. 200'x 60'x 15',WOOD DECK			*Non-EP / Average*	*73.88*			*1.00*	*73.88*	
EP B25HB013 BUCKET, CLAMSHELL, 5.0 CY, HEAVY DUTY/DIGGING			*EP / Average*	*19.43*			*1.00*	*19.43*	
					4.00	*211.12*	*2.00*	*644.75*	*855.87*
USR Z10 Land Based Rock Placement Crew	LaborCost1	488.08			1,952.32	103,043.70	976.16	314,692.43	417,736.13

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
MIL B-EQOPRCRN Equip. Operators, Heavy			*Journeyman*	*56.43*	*1.00*	*56.43*			
MIL B-EQOPRLT Equip. Operators, Light			*Journeyman*	*54.94*	*1.00*	*54.94*			
MIL B-EQOPROIL Equip. Operators, Oilers / Grade Checker			*Journeyman*	*48.73*	*1.00*	*48.73*			
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
EP H25CA030 HYDRAULIC EXCAVATOR, CRAWLER, 175,500 LBS, 5.00 CY BUCKET, 34.75' MAX DIGGING DEPTH			*EP / Average*	*240.16*			*1.00*	*240.16*	
MAP L40CA009 LOADER, FRONT END, WHEEL, 16.00 CY BUCKET, ARTICULATED, 4X4			*EP / Average*	*404.60*			*1.00*	*404.60*	
					2.00	*105.96*	*3.00*	*585.05*	*691.01*
USR Z10 Mob/Demob Land Based Rock Placement Crew	LaborCost1	228.57			457.14	24,219.43	685.71	133,726.24	157,945.67
MIL B-LABORER Laborers Semi-Skilled			*Foreman*	*51.02*	*1.00*	*51.02*			
MIL B-EQOPRLT Equip. Operators, Light			*Journeyman*	*54.94*	*1.00*	*54.94*			
EP B25HB013 BUCKET, CLAMSHELL, 5.0 CY, HEAVY DUTY/DIGGING			*EP / Average*	*19.43*			*1.00*	*19.43*	
GEN C85Z2370 CRANE, MECHANICAL, LATTICE BOOM, CRAWLER, DRAGLINE/CLAMSHELL, 0.50 CY (0.4 M3), 17 TON (15 MT), 100' (30.5 M) BOOM (ADD BUCKET)			*EP / Average*	*161.03*			*1.00*	*161.03*	
MAP L40CA009 LOADER, FRONT END, WHEEL, 16.00 CY BUCKET, ARTICULATED, 4X4			*EP / Average*	*404.60*			*1.00*	*404.60*	
					0.00	*0.00*	*2.00*	*644.75*	*644.75*
USR Z10 Standby Land Based Rock Placement Crew	LaborCost1	114.29			0.00	0.00	228.57	73,686.20	73,686.20
EP H25CA030 HYDRAULIC EXCAVATOR, CRAWLER, 175,500 LBS, 5.00 CY BUCKET, 34.75' MAX DIGGING DEPTH			*EP / Average*	*240.16*			*1.00*	*240.16*	
MAP L40CA009 LOADER, FRONT END, WHEEL, 16.00 CY BUCKET, ARTICULATED, 4X4			*EP / Average*	*404.60*			*1.00*	*404.60*	
					3.00	*164.06*	*3.00*	*384.86*	*548.92*
USR Z15 Fill Transport Crew	LaborCost1	2,608.68			7,826.03	427,979.70	7,826.03	1,003,968.17	1,431,947.87
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
MIL B-TRKDVRHV Truck Drivers, Heavy			*Journeyman*	*54.20*	*2.00*	*108.40*			
MAP L40CA007 LOADER, FRONT END, WHEEL, 6.00 CY BUCKET, ARTICULATED, 4X4			*EP / Standby*	*26.64*			*0.67*	*17.85*	

Description	LaborRate	CrewHours	MemberType	MemberRate	ManHours	LaborCost	EQHours	EQCost	CrewCost
MAP L40CA007 LOADER, FRONT END, WHEEL, 6.00 CY BUCKET, ARTICULATED, 4X4			*EP / Average*	*136.31*			*0.33*	*44.98*	
EP T55JD004 TRUCK, OFF-HIGHWAY, ARTICULATED FRAME, 29 CY, 40 TON, 6X6, REAR DUMP			*EP / Average*	*161.01*			*2.00*	*322.03*	
LANDSCAPE SUBCONTRACTOR	**LaborCost1**	**2,742.61**		**0.00**	**4,124.98**	**209,912.37**	**1,216.93**	**84,575.23**	**294,487.60**
					8.00	*398.18*	*2.00*	*44.14*	*442.32*
GOV USKCF 6 laborers + 1 truck, flatbed,20,000-25,000 GVW	LaborCost1	128.98			1,031.86	51,358.39	257.97	5,693.41	57,051.80
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*6.00*	*300.12*			
MIL B-SKILLWKR Skilled Workers			*Foreman*	*49.53*	*1.00*	*49.53*			
MIL B-SKILLWKR Skilled Workers			*Journeyman*	*48.53*	*1.00*	*48.53*			
GEN T40Z7010 TRUCK OPTION, FLATBED, 8' (2.4 M) x 16' (4.9 M) (ADD 25,000 LB (11,340 KG) GVW TRUCK)			*EP / Average*	*1.31*			*1.00*	*1.31*	
GEN T50Z7400 TRUCK, HIGHWAY, 25,000 LB (11,340 KG) GVW, 4X2, 2 AXLE (ADD ACCESSORIES)			*EP / Average*	*42.83*			*1.00*	*42.83*	
					1.00	*50.02*	*0.00*	*0.00*	*50.02*
RSM 1CLAB 1 CLAB	LaborCost1	82.57			82.57	4,130.09	0.00	0.00	4,130.09
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*1.00*	*50.02*			
					1.50	*80.67*	*1.00*	*82.26*	*162.93*
RSM B10O B10O	LaborCost1	958.96			1,438.45	77,359.65	958.96	78,881.82	156,241.47
MIL B-LABORER Laborers Semi-Skilled			*Journeyman*	*50.02*	*0.50*	*25.01*			
MIL B-EQOPRMED Equip. Operators, Medium			*Journeyman*	*55.66*	*1.00*	*55.66*			
GEN L35Z4250 LOADER, FRONT END, CRAWLER, 2.00 CY (1.5 M3) BUCKET			*EP / Average*	*82.26*			*1.00*	*82.26*	
					1.00	*49.02*	*0.00*	*0.00*	*49.02*
RSM CLAB CLAB	LaborCost1	1,572.10			1,572.10	77,064.23	0.00	0.00	77,064.23
MIL B-LABORERG Laborers, General			*Journeyman*	*49.02*	*1.00*	*49.02*			

ATTACHMENT I

ENGINEERING CONSIDERATIONS AND INSTRUCTIONS FOR FIELD PERSONNEL

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Design Services for Kenai Bluff Stabilization

Engineering Considerations and Instructions for Field Personnel

December 2012

1.0 *Introduction.*

1.1. Purpose
This report provides specific instructions to field personnel to supplement the design details outlined in the Initial Design Documentation Report and highlight unique elements of the design. The purpose of this report is to provide field personnel with a better understanding of the project's function and to ensure that field personnel are aware of all special details of the project, including design assumptions regarding field conditions.

1.2. Scope
The report outline is generally based on Appendix G of ER 1110-2-1150. This is a draft report and shall be reviewed and updated in coordination with field personnel prior to publication in final form. This report is intended to serve as a working outline appropriate to the current level of detail of the accompanying design plans; detailed notes relevant to field personnel may be added throughout the development of final plans and specifications.

1.3. Special Field Conditions
Wet, saturated soils can be expected during excavation, particularly along the bluff below the water table. The toe of the bluff is subject to extreme tidal fluctuations. Cold weather, turbulent waters, and ice within the river are likely to be encountered at the project site, particularly during winter construction.

1.4. Special Construction Techniques
The height and steepness of the bluff and the nature of the soils along the toe of the bluff may require specialized equipment or construction techniques. A portion of the rock placement is anticipated to be in-water work using specialty equipment. The construction schedule currently assumes 12 hours per day and 6 days per week; however, this may be adjusted by the contractor and additional shifts may be incorporated to take advantage of tidal cycles or frozen ground.

1.5 Safety Plan
All field personnel shall be trained in the Safety Plan prior to entering the site. Daily safety briefings shall be held during construction. Do not conduct any construction activities without prior training in relevant elements of the safety plan. Safety concerns shall immediately be reported to supervisors and documented in adherence with the approved safety plan.

2.0 *Site Preparation*

2.1. Traffic Control
All traffic control activities, including road closures and detours, shall be in keeping with the traffic management plan prepared by the contractor and adopted by the owner. Do not engage in any traffic control activities without prior consultation of the traffic management plan; particular caution is to be exercised for truck access to the Kenai Spur Highway. All repaving of disturbed areas and the implementation of road works, including the installation of a guardrail system along Mission Avenue, are subject to the requirements of the traffic management plan.

2.2. Site Security
Prior to initiating construction activities, temporary fencing is to be installed along the bluff above the construction area according to the fencing details in the plans. The temporary fencing is intended to

prevent public access to the bluff are during construction. All access gates must be locked when construction staff are not present.

2.3. Clearing and Grubbing
The temporary staging areas and permanent construction zones along the top of the bluff are to be cleared and grubbed of vegetation and debris, with the materials stockpiled on site or removed for off-site disposal. Several passes with a scraper will likely be needed to remove organics and the upper silt layer. Organics and topsoil shall be separated and stored separately for later disposal or reuse. Clearing and grubbing of vegetation and debris shall occur only within the defined limits of construction. The project requires the removal of large trees lining the top of the bluff. For trees larger than 6" DBH, only remove trees specifically tagged for removal, even within the designated staging areas, temporary construction easements, or permanent project easements.

2.4. Site Access
The project requires the construction of a temporary gravel haul road to allow access to the toe of the bluff. The temporary haul road is to remain in place following construction for use by maintenance vehicles. Excavation equipment for access road construction will need to be located a sufficient distance from the edge of the bluff to avoid the risk of bank failure caused by the equipment. During limited time periods in extreme high tide conditions, the haul road may become submerged. All field personnel shall be briefed daily on tidal conditions.

Due to the nature of the tide flat, the preliminary grading, material placement and compaction would be done with specialized equipment from each constructed reach of the haul road itself. Haul road fill is intended for use as backing for the geotextile underlying the rock and should thus be constructed to the specified grade and slopes. A temporary bridge crossing is required across Ryan's Creek. This area is subject to special environmental restrictions as described in the environmental considerations below.

2.5. Care and Diversion of Water
Temporary stormwater and groundwater diversion and dewatering systems are to be installed in accordance with the approved water management plan. Groundwater discharge shall be monitored and documented during construction. Silt fencing is required along the bluff above the construction area according to the design plan details.

2.6. Demolition and Utilities
Affected utilities located within the construction area are to be re-routed as needed. Some small structures within the project footprint require demolition, and the resulting debris is to be hauled off-site in accordance with the disposal plan. All abandoned concrete and timber foundations located within the construction area are be removed and hauled to the selected disposal area. All utilities located within the construction area are to be rerouted during construction in coordination with the Alaska Dig Line.

3.0 *Armor Rock*

3.1. Placement
Armor rock is to be specially placed in accordance with procedures outlined in the U.S. Army Corps of Engineers Shore Protection Manual. Specifically, armor rock is to be placed with the long axis of each stone perpendicular to the structure face. Armor rock is to be placed in several stages as backfill is placed on the haul road. Rock may be imported through a combination of barging and land-based equipment with the barge placing apron material at high tide, and the land-based equipment placing the remaining armoring at low tide. Land-based equipment may operate for a portion of each shift, with water-based equipment operating in the remaining portion. Complete segments of the armor section are to be completed during each low tide cycle to at least the elevation of the maximum tide lines. Any trenching from land-based equipment would have to be completed at low tide and backfilled in sections prior to high tide, requiring construction of the entire cross section in lateral sections rather than vertical layers across the entire project site. The revetment face and foreslope toe must remain continuous and smooth to avoid

scour from incoming wave refraction; transition zones must therefore be constructed with gradual changes in revetment height, armor size, and layer thickness.

3.2. Trenching
Geotechnical analyses indicate that trenching efforts may encounter difficulties in specific areas. In these areas, the equivalent toe depth might be provided as an apron of launch material. Criteria for determining the appropriate toe configuration are to be adopted prior to construction and refined as needed, subject to the approval of the contracting officer. Preliminary bearing capacity analyses based on the results of borings at the toe of the slope indicate that no additional compaction is required at the toe once the initial overexcavation for the bedding layer is completed. Settlement is anticipated to be on the order of several inches; therefore, a slight overbuild is recommended in terms of the top of revetment elevation. This overbuild is not accounted for in the design grades and shall be incorporated by the contractor.

3.2. Filter Fabric
Filter fabric is included beneath the revetment bedding to prevent piping of material through the revetment while relieving the buildup of excessive pressure from the groundwater and/or tidal cycles. The geotextile fabric, sublayers, and armor rock would need to be placed while the haul road is at a sufficient elevation to allow equipment access.

4.0 *Excavation and Placement of Fill*

The bluff is to be excavated and laid back at the specified slope. Excavated material is to be hauled to the designated stockpile areas for later reuse as backfill in the construction of the new, stabilized bluff. Material unsuitable for reuse must be hauled offsite for disposal. All fill material is to be placed in lifts according to the project specifications. Fill material should not be allowed to become excessively wet prior to compaction. The exposed bluff face in any proposed fill areas must be notched to avoid a smooth interface between soil types. Benching into the bluff face is recommended to expose undisturbed material. No equipment is to be operated on the sloping bluff face but must rather be located on horizontal layers, with a bucket or other extension performing the final smoothing and compaction of the immediate face. The topsoil layer must be placed in several increments so as not to exceed the reach of the construction equipment.

Granular material that meets the specification for use as the filter layer must be separated and stockpiled for placement. In isolated areas, there is some risk of flow concentration surfacing. These flow concentration areas must be documented during construction and may require localized maintenance efforts involving the placement of a rock mattress or other erosion mitigation following construction.

A bench is incorporated into the typical cross section in order to prevent groundwater flows from surfacing. The bench also serves additional purposes for constructability and maintenance. Excavation activities will most likely uncover some material unsuitable for reuse onsite that will have to be hauled for offsite disposal. Some reuse of the excess till material is assumed within the toe trench backfill in order to minimize voids and reduce the potential for fish stranding. During construction, any loose and/or saturated debris should be removed from the face of the bluff prior to placing the fill material.

5.0 *Geogrid*

Placement of a geogrid, as shown in the design plans is required for operation of vehicles in lifts along the slope. Geogrid placement is required at every second compaction lift (18-inch vertical spacing) with a minimum width of five feet. For products manufactured in six-foot rolls, a six foot width would be recommended in favor of cutting the roll. Uniaxial products would need to be rolled with frequent cuts and excessive overlap requirements; a biaxial geogrid is therefore recommended. The opening size should be at least one inch square to accommodate roots from the vegetation planted along the bluff face. The geogrid should be flexible fabric rather than stiff plastic so that establishment of roots reinforces rather than destabilizes the slope.

6.0 *Drainage Features*

The design is intended to prevent overland runoff from flowing over the edge of the bluff in order to reduce the risk of head cuts and other associated drainage problems using a combination of basins and rock chutes. A small berm is required along the edge of the bluff to direct overland flows away from the bluff face. The twelve-foot wide access route adjacent to the berm is graded with a reverse cross slope and a small ditch is proposed on the landward side of the road to collect sheet flow runoff. The ditch should be vegetated in order to act as a bioswale for filtering stormwater runoff. Vegetated settling basins are to be constructed at the three designated concentration points. The swales are intended to route flow into the settling basins, which attenuate peak flows while allowing pollutants to settle, and the vegetation within the basins filters urban runoff from adjacent streets prior to being released. The bed of the ditches and basins should be lined per the design plans in order to prevent infiltration that might otherwise surcharge the groundwater table.

Connection of outlets to the City of Kenai storm drain network shall occur only in coordination with City of Kenai authorities. A rain-on-snow event occurring while culverts are blocked by ice or a design rainfall event occurring over frozen ground with highly limited infiltration may result in exceeding the system capacity. Should a greater-than-design event occur, immediate inspection is recommended to address potential erosion problems and prevent large-scale slope failure.

7.0 *Vegetation*

During the period immediately following construction, prior to the establishment of vegetation, the slope will be more susceptible to erosion, and the placement of topsoil and a high-performance erosion control mat is intended to speed the greening process. Erosion control fabric is required for the entire bluff face above the armor rock. Replacement of some plants may be required during establishment, particularly if design-level or greater-than-design rainfall events occur during the establishment period.

The planting plan for the project includes the following components:

- During Construction: Place, key in and stake erosion control fabric along entire bluff face.
- Phase I (Mandatory): Seed entire area with emergent native grasses, including beach wildrye (Elymus mollis), blue joint reed grass (Calamagrostis canadensis) at 5 lb/ac and tufted hairgrass (Deschampsia cespitosa) at 5 lb/acre.
- Phase II (Optional): Plant riparian vegetation. Plant willow stakes immediately uphill of the revetment 5 feet on center. Extend the willows 3 feet along the slope uphill from the revetment in the near mouth area and 4.5 feet in the remaining area. Plant one row of alders adjacent to willows spaced 10 feet on center.
- Phase III (Optional): Plant upland vegetation. Plant rows of spruce 15 feet on center to the top of the bluff.

A 100% biodegradable erosion control blanket meeting ASTM testing standards is required. Due to the relatively harsh environment at Kenai, several considerations should be followed during installation to extend the life and functionality of the product. Because the bluff face is south-facing, UV exposure will be intense, particularly in the summer months. A heavy-grade fabric is recommended in order to resist degradation from UV exposure. Because of the steep slope, high winds, and freeze-thaw action, the standard spacing for stakes should be doubled (quadrupling the number of required stakes) from the standard vendor recommendations. Particular care must be taken to ensure the mat lies flush against the topsoil. Key-in and overlap requirements should also be strictly adhered to.

For placement of the erosion control fabric, prepare the soil, including grading, application of lime, fertilizer, and seeds. The surface of the soil should be smooth and free of rocks, roots, and other obstructions. Starting at the top of the slope, anchor blankets in a 6” deep and 6” wide anchor trench. Place blankets, staple, backfill, and compact. Roll the blankets down the slope. Staple the open blanket edge using one row of staples at half the manufacturer recommended interval. The middle of the blankets should be stapled ensuring a good contact between the soil and blanket. When blanket splicing is necessary, use an 8" overlap with two rows of staples. Provide an anchor trench at the toe of the slope.

Wherever the fabric is sliced for planting (including phased planting in seasons following completion of construction), the flaps should be buried into the hole for the rootball as a key-in. Plantings should be mulched as needed above the fabric. Some seeding can be completed prior to installation. In some cases, plugs can be planted through the openings in the blanket without slicing. Prevention of rilling and gullying along the bluff face relies on the infiltration. The subsurface material is likewise designed to be a pervious layer. As such, irrigation may be required during the initial phases until root depth are sufficiently established to prevent dessication.

8.0 *OMRRR requirements*

The implemented project will require ongoing monitoring of vegetation, armor rock, bluff face integrity, river thalweg location, and other aspects of the project throughout the project life. Slopes shall be monitored for creep according to instrumentation requirements in the approved OMRRR plan. Annual inspection of vegetation is required. Results of the annual inspection will drive the timing of subsequent planting phases, should they be required. The monitoring plan should also include periodic hydrographic surveys to determine whether the thalweg is migrating toward the bluff face.

OMRRR needs will be assessed, prioritized, and implemented based on the contents of the monitoring plan. Due to the slope length, the types of equipment that may be mobilized to implement maintenance activities are limited and the suitability of the equipment must be reviewed prior to implementation. Construction of rock mattresses over the slope in areas of high groundwater discharge may require manual placement.

Specifications of maintenance equipment, including width requirements for extensions, must be coordinated in further detail prior to use of equipment on the bench. Placement of additional rock at the toe in areas threatened by a thalweg shift will be guided by the results of the hydrographic survey. The top of the armor layer is not suitable as a driving surface, and maintenance of the rock may need to be provided with barge access at high tide.

9.0. *Special environmental considerations or procedures.*

As a catalogued anadromous stream supporting high value resident fish species, the Kenai River is a sensitive environmental area. The entire project site is located within the Kenai Peninsula Borough Coastal District and subject to all relevant requirements. Lands within 50 feet of Mean High Tide are covered by Kenai Pensinsula Borough's Habitat Protection Area ordinances. Areas at or below Mean High Tide are covered by the Department of Natural Resources Kenai River Special Management Area. All activities which may result in the discharge of pollutants to the Kenai River are subject to the Environmental Protection Agency. The toe of the bluff is a mapped floodplain, with lands under the jurisdiction of the KPB floodplain administrator. The Corps of Engineers has additional regulatory authority and subject to all permits.

10.0 *Demobilization*

All temporary staging areas are to be restored according to the project specifications following construction. Any damage to public roadways along haul routes is to be repaired.

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ATTACHMENT J

ANNOTATED COMMENTS AND ITR CERTIFICATION

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Comment Report: All Comments
Project: (102790) Kenai Bluff Technical Report Review   Review: Technical documents
Displaying 93 comments for the criteria specified in this report.

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Id	Discipline	DocType	Spec	Sheet	Detail
4227909	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Kenai River Bluff Stabilization Cost Estimate, Tetra Tech, 6/22/2011)

Labor rates look reasonable; fuel prices appear current for the area; Ctr Markups generally appear reasonable. Current labor market doesn't seem to be short of experienced workers, methodology for earthwork hard to quantify, and difficulty of task effort is better explained in individual line items production rates rather than averaging overall.

Submitted By: Al Arruda (907-753-5679). Submitted On: Oct 12 2011

1-0 Evaluation **Concurred**
Added further clarification to earthwork methodology in MII in accordance with recommendations set forth in the constructibility memorandum. Explanation of production rates added in individual line items.

Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Al Arruda (907-753-5679) Submitted On: Aug 17 2012

Current Comment Status: **Comment Closed**

Id	Discipline	DocType	Spec	Sheet	Detail
4227913	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Kenai River Bluff Stabilization Cost Estimate, Tetra Tech, 6/22/2011)

Estimator General Notes are fairly thorough. (ref Notes par 3. Construction Schedule) Construction duration assumed at 15 months agrees with simplified Project Schedule using same work shifts as Mii CWE. However, not certain of basis for conservative decision to road-haul quarry materials 102 miles from Seward given highway traffic, safety risks and potential delays (ref Notes par 5.B: Borrow/Disposal Areas and Materials) vs barge-haul to in-water and near-water placement at river bank toe with "specialty equipment" (ref Notes par E. Unique Construction Techniques). Do river levels or tide cycles preclude floating materials or equipment on barges? River barge hauling and floating cranes/backhoes are not unusual methodologies for well-equipped and experienced coastal and marine contractors (Alaska Marine Transport, Brice, Kiewit, Kelly-Ryan, Knik Construction, West Construction, Western Marine, etc).

Submitted By: Al Arruda (907-753-5679). Submitted On: Oct 12 2011

1-0 Evaluation **For Information Only**
Placement from a barge-mounted crane would be possible for several hours each day. We made assumptions on the proportion of land- vs. water-based placement. The actual proportion would likely vary with each contractor's bid. We spoke to general contractors about land- vs. water-based hauling. Some were nervous about letting barges beach during low tide vs inefficiency of moving in and out with each tide cycle and leaving offshore during low tide. We have assumed overland haul but contractors may be able to beat cost/risk with barge either in part or in full. Would depend on fuel prices and other variables at the time of bid as well as any quarries that might be identified in the future close to docks. Permitting agencies have requested that if barging and water-based placement is going to be an option for the bids that we leave it mentioned in the documentation even if it isn't used as the basis for cost estimates so that the proper permits are still pursued to leave that option open when project nears construction.

	Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Concur with leaving available options open to increase competition and encourage lower proposal prices. Submitted By: Al Arruda (907-753-5679) Submitted On: Aug 17 2012
	Current Comment Status: **Comment Closed**

4227916	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Kenai River Bluff Stabilization Cost Estimate, Tetra Tech, 6/22/2011)

Owner markups appropriate for Escalation and Contingency; but 15% for Construction Management seems high compared to Alaska District standard of 8% - please explain (ref notes par 10.C).

Submitted By: Al Arruda (907-753-5679). Submitted On: Oct 12 2011

1-0	Evaluation **Concurred** 15% had been requested by another district. Changed to 8% in accordance with AK District standards. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Construction Division should provide project specific budget cost to the estimator when the standard 8% is judged insufficient for expected tasks. Submitted By: Al Arruda (907-753-5679) Submitted On: Aug 17 2012
	Current Comment Status: **Comment Closed**

4227923	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Kenai River Bluff Stabilization COST ENGINEERING REPORT DRAFT SUBMITTAL June 2011)

Quantity takeoffs are fairly well documented with good detail calc sheets. However, App B, page 3, Detailed Quantity Take-Offs, [02] RELOCATIONS, [02.01] Relocations, [02.01.01] Pipe Demolition, 24" CMP, Demolition, Excavating, Trench Length = 200 ft, Trench Depth = 6.0 ft, Trench Width = 4.0 ft, Volume = 178 BCY, Backfill, Bank Volume = 178 BCY, Swell/Shrinkage Factor = 20%, Loose Volume = 213 LCY, Compaction, Volume = 213 ECY Doesn't appear to agree with Mii, or App B, page 1, quantities for same item (?): [02] RELOCATIONS - LS 1, [02.01] Relcoations - LS 1, [02.01.01] Pipe Demolition - LF 850, [02.01.01.01] Pipe Demo Earthwork - CY 611 Excavation - CY 6 11, Backfill - CY 7 33, Compaction - CY 6 11 Please back check quantities in design, reports, takeoff sheets and Mii CWE for agreement.

Submitted By: Al Arruda (907-753-5679). Submitted On: Oct 12 2011

1-0	Evaluation **Concurred** All quantities have been back checked for accuracy and consistency within MII and the cost report Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Al Arruda (907-753-5679) Submitted On: Aug 17 2012
	Current Comment Status: **Comment Closed**

4234951	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

The drawings are not ready for COE tech review. Missing line work, incorrect detail call outs, and missing information, ect. An in-house review should have picked up much of this.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Corrections made. Additional internal review conducted for revisions. QAQC comments and backchecks with certification will be provided. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 13 2012
	Current Comment Status: **Comment Closed**

4234952	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

The Primary Control Line (PCL) is missing on some plan sheets and has different line types when shown. Show the PCL on all plan sheets using consistent line types.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** PCL added to all plan views. Adjusted line scale to be consistent with legend. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 13 2012
	Current Comment Status: **Comment Closed**

4234954	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

The Primary Control Line (PCL) is not shown on typical section 1 on sheet C-11. Show the PCL on section 1, sheet C-11.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Added vertical line at center of bench to represent PCL location Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment.

	Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 13 2012
	Current Comment Status: **Comment Closed**

4234957	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

Underlying stationing is unreadable on the plan sheets. Show stationing on the Primary Control Line (PCL) on all plan sheets in a type size large enough to read.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Adjusted font size and corrected pen table and plot driver for improved readability Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 13 2012
	Current Comment Status: **Comment Closed**

4234959	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

The text on the PC & PT stationing, Primary Control Line (PCL), on all plan sheets is not large enough to read easily. Increase the text size on PC & PT stationing on all plan sheets.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Adjusted font size and corrected pen tables and plot drivers for improved readability. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 13 2012
	Current Comment Status: **Comment Closed**

4234960	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

Note 3 on plan sheets says "min 2% cross slope" yet typical section 1 on sht C -11 shows 2% slope. Correct discrepancy.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Deleted "min" in Note 3 for consistency with typ section Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234962	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

Note 4 on plan sheets says "min 2% cross slope" yet grading cross sections and typical section 1 on sht C-11 show 2% slope. Correct discrepancy.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Deleted "min" from Note 4 for consistency with typ section Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234963	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

Note: Construct water bars.... references Det 7/C-13. The water bar detail on sht C-13 is detail 6. Correct discrepancy.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Changed note on C-1 to "Det 6/C-13" Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234964	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

Plan sheets do not differenciate between existing and new in use of fence legend. Also the fence legend on sht G-3 shows the new fence legend as chain link fence and the proposed new fence is wood as shown of Fence and Post details, typical detail 4 on sht C-14. Correct legend and details as necessary to be consistent in intent.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Heavier/darker line type used for new fence. Legend corrected to "wood fence" for consistency with intent in cost estimate details and standard drawings. Alternative standard plans for chain link are presented in report (Attachment E) for further discussion with local sponsors. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234966	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

Plan sheets do not show the legend or starting and ending of fence in all locations where fence is intended. Add starting points and ending points for fence sections and use consistent legend.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Added stationing call-out for begin and end fence and adjusted line type. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234967	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

Trench Detail 4 on sht C-13 has note "For Restoration See". Complete the callout as needed.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Inserted text to read "For restoration see planting sheets L-1, L-2, and L-3" Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012

	Current Comment Status: **Comment Closed**

4234968	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

Flashboard Riser Plan and Section, typical detail 5 on sht C-13 has 2 incomplete callouts, "Channel (See Detail)" and "Planks (Stop Logs) See Detail". Complete the callouts as needed.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Deleted "See Detail" from callouts Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234969	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011)
Coordinating Discipline(s): Civil

Abbreviation "PROP" as used on the plan sheets is not in the abbreviations list on sht G-3. Add the abbreviation "PROP" and definition to the list.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Added PROP PROPOSED to list of abbreviations Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234970	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011/Bluff Stabilization Alternatives dtd March 2009)
Coordinating Discipline(s): Civil

The draft design report, Kenai River Bluff Erosion, Bluff Stabilization Design Alternatives dated March 2009 in several places refers to Ryan's Creek and the drawings Kenai Bluff Stabilization, Preliminary Design, dated 15Jun2011 labels it Ryans Creek. Correct discrepancy.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Correct spelling is "Ryan's Creek". Corrected throughout plans for consistency with report.

	Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234973	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011/Bluff Stabilization Alternatives dtd March 2009)
Coordinating Discipline(s): Civil

The draft design report, Kenai River Bluff Erosion, Bluff Stabilization Design Alternatives dated March 2009, page 58, second paragraph in section 5.5 Vegetation refers to phased planting with phase II taking place after several seasons followed by phase III after the establishment of phase II plantings. Sheets L-1, L-2, and L-3 do not indicate any time requirements between phased plantings. Indicate time/establishment requirements on these sheets for phased plantings.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Added "following establishment of previous phase" to references to Phase II and Phase III Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234975	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Preliminary Design dtd 15JUN2011/Bluff Stabilization Alternatives dtd March 2009/Cost Estimate dtd June 2011)
Coordinating Discipline(s): Civil

The draft design report, Kenai River Bluff Erosion, Bluff Stabilization Design Alternatives dated March 2009, page 58, second paragraph in section 5.5 Vegetation refers to phased planting with phase II taking place after several seasons followed by phase III after the establishment of phase II plantings. The cost estimate does not indicate time requirements between phased plantings. Show the cost considerations inherent in time intervals between phased plantings which may include additional mob/demob and/or follow on contracts.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Corrected schedule in cost report to reflect phasing, split in MII and added mob/demob for each phase. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4234977	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Bluff Stabilization Alternatives dtd March 2009)
Coordinating Discipline(s): Civil

The draft design report, Kenai River Bluff Erosion, Bluff Stabilization Design Alternatives dated March 2009, page 20, last paragraph refers to a model of the storm drain network and says "a functioning model is anticipated in Summer 2009. Findings from the model will be incorporated during future design phases." What is the status of the model? I see no indication findings have been incorporated in the design.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0 Evaluation **Concurred**
The model was not completed. Acc to last e-mail on June 7 2011 from Stephanie Kobylarz at Kenai Watershed Forum (former lead for modeling efforts) "I am leaving my position...We don't have any updates on the Kenai stormwater project...No new work on this project is anticipated" Updated design report to reflect status.

Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012

Current Comment Status: **Comment Closed**

4234978	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Bluff Stabilization Alternatives dtd March 2009)
Coordinating Discipline(s): Civil

The draft design report, Kenai River Bluff Erosion, Bluff Stabilization Design Alternatives dated March 2009, page 21, first paragraph refers "Dye testing is anticipated in the late spring of 2009 in order to verify flow paths,..." and last paragraph on page 56 refers to dye testing. What is the status of the dye testing and were the results incorporated into the storm drain model?

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0 Evaluation **Concurred**
Dye testing was completed in spring of 2009. Several directional arrows on the maps were updated and we have acquired and incorporated the new map into the report; however, no model was developed. Updated design report to reflect status.

Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012

Current Comment Status: **Comment Closed**

4234979	Planning - Plan Formulation	Plans	n/a'	n/a	n/a

Comment Classification: N/A
(Document Reference: Bluff Stabilization Alternatives dtd March 2009)
Coordinating Discipline(s): Civil

The draft design report, Kenai River Bluff Erosion, Bluff Stabilization Design Alternatives dated March 2009. Update table 5 on page 33 and table 6 on page 39 to reflect the new design criteria regarding wave heights.

Submitted By: Clarke Hemphill (907-753-5602). Submitted On: Oct 17 2011

1-0	Evaluation **Concurred** Updates from 7/23/2010 revetment design memo incorporated into current draft of DDR. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Ronnie Barcak (907-753-5755) Submitted On: Sep 17 2012
	Current Comment Status: **Comment Closed**

4253263	Real Estate	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Civil

Real Estate, Access and Staging, Sheet G-5: The current temporary staging area of 2.1 acres is not adequate to stockpile materials during construction. Are there other options for increasing the temporary staging areas near the site?

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Available open space is limited from Sta 0+00 to 60+00 so need to add multiple smaller areas along the project. Added stockpile/temporary staging areas on each side of access road station 0+00 to 2+00 (approx 0.4 acres). Added approx 1 acre at 22+50 to 24+50 and 0.5 acre between 14+50 and 16+50. Some sorting will be required by antipicated construction sequence attempts to avoid excessive stockpiling by continuous placement (see constructibility memorandum). Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253264	Real Estate	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Civil

Real Estate, Access and Staging, Sheet G-5: Need to establish and show temporary construction easement crossing Ryan's Creek.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Added temporary construction easement for Ryan's Creek crossing Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253265	Real Estate	Plans	n/a'	n/a	n/a

Comment Classification: N/A

Coordinating Discipline(s): Civil

Real Estate, Access and Staging, Sheet G-5: Need to establish and show temporary construction easement along the entire length of the Kenai River. This will allow marine transportation of construction equipment and materials.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Added temporary construction easement as a 100-foot strip along outside of toe trench to allow for marine access. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253266	Environmental	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Civil

Erosion Control and Wetlands, G-6 and G-7: Do the recommend erosion control measures meet the current storm water pollution prevention plan (SWPPP) standards? Project limits or wetland limits are not provided on sheets G-6 and G-7.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Proposed erosion control measures are derived from ADOT and Corps standard drawings and generally meet highway dept standards for erosion control on roadway cuts. Detailed development of a storm water pollution prevention plan would be included as part of the plans and specs with contractor responsible for submission of their own plan subject to approval by relevant jurisdictional authorities. Special attention will be needed at Cemetery Creek and Ryan's Creek. Added notes to drawings calling out further requirements. We can check against additional applicable Corps-provided guidelines as needed. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253268	Civil	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Civil

Project Plan and Site Map, Sheet C-1 through C-7: Need to provide legible project stationing in plan view.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Adjusted font size and corrected pen table and plot driver to improve readability Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment.

	Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253269	Civil	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Project Plan and Site Map, Sheet C-1 through C-7: Need to provide all exploration test boring locations in plan view. See Geotechnical Reports for coordinate locations.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Added R&M boring/piezometer locations to plan views Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253271	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Cost Engineering Report Draft Submittal, June 2011, 16.01.02.01 Alluvial Deposits: How was the quantity of 500 BCY of unsuitable alluvial material determined? We anticipate the volume of unsuitable material excavated from the alluvial soil unit will be greater than the current estimate. For example test boring AP-608-MW shows 17.5 feet of silt and sandy silt (ML) below the ground surface before encountering the poorly graded sand. Other test borings drilled on top of the bluff show near surface silt and fine grained soils to depths of 2.5 feet. We recommend reevaluating the estimated volume of unsuitable alluvial material.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Bore logs have been reviewed and the previously estimated quantities for the unsuitable alluvial material have been updated/increased in the estimate as appropriate to account for the near surface/organic material. Additional sorting costs have also been added. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253273	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Cost Engineering Report Draft Submittal, June 2011, 16.01.02.01 Alluvial Deposits: How was the swell/shrinkage factor of 20% selected for the alluvial soil unit? We anticipate the loose poorly graded sand will not swell or shrink in volume by 20%. Provide justification for using a swell/shrinkage factor of 20% in the cost engineering report.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Factor was applied as an average from various soil types. Decreased to 10% to better account for granular material. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253274	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Cost Engineering Report Draft Submittal, June 2011, 16.01.02.02 Glacial Till: How was the swell/shrinkage factor of 20% selected for the glacial till soil unit? We anticipate the excavation of glacial till consisting of firm clay will swell in volume greater than 20%. Provide justification for using a swell/shrinkage factor of 20% in the cost engineering report.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Factor had been applied as an average from various soil types. Increased to 25% to account for presence of clays. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253276	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Cost Engineering Report Draft Submittal, June 2011, 16.01.02.02.03 Borrow Material: How was the unit weight of 120 PCF selected for imported material? Imported classified materials from the Kenai area meeting the "Filter Layer Gradation" requirements will most likely have an in-place compacted unit weight between 130 and 135 PCF. We recommend increasing the estimated unit weight of borrow material in the cost engineering report.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Increased the unity weight to 130 pcf for filter layer material. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253278	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Cost Engineering Report Draft Submittal, June 2011, Appendix E Productivity Index and Notes and Estimated Production Rates, Land Based Rock Placement Output Rate: Placement of the filter, B, and armor rock is assumed to be conducted by "Dragline Cranes on crawler w/ clamshell bucket". Recently we have seen the use of large hydraulic excavators for the placement of shore protection rock above and below water. We expect that same type of equipment used for this project. Recommend changing the cost estimate to reflect the anticipated equipment.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** The land-based rock placement crew has been changed to include the use of hydraulic excavators instead of the dragline cranes previously in the estimate Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253280	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Cost Engineering Report Draft Submittal, June 2011, Appendix G MCACES Construction Cost Estimate, Page 15, 16.01.02.01.01 and 16.01.02.02.01, Excavation of Alluvial Deposits and Glacial Till: The estimator has assumed the hauling of excavated material with 60 CY off highway haulers to a stockpile area onsite. We do not agree with this assumption. A 60 CY off highway hauler is equivalent to a Caterpillar 777. In our opinion this size of truck will not be used on the site given the relatively small volume of material that needs to be transported and the narrow and tight turning radiuses that are expected during construction. We anticipate 6-wheel drive articulated trucks such as the Volvo A40 or Caterpillar D400 or smaller to be used during construction. These trucks have a haul capacity of about 30 CY. Recommend revising the hauling production rates for the alluvial and glacial till materials.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** The hauling cost item under the excavation folders for the alluvial deposits and glacial till have been changed to use haulers that have a 30-CY capacity Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253281	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Cost Engineering Report Draft Submittal, June 2011, Appendix G MCACES Construction Cost Estimate, Page 15, 16.01.02.01.02 Backfill: The estimator has assumed a dozer and front-end loader will haul, place, and spread backfill material with an average haul distance of 300 feet. Given the location of the temporary staging area, we estimate the average haul distance will be greater than 300 feet. We also believe 6-wheel drive articulated trucks will be used to haul material to the point of placement. Provide justification for using a 300 foot haul distance and clarify the assumed method of transporting backfill material with a front end loader from temporary stockpiles to final placement.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** The crews and production rates for the backfill placement have been modified to have an increased travel distance between stockpile site and placement. Also the crews have been modified to include the equipment mentioned in the comment Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253282	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Cost Engineering Report Draft Submittal, June 2011, Appendix G MCACES Construction Cost Estimate, Page 15, 16.01.02.01.02 Backfill, Borrow Material Compaction: Generally 2 passes with a compactor will not achieve the required density of material used to construct a stable slope. Provide justification for the level of effort assumed in the cost estimate for compaction of backfill material.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** The estimate has been modified to assume 4 passes for compaction of borrow material Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253283	Civil	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Grading Cross Sections III, C-10, Construction Phasing, Phase I: Excavation of the upper alluvium soil, which accounts for approximately 169,133 loose cubic yards, is planned to be hauled and stockpiled onsite. Currently the 2.1 acre temporary staging area will not be adequate to stockpile this volume of material. Where does the designer anticipate the contractor stockpiling this material until construction phase 4 and 5 are started?

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Added temporary staging/stockpiling areas. We anticipate several continuous loops that would minimize the amount of stockpiling needed (see constructibility memorandum) Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253285	Civil	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Cost Engineering

Grading Cross Sections III, C-10, Construction Phasing, Phase I, Cost Engineering Report Draft Submittal, June 2011: Construction access to the beach to start Phase II and III will require the construction of a temporary road. A temporary road consisting of the sand and fine grained soils excavated in Phase I and II will not be adequate to support construction equipment. The construction phasing should display the need for a temporary road constructed with rock at the toe of the slope. The cost engineering report should account for this additional material requirement.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Temporary Road line item accounts for a roadway along the entire toe; however, we have increased the material quantity to reflect the nonuniform conditions. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 08 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253286	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Civil

Cost Engineering Report Draft Submittal, June 2011, Appendix G MCACES Construction Cost Estimate: A temporary construction crossing at Ryan Creek will most likely be required to efficiently construct the project. Has the cost estimate accounted for this effort?

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** The "Temporary Road" line item accounts for a haul road along the entire toe of the bluff; however, we have increased the average depth and volume of material previously listed for the roadway and added costs for construction of temporary diversion and drainage control associated with construction of temporary culverts for Ryan's Creek under the access road. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 08 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253287	Civil	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Typical Sections, C-11: The typical section has too many notes which make it difficult to understand. Remove the construction sequence notes and line hatching and provide a typical section that clearly shows construction material layer thickness, centerline stationing, and elevations.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Removed/reduced sequence-related notes and revised hatch patterns for clarity Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment.

	Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253288	Civil	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Typical Sections, C-11and C-12: The excavation and backfill material layers and definitions are not clearly defined. Provide standard construction terms and material requirements (ie gradation requirements, material classifications, PI requirements, stone weight limits, etc.) for each construction material layer (Filter Layer, Granular Material, Glacial Till Mix with Alluvium, Topsoil, Gravel Bedding, B Rock, and Armor Rock). Use standard earthwork excavation and backfill terms and define the construction material requirements using standard terms from UFGS specifications.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Added table of definitions and inclusion criteria for each material type to report and reworded layer names/types. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253291	Civil	Plans	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Typical Sections, C-11: Placement and constructability of the 1 foot topsoil layer at a 1.5H to 1V slope is a concern. What are the topsoil gradation and material requirements? Has the design evaluated the slope stability of this topsoil layer during and after construction from a geotechnical and maintenance standpoint? Has the designer considered using a thinner layer of topsoil?

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Check and Resolve** 1-foot layer was minimum recommended by Alaska Plant Materials staff. We have reviewed the fabric, pinning, and vegetation establishment criteria with geotechnical engineer and anticipate the 1-foot topsoil layer being stable on the 1.5:1 slope due to fabric/pinning during the establishment period. Localized rilling and gullying may be risks on a smaller scale; however, drainage control measures are proposed to prevent overland drainage from the upper slopes, with only direct rainfall on the topsoil itself. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4253298	Cost Engineering	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A
Coordinating Discipline(s): Geotechnical

Cost Engineering Report Draft Submittal, June 2011, 16.01.03.01 Land Base Placement: How was the over place / loss factor of 20%, 15%, and 10% for filter, B, and Armor rock selected? We would anticipate some lose during the filter rock placement, however, after that layer is placed assuming a loss of 15% for B rock and 10% for armor rock seems high. Provide justification for using the current over place / loss factors.

Submitted By: John Rajek (907-753-5695). Submitted On: Oct 28 2011

1-0	Evaluation **Concurred** Selected based on conservative estimate. Tight controls during construction should allow a reduction of factors. The over place/loss factors for the B rock and armor rock have been lowered to 5% for both. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: John Rajek (907-753-5695) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4255908	Civil	Plans	n/a'	n/a	G-4

Comment Classification: N/A

Clean up sheet presentation e.g. Curve stationing is too small to read. Increase font size. Photo control survey notes seem to overrun each other. Look at notes and correct overlapping. Numbering font should not be shaded. Monument legend should not be in bold.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Adjusted font size and corrected pen table and plot driver to improve readability. Fixed text justification issue and font formatting Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4255920	Civil	Plans	n/a'	n/a	G-5 and cost estimate

Comment Classification: N/A

Is the cost for purchasing properties for the permanent easement included in the cost estimate?

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Placeholder costs of $100,000 per acre for 30 acres have been assumed in lieu of assessor's report as previously directed. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4255978	Civil	Plans	n/a'	n/a	G-6

Comment Classification: N/A

Add BDY to the list of abbreviations

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Added BDY BOUNDARY to abbreviations Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4255982	Civil	Plans	n/a'	n/a	C-1

Comment Classification: N/A

Fix line type for Security fencing to be consistent with line type shown in Legend

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Fixed line types for consistency and changed to "wood fence" rather than chain link. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4255990	Civil	Plans	n/a'	n/a	C-1

Comment Classification: N/A

There is a bold line on the slope at the start of the project that appears to be a cut and fill line. Clarify what this line is or remove it, if it is nothing.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** labeled cut/fill interface Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4255992	Civil	Plans	n/a'	n/a	C-1

Comment Classification: N/A

Use an unfilled triangle on the top slope line to indicate a cut section.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Changes symbol to unfilled triangle Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4255999	Civil	Plans	n/a'	n/a	C-1

Comment Classification: N/A

Does the swale start at the gate by Mission Road, or does it connect to a culvert? If the swale starts there add note to indicate it starts there, if it connects to a culvert note that.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Added start/stop stationing to notes Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256002	Civil	Plans	n/a'	n/a	C-1

Comment Classification: N/A

There is a callout for EP. Clarify what that is and add it to the list of abbreviations

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Added EP EDGE OF PAVEMENT to abbreviations list Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256009	Civil	Plans	n/a'	n/a	C-1

Comment Classification: N/A

Profile. Arrow to top of bluff does not go to a bluff. Check the arrow positioning, or clarify the callout.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Extended top of bluff line to Sta 8+00

	Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256015	Civil	Plans	n/a'	General	n/a

Comment Classification: N/A

Include PROP REG in the list of abbreviations

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Added PROP PROPOSED and REG REGULATORY to abbreviations list Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256019	Civil	Plans	n/a'	C-2	n/a

Comment Classification: N/A

Correct spelling of Concrete from concretee.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Corrected note Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256024	Civil	Plans	n/a'	C-2	n/a

Comment Classification: N/A

Clarify whether the CMP is existing or new in the call out "Constr CMP culv connect to exist storm drain network". Line type looks like it is existing, but the note sounds like it is new work.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** New feature. Changed line type/thickness to represent new feature. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment.

	Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256027	Civil	Plans	n/a'	C-2	n/a

Comment Classification: N/A

Extend line to building or pad to be demolished

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** line extended Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256061	Civil	Plans	n/a'	C-2	n/a

Comment Classification: N/A

Provide cross section of stormwater settling basin.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Added cross section Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256094	Civil	Plans	n/a'	G-6 and G-7	n/a

Comment Classification: N/A

Remove note on straw bales and silt fences. This is a detail that the contractor will need to include as part of his SWPP and the call out implies that some sort of coordination has taken place. Suggest the callout to be more general indicating that sediment management needs to be an intergral part of the construction and will need an estableished SWPP for work.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Replaced note with suggested callout Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012

	Current Comment Status: **Comment Closed**

4256100	Civil	Plans	n/a'	C-3	n/a

Comment Classification: N/A

There are grey diagonal lines across the slope face. Indicate what these lines are, or remove them if they serve no purpose.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** They are parcel/easement boundaries. Added labels for clarification Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256123	Civil	Plans	n/a'	C-4	n/a

Comment Classification: N/A

Am unclear as to what is occurring at the settling basin. Please clarify. How is the basin being regraded? What is the future primary outlet connection to city storm drain network? Does it effect this work?

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Added typical connection detail and additional grading contours. Connection to the storm drain system would need to be coordinated with City plans for future upgrades, potentially requiring some improvements to their system. Added notes regarding work to be undertaken by others. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Jan 13 2012
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256128	Civil	Plans	n/a'	C-5	n/a

Comment Classification: N/A

Move the 12' dimension from its current location. At its current location the 12' looks to be at the top of the bluff and not between the berm and swale.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Moved dimension and text Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256135	Civil	Plans	n/a'	C-5	n/a

Comment Classification: N/A

Check stationing at the end and start of the project across Ryan's Creek. Stationing is the same.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **For Information Only** Work ends at Station 38+25 on the west side of Ryan's Creek and begins at Station 50+00 on the east side. A gap was left in between to avoid any overlap and account for the access road. The access road gate is located at approximately Station 41+40. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 08 2011
1-1	Backcheck Recommendation **Open Comment** Water bar stationing on the east side of Ryan's creek needs to match stationing shown Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
1-2	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Feb 04 2013
2-0	Evaluation **Concurred** Changed callout to Sta 50+00 to 52+54 to match east side stationing. Revised pdf attached. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 19 2012 (Attachment: Kenai_C-5_C-5_(2).pdf)
	Backcheck not conducted
	Current Comment Status: **Comment Closed**

4256137	Civil	Plans	n/a'	C-6	n/a

Comment Classification: N/A

On the bottom right side of the plan view there is duplicated lines and an angled line that cuts across the contours. Clean up the line work.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Angled line is easement line. Duplicated line is water level running near a contour. Added callouts for clarification Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256139	Civil	Plans	n/a'	C-6	n/a

Comment Classification: N/A

Add an arrow noting the location of the earthen bern called out in the plan view.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Arrow added Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256142	Civil	Plans	n/a'	C-7	n/a

Comment Classification: N/A

Correct spelling of Ditch. Also clarify the routing of the swale ditch to the inlet

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Corrected spelling and adjusted contouring around inlet for drainage Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256143	Civil	Plans	n/a'	C-7	n/a

Comment Classification: N/A

Provide cross section and clarify plan view of 2' of B rock by Pacific Seastar Foods. Looks like rock work stops abruptly. Also are there any real estate issues with putting rock on this side?

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Project already encroaches on their parcel and real estate negotiations would be required. Intention of B rock is to protect against further erosion along the existing sheet pile bulkhead, particularly as the erosion might be exacerbated by energy reflection from the constructed revetment and bank slope that will protrude further from the bluff than the existing toe. Some argument for dissipation due to large rock vs existing hardened till slope - placement of rock is precautionary. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256151	Civil	Plans	n/a'	General - cross sections	n/a

Comment Classification: N/A

Provide cross sections of the project beginning and ending where there is no revetment only the dressing of the upper slope

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Sections added Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 08 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256155	Civil	Plans	n/a'	C-11	n/a

Comment Classification: N/A

Where is the filter layer being placed? May want to call out the location in the filter layer gradation title so it is easier to find it in the cross section.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Moved table and added arrow to filter layer (within 10' of surface) Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256160	Civil	Plans	n/a'	C-11	n/a

Comment Classification: N/A

What is the thickness of the fill at the bottom of the slope (the imported material or glacial till mixed with alluvium as necessary)

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** The thickness varies as the existing ground rises and falls along the project. The layer can extend upwards to an elevation that is at least 10' below the top of the revetment Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Open Comment** Need to identify the different material type at the base of the bluff - previously identified as glacial till, mixed with alluvium. That is the thickness in question. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
2-0	Evaluation **Concurred** Added callout for clay/sand backfill mix to match categories requested by John Rajek Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 19 2012 (Attachment: Kenai_C-11_rev_C-11_(2).pdf)
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Feb 04 2013

	Current Comment Status: **Comment Closed**

4256162	Civil	Plans	n/a'	C-11	n/a

Comment Classification: N/A

Clarify the intent of the 10' Min dimension behind the revetment.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** The 10' min dimension refers to the thickness of the filter layer (measured vertically in this location but measured perpendicular to the slope above the revetment) Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Open Comment** Clarify what is meant by ACC in the armor note Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
2-0	Evaluation **Concurred** spelled out "according to" for clarity and to avoid confusion with Asphalt Cement Concrete (not used in this project) Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 19 2012 (Attachment: Kenai_C-11_rev_C-11_(2)1.pdf)
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4256163	Civil	Plans	n/a'	C-11	n/a

Comment Classification: N/A

Check the stationing on the cross section title

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Corrected stationing to reflect newly adjusted transition zones Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256164	Civil	Plans	n/a'	C-11	n/a

Comment Classification: N/A

describe how far up and down the slope the geogrid is placed.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Geogrids are included on the 1.5:1 slope only. Added note to clarify

	Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256166	Civil	Plans	n/a'	C-11	n/a

Comment Classification: N/A

Remove note in parenthesis indicating that safety railing and surface treatment for birding trial by others.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Note removed Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4256189	Civil	Plans	n/a'	C-11	n/a

Comment Classification: N/A

I thought the upper slope was left undisturbed, but upper slope surface treatment detail indicates that it is being compacted. Clarify.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** It is generally undisturbed and requires only scarifying for placement of topsoil, but there are locations where it is in fill rather than cut. Fill sections would require compaction. Added note to clarify Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Open Comment** Shouldn't the detail call out circle the 2H:1V slope behind the bench? Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
2-0	Evaluation **Concurred** Moved detail callout from existing slope to the proposed slope. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 19 2012 (Attachment: Kenai_C-11_rev_C-11_(2)2.pdf)
2-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Feb 04 2013
	Current Comment Status: **Comment Closed**

4256195	Civil	Plans	n/a'	C-12	n/a

Comment Classification: N/A

Provide top of revetment elevation for each typical section

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Elevations added Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256196	Civil	Plans	n/a'	C-12	n/a

Comment Classification: N/A

Remove "Per SPM" in note.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Text removed Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256197	Civil	Plans	n/a'	C-12	n/a

Comment Classification: N/A

Check stationing. There does not appear to be a station 45+00

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Revetment ends at Sta 37+00 and begins at 51+35. Corrected titles. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256199	Civil	Plans	n/a'	C-12	n/a

Comment Classification: N/A

Check and see if call out indicating that excess till material would be toe nourishment is permissible or would it be dependent on the permits obtained?

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011					
1-0	Evaluation **For Information Only** Toe nourishment concept was presented to regulatory and others and appears to be acceptable, however subject to permit requirements. Using excess till to create smooth, consistent backfill slopes would be much preferable to an undulating surface that would cause additional scour and erosion problems. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 08 2011				
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012				
	Current Comment Status: **Comment Closed**				
4256200	Civil	Plans	n/a'	C-13	n/a
Comment Classification: N/A Provide slope arrow on Schematic Drain Pipe Profile Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011					
1-0	Evaluation **Concurred** Slope arrows added Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011				
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012				
	Current Comment Status: **Comment Closed**				
4256201	Civil	Plans	n/a'	C-13	n/a
Comment Classification: N/A On Riprap V Ditch detail there is a gap between the geotextile and the rip rap. Note if that is bedding material and its thickness Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011					
1-0	Evaluation **Concurred** A bedding layer of 3"-6" should be used to prevent tearing the fabric during placement. Added notes. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011				
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012				
	Current Comment Status: **Comment Closed**				
4256202	Civil	Plans	n/a'	C-13	n/a
Comment Classification: N/A On trench detail complete call out that notes "For Restoration See...."					

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Changed to "For restoration see planting plans L-1, L-2, and L-3" Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256203	Civil	Plans	n/a'	C-13	n/a

Comment Classification: N/A

Clarify hidden lines in V Ditch shown in Flared End Section Detail

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** The hidden lines represent a foundation and base for the flared end section apron. Removed for clarity. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256205	Civil	Plans	n/a'	C-13	n/a

Comment Classification: N/A

Riprap V Ditch - Would you really compact the riprap with a vibratory compactor?

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** The compactor would be used to make sure the smaller material fills the voids and settles into place, not necessarily to compact the rip rap itself. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256206	Civil	Plans	n/a'	C-13	n/a

Comment Classification: N/A

Flashboard riser - Note bar spacing for trash rack.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Estimated spacing at 6". Added note Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256207	Civil	Plans	n/a'	C-13	n/a

Comment Classification: N/A

Are wood plank stop logs to be treated wood?

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Yes. Should be treated wood or alternative materials that might also also include fiberglass, plastic, etc. Added callout for treated wood for initial estimates. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256211	Civil	Plans	n/a'	C-13	n/a

Comment Classification: N/A

Flashboard riser plan - provide details on welds. One weld indicator is missing size. Other weld indicator is missing units. Are these intended to be field welds? If they are filed welds, it looks like there could be a conflict with the all around weld and the concrete block.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Check and Resolve** Suggest removing weld details to avoid potential conflicts and unwarranted detail. These are based on standard drawings and we would likely want to allow the contractor to propose an alternative product. Suggest adding note "Contractor shall submit shop drawings of riser subject to COR representative's approval." Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 08 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256213	Civil	Plans	n/a'	C-13	n/a

Comment Classification: N/A

Flashboard riser plan - Looks like there is a size conflict on the 2nd detail. On the left it looks like the CMP is at least 48 inches and on the right it is called out as 42 inches. Also, it appears that the CMP extends down into the concrete. Is that correct?

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **For Information Only** The 42" and 48" dimensions refer to different directions. The riser is a 42" diameter pipe that is sliced and stood up on end. The height of the riser (length of pipe) once it is up on end is 48". CMP does extend into the concrete. The intention is for the concrete to be cast around the embedded part of the riser. Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 08 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256214	Civil	Plans	n/a'	C-14	n/a

Comment Classification: N/A

The legend indicates that the fence is chain link. Coordinate the the legend and the detail.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Changed legend to "wood fence" Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256215	Civil	Plans	n/a'	C-14	n/a

Comment Classification: N/A

Include the SWPP measures and the Boardwalk information in the Design Analysis Report, so as not to imply permit coordination or complete boardwalk design.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Typical details and description added to detailed design report Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 08 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

4256217	Civil	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A

Page 2 paragraph 5. C. 2) Plans indicate that the geogrid is to be placed on every other lift not every lift. Clarify.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Added clarification Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 12 2012
	Current Comment Status: **Comment Closed**

4256219	Civil	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A

Page 3 bullet 4) There isno birding trail or interpretive signage that is part of this design

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Removed reference Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 12 2012
	Current Comment Status: **Comment Closed**

4256221	Civil	Cost Estimate	n/a'	n/a	n/a

Comment Classification: N/A

page 3. Paragraph D. Note that ice can also be encountered on the river.

Submitted By: Deirdre Ginter (907-753-2805). Submitted On: Oct 31 2011

1-0	Evaluation **Concurred** Note added Submitted By: Krey Price (+610-434-087-251 (Australia)) Submitted On: Dec 05 2011
1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Deirdre Ginter (907-753-2805) Submitted On: Sep 04 2012
	Current Comment Status: **Comment Closed**

KENAI BLUFF STABILIZATION
STATEMENT OF QUALITY CONTROL

Tetra Tech Inc., Surface Water Group has completed the Draft Design Report for the Kenai Bluff Stabilization Project in Kenai, Alaska. Notice is hereby given that all quality control activities appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan, have been completed. Compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy. Documentation of the quality control process is attached.

March 27, 2009
Krey Price, Technical Development Team Leader

March 27, 2009
Ike Pace, Independent Technical Review Team, Costs

Bob Hall
March 27, 2009
Bob Hall, Independent Technical Review Team, Civil

March 27, 2009
Harry Gibbons, Independent Technical Review Team, Environmental

March 27, 2009
Ridge Robinson, Independent Technical Review Team, Planning

CERTIFICATION OF QUALITY CONTROL

Significant concerns and the explanation of their resolution are included in the attached documentation. As noted above, all concerns resulting from the independent technical review of the project have been considered.

March 27, 2009
Quality Assurance Manager
Tetra Tech Inc., Surface Water Group

Technical Review Comments		Project: Kenai Bluff Stabilization	Location: Kenai, Alaska	
Date: 3/17/2009		Reviewer: Ridge Robinson / Tel: (206) 728-9655		Back Check By: (initials)
Office Seattle		**Type of Document** Design Report / **Discipline** Planning		

Item No.	Page/Sheet	COMMENTS	Action Taken:	By:
1	General	Text in some locations indicates future analysis to support design refinements. Is District planning on doing any additional analysis to refine design? If so please note what types of analyses and refinements are planned upfront where appropriate.	Wind/wave analysis is expected to be initiated by the District, stormwater modeling by the City. Details/discussion added	RR
2	2	Add a statement regarding future expected erosion extent and types of damages	Statement added	RR
3	19	Do ice conditions have any effect on the erosion and if so were they factored into modeling and design criteria?	Shore ice doesn't appear to affect bluff recession significantly relative to freeze-thaw action on the bluff face, which does contribute significantly. Discussion added.	RR
4	23	Should we add a statement of relation between the referenced flow rates	Discussion added	RR
5	27	Can statement be added that notes general economic activity at top of bluff relative to rest of community? Is there any public utility infrastructure that other parts of community depend on?	Birdwatching is a common use at the top of the bluff. Public infrastructure includes public parks along the top of the bluff. Discussion added.	RR
6	27	Can statement be added noting types of commercial facilities.	Commercial facilities include fish processing and boat storage. Description added.	RR
7	29	Text references economic analysis of project benefits. Were benefits analyzed in this study? Please edit as appropriate.	Benefits were analyzed qualitatively only. Statements edited.	RR
8	30	Can we add a statement of tsunami risk to proposed structure/project?	Coordination with jurisdictional authorities required. Statement added.	RR
9	33	Should we note the risk (implications) to proposed project of thalweg shift	Thalweg shift would require additional rock placement. Hydrographic surveying to monitor thalweg shift is included in operation and maintenance activities. Reference added.	RR
10	35	Can statement be added about without project expected retreat extent?	Statement added.	RR
11	38	Should we note potential risk of rainfall events during vegetation establishment to project?	Maintenance costs assume replacement of some vegetation. Text added.	RR
12	43	Please clarify to relate discussion in 4.1-4.3. Explain "varying by zone".	Clarification/explanation added.	RR
13	43	Add table of combinations or add reference to previous report for more information	Reference to Alternatives Report added	RR
14	46	I thought I saw previously in report that public access would not be allowed (fencing). Please confirm statement.	Corps project will prevent access. Local agencies may add recreational access. Statement edited.	RR

Technical Review Comments		Project: Kenai Bluff Stabilization	Location: Kenai, Alaska	
Date: 3/17/2009		Reviewer: Ridge Robinson / Tel: (206) 728-9655		Back Check By: (initials)
Office Seattle		**Type of Document** Design Report / **Discipline** Planning		
Item No.	Page/Sheet	**COMMENTS**	Action Taken:	By:
15	46	Reference consistency with shore protection manual	Reference added.	RR
16	49	Are proposed plantings compatible with project performance (would they impact or destabilize the erosion control methods) and can the proposed plantings establish necessary roots for viability through proposed erosion control methods?	Geogrid is flexible fabric with openings large enough to allow root establishment. Contacted vendor to confirm that vegetation stabilizes rather than destabilizes slopes with the specified geogrid.	RR
17	52	Is there risk of losing project during large event prior to vegetation establishment?	Risk is localized for rilling/gullying rather than general slope stability. Discussion added.	RR
18	54	Is irrigation included in O&M costs?	O&M costs include higher vegetation maintenance costs during establishment period, accounting for irrigation and/or replacement of individual plants. Text added.	RR
19	63	Does cost estimate have a contingency for hazardous materials?	Cost estimate has high contingency (25%) to account for unforeseen conditions. Added note that cost estimate needs to be revisited following HTRW investigations	RR
20	63	Do we need to note that identification of HTRW in proposed project area would have implications on cost not currently accounted for?	Noted	RR
21	64	Documentation of existing delineation or additional wetlands delineations?	Wetlands have not been delineated. Reworded statement	RR
22	66	Note # of structures to be removed for construction under project conditions and number of structures that would be saved from continued erosion under without project conditions.	# of structures added	RR
23	68	Should add note that any proposed recreational features should be evaluated for compatibility with proposed project purposes and any potential impacts to project performance and life.	Note added	RR
24	General	See editorial changes made via track changes in electronic ITR document	Editorial changes made as suggested	RR

Technical Review Comments		Project: Kenai Bluff Stabilization		Location: Kenai, Alaska	
Date: 10 March 2009		Reviewer: IKE PACE	Tel: 949-250-6788	Irvine, CA	Back Check By: (initials)
Office		Type of Document Cost Engineering Report	Discipline Cost Engineering		

Item No.	Page/Sheet	COMMENTS	Action Taken:	By:
GENERAL				
1	1	Report – Use consistent terminology within the report (i.e. filter rock vs. core rock)	Consistent terminology used.	IGP
2	2	Report – Section 5.b refers to price quotes and plant locations as being listed in Appendix B, however they are not in Appendix B.	Price quotes inserted into Appendix F.	IGP
3	4	Report – Section 8.a states there are no costs for lands and damages, however there is a $3 million cost in the estimate.	Real Estate costs added.	IGP
4		Appendix B – quantities are hard to follow. What is the numbering system next to the item and how does it relate to the MCACES WBS? Suggest reorganizing quantities and listing the WBS next to the item as it is in the MCACES.	Quantities reorganized to align with MCACES WBS.	IGP
5		Appendix C – it will take much longer than 19 days to mobilize. Verify the construction schedule is consistent with the productivity calculated in the MCACES.	Mob has been revised to a more appropriate duration.	IGP
6		MCACES – cost estimate is missing the productivity index and overtime markups that are discussed in the report.	Productivity index and overtime markups added.	IGP
7		MCACES – prime contractor is shown to be from North Carolina, change to Alaska	Changed.	IGP
8		MCACES – sub contractor is shown to do concrete work, change to landscaping	Changed.	IGP
9		MCACES – the job office overhead of 4.54% is way too low. This should be much higher especially since mob/demob is included. Review assumptions.	JOOH calculation revised.	IGP
10		MCACES – the weighted profit seems low. Review assumptions.	Changed.	IGP
11		MCACES – there are no markups under the landscape sub contractor.	Markups added.	IGP
12		MCACES – mob/demob under the job office overhead calculation does not reflect mobilizing the overwater crews and equipment. These costs should be much higher. Review assumptions. Consider adding overwater insurance markup.	Cost of mob/demob was updated to reflect overwater crews and equipment. Overwater insurance also added.	IGP
13		MCACES – provide clarifying notes within the MCACES to inform where costs, quotes, quantities…..etc. are coming from as appropriate.	Clarifying notes added where appropriate.	IGP
14		MCACES – folder levels above the detail should display the appropriate unit cost for that item.	Appropriate unit cost added to the folder levels above the detail.	IGP
SPECIFIC				
1		MCACES – 01 Lands and Damages; provide clarifying notes within the MCACES	Notes added.	IGP
2		MCACES – 02 Relocations; add folders to separate each type of relocation, and show the cost items in order to match the quantity take-offs.	Folders added and quantities reorganized to align with MCACES WBS.	IGP
3		MCACES – 02 Relocations; what about disposal fees?	Dumping fees added.	IGP
4		MCACES – 14 Recreation Facilities; add folders to separate each type of facility, and show the cost items in order to match the quantity take-offs.	Folders added and quantities reorganized to align with MCACES WBS.	IGP

Technical Review Comments		Project: Kenai Bluff Stabilization		Location: Kenai, Alaska	
Date: 10 March 2009		Reviewer: IKE PACE	Tel: 949-250-6788	Irvine, CA	Back Check By: (initials)
Office		Type of Document Cost Engineering Report	Discipline Cost Engineering		
Item No.	Page/Sheet	COMMENTS		Action Taken:	By:
5		MCACES – 16 Bank Stabilization – 01 01 Site Preparation; how are costs for grading the path captured? What about disposal fees? May need to revisit the dewatering assumptions. Add folders to separate each type of construction, and show the cost items in order to match the quantity take-offs.		Costs for grading are captured under the rough grading item located under the 01 02 folder. Folders added and quantities reorganized to align with MCACES WBS.	IGP
6		MCACES – 16 Bank Stabilization – 01 02 Earthwork; What about disposal fees? Add folders to separate each type of construction, and show the cost items in order to match the quantity take-offs.		Folders added and quantities reorganized to align with MCACES WBS. Dumping fees added.	IGP
7		MCACES – 16 Bank Stabilization – 01 03 02 Armor (water based placement); Rename to be consistent with report. The water based placement shows 7-CY buckets, however the production rates in the report show 5-CY bucket, revise as appropriate. Why is the cost of the rock the same for armor, b-, and filter rock? They should be different. How are the costs for getting the rock loaded on the barge accounted for?		Renamed. Rock placement items revised. Multiple quotes were obtained from several different quarries. The quarry chosen to provide materials for this project gave a single quote for the three rock types. Costs for loading the rock from land onto a barge were added.	IGP
8		MCACES – 16 Bank Stabilization – 01 03 01 Armor (land based placement); Rename to be consistent with report. Why is there only one production rate for the different types of rock? Why is the cost of the rock the same for armor, b-, and filter rock? They should be different. Where did the costs for getting the rock hauled in come from? Move the filter fabric out of this folder as it applies to both types of placement.		Core rock changed to filter rock. Armor (land based placement); Renamed to be consistent with report. More production rates added for the different types of rock. Multiple quotes were obtained from several different quarries. The quarry chosen to provide materials for this project gave a single quote for the three rock types. The costs for getting the rock hauled in came from Girdwood. Filter fabric moved out of this folder.	IGP
9		MCACES – 16 Bank Stabilization – 01 04 Vegetation; Where did the quantity of trees come from? Provide calculations in Appendix B. Add folders to separate each type of construction, and show the cost items in order to match the quantity take-offs.		Tree quantities provided by designer. Quantities added to overall quantity summary.	IGP
10		MCACES – 30 PED; provide clarifying notes within the MCACES		Clarifying notes added.	IGP
11		MCACES – 31 CM; provide clarifying notes within the MCACES		Clarifying notes added.	IGP

Technical Review Comments		Project: Kenai Bluff Stabilization		Location: Kenai, Alaska	
Date: March 17, 2009		Reviewer: Bob Hall	Tel: (213) 327-0800		Back Check By: (initials)
Office Los Angeles		**Type of Document** Design Report	**Discipline** Civil/Geotech		
Item No.	Page/Sheet	COMMENTS		Action Taken:	By:
GENERAL					
1	General	The interface between the alluvium and the glacial till has a significant volume of water exiting the slope. Without providing a means to control the outflow from the slope, I would think that the water would erode the bottom surface of the alluvium and eventually undermine it, causing additional collapses in the future.		Discharge from the interface is captured under a filter layer of granular material. The gradation of the filter material and the filter fabric are designed to prevent piping. Benching/scarifying along the exposed overexcavated slope face prevents flow along the interface. Added discussion of additional testing recommendations and tighter gradation standards to Section 5.1, Appendix C, and Typical Section Plate C-11 in Attachment I.	BH
2	General	The established equilibrium slope of 1 on 1.5 for the alluvium seems steep compared with other dam, levee, and natural stream slopes I have designed.		The 1:1.5 slope is the maximum allowable side slope based on the geotechnical investigations report. The draft design slope for the alluvium is cut back to a milder slope of 2:1. A 1.5:1 slope is proposed for the till layer and the filter layer. Geogrid is included in the filter layer to provide additional slope stability, particularly during construction. Further discussion added to Section 5.3 and notes on Typical Section Plate C-11 in Attachment I.	BH

Technical Review Comments		Project: Kenai Bluff Stabilization		Location: Kenai, Alaska	
Date: March 17, 2009		Reviewer: Harry Gibbons	Tel: (206) 728-9655		Back Check By: (initials)
Office Seattle		**Type of Document** Design Report	**Discipline** Environmental		
Item No.	Page/Sheet	COMMENTS		Action Taken:	By:
GENERAL					
1	General	The existing environmental conditions and proposed environmental impacts lack sufficient detail for a typical design report.		Baseline environmental data are cited from the Corps 2006 environmental appendix. Any additional required environmental work would be determined/scoped following a decision of EA vs. EIS. Report sections are intended to be placeholders for tabulation of existing available data and insertion of future data.	HG

Technical Development Comments	Project: Kenai Bluff Stabilization		Location: Kenai, Alaska	
Date: March 17, 2009				Team Member: David Broadfoot, John Oliver, David Bohman, Rick Waddell, Yen-Hsu Chen
Office Various	**Type of Document** Design Report	**Discipline** Various		

Item No.	Page/Sheet	COMMENTS	Action Taken:	Comment By:
GENERAL				
1	General	The existing environmental conditions and proposed environmental impacts lack sufficient detail for a typical design report.	Baseline environmental data are cited from the Corps 2006 environmental appendix. Any additional required environmental work would be determined/scoped following a decision of EA vs. EIS. Report sections are intended to be placeholders for tabulation of existing available data and insertion of future data.	DB
2	2.11	The report says water quality data are being collected in the project area but we don't report what they are. Can we add a table or draw some conclusions as to the existing water quality.	Compilation as well as analysis of environmental data documenting the existing condition may be included in future project phases.	DB
3	2.12	Aquatic Habitat and Wetlands section also describes riparian and upland habitat. Suggest renaming the section	Section renamed.	DB
4	2.13	List invertebrate species	Species listed	DB
5	3.14	Environmental constraints listed are actually design criteria	Added project construction windows and other constraints	DB
6	G-4	Add stationing, N/E, Delta Tangent to survey control table	Details added to table	YHC
7	G-5	Temporary crossing over Ryan's Creek may require conditions/limitations by environmental agencies	Notes added	YHC
8	C-1 to C-7	Make each construction note unique and identical on all sheets. All constructed items need to be listed/associated with a construction note number.	Notes revised	YHC
9	C-1 to C-7	How does the swale drain? The flow line of the swale is controlled by the FG.	Flow line added	YHC
10	C-11	Add swale and berm details	Details added	YHC

Technical Development Comments		Project: Kenai Bluff Stabilization		Location: Kenai, Alaska	
Date: March 17, 2009					Team Member: David Broadfoot, John Oliver, David Bohman, Rick Waddell, Yen-Hsu Chen
Office Various		**Type of Document** Design Report	**Discipline** Various		
Item No.	Page/Sheet	COMMENTS		Action Taken:	Comment By:
11	C-11	Will this slope be stable? Is piping a concern?		The 1:1.5 slope is the maximum allowable side slope based on the geotechnical investigations report. The draft design slope for the alluvium is cut back to a milder slope of 2:1. A 1.5:1 slope is proposed for the till layer and the filter layer. Geogrid is included in the filter layer to provide additional slope stability, particularly during construction. The gradation of the filter material and the filter fabric are designed to prevent piping. Benching/scarifying along the exposed overexcavated slope face prevents flow along the interface. Added notes to Typical Section Plate C-11 in Attachment I.	YHC
12	C-13	Add rip rap gradation. Check hydraulics.		Gradation added. Hydraulic calculations added to Attachment E.	YHC
13	Plans	Markup changes as noted in ITR plan set		CAD changes made as suggested	YHC
14	C-1 to C-7	Infiltration basins at the top of the bluff are too close to the edge. May surcharge groundwater and cause soil piping.		Lining added to basins and swale ditches to prevent infiltration while allowing pollutant settling and filtration	JO
15	Attachment E	Hydraulic conductivity of the reworked and compacted alluvial material as the filter layer is uncertain		Physical testing recommendations added	DB/RW
16	Attachment E	The percentage of fines in the existing alluvial material may cause clogging, and the damming effect would lead to an increase in pore pressure in the bluff		Screening/sieving/sorting requirements added to specifications to remove fines from the deepest portion of the filter layer	DB/RW
17	Attachment E	The recommended grain size distribution in Table E-4 presents too large of a range, which could cause damming with a high percentage of fines or piping with a high percentage of coarse material		Sorting requirements added to provide layering of soils within the filter layer. Gravels would be precluded from use in the lowest layer.	DB/RW

Technical Review Comments		Project: Kenai Bluff Stabilization	Location: Kenai, Alaska	
Date: June 15, 2011		Reviewer: Yen-Hsu Chen / Tel: (949) 809-5000		Back Check By: (initials)
Office Irvine - CA		Type of Document: Plans & Report / Discipline: Civil/Geotech		
Item No.	Page/Sheet	COMMENTS	Action Taken:	By:
GENERAL				
1	Sht 1	The graph in the lower right corner is not legible	Increased image resolution	YHC
2	Sht 3	Abbreviation – Revise “Elev” to “EL.” and add “GB – Grade Break”	Changed as recommended	YHC
3	Sht 4	Most of sheet is not legible due to font and line weight.	Changed text size and weight to improve legibility	YHC
4	Sht 5	The parcel numbers are not legible. The left vertical line in the table is missing.	Changed text size and added table border line	YHC
5	Sht 6	The downstream closure is missing	Closed shape	YHC
6	Sht 7	The downstream closure of the upstream embankment is missing. The “Grading Limit” is pointed to the wrong location.	Closed shape and corrected leader line	YHC
7	Sht 8	Plan – It appears “Prop Reg High Tide” and “Prop Reg High Water” are reversed? Applicable to all sheets.	Changed as recommended	YHC
8	Sht 8	Plan – Rev Note 1 as “Construct Swale Ditch Per Det 1/C-11” Applicable to all sheets.	Changed as recommended	YHC
9	Sht 8	Plan – Rev Note 2 as “Construct Earthen Berm Per Det 1/C-11”. Applicable to all sheets.	Changed as recommended	YHC
10	Sht 8	Profile – Show STA/EL at downstream end of improvement	Changed as recommended	YHC
11	Sht 8	Profile – How to drain LP at Sta 3+00?	Additional culvert installation	YHC
12	Sht 8	Profile – Indicate “GB” at Sta 4+18.	Changed as recommended	YHC
13	Sht 8	Profile – Rev “ELEV=65’” to “EL. 65’”. Applicable to all sheets.	Changed as recommended	YHC
14	Sht 8	Profile – Provide STA/EL at all GB of the excavation and toe of armored rock.	Toe excavation will be to minimum depths below existing ground, with elevations to be confirmed by preconstruction survey.	YHC
15	Sht 9	Plan – Indicator of ‘gate’ and ‘CMP Connection’ appears to be wrong.	Changed as recommended	YHC
16	Sht 9	Plan – Show security fence along edge of swale.	Changed as recommended	YHC
17	Sht 9	Plan - Add construction note for ‘Security Fence’. Applicable to all sheets.	Changed as recommended	YHC
18	Sht 9	Profile – Correct water surface indicator of ‘Design Wave + Runup + Surge’. Applicable to all sheet.	Corrected to match design report	YHC
19	Sht 10	Plan – Zone A to Zone B shown is wrong. How is the transition taking place? Need to show dimensional changes.	Corrected stationing for the transition	YHC
20	Sht 10	Plan - Indicator of ‘Security Fence’ pointed to wrong location.	Changed as recommended	YHC
21	Sht 11	Plan – Rev ‘Rip Rap’ to “Riprap’	Changed as recommended	YHC
22	Sht 12	Plan – Indicate the end of improvement	Changed as recommended	YHC
23	Sht 12	Profile – Add ‘GB’ at Sta 34+75	Changed as recommended	YHC
24	Sht 12	Profile – Rev dashed lines to solid lines.	Changed as recommended	YHC
25	Sht 13	Plan – Portions of topo and proposed works are missing on the left side.	Changed as recommended	YHC
26	Sht 14	Plan – Missing lines for the Prop Reg High Tide and High Water.	Changed as recommended	YHC
27	Sht 14	Plan – Rev ‘Rip Rap’ to ‘Riprap’	Changed as recommended	YHC

Technical Review Comments		Project: Kenai Bluff Stabilization	Location: Kenai, Alaska	
Date: June 15, 2011		Reviewer: Yen-Hsu Chen / Tel: (949) 809-5000		Back Check By: (initials)
Office Irvine - CA		Type of Document: Plans & Report / Discipline: Civil/Geotech		
Item No.	Page/Sheet	COMMENTS	Action Taken:	By:
28	Sht 14	Profile – Add 'GB' at Sta 65+12	Changed as recommended	YHC
29	Sht 15	Add Note on Sht 17 to this sht.	Changed as recommended	YHC
30	Sht 16	Add Note on Sht 17 to this sht.	Changed as recommended	YHC
31	Sht 18	Swale – extend geomembrane to surface	Changed as recommended	YHC
32	Sht 18	Berm – The top of bluff is as much as 5' higher than the prop swale. Is the berm suppose to be 5' high and to the right of swale? Or is there another berm or grading in the 20'easement left of the swale? Either way, the 12' perm access or the 20' easement will be reduced.	Top of bluff will be regraded for use as haul road during construction and the haul road will likely extend well into the temporary 20' easement to the left of the swale.	YHC
33	Sht 18	Rev Sta 2+00 to Sta 2+10	Changed as recommended	YHC
34	Sht 19	Delete notes regarding 'Factor of Safety'.	Changed as recommended	YHC
35	Sht 19	Rev B rock layer thickness for 1.7' to 1.8'to make to overall dimension thickness to 15'.	Changed as recommended	YHC
36	Sht 22	The downstream terminus of embankment is not the same as civil drawing.	Adjusted terminus for consistency	YHC
1	Table 1	Rev B Layer thickness to 1.8 feet	Changed as recommended	YHC
2	Sht 19	Delete noted regarding 'Factor of Safety'	Changed as recommended	YHC
3	Sht 19	Rev B Layer thickness to 1.8 feet	Changed as recommended	YHC

ATTACHMENT K

TRIP REPORTS AND MEETING MINUTES

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Meeting Minutes
Kenai Bluff Stabilization Design Alternatives

Meeting Date:	4/30/2008
Meeting Time:	10:00 am – 11:30 am
Meeting Place:	Corps Office
Meeting Purpose:	Review Project Status
Attendees:	Ken Eisses and Dee Ginter, Hydraulics, Chuck Wilson and John Rajek, Geotechnical, Dave Martinson, Project Management, and Pat Fitzgerald, Planning Bob Pintner and Pete Hardcastle, R&M, Krey Price, Tetra Tech, John Oliver, John Oliver Consulting (via teleconference)

Background:

- Purpose of meeting is to work through outstanding design issues and arrive at an agreement on a typical section to recommend in the alternatives report.
- Reviewed action items from 12/13/2007 meeting. Action items included Tetra Tech responding to questions and concerns regarding drainage, plantings, and slope stability.
- Agenda for meeting is based on the 4/4/2008 memo by Tetra Tech responding to questions and concerns.

Agenda Items/Action Items:

- *Drainage*. All team members prefer to route any runoff currently draining over the bluff face to the City storm drain network if possible. Second choice would be infiltration. Third choice would be rock ditch. Pipe option will not be carried forward due to potential safety and maintenance concerns. Krey will send a memo with modeling results once the drainage area delineations and rainfall-runoff computations are completed.
- *Planting*. All team members agreed with a long-term, phased approach to the plantings. Krey will forward the current planting plan to Pat for distribution to interested team members. Any comments or recommendations regarding the plantings will be coordinated with Stoney Wright of the Alaska Plant Materials Center.
- *Slope Stability*. Bob and Pete mentioned that the available geotechnical data continue to support the stability of the proposed 1.5H:1V slope.
- *Reference Sites*. Pete mentioned the presence of winter aufeis on the naturally vegetated slopes in the Ryans Creek and Cemetery Creek areas. Ken expressed concern that no additional field work was completed to verify groundwater conditions. Krey mentioned that, although the presence of groundwater is indicative of a similar process, the quantity of groundwater discharge per lineal foot in these areas is likely less than along the exposed bluff face due to the overall topography of the area. Bob and Pete thought that the effort involved in quantifying discharge to any reasonable degree of certainty would be too cumbersome to be practical.
- *Dewatering Scheme*. Krey summarized the currently favored dewatering scheme, which involves preventing flows from surfacing by placing a layer of granular material over the

till where applicable. After some discussion, all team members agreed to carry this alternative forward as a preliminary recommendation to the agencies rather than revisiting a structural solution involving drainage pipes or pumps.

- *Frost depth*. John asked if anyone could estimate the frost depth. Bob and Pete estimated depths ranging from 3 to 7 feet. Krey proposed increasing the minimum thickness of the sandy layer over the till to accommodate the maximum frost depth.
- *Bench*. Krey brought up the bench concept proposed by PND in 2000. In that scenario, the bench was to be located below the lag gravel in order to collect groundwater emerging from the bluff face. In the revised concept, we would locate the bench above the lag gravel and construct the bench with granular fill material to provide additional conveyance area for groundwater.
- *Adaptive Maintenance*. Krey mentioned that one of the risks of a less structural dewatering scheme is the potential need for localized patching with a shotrock mattress following construction, most likely a year or so following construction. This approach may cause some concerns related to public perception of failures or contracting. Dave felt those issues could be worked around.
- *Maintenance*. The bench would provide an additional contingency against localized groundwater percolation and would reduce the potential need; however, the need may not be entirely eliminated and the bench would provide for future maintenance access to the slope. The top of the rock armor layer would not present a drivable surface.
- *Overland Flow*. Krey mentioned that many jurisdictions do not allow a continuous slope without intermittent terracing. The bench would interrupt surface flow that otherwise would increase down the slope. Surface drainage collected along the bench would still have to be worked out.
- *Fabric*. Bob mentioned several alternative seed-embedded matting products. Krey will take a look at the product specifications and run them by Stoney Wright as applicable.
- *Armor Sublayer*. Dee mentioned concerns about the sublayer shown in the typical section. John agreed that the sublayer ought to be extended below the armor layer throughout the section. John also recommended trenching the toe if possible from a geotechnical standpoint. Bob and Pete agreed that it should be possible, and in areas with refusal, the same quantity of rock that would otherwise be buried could be used as a weighted toe.
- *Demonstration Section*. Krey asked whether a demonstration section would be feasible if partial construction funding were received. Dave did not think that warranted inclusion in the report.
- *Rock Armoring*. Krey asked if there were any other concerns or recommendations regarding the use of rock at the toe of the slope (versus alternative materials). No concerns were raised.
- *Schedule*. Krey reviewed the potential schedule, which would involve finalizing the alternatives report with the decisions made at this meeting during May, allowing the Corps several weeks to review, and presenting the report at an agency meeting in June. By that time, the updated topography would be available, and assuming agency concerns regarding the typical section are addressed, the detailed design showing the overall project footpring would begin at that point.

Meeting Minutes
Kenai Bluff Stabilization Design Alternatives

Meeting Date:	12/13/2007
Meeting Time:	11:00 am – 12:00 pm
Meeting Place:	City Manager's Office
Meeting Purpose:	Prep for Agency/Public Meeting
Attendees:	Rick Koch, City Manager Pat Porter, Mayor Krey, Pat, Chris, Lizette, Bob

Agenda Items/Action Items:

- Discussed progress on alternative development, cost estimates, layouts and typical sections.
- Discussed revetment material (biostabilization vs. rock vs. sheetpile). Rick is ok with selection of rock over alternative materials.
- Discussed revetment location. Rick does not favor a detached breakwater.
- Discussed cut and fill balance. Rick agreed that a balanced alternative is most efficient on the whole, so long as attempts are made to preserve some areas near the toe (near Cemetery Creek, for example) that will require more cut and some areas with critical parcels/infrastructure at the top of bluff, requiring more fill.
- Discussed seismic concerns. Rick noted that recent seismic design criteria were developed for a local Wal-Mart design. Rick also mentioned that to his knowledge, there were no catastrophic failures along the bluff during the 1964 earthquake.
- Rick mentioned the existence of a tidelands survey map showing the original platting. Krey will request the tidelands survey data from Rick.
- Discussed project status, funding, and other concerns.

Meeting Date:	12/13/2007
Meeting Time:	1:00 pm – 4:00 pm
Meeting Place:	Aquaculture Center
Meeting Purpose:	Agency Meeting
Attendees:	See attendee list

Agenda Items/Action Items:

- Pat opened the meeting and described the project.
- Rick discussed the history of the project and previous community involvement.
- Krey described the features of alternatives currently under consideration

- Discussed revetment material (biostabilization vs. rock vs. sheetpile). Agencies were ok with selection of rock over alternative materials. Krey discussed geotubes and other bank stabilization alternatives that have not been tried and tested at this scale in the region.
- Discussed revetment location. Agencies agreed that the potential hazards of landslides behind a detached revetment justify dismissing the alternative.
- Discussed using excavated till material to smooth the foreslope toe of the revetment. Agencies anticipate some concerns if this is used solely as waste material. Any material disposed at the toe must have a functional, long-term purpose.
- Discussed coastal trail component. According to comments, previous objections were not to a trail in general, but to the size of the trail. A smaller trail for birdwatching was recommended. Krey mentioned that the trail could be placed on the bench previously proposed in the PND concept design. Aesthetic fencing would be required in conjunction with any trail alternative. The trail could perhaps be constructed at a lower cost on an earthen bench (higher elevation) than on the armor rock, since the armor rock contains large voids that would require filling with well-graded material and subsequent compaction.
- Bob discussed the consistency of the till material. Till material is not suitable for use behind the revetment. If the amount of excavated till material is small, mixing the till with the alluvial material in small percentages may be acceptable. If more alluvial material is required, the upper layer could be cut back to a milder slope than 1.5H:1V to generate sufficient fill material.
- Discussed revegetation plan. Agreed that all alternatives will have a revegetation component consisting of spruce, alder, and willows.
- Some agencies commented that the environmental data presented would not support an EIS. Corps agreed, since a preferred design would be required first.
- Agencies requested determination of path (EA vs EIS) up front, with coordination between Corps Planning and Regulatory occurring as early as possible.
- No comments or concerns were raised regarding the baseline data in the Corps technical report or the conclusions of the report regarding impacts.
- The project as a whole seemed to have the support of the agencies, so long as concerns continue to be addressed.

Meeting Date:	12/13/2007
Meeting Time:	6:30 pm – 8:00 pm
Meeting Place:	City Hall
Meeting Purpose:	Agency Meeting
Attendees:	City Council Public (landowners) Krey, Pat, Chris, Lizette, Bob

Agenda Items/Action Items:

- Summary of project presented by Rick Koch
- Current status, funding, and opportunities for public involvement were discussed by Pat.
- Landowners and council members wanted to know about the future schedule for the project, how much money had been spent to date, and how many more studies would be required before a project is built.
- One landowner expressed geotechnical concerns with slippage and seepage along the interface between the till and the alluvial fill material. Bob mentioned that benching would be integrated into the construction sequence and discussed the overall slope stability.
- Individual questions were raised to the team members during the work session.

Meeting Date:	12/14/2007
Meeting Time:	10:00 am – 11:00 am
Meeting Place:	Corps Office
Meeting Purpose:	Review Project Status
Attendees:	Krey Price, Tetra Tech
	Corps HH, Geotech, Planning Staff

Agenda Items/Action Items:

- Discussed current status of alternatives and results of 12/13 meetings.
- Discussed revetment material (biostabilization vs. rock vs. sheetpile). Geotech and H/H staff are ok with selection of rock.
- Ken expressed concern regarding overland drainage. Krey mentioned that a detailed drainage analysis will be conducted after receipt of updated topo. The overland drainage from a design rainfall event is likely to result in higher surface runoff than discharge from the bluff.
- Ken and Dierdre expressed concerns regarding the establishment and survivability of vegetation. Ken suggested using several planting schemes rather than putting all eggs into one basket. Tetra Tech will coordinate the proposed planting plan with Stoney Wright of the Alaska Plant Materials Center and document monitoring results for reference sites.
- Ken expressed concern over using Ryans Creek and Cemetery Creek bluff as models for the main part of the bluff. Geotech staff from R&M will finalize results and interpretations of monitoring data. Comparison of conditions between the bluff and creek areas will be expanded in the discussion. A meeting with Krey, R&M geotech staff, and Corps geotech and H/H staff will be facilitated after completion of geotech recommendations. Anticipated time for the meeting would be February or March.

Meeting Minutes
Kenai Bluff Stabilization Design Alternatives

Date of Meeting:	August 24, 2007
Location of Meeting:	Kenai City Hall, Manager's Office Conference Room
Project No.:	T19229
Project Name:	Kenai Bluff Erosion Design Alternatives
Subject:	Review of draft alternatives and proposed schedule
In Attendance:	Rick Koch, City of Kenai, rkoch@ci.kenai.ak.us Keith Kornelis, City of Kenai, kkornelis@ci.kena.ak.us Pat Fitzgerald, Corps of Engineers, Patrick.S.Fitzgerald@poa02.usace.army.mil Dave Martinson, Corps of Engineers, David.A.Martinson@poa02.usace.army.mil Krey Price, Tetra Tech, krey.price@tetratech.com
Minutes Prepared by:	Krey Price and Dave Martinson

AGENDA ITEMS	ACTION
Report distribution and review	✓
Funding issues	✓
Upcoming schedule	✓

The goal of this meeting was to present the preliminary alternatives currently under consideration to the City of Kenai, update the City on the current project status and schedule, receive input on the alternatives, and address issues related to project funding.

Krey presented a summary of the current geotechnical investigations and the draft report, which was provided to the City in hard copy at the meeting. The summary of the report focused on the design criteria and some preliminary alternatives that were being developed. Following are some items of discussion regarding the report:

Existing Condition

The existing conditions chapter of the report currently includes placeholders in some of the sections. Krey mentioned that any additional information provided to him by the City or the Corps prior to the next submittal will be incorporated.

Design Criteria

Rick suggested adding seismic design criteria. Krey will review seismic design criteria with geotechnical engineers and incorporate the recommendations into the next draft of the report. The report should include an earthquake impact analysis that addresses how an earthquake would impact the project and what the expected danger or risk would be if the project were to fail. The question of whether to design for a specific earthquake will be addressed during further discussions.

Rick asked about the design criteria regarding glaciation, i.e. what design considerations are needed to handle freezing and thawing of the seepage and are we considering ice forces from the river. Krey answered that ice design will be included with the armor calculations and that some ongoing maintenance of surface drainage ditches might be anticipated.

Alternatives

The detached breakwater alternative was presented to the City. The City prefers the original design (armored toe as a revetment) rather than the detached breakwater because the detached breakwater would require more rock and increase the shoreline impacts by extending the project footprint further toward the river.

Krey also presented options for the overall cut-fill balance. Three options are currently being considered: balancing the cuts and fills along the entire project length, cutting more from the senior center area for use as fill material in the downtown area, and cutting more in the downtown area to use as fill for the senior center area. Rick indicated a preference for the balanced approach.

Design Issues

Maintenance issues were raised, including the need to consider the maintenance requirements of the different alternatives, weighing the cost of maintenance vs. initial construction costs. Rick made several suggestions related to access. The need for a permanent maintenance easement (approximately 15’ wide) along the top of the bluff was discussed. Fencing and access control will be critical for the landowners along the top of the bluff. Set back ordinances (accounting for seismic concerns) should be enforced with any new permitted development.

Another design thought was considering if there were properties that needed to be protected in place, restricting the alternatives that were being proposed. Rick was going to provide this information during his review of the draft document. Rick indicated he would try to have comments back to us by the 31st of August.

Dave noted that the draft report that Krey provided should be sent to Lorraine Cordova for her to review and to help in her Econ evaluation. We might also consider how or if an Econ section should be incorporated into the Tetra Tech document.

Schedule

The proposed schedule for the study was also discussed. A meeting with stakeholders was suggested for the week of September 24-28. The meeting would be held in Kenai. The Challenger Learning Center was suggested by Rick as a potential venue. Pat and Rick will look into setting that up. The meeting would present the alternatives being proposed along with a preliminary recommendation. Krey will put together the presentation. The meeting would also be open to the community. Comment cards for the public may be provided in lieu of a Q&A meeting. Krey will provide a Draft Alternative Report in time for the Corps to have one week review and the agencies to have one week to review prior to the meeting.

Rick mentioned rock sources and there was some discussion on rock availability and how that would impact design costs and alternative selection. Rick provided Krey with recommendations for earthwork and coastal contractors. Rick asked about authorization language for the project. Dave agreed to provide some information on suggestions for getting the project authorized, which was completed the following week.

Following the meeting, Krey, Pat, and Dave walked the top and toe of the bluff, collecting GPS points, water measurements, and visual observations. Prior to the meeting, Krey, Pat, and Dave met in the field with Bob Scher of R&M to discuss groundwater data collection efforts and to pull the transducer data.

Meeting Minutes
Kenai Bluff Stabilization Design Alternatives

TUESDAY, MARCH 14, 2006

Project Team meeting, Alaska District offices

Attendees:

Pat Fitzgerald	Corps
Dave Martinson	Corps
Deirdre Ginter	Corps
Margan Grover	Corps
Chris Hoffman	Corps
Chuck Wilson	Corps
Krey Price	Tetra Tech
Dave Broadfoot	Tetra Tech

Meeting Summary:

The Corps summarized the project history. Results and recommendations from previous studies were presented, including initial assessment studies conducted in 1982 and subsequent analyses, conceptual designs, and environmental studies conducted since 2000. An ongoing study by the Corps has been reviewed at the draft level and is awaiting a final backcheck of responses. The Corps anticipates finalizing the "Draft Kenai Bluff Erosion Technical Report" in the next month.

The 2002 PND concept study was discussed, particularly in regard to its level of detail. The study did not have funding to address agency comments or incorporate supporting engineering studies.

Allocation of the current Corps funding was discussed. The Corps is hoping that the current $500,000 allocation will cover all of Phase I and the portions of Phase II that will be completed during the current fiscal year.

The Corps emphasized that Tetra Tech should focus on design issues. Less emphasis should be placed on determining/verifying historical bank erosion rates and estimating the relative contribution of coastal, riverine, and hydrogeological impacts on the erosion rate. The study should focus on determining a viable solution that will be designed to accommodate all erosive forces.

Hard copies and digital files of additional existing information, including maps, aerial photographs, and previous erosion studies were provided to Tetra Tech after the meeting. A bibliography of acquired materials (including reports provided to Tetra Tech by the Corps prior to the meeting) will be included in the work plan.

WEDNESDAY, MARCH 15, 2006

Meeting #1: Introductory Meeting with City of Kenai Public Works Director, City Hall

Attendees:

Keith Kornelis	City of Kenai
Pat Fitzgerald	Corps
Dave Martinson	Corps
Dierdre Ginter	Corps
Chuck Wilson	Corps
Dave Broadfoot	Tetra Tech
Rick Waddell	Tetra Tech
Krey Price	Tetra Tech

Meeting Summary:
The project team met briefly in the City of Kenai City Hall to review the project history with City of Kenai Public Works Director Keith Kornelis. Aerial photos of the bluff provided by Keith were examined and discussed. One of the aerials included a GIS layer showing property boundaries.

Keith indicated the following during the discussion with the project team:

- There are few if any septic systems in current usage. If a building is within 100 ft of a sewage line, sewage from the building must be discharged to the sanitary sewer system.
- Few water meters are used, so there is no way to perform mass-balance calculations for the water system.
- Keith does not believe that the water or sewer systems can be the main source of the water discharging from the bluff.
- Keith provided paper copies of GIS maps that show the water and sewer lines. He indicated that the sewage map was out of date. Some lines shown on the map at the western end of the bluff are no longer part of the system.
- Water and sewer lines are generally buried to a depth of 10 feet. In some areas, this is below the water table.
- Management of surface water is the responsibility of AK DOT-PF in conjunction with the Kenai Spur. There does not appear to be any management of surface water flow between the Kenai Spur and the bluff.

- The city will provide copies of photographs showing the bluff. Of particular interest are older photos of the old town area, and of another bluff that is west of town and facing the Cook Inlet. The city will also share any GIS layers they can with the project team.

- Keith believes the property boundaries extending out into the Kenai River shown on the plat overlay are indicative of the previous location of the bluff when the plats were defined, although some of the U.S. government plats may have extended beneath the river rather than the river's edge.

Project Site Visit, Kenai Bluff

The project team, accompanied by Public Works Manager Keith Kornelis, visited the Kenai Bluff project site at low tide (~+2' MLLW) in the vicinity of the Coast Guard signal station at the east end of the Kenai Dunes recreation area. The face of the bluff was exposed, and snow and ice covered the bench at the bluff base. Members of the project team (Chuck Wilson, Deirdre Ginter, Rick Waddell, and Krey Price) walked along the base of the bluff from Cemetery Creek to the mouth of Ryan's Creek near the Senior Citizens Center to make closer observations of the bluff.

The following observations were made by the group that walked along the bench at the bluff face:

- The clay layer appeared wet between the interface with the overlying sandy layer down to the bench. There was no visible discharge from the sandy layer, but the there was discharge from the clay immediately below.

- At the west end of the bluff, sandy material had apparently been dumped over the edge of the bluff, covering up the natural stratigraphy. It was presumed that the clay layer that was covered up by this sandy material was wet.

- The clay layer also contains sandy layers within it. These sandy layers will probably be important in efforts to reduce pore pressures in the clay layer.

- Erosion along the bluff face was actively occurring through several processes. The effects of slumping were observed in some areas. Direct erosion by water discharging from the clay layer was observed, as was debris flow. In one area, dry sand was observed flowing across the interface between the (upper) sandy and (lower) clay layers. Numerous areas that had experienced piping within the clay were seen; some of these were dry, but others were actively flowing. A flowing piping area in the sandy layer was also observed. Small gravel to cobble sized particles also were observed to occasionally fall from the face of the bluff.

- There was a notable absence of accumulated sediment at the base of the bluff, indicating that removal of sediment by surface water is occurring periodically.

- In some areas iron staining was observed along the interface of the sandy and clay layers. Also, in one area, where it appeared that calving from the bluff had recently occurred along a plane of weakness or fracture striking approximately parallel to the face, iron stains were present over approximately half of the fracture length.

Meeting #2: Meeting with Kenai City Manager, City Hall

Attendees:

Keith Kornelis	City of Kenai
Rick Koch	City of Kenai
Pat Fitzgerald	Corps
Dave Martinson	Corps
Dierdre Ginter	Corps
Chuck Wilson	Corps
Dave Broadfoot	Tetra Tech
Rick Waddell	Tetra Tech
Krey Price	Tetra Tech

Meeting Summary:
The project team and Keith met briefly with City Manager Rick Koch to discuss the purposes of today's visit and meetings, and the current status of Corps activities and plans regarding the Kenai Bluffs erosion.

In response to a question by Rick Koch, the Corps discussed the schedule and anticipated level of detail for further study and designs under the current $500,000 funding allocation. The Corps also described the criteria, guidelines, and limitations of the current funding authorities the Corps can make use of for this project, and the actions that could be taken by the City to help secure adequate funding for the project.

Rick Koch offered the city's assistance with providing the project team with any supporting data available from the city. Rick requested a pre-final copy of the Draft Technical Report currently being prepared by Corps, to provide to congressional representatives when they visit the City the week of March 20th.

Rick Koch mentioned that the dip-net fishing activities along the Kenai attract 20-30,000 visitors to the bluff area each summer.

Additional Field Observations

Following the meeting with the City Manager, the team members separated into subgroups to make additional field observations and gather further data.

Group 1. Chuck Wilson, Dee Ginter, and Rick Waddell drove to and walked along the beach north of the sewage treatment plant to observe the portion of the Kenai Bluffs that face Cook Inlet. Snowy and icy conditions and time constraints prevented close observation of this area, but wet areas were observed along this bluff as well. The interface between the upper sandy layer and the underlying clay layer appeared to be at a lower elevation in this area than in the area south of the City.

This group then traveled to the cannery at the eastern end of the bluff, but did not walk along the entire stretch. The easternmost 200-300 feet were much drier than the stretch further to the west. When leaving this area, a monitoring well was noticed on the north side of the parking lot. In a subsequent discussion at the City office, Keith Kornelis indicated that there had been 2 or 3 monitoring wells installed at a former FAA site, where hydrocarbon contamination had occurred. No other monitoring wells or environmental remediation projects near the Old Town area were known.

Group 2. Krey Price met with Marylin Kebschull of the City of Kenai Planning Administration to discuss geospatial data needs. Ms. Kebschull provided a DVD with GIS layers, including infrastructure, parcel data, and background aerial photography. Tetra Tech agreed to non-disclosure clauses for the aerial imagery. Under this the project team may use the data in analyses, but may not publish the photographs, and must destroy/delete the data upon completion of the project.

Group 3. Krey joined the remaining project team members to drive to tour the historical/cultural sites in the Old Town near the top of the bluff. During this tour, this group met several residents who inquired about the project. The corps described the project, the status and plans as appropriate. In general, landowners and residents talked to viewed the project favorably.

Members of this group also observed the bluff face at high tide (~+21' MLLW) from the Scout Park and Upland Street overlooks. Tide levels were observed to be approaching the toe of the bluff in some locations.

Meeting #3: Evening Kenai City Council Meeting, Council Chambers, City Hall

The project team (except for Dee Ginter and Chuck Wilson) attended the evening City Council Meeting. The Council meeting was well publicized and well attended. Articles had appeared in the *Peninsula Clarion* describing the Corps field visit and appearance on the agenda (see Attachment 2 for the excerpts of the articles).

A presentation by the Corps was the first item on the agenda. Pat Fitzgerald and Dave Martinson addressed the City Council, described the project history, the previous studies, the purpose and objectives of today's visit and the current investigation, and the upcoming work and Corps plans to help the city with the bluff erosion problems.

The following questions were raised by City Council members and discussed by the Corps during the meeting:

- Will the design attempt to incorporate "greener" solutions? Mr. Martinson answered that previous designs were conceptual only. Rather than a single cross section as shown in the concept report, the actual design may incorporate transitions to "greener" or "softer" sections.
- Will the Coastal Trail be incorporated? Mayor Pat Porter indicated she was under the impression that it is foremost an erosion control project and that any trail functions would be the City's responsibility rather than the Corps'.
- When will the project begin? Mr. Martinson suggested that if things go smoothly, alternatives to be evaluated should be ready by this coming fall. A very optimistic prediction is that construction of the most practicable and cost-effective solution could commence as early as 2008.

No public comments were voiced during the meeting. Mayor Pat Porter thanked the team for their participation, and expressed the enthusiasm of the City to have this project implemented. She pledged the support of the council and staff in helping the Corps make this a successful endeavor.

THURSDAY, MARCH 16, 2006

Debriefing Meeting, Aspen Hotel, Soldotna

Pat Fitzgerald, Dave Martinson, Dave Broadfoot, and Krey Price held a short debriefing meeting to discuss the results of the previous day's meetings, site visit, field observations, and upcoming deliverables. It was the general observation of the team that local support for the project and Corps's participation is strong. An important specific observation made by the team was that incorporation of a trail into the project design, while desirable to the city, does not appear to be a major factor in local endorsement by the city government. The foremost issue in everyone's minds appears to be stabilization of the bluff to protect the City's infrastructure and historical resources.

PROJECT SITE VISIT PHOTOS

Looking east from Coast Guard signal

HDPE pipe outfall near Upland Street

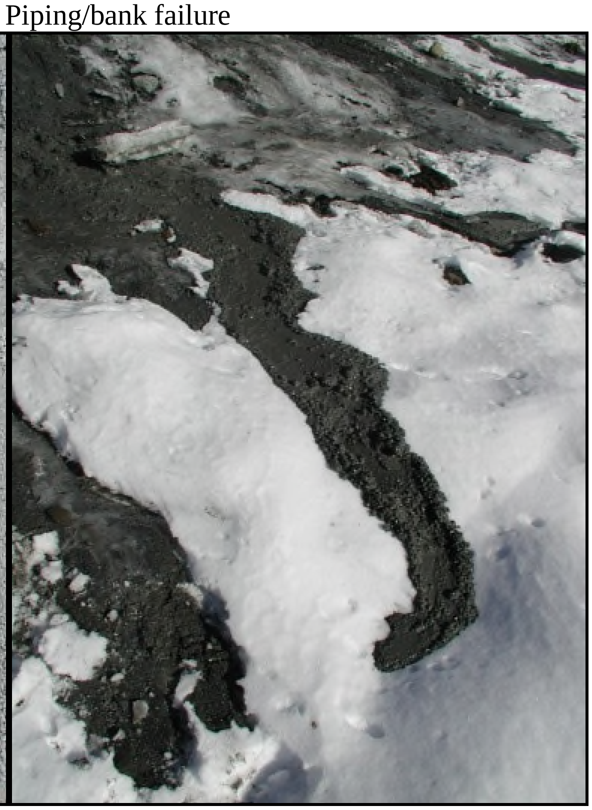
Abandoned sheet pile/tank on tide flat

Abandoned protruding PVC pipe near Bluff Street

Debris and iron stains

Piping/bank failure

Piping holes near toe



Mud flow over snow


Bluff from tide flat, Cemetery Creek mouth

Near-vertical slope, no material at toe


Erosion control fabric and debris

Looking west from top of bluff at Ryan's Creek

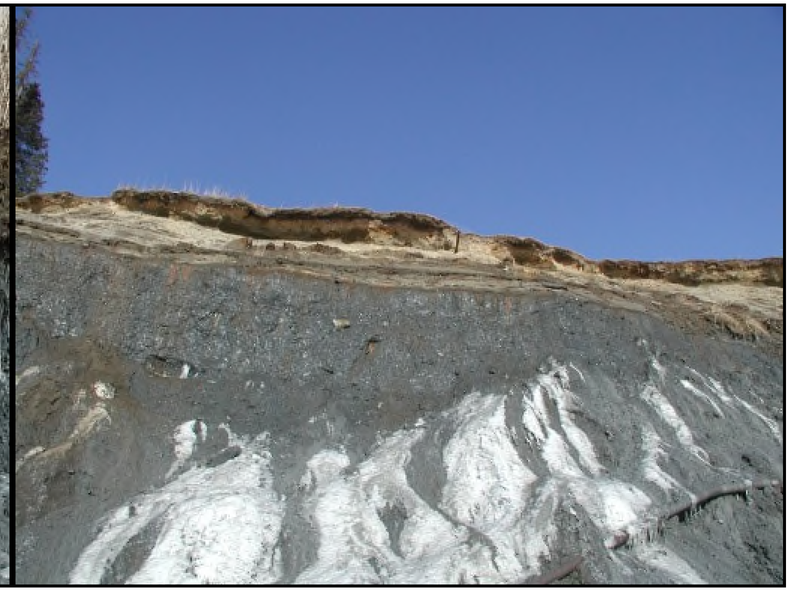
Looking west from tide flat near Cemetery Creek mouth

Looking west from tide flat near Cemetery Creek

Looking west from tide flat near Cemetery Creek mouth

Ice and seepage under topsoil

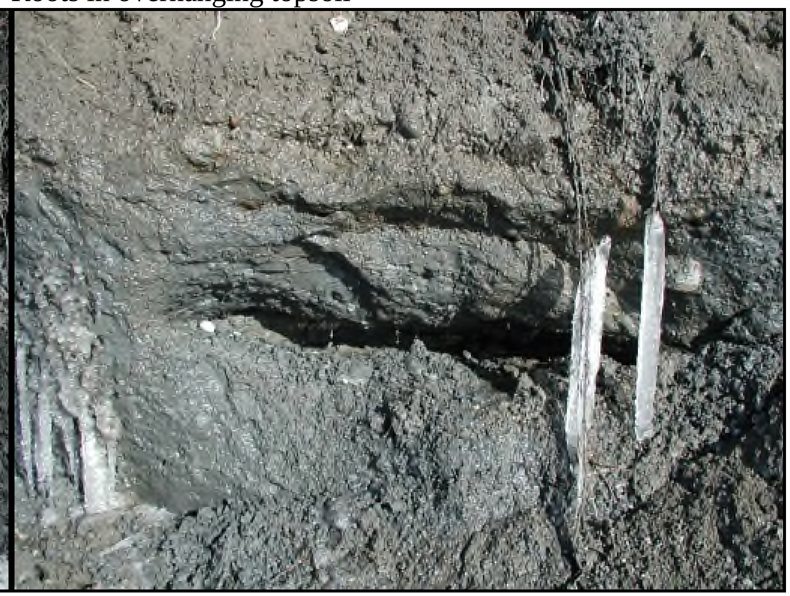
Ice on bluff face



Exposed section of buried pipe


Buried structure and debris

Roots in overhanging topsoil

Piping holes

Ice and snow on bluff face

Piping holes

Iron staining in clay layer


Asphalt debris near Willow Street


Overhanging foundation near Willow Street

Looking west from top of bluff at Willow Street

Irrigation line and sprinkler head

Looking east from top of bluff at Willow Street

Looking west from right bank of Ryan's Creek near senior center


Irrigation line and sprinkler head


Historical photo in city office - year unknown

Looking west at shoal from Coast Guard tower

Looking west at bluff from cannery

Panorama of bluff looking north from Coast Guard signal

Looking east from toe of bluff near Main Street

Overhanging topsoil and ice on bluff

PENINSULA CLARION ARTICLES

The following articles appeared in the Peninsula Clarion prior to and following the 3/15/2006 Kenai City Council meeting. An article appeared on March 15 announcing the site investigations and City Council meeting agenda, and a follow-up article appeared March 19 summarizing the proceedings of the meeting.

Peninsula Clarion, March 19, 2006.

http://peninsulaclarion.com/stories/031906/news_0319new004.shtml

Kenai boat ramp will get overhaul before dipnet season begins

By PHIL HERMANEK
Peninsula Clarion

(excerpt)

...

In other business, the council heard from Army Corps of Engineers representatives on the Kenai bluff stabilization project.

Project formulator Patrick Fitzgerald said the Corps only has funding to study environmental impacts and other issues involved with the project and the city needs to lobby for funding for the design and construction.

Project Manager Dave Martinson said preliminary scoping could begin in May or June with alternatives ready by the fall.

“If given the authority to build, the work could be done possibly in 2008,” he said.

Council member Joe Moore asked if a coastal trail is part of the Corps’ plan, and Martinson said, “We need the lead from you ... what you want.”

Mayor Pat Porter said when she was in Washington, D.C., last year, it was made clear to her that “the Corps does not do trails.”

“The main concern is bluff stabilization,” she said.

...

Peninsula Clarion, Wednesday March 15, 2006

http://peninsulaclarion.com/stories/031506/news_0315new003.shtml

Bluff work starts *Army engineers to outline studies at council tonight*

By PHIL HERMANEK
Peninsula Clarion

(excerpt) What mammals, fish and birds use the area near the Kenai bluffs?

The mouth of the Kenai River has long been important to people inhabiting the lands above. Are any archeological sites or possibly burial areas hiding below?

An Army Corps of Engineers official working on the Kenai bluff erosion project will visit the Kenai City Council meeting tonight to outline these issues and other concerns that will be studied as the city prepares to go ahead with bluff stabilization efforts.

Project formulator Patrick Fitzgerald, from the Corps' office in Anchorage, is slated to tell the council about studies that need to be completed prior to work beginning.

The studies include determining the environmental impact of the work on mammals that use the mud areas below the bluffs, fish swimming in the waters where the river meets Cook Inlet and birds that are present along the shore and the bluffs, according to Fitzgerald.

Studies also will look at potential impact on cultural resources in the area of the bluffs.

"There certainly are historic buildings on the ground above, in Kenai," Fitzgerald said.

Archeological sites also may be in the ground that have not already been determined, he said.

"Our investigation could check into issues such as burials areas," he said.

Consultants also will look into the flow of groundwater along the bluff.

"Basically the bluff is two layers," Fitzgerald said.

"The lower 30, 35 feet is real silty, like clay. The upper layer is sandy. Rainfall and snow melt percolates down through the sandy layer and then travels along the silt layer. We need to address the groundwater issue — not just wave and wind erosion," he said.

The consultants also will analyze inlet wave effects and look at designs of bluff stabilization alternatives.

The studies are expected to begin this summer.

Fitzgerald said he and the contractor were to meet with Kenai city officials this morning to walk the bluff.
...

ATTACHMENT L: HYDROGEOLOGY AND R&M GROUNDWATER MONITORING REPORT

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Table L-1: 2006-2007 Groundwater Reading Summary (R&M Consultants 2008)

MW ID	TEST HOLE ID	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07
AP-608	TB-1A	21.1	22.0	22.0	21.9	22.6	22.1	22.0	21.6	21.9	22.1	22.1	21.7	22.2
AP-609	TB-1B	21.4	21.8	21.6	21.7	21.8	21.8	21.5	21.2	21.1	21.1	21.2	21.2	21.4
AP-610	TB-1C	54.4	54.5	54.4	54.3	54.3	54.3	54.3	54.2	54.2	54.2	54.2	54.2	54.3
AP-611	TB-2C	15.6	10.7	9.7	11.6	13.5	9.8	13.1	9.3	9.4	9.4	9.2	9.2	14.1
AP-612	TB-2B	53.3	39.3	39.1	39.0	38.7	38.4	38.2	38.0	38.5	38.0	37.9	37.8	37.8
AP-613	TB-2A	57.8	57.8	57.8	57.8	57.7	57.7	57.7	57.6	57.6	57.6	57.6	57.6	57.6
AP-614	TB-3A	11.0	12.9	11.8	12.8	13.8	10.4	11.7	9.4	9.4	10.4	10.1	10.2	14.1
AP-615	TB-3B	40.3	34.0	34.5	31.9	31.0	30.5	30.6	30.5	30.6	30.6	30.6	30.7	30.8
AP-616	TB-3C	56.8	56.9	56.9	56.8	56.8	56.8	56.8	56.7	56.7	56.6	56.8	56.8	56.8
AP-617	TB-4A	14.2	12.9	8.5	15.8	10.3	7.4	13.0	6.0	6.3	6.0	4.6	4.8	15.6
AP-618	TB-4B	54.9	54.8	54.6	54.3	53.9	54.1	53.8	53.8	53.6	53.5	53.4	53.6	53.1
AP-619	TB-4C	63.3	63.2	63.1	63.0	62.9	62.9	62.9	62.9	62.8	62.8	62.9	62.8	62.9
AP-620	TB-02	63.9	63.9	63.7	63.6	63.5	63.4	63.4	63.3	63.2	63.2	63.2	63.1	63.3
AP-621	TB-03	71.0	70.7	70.5	70.2	70.1	70.0	69.9	69.9	69.9	69.8	70.0	69.9	70.0
	MW-1	69.0	69.1	68.9	68.7	68.6	68.6	68.5	68.4	68.3	68.3	68.4	68.3	68.4
	MW-2	72.0	71.7	71.5	71.3	71.2	71.1	71.0	70.9	70.9	70.8	71.0	71.0	71.1
	MW-3	67.0	66.8	66.6	66.5	66.4	66.3	66.3	66.2	66.2	66.2	66.2	66.2	66.3

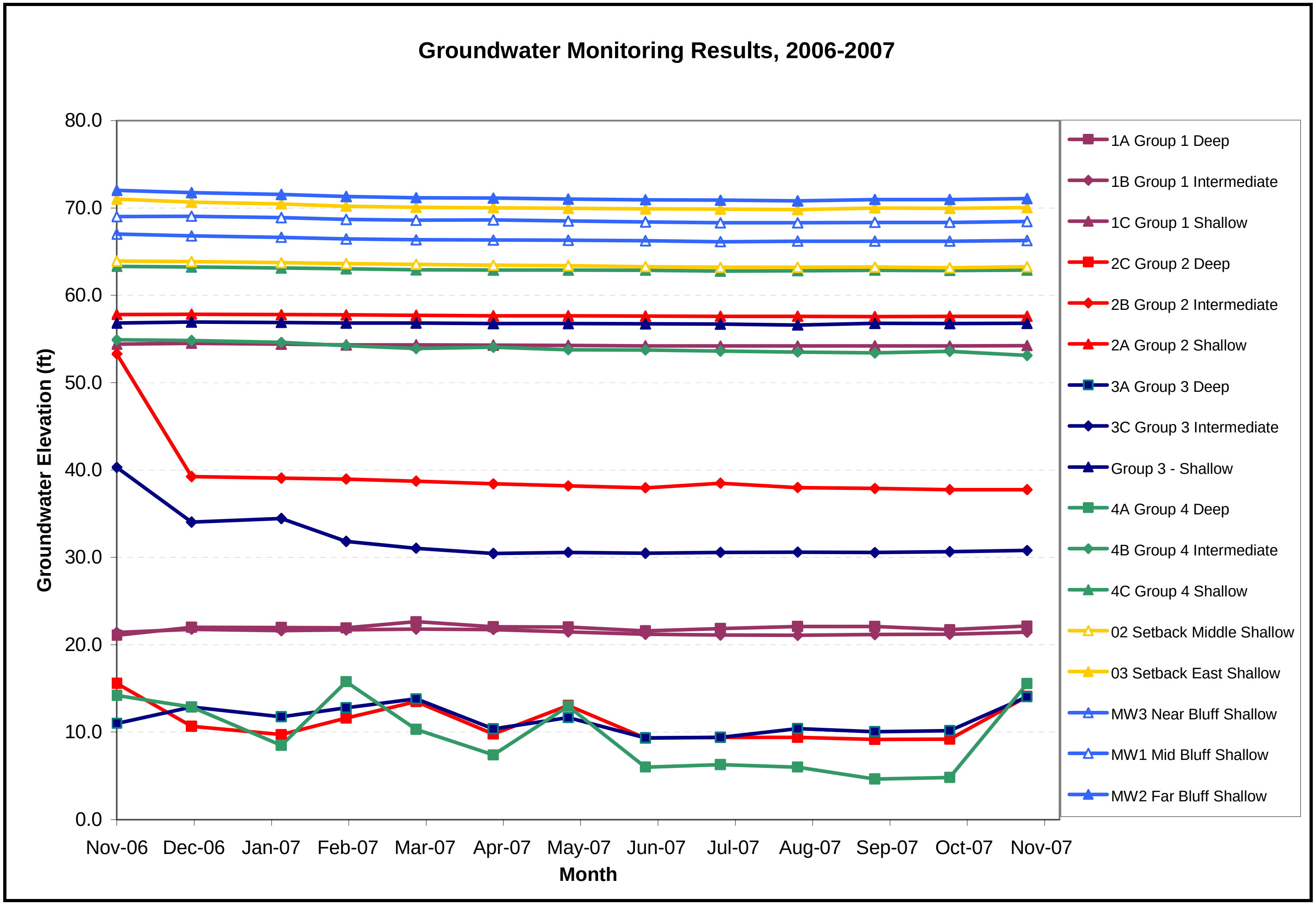

Figure L-1. Preliminary Groundwater Readings at Kenai

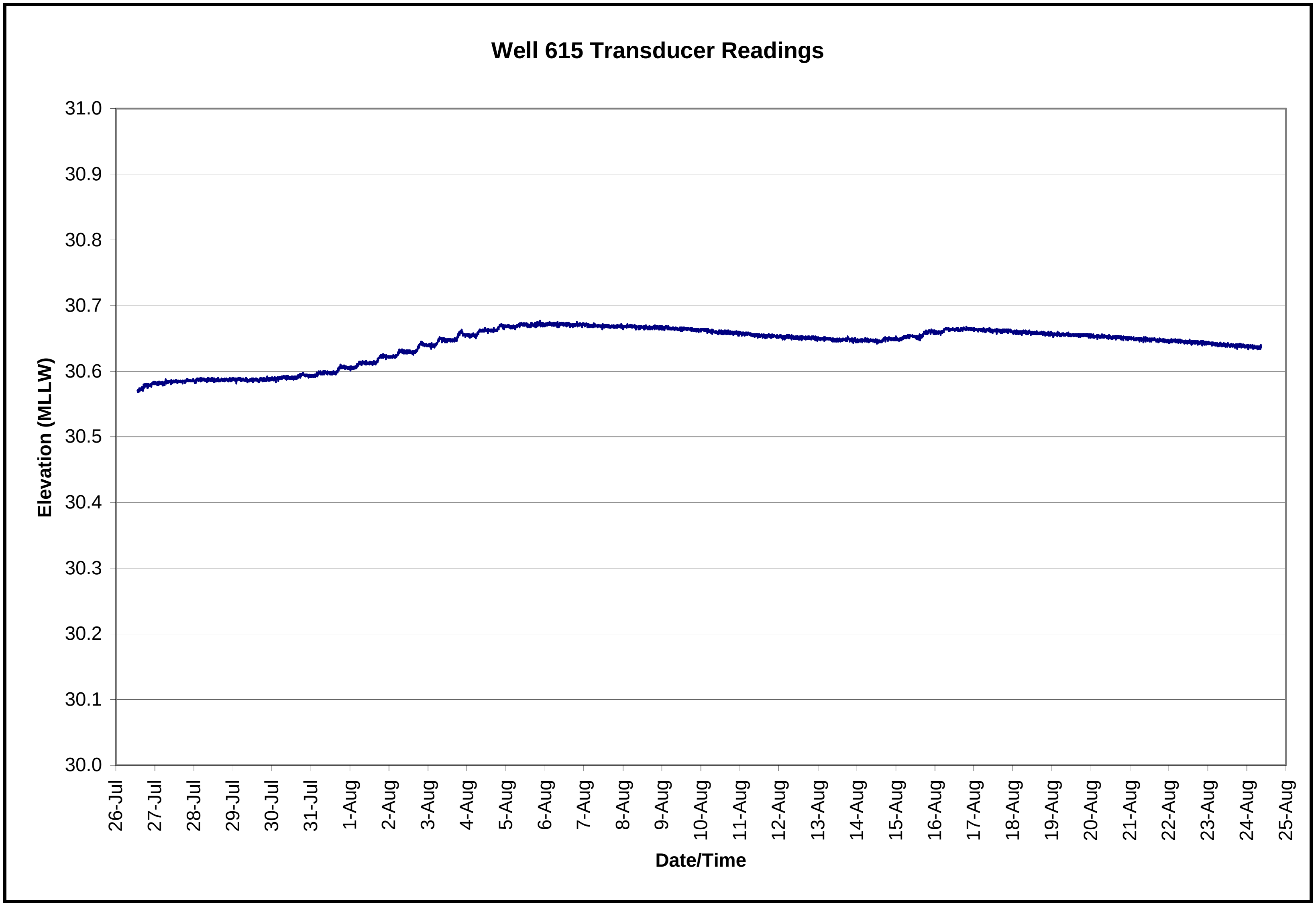

Figure L-2. August 2007 Groundwater Readings at Kenai, Intermediate Well

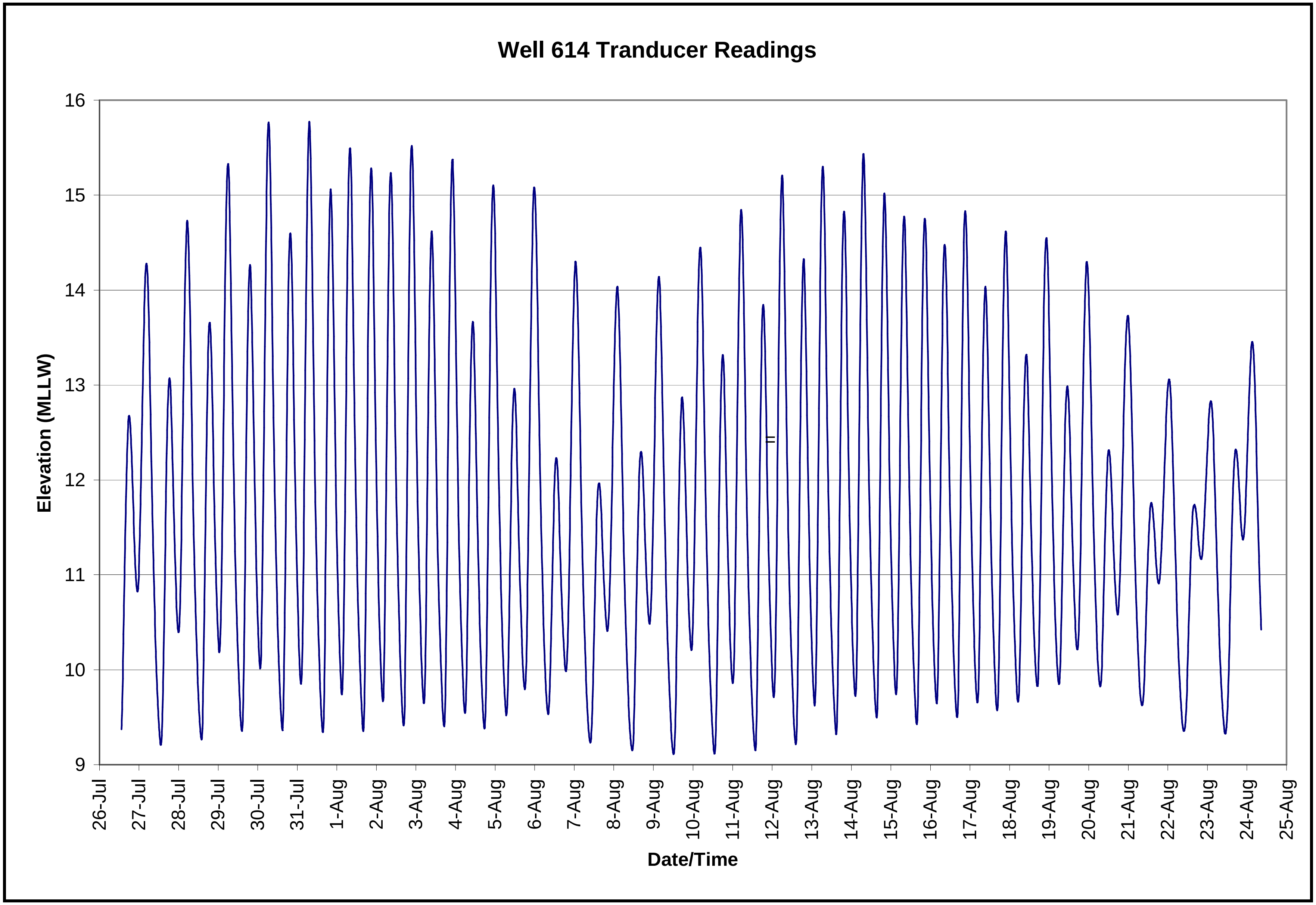

Figure L-3. August 2007 Groundwater Readings at Kenai, Deep Well

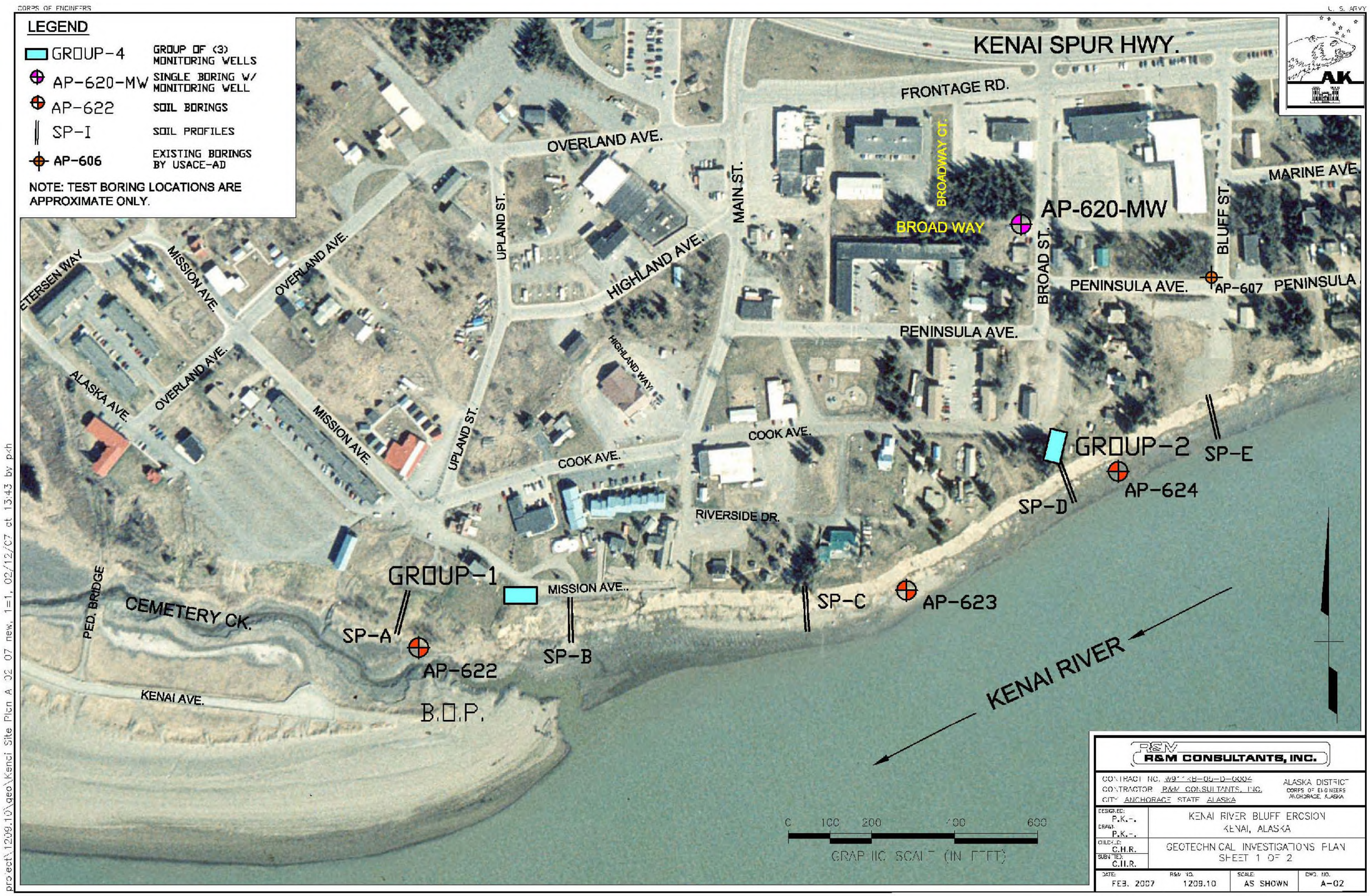

Figure L-4. West Project Area Groundwater Well Locations (R&M Consultants 2007)

Figure L-5. East Project Area Groundwater Well Locations (R&M Consultants 2007)

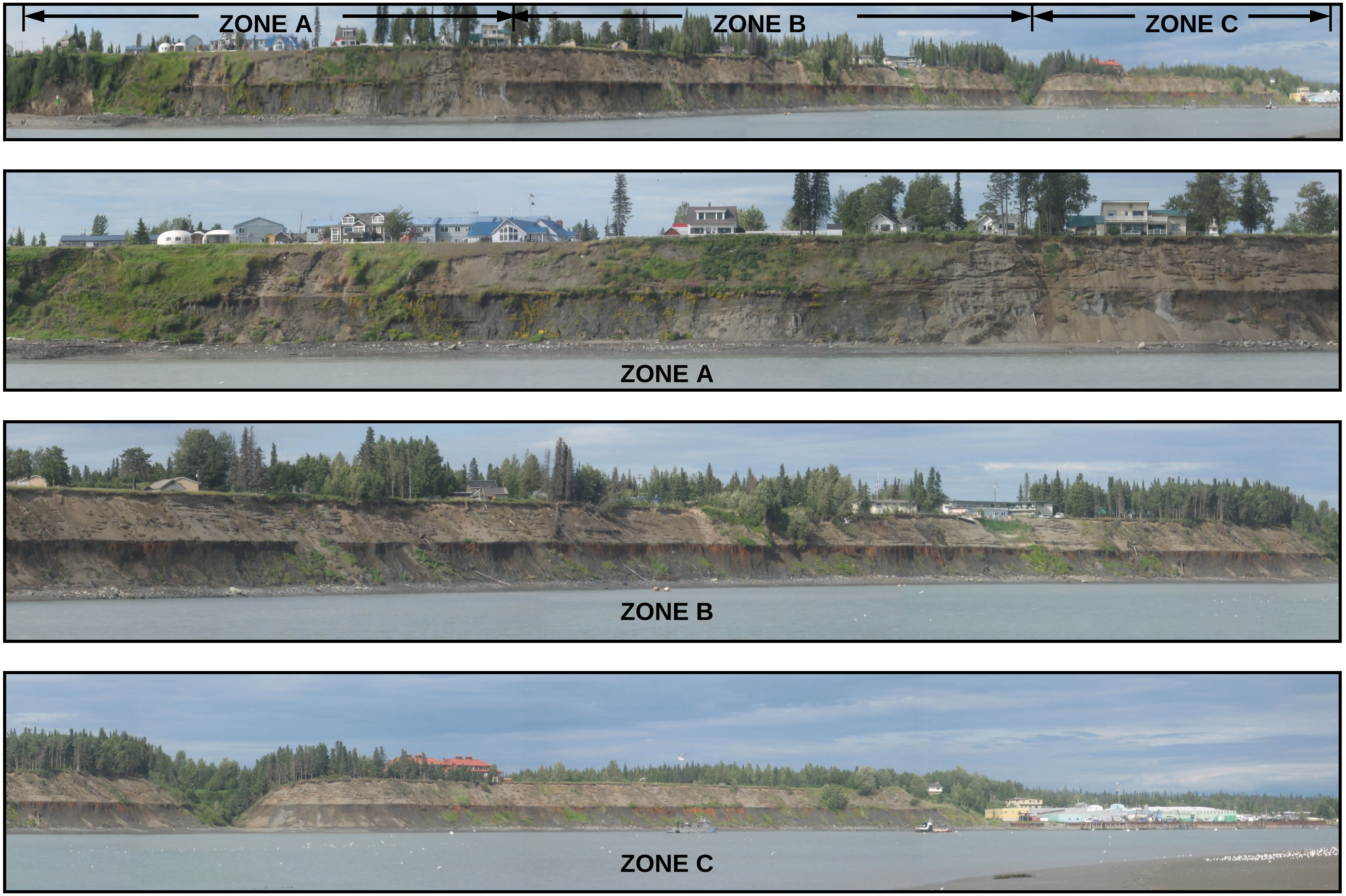

Figure L-6. Groundwater Zones

Quantification of Groundwater Seepage

In order to prevent further erosion, the project is designed to drain the maximum estimated groundwater seepage out of the bluff face during sustained, saturated conditions. Seepage was quantified with measurements and calculations. As part of the R&M Consultants study, ten soil profiles were characterized during a December 2006 field visit, including measurements of groundwater discharge rates from the bluff. Measurable flows were encountered at three of the ten soil profiles. The measured flow rate at these three profile locations ranged from 0.25 to 1.5 gallons per minute (gpm) per lineal foot. These rates apply to the immediate vicinity where significant flow was encountered and are not representative of the average discharge rate for the overall bluff face.

Supplemental measurements were taken along the entire toe of the bluff in July and August, 2007. The measurements were taken with a graduated cylinder in representative channel paths combined with a count of similar channels. The measurements indicate a total surface discharge of approximately 100 to 200 gallons per minute along the project extents. Additional subsurface flow was apparent just below the river’s water surface. The measurements show some variation in discharge rate along the lateral extent of the bluff that can be divided into three groundwater seepage zones. Zone A, nearest the mouth, exhibits very little groundwater seepage along the bluff slope. Because this zone includes the area of the bluff protruding out into the inlet, the groundwater gradient may push water out to the sides of the point rather than continuing to the toe in this zone. As described in R&M Consultants (2007), cementation may also be a cause or result of the low seepage rate in this zone. Historical oblique aerial photographs show the presence of fill that may be free-draining to the toe in portions of this zone. Measured discharges in Zone A were approximately 20% of the discharge measured in Zone B, which extends from the protruding point to Ryan’s Creek. Within Zone B, steady streams of surface flow are present in very small, trickling channels are present every few feet along the toe of the bluff. These streams have been observed year-round with very consistent flow rates. Flows in Zone C (the senior center reach) were approximately 50% higher than in Zone B. The design capacity of any implemented solution should account for the differences between these zones. Flows within each zone were found to be relatively constant, although a slight concentration in discharge rate occurs in areas where the top of the bluff is slightly lower (R&M Consultants 2007).

Preliminary calculations of the discharge to be accommodated by the subsurface drainage system were performed based on the porosity and other soil parameters presented in the Geotechnical Investigations Report (R&M Consultants 2007). These results were compared to measurements taken along the lag gravel layer and along the toe of the slope. The measurements in the lag gravel layer were taken in areas representative of typical flow conditions at each given profile location, where concentrated flows emerged from the bluff. As mentioned above, these measurements are not necessarily representative of the entire bluff face from one profile location to the next. The lower, calculated value is considered appropriate for preliminary design of the subdrainage system and has been verified as conservative by supplemental measurements along the toe.

Geotechnical laboratory testing was performed on the soil samples collected by R&M Consultants in November and December 2006 to assist with characterization of subsurface conditions along the bluff. The samples were analyzed for particle size distribution and moisture content. Select samples were also analyzed for Atterberg limits and specific gravity. In order to estimate the necessary soil parameters, the particle size distribution and Atterberg limit test results were utilized to calculate estimated hydraulic conductivities of the samples. Three approaches for performing this calculation were identified: the Hazen approximation, the Shephard method, and the Krumbein and Monk method. The geotechnical sample results were grouped based on similar soil classifications and particle size distributions, and the appropriate method for calculating hydraulic conductivity was selected for each group. In general, the Hazen approximation was utilized for samples consisting primarily of sand, the Shephard method was utilized for samples consisting of a mixture of sand and fines, and the Krumbein and Monk method was used for samples consisting of primarily fines.

Following calculation of hydraulic conductivities for individual soil samples, the samples were regrouped based on the stratigraphy observed in the bluff. Three groups were selected, including surficial soil/fill, alluvial deposits, and glacial till. An average hydraulic conductivity was then calculated for each group. These averages were converted to an average groundwater flux per linear foot along the bluff. Since groundwater seepage has not been observed from the surficial soils (within 1.5 ft bgs), this thin layer was not utilized for flux calculations.

Applying these average rates to the entire 5,000-foot length of the bluff in the study area results in an estimated total groundwater flux from the alluvial deposits and glacial till of 106 and 270 gallons per minute, respectively. Table L-2 shows a summary of the groundwater seepage calculations. Table L-3 shows the soil parameters used in the calculations.

Table L-2. Groundwater Flux Calculations

Unit Description	Depth Range	Avg K (cm/sec)	Avg K (ft/sec)	Avg Gradient	Q (ft^3/ min/ ft)	Q (gal/ min/ ft)	Approx. Bluff Length (ft)	Q (gal/ min)
Surficial Soil/Fill	0.5 - 1.5 ft bgs	3.28E-04	1.07E-05	NA	NA	NA	5,000	NA
Alluvial Deposits	2.5 - 36.5 ft bgs	7.36E-03	2.42E-04	0.013	2.83E-03	0.02	5,000	106
Glacial Till	40.0 - 101.5 ft bgs	4.21E-03	1.38E-04	0.029	7.20E-03	0.05	5,000	270

Recommendations for Test Section

The following recommendations apply to construction of a test section and additional testing performed on in-situ materials to verify design parameters. Slug testing of monitoring wells completed in the alluvial material and glacial till should be completed to provide estimates of in-situ permeability. Slug tests should be performed in at least five wells completed in each formation. Data from the tests should be collected using data logging pressure transducers. The data will provide better approximations of in-situ permeability from these units, and refine the estimated groundwater flux from the face of the bluff.

Soil samples should also be collected from the alluvial material and glacial till, and tested in a laboratory for permeability. The alluvial material samples should then be disturbed and compacted to the specifications determined for placement of the alluvial material as a filter layer on the face of the bluff. The compacted alluvium material should then be tested again for laboratory permeability. A mixture of alluvial material and glacial till, as proposed at the toe of the bluff, should also be mixed and compacted to the specifications determined for placement at the base of the bluff. The compacted mixture of alluvium material and glacial till should then be tested again for laboratory permeability.

A test section of the bluff stabilization is recommended prior to full-scale implementation. The test section would examine both the potential for quick conditions at the base of the bluff and pore pressure build up behind the bluff. Piezometers should be completed in the alluvial material and glacial till adjacent to the proposed test section prior to construction. The piezometers should be completed as close as possible to the edge of the top of the bluff. Data logging pressure transducers should be placed in each piezometer prior to construction of the test section, and data should be collected for approximately two weeks before and two months after construction. In addition to the data logging pressure transducers, manual water level measurements should be collected from the new piezometers and nearby previously existing monitoring wells/piezometers on a weekly basis for the same time frame. This data will be used to investigate potential changes in pore pressure as a result of construction.

Table L-3: Groundwater Seepage Calculations

SAMPLE IDENTIFICATION				PARTICLE SIZE ANALYSIS (% FINER)																	ATTERBERG LIMITS			MOIST. CONT.	SPECIFIC GRAVITY	ASTM CLASS.	FROST CLASS.		
				STANDARD SIEVE SIZE (mm on bottom)														(mm)											
HOLE	HOLE	NO.		3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	%					
			DEPTH (FT.)	76.2	50.8	38.1	25.4	19.1	12.7	9.53	4.76	2	0.84	0.42	0.25	0.11	0.07	0.0	0.005	0.002								K (cm/sec)	K (ft/sec)
Surficial Soil/Fill																													
AP-626	TB-04	1	0.5 - 1.5					100	98	96	91	82	80	77	72	64	56	35.5	22.6	14.1				25		CL-ML*	F4*	4.95E-04	1.62E-05
AP-625	TB-05	1	0.5 - 1.0					100	98	95	90	79	76	71	65	58	55	39.1	25.0	16.0				78		CL-ML*	F4*	4.80E-04	1.58E-05
AP-624	TB-06	1	0.5 - 1.0			100	95	83	70	64	55	46	43	39	31	26	25	16.9	10.9	7.1				22		GC*	F2	7.36E-06	2.41E-07
																											Average =	**3.28E-04**	**1.07E-05**
Glacial Till																													
AP-620-MW	TB-02	10	40.0 - 41.4				100	99	98	98	97	96	94	90	87	83	81				35	21	14	16	2.747	CL	F3	7.77E-05	2.55E-06
AP-608-MW	TB-1a	11	45.0 - 46.5			100	98	97	95	93	88	84	67	16	5	2	1.8							2.3		SP	NFS	4.28E-02	1.41E-03
AP-614-MW	TB-3a	11	45.0 - 46.5						100	99	98	96	94	86	72	48	42							16		SC*	F3*	1.41E-03	4.64E-05
AP-617-MW	TB-4a	11	45.0 - 46.5				100	98	97	96	93	89	86	83	75	57	54							15		CL*	F3*	7.10E-04	2.33E-05
AP-611-MW	TB-2c	12	50.0 - 51.5		100	82	82	79	79	79	78	76	75	73	70	63	60				27	16	11	11		CL	F4	1.34E-05	4.40E-07
AP-608-MW	TB-1a	13	55.0 - 56.5										100	53	6	2	1.3							2.8		SP	NFS	2.80E-02	9.18E-04
AP-614-MW	TB-3a	13	55.0 - 56.5						100	99	99	98	96	94	90	83	79				24	15	9	14	2.682	CL	F4	3.72E-05	1.22E-06
AP-617-MW	TB-4a	13	55.0 - 56.5				100	92	90	87	84	81	78	74	69	65	63				31	18	13	13		CL	F3	1.78E-04	5.84E-06
AP-611-MW	TB-2c	14	60.0 - 61.5							100	98	97	95	93	90	78	72				26	16	10	15		CL	F4	4.02E-05	1.32E-06
AP-614-MW	TB-3a	14	60.0 - 61.5					100	99	98	97	95	94	92	88	79	75				27	15	12	13		CL	F4	8.20E-05	2.69E-06
AP-617-MW	TB-4a	14	60.0 - 61.5					100	98	97	94	92	90	88	82	74	71				33	17	16	15		CL	F3	1.15E-04	3.77E-06
AP-608-MW	TB-1a	15	65.0 - 66.5					100	99	99	99	98	96	49	8	4	3.0							9.7		SP	NFS	2.67E-02	8.76E-04
AP-611-MW	TB-2c	16	70.0 - 71.5										100	99	95	82	75				22	14	8	18		CL	F4	1.19E-05	3.91E-07
AP-614-MW	TB-3a	16	70.0 - 71.5						100	99	98	97	97	95	93	83	79				31	18	13	17		CL	F3	4.28E-05	1.40E-06
AP-617-MW	TB-4a	16	70.0 - 71.5			100	98	96	95	95	93	92	91	89	86	78	74				27	16	11	13	2.724	CL*	F3*	1.46E-04	4.78E-06
AP-611-MW	TB-2c	17	75.0 - 76.5							100	99	99	99	98	96	86	78				24	16	8	15		CL	F4	1.82E-05	5.99E-07
AP-614-MW	TB-3a	17	75.0 - 76.5					100	99	98	96	94	93	90	84	61	53							15		CL*	F3*	7.10E-04	2.33E-05
AP-615-MW	TB-3b	1	75.0 - 76.5				100	99	99	99	98	98	97	96	92	61	51							19		CL*	F3*	7.10E-04	2.33E-05
AP-617-MW	TB-4a	17	75.0 - 76.5		100	97	96	95	93	89	79	66	65	63	60	54	51	36.2	23.8	15.4				15		CL*	F3*	6.58E-04	2.16E-05
AP-608-MW	TB-1a	18	80.0 - 81.5					100	98	97	94	88	79	66	24	12	11							17		SP-SM*	F2*	2.19E-03	7.19E-05
AP-614-MW	TB-3a	18	80.0 - 81.5				100	99	99	99	98	94	93	92	88	80	76	52.8	34.9	21.4				17		CL*	F3*	8.27E-05	2.71E-06
AP-617-MW	TB-4a	18	80.0 - 81.5					100	99	99	97	96	95	93	89	75	69				24	16	8	14		CL	F4	6.15E-05	2.02E-06
AP-608-MW	TB-1a	19	85.0 - 86.5			100	94	94	93	92	85	83	81	78	74	67	63				24	15	9	13		CL	F4	1.52E-04	4.98E-06
AP-614-MW	TB-3a	19	85.0 - 86.0					100	97	97	94	94	91	68	42	33	30							18		SC*	F3*	5.86E-03	1.92E-04
AP-617-MW	TB-4a	20	90.0 - 91.5				100	99	98	98	96	95	94	92	88	80	76							17		CL*	F3*	8.84E-05	2.90E-06
AP-608-MW	TB-1a	21	95.0 - 96.5					100	99	99	98	97	96	95	91	84	80				27	16	11	16		CL	F4	4.27E-05	1.40E-06
AP-611-MW	TB-2c	22	100.0 - 101.5								100	99	99	99	97	91	82							20		CL*	F3*	1.42E-05	4.64E-07
AP-614-MW	TB-3a	22	100.0 - 101.5									100	99	87	24	7	6.1							24		SP-SM*	S2*	6.82E-03	2.24E-04
																											Average =	**4.21E-03**	**1.38E-04**

SAMPLE IDENTIFICATION HOLE	HOLE	NO.	DEPTH (FT.)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	MOIST. CONT. %	SPECIFIC GRAVITY	ASTM CLASS.	FROST CLASS.	K (cm/sec)	K (ft/sec)
				PARTICLE SIZE ANALYSIS (% FINER) STANDARD SIEVE SIZE (mm on bottom) 76.2	50.8	38.1	25.4	19.1	12.7	9.53	4.76	2	0.84	0.42	0.25	0.11	0.07	(mm) 0.0	0.005	0.002	ATTERBERG LIMITS								
Alluvial Deposits																													
AP-627	TB-01	2	2.5 - 4.0					100	98	97	95	93	90	87	77	64	59							17		CL*	F3*	1.45E-04	4.76E-06
AP-620-MW	TB-02	2	2.5 - 4.0						100	99	98	98	96	88	64	27	22							10		SM*	F3*	3.04E-03	9.98E-05
AP-626	TB-04	2	2.5 - 4.0			100	90	90	89	89	88	87	86	85	77	58	51				19	13	6	28		CL-ML	F4	7.10E-04	2.33E-05
AP-625	TB-05	2	2.5 - 4.0				100	99	98	97	96	94	93	91	88	81	77				27	16	11	17		CL	F4	1.16E-04	3.80E-06
AP-622	TB-08	2	2.5 - 4.5										100	99	98	95	94				49	28	21	37		ML	F4	3.67E-06	1.20E-07
AP-611-MW	TB-2c	2	2.5 - 4.0						100	99	98	97	96	87	49	29	27							10		SM*	F3*	4.53E-03	1.49E-04
AP-624	TB-06	3	3.0 - 4.0									100	99	98	55	8	4.5							21		SP*	NFS*	4.94E-03	1.62E-04
AP-627	TB-01	3	5.0 - 6.5				100	99	97	96	92	86	85	83	80	72	68	47.3	30.5	19.1				15		CL*	F3*	1.57E-04	5.15E-06
AP-621-MW	TB-03	3	5.0 - 6.5					100	98	95	89	84	79	62	18	3	2.7							6.2		SP	NFS	1.19E-02	3.91E-04
AP-626	TB-04	3	5.0 - 6.5				100	98	97	96	94	93	92	90	85	76	72				27	16	11	15		CL	F4	1.32E-04	4.34E-06
AP-625	TB-05	3	5.0 - 6.5						100	99	98	96	95	93	90	84	81				26	16	10	17		CL	F4	4.65E-05	1.52E-06
AP-623	TB-07	3	5.0 - 6.5								100	99	99	96	26	2	1.6							3.8		SP	NFS	9.40E-03	3.09E-04
AP-608-MW	TB-1a	3	5.0 - 6.5							100	97	95	91	82	66	56	52							27		ML*	F4	7.10E-04	2.33E-05
AP-614-MW	TB-3a	3	5.0 - 6.5				100	99	99	97	89	80	67	42	14	5	4.2							5.8		SP	PFS*	1.38E-02	4.52E-04
AP-627	TB-01	4	10.0 - 11.5					100	99	99	98	97	96	94	91	74	68				29	17	12	17		CL	F4	5.33E-05	1.75E-06
AP-620-MW	TB-02	4	10.0 - 11.5			100	99	99	97	96	93	87	76	43	12	2	1.7							5.1		SP	NFS	1.95E-02	6.41E-04
AP-625	TB-05	4	10.0 - 11.5							100	98	97	93	40	10	3	2.3							14		SP	NFS	2.50E-02	8.20E-04
AP-624	TB-06	6	10.0 - 11.5			100	97	94	93	92	90	88	87	86	83	76	72				29	16	13	15		CL	F3	1.87E-04	6.13E-06
AP-623	TB-07	4	10.0 - 11.5								100	99	98	94	53	14	10							13		SP-SC*	F2*	2.19E-03	7.19E-05
AP-617-MW	TB-4a	4	10.0 - 11.5							100	99	97	94	69	22	5	3.9							6.5		SP	NFS*	8.72E-03	2.86E-04
AP-626	TB-04	5	10.5 - 11.5				100	99	99	97	94	92	89	58	24	5	3.9							16		SP	S2*	8.20E-03	2.69E-04
AP-622	TB-08	5	10.5 - 11.5			100	94	87	74	67	52	42	38	30	17	10	9.1							10		GP-GM*	F1*	4.41E-03	1.45E-04
AP-620-MW	TB-02	5	15.0 - 16.5								100	99	96	77	25	5	4.4				NV	NV	NP	4.6	2.716	SP	S2*	7.98E-03	2.62E-04
AP-621-MW	TB-03	5	15.0 - 16.5							100	99	98	94	72	25	5	4.3							7.7		SP	S2*	7.98E-03	2.62E-04
AP-626	TB-04	6	15.0 - 16.0							100	99	99	96	45	17	6	4.9							20		SP	S2*	9.95E-03	3.26E-04
AP-625	TB-05	5	15.0 - 16.5								100	99	90	37	5	1.4	1.2							20		SP	NFS	3.06E-02	1.00E-03
AP-624	TB-06	7	15.0 - 16.0										100	66	18	2	1.3							22		SP	NFS	1.26E-02	4.13E-04
AP-623	TB-07	5	15.0 - 16.5										100	95	30	3	1.9							22		SP	NFS	8.13E-03	2.67E-04
AP-622	TB-08	6	15.0 - 16.5				100	94	93	92	88	83	79	73	61	52	49				18	12	6	14		SC-SM	F4*	8.64E-04	2.83E-05
AP-611-MW	TB-2c	5	15.0 - 16.5				100	98	97	96	93	88	77	38	7	2	1.2							3.5		SP	NFS	2.84E-02	9.32E-04
AP-614-MW	TB-3a	5	15.0 - 16.5								100	99	97	78	23	4	3.1							4.8		SP	NFS*	9.09E-03	2.98E-04
AP-624	TB-06	8	16.0 - 16.5						100	99	99	98	97	94	87	77	73				26	15	11	17		CL	F4	4.03E-05	1.32E-06
AP-627	TB-01	6	20.0 - 21.5				100	99	99	98	97	95	94	91	85	62	54							17		CL*	F3*	7.10E-04	2.33E-05
AP-620-MW	TB-02	6	20.0 - 21.5							100	99	99	97	83	37	5	3.9							6.0		SP	NFS*	6.52E-03	2.14E-04
AP-621-MW	TB-03	6	20.0 - 21.5					100	97	96	92	90	89	81	37	6	3.6							12		SP	NFS*	6.12E-03	2.01E-04
AP-620-MW	TB-02	7	25.0 - 26.5			100	98	97	95	94	90	86	80	52	18	4	3.3							7.6		SP	NFS*	1.12E-02	3.67E-04
AP-622	TB-08	8	25.0 - 26.5				100	97	97	96	91	90	88	86	82	74	70				25	14	11	14		CL	F4	1.10E-04	3.62E-06
AP-608-MW	TB-1a	7	25.0 - 26.5						100	99	99	99	97	67	17	5	3.7							4.3		SP	NFS*	1.09E-02	3.59E-04
AP-614-MW	TB-3a	7	25.0 - 26.5								100	99	99	84	30	8	5.3							4.9		SP-SM*	S2*	5.59E-03	1.83E-04
AP-617-MW	TB-4a	7	25.0 - 26.5								100	99	96	67	22	6	4.3							8.4		SP	NFS*	7.98E-03	2.62E-04
AP-620-MW	TB-02	8	30.0 - 31.5			100	99	98	96	93	88	82	72	42	19	5	3.2							21		SP	NFS*	9.83E-03	3.23E-04
AP-621-MW	TB-03	8	30.0 - 31.5						100	99	98	97	92	66	29	9	6.5							19		SP-SM*	S2*	5.04E-03	1.65E-04
AP-622	TB-08	9	30.0 - 31.5								100	99	98	97	94	90	88				29	16	13	17		CL	F3	1.21E-05	3.98E-07
AP-611-MW	TB-2c	8	30.0 - 31.5				100	99	98	97	94	92	86	50	12	5	3.0							5.1		SP	NFS	1.74E-02	5.71E-04
AP-614-MW	TB-3a	9	35.0 - 36.5			100	98	96	90	85	68	53	44	27	12	6	5.5	3.3	1.3	0.6				2.4		SP-SM*	S2	1.63E-02	5.34E-04
																											Average =	**7.36E-03**	**2.42E-04**

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FINAL SUBMITTAL

GROUNDWATER MONITORING REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

CONTRACT NO. W911KB-05-D-0004
DELIVERY ORDER NO. 0010
MODIFICATION NO. 01

Prepared for:

U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. Box 6898
Elmendorf AFB, Alaska 99506

January, 2008

R&M
R&M CONSULTANTS, INC.

R&M CONSULTANTS, INC. (907) 522-1707, FAX (907) 522-3403, www.rmconsult.com
9101 Vanguard Drive, Anchorage, Alaska 99507

January 15, 2008

R&M No. 1209.10

U.S. Army Engineer District, Alaska
ATTN: Mr. Chuck Wilson (CEPOA-EN-ES-SG)
P.O. Box 6898
Elmendorf AFB, Alaska 99506

RE: Groundwater Monitoring Report
Kenai River Bluff Erosion
Kenai, Alaska
Contract No. W911KB-05-D-0004, Delivery Order No. 0010, Modification No. 01

Gentlemen:

Attached find our final submittal for the above-referenced groundwater monitoring. This report was prepared under the terms of Contract No. W911KB-05-D-0004, Delivery Order No. 0010, Modification No. 01.

We trust that this final report is found to be responsive to your requirements. Should you have any questions or require further information, please contact us.

Very truly yours,

R&M CONSULTANTS, INC.

Charles H. Riddle, C.P.G.
Vice President

CHR:ATB*slv

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FINAL SUBMITTAL

GROUNDWATER MONITORING REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

CONTRACT NO. W911KB-05-D-0004
DELIVERY ORDER NO. 0010
MODIFICATION NO. 01

Prepared for:

U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. Box 6898
Elmendorf AFB, Alaska 99506

Attention:
Mr. Chuck Wilson
CEPOA-EN-ES-SG

Prepared by:

R&M CONSULTANTS, INC.
9101 Vanguard Drive
Anchorage, Alaska 99507

January, 2008

GROUNDWATER MONITORING REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

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KENAI RIVER BLUFF EROSION

KENAI, ALASKA

1.0 INTRODUCTION

1.1 Background

For many years, the City of Kenai has been concerned with the ongoing erosion of a one mile portion of the steep bluff along the right bank of the Kenai River within the city. This erosion has required the relocation of privately owned buildings as well as city infrastructure and utilities. Unless measures to control the erosion and protect the bluff are implemented, bluff erosion is expected to continue, further threatening existing buildings, infrastructure, and utilities within proximity to the bluff.

The U.S. Army Corps of Engineers - Alaska District (USACE-AD) has conducted a geotechnical investigation to provide design-level information for the Kenai River Bluff Erosion Project. The geotechnical investigation provides site-specific geotechnical design information necessary to establish an erosion control method that is technically feasible and satisfies resource agency needs. The work consisted of drilling and logging test borings, installing groundwater monitoring wells, laboratory testing, and the preparation of various reports. Ultimately, the geotechnical data obtained will be used, in conjunction with other considerations, in developing the specifications and design criteria for the project.

R&M Consultants, Inc. (R&M) was tasked by the USACE-AD to provide professional geotechnical services for the project. Drilling, sampling, and groundwater monitoring well installation services were performed by Discovery Drilling, Inc. of Anchorage, Alaska under direct contract to R&M. During the geotechnical field investigations, a total of 20 test borings were drilled and sampled at the project site. Fourteen (14) of these test borings were completed as groundwater monitoring wells.

The regional setting, site conditions, geotechnical conditions, bluff mapping results, and groundwater conditions are discussed in R&M's prior Geotechnical Investigation and Site Conditions Report (R&M, 2007).

1.2 Contract Authorization

This work was completed under the terms of Contract No. W911KB-05-D-0004 between the U.S. Army Corps of Engineers – Alaska District and R&M Consultants, Inc. The groundwater monitoring and this report were completed in specific fulfillment of Delivery Order No. 0010, Modification No. 01.

Measurements and weights presented in this report are generally shown as U.S. customary units. Where previous investigations and reports have utilized SI units, we have retained the units expressed in the original document. A conversion chart is included as Table 1 for use in conversion from U.S. customary units to the International System (SI) units. Actual conversion should be made with the appropriate numbers carried to three or more significant figures.

1.3 Purpose and Scope-of-Work

The intent of this groundwater monitoring program has been to provide a monthly cycle of groundwater table elevation information to evaluate the hydraulic conditions for the analysis and design of a bluff stabilization project. This report presents a summary of the results of R&M's monthly groundwater monitoring program.

This work was performed under a Statement-of-Work prepared by the USACE-AD, revised 13 September 2006.

No hydrogeologic analysis or recommendations were required under the Statement-of-Work.

1.4 Existing Information

The following document is a predecessor to the current report and provides detailed information concerning our site investigation.

R&M Consultants, Inc. (R&M), "Geotechnical Investigation and Site Conditions Report, Kenai River Bluff Erosion, Kenai, Alaska", Final Submittal, Contract No. W911KB-05-D-0004, Delivery Order 0010, prepared for U.S. Army Engineer District, Alaska, 14 February 2007.

Additionally, a number of pertinent U.S. Geological Survey documents and other technical reports are cited and listed within the References section of the February 2007 report.

2.0 GROUNDWATER MONITORING

Methods of groundwater monitoring for the Kenai River Bluff Erosion project can be divided into the following categories.

- Test Borings
- Groundwater Monitoring Well Installation
- Groundwater Monitoring
- Monitoring Well Location Surveys

2.1 Test Borings

Test borings were located and drilled to meet two primary objectives. Both of which are presented in R&M's Geotechnical Investigation and Site Conditions Report (R&M, 2007). The first objective involves delineating the subsurface soil conditions, and the second entails a study of the groundwater regime in the area.

A total of twenty (20) test borings were drilled by R&M at the project site during the period of November 9, 2006 through December 16, 2006, fourteen (14) of which were completed as groundwater monitoring wells. Each of the borings was logged in accordance with standard engineering practices, and data obtained in this manner were utilized to determine geotechnical site conditions. The depth of the test borings ranged from 30 to 101.5 feet. The total number of feet drilled during the field program was approximately 1,135. Drilling and sampling operations were performed by Discovery Drilling, Inc. of Anchorage, Alaska under direct contract to R&M. Approximate test boring locations are shown on Drawings A-02 through A-07 of Appendix A. Logs of the monitoring well test borings, including logs provided by others are illustrated in Appendix B, Drawings B-03 through B-29. A key to the test hole log general notes and an example of a typical log are illustrated on Drawings B-01 and B-02, respectively. Table 2 provides a summary of R&M monitoring well test borings performed for the project.

Soil boring, sampling, and groundwater well installation on the bluff crest were performed utilizing a truck-mounted CME-75 drill rig. Test borings were advanced using continuous flight, hollow-stem augers. Representative soil samples were generally obtained at the surface, at 2.5 feet and five feet, and then at approximately five-foot intervals or at obvious changes in soil strata. However at each grouping of three groundwater monitoring well installations (e.g. AP-608-MW through AP-610-MW), only one of the three borings was sampled and logged in detail. The other two borings were only sampled at the bottom of the boring.

The drilling program was conducted under the supervision of an experienced engineering geologist who maintained a detailed log of the materials encountered and the samples attempted and recovered. Representative soil samples generally were collected either by means of grab samples taken directly off of the augers, in the case of the surface sample, or via split-spoon samplers. In all but one boring, disturbed samples were obtained using a 2.5-inch I.D. (3.0-inch O.D.) split-spoon sampler driven by means of a 340-lb hammer with a 30-inch free-fall stroke.

Both manual (rope and cathead) and automatic (hydraulic) hammers were used on this project, as denoted for each sample on the logs of test borings in Appendix B. The penetration resistance, defined as the number of blows required to drive the sampler the last 12 inches of an 18-inch interval, gives an indication of the in-place relative density for unfrozen cohesionless soils. Blow counts reported per six-inch interval are shown on boring logs in Appendix B. Penetration resistances thus obtained can be corrected to approximate the Standard Penetration Test (SPT) "N" values by an energy to area ratio adjustment. A correction factor should be used to convert actual blow counts to the corresponding approximate SPT blow counts. Note, however, that the blow counts appearing on the logs of test borings are actual values, not converted SPT values. The Standard Penetration Test (SPT) was performed in the upper 40 feet of Test Boring AP-617-MW utilizing the 1.4-inch I.D. (2.0-inch O.D.) drive sampler and a 140-pound automatic drop hammer.

It should be noted that heaving or flowing sands interfered with sampling in the deeper test borings located on the bluff crest. The logs of test borings in Appendix B include notes on whether a sampler was overfilled with heaving sand, or whether samples were not attempted below a certain depth due to heaving sand flowing up into the augers.

All soils recovered were visually classified and logged in the field following ASTM Designation D 2488. After visual and tactile classification in the field, all soil samples were returned to the R&M laboratory. Representative samples were then selected for further examination and testing.

2.2 Groundwater Monitoring Well Installation

After completion of drilling, fourteen (14) of the test borings on the crest of the bluff were completed as groundwater monitoring wells. Groundwater monitoring wells were installed in general accordance with ASTM Designation D 5092, "Design and Installation of Groundwater Monitoring Wells in Aquifers". Each monitoring well was constructed to allow for the accurate measurement of groundwater depths relative to the top of the well riser. The well riser pipe was constructed of 2-inch I.D. polyvinyl chloride (PVC) pipe. A locking steel protective over casing was installed around the well riser pipe extending approximately three feet below and three feet above the top of ground surface. Bollards were placed around some of the installations to protect the wells from traffic and snow removal equipment.

A typical groundwater monitoring well schematic for wells installed by R&M is presented as Figure 1. Monitoring well photographs are shown in Figure 2.

2.3 Groundwater Monitoring

Groundwater monitoring occurred on a monthly basis in the 14 R&M test borings that were converted to monitoring wells and the three pre-existing American Environmental monitoring wells. Prior to the fifth reading, groundwater monitoring was expanded, at the request of the USACE, to include the four pre-existing USACE monitoring wells. This monitoring continued to occur on this basis for a period of one year from the installation date of the original 14 R&M monitoring wells.

FIGURE 1

TYPICAL GROUNDWATER MONITORING WELL GROUP

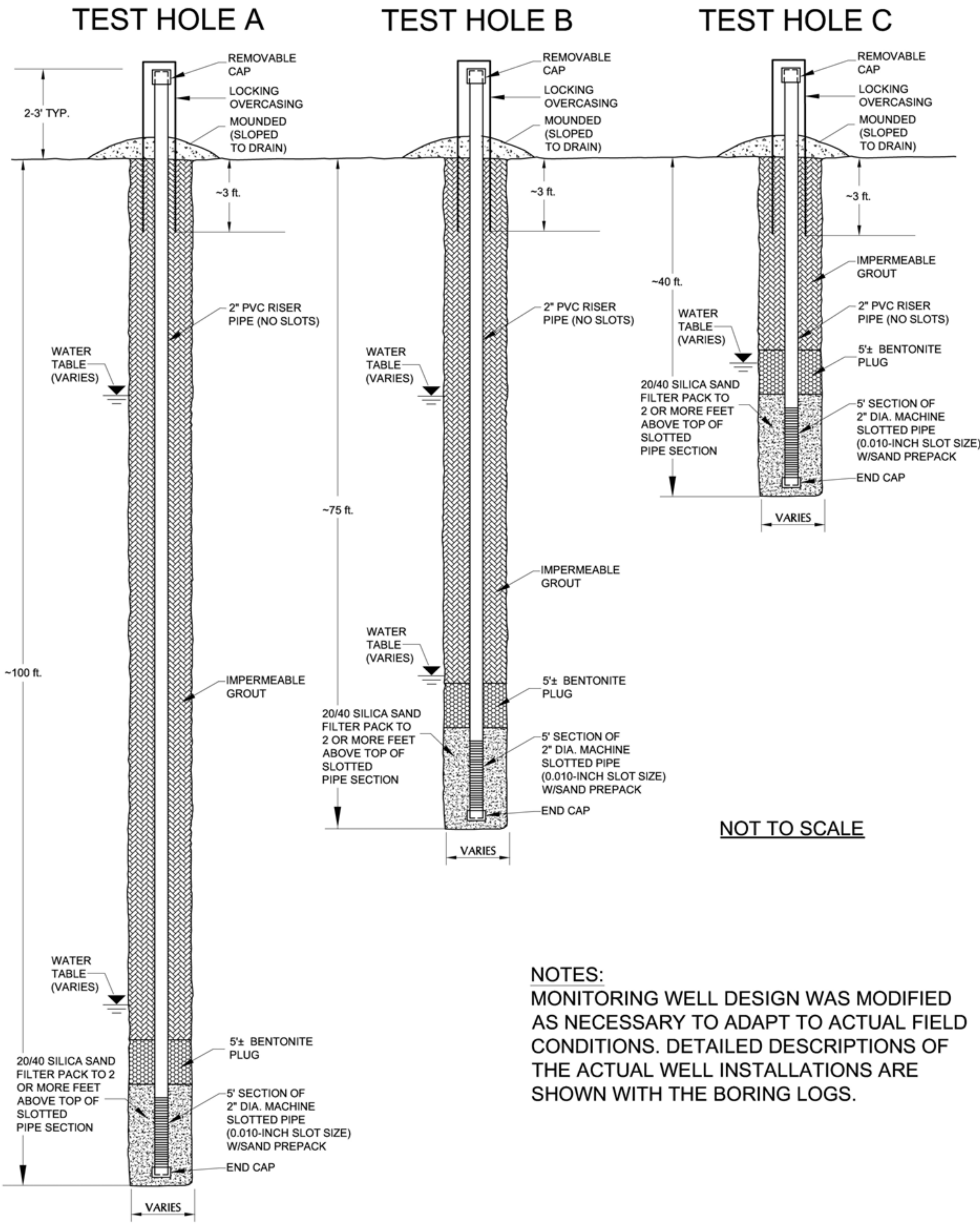


FIGURE 2

PHOTOGRAPHS SHOWING MONITORING WELLS

a. Monitoring well installation at Group 3 borings with protective bollards. December, 2006.

b. Grouting at Group 2 borings. November, 2006.

Access to the protective over casings was gained and a Solinst Model 101 water level meter was lowered down the well to measure the groundwater level. The water level meter tape is measured against a constant point on each well casing to ensure a consistent measuring point.

Two exceptions to this process were with regard to Monitoring Wells AP-606 and AP-607, which were installed by the USACE. Monitoring Well AP-606 was unable to be located in the field and no readings were obtained. Monitoring Well AP-607 was constructed with ¾-inch nominal O.D. PVC piping, and a wooden dowel float was lowered down the well until reaching equilibrium. The measuring point along the float line was then marked against a constant point on the well casing and the groundwater depth was measured with a tape after removal.

Groundwater levels were measured upon completion of the monitoring well installation and were measured monthly for one year, with a total of 13 readings for most monitoring wells. A summary presenting monitoring well identification, date, time, and groundwater elevations is provided in Appendix C as Table C-01. A summary of groundwater elevation trends for the year-long monitoring period is presented in Appendix C as Figures C-02 through C-06.

2.4 Monitoring Well Location Surveys

Survey information was based on a field survey performed by R&M Consultants, Inc. during January, 2007. The project coordinates are ACS83 Zone 4, U.S. Survey Feet. The project datum is NAD83 (CORS). The project coordinates and datum were established by ties to CP 1 and USC&GS BM NO. 3 1966 from the DOWL Engineers drawing "Kenai River Bluff Erosion Survey Topography" dated July 16, 2003. The vertical datum was established by holding USC&GS BM NO. 3 1966 with an elevation of 31.44 feet. The drawing indicates that the vertical datum is referenced to Mean Lower Low Water (2003) in U.S. Survey Feet.

Monitor wells and test borings were located horizontally using RTK GPS techniques and vertically by a combination of RTK GPS and differential leveling techniques. The RTK GPS accuracy was quality controlled by taking three-dimensional check shots on established control positions. All of the check positions fell within the tolerances defined in the scope of the project.

The elevations for the top of the pipe of the monitor wells were determined by differential levels run from TBMs with elevations established by RTK GPS. The wells were broken up into four groups based on proximity. One TBM was established for each group of wells with RTK GPS. Differential levels were then run from the TBM to the group of wells in the surrounding area. All level loops closed well within the tolerances defined in the scope of the project.

Elevations for Monitoring Wells AP-604 through AP-607 were based on information provided on the monitoring well installation logs provided by the USACE. Distances between the collar elevations and the well casing measuring points are approximate and accuracy of groundwater elevations within these wells should also be considered approximate.

3.0 CLOSURE

R&M Consultants, Inc. performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. This report is intended for use only in accordance with the purposes of study described within.

We appreciate the opportunity to perform this groundwater monitoring program. Should you require further information concerning the monitoring or this report, please contact us at your convenience.

Very truly yours,

R&M CONSULTANTS, INC.

STATE OF ALASKA
49TH
Robert M. Pintner
CE 8525
1/15/2008
REGISTERED PROFESSIONAL ENGINEER

Aaron T. Banks
Engineering Geologist

Robert M. Pintner, P.E.
Senior Geotechnical Engineer

Charles H. Riddle, C.P.G.
Vice President

CHR:ATB*slv

TABLE 1

CONVERSION FACTORS FOR SI UNITS

CONVERSION TO THE SI INTERNATIONAL SYSTEM OF UNITS		
To Convert From	**To**	**Multiply By**
Mile	Kilometer (km)	1.609344
Mile	Meter (m)	1,609.344
Foot	Meter (m)	0.3048
Foot	Centimeter (cm)	30.48
Inch	Centimeter (cm)	2.54
Square Foot	Square Meter (m^2)	0.09290304
Square Yard	Square Meter (m^2)	0.8361274
Acre	Square Meter (m^2)	4,046.825
Cubic Foot (cf)	Cubic Meter (m^3)	0.02831685
Cubic Yard (cy)	Cubic Meter (m^3)	0.7645549
Gallon (U.S. Liquid)	Cubic Meter (m^3)	0.003785412
Pound-Mass (lbf)	Kilogram (kg)	0.4535924
Ton (short)	Kilogram (kg)	907.1847
Pound-Force (lbf)	Newton (N)	4.448222
Degree Fahrenheit (°F)	Degree Celsius (°C)	T°C=(T°F-32)/1.8
Pound per Square Foot (psf)	Kilonewtons per Square Meter (kN/m^2)	0.47880
Pound per Cubic Foot (pcf)	Kilonewtons per Cubic Meter (kN/m^3)	0.157087

TABLE 2

SUMMARY OF MONITORING WELL TEST BORINGS
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

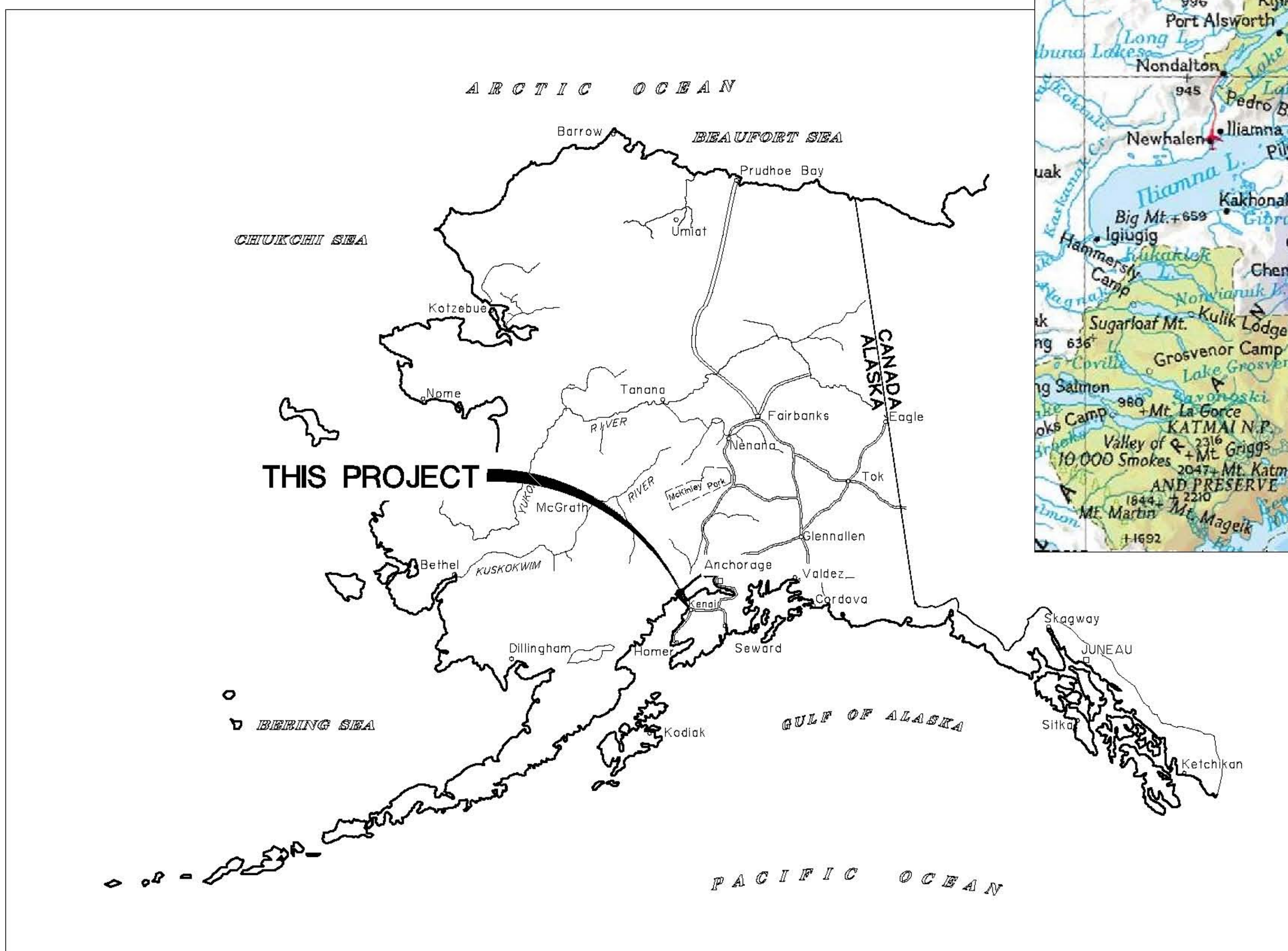
TEST BORING NUMBER (FINAL)	TEST BORING NUMBER (FIELD)	COORDINATES (FEET)		COLLAR ELEVATION (FEET)	TOTAL DEPTH (FEET)
		NORTHING	EASTING		
AP-608-MW	TB-1A	2,395,412.81	1,413,139.72	88.4	101.2
AP-609-MW	TB-1B	2,395,415.41	1,413,150.90	88.6	76.5
AP-610-MW	TB-1C	2,395,430.86	1,413,141.62	88.9	41.3
AP-611-MW	TB-2C	2,395,775.73	1,414,431.97	91.1	101.5
AP-612-MW	TB-2B	2,395,786.22	1,414,437.68	91.3	76.5
AP-613-MW	TB-2A	2,395,795.10	1,414,440.67	91.0	41.5
AP-614-MW	TB-3A	2,396,258.31	1,415,755.43	93.9	101.5
AP-615-MW	TB-3B	2,396,268.68	1,415,756.19	93.5	76.5
AP-616-MW	TB-3C	2,396,280.50	1,415,756.60	93.7	41.5
AP-617-MW	TB-4A	2,396,189.80	1,416,979.96	92.9	101.5
AP-618-MW	TB-4B	2,396,207.48	1,416,981.72	93.1	70.0
AP-619-MW	TB-4C	2,396,224.77	1,416,982.32	93.1	40.0
AP-620-MW	TB-02	2,396,321.05	1,414,354.82	92.2	41.4
AP-621-MW	TB-03	2,396,759.77	1,417,031.71	92.7	41.0

AP = Auger Point
TB = Test Boring
MW = Monitoring Well

APPENDIX A
SITE MAPS

CORPS OF ENGINEERS

U. S. ARMY



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R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

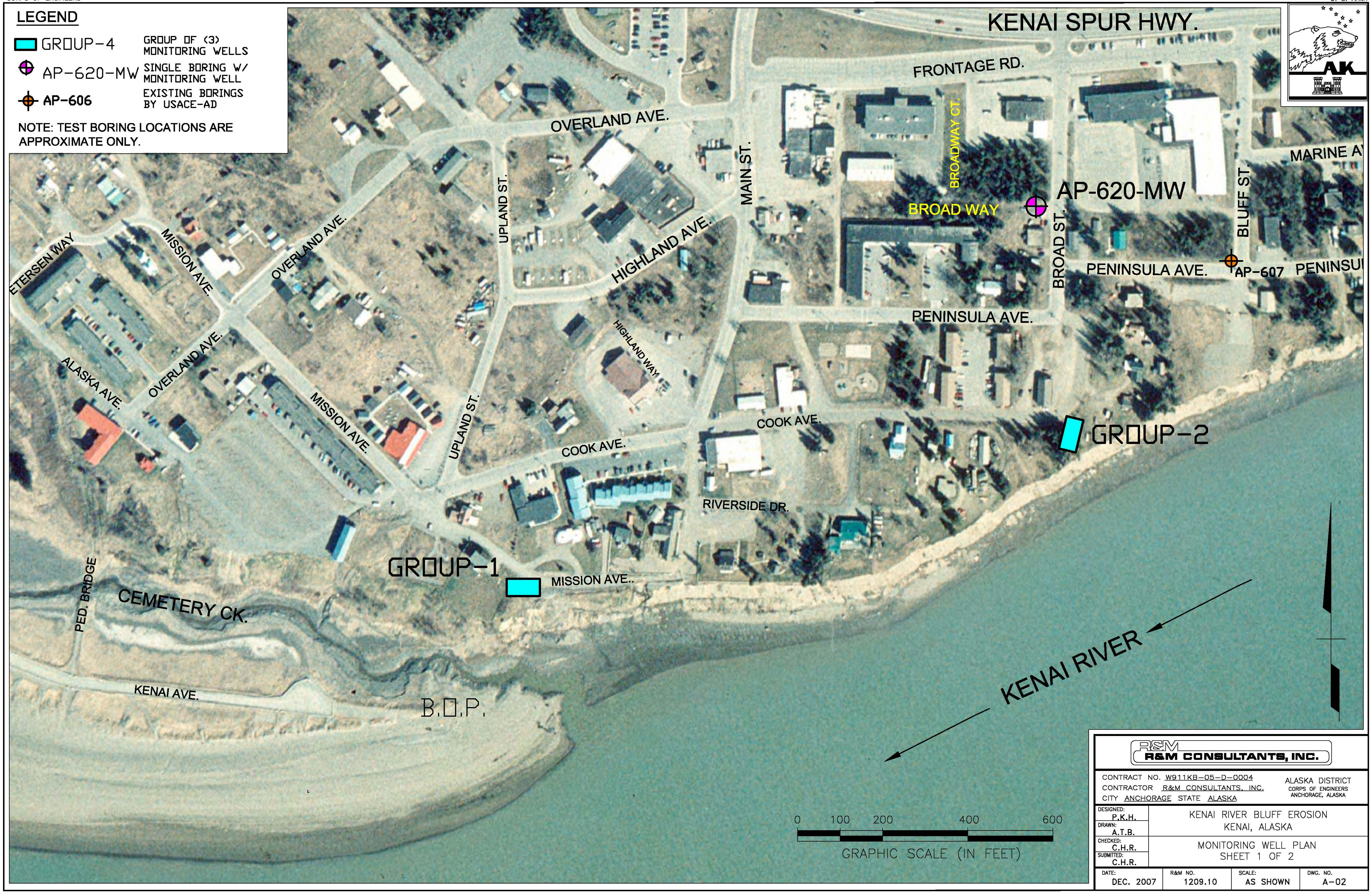
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	VICINITY MAP
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	A-01

CORPS OF ENGINEERS

U. S. ARMY



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Plotted 1/15/2008 9:38 AM by PHardcastle

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: A.T.B.	
CHECKED: C.H.R.	MONITORING WELL PLAN SHEET 1 OF 2
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
DEC. 2007	1209.10	AS SHOWN	A-02

CORPS OF ENGINEERS

U. S. ARMY

LEGEND

GROUP-4	GROUP OF (3) MONITORING WELLS
AP-620-MW	SINGLE SOILS BORING W/MONITORING WELL
AP-606	EXISTING BORINGS BY USACE-AD
MW-1	EXISTING BORINGS BY AMER. ENV.

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: A.T.B.	
CHECKED: C.H.R.	MONITORING WELL PLAN SHEET 2 OF 2
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
DEC. 2007	1209.10	AS SHOWN	A-03

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NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300

GRAPHIC SCALE (IN FEET)

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CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.
DRAWN: A.T.B.
CHECKED: C.H.R.
SUBMITTED: C.H.R.

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

MONITORING WELL LOCATION MAP
GROUP 1 AND VICINITY

DATE: DEC. 2007
R&M NO. 1209.10
SCALE: AS SHOWN
DWG. NO. A-04

Plotted 1/15/2008 9:51 AM by PHardcastle

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300

GRAPHIC SCALE (IN FEET)

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA		ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA	
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION		
DRAWN: A.T.B.	KENAI, ALASKA		
CHECKED: C.H.R.	MONITORING WELL LOCATION MAP		
SUBMITTED: C.H.R.	GROUP 2 AND VICINITY		
DATE: DEC. 2007	R&M NO. 1209.10	SCALE: AS SHOWN	DWG. NO. A-05

Plotted 1/15/2008 9:55 AM by PHardcastle Z:\project\1209.10\acad\geo\acad\GW Report Kenai Site Plan A-02-07 New.dwg

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300

GRAPHIC SCALE (IN FEET)

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

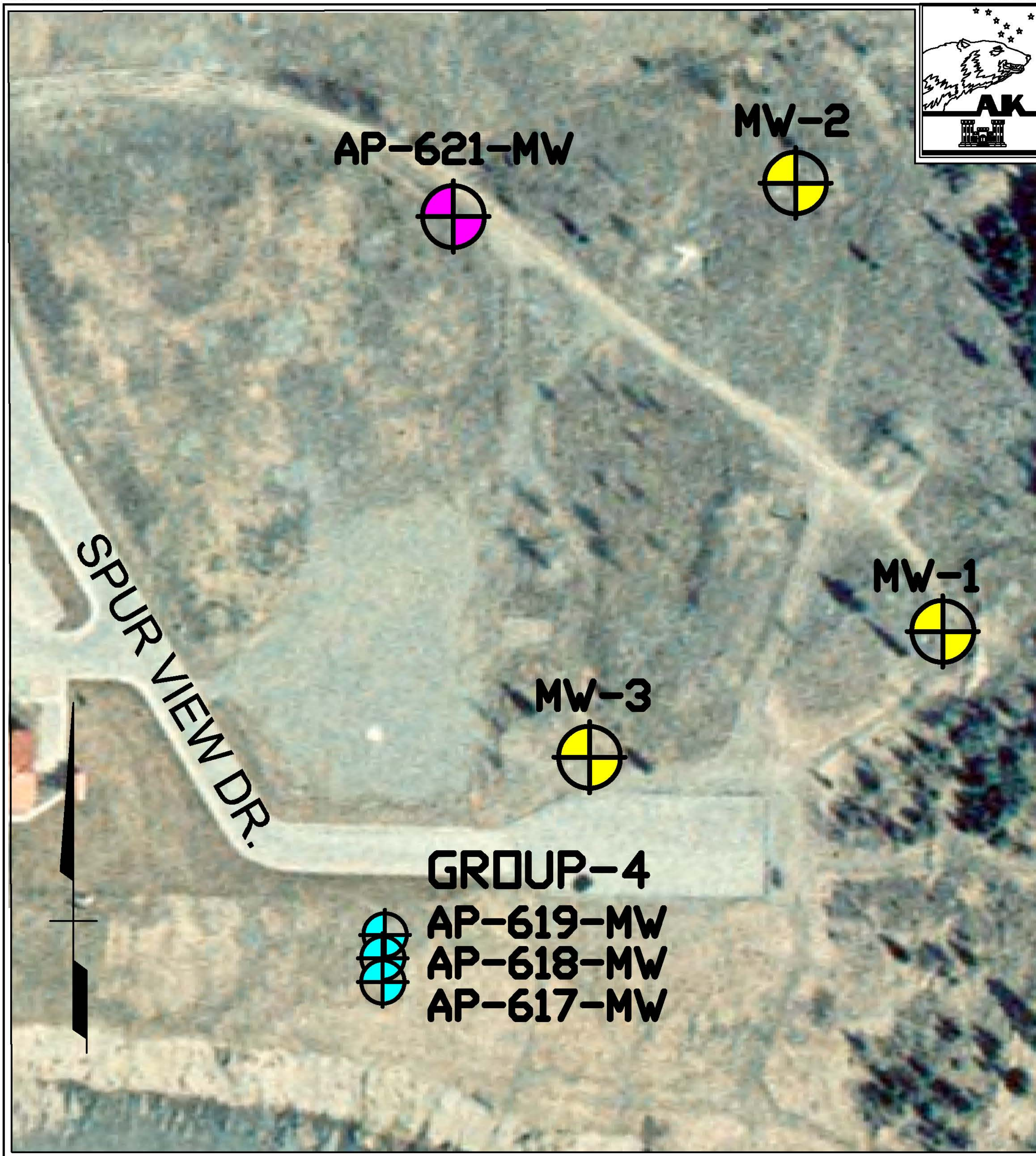
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: A.T.B.	KENAI, ALASKA
CHECKED: C.H.R.	MONITORING WELL LOCATION MAP
SUBMITTED: C.H.R.	GROUP 3 AND VICINITY

DATE:	R&M NO.	SCALE:	DWG. NO.
DEC. 2007	1209.10	AS SHOWN	A-06

Plotted 1/15/2008 9:59 AM by PHardcastle Z:\project\1209.10\acad\geo\acad\GW Report Kenai Site Plan A-02-07 New.dwg

CORPS OF ENGINEERS U. S. ARMY



NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300
GRAPHIC SCALE (IN FEET)

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: A.T.B.	KENAI, ALASKA
CHECKED: C.H.R.	MONITORING WELL LOCATION MAP
SUBMITTED: C.H.R.	GROUP 4 AND VICINITY

DATE:	R&M NO.	SCALE:	DWG. NO.
DEC. 2007	1209.10	AS SHOWN	A-07

Plotted 1/15/2008 10:03 AM by PHardcastle Z:\project\1209.10\acad\geo\acad\GW Report Kenai Site Plan A-02-07 New.dwg

APPENDIX B
LOGS OF TEST BORINGS

SOILS
CONSISTENCY AND SYMBOLS

CLASSIFICATION: Identification and classification of the soil is accomplished in accordance with the ASTM version of the Unified Soil Classification System. When laboratory testing data on material passing the 75-mm sieve is available Standard D 2487 (Classification of Soils for Engineering Purposes) is used and when laboratory data is not available D 2488 Visual-Manual Procedure) is used. This classification system identifies three major soil divisions: coarse-grained soils, fine-grained soils, and highly organic soils. These three divisions are further subdivided into a total of 15 basic soils groups. Based on the results of visual observations and prescribed laboratory tests, a soil is catalogued according to the basic soil groups, assigned a group symbol(s) and name, and thereby classified. Flow charts contained in the two standards can be used to assign the appropriate group symbol(s) and name.

SOIL DENSITY/CONSISTENCY - CRITERIA: Soil density/consistency as defined below and determined by normal field and laboratory methods applies only to non-frozen material. For these materials, the influence of such factors as soil structure, i.e. fissure systems shrinkage cracks, slickensides, etc., must be taken into consideration in making any correlation with the consistency values listed below. In permafrost zones, the consistency and strength of frozen soil may vary significantly and inexplicably with ice content, thermal regime and soil type.

COHESIONLESS

Description	N * (blows/FT.)	Relative Density
Loose	0 - 10	0 to 40%
Medium Dense	10 - 30	40 to 70%
Dense	30 - 60	70 to 90%
Very Dense	>60	90 to 100%

* Standard Penetration "N": Blows per 12 inches of a 140-pound manual hammer (lifted with rope & cathead) falling 30 inches on a 2-inch O.D. split-spoon sampler except where noted.

COHESIVE

Consistency	Shear Strength (TSF)	Unconfined Compressive Strength (TSF)
Very Soft	0.0 - 0.25	0.0 - 0.5
Soft	0.25 - 0.5	0.5 - 1.0
Firm	0.5 - 1.0	1.0 - 2.0
Stiff	1.0 - 2.0	2.0 - 4.0
Very Stiff	2.0 - 4.0	4.0 - 8.0
Hard	OVER 4.0	OVER 8.0

KEY TO TEST RESULTS

DD - Dry Density
LL - Liquid Limit
MC - Moisture Content
Org - Organic Content
PI - Plastic Index
PL - Plastic Limit
PP - Pocket Penetrometer
P200 - % Passing No. 200 Screen
P.02 - % Passing 0.02 mm
SG - Specific Gravity
TV - Torvane

DWN:	K.J.P.
CKD:	R.M.P.
DATE:	FEB 06
SCALE:	NONE

R&M CONSULTANTS, INC.
ENGINEERING ∘ SURVEYING ∘ EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

GENERAL NOTES

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	B-01

STANDARD SYMBOLS

SYMBOL	NAME	PARTICLE SIZE	SYMBOL	NAME
	CLAY	< 0.002mm, Plastic		ORGANICS
	SILT	0.002mm, - #200		ICE
	SAND	#200, - #4		ICE W/SOIL INCLUSIONS
	GRAVEL	#4, - 3"		ICE LENSE IN SILT
	COBBLES & BOULDERS	3" - 12" & > 12"		ICE CRYSTALS IN CLAY

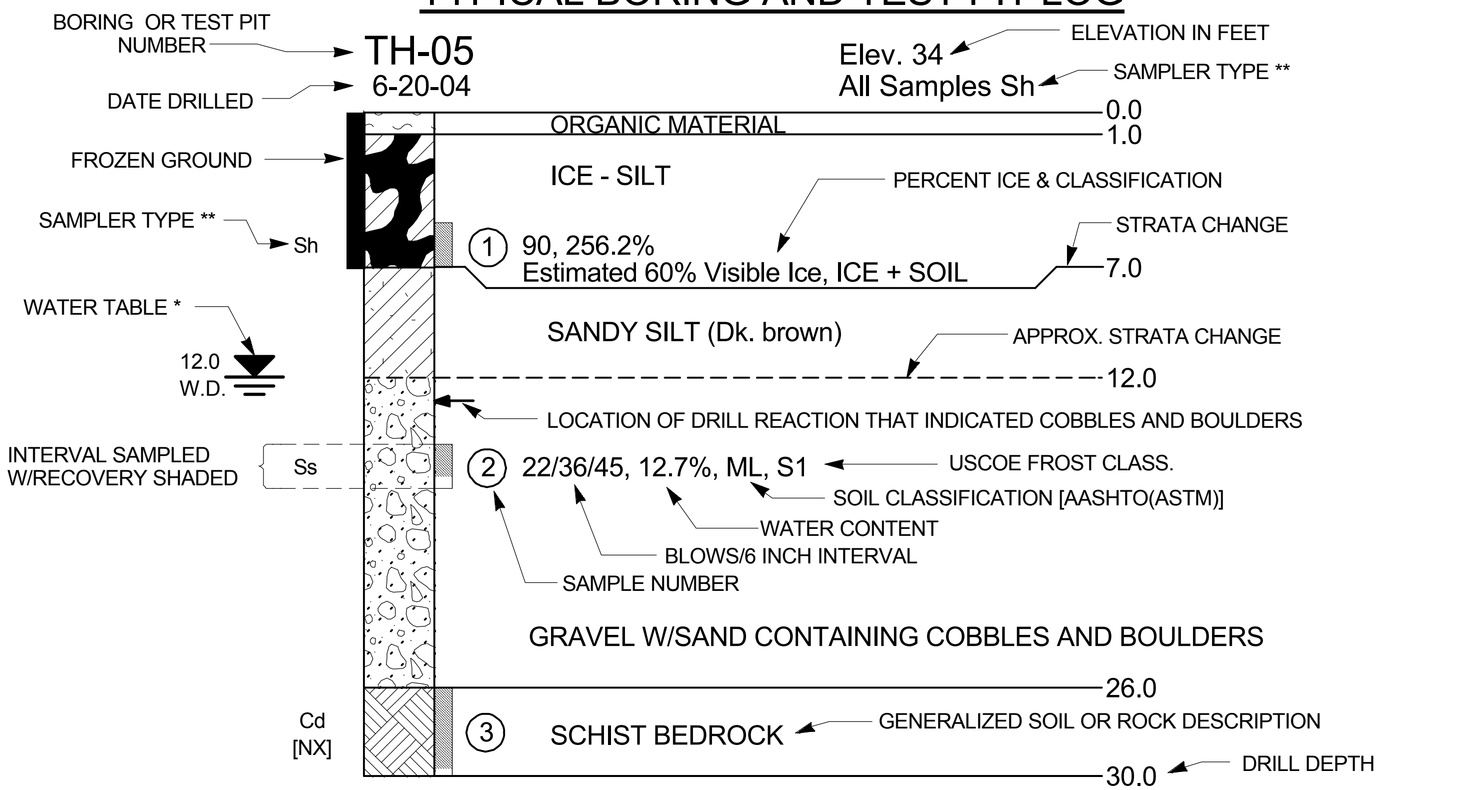
(The symbols shown above are frequently used in combinations, e. g. GRAVEL W/SILT AND SAND)

SAMPLER TYPE SYMBOLS

A	Auger Sample	Sh	2.5 In. Split Spoon w/340 lb. Manual Hammer	Sp	2.5 In. Split Spoon Pushed
C	Cuttings Sample	Sha	2.5 In. Split Spoon w/340 lb. Auto Hammer	Sz	1.4 In. Split Spoon w/340 lb. Hammer
Cd	Double Tube Core Barrel	Sl	2.5 In. Split Spoon w/140 lb. Hammer	Ts	Shelby Tube
Ct	Triple Tube Core Barrel	Ss	1.4 In. Split Spoon w/140 lb. Manual Hammer	Tm	Modified Shelby Tube
Cs	Auger Core Barrel	Ssa	1.4 In. Split Spoon w/140 lb. Auto Hammer	[x]	Sampler I. D. (Added to Symbol)
G	Grab Sample				

NOTE: Sampler types are either noted above the boring log or adjacent to it at the respective depth. An individual log may not utilize all of the items listed.

TYPICAL BORING AND TEST PIT LOG



* W.D. - WHILE DRILLING, A.B. - AFTER BORING, Ref. - SAMPLER REFUSAL
** - REFER TO SAMPLER SYMBOL (Ss, Sh, ETC.) FOR SAMPLER I.D. & HAMMER WEIGHT/TYPE
NOTE: Water levels shown on the boring logs are the levels measured in the boring at the times indicated.

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JUNE 04
SCALE:	NONE

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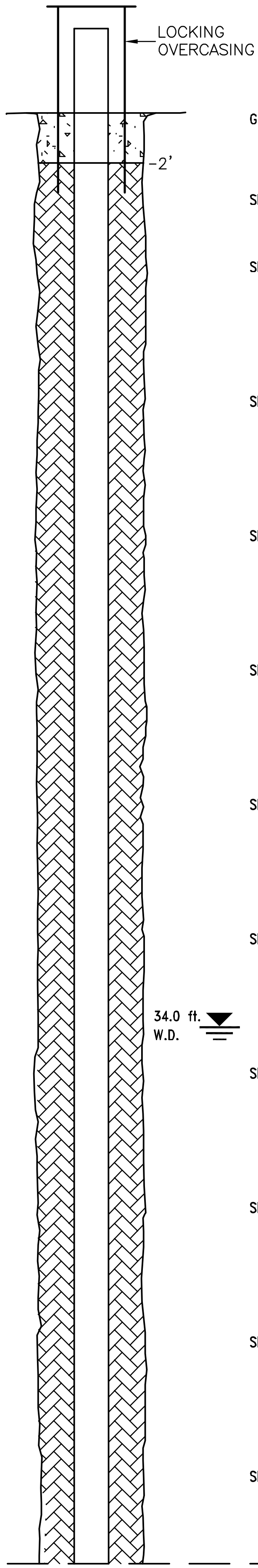
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

EXPLANATION OF SELECTED SYMBOLS

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	B-02



AP–608–MW (TB–1a)

N 2,395,412.81
E 1,413,139.72 Elev. 88.4
11/17/06

G — 0.0
(1) ML*, F4*
SILT CONTAINING ORGANICS — 0.5

Sha (2) 5/12/10, ML*, F4*

Sha (3) 3/3/4, 27%, ML*, F4
Gr=3, Sa=45, Fines=52

SANDY SILT (FILL) (Dk. brown, Trace gravel to 1/2" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Loose, Moist)

Sha (4) 1/2/2, ML*, F4*

Sha (5) 2/2/2, ML*, F4*
Fragments of glass in bottom of sample — 17.5

Drilled fast and smooth to 27.5 feet

Sha (6) 3/8/10, SP*, NFS*

POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry)

Sha (7) 8/12/15, 4.3%, SP, NFS*
Gr=1, Sa=95, Fines=3.7

Ferruginous cementation 27.5 to 30 feet, tougher drilling.

Sha (8) 7/8/6, SP*, NFS*

Drilled fast and slightly rough 30 to 37.5 feet. — 32.5

POORLY GRADED SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Wet)

Sha (9) 18/29/29, SP*, S2*

Driller noted a gravel layer from 37.5 to 38.0 feet. — 37.5
POORLY GRADED GRAVEL W/SAND — 38.0
Driller indicated clay at 38.0 feet.

Sha (10) 7/11/13, CL*, F3*, PP=4.5+ tsf

SANDY LEAN CLAY (Dk. gray, Gravel to 3/4" dia., rounded to subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)

Drilled slower, tighter, w/gravel hits 38 to 43 feet, Very slow and hard 43 to 45 feet. — 45.0

Sha (11) 13/20/22, 2.3%, SP, NFS, Gr=12, Sa=86, Fines=1.8

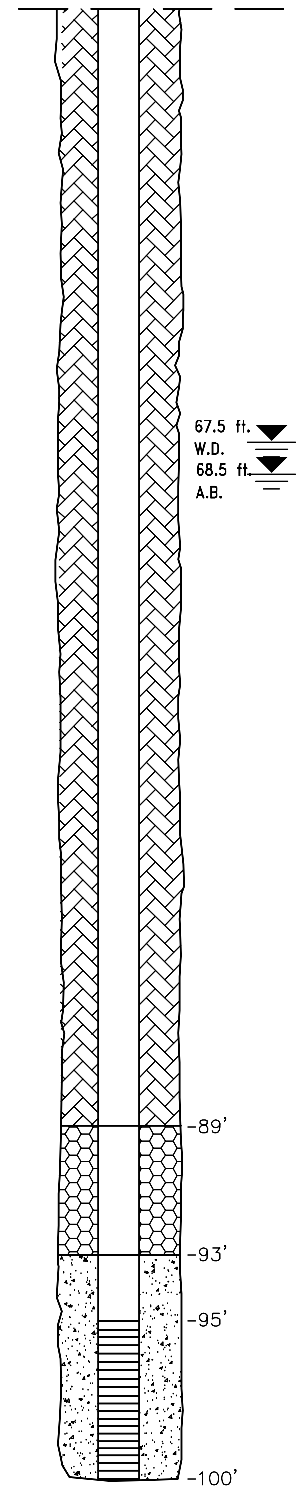
POORLY GRADED SAND (Dk. gray, Gravel to 1.5" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Dry) — 47.0

SANDY LEAN CLAY (Dk. gray) — 49.5
Drilled faster 45 to 50 feet.

Sha (12) 9/12/16, SP*, NFS*

POORLY GRADED SAND (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Dry) — 54.0

(Continued Above)



AP–608–MW (Continued)

11/17/06 — 54.0

Sha (13) 6/12/18, 2.8%, SP, NFS
Sa=99, Fines=1.3

Drilled slow, very tight, bit smoking 50 to 60 feet.

Sha (14) 6/16/19, SP*, NFS*

Drilled faster and smooth 60 to 85 feet.

Sha (15) 3/8/15, 9.7%, SP, NFS
Gr=1, Sa=96, Fines=3.0

Gravel increases with depth.

Sha (16) 6/18/26, SP*, NFS
Sampler overfilled — 72.5

SANDY LEAN CLAY (Dk. gray, Trace gravel to 3/4" dia., subrounded, hard, Fine to coarse sand, Plastic, Very stiff, Dry)

Sha (17) 6/11/12, CL*, F3, PP=3.0 tsf — 77.5

POORLY GRADED SAND W/SILT (Dk. gray, Gravel to 1" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Wet)

Sha (18) 18/35 blows for 6", 17%, SP-SM*, F2*
Gr=6, Sa=83, Fines=11, Sampler overfilled — 84.0

Sha (19) 6/18/23, 13%, CL, F4, PP=4.5+ tsf
Gr=15, Sa=22, Fines=63, LL=24, PL=15, PI=9

SANDY LEAN CLAY (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Layers of sand to 1/16" thick, irregular dip, Plastic, Very hard, Wet to dry)

Sha (20) 7/13/18, CL*, F3*, PP=4.5+ tsf

Drilled hard, slow, and smooth 85 to 100 feet.

Sha (21) 6/12/18, 16%, CL, F4, PP=4.5+ tsf
Gr=2, Sa=18, Fines=80, LL=27, PL=16, PI=11 — 97.5

POORLY GRADED SAND (Dk. gray, Fine sand, Nonplastic, Dense, Wet)

Sha (22) 8/18/22 blows for 3", SP*, PFS*
Sampler bouncing — 101.2

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 95 and 100 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

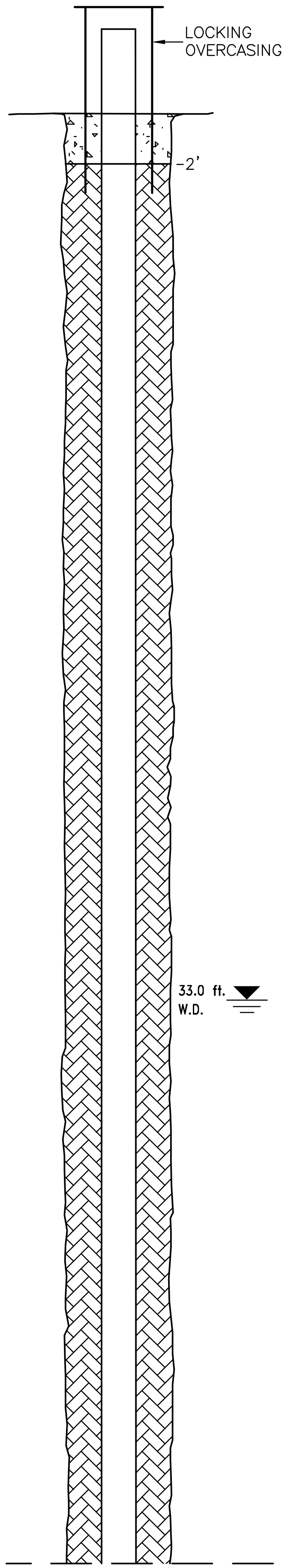
CONTRACT NO. W911KB–05–D–0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP–608–MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B–03

project\1209.10\geo\KENAI AP–608–MW (1a), 1=1, 01/17/07 at 11:29 by pkh



AP-609-MW (TB-1b)

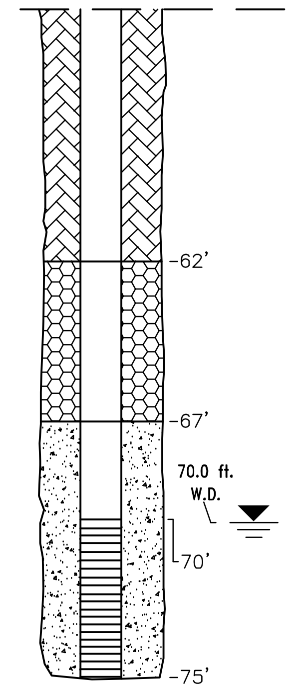
N 2,395,415.41
E 1,413,150.90
Elev. 88.6
11/18/06

Depth	Description
0.0 – 0.5	SILT CONTAINING ORGANICS
0.5 – 17.5	Drilled fast and smooth to 25 feet. SANDY SILT (FILL) (Dk. brown, Gravel to 1/2" dia., Fine to medium sand, Nonplastic) Driller indicated looser material at about 17.5 feet.
17.5 – 37.5	POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry) Ferruginous cementation 25 to 30 feet, tougher drilling. Drilled fast and smooth to 30 to 37.5 feet. Drilled slightly rough 37.5 to 38 feet.
37.5 – 38.0	
38.0 – 44.0	Drilled tight and smooth 38 to 44 feet. SANDY LEAN CLAY (Dk. gray) Drilled tight and smooth 38 to 44 feet.
44.0 – 45.0	POORLY GRADED SAND W/GRAVEL Drilled fast, slightly rough 44 to 45 feet.
45.0 – 46.0	POORLY GRADED SAND
46.0 – 47.0	POORLY GRADED SAND W/GRAVEL
47.0 – 54.0	Drilled fast and smooth 45 to 46 feet, Slightly rough 46 to 47 feet. POORLY GRADED SAND (Dk. gray, Gravel to 1.5" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Dry)

(Continued Above)

AP-609-MW (Continued)

11/17/06



Depth	Description
54.0 – 76.2	Drilled fast and smooth 47 to 75 feet.
Sha (1)	6/12/18**, 9" heave, sampler floated, SP-SM*, F2*

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

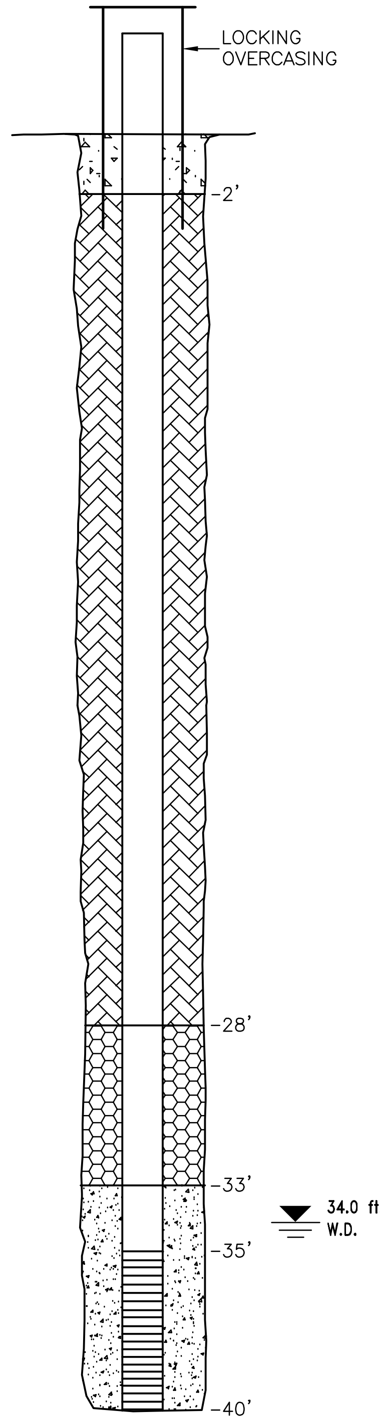
1. Screen w/prepacked sand was installed between 70 and 75 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

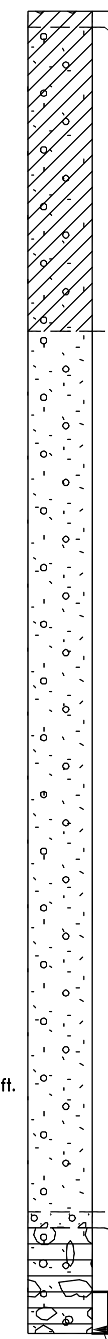
CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	TEST BORING LOG AP-609-MW
DATE: JAN. 2007	R&M NO. 1209.10
SCALE: AS SHOWN	DWG. NO. B-04

project\1209.10\geo\KENAI AP-609-MW (1b), 1=1, 01/17/07 at 11:38 by pkh



AP-610-MW (TB-1c)

N 2,395,430.86
E 1,413,141.62 Elev. 88.9
11/18/06



0.0 — 0.5 SILT CONTAINING ORGANICS

0.5 — 10.0 SANDY SILT (FILL) (Dk. brown, Gravel to 1/2" dia., Fine to medium sand)

10.0 — 37.5

Drilled fast and smooth to 40 feet.

POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry)

Ferruginous cementation 25 to 30 feet, tougher drilling.

Drilled fast and smooth to 30 to 37.5 feet, slightly rough to 38 feet.

Drilled tight and smooth 38 to 40 feet.

37.5 — 38.0 POORLY GRADED GRAVEL W/SAND
Drilled tight and smooth 38 to 40 feet.

38.0 — 41.3 SANDY LEAN CLAY CONTAINING COBBLES & BOULDERS (Dk. gray)

Sha (1) 7/11/14 blows for 3"
Sampler bouncing on cobble/boulder

41.3

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 35 and 40 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

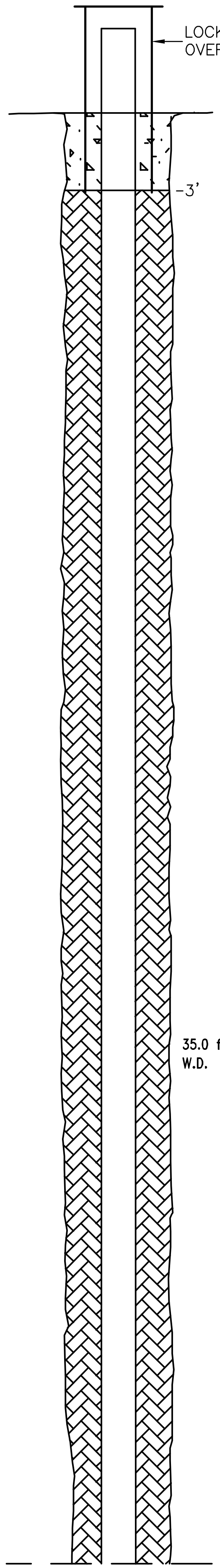
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-610-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-05

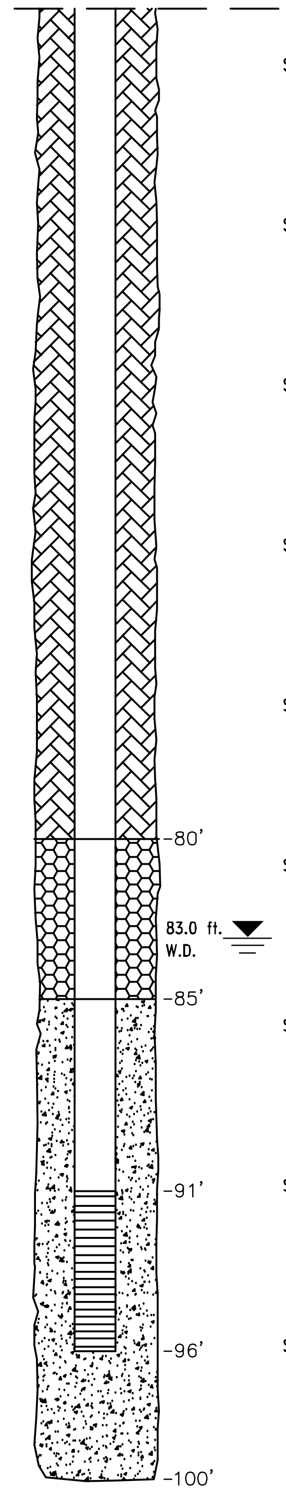


AP-611-MW (TB-2c)

N 2,395,775.73
E 1,414,431.97 Elev. 91.1
11/14/06 - 11/15/06

Depth	Sampler	No.	Description
0.0	G	(1)	ML*, F4* SILT (Dk. brown)
2.5	Sha	(2)	1/2/3, 10%, SM*, F3*, Gr=2, Sa=71, Fines=27 SILTY SAND (Dk. brown, Fine to medium sand, Nonplastic, Loose, Dry)
4.0	Sha	(3)	2/4/3, SP*, NFS* POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Loose to medium dense, Dry to wet)
	Sha	(4)	2/5/6, SP*, NFS* Drilled fast and smooth w/fine gravel to 38 feet.
	Sha	(5)	2/4/4, 3.5%, SP, NFS, Gr=7, Sa=92, Fines=1.2
	Sha	(6)	4/6/8, SP*, NFS*
	Sha	(7)	3/5/8, SP*, NFS*
	Sha	(8)	3/7/6, 5.1%, SP, NFS, Gr=6, Sa=91, Fines=3
	Sha	(9)	2/4/6, SP*, NFS* Driller indicated clay encountered at 38 feet.
38.0	Sha	(10)	6/9/14, CL*, F3* SANDY LEAN CLAY (Dk. gray, Gravel to 1.5" dia., rounded to angular, hard, Fine to medium sand, Plastic, Very hard, Dry)
	Sha	(11)	8/12/16, CL*, F3* Drilled moderately fast, smooth and tight 38 to 83 feet.
	Sha	(12)	6/11/14***, 11%, CL, F4 Gr=22, Sa=18, Fines=60, LL=27, PL=16, PI=11
54.0			

(Continued Above)



AP-611-MW (Continued)

11/14/06 - 11/15/06

Depth	Sampler	No.	Description
54.0	Sha	(13)	3/7/11***, CL*, F4*
	Sha	(14)	7/12/16***, 15%, CL, F4 Gr=2, Sa=26, Fines=72, LL=26, PL=16, PI=10
	Sha	(15)	8/17/21***, CL*, F4* Sampler overfilled
	Sha	(16)	10/12/13***, 18%, CL, F4 Sa=25, Fines=75, LL=22, PL=14, PI=8
	Sha	(17)	8/16/18***, 15%, CL, F4 Gr=1, Sa=21, Fines=78.0, LL=24, PL=16, PI=8
	Sha	(18)	8/12/19, CL*, F3* Fine sand layers <1/4" thick
83.0	Sha	(19)	10/21 blows for 6" **, SP*, S2* 6" heave, Sampler floated POORLY GRADED SAND (Black, Fine angular sand, Nonplastic, Medium dense, Wet)
	Sha	(20)	2/6/10**, SP*, S2* 15 feet of heave after sample 19, pulled auger back 15 feet, and redrilled to 90 feet. 12" heave at 90 feet, sampler floated.
95.0	Sha	(21)	3/5/7, CL*, F3*, PP=4.5+ tsf SANDY LEAN CLAY (Dk. gray, Trace gravel to 1/2" dia., subrounded to subangular, hard, Fine to coarse sand, Plastic, Very hard, Dry)
	Sha	(22)	3/6/8, 20%, CL*, F3*, PP=4.5+ tsf Sa=18, Fines=82
101.5			

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with plastic liners.
Unconsolidated-undrained triaxial compression test performed on samples #12, #14, and #16.

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 91 and 96 ft.
2. Installation was uneventful.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

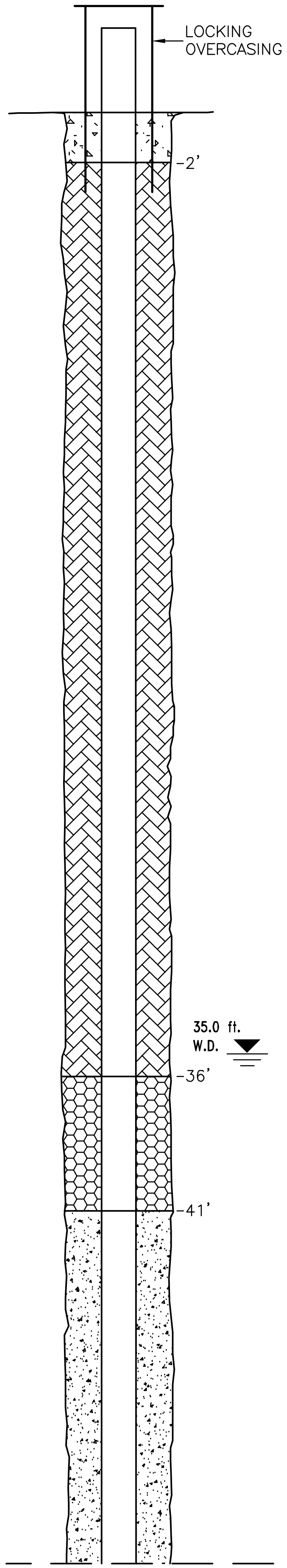
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-611-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-06



AP-612-MW (TB-2b)
N 2,395,786.22
E 1,414,437.68 Elev. TBD
11/15/06 - 11/16/06

0.0

SILT (Dk. brown)

2.5

POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Dry to wet)

Drilled fast and smooth w/fine gravel to 38 feet.

Color change to red-brown at 30 feet, may indicate ferruginous cementation.

Driller indicated clay encountered at 38 feet.

38.0

Drill reaction indicates pieces of gravel in top 1-inch of clay.

Gravelly layer at 43 feet.

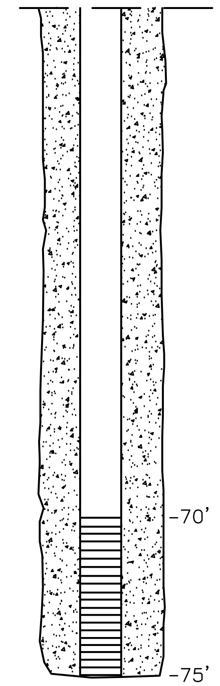
Soft sand layer between 44 and 44.5 feet.

SANDY LEAN CLAY (Dk. gray, Gravel to 1.5" dia., rounded to angular, hard, Fine to medium sand, Plastic, Very hard, Dry)

Drilled slower, tight, and smooth 38 to 75 feet.

54.0

(Continued Above)



AP-612-MW (Continued)
11/17/06

54.0

Pieces of fine gravel between 45 and 75 feet.

Sha 1 1/5/6, CL*, F3*, PP=4.5+ tsf

76.5

* Estimated Classification

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 70 and 75 ft.
2. Silica sand bridged in augers and bridge could not be removed until augers were pulled to 40 feet.
3. Sand from upper sand unit caved into hole to a depth of 41 feet.
4. Well appeared to be measuring water level of upper aquifer.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

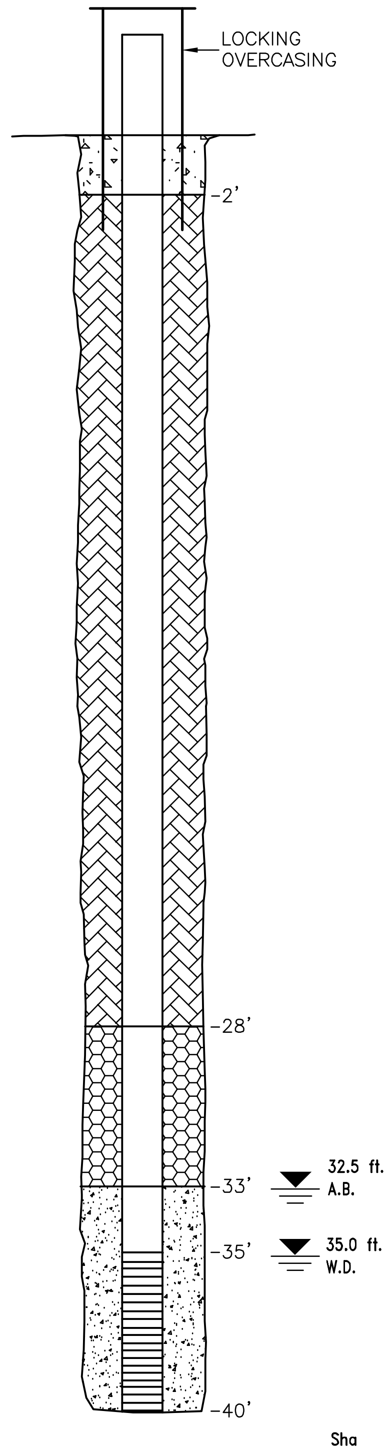
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-612-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-07

project\1209.10\geo\KENAI AP-612-MW (2b), 1=1, 01/17/07 at 09:03 by pkh



AP-613-MW (TB-2a)
N 2,395,795.10
E 1,414,440.67
11/15/06

Elev. 91.0

0.0

SILT (Dk. brown)

2.5

POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Fine to coarse sand, Nonplastic, Dry to wet)

Drilled fast and smooth w/fine gravel to 38 feet.

Color change to red-brown at 30 feet, may be ferruginous cementation.

Driller indicated gravel encountered on top of clay at 38 feet.

38.0

SANDY LEAN CLAY (Dk. gray)

1 4/8/12, CL*, F3*, PP=4.5+ tsf

41.5

* Estimated Classification

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 35 and 40 ft.
2. Installation was uneventful.

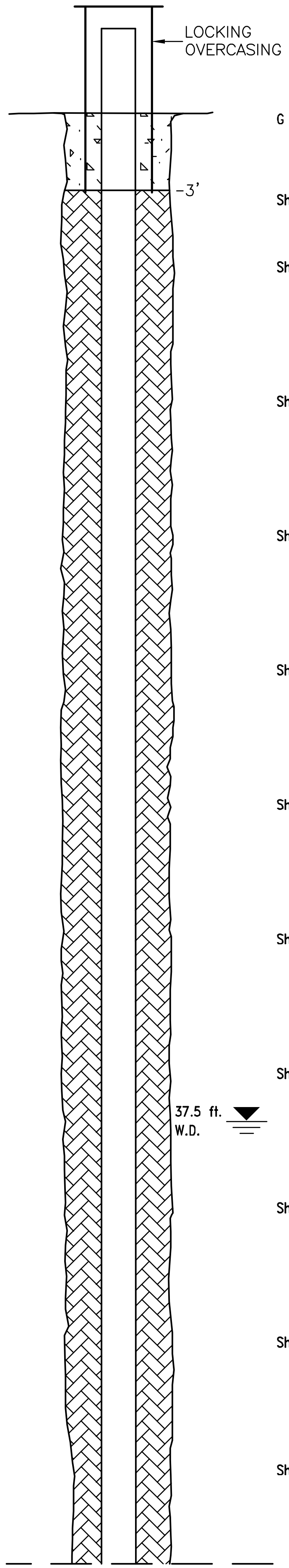
See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	TEST BORING LOG AP-613-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-08

project\1209.10\geo\KENAI AP-613-MW (2a), 1=1, 01/17/07 at 09:37 by pkh



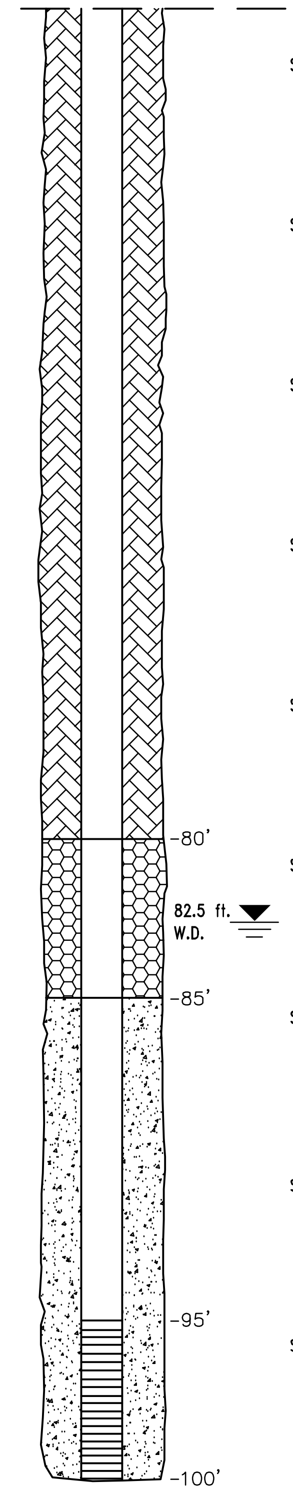
AP-614-MW (TB-3a)

N 2,396,258.31
E 1,415,755.43
11/11/06

Elev. 93.9

	Depth	Sample	Description
G	0.0	(1)	ML* to SM*, F4* SILT GRADING TO SILTY SAND (Dk. brown, Fine to coarse sand, Nonplastic)
Sha	1.0	(2)	1/4/6, SM*, F3* SILTY SAND GRADING TO POORLY GRADED SAND (Dk. brown, Fine sand, Nonplastic, Medium dense, Dry)
Sha	4.0	(3)	3/4/4, 5.8%, SP, PFS* Gr=11, Sa=85, Fines=4.2
Sha		(4)	3/6/8, SP*, NFS* POORLY GRADED SAND TO SAND W/SILT CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded to rounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry)
Sha		(5)	2/5/6, 4.8%, SP, NFS* Sa=97, Fines=3.1 Drilled fast and smooth to 32.5 feet.
Sha		(6)	2/4/6, SP*, NFS* Ferruginous cementation 22.5 to 32.5 feet.
Sha	24.0	(7)	7/10/15, 4.9%, SP-SM*, S2* Sa=95, Fines=5.3
Sha		(8)	6/10/11, SP*, NFS* Driller indicated change at 32.5 feet.
	32.5		Drilled fast and slightly rough 32.5 to 42.5 feet.
Sha		(9)	8/18/22, 2.4%, SP-SM*, S2 Gr=32, Sa=63, Fines=5.5, P.02=3.3 POORLY GRADED SAND W/SILT AND GRAVEL (Dk. brown, Gravel to 1.5" dia., subrounded to rounded, hard, Fine to coarse sand, Nonplastic, Medium dense to dense, Dry to wet)
Sha		(10)	10/12/10, SP-SM*, S2*
	42.5		Driller indicated gravel layer at 42.5 feet. Drilled slightly rough and tight 42.5 to 52.5 feet.
Sha		(11)	10/15/16, 16%, SC*, F3*, Gr=2, Sa=56, Fines=42 Gravel layer to 6" thick at 47.5 feet. CLAYEY SAND W/GRAVEL LAYERS CONTAINING COBBLES & BOULDERS (Dk. gray, Gravel subrounded to angular, hard, Fine to coarse sand, Sand layers to 1/4" thick, Plastic, Very hard, Dry)
Sha	52.5	(12)	12/32 blows for 6", CL*, F3*, Sampler bouncing on cobble/boulder

(Continued Above)



AP-614-MW (Continued)

11/17/06

	Depth	Sample	Description
Sha		(13)	10/20/18***, 14%, CL, F4, Gr=1, Sa=20, Fines=79, LL=24, PL=15, PI=9, SG=2.682 SANDY LEAN CLAY TO LEAN CLAY W/SAND (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)
Sha		(14)	5/12/16***, 13%, CL, F4 Gr=3, Sa=22, Fines=75, LL=27, PL=15, PI=12 Drilled moderately fast, smooth and tight 52.5 to 82.5 feet.
Sha		(15)	7/12/19***, 16%, CL*, F4*
Sha		(16)	7/9/14***, 17%, CL, F3 Gr=2, Sa=19, Fines=79, LL=31, PL=18, PI=13
Sha		(17)	8/14/15, 15%, CL*, F3* Gr=4, Sa=43, Fines=53, Thin layers of sand
Sha		(18)	6/10/10, 17%, CL*, F3* Gr=2, Sa=22, Fines=76, P.02=52.8
	82.5		Drilled fast, easy and smooth 82.5 to 100 feet.
Sha		(19)	7/17 blows for 6"**, 18%, SC*, F3*, Gr=6, Sa=64, Fines=30, 6" heave, sampler floated, sampler overfilled POORLY GRADED SAND CONTAINING LAYERS OF LEAN CLAY (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to medium sand, Nonplastic, Medium dense, Wet)
	87.5		
Sha		(20)	6/12/11**, SP-SM*, S2* 18" heave, sampler floated POORLY GRADED SAND TO SAND W/SILT (Dk. gray, Fine to medium sand, Nonplastic, Medium dense to dense, Wet)
Sha		(21)	7/15/17**, 24" heave sampler floated
Sha	101.5	(22)	6/10/17**, 24%, SP-SM*, S2* Sa=94, Fines=6.1, 24" heave, sampler floated

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with plastic liners.
Consolidated undrained triaxial compression test performed on samples #13, #14, and #15.

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 95 and 100 ft.
2. Due to heaving conditions the screen could not be placed down the hole and the augers were reinstalled with a wooden plug. Otherwise installation was uneventful.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

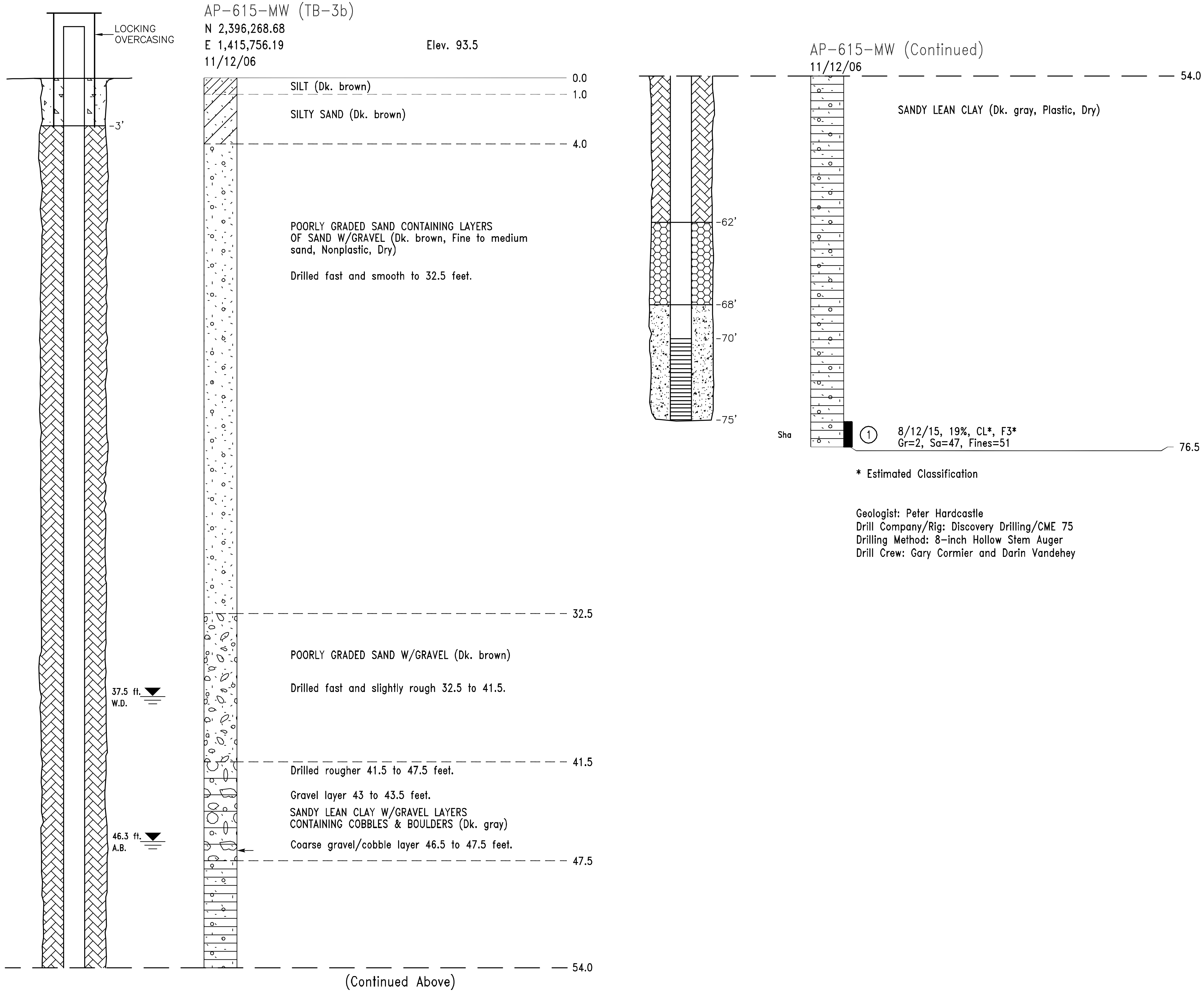
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-614-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	B-09

project\1209.10\geo\KENAI AP-614-MW (3a), 1=1, 02/13/07 at 09:40 by kjp



* Estimated Classification

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 70 and 75 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

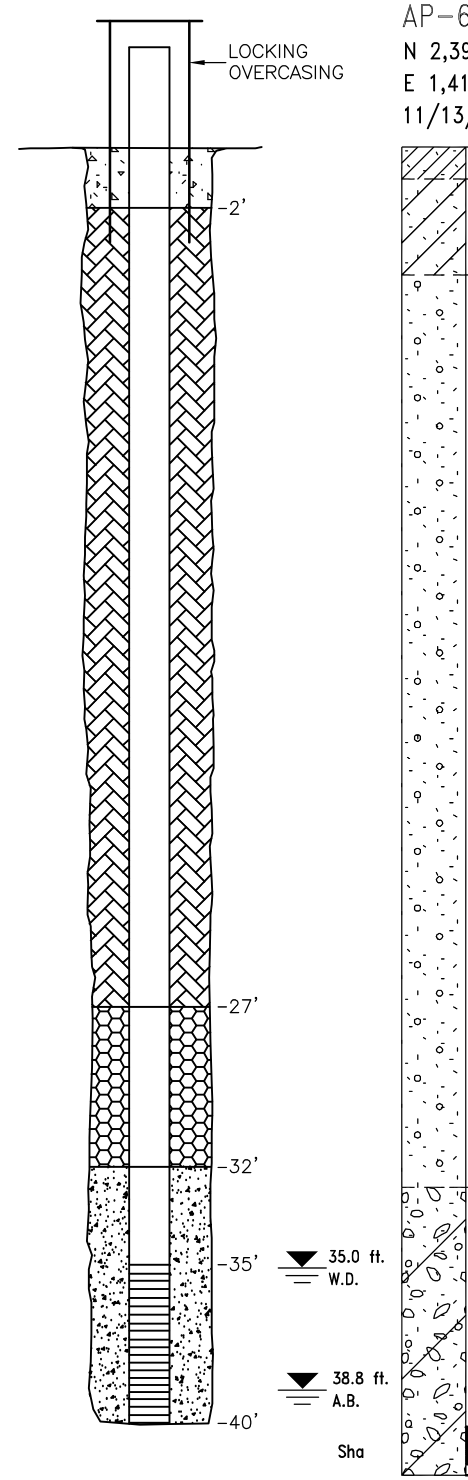
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-615-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-10

project\1209.10\geo\KENAI AP-615-MW (3b), 1=1, 01/17/07 at 08:57 by pkh

CORPS OF ENGINEERS

U. S. ARMY



AP-616-MW (TB-3c)
N 2,396,280.50
E 1,415,756.60
11/13/06

Elev. 93.7

0.0 SILT (Dk. brown)

1.0 SILTY SAND GRADING TO POORLY GRADED SAND (Dk. brown, Nonplastic)

4.0 POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Fine to medium sand, Nonplastic, Dry)

Drilled fast and smooth to 32.5 feet.

32.5 POORLY GRADED SAND W/GRAVEL (Dk. brown)

Drilled fast and slightly rough 32.5 to 40 feet.

1 10/9/11***, SP*, S2*

41.5

* Estimated Classification
*** Sampler driven with plastic liners.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger Drill
Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 35 and 40 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

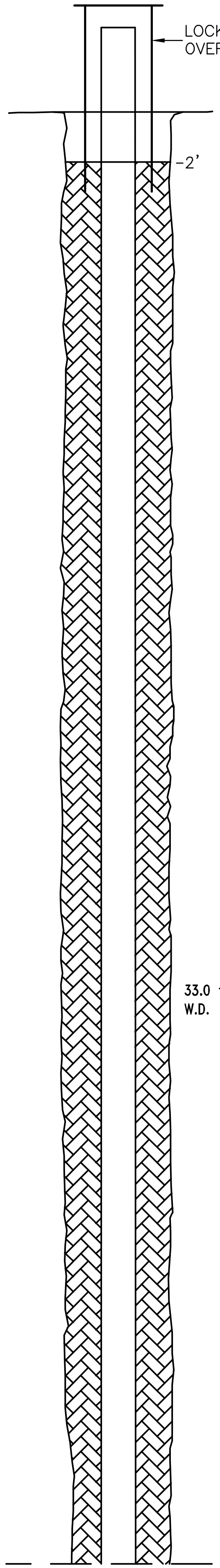
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-616-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-11

project\1209.10\geo\KENAI AP-616-MW (3c), 1=1, 01/17/07 at 09:51 by pkh

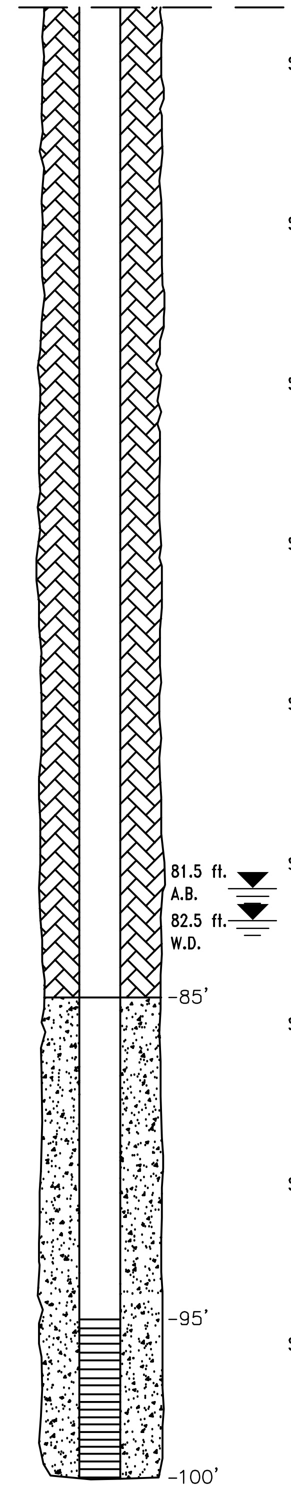


AP-617-MW (TB-4a)

N 2,396,189.80
E 1,416,979.96 Elev. 92.9
11/19/06

Sample Type	Sample	Description	Depth
G		ORGANIC MAT	0.0 / 0.2
	1	SM*, F3*	
		SILTY SAND GRADING TO SAND (Dk. brown, Gravel to 1/4" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dry)	
Ssa	2	5/8/9, SM*, F3*	4.0
Ssa	3	3/5/5, SP*, NFS*	
		POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 3/8" dia., subrounded, hard, Fine to medium sand, Nonplastic, Medium dense, Dry)	
Ssa	4	3/7/10, 6.5%, SP, PFS* Gr=1, Sa=95, Fines=3.9	
Ssa	5	3/12/15, SP*, NFS*	
Ssa	6	4/12/11, SP*, NFS*	
		Drilled fast and smooth to 39.5 feet.	
Ssa	7	3/5/10, 8.4%, SP, NFS*, Sa=96, Fines=4.3, Ferruginous cementation in portions of sample, Fragments of carbonized wood in sample	
Ssa	8	3/11/16, SP*, NFS* Ferruginous cementation in portions of sample	
Ssa	9	7/18/27, SP*, NFS*	
		Driller indicated clay at 39.5 feet.	39.5
Sha	10	5/7/12, CL*, F3*, PP=4.5+ tsf, Pocket penetrometer leaves little impression	
		Drilled moderately fast, tight, and smooth 39.5 to 55 feet.	
Sha	11	5/11/12, 15%, CL*, F3* Gr=7, Sa=39, Fines=54, PP=4.5+ tsf, Pocket penetrometer doesn't leave impression, Fine sand layer to 1/8" thick, dipping at ~50°	
Sha	12	15/35 blows for 6"**, CL*, F3* 12" heave in augers, sampler floated	
		Drilled faster and smooth 55 to 60 feet.	54.0

(Continued Above)



AP-617-MW (Continued)

11/19/06

Sample Type	Sample	Description	Depth
			54.0
Sha	13	9/11/12***, 13%, CL, F3 Gr=16, Sa=21, Fines=63, LL=31, PL=18, PI=13	
		SANDY LEAN CLAY W/GRAVEL TO LEAN CLAY W/SAND (Dk. gray, Gravel to 1.5" dia., subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)	
Sha	14	4/10/19, 15%, CL, F3, PP=4.5+ tsf Gr=6, Sa=23, Fines=71, LL=33, PL=17, PI=16	
		Drilled slow and tight 60 to 75 feet.	
Sha	15	8/16/22, CL*, F3*, PP=4.5+ tsf Sand layer to 6" thick	
		Drilled slow and tight 70 to 75 feet.	
Sha	16	5/10/13, 13%, CL*, F3*, PP=4.5+ tsf Gr=7, Sa=19, Fines=74, LL=27, PL=16, PI=11, SG=2.724	
Sha	17	3/7/10, 15%, CL*, F3*, PP=4.5+ tsf Gr=21, Sa=28, Fines=51, P.02=36.2	
		Drilled fast and smooth 75 to 85 feet.	
Sha	18	6/9/14, 14%, CL, F4 Gr=3, Sa=28, Fines=69, LL=24, PL=16, PI=8	
		Drilled easy and smooth 85 to 90 feet.	85.0
Sha	19	4/7/11, SP & CL*, PFS & F3*	
		POORLY GRADED SAND CONTAINING LAYERS OF LEAN CLAY (Dk. gray, Fine sand, Nonplastic sand and plastic clay, Medium dense, Wet)	
		Drilled slower and smooth 90 to 92.5 feet	90.0
Sha	20	3/7/12, 17%, CL*, F3*, PP=3.5 tsf, Gr=4, Sa=20, Fines=76	
		LEAN CLAY W/SAND (Dk. gray, Gravel to 1/4" dia., subrounded, hard, Plastic, Very stiff, Moist)	92.5
		POORLY GRADED SAND (Dk. gray, Fine to medium sand, Nonplastic, Medium dense, Wet)	
Sha	21	3/5/7**, 6 ft. of heave after sampling	
		Drilled fast and smooth 92.5 to 100 feet.	
Sha	22	18/28/11**, SP*, PFS* 5 ft. of heave, Sampler floated down and sanded in	101.5

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
One-dimensional consolidation test performed on sample #16.
Unconsolidated-undrained triaxial compression test performed on sample #13.

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES:

1. Due to heaving conditions the screen could not be placed down the hole and the augers were reinstalled with a wooden plug.
2. Screen w/prepacked sand was installed between 95 and 100 ft.
3. Unable to get bentonite down hole due to slurry in hole.
4. Pulled augers to 40 feet and backfilled with grout to surface. Grout sank to 35 by the next morning.
5. Additional grout was placed in hole until it came to within 2 feet of surface.
6. Water measurement indicated that the grout had sealed off the upper aquifer.
7. Water levels were observed to changed over time, apparently relative to the tides.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

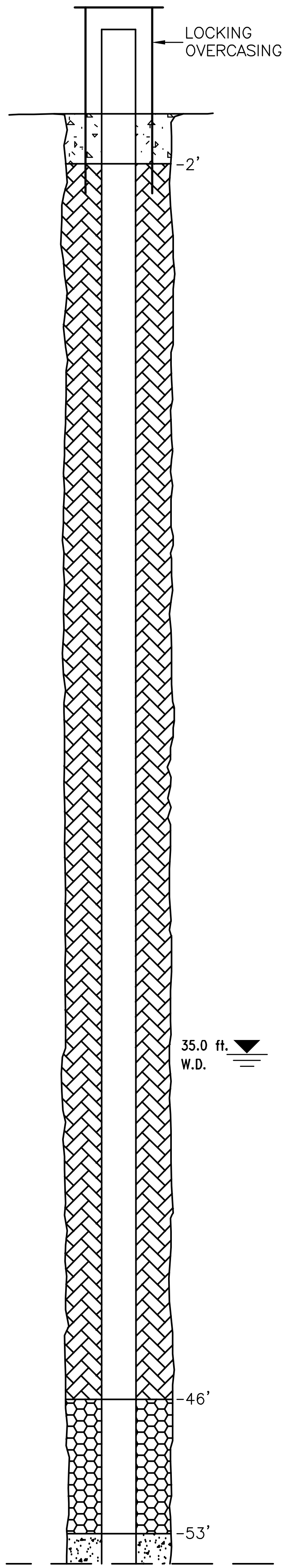
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

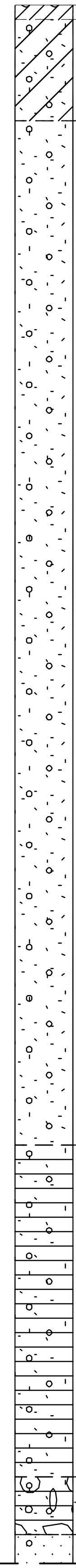
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-617-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	B-12



AP-618-MW (TB-4b)

N 2,396,207.48
E 1,416,981.72 Elev. 93.1
11/20/06

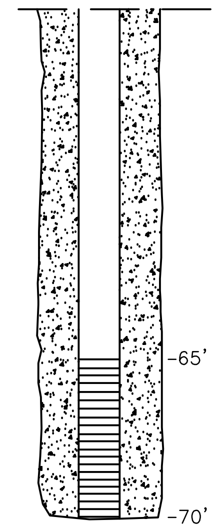


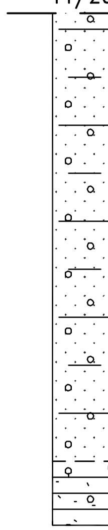
Depth	Description
0.0	SILT CONTAINING ORGANICS (Dk. brown)
0.5	SILTY SAND (Dk. brown, Gravel to 1/4" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dry)
4.0	POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown)
	Drilled fast and smooth to 35.0 feet. Faster to 40 feet.
	Driller indicated clay at 39.5 feet.
39.5	Smooth drilling alternated between slow and fast 40 to 45 feet. Tight hard drilling from 45 to 48 feet, faster 48 to 50 feet.
	SANDY LEAN CLAY CONTAINING LAYERS OF POORLY GRADED SAND (Dk. gray, Gravel to 1.5" dia., subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)
	Drilled fast and smooth 50 to 50.5 feet, slower 50.5 to 51 feet. Rough from 51 to 53 feet, and faster and smooth 53 to 55 feet.
51.0	SANDY LEAN CLAY CONTAINING COBBLES & BOULDERS (Dk. gray, Plastic, Very hard, Dry)
53.0	
54.0	

(Continued Above)

AP-618-MW (Continued)

11/20/06





Depth	Description
54.0	Drilled slow and tight 55 to 56.5 feet. Faster and smooth w/ occasional small cobbles 56.5 to 60 feet.
	POORLY GRADED SAND CONTAINING LAYERS OF LEAN CLAY (Dk. gray)
	Drilled fast 60 to 63 feet, slower and tighter 63 to 65 feet. Drilled fast and smooth 65 to 68 feet, tighter 68 to 70 feet.
68.0	SANDY LEAN CLAY (Dk. gray, Plastic)
70.0	

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Hole was drilled with wooden plug in end of augers.
2. Screen w/prepacked sand was installed between 65 and 70 ft.
3. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

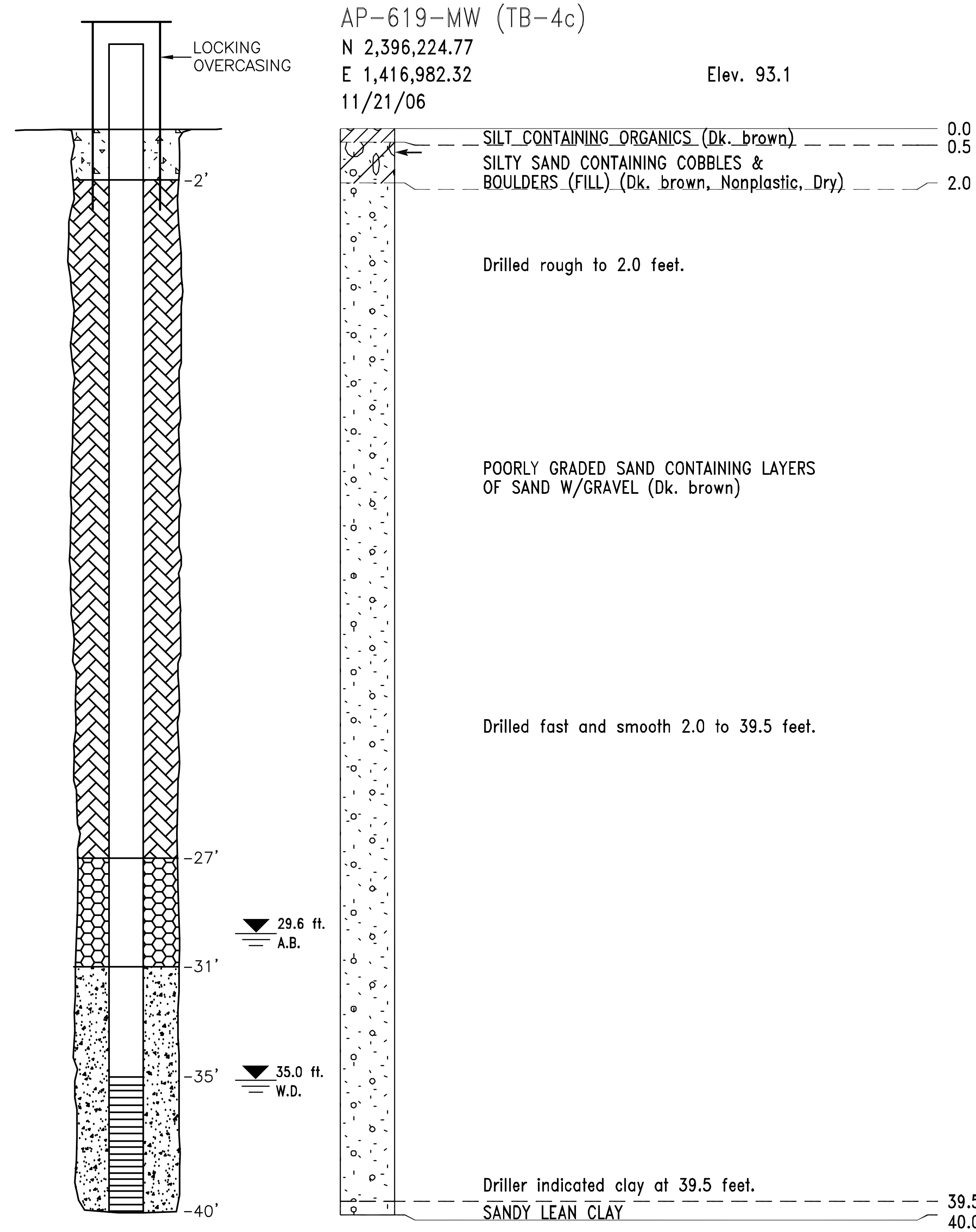
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-618-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-13

project\1209.10\geo\KENAI AP-618-MW (4b), 1=1, 01/17/07 at 09:50 by pkh

AP-619-MW (TB-4c)
N 2,396,224.77
E 1,416,982.32 Elev. 93.1
11/21/06



Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Hole was drilled with wooden plug in end of augers.
2. Screen w/prepacked sand was installed between 35 and 40 ft.
3. Hole walls caved to 31 feet when augers were withdrawn. Sand backfill is mixture of silica sand and natural sand.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

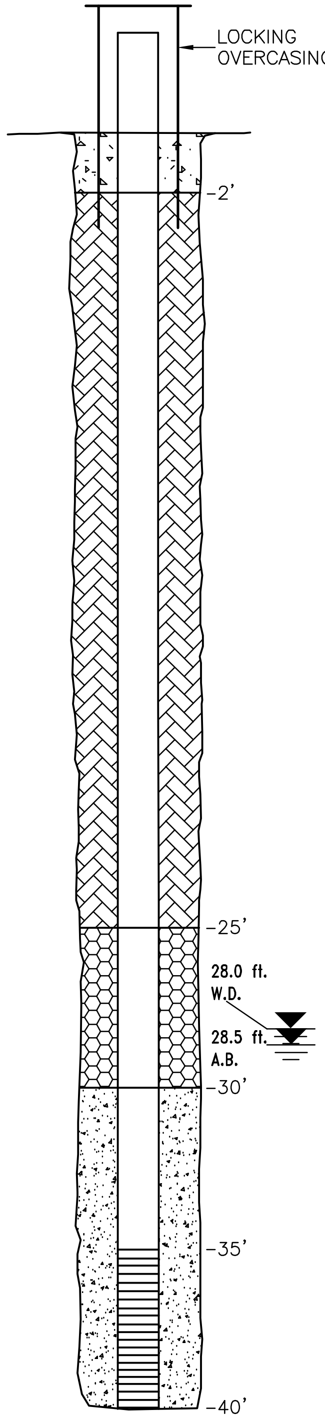
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-619-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-14



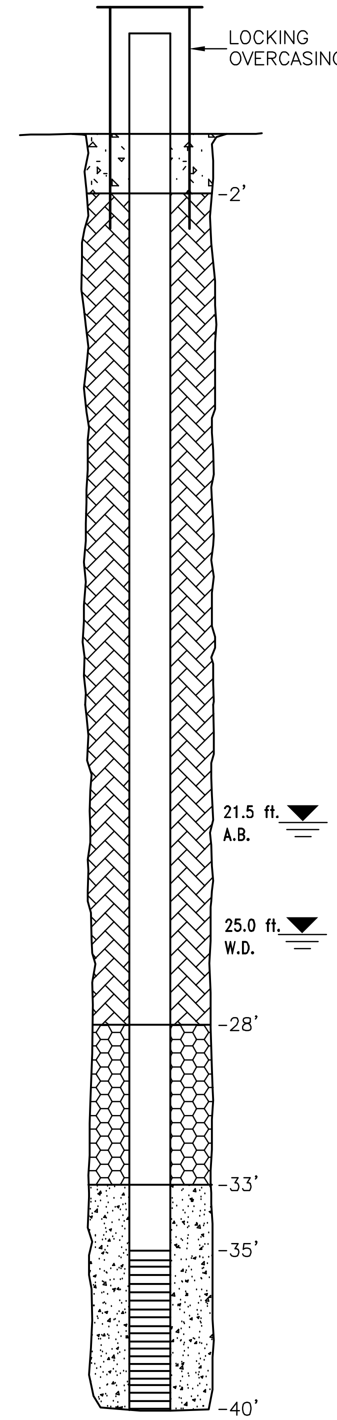
AP-620-MW (TB-02)

N 2,396,321.05
E 1,414,354.82 Elev. 92.2
11/13/06

Depth	Sampler	No.	Description
0.0	G	1	ML*, F4* SILT CONTAINING ORGANICS (Dk. brown)
2.5	Sha	2	3/3/5, 10%, SM*, F3*, Gr=2, Sa=76, Fines=22 SILTY SAND (Dk. brown, Fine to medium sand)
4.0	Sha	3	3/4/4, SP*, NFS* Drilled fast and smooth to 39 feet.
	Sha	4	1/3/4, 5.1%, SP, NFS, Gr=7, Sa=92, Fines=1.7 POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL, Gravel to 2" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry becoming wet below 28 ft.
	Sha	5	3/5/8***, 4.6%, SP, S2*, Sa=96, Fines=4.4, LL=NV, PL=NP, PI=NP, SG=2.716
	Sha	6	5/8/8, 6.0%, SP, NFS*, Gr=1, Sa=95, Fines=3.9
	Sha	7	3/6/12***, 7.6%, SP, NFS*, Gr=10, Sa=87, Fines=3.3
	Sha	8	5/8/6, 21%, SP, NFS*, Gr=12, Sa=85, Fines=3.2
	Sha	9	7/13/15 blows for 4"***, SP*, NFS* Sampler had a piece of wood blocking shoe. Driller indicated clay at 39 feet.
39.0	Sha	10	LEAN CLAY W/SAND CONTAINING COBBLES & BOULDERS (Dk. gray, Plastic, Very hard, Dry) 4/10/16 blows for 5"**, 16%, CL, F3, Gr=3, Sa=16, Fines=81, LL=35, PL=21, PI=14, SG=2.747, 1 foot of heave in augers, sampler floated. Sampler bouncing on cobble/boulder
41.4			

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
One-dimensional consolidation performed on sample #10.
Constant head permeability test performed on sample #5.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey



AP-621-MW (TB-03)

N 2,396,759.77
E 1,417,031.71 Elev. 92.7
11/14/06

Depth	Sampler	No.	Description
0.0	G	1	SM*, F3* SILT W/ORGANICS (Dk. brown)
2.0	Sha	2	4/10/11, SP*, NFS*
	Sha	3	3/9/8, 6.2%, SP, NFS, Gr=11, Sa=86, Fines=2.7 Drilled fast and smooth to 40 feet.
	Sha	4	2/4/3***, SP*, NFS* POORLY GRADED SAND TO SAND W/SILT CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 3/4" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry becoming wet below 28 ft.)
	Sha	5	3/3/7, 7.7%, SP, S2*, Gr=1, Sa=95, Fines=4.3
	Sha	6	4/6/7***, 12%, SP, NFS*, Gr=8, Sa=88, Fines=3.6
	Sha	7	5/8/12, SP*, NFS*
	Sha	8	3/6/12**, 19%, SP-SM*, S2*, Gr=2, Sa=92, Fines=6.5, 6" heave, sampler floated
	Sha	9	3/7/10**, SP*, NFS*, 6" heave, sampler floated
40.0	Sha	10	6/11 blows for 1", Sampler bouncing on cobble/boulder GRAVEL W/SAND CONTAINING COBBLES & BOULDERS
41.0			

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
Constant head permeability test performed on samples #4 and #6.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screens w/prepacked sand were installed between 35 and 40 ft.
2. Caving sand prevented placement of silica sand through the augers until they had been pulled back 10 feet in AP-620-MW. Sand backfill was a mixture of silica sand and sand cave in.
2. Installation of AP-621-MW was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.
DRAWN: P.K.H.
CHECKED: C.H.R.
SUBMITTED: C.H.R.

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

TEST BORING LOG
AP-620-MW & AP-621-MW

DATE: JAN. 2007
R&M NO. 1209.10
SCALE: AS SHOWN
DWG. NO. B-15

project\1209.10\geo\KENAI AP-620-MW & 621-MW, 1=1, 01/17/07 at 09:50 by pkh

WELL LOG DATA

American Environmental

PROJECT: Daubenspeck Property	WELL NO. MW-1
LOCATION: Grid 337.7, 315.1	DATE DRILLED: 6/14/2000
DRILLING METHOD: Hollow Stem Auger \ Split Spoon Sample	CASING TYPE/DIA. PVC 2"
DEPTH DRILLED: 28 feet	TOTAL CASING: 20 feet
GROUND ELEVATION:	T.O.C. ELEVATION:
GROUT TYPE/QUANTITY: Bentonite Chips ½ bag \ Bentonite slurry 20 gallons	SCREEN TYPE/ LENGTH: 0.20 slot PVC \ 10 feet
GROUT INTERVAL: Chips 12 to 14.11' Slurry 1 to 12'	SCREENED INTERVAL:
SAND PACK TYPE/INTERVAL: 14.11 to 28 feet	STATIC WATER LEVEL/DATE:
DEPTH TO WATER WHILE DRILLING: 21.5' bgl	LOGGED BY: PETE CAMPBELL
WATER LEVEL ELEVATION:	DRILLER: Hughes Drilling

DEPTH	H20\SOIL SAMPLE	FORMATION DESCRIPTION
0-5'		Sand, brown, clean
5-7	SSS #1 BC:3-5-5-5	5-6' Sand, medium, brown with minor gravel, moist 6-7' Sand, fine brown, moist PID 8.1
7-9'	SSS#2 BC: 3-3-4-5	7-8' Sand, fine brown, moist 8-9' Sand, fine, gray PID 0.0
9-11	SSS#3 BC: 3-4-6-8	Sand, fine, gray PID 0.0
11-13	SSS#4 BC: 4-8-8-4	Sand, fine, gray PID 0.0
13-15	SSS#5 BC: 6-7-8-9	Sand, fine, gray to 13.8 13.8-15 Sand, very fine, gray, moist PID 0.0
15-17	SSS#6 BC: 4-7-9-8	Sand, medium, brown salt & pepper. PID 0.0 Drill to 20
20-28	SSS#7 BC: 5-10-13-15	20-21' Sand fine, brown, wet 21-22' Sand with minor silt, wet, approximately 6" of water in augers PID 5.1 Sample Collected: MW-1-20-22 @09:34 Drill to 24', water at 21.5 Drill to 28' EOB

WELL LOG DATA

American Environmental

PROJECT: Daubenspeck Property	WELL NO. MW-2
LOCATION: Grid 669.3, 198.9	DATE DRILLED: 6/14/2000
DRILLING METHOD: Hollow Stem Auger \ Split Spoon Sample	CASING TYPE/DIA: PVC 2"
DEPTH DRILLED: 25 feet	TOTAL CASING: 13'
GROUND ELEVATION:	T.O.C. ELEVATION:
GROUT TYPE/QUANTITY: Bentonite Chips ½ bag \ Bentonite slurry 20 gallons	SCREEN TYPE/ LENGTH: 0.20 slot PVC \ 10 feet
GROUT INTERVAL: Chips 8 to 10' Slurry 1 to 8'	SCREENED INTERVAL: 15 to 25'
SAND PACK TYPE/INTERVAL: 10 to 25 feet	STATIC WATER LEVEL/DATE:
DEPTH TO WATER WHILE DRILLING: 18.8' bgl	LOGGED BY: PETE CAMPBELL
WATER LEVEL ELEVATION:	DRILLER: Hughes Drilling

DEPTH	H20\SOIL SAMPLE	FORMATION DESCRIPTION
0-4'		Drill, no cuttings
4-6	SSS #1 BC: 1-1	Sand, brown with some surface litter, (wood) 50% recovery PID 4.5
6-8'	SSS#2 BC: 1-1-1-0	Sand, brown, dry 30% recovery PID 6.6
8-10	SSS#3 BC: 3-3-2-2	0% recovery, Spoon bounced as if on a log. Bailing wire on tip of bit
10-12	SSS#4 BC: 2-1-1-1	Sand, brown with some organics PID 7.5 20% recovery
12-14	SSS#5 BC: 3-5-5-6	Sand, brown dry to moist PID 4.5
14-16	SSS#6 BC: 4-7-7-8	Sand, brown dry to moist PID 1.3 Drill to 20
20-22	SSS#7 BC: 4-4-4-7	Sand, brown wet PID 2.5 Water at 18.8 Sample Collected: MW-2-20-22 @ 12:14 Drill to 25', water at 18.8 EOB As the augers were removed from the hole a large chunk of metal came up the augers with several pieces of copper wire.

DWG. NO. B-17

WELL LOG DATA

American Environmental

PROJECT: Daubenspeck Property	WELL NO. MW-3
LOCATION: Grid 238.7, 54.1	DATE DRILLED: 6/14/2000
DRILLING METHOD: Hollow Stem Auger \ Split Spoon Sample	CASING TYPE/DIA: PVC 2"
DEPTH DRILLED: 30 feet	TOTAL CASING: 22.9'
GROUND ELEVATION: 100.3	T.O.C. ELEVATION: 103.41
GROUT TYPE/QUANTITY: Bentonite Chips 1 bag \ Bentonite slurry 20 gallons	SCREEN TYPE/ LENGTH: 0.20 slot PVC \ 10 feet
GROUT INTERVAL: Chips 12.5 to 17' Slurry 4.5 to 12.5'	SCREENED INTERVAL: 20 to 30'
SAND PACK TYPE/INTERVAL: 17 to 30 feet	STATIC WATER LEVEL/DATE:
DEPTH TO WATER WHILE DRILLING: 24' bgl	LOGGED BY: PETE CAMPBELL
WATER LEVEL ELEVATION:	DRILLER: Hughes Drilling

DEPTH	H20\SOIL SAMPLE	FORMATION DESCRIPTION
0-5'		Sand, brown
5-7	SSS #1 BC: 1-1-1-1	Sand, brown, moist, fine PID 0.0
7-9'	SSS#2 BC: 1-1-1-1	7-8 Sand, medium, brown, moist 8-8.3 Sand, fine, brown 8.3-9 Sand, medium, brown, some organics PID 0.0
9-11	SSS#3 BC: 1-1-1-1	Sand, medium, brown, with minor gravel. PID 0.0
11-13	SSS#4 BC: 1-1-1-1	Sand, medium, brown. PID 0.0
13-15	SSS#5 BC: 1-1-1-1	Sand, medium, brown. PID 0.0
15-17	SSS#6 BC: 1-1-1-1	Sand, medium, brown. PID 0.0
17-19	SSS#7 BC: 1-1-1-1	Sand, medium, brown, with minor gravel. PID 5.0
19-21	SSS#8 BC: 1-1-1-1	Sand, medium, brown, with minor gravel. PID 8.5
21-23	SSS#9 BC: 2-7-23	21-22 Sand, fine, brown. 22-23 Pea Gravel with concrete in tip, refusal. PID 8.6
		The augers apparently hit the suspected lip of the cistern that was rumored to be in the area. The rig was moved east 10 feet and re-drilled to 23'
23-25	SSS#10 BC: 3-7-7-10	Sand, brown with minor gravel, wet. PID 8.2 Sample Collected MW-3-23-25 @17:57

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 15 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,502 ft. Easting: 1,415,363 ft.

Top of Hole Elevation: 90.0 ft.

Hole Number, Field: TB-1 Permanent: AP-604-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.0 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
													Surface: Second growth willows
0	1		NFS	Grab	SP	Poorly graded SAND					-/ 0.0		Brown, moist, fine to medium sand
3	2		NFS	1 1 2 1	SP	Poorly graded SAND	8	87	5		-/ 0.0	3	Brown, moist, fine to medium sand
5	3		NFS	1 1 1 1	SP	Poorly graded SAND					-/ 0.0		Brown, moist, fine to medium sand
10	4		NFS	2 3 3 5	SP	Poorly graded SAND	4	93	3		-/ 0.0	5	Gray, moist, fine to medium sand
15	5		NFS	2 5 7 9	SP	Poorly graded SAND					-/ 0.0		Gray, moist, fine to medium sand
20	6			3 4 3 5	SP	Poorly graded SAND					-/ 0.0		Gray, moist, fine to medium sand
25	7a			3 5 5 9	SP	Poorly graded SAND							
26	7b				SM	Silty SAND	1	75	24			22	Dark gray, moist, fine sand, nonplastic (NP) fines
	7c				SP	Poorly graded SAND							
30	8			7 11 15	SP	Poorly graded SAND							Gray, wet, medium sand
35	9			5 8	SP	Poorly graded SAND							Gray, wet, fine to medium sand

EXPLORATION LOG KENAI BLUFFS.GPJ ACE_ANC.GDT 9/3/04

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: Kenai River Bluff Erosion Study
Kenai, Alaska

Date: 15 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,502 ft. Easting: 1,415,363 ft.

Top of Hole Elevation: 90.0 ft.

Hole Number, Field: TB-1

Permanent: AP-604-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.0 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks Surface: Second growth willows
38					13									
40		10			6 11 14	CL	Lean CLAY with Sand	0	22	78				Dark gray, moist, fine sand, plastic fines. LL=30.8, PI=15.5
46		11			7 7 10	CL	Lean CLAY with Sand							Dark gray, moist, rounded gravel, fine sand, plastic fines, very stiff
50		12			6 8 13	CL	Lean CLAY with Sand							Dark gray, moist, plastic fines, very stiff
55		13			8 20 12	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
60		14			5 9 8	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
65		15			4 9 12	CL	Lean CLAY with Sand	7	18	75	0.25		15	Dark gray, moist, fine sand, plastic fines, very stiff
70		16			4 6 9	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska	
	Date: 15 Sep 2003
Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling	Elevation Datum: MLLW ☐ MSL ☒ other
Location: Northing: 2,396,502 ft. Easting: 1,415,363 ft.	Top of Hole Elevation: 90.0 ft.

Hole Number, Field:	Permanent:	Operator:	Inspector:
TB-1	AP-604-P	Pat Kelley	Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer	Depth to Groundwater: 27.0 ft. WD	Depth Drilled: 100.0 ft.	Total Depth: 101.5 ft.

Hammer Weight:	Split Spoon I.D:	Size and Type of Bit:	Type of Equipment:	Type of Samples:
340 lbs	2.5 in.	8 in. HSA	CME-75 with Autohammer	Grab and Drive

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
													Surface: Second growth willows
74–75					CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
75–81	17			6 14 21	SP-SM	Poorly graded SAND with Silt							Gray, wet, fine to medium sand
	18			10 14 18	SP-SM	Poorly graded SAND with Silt	1	92	7				Gray, wet, medium sand
	19a			4 12 11	SP-SM	Poorly graded SAND with Silt							Gray, wet, medium sand
91–94	19b				CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines
94–101.5				7 15 18	SP	Poorly graded SAND							Gray, wet, fine to medium sand

Bottom of Hole 101.5 ft.
Groundwater Encountered While Drilling: at an elevation of 63.0 ft.
PID = (Cold/Hot) Photo Ionization Detector

Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 16 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,309 ft. Easting: 1,415,302 ft.

Top of Hole Elevation: 89.8 ft.

Hole Number, Field: TB-2 Permanent: AP-605-MW

Operator: Pat Kelley

Inspector: Steven Hensiee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☒ Monitoring Well ☐ Piezometer

Depth to Groundwater: 29.9 ft. WD

Depth Drilled: 37.5 ft.

Total Depth: 38.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Sample	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks (Surface: Lawn)
0	1a	Grab	ML	SILT					-/		Brown, moist, nonplastic (NP) fines, organics (sixty percent by volume)
	1b		SP	Poorly graded SAND				1	1.0		Brown, moist, rounded gravel, fine to medium sand
2–4	2	2 2 4 6	SP	Poorly graded SAND				0.5	-/ 1.0		Brown, moist, fine to medium sand
6	3	2 3 4 5	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine to medium sand
10	4	5 4 6	SP	Poorly graded SAND				0.75	-/ 0.0		Gray, moist, fine to medium sand
15	5	2 6 7	SP	Poorly graded SAND	4	92	4	0.75	-/ 1.0	5	Gray, moist, fine to medium sand
20	6	3 3 5	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine to medium sand
25	7	3 4 8	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine to medium sand, localized evidence of mottling, one small area (one inch thick) of 30% silt
30	8	2 6 10	SP	Poorly graded SAND with Gravel	24	74	2	1			Brown, wet, rounded gravel, fine to coarse sand
35	9	2 3	SP	Poorly graded SAND							Twelve inches of heaving sand Gray, wet, fine to medium sand

NPA Form 19-E
May 94 Prev. Ed. Obsolete

Project: Kenai River Bluff Erosion Study

Hole Number: AP-605-MW

EXPLORATION LOG KENAI_BLUFFS.GPJ ACE_ANC.GDT 9/3/04

DWG. NO. B-22

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 16 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,309 ft. Easting: 1,415,302 ft.

Top of Hole Elevation: 89.8 ft.

Hole Number, Field: TB-2 Permanent: AP-605-MW

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☒ Monitoring Well ☐ Piezometer

Depth to Groundwater: 29.9 ft. WD

Depth Drilled: 37.5 ft.

Total Depth: 38.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Lawn
					4									
38		10			3 7	CL	Lean CLAY with Sand	4	14	82			17	Dark gray, moist, fine sand, plastic fines, very stiff
40														Bottom of Hole 38.5 ft. Groundwater Encountered While Drilling: at an elevation of 59.9 ft. PID = (Cold/Hot) Photo Ionization Detector
42														
44														Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.
46														
48														
50														
52														
54														
56														
58														
60														
62														
64														
66														
68														
70														
72														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 17 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,225 ft. Easting: 1,415,366 ft.

Top of Hole Elevation: 88.7 ft.

Hole Number, Field: TB-3 Permanent: AP-606-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 99.5 ft.

Total Depth: 101.0 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks (Surface: Dirt parking lot)
0	1			Grab	SP	Poorly graded SAND with Gravel				0.75			Brown, moist, rounded gravel, fine to medium sand, FILL
3	2			2 3 4 4	SP	Poorly graded SAND							Brown, moist, fine sand
5.5	3			2 3 1 4	SP	Poorly graded SAND				0.25	-/ 0.0		Brown, moist, fine sand
10	4			2 1 3	SP	Poorly graded SAND				0.25	-/ 0.0		Brown, moist, fine sand
15	5			2 2 3 4	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine sand
20	6			2 4 6	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine sand
25	7			4 7 9	SM	Silty SAND	0	79	21		-/ 0.0	15	Brown, moist, fine sand
30	8			7 9 15	SP	Poorly graded SAND with Gravel	17	81	2				Brown, moist, medium to coarse sand
35	9			1 6 9	SP	Poorly graded SAND with Gravel	32	66	2				Brown, wet, rounded gravel, fine to coarse sand

EXPLORATION LOG KENAI BLUFFS.GPJ ACE_ANC.GDT 9/3/04

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project:	Kenai River Bluff Erosion Study, Kenai, Alaska
Date:	17 Sep 2003
Drilling Agency:	☐ Alaska District ☒ Other Hughes Drilling
Elevation Datum:	MLLW ☐ MSL ☒ other
Location:	Northing: 2,396,225 ft. Easting: 1,415,366 ft.
Top of Hole Elevation:	88.7 ft.
Hole Number, Field:	TB-3
Permanent:	AP-606-P
Operator:	Pat Kelley
Inspector:	Steven Henslee
Type of Hole:	☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer
Depth to Groundwater:	27.9 ft. WD
Depth Drilled:	99.5 ft.
Total Depth:	101.0 ft.
Hammer Weight:	340 lbs
Split Spoon I.D:	2.5 in.
Size and Type of Bit:	8 in. HSA
Type of Equipment:	CME-75 with Autohammer
Type of Samples:	Grab and Drive

Depth (ft.)	Sample	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
											Surface: Dirt parking lot
40	10a	4 8 15	CL	Lean CLAY with Sand					-/ 1.0		Gray, moist, plastic fines, very stiff
	10b		GP	Poorly graded GRAVEL							Gray, moist, rounded gravel, coarse sand, 1.5 inches thick
	10c		CL	Lean CLAY with Sand							
45	11a	7 17 24	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
	11b		SP	Poorly graded SAND							Dark gray, moist, medium sand
	11c		CL	Lean CLAY with Sand							Dark, gray, moist, fine sand, plastic fines, very stiff
50	12	7 13 16	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, fine sand, plastic fines, very stiff
52–54			SP	Poorly graded SAND							Estimated by drill action
55	13	6 13 16	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, fine sand, plastic fines, very stiff, marbled with clean gray medium sand to one and one sixteen inches thick
60	14	9 13 38	CL	Lean CLAY with Sand	0	23	77		-/ 0.0	17	Dark gray, moist, fine sand, plastic fines. LL=29, PI=15
65	15	7 11 15	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, fine sand, plastic fines
70	16	4 8 12	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, fine sand, plastic fines

ALASKA DISTRICT
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Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 17 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,225 ft. Easting: 1,415,366 ft.

Top of Hole Elevation: 88.7 ft.

Hole Number, Field: TB-3 Permanent: AP-606-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 99.5 ft.

Total Depth: 101.0 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Dirt parking lot
75		17			4 9 11	CL	Lean CLAY with Sand	1	26	73		-/ 0.0	17	Dark gray, moist, fine sand, plastic fines, very stiff
80		18			5 9 12	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, fine sand, plastic fines, 1.25-inch thick seam of fine gray sand in sample
85		19			5 13 21	SP-SM	Poorly graded SAND with Silt					-/ 0.0		Dark gray, moist, fine to medium sand, NP fines
90		20			3 7 17	SP-SM	Poorly graded SAND with Silt	0	89	11		-/ 0.0	20	Dark gray, moist, fine to medium sand, NP fines
95		21			7 12 12	SP-SM	Poorly graded SAND with Silt					-/ 1.0		Dark gray, moist, medium sand, NP fines
100		22			6 17	SP-SM	Poorly graded SAND with Silt					-/ 0.0		Dark gray, moist, fine to medium sand, NP fines

Depth scale: 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108

Bottom of Hole 101.0 ft.
Groundwater Encountered While Drilling: at an elevation of 60.8 ft.
PID = (Cold/Hot) Photo Ionization Detector

Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.

EXPLORATION LOG KENAI BLUFFS.GPJ ACE_ANC.GDT 9/3/04

ALASKA DISTRICT
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Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 18 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,206 ft. Easting: 1,414,825 ft.

Top of Hole Elevation: 89.6 ft.

Hole Number, Field: TB-4 Permanent: AP-607-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class, TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Second growth willows and spruce
0–2		1		F2	Grab	SM	Silty SAND with Gravel				2	-/ 0.0		Brown, moist, rounded gravel, fine to medium sand, nonplastic (NP) fines
5–7		2		NFS	4 3 3 5	SP	Poorly graded SAND				0.25	-/ 1.0		Brown, moist, fine sand
15–17		3		NFS	3 3 4 5	SP	Poorly graded SAND				1.25	-/ 0.0		Brown, moist, rounded gravel, fine sand
25–27		4a			5 4 4 4	SP	Poorly graded SAND	0	65	35		-/ 0.0	23	Brown, moist, fine sand
		4b				SM	Silty SAND							Brown, moist, fine sand, NP fines
		4c				SP	Poorly graded SAND							Brown, moist, fine sand
30–31.5		5			4 7 6	SP	Poorly graded SAND	7	92	1				Brown, wet, medium to coarse sand
35–36.5		6			2 9	GP	Poorly graded GRAVEL with Sand	50	48	2				Twelve inches of heaving sand. Dark gray, wet, rounded gravel, fine to coarse sand

ALASKA DISTRICT CORPS OF ENGINEERS ENGINEERING SERVICES	Project: Kenai River Bluff Erosion Study, Kenai, Alaska	Page 2 of 3 / Date: 18 Sep 2003
Soils and Geology Section	Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling	Elevation Datum: MLLW ☐ MSL ☒ other
EXPLORATION LOG	Location: Northing: 2,396,206 ft. Easting: 1,414,825 ft.	Top of Hole Elevation: 89.6 ft.

Hole Number, Field: TB-4	Permanent: AP-607-P	Operator: Pat Kelley	Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer	Depth to Groundwater: 27.9 ft. WD	Depth Drilled: 100.0 ft.	Total Depth: 101.5 ft.

Hammer Weight: 340 lbs	Split Spoon I.D: 2.5 in.	Size and Type of Bit: 8 in. HSA	Type of Equipment: CME-75 with Autohammer	Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks Surface: Second growth willows and spruce
38					13									
46		7			5 15 18	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, find sand, plastic fines, very stiff
56		8			3 6 10	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, rounded gravel, fine sand, plastic fines, very stiff
66		9a			2 6 8	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, fine sand, plastic fines, very stiff
		9b				SP	Poorly graded SAND							Dark gray, moist, fine to medium sand
70		10			6 11 14	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff, 1.25-inch layer of gray fine sand

Depth scale: 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72

EXPLORATION LOG KENAI_BLUFFS.GPJ ACE_ANC.GDT 9/3/04

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska	Page 3 of 3
	Date: 18 Sep 2003
Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling	Elevation Datum: MLLW ☐ MSL ☒ other
Location: Northing: 2,396,206 ft. Easting: 1,414,825 ft.	Top of Hole Elevation: 89.6 ft.
Hole Number, Field: TB-4 Permanent: AP-607-P	Operator: Pat Kelley / Inspector: Steven Henslee
Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer	Depth to Groundwater: 27.9 ft. WD / Depth Drilled: 100.0 ft. / Total Depth: 101.5 ft.
Hammer Weight: 340 lbs / Split Spoon I.D: 2.5 in. / Size and Type of Bit: 8 In. HSA	Type of Equipment: CME-75 with Autohammer / Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Second growth willows and spruce
80		11			5 6 9	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, fine sand, plastic fines
85		12a			5	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines
86		12b			12 25	SP	Poorly graded SAND							Dark gray, moist, fine to medium sand
89						CL	Lean CLAY with Sand							
90		13			3 9 12	SP	Poorly graded SAND					-/ 1.0		Dark gray, moist, fine to medium sand
95		14			3 4 16	SP	Poorly graded SAND	0	98	2		-/ 1.0	20	Dark gray, moist, fine to medium sand
100		15			.33	CL	Lean CLAY	0	8	92		-/ 0.0	27	Dark gray, moist, fine sand, plastic fines, very soft

Bottom of Hole 101.5 ft.
Groundwater Encountered While Drilling: at an elevation of 61.6 ft.
PID = (Cold/Hot) Photo Ionization Detector

Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.

EXPLORATION LOG KENAI BLUFFS.GPJ ACE_ANC.GDT 9/3/04

APPENDIX C
GROUNDWATER MONITORING DATA

TABLE C-01
KENAI RIVER BLUFF EROSION STUDY
GROUNDWATER MONITORING PROGRAM
GROUNDWATER ELEVATION SUMMARY

Group ID	Monitoring Well ID	Test Hole ID	Total Depth (ft.)	Aquifer	Groundwater Elevations[a]																									
					Reading No. 1 20/21-Nov-2006		Reading No. 2 27-Dec-2006		Reading No. 3 24-Jan-2007		Reading No. 4 28-Feb-2007		Reading No. 5 23-Mar-2007		Reading No. 6 28-Apr-2007		Reading No. 7 24-May-2007		Reading No. 8 26-Jun-2007		Reading No. 9 26-Jul-2007		Reading No. 10 24-Aug-2007		Reading No. 11 25-Sep-2007		Reading No. 12 24-Oct-2007		Reading No. 13 3-Dec-2007	
					Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.	Time	Elev.
GROUP-1	AP-608-MW	TB-1A	100	LOWER	NA	21.1	14:45	22.0	14:15	22.0	12:13	21.9	10:55	22.6	9:00	22.1	12:15	22.0	12:10	21.6	12:25	21.9	9:33	22.1	12:25	22.1	11:35	21.7	14:35	22.2
	AP-609-MW	TB-1B	75	LOWER	NA	21.4	14:45	21.8	14:12	21.6	12:08	21.7	10:59	21.8	9:05	21.8	12:12	21.5	12:07	21.2	12:23	21.1	9:30	21.1	12:22	21.2	11:32	21.2	14:34	21.4
	AP-610-MW	TB-1C	40	UPPER	NA	54.4	14:40	54.5	14:10	54.4	12:16	54.3	11:02	54.3	8:55	54.3	12:10	54.3	12:05	54.2	12:20	54.2	9:26	54.2	12:20	54.2	11:30	54.2	14:33	54.3
GROUP-2	AP-611-MW	TB-2C	100	LOWER	NA	15.6	14:15	10.7	14:00	9.7	12:32	11.6	11:10	13.5	9:10	9.8	12:00	13.1	12:00	9.3	12:15	9.4	9:45	9.4	12:15	9.2	11:25	9.2	14:30	14.1
	AP-612-MW	TB-2B	75	UPPER	NA	53.3	14:10	39.3	13:57	39.1	12:28	39.0	11:13	38.7	9:13	38.4	11:57	38.2	11:58	38.0	12:12	38.5	9:40	38.0	12:12	37.9	11:22	37.8	14:27	37.8
	AP-613-MW	TB-2A	40	UPPER	NA	57.8	14:10	57.8	13:55	57.8	12:27	57.8	11:15	57.7	9:15	57.7	11:55	57.7	11:57	57.6	12:10	57.6	9:48	57.6	12:10	57.6	11:20	57.6	14:25	57.6
GROUP-3	AP-614-MW	TB-3A	100	LOWER	NA	11.0	14:00	12.9	13:40	11.8	14:56	12.8	12:20	13.8	10:30	10.4	11:50	11.7	11:25	9.4	12:30	9.4	8:58	10.4	11:45	10.1	10:45	10.2	14:00	14.1
	AP-615-MW	TB-3B	75	UPPER	NA	40.3	13:55	34.0	13:37	34.5	14:54	31.9	12:22	31.0	10:32	30.5	11:45	30.6	11:20	30.5	12:32	30.6	9:06	30.6	11:42	30.6	10:42	30.7	13:57	30.8
	AP-616-MW	TB-3C	40	UPPER	NA	56.8	13:50	56.9	13:35	56.9	14:51	56.8	12:25	56.8	10:35	56.8	11:40	56.8	11:18	56.7	12:35	56.7	8:50	56.6	11:40	56.8	10:40	56.8	13:55	56.8
GROUP-4	AP-617-MW	TB-4A	100	LOWER	NA	14.2	13:15	12.9	13:28	8.5	15:27	15.8	12:50	10.3	11:33	7.4	11:00	13.0	11:15	6.0	11:40	6.3	9:56	6.0	11:35	4.6	10:30	4.8	13:50	15.6
	AP-618-MW	TB-4B	70	UPPER	NA	54.9	13:10	54.8	13:25	54.6	15:25	54.3	12:55	53.9	11:35	54.1	10:55	53.8	11:10	53.8	11:38	53.6	9:58	53.5	11:32	53.4	10:27	53.6	13:47	53.1
	AP-619-MW	TB-4C	40	UPPER	NA	63.3	13:05	63.2	13:20	63.1	15:24	63.0	13:00	62.9	11:40	62.9	10:50	62.9	11:05	62.9	11:35	62.8	10:01	62.8	11:30	62.9	10:25	62.8	13:45	62.9
SINGLE WELLS	AP-620-MW	TB-02	40	UPPER	NA	63.9	14:25	63.9	13:50	63.7	14:37	63.6	12:09	63.5	9:20	63.4	12:05	63.4	11:55	63.3	12:05	63.2	9:18	63.2	12:05	63.2	11:15	63.1	14:20	63.3
	AP-621-MW	TB-03	40	UPPER	NA	71.0	12:10	70.7	13:00	70.5	15:06	70.2	12:34	70.1	10:40	70.0	10:35	69.9	10:50	69.9	11:15	69.9	10:10	69.8	11:05	70.0	10:05	69.9	13:25	70.0
	MW-1[b]	NA	25	UPPER	NA	69.0	12:25	69.1	13:10	68.9	15:17	68.7	12:38	68.6	10:55	68.6	10:45	68.5	10:58	68.4	11:25	68.3	10:22	68.3	11:20	68.4	10:15	68.3	13:35	68.4
	MW-2[b]	NA	25	UPPER	NA	72.0	12:20	71.7	13:05	71.5	15:11	71.3	12:40	71.2	10:51	71.1	10:40	71.0	10:55	70.9	11:20	70.9	10:15	70.8	11:15	71.0	10:10	71.0	13:30	71.1
	MW-3[b]	NA	30	UPPER	NA	67.0	12:00	66.8	12:50	66.6	15:20	66.5	12:45	66.4	11:30	66.3	10:30	66.3	11:00	66.2	11:30	66.2	10:06	66.2	11:25	66.2	10:20	66.2	13:40	66.3
	AP-604[c]	TB-1	101.5	UPPER	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10:25	29.5	13:00	27.5	1145	27.4	11:45	27.4	11:25	27.5	11:55	27.3	11:00	27.6	14:10	27.3
	AP-605[c]	TB-2	38.5	UPPER	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10:15	29.8	13:05	29.8	1140	29.9	11:50	29.9	11:16	29.9	12:00	29.8	11:10	29.8	14:15	29.8
	AP-606[c,d]	TB-3	101	UPPER	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	AP-607[c,e]	TB-4	101.5	UPPER	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10:00	30.0	12:51	27.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Key:

a - The groundwater elevations shown are in feet above mean sea level.
b - MW-1 through MW-3 were installed by American Environmental, and have not been assigned an AP number.
c - AP-604 through AP-607 were installed by the USACE and were not scheduled for a complete 12 month reading cycle.
d - AP-606 was unable to be located.
e - Tooling became jammed in AP-607 and was not operable after Reading No. 6.

FIGURE C-02
GROUP ONE-GROUNDWATER ELEVATION TRENDS
KENAI RIVER BLUFF EROSION

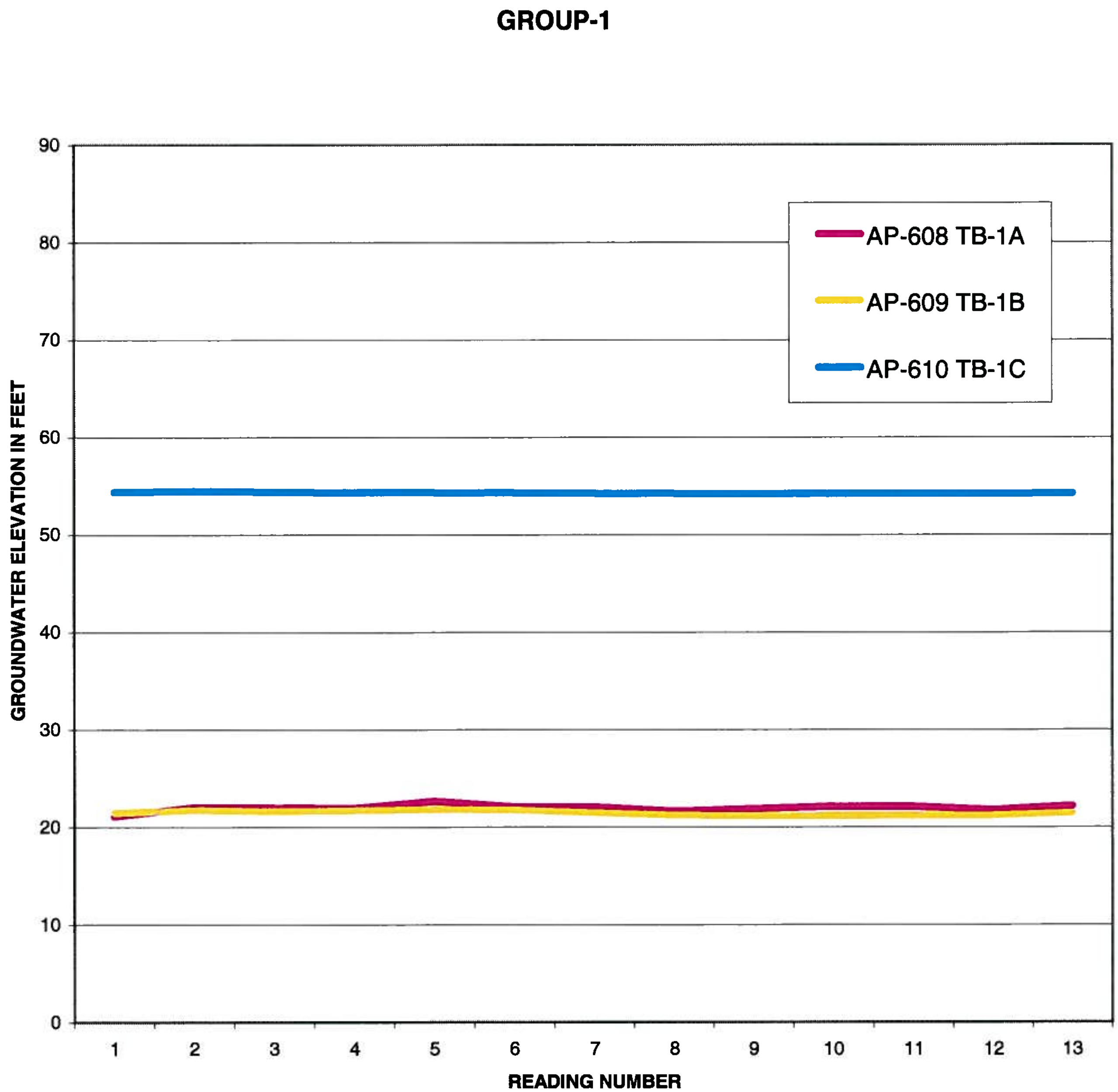


FIGURE C-03
GROUP TWO-GROUNDWATER ELEVATION TRENDS
KENAI RIVER BLUFF EROSION

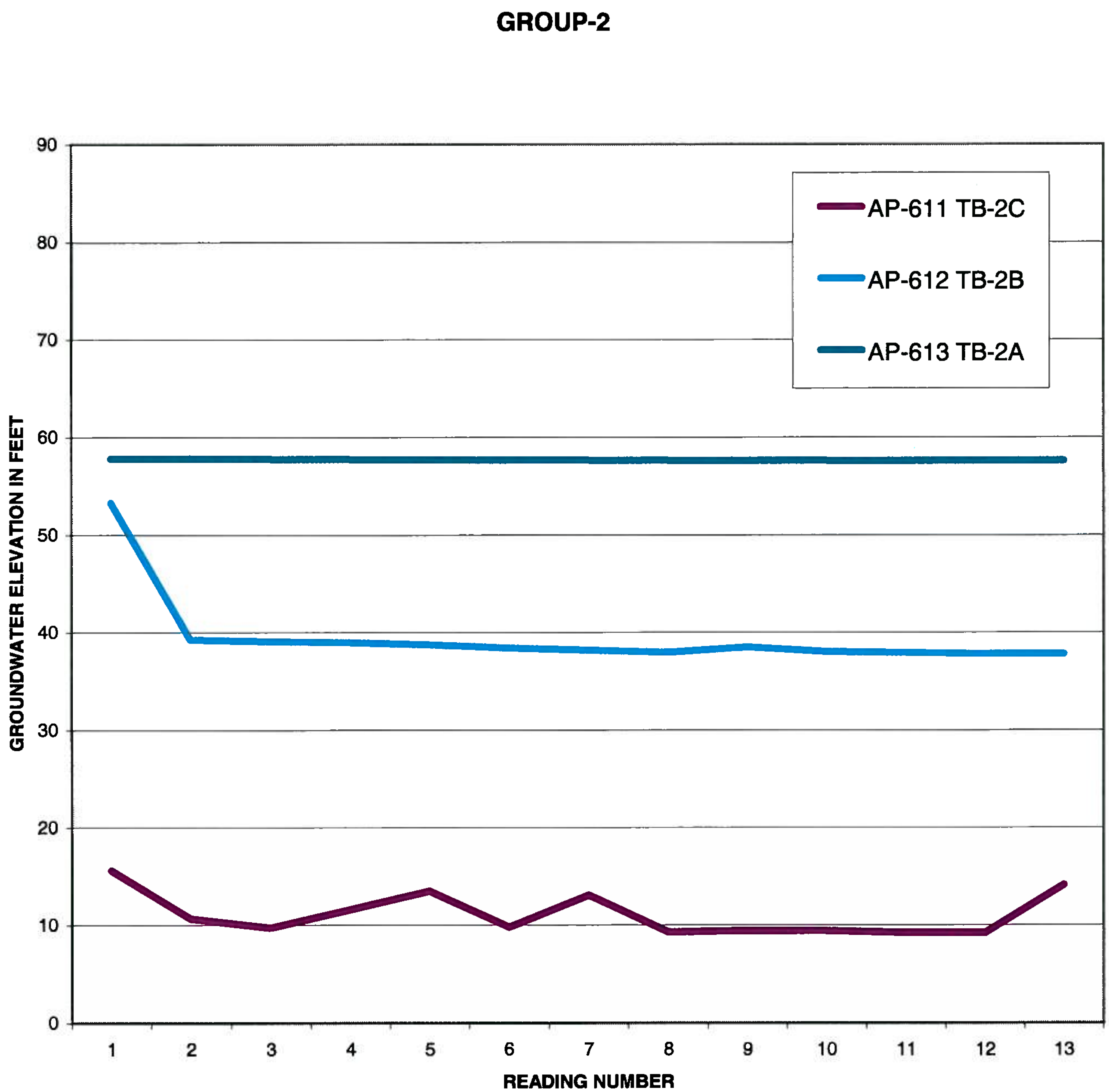


FIGURE C-04
GROUP THREE-GROUNDWATER ELEVATION TRENDS
KENAI RIVER BLUFF EROSION

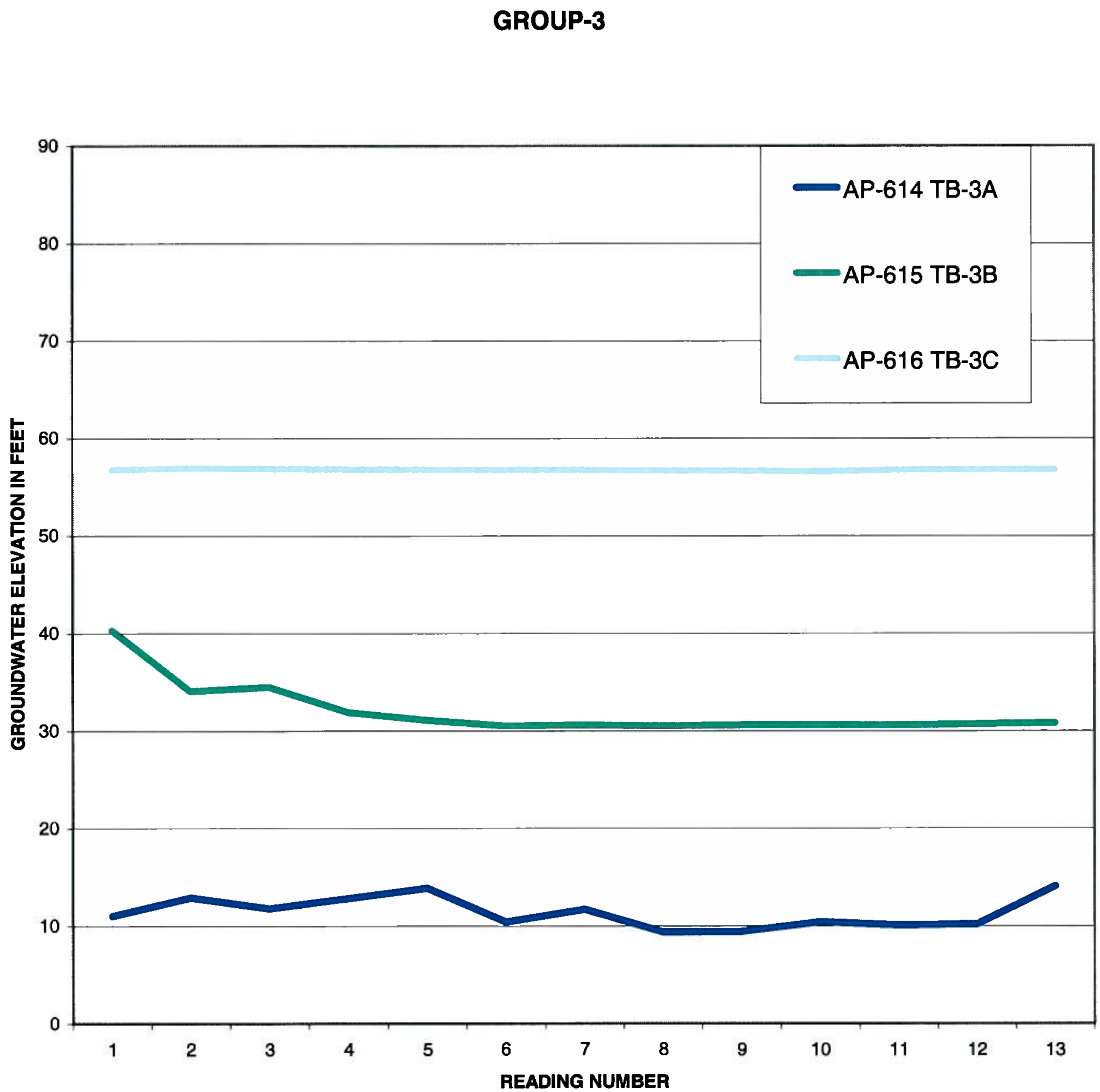


FIGURE C-05
GROUP FOUR-GROUNDWATER ELEVATIONS TRENDS
KENAI RIVER BLUFF EROSION

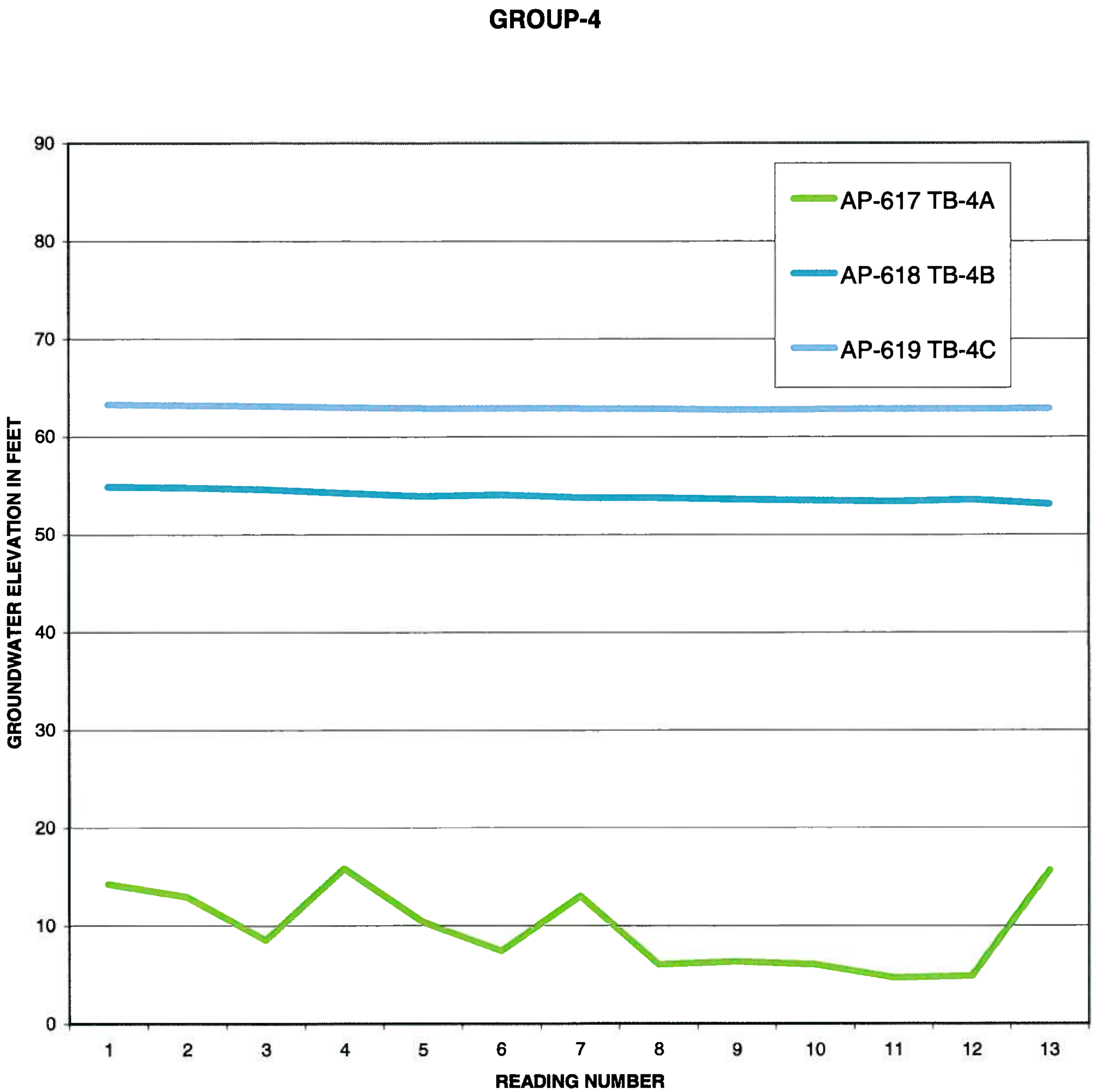
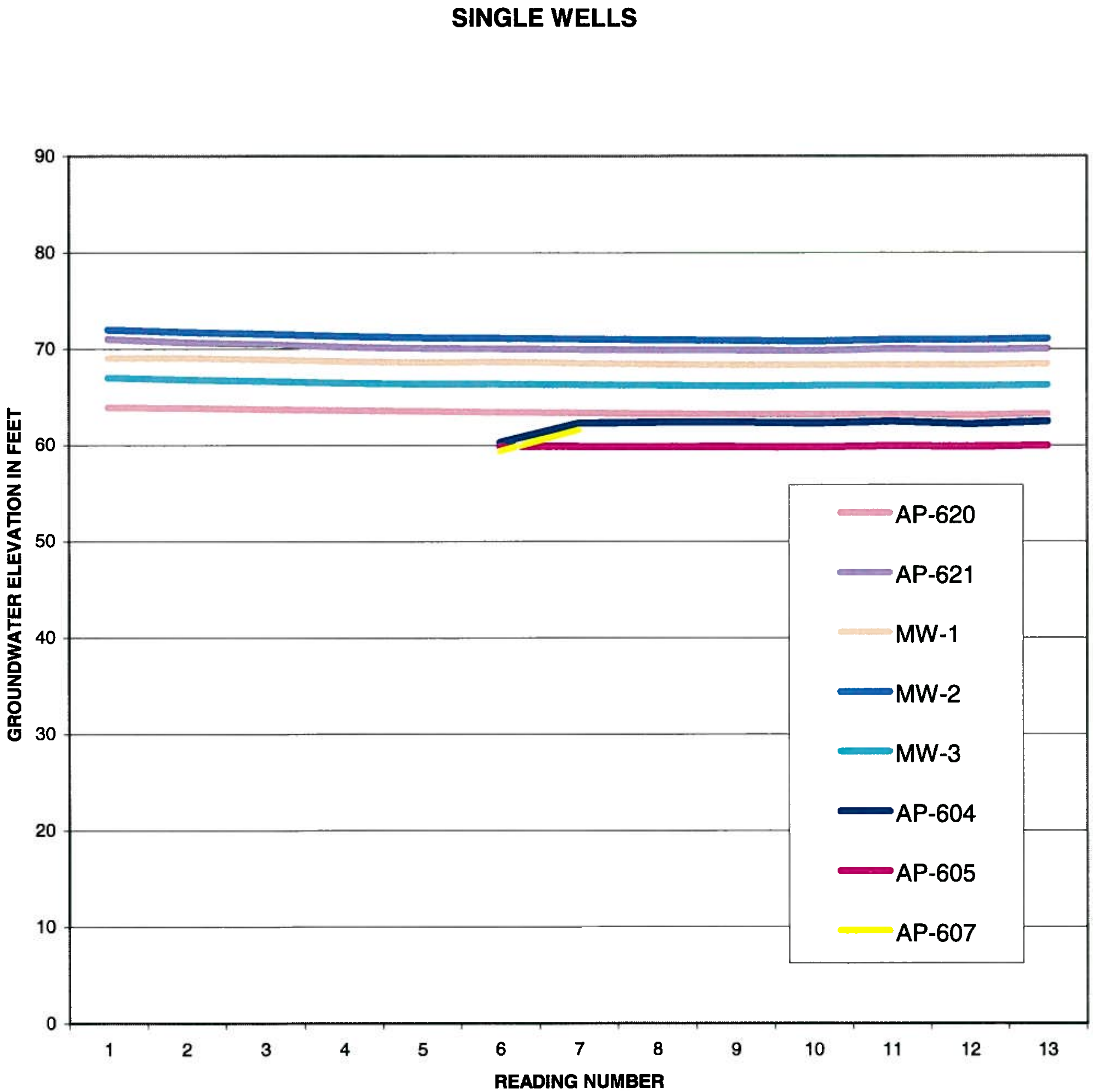


FIGURE C-06
SINGLE WELLS-GROUNDWATER ELEVATION TRENDS
KENAI RIVER BLUFF EROSION



ATTACHMENT M: R&M GEOTECHNICAL INVESTIGATIONS REPORT

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FINAL SUBMITTAL

GEOTECHNICAL INVESTIGATION AND SITE CONDITIONS REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

CONTRACT NO. W911KB-05-D-0004
DELIVERY ORDER NO. 0010
MODIFICATION NO. 01

Prepared for:

U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. Box 6898
Elmendorf AFB, Alaska 99506

February, 2007

R&M CONSULTANTS, INC.

R&M CONSULTANTS, INC.
9101 Vanguard Drive, Anchorage, Alaska 99507
(907) 522-1707, FAX (907) 522-3403, www.rmconsult.com

February 14, 2007

R&M No. 1209.10

U.S. Army Engineer District, Alaska
ATTN: Mr. Chuck Wilson (CEPOA-EN-ES-SG)
P.O. Box 6898
Elmendorf AFB, Alaska 99506

RE: Geotechnical Investigation and Site Conditions Report
Kenai River Bluff Erosion
Kenai, Alaska
Contract No. W911KB-05-D-0004, Delivery Order No. 0010, Modification No. 01

Gentlemen:

Attached find our final report for the above-referenced geotechnical investigation. This report was prepared under the terms of Contract No. W911KB-05-D-0004, Delivery Order No. 0010, Modification No. 01. This final submittal includes the incorporation of your verbal review comments of February 6, and February 13, 2007.

We trust that this report is found to be responsive to your requirements. Should you have any questions or require further information, please contact us.

Very truly yours,

R&M CONSULTANTS, INC.

Charles H. Riddle, C.P.G.
Vice President

CHR*slv

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FINAL SUBMITTAL

GEOTECHNICAL INVESTIGATION AND SITE CONDITIONS REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

CONTRACT NO. W911KB-05-D-0004
DELIVERY ORDER NO. 0010
MODIFICATION NO. 01

Prepared for:

U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. Box 6898
Elmendorf AFB, Alaska 99506

Attention:
Mr. Chuck Wilson
CEPOA-EN-ES-SG

Prepared by:

R&M CONSULTANTS, INC.
9101 Vanguard Drive
Anchorage, Alaska 99507

February, 2007

GEOTECHNICAL INVESTIGATION AND SITE CONDITIONS REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

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GEOTECHNICAL INVESTIGATION AND SITE CONDITIONS REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

1.0 INTRODUCTION

1.1 Background

For many years, the City of Kenai has been concerned with the ongoing erosion of a one mile portion of the steep bluff along the right bank of the Kenai River within the city. This erosion has required the relocation of privately owned buildings as well as city infrastructure and utilities. Unless measures to control the erosion and protect the bluff are implemented, bluff erosion is expected to continue, further threatening existing buildings, infrastructure, and utilities within proximity to the bluff.

The U.S. Army Corps of Engineers - Alaska District (USACE-AD) has conducted a geotechnical investigation to provide design-level information for the Kenai River Bluff Erosion Project. The geotechnical investigation provides site-specific geotechnical design information necessary to establish an erosion control method that is technically feasible and satisfies resource agency needs. The work consisted of drilling and logging test borings, installing groundwater monitoring wells, laboratory testing, and the preparation of various reports. Ultimately, the geotechnical data obtained will be used, in conjunction with other considerations, in developing the specifications and design criteria for the project. An area map is provided as Figure 1.

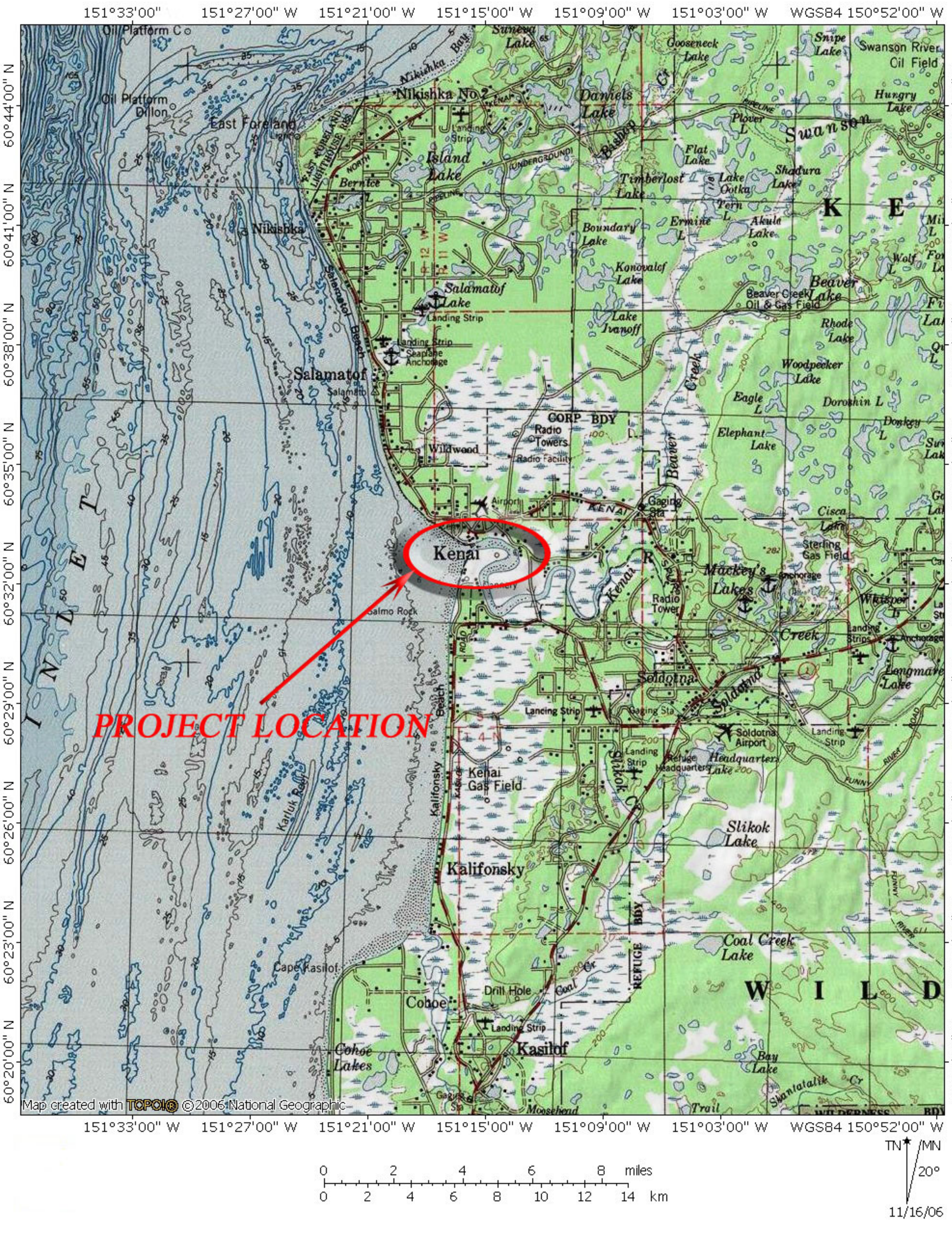
R&M Consultants, Inc. (R&M) has been tasked by the USACE-AD to provide professional geotechnical services for the project. Drilling, sampling, and groundwater monitoring well installation services were performed by Discovery Drilling, Inc. of Anchorage, Alaska under direct contract to R&M.

To gain a better understanding of the area and to formulate the scope-of-work needed for this exploration, a reconnaissance visit to the area was undertaken by personnel from the USACE-AD and R&M. As a result of the reconnaissance and previous meetings, two areas were selected for exploration. These are designated as the bluff crest and the bluff toe. General bluff conditions are discussed in R&M's prior geotechnical scope-of-work report (R&M, 2006). All test boring explorations along the bluff toe were performed in the Kenai River Habitat Protection Area and within 50 feet of the ordinary high water (OHW) zone, thus requiring special permits and minimal disturbance to the drill sites.

During the geotechnical field investigations, a total of 20 test borings were drilled and sampled at the project site. Fourteen (14) of these test borings were completed as groundwater monitoring wells. Soil samples have been subjected to a number of laboratory tests for the determination of

FIGURE 1

AREA MAP



soil classification and engineering properties useful in geotechnical/geohydrologic analysis and future civil design.

The site conditions presented herein are based on our current understanding of the project as outlined within this report and illustrated on the drawings in Appendix A. Any deviation from the proposed locations may necessitate further evaluation of subsurface conditions.

1.2 Contract Authorization

This work was completed under the terms of Contract No. W911KB-05-D-0004 between the U.S. Army Corps of Engineers – Alaska District and R&M Consultants, Inc. The geotechnical investigation and this report were completed in specific fulfillment of Delivery Order No. 0010, Modification No. 01.

Measurements and weights presented in this report are generally shown as U.S. customary units. Where previous investigations and reports have utilized SI units, we have retained the units expressed in the original document. A conversion chart is included as Table 1 for use in conversion from U.S. customary units to the International System (SI) units. Actual conversion should be made with the appropriate numbers carried to three or more significant figures.

1.3 Purpose and Scope-of-Work

The intent of this investigation has been to provide geotechnical information to evaluate the subsurface conditions for the analysis and design of a bluff stabilization project. Geotechnical investigations were performed in accordance with procedures outlined in “Geotechnical Investigations” (USACE, 2001), “Soils and Geology” (USACE, 1983), and “Soil Sampling” (USACE, 1996). This report presents a summary of the results of R&M’s field exploration programs and our interpretation of subsurface conditions.

This work was performed under a Statement-of-Work prepared by the USACE-AD, revised 13 September 2006. The Statement-of-Work is presented as Appendix E to this report.

The Scope-of-Work for R&M’s geotechnical investigation was comprised of seven tasks (with various subtasks) as follows:

- Task 1: Planning
  - Subtask 1a – Work Plan
  - Subtask 1b – Rights of Entry, Utility Locates and Permits
- Task 2: Geologic Logging of Bluff
- Task 3: Location Surveys of Test Borings
- Task 4: Drilling and Groundwater Monitoring Well Installation
- Task 5: Laboratory Testing
- Task 6: Report Preparation
- Task 7: Groundwater Monitoring

No geotechnical analysis or recommendations were required under the Statement-of-Work. Additionally, groundwater monitoring will continue on a periodic basis. A groundwater monitoring report will be submitted under separate cover.

1.4 Existing Information

R&M reviewed the following documents, provided by the USACE-AD, which included some geologic and/or geotechnical information specific to the subject project.

Peratrovich, Nottingham, and Drage, Inc. (PN&D). 2000. Kenai Coastal Trail & Erosion Control Project, Design Concept Report. *Prepared for* City of Kenai, Alaska.

Smith, O., W. Lee and H. Merkel. 2001. Erosion at the Mouth of the Kenai River, Alaska; Analysis of Sediment Budget with regard to the proposed Kenai Coastal Trail & Erosion Control Project. University of Alaska Anchorage. *Prepared for* Peratrovich, Nottingham, and Drage, Inc.

Tibbetts-Abbett-McCarthy-Stratton (TAMS). 1982. City of Kenai, Bluff Erosion Study, Draft Report. *Prepared for* City of Kenai, Alaska.

U.S. Army Corps of Engineers (USACE-AD). 2004. Geotechnical Findings Report, Kenai River Bluff Erosion, Kenai, Alaska. Alaska District, Soils and Geology Section.

Note that only the 2004 USACE-AD report included any factual data pertaining to the geologic and geotechnical conditions in the project area (e.g. test hole logs, laboratory soil tests, groundwater levels, etc.). Exploration logs from the 2004 USACE-AD report are reproduced in Appendix B of this report. Well logs by American Environmental are also included in Appendix B. In addition, a number of U.S. Geological Survey documents and other technical reports were reviewed in regards to regional conditions. These various reports are cited herein and listed in the references section of this report.

2.0 REGIONAL SETTING AND GENERAL SITE CONDITIONS

2.1 Regional Setting

2.1.1 Location

The City of Kenai is located about 65 air miles southwest of Anchorage, Alaska. The bluff area that is the subject of this investigation lies along the right bank of the Kenai River near where the river empties into Cook Inlet. The project site is located on U.S. Geological Survey (USGS) Kenai (C-4) Quadrangle, Township 5 North, Range 11 West, Sections 5 and 6, Seward Meridian, Alaska. A site map is included as Figure 2.

A fortified post called Fort St. Nicholas was built in the area by Russians in 1791. The village was also called Paul's Fort. In 1869 a U.S. Military Post, named Fort Kenai for the Indians living in the area, was established (Orth, 1967).

2.1.2 Regional Geology

Kenai is situated on the Kenai Peninsula, which lies within the Cook Inlet-Susitna Lowland physiographic province (Wahrhaftig, 1965). The area is characterized as a glaciated lowland containing areas of ground moraine and stagnant ice topography, drumlin fields, eskers and outwash plains with rugged mountains located to the east.

The Kenai Peninsula is bounded by Turnagain Arm to the north, Cook Inlet to the west, the North Pacific Ocean to the south, and includes the Kenai Mountains to the east (see Appendix A, Drawing A-01). The Kenai Lowland is the portion of the peninsula located west of the Kenai Mountains; it is part of the larger Cook Inlet-Susitna geologic structural basin which is surrounded by the Chugach, Talkeetna, and Alaska Mountain Ranges. The Cook Inlet-Susitna basin and adjacent Kenai Mountains are in a relatively active seismic zone and are bisected by several inactive and active faults. Within the basin, bedrock is generally overlain by relatively thick unconsolidated glacial, fluvial, and marine sediments, whereas in the adjacent mountains bedrock is commonly exposed at the surface or covered with a relatively thin veneer of soil.

Bedrock beneath the lowland consists mainly of poorly consolidated coal-bearing rocks of Tertiary-age, generally mildly deformed or flat-lying. This poorly consolidated bedrock is mantled by glacial moraine and outwash, and marine and lake deposits.

This portion of southcentral Alaska was covered with glacial ice during glacial advances of early to middle Pleistocene-age (Coulter et al., 1965), as evidenced by local topography and soil stratigraphy. This region of Alaska is considered to be generally free of permafrost except where isolated masses of permafrost occur in lowland areas where ground insulation is high, such as peat bogs and swamps (Ferrains, 1965).

FIGURE 2

SITE MAP

Not to Scale

Regional geologic mapping for the area has been published at a scale of 1:250,000 (1 inch = 4 miles) by the U.S. Geological Survey (Magoon et al, 1976). Quaternary geology of the Kenai Lowland has also been published at a scale of 1:250,000 (Karlstrom, 1964). Additionally, Karlstrom (1958) has mapped ground conditions and surficial geology of the Kenai-Kasilof area at a scale of 1:63,360 (1 inch = 1 mile). Although quite dated, Martin et al. (1915) present data on the geology and mineral resources of the Kenai Peninsula.

2.1.3 General Seismicity

Southcentral Alaska, including the Kenai Peninsula, is located in a very active seismic region associated with the collision of two tectonic plates (Plafker et al., 1993). The Pacific Plate is being thrust under the North American Plate along a northwestward-dipping Aleutian subduction zone. This under-thrusting produces compression in the crust of the overlying North American Plate expressed as folds and high-angle reverse and thrust fault systems. Evaluations of seismic hazards in southcentral Alaska typically recognize four faults or faulting zones, including: the Megathrust and Benioff segments of the Aleutian subduction zone, the Lake Clark-Castle Mountain Fault System, and the Border Ranges Fault Zone.

The Aleutian subduction zone is represented as two distinct planes, Megathrust and Benioff, each with different characteristic earthquakes. From the Aleutian Trench, about 200 miles east-southeast of Kenai, the subduction plane maintains a shallow dip to the northwest extending to a depth of about 12 to 15 miles (Megathrust zone). The seismicity of the Megathrust zone is characterized by shallow, very large magnitude, but infrequent earthquakes. The 1964 Great Alaska Earthquake (Moment Magnitude, 9.2 Mw) occurred within this zone, with the epicenter about 125 miles northeast of Kenai in Prince William Sound. At a depth of about 25 to 30 miles, the subducting Pacific plate dips steeply to the northwest (Benioff or Intra-Plate zone). The seismicity of the Benioff zone is characterized by deep (>30 miles), moderate magnitude and frequent earthquakes. Based on theoretical models, maximum credible earthquakes (MCE) of magnitude 9.5 Mw and 7.5 Mw have been predicted for the Megathrust and Benioff zones, respectively (WCC, 1982).

The Castle Mountain Fault is a prominent, right-lateral strike-slip, reverse fault which traces from the Talkeetna Mountains northeast of the Matanuska Glacier, southwesterly through the lowlands along the Susitna River and southern flank of Mount Susitna (Determan et al., 1974). Kenai is about 60 miles south of the fault trace. A magnitude 5.2 Ms earthquake in 1984 about 125 miles northeast of Kenai was attributed to a rupture along this fault (Lahr et al., 1986). A MCE of magnitude 7.5 Mw has been predicted for the Castle Mountain Fault (WCC, 1982).

The Border Ranges Fault zone is a major reverse fault, locally positioned along the western flank of the Kenai Mountains, and interpreted to be an ancient subduction zone from the Mesozoic or early Tertiary time (MacKevett and Plafker, 1974). A surface trace of this fault in the area is unknown, but has been mapped within about 35 miles west of the site (Magoon et al., 1976). The seismic activity along this fault subsequent to early Tertiary time is unknown. In terms of considering seismic risk for building design, the MOA Geotechnical Advisory Commission (GAC, 1997) characterized the Border Ranges Fault zone as exhibiting a relatively low rate of seismic activity and not capable of producing large magnitude earthquakes.

According to the U.S. Geological Survey (Stanley, 1968 and Plafker et al., 1969), the two communities most seriously affected by coastal erosion following the 1964 Great Alaska Earthquake were Homer and Kenai. Stanley (1968) states that, "During the earthquake the area (Kenai) subsided 12 to 18 inches… After regional subsidence, the pre-earthquake accumulation of sloughed debris along the toe of the bluffs was quickly removed. Undercutting by waves and by the river began a few days after the earthquake, and within three months the bluff had receded as much as 20 feet."

2.1.4 Climate

Lying between Cook Inlet and the Kenai Mountains, Kenai has a transitional climate which may be characterized as variable with the influence of both maritime and continental climate regimes. Kenai receives an average of about 19.1 inches of precipitation per year. The temperature ranges from daily extremes of about minus 47°F to 93°F with an annual mean of 34°F. The mean monthly temperature ranges from about 12.5°F in January to 54.7°F in July. The annual heating degree days (base temperature equals 65°F) for the Kenai area is 11,288°F days (Hartman and Johnson, 1984).

A summary of climatological data obtained from the Kenai FAA Airport recording station is presented in Table 2.

2.2 General Site Conditions

2.2.1 Topography

Topography of the project site is marked by the Kenai River bluff, a feature which drops 60 to 70 feet at slope angles ranging from about 18 degrees to 90 degrees from the City of Kenai to the Kenai River (Figure 2). The project site may thus be divided into two distinct topographic areas, the bluff crest and the bluff toe. The bluff crest area is relatively flat. The bluff toe area slopes gently from the base of the bluff to the river's edge and is inundated by high tides.

2.2.2 Surface Drainage

Surface drainage at the site is interpreted to occur through two mechanisms, infiltration and surface flow to natural drainage courses. The two primary natural drainage courses within the project site are Ryan's Creek and Cemetery Creek, both of which are shown on Figure 2.

2.2.3 Vegetative Cover

The project site is located within a Bottomland Spruce-Poplar Forest system (AEIDC, 1974), as characterized by the local white spruce forests with large cottonwood and balsam poplar trees. Alaska paper birch, quaking aspen, and black spruce trees are also in evidence, along with willow and alder shrubs. Much of the bluff crest portion of the project site has been developed, though segregated stands of primarily spruce trees are present along intermittent portions of the bluff crest. Toppling of these trees is in evidence where the bluff has been receding in recent years. The toe of the bluff area is primarily devoid of vegetation, with the exception of localized grasses and the occasional shrub in the summer months. The area of the bluff toe that abuts Cemetery Creek, however, is vegetated with grasses and shrubs, as well as cottonwood, birch, willow and the occasional spruce tree.

2.2.4 Soils

Soils exposed along the bluff at Kenai consisted of marine, glacial, and alluvial deposits that have been altered by glacial action and erosion (Figure 3). The surficial soils and features in the area around Kenai have been created by several major Pleistocene glacial events. These included the deposition of marine sandy clays of the Bootlegger Cove Formation (Reger, 1997) in glacioestuarine waters approximately 16,500 years ago. A Killey-age tidewater glacier then passed over the site from the northwest. It apparently floated over the site as the effects of the glacial override did not penetrate deeply into the marine clay. Submarine-fan deposits were spread over the clay. Folding and displacement of the marine sediments occurred when the glacier grounded.

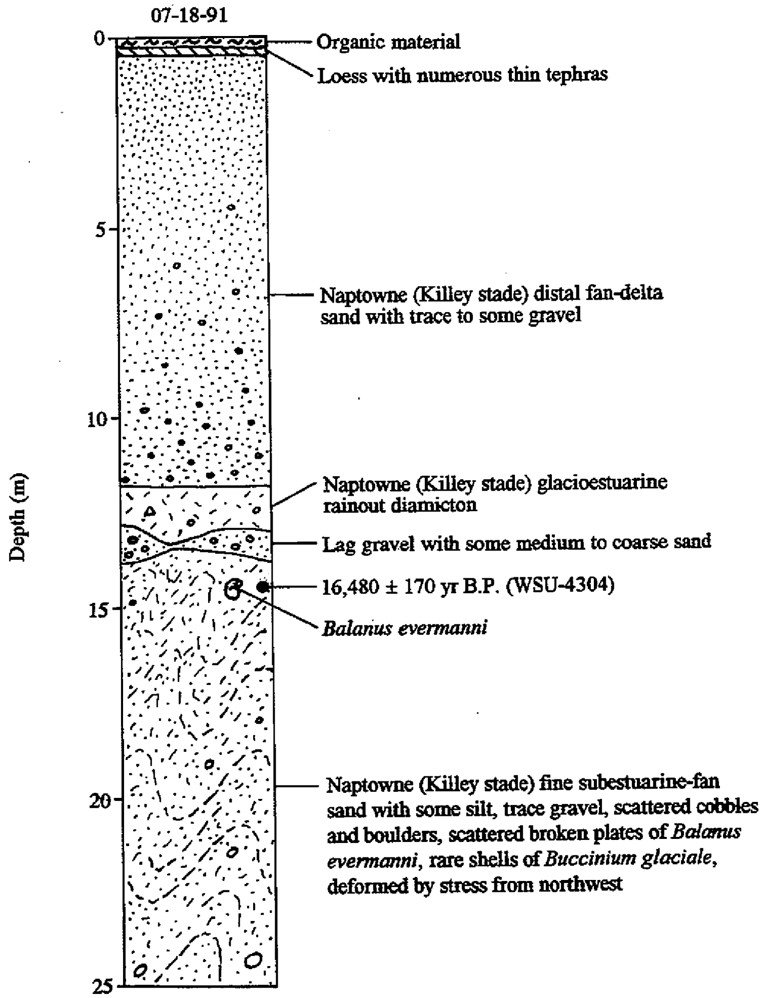
The first recorded description of the geology at the bluff at Kenai was provided by Moffit in 1906. He described partially cemented (ferruginous) sands overlying bluish-black silt (till). He also noted springs flowing from the bluff on top of the glacial till. Site-specific soils data obtained from the current bluff logging and test borings are provided in Section 5.0.

2.2.5 Bedrock

The Kenai area is reportedly underlain by rocks of the Sterling Formation which is the upper unit of the Tertiary Kenai Group (Hartman et al., 1972). The Sterling Formation consists of sandstone deposited during late Tertiary – early Quaternary-age. The sandstone is similar to sand deposits in the overlying Quaternary material and thus it is difficult to define the top of the formation. However, on the Kenai Peninsula depths to the formation of approximately 500 to 3,000 feet were indicated. Kirschner and Lyon (1973) present additional information on the stratigraphic and tectonic development of the area. Bedrock was not encountered in any of the 20 test borings drilled for this program.

FIGURE 3

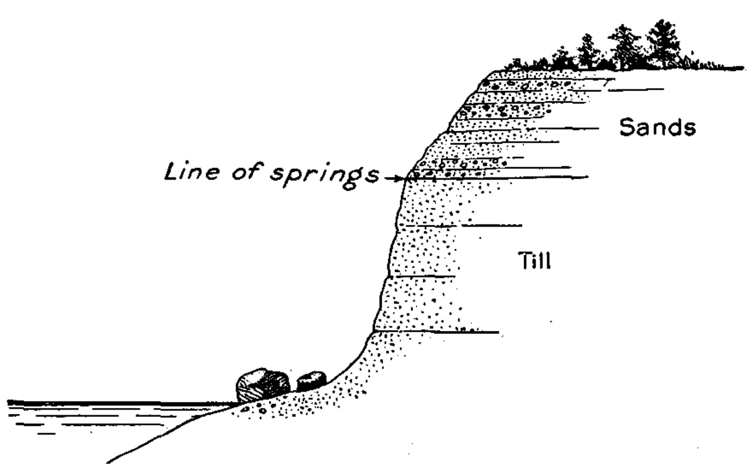
RIVER BLUFF STRATIGRAPHY



a. Stratigraphy exposed near project site (60º33'07"N, 151º14'17"W), Kenai C-4 SE Quadrangle.

After Reger et al., 1996.

b. Diagrammatic sketch showing relations of stratified sands and till at Kenai.



After Moffit, 1906.

On the basis of available information, it appears that bedrock is located at a considerable depth beneath the project site. Therefore, bedrock is not expected to be involved with any design or construction consideration.

2.2.6 Groundwater

Various water resources and groundwater studies have been performed in the area. Freethey and Scully (1980), explain regional groundwater potential in terms of geologic materials, depositional environment, and sediment thickness. The document also describes aquifers in five different areas and estimates groundwater yield. Anderson (1971) presents data on groundwater exploration and testing at Beaver Creek Valley near Kenai. The report further documents that an artesian aquifer is the principal source of groundwater. Anderson and Jones (1972), provide additional data on the water resources of the Kenai-Soldotna area. Bailey and Hogan (1995), in cooperation with the Federal Aviation Administration, give an overview of environmental and hydrogeologic conditions near Kenai while Glass (1996) documents groundwater conditions and quality in the area.

Each of the above cited studies focuses on area-wide groundwater conditions. Discussion of site-specific groundwater conditions is presented in Section 5.0.

3.0 FIELD INVESTIGATION

Methods of field investigation for the Kenai River Bluff Erosion geotechnical study can be divided into the following six categories.

- Planning and Site Reconnaissance
- Geologic Logging of Bluff
- Test Borings
- Groundwater Monitoring Well Installation
- Groundwater Monitoring
- Location Surveys

Following is a brief description of each of these categories along with methods and procedures used in acquiring the various geologic and geotechnical information.

3.1 Planning and Site Reconnaissance

On 29 June 2006, Robert (Buzz) Scher, P.E., R&M's senior geotechnical engineer, and John Rajek, P.E., USACE-AD geotechnical engineer, visited the project site to observe the stratigraphy, groundwater and erosion conditions exposed along the bluff at that time. During this visit, Scher and Rajek walked the entire length of the project area, along both the toe and crest of the bluff. Detailed observations of site conditions are presented in the Final Geotechnical Scope-of-Work (R&M, 2006) that was compiled to guide this geotechnical investigation. Based on the observations set forth in that document, as well as further research of existing information, the following geotechnical explorations were planned.

- Detailed Bluff Log
- Geotechnical Borings
- Geohydrology Borings
- Laboratory Soil Testing

Once the scope of geotechnical explorations was decided upon, R&M began laying the necessary groundwork to facilitate field work. This effort included obtaining rights of entry from property owners adjacent to the bluff, utility locates for subsurface utility lines, and permits to allow stream crossings and drilling adjacent to the Kenai River.

3.2 Geologic Logging of Bluff

During the period of December 10 through 13, 2006, a team of two R&M geologists/engineers obtained soil profiles at 10 locations along the bluff face (Soil Profiles SP-A through SP-J). At each profile location, an engineer, secured by harness and climbing rope, traversed the bluff from top to bottom (Figure 4). Data collection included measuring the slope profile using a rope tape and a four-foot digital level. Shallow test pits were excavated to expose soils and collect samples. A detailed description of soil and groundwater conditions was also made. Soil profiles are presented in Appendix D. Soil profile locations are shown in plan on Drawings A-02 and A-

FIGURE 4

BLUFF MAPPING PHOTOGRAPHS

a. Rappelling down the bluff face at Soil Profile SP-D. The four-foot yellow electronic level was used to measure slope angle. Slope distances were measured using the white tape. October, 2006.

b. Measuring water flow from the bluff at Soil Profile SP-E.
The procedure involved catching the flow and then measuring in a bucket. October, 2006.

03 of Appendix A. Soil profile locations are also shown on the annotated photo mosaic presented as Drawings A-08 through A-10.

Groundwater flow measurements were made at three locations (Soil Profiles SP-E, SP-F and SP-I) using a section of six-inch PVC pipe cut in half lengthwise. The end of the PVC pipe was pushed into the slope on top of the glacial till where water was issuing out of the bluff so as to seal off water flow under the pipe. The water was collected in a calibrated bucket for a period of five minutes and an approximate flow rate determined. The calculated flow rates are as follows:

- SP-E 0.75 gallons per minute per foot
- SP-F 1.5 gallons per minute per foot
- SP-I 0.25 gallons per minute per foot

3.3 Test Borings

Test borings were located and drilled to meet two primary objectives. The first objective involves delineating the subsurface soil conditions, and the second entails a study of the groundwater regime in the area.

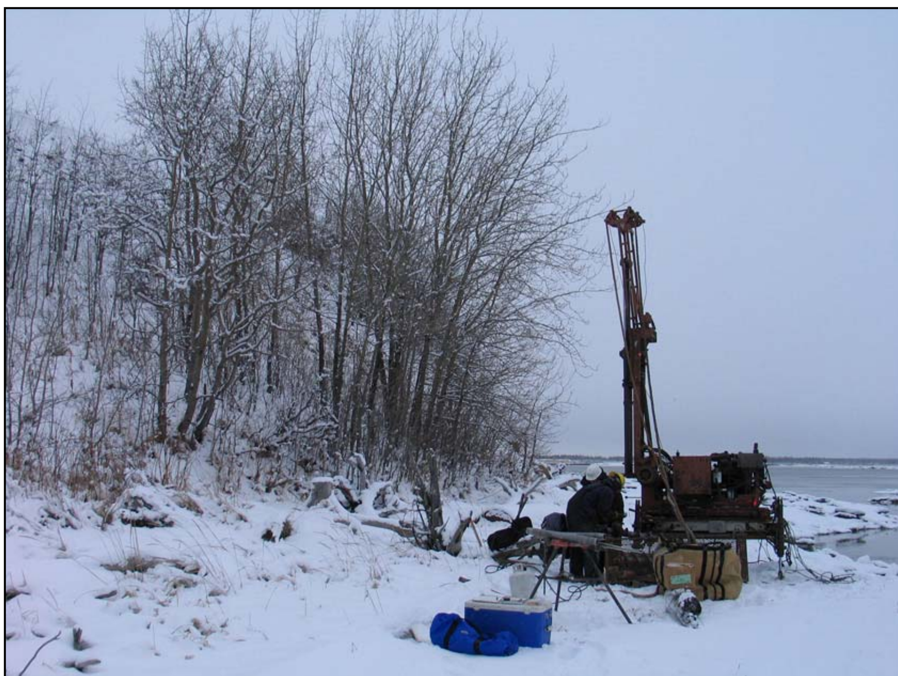
A total of twenty (20) test borings were drilled by R&M at the project site during the period of November 9, 2006 through December 16, 2006, fourteen (14) of which were completed as groundwater monitoring wells. Each of the borings was logged in accordance with standard engineering practices, and data obtained in this manner were utilized to determine geotechnical site conditions. The depth of the test borings ranged from 30 to 101.5 feet. The total number of feet drilled during the field program was approximately 1,135. Drilling and sampling operations were performed by Discovery Drilling, Inc. of Anchorage, Alaska under direct contract to R&M. Approximate test boring locations are shown on Drawings A-02 through A-06 of Appendix A. Logs of the test borings are illustrated in Appendix B, Drawings B-03 through B-17. A key to the test hole log general notes and an example of a typical log are illustrated on Drawings B-01 and B-02, respectively. Table 3 provides a summary of all R&M test borings performed for the project.

Soil boring, sampling, and groundwater well installation on the bluff crest were performed utilizing a truck-mounted CME-75 drill rig (Figure 5a). Soil boring and sampling operations on the bluff toe were performed either with a Nodwell-mounted CME-75 drill rig (Test Boring AP-627 as shown in Figure 6b) or with a helicopter portable CME-45 drill rig (Test Borings AP-622 through AP-626 as shown in Figure 5b). Maritime Helicopters of Homer, Alaska provided a Bell Model 207 helicopter under contract with Discovery Drilling. Test borings were advanced using continuous flight, hollow-stem augers. Representative soil samples were generally obtained at the surface, at 2.5 feet and five feet, and then at approximately five-foot intervals or at obvious changes in soil strata. However at each grouping of three groundwater monitoring well installations (e.g. AP-608-MW through AP-610-MW), only one of the three borings was sampled and logged in detail. The other two borings were only sampled at the bottom of the boring.

FIGURE 5

PHOTOGRAPHS SHOWING DRILLING OPERATIONS

a. Drilling at Group 4 borings. November, 2006.



b. Drilling at Test Boring AP-622 with helicopter portable drill rig. December, 2006.

FIGURE 6

PHOTOGRAPHS SHOWING DRILLING OPERATIONS

a. Tide flats at high tide along the eastern part of the project.
High tides made it difficult to access drills along the beach. October, 2006.

b. Drill struck in mud near Senior Center.
The soft mud made it difficult to use tracked equipment on tide flats. November, 2006.

The drilling program was conducted under the supervision of an experienced engineering geologist who maintained a detailed log of the materials encountered and the samples attempted and recovered. Representative soil samples generally were collected either by means of grab samples taken directly off of the augers, in the case of the surface sample, or via split-spoon samplers. In all but one boring, disturbed samples were obtained using a 2.5-inch I.D. (3.0-inch O.D.) split-spoon sampler driven by means of a 340-lb hammer with a 30-inch free-fall stroke.

Both manual (rope and cathead) and automatic (hydraulic) hammers were used on this project, as denoted for each sample on the logs of test borings in Appendix B. The penetration resistance, defined as the number of blows required to drive the sampler the last 12 inches of an 18-inch interval, gives an indication of the in-place relative density for unfrozen cohesionless soils. Blow counts reported per six-inch interval are shown on boring logs in Appendix B. Penetration resistances thus obtained can be corrected to approximate the Standard Penetration Test (SPT) “N” values by an energy to area ratio adjustment. A correction factor should be used to convert actual blow counts to the corresponding approximate SPT blow counts. Note, however, that the blow counts appearing on the logs of test borings are actual values, not converted SPT values. The Standard Penetration Test (SPT) was performed in the upper 40 feet of Test Boring AP-617-MW utilizing the 1.4-inch I.D. (2.0-inch O.D.) drive sampler and a 140-pound automatic drop hammer. When judged appropriate by the field geologist, brass liners were used inside the split-spoon sampler to retain soil for later laboratory testing. Most of the soils encountered proved unsuitable for “undisturbed” Shelby tube sampling (ASTM Designation D 1587), but one such sample was able to be collected in Test Boring AP-622.

It should be noted that heaving or flowing sands interfered with sampling in every test boring along the bluff toe, as well as in the deeper test borings located on the bluff crest. The logs of test borings in Appendix B include notes on whether a sampler was overfilled with heaving sand, or whether samples were not attempted below a certain depth due to heaving sand flowing up into the augers.

All soils recovered were visually classified and logged in the field following ASTM Designation D 2488. After visual and tactile classification in the field, all soil samples were returned to the R&M laboratory. Representative samples were then selected for further examination and testing.

3.4 Groundwater Monitoring Well Installation

After completion of drilling, fourteen (14) of the test borings on the crest of the bluff were completed as groundwater monitoring wells. Groundwater monitoring wells were installed in general accordance with ASTM Designation D 5092, “Design and Installation of Groundwater Monitoring Wells in Aquifers”. Each monitoring well was constructed to allow for the accurate measurement of groundwater depths relative to the top of the well riser. The well riser pipe was constructed of 2-inch I.D. polyvinyl chloride (PVC) pipe. A locking steel protective over casing was installed around the well riser pipe extending approximately three feet below and three feet above the top of ground surface. Bollards were placed around some of the installations to protect the wells from traffic and snow removal equipment.

Groundwater levels were measured upon completion of the installation and will be measured monthly for one year, with a total of 13 readings for each monitoring well. Groundwater elevations and a groundwater monitoring report will be furnished to the USACE-AD after completion of the groundwater monitoring program.

A typical groundwater monitoring well schematic is presented as Figure 7. Monitoring well photographs are shown in Figure 8.

3.5 Groundwater Monitoring

Groundwater monitoring will occur on a monthly basis in the 14 R&M test borings that were converted to monitoring wells and the three pre-existing American Environmental monitoring wells. This monitoring is anticipated to continue to occur on this basis for a period of one year from the installation date. Access to the protective over casings is gained and a Solinst Model 101 water level meter is lowered down the well to measure the groundwater level. The water level meter tape is measured against a constant point on each well casing to ensure a consistent measuring point.

3.6 Borehole Location Surveys

Survey information was based on a field survey performed by R&M Consultants, Inc. during January, 2007. The project coordinates are ACS83 Zone 4, U.S. Survey Feet. The project datum is NAD83 (CORS). The project coordinates and datum were established by ties to CP 1 and USC&GS BM NO. 3 1966 from the DOWL Engineers drawing “Kenai River Bluff Erosion Survey Topography” dated July 16, 2003. The vertical datum was established by holding USC&GS BM NO. 3 1966 with an elevation of 31.44 feet. The drawing indicates that the vertical datum is referenced to Mean Lower Low Water (2003) in U.S. Survey Feet.

Monitor wells and test borings were located horizontally using RTK GPS techniques and vertically by a combination of RTK GPS and differential leveling techniques. The RTK GPS accuracy was quality controlled by taking three-dimensional check shots on established control positions. All of the check positions fell within the tolerances defined in the scope of the project.

The elevations for the top of the pipe of the monitor wells were determined by differential levels run from TBMs with elevations established by RTK GPS. The wells were broken up into four groups based on proximity. One TBM was established for each group of wells with RTK GPS. Differential levels were then run from the TBM to the group of wells in the surrounding area. All level loops closed well within the tolerances defined in the scope of the project.

FIGURE 7

TYPICAL GROUNDWATER MONITORING WELL GROUP

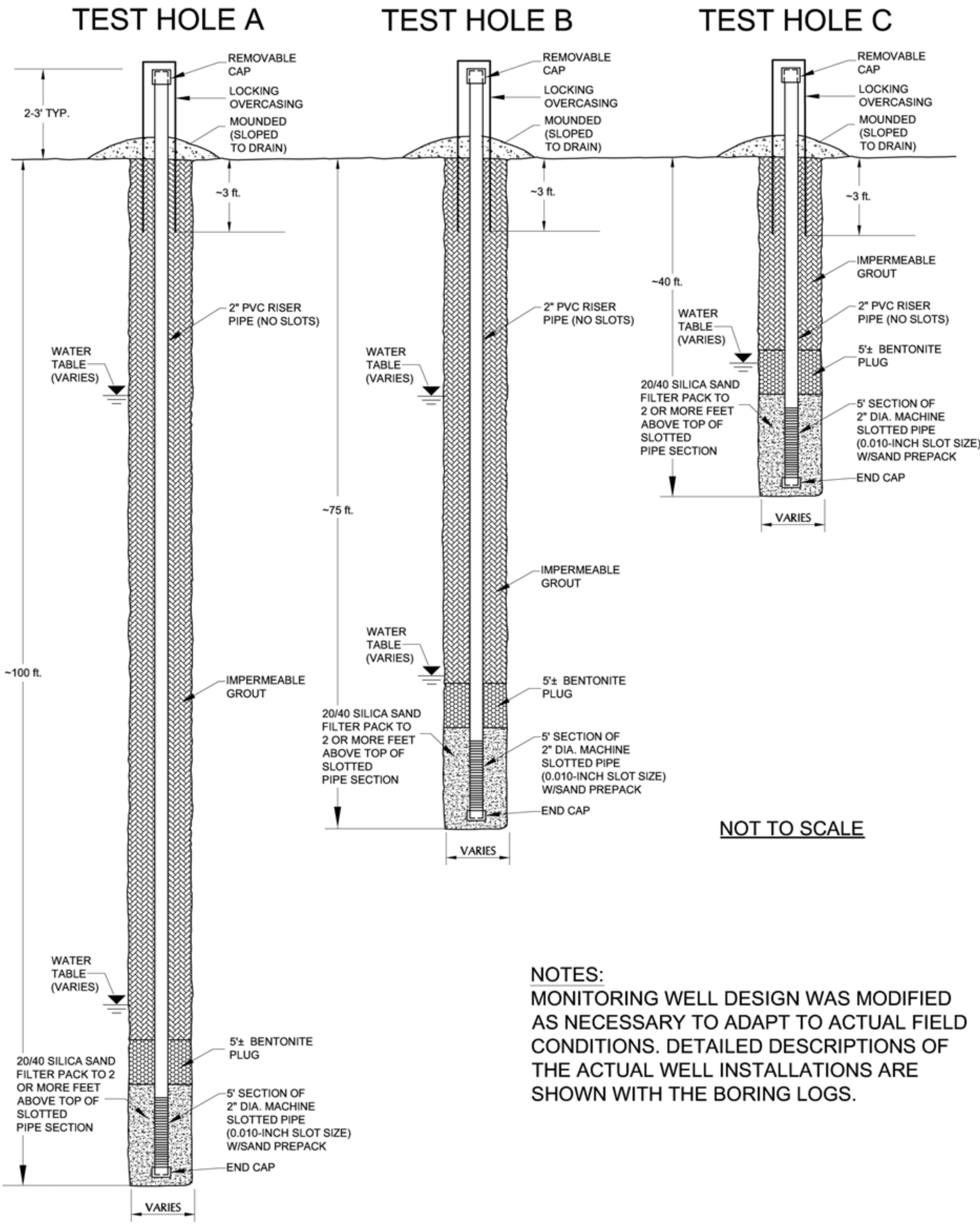


FIGURE 8

PHOTOGRAPHS SHOWING MONITORING WELLS

a. Monitoring well installation at Group 3 borings with protective bollards. December, 2006.

b. Grouting at Group 2 borings. November, 2006.

4.0 LABORATORY TESTING PROGRAM

The laboratory testing program was developed to provide data on the important subsoil characteristics necessary for subsurface characterization of the site. A select number of the soil samples collected during the bluff logging field work and recovered from the test borings were tested both to measure key index properties and to determine the engineering or mechanical properties of the soils. These tests verified and allowed modification of the field descriptions, thereby improving the data base for engineering application and geotechnical interpretation of site conditions.

4.1 Index Testing of Soils

Selected soil samples were tested to measure index properties, which are important for classification and grouping of the soils into general units. Laboratory index testing and soil classification were performed in accordance with the following ASTM designations (ASTM, 2006).

TEST	ASTM DESIGNATION
Description and Identification of Soils (Visual-Manual Procedure)	D 2488
Classification of Soils for Engineering Purposes	D 2487
Laboratory Determination of Water (Moisture) Content	D 2216
Particle Size Analysis (Sieve)	D 422
Particle Size Analysis (Hydrometer)	D 422
Liquid Limit, Plastic Limit, and Plasticity Index of Soils	D 4318
Specific Gravity of Soil Solids by Water Pycnometer	D 854

In addition to the ASTM version of the Unified Soil Classification (USC) System, the samples received a frost classification based on the Army Corps of Engineers Method (USACE, 1992). Each classification method (USC and USACE) is presented on the log of test borings for those representative samples tested. When a classification was estimated, the estimated classification symbol is followed by an asterisk (*) on the test boring log and the laboratory data summary sheets.

A summary of soil index property data is provided in Appendix C, Drawings C-03 through C-06. Particle size distribution (gradation) curves are presented for Soil Profile samples only in Appendix D, Drawings D-11 through D-16. Gradation curves for glacial till samples with a 24-hour hydrometer are shown on Drawings C-19 and C-20 of Appendix C. For clarification of soil call outs, Drawing C-01 defines the classification of soils for engineering purposes. Drawing C-02 provides an explanation of the USACE Frost Design Soil Classification.

It should be noted that the size of the gravel particles obtained with either the 1.4-inch or 2.5-inch I.D. drive samplers is limited by the size of the opening of the sampler, and the sample may thus not necessarily be representative of the coarse gravel fraction.

4.2 Engineering Properties Testing of Soils

Selected soil samples were tested to measure certain engineering properties, such as shear strength and permeability. This testing was performed in accordance with the following ASTM designations (ASTM, 2006).

TEST	ASTM DESIGNATION
One-Dimensional Consolidation Properties of Soils Using Incremental Loading	D 2435
Consolidated Undrained Triaxial Compression Test for Cohesive Soils	D 4767
Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils	D 2850
Permeability of Granular Soils (Constant Head)	D 2434

4.2.1 One-Dimensional Consolidation Tests

One-dimensional, incremental loading consolidation tests were conducted on selected specimens to assess stress history and compressibility characteristics. Tests were performed following ASTM D 2435-04. All samples were trimmed into brass rings prior to testing to produce initial specimen dimensions of approximately 2.4 inches in diameter and one inch in height. Tested samples were set with an initial seating load, and then loaded in the following increments of 1/8-ton per square foot (tsf), ¼ tsf, ½ tsf, 1 tsf, 2 tsf, 4 tsf, 8 tsf, 12 tsf, and 20 tsf. Samples were kept saturated throughout the test.

Results of the consolidation tests are presented graphically in Drawings C-07 through C-09 of Appendix C. Plots are provided as void ratio versus load.

4.2.2 Triaxial Compression Tests

Triaxial shear strength tests were performed for the purpose of determining the stress-strain behavior of the glacial till unit. Triaxial tests were conducted on drive-sampled plastic liner specimens. Consolidated-undrained (CU) tests were performed following ASTM D 4767-02. Unconsolidated-undrained (UU) tests were conducted following ASTM D 2850-03.

The CU tests could not be run at a rate slow enough to allow equalization of pore pressure. The tests were performed on specimens with diameters of approximately 2.4 inches. Specimen height/width ratios were between 2.0 and 2.5. Because of the presence of small gravel particles in the material it was not possible to trim the specimens to smaller diameters. Filter strips were applied to the perimeter of the specimens to allow radial drainage. However, even with radial drainage, the measured consolidation rate required strain rates of about 0.02 to 0.03% per minute for the equalization of pore pressure. The CU tests were run at about 0.1% per minute, which is the slowest strain rate the test equipment can accommodate. Photographs showing triaxial test procedures are presented in Figure 9.

FIGURE 9

TRIAXIAL COMPRESSION TEST PHOTOGRAPHS

a. Triaxial test apparatus.

b. Sample TB-2C No. 16 (AP-611-MW) after testing. Note failure plane.

Triaxial test data are presented in Drawings C-10 through C-16. Pore pressures were measured in CU tests, utilizing a pressure transducer connected to the base of the specimen. Total deviator stress, and pore pressure are plotted against axial strain in the drawings. Mohr diagrams for both CU and UU tests are shown on Drawing C-17.

4.2.3 Permeability Tests

Constant head permeability tests (ASTM Designation D 2434) were performed to assess the permeability of the granular alluvial material. The tests were performed on specimens in brass liner sampling tubes. Results from all permeability tests are tabulated on Drawing C-18.

5.0 GEOTECHNICAL CONDITIONS

Our field investigation has revealed variable subsurface conditions at the Kenai River Bluff Erosion site. To facilitate a discussion of the soil and groundwater conditions, the following sections have been set out to characterize each parameter on an individual basis. The reader is referred to the drawings included within the appendices of this report for graphic representation of the various conditions encountered.

A field log was prepared for each boring by the field geologist. The log contains information concerning the boring methods, samples attempted and recovered, and descriptions of the various soils and groundwater conditions encountered. It also contains the field geologist's interpretation of the conditions in intervals between recovered samples. Therefore, these logs contain both factual and interpretive information. The final drafted logs also represent additional interpretation of the contents of the field logs and the results of the laboratory tests of samples. The final logs are included within Appendix B of this report. It is emphasized that because of the inclusion of laboratory data, our interpretations are based on the contents of the final logs and the information contained therein, and not solely on the field logs.

The final drafted logs included in Appendix B have a two-fold function: they serve as a format for the presentation of some of the significant raw field and laboratory data gained from the test boring as well as illustrating the interpretation of this data – the delineating of the different soil strata encountered. From the standpoint of preparing the test boring logs, the first function involved the mechanical extraction and transferal of data, whereas the second function requires knowledge of soil mechanics, and a good understanding of field soil sampling techniques and geomorphic processes, especially those of the northern environment.

Soil profiles are provided as Drawings D-01 through D-10 of Appendix D. An annotated photo mosaic is presented on Drawings A-08 through A-10. Additionally, a generalized subsurface profile showing interpreted soils and groundwater conditions is presented in Appendix A, Drawing A-11. Soil units reflect those found on the soil logs in Appendix B, but have been generalized and abbreviated for clarity of presentation.

5.1 General Soil Stratigraphy

Between the mouth of Cemetery Creek and the Pacific Star Seafoods Plant (Drawings A-02 and A-03), the river bluffs were underlain by alluvial deposits overlying glacially modified marine deposits (glacial till). The two units were separated by a thin layer of lag gravel from which a year-round flow of groundwater emerges from the bluff.

The upper alluvial deposits consisted of sands that were interpreted by Reger in Karl et al., (1997) to be a distal fan and/or delta deposits (see Figure 3). The deposits had previously been interpreted by Karlstrom (1964) to be reworked alluvial/lake deposits, laid down along the shoreline of a proglacial lake during the retreat of the Naptowne Glaciers. Paleosols buried in the sands indicate an intermittent depositional environment.

Generally, the glacial till unit was interpreted to have originally consisted of Quaternary-age marine clays similar to the Bootlegger Cove deposits near Anchorage. However, the material contained more gravel ("dropstones") than was typically found in the Bootlegger deposits. These marine deposits at Kenai were reportedly older than the Bootlegger Cove deposits (Karl et al., 1997). The marine clays were overridden by one or more glaciers, consolidating and deforming the clay deposits and incorporating significant amounts of coarser gravel, cobbles, boulders, and larger glacial erratics into the clay. Layers of fine sands deposited either before or interbedded with the clays also formed irregularly shaped pockets.

The interlayered lag gravel was interpreted to be a residual accumulation of coarse, hard rock remaining on the glacial till surface after the fines were washed or blown away. Thus, it assumes an unconformity exists between the alluvial deposits and glacial till after the retreat of the glacial ice. An unconformity can be defined as a period in the geologic record when deposition ceased and erosional processes dominated (Bates and Jackson, 1980).

5.2 Soil Conditions

Generally, the soils encountered in the 20 test borings drilled during the current program can be divided into two major units. These units were an upper alluvial unit overlain by surficial silts and a lower glacial till unit; separated from the alluvial unit by a thin bed of lag gravel formed at the unconformity between the two units. The glacial till unit contains distinct pockets of nonplastic sand that for the purposes of this discussion are described as a subunit. Minor stream/coastal deposits were encountered near the mouth of Cemetery Creek and a large man-made disposal site was identified near the Group 1 test borings. General interpretations and compilations of laboratory test data are presented below.

COMPILATION OF LABORATORY TEST RESULTS*
Average / [Range]
(Number of Tests) "Standard Deviation"

	Avg. % Gravel (1)	Avg. % Sand	Avg. % Fines	Avg. Liquid Limit	Avg. Plastic Index	Avg. % Moisture Content
Alluvial Unit	**6** / [0-32] (28) "12"	**88** / [45-99] (28) "10"	**5.6** / [1-52] (28) "2"	**NV** / [--] (1) "4"	**NP** / [--] (1) "1"	**7** / [1-27] (28) "6"
Lag Gravel	**45** / [39-54] (5) "6"	**53** / [46-59] (5) "6"	**1.4** / [0.5-2.7] (5) "1"	**No Tests**	**No Tests**	**8** / [3-13] (5) "4"
Glacial Till Unit	**6** / [0-22] (43) "6"	**25** / [8-56] (43) "10"	**68** / [42-91] (43) "12"	**27** / [18-38] (30) "4"	**11** / [6-20] (30) "3"	**17** / [11-78] (46) "10"
Sand Pockets	**2** / [0-12] (17) "3"	**95** / [83-99] (17) "5"	**3.6** / [1-11] (17) "3"	**No Tests**	**No Tests**	**13** / [2-24] (18) "7"

* Test results for five samples – two of the surficial soils (AP-611-MW #2 and AP-624 #1), one of interlayered sand and clay (AP-614-MW #19) and two of soils interpreted to be stream or coastal deposits (AP-622 #2 and #5) – were omitted from this table.

(1) As previously mentioned, the size of the gravel particles in samples obtained with the 1.4-inch and 2.5-inch I.D. drive samplers used in test borings at this site was limited by the size of the opening of the sampler, and the

sample was thus not necessarily representative of the coarse gravel fraction. Results from surface grab samples contained larger particles of gravel, but the sample sizes still were not large enough to be entirely representative.

5.2.1 Surficial Soils

Surficial deposits at the top of the bluff consisted of an organic mat overlying silt grading to sandy silt (ML), with localized deposits of clayey gravel with sand (GC). These surficial deposits ranged up to four feet thick. In some places, the upper one to two feet of the surficial soils were bound together by roots and overhung the lower slopes as the sand raveled down the bluff. Large trees have tended to break off “chunks” of this organic mat and pulled them downhill as the slope retreats.

5.2.2 Fills

Small fills containing construction debris were observed dispersed throughout the surficial soils along the crest of the bluff, which included abandoned parking lots, abandoned utility trenches, and building foundations. At the west end of the project there was a large fill consisting of debris, organic material and silty soils located near the Group 1 test borings (see Figure 10a). This area was reportedly used as a disposal site for many years until a portion of the fill failed and some of the material slid down onto the tidal flats. Based on observations of the slope and data from the test borings, it appeared that fill material was dumped over the bluff between Hansen Park and Mission Avenue near Broad Street. Most of the remaining fill was encountered on the property on which the Group 1 test borings were drilled and the property to the west between the Group 1 borings and Hansen Park. It appeared that the fill slope was being undercut near these two properties as the slope was actively raveling (see Figure 10b).

5.2.3 Alluvial Unit

Alluvial deposits were found underlying the entire upper bluff area to a depth of about 40 feet (37.5 to 42.5 feet). The material consisted of a thick layer of medium dense, fine to medium sand interspersed with layers of sand with gravel (SP, SP-SM). The gravel was rounded to subrounded, and ranged up to two inches in diameter. The sand with gravel layers typically ranged up to one foot thick. At Test Boring Groups 1 and 3, five-foot thick sand with gravel layers were noted. This unit exhibited horizontal layering and cross bedding. Measured slope angles in the sand ranged from 30 to 40 degrees (see Figure 11a). Slope angles were steepest at Soil Profiles SP-B, SP-C, and SP-D, near the west end of the project. Near Soil Profile SP-C, what appeared to be dark brown to black ferruginous cementation was observed in the sands. The cementation apparently allowed the slopes to stand steeper here than elsewhere (Figure 11b). A temporary increase in drilling resistance noted in the sand layer at other locations may also indicate the presence of cemented sands.

FIGURE 10

PHOTOGRAPHS OF EXISTING FILL MATERIAL

a. Area adjacent to Mission Road where fill was pushed over the edge of the bluff.
The black material on the flats was broken asphalt.
The fill slopes have reportedly failed during the past. September, 2006.

b. Photograph taken at bottom of slope on left side of photo above.
Note undermining of the slope and "Marston Mat" in foreground. October, 2006.

FIGURE 11

PHOTOGRAPHS OF ALLUVIAL DEPOSITS

a. Slope in alluvial unit at Soil Profile SP-F.
Overhanging surficial soil layer can be seen at upper left. October, 2006.

b. Cemented layers of sand at Soil Profile SP-C.
Cementation appears to allow the sand to stand almost vertical. October, 2006.

5.2.4 Lag Gravel

Lag gravel consisted of a relatively thin layer of more highly permeable material on top of the glacial till. For the most part, this layer was observed to be less than one foot thick; however near Soil Profile SP-C it was approximately six feet thick (see Figure 12).

Typically, on a geotechnical exploration project for foundation evaluation, a layer this thin would not be differentiated from the glacial till below, except that in this case it was the principal avenue for water flowing out of the bluff face.

This unit consisted of sand and gravel with cobbles (SP, SW and GP). The layer contained significantly more gravel and cobbles than the alluvial unit above. The coarse material was subrounded to rounded and hard. Laboratory tests indicate the material contained 0.5 to 2.7 percent fines and the sand was predominately medium to coarse-grained. For the most part, the material was saturated with moisture contents ranging up to 13 percent. Near Soil Profile SP-C, the gravel appeared to be cemented and no water was observed flowing from the bluff at that location.

5.2.5 Glacial Till Unit

The glacial till consisted of a very hard, heterogeneous mixture of clay, sand, and gravel, with cobbles and boulders ranging widely in shape and size. The glacial till stood near vertical close to the top of the unit (Figure 13a). In some locations the glacial till had the appearance of soft, poorly indurated bedrock similar to the Tertiary-age Kenai Group found on the lower Kenai Peninsula (Figures 13b and 14a). The clay was very hard when dry, becoming softer when exposed to water. It could be carved with a knife, excavated with difficultly using a hand pick, and scratched readily with the fingernail. The clay was plastic with an average liquid limit of 27 and a plasticity index of 11. The plasticity index generally appeared to decrease with increasing sand content.

Thin layers of sand were observed throughout the clay. These layers ranged from as thin as 1/16-inch up to ¼-inch thick and were oriented at 25 to 60 degrees from the horizontal. The layers were observed to be both dry and wet. They also appeared as sand fillings of fractures or fissures in the clay. The clay apparently contained fine to coarse sand dispersed throughout and was classified in most places as a sandy lean clay.

The marine clay appeared to contain gravel scattered throughout. These gravel particles have been interpreted to be dropstones (Karl et al., 1997). Dropstones are defined as stones that drop out of glacial ice when the ice melts over water (Figure 14b). Layers of gravel with cobbles and boulders up to six feet thick were observed scattered throughout the upper portion of the glacial till unit. Typically, the large cobbles and boulders were hard, and subangular to angular. The gravel and some small cobbles were hard and rounded to angular. More and larger gravel and cobbles were observed exposed in the upper portion of the glacial till than lower in the glacial till along the tide flats.

FIGURE 12

PHOTOGRAPHS OF LAG GRAVEL DEPOSIT

a. Cemented lag gravel (darker center bed in photo) at Soil Profile SP-C.
The light gray bed below it was the dense glacial till with cobbles and boulders.
There was no water observed seeping from the bluff at this location. October, 2006.

b. Thin layer of lag gravel near Soil Profile SP-H. Layer ranged from two to six inches thick and can be seen between the rust stained glacial till below and brown sand above.
Water was observed flowing out of the gravel at this location. October, 2006.

FIGURE 13

PHOTOGRAPHS OF GLACIAL TILL DEPOSIT

a. Top of glacial till unit at Soil Profile SP-H. Note gravel layers in till. October, 2006.

b. Glacial till exposed at the bottom of the bluff.
Note the bedrock-like jointed appearance of the clay. October, 2006.

FIGURE 14

PHOTOGRAPHS OF GLACIAL TILL DEPOSIT

a. Large chunks (boulders) of clay found at bottom of bluff.
From a distance, these chunks can be mistaken for cobbles and boulders. October, 2006.

b. Scattered gravel in clayey glacial till.
Much of this gravel may be "dropstones" derived from floating glacial ice. October, 2006.

Large glacial erratics were observed protruding from the bluff in several places and there were many large boulders located on the tide flats (Figure 15). Bates and Jackson (1980) define erratics as rock fragments carried by glacial ice and deposited at some distance from the outcrop from which they were derived. Erratics are often randomly scattered throughout glacially derived material.

The tide flats located at the base of the bluff lie on a marine platform cut into the glacial till. The platform slopes gently toward the river for a horizontal distance of about 100 to 200 feet. The platform was covered with what appeared to be a thin veneer of boulders, cobbles, gravel and sand apparently washed down from the bluff above. Under this veneer of soil, the clays had become soft in many places making travel on the tide flats treacherous for vehicles or personnel (Figure 6b).

5.2.6 Sand Pockets in the Glacial Till

Sand pockets within the glacial till consisted predominately of fine sand with some fine to medium dark gray nonplastic sand (SP and SP-SM). Larger pockets of sand were also noted along the bluff (Figure 16a). The largest of these pockets ranged up to about 12 feet high and 100 feet long (Figure 17b). The size and incidence of the sand pockets appeared to increase toward the west end of the project and a significant portion of the glacial till unit was composed of this sand at the Group 1 test boring location.

These sand pockets often occurred along the toe of the bluff, where they were rapidly eroded leaving small caves in the bluff (Figure 16b). The presence of these caves along the toe of the bluff appeared to accelerate undermining of the glacial till (Figure 17a). There were significant quantities of sand encountered in the eight test borings drilled along the tide flats. It appeared that the sand unit was becoming continuous and that the clay lenses were decreasing with depth.

The material consisted of a dark gray, poorly graded sand (SP) and sand with silt (SP-SM). The sands heaved when encountered during drilling, particularly in the test holes drilled on the tide flats. Layers of clay in the sand bed were noted in several of the borings, ranging from two inches to three feet thick. Samples of the material indicated the sand has an average fines content of 3.6 percent and a sand content of 95 percent. The sand ranged from fine to coarse but had little of the very fine sands (P140). There were minor amounts of gravel to 1.5 inches in diameter in some samples. Blow counts indicate the sand was medium dense to dense.

5.3 Groundwater Conditions

Observations along the bluff face coupled with test borings and measurements of monitoring wells indicate that there were two groundwater aquifers in the project area, within the 100-foot depth explored. Fourteen groundwater monitoring wells were installed in test borings drilled during this program (AP-608-MW through AP-621-MW) to provide ongoing groundwater measurements. Three monitoring wells (MW-1 through MW-3) previously installed by

FIGURE 15

PHOTOGRAPHS OF GLACIAL ERRATICS

a. Large boulder protruding from glacial till unit in bluff near Soil Profile SP-E. The boulder was approximately five feet in length. October, 2006.

b. Large boulders on beach near Soil Profile SP-C. October, 2006.

FIGURE 16

PHOTOGRAPHS OF SAND POCKETS IN BLUFF

a. Sand pocket in glacial till showing signs of erosion. October, 2006.

b. Caves interpreted to have been created by the erosion of sand pockets along bottom of the bluff near Soil Profile SP-C. October, 2006.

FIGURE 17

PHOTOGRAPHS OF SAND POCKETS IN BLUFF

a. Caves formed in bluff by erosion of sand pockets.
Note caving of clay caused by undermining due to removal of sand. October, 2006.

b. Light gray material in center of photo was part of a large
sand pocket observed west of Soil Profile SP-C. October, 2006.

American Environmental in June, 2000 were also included in the groundwater monitoring program. Groundwater measurements in all wells will continue monthly for one year and will be published in a separate project report.

Initial groundwater measurements are presented in the following table.

GROUNDWATER MEASUREMENTS AT COMPLETION OF DRILLING PROGRAM
20-21 NOVEMBER 2006

MW ID	TOTAL DEPTH	Depth to GWT	Elev. of GWT	AQUIFER
Wells Installed by R&M in November, 2006				
AP-608-MW	100	67.3	21.1	Lower
AP-609-MW	75	67.2 (1)	21.4	Lower
AP-610-MW	40	34.5	54.4	Upper
AP-611-MW	100	75.5	15.6	Lower
AP-612-MW	75	38.0 (2)	53.3	Upper (?)
AP-613-MW	40	33.2	57.8	Upper
AP-614-MW	100	82.9	11.0	Lower
AP-615-MW	75	53.2 (3)	40.3	Upper (?)
AP-616-MW	40	36.9	56.8	Upper
AP-617-MW	100	78.7	14.2	Lower
AP-618-MW	70	38.2 (4)	54.9	Upper
AP-619-MW	40	29.8	63.3	Upper
AP-620-MW	40	28.3	63.9	Upper
AP-621-MW	40	21.7	71.0	Upper
Wells Installed by American Environmental in 2000				
MW-1	25	21.8	69.0	Upper
MW-2	25	20.3	72.0	Upper
MW-3	30	25.9	67.0	Upper

(1) A concerted effort to lower the water level with a manual baler resulted in only a 0.2-foot drop in the water level.

(2) The water level was lowered to 56.1 feet below ground surface after this reading by using a manual baler. The water level had recovered to 52.9 feet two hours later. The measured water level on December 27, 2006 was 52.1 feet. Thus, it appeared the upper aquifer had been sealed off and the water level measured in the monitoring well may have been either an aquifer in the clay or water remaining in the drill hole and/or surrounding formation after installation.

(3) The water level was lowered to 69.8 feet below ground surface after this reading by using a manual baler. The water level had recovered to 52.8 feet two hours later. The measured water level on December 27, 2006 was 59.5 feet. Further monitoring will be required to determine if this well was reading an aquifer in the clay or whether it was reading water remaining in the drill hole and/or surrounding formation after installation.

(4) After this reading the water level was lowered to 47.3 feet below ground surface by manual baling. Two hours later the water level had returned to 38.2 feet. This indicates that the well is recording water levels in the upper aquifer due to leakage in the seal or due to water entering the well from around the seal.

One of the prominent features of the Kenai River bluff within the project area was the groundwater flow from the upper aquifer at the contact between the upper alluvial deposit and the lower glacial till. Water flowing over the glacial till creates bright orange rust staining of the glacial till (Figure 18). The upper aquifer appeared to be perched on the glacial till and flowed south and west toward the bluff face. Measured depths to groundwater in this aquifer during November, 2006 varied from 20.3 feet to 38.2 feet. The groundwater table appeared be higher, the further from the bluff the monitoring well was installed. East of about Ryan’s Creek, American Environmental reported a southwesterly water table gradient of about six feet in 400 feet, or approximately a 1.5 percent grade. Measurements taken from the monitoring wells in Group 4 indicated a steeper gradient closer to the bluff face (see Drawing A-11 of Appendix A). While there was less data available west of Ryan’s Creek, it appeared that the groundwater gradient in that area may be lower.

Groundwater from the upper aquifer flowed out of the bluff face through a lag gravel layer that varied in thickness from about two inches to six feet. This flow occurred along the entire bluff face with the exceptions of areas near Soil Profile SP-C. Aufeis formed along the vegetated slopes between the project area and South Spruce Street in November, 2006 and it appeared that groundwater flow from the bluff face was also occurring there (Drawing A-08).

Water was noted flowing out of a sand layer near the top of the glacial till unit near the Senior Center facility. This was interpreted to be groundwater from the upper aquifer entering the glacial till through thin sand layers. Small isolated pockets of groundwater in the sand may also occur. Otherwise, there appeared to be no notable aquifer in the glacial till.

Near Soil Profile SP-C, groundwater seepage was observed as being minor or nonexistent. A significant amount of cementation was noted in the alluvial deposits and lag gravels at Soil Profile SP-C and this may have been the cause of the decreased flow in this immediate area (see Figure 12a). However, the cementation itself may be a result of lower groundwater flow. Water levels in Test Boring AP-620-MW and in Group 2 borings indicate there may be a lower groundwater gradient toward the bluff face in this area, but with limited data this was not conclusive. Flow rates out of the bluff varied, with higher flow rates at locations where the top of the bluff was slightly lower. This appeared to concentrate water flow across the flats producing small drainages that become more apparent in the winter (Figure 19).

The lower aquifer lies at about sea level and may in part be connected to the river. As shown in the table below, water levels in the Test Boring AP-617-MW monitoring well were noted to vary over time, possibly in relation to tide levels. However, if this was true there appeared to be about a four to six hour lag between the tide and measured groundwater levels.

FIGURE 18

PHOTOGRAPHS OF GROUNDWATER SEEPAGE

a. Groundwater seeping out of bluff at Soil Profile SP-D west of Ryan's Creek. October, 2006.

b. Small stream flowing out of bluff face near Soil Profile SP-I,
east of Ryan's Creek. October, 2006.

FIGURE 19

PHOTOGRAPH OF TIDE FLATS, NOVEMBER, 2006

Looking east along tide flats from Group 2 test borings at low tide on one of the first cold days of the winter. Later in the winter the flats were completely covered by ice. Note the high water line above (white area on left side of flats) and the frozen streams of fresh water as they flow into the river.

WATER LEVEL MEASUREMENTS OVER TIME
IN TEST BORING AP-617-MW (21 NOVEMBER 2006)

Time (AST)	Depth bgs (feet)	Tides [(1)]
8:00 AM	78.7	
10:00 AM	82.3	Low Tide 10:30 AM 4.7 feet
12:30 PM	83.8	
4:00 PM	75.3	High Tide 3:58 PM 22.4 feet

(1) From NOAA http://tidesandcurrents.noaa.gov; Kenai River Entrance

5.4 Bluff Erosion

The cause of continued bluff erosion within the project area was interpreted to be removal of material from the toe of the bluff by river and tidal action. This can be seen when one compares the bluff within the project area to its continuation to the west where the toe was set back from the water (Drawing A-08). Without the removal of debris at the toe by river and tidal action, the slope in that area stabilized at an angle of about 38 degrees and became vegetated. No active erosion was observed in that area. There is no reason to believe that soil conditions to the west of the project area were significantly different than those within the project area. The bluff face tends to retreat due to continuous removal of both in-place material and material sloughed off the slope face.

Numerous secondary processes were interpreted to be involved in the raveling and sloughing of the bluff face, including the following:

- Softening of the clay by water, particularly the water flowing off the top of the glacial till and river water along the toe of the bluff.
- Undercutting of the alluvial sand by retreat of the glacial till.
- Undermining of glacial till by erosion of sand pockets as described in Section 5.2.6.
- Groundwater sapping undercutting the base of the alluvial sand along the bluff face.
- Falling trees dragging the organic mat down the slope.
- Frost action.

It appeared that the very hard clay would soften when exposed to water (slaking). In areas where the clay was exposed to standing or slow moving water it was soft. This did not occur in areas where water was observed to be actively flowing over the clay, which may have been due to flowing water carrying the clay away as it softened it. As the clay retreats, it undermines the alluvial sands above causing them to also retreat.

Small local areas of what appeared to be groundwater sapping were noted along the bluff. Groundwater sapping occurs where groundwater flows out of a bank or hillslope laterally as seeps or springs and erodes soil away. This may cause the slope above to be undermined and fail. In areas along the bluff where sapping appeared to have occurred, a relatively higher rate of flow was observed. These areas were typically between 10 and 20 feet wide. The steep walled gully through which Ryan's Creek flowed may have been created by groundwater sapping. Groundwater sapping appeared to have only a locally significant effect on erosion along the bluff.

Trees that had fallen at the crest of the bluff were observed to drag large sections of topsoil in their root wads down the bluff, accelerating the erosion along the top of the bluff. Where trees had been cut, the organic mat would lie over the slope, apparently slowing the erosion.
During the November, 2006 drilling program the lower slopes of the bluff were covered by a thick layer of ice. One afternoon temperatures warmed into the upper 30s with the sun shining directly on the bluff face. We noted cobbles and boulders falling out of the bluff face as it thawed. Large pieces of ice also slid down the slope carrying soil with it. It appeared that a significant amount of material moved downslope during the four to five hours these conditions existed.

Debris piles were also observed along the toe of the slope. These debris piles consisted of a heterogeneous mixture of wet, very soft clay, sand, gravel, organic material. This material appeared to have raveled or flowed downslope from the bluff above. It also included trees that have broken off from the crest of the slope. Flow failures were noted in the debris slopes where they had been undercut.

Presumably, if the erosion of the toe by current and wave action stopped, the debris piles would build up. As the slope retreated back to an angle of about 35 to 40 degrees, vegetation would become established which would further stabilize the slope. The stable slope condition which occurs in the absence of toe erosion can be seen in Soil Profile SP-A.

6.0 CONCLUSIONS

The following conclusions are based on data collected from library searches, report reviews and R&M's field work and testing. Geotechnical investigations for the Kenai River Bluff Erosion Study reveal that:

1. The site is located within the Kenai Lowland portion of the Cook Inlet-Susitna Lowland physiographic province.

2. Segregated stands of primarily spruce trees are present along intermittent portions of the bluff crest. The toe of the bluff area is primarily devoid of vegetation.

3. Soils at the project site generally consist of alluvial deposits overlying glacially modified marine deposits (glacial till). The two units were separated by a thin layer of lag gravel from which a year-round flow of groundwater emerges from the bluff.

4. On the basis of currently available information, it appears that bedrock is located at a considerable depth beneath the project site. Therefore, bedrock is not expected to be involved with any construction considerations.

5. Observations and monitoring well readings indicate that there were two separate groundwater aquifers within the upper 100 feet at the project area. The upper aquifer flows from the bluff at the contact between the upper alluvial deposit and the lower glacial till. Technical studies and reports have noted seeps and springs emerging from the bluff at this contact for at least the past 100 years.

6. The elevation of the lower aquifer along the face of the bluff appeared to be influenced by tides.

7. Permafrost has not been encountered, nor should it be expected, within the project area.

8. Cemented layers of sand and gravel appeared to allow the soil to stand near vertical where the cementation occurred. There was no water observed seeping from the bluff at some of these cemented locations.

9. Marine clay within the glacial till unit was plastic with an average liquid limit of 27, and a plasticity index of 11.

10. Permeability tests conducted on the alluvial material indicated a permeability in the vertical direction of about 10^{-4} ft/sec. It is likely that this value does not represent the overall permeability of the unit. The presence of gravel layers would likely result in a much higher permeability in the horizontal direction.

11. Consolidation and triaxial strength tests conducted on the glacial till material indicated that the material was hard, overconsolidated, and strong. The average dry density of the specimens was 118 pcf. The compression index (C_c) ranged from 0.06 to 0.07.

12. Geologic logging of the bluff and the test borings indicated that the soils contain a large number of boulders. Therefore, any excavation contractor should be prepared to deal with said over-size material.

13. Contractors should also be prepared to deal with the soft, quick conditions of the soils along the tide flats (see Figure 20).

14. Within three months of the 1964 Great Alaska Earthquake, the bluff had receded as much as 20 feet within the project area. This was attributed to regional subsidence, rapid removal of sloughed debris along the toe, and undercutting by waves and the river.

15. The retreat of the bluff appears to be caused by several processes including erosion at the toe of the bluff by river and tidal action, slaking of the glacial till by groundwater and surface water, groundwater sapping of the alluvial sand, and frost action.

16. It is expected that in the absence of river and tidal action, the slope will naturally flatten to an angle between 35 and 40 degrees and become vegetated.

FIGURE 20

DRILL RIG STUCK ON TIDE FLATS

a. Nodwell stuck in mud near Test Boring AP-627 at low tide. November 10, 2006.

b. The Nodwell has sunk into unfrozen mud below the high tide line (edge of snow covered area). The surface of the mud was frozen under the snow covered area. November 10, 2006.

7.0 CLOSURE

The interpretations of geotechnical conditions presented in this report are based on our understanding of the project requirements, our limited bluff logging and test boring explorations, and other pertinent information listed herein. Significant alteration of any of these concepts or site locations could substantially alter the foregoing interpretations. We would, therefore, appreciate having the opportunity to review and evaluate the final design, and where necessary, present any required changes to our present conclusions. Additionally, because subsurface characteristics can change significantly within a given area, and with the passing of time, the possibility exists that important subsurface conditions not disclosed during our current investigation may be discovered during any future investigation or construction. Should this situation occur, the influence of the new information on the present interpretations should be evaluated without delay.

R&M Consultants, Inc. performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. This report is intended for use only in accordance with the purposes of study described within.

We appreciate the opportunity to perform this geotechnical investigation. Should you require further information concerning the investigation or this report, please contact us at your convenience.

Very truly yours,

R&M CONSULTANTS, INC.

Peter K. Hardcastle
Senior Engineering Geologist

Charles H. Riddle, C.P.G.
Vice President

STATE OF ALASKA
49TH
Robert M. Pintner
CE 8525
2/14/07
REGISTERED PROFESSIONAL ENGINEER

Robert M. Pintner, P.E.
Senior Geotechnical Engineer

CHR*slv

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TABLE 1

CONVERSION FACTORS FOR SI UNITS

CONVERSION TO THE SI INTERNATIONAL SYSTEM OF UNITS		
To Convert From	**To**	**Multiply By**
Mile	Kilometer (km)	1.609344
Mile	Meter (m)	1,609.344
Foot	Meter (m)	0.3048
Foot	Centimeter (cm)	30.48
Inch	Centimeter (cm)	2.54
Square Foot	Square Meter (m^2)	0.09290304
Square Yard	Square Meter (m^2)	0.8361274
Acre	Square Meter (m^2)	4,046.825
Cubic Foot (cf)	Cubic Meter (m^3)	0.02831685
Cubic Yard (cy)	Cubic Meter (m^3)	0.7645549
Gallon (U.S. Liquid)	Cubic Meter (m^3)	0.003785412
Pound-Mass (lbf)	Kilogram (kg)	0.4535924
Ton (short)	Kilogram (kg)	907.1847
Pound-Force (lbf)	Newton (N)	4.448222
Degree Fahrenheit (°F)	Degree Celsius (°C)	T°C=(T°F-32)/1.8
Pound per Square Foot (psf)	Kilonewtons per Square Meter (kN/m^2)	0.47880
Pound per Cubic Foot (pcf)	Kilonewtons per Cubic Meter (kN/m^3)	0.157087

TABLE 2

CLIMATOLOGICAL DATA

LOCATION	KENAI FAA AIRPORT
Period of Record	1949 – 2006
Elevation (ft)	90
Mean Annual Temperature (°F)	34.0
Record High Temperature (°F)	93 (June 14, 1969)
Record Low Temperature (°F)	-47 (Jan. 4, 1975)
Mean Annual Precipitation (in.)	19.1
Highest Monthly Precipitation (in.)	7.36 (Oct., 1986)
Maximum Daily Precipitation (in.)	4.28 (Oct. 10, 1986)
Mean Annual Total Snowfall (in.)	61.2
Highest Monthly Snowfall (in.)	51.6 (Nov., 1994)
Maximum Annual Snowfall (in.)	133.8 (1994)

After Western Regional Climate Center (WRCC)
http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?akkena

TABLE 3

SUMMARY OF TEST BORINGS
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

TEST BORING NUMBER (FINAL)	TEST BORING NUMBER (FIELD)	COORDINATES (FEET)		COLLAR ELEVATION (FEET)	TOTAL DEPTH (FEET)	GROUNDWATER DEPTH (FEET)
		NORTHING	EASTING			
AP-608-MW	TB-1A	2,395,412.81	1,413,139.72	88.4	101.2	34 W.D. – 67.5 A.B.
AP-609-MW	TB-1B	2,395,415.41	1,413,150.90	88.6	76.5	33 W.D. – 70 A.B.
AP-610-MW	TB-1C	2,395,430.86	1,413,141.62	88.9	41.3	34 W.D.
AP-611-MW	TB-2C	2,395,775.73	1,414,431.97	91.1	101.5	35 W.D. – 83 A.B.
AP-612-MW	TB-2B	2,395,786.22	1,414,437.68	91.3	76.5	35 W.D.
AP-613-MW	TB-2A	2,395,795.10	1,414,440.67	91.0	41.5	35 W.D. – 32.9 A.B.
AP-614-MW	TB-3A	2,396,258.31	1,415,755.43	93.9	101.5	37.5 W.D. – 82.5 A.B.
AP-615-MW	TB-3B	2,396,268.68	1,415,756.19	93.5	76.5	37.5 W.D. – 46.3 A.B.
AP-616-MW	TB-3C	2,396,280.50	1,415,756.60	93.7	41.5	35 W.D. – 38.8 A.B.
AP-617-MW	TB-4A	2,396,189.80	1,416,979.96	92.9	101.5	33 W.D. – 82.5 A.B.
AP-618-MW	TB-4B	2,396,207.48	1,416,981.72	93.1	70.0	35 W.D.
AP-619-MW	TB-4C	2,396,224.77	1,416,982.32	93.1	40.0	35 W.D. – 29.6 A.B.
AP-620-MW	TB-02	2,396,321.05	1,414,354.82	92.2	41.4	28 W.D. – 28.5 A.B.
AP-621-MW	TB-03	2,396,759.77	1,417,031.71	92.7	41.0	25 W.D. – 21.5 A.B.
AP-622	TB-08	2,395,300.06	1,412,903.84	24*	31.5	6.5 W.D.
AP-623	TB-07	2,395,437.96	1,414,078.32	20*	30.0	14 W.D.
AP-624	TB-06	2,395,725.08	1,414,587.74	20*	30.0	13.5 W.D.
AP-625	TB-05	2,396,055.30	1,415,467.21	20*	30.0	10 W.D.
AP-626	TB-04	2,396,137.75	1,416,086.29	19*	30.0	10.5 W.D.
AP-627	TB-01	2,395,983.03	1,417,218.15	21*	31.5	22.5 W.D.

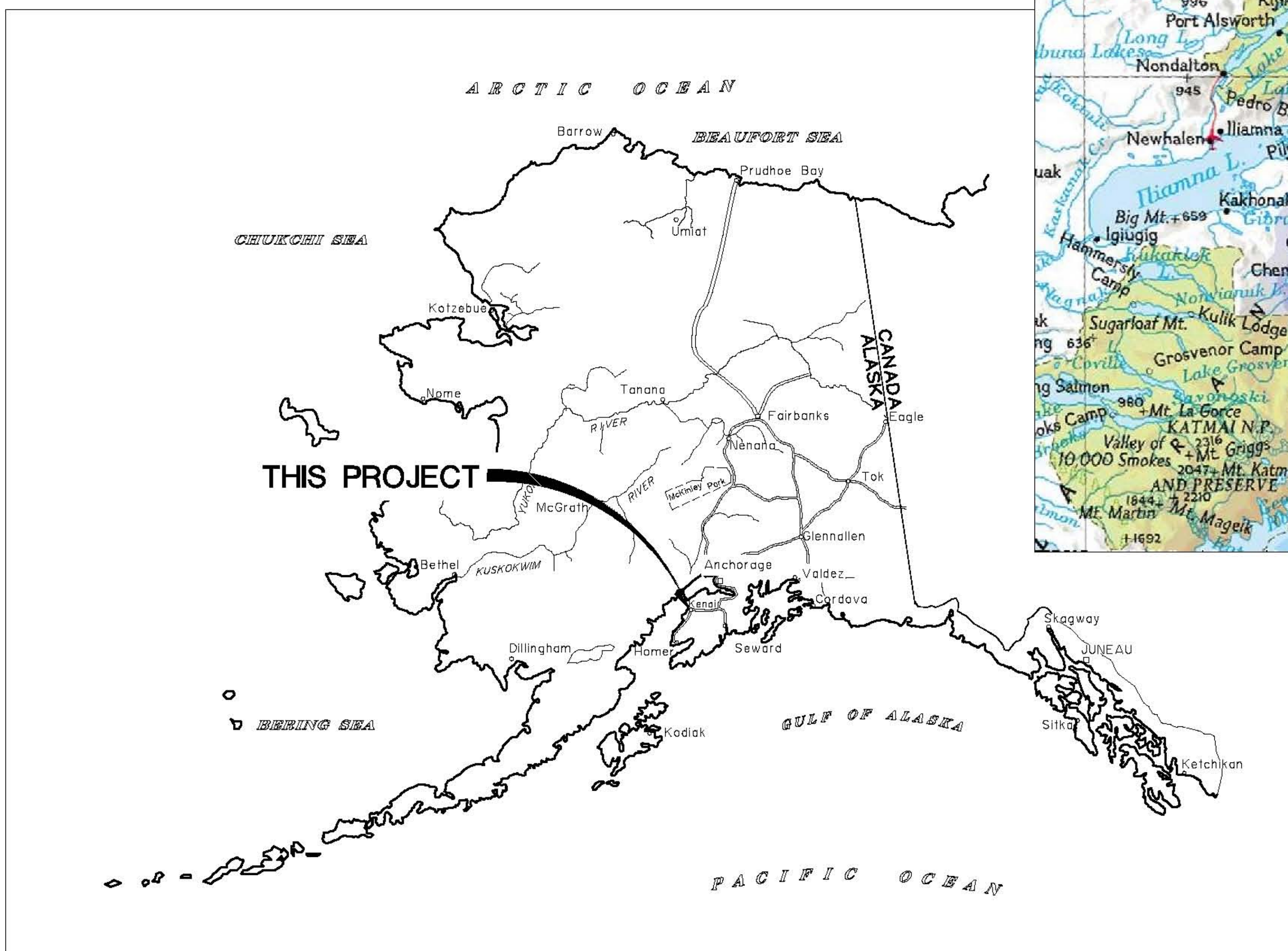
NOTE: The test boring elevations shown with an asterisk were surveyed at the top of ice cover of varying thickness. The elevations shown were therefore determined by subtracting the estimated ice thickness at the time of survey from the elevation surveyed at the top of the ice. These elevations are estimated, and due to the thick snow and ice cover are considered only accurate to +/- 5 feet.

A.B. = After Boring
AP = Auger Point
TB = Test Boring
W.D. = While Drilling

APPENDIX A
SITE MAPS

CORPS OF ENGINEERS

U. S. ARMY



R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	VICINITY MAP
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	A-01

project\1209.10\geo\Kenai Bluff-A-01, 1=1, 10/03/06 at 08:42 by pkh

CORPS OF ENGINEERS

U. S. ARMY

LEGEND

GROUP-4	GROUP OF (3) MONITORING WELLS
AP-620-MW	SINGLE BORING W/ MONITORING WELL
AP-622	SOIL BORINGS
SP-I	SOIL PROFILES
AP-606	EXISTING BORINGS BY USACE-AD

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

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CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

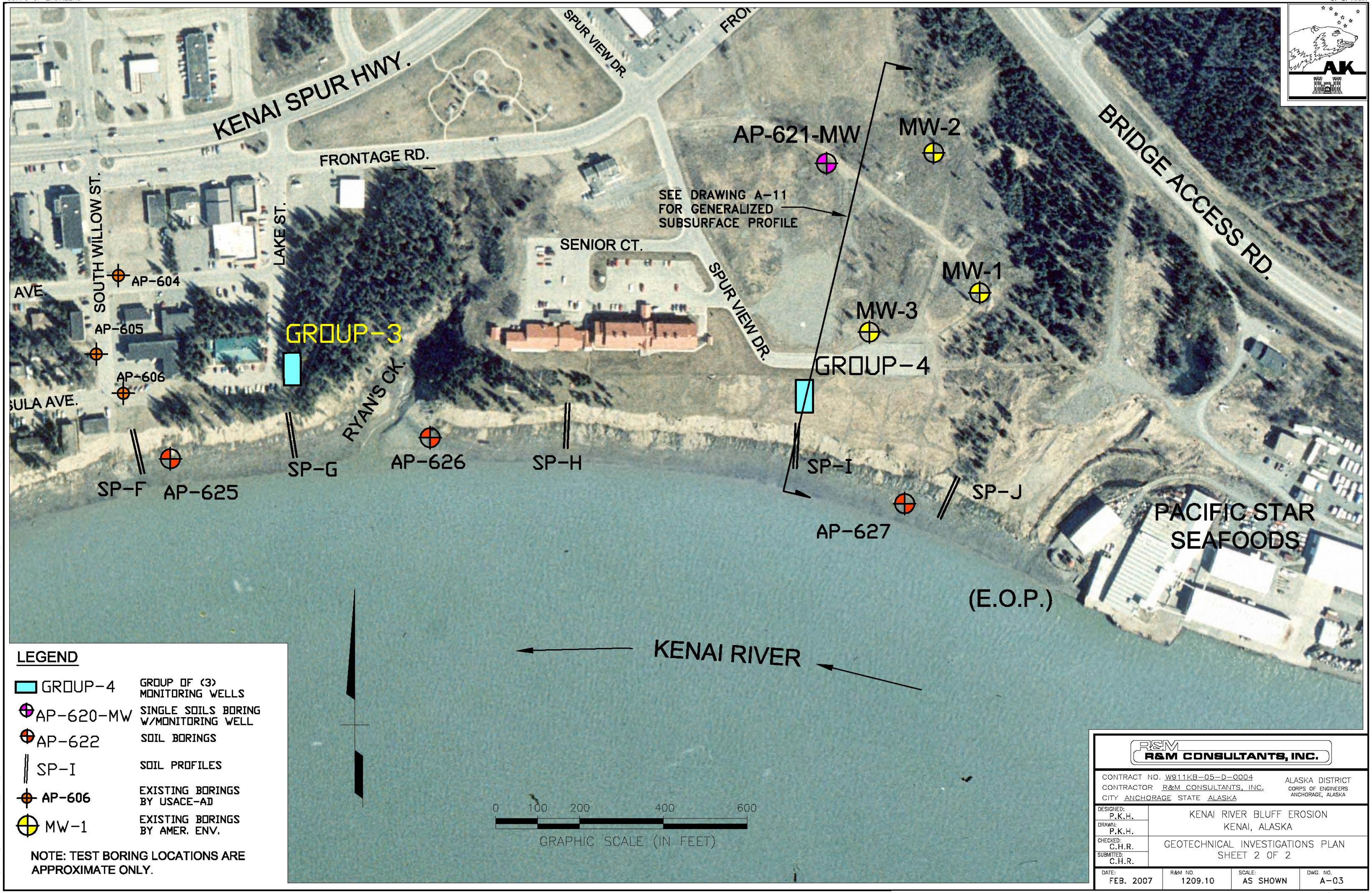
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	GEOTECHNICAL INVESTIGATIONS PLAN SHEET 1 OF 2
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-02

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

CORPS OF ENGINEERS

U. S. ARMY



project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

AK

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300

GRAPHIC SCALE (IN FEET)

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CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	BOREHOLE LOCATION MAP
SUBMITTED: C.H.R.	GROUP 1 AND VICINITY

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-04

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

CORPS OF ENGINEERS U. S. ARMY

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300

GRAPHIC SCALE (IN FEET)

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	BOREHOLE LOCATION MAP
SUBMITTED: C.H.R.	GROUP 2 AND VICINITY

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-05

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300

GRAPHIC SCALE (IN FEET)

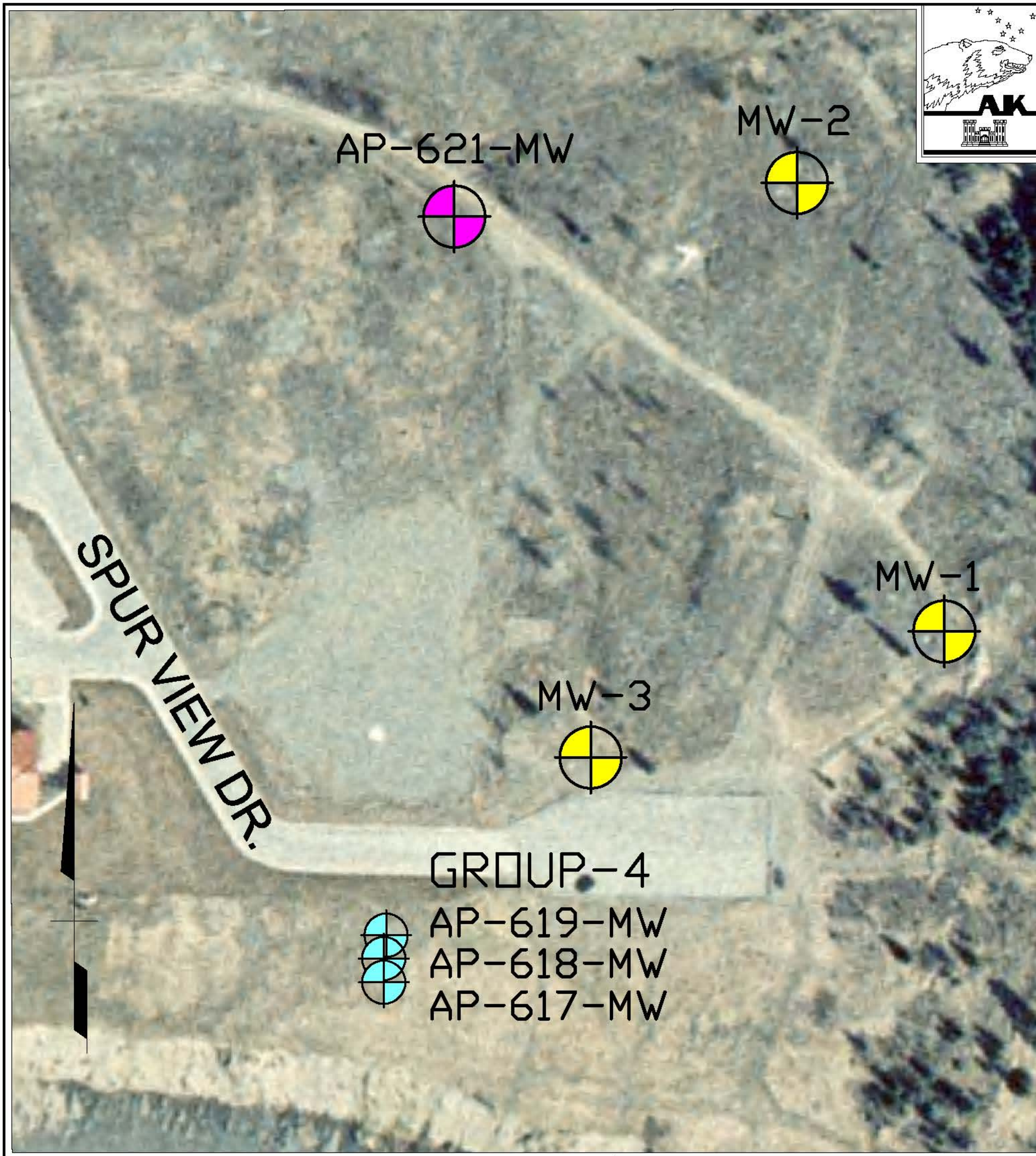
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	BOREHOLE LOCATION MAP
SUBMITTED: C.H.R.	GROUP 3 AND VICINITY

DATE:	R&M NO.	SCALE:	DWG. NO.
FRB. 2007	1209.10	AS SHOWN	A-06



NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300
GRAPHIC SCALE (IN FEET)

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	BOREHOLE LOCATION MAP
SUBMITTED: C.H.R.	GROUP 4 AND VICINITY

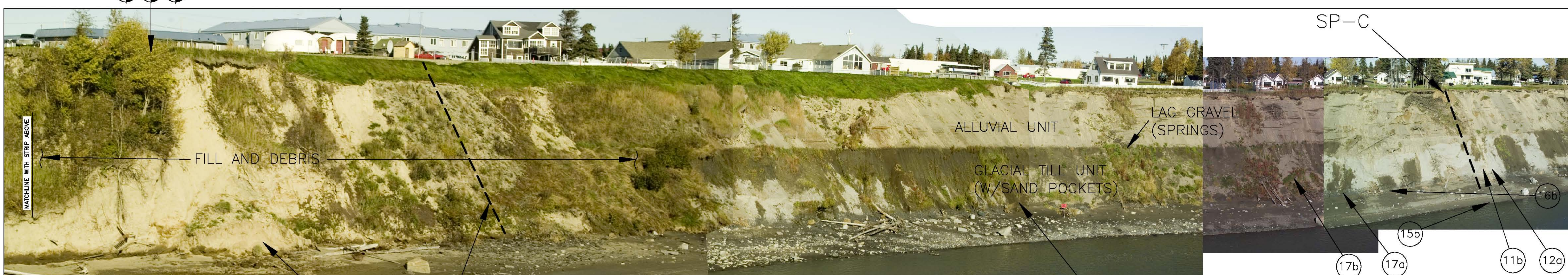
DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-07

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

WEST SOUTH SPRUCE ST. PETERSEN WAY OVERLAND AVE. UPLAND ST. SP–A EAST

B.O.P.

WEST GROUP 1 MISSION AVE. MAIN ST. EAST



B.O.P. 10b SP–B 16a KENAI RIVER

10a

LEGEND:

- – – – – – SOIL PROFILES
- AP–622 TEST BORINGS
- ← 16a FIGURES (PHOTOS) IN REPORT

Photography dated September 19, 2001 by Eagle Eye Helicopter.

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CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.H.K.	
CHECKED: C.H.R.	ANNOTATED PHOTO MOSAIC SHEET 1 OF 3
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	NOT TO SCALE	A–08

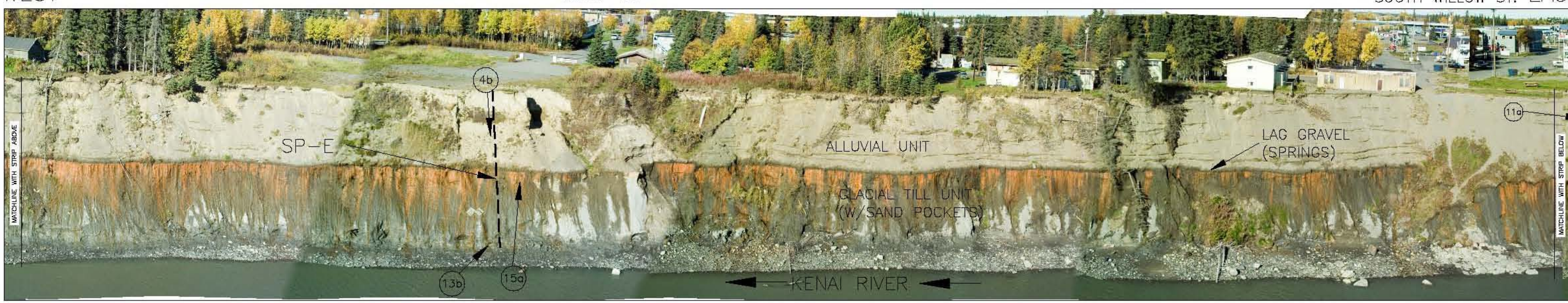
project\1209.10\geo\Kenai Photo Mosaic 1, 1=1, 02/14/07 at 11:03 by pkh

CORPS OF ENGINEERS

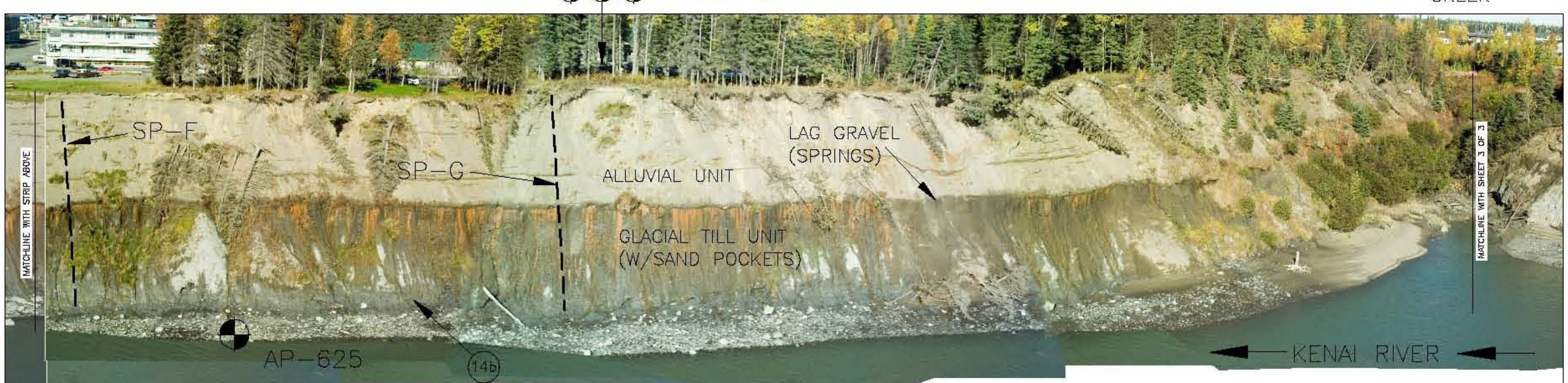
U. S. ARMY

WEST GROUP 2 BROAD ST. EAST

WEST BLUFF ST. SOUTH WILLOW ST. EAST



WEST SOUTH WILLOW ST. LAKE ST. GROUP 3 RYAN'S CREEK EAST



Photography dated September 19, 2001 by Eagle Eye Helicopter.

LEGEND:

- SOIL PROFILES
- AP-622 TEST BORINGS
- 16a FIGURES (PHOTOS) IN REPORT

R&M CONSULTANTS, INC.

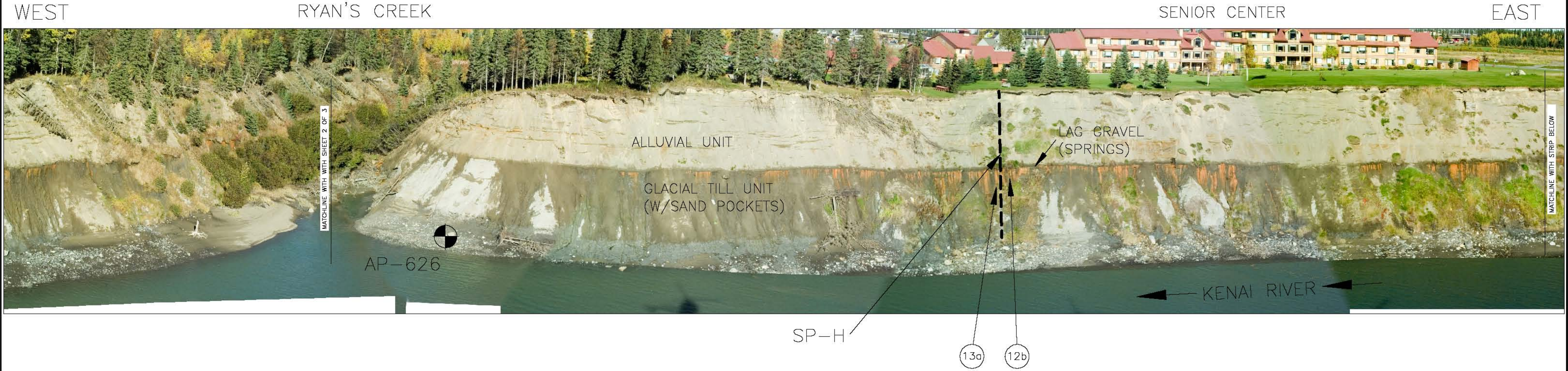
CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	ANNOTATED PHOTO MOSAIC SHEET 2 OF 3

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	NOT TO SCALE	A-09

project\1209.10\geo\Keni Photo Mosaic 2, 1=1, 02/14/07 at 11:02 by pkh

CORPS OF ENGINEERS

U. S. ARMY



LEGEND:

SOIL PROFILES

AP-622 TEST BORINGS

16a FIGURES (PHOTOS) IN REPORT

Photography dated September 19, 2001 by Eagle Eye Helicopter.

R&M CONSULTANTS, INC.

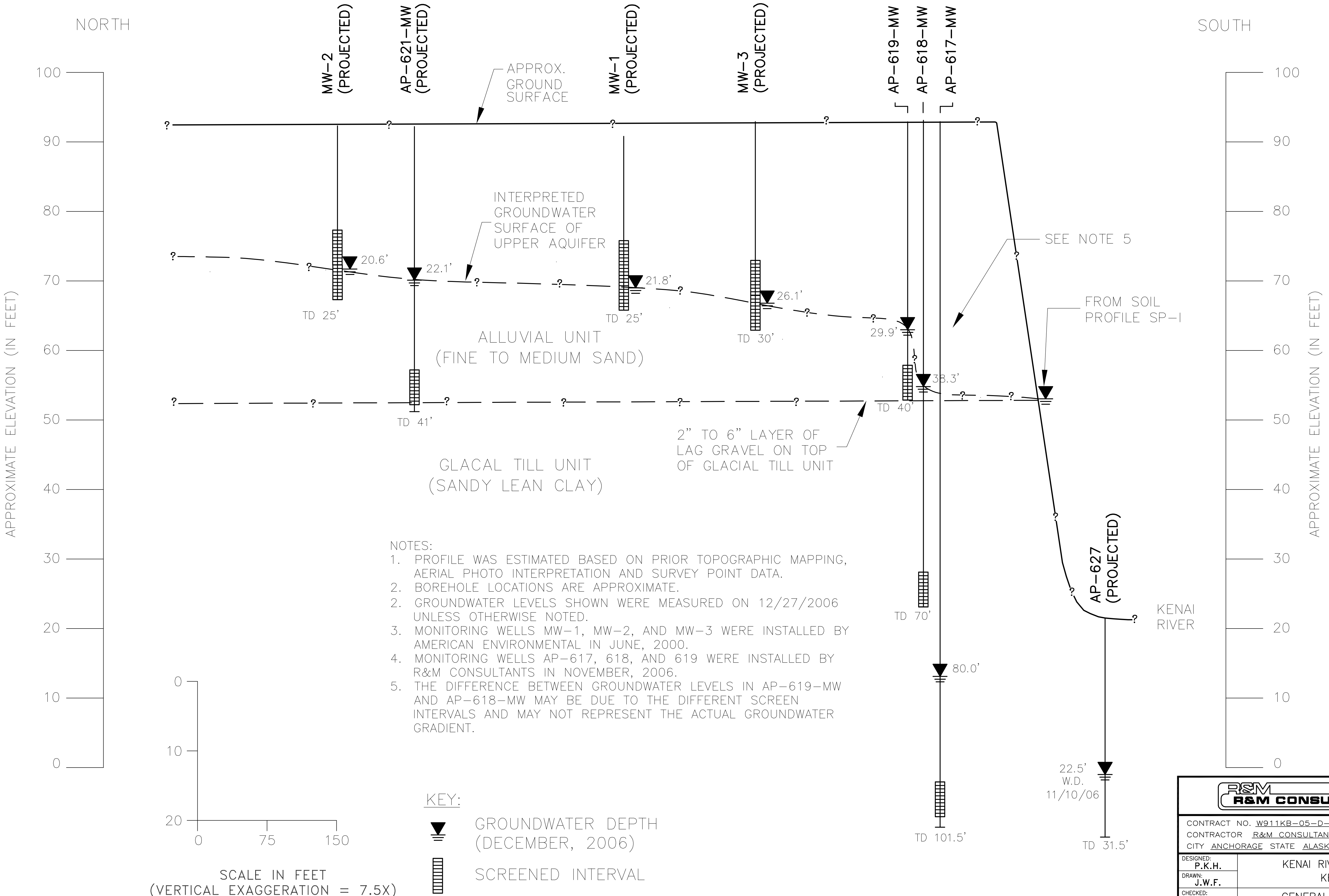
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	ANNOTATED PHOTO MOSAIC SHEET 3 OF 3
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	NOT TO SCALE	A-10

project\1209.10\geo\Kenai Photo Mosaic 3, 1=1, 02/14/07 at 11:02 by pkh



NOTES:
1. PROFILE WAS ESTIMATED BASED ON PRIOR TOPOGRAPHIC MAPPING, AERIAL PHOTO INTERPRETATION AND SURVEY POINT DATA.
2. BOREHOLE LOCATIONS ARE APPROXIMATE.
2. GROUNDWATER LEVELS SHOWN WERE MEASURED ON 12/27/2006 UNLESS OTHERWISE NOTED.
3. MONITORING WELLS MW-1, MW-2, AND MW-3 WERE INSTALLED BY AMERICAN ENVIRONMENTAL IN JUNE, 2000.
4. MONITORING WELLS AP-617, 618, AND 619 WERE INSTALLED BY R&M CONSULTANTS IN NOVEMBER, 2006.
5. THE DIFFERENCE BETWEEN GROUNDWATER LEVELS IN AP-619-MW AND AP-618-MW MAY BE DUE TO THE DIFFERENT SCREEN INTERVALS AND MAY NOT REPRESENT THE ACTUAL GROUNDWATER GRADIENT.

KEY:
GROUNDWATER DEPTH (DECEMBER, 2006)
SCREENED INTERVAL
W.D. WHILE DRILLING

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: J.W.F.	KENAI, ALASKA
CHECKED: C.H.R.	GENERALIZED SUBSURFACE PROFILE
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-11

project\1209.10\geo\1209.10-GGP NEW, 1=1, 02/12/07 at 13:41 by pkh

APPENDIX B
LOGS OF TEST BORINGS

SOILS
CONSISTENCY AND SYMBOLS

CLASSIFICATION: Identification and classification of the soil is accomplished in accordance with the ASTM version of the Unified Soil Classification System. When laboratory testing data on material passing the 75-mm sieve is available Standard D 2487 (Classification of Soils for Engineering Purposes) is used and when laboratory data is not available D 2488 Visual-Manual Procedure) is used. This classification system identifies three major soil divisions: coarse-grained soils, fine-grained soils, and highly organic soils. These three divisions are further subdivided into a total of 15 basic soils groups. Based on the results of visual observations and prescribed laboratory tests, a soil is catalogued according to the basic soil groups, assigned a group symbol(s) and name, and thereby classified. Flow charts contained in the two standards can be used to assign the appropriate group symbol(s) and name.

SOIL DENSITY/CONSISTENCY - CRITERIA: Soil density/consistency as defined below and determined by normal field and laboratory methods applies only to non-frozen material. For these materials, the influence of such factors as soil structure, i.e. fissure systems shrinkage cracks, slickensides, etc., must be taken into consideration in making any correlation with the consistency values listed below. In permafrost zones, the consistency and strength of frozen soil may vary significantly and inexplicably with ice content, thermal regime and soil type.

COHESIONLESS

Description	N * (blows/FT.)	Relative Density
Loose	0 - 10	0 to 40%
Medium Dense	10 - 30	40 to 70%
Dense	30 - 60	70 to 90%
Very Dense	>60	90 to 100%

* Standard Penetration "N": Blows per 12 inches of a 140-pound manual hammer (lifted with rope & cathead) falling 30 inches on a 2-inch O.D. split-spoon sampler except where noted.

COHESIVE

Consistency	Shear Strength (TSF)	Unconfined Compressive Strength (TSF)
Very Soft	0.0 - 0.25	0.0 - 0.5
Soft	0.25 - 0.5	0.5 - 1.0
Firm	0.5 - 1.0	1.0 - 2.0
Stiff	1.0 - 2.0	2.0 - 4.0
Very Stiff	2.0 - 4.0	4.0 - 8.0
Hard	OVER 4.0	OVER 8.0

KEY TO TEST RESULTS

DD - Dry Density
LL - Liquid Limit
MC - Moisture Content
Org - Organic Content
PI - Plastic Index
PL - Plastic Limit
PP - Pocket Penetrometer
P200 - % Passing No. 200 Screen
P.02 - % Passing 0.02 mm
SG - Specific Gravity
TV - Torvane

DWN:	K.J.P.
CKD:	R.M.P.
DATE:	FEB 06
SCALE:	NONE

R&M
R&M CONSULTANTS, INC.
ENGINEERING • SURVEYING • EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522–1707

GENERAL NOTES

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	B-01

Z:\PROJECT\1209.10\LOGS\B01&B02.GDW (DRAWING C - B-01 COE ASTM (ENGLISH) (CURRENT)) 2/14/07 03:38 PM

STANDARD SYMBOLS

SYMBOL	NAME	PARTICLE SIZE	SYMBOL	NAME
	CLAY	< 0.002mm, Plastic		ORGANICS
	SILT	0.002mm, - #200		ICE
	SAND	#200, - #4		ICE W/SOIL INCLUSIONS
	GRAVEL	#4, - 3"		ICE LENSE IN SILT
	COBBLES & BOULDERS	3" - 12" & > 12"		ICE CRYSTALS IN CLAY

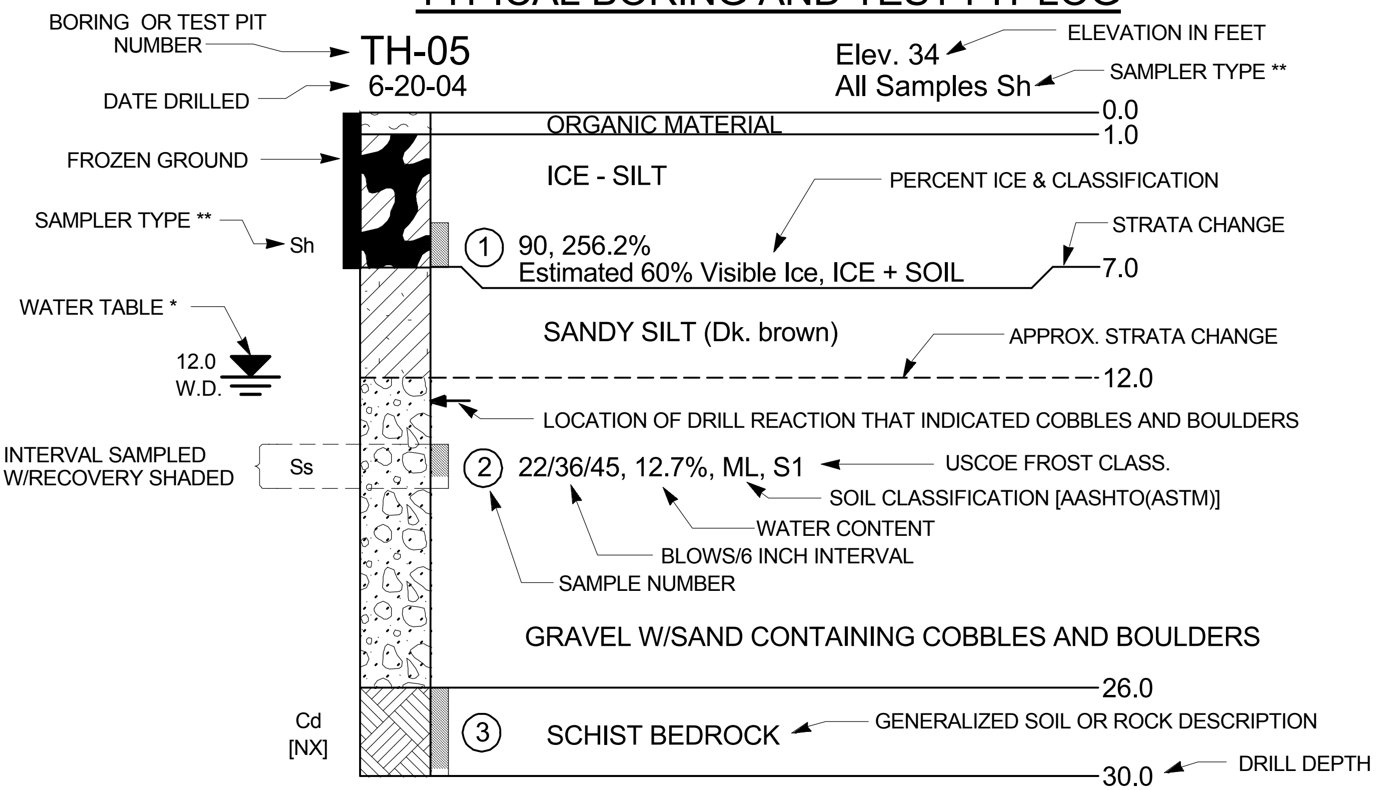
(The symbols shown above are frequently used in combinations, e. g. GRAVEL W/SILT AND SAND)

SAMPLER TYPE SYMBOLS

A	Auger Sample	Sh	2.5 In. Split Spoon w/340 lb. Manual Hammer	Sp	2.5 In. Split Spoon Pushed
C	Cuttings Sample	Sha	2.5 In. Split Spoon w/340 lb. Auto Hammer	Sz	1.4 In. Split Spoon w/340 lb. Hammer
Cd	Double Tube Core Barrel	Sl	2.5 In. Split Spoon w/140 lb. Hammer	Ts	Shelby Tube
Ct	Triple Tube Core Barrel	Ss	1.4 In. Split Spoon w/140 lb. Manual Hammer	Tm	Modified Shelby Tube
Cs	Auger Core Barrel	Ssa	1.4 In. Split Spoon w/140 lb. Auto Hammer	[x]	Sampler I. D. (Added to Symbol)
G	Grab Sample				

NOTE: Sampler types are either noted above the boring log or adjacent to it at the respective depth. An individual log may not utilize all of the items listed.

TYPICAL BORING AND TEST PIT LOG



* W.D. - WHILE DRILLING, A.B. - AFTER BORING, Ref. - SAMPLER REFUSAL
** - REFER TO SAMPLER SYMBOL (Ss, Sh, ETC.) FOR SAMPLER I.D. & HAMMER WEIGHT/TYPE
NOTE: Water levels shown on the boring logs are the levels measured in the boring at the times indicated.

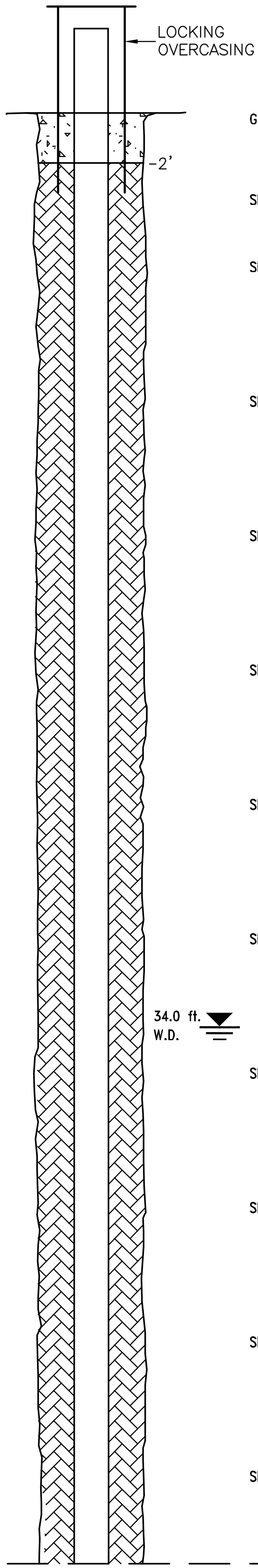
Z:\PROJECT\1209.10\LOGS\B01&B02.GDW (DRAWING T - B-02 COE (ENG.) (CURRENT)) 2/14/07 03:39 PM

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JUNE 04
SCALE:	NONE

R&M
R&M CONSULTANTS, INC.
ENGINEERING ∘ SURVEYING ∘ EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

EXPLANATION OF SELECTED SYMBOLS

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	B-02

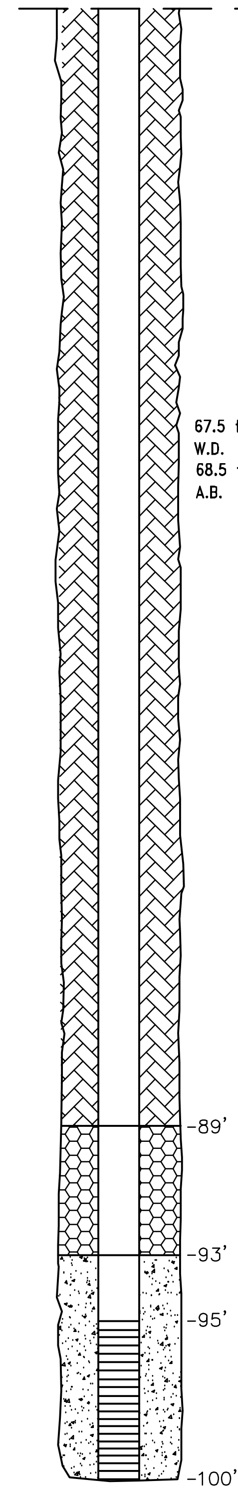


AP-608-MW (TB-1a)

N 2,395,412.81
E 1,413,139.72 Elev. 88.4
11/17/06

Depth (ft)		Sample	Description
0.0	G	(1)	ML*, F4*
0.5			SILT CONTAINING ORGANICS
	Sha	(2)	5/12/10, ML*, F4*
	Sha	(3)	3/3/4, 27%, ML*, F4 Gr=3, Sa=45, Fines=52
			SANDY SILT (FILL) (Dk. brown, Trace gravel to 1/2" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Loose, Moist)
	Sha	(4)	1/2/2, ML*, F4*
	Sha	(5)	2/2/2, ML*, F4* Fragments of glass in bottom of sample
17.5			Drilled fast and smooth to 27.5 feet
	Sha	(6)	3/8/10, SP*, NFS*
			POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry)
	Sha	(7)	8/12/15, 4.3%, SP, NFS* Gr=1, Sa=95, Fines=3.7
			Ferruginous cementation 27.5 to 30 feet, tougher drilling.
	Sha	(8)	7/8/6, SP*, NFS*
			Drilled fast and slightly rough 30 to 37.5 feet.
32.5			POORLY GRADED SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Wet)
	Sha	(9)	18/29/29, SP*, S2*
			Driller noted a gravel layer from 37.5 to 38.0 feet.
37.5			POORLY GRADED GRAVEL W/SAND
38.0			Driller indicated clay at 38.0 feet.
	Sha	(10)	7/11/13, CL*, F3*, PP=4.5+ tsf
			SANDY LEAN CLAY (Dk. gray, Gravel to 3/4" dia., rounded to subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)
			Drilled slower, tighter, w/gravel hits 38 to 43 feet, Very slow and hard 43 to 45 feet.
45.0	Sha	(11)	13/20/22, 2.3%, SP, NFS, Gr=12, Sa=86, Fines=1.8
			POORLY GRADED SAND (Dk. gray, Gravel to 1.5" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Dry)
47.0			SANDY LEAN CLAY (Dk. gray)
49.5			Drilled faster 45 to 50 feet.
	Sha	(12)	9/12/16, SP*, NFS*
			POORLY GRADED SAND (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Dry)
54.0			

(Continued Above)



AP-608-MW (Continued)

11/17/06

Depth (ft)		Sample	Description
54.0	Sha	(13)	6/12/18, 2.8%, SP, NFS Sa=99, Fines=1.3
			Drilled slow, very tight, bit smoking 50 to 60 feet.
	Sha	(14)	6/16/19, SP*, NFS*
			Drilled faster and smooth 60 to 85 feet.
	Sha	(15)	3/8/15, 9.7%, SP, NFS Gr=1, Sa=96, Fines=3.0
			Gravel increases with depth.
	Sha	(16)	6/18/26, SP*, NFS Sampler overfilled
72.5			SANDY LEAN CLAY (Dk. gray, Trace gravel to 3/4" dia., subrounded, hard, Fine to coarse sand, Plastic, Very stiff, Dry)
	Sha	(17)	6/11/12, CL*, F3, PP=3.0 tsf
77.5			POORLY GRADED SAND W/SILT (Dk. gray, Gravel to 1" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Wet)
	Sha	(18)	18/35 blows for 6", 17%, SP-SM*, F2* Gr=6, Sa=83, Fines=11, Sampler overfilled
84.0	Sha	(19)	6/18/23, 13%, CL, F4, PP=4.5+ tsf Gr=15, Sa=22, Fines=63, LL=24, PL=15, PI=9
			SANDY LEAN CLAY (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Layers of sand to 1/16" thick, irregular dip, Plastic, Very hard, Wet to dry)
	Sha	(20)	7/13/18, CL*, F3*, PP=4.5+ tsf
			Drilled hard, slow, and smooth 85 to 100 feet.
	Sha	(21)	6/12/18, 16%, CL, F4, PP=4.5+ tsf Gr=2, Sa=18, Fines=80, LL=27, PL=16, PI=11
97.5			POORLY GRADED SAND (Dk. gray, Fine sand, Nonplastic, Dense, Wet)
	Sha	(22)	8/18/22 blows for 3", SP*, PFS* Sampler bouncing
101.2			

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 95 and 100 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

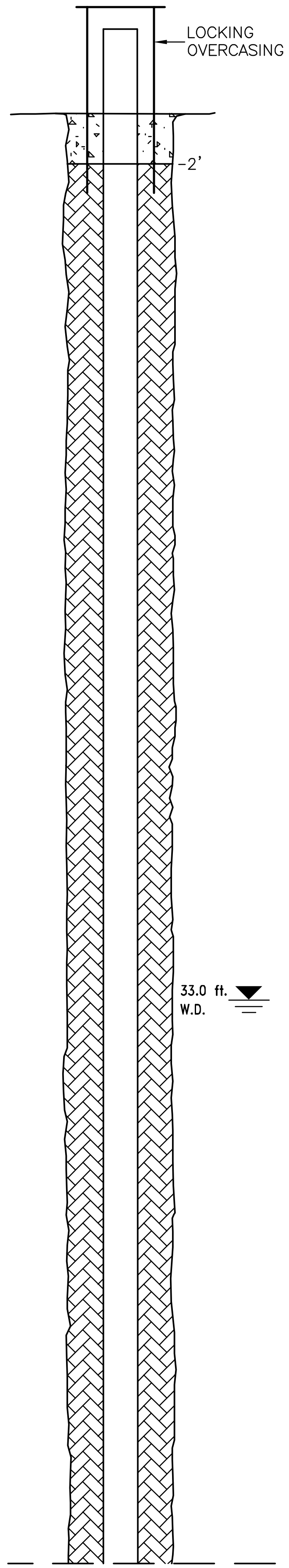
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-608-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-03



AP-609-MW (TB-1b)

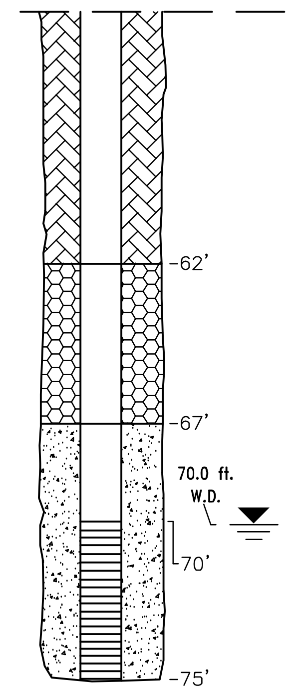
N 2,395,415.41
E 1,413,150.90
Elev. 88.6
11/18/06

Depth (ft)	Description
0.0 – 0.5	SILT CONTAINING ORGANICS
0.5 – 17.5	Drilled fast and smooth to 25 feet. SANDY SILT (FILL) (Dk. brown, Gravel to 1/2" dia., Fine to medium sand, Nonplastic) Driller indicated looser material at about 17.5 feet.
17.5 – 37.5	POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry) Ferruginous cementation 25 to 30 feet, tougher drilling. Drilled fast and smooth to 30 to 37.5 feet. Drilled slightly rough 37.5 to 38 feet.
37.5 – 38.0	
38.0 – 44.0	Drilled tight and smooth 38 to 44 feet. SANDY LEAN CLAY (Dk. gray) Drilled tight and smooth 38 to 44 feet.
44.0 – 45.0	POORLY GRADED SAND W/GRAVEL
45.0 – 46.0	Drilled fast, slightly rough 44 to 45 feet.
46.0 – 47.0	POORLY GRADED SAND
47.0 – 54.0	POORLY GRADED SAND W/GRAVEL. Drilled fast and smooth 45 to 46 feet, Slightly rough 46 to 47 feet. POORLY GRADED SAND (Dk. gray, Gravel to 1.5" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Dry)

(Continued Above)

AP-609-MW (Continued)

11/17/06



Depth (ft)	Description
54.0 – 76.2	Drilled fast and smooth 47 to 75 feet.
Sha	(1) 6/12/18**, 9" heave, sampler floated, SP-SM*, F2*

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 70 and 75 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

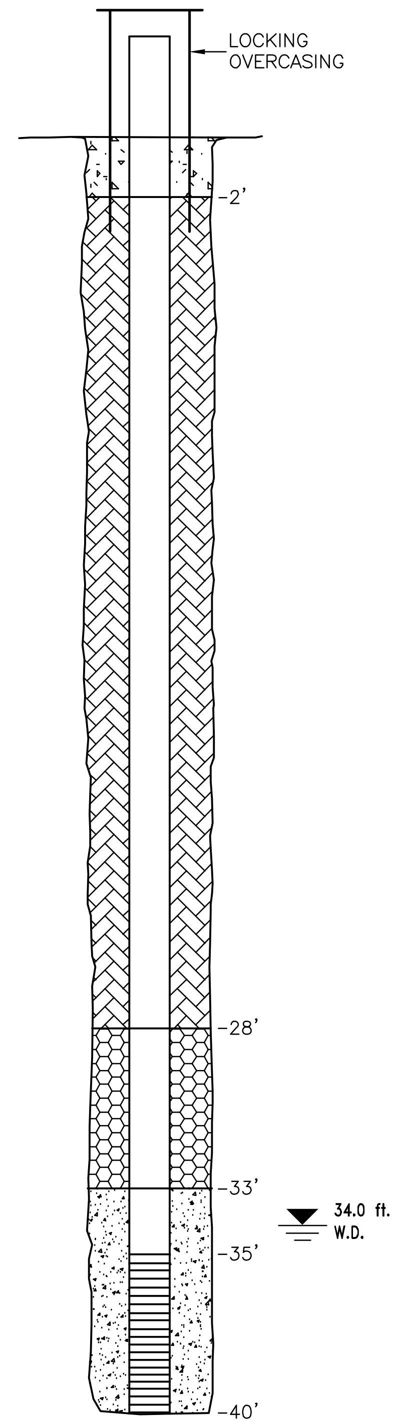
DESIGNED: P.K.H.
DRAWN: P.K.H.
CHECKED: C.H.R.
SUBMITTED: C.H.R.

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

TEST BORING LOG
AP-609-MW

DATE: JAN. 2007 | R&M NO. 1209.10 | SCALE: AS SHOWN | DWG. NO. B-04

project\1209.10\geo\KENAI AP-609-MW (1b), 1=1, 01/17/07 at 11:38 by pkh



AP-610-MW (TB-1c)
N 2,395,430.86
E 1,413,141.62
Elev. 88.9
11/18/06

Depth	Description
0.0 – 0.5	SILT CONTAINING ORGANICS
0.5 – 10.0	SANDY SILT (FILL) (Dk. brown, Gravel to 1/2" dia., Fine to medium sand)
10.0 – 37.5	Drilled fast and smooth to 40 feet. POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry) Ferruginous cementation 25 to 30 feet, tougher drilling. Drilled fast and smooth to 30 to 37.5 feet, slightly rough to 38 feet. Drilled tight and smooth 38 to 40 feet.
37.5 – 38.0	POORLY GRADED GRAVEL W/SAND
38.0 – 41.3	Drilled tight and smooth 38 to 40 feet. SANDY LEAN CLAY CONTAINING COBBLES & BOULDERS (Dk. gray)

Sha (1) 7/11/14 blows for 3"
Sampler bouncing on cobble/boulder

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 35 and 40 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

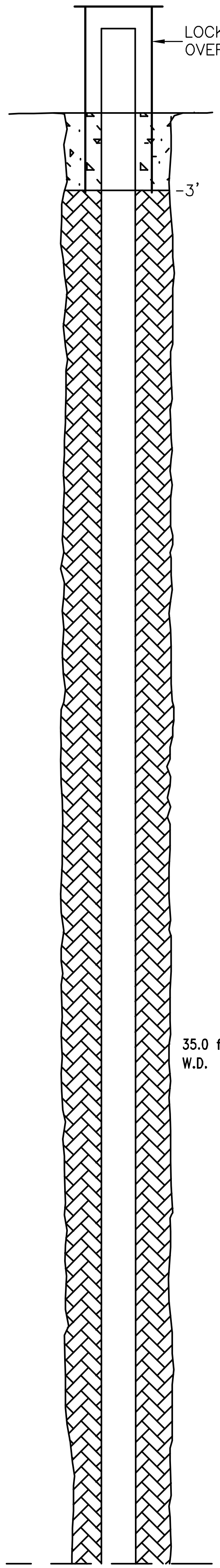
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.
DRAWN: P.K.H.
CHECKED: C.H.R.
SUBMITTED: C.H.R.

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

TEST BORING LOG
AP-610-MW

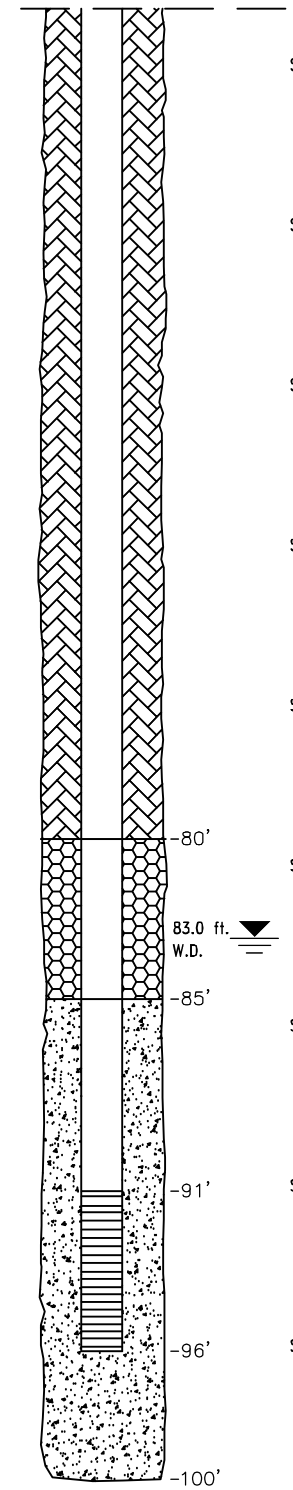
DATE: JAN. 2007 | R&M NO. 1209.10 | SCALE: AS SHOWN | DWG. NO. B-05



AP-611-MW (TB-2c)
N 2,395,775.73
E 1,414,431.97 Elev. 91.1
11/14/06 - 11/15/06

0.0
G (1) ML*, F4*
SILT (Dk. brown)
2.5
Sha (2) 1/2/3, 10%, SM*, F3*, Gr=2, Sa=71, Fines=27
SILTY SAND (Dk. brown, Fine to medium sand, Nonplastic, Loose, Dry)
4.0
Sha (3) 2/4/3, SP*, NFS*
POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Loose to medium dense, Dry to wet)
Sha (4) 2/5/6, SP*, NFS*
Drilled fast and smooth w/fine gravel to 38 feet.
Sha (5) 2/4/4, 3.5%, SP, NFS, Gr=7, Sa=92, Fines=1.2
Sha (6) 4/6/8, SP*, NFS*
Sha (7) 3/5/8, SP*, NFS*
Sha (8) 3/7/6, 5.1%, SP, NFS, Gr=6, Sa=91, Fines=3
Sha (9) 2/4/6, SP*, NFS*
Driller indicated clay encountered at 38 feet.
38.0
Sha (10) 6/9/14, CL*, F3*
SANDY LEAN CLAY (Dk. gray, Gravel to 1.5" dia., rounded to angular, hard, Fine to medium sand, Plastic, Very hard, Dry)
Sha (11) 8/12/16, CL*, F3*
Drilled moderately fast, smooth and tight 38 to 83 feet.
Sha (12) 6/11/14***, 11%, CL, F4
Gr=22, Sa=18, Fines=60, LL=27, PL=16, PI=11
54.0

(Continued Above)



AP-611-MW (Continued)
11/14/06 - 11/15/06
54.0
Sha (13) 3/7/11***, CL*, F4*
Sha (14) 7/12/16***, 15%, CL, F4
Gr=2, Sa=26, Fines=72, LL=26, PL=16, PI=10
Sha (15) 8/17/21***, CL*, F4*
Sampler overfilled
Sha (16) 10/12/13***, 18%, CL, F4
Sa=25, Fines=75, LL=22, PL=14, PI=8
Sha (17) 8/16/18***, 15%, CL, F4
Gr=1, Sa=21, Fines=78.0, LL=24, PL=16, PI=8
Sha (18) 8/12/19, CL*, F3*
Fine sand layers <1/4" thick
83.0
Sha (19) 10/21 blows for 6" **, SP*, S2*
6" heave, Sampler floated
POORLY GRADED SAND (Black, Fine angular sand, Nonplastic, Medium dense, Wet)
Sha (20) 2/6/10**, SP*, S2*
15 feet of heave after sample 19, pulled auger back 15 feet, and redrilled to 90 feet. 12" heave at 90 feet, sampler floated.
95.0
Sha (21) 3/5/7, CL*, F3*, PP=4.5+ tsf
SANDY LEAN CLAY (Dk. gray, Trace gravel to 1/2" dia., subrounded to subangular, hard, Fine to coarse sand, Plastic, Very hard, Dry)
Sha (22) 3/6/8, 20%, CL*, F3*, PP=4.5+ tsf
Sa=18, Fines=82
101.5

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with plastic liners.
Unconsolidated-undrained triaxial compression test performed on samples #12, #14, and #16.

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 91 and 96 ft.
2. Installation was uneventful.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

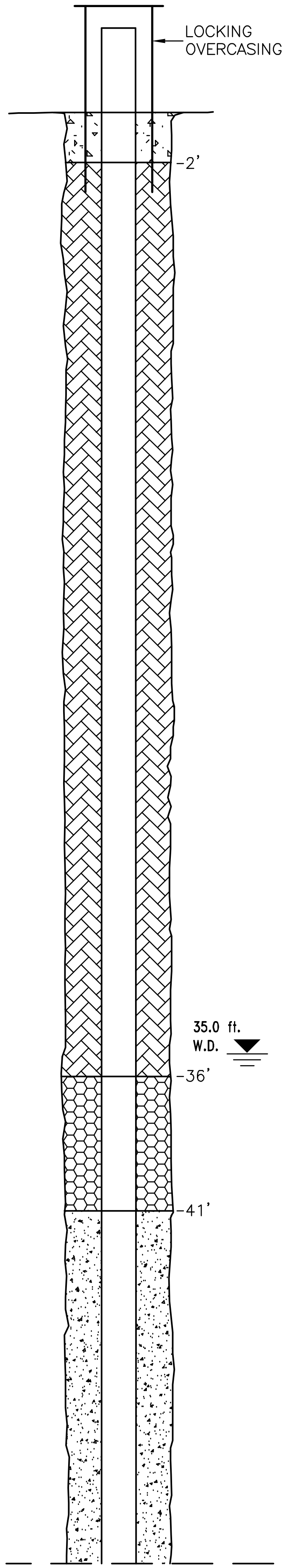
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

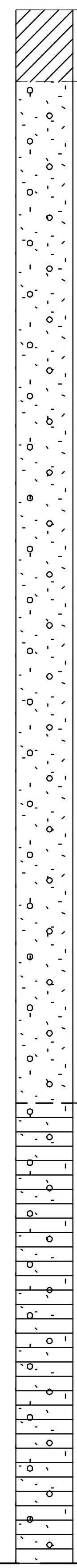
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-611-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-06

project\1209.10\geo\KENAI AP-611-MW (2c), 1=1, 01/17/07 at 09:08 by pkh



AP-612-MW (TB-2b)
N 2,395,786.22
E 1,414,437.68
Elev. TBD
11/15/06 - 11/16/06



0.0

SILT (Dk. brown)

2.5

POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Dry to wet)

Drilled fast and smooth w/fine gravel to 38 feet.

Color change to red-brown at 30 feet, may indicate ferruginous cementation.

Driller indicated clay encountered at 38 feet.

38.0

Drill reaction indicates pieces of gravel in top 1-inch of clay.

Gravelly layer at 43 feet.

Soft sand layer between 44 and 44.5 feet.

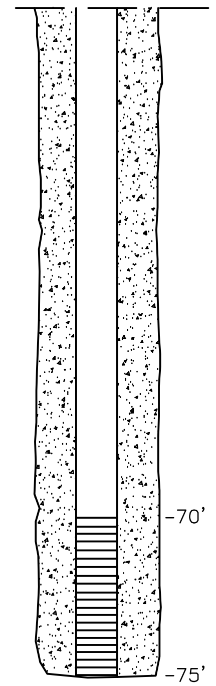
SANDY LEAN CLAY (Dk. gray, Gravel to 1.5" dia., rounded to angular, hard, Fine to medium sand, Plastic, Very hard, Dry)

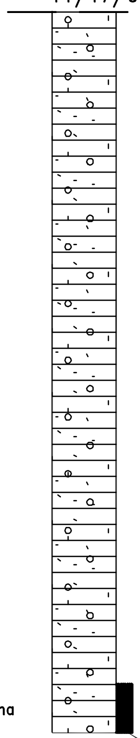
Drilled slower, tight, and smooth 38 to 75 feet.

54.0

(Continued Above)

AP-612-MW (Continued)
11/17/06





54.0

Pieces of fine gravel between 45 and 75 feet.

Sha (1) 1/5/6, CL*, F3*, PP=4.5+ tsf

76.5

* Estimated Classification

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 70 and 75 ft.
2. Silica sand bridged in augers and bridge could not be removed until augers were pulled to 40 feet.
3. Sand from upper sand unit caved into hole to a depth of 41 feet.
4. Well appeared to be measuring water level of upper aquifer.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

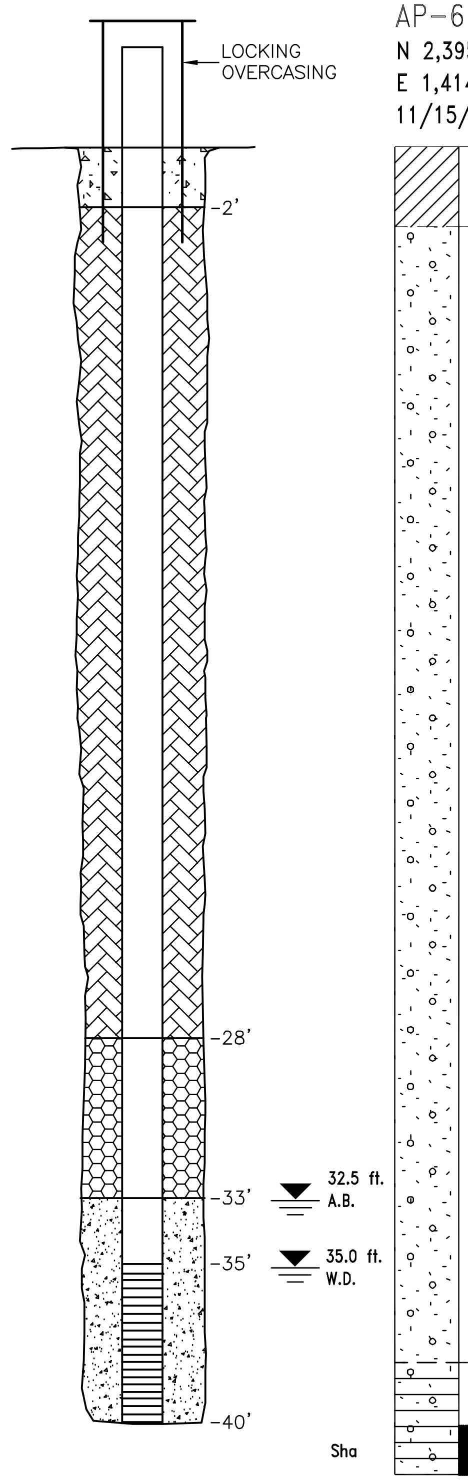
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-612-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-07

project\1209.10\geo\KENAI AP-612-MW (2b), 1=1, 01/17/07 at 09:03 by pkh

AP-613-MW (TB-2a)
N 2,395,795.10
E 1,414,440.67 Elev. 91.0
11/15/06



0.0
SILT (Dk. brown)
2.5

POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Fine to coarse sand, Nonplastic, Dry to wet)

Drilled fast and smooth w/fine gravel to 38 feet.

Color change to red-brown at 30 feet, may be ferruginous cementation.

Driller indicated gravel encountered on top of clay at 38 feet.

38.0
SANDY LEAN CLAY (Dk. gray)

(1) 4/8/12, CL*, F3*, PP=4.5+ tsf

41.5

* Estimated Classification

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 35 and 40 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

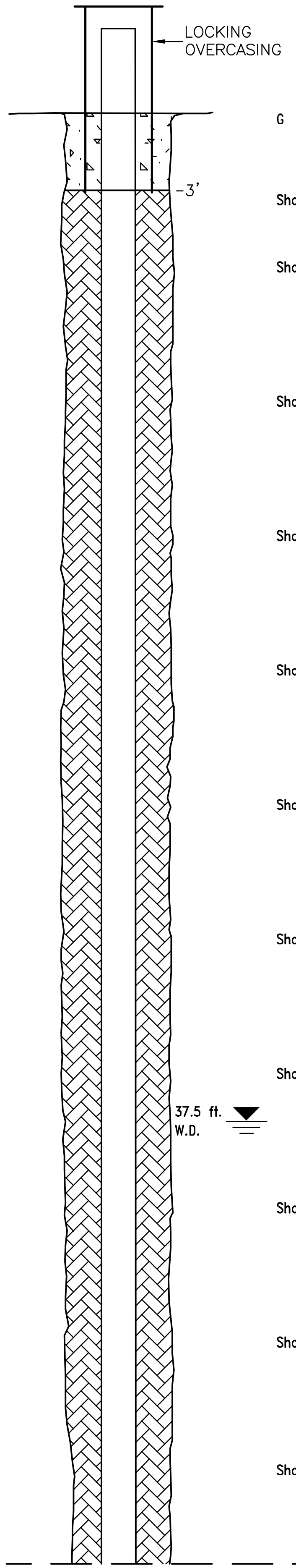
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-613-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-08

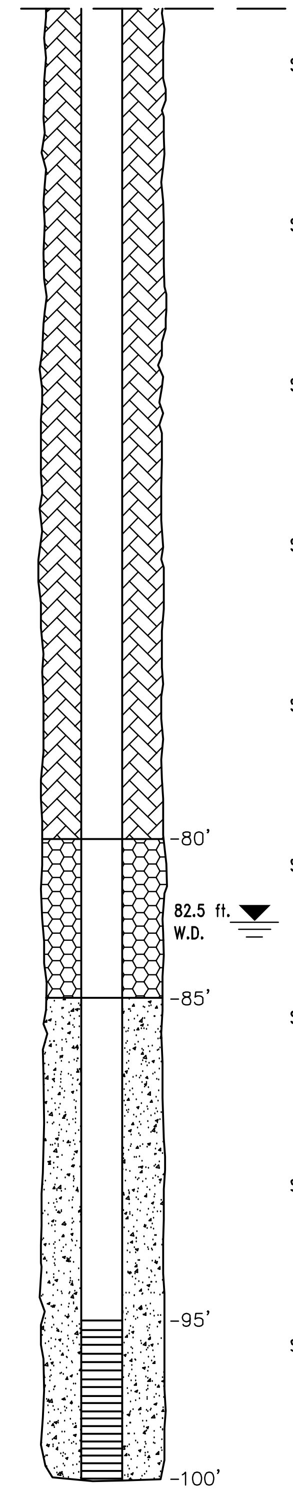


AP-614-MW (TB-3a)

N 2,396,258.31
E 1,415,755.43
Elev. 93.9
11/11/06

Depth	Sampler	No.	Description
0.0	G	1	ML* to SM*, F4* SILT GRADING TO SILTY SAND (Dk. brown, Fine to coarse sand, Nonplastic)
1.0	Sha	2	1/4/6, SM*, F3* SILTY SAND GRADING TO POORLY GRADED SAND (Dk. brown, Fine sand, Nonplastic, Medium dense, Dry)
4.0	Sha	3	3/4/4, 5.8%, SP, PFS* Gr=11, Sa=85, Fines=4.2
	Sha	4	3/6/8, SP*, NFS* POORLY GRADED SAND TO SAND W/SILT CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded to rounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry)
	Sha	5	2/5/6, 4.8%, SP, NFS* Sa=97, Fines=3.1 Drilled fast and smooth to 32.5 feet.
	Sha	6	2/4/6, SP*, NFS* Ferruginous cementation 22.5 to 32.5 feet.
24.0	Sha	7	7/10/15, 4.9%, SP-SM*, S2* Sa=95, Fines=5.3
	Sha	8	6/10/11, SP*, NFS* Driller indicated change at 32.5 feet.
32.5			Drilled fast and slightly rough 32.5 to 42.5 feet.
	Sha	9	8/18/22, 2.4%, SP-SM*, S2 Gr=32, Sa=63, Fines=5.5, P.02=3.3 POORLY GRADED SAND W/SILT AND GRAVEL (Dk. brown, Gravel to 1.5" dia., subrounded to rounded, hard, Fine to coarse sand, Nonplastic, Medium dense to dense, Dry to wet)
	Sha	10	10/12/10, SP-SM*, S2*
42.5			Driller indicated gravel layer at 42.5 feet. Drilled slightly rough and tight 42.5 to 52.5 feet.
	Sha	11	10/15/16, 16%, SC*, F3*, Gr=2, Sa=56, Fines=42 Gravel layer to 6" thick at 47.5 feet. CLAYEY SAND W/GRAVEL LAYERS CONTAINING COBBLES & BOULDERS (Dk. gray, Gravel subrounded to angular, hard, Fine to coarse sand, Sand layers to 1/4" thick, Plastic, Very hard, Dry)
52.5	Sha	12	12/32 blows for 6", CL*, F3*, Sampler bouncing on cobble/boulder

(Continued Above)



AP-614-MW (Continued)

11/17/06

Depth	Sampler	No.	Description
	Sha	13	10/20/18***, 14%, CL, F4, Gr=1, Sa=20, Fines=79, LL=24, PL=15, PI=9, SG=2.682 SANDY LEAN CLAY TO LEAN CLAY W/SAND (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)
	Sha	14	5/12/16***, 13%, CL, F4 Gr=3, Sa=22, Fines=75, LL=27, PL=15, PI=12 Drilled moderately fast, smooth and tight 52.5 to 82.5 feet.
	Sha	15	7/12/19***, 16%, CL*, F4*
	Sha	16	7/9/14***, 17%, CL, F3 Gr=2, Sa=19, Fines=79, LL=31, PL=18, PI=13
	Sha	17	8/14/15, 15%, CL*, F3* Gr=4, Sa=43, Fines=53, Thin layers of sand
	Sha	18	6/10/10, 17%, CL*, F3* Gr=2, Sa=22, Fines=76, P.02=52.8
82.5			Drilled fast, easy and smooth 82.5 to 100 feet.
	Sha	19	7/17 blows for 6"**, 18%, SC*, F3*, Gr=6, Sa=64, Fines=30, 6" heave, sampler floated, sampler overfilled POORLY GRADED SAND CONTAINING LAYERS OF LEAN CLAY (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to medium sand, Nonplastic, Medium dense, Wet)
87.5	Sha	20	6/12/11**, SP-SM*, S2* 18" heave, sampler floated POORLY GRADED SAND TO SAND W/SILT (Dk. gray, Fine to medium sand, Nonplastic, Medium dense to dense, Wet)
	Sha	21	7/15/17**, 24" heave sampler floated
101.5	Sha	22	6/10/17**, 24%, SP-SM*, S2* Sa=94, Fines=6.1, 24" heave, sampler floated

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with plastic liners.
Consolidated undrained triaxial compression test performed on samples #13, #14, and #15.

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES:

1. Screen w/prepacked sand was installed between 95 and 100 ft.
2. Due to heaving conditions the screen could not be placed down the hole and the augers were reinstalled with a wooden plug. Otherwise installation was uneventful.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

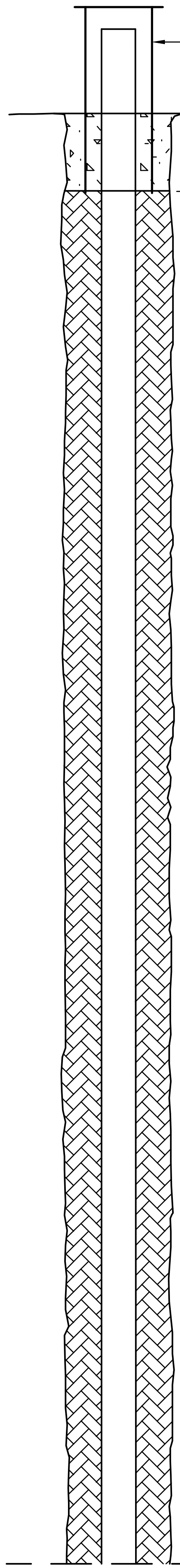
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

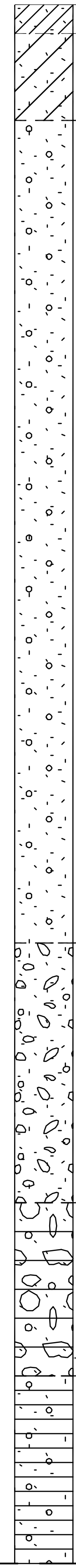
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-614-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	B-09



AP-615-MW (TB-3b)

N 2,396,268.68
E 1,415,756.19
Elev. 93.5
11/12/06

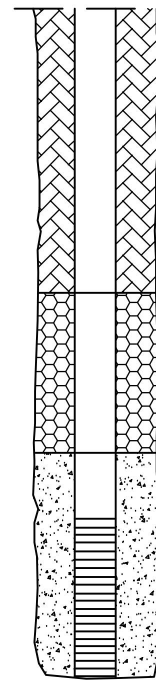


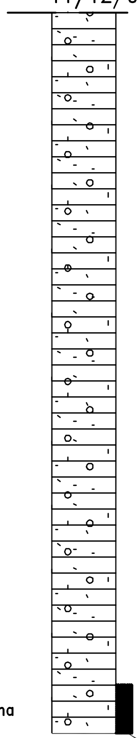
Depth	Description
0.0	SILT (Dk. brown)
1.0	SILTY SAND (Dk. brown)
4.0	POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Fine to medium sand, Nonplastic, Dry) Drilled fast and smooth to 32.5 feet.
32.5	POORLY GRADED SAND W/GRAVEL (Dk. brown) Drilled fast and slightly rough 32.5 to 41.5.
41.5	Drilled rougher 41.5 to 47.5 feet. Gravel layer 43 to 43.5 feet. SANDY LEAN CLAY W/GRAVEL LAYERS CONTAINING COBBLES & BOULDERS (Dk. gray) Coarse gravel/cobble layer 46.5 to 47.5 feet.
47.5	
54.0	

(Continued Above)

AP-615-MW (Continued)

11/12/06





Depth	Description
54.0	SANDY LEAN CLAY (Dk. gray, Plastic, Dry)
	Sha ① 8/12/15, 19%, CL*, F3* Gr=2, Sa=47, Fines=51
76.5	

* Estimated Classification

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 70 and 75 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

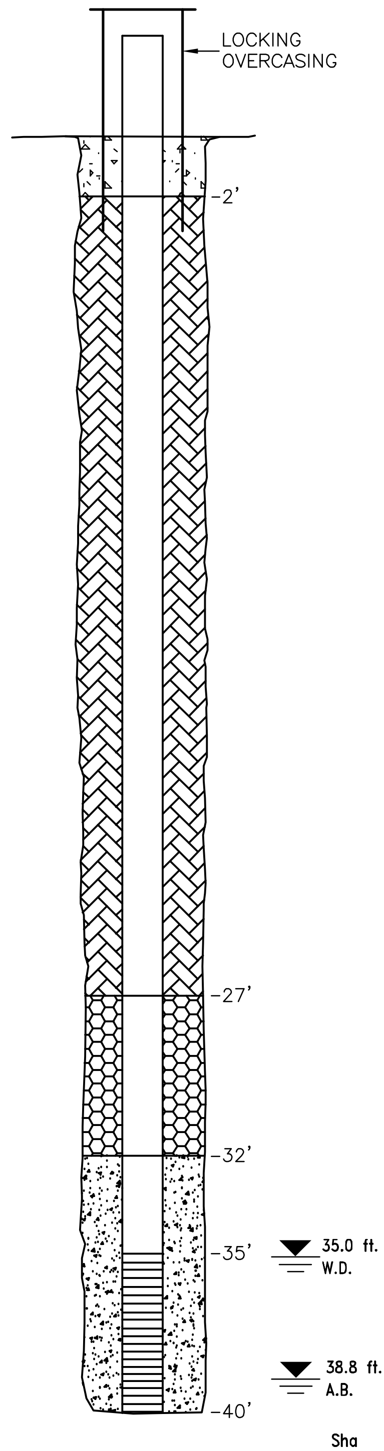
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-615-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-10

project\1209.10\geo\KENAI AP-615-MW (3b), 1=1, 01/17/07 at 08:57 by pkh



AP-616-MW (TB-3c)
N 2,396,280.50
E 1,415,756.60 Elev. 93.7
11/13/06

Depth	Description
0.0	SILT (Dk. brown)
1.0	SILTY SAND GRADING TO POORLY GRADED SAND (Dk. brown, Nonplastic)
4.0	POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Fine to medium sand, Nonplastic, Dry) Drilled fast and smooth to 32.5 feet.
32.5	POORLY GRADED SAND W/GRAVEL (Dk. brown) Drilled fast and slightly rough 32.5 to 40 feet. Sha (1) 10/9/11***, SP*, S2*
41.5	

* Estimated Classification
*** Sampler driven with plastic liners.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger Drill
Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 35 and 40 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

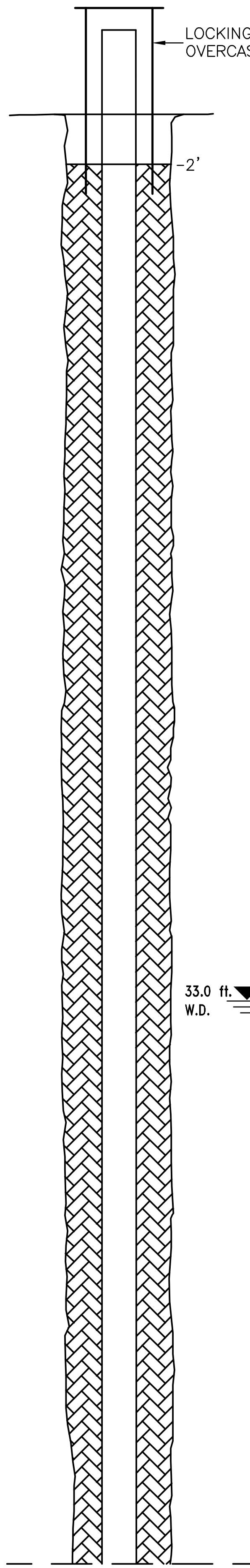
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-616-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-11

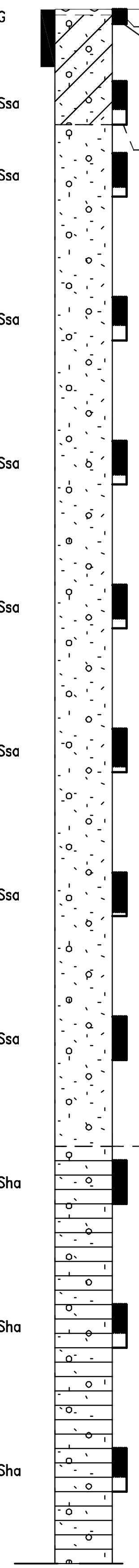
project\1209.10\geo\KENAI AP-616-MW (3c), 1=1, 01/17/07 at 09:51 by pkh

LOCKING OVERCASING



AP-617-MW (TB-4a)

N 2,396,189.80
E 1,416,979.96 Elev. 92.9
11/19/06

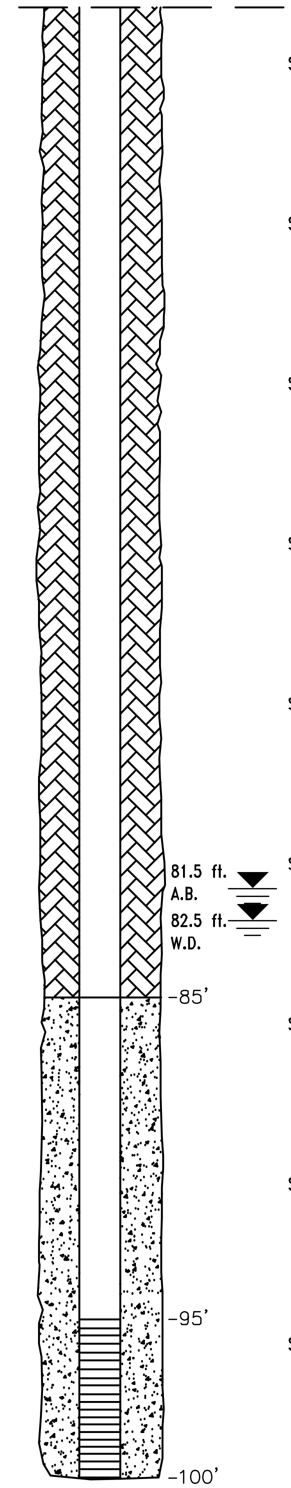


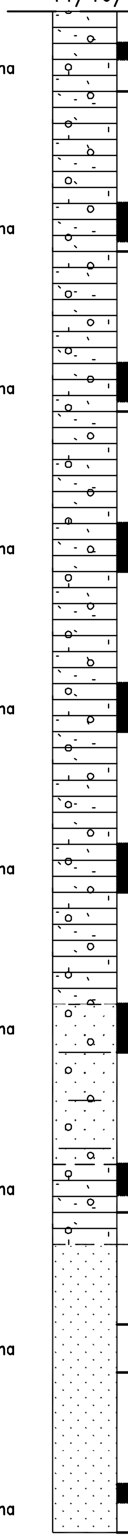
Depth	Sampler	No.	Description
0.0	G		ORGANIC MAT
0.2		(1)	SM*, F3*
	Ssa	(2)	SILTY SAND GRADING TO SAND (Dk. brown, Gravel to 1/4" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dry) 5/8/9, SM*, F3*
4.0	Ssa	(3)	3/5/5, SP*, NFS* POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 3/8" dia., subrounded, hard, Fine to medium sand, Nonplastic, Medium dense, Dry)
	Ssa	(4)	3/7/10, 6.5%, SP, PFS* Gr=1, Sa=95, Fines=3.9
	Ssa	(5)	3/12/15, SP*, NFS*
	Ssa	(6)	4/12/11, SP*, NFS* Drilled fast and smooth to 39.5 feet.
	Ssa	(7)	3/5/10, 8.4%, SP, NFS*, Sa=96, Fines=4.3, Ferruginous cementation in portions of sample, Fragments of carbonized wood in sample
	Ssa	(8)	3/11/16, SP*, NFS* Ferruginous cementation in portions of sample
	Ssa	(9)	7/18/27, SP*, NFS* Driller indicated clay at 39.5 feet.
39.5	Sha	(10)	5/7/12, CL*, F3*, PP=4.5+ tsf, Pocket penetrometer leaves little impression. Drilled moderately fast, tight, and smooth 39.5 to 55 feet.
	Sha	(11)	5/11/12, 15%, CL*, F3* Gr=7, Sa=39, Fines=54, PP=4.5+ tsf, Pocket penetrometer doesn't leave impression, Fine sand layer to 1/8" thick, dipping at ~50°
	Sha	(12)	15/35 blows for 6"**, CL*, F3* 12" heave in augers, sampler floated. Drilled faster and smooth 55 to 60 feet.
54.0			

(Continued Above)

AP-617-MW (Continued)

11/19/06





Depth	Sampler	No.	Description
54.0	Sha	(13)	9/11/12***, 13%, CL, F3 Gr=16, Sa=21, Fines=63, LL=31, PL=18, PI=13 SANDY LEAN CLAY W/GRAVEL TO LEAN CLAY W/SAND (Dk. gray, Gravel to 1.5" dia., subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)
	Sha	(14)	4/10/19, 15%, CL, F3, PP=4.5+ tsf Gr=6, Sa=23, Fines=71, LL=33, PL=17, PI=16 Drilled slow and tight 60 to 75 feet.
	Sha	(15)	8/16/22, CL*, F3*, PP=4.5+ tsf Sand layer to 6" thick Drilled slow and tight 70 to 75 feet.
	Sha	(16)	5/10/13, 13%, CL*, F3*, PP=4.5+ tsf Gr=7, Sa=19, Fines=74, LL=27, PL=16, PI=11, SG=2.724
	Sha	(17)	3/7/10, 15%, CL*, F3*, PP=4.5+ tsf Gr=21, Sa=28, Fines=51, P.02=36.2 Drilled fast and smooth 75 to 85 feet.
	Sha	(18)	6/9/14, 14%, CL, F4 Gr=3, Sa=28, Fines=69, LL=24, PL=16, PI=8 Drilled easy and smooth 85 to 90 feet.
85.0	Sha	(19)	4/7/11, SP & CL*, PFS & F3* POORLY GRADED SAND CONTAINING LAYERS OF LEAN CLAY (Dk. gray, Fine sand, Nonplastic sand and plastic clay, Medium dense, Wet) Drilled slower and smooth 90 to 92.5 feet
90.0	Sha	(20)	3/7/12, 17%, CL*, F3*, PP=3.5 tsf, Gr=4, Sa=20, Fines=76 LEAN CLAY W/SAND (Dk. gray, Gravel to 1/4" dia., subrounded, hard, Plastic, Very stiff, Moist)
92.5	Sha	(21)	POORLY GRADED SAND (Dk. gray, Fine to medium sand, Nonplastic, Medium dense, Wet) 3/5/7**, 6 ft. of heave after sampling Drilled fast and smooth 92.5 to 100 feet.
101.5	Sha	(22)	18/28/11**, SP*, PFS* 5 ft. of heave, Sampler floated down and sanded in

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
One-dimensional consolidation test performed on sample #16.
Unconsolidated-undrained triaxial compression test performed on sample #13.

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Due to heaving conditions the screen could not be placed down the hole and the augers were reinstalled with a wooden plug.
2. Screen w/prepacked sand was installed between 95 and 100 ft.
3. Unable to get bentonite down hole due to slurry in hole.
4. Pulled augers to 40 feet and backfilled with grout to surface. Grout sank to 35 by the next morning.
5. Additional grout was placed in hole until it came to within 2 feet of surface.
6. Water measurement indicated that the grout had sealed off the upper aquifer.
7. Water levels were observed to changed over time, apparently relative to the tides.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

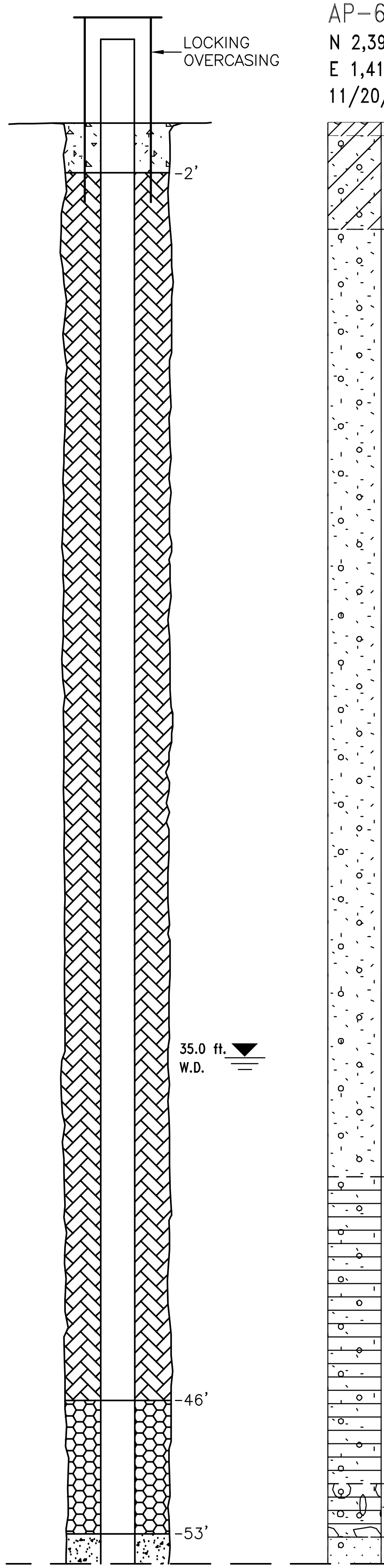
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-617-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	B-12

project\1209.10\geo\KENAI AP-617-MW (4a), 1=1, 02/13/07 at 09:41 by kjp

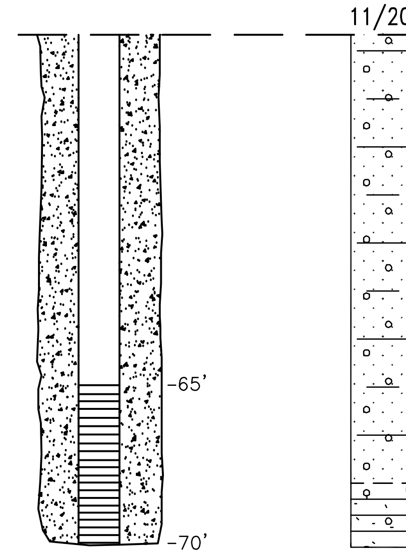
AP-618-MW (TB-4b)
N 2,396,207.48
E 1,416,981.72 Elev. 93.1
11/20/06



Depth	Description
0.0	SILT CONTAINING ORGANICS (Dk. brown)
0.5	SILTY SAND (Dk. brown, Gravel to 1/4" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dry)
4.0	POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown) Drilled fast and smooth to 35.0 feet. Faster to 40 feet. Driller indicated clay at 39.5 feet.
39.5	Smooth drilling alternated between slow and fast 40 to 45 feet. Tight hard drilling from 45 to 48 feet, faster 48 to 50 feet. SANDY LEAN CLAY CONTAINING LAYERS OF POORLY GRADED SAND (Dk. gray, Gravel to 1.5" dia., subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry) Drilled fast and smooth 50 to 50.5 feet, slower 50.5 to 51 feet. Rough from 51 to 53 feet, and faster and smooth 53 to 55 feet.
51.0	SANDY LEAN CLAY CONTAINING COBBLES & BOULDERS (Dk. gray, Plastic, Very hard, Dry)
53.0	
54.0	

(Continued Above)

AP-618-MW (Continued)
11/20/06



Depth	Description
54.0	Drilled slow and tight 55 to 56.5 feet. Faster and smooth w/ occasional small cobbles 56.5 to 60 feet. POORLY GRADED SAND CONTAINING LAYERS OF LEAN CLAY (Dk. gray) Drilled fast 60 to 63 feet, slower and tighter 63 to 65 feet. Drilled fast and smooth 65 to 68 feet, tighter 68 to 70 feet.
68.0	SANDY LEAN CLAY (Dk. gray, Plastic)
70.0	

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Hole was drilled with wooden plug in end of augers.
2. Screen w/prepacked sand was installed between 65 and 70 ft.
3. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

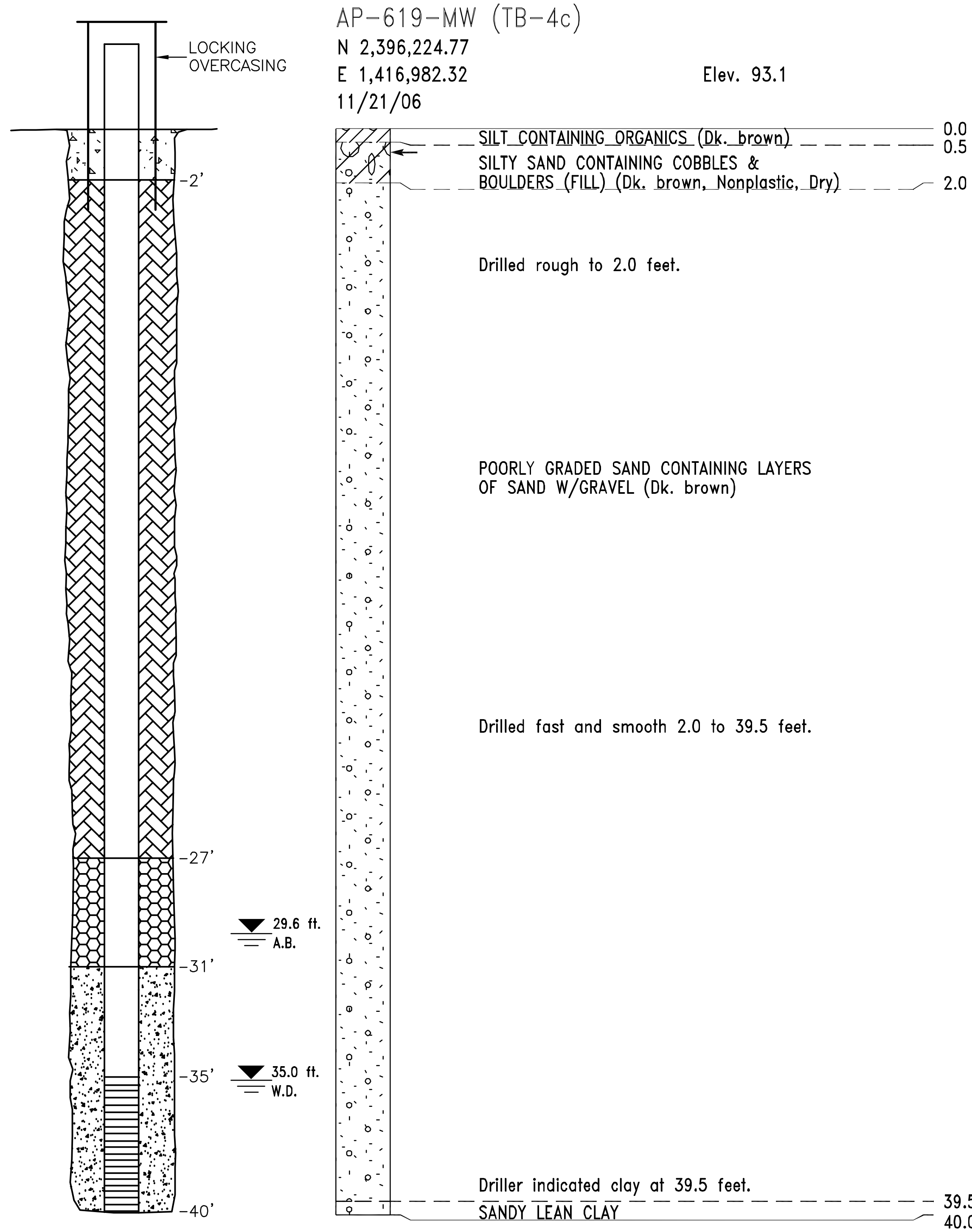
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-618-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-13

project\1209.10\geo\KENAI AP-618-MW (4b), 1=1, 01/17/07 at 09:50 by pkh

AP-619-MW (TB-4c)

N 2,396,224.77
E 1,416,982.32
11/21/06
Elev. 93.1



SILT CONTAINING ORGANICS (Dk. brown)

SILTY SAND CONTAINING COBBLES & BOULDERS (FILL) (Dk. brown, Nonplastic, Dry)

Drilled rough to 2.0 feet.

POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown)

Drilled fast and smooth 2.0 to 39.5 feet.

Driller indicated clay at 39.5 feet.

SANDY LEAN CLAY

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Hole was drilled with wooden plug in end of augers.
2. Screen w/prepacked sand was installed between 35 and 40 ft.
3. Hole walls caved to 31 feet when augers were withdrawn. Sand backfill is mixture of silica sand and natural sand.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

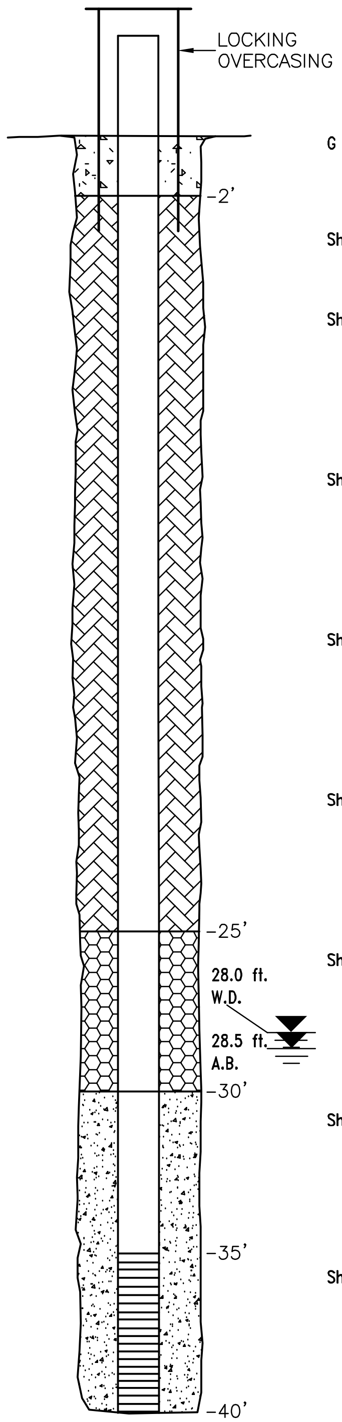
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-619-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-14

project\1209.10\geo\KENAI AP-619-MW (4c), 1=1, 01/17/07 at 08:38 by pkh



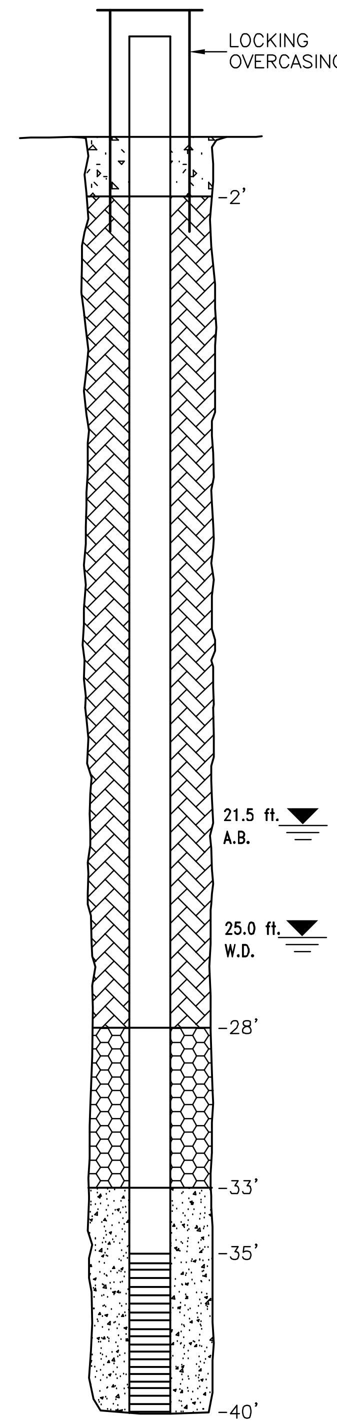
AP-620-MW (TB-02)

N 2,396,321.05
E 1,414,354.82 Elev. 92.2
11/13/06

- 0.0 — G — 1 — ML*, F4*
  SILT CONTAINING ORGANICS (Dk. brown)
- 2.5 — Sha — 2 — 3/3/5, 10%, SM*, F3*, Gr=2, Sa=76, Fines=22
  SILTY SAND (Dk. brown, Fine to medium sand)
- 4.0 — Sha — 3 — 3/4/4, SP*, NFS*
  Drilled fast and smooth to 39 feet.
- Sha — 4 — 1/3/4, 5.1%, SP, NFS, Gr=7, Sa=92, Fines=1.7
  POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL, Gravel to 2" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry becoming wet below 28 ft.
- Sha — 5 — 3/5/8***, 4.6%, SP, S2*, Sa=96, Fines=4.4, LL=NV, PL=NP, PI=NP, SG=2.716
- Sha — 6 — 5/8/8, 6.0%, SP, NFS*, Gr=1, Sa=95, Fines=3.9
- Sha — 7 — 3/6/12***, 7.6%, SP, NFS*, Gr=10, Sa=87, Fines=3.3
- Sha — 8 — 5/8/6, 21%, SP, NFS*, Gr=12, Sa=85, Fines=3.2
- Sha — 9 — 7/13/15 blows for 4"***, SP*, NFS*
  Sampler had a piece of wood blocking shoe.
  Driller indicated clay at 39 feet.
- 39.0 — Sha — 10 — LEAN CLAY W/SAND CONTAINING COBBLES & BOULDERS (Dk. gray, Plastic, Very hard, Dry)
  4/10/16 blows for 5"**, 16%, CL, F3, Gr=3, Sa=16, Fines=81, LL=35, PL=21, PI=14, SG=2.747, 1 foot of heave in augers, sampler floated. Sampler bouncing on cobble/boulder
- 41.4

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
One-dimensional consolidation performed on sample #10.
Constant head permeability test performed on sample #5.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey



AP-621-MW (TB-03)

N 2,396,759.77
E 1,417,031.71 Elev. 92.7
11/14/06

- 0.0 — G — 1 — SM*, F3*
  SILT W/ORGANICS (Dk. brown)
- 2.0 — Sha — 2 — 4/10/11, SP*, NFS*
- Sha — 3 — 3/9/8, 6.2%, SP, NFS, Gr=11, Sa=86, Fines=2.7
  Drilled fast and smooth to 40 feet.
- Sha — 4 — 2/4/3***, SP*, NFS*
  POORLY GRADED SAND TO SAND W/SILT CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 3/4" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry becoming wet below 28 ft.)
- Sha — 5 — 3/3/7, 7.7%, SP, S2*, Gr=1, Sa=95, Fines=4.3
- Sha — 6 — 4/6/7***, 12%, SP, NFS*, Gr=8, Sa=88, Fines=3.6
- Sha — 7 — 5/8/12, SP*, NFS*
- Sha — 8 — 3/6/12**, 19%, SP-SM*, S2*, Gr=2, Sa=92, Fines=6.5, 6" heave, sampler floated
- Sha — 9 — 3/7/10**, SP*, NFS*, 6" heave, sampler floated
- 40.0 — Sha — 10 — 6/11 blows for 1", Sampler bouncing on cobble/boulder
  GRAVEL W/SAND CONTAINING COBBLES & BOULDERS
- 41.0

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
Constant head permeability test performed on samples #4 and #6.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screens w/prepacked sand were installed between 35 and 40 ft.
2. Caving sand prevented placement of silica sand through the augers until they had been pulled back 10 feet in AP-620-MW. Sand backfill was a mixture of silica sand and sand cave in.
2. Installation of AP-621-MW was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.	
CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	TEST BORING LOG AP-620-MW & AP-621-MW
DATE: JAN. 2007 · R&M NO. 1209.10	SCALE: AS SHOWN · DWG. NO. B-15

AP-622 (TB-08)

N 2,395,300.06
E 1,412,903.84 Elev. 24.1
12/16/06

Depth (ft)	Sample type	No.	Description
0.0	G	1	ML*, F4*
			SILT W/ SAND (Brown, Very fine to fine sand, Nonplastic)
1.5	Sh	2	SILT (Mottled gray and brown, Nonplastic, Firm, Moist)
			2/2/33***, 37%, ML, F4 Sa=6, Fines=94, LL=49, PL=28, PI=21
	Ts	3	ML*, F4*
6.5			POORLY GRADED SAND (Gray, Fine to coarse sand, Moist to saturated)
8.5			SILT (Nonplastic, Moist to wet)
	Sh	4	5//
10.5		5	//13/12, 10%, GP-GM*, F1*, Gr=48, Sa=43, Fines=9.1
			POORLY GRADED GRAVEL W/SILT AND SAND (Brown, Gravel to 1" dia., rounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Wet)
14.0			SILTY, CLAYEY SAND (Dk. gray, Gravel angular, hard, Plastic, Hard, Moist)
	Sh	6	6/18/26***, 14%, SC-SM, F4* Gr=12, Sa=39, Fines=49, LL=18, PL=12, PI=6
16.5			SILTY GRAVEL W/SAND (Brown, Gravel subrounded, hard, Fine to coarse sand, Nonplastic)
18.0			POORLY GRADED SAND (Gray, Fine to coarse sand)
20.0	Sh	7	6/18/18, 14%, CL*, F3*, PP=>4.5 tsf
			LEAN CLAY W/SAND TO SANDY LEAN CLAY (Dk. gray, Plastic, Hard, Moist)
	Sh	8	11/16/21***, 14%, CL, F4 Gr=9, Sa=21, Fines=70, LL=25, PL=14, PI=11
	Sh	9	13/23/33, 17%, CL, F3 Sa=12, Fines=88, LL=29, PL=16, PI=13
31.5			

6.5 ft. W.D.

* Estimated Classification
*** Sampler driven with brass liners.

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

AP-623 (TB-07)

N 2,395,437.96
E 1,414,078.32 Elev. 20 (See note below)
12/16/06

Depth (ft)	Sample type	No.	Description
0.0			ICE
0.5	G	1	No recovery, grinding on cobble
			POORLY GRADED SAND W/ GRAVEL (Gray, Gravel subrounded, hard, Fine to coarse sand)
2.0	Sh	2	6/7/6***, 8.2%, SP*, NFS*
	Sh	3	3/5/5, 3.8%, SP, NFS, Sa=98, Fines=1.6
	Sh	4	7/9/12, 13%, SP-SC*, F2*, Sa=90, Fines=10, Sample is contaminated with clay layer
			POORLY GRADED SAND CONTAINING LAYERS OF SAND W/CLAY (Gray, Fine to medium sand, Nonplastic, Loose to medium dense, Dry to saturated)
	Sh	5	8/14/18**, 22%, SP, NFS, Sa=98, Fines=1.9, Sampler overfilled
			Sampling was not successful between 20 ft. bgs and 30 ft. bgs due to excessive heave within the augers
			Borehole was advanced to 30 ft. and soil description is based upon cuttings observation and rig reaction
30.0			

14 ft. W.D.

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

AP-624 (TB-06)

N 2,395,725.08
E 1,414,587.74 Elev. 20 (See note below)
12/15/06

Depth (ft)	Sample type	No.	Description
0.0			ICE
0.5	G	1	22%, GC*, F2, Gr=45, Sa=30, Fines=25, P.02=16.9
			CLAYEY GRAVEL W/SAND (Dk. gray, Gravel to 2" dia., angular, hard, Fine sand, Plastic, Moist)
	Sh	2	6//
3.0		3	//6/12, 21%, SP*, NFS*, Sa=96, Fines=4.5
	Sh	4	POORLY GRADED SAND (Dk. gray, Fine to medium sand, Medium dense, Moist) 10//, 18%, SP*, NFS*
5.5		5	//11/19, 18%, CL*, F4
			LEAN CLAY W/SAND (Dk. gray, Gravel to 1.5" dia., rounded, hard, Plastic, Hard, Moist)
	Sh	6	5/12/16, 15%, CL, F3, PP=>4.5 tsf, Gr=10, Sa=18, Fines=72, LL=29, PL=16, PI=13
13.5			POORLY GRADED SAND (Dk. gray, Fine to medium sand, Medium dense, Saturated)
	Sh	7	7/7//, 22%, SP, NFS, Sa=99, Fines=1.3
16.0		8	//6, 17%, CL, F4, Gr=1, Sa=26, Fines=73, LL=26, PL=15, PI=11
			LEAN CLAY W/SAND (Dk. gray, Plastic, Hard, Moist)
17.0			Sampling was not successful between 20 ft. bgs and 30 ft. bgs due to excessive heave within the augers
			POORLY GRADED SAND (Gray, Fine to coarse sand, Moist to saturated)
			Borehole was advanced to 30 ft. and soil description is based upon cuttings observation and rig reaction
30.0			

13.5 ft. W.D.

* Estimated Classification

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

Note: The above test boring elevations for TB-06 and TB-07 were surveyed at the top of ice cover of varying thickness. The elevations shown were therefore determined by subtracting the estimated ice thickness at the time of survey from the elevation surveyed at the top of the ice. These elevations are estimated, and due to the thick snow and ice cover are considered only accurate to +/- 5 feet.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.
DRAWN: P.K.H.
CHECKED: C.H.R.
SUBMITTED: C.H.R.

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

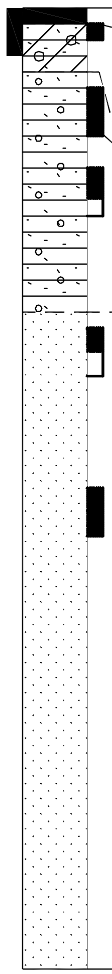
TEST BORING LOG
AP-622 THRU AP-624

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	B-16

project\1209.10\geo\KENAI AP-622-24, 1=1, 02/13/07 at 09:41 by kjp

AP-625 (TB-05)

N 2,396,055.30
E 1,415,467.21 Elev. 20 (See note below)
12/15/06



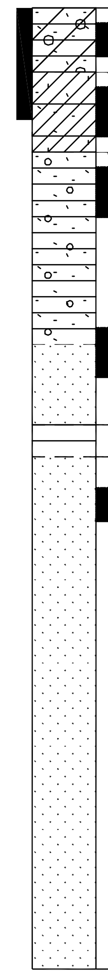
0.0 ICE
0.5
G (1) 78%, CL-ML*, F4*
Gr=10, Sa=35, Fines=55, P.02=39.1
SANDY SILTY CLAY (Dk. gray, Gravel to 2" dia., rounded to subangular, hard, Fine to coarse sand, Plastic)
2.0
Sh (2) 4/6/9, 17%, CL, F4, Gr=4, Sa=19, Fines=77, LL=27, PL=16, PI=11
Sh (3) 4/6/8***, 17%, CL, F4, Gr=2, Sa=17, Fines=81, LL=26, PL=16, PI=10
LEAN CLAY W/SAND (Dk. gray, Plastic, Hard, Moist)
9.5
10 ft. W.D.
Sh (4) 2/10/18, 14%, SP, NFS, Gr=2, Sa=96, Fines=2.3
POORLY GRADED SAND (Gray, Fine to coarse sand, Moist to saturated)
Sh (5) 17/19/23**, 20%, SP, NFS, Sa=99, Fines=1.2
Sampling was not successful between 20 ft. bgs and 30 ft. bgs due to excessive heave within the augers
Borehole was advanced to 30 ft. and soil description is based upon cuttings observation and rig reaction
30.0

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
One-dimensional consolidation test performed on sample #3.

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

AP-626 (TB-04)

N 2,396,137.75
E 1,416,086.29 Elev. 19 (See note below)
12/14/06



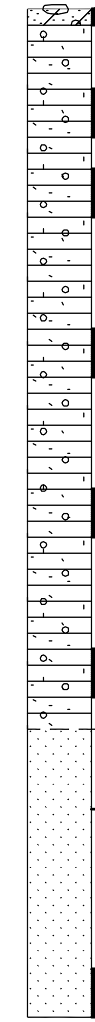
0.0 Cobbles observed on surface
G (1) SANDY SILTY CLAY (Dk. gray, Gravel to 1.5" dia., subangular, hard, Very fine sand, Plastic)
25%, CL-ML*, F4*, Gr=9, Sa=35, Fines=56, P.02=35.5
2.0
Sh (2) 5/5/2, 28%, CL-ML, F4
PP=>4.5 tsf, Gr=12, Sa=37, Fines=51, LL=19, PL=13, PI=6
Sh SANDY SILTY CLAY (Gray, Fine to medium sand, Plastic)
4.5
(3) 6/13/18, 15%, CL, F4, PP=>4.5 tsf, Gr=6, Sa=22, Fines=72, LL=27, PL=16, PI=11
LEAN CLAY W/SAND, Plastic, Hard, Moist
(4) 5//, CL*, F4*
10.5 ft. W.D. Sh
10.5
(5) //10/12, 16%, SP, S2*, Gr=6, Sa=90, Fines=3.9
POORLY GRADED SAND (Gray, Fine to coarse sand, Medium dense, Saturated)
13.0
LEAN CLAY, Soil description based on rig reaction
14.0
Sh (6) 9/7/8**, 20%, SP, S2*, Gr=1, Sa=94, Fines=4.9
POORLY GRADED SAND (Gray, Fine to coarse sand, Medium dense, Saturated)
Sampling was not successful between 20 ft. bgs and 30 ft. bgs due to excessive heave within the augers
Borehole was advanced to 30 ft. and soil description is based upon cuttings observation and rig reaction
30.0

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

AP-627 (TB-01)

N 2,395,983.03
E 1,417,218.15 Elev. 21 (See note below)
11/10/06



0.0
G (1) SILTY SAND W/GRAVEL CONTAINING COBBLES & BOULDERS (Dk. gray, Gravel subrounded to angular, hard, Fine sand, Cobbles and boulders on surface, Nonplastic, Wet)
SM*, F3*
0.5
Sha (2) 4/5/8, 17%, CL*, F3*, PP=4.5+ tsf, Gr=5, Sa=36, Fines=59, Sand Layers to 1/8" thick, dipping at ~25° to 45°
Sha (3) 3/7/8, 15%, CL*, F3*, PP=4.5+ tsf, No sand lenses apparent
Gr=8, Sa=24, Fines=68, P.02=47.3
Drilled fast and smooth to 22.5 ft.
Sha (4) 4/6/7, 17%, CL, F4, PP=4.5+ tsf, Gr=2, Sa=30, Fines=68, LL=29, PL=17, PI=12, No sand lenses apparent
SANDY LEAN CLAY CONTAINING LAYERS OF POORLY GRADED SAND (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine sand, Plastic, Very hard, Dry)
Sha (5) 2/6/9, CL*, F3*, PP=4.5+ tsf, Sand layers to 1/8" thick, dipping at ~60°
Sha (6) 2/5/8, 17%, CL*, F3*, PP=4.5+ tsf, Gr=3, Sa=43, Fines=54, No sand lenses apparent
22.5 ft. W.D.
22.5
Sha (7) 6 ft. of heave, unable to sample
SAND (Dk. gray, Fine sand, Nonplastic, Wet)
Sha (8) 4/8/9**, SP*, NFS*, 6" heave, sampler floated
31.5

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

Note: The above test boring elevations were surveyed at the top of ice cover of varying thickness. The elevations shown were therefore determined by subtracting the estimated ice thickness at the time of survey from the elevation surveyed at the top of the ice. These elevations are estimated, and due to the thick snow and ice cover are considered only accurate to +/- 5 feet.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-625 THRU AP-627
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	B-17

project\1209.10\geo\KENAI AP-625-27, 1=1, 02/13/07 at 09:41 by kjp

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 15 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,502 ft. Easting: 1,415,363 ft.

Top of Hole Elevation: 90.0 ft.

Hole Number, Field: TB-1 Permanent: AP-604-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.0 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Second growth willows
		1		NFS	Grab	SP	Poorly graded SAND					-/ 0.0		Brown, moist, fine to medium sand
2		2		NFS	1 1 2 1	SP	Poorly graded SAND	8	87	5		-/ 0.0	3	Brown, moist, fine to medium sand
4		3		NFS	1 1 1 1	SP	Poorly graded SAND					-/ 0.0		Brown, moist, fine to medium sand
6														
8														
10		4		NFS	2 3 3 5	SP	Poorly graded SAND	4	93	3		-/ 0.0	5	Gray, moist, fine to medium sand
12														
14														
16		5		NFS	2 5 7 9	SP	Poorly graded SAND					-/ 0.0		Gray, moist, fine to medium sand
18														
20		6			3 4 3 5	SP	Poorly graded SAND					-/ 0.0		Gray, moist, fine to medium sand
22														
24														
		7a			3	SP	Poorly graded SAND							
26		7b			5 5	SM	Silty SAND	1	75	24			22	Dark gray, moist, fine sand, nonplastic (NP) fines
		7c			9	SP	Poorly graded SAND							
28														
30		8			7 11 15	SP	Poorly graded SAND							Gray, wet, medium sand
32														
34														
36		9			5 8	SP	Poorly graded SAND							Gray, wet, fine to medium sand

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study
Kenai, Alaska

Date: 15 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,502 ft. Easting: 1,415,363 ft.

Top of Hole Elevation: 90.0 ft.

Hole Number, Field: TB-1 | Permanent: AP-604-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.0 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks Surface: Second growth willows
38					13									
40		10			6 11 14	CL	Lean CLAY with Sand	0	22	78				Dark gray, moist, fine sand, plastic fines. LL=30.8, PI=15.5
46		11			7 7 10	CL	Lean CLAY with Sand							Dark gray, moist, rounded gravel, fine sand, plastic fines, very stiff
50		12			6 8 13	CL	Lean CLAY with Sand							Dark gray, moist, plastic fines, very stiff
56		13			8 20 12	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
60		14			5 9 8	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
66		15			4 9 12	CL	Lean CLAY with Sand	7	18	75	0.25		15	Dark gray, moist, fine sand, plastic fines, very stiff
70		16			4 6 9	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 15 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,502 ft. Easting: 1,415,363 ft.

Top of Hole Elevation: 90.0 ft.

Hole Number, Field: TB-1 Permanent: AP-604-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.0 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Sample	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Description and Remarks
								Surface: Second growth willows
74–75.5			CL	Lean CLAY with Sand				Dark gray, moist, fine sand, plastic fines, very stiff
75.5	17	6 14 21	SP-SM	Poorly graded SAND with Silt				Gray, wet, fine to medium sand
80	18	10 14 18	SP-SM	Poorly graded SAND with Silt	1	92	7	Gray, wet, medium sand
90	19a	4 12 11	SP-SM	Poorly graded SAND with Silt				Gray, wet, medium sand
91	19b		CL	Lean CLAY with Sand				Dark gray, moist, fine sand, plastic fines
100		7 15 18	SP	Poorly graded SAND				Gray, wet, fine to medium sand

Bottom of Hole 101.5 ft.
Groundwater Encountered While Drilling: at an elevation of 63.0 ft.
PID = (Cold/Hot) Photo Ionization Detector

Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 16 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,309 ft. Easting: 1,415,302 ft.

Top of Hole Elevation: 89.8 ft.

Hole Number, Field: TB-2 Permanent: AP-605-MW

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☒ Monitoring Well ☐ Piezometer

Depth to Groundwater: 29.9 ft. WD

Depth Drilled: 37.5 ft.

Total Depth: 38.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM-5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Lawn
		1a			Grab	ML	SILT					-/		Brown, moist, nonplastic (NP) fines, organics (sixty percent by volume)
		1b				SP	Poorly graded SAND				1	1.0		Brown, moist, rounded gravel, fine to medium sand
2		2			2 2 4 6	SP	Poorly graded SAND				0.5	-/ 1.0		Brown, moist, fine to medium sand
6		3			2 3 4 5	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine to medium sand
10		4			5 4 6	SP	Poorly graded SAND				0.75	-/ 0.0		Gray, moist, fine to medium sand
16		5			2 6 7	SP	Poorly graded SAND	4	92	4	0.75	-/ 1.0	5	Gray, moist, fine to medium sand
20		6			3 3 5	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine to medium sand
26		7			3 4 8	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine to medium sand, localized evidence of mottling, one small area (one inch thick) of 30% silt
30		8			2 6 10	SP	Poorly graded SAND with Gravel	24	74	2	1			Brown, wet, rounded gravel, fine to coarse sand
36		9			2 3	SP	Poorly graded SAND							Twelve inches of heaving sand. Gray, wet, fine to medium sand

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 16 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,309 ft. Easting: 1,415,302 ft.

Top of Hole Elevation: 89.8 ft.

Hole Number, Field: TB-2 Permanent: AP-605-MW

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☒ Monitoring Well ☐ Piezometer

Depth to Groundwater: 29.9 ft. WD

Depth Drilled: 37.5 ft.

Total Depth: 38.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Lawn
					4									
38		10			3 7	CL	Lean CLAY with Sand	4	14	82			17	Dark gray, moist, fine sand, plastic fines, very stiff
40														Bottom of Hole 38.5 ft. Groundwater Encountered While Drilling: at an elevation of 59.9 ft. PID = (Cold/Hot) Photo Ionization Detector
42														
44														Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.
46														
48														
50														
52														
54														
56														
58														
60														
62														
64														
66														
68														
70														
72														

ALASKA DISTRICT
CORPS OF ENGINEERS
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Soils and Geology Section
EXPLORATION LOG

Project:	Kenai River Bluff Erosion Study, Kenai, Alaska
Page	1 of 3
Date:	17 Sep 2003
Drilling Agency:	☐ Alaska District ☒ Other Hughes Drilling
Elevation Datum:	MLLW ☐ MSL ☒ other
Location:	Northing: 2,396,225 ft. Easting: 1,415,366 ft.
Top of Hole Elevation:	88.7 ft.
Hole Number, Field:	TB-3
Permanent:	AP-606-P
Operator:	Pat Kelley
Inspector:	Steven Henslee
Type of Hole:	☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer
Depth to Groundwater:	27.9 ft. WD
Depth Drilled:	99.5 ft.
Total Depth:	101.0 ft.
Hammer Weight:	340 lbs
Split Spoon I.D:	2.5 in.
Size and Type of Bit:	8 in. HSA
Type of Equipment:	CME-75 with Autohammer
Type of Samples:	Grab and Drive

Surface: Dirt parking lot

Depth (ft.): 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36

Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
1			Grab	SP	Poorly graded SAND with Gravel				0.75			Brown, moist, rounded gravel, fine to medium sand, FILL
2			2 3 4 4	SP	Poorly graded SAND							Brown, moist, fine sand
3			2 3 1 4	SP	Poorly graded SAND				0.25	-/ 0.0		Brown, moist, fine sand
4			2 1 3	SP	Poorly graded SAND				0.25	-/ 0.0		Brown, moist, fine sand
5			2 2 3 4	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine sand
6			2 4 6	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine sand
7			4 7 9	SM	Silty SAND	0	79	21		-/ 0.0	15	Brown, moist, fine sand
8			7 9 15	SP	Poorly graded SAND with Gravel	17	81	2				Brown, moist, medium to coarse sand
9			1 6 9	SP	Poorly graded SAND with Gravel	32	66	2				Brown, wet, rounded gravel, fine to coarse sand

EXPLORATION LOG KENAI_BLUFFS.GPJ ACE_ANC.GDT 9/3/04

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 17 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,225 ft. Easting: 1,415,366 ft.

Top of Hole Elevation: 88.7 ft.

Hole Number, Field: TB-3 Permanent: AP-606-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 99.5 ft.

Total Depth: 101.0 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks Surface: Dirt parking lot
38														
40		10a			4 8 15	CL	Lean CLAY with Sand					-/ 1.0		Gray, moist, plastic fines, very stiff
		10b				GP	Poorly graded GRAVEL							Gray, moist, rounded gravel, coarse sand, 1.5 inches thick
42		10c				CL	Lean CLAY with Sand							
44														
		11a			7 17 24	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
		11b				SP	Poorly graded SAND							Dark gray, moist, medium sand
46		11c				CL	Lean CLAY with Sand							Dark, gray, moist, fine sand, plastic fines, very stiff
48														
50		12			7 13 16	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, fine sand, plastic fines, very stiff
52						SP	Poorly graded SAND							Estimated by drill action
54		13			6 13 16	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, fine sand, plastic fines, very stiff, marbled with clean gray medium sand to one and one sixteen inches thick
56														
58														
60		14			9 13 38	CL	Lean CLAY with Sand	0	23	77		-/ 0.0	17	Dark gray, moist, fine sand, plastic fines. LL=29, PI=15
62														
64		15			7 11 15	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, fine sand, plastic fines
66														
68														
70		16			4 8 12	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, fine sand, plastic fines
72														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 17 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,225 ft. Easting: 1,415,366 ft.

Top of Hole Elevation: 88.7 ft.

Hole Number, Field: TB-3 Permanent: AP-606-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 99.5 ft.

Total Depth: 101.0 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
													Surface: Dirt parking lot
74–76	17			4 9 11	CL	Lean CLAY with Sand	1	26	73		-/ 0.0	17	Dark gray, moist, fine sand, plastic fines, very stiff
80–81	18			5 9 12	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, fine sand, plastic fines, 1.25-inch thick seam of fine gray sand in sample
85–86	19			5 13 21	SP-SM	Poorly graded SAND with Silt					-/ 0.0		Dark gray, moist, fine to medium sand, NP fines
90–91	20			3 7 17	SP-SM	Poorly graded SAND with Silt	0	89	11		-/ 0.0	20	Dark gray, moist, fine to medium sand, NP fines
95–96	21			7 12 12	SP-SM	Poorly graded SAND with Silt					-/ 1.0		Dark gray, moist, medium sand, NP fines
100–101	22			6 17	SP-SM	Poorly graded SAND with Silt					-/ 0.0		Dark gray, moist, fine to medium sand, NP fines

Bottom of Hole 101.0 ft.
Groundwater Encountered While Drilling: at an elevation of 60.8 ft.
PID = (Cold/Hot) Photo Ionization Detector

Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 18 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,206 ft. Easting: 1,414,825 ft.

Top of Hole Elevation: 89.6 ft.

Hole Number, Field: TB-4 Permanent: AP-607-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D.: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class, TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
													Surface: Second growth willows and spruce
0–2	1		F2	Grab	SM	Silty SAND with Gravel				2	-/ 0.0		Brown, moist, rounded gravel, fine to medium sand, nonplastic (NP) fines
5–7	2		NFS	4 3 3 5	SP	Poorly graded SAND				0.25	-/ 1.0		Brown, moist, fine sand
15–17	3		NFS	3 3 4 5	SP	Poorly graded SAND				1.25	-/ 0.0		Brown, moist, rounded gravel, fine sand
25–27	4a			5 4 4 4	SP	Poorly graded SAND							Brown, moist, fine sand
	4b				SM	Silty SAND	0	65	35		-/ 0.0	23	Brown, moist, fine sand, NP fines
	4c				SP	Poorly graded SAND							Brown, moist, fine sand
30–31.5	5			4 7 6	SP	Poorly graded SAND	7	92	1				Brown, wet, medium to coarse sand
35–36.5	6			2 9	GP	Poorly graded GRAVEL with Sand	50	48	2				Twelve inches of heaving sand; Dark gray, wet, rounded gravel, fine to coarse sand

EXPLORATION LOG KENAI BLUFFS.GPJ ACE_ANC.GDT 9/3/04

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study
Kenai, Alaska

Date: 18 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,206 ft. Easting: 1,414,825 ft.

Top of Hole Elevation: 89.6 ft.

Hole Number, Field: TB-4 Permanent: AP-607-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Surface: Second growth willows and spruce

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
38				13									
46	7			5 15 18	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, find sand, plastic fines, very stiff
56	8			3 6 10	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, rounded gravel, fine sand, plastic fines, very stiff
66	9a			2 6 8	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, fine sand, plastic fines, very stiff
66	9b				SP	Poorly graded SAND							Dark gray, moist, fine to medium sand
71	10			6 11 14	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff, 1.25-inch layer of gray fine sand

EXPLORATION LOG KENAI BLUFFS.GPJ ACE ANC.GDT 9/3/04

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska
Date: 18 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling
Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,206 ft. Easting: 1,414,825 ft.
Top of Hole Elevation: 89.6 ft.

Hole Number, Field: TB-4 Permanent: AP-607-P
Operator: Pat Kelley
Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer
Depth to Groundwater: 27.9 ft. WD
Depth Drilled: 100.0 ft.
Total Depth: 101.5 ft.

Hammer Weight: 340 lbs
Split Spoon I.D: 2.5 in.
Size and Type of Bit: 8 in. HSA
Type of Equipment: CME-75 with Autohammer
Type of Samples: Grab and Drive

Depth (ft.)	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
													Surface: Second growth willows and spruce
80	11			5 6 9	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, fine sand, plastic fines
85.5	12a			5 12 25	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines
86	12b				SP	Poorly graded SAND							Dark gray, moist, fine to medium sand
88					CL	Lean CLAY with Sand							
90	13			3 9 12	SP	Poorly graded SAND					-/ 1.0		Dark gray, moist, fine to medium sand
95	14			3 4 16	SP	Poorly graded SAND	0	98	2		-/ 1.0	20	Dark gray, moist, fine to medium sand
100	15			.33	CL	Lean CLAY	0	8	92		-/ 0.0	27	Dark gray, moist, fine sand, plastic fines, very soft

Bottom of Hole 101.5 ft.
Groundwater Encountered While Drilling: at an elevation of 61.6 ft.
PID = (Cold/Hot) Photo Ionization Detector

Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.

WELL LOG DATA

American Environmental

PROJECT: Daubenspeck Property	WELL NO. MW-1
LOCATION: Grid 337.7, 315.1	DATE DRILLED: 6/14/2000
DRILLING METHOD: Hollow Stem Auger \ Split Spoon Sample	CASING TYPE/DIA. PVC 2"
DEPTH DRILLED: 28 feet	TOTAL CASING: 20 feet
GROUND ELEVATION:	T.O.C. ELEVATION:
GROUT TYPE/QUANTITY: Bentonite Chips ½ bag \ Bentonite slurry 20 gallons	SCREEN TYPE/ LENGTH: 0.20 slot PVC \ 10 feet
GROUT INTERVAL: Chips 12 to 14.11' Slurry 1 to 12'	SCREENED INTERVAL:
SAND PACK TYPE/INTERVAL: 14.11 to 28 feet	STATIC WATER LEVEL/DATE:
DEPTH TO WATER WHILE DRILLING: 21.5' bgl	LOGGED BY: PETE CAMPBELL
WATER LEVEL ELEVATION:	DRILLER: Hughes Drilling

DEPTH	H20\SOIL SAMPLE	FORMATION DESCRIPTION
0-5'		Sand, brown, clean
5-7	SSS #1 BC:3-5-5-5	5-6' Sand, medium, brown with minor gravel, moist 6-7' Sand, fine brown, moist PID 8.1
7-9'	SSS#2 BC: 3-3-4-5	7-8' Sand, fine brown, moist 8-9' Sand, fine, gray PID 0.0
9-11	SSS#3 BC: 3-4-6-8	Sand, fine, gray PID 0.0
11-13	SSS#4 BC: 4-8-8-4	Sand, fine, gray PID 0.0
13-15	SSS#5 BC: 6-7-8-9	Sand, fine, gray to 13.8 13.8-15 Sand, very fine, gray, moist PID 0.0
15-17	SSS#6 BC: 4-7-9-8	Sand, medium, brown salt & pepper. PID 0.0 Drill to 20
20-28	SSS#7 BC: 5-10-13-15	20-21' Sand fine, brown, wet 21-22' Sand with minor silt, wet, approximately 6" of water in augers PID 5.1 Sample Collected: MW-1-20-22 @09:34 Drill to 24', water at 21.5 Drill to 28' EOB

DWG. NO. B-29

WELL LOG DATA

American Environmental

PROJECT: Daubenspeck Property	WELL NO. MW-2
LOCATION: Grid 669.3, 198.9	DATE DRILLED: 6/14/2000
DRILLING METHOD: Hollow Stem Auger \ Split Spoon Sample	CASING TYPE/DIA: PVC 2"
DEPTH DRILLED: 25 feet	TOTAL CASING: 13'
GROUND ELEVATION:	T.O.C. ELEVATION:
GROUT TYPE/QUANTITY: Bentonite Chips ½ bag \ Bentonite slurry 20 gallons	SCREEN TYPE/ LENGTH: 0.20 slot PVC \ 10 feet
GROUT INTERVAL: Chips 8 to 10' Slurry 1 to 8'	SCREENED INTERVAL: 15 to 25'
SAND PACK TYPE/INTERVAL: 10 to 25 feet	STATIC WATER LEVEL/DATE:
DEPTH TO WATER WHILE DRILLING: 18.8' bgl	LOGGED BY: PETE CAMPBELL
WATER LEVEL ELEVATION:	DRILLER: Hughes Drilling

DEPTH	H20\SOIL SAMPLE	FORMATION DESCRIPTION
0-4'		Drill, no cuttings
4-6	SSS #1 BC: 1-1	Sand, brown with some surface litter, (wood) 50% recovery PID 4.5
6-8'	SSS#2 BC: 1-1-1-0	Sand, brown, dry 30% recovery PID 6.6
8-10	SSS#3 BC: 3-3-2-2	0% recovery, Spoon bounced as if on a log. Bailing wire on tip of bit
10-12	SSS#4 BC: 2-1-1-1	Sand, brown with some organics PID 7.5 20% recovery
12-14	SSS#5 BC: 3-5-5-6	Sand, brown dry to moist PID 4.5
14-16	SSS#6 BC: 4-7-7-8	Sand, brown dry to moist PID 1.3 Drill to 20
20-22	SSS#7 BC: 4-4-4-7	Sand, brown wet PID 2.5 Water at 18.8 Sample Collected: MW-2-20-22 @ 12:14 Drill to 25', water at 18.8 EOB As the augers were removed from the hole a large chunk of metal came up the augers with several pieces of copper wire.

WELL LOG DATA

American Environmental

PROJECT: Daubenspeck Property	WELL NO. MW-3
LOCATION: Grid 238.7, 54.1	DATE DRILLED: 6/14/2000
DRILLING METHOD: Hollow Stem Auger \ Split Spoon Sample	CASING TYPE/DIA: PVC 2"
DEPTH DRILLED: 30 feet	TOTAL CASING: 22.9'
GROUND ELEVATION: 100.3	T.O.C. ELEVATION: 103.41
GROUT TYPE/QUANTITY: Bentonite Chips 1 bag \ Bentonite slurry 20 gallons	SCREEN TYPE/ LENGTH: 0.20 slot PVC \ 10 feet
GROUT INTERVAL: Chips 12.5 to 17' Slurry 4.5 to 12.5'	SCREENED INTERVAL: 20 to 30'
SAND PACK TYPE/INTERVAL: 17 to 30 feet	STATIC WATER LEVEL/DATE:
DEPTH TO WATER WHILE DRILLING: 24' bgl	LOGGED BY: PETE CAMPBELL
WATER LEVEL ELEVATION:	DRILLER: Hughes Drilling

DEPTH	H20\SOIL SAMPLE	FORMATION DESCRIPTION
0-5'		Sand, brown
5-7	SSS #1 BC: 1-1-1-1	Sand, brown, moist, fine PID 0.0
7-9'	SSS#2 BC: 1-1-1-1	7-8 Sand, medium, brown, moist 8-8.3 Sand, fine, brown 8.3-9 Sand, medium, brown, some organics PID 0.0
9-11	SSS#3 BC: 1-1-1-1	Sand, medium, brown, with minor gravel. PID 0.0
11-13	SSS#4 BC: 1-1-1-1	Sand, medium, brown. PID 0.0
13-15	SSS#5 BC: 1-1-1-1	Sand, medium, brown. PID 0.0
15-17	SSS#6 BC: 1-1-1-1	Sand, medium, brown. PID 0.0
17-19	SSS#7 BC: 1-1-1-1	Sand, medium, brown, with minor gravel. PID 5.0
19-21	SSS#8 BC: 1-1-1-1	Sand, medium, brown, with minor gravel. PID 8.5
21-23	SSS#9 BC: 2-7-23	21-22 Sand, fine, brown. 22-23 Pea Gravel with concrete in tip, refusal. PID 8.6
		The augers apparently hit the suspected lip of the cistern that was rumored to be in the area. The rig was moved east 10 feet and re-drilled to 23'
23-25	SSS#10 BC: 3-7-7-10	Sand, brown with minor gravel, wet. PID 8.2 Sample Collected MW-3-23-25 @17:57

APPENDIX C
LABORATORY TEST DATA

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse-grained Soils More than 50% retained on the No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]	GP	Poorly-graded gravel [F]
		Gravels with Fines More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel [F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5 % fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]	SP	Poorly-graded sand [I]
		Sands with Fines More than 12 % fines [D]	Fines classify as ML or MH	SM	Silty sand [G,H,I]
			Fines classify as CL or CH	SC	Clayey sand [G,H,I]
Fine-grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	inorganic	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 and plots below "A" line [J]	ML	Silt [K, L, M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic Clay [K, L, M,N] / Organic Silt [K, L, M,O]
	Silts and Clays Liquid Limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic Clay [K, L, M,P] / Organic Silt [K, L, M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravel with 5 to 12 % fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly-graded gravel with silt
GP-GC poorly-graded gravel with clay

[D] Sands with 5 to 12 % fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly-graded sand with silt
SP-SC poorly-graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥15% sand, add "with sand " to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.

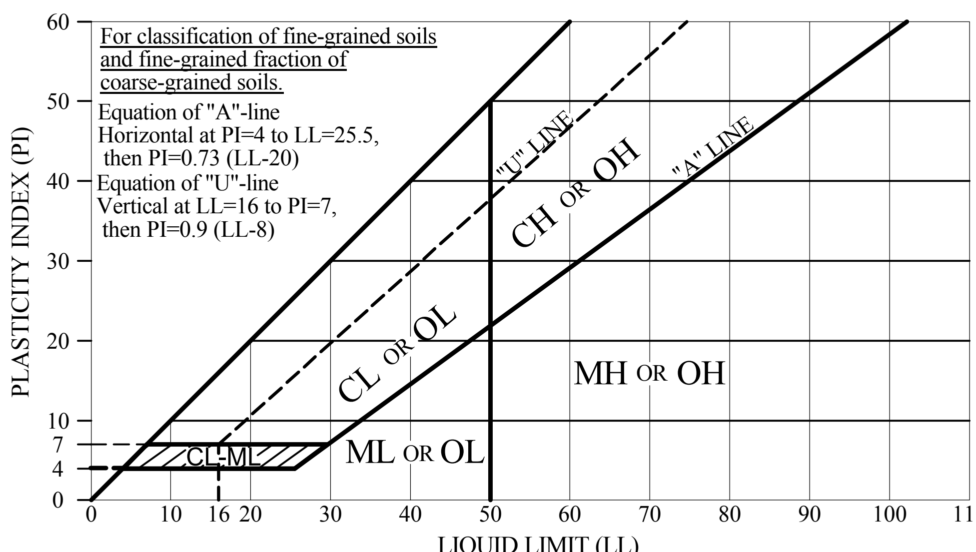
[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 and plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JUNE 04
SCALE:	NONE

R&M CONSULTANTS, INC.
ENGINEERING • SURVEYING • EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES ASTM D 2487

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	C-01

Z:\PROJECT\1209.10\LOGS\ASTM.GDW (DRAWING ASTM CLASS) 2/14/07 03:44 PM

U.S. ARMY CORPS OF ENGINEERS
FROST DESIGN SOIL CLASSIFICATION

FROST GROUP	KIND OF SOIL	PERCENTAGE FINER THAN 0.02 mm BY WEIGHT	TYPICAL SOIL TYPES UNDER UNIFIED SOIL CLASSIFICATION SYSTEM
NFS*	(a) Gravels Crushed Stone Crushed Rock (b) Sands	0 - 1.5 0 - 3	GW, GP SW, SP
PFS+	(a) Gravels Crushed Stone Crushed Rock (b) Sands	1.5 - 3 3 - 10	GW, GP SW, SP
S1	Gravelly Soils	3 - 6	GW, GP, GW-GM, GP-GM
S2	Sandy Soils	3 - 6	SW, SP, SW-SM, SP-SM
F1	Gravelly Soils	6 - 10	GM, GW-GM, GP-GM
F2	(a) Gravelly Soils (b) Sands	10 - 20 6 - 15	GM, GW-GM, GP-GM SM, SW-SM, SP-SM
F3	(a) Gravelly Soils (b) Sands, Except Very Fine Silty Sands (c) Clays, PI>12	Over 20 Over 15 --------	GM, GC SM, SC CL, CH
F4	(a) All Silts (b) Very Fine Silty Sand (c) Clays PI<12 (d) Varved Clays and Other Fine-grained Banded Sediments	-------- Over 15 -------- --------	ML, MH SM CL, CL-ML CL, CL-ML CL and ML CL, ML, and SM; CL, CH and ML; CL, CH, ML and SM

* Non-frost-susceptible
\+ Possibly frost-susceptible, but requires laboratory test to determine frost design soils classification.

From: "Seasonal Frost Conditions", June, 1992, U.S. Army Corps of Engineers TM-5-822-5.

Z:\PROJECT\1209.10\LOGS\FROST.GDW (DRAWING FROST CLASSIFICATION) 2/14/07 03:44 PM

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JUNE 04
SCALE:	NONE

R&M CONSULTANTS, INC.
ENGINEERING ∘ SURVEYING ∘ EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

FROST DESIGN SOIL CLASSIFICATION

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	C-02

SUMMARY OF SOIL INDEX PROPERTY DATA

KENAI RIVER BLUFF EROSION

SAMPLE IDENTIFICATION				PARTICLE SIZE ANALYSIS (% FINER)																	ATTERBERG LIMITS			MOIST. CONT.	SPECIFIC GRAVITY	ASTM CLASS.	FROST CLASS.
				STANDARD SIEVE SIZE														(mm)									
	SOIL PROFILE	NO.	DEPTH (FT.)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	%			
SURFACE SAMPLES COLLECTED FROM SOIL PROFILES	SP-B	1	SURFACE		100	98	97	94	85	77	58	37	18	6	3	1	0.6							5.1		SP	NFS
	SP-C	1	SURFACE		100	88	81	79	75	73	61	49	38	19	7	3	2.0							3.3		SP	NFS
	SP-C	2	SURFACE								100	99	99	95	22	3	2.3							4.2		SP	NFS
	SP-C	3	SURFACE							100	99	99	99	98	97	92	91				38	18	20	16		CL	F3
	SP-C	4	SURFACE				100	99	99	98	95	88	64	20	7	3	2.9							9.8		SP	NFS
	SP-D	1	SURFACE							100	99	98	94	65	26	2	1.6							0.9		SP	NFS
	SP-D	2	SURFACE	100	86	86	86	86	86	86	85	84	83	82	79	73	69				25	14	11	16		CL	F4
	SP-D	3	SURFACE										100	96	18	1	0.7							3.5		SP	NFS
	SP-E	1	SURFACE	100	93	90	85	80	73	68	57	47	41	24	6	1	1.3							13		SP	NFS
	SP-E	2	SURFACE					100	99	98	97	96	94	93	90	82	78				28	15	13	14		CL	F3
	SP-F	1	SURFACE			100	97	89	81	72	52	32	21	13	9	4	2.7							11		SW	NFS
	SP-G	1	SURFACE					100	98	97	93	89	84	53	13	1	0.7							3.0		SP	NFS
	SP-G	2	SURFACE		100	81	81	81	81	80	80	78	78	76	73	67	64				28	15	13	11		CL	F3
	SP-H	1	SURFACE								100	99	99	88	25	2	0.8							1.6		SP	NFS
	SP-H	2	SURFACE		100	95	86	80	69	62	46	32	24	13	5	1	0.5							6.8		GP	NFS
	SP-H	3	SURFACE	100	87	87	87	86	86	85	84	82	81	79	76	69	66				26	15	11	15		CL	F4
	SP-H	4	SURFACE									100	99	98	40	4	3.1							17		SP	NFS
	SP-I	1	SURFACE				100	98	90	86	71	56	42	15	5	1	0.6							2.4		SP	NFS
	SP-I	2	SURFACE				100	99	98	97	95	93	87	45	10	1	1.0							5.2		SP	NFS
	SP-I	3	SURFACE			100	99	99	99	99	98	96	95	93	90	81	76				24	14	10	14		CL	F4
	SP-J	1	SURFACE								100	99	98	86	47	11	5.7							9.9		SP-SM*	S2*
	SP-J	2	SURFACE			100	99	98	93	90	83	73	59	22	5	1	0.6							4.2		SP	NFS

* Estimated Classification

SUMMARY OF SOIL INDEX PROPERTY DATA

KENAI RIVER BLUFF EROSION

SAMPLE IDENTIFICATION				PARTICLE SIZE ANALYSIS (% FINER) ** STANDARD SIEVE SIZE														(mm)			ATTERBERG LIMITS			MOIST. CONT.	SPECIFIC GRAVITY	ASTM CLASS.	FROST CLASS.
HOLE	HOLE	NO.	DEPTH (FT.)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	%			
AP-608-MW	TB-1a	3	5.0 - 6.5							100	97	95	91	82	66	56	52							27		ML*	F4
AP-608-MW	TB-1a	7	25.0 - 26.5						100	99	99	99	97	67	17	5	3.7							4.3		SP	NFS*
AP-608-MW	TB-1a	11	45.0 - 46.5			100	98	97	95	93	88	84	67	16	5	2	1.8							2.3		SP	NFS
AP-608-MW	TB-1a	13	55.0 - 56.5										100	53	6	2	1.3							2.8		SP	NFS
AP-608-MW	TB-1a	15	65.0 - 66.5					100	99	99	99	98	96	49	8	4	3.0							9.7		SP	NFS
AP-608-MW	TB-1a	18	80.0 - 81.5					100	98	97	94	88	79	66	24	12	11							17		SP-SM*	F2*
AP-608-MW	TB-1a	19	85.0 - 86.5			100	94	94	93	92	85	83	81	78	74	67	63				24	15	9	13		CL	F4
AP-608-MW	TB-1a	21	95.0 - 96.5					100	99	99	98	97	96	95	91	84	80				27	16	11	16		CL	F4
AP-611-MW	TB-2c	2	2.5 - 4.0						100	99	98	97	96	87	49	29	27							10		SM*	F3*
AP-611-MW	TB-2c	5	15.0 - 16.5				100	98	97	96	93	88	77	38	7	2	1.2							3.5		SP	NFS
AP-611-MW	TB-2c	8	30.0 - 31.5				100	99	98	97	94	92	86	50	12	5	3.0							5.1		SP	NFS
AP-611-MW	TB-2c	12	50.0 - 51.5		100	82	82	79	79	79	78	76	75	73	70	63	60				27	16	11	11		CL	F4
AP-611-MW	TB-2c	14	60.0 - 61.5							100	98	97	95	93	90	78	72				26	16	10	15		CL	F4
AP-611-MW	TB-2c	16	70.0 - 71.5										100	99	95	82	75				22	14	8	18		CL	F4
AP-611-MW	TB-2c	17	75.0 - 76.5							100	99	99	99	98	96	86	78				24	16	8	15		CL	F4
AP-611-MW	TB-2c	22	100.0 - 101.5								100	99	99	99	97	91	82							20		CL*	F3*
AP-614-MW	TB-3a	3	5.0 - 6.5				100	99	99	97	89	80	67	42	14	5	4.2							5.8		SP	PFS*
AP-614-MW	TB-3a	5	15.0 - 16.5								100	99	97	78	23	4	3.1							4.8		SP	NFS*
AP-614-MW	TB-3a	7	25.0 - 26.5								100	99	99	84	30	8	5.3							4.9		SP-SM*	S2*
AP-614-MW	TB-3a	9	35.0 - 36.5			100	98	96	90	85	68	53	44	27	12	6	5.5	3.3	1.3	0.6				2.4		SP-SM*	S2
AP-614-MW	TB-3a	11	45.0 - 46.5						100	99	98	96	94	86	72	48	42							16		SC*	F3*
AP-614-MW	TB-3a	13	55.0 - 56.5						100	99	99	98	96	94	90	83	79				24	15	9	14	2.682	CL	F4
AP-614-MW	TB-3a	14	60.0 - 61.5					100	99	98	97	95	94	92	88	79	75				27	15	12	13		CL	F4
AP-614-MW	TB-3a	15	65.0 - 66.5																					16		CL*	F4*
AP-614-MW	TB-3a	16	70.0 - 71.5						100	99	98	97	97	95	93	83	79				31	18	13	17		CL	F3
AP-614-MW	TB-3a	17	75.0 - 76.5					100	99	98	96	94	93	90	84	61	53							15		CL*	F3*
AP-614-MW	TB-3a	18	80.0 - 81.5				100	99	99	99	98	94	93	92	88	80	76	52.8	34.9	21.4				17		CL*	F3*
AP-614-MW	TB-3a	19	85.0 - 86.0					100	97	97	94	94	91	68	42	33	30							18		SC*	F3*
AP-614-MW	TB-3a	22	100.0 - 101.5									100	99	87	24	7	6.1							24		SP-SM*	S2*

* Estimated Classification

** The maximum particle size of samples is limited by the I.D. of the sampler opening or the width of the auger flights.

SUMMARY OF SOIL INDEX PROPERTY DATA

KENAI RIVER BLUFF EROSION

SAMPLE				PARTICLE SIZE ANALYSIS (% FINER) **																	ATTERBERG			MOIST.	SPECIFIC	ASTM	FROST
IDENTIFICATION				STANDARD SIEVE SIZE														(mm)			LIMITS			CONT.	GRAVITY	CLASS.	CLASS.
HOLE	HOLE	NO.	DEPTH (FT.)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	%			
AP-615-MW	TB-3b	1	75.0 - 76.5				100	99	99	99	98	98	97	96	92	61	51							19		CL*	F3*
AP-617-MW	TB-4a	4	10.0 - 11.5							100	99	97	94	69	22	5	3.9							6.5		SP	NFS*
AP-617-MW	TB-4a	7	25.0 - 26.5								100	99	96	67	22	6	4.3							8.4		SP	NFS*
AP-617-MW	TB-4a	11	45.0 - 46.5				100	98	97	96	93	89	86	83	75	57	54							15		CL*	F3*
AP-617-MW	TB-4a	13	55.0 - 56.5				100	92	90	87	84	81	78	74	69	65	63				31	18	13	13		CL	F3
AP-617-MW	TB-4a	14	60.0 - 61.5					100	98	97	94	92	90	88	82	74	71				33	17	16	15		CL	F3
AP-617-MW	TB-4a	16	70.0 - 71.5			100	98	96	95	95	93	92	91	89	86	78	74				27	16	11	13	2.724	CL*	F3*
AP-617-MW	TB-4a	17	75.0 - 76.5		100	97	96	95	93	89	79	66	65	63	60	54	51	36.2	23.8	15.4				15		CL*	F3*
AP-617-MW	TB-4a	18	80.0 - 81.5					100	99	99	97	96	95	93	89	75	69				24	16	8	14		CL	F4
AP-617-MW	TB-4a	20	90.0 - 91.5				100	99	98	98	96	95	94	92	88	80	76							17		CL*	F3*
AP-620-MW	TB-02	2	2.5 - 4.0						100	99	98	98	96	88	64	27	22							10		SM*	F3*
AP-620-MW	TB-02	4	10.0 - 11.5			100	99	99	97	96	93	87	76	43	12	2	1.7							5.1		SP	NFS
AP-620-MW	TB-02	5	15.0 - 16.5								100	99	96	77	25	5	4.4				NV	NV	NP	4.6	2.716	SP	S2*
AP-620-MW	TB-02	6	20.0 - 21.5							100	99	99	97	83	37	5	3.9							6.0		SP	NFS*
AP-620-MW	TB-02	7	25.0 - 26.5			100	98	97	95	94	90	86	80	52	18	4	3.3							7.6		SP	NFS*
AP-620-MW	TB-02	8	30.0 - 31.5			100	99	98	96	93	88	82	72	42	19	5	3.2							21		SP	NFS*
AP-620-MW	TB-02	10	40.0 - 41.4				100	99	98	98	97	96	94	90	87	83	81				35	21	14	16	2.747	CL	F3
AP-621-MW	TB-03	3	5.0 - 6.5					100	98	95	89	84	79	62	18	3	2.7							6.2		SP	NFS
AP-621-MW	TB-03	5	15.0 - 16.5							100	99	98	94	72	25	5	4.3							7.7		SP	S2*
AP-621-MW	TB-03	6	20.0 - 21.5					100	97	96	92	90	89	81	37	6	3.6							12		SP	NFS*
AP-621-MW	TB-03	8	30.0 - 31.5						100	99	98	97	92	66	29	9	6.5							19		SP-SM*	S2*
AP-622	TB-08	2	2.5 - 4.5										100	99	98	95	94				49	28	21	37		ML	F4
AP-622	TB-08	5	10.5 - 11.5			100	94	87	74	67	52	42	38	30	17	10	9.1							10		GP-GM*	F1*
AP-622	TB-08	6	15.0 - 16.5				100	94	93	92	88	83	79	73	61	52	49				18	12	6	14		SC-SM	F4*
AP-622	TB-08	7	20.0 - 21.5																					14		CL*	F3*
AP-622	TB-08	8	25.0 - 26.5				100	97	97	96	91	90	88	86	82	74	70				25	14	11	14		CL	F4
AP-622	TB-08	9	30.0 - 31.5								100	99	98	97	94	90	88				29	16	13	17		CL	F3

* Estimated Classification

** The maximum particle size of samples is limited by the I.D. of the sampler opening or the width of the auger flights.

SUMMARY OF SOIL INDEX PROPERTY DATA

KENAI RIVER BLUFF EROSION

SAMPLE IDENTIFICATION				PARTICLE SIZE ANALYSIS (% FINER) **																	ATTERBERG LIMITS			MOIST. CONT.	SPECIFIC GRAVITY	ASTM CLASS.	FROST CLASS.
				STANDARD SIEVE SIZE														(mm)									
HOLE	HOLE	NO.	DEPTH (FT.)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	%			
AP-623	TB-07	2	2.5 - 4.0																					8.2		SP*	NFS*
AP-623	TB-07	3	5.0 - 6.5								100	99	99	96	26	2	1.6							3.8		SP	NFS
AP-623	TB-07	4	10.0 - 11.5								100	99	98	94	53	14	10							13		SP-SC*	F2*
AP-623	TB-07	5	15.0 - 16.5										100	95	30	3	1.9							22		SP	NFS
AP-624	TB-06	1	0.5 - 1.0			100	95	83	70	64	55	46	43	39	31	26	25	16.9	10.9	7.1				22		GC*	F2
AP-624	TB-06	3	3.0 - 4.0									100	99	98	55	8	4.5							21		SP*	NFS*
AP-624	TB-06	4	5.0 - 5.5																					18		SP*	NFS*
AP-624	TB-06	5	5.5 - 6.5																					18		CL*	F4*
AP-624	TB-06	6	10.0 - 11.5			100	97	94	93	92	90	88	87	86	83	76	72				29	16	13	15		CL	F3
AP-624	TB-06	7	15.0 - 16.0										100	66	18	2	1.3							22		SP	NFS
AP-624	TB-06	8	16.0 - 16.5						100	99	99	98	97	94	87	77	73				26	15	11	17		CL	F4
AP-625	TB-05	1	0.5 - 1.0					100	98	95	90	79	76	71	65	58	55	39.1	25.0	16.0				78		CL-ML*	F4*
AP-625	TB-05	2	2.5 - 4.0				100	99	98	97	96	94	93	91	88	81	77				27	16	11	17		CL	F4
AP-625	TB-05	3	5.0 - 6.5						100	99	98	96	95	93	90	84	81				26	16	10	17		CL	F4
AP-625	TB-05	4	10.0 - 11.5							100	98	97	93	40	10	3	2.3							14		SP	NFS
AP-625	TB-05	5	15.0 - 16.5								100	99	90	37	5	1.4	1.2							20		SP	NFS
AP-626	TB-04	1	0.5 - 1.5					100	98	96	91	82	80	77	72	64	56	35.5	22.6	14.1				25		CL-ML*	F4*
AP-626	TB-04	2	2.5 - 4.0			100	90	90	89	89	88	87	86	85	77	58	51				19	13	6	28		CL-ML	F4
AP-626	TB-04	3	5.0 - 6.5				100	98	97	96	94	93	92	90	85	76	72				27	16	11	15		CL	F4
AP-626	TB-04	5	10.5 - 11.5				100	99	99	97	94	92	89	58	24	5	3.9							16		SP	S2*
AP-626	TB-04	6	15.0 - 16.0							100	99	99	96	45	17	6	4.9							20		SP	S2*
AP-627	TB-01	2	2.5 - 4.0					100	98	97	95	93	90	87	77	64	59							17		CL*	F3*
AP-627	TB-01	3	5.0 - 6.5				100	99	97	96	92	86	85	83	80	72	68	47.3	30.5	19.1				15		CL*	F3*
AP-627	TB-01	4	10.0 - 11.5					100	99	99	98	97	96	94	91	74	68				29	17	12	17		CL	F4
AP-627	TB-01	6	20.0 - 21.5				100	99	99	98	97	95	94	91	85	62	54							17		CL*	F3*

* Estimated Classification

** The maximum particle size of samples is limited by the I.D. of the sampler opening or the width of the auger flights.

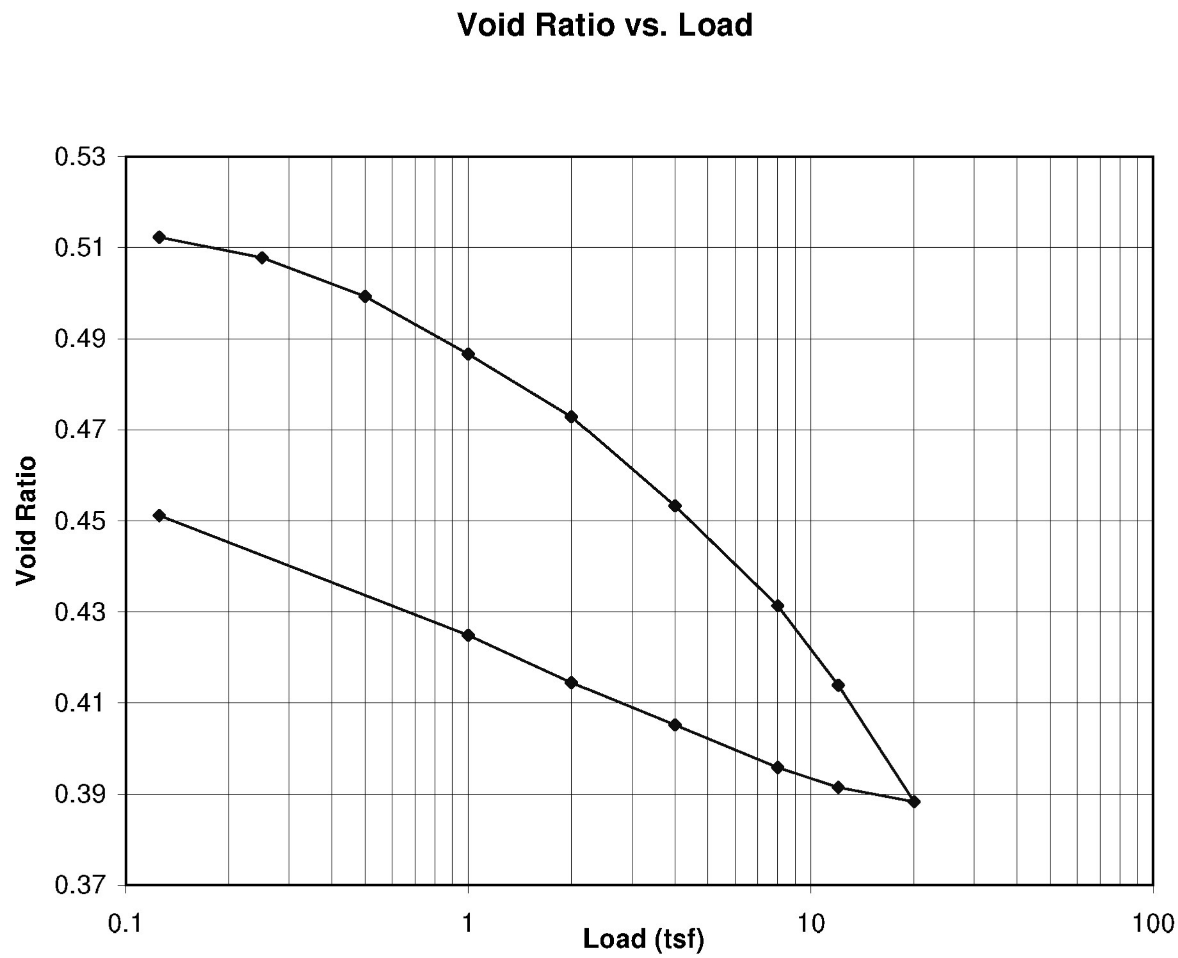
R&M Laboratory Test Report - One-Dimensional Consolidation

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-620-MW (TB-02)	Sampled by:	PKH	Date Sampled:	11/13/2006
Sample No.:	10	Received by:	RJM	Date Received:	11/17/2006
Depth:	40 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/12/2006	Lab #:	534

Test Method: ASTM D 2435 - 04 - One-Dimensional Consolidation Properties of Soils

Sample Diameter (in)	2.40
Sample Height (in)	1.01
Specific Gravity	2.747
Liquid Limit	35
Plasticity Index	14

	Initial	Final
Dry Density (pcf)	113.2	118.1
Moisture (%)	17.3%	20.9%
Void Ratio	0.514	0.451
Saturation (%)	93%	100%



DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES	KENAI, ALASKA	GRID: KENAI
DATE: JAN. 2007	CONSTRUCTION SERVICES	CONSOLIDATION TEST	PROJ.NO: 1209.10
SCALE: N.T.S.	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	DATA	DWG.NO: C-07

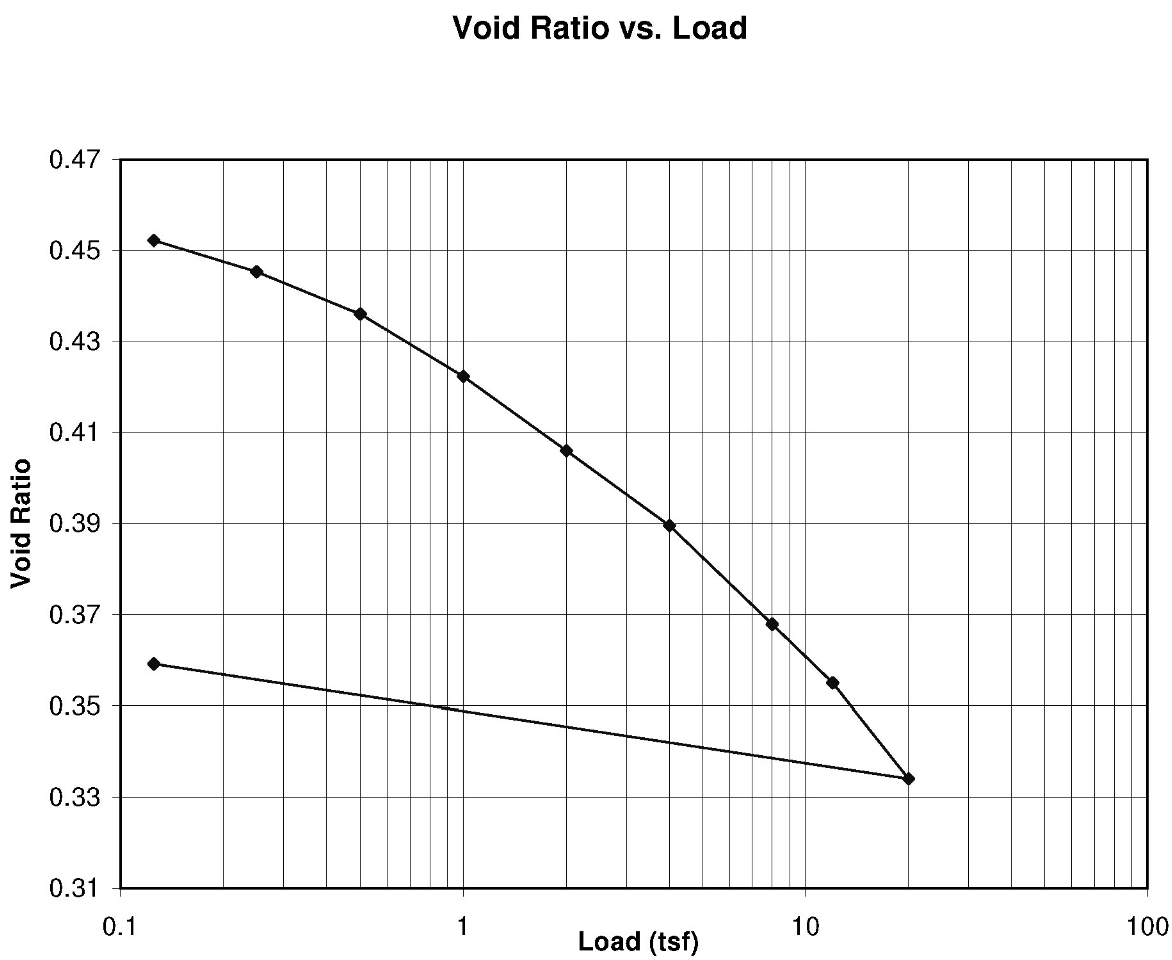
R&M Laboratory Test Report - One-Dimensional Consolidation

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-617-MW (TB-4a)	Sampled by:	PKH	Date Sampled:	11/19/2006
Sample No.:	16	Received by:	RJM	Date Received:	11/21/2006
Depth:	70 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/7/2006	Lab #:	534

Test Method: ASTM D 2435 - 04 - One-Dimensional Consolidation Properties of Soils

Sample Diameter (in)	2.40
Sample Height (in)	1.01
Specific Gravity	2.724
Liquid Limit	27
Plasticity Index	11

	Initial	Final
Dry Density (pcf)	116.8	117.8
Moisture (%)	15.1%	15.7%
Void Ratio	0.455	0.359
Saturation (%)	90%	100%



DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

R&M CONSULTANTS, INC.
ENGINEERING • SURVEYING • EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

CONSOLIDATION TEST DATA

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-08

R&M Laboratory Test Report - One-Dimensional Consolidation

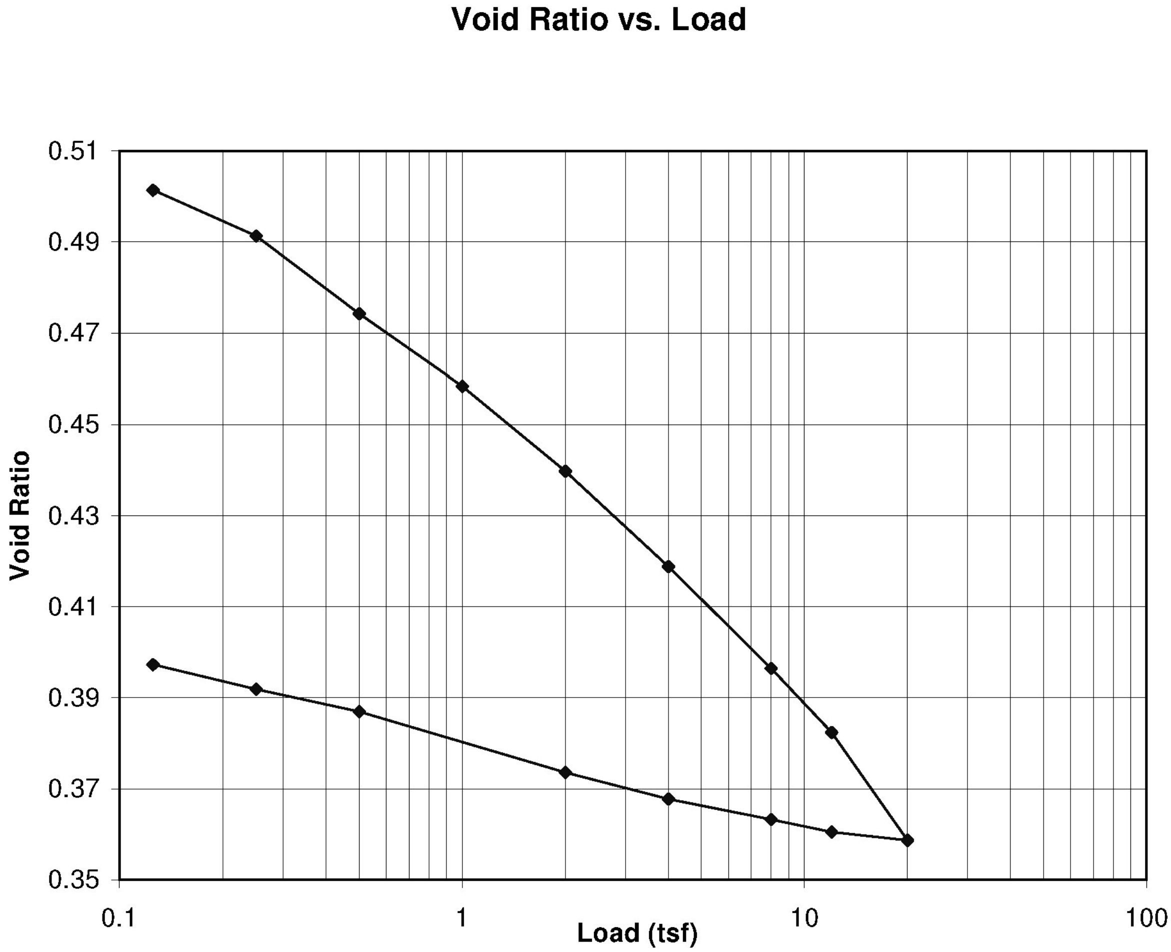
Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-625 (TB-05)	Sampled by:	PKH	Date Sampled:	11/15/2006
Sample No.:	3	Received by:	RJM	Date Received:	11/21/2006
Depth:	5 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Lean Clay with Sand	Date Completed:	12/22/2006	Lab #:	534

Test Method: ASTM D 2435 - 04 - One-Dimensional Consolidation Properties of Soils

Sample Diameter (in)	2.40	
Sample Height (in)	1.01	
Specific Gravity	2.73	assumed
Liquid Limit	26	
Plasticity Index	10	

	Initial	Final
Dry Density (pcf)	112.8	121.9
Moisture (%)	15.8%	17.2%
Void Ratio	0.510	0.397
Saturation (%)	84%	100%

Note, after testing the specimen was found to contain a gravel particle with a thickness of 0.5 inches.



DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

R&M CONSULTANTS, INC.
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CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

CONSOLIDATION TEST DATA

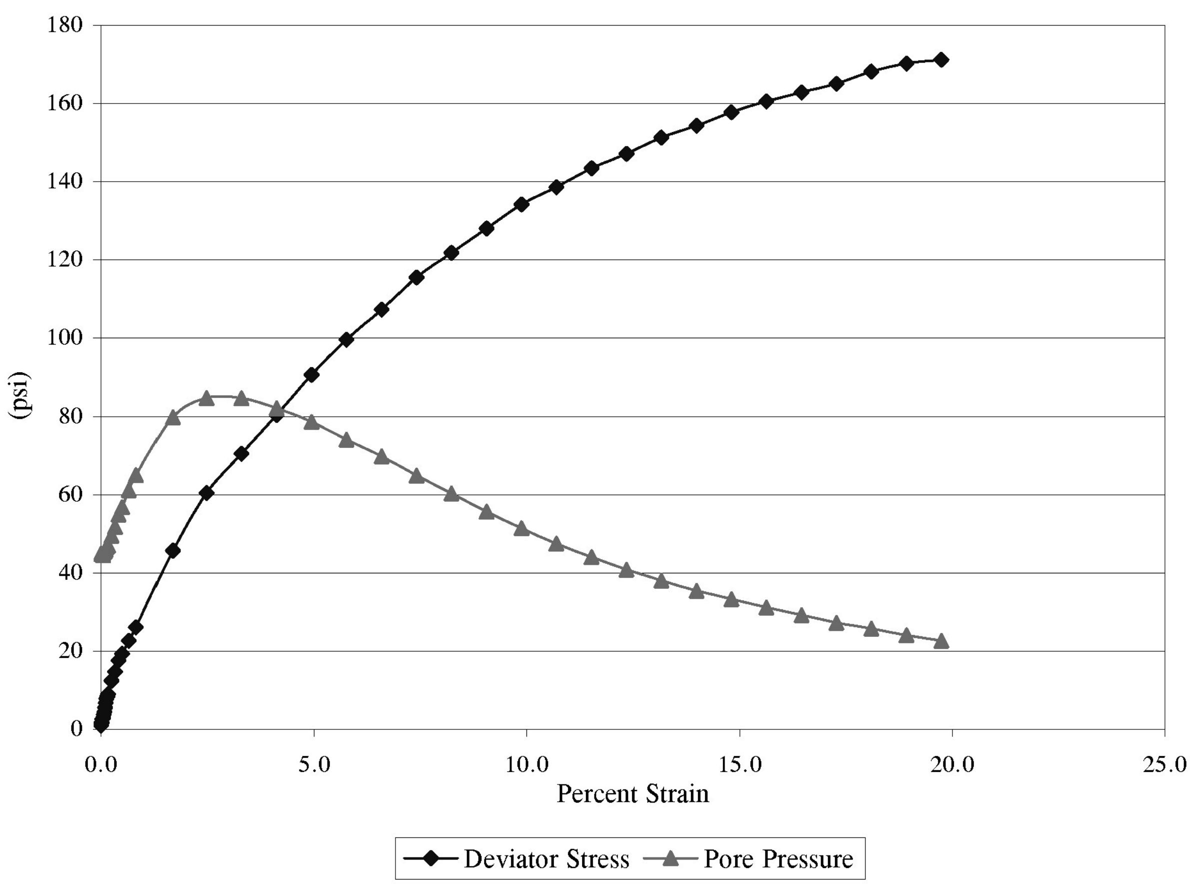
FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-09

R&M Laboratory Test Report - CU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-614-MW (TB-3a)	Sampled by:	PKH	Date Sampled:	11/11/2006
Sample No.:	13	Received by:	RJM	Date Received:	11/17/2006
Depth:	55 ft	Tested by:	RMP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/8/2006	Lab #:	534

Test Method: ASTM D 4767 - 02 - Consolidated Undrained Compression Test for Cohesive Soils

Initial Dry Density	121.9 pcf
Initial Moisture Content	14.3 %
Final Moisture Content	13.9 %
Initial Height	6.08 inches
Initial Diameter	2.33 inches
Effective Confining Pressure	44.5 psi
Back Pressure	44.7 psi
B Pore Pressure Parameter	0.96
T_{50}	144 min
Load Rate	0.0055 in/min



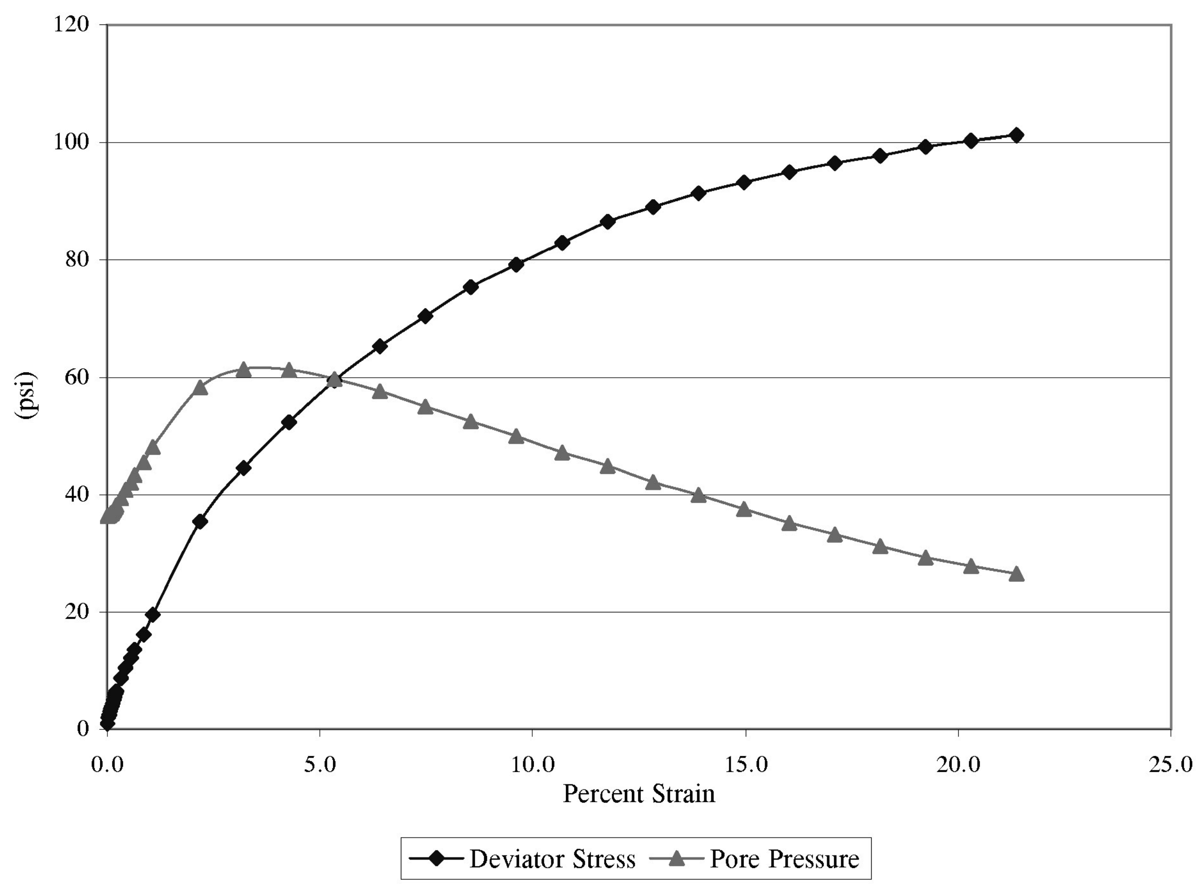
DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES		GRID: KENAI
DATE: JAN. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	CU TRIAXIAL TEST DATA	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-10

R&M Laboratory Test Report - CU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-614-MW (TB-3a)	Sampled by:	PKH	Date Sampled:	11/11/2006
Sample No.:	14	Received by:	RJM	Date Received:	11/17/2006
Depth:	60 ft	Tech Assigned:	RMP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/14/2006	Lab #:	534

Test Method: ASTM D 4767 - 02 - Consolidated Undrained Compression Test for Cohesive Soils

Initial Dry Density	124.9 pcf
Initial Moisture Content	13.2 %
Final Moisture Content	14.8 %
Initial Height	4.68 inches
Initial Diameter	2.33 inches
Effective Confining Pressure	32.1 psi
Back Pressure	35.4 psi
B Pore Pressure Parameter	0.97
T_{50}	70 min
Load Rate	0.0057 in/min



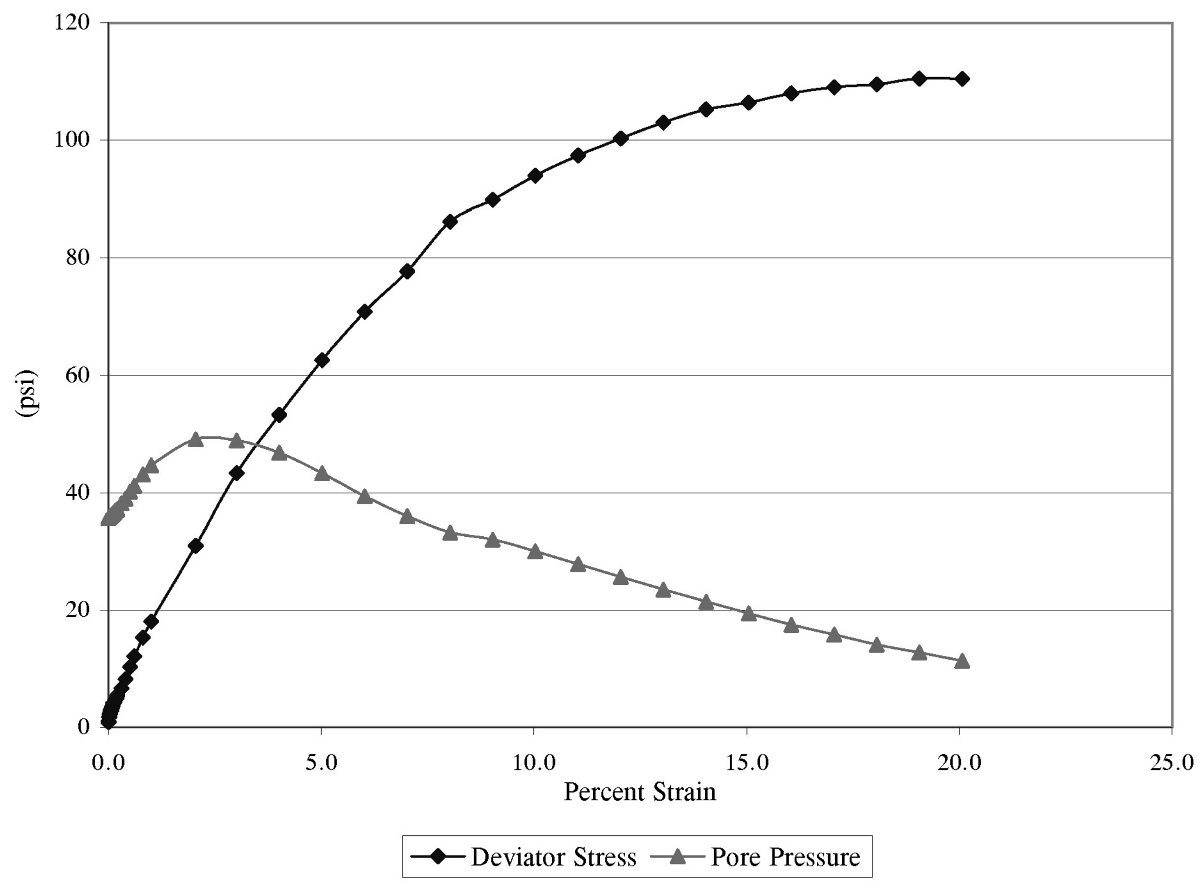
DWN: P.K.H.	R&M CONSULTANTS, INC. ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES 9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.			GRID: KENAI
DATE: JAN. 2007		CU TRIAXIAL TEST DATA	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-11

R&M Laboratory Test Report - CU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-614-MW (TB-3a)	Sampled by:	PKH	Date Sampled:	11/11/2006
Sample No.:	15	Received by:	RJM	Date Received:	11/17/2006
Depth:	65 ft	Tech Assigned:	RMP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/20/2006	Lab #:	534

Test Method: ASTM D 4767 - 02 - Consolidated Undrained Compression Test for Cohesive Soils

Initial Dry Density	117.4 pcf
Initial Moisture Content	15.7 %
Final Moisture Content	15.9 %
Initial Height	4.98 inches
Initial Diameter	2.36 inches
Effective Confining Pressure	15.5 psi
Back Pressure	34.5 psi
B Pore Pressure Parameter	0.97
T_{50}	90 min
Load Rate	0.0066 in/min



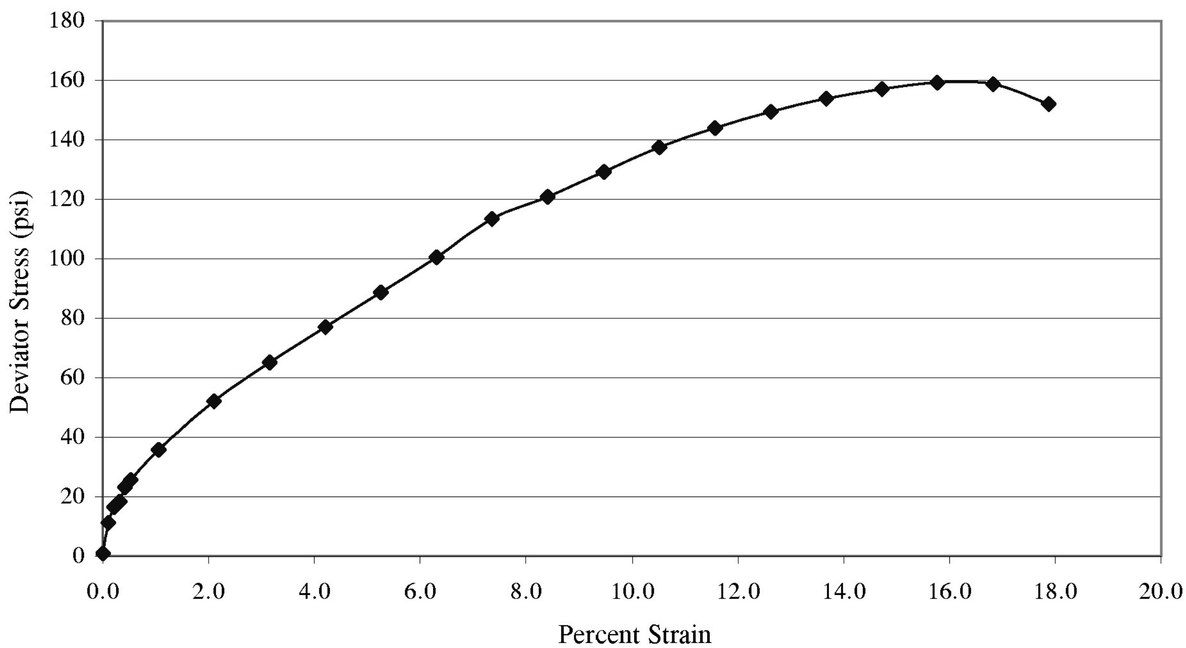
DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES		GRID: KENAI
DATE: JAN. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	CU TRIAXIAL TEST DATA	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-12

R&M Laboratory Test Report - UU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-611-MW (TB-2c)	Sampled by:	PKH	Date Sampled:	11/15/2006
Sample No.:	12	Received by:	RJM	Date Received:	11/20/2006
Depth:	50 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/21/2006	Lab #:	534

Test Method: ASTM D 2850 - 03 - Unconsolidated Undrained Triaxial Compression Test on Cohesive Soils

Initial Dry Density	122.2 pcf
Initial Moisture Content	13.8 %
Initial Height	4.76 inches
Initial Diameter	2.34 inches
Effective Confining Pressure	10.0 psi
Back Pressure	0.0 psi
B Pore Pressure Parameter	NA
T_{50}	NA
Load Rate	0.044 in/min



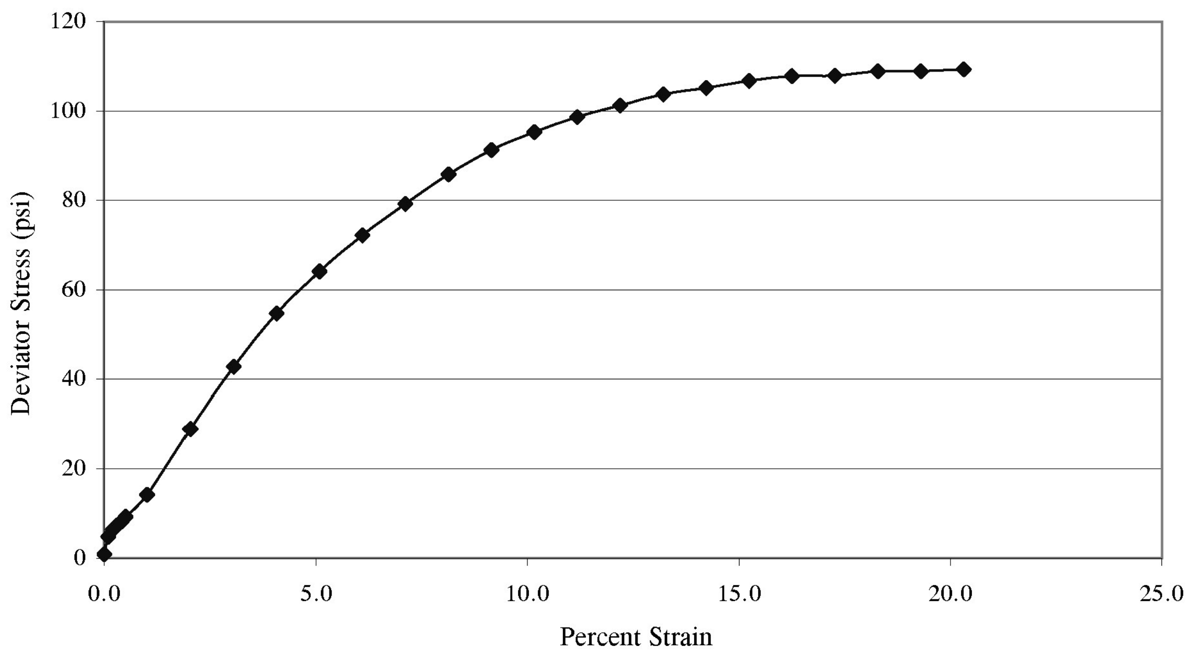
DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES		GRID: KENAI
DATE: JAN. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	UU TRIAXIAL TEST DATA	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-13

R&M Laboratory Test Report - UU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-611-MW (TB-2c)	Sampled by:	PKH	Date Sampled:	11/15/2006
Sample No.:	14	Received by:	RJM	Date Received:	11/20/2006
Depth:	60 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/22/2006	Lab #:	534

Test Method: ASTM D 2850 - 03 - Unconsolidated Undrained Triaxial Compression Test on Cohesive Soils

Initial Dry Density	121.6 pcf
Initial Moisture Content	14.2 %
Initial Height	4.92 inches
Initial Diameter	2.37 inches
Effective Confining Pressure	20.0 psi
Back Pressure	0.0 psi
B Pore Pressure Parameter	NA
T_{50}	NA
Load Rate	0.047 in/min



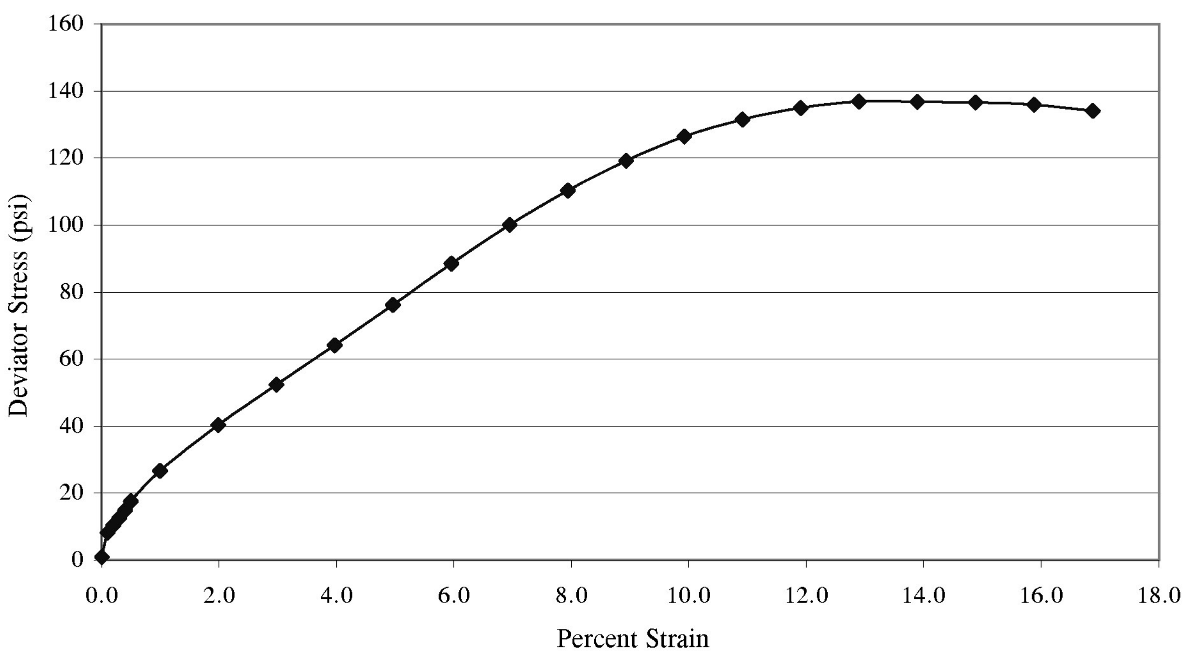
DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES		GRID: KENAI
DATE: JAN. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	UU TRIAXIAL TEST DATA	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-14

R&M Laboratory Test Report - UU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-611-MW (TB-2c)	Sampled by:	PKH	Date Sampled:	11/15/2006
Sample No.:	16	Received by:	RJM	Date Received:	11/20/2006
Depth:	80 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/22/2006	Lab #:	534

Test Method: ASTM D 2850 - 03 - Unconsolidated Undrained Triaxial Compression Test on Cohesive Soils

Initial Dry Density	115.3 pcf
Initial Moisture Content	17.0 %
Initial Height	5.04 inches
Initial Diameter	2.37 inches
Effective Confining Pressure	30.0 psi
Back Pressure	0.0 psi
B Pore Pressure Parameter	NA
T_{50}	NA
Load Rate	0.046 in/min



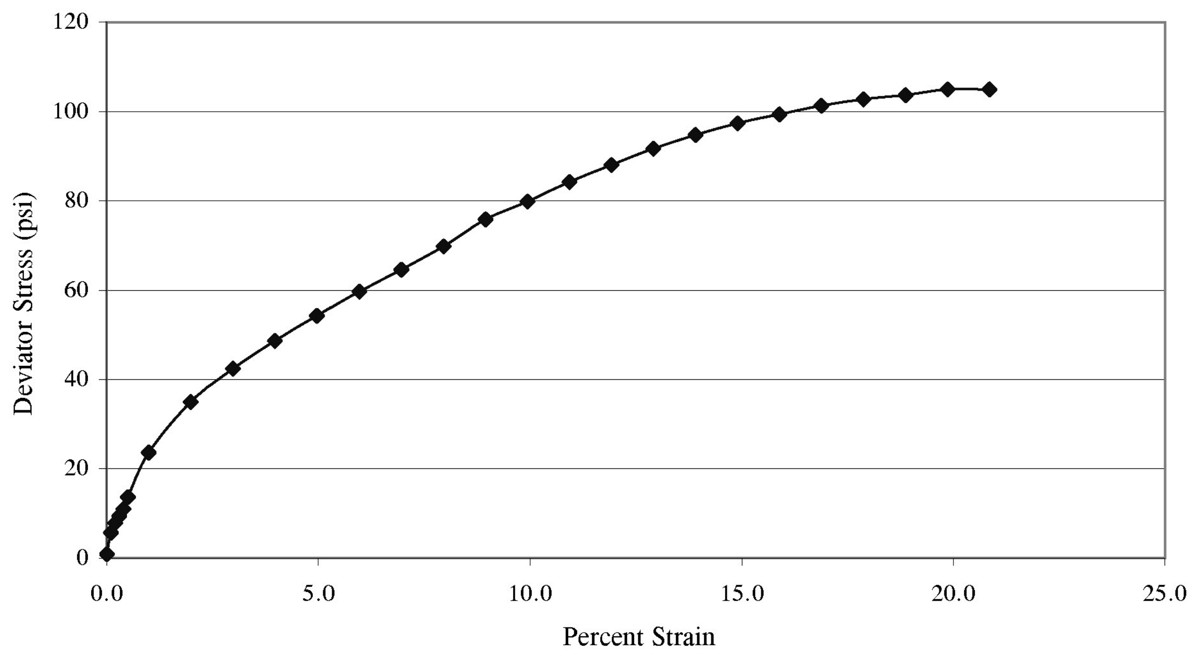
DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA		FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES			GRID: KENAI
DATE: JAN. 2007	CONSTRUCTION SERVICES	UU TRIAXIAL		PROJ.NO: 1209.10
SCALE: N.T.S.	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	TEST DATA		DWG.NO: C-15

R&M Laboratory Test Report - UU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-617-MW (TB-4a)	Sampled by:	PKH	Date Sampled:	11/19/2006
Sample No.:	13	Received by:	RJM	Date Received:	11/20/2006
Depth:	55 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/26/2006	Lab #:	534

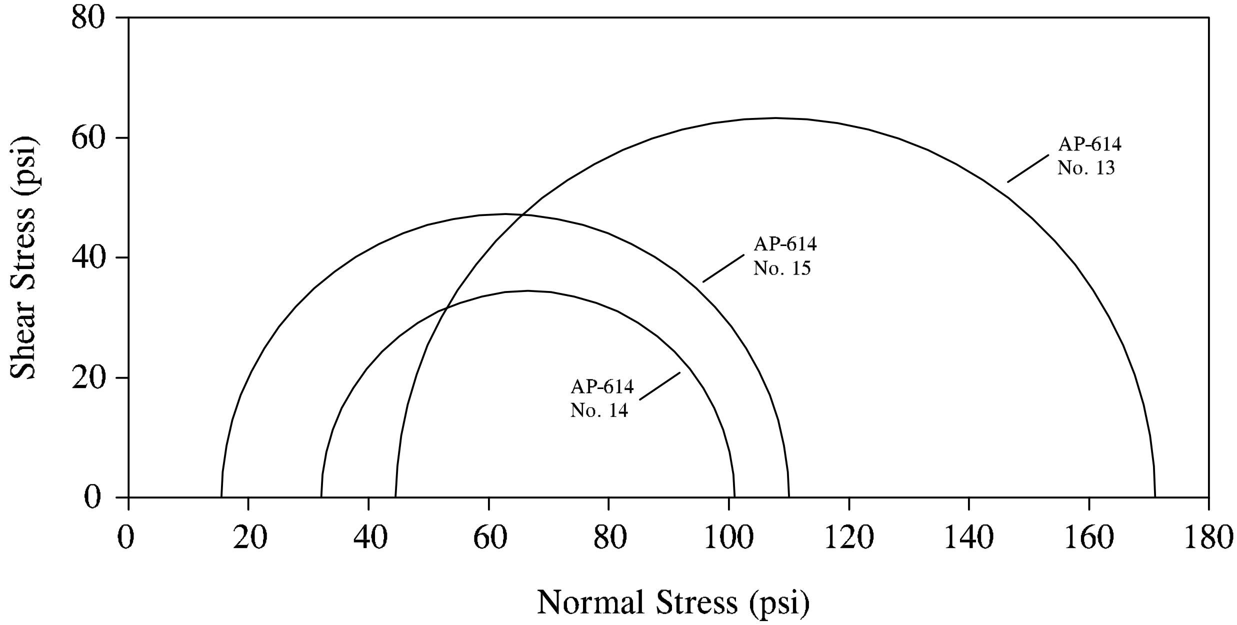
Test Method: ASTM D 2850 - 03 - Unconsolidated Undrained Triaxial Compression Test on Cohesive Soils

Initial Dry Density	115.6 pcf
Initial Moisture Content	17.1 %
Initial Height	5.04 inches
Initial Diameter	2.42 inches
Effective Confining Pressure	40.0 psi
Back Pressure	0.0 psi
B Pore Pressure Parameter	NA
T_{50}	NA
Load Rate	0.047 in/min

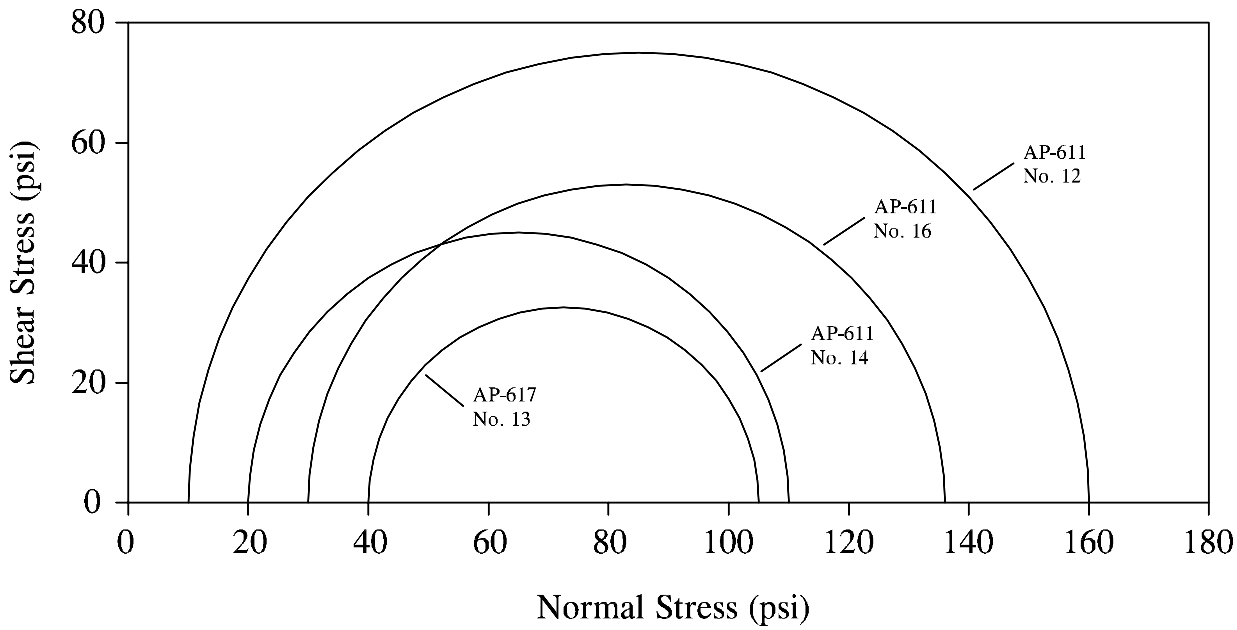


DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES		GRID: KENAI
DATE: JAN. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	UU TRIAXIAL TEST DATA	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-16

Mohr Diagram - CU Triaxial Tests



Mohr Diagram - UU Triaxial Tests



DWN:	R.M.P
CKD:	C.H.R.
DATE:	FEB. 2007
SCALE:	N.T.S.

R&M
R&M CONSULTANTS, INC.
ENGINEERING ∘ SURVEYING ∘ EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

MOHR DIAGRAMS

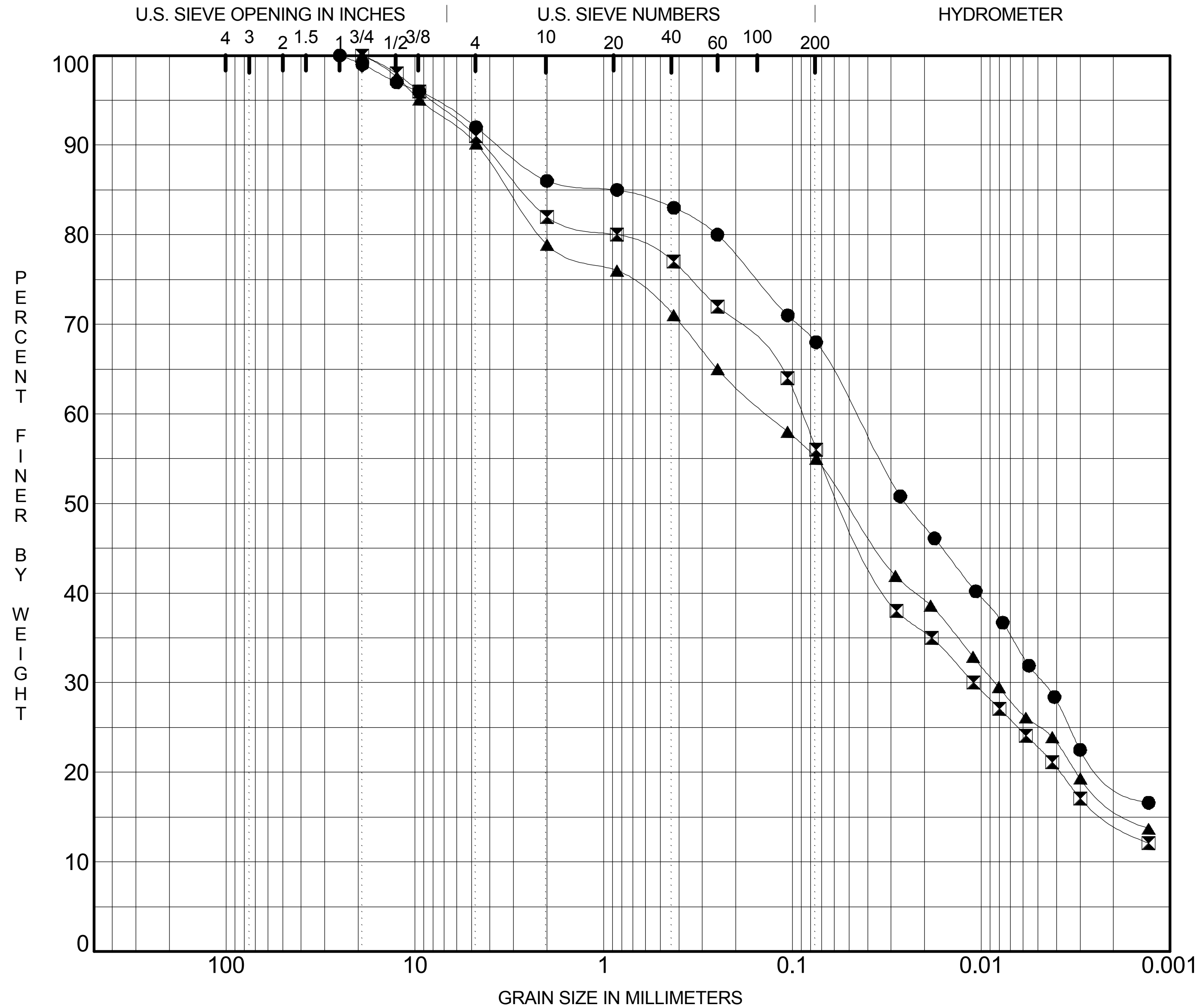
FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-17

Permeability Test Results

ASTM D 2434-68(2000) Permeability of Granular Soils (Constant Head)

Test Hole	Sample No.	Depth (ft)	Soil Description	Dry Density (pcf)	K (ft/sec)
AP-620-MW (TB-02)	5	15	Poorly Graded Sand with Gravel	95.3	1.3×10^{-4}
AP-621-MW (TB-03)	4	10	Poorly Graded Sand with Gravel	98.6	1.8×10^{-4}
AP-621-MW (TB-03)	6	20	Poorly Graded Sand with Gravel	100.5	1.3×10^{-4}

DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES		GRID: KENAI
DATE: FEB. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	PERMEABILITY TEST RESULTS	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-18



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	AP-627	3	5.0 - 6.5	CL*	F3*	15%					
⧗	AP-626	1	0.5 - 1.5	CL-ML*	F4*	25%					
▲	AP-625	1	0.5 - 1.0	CL-ML*	F4*	78%					

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	AP-627	3	25.000	0.047	0.005		8	24	68	47.3
⧗	AP-626	1	19.000	0.089	0.011		9	35	56	35.5
▲	AP-625	1	19.000	0.135	0.008		10	35	55	39.1

*Estimated Classification

DWN:	R.M.P.
CKD:	C.H.R.
DATE:	FEB. 07
SCALE:	N.T.S.

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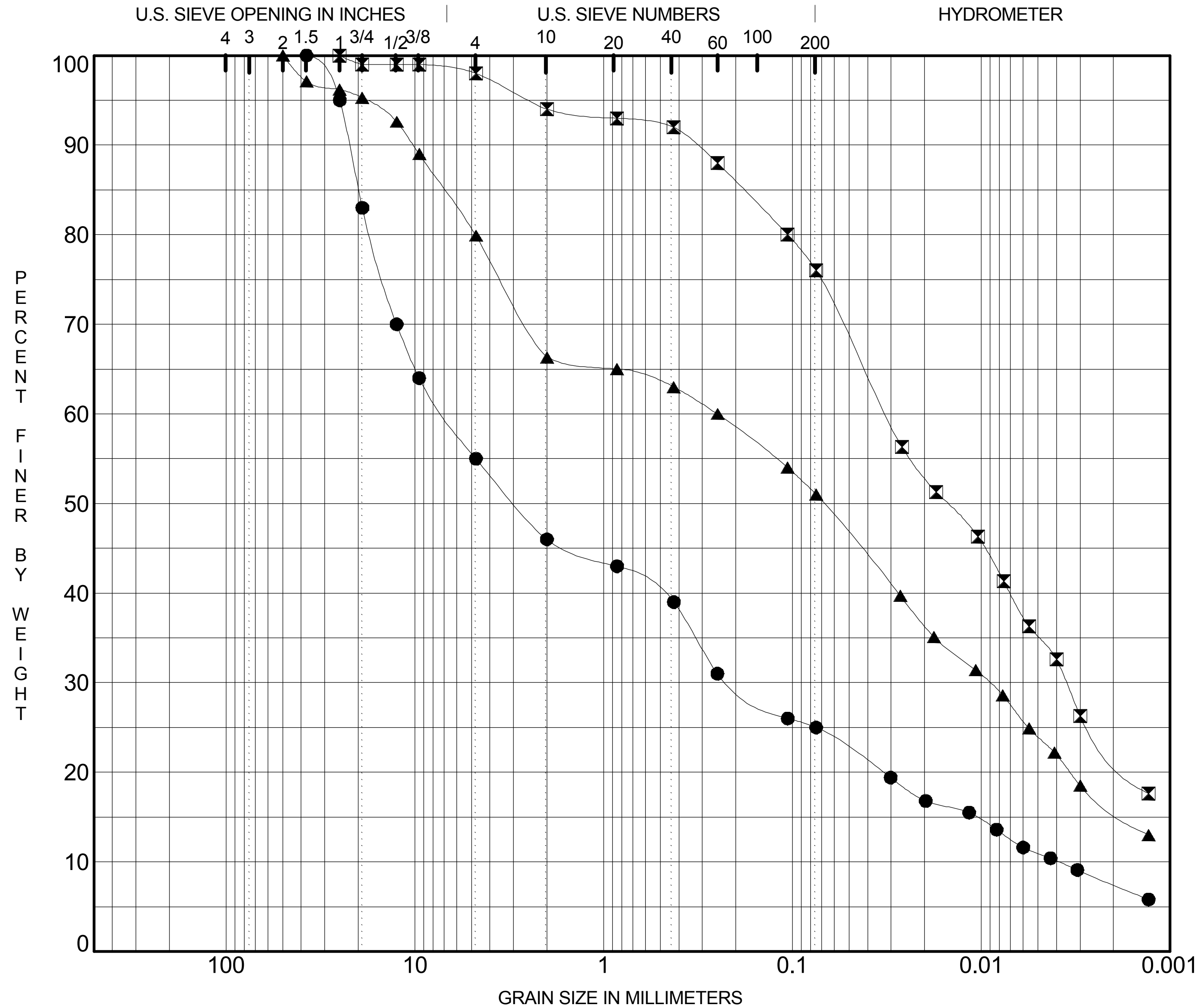
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI BLUFF EROSION
KENAI, ALASKA
GRADATION CURVES
(TILL W/24 HR. HYDROMETER)

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-19



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	AP-624	1	0.5 - 1.0	GC*	F2	22%				1.63	1795.52
⧗	AP-614-MW	18	80.0 - 81.5	CL*	F3*	17%					
▲	AP-617-MW	17	75.0 - 76.5	CL*	F3*	15%					

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	AP-624	1	37.500	6.981	0.211	0.004	45	30	25	16.9
⧗	AP-614-MW	18	25.000	0.032	0.004		2	22	76	52.8
▲	AP-617-MW	17	50.000	0.25	0.009		21	28	51	36.2

*Estimated Classification

DWN:	R.M.P.
CKD:	C.H.R.
DATE:	FEB. 07
SCALE:	N.T.S.

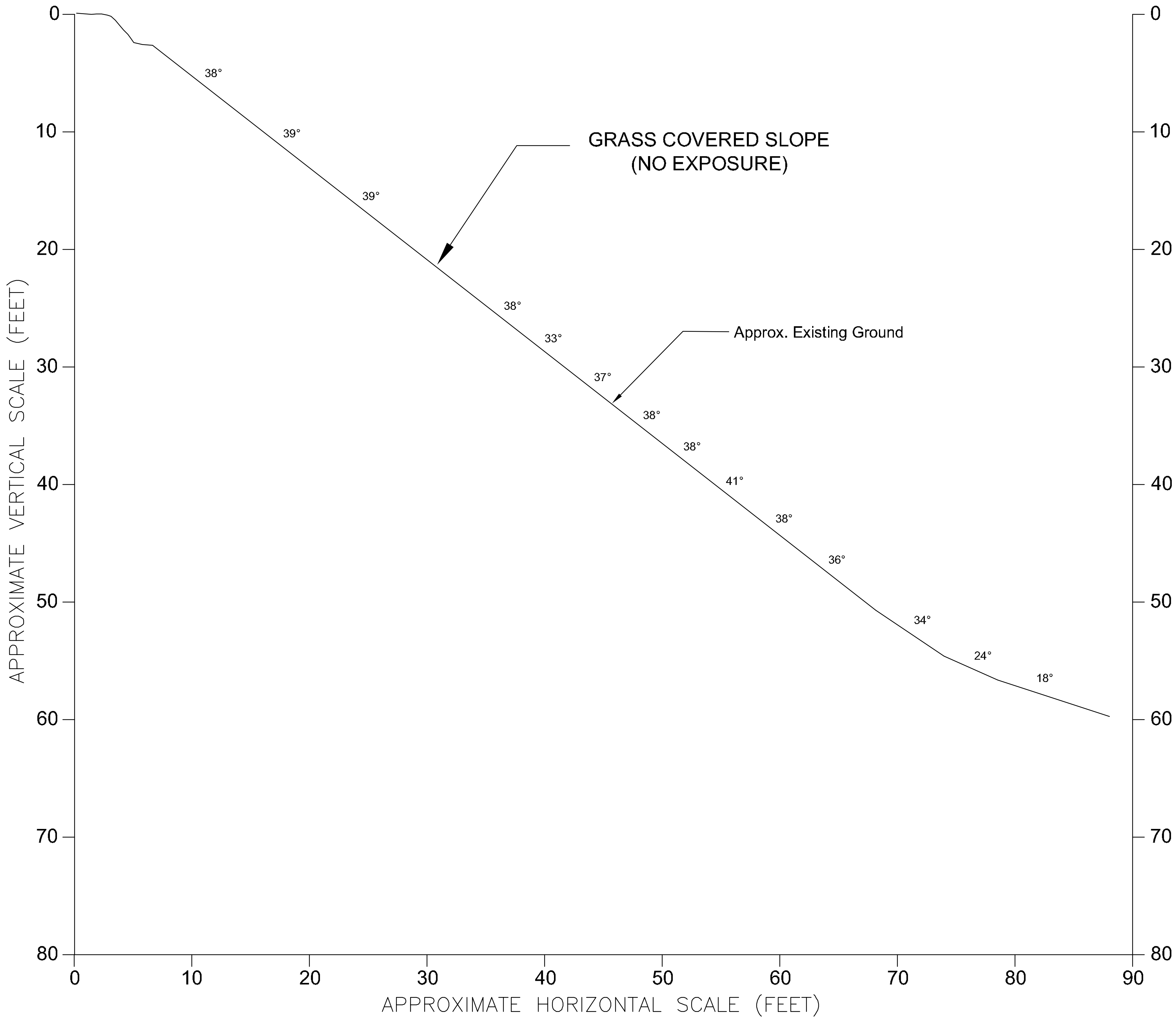
R&M CONSULTANTS, INC.
ENGINEERING • SURVEYING • EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI BLUFF EROSION
KENAI, ALASKA
GRADATION CURVES
(TILL W/24 HR. HYDROMETER)

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-20

APPENDIX D
SOIL PROFILES

SP-A



LOOKING NORTH ACROSS CEMETERY CREEK AT SP-A.
ICINGS WERE OBSERVED IN THE TREES ON EITHER SIDE
OF THE GRASSY STRIP IN NOVEMBER, 2006.
5 OCT. 2006

LEGEND

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

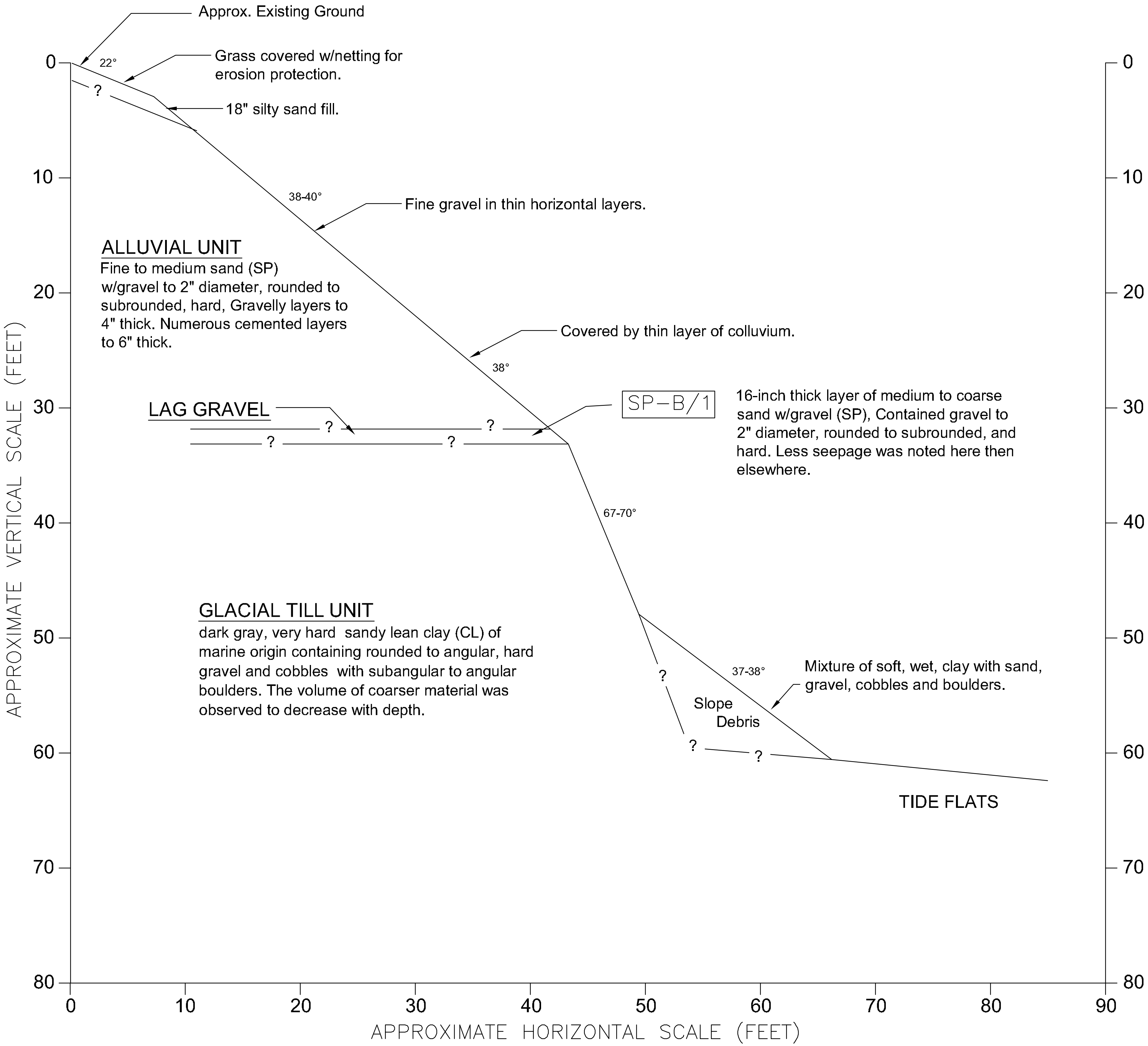
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE
SUBMITTED: C.H.R.	SP-A

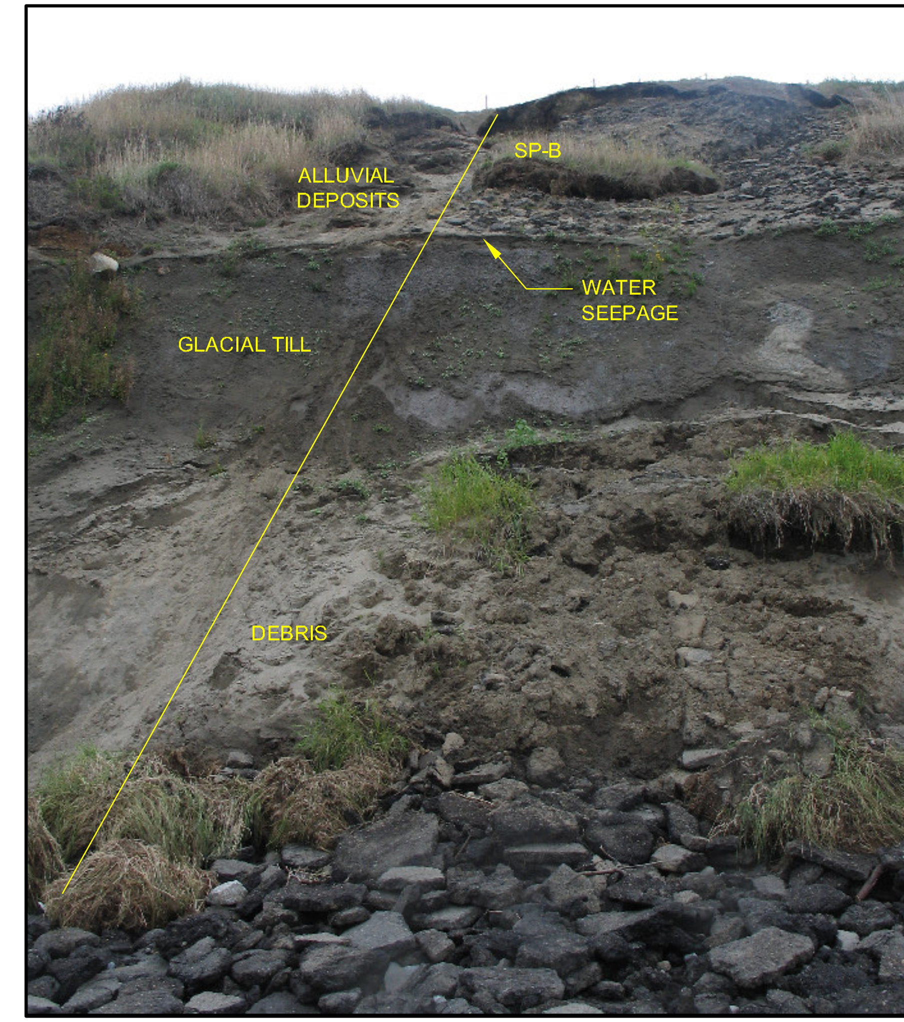
DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D-01

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

CORPS OF ENGINEERS U. S. ARMY

SP-B





LOOKING NORTH AT SP-B. THE SLABS AT THE BASE OF THE SLOPE CONSIST OF ASPHALT.
10 OCT. 2006

LEGEND

SP–A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

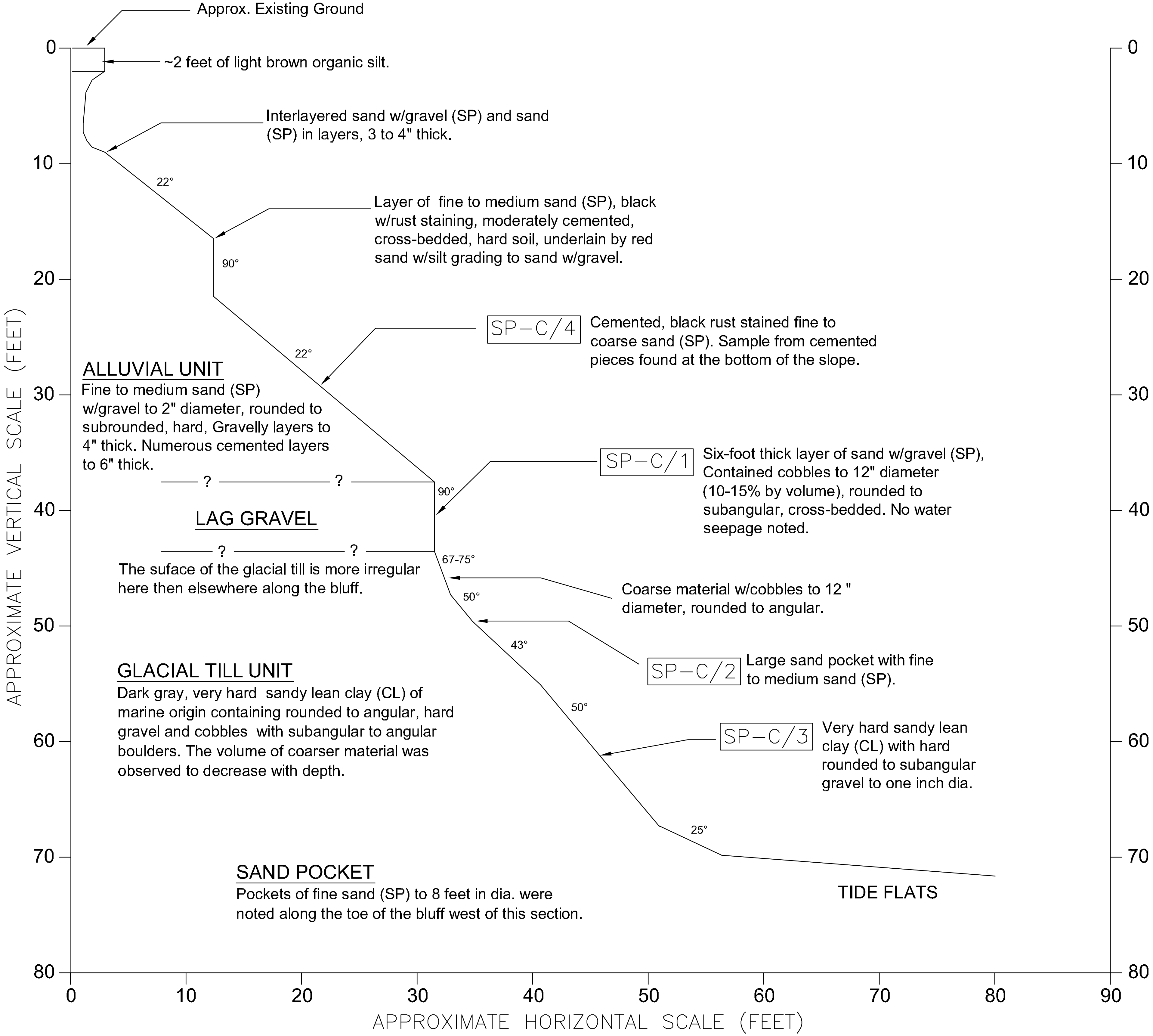
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB–05–D–0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	GENERALIZED SOIL PROFILE SP–B

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D–02

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-C



LOOKING NORTH AT SP-C. UPPER SLOPES ARE STEEPER THAN ELSEWHERE, APPARENTLY DUE TO CEMENTATION. THE PRESENCE OF THIS CEMENT MAY BE BLOCKING WATER FLOW OUT OF THE SLOPE IN THIS AREA. WHAT APPEAR TO BE LARGE DARK GRAY BOULDERS AT THE BOTTOM OF THE BLUFF ARE COMPOSED OF VERY HARD CLAY.
12 OCT. 2006

LEGEND

SP–A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB–05–D–0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	GENERALIZED SOIL PROFILE SP–C

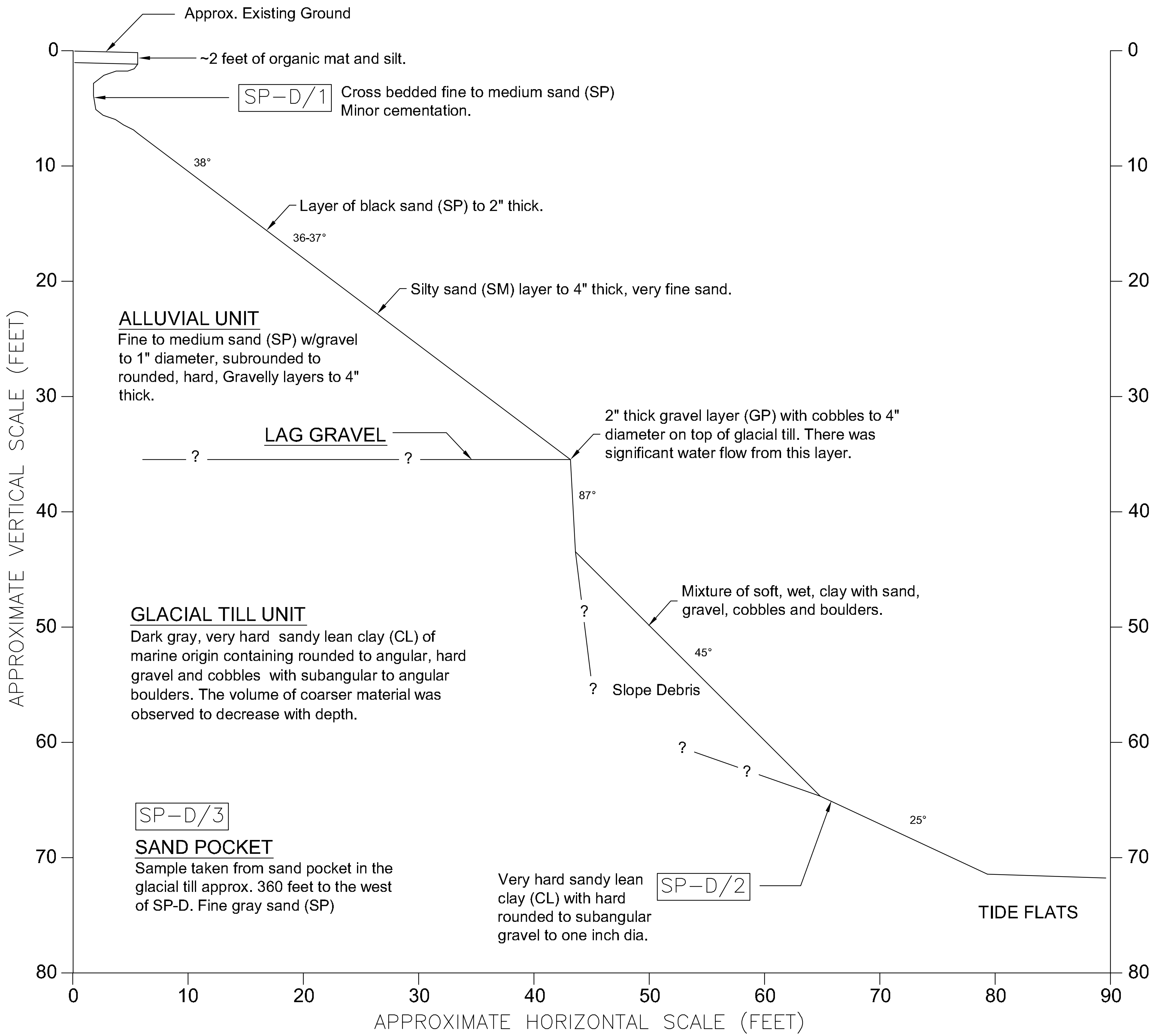
DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D–03

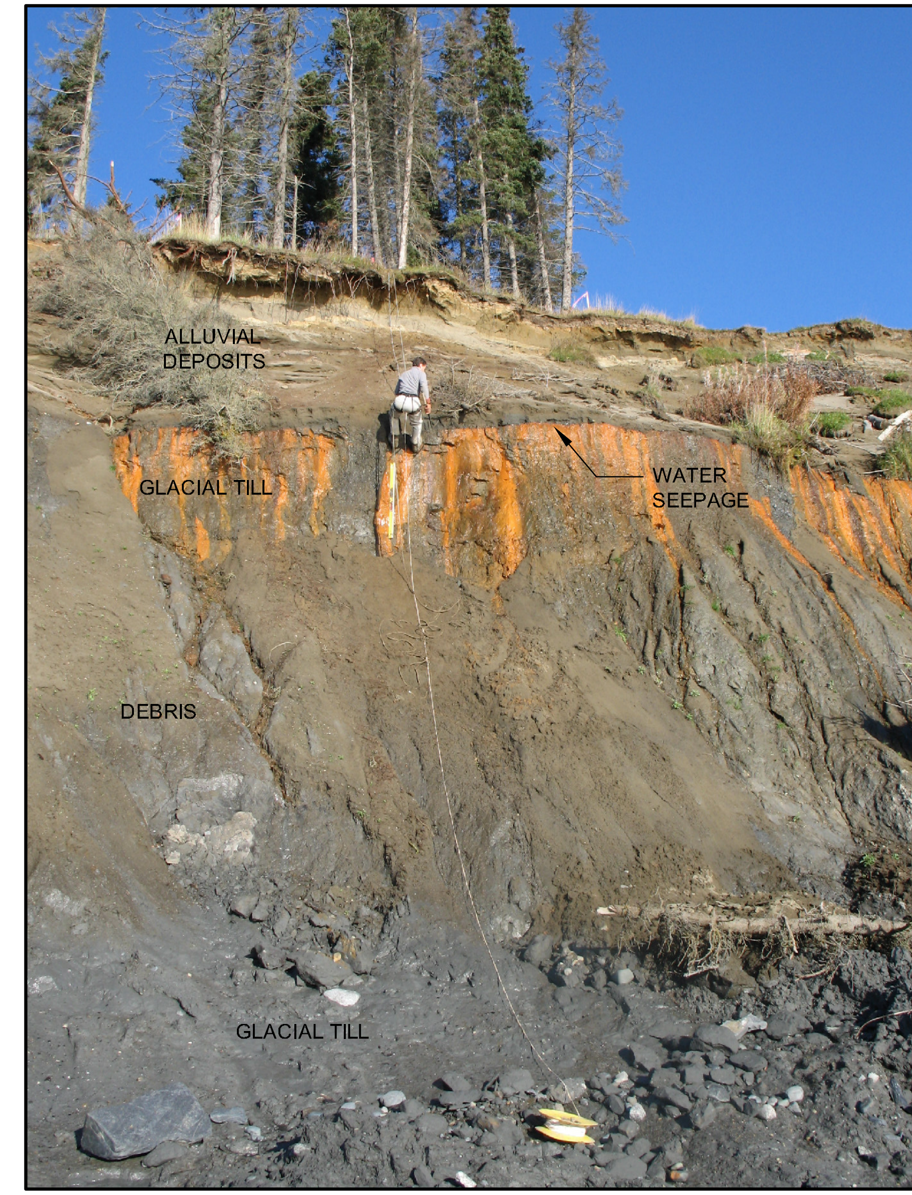
project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

CORPS OF ENGINEERS

U. S. ARMY

SP-D





LOOKING NORTH AT SP-D. ORANGE RUST STAINING WAS FOUND ON THE GLACIAL TILL IN AREAS WHERE SIGNIFICANT WATER FLOWS OUT OF THE LAG GRAVEL.
12 OCT. 2006

LEGEND

SP–A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

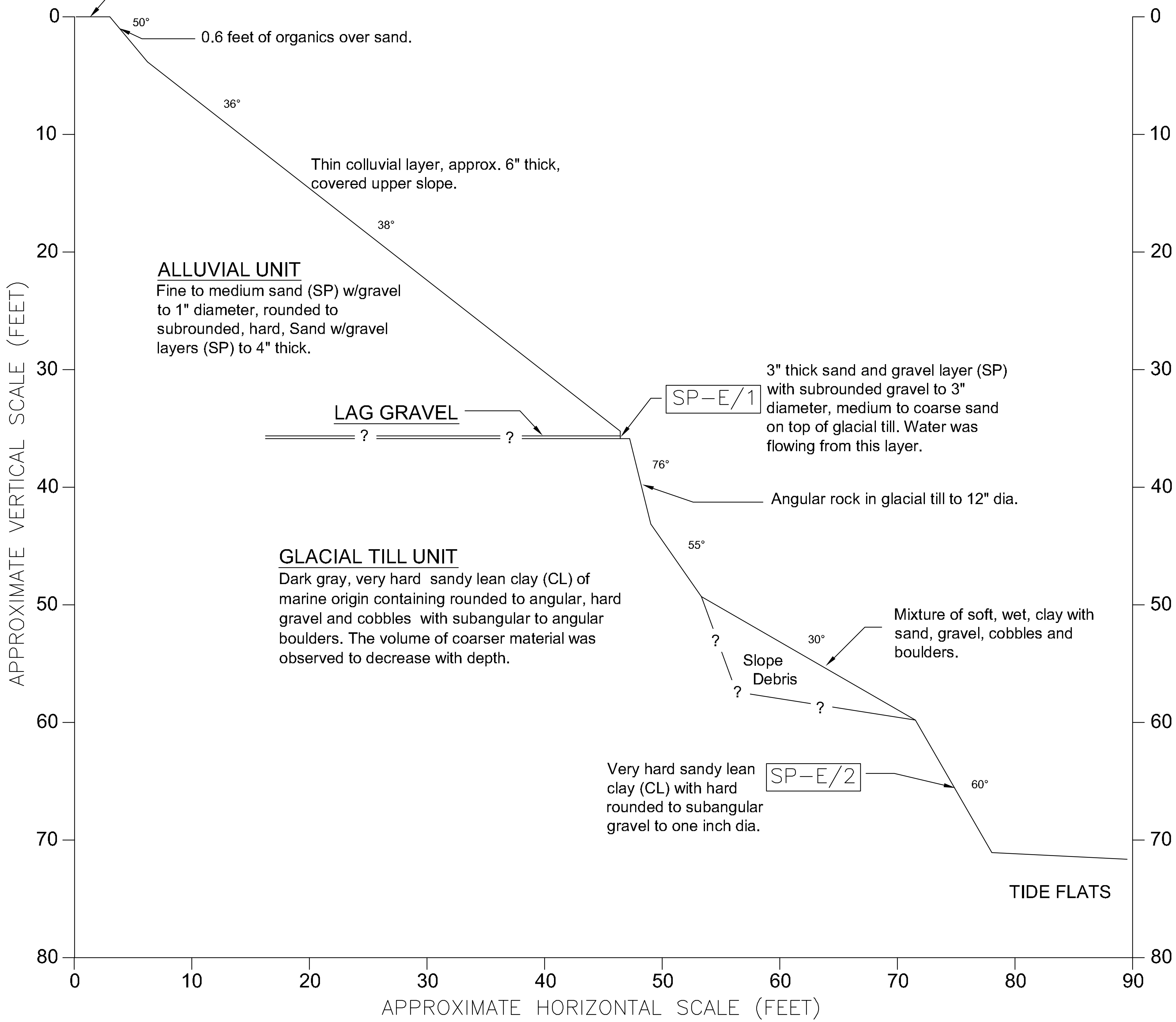
CONTRACT NO. W911KB–05–D–0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	GENERALIZED SOIL PROFILE SP–D

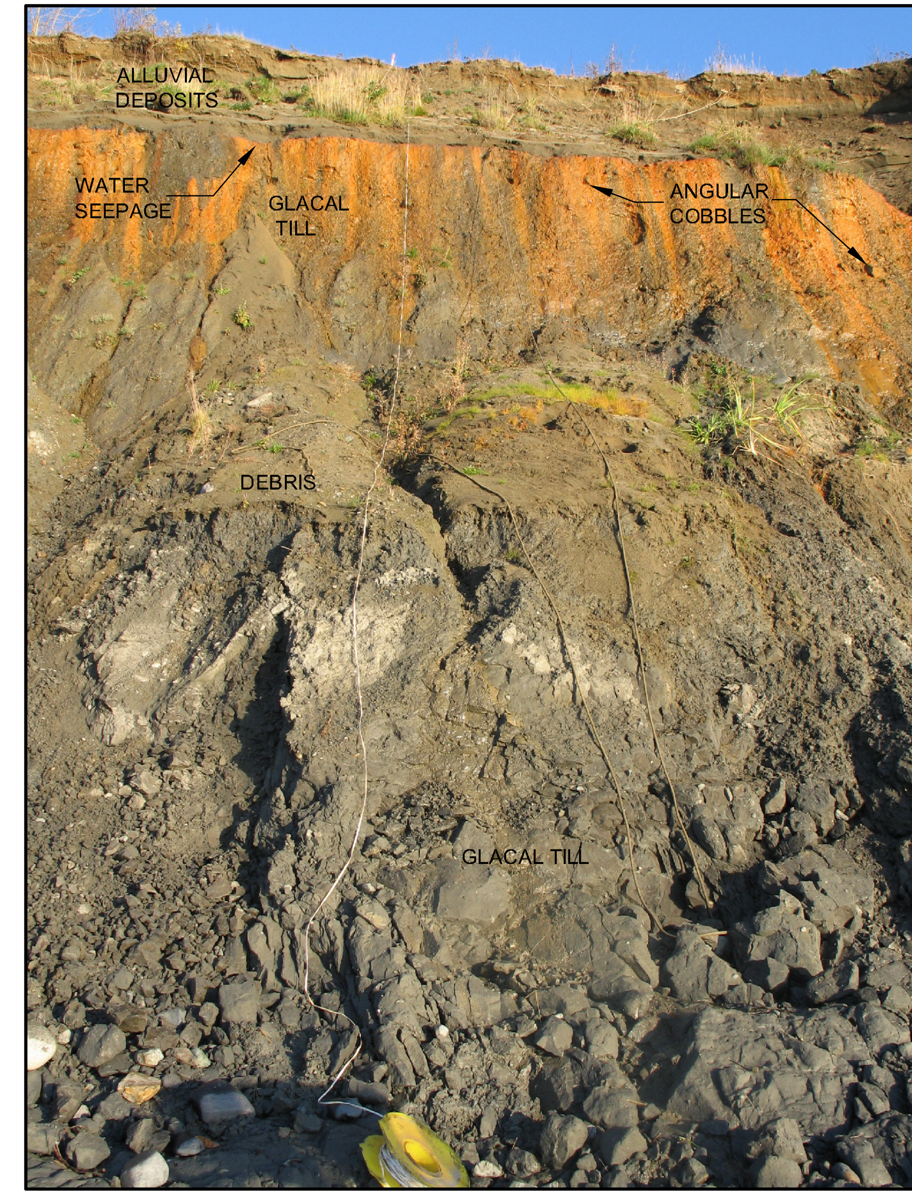
DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D–04

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

CORPS OF ENGINEERS U. S. ARMY

SP-E





LOOKING NORTH AT SP-E. THE GLACIAL TILL EXHIBITS THE CHARACTERISTICS OF SOFT BEDROCK SUCH AS JOINTS AND OTHER STRUCTURAL FEATURES.
13 OCT. 2006

LEGEND

SP-A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

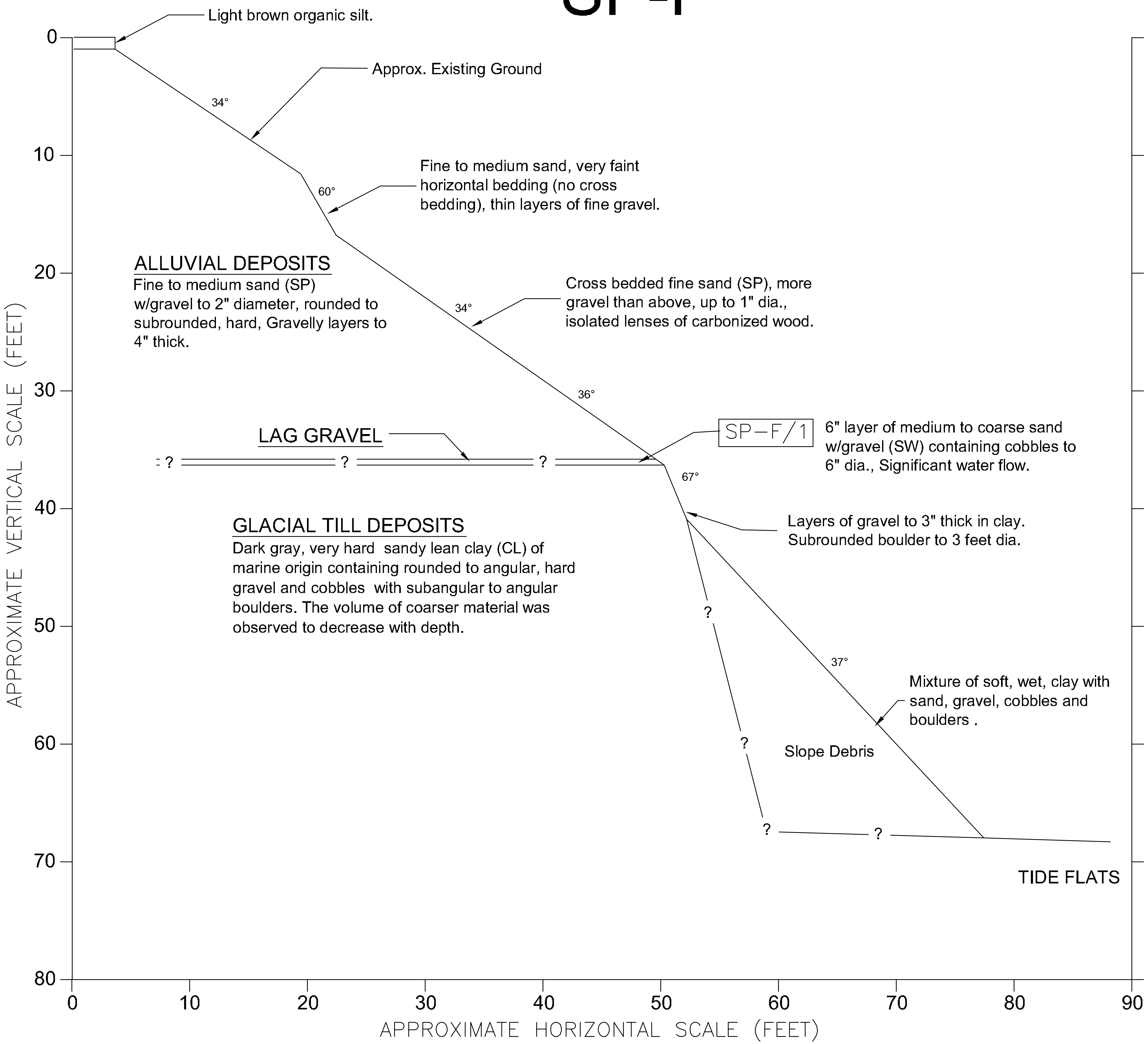
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

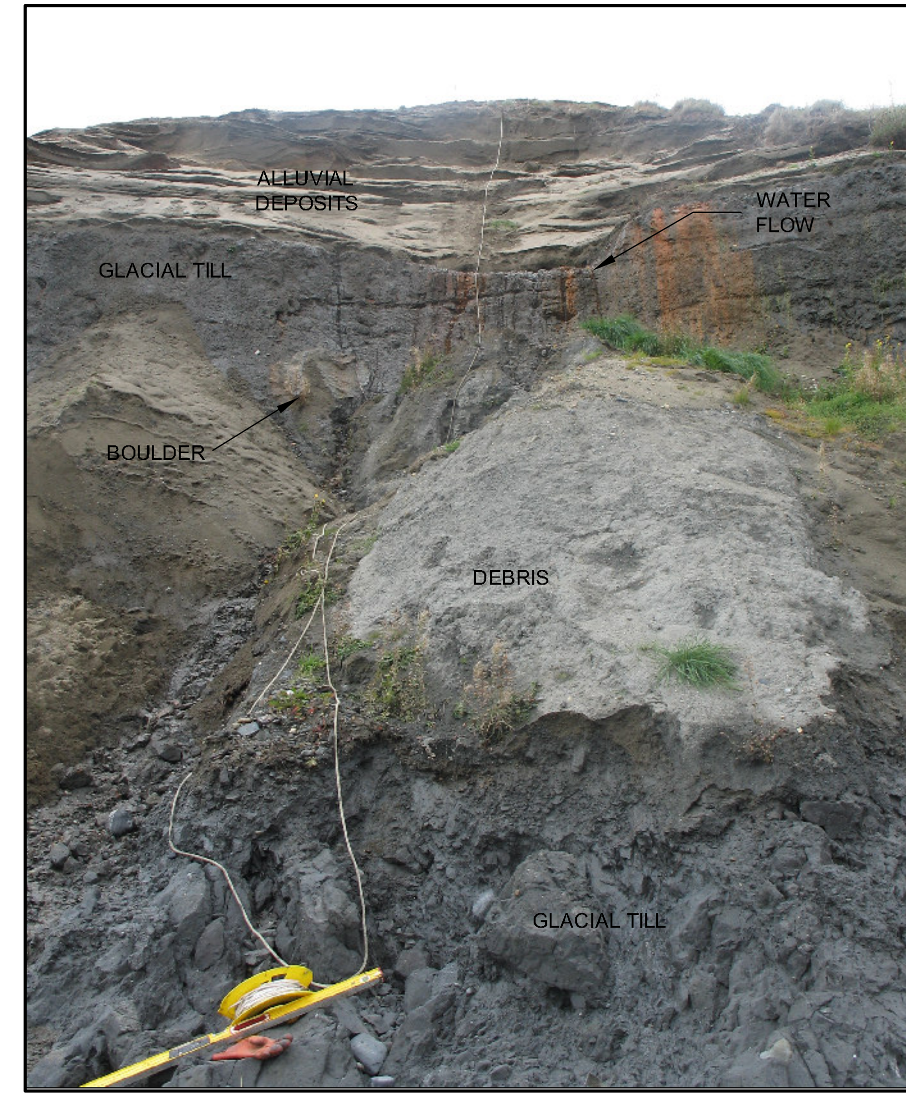
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE SP-E
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D-05

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-F





LOOKING NORTH AT SP-F. WATER FLOW IS HIGHER FROM LOW SPOT ON TOP OF GLACIAL TILL. OLD DRAINAGE CHANNELS ON TOP OF GLACIAL TILL MAY CONCENTRATE WATER FLOW IN SOME AREAS.
10 OCT. 2006

LEGEND

SP-A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.
DRAWN: P.K.H.
CHECKED: C.H.R.
SUBMITTED: C.H.R.

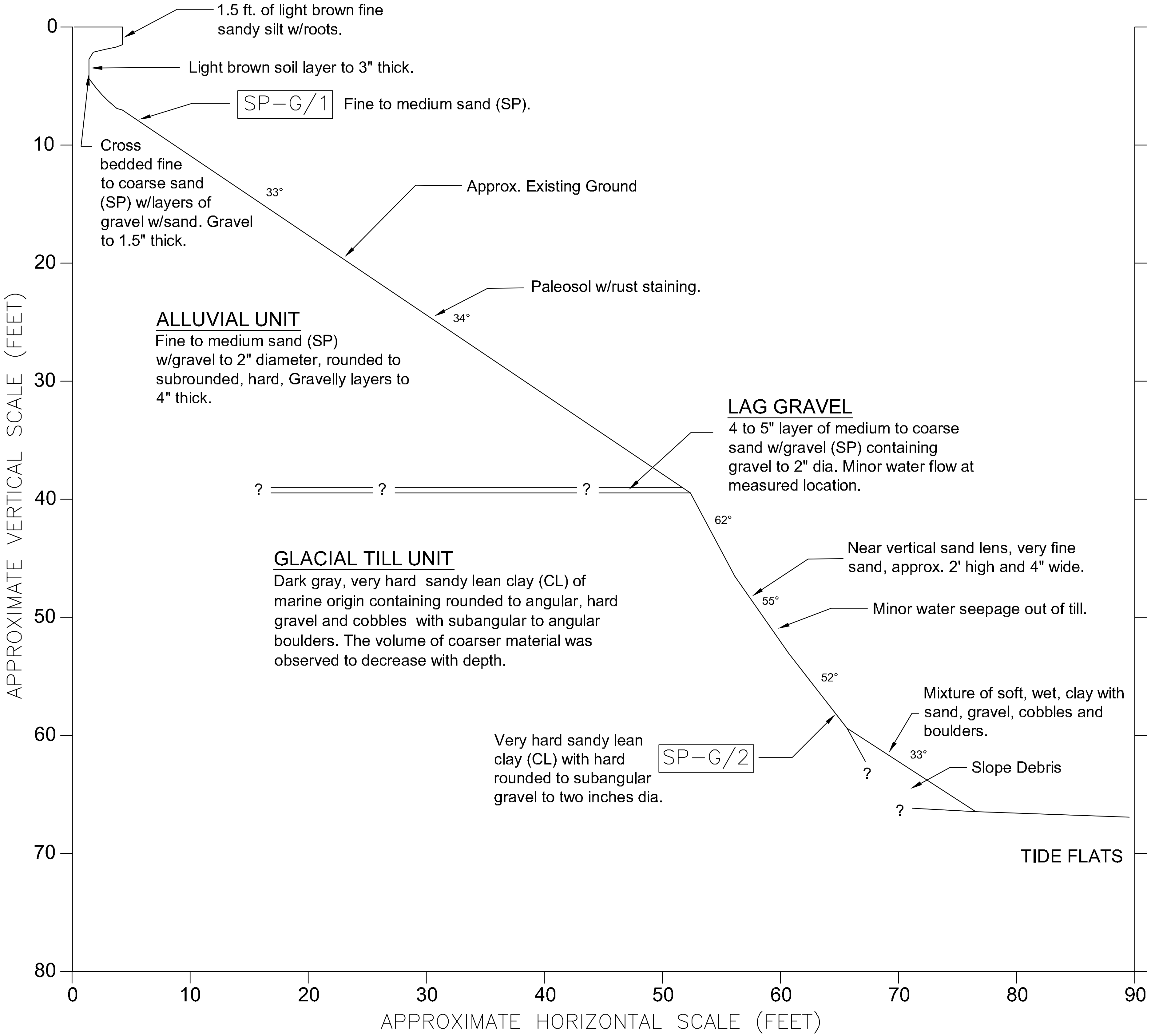
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

GENERALIZED SOIL PROFILE
SP-F

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D-06

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-G



LOOKING NORTH AT SP-G. MOST OF THE EXPOSURE IS COVERED BY A THIN LAYER OF SAND. NOTE CHUNKS OF DARK GRAY CLAY AT BASE OF SLOPE.
10 OCT. 2006

LEGEND

SP–A/1	SAMPLE NO. AND APPROX. LOCATION
36°	APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB–05–D–0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

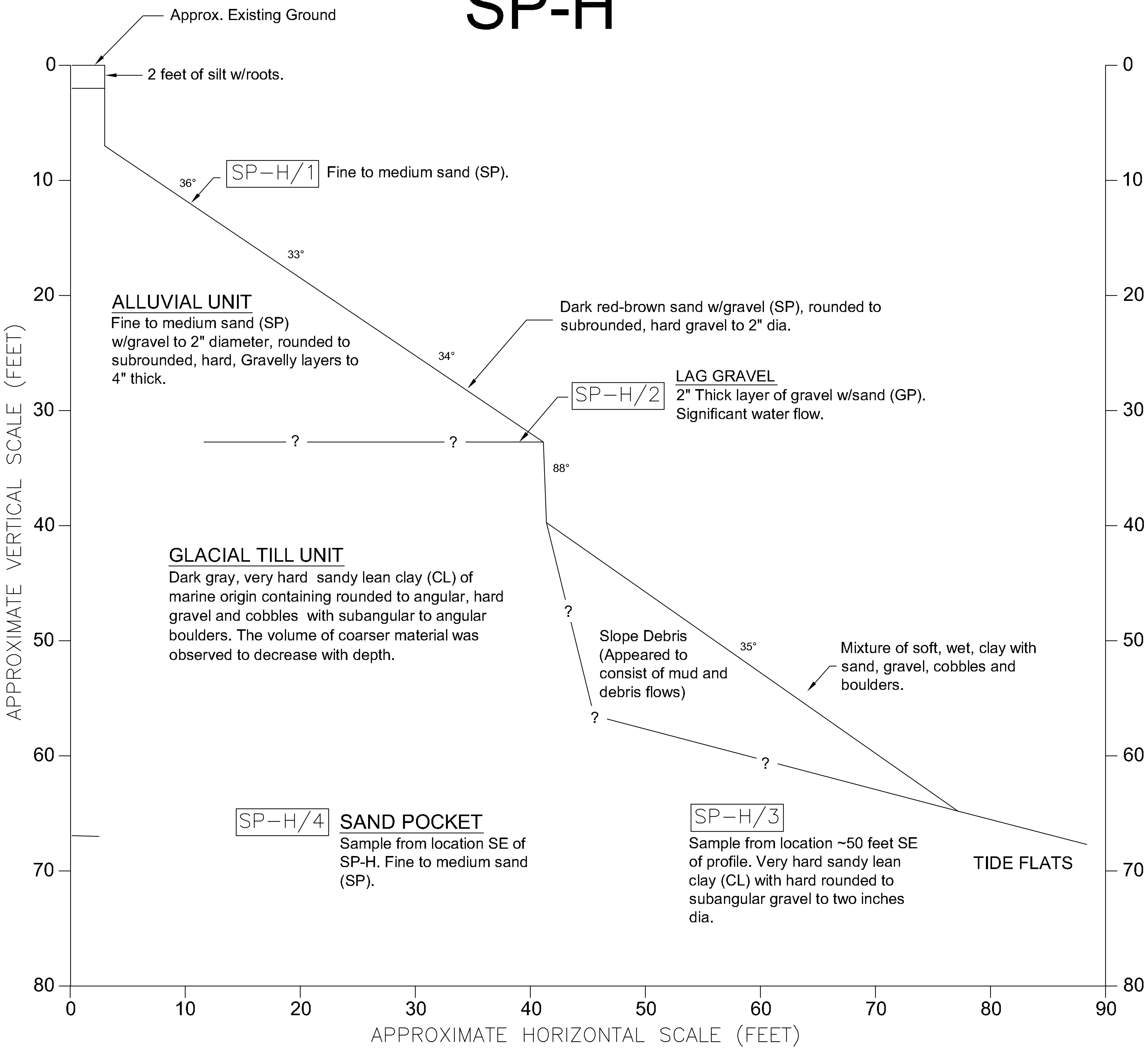
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

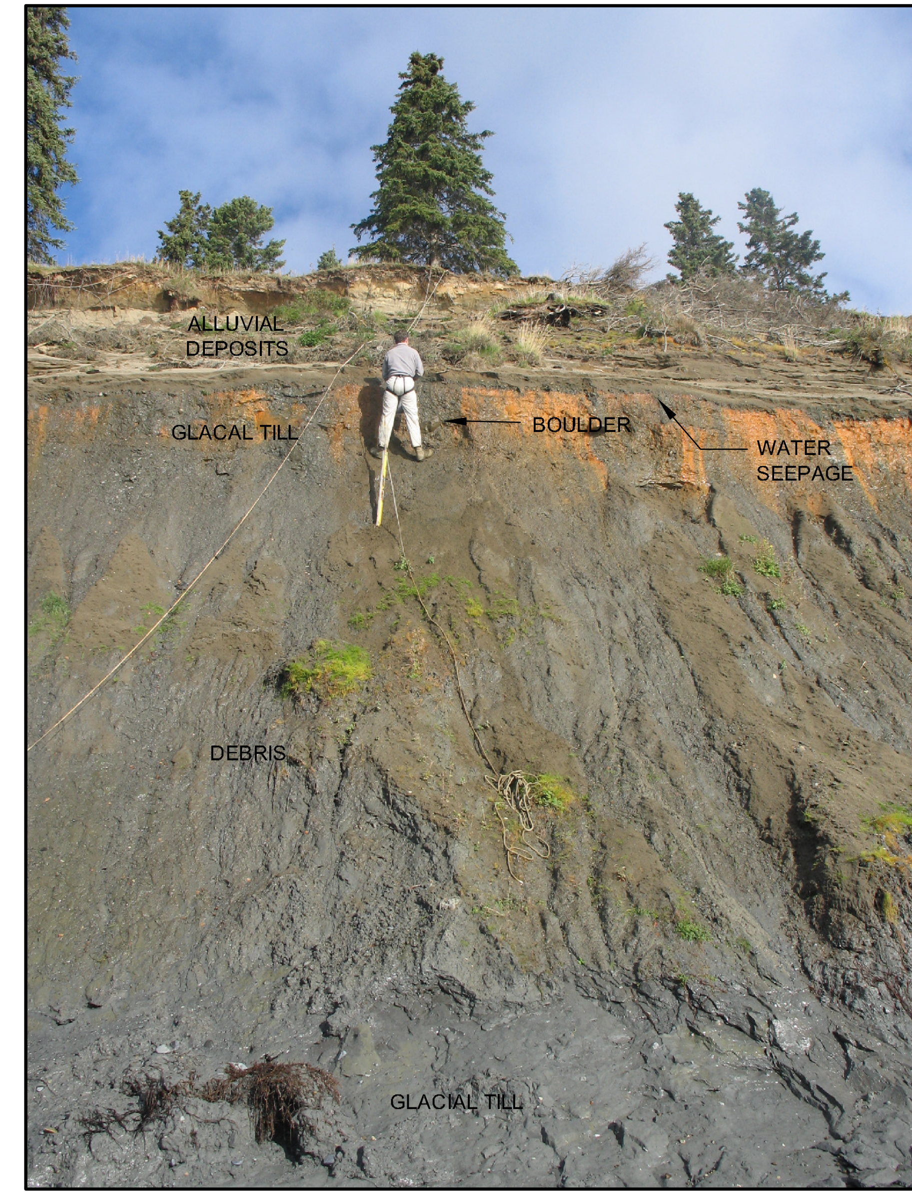
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE SP–G
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D–07

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-H





LOOKING NORTH AT SP-H.
12 OCT. 2006

LEGEND

SP–A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB–05–D–0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE
SUBMITTED: C.H.R.	SP–H

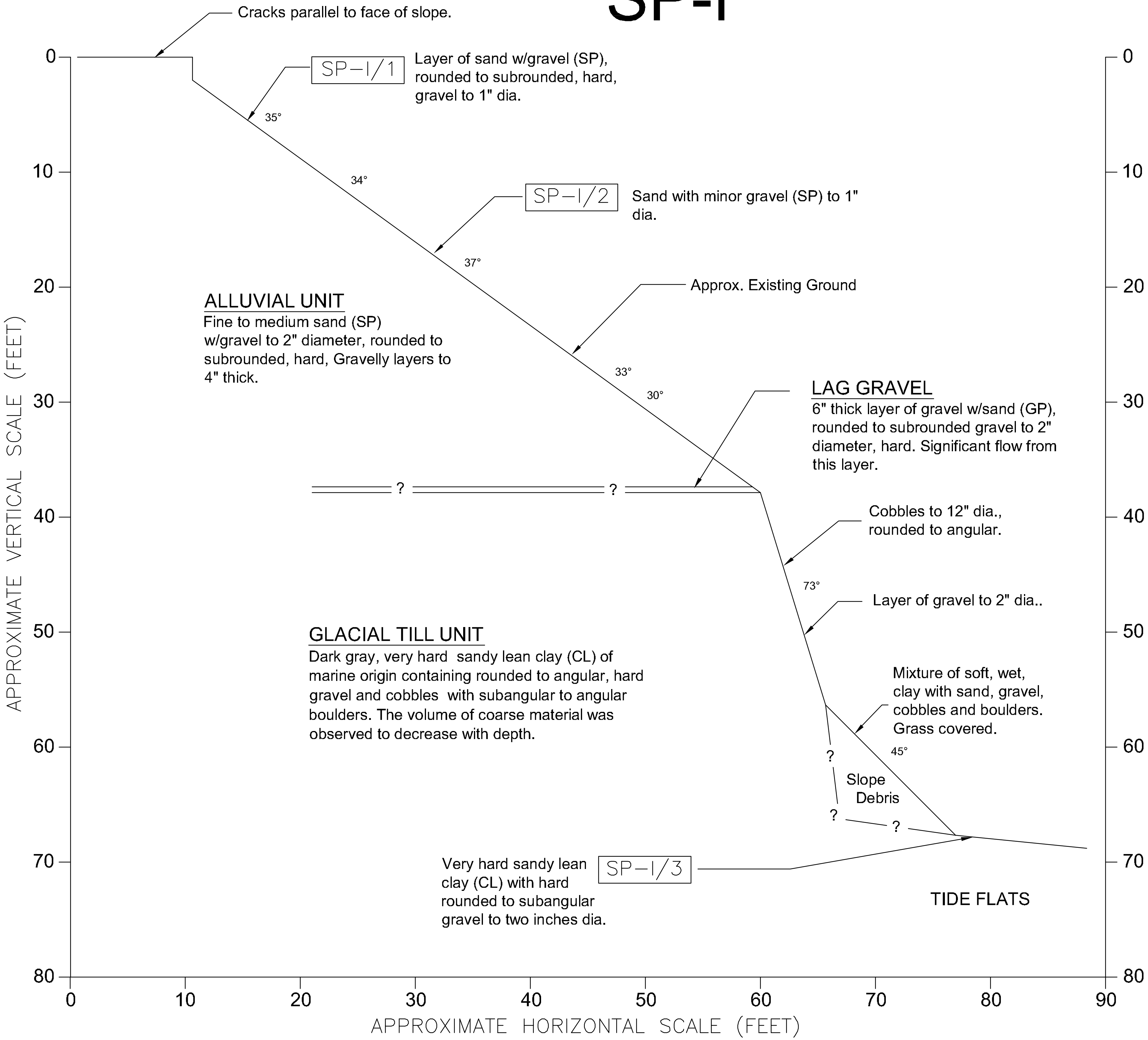
DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D–08

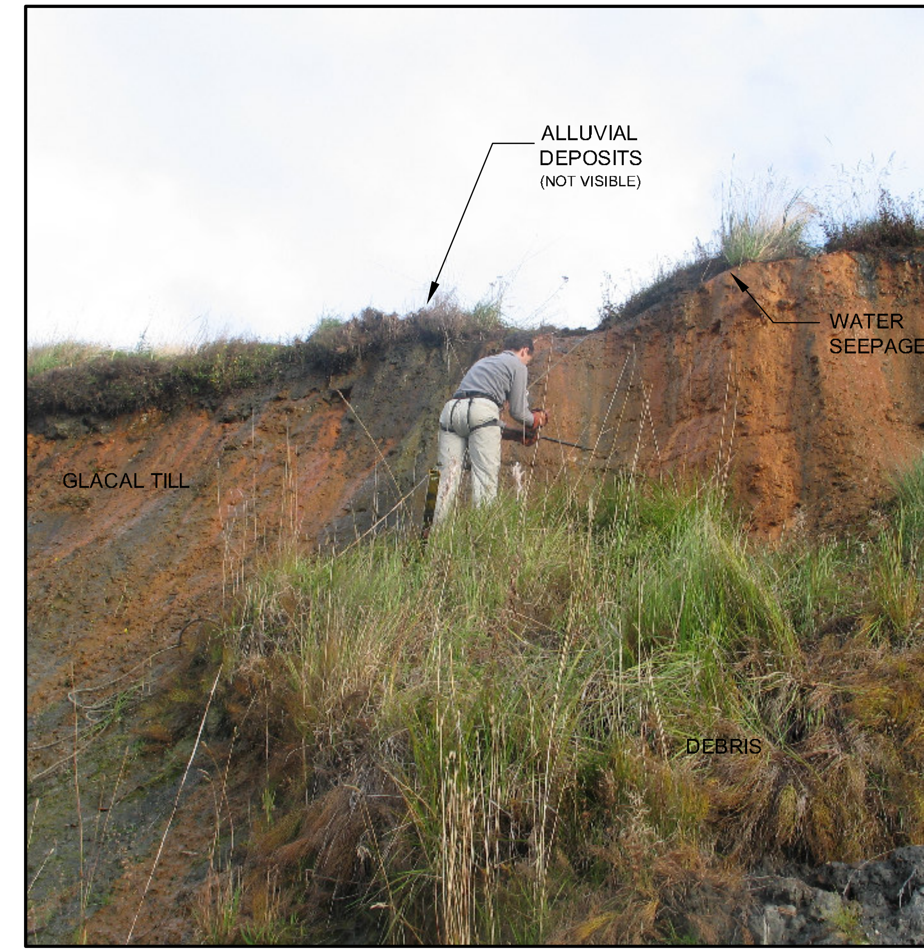
project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

CORPS OF ENGINEERS

U. S. ARMY

SP-I





LOOKING NORTH AT SP-I. THE AREA NEAR THIS PROFILE APPEARED TO HAVE THE HIGHEST RATE OF FLOW OF ANY LOCATION WITHIN THE STUDY AREA.
12 OCT. 2006

LEGEND

SP–A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB–05–D–0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

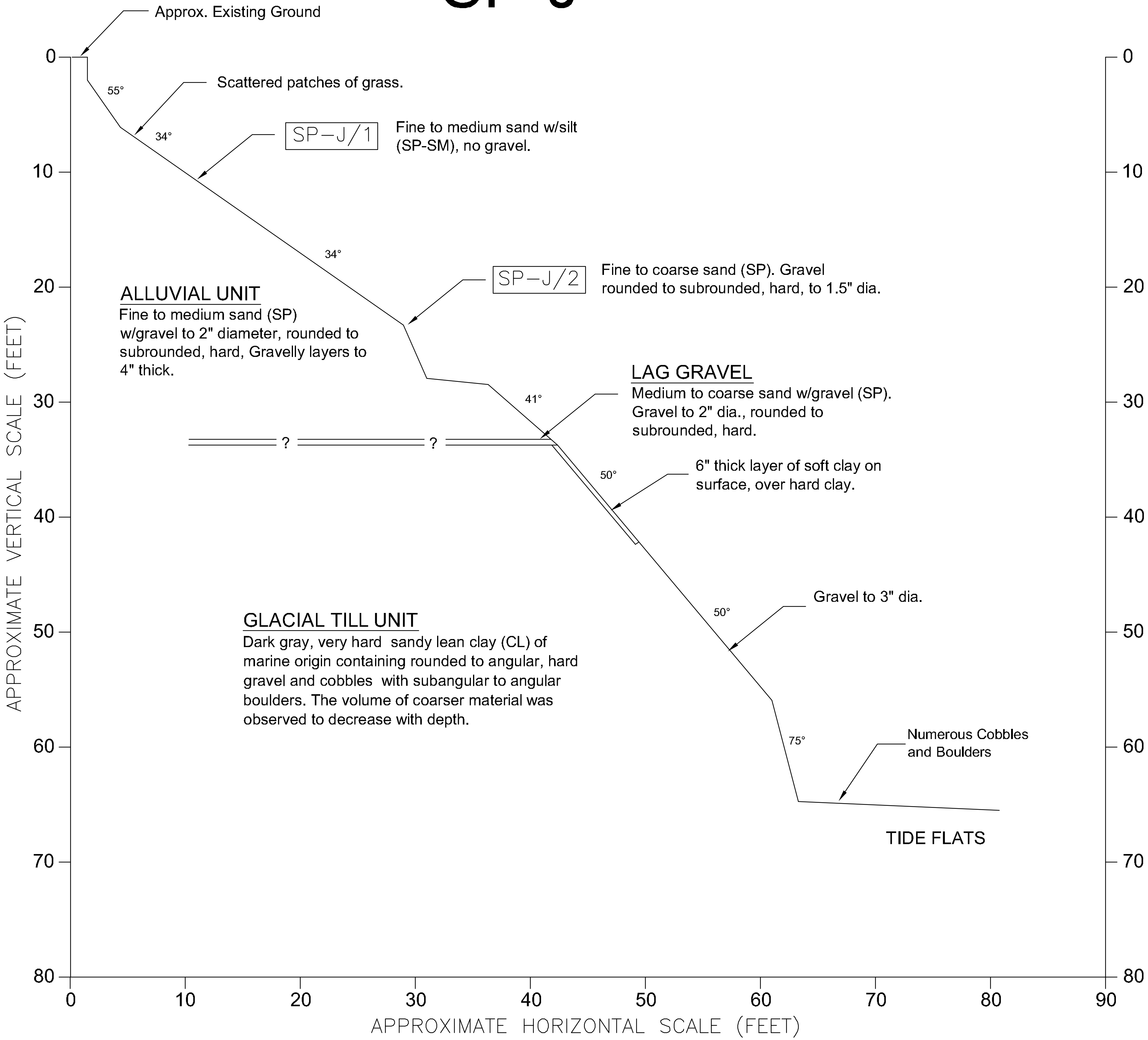
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

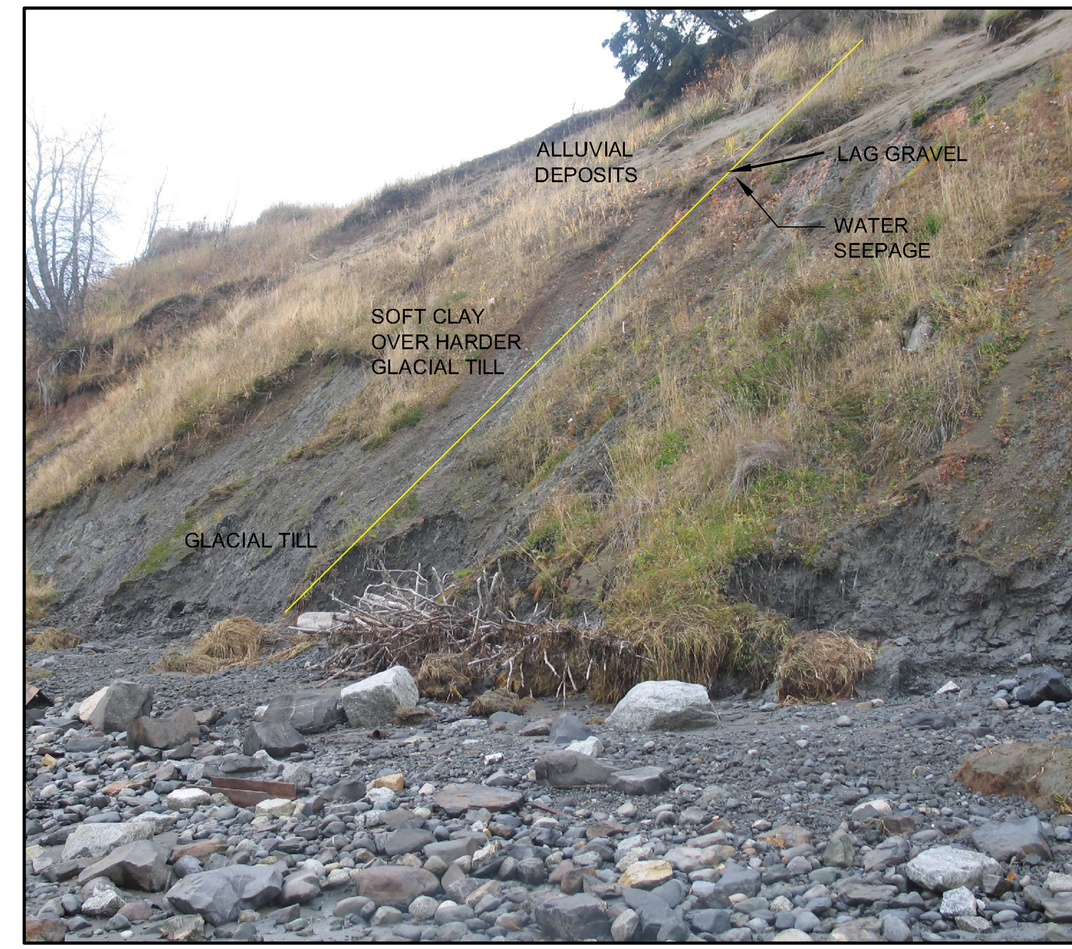
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE SP–I
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D–09

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-J





LOOKING NORTH AT SP-J.
12 OCT. 2006

LEGEND

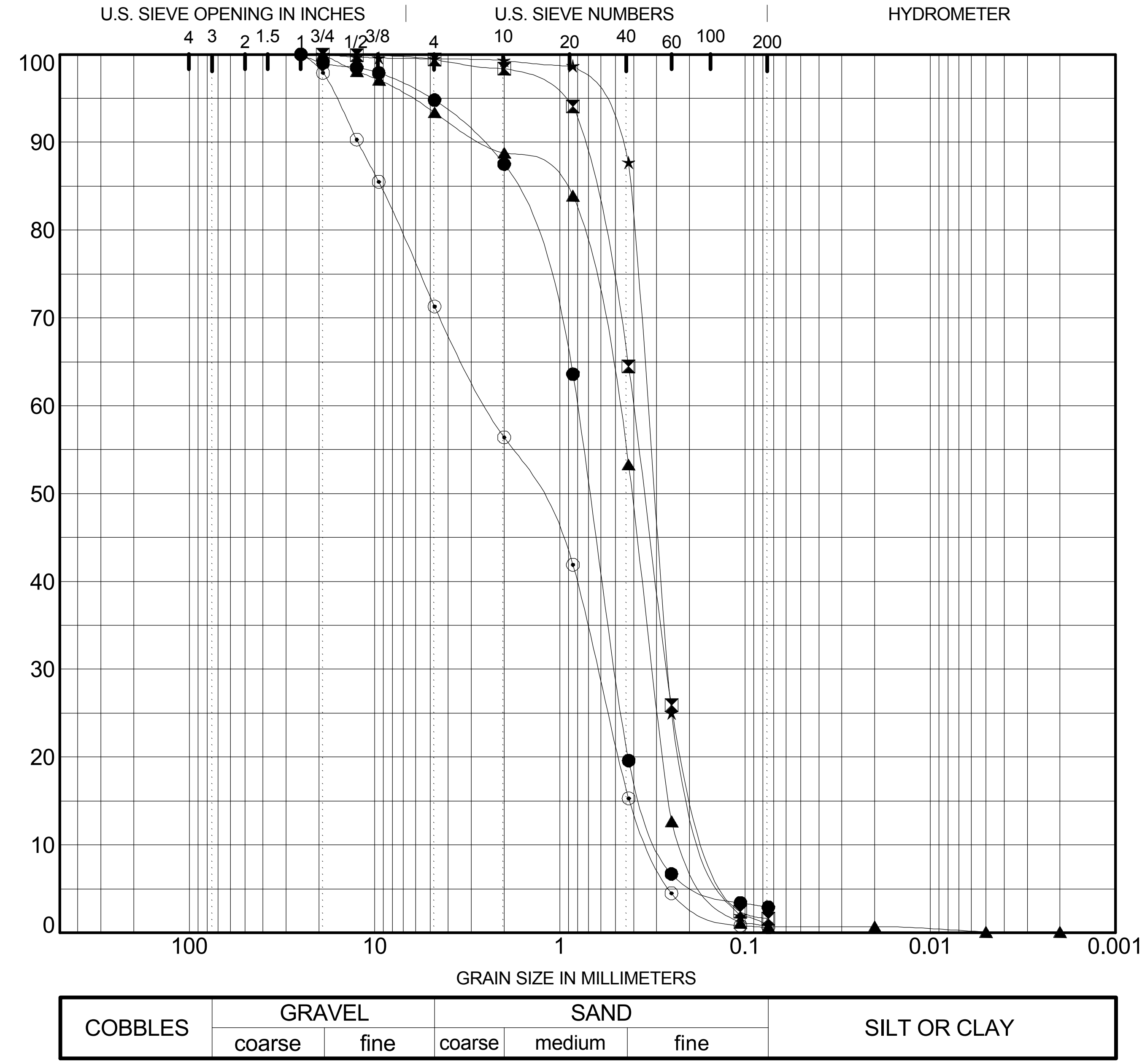
SP-A/1 SAMPLE NO. & APPROX. SAMPLE LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	GENERALIZED SOIL PROFILE SP-J

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D-10



	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-C	4	SURFACE	SP	NFS	9.8				1.09	2.80
⧗	SP-D	1	SURFACE	SP	NFS	0.9				1.25	2.86
▲	SP-G	1	SURFACE	SP	NFS	3.0				0.97	2.42
★	SP-H	1	SURFACE	SP	NFS	1.6				1.41	2.35
⊙	SP-I	1	SURFACE	SP	NFS	2.4				0.48	7.52

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-C	4	25.000	0.803	0.501	0.286	5	92	3	
⧗	SP-D	1	19.000	0.4	0.264	0.14	1	98	2	
▲	SP-G	1	19.000	0.495	0.313	0.205	7	93	1	
★	SP-H	1	19.000	0.336	0.261	0.143	1	99	1	
⊙	SP-I	1	25.000	2.465	0.623	0.328	29	71	1	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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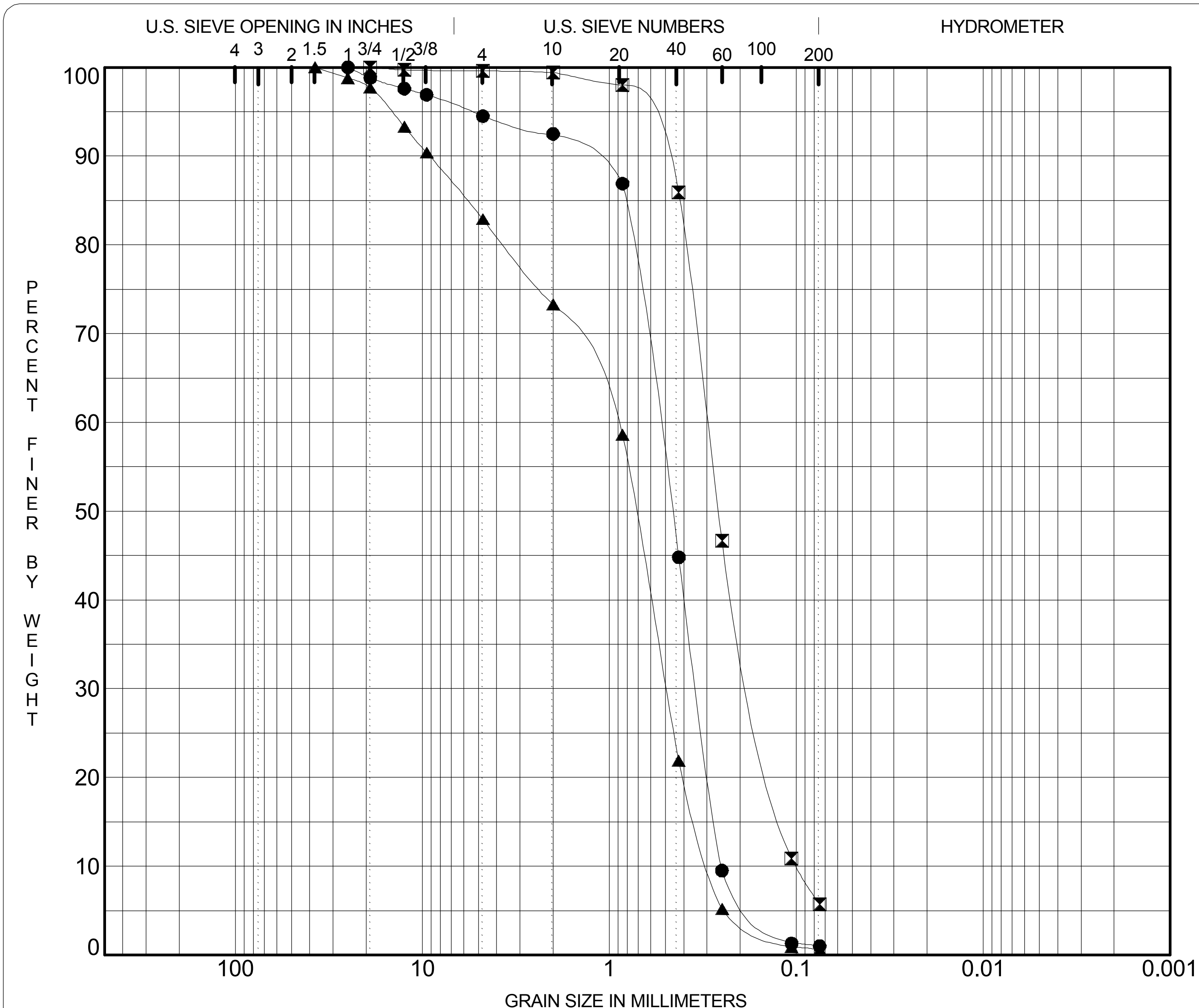
ENGINEERING ∘ SURVEYING ∘ EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

ALLUVIAL UNIT
GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-11



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-I	2	SURFACE	SP	NFS	5.2				0.84	2.17
⧗	SP-J	1	SURFACE	SP-SM*	S2*	9.9				0.94	3.00
▲	SP-J	2	SURFACE	SP	NFS	4.2				0.91	3.17

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-I	2	25.000	0.546	0.34	0.252	6	94	1	
⧗	SP-J	1	19.000	0.299	0.168	0.1	0	94	6	
▲	SP-J	2	37.500	0.922	0.495	0.291	17	82	1	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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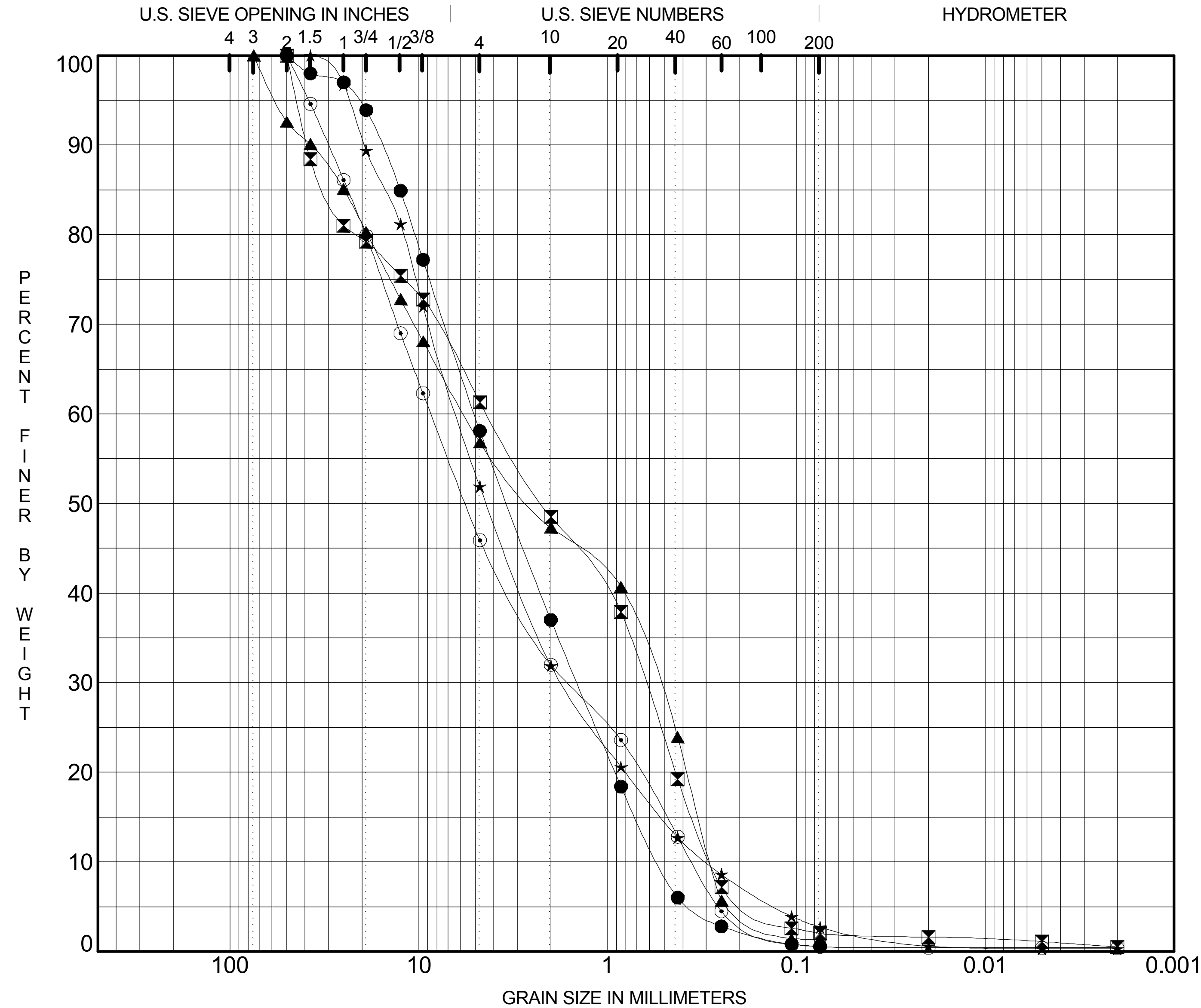
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

ALLUVIAL UNIT
GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-B	1	SURFACE	SP	NFS	5.1				0.78	9.58
⧗	SP-C	1	SURFACE	SP	NFS	3.3				0.33	15.38
▲	SP-E	1	SURFACE	SP	NFS	13				0.18	20.40
★	SP-F	1	SURFACE	SW	NFS	11				1.59	20.96
⊙	SP-H	2	SURFACE	GP	NFS	6.8				0.87	24.26

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-B	1	50.000	5.089	1.449	0.531	42	58	1	
⧗	SP-C	1	50.000	4.351	0.634	0.283	39	59	2	
▲	SP-E	1	75.000	5.78	0.547	0.283	43	56	1	
★	SP-F	1	37.500	6.281	1.732	0.3	48	49	3	
⊙	SP-H	2	50.000	8.62	1.631	0.355	54	45	1	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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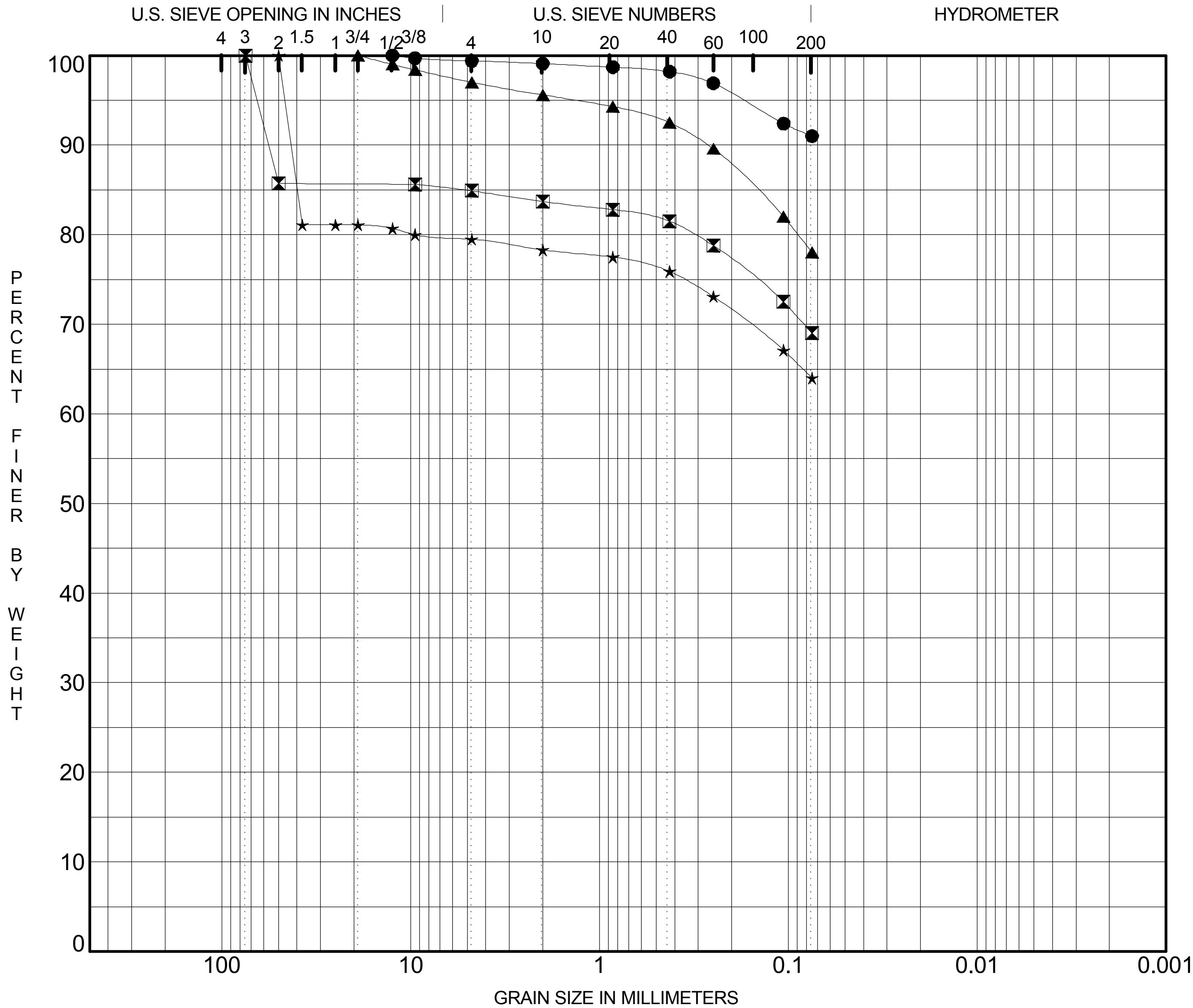
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

LAG GRAVEL GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-13



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-C	3	SURFACE	CL	F3	16	38	18	20		
⧗	SP-D	2	SURFACE	CL	F4	16	25	14	11		
▲	SP-E	2	SURFACE	CL	F3	14	28	14	14		
★	SP-G	2	SURFACE	CL	F3	11	28	15	13		

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-C	3	12.500				1	8	91	
⧗	SP-D	2	75.000				15	16	69	
▲	SP-E	2	19.000				3	19	78	
★	SP-G	2	50.000				21	16	64	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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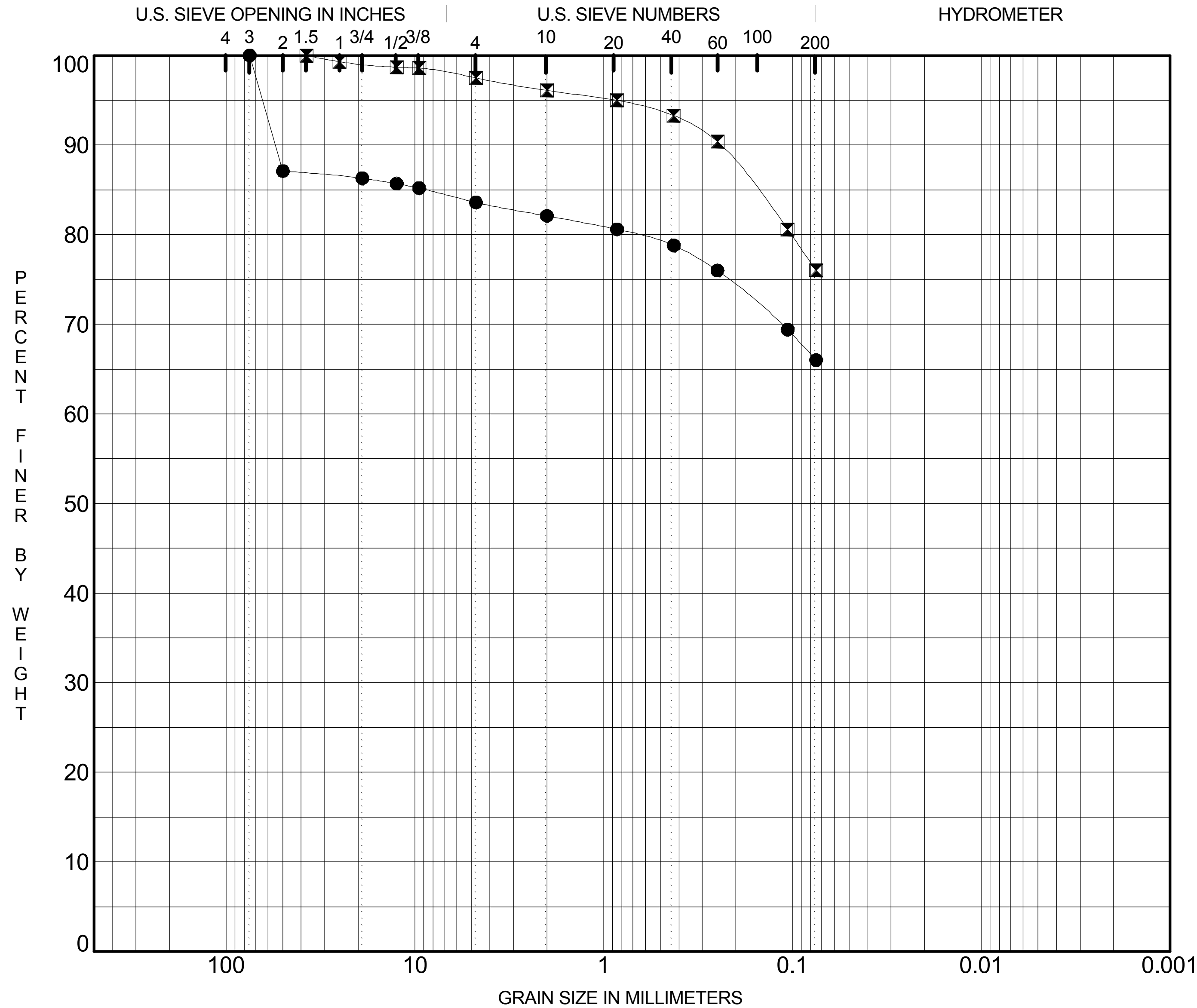
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA
GLACIAL TILL UNIT
GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-14



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-H	3	SURFACE	CL	F4	15	26	15	11		
⧗	SP-I	3	SURFACE	CL	F4	14	24	14	10		

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-H	3	75.000				16	18	66	
⧗	SP-I	3	37.500				3	22	76	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

R&M CONSULTANTS, INC.
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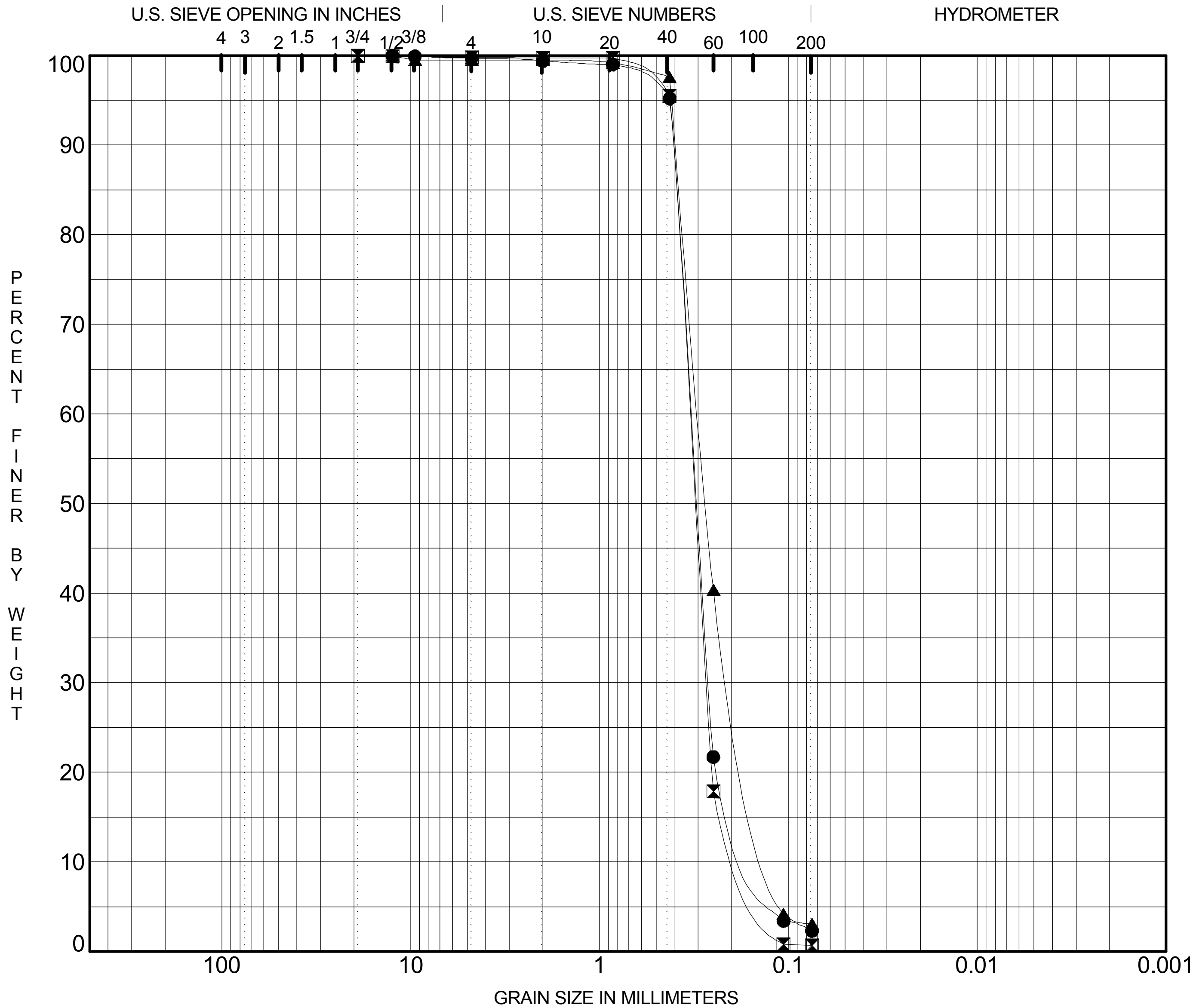
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

GLACIAL TILL UNIT
GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-C	2	SURFACE	SP	NFS	4.2				1.48	2.28
⧗	SP-D	3	SURFACE	SP	NFS	3.5				1.32	1.98
▲	SP-H	4	SURFACE	SP	NFS	17				1.05	2.47

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-C	2	12.500	0.33	0.265	0.144	0	97	2	
⧗	SP-D	3	19.000	0.333	0.272	0.168	0	99	1	
▲	SP-H	4	12.500	0.3	0.195	0.122	1	96	3	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

R&M CONSULTANTS, INC.
ENGINEERING ∘ SURVEYING ∘ EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

SAND POCKETS
GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-16

APPENDIX E
STATEMENT-OF-WORK

REVISED STATEMENT OF WORK

CONTRACT NO. W911KB-05-D-0004

DELIVERY ORDER NO. 0010

GEOTECHNICAL INVESTIGATION KENAI RIVER BLUFF EROSION

KENAI, ALASKA

REVISED 13 SEPTEMBER 2006

1.0 GENERAL

The U.S. Army Corps of Engineers - Alaska District (USACE-AD) is preparing to conduct a geotechnical investigation to provide design information for the Kenai River Bluff Erosion Project. The work described herein is intended to provide specific geotechnical design information for establishing an erosion control method that is technically feasible and satisfies resource agency needs. The work will consist of drilling, logging test borings, laboratory testing, and preparing Geotechnical Findings and Ground Water Monitoring Reports. Ultimately, the geotechnical data obtained will be used, in conjunction with other considerations, in developing the specifications and design criteria for the project.

1.2 Location of Work

The project lies along the bluff on the north bank of the Kenai River from its mouth at Cook Inlet upstream to the Pacific Star Seafood plant. The surface conditions on top of the bluff consist of established business and residential properties with paved streets and utilities. The topography is relatively flat with little vertical relief. The bluff is approximately 70 feet high and very steep, with a slope angle greater than 45° in some areas. There is very little vegetation on the slope of the bluff. A project vicinity map and approximate boring locations are indicated on maps included in the "Geotechnical Scope of Work Kenai River Bluff Erosion Study" prepared by R&M Consultants, Inc. August 2006.

1.3 Work Included

The work to be performed by the Contractor includes, but is not limited to, the tasks described in the following:

- Provide final geotechnical and ground water monitoring well drilling plans
- Provide ground water monitoring well design
- Provide all supervision, labor, materials, tools, equipment, and transportation necessary to perform the fieldwork which includes drilling, disturbed and undisturbed soil sampling, backfilling or grouting of borings, moving between borings, preparation of boring logs, preservation and transportation of soil samples, installation of ground water monitoring wells, and measurement of ground water levels during and periodically after field operations.
- Prior to commencing drilling, obtain all necessary site access and digging permits. USACE-AD will provide a map showing property boundaries. Keith Kornelis, City of Kenai Public Works Manager, can be contacted at 907-283-8232 for assistance with rights of entry permits.
- Provide daily logs of all operations, observations, and measurements, and compile these logs into the specified field report.

- Provide all supervision, labor, materials, tools, equipment, and transportation necessary to perform laboratory testing of soils.

- Provide coordinates and elevations obtained by standard survey techniques for all boring and ground water monitoring wells.

- Provide draft and final Geotechnical Findings Reports presenting the results of drilling, sampling, lab testing, and data interpretation.

- Provide draft and final Ground Water Monitoring Reports presenting ground water measurements.

2.0 DETAILED STATEMENT OF WORK

2.1 Task 1: Work Plan

Before the starting of work, the Contractor shall prepare and submit to USACE-AD a draft work plan. This plan shall describe in detail the Contractor's schedule for completing the work. The work plan shall include the safety, quality control, drilling and sampling, and ground water monitoring plans. The work plan shall describe the operational procedures, the equipment to be used in the work, proposed access and other pertinent information relating to the planning and executing the fieldwork. The work plan must be reviewed and approved by USACE-AD prior to the start of work. Any deviations from the work plan during execution of the work shall be noted in the daily logs and reports.

2.2 Task 2: Geotechnical Investigation

2.2.1 Subtask 2a: Clearing

The Contractor will provide the required clearing of brush and vegetation in a manner and detail sufficient to perform the work. Clearing for access, equipment set up and staging of drilling supplies shall be kept to the minimum required for safe operation. Access shall generally be limited to existing roads, trails and open areas.

2.2.2 Subtask 2b: Drilling and Sampling

The investigation objectives during the drilling and sampling effort are as follows:

- Provide classification and descriptions of the soils and rock.

- Provide the physical and engineering properties of the soils and rock encountered.

- Provide the depth to ground water within depth of investigation.

Borehole logging and sampling shall be accomplished by an experienced geotechnical engineer, engineering technician, or geologist. These individuals and their qualifications shall be identified in the required work plan.

The drilling plan found in the submittal titled "Geotechnical Scope of Work Kenai River Bluff Erosion Study" prepared by R&M shows the approximate locations of proposed geotechnical and groundwater monitoring boring locations. Table 1 presents the adjusted number and depths of borings. After site access issues are resolved the Contractor shall provide a final drilling plan using the depth and number of borings found in Table 1.

Table 1: Proposed Geotechnical and Groundwater Borings

Boring Description	No. Borings	Depth (ft)	Sample Interval	Notes
Geotechnical Boring along Crest of Bluff	2	40	Surface, 2.5 ft. and each 5 ft. interval	Ground water well points installed at base of sand unit
Geotechnical Boring along Crest of Bluff	4	100	Surface, 2.5 ft. and each 5 ft. interval	Ground water well points installed below Clay unit
Geotechnical Boring along Toe of Bluff	6	30	Surface, 2.5 ft. and each 5 ft. interval	
Groundwater Monitoring Boring	4	40	At bottom of well point	Ground water well points installed at base of sand unit
	4	75	At bottom of well point	Ground water well points installed at bluff toe elevation in Clay unit
Totals	**20**	**1120**		

2.2.2.2 Geologic Map of Bluff

Provide a continuous geologic Map of the bluff surface, based on visual inspection. Classify the exposed soil units in accordance with ASTM D 2488 "Description and Identification of Soils (Visual-Manual Procedure), measure and record general soil units and groundwater seepage. Groundwater flow on the face of the bluff shall be measured in at least three places.

2.2.2.3 Drilling Methods and Equipment

Borings shall be drilled with a rotary type machine equipped with a hydraulic feed, and means to maintain an open and clean hole for purposes of sampling and PVC casing installation. The diameters of the borings shall be sufficient to permit the specified sampling, and the installation of 2.0-inch I.D. casing used for ground water monitoring. When gravel, boulders, abandoned man-made obstacles or any other type of obstruction are encountered in drill holes, suitable methods shall be used to drill through such obstructions. The Contractor shall submit for approval requests to bypass obstructions or abandon a hole and drill another hole nearby prior to commencing. The actions taken shall be documented.

2.2.2.4 Sampling in Soil

Grab samples shall be obtained at the surface. Drive samples shall be obtained at 2.5 and 5 feet and at intervals of 5-feet thereafter or at major soil type transitions. Drive samples shall generally be obtained using split-barrel sampling in accordance with ASTM D 1586, "Standard Test Method for Penetration Test and Split Barrel Sampling of Soils". In coarse-grained materials where insufficient penetration and material recovery is obtained using the equipment required by the ASTM 1586 test method, a modified penetration test shall be performed with a 2.5-inch I.D. split-barrel sampler and impact hammer weighing 340 lb. falling 30 inches. Otherwise, all the provisions of ASTM 1586 shall apply.

Up to five undisturbed samples shall be obtained of silt or clay soils in accordance with ASTM D 1587, "Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes". Use 3-inch diameter 36-inch long thin-walled steel sampling tubes.

Each soil sample shall be classified in accordance with ASTM D 2488, "Description and Identification of Soils (Visual-Manual Procedure)". All soil samples shall be handled in accordance with ASTM D 4220, "Standard Practices of Preserving and Transporting Soil Samples". Disturbed samples shall be handled in accordance with ASTM D4220, Group B. Undisturbed samples shall be handled in accordance with ASTM D 4220, Group D.

2.2.2.5 Installation and Monitoring of Ground Water Wells

After completion of drilling and soil sampling the geotechnical and ground water monitoring borings on the crest of the bluff, the Contractor shall install a ground water monitoring well. Each monitoring well shall be constructed to allow for the accurate measurement of ground water depths relative to the top of the well riser. The monitoring wells shall be designed by the Contractor in general accordance with ASTM D 5092, "Design and Installation of Ground Water Monitoring Wells in Aquifers". The well riser pipe shall be constructed of 2-inch I.D. polyvinyl chloride (PVC) pipe. A protective casing shall be installed around the well riser pipe extending a minimum of three feet below and three feet above the top of ground surface.

Depths of individual ground water monitoring wells shall be determined as specified in the approved drilling plan.

The Contractor will be responsible for measuring and providing a report to USACE-AD on ground water levels. The measurements shall be made upon completion of the installation and monthly for one year, with a total of 13 readings for each monitoring well.

2.2.2.6 Backfilling Borings

Geotechnical borings not having ground water monitoring wells installed shall be backfilled with cuttings removed for the borings. Borings shall be sealed near the surface with 25 lbs. of bentonite chips. Requests to use an alternative method and the procedure for such method shall be submitted by the Contractor for approval.

2.2.2.7 Cleanup

The work areas shall be kept in neat and orderly condition at all times. On completion of work, the material removed from the holes and not used as backfill shall be disposed of off site by the Contractor. The Contractor shall leave the area in a clean condition with all equipment and trash removed, all to the satisfaction of USACE-AD.

2.2.3 Subtask 2c: Laboratory Testing

All testing shall be completed in a Corps of Engineers approved laboratory. The Contractor shall transport samples from the site to their laboratory. The Contractor shall select samples representative of the soil types encountered during drilling for testing.

2.2.3.1 Test Procedures and Quantities

Test methods shall correspond to the latest addition of the referenced standard and as modified herein. All tests shall be performed on samples selected by the Contractor. Other tests may be requested based on the soil type encountered.

ASTM Test Procedures	No. of Tests
ASTM D 2487 "Classification of Soils for Engineering Purposes"	100
ASTM C-422 "Particle-Size Analysis of Soils" (24 Hour)	15
ASTM C136 "Sieve Analysis of Fine and Coarse Aggregates" and ASTM C117 "Materials Finer than 75-um (No.200) Sieve in Mineral Aggregates by Washing"	100
ASTM D 2216 "Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock and Soil-Aggregate"	100
ASTM D 4318 "Liquid Limit, Plastic Limit and Plasticity Index of Soils"	12
ASTM D 4767 "Consolidated-Undrained Triaxial Compression Test for Cohesive Soils"	6

ASTM D 2435 "One-Dimensional Consolidation Properties of Soils"	3
ASTM D2434 "Permeability of Granular Soils" (Constant Head)	3

2.3 Reports

2.3.1 Field Logs and Daily Reports

Field Logs

The Contractor shall keep, and furnish to USACE-AD with the final report, copies of an accurate field log of each boring. The log shall show the boring number, the date the boring began and finished, air temperature and weather conditions on each day of drilling, boring coordinates or other location identification, total depth, tools utilized in the drilling and sampling process, collar elevation of the boring hole (if available), description of the material in the boring, depth at which each change in material occurs, depth at which samples were obtained and the type of sample in each instance, penetration resistance, percentage of sample recovery, depth to water table and any other data pertinent to the identification of material or to the strength or consistency of the materials in undisturbed formations.

Daily Reports

The Contractor shall keep continuous logs of all operations, observations, and measurements. These logs will be made available to the USACE-AD on a day-to-day basis to assist in planning subsequent surveys and in planning other exploration activities. These detailed logs shall contain at least the items listed below.

The following gives the minimum requirements for the contents of the daily log:

- Names and affiliations of personnel engaged in the work
- Weather conditions
- All events affecting data acquisition or quality
- Equipment used
- Equipment adjustments, malfunctions, and downtime with explanations
- System calibration details
- Details of check observations and computations
- Dates and times of mobilization and demobilization
- A copy or description of all preliminary data
- All written and verbal instructions issued by USACE-AD and a description of the resolution of any issues
- All other relevant information and occurrences, including a general narrative of the total activity

2.3.3 Final Reports

The following gives the minimum requirements for the contents of the geotechnical findings report:

1. Purpose and scope of investigation including site location descriptions.

2. Description of drilling, sampling and testing equipment and methods used including horizontal and vertical control.

3. Description of pertinent regional and site geology

4. Site surface descriptions and detailed geologic map of bluff

5. Site subsurface descriptions based upon interpretation of test borings, laboratory testing, and other observations on site during the course of the fieldwork.

6. Maps and figures as necessary to support the interpretations and recommendations including as appropriate: location and vicinity maps, boring location maps, geologic map of bluff, interpretive plans and cross sections as appropriate. The drawings provided shall show all survey control as recovered or set, all elevations and features as obtained.

7. Final boring logs:

The boring logs shall be at a scale not smaller than 1:60 and shall contain the following information:

Temporary I. D. (assigned by A/E)
Permanent I. D. (assigned by USACE-AD after completion)
Coordinates and elevation
Names of individuals and firms doing drilling and logging
Type, make and model of drill rig
Size and type of casing and tools
Water table depth(s)
Sampling interval
Lab classification- ASTM D 2487
Field classification (where not lab tested)- ASTM D 2488
Frost susceptibility- TM 5-822-5
Sample drive hammer weight
Sampling device description
Blow count per 6-inch interval
Date(s) of boring

8. Laboratory test reports

9. An appendix containing this statement of work, the approved work plans, the daily reports, the field logs and a discussion of the events, changes to the work plan successes, failures and difficulties encountered during the investigation.

Ground Water Monitoring Report

The following gives the minimum requirements for the contents of the ground water monitoring report:

1. Purpose and scope of investigation including site location descriptions.

2. Description of drilling, sampling and testing equipment and methods used including horizontal and vertical control.

3. Final ground water boring logs:

The boring logs shall be at a scale not smaller than 1:60 and shall contain the following information:

Temporary I. D. (assigned by A/E)
Permanent I. D. (assigned by USACE-AD after completion)
Coordinates and elevation
Names of individuals and firms doing drilling and logging
Type, make and model of drill rig
Size and type of casing and tools
Water table depth(s)
Sampling interval
Lab classification- ASTM D 2487
Field classification (where not lab tested)- ASTM D 2488
Frost susceptibility- TM 5-822-5
Sample drive hammer weight
Sampling device description
Blow count per 6-inch interval
Date(s) of boring

4. Well installation diagrams which include a description of materials from which the well is constructed.

5. Ground water monitoring records which include, date, time, and elevation of water level measured.

Task 3 Test Boring Location Survey

The Contractor shall establish coordinates and elevations for each boring location. The survey shall conform to standards specified in EM 1110-1-1005 Topographic Surveying. Horizontal coordinates shall be surveyed to the nearest 3 foot and elevations for monitoring wells shall be surveyed to the nearest 0.1 foot. Elevations for Geotechnical borings located at the toe of the bluff shall be surveyed to nearest 1 foot. Survey control shall be based on provided information in the appendix. Electronic files which include survey field notes, photos of survey control points, and an AutoCAD drawing with aerial photo will be emailed to the Contractor.

3.0 SAFETY

The Contractor is responsible for the safety of his and the subContractor's personnel, equipment, materials, and the public at all times. Drill holes shall not be left open overnight. A specific safety and accident plan in accordance with EM 385-1-1 shall be submitted with the work plan.

4.0 QUALITY CONTROL

Quality Control Plan (QCP). The Contractor shall propose a system to manage, control, and document the performance of these tasks. The quality control activities shall be documented and included in the final reports. The Contractor shall ensure that the corporate quality policy is understood, implemented, and maintained at all levels in the organization. The Contractor shall perform continuous tracking, checks, representations, adjustments and visualization of his field data for quality control and to establish efficient field procedures. The Contractor is responsible for ensuring that project work proceeds smoothly in accordance with the statement of work and maintaining a continual vigilance for ways to increase efficiency and quality, as well as providing weekly summaries of Quality Control activities.

5.0 SITE INVESTIGATION AND REPRESENTATION:

The Contractor assumes responsibility for all investigations such as the nature and location of the work, the general and local conditions, particularly those bearing upon transportation and the availability of roads and airports, the uncertainties of weather, topography and conditions of the ground, the character of equipment and facilities needed prior to and during prosecution of the work, and all other matters upon which information is reasonably obtainable and which can in any way effect the work or the cost thereof under this modification. Any failure by the Contractor to acquaint himself with all the available information will not relieve him from responsibility for estimating properly the difficulty or cost of successfully performing the work.

6.0 AVAILABILITY OF MATERIALS:

All field notes, sketches, recordings and computations made by the Contractor in completing this work shall be available at all times during the progress of the work for examination by the contracting officer, or his authorized representative. All such material shall become the property of the Government upon completion of the delivery order.

7.0 SCHEDULE:

The required work plan shall be submitted to the Government within 7 days of notice to proceed. Fieldwork shall commence within 30 days of notice to proceed. A draft geotechnical findings report shall be submitted not later than 60 days after notice to proceed. The Government then expects to use 10 days for review and comment. A final Geotechnical Findings Report, including original notes and data shall be submitted 15 days after review and comments are complete. A draft Ground water Monitoring Report shall be submitted 15 days after the final ground water elevation measurement. The Government then expects to use 10 days for review and comment. A final Ground water Monitoring Report shall be submitted 15 days after review and comments are complete.

8.0 DELIVERABLES:

Six copies of all reports shall be delivered to:

U.S. ARMY CORPS OF ENGINEERS, ALASKA DISTRICT
ATTN: CEPOA-EN-ES-SG (Chuck Wilson)
P.O. BOX 6898
ELMENDORF AFB, ALASKA 99506-0898

and shall be accompanied by a letter or shipping form listing the materials being transmitted. In addition to the hard copies, the Contractor shall provide two copies of the reports in Microsoft Word and PDF formats, and all drawings shall be provided in AutoCAD format on compact discs.

ATTACHMENT N: OCEANWEATHER EXTREME WAVE STUDY

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Wave Extreme Storm Study for Cook Inlet: Kenai, Alaska

Submitted to

U.S. Army Corps of Engineers – Alaska District
Attn: CEPOA-EN-CW-HH
Dee Ginter
Deirdre.m.inter@poa02.usace.army.mil
Tel: 907-753-2805
Fax: 907-753-2625

Work Performed under Tetra Tech Inc. Job # T19229

November 26, 2009

oceanweather inc.
5 River Road
Cos Cob, CT, USA
Tel: 203-661-3091
Fax: 203-661-6809
Email: oceanwx@oceanweather.com
Web: www.oceanweather.com

Table of Contents

1. INTRODUCTION

This report details a database of wave hindcasts in a certain class of Cook Inlet, Alaska storms, in aid of the redesign of a revetment that protects land on the north side of and near the entrance to the Kenai River, Cook Inlet. The redesign requires specification of 50-year return period extremes. The total design profile requires the generation of winds, waves, water level variations (from the semi-diurnal tidal range, and wind/pressure forcing surge effects), and temporal varying ice field covering Cook Inlet. The engineering need is being satisfied through a series of linked-studies, beginning with a survey and assembly of historical metocean data in the area of interest, followed by reconstruction of wind fields for a population of the highest ranked storms of the relevant type, use of the wind fields to drive a proven third-generation (3G) basin and regional scale numerical spectral wave prediction model that considers not only sea states generated within Cook Inlet but also wave energy propagated into the Inlet from the contiguous North Pacific Ocean and that ultimately provides boundary conditions to a local hyperfine wave model (STWAVE) that provides the data needed for the coastal engineering associated with the revetment design. This report does not include STWAVE or storm surge modeling, which will be carried out by separate parties.

The metocean data assembly and wind field analysis phases of the study were carried out by Oceanweather in 2009. The storm type of interest has been identified to be the transient episodes of strongly inlet rectified and accelerated southwesterly flows. Thirty such events have been identified within the period 1970-2007 and the wind fields produced are available for the wave hindcast.

2. WAVE MODEL SETUP

UNIWAVE Model

Overview

OWI's standard UNIWAVE high-resolution full spectral wave hindcast model was used for all wave hindcasts. UNIWAVE incorporates deep water and shallow processes and the option to use either OWI's highly calibrated first generation source term physics (ODGP2) or third generation (3G) physics (OWI3G). OWI3G was developed in the early 1990s under sponsorship of Environment Canada and for a time the model served as the operational wave forecast model of the Canadian Meteorological Center, and was known as CSOWM.

Computational details on the OWI's 3rd generation physics can be found in Khandekar *et al.* (1994) and Forristall and Greenwood (1998). OWI3G follows rather faithfully the formulation of the first 3G spectral wave model, WAM (WAMDI, 1988) with a few notable exceptions as noted below. In general, 3G models solve the action balance equation for the time rate change of directional wave spectra

$$\frac{DN(\vec{x},t,f,\theta)}{Dt} = \sum_i S_i$$

where $N(\vec{x},t,f,\theta)$ is the wave action and equal to $E(\vec{x},t,f,\theta)/\omega$ where E is the directional wave spectrum in frequency (f) and direction (θ), and ω is the radial frequency. S_i represents the source sink mechanisms:

$$\sum_i S_i = S_{in} + S_{nl} + S_{ds} + S_{w-b} + S_b$$

and S_{in} is the atmospheric input S_{nl} is the nonlinear wave-wave interaction, S_{ds} is dissipation due to high frequency wave breaking, S_b is the bottom dissipation and S_{w-b} is the sink mechanism for depth limited wave breaking (depth-limited breaking is not included in OWI3G).

The action balance equation is solved by what is called the "fractional-step" method; that is, solution of the action balance equation is split into the advective and source-sink parts and solved in alternative steps. The advective effect operated only on the spatial distribution in action density, or the second term on the right hand side of the equation below:

$$\frac{DN(\vec{x},t,f,\theta)}{Dt} = \left\{ \frac{\partial}{\partial t} + \vec{c}_g \cdot \frac{\partial}{\partial \vec{x}} \right\} N(\vec{x},t,f,\theta)$$

where $\vec{c}_g$ is the group speed of each spectral wave component defined for each frequency by the depth-dependent linear dispersion relationship:

$$\omega^2 = g\kappa \tanh(\kappa h)$$

and ω is the radial frequency ($\omega=2\pi f$), h is the water depth and κ is the wave number ($\kappa=2\pi/L$, where L is the wavelength defined at frequency f, and dependent on the water depth).

The advection scheme in OWI3G is described briefly below. Once the spectra are updated for propagation over the fixed grid, the source term integration is computed or $\partial N/\partial t$.

The Spectral Resolution

Direction: 24 bands. Band 1 is centered 7.5° clockwise from true north; the width of each band is 15°

Frequency: Band 1 is centered on 0.039 hz; the bands increase in geometric progression (ratio = 1.10064) to band 23, .32157 hz. This binning is negligibly coarser than used WAMDI (ratio = 1.100) and no coarser than that used in typical 15 frequency binning of ODGP.

Propagation Scheme

The downstream interpolation scheme described by Greenwood et al. (1985) is used throughout. Propagation over a time step at a grid point is implemented within the alternate growth-propagation cycle in the model integration by forming linear combinations of spectral variances at neighboring points. The weights used are extracted from a pre-computed table of propagation coefficients, which vary by latitude only in deep water, and are specific to each grid point in shallow water. The table of interpolation coefficients is calculated based upon great circle wave ray paths in deep water; in shallow water the weights are calculated following a ray tracing study through a digital bathymetry resolved on the wave model grid and thereby include the effects of refraction and shoaling.

The limiting water depth for shallow propagation and growth processes is taken according to the conventional definition:

$kd > \pi$, where $k = .006123\ m^{-1}$ for the .039 Hz frequency bin.

Spectral Growth/Dissipation Algorithms

The spectral growth algorithm used in OWI3G follows closely that of WAM. Also, the individual source terms follows the theoretical forms used in WAM but with different numerics and code and with the following modifications. First, a linear excitation source term is added to atmospheric input terms, S_{in}, taken as a downscaled variant of the term used in OWI's 1G ODGP model (see e.g. Khandakar et al., 1994 for a description of the 1G model source terms). This allows the sea to grow from a flat calm initial condition in OWI3G, unlike all cycles of WAM which require an artificial warm start from a prescribed initial spectrum. The exponential input term is the empirical form of Snyder et al. (1981) with a slightly rescaled coefficient, in which S_{in} is taken as a linear function of friction velocity U_*. However, unlike WAM in which U_* is computed from the 10 meter wind speed U_{10} following the drag law of Wu (1982), in OWI3G, a different drag law is used that was developed in the model tuning stage. That drag law follows Wu closely up to about 20 m/sec then becomes asymptotic to a constant at wind speeds above 30 m/s. It appears that OWI3G was the first wave model to incorporate a saturation surface drag formulation. That is, rather than retain the usual unlimited linear increase of the drag coefficient with increasing wind speed; OWI3G capped the drag coefficient at a value of 2.2×10^{-3} which is reached at a wind speed of 29.5 m/s. Recent estimates of the 10-m surface marine drag coefficient in extreme winds in the field (Powell et al., 2003) and in a wind-tunnel/wave-tank set up (Donelan et al., 2005) tend to support the notion of saturation of the drag coefficient at high wind speeds.

The non-linear term is approximated by the standard Discrete Interaction Approximation (DIA) except that in OWI's model a second quartet of interactions is included as described by Forristall and Greenwood (1998). As in WAM, the non-linear transfer for waves in shallow water are described by the deep water transfer multiplied by a scaling factor which is a function of wave number and water depth (see Hasselman and Hasselman, 1985).

The dissipation source term, S_{ds} is also taken from WAM except that the dependence on frequency is cubic rather than quadratic.

OWI3G was developed based upon tuning runs against the fetch-limited growth benchmark for 20 m/s wind speeds under constant winds used to tune WAM, and trial hindcasts of a well-documented moderate extratropical cyclone (SWADE IOP-1, see Cardone et al., 1995) and two intense Gulf of Mexico hurricanes (Camille, 1969; Frederick, 1979). The bottom friction source term is a simple quadratic law with a specified tunable friction factor. The friction factor adopted in the North Sea version of WAM (NEDWAM) is .076, which is exactly twice the value originally proposed for WAM, which was based upon studies of pure swell attenuation in the North Sea JONSWAP experiment. In GOMOS we have used the smaller JONSWAP friction coefficient since it appears to provide more nearly unbiased wave predictions in shallow water.

An interesting comparison of the performance of OWI's first generation (1G) model and OWI3G in an extratropical setting is given by Khandekar, et al. (1994) a comparison of the performance of OWI1G, OWI3G and the latest cycle of WAM (WAM-4) in extreme storms is given in Cardone et al. (1996). Much more extensive validations of OWI's 3G wave model in long-term hindcast studies are given recently by Swail and Cox (2000) and Cox and Swail (2001) and Swail et al.(2006).

Kenai7km

The Kenai7km mesh is a 3G application of the UNIWAVE model on a latitude-longitude grid of .0625 degree in latitude by 0.125 degree in longitude (Figure 1). The model grid covers the domain of 55.3125-61.8125N and 201.250-211E and has 1,982 active grid points. Bathymetry for the grid was obtained from the Alaska Ocean Observing System (AOOS) Digital Elevation Model (DEM) version 1.03 which provides a netCDF archive with nominal spacing of 1km. The DEM datum is not specified, but source documentation indicates that the data was primarily based on electronic navigation charts. A comparison of DEM data in the Kenai area against Chart 16662 shows good agreement and it was assumed that the data represent a mean lower low water reference. DEM data were not modified for use in the Kenai7km model. A model minimum depth of 3 meters was applied at all locations. All simulations were made assuming zero-ice with all wave points active in the model.

Boundary spectra along the exposed southern boundary of the model were provided from the Global Reanalysis of Ocean Waves Fine Northeast Pacific (GROWFine:NEPAC) model which is an hourly archive of wave spectra from a 35 km Northeast Pacific hindcast. The GROWFine: NEPAC also includes pickup from a global archive, so all northern and southern hemisphere swells reaching the Kenai7km wave grid are represented. Details on the GROWFine: NEPAC hindcast are found in the *GROWFINE: NEPAC Project Description* document which has been delivered with the hindcast.

Kenai/KenaiMTR

Nested within the Kenai7km grid are the Kenai and KenaiMTR grids. Both grids apply the UNIWAVE model on a latitude-longitude grid of .0125 degree in latitude by 0.025 degree in longitude (Figure 2/3). The model grids cover the domain of 60-61.25N and 207-209E and have 2,860 active grid points. Bathymetry for the grids was also obtained from the AOOS DEM, with the Kenai model applying the unmodified depths and KenaiMTR (Mean Tidal Range) applies an additional 5.38 meters added to all depths to represent the mean tidal range as obtained from chart 16662. A model minimum depth of 3 meters was applied at all locations. Results from both Kenai and KenaiMTR model grid are provided, but only the KenaiMTR results are applied to derive the 50-year wave conditions. All simulations were made assuming zero-ice with all wave points active in the model.

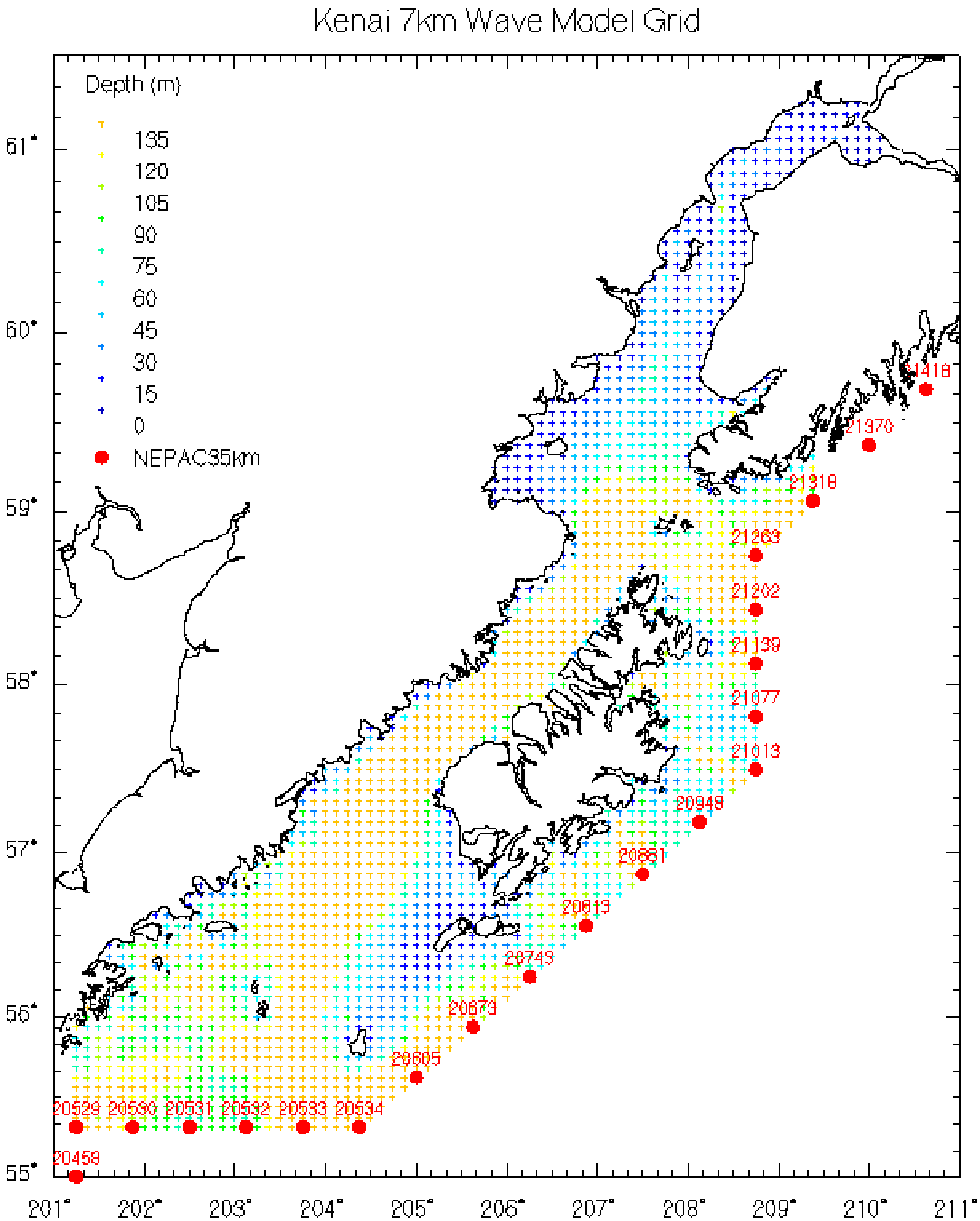


Figure 1 Kenai7km wave model grid with GROWFine:NEPAC spectral boundary locations

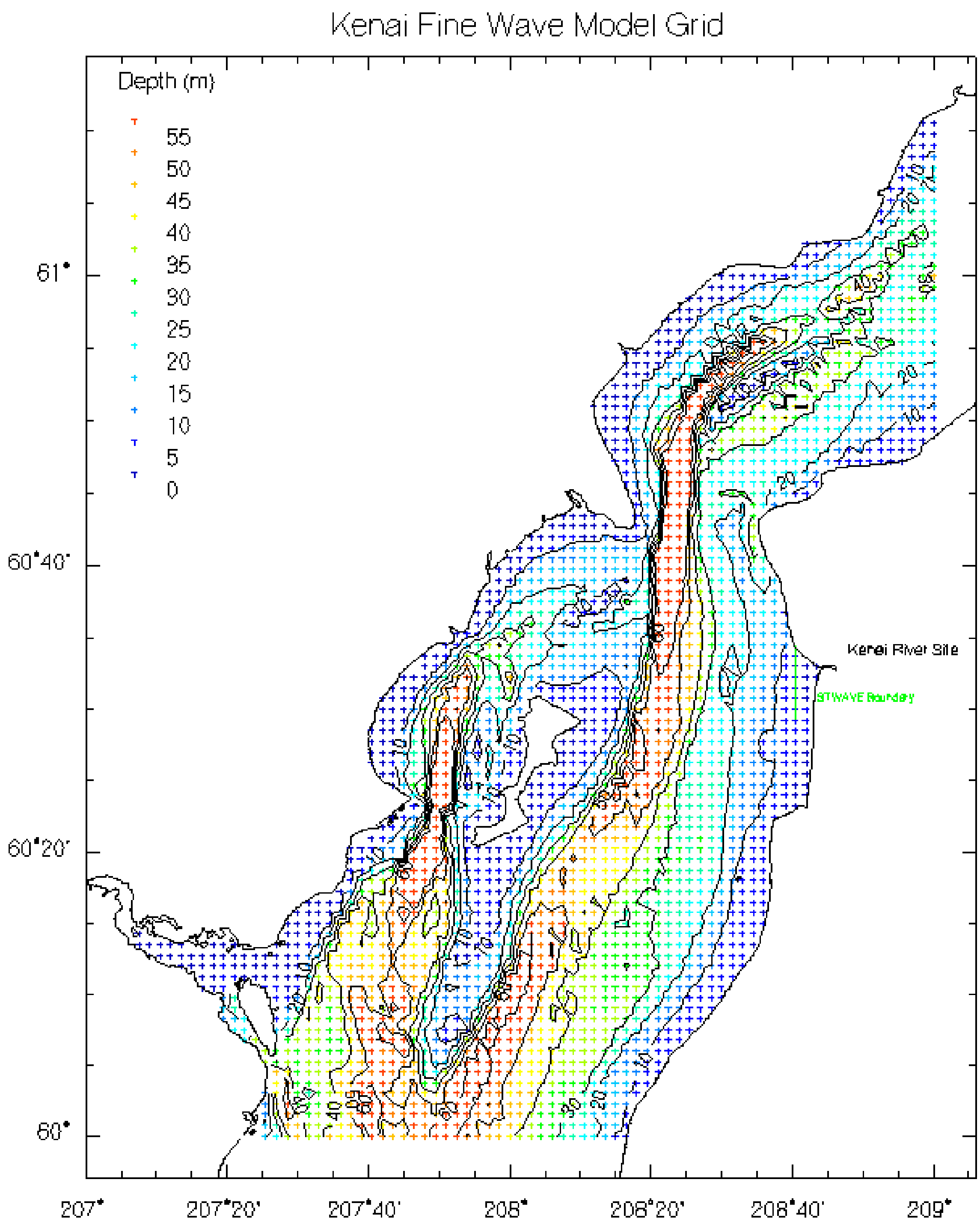


Figure 2. Kenai wave model grid applying unmodified AOOS DEM bathymetry

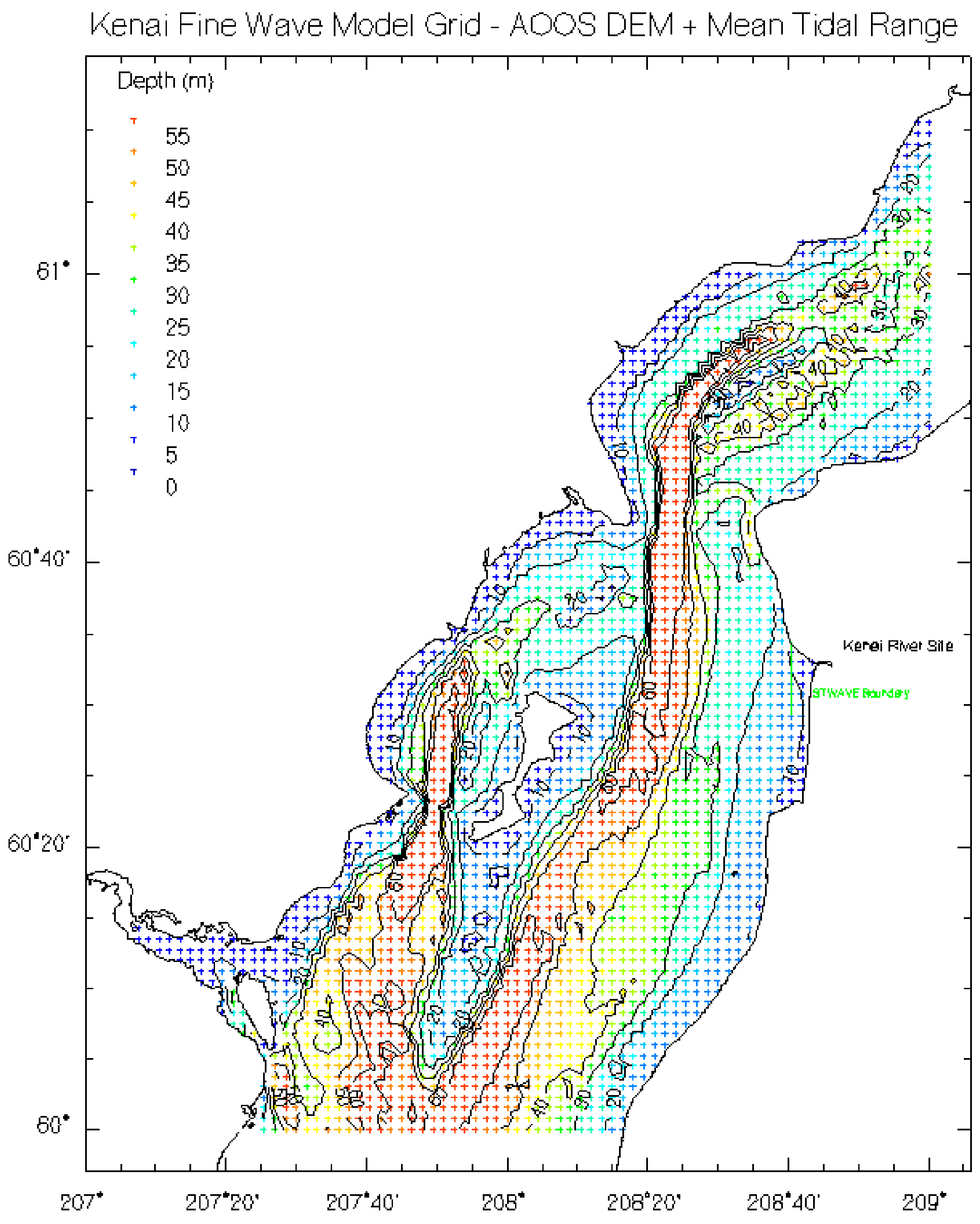


Figure 3 KenaiMTR wave model grid applying unmodified AOOS DEM bathymetry plus the mean tidal range at Kenai

CONTINUOUS HINDCAST VERIFICATION

Of the many NDBC (National Data Buoy Center) buoys deployed in the eastern North Pacific, the only buoy situated within Cook Inlet is buoy 46106 (59°45'36" N 152°5'24" W) and it has been deployed only since 2007. Also of interest is buoy 46077 (57°55'12" N 154°15'15" W) which is located in the Shelikof Strait and is more exposed to North Pacific swells. Unfortunately, no high ranked storms analyzed by Oceanweather were selected from 2007 or 2008. Thus, the need for continuous hindcasting during 2007/2008 was tasked to search for swell events and establish the model swell performance.

Complicating the validation procedure was the lack of good local wind fields. In the storm hindcast study, winds within Cook Inlet were subject to individual storm analysis. In the continuous hindcast, GROWFine:NEPAC winds were applied which do not include very localized effects. To properly evaluate the swell performance, statistical comparisons were restricted to time periods were the measured peak spectral period is 10 seconds or greater to remove contamination due to local events. Figure 4 shows a monthly timeseries of measurements and hindcast winds and waves during January 2008. Waves with measured periods >= 10 seconds are highlighted in blue. All 10+ second events are extracted for the two buoys over the 2007-2008 period are shown in Figure 5 as a scatter plot with summary statistics. Most of the events selected are from buoy 46077 which is more exposed to Northeast Pacific swells. Overall, there was zero wave bias and a RMS error of 40 cm in the significant wave height comparisons.

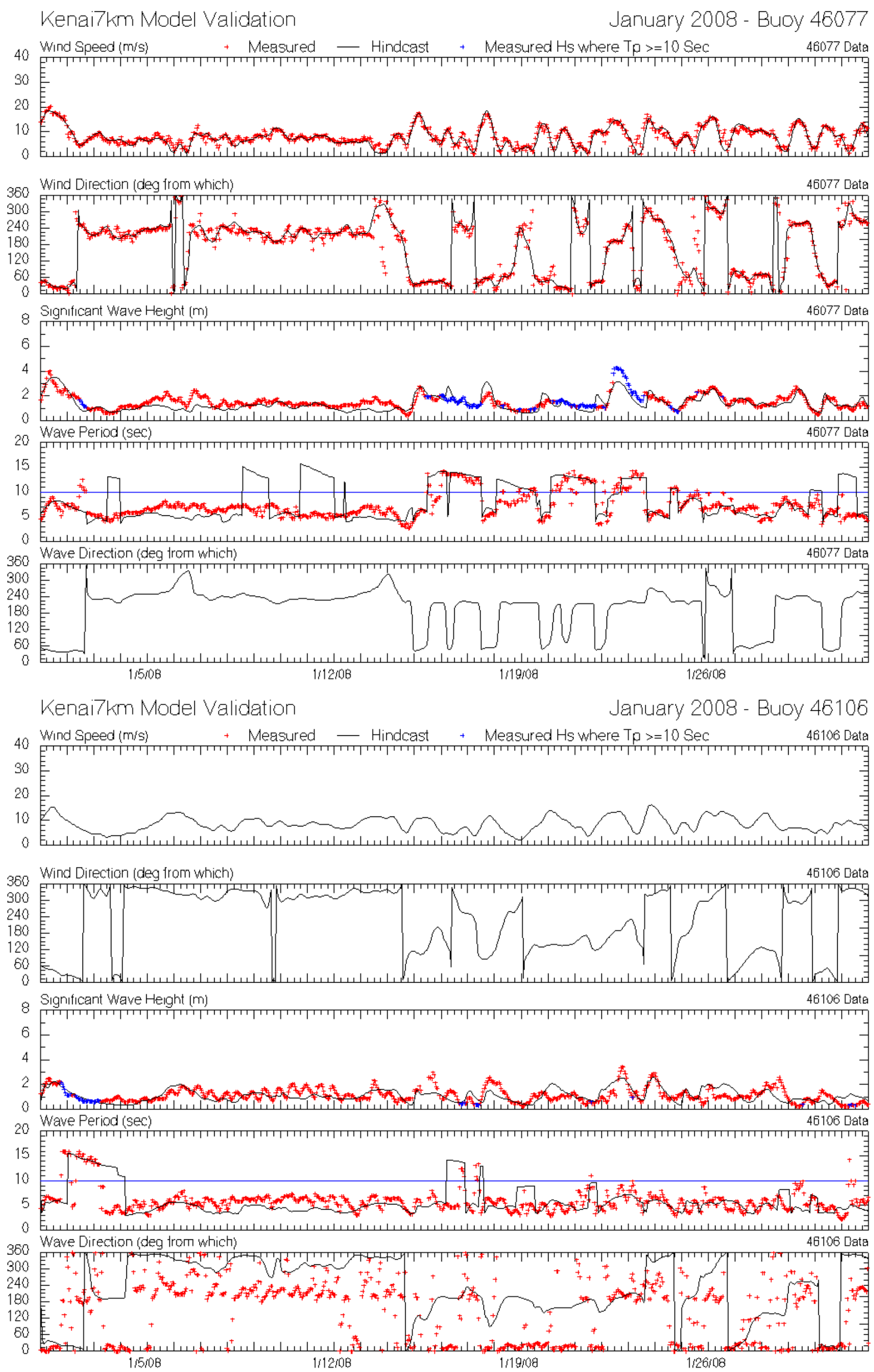
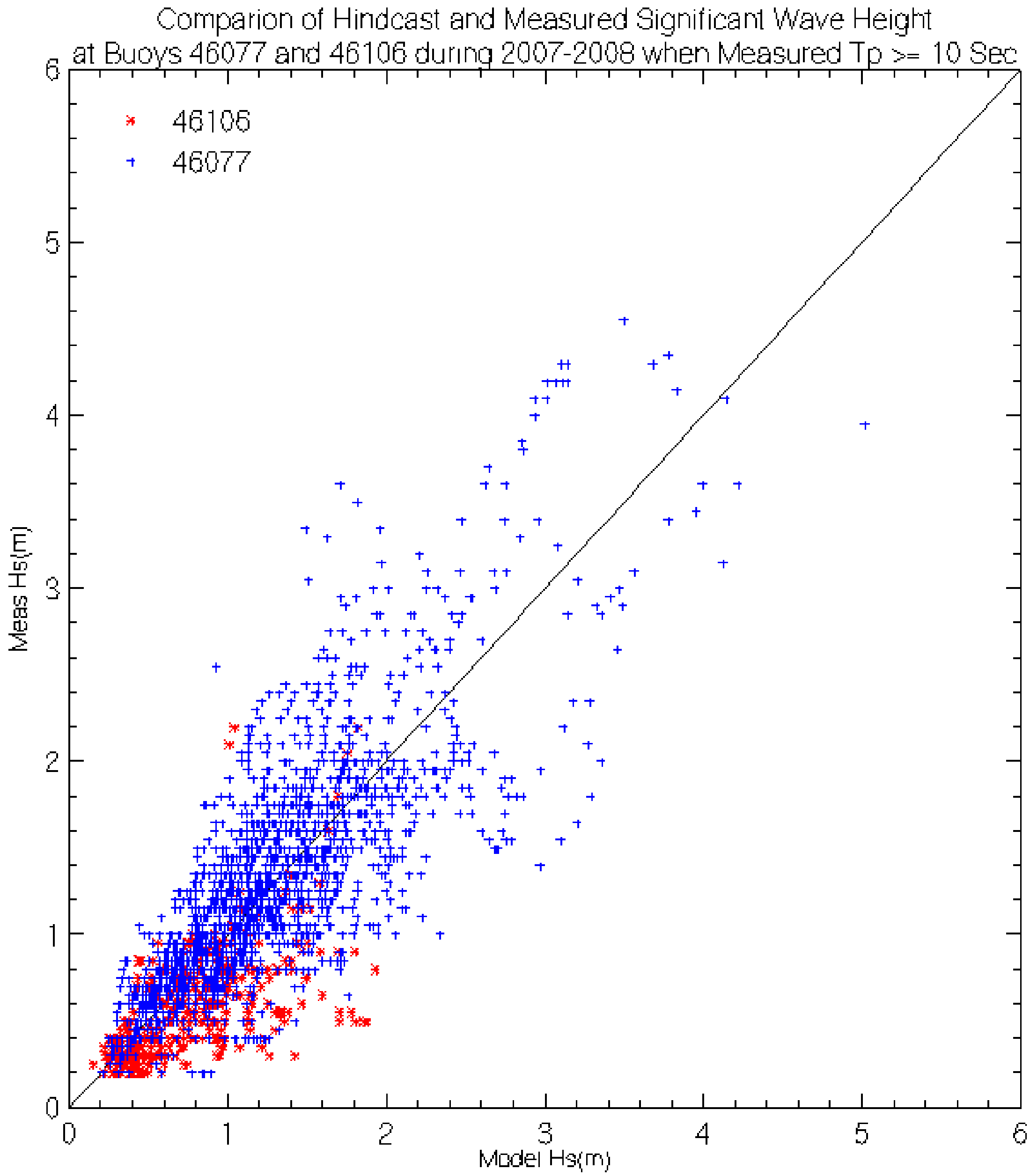


Figure 4. Monthly timeseries plots of winds and waves at buoys 46077 (top) and 46106 (bottom) during January 2008.



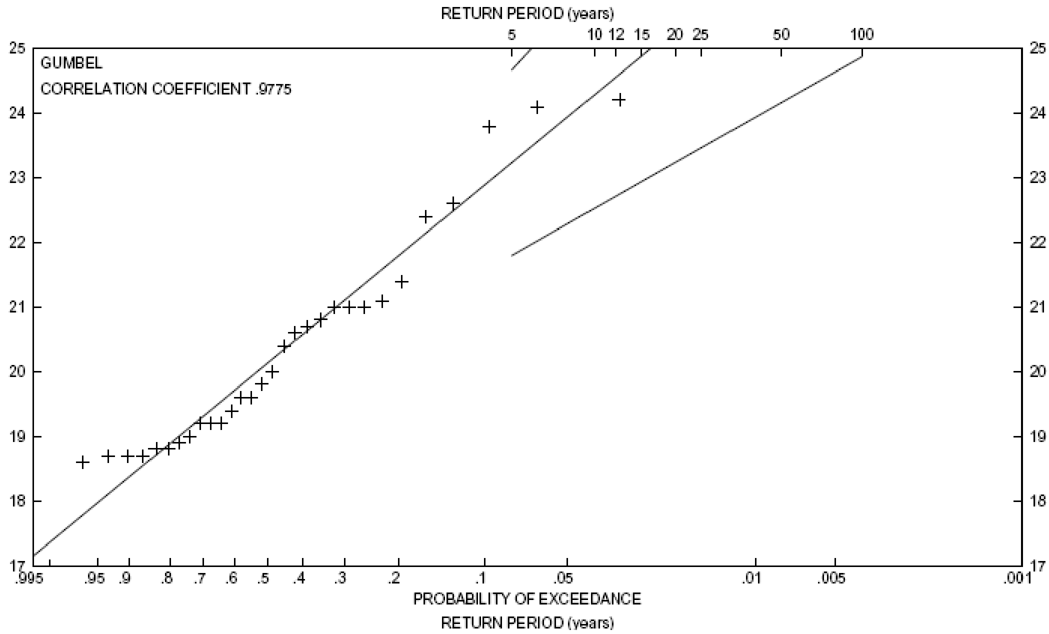
	Station	Grid Point	Number of Pts	Mean Meas	Mean Hind	Diff (H-M)	RMS Error	Stnd Dev	Scat Index	Ratio	Corr Coeff
Wind Spd. (m/s)	Combined	0	1589	6.03	6.76	0.73	2.76	2.66	0.44	0.57	0.69
Wind Dir. (deg)	Combined	0	1589	129.97	216.74	5.37	N/A	46.04	0.13	N/A	N/A
Sig Wave Ht (m)	Combined	0	2151	1.19	1.19	0.00	0.40	0.40	0.34	0.50	0.81
Wave Period (s)	Combined	0	2151	11.48	9.99	-1.49	3.77	3.46	0.30	0.45	0.27
Wave Dir (deg)	Combined	0	349	199.85	170.97	-34.67	N/A	83.50	0.23	N/A	N/A

Figure 5. Scatter plot of significant wave heights when measured peak wave period was >= 10 seconds with summary statistics

50-YEAR CONDITIONS BASED ON NIKISKI

A task requested in the original proposal was to test constant winds through various wind directions to determine the most energetic wind direction for wind-sea extremes. In order to run a series of winds that were consistent with the desired 50-year conditions it was proposed to run a series of eight wind directions using the 50-year return period wind speed as determined by an analysis of measured wind peaks at National Ocean Station 9455750 (NKTA2) at Nikiski, Alaska (60°41'0" N 151°23'54" W). This measurement station provides a 13 year record of measured winds at a coastal location just north of Kenai. It was determined during the previous wind study to be the best dataset for local winds.

Data for Nikiski were obtained from the National Ocean Service and were adjusted for height, stability and directional roughness (see wind report for details) to obtain a 13 year record (Sept-1996 to Sept 2008) of wind speeds and wind directions. Some manual editing was performed to remove spurious spikes in the dataset, but overall the data was very clean. A peak over threshold analysis applying Gumbel distribution (see Appendix for Gumbel definition) on the top 30 wind peaks was performed for the omni-directional, and eight wind directional sectors. Figure 6 shows an example of the omni directional fit and extremes using the Gumbel distribution resulting in an omni-directional 50-year wind speed of 26.3 m/s. This procedure was repeated for eight directional bins, based on measured wind direction, and extremes are summaried in Table 1.




```
Onmi Directional Extremes at Nikiski
Top 30 storms
24.20, 24.10, 23.80, 22.60, 22.40, 21.40, 21.10, 21.00, 21.00, 21.00, 20.80, 20.70, 20.60, 20.40, 20.00,
19.80, 19.60, 19.60, 19.40, 19.20, 19.20, 19.20, 19.00, 18.90, 18.80, 18.80, 18.70, 18.70, 18.70, 18.60,
```

Period	Prob.	Gumbel	lcl	ucl
5.	0.0800	23.23	21.80	24.67
10.	0.0400	24.28	22.52	26.03
12.	0.0333	24.55	22.71	26.39
15.	0.0267	24.88	22.94	26.82
20.	0.0200	25.31	23.24	27.38
25.	0.0160	25.64	23.46	27.82
50.	0.0080	26.66	24.17	29.16
100.	0.0040	27.68	24.87	30.49

Figure 6. Gumbel fit to Nikiski wind speeds

Table 1 50-year wind speed extremes at Nikiski by wind direction

Sector	Wind Direction (deg, from which)	50-year Wind Speed (m/s)
NNE	22.5°	26.1
ENE	67.5°	19.4
ESE	112.5°	21.4
SSE	157.5°	25.0
SSW	202.5°	26.5
WSW	247.5°	24.6
WNW	292.5°	19.0
NNW	337.5°	22.9

Each storm period applied a sector direction/50-year wind speed held constant over a 48-hour period. The Kenai7km model was run with no spectral boundary conditions, while the Kenai and KenaiMTR grids used the corresponding Kenai7km boundary conditions. Figure 7 shows the contours of maximum winds and waves resulting from each of the hindcasts for the SSW (South-Southwest) run. Maximum plots of all sector runs for each model are contained in the Appendix.

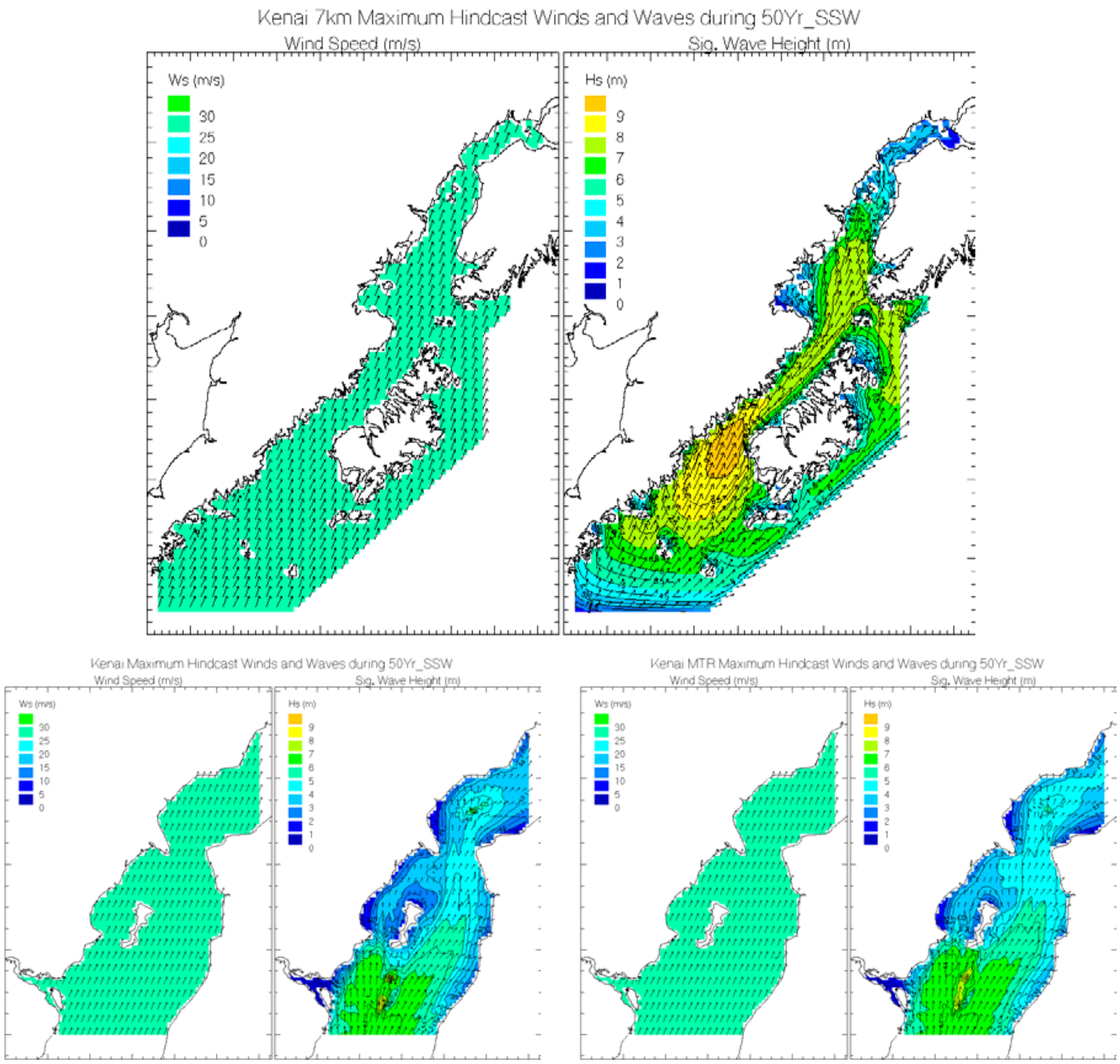


Figure 7 Maximum winds (m/s, left) and waves (m, right) for the SSW constant test on the Kenai7km (top), Kenai (bottom left) and KenaiMTR (bottom right) grids

STORM PRODUCTION AN D EXTREMES

Storm Production

In the previous wind study, a series of 30 storm events were hindcast to represent the most intense wave generation candidates (Table 2). Boundary spectra from the GROWFINE: NEPAC model were extracted for each storm period and applied along the boundary of the Kenai7km model grid. Each storm period was run with an additional 36 hours spin-up to the start times indicated in Table 2, this spin-up period was removed from all archived timeseries. All three model grids: Kenai7km, Kenai and KenaiMTR were run for all storms and wave fields archived on the Kenai and KenaiMTR at 15-minute timestep for all active grid points. All simulations were made assuming zero-ice with all wave points active in the model. Maximum wind and wave conditions during the 19730310 storm are shown in Figure 8. Plots of all storm maximum conditions are detailed in the Appendix.

Table 2. Storm periods from wind study

Storm ID	Start (CYMDH)	End (CYMDH)
19730310	1973030900	1973031112
19740303	1974030118	1974030412
19750126	1975012512	1975012718
19751021	1975102000	1975102206
19760130	1976012900	1976013112
19780820	1978081812	1978082112
19800207	1980020518	1980020806
19850228	1985022606	1985022812
19870222	1987022012	1987022300
19900827	1990082506	1990082800
19920515	1992051312	1992051606
19930921	1993092000	1993092200
19960925	1996092406	1996092700
19971229	1997122718	1997123006
19980817	1998081418	1998081806

19991223	1999122118	1999122406
20000128	2000012612	2000012900
20010228	2001022518	2001030100
20010404	2001040306	2001040512
20010502	2001042912	2001050218
20020213	2002021100	2002021318
20020501	2002042918	2002050200
20020927	2002092512	2002092800
20021008	2002100606	2002100818
20030105	2003010312	2003010606
20030727	2003072600	2003072818
20050924	2005092218	2005092600
20051019	2005101618	2005101906
20051124	2005112206	2005112418
20060818	2006081612	2006082018

Extremes

Timeseries from the KenaiMTR storm runs for grid point number 1780 located at 60.5375N 208.7000E at water depth of 7.08 meters were extracted for computing a 50-year return period significant wave height. Figure 9 shows the resulting Gumbel fit to the 30 hindcast significant wave heights which results in a 50-year return period of 3.1 meters at the grid point location. Interestingly, this result is within 10% of the significant wave height hindcast (2.9 meters at GP 1780) in the SSW test run which applied the steady-state Nikiski 50-year wind speed. The 50-year wave period associated with respect to wave height extreme (7.9 seconds) from storms is found from regressions of the form TP = C0* HS** C1 (TP in seconds, HS in meters). The wind speed 50-year return period (23.7 m/s) is obtained by the Gumbel peaks over threshold fit to the wind peaks in the 30 storms. All derived extremes at grid point 1780 as shown in Table 3.

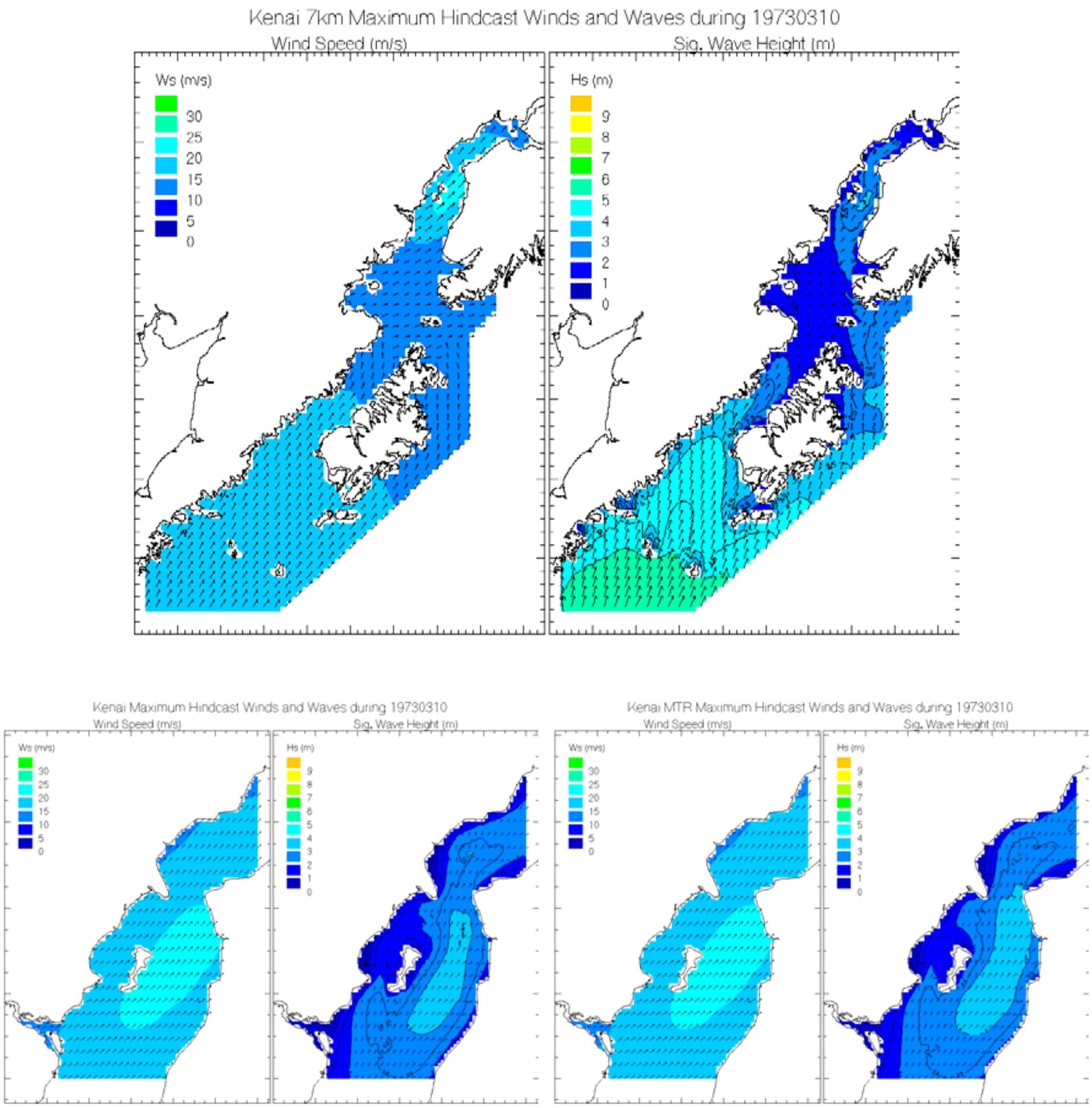
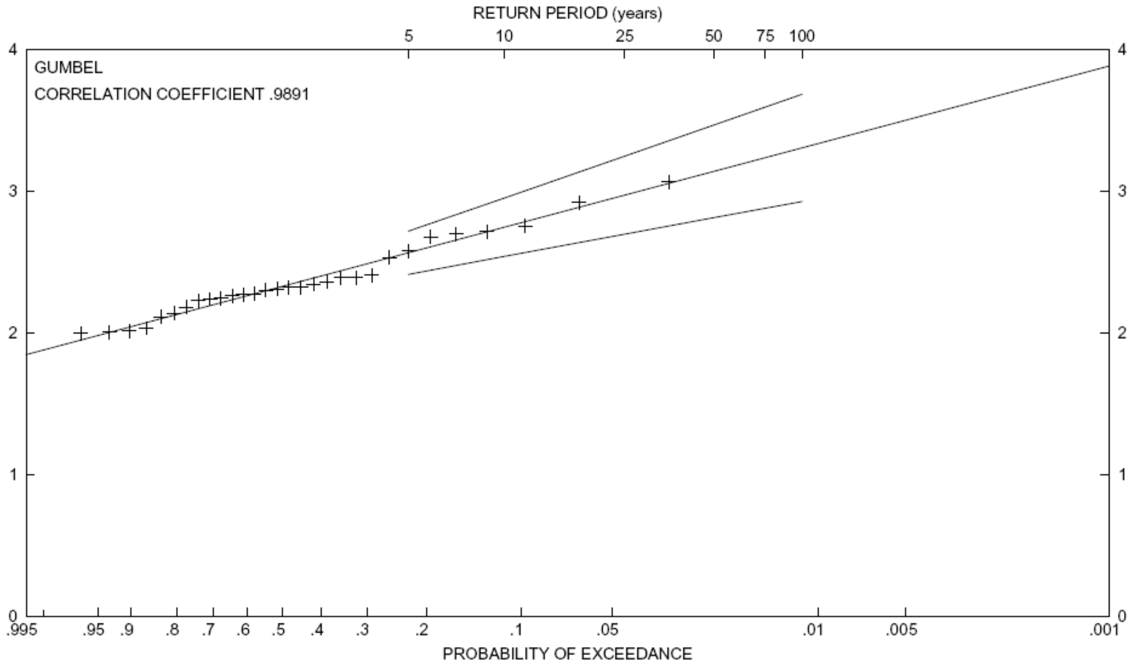


Figure 8. Maximum winds (m/s, left) and waves (m. right) for the 19730310 storm event on the Kenai7km (top), Kenai (bottom left) and KenaiMTR (bottom, right) grids.




```
Onmi Directional Sig. Wave Height at GP1780 (KenaiMTR)
Max 3.069 * 0.5 = 1.5345; 30 storms
3.07, 2.92, 2.76, 2.71, 2.70, 2.68, 2.58, 2.53, 2.41, 2.39, 2.39, 2.36, 2.35, 2.33, 2.33,
2.31, 2.30, 2.28, 2.27, 2.27, 2.25, 2.24, 2.23, 2.18, 2.14, 2.12, 2.03, 2.01, 2.01, 2.00,
```

Period	Prob.	Gumbel	lcl	ucl
0.	0.0000	0.00	0.00	0.00
5.	0.2267	2.57	2.41	2.72
10.	0.1133	2.75	2.54	2.95
25.	0.0453	2.97	2.70	3.25
50.	0.0227	3.14	2.81	3.47
75.	0.0151	3.24	2.88	3.60
100.	0.0113	3.31	2.93	3.69

Figure 9 Gumbel distribution fit to the peak sig. wave heights hindcast at GP 1780 from the KenaiMTR hindcast

Table 3 50-Year return period extremes at GP 1780 based on KenaiMTR storm runs

Variable	50-Year Return Period
Significant Wave Height (m)	3.1
Associated Wave Period (s)	7.9
Wind Speed (m/s)	23.7

DELIVERABLES

All hindcast deliverables are contained on a single DVD volume, including a copy of this report in PDF format.

Data-Sources-Grids

The Data-Sources-Grids directory contains much of the source data tapped for this study. Complete buoy data files obtained from the National Ocean Data Center in F291 format are contained in two zip files for NOAA buoys 46077 and 46016. See http://www.nodc.noaa.gov/General/NODC-Archive/f291.html for information on the F291 format. Source data for the Nikiski site was obtained from the National Ocean Service in METO.NOS format, see http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=9455760 Nikiski, AK&type=Meteorological+Observations for information. Decoded measurements in a comma-delimited file (with hand edits for data spikes) are contained in the NTKA2-ED.csv file. Variables/units are given in the file header. Source bathymetry from AOOS (www.aoos.org) are provided in the AOOSbathymetricDEMv1.03.nc. This file is in netCDF format and contains header information as to its contents.

Grid files for the Kenai and KenaiMTR models are give both as ascii files and graphically as GIF images. Grid ascii files contain model lat and long (I,J), grid point number (kpt, 0=land), latitudes and longitudes (alat, along), landsea indicator (zang, 0=land, 360=water) as well as depth (meters, decimal and nearest integer).

Buoy-Verif

The Buoy-Verif directory contains comma-delimited CSV files and GIF images which contain the evaluations of the 2007-2008 continuous hindcasts against buoys 46077 and 46106. Periods where the measured peak period are >= 10 seconds are highlighted in blue in the GIF images. All CSV files contain modeled/measurement headers with units. Dates are provided in Julian format which is in the same definition as Microsoft Excel.

Wave-Hindcasts

The Wave-Hindcast directory contains plots, timeseries and spectra for all the storm runs (30 events plus 8 constant wind runs) for both the Kenai and KenaiMTR model grids. Each storm is in a unique directory and each contains a Plots, PtSort, and Spectra directory. The Plots contain the maximum wind/wave plots for each run. The PtSort directory contains the complete archive of winds and waves at each model grid point for the Kenai and KenaiMTR hindcasts. All dates are UTC and Julian dates in Microsoft Excel format. Definitions of the standard OWI wind and wave fields are shown in the Appendix. Timestep for all output is every 15-minute. Wave spectra were archived at 27 locations (see Table 4 and Figure 10) offshore of Kenai for use in follow-on STWAVE modeling. Each file contains the variances in each 23 frequency by 24 direction bands applied in the UNIWAVE model. Format description of the wave spectra may be found in the Appendix.

Wind-Study

This directory contains the complete wind study report and output previously delivered. This directory has not been modified from the original delivery and it contained here for convenience.

Table 4 Wave Spectra Archive Locations

Grid Point Number	Latitude (deg)	Longitude (deg)
1588	60.4750	208.6500
1589	60.4750	208.6750
1590	60.4750	208.7000
1623	60.4874	208.6500
1624	60.4875	208.6750
1625	60.4875	208.7000
1660	60.5000	208.6500
1661	60.5000	208.6750
1662	60.5000	208.7000
1669	60.5125	208.6500
1700	60.5125	208.6750
1701	60.5125	208.7000
1739	60.5250	208.6500
1740	60.5250	208.6750
1741	60.5250	208.7000
1778	60.5375	208.6500
1779	60.5375	208.6750
1780	60.5375	208.7000
1816	60.5500	208.6500
1817	60.5500	208.6750
1818	60.5500	208.7000
1854	60.5625	208.6500
1855	60.5625	208.6750
1888	60.5750	208.6500
1920	60.5875	208.6500
1950	60.6000	208.6500
1980	60.6125	208.6500

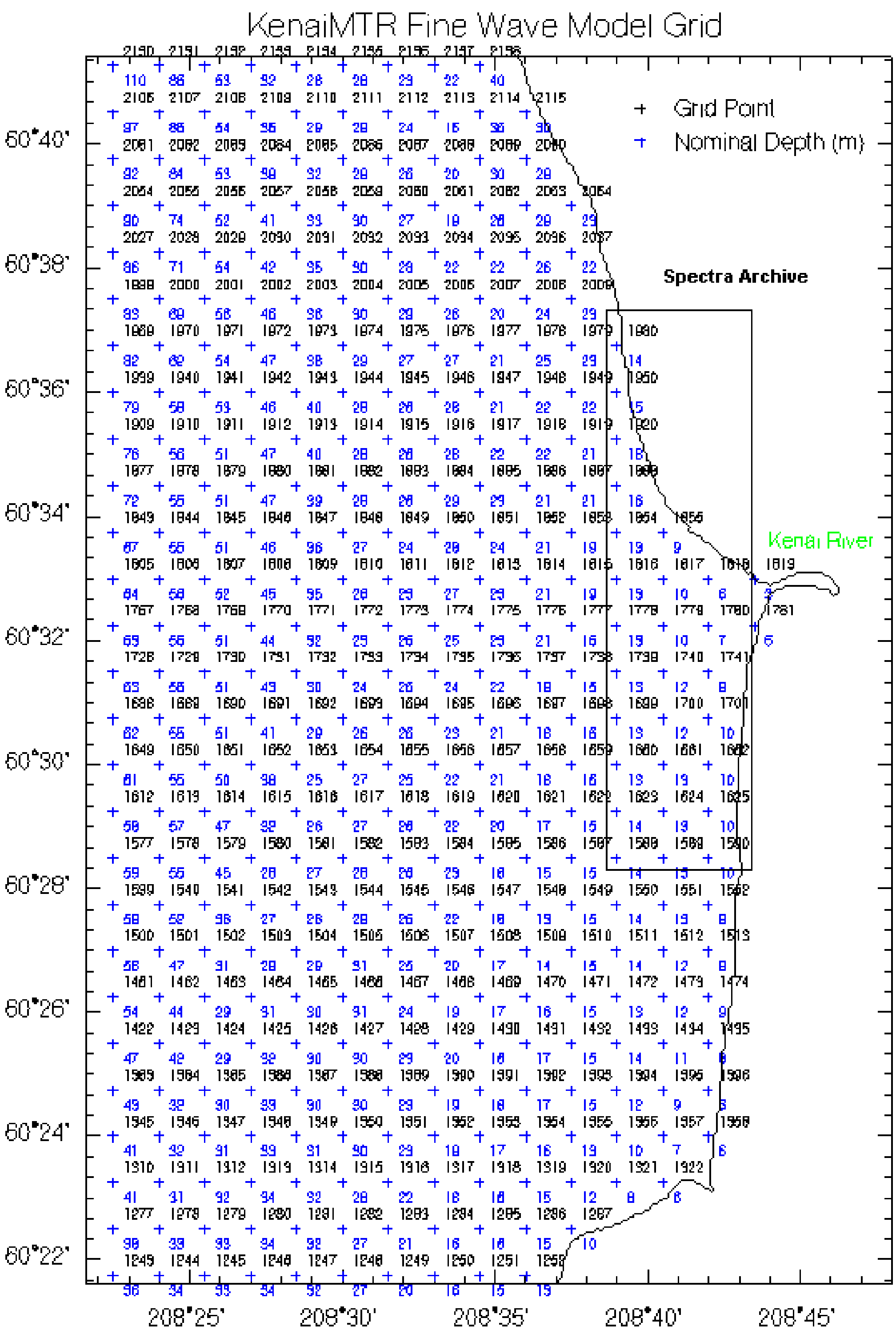


Figure 10 Wave spectra archive locations

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APPENDIX A OWI Wind and Wave Fields Definitions

Date in YYYYMM format (UTC)
Date in DDHHMM format (UTC)
Date in Julian format (MS-Excel definition)

WD Wind Direction:
From which the wind is blowing, clockwise from true north in degrees (meteorological convention).

WS Wind Speed:
1-hour average of the effective neutral wind at a height of 10 meters, units in meters/second.

ETOT Total Variance of Total Spectrum:
The sum of the variance components of the hindcast spectrum, over the 552 bins of the 3G wave model, in
meters squared.

TP Peak Spectral Period of Total Spectrum:
Peak period is the reciprocal of peak frequency, in seconds. Peak frequency is computed by taking the spectral density in each frequency bin, and fitting a parabola to the highest density and one neighbor on each side. If highest density is in the .32157 Hz bin, the peak period reported is the peak period of a Pierson-Moskowitz spectrum having the same total variance as the hindcast spectrum.

VMD Vector Mean Direction of Total Spectrum:
To which waves are traveling, clockwise from north in degrees
(oceanographic convention).

$$\mathrm{VMD} = \tan^{-1} \frac{\int_0^{2\pi}\int_0^{\infty} \sin\theta E(f,\theta)\,df\,d\theta}{\int_0^{2\pi}\int_0^{\infty} \cos\theta E(f,\theta)\,df\,d\theta}$$

Explanation of sea/swell computation:
The sum of the variance components of the hindcast spectrum, over the 552 bins of the 3G model, in meters
squared. To partition sea (primary) and swell (secondary) we compute a P-M (Pierson-Moskowitz) spectrum, with a cos^3 spreading, from the adopted wind speed and direction. For each of the 552 bins, the lesser of the hindcast variance component and P-M variance component is thrown into the sea partition; the excess, if any, of hindcast over P-M is thrown into the swell partition.

ETTSEA Total Variance of Primary Partition "Sea"
TPSEA Peak Spectral Period of Primary Partition:
VMDSEA Vector Mean Direction of Primary Partition:

ETTSW Total Variance of Secondary Partition: "Swell"
TPSW Peak Spectral Period of Secondary Partition:
VMDSW Vector Mean Direction of Secondary Partition:

MO1 First Spectral Moment of Total Spectrum:

Following Haring and Heideman (OTC 3230, 1978) the first and second moments contain powers of $\omega = 2\pi f$; thus:

$$M_1 = \sum\sum 2\pi f dS$$
$$M_2 = \sum\sum (2\pi f)^2 dS$$

where dS is a variance component and the double sum extend over
552 bins.

MO2 Second Spectral Moment of Total Spectrum:

HS Significant Wave Height:
4.000 times the square root of the total variance, in meters.

Dominant Direction: Following Haring and Heideman, the dominant direction ψ is the solution of the equations

$$A\cos 2\psi = \sum\sum \cos 2\theta\pi dS$$
$$A\sin 2\psi = \sum\sum \sin 2\theta\pi dS$$

The angle ψ is determined only to within 180 degrees. Haring and Heideman choose from the pair (ψ, ψ+180) the value closer to the peak direction.

Angular Spreading Function: The angular spreading function (Gumbel, Greenwood & Durand) is the mean value, over the 552 bins, of cos(θ -VMD), weighted by the variance component in each bin. If the angular spectrum is uniformly distributed over 360 degrees, this statistic is zero if uniformly distributed over 180 degrees, $2/\pi$ if all variance is concentrated at the VMD, 1. For the use of this statistic in fitting an exponential distribution to the angular spectrum, see Pearson & Hartley, Biometrika Tables for statisticians, 2:123 ff.
Angular spreading (ANGSPR) is related to $\cos^n(\theta)$ spreading as follows:
n = (2*ANGSPR)/(1-ANGSPR)

In-Line Variance Ratio: called directional spreading by Haring and Heideman, p 1542. Computed as:

$$Rat = \frac{\sum\sum \cos^2(\theta - \psi) ds}{\sum\sum dS}$$

If spectral variance is uniformly distributed over the entire compass, or over a semicircle, Rat = 0.5; if variance is confined to one angular band, or to two band 180 degrees apart, Rat = 1.00 . According to Haring and Heideman, cos^2 spreading corresponds to Rat = 0.75 .

APPENDIX B: Wave Spectra Format

Description of Two-Dimensional Hindcast Spectrum Table

The first line of each spectrum gives date, grid point number, latitude, longitude, water depth, wind speed, wind direction (measured from which) and significant wave height. The next line gives the nominal frequencies of each frequency bin. Directional bands are identified at the left. The 552 element array contains the variance components (NOT spectral densities) for 23 frequencies and 24 directions. The 24 directional bins, each 15 degrees wide, are numbered clockwise from north; the first bin, with a nominal direction 7.5 degrees, extends from 0 to 15 degrees.

Frequency bins are spaced in geometric progression (to facilitate the computation of interactions); the nominal frequency is the geometric mean of the two ends. The frequency ratio is .75**(-1./3.), i.e. 1.100642416; this ratio was chosen in preference to the 1.1000 of official WAM to simplify interaction formulas. The first 22 bins are straightforward; the last requires explanation (continued below table).

	nom. freq	left end	right end	bandwidth
1	0.0390000	0.0371742	0.0409155	0.0037413
2	0.0429251	0.0409155	0.0450333	0.0041178
3	0.0472451	0.0450333	0.0495656	0.0045323
4	0.0520000	0.0495656	0.0545540	0.0049884
5	0.0572334	0.0545540	0.0600444	0.0054904
6	0.0629935	0.0600444	0.0660874	0.0060430
7	0.0693333	0.0660874	0.0727386	0.0066512
8	0.0763112	0.0727386	0.0800592	0.0073206
9	0.0839914	0.0800592	0.0881166	0.0080574
10	0.0924444	0.0881166	0.0969849	0.0088683
11	0.1017483	0.0969849	0.1067457	0.0097608
12	0.1119885	0.1067457	0.1174888	0.0107431
13	0.1232593	0.1174888	0.1293131	0.0118244
14	0.1356644	0.1293132	0.1423275	0.0130144
15	0.1493180	0.1423275	0.1566517	0.0143242
16	0.1643457	0.1566517	0.1724175	0.0157658
17	0.1808858	0.1724175	0.1897700	0.0173525
18	0.1990906	0.1897700	0.2088690	0.0190989
19	0.2191276	0.2088690	0.2298900	0.0210211
20	0.2411811	0.2298900	0.2530267	0.0231367
21	0.2654541	0.2530267	0.2784919	0.0254652
22	0.2921701	0.2784919	0.3065200	0.0280281
23	0.3215748	0.3065200	2.5274134	

The 23rd frequency band is an integrated band comprising what would be bins 23 through 44 (continuing the geometric progression) of a fully discrete bin system. To model the cascade of wave energy from high to low frequencies endorsed by non-linear interactions, we compute interactions involving bins out to 44. This requires a parametric assumption about the spectral density between 0.30652 and 2.52741 Hz; and the customary assumption is that density is proportional to omega**(-x), where x is a disposable parameter. We are using x = 4.5 for the following reasons:

(1) There are quasi-physical arguments supporting the exponents 4 & 5. The exponent 5 is germane to a Pierson-Moskowitz spectrum.

(2) A crude energy balance computation in the tail, with wind input scaled as omega**2 and interactions scaled as omega**11, shows that 4.5 is the only exponent capable of yielding an equilibrium spectrum in the tail.

To compute a "density" at 0.32157 Hz, we compute what fraction of the integrated band belongs to the bin from 0.30652 to 0.33737 Hz. Sparing a few details, the result is:

```
dens = (variance component)*rbw
```

where rbw (dimensions seconds) is a function of the exponent as follows:

```
  x      rbw
 4.0   8.11849
 4.5   9.24794
 5.0  10.32933
```

Anspec is the variance summed over frequency per direction bin.
Fspec is the variance summed over direction per frequency.
Dens is the frequency spectrum represented as density in units of m^2Hz.

```
Sample Table:
196301.240600.  gp  1121.  lat  34.00  long   31.00  depth 2590.89   10.95 m/s from 273.97 deg; hsig =  3.37
frequency 0.0390 0.0429 0.0472 0.0520 0.0572 0.0630 0.0693 0.0763 0.0840 0.0924 0.1017 0.1120 0.1233 0.1357 0.1493 0.1643 0.1809 0.1991 0.2191 0.2412 0.2655 0.2922 0.3216   anspec
 direction

    7.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0001 0.0001 0.0001 0.0002 0.0002 0.0002 0.0002 0.0009   0.0020
   22.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0002 0.0003 0.0004 0.0005 0.0006 0.0006 0.0006 0.0006 0.0005 0.0016   0.0059
   37.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0002 0.0004 0.0006 0.0011 0.0014 0.0015 0.0014 0.0014 0.0012 0.0011 0.0009 0.0025   0.0137
   52.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0003 0.0006 0.0012 0.0021 0.0030 0.0032 0.0031 0.0028 0.0024 0.0020 0.0016 0.0012 0.0031   0.0268
   67.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0002 0.0005 0.0010 0.0018 0.0034 0.0054 0.0061 0.0056 0.0049 0.0041 0.0032 0.0025 0.0018 0.0013 0.0034   0.0454
   82.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0003 0.0008 0.0018 0.0031 0.0051 0.0086 0.0098 0.0087 0.0075 0.0061 0.0048 0.0036 0.0026 0.0019 0.0014 0.0035   0.0695
   97.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0002 0.0010 0.0028 0.0056 0.0087 0.0130 0.0148 0.0128 0.0104 0.0083 0.0064 0.0047 0.0035 0.0025 0.0019 0.0014 0.0035   0.1015
  112.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0005 0.0024 0.0068 0.0129 0.0188 0.0223 0.0185 0.0144 0.0107 0.0079 0.0058 0.0044 0.0032 0.0024 0.0018 0.0013 0.0035   0.1376
  127.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0004 0.0024 0.0072 0.0147 0.0231 0.0242 0.0178 0.0127 0.0091 0.0066 0.0050 0.0039 0.0029 0.0022 0.0017 0.0012 0.0033   0.1385
  142.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0005 0.0023 0.0072 0.0148 0.0175 0.0127 0.0089 0.0066 0.0051 0.0040 0.0032 0.0025 0.0019 0.0015 0.0011 0.0029   0.0930
  157.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0002 0.0008 0.0025 0.0050 0.0072 0.0068 0.0053 0.0043 0.0036 0.0030 0.0025 0.0020 0.0015 0.0012 0.0009 0.0024   0.0493
  172.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0003 0.0006 0.0009 0.0013 0.0015 0.0018 0.0020 0.0020 0.0019 0.0016 0.0013 0.0011 0.0009 0.0006 0.0018   0.0197
  187.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0001 0.0001 0.0002 0.0003 0.0004 0.0005 0.0007 0.0007 0.0007 0.0006 0.0005 0.0004 0.0012   0.0064
  202.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0001 0.0001 0.0001 0.0001 0.0002 0.0002 0.0001 0.0006   0.0016
  217.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0001   0.0003
  232.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   0.0000
  247.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   0.0000
  262.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   0.0000
  277.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   0.0000
  292.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   0.0000
  307.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   0.0000
  322.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   0.0000
  337.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   0.0001
  352.50   0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0003   0.0005
fspec      0.0000 0.0000 0.0000 0.0000 0.0000 0.0002 0.0013 0.0069 0.0213 0.0460 0.0760 0.0934 0.0859 0.0744 0.0627 0.0525 0.0433 0.0350 0.0276 0.0216 0.0167 0.0125 0.0345   0.7118
dens         0.00   0.00   0.00   0.00   0.00   0.03   0.20   0.94   2.64   5.18   7.78   8.70   7.27   5.72   4.38   3.33   2.50   1.83   1.31   0.93   0.66   0.45   0.32
```

Each table can be read with the following FORTRAN format statements:

```
      REAL THETA(24), SPEC(23,24), FREQ(23), ANGSPEC(24)
      REAL FSPEC(23), ETOT, DENS(23)
      REAL CYM, DHM, GP, Lat, Long, Depth, WS, WD, HSig

10    format (2f7.0, 4x, f7.0, 5x, f7.2, 6x, f8.2, 7x, 2f8.2,
     & 9x, f7.2, 12x, f6.2)
101   format (9x, 23f7.4)
11    format (f8.2, 2x, 23f7.4, 2x, f7.4)
12    format (10x, 23f7.4, 2x, f7.4)
13    format (10x, 23f7.2)

20    READ (10,10,END=30) CYM, DHM, GP, Lat, Long, Depth, WS, WD, HSig
      READ (10,101) (FREQ(I), I=1,23)
      READ (10,*)
      READ (10,*)
      READ (10,11) (THETA(J), (SPEC(I,J), I=1,23), ANGSPEC(J), J=1,24)
      READ (10,12) (FSPEC(I), I=1,23), ETOT
      READ (10,13) (DENS(I), I=1,23)
      READ (10,*)
      ! [insert processing code here]
      GO TO 20  !read next table
30    CONTINUE  !end of file during read
```

Variable definitions:

CYM - Year and month in the format CCYYMM

DHM - Day, hour and minute (gmt) in the format DDHHmm
GP - Grid point
LAT - Latitude of grid point
LONG - Longitude of grid point
DEPTH - Depth of grid point
WS - Wind speed (m/s) at grid point
WD - Wind direction (from which, clockwise from true north)
HS - Significant wave height (m)
FREQ(I) - Geometric mean of the lower and upper ends of the bandwidth. The frequency bands are given below.
THETA(J) - Mean direction of angular bin, to which waves are traveling, clockwise from true north. The bin extends +/- 7.5 degrees from the center (the value displayed in the table).
SPEC(I,J) - Variance component (not spectral density), in m**2, in frequency band I and angular band J.
ANGSPEC(J)- Variance summed over all frequencies per direction (the right most column).
FSPEC(I) - Variance summed over all directions per frequency (the first footer line).
ETOT - Total variance located at the end of the first footer line.
DENS(I) - Frequency spectrum represented as density in units of m**2 Hz (second footer line).

APPENDIX C: OWI Extremal Analysis Description

Calculation of Return-Period Extremes

The distributional assumptions used are:

1. Gumbel distribution of extremes:

$$Pr\{H \le h\} = \exp\left[-\exp\left(\frac{a_1 - h}{b_1}\right)\right]$$

2. Borgman distributions of extremes, i.e., Gumbel distribution of squared extremes:

$$Pr\{H \le h\} = \exp\left[-\exp\left(\frac{a_2 - h^2}{b_2}\right)\right]$$

3. Galton distribution of height, i.e. normal distribution of log heights:

$$Pr\{H \le h\} = \frac{1}{\sqrt{2\pi}}\int_{\infty}^{x}\exp\left(-\frac{t^2}{2}\right)dt$$, where $$x = \frac{\log h - a_3}{b_3}$$

4. Weibull distribution described in next section

The fitting procedure of Gumbel (1958, pp. 34 - 36) was followed for Gumbel, Borgman and Galton, with plotting positions based in i/(n+1), often called Weibull plotting position. Specifically, let

$$y_i = -\log_e\left[-\log_e\left(\frac{i}{n+1}\right)\right],$$

and define zi as the root of the equation

$$\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{z}\exp\left(\frac{-1}{2t^2}\right)dt = \frac{1}{n+1}.$$

Then the constants a and b are determined from

$$b_1 = \sqrt{\frac{Var(h)}{Var(y_i)}}, a_1 = Av(h) - b_1 Av(y_i)$$

$$b_2 = \sqrt{\frac{Var(h^2)}{Var(y_i)}}, a_2 = Av(h^2) - b_2 Av(y_i)$$

$$b_3 = \sqrt{\frac{Var\ (\log_e h)}{Var\ (z_i)}}, a_3 = Av(\log_e h)$$

where Av and Var denote the average and the variance of the operand.

The extrapolations corresponding to a return period of T years are based upon n storms as a complete enumeration of the relevant storm events in Y years.

The cumulative distribution function corresponding to return period T is

$$P_T = 1 - \frac{Y}{nT}.$$

Define zT as the root of

$$\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{z}\exp\left(\frac{-1}{2t^2}\right)dt = P_T.$$

Then the height with return period T is computed as

$$h_{T1} = a_1 - b_1\log_e(-\log_e P_T);$$

$$h_{T2} = \sqrt{a_2 - b_2\log_e(-\log_e P_T)};$$

$$h_{T3} = \exp(a_3 + b_3 z_T).$$

The 90% confidence limits shown on the individual predicted extreme values were computed according to the method of Dick and Darwin (1954) (see also Gumbel, 1958, p. 218). In 90% of extrapolations, the true values of the return period extremes will be between the limits indicated.

Weibull Distribution

The Weibull distribution is a generalization of the exponential distribution, most expediently defined in terms of the exceedance probability:

$Q = \Pr\{X \geq x\} = \exp[-y^{\alpha}]$, where $y = (x-\mu)/\sigma$;

X is the variable to be distributed (for example, wave height);

α is the shape parameter:

for $\alpha = 1$, the distribution is exponential

for $\alpha < 1$, the distribution is long-tailed

for $\alpha > 1$, the distribution is short-tailed

μ is the lower limit of the distribution; $\Pr\{X < \mu\} = 0$;

σ is a scale parameter such that $\Pr\{X \geq \mu + \sigma\} = 1/e$

The parameter α is a pure number; μ and σ have the same units as X; whence it follows that y is dimensionless. For some purposes, the probability density, -dQ/dx, is more convenient than Q:

$$-\frac{dQ}{dx} = \frac{Q\alpha}{\sigma} y^{\alpha-1}$$

The fitting method adopted is to take an arbitrary value for μ, and then fit σ and α by the method of maximum likelihood. The value assumed for μ is

$\mathrm{M} = 0.5(H_1 + 0.98H_2)$, where

M is the assumed μ, used in the subsequent computation;

H1 is a value, often taken as a percentage of the largest X reported, such that X-values less than H1 are excluded from extremal analysis.

H2 is the smallest X used in the extremal analysis. Thus $H_2 \geq H_1$.

The method of maximum likelihood finds $\hat{\alpha}, \hat{\beta}$, such that

$\frac{d}{d\alpha}\left[\log\frac{dP}{dx}\right] = 0$ and $\frac{d}{d\beta} = \left[\log\frac{dP}{dx}\right] = 0$ when evaluated at the point ($\hat{\alpha}, \hat{\beta}$);

then the adopted is given by $\sigma = \hat{\beta}^{-1/\hat{\alpha}}$.

Printed and plotted extremes are based on the observation that if X is Weibull distributed, then

$Z = -\log_e[X - \mathrm{M}]$ is Gumbel distributed; specifically,

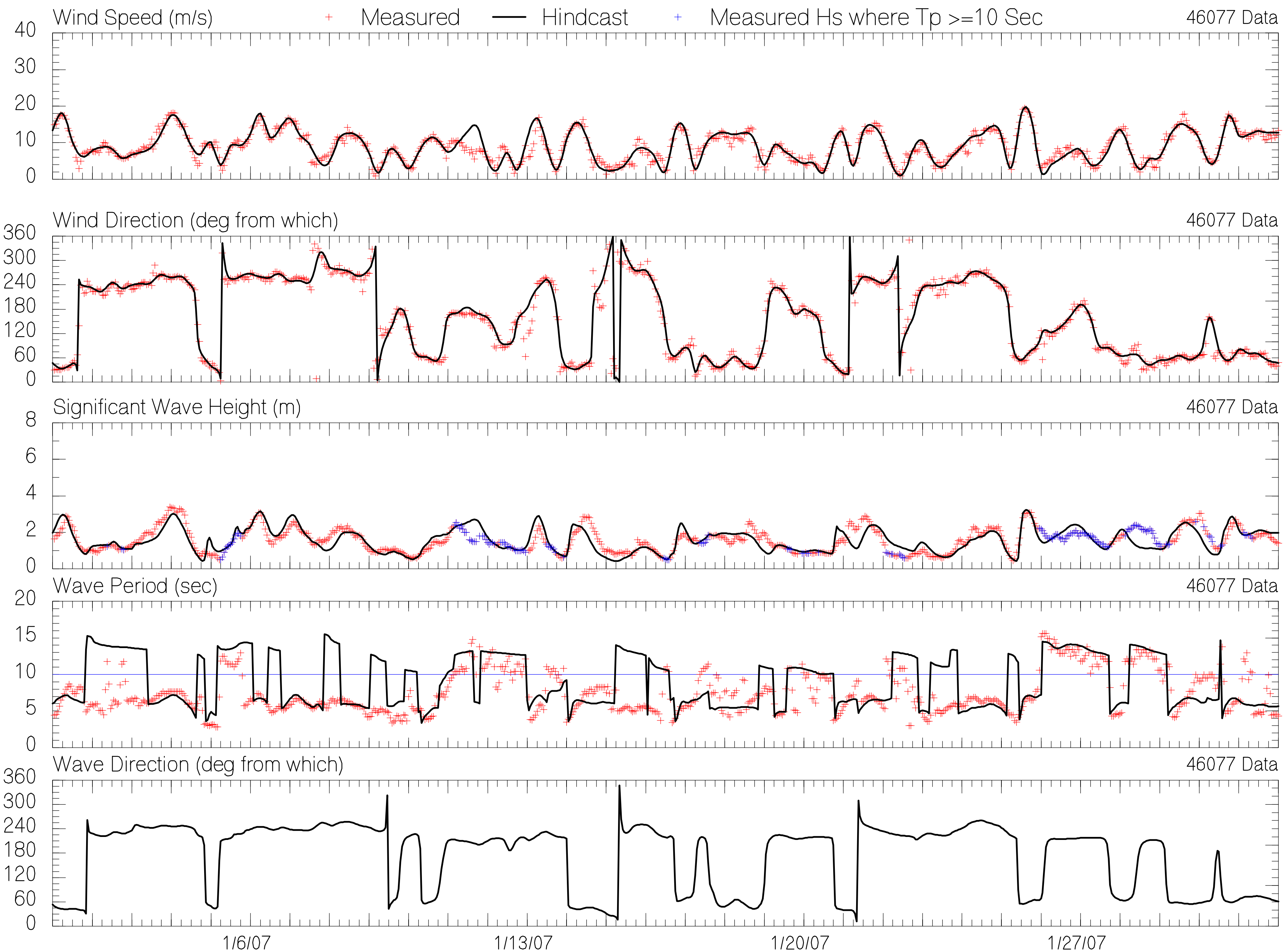
$$Q = \Pr\{Z \leq z\} = \exp\left[-\exp\left(\frac{z-A}{B}\right)\right], A = \sigma, B = \frac{1}{\alpha}.$$

The ordinate and abscissa of a Weibull exceedance plot are respectively log X and log(log Q).

APPENDIX D: Buoy Verification Plots for Continuous and Maximum Plots from Storm Runs

Kenai7km Model Validation

January 2007 - Buoy 46077



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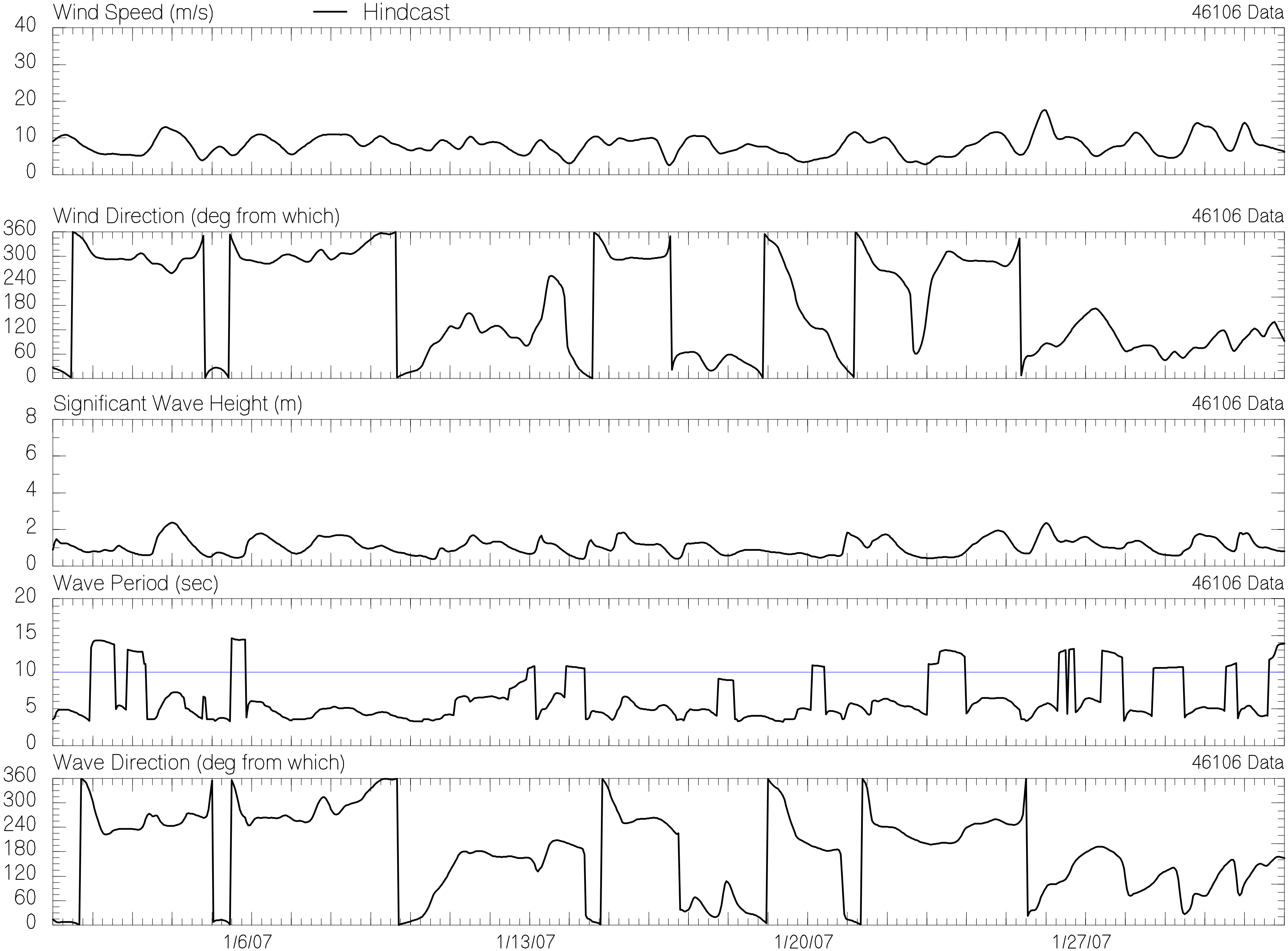
oceanweather inc.

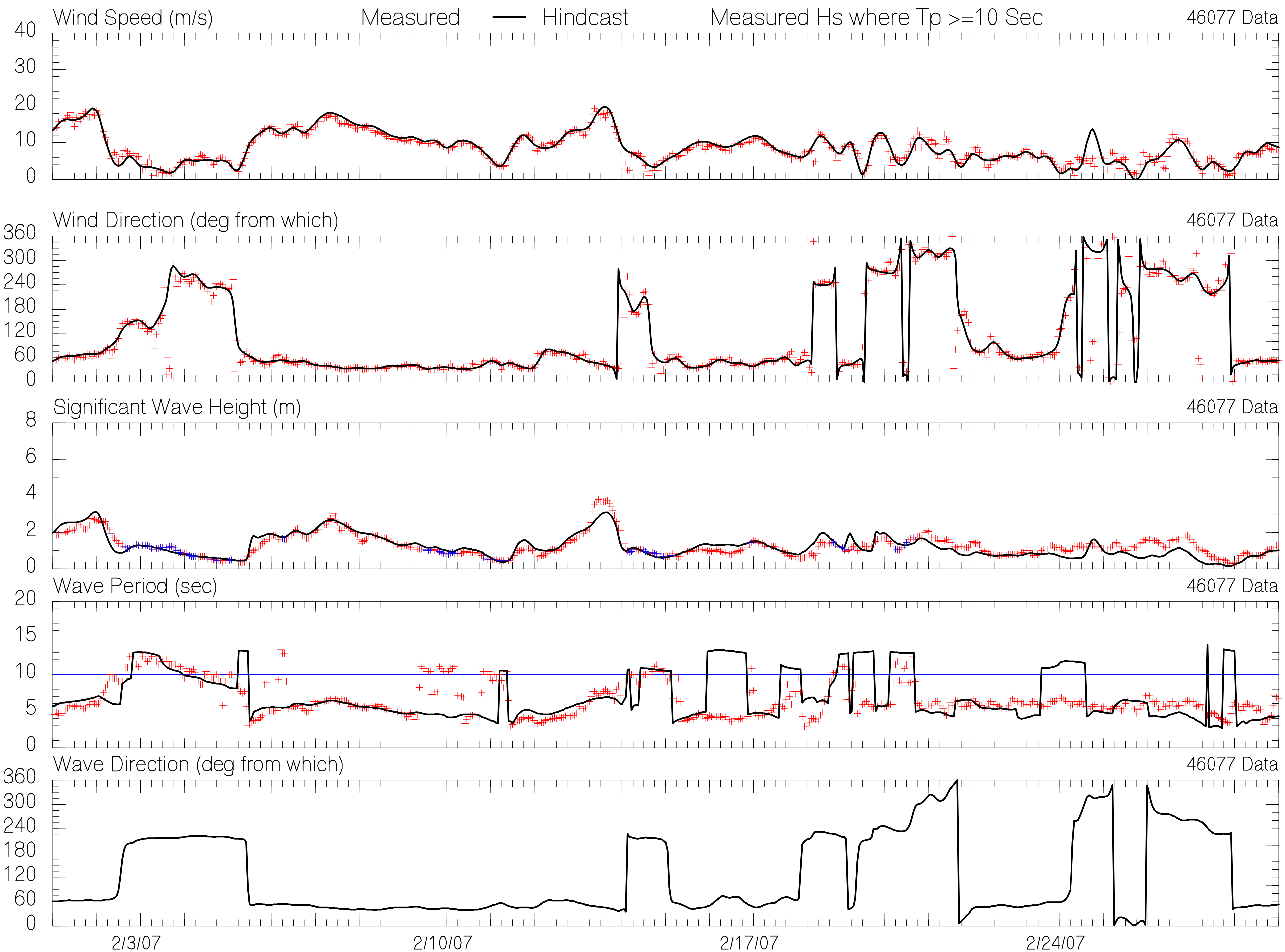
Kenai7km Model Validation

January 2007 - Buoy 46106



Kenai7km Model Validation

February 2007 - Buoy 46077



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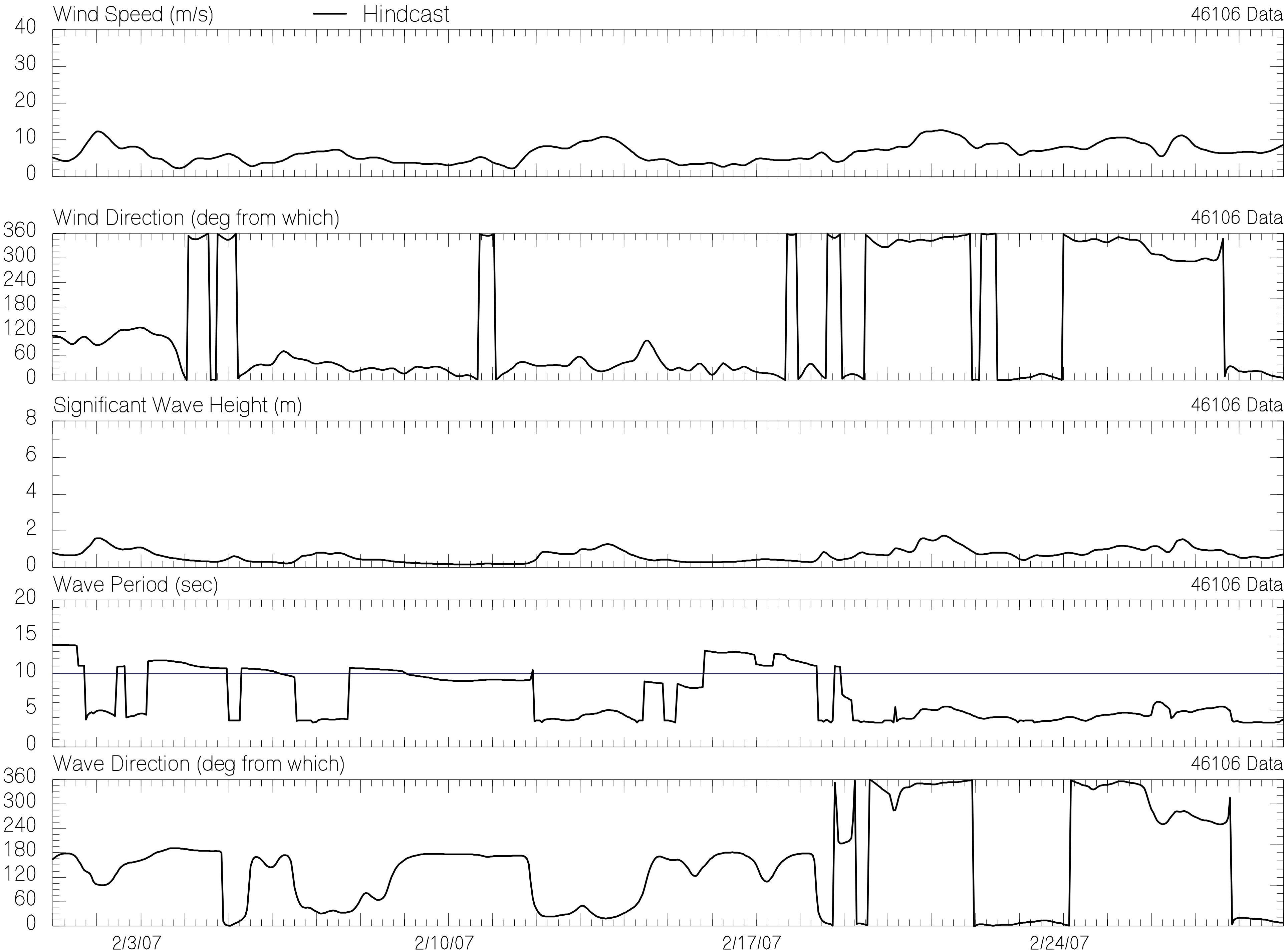
oceanweather inc.

Kenai7km Model Validation

February 2007 - Buoy 46106



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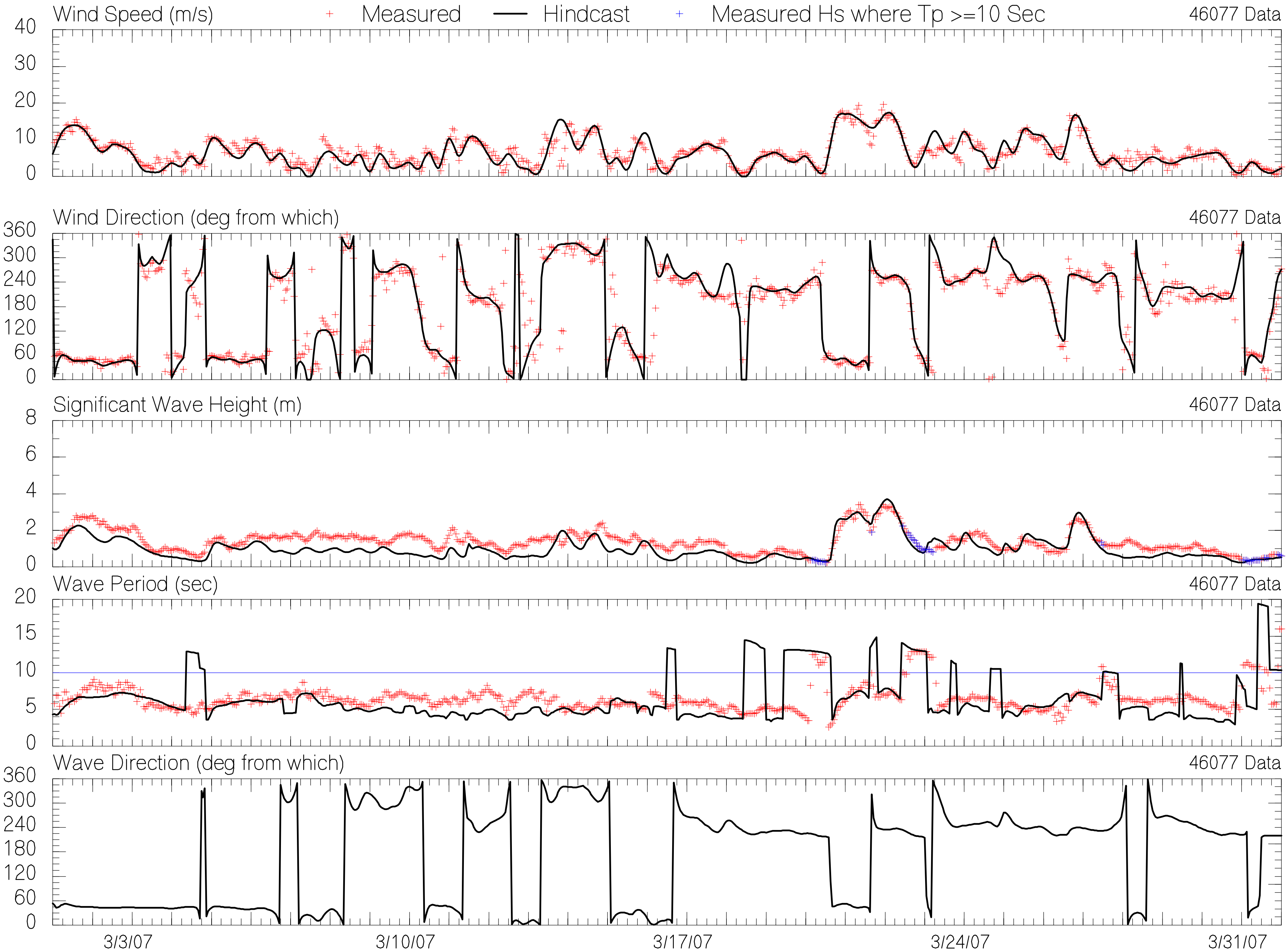
oceanweather inc.

Kenai7km Model Validation

March 2007 - Buoy 46077



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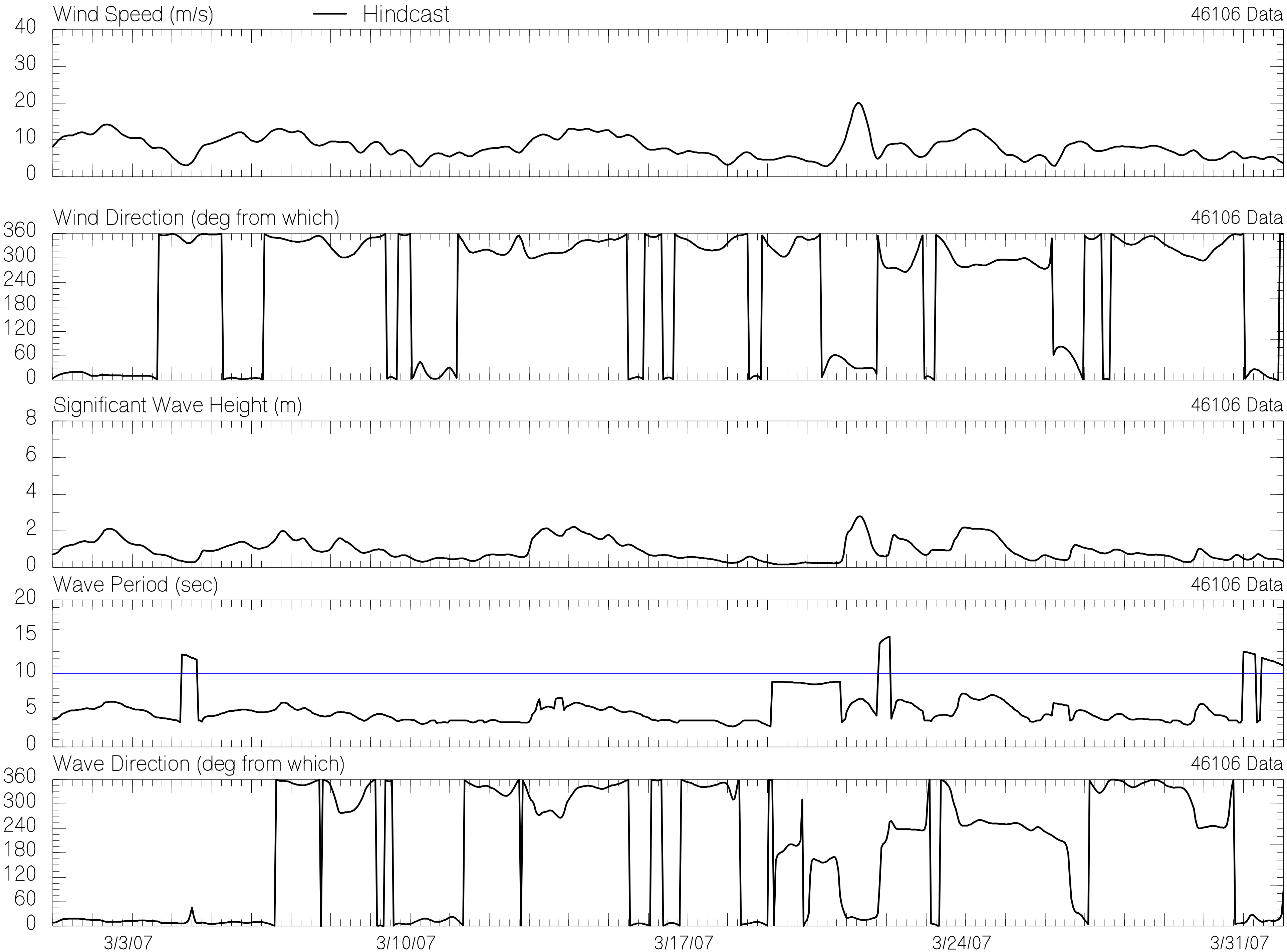
oceanweather inc.

Kenai7km Model Validation March 2007 - Buoy 46106



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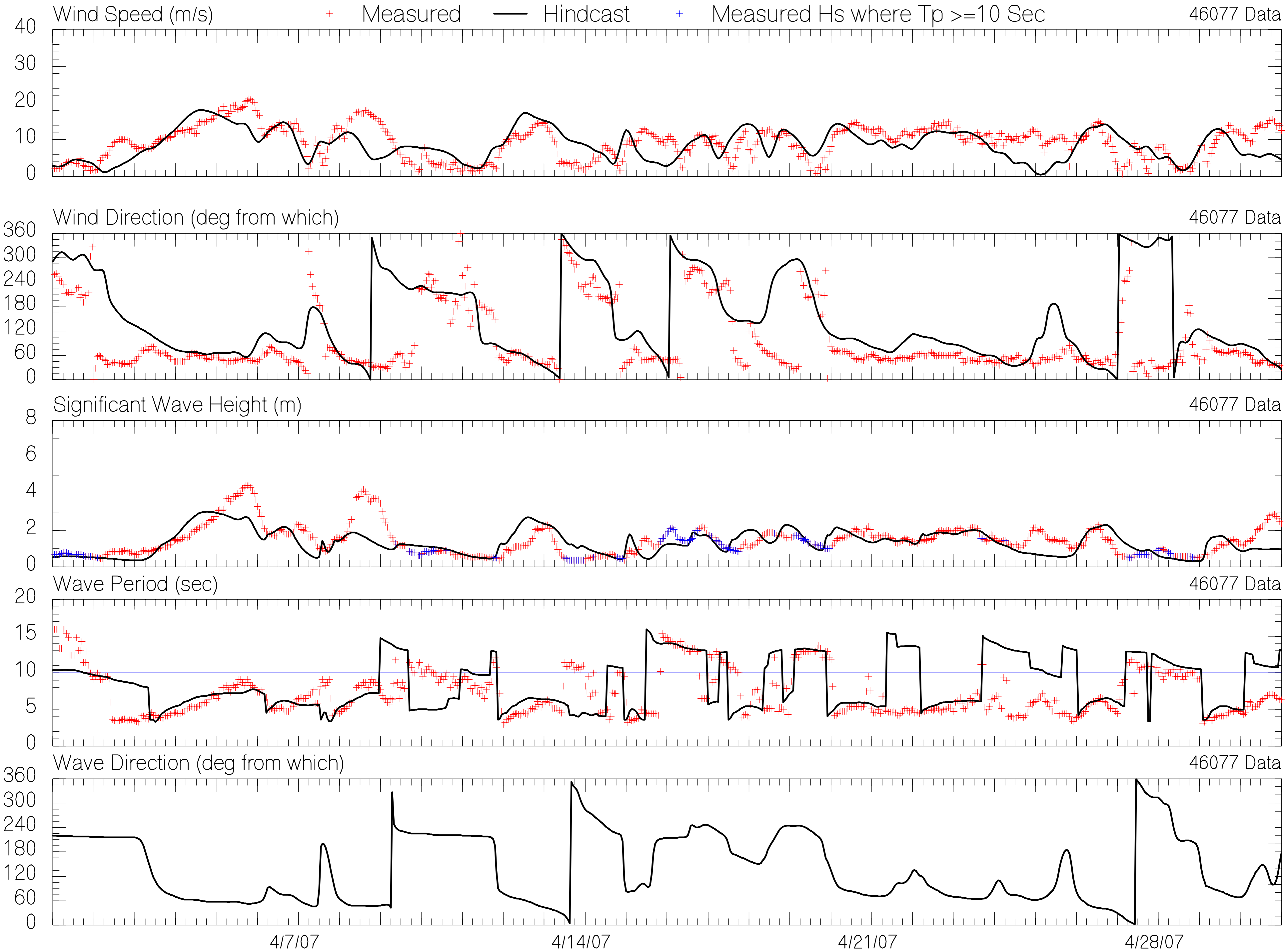
oceanweather inc.

Kenai7km Model Validation

April 2007 - Buoy 46077



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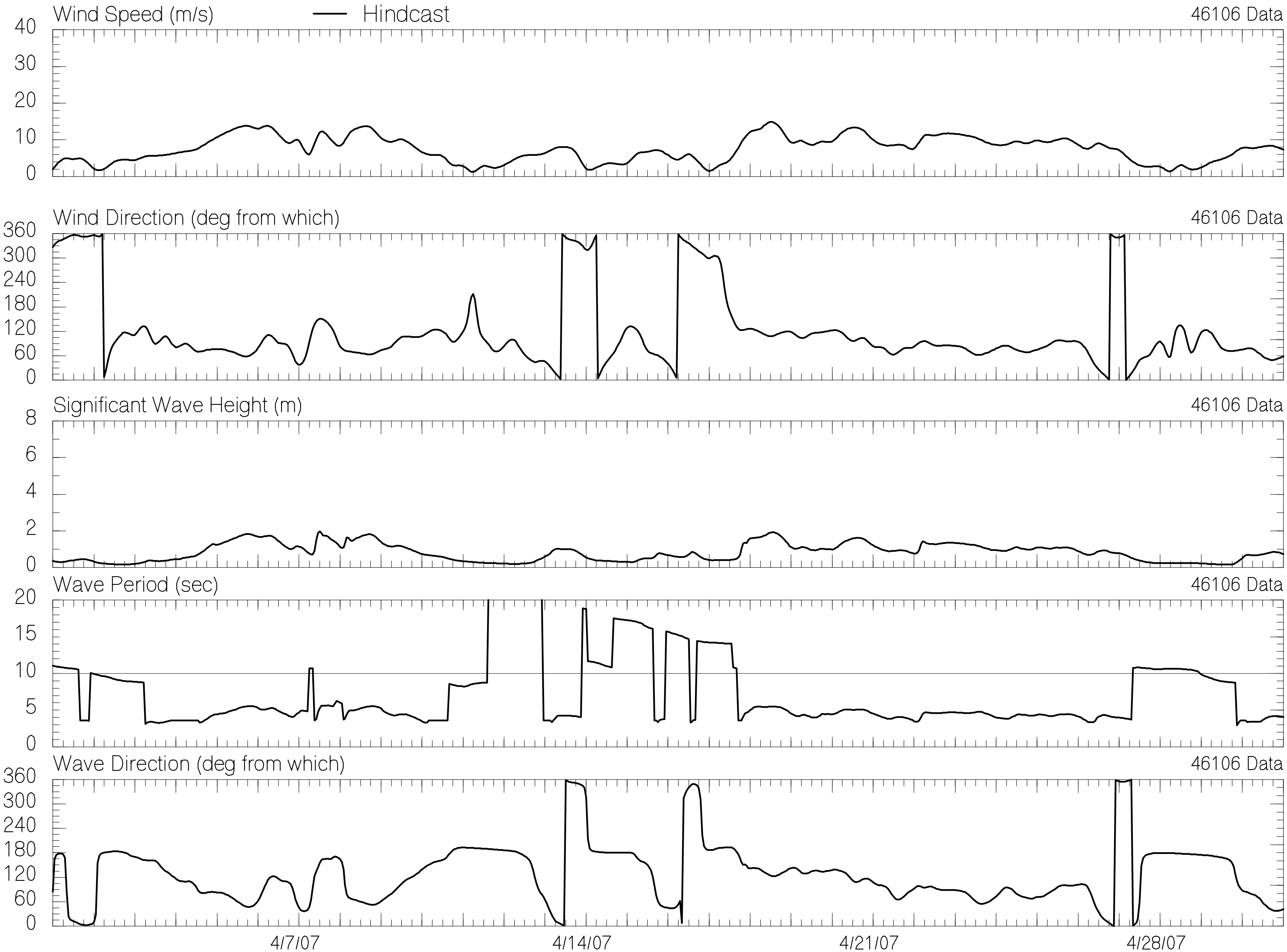
Kenai7km Model Validation

April 2007 - Buoy 46106



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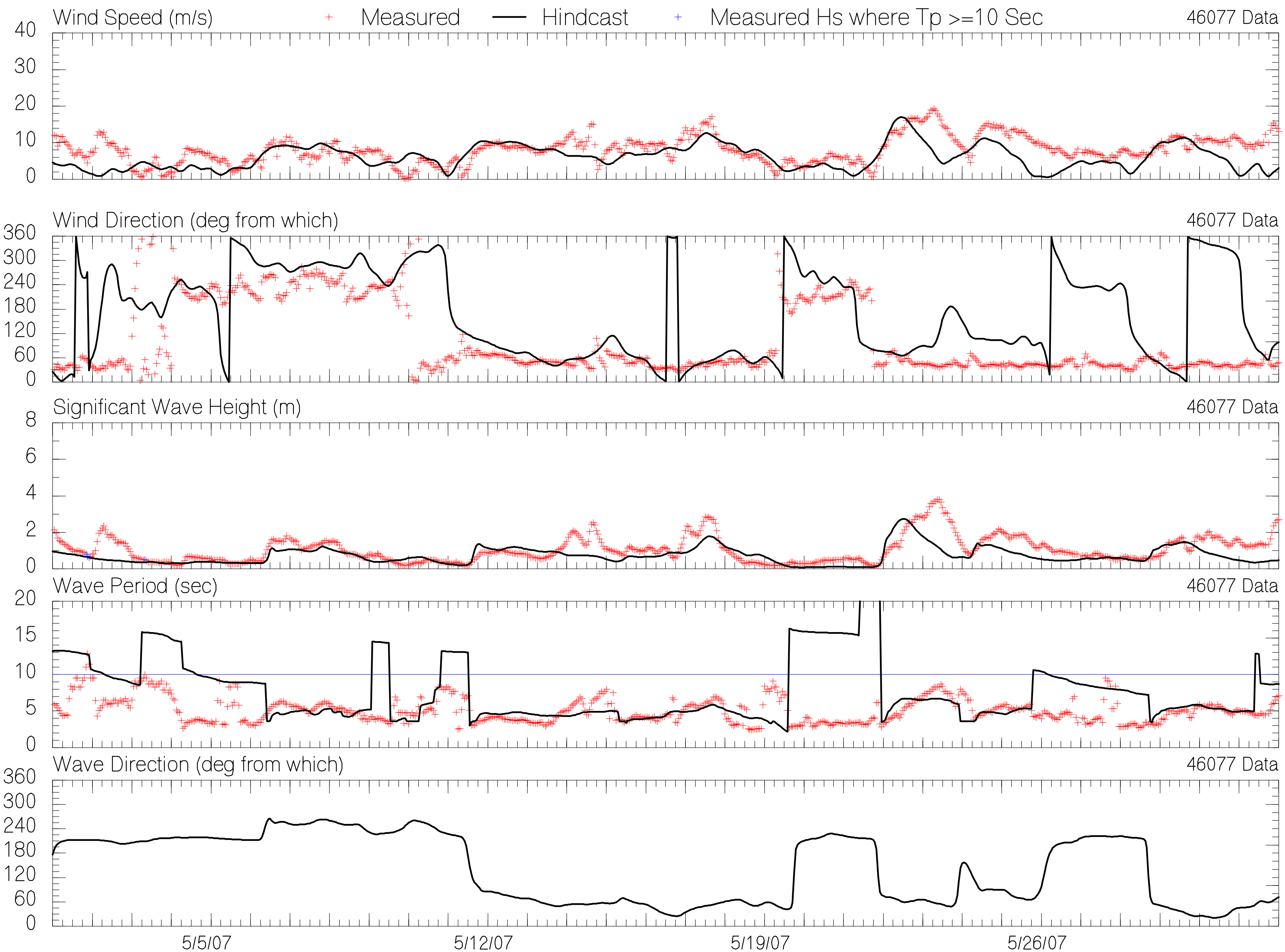
Kenai7km Model Validation

May 2007 - Buoy 46077



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Kenai7km Model Validation

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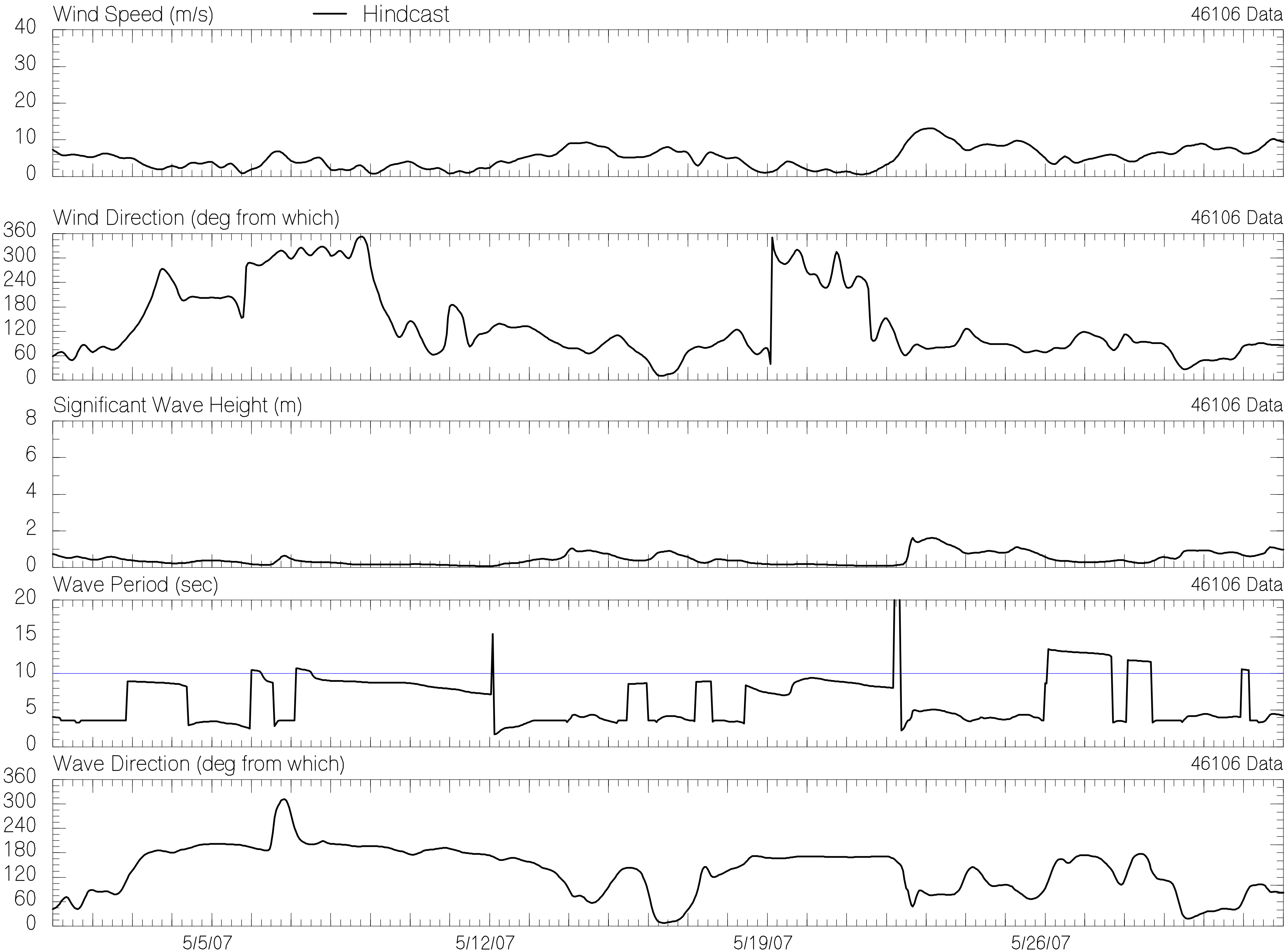

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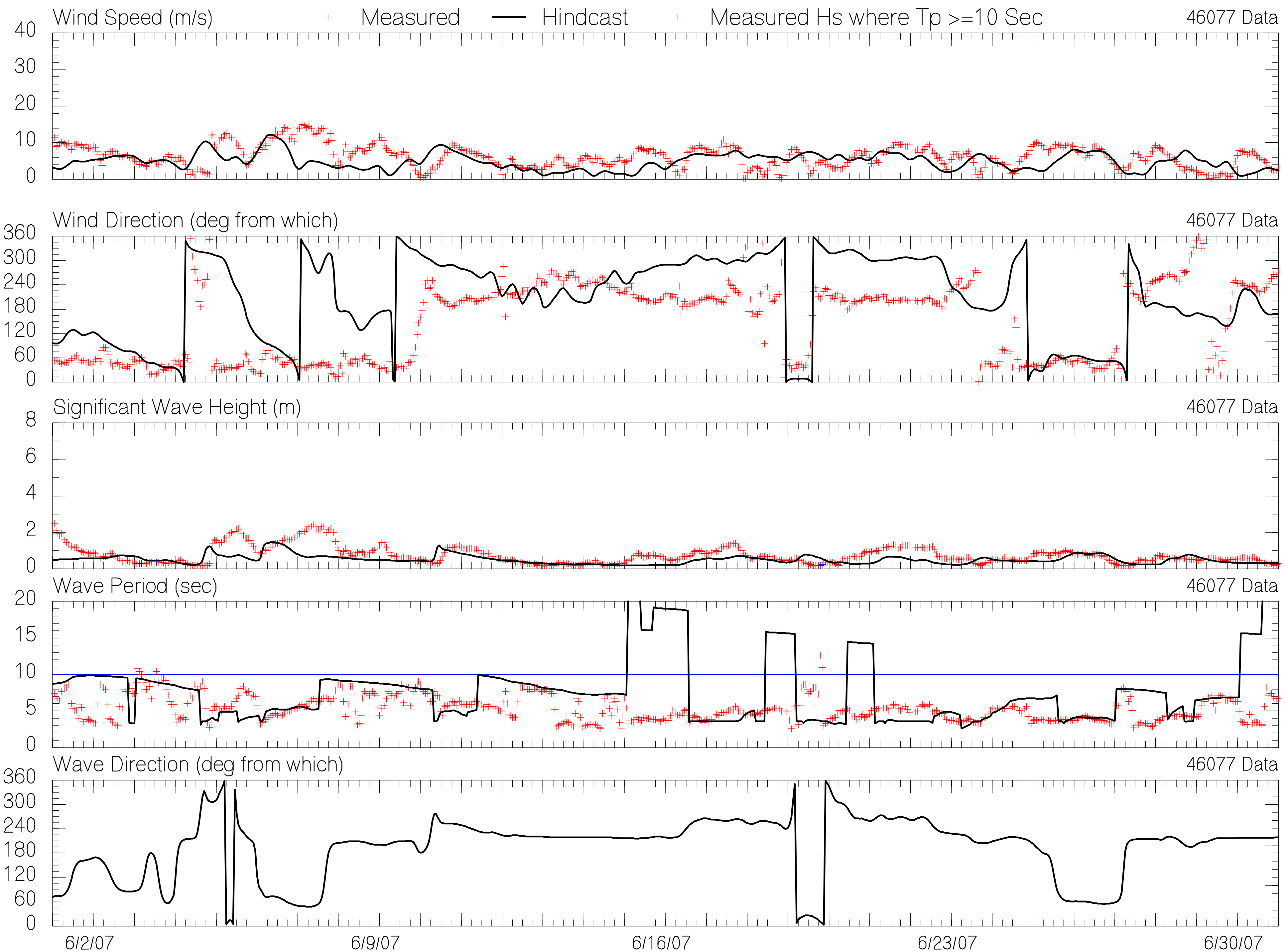
Kenai7km Model Validation

June 2007 - Buoy 46077



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oceanweather inc.

Kenai7km Model Validation

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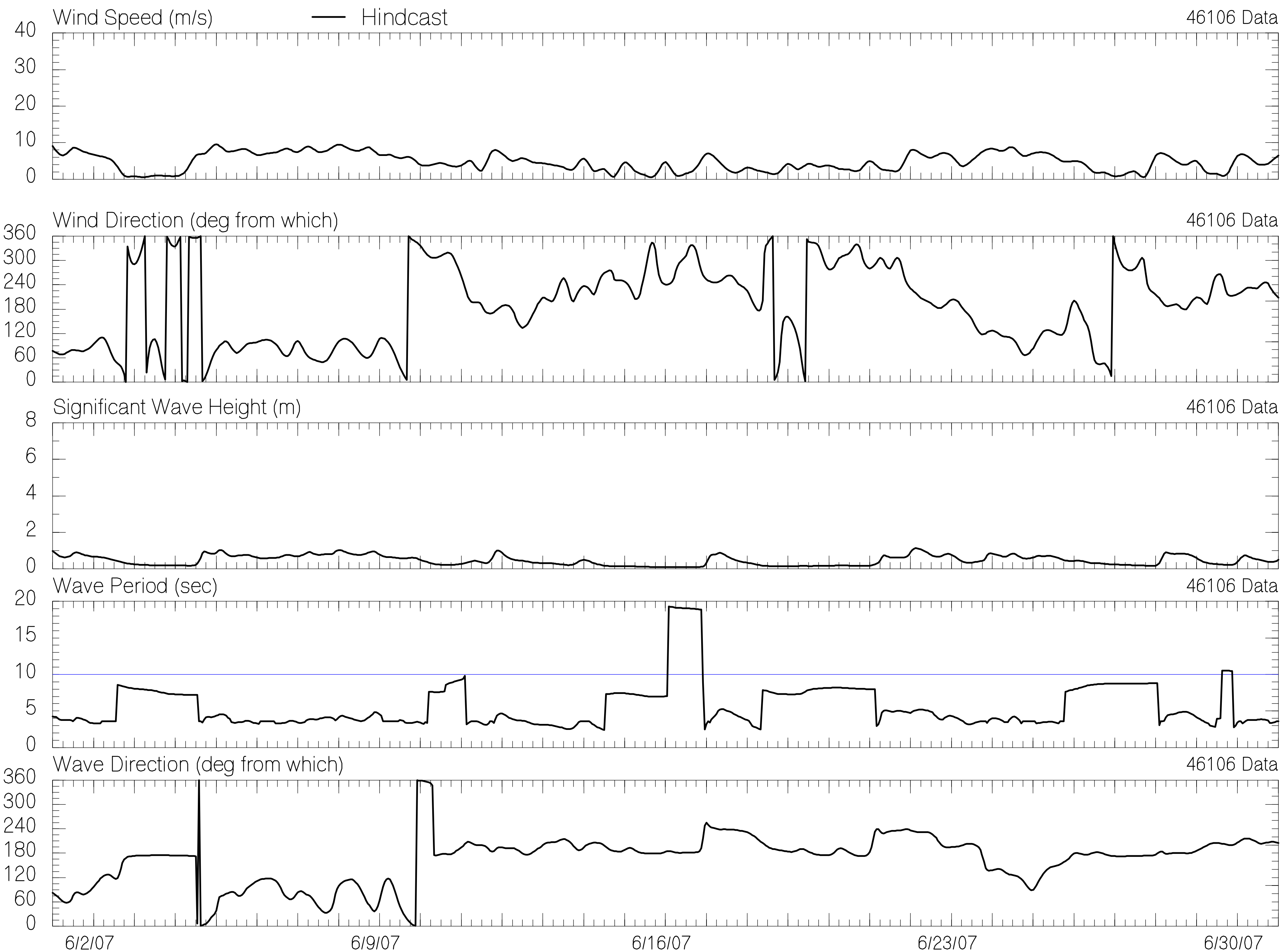
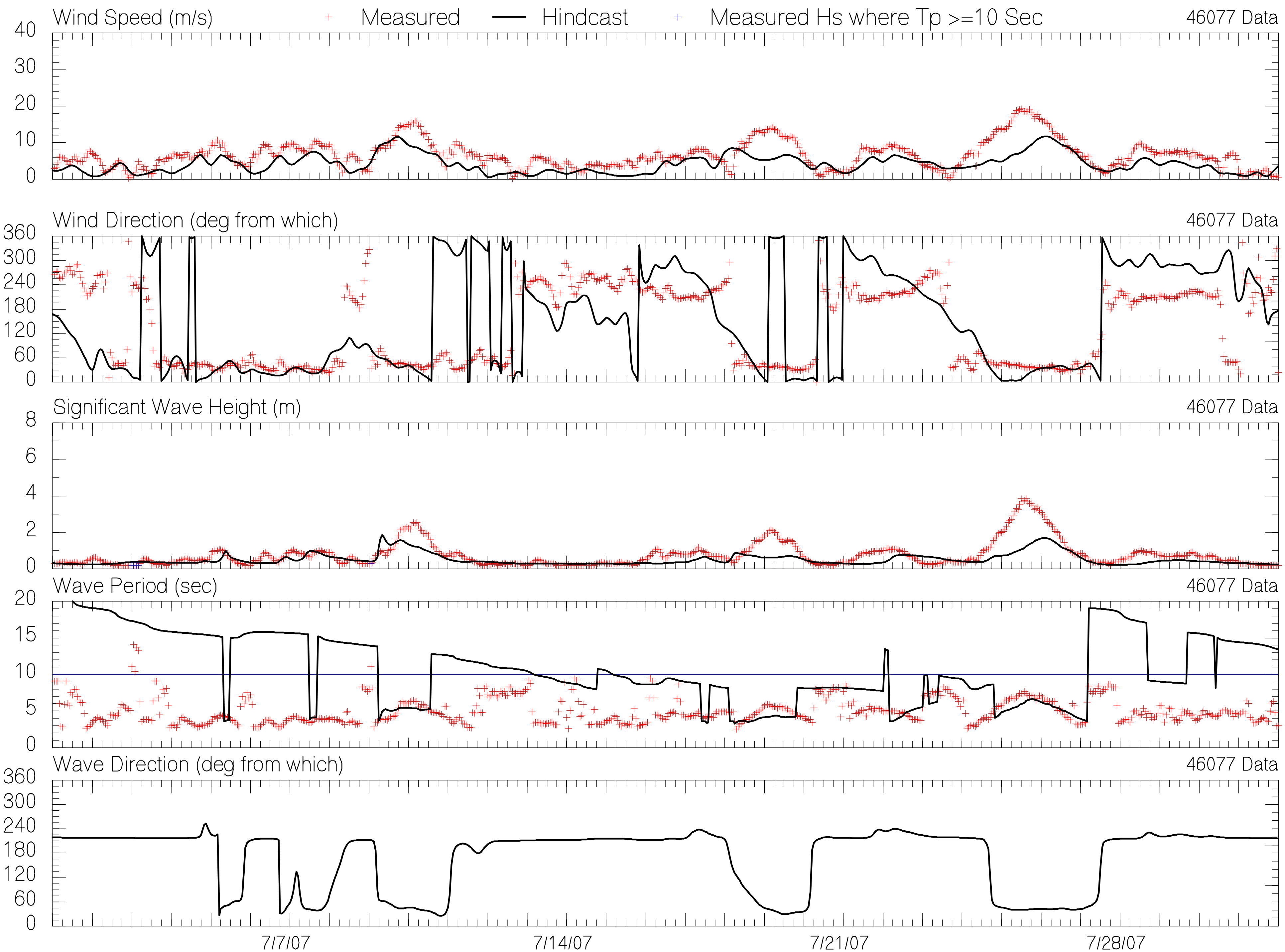


Kenai7km Model Validation

July 2007 - Buoy 46077



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oceanweather inc.

Kenai7km Model Validation

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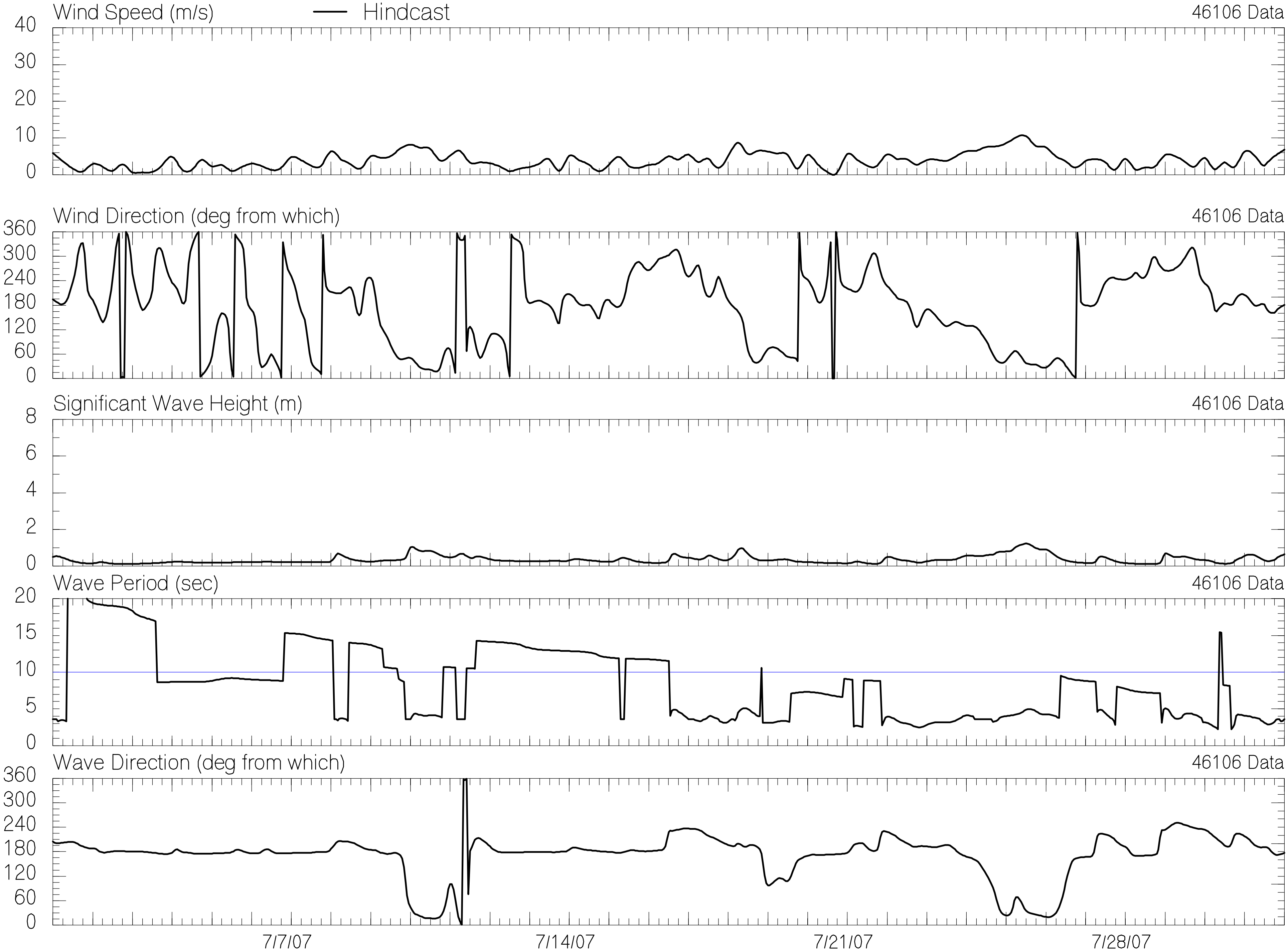

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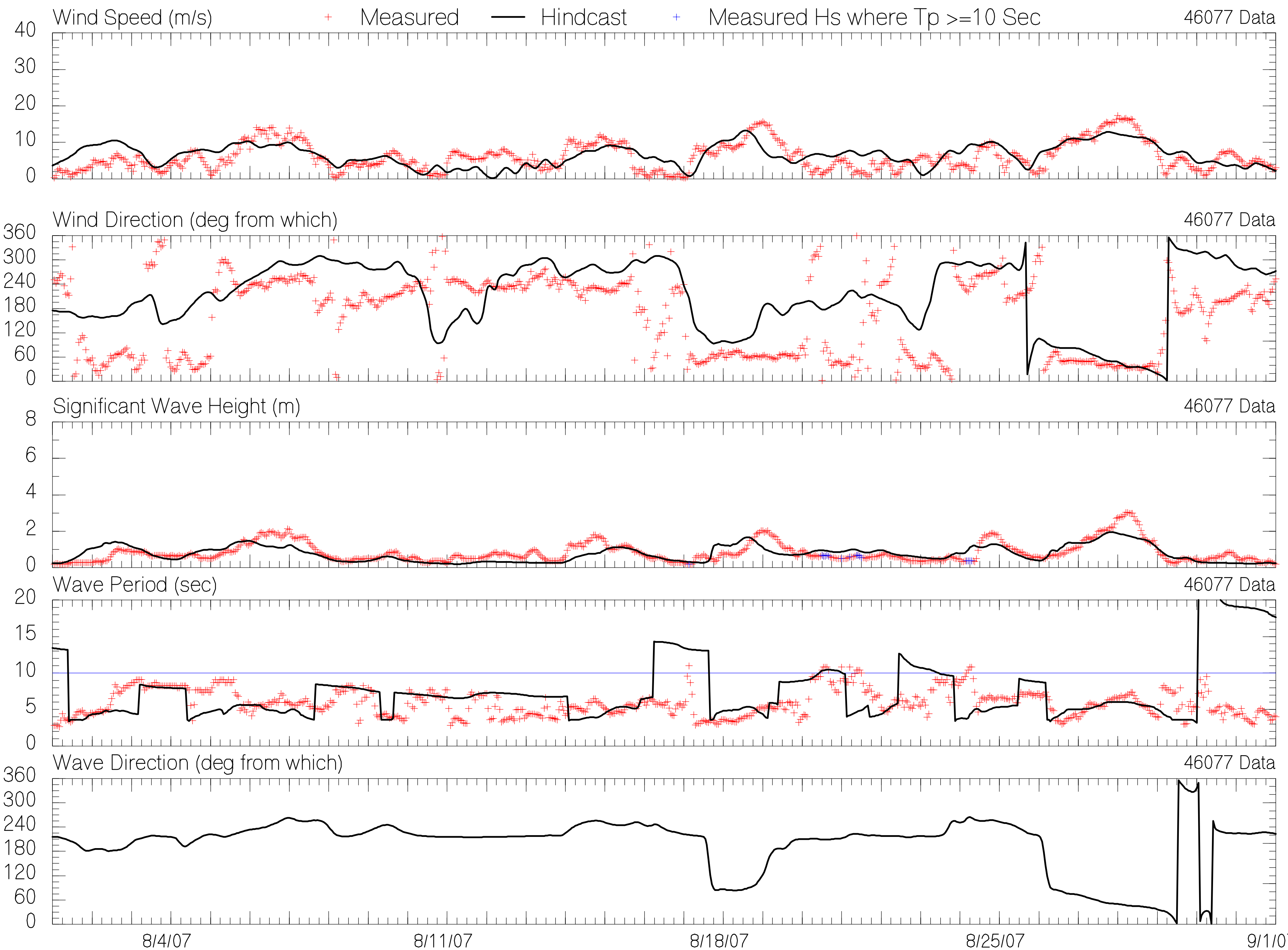
Kenai7km Model Validation

August 2007 - Buoy 46077



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Kenai7km Model Validation

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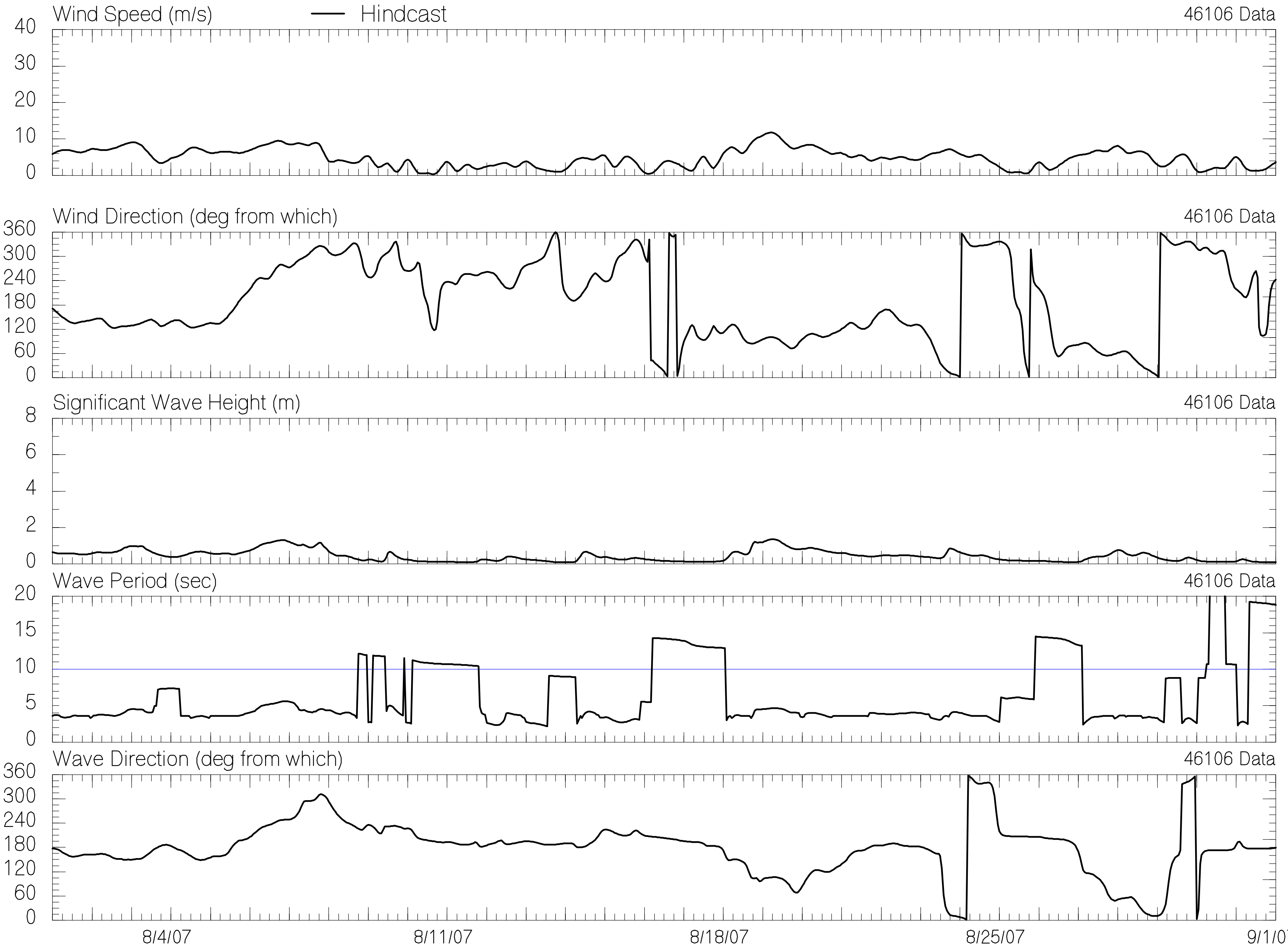

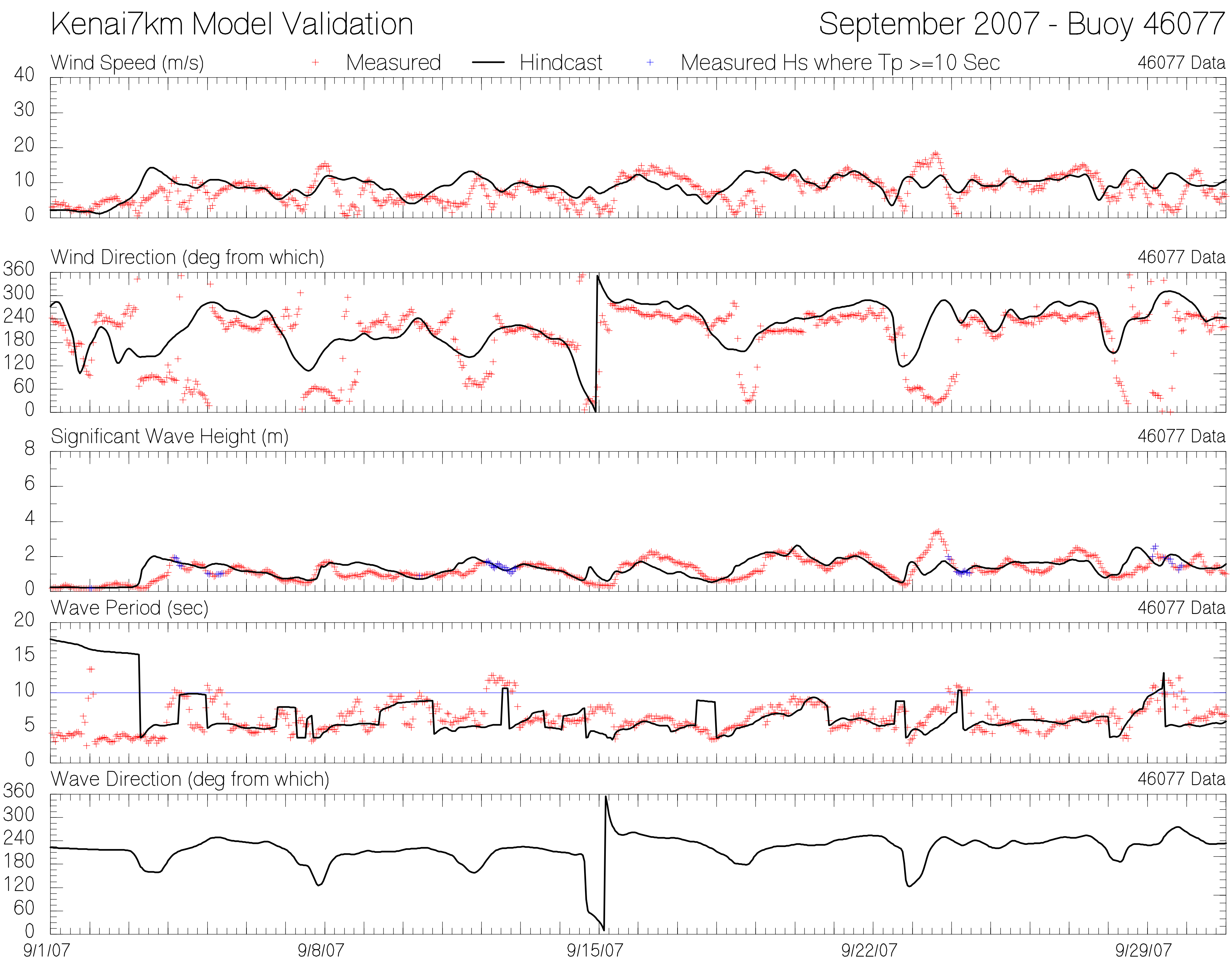

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Kenai7km Model Validation

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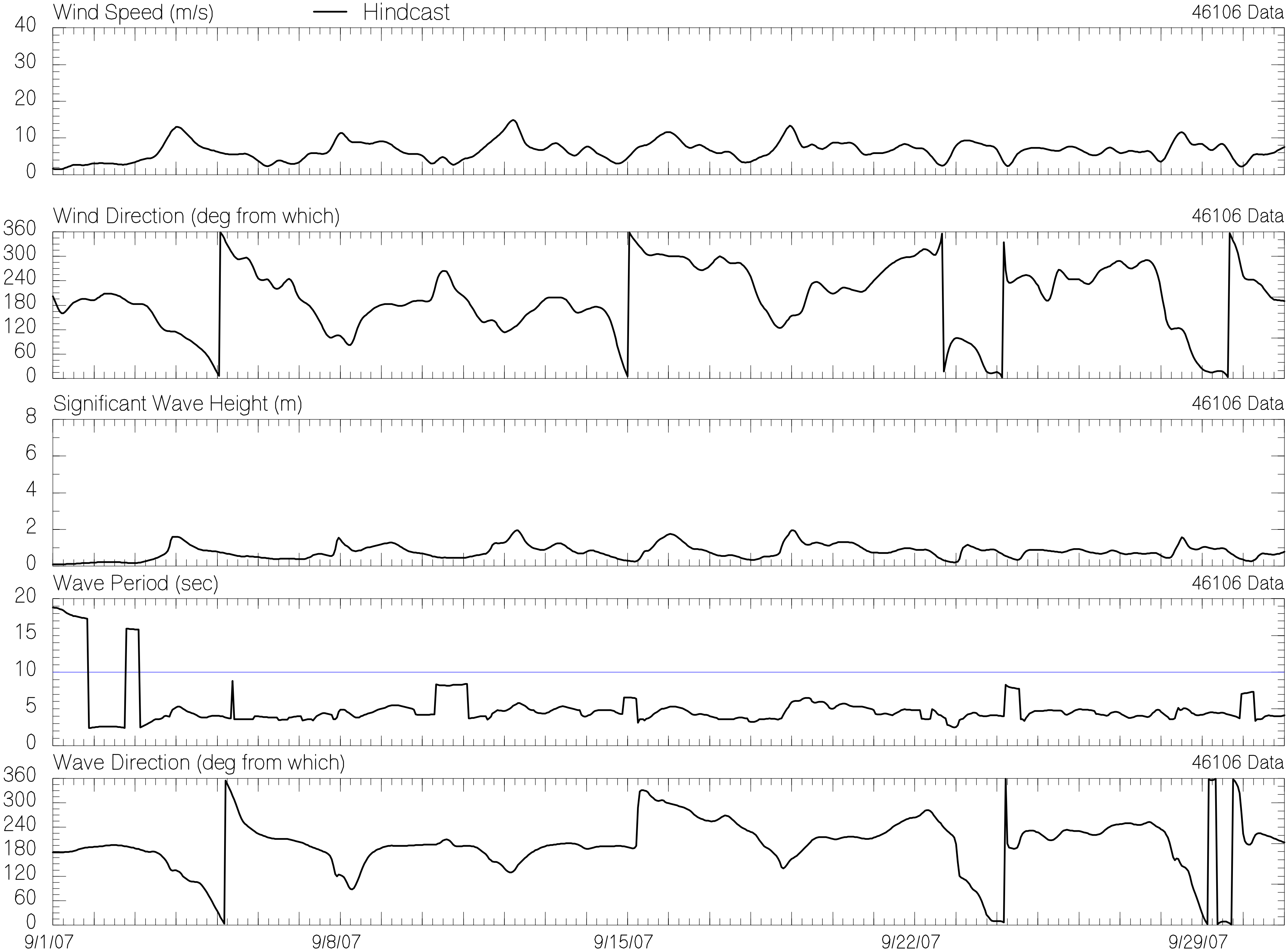

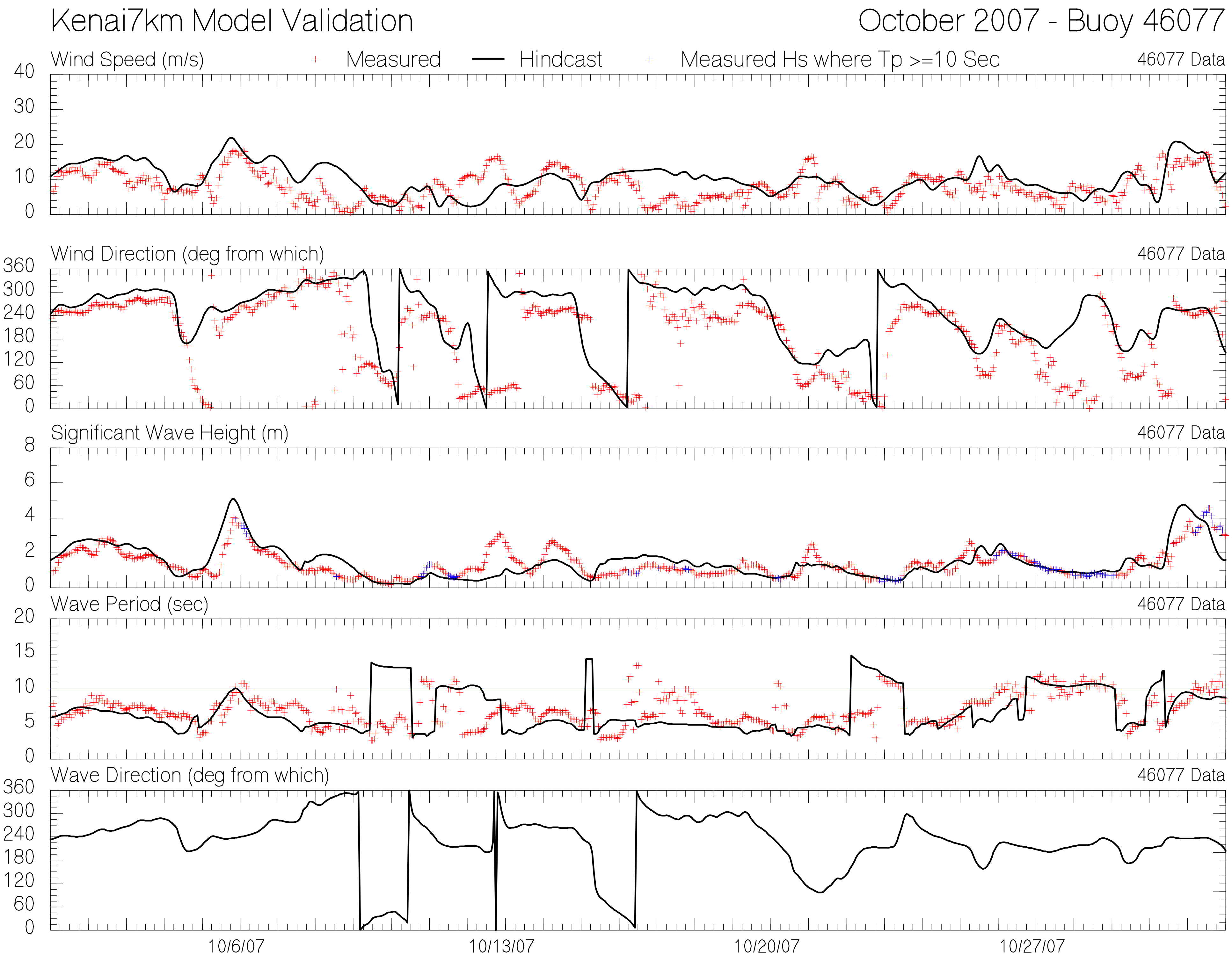

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Kenai7km Model Validation

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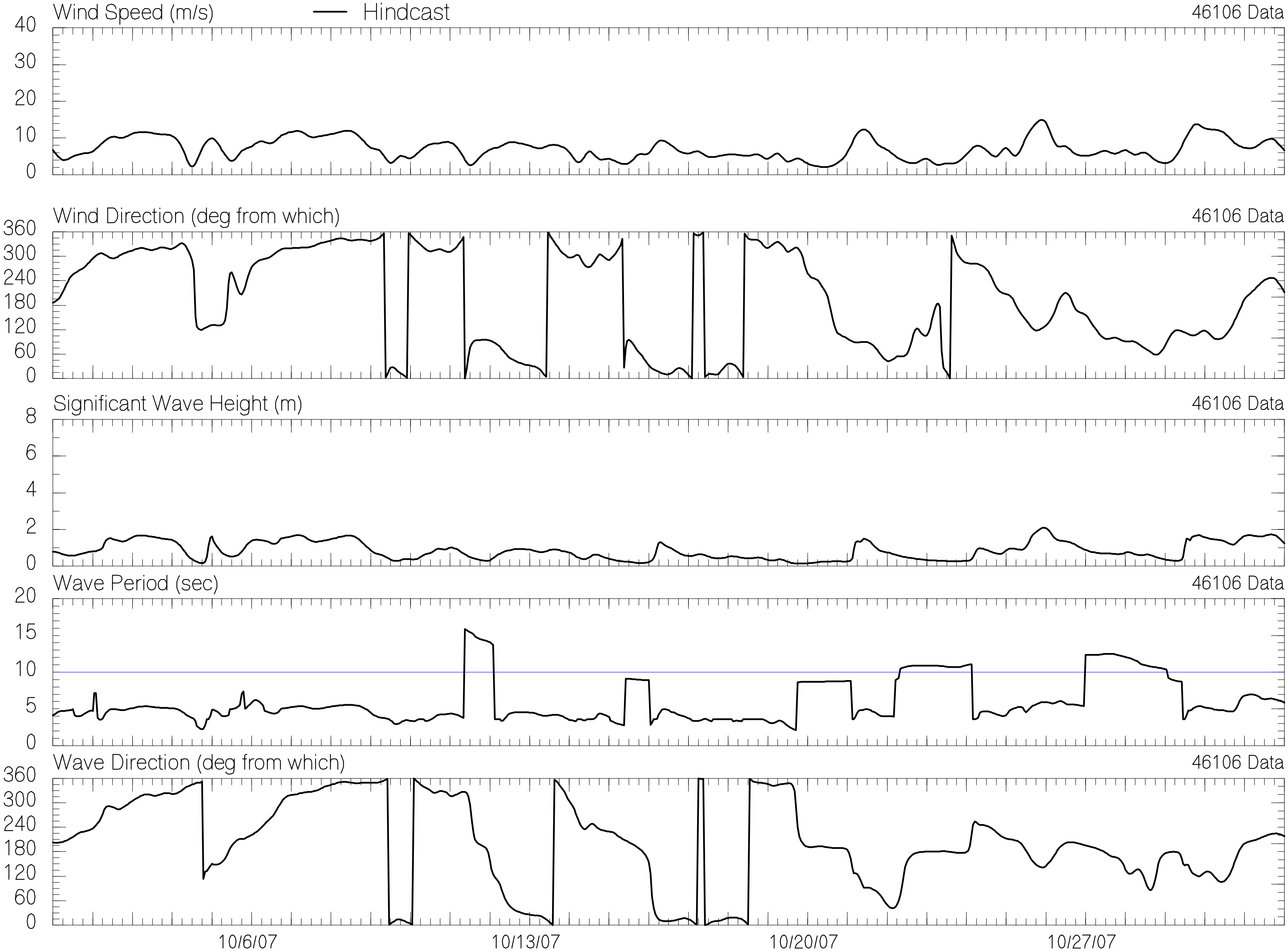

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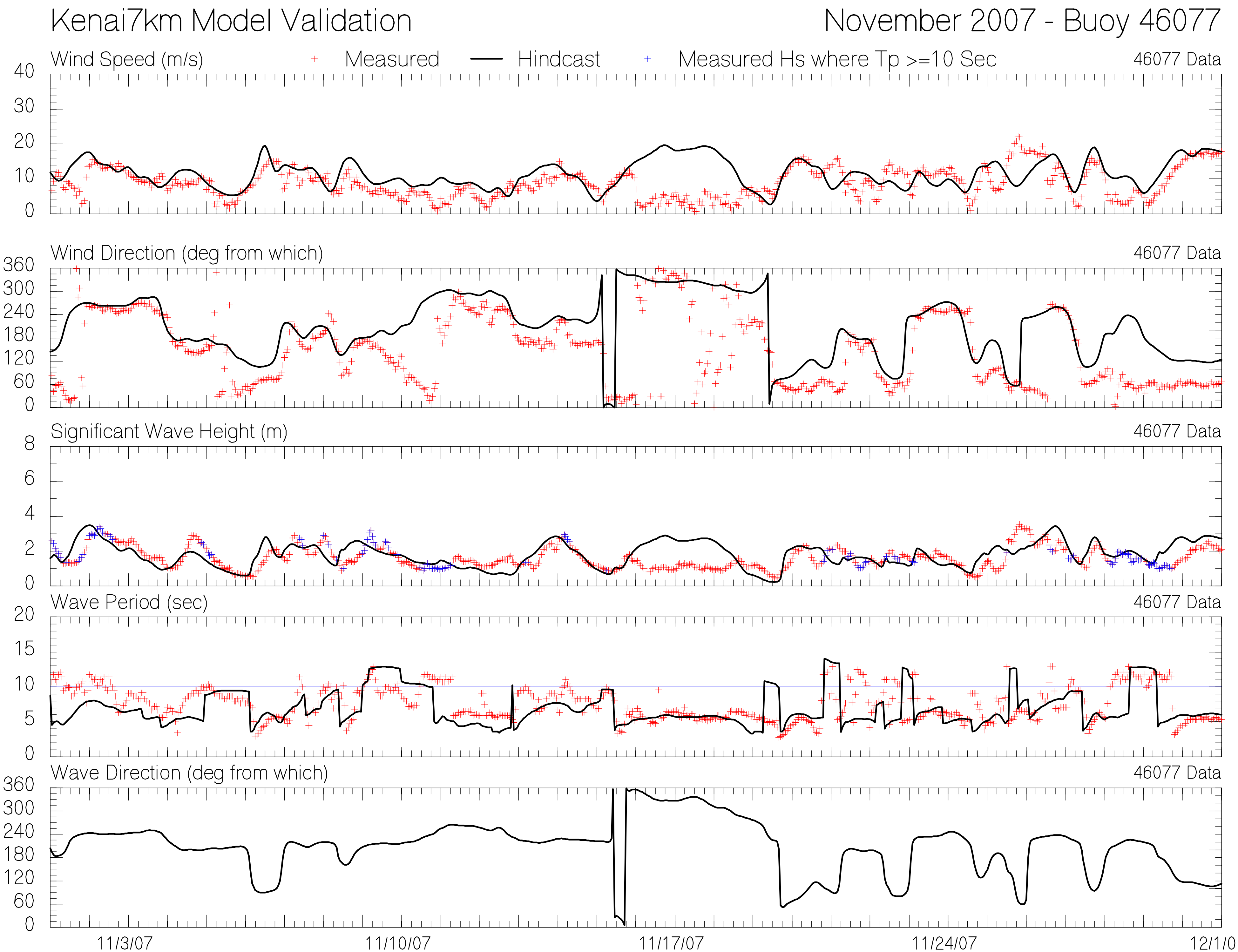

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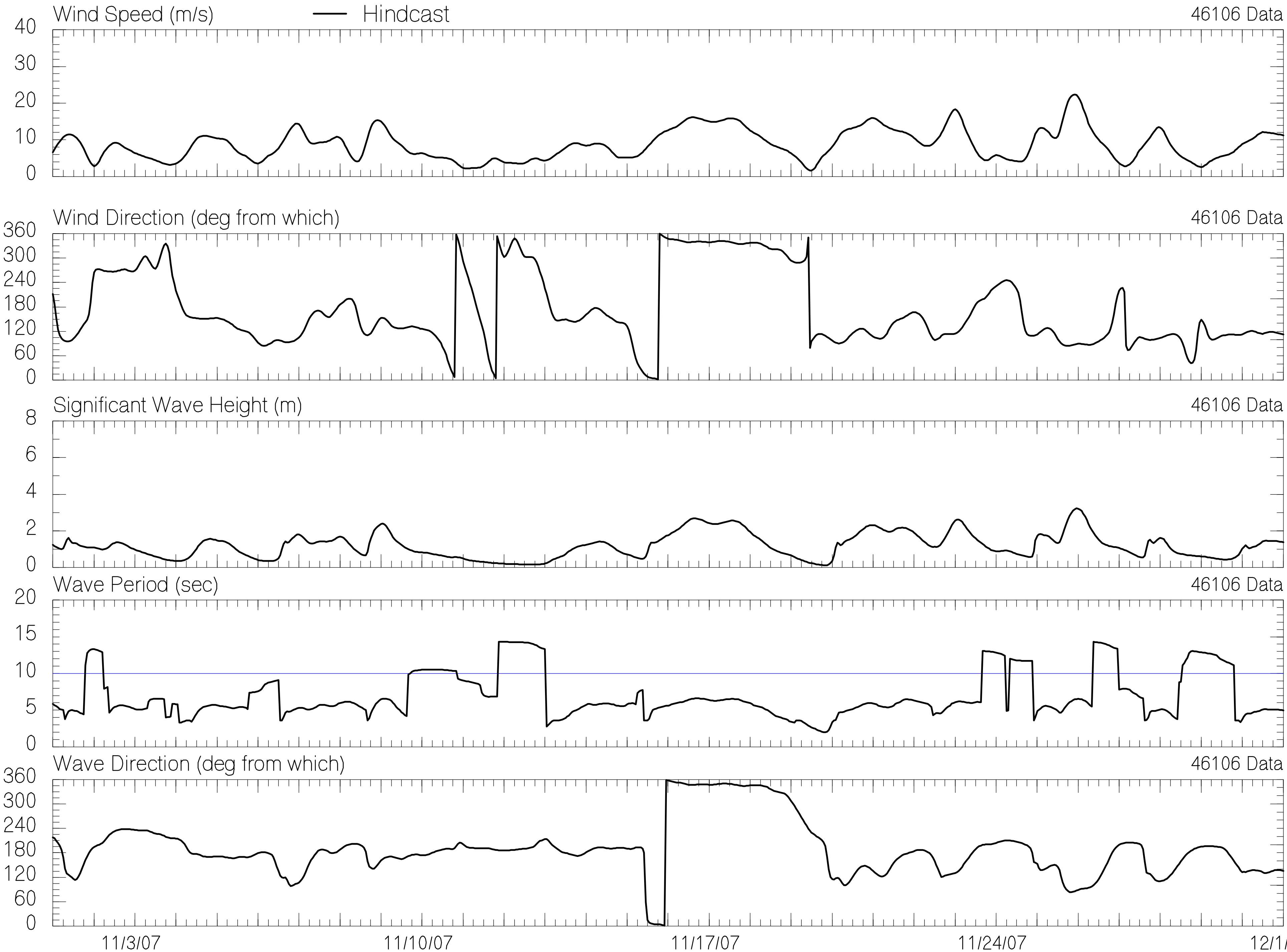
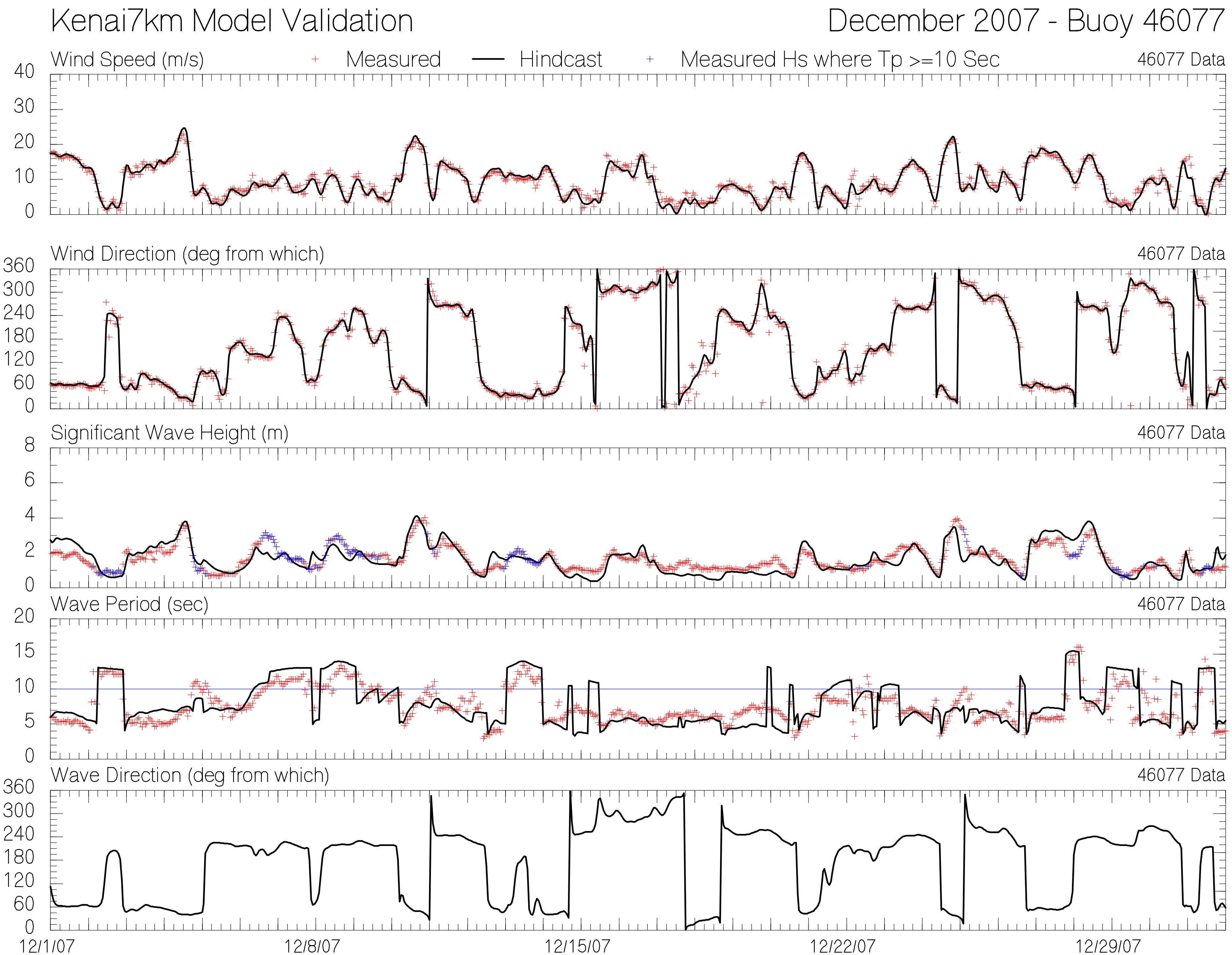
Kenai7km Model Validation

November 2007 - Buoy 46106





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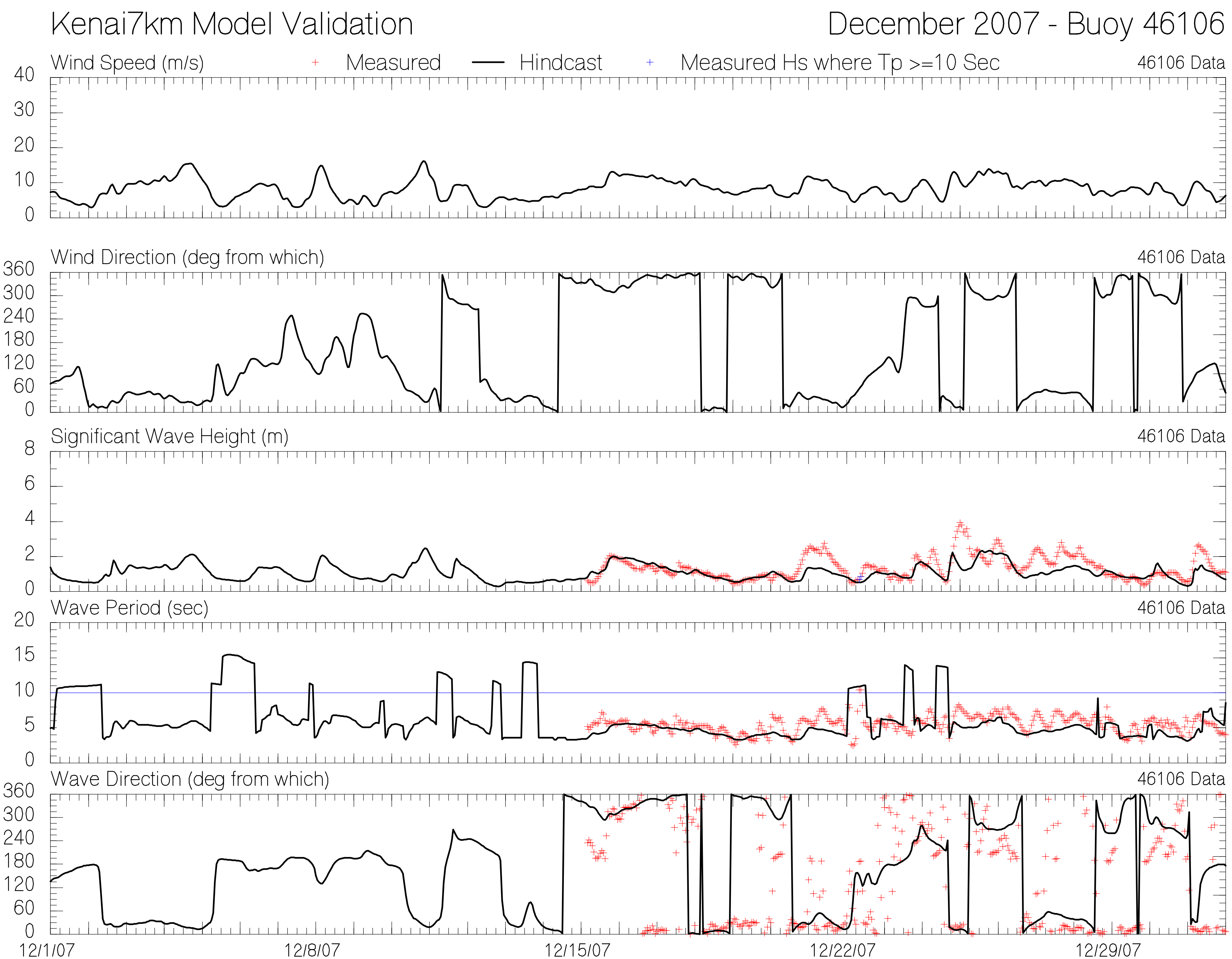

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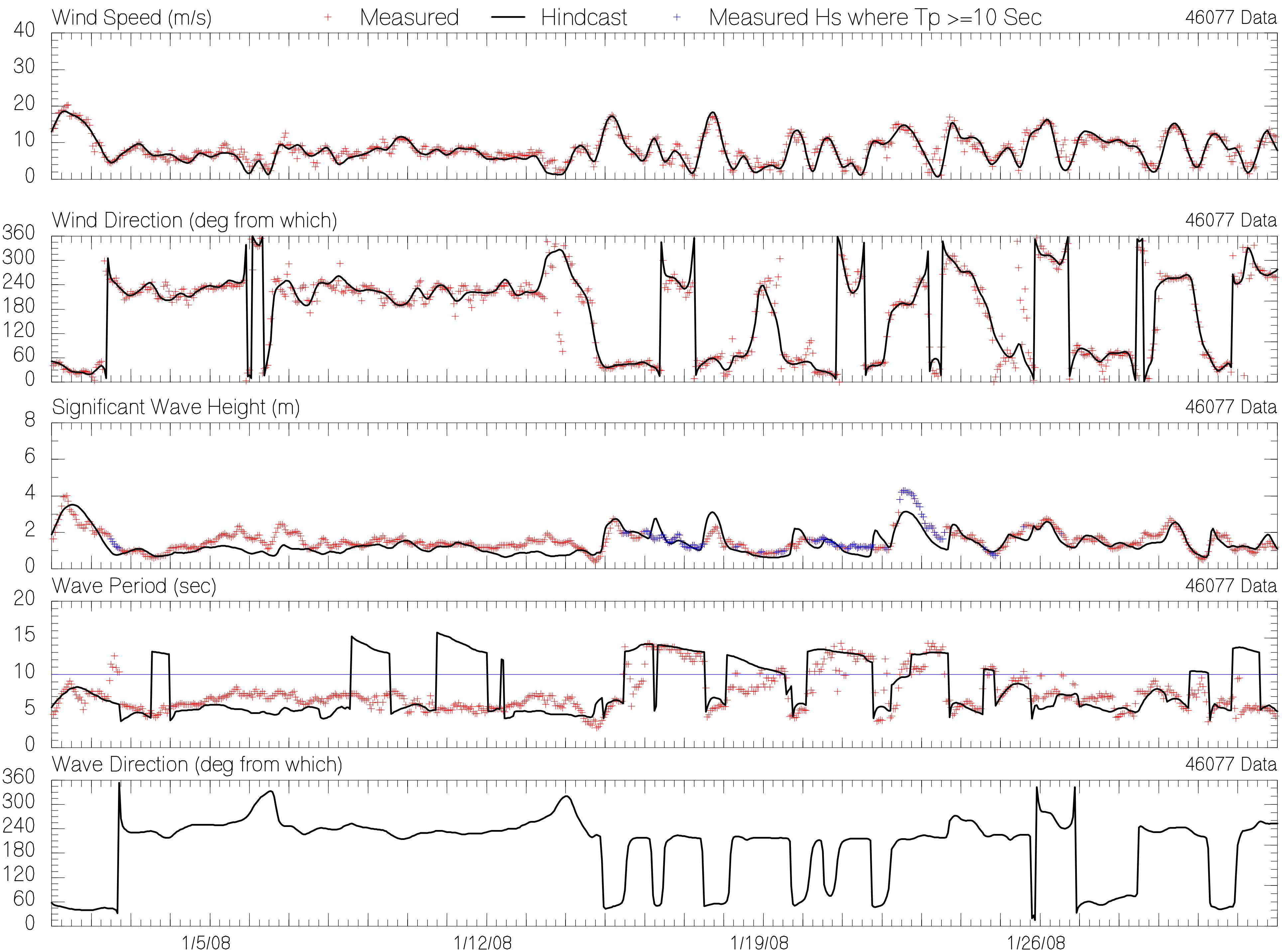
Kenai7km Model Validation

January 2008 - Buoy 46077



Kenai7km Model Validation

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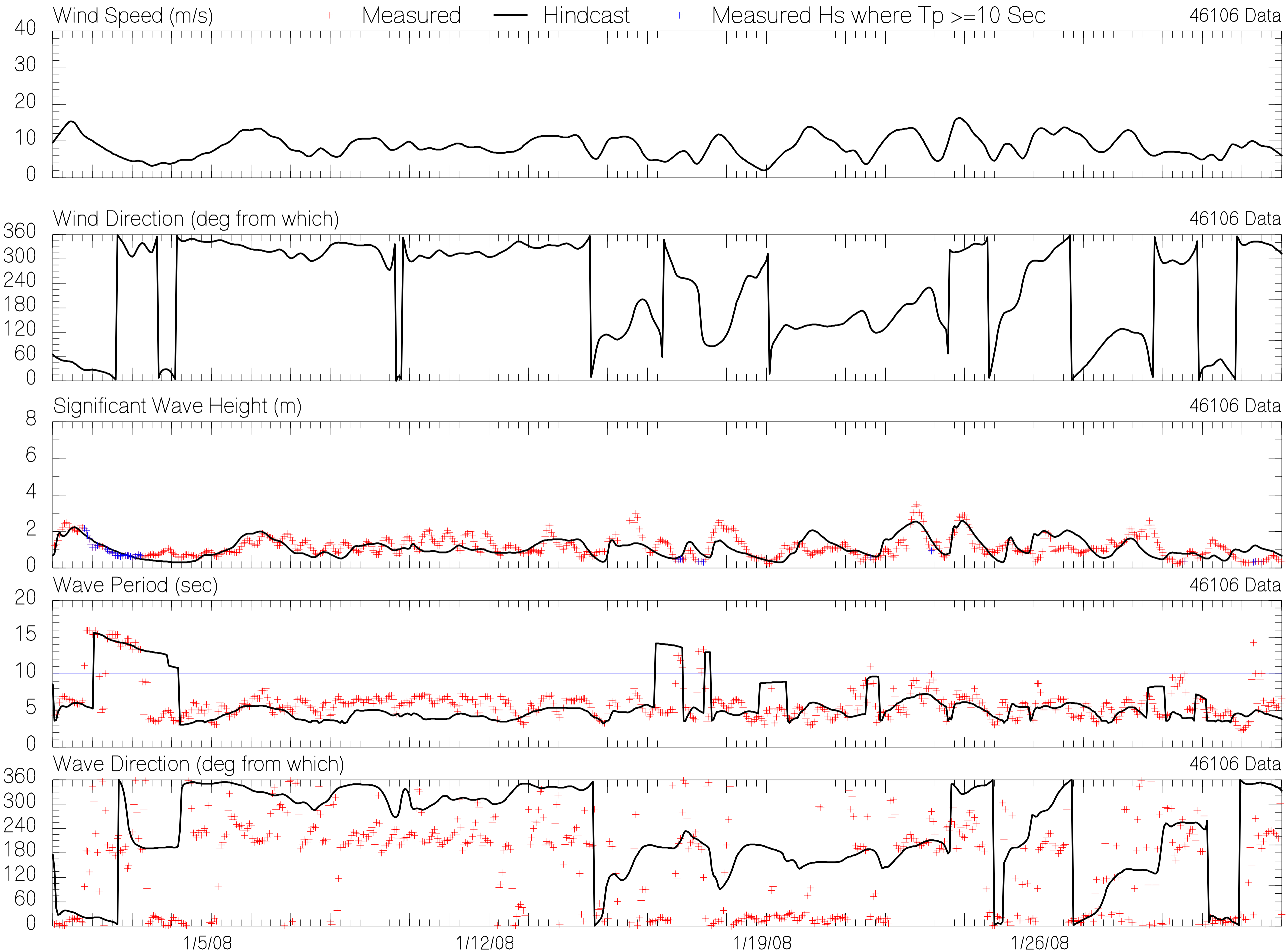

Kenai7km Model Validation

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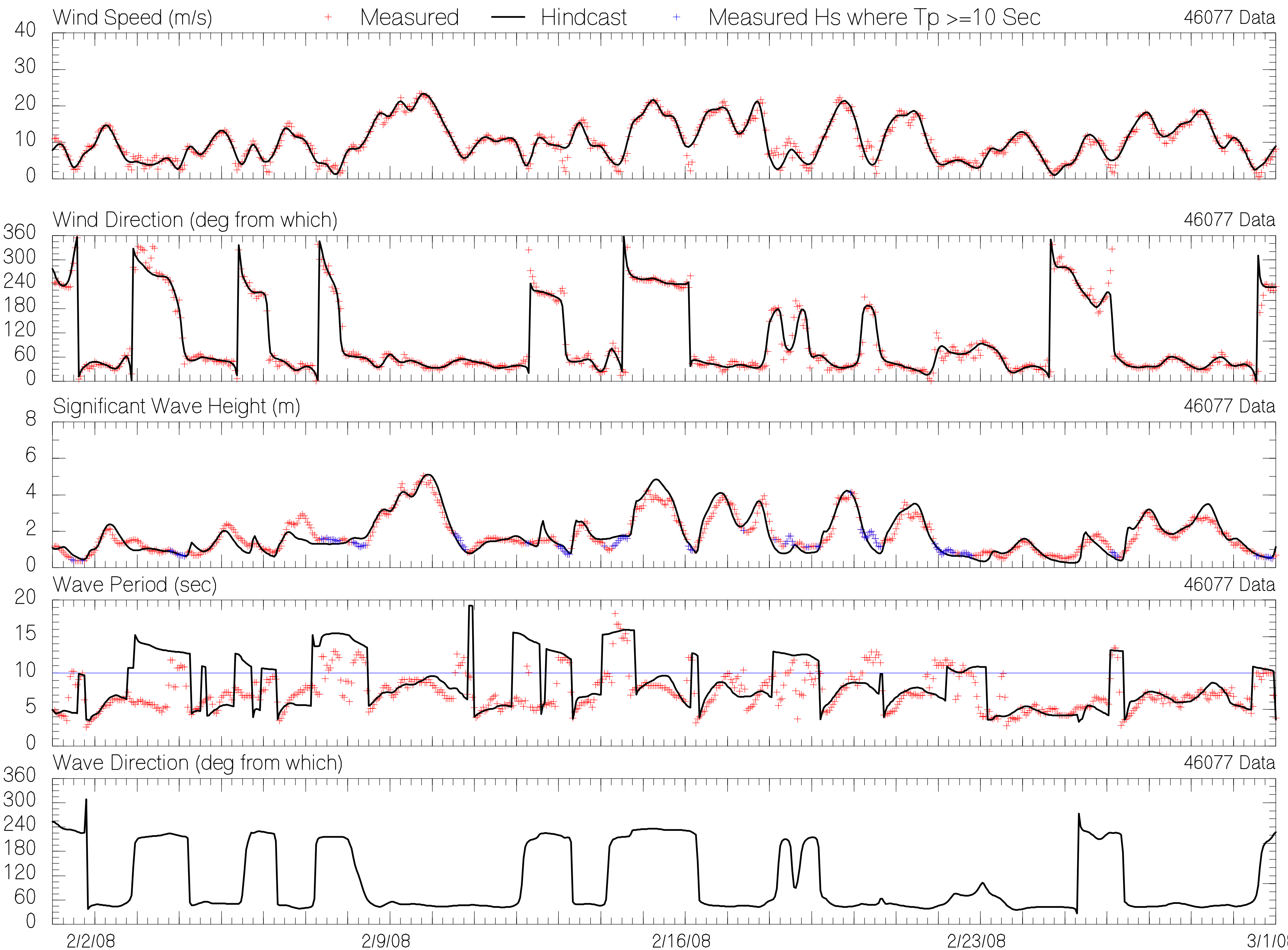

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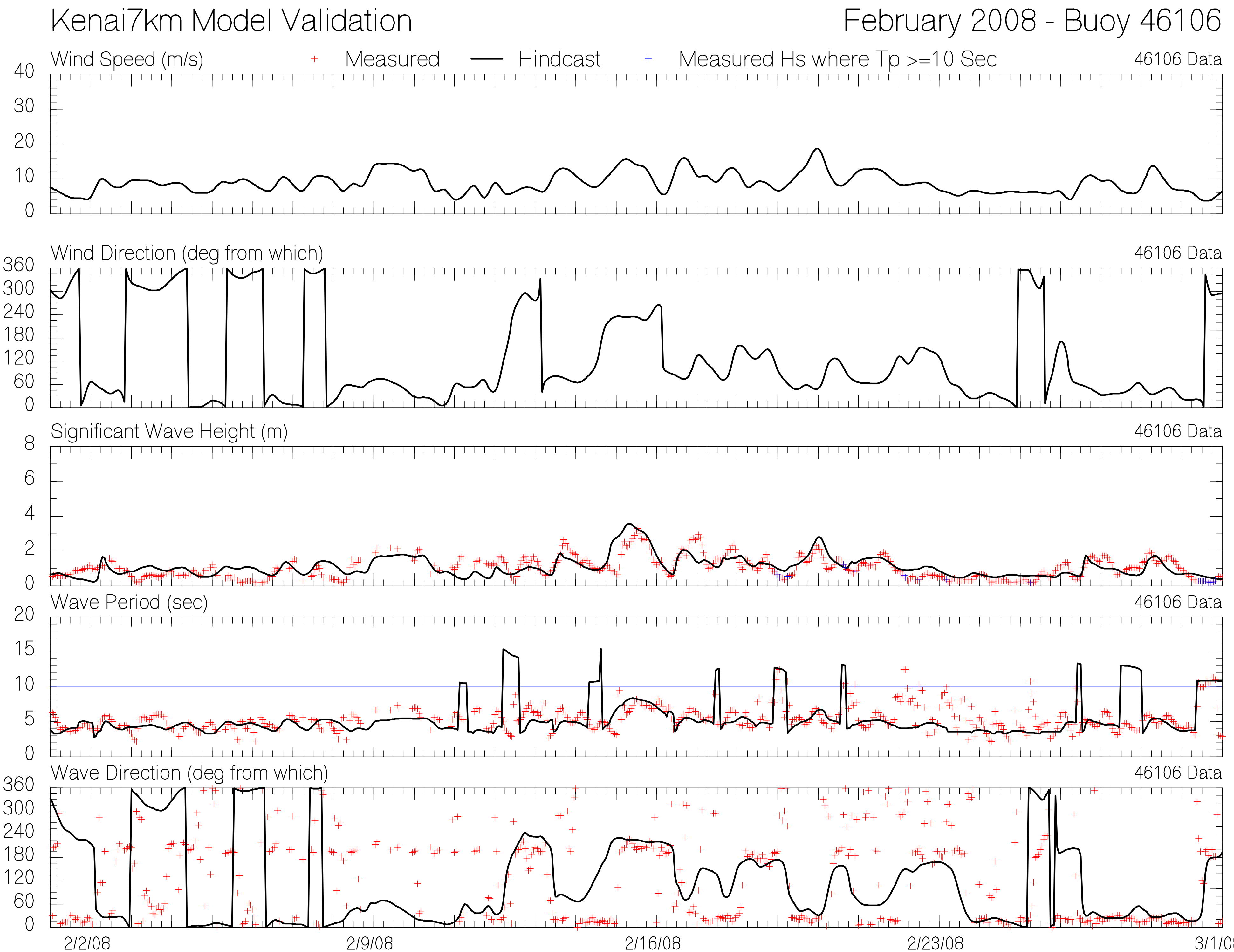

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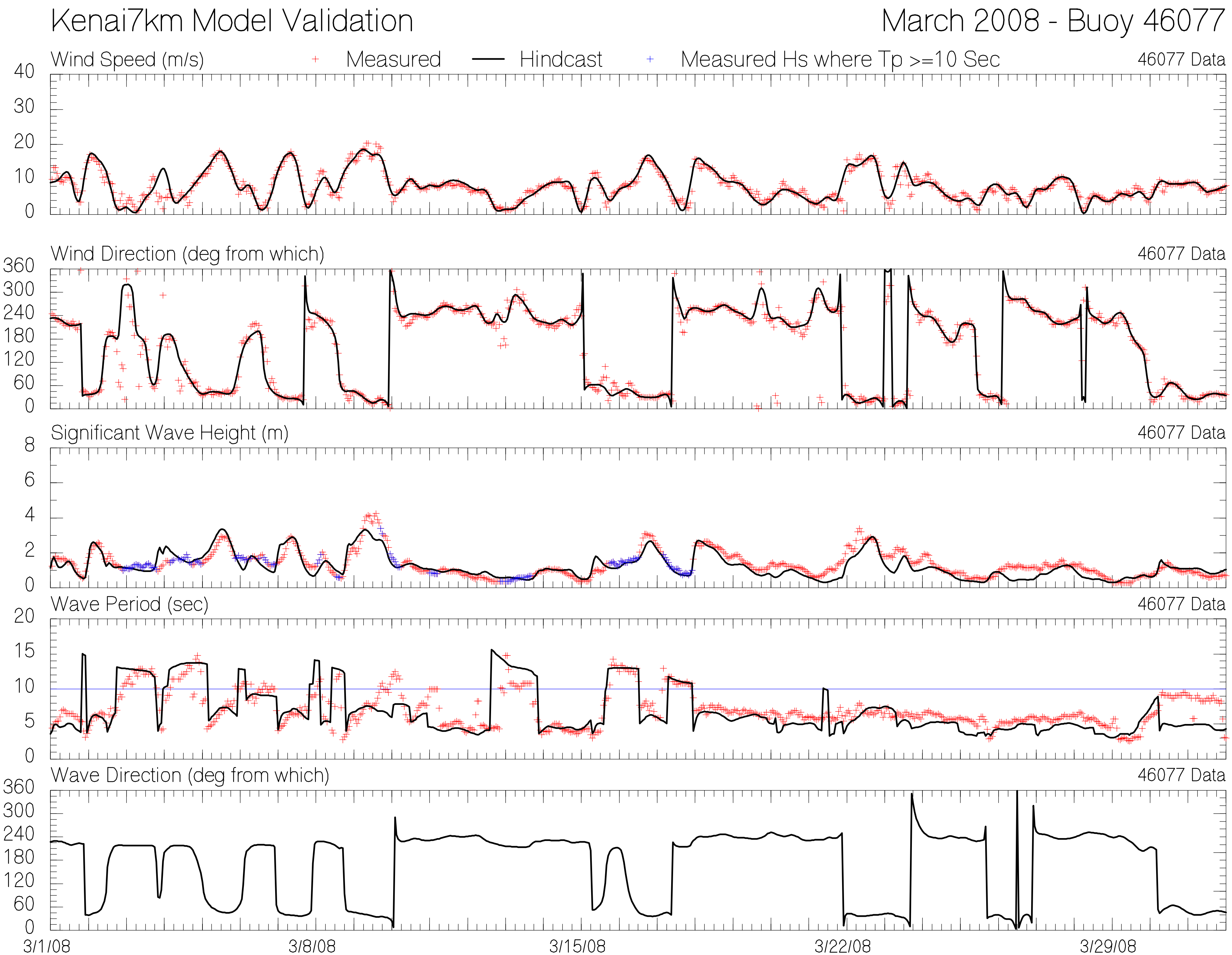

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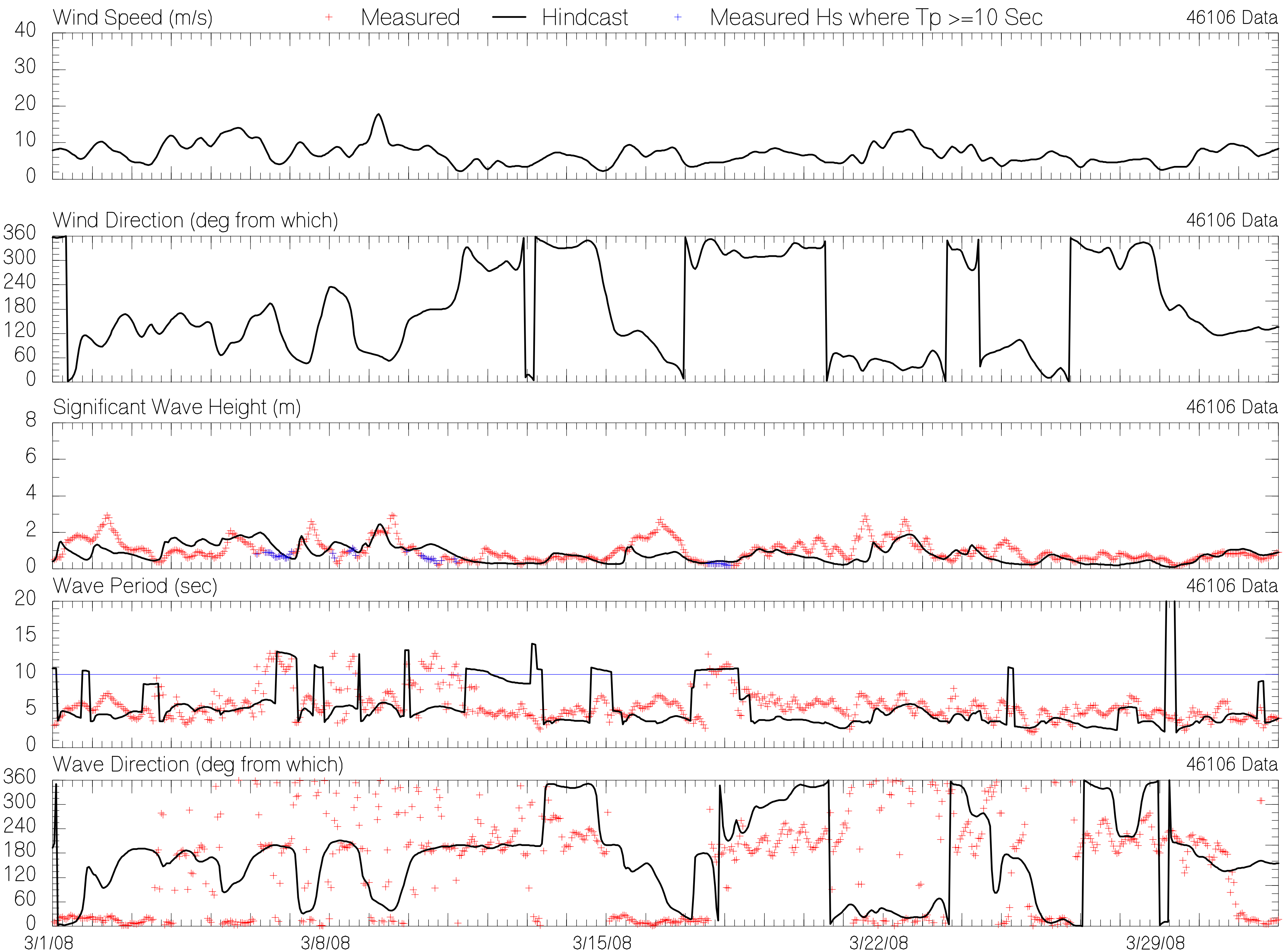
Kenai7km Model Validation

March 2008 - Buoy 46106



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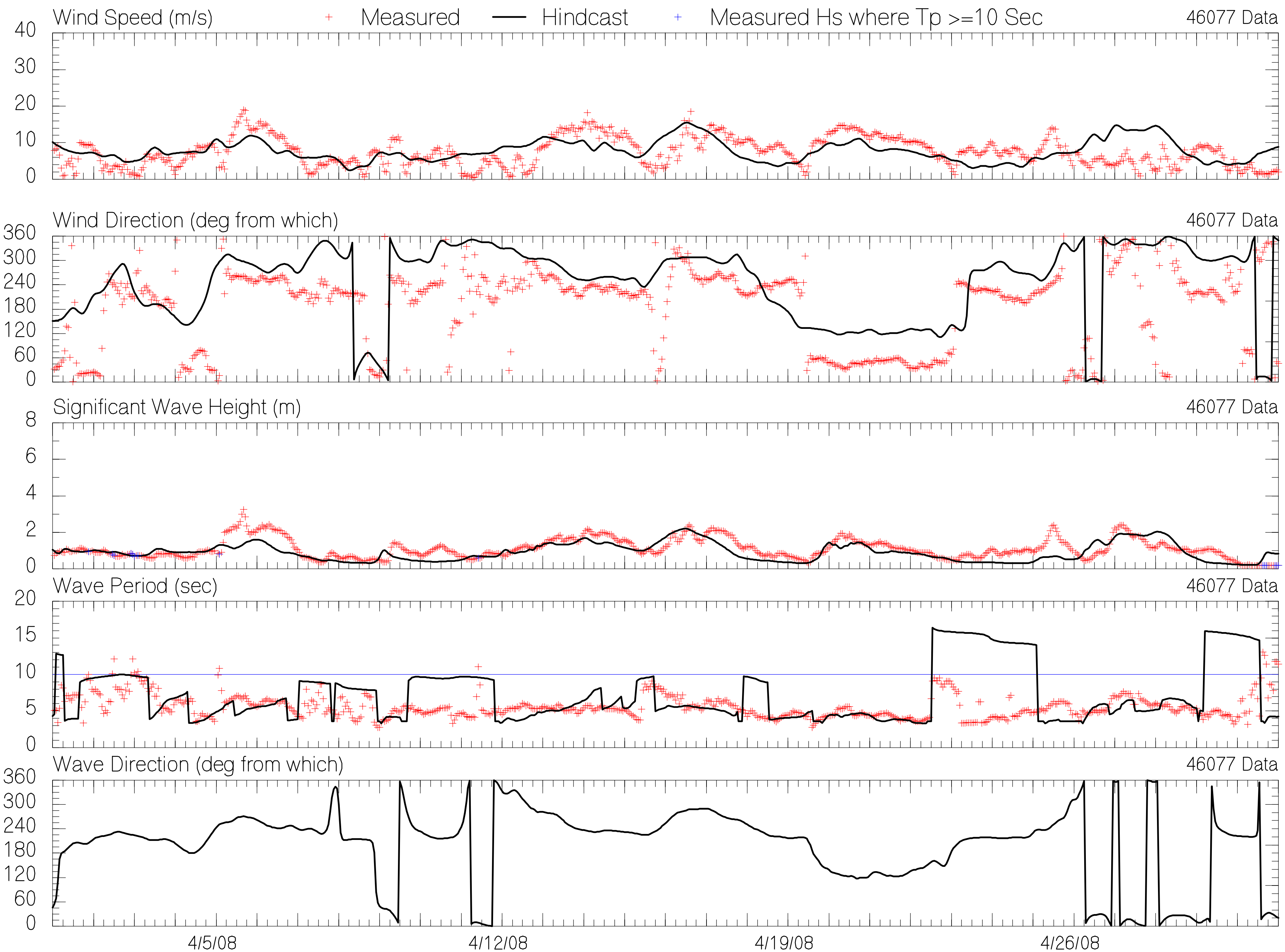
Kenai7km Model Validation

April 2008 - Buoy 46077



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Kenai7km Model Validation

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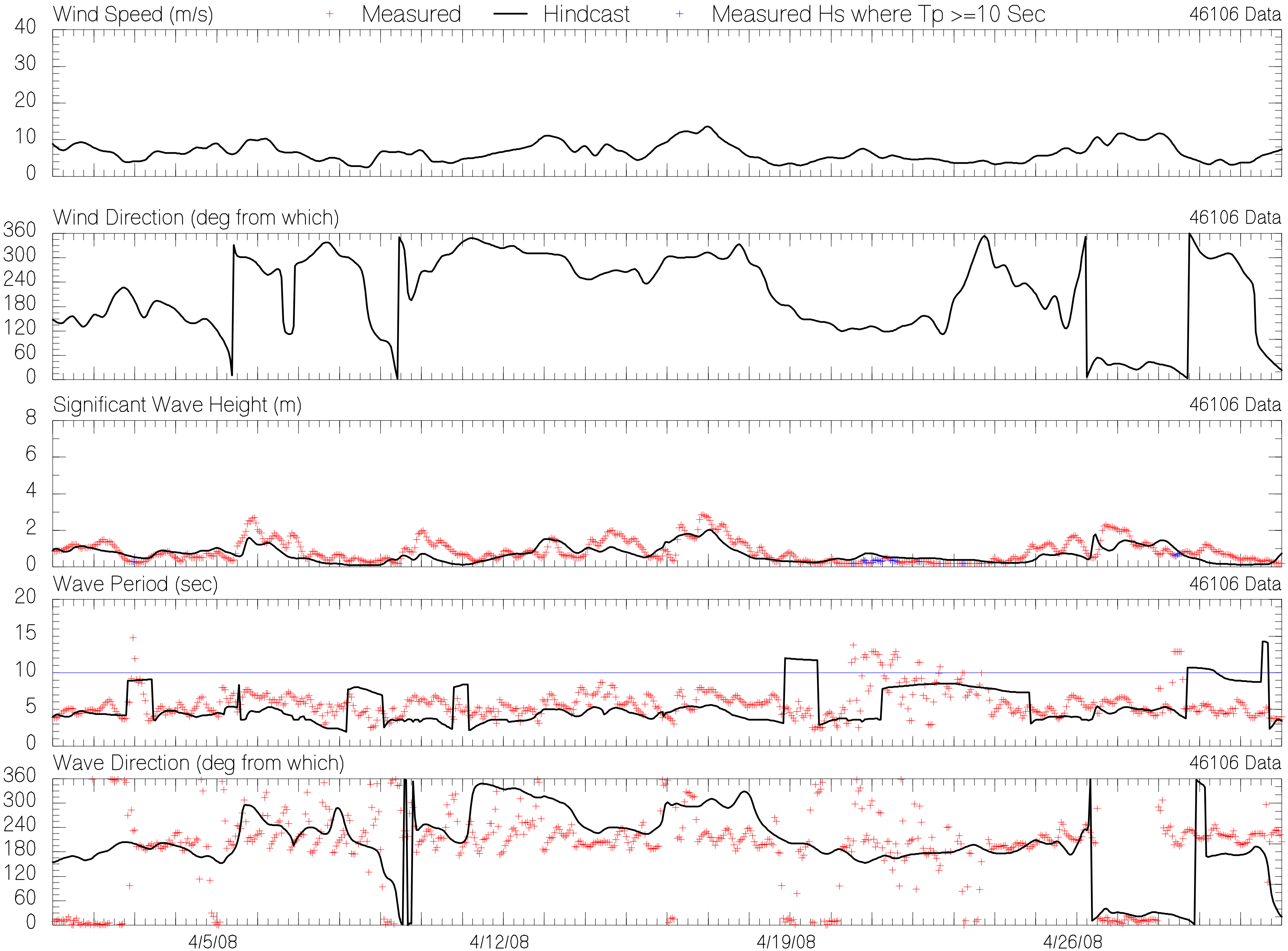

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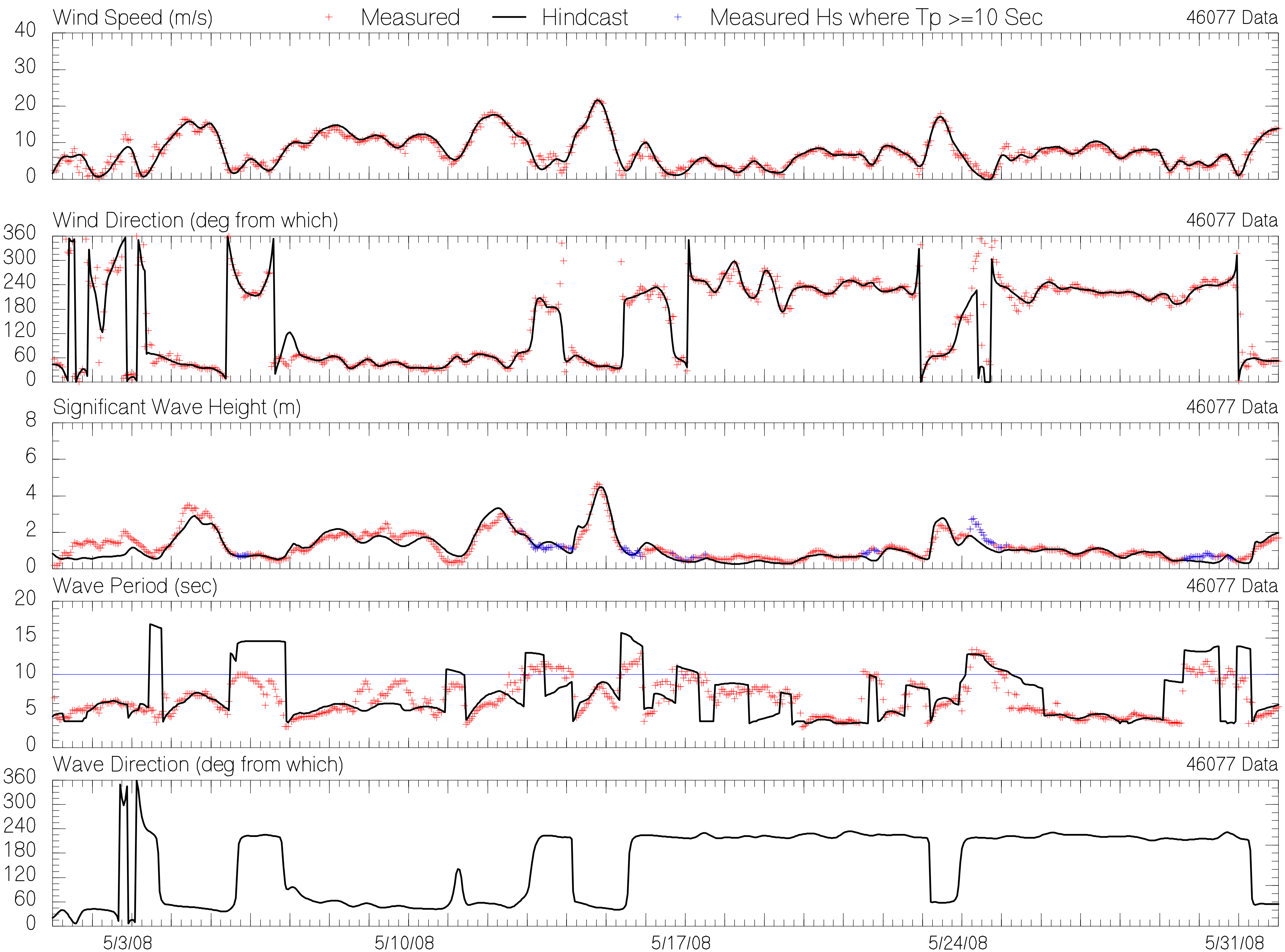

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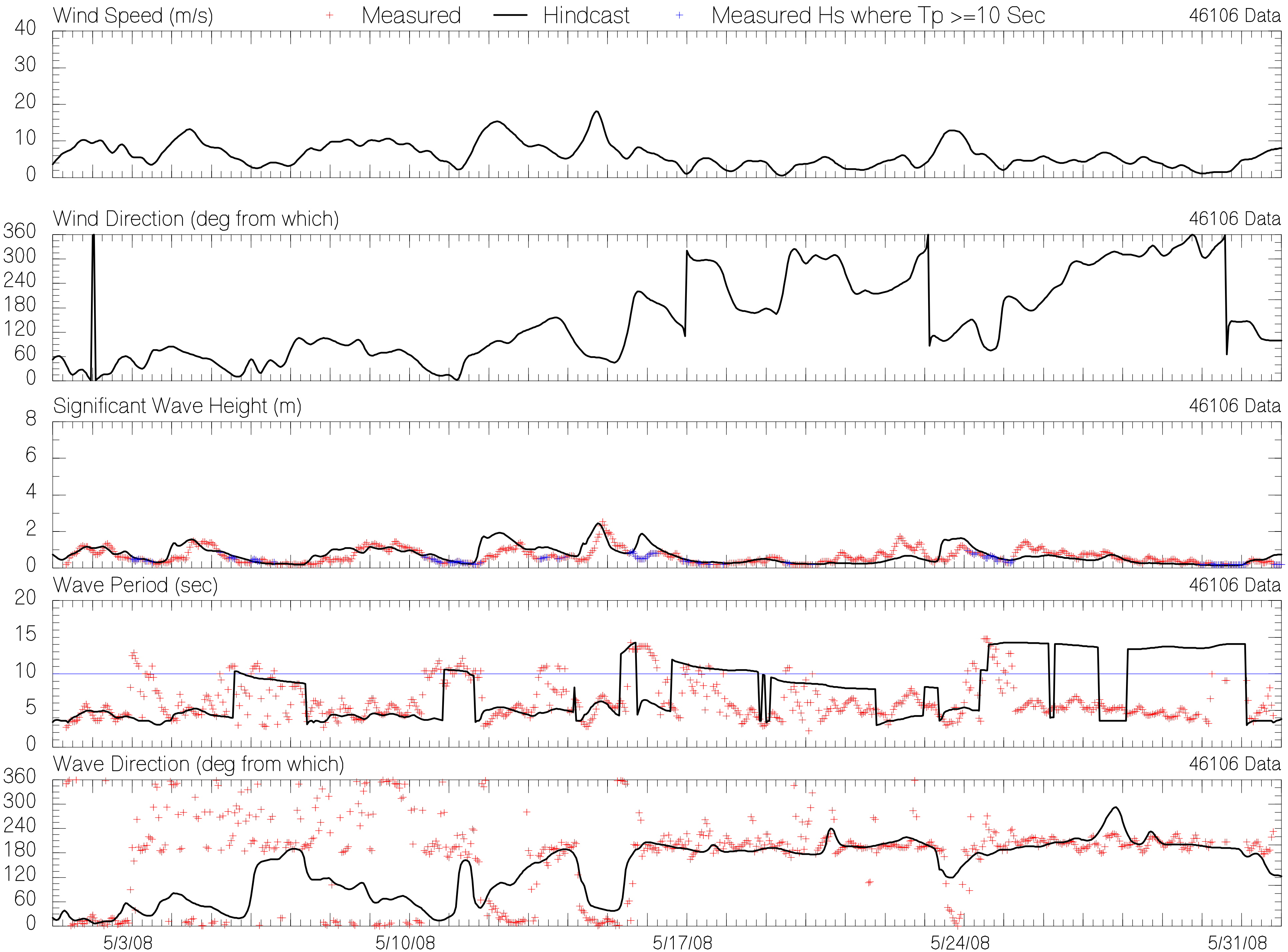
May 2008 - Buoy 46106



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oceanweather inc.

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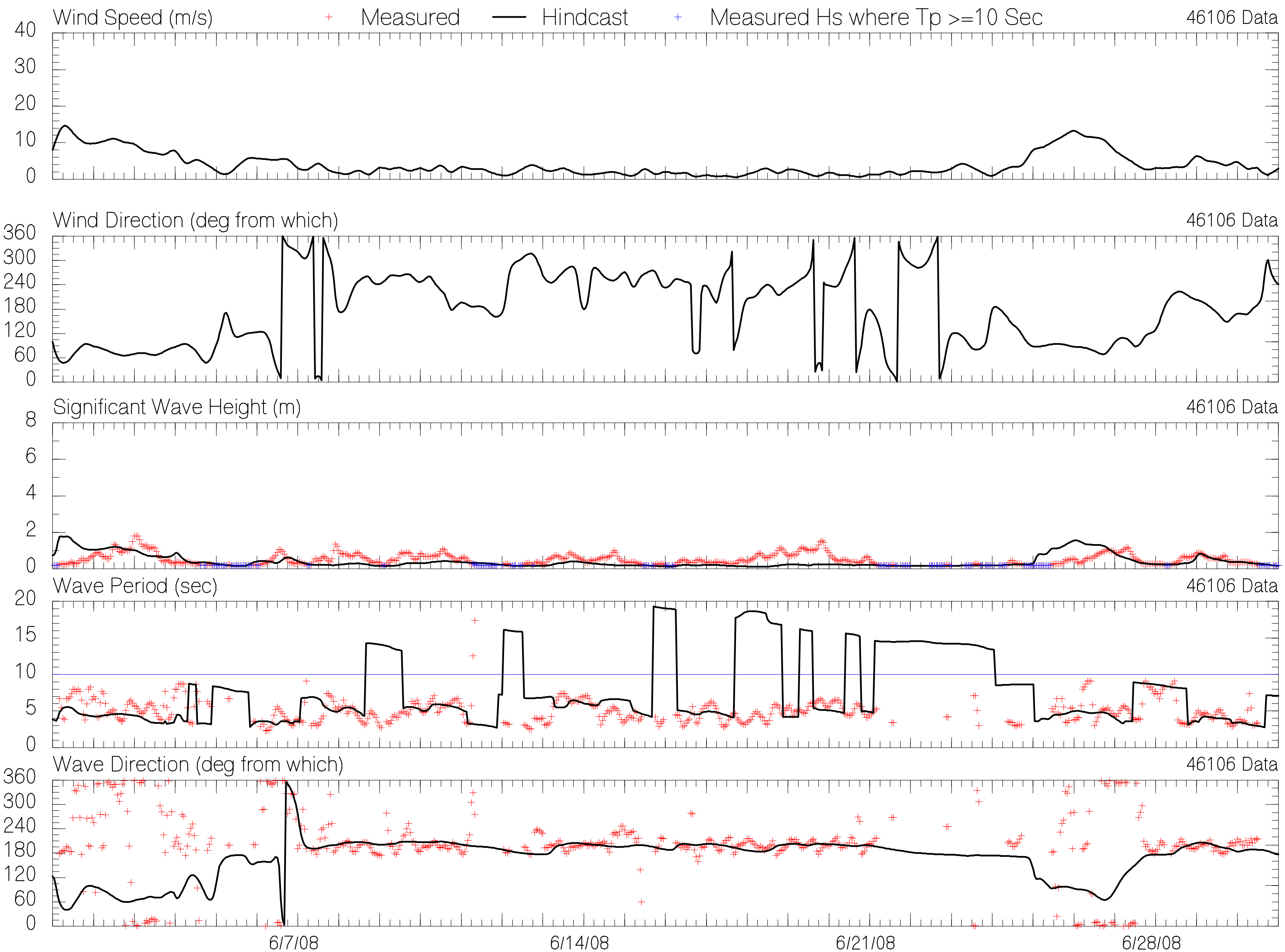
oceanweather inc.

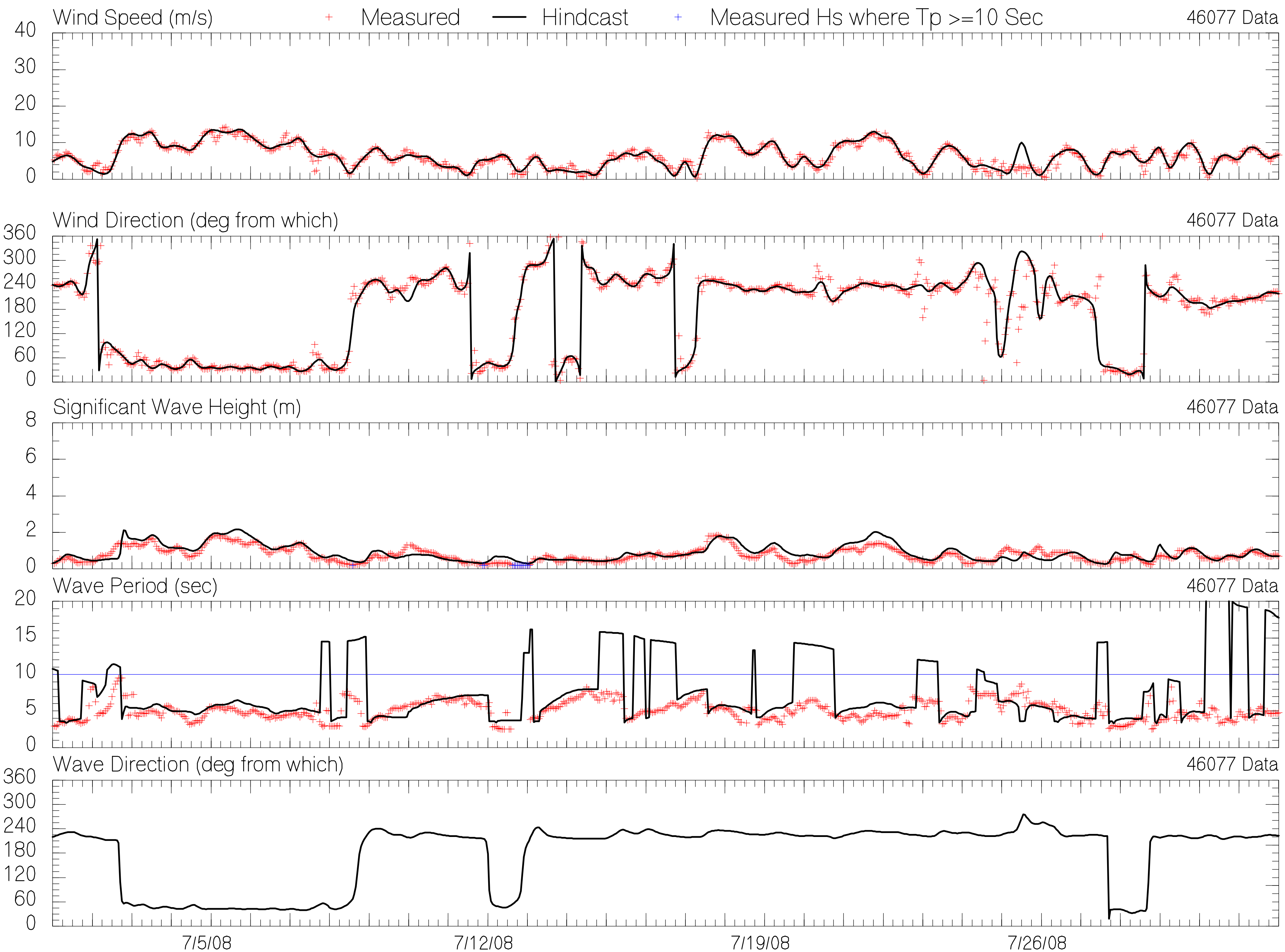
Kenai7km Model Validation

June 2008 - Buoy 46106



Kenai7km Model Validation

July 2008 - Buoy 46077



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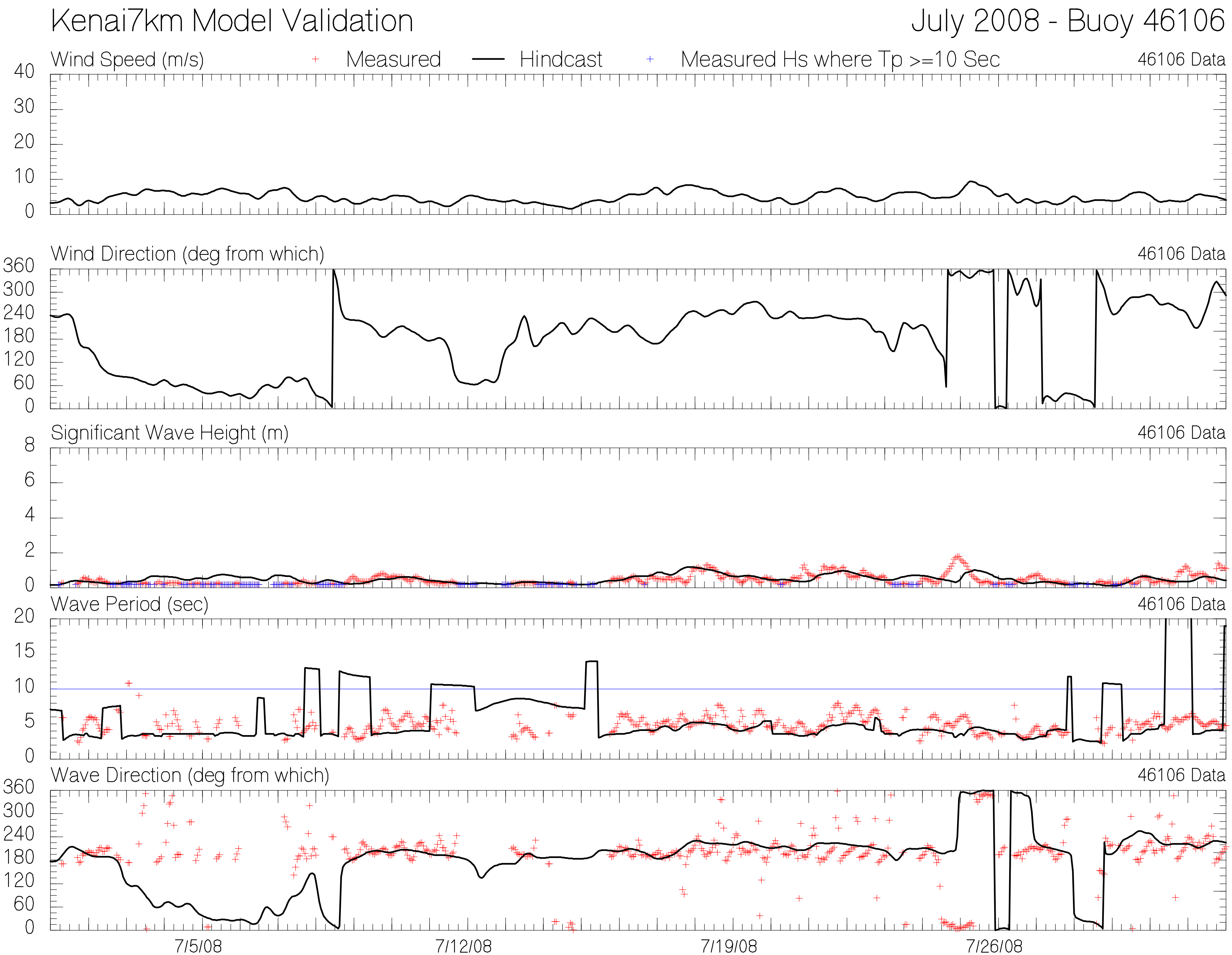

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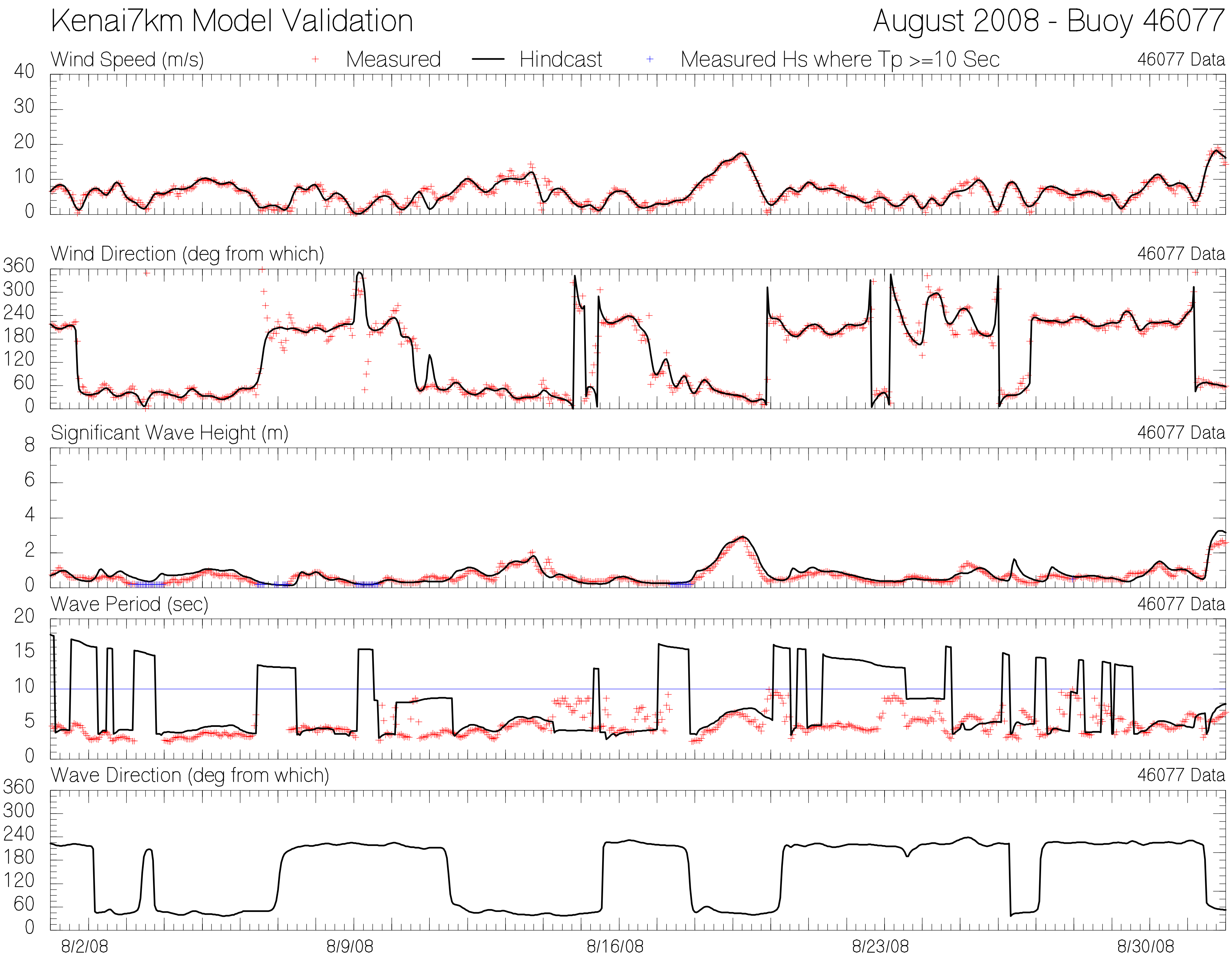

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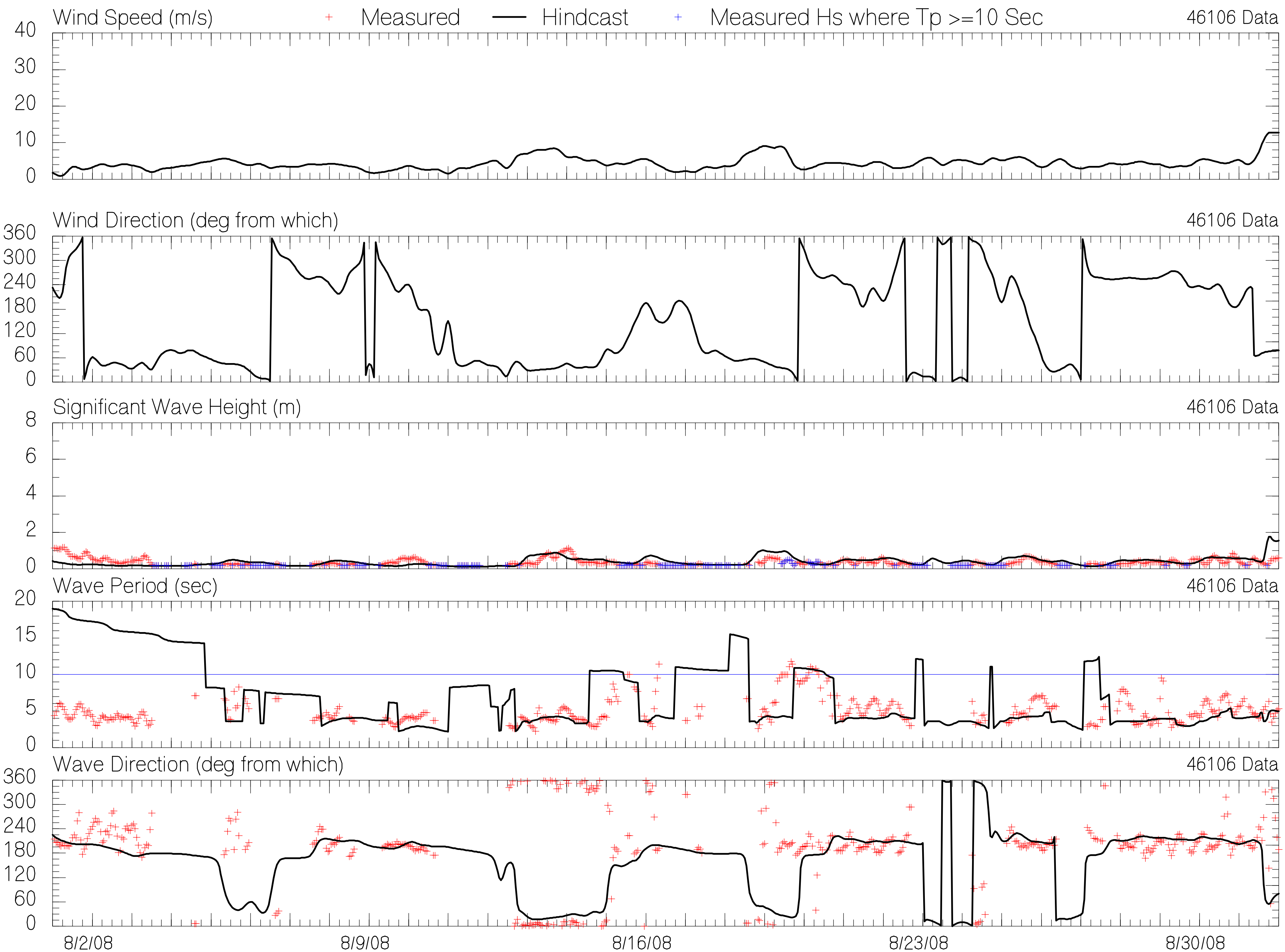
oceanweather inc.

Kenai7km Model Validation

August 2008 - Buoy 46106



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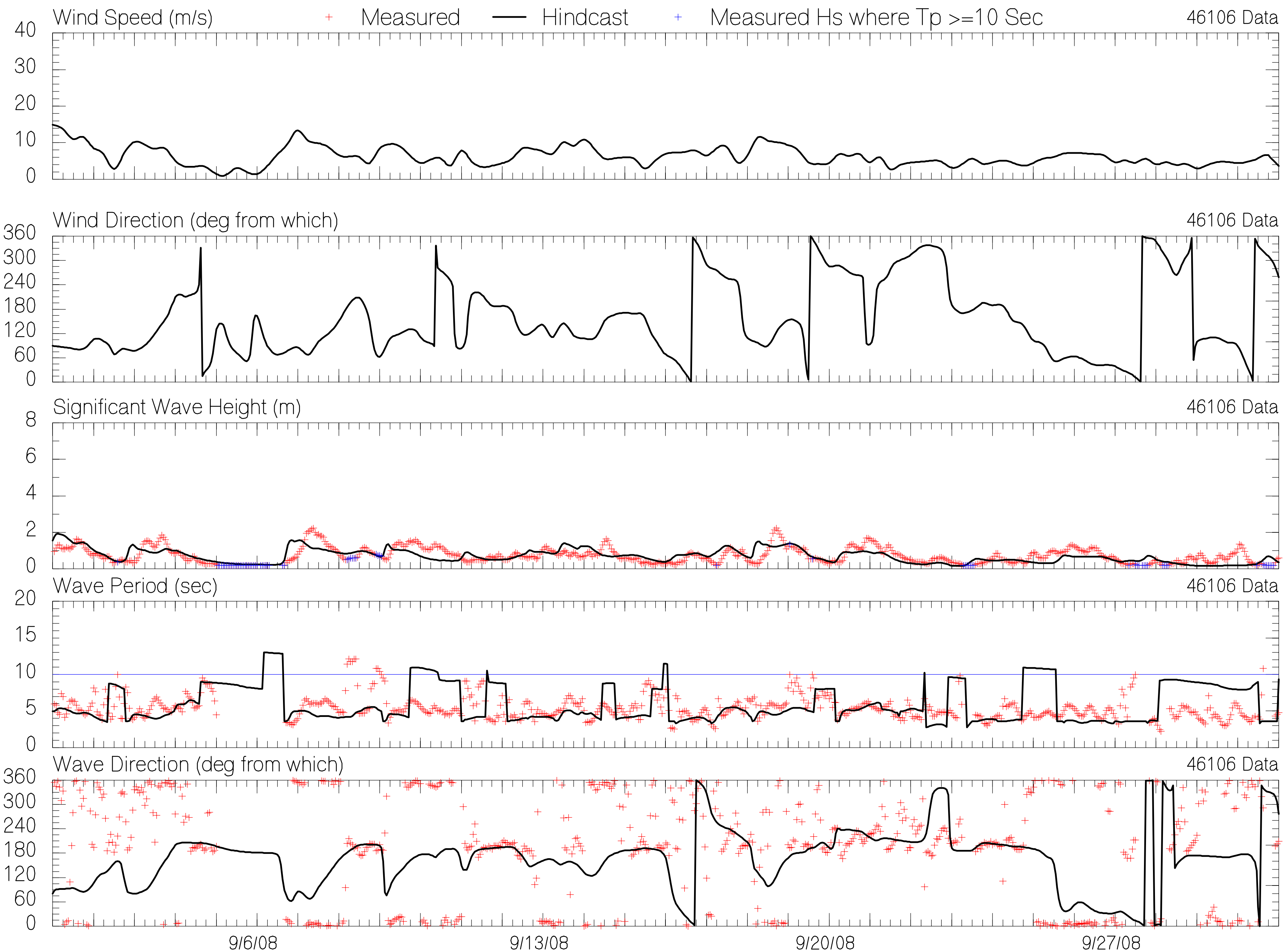
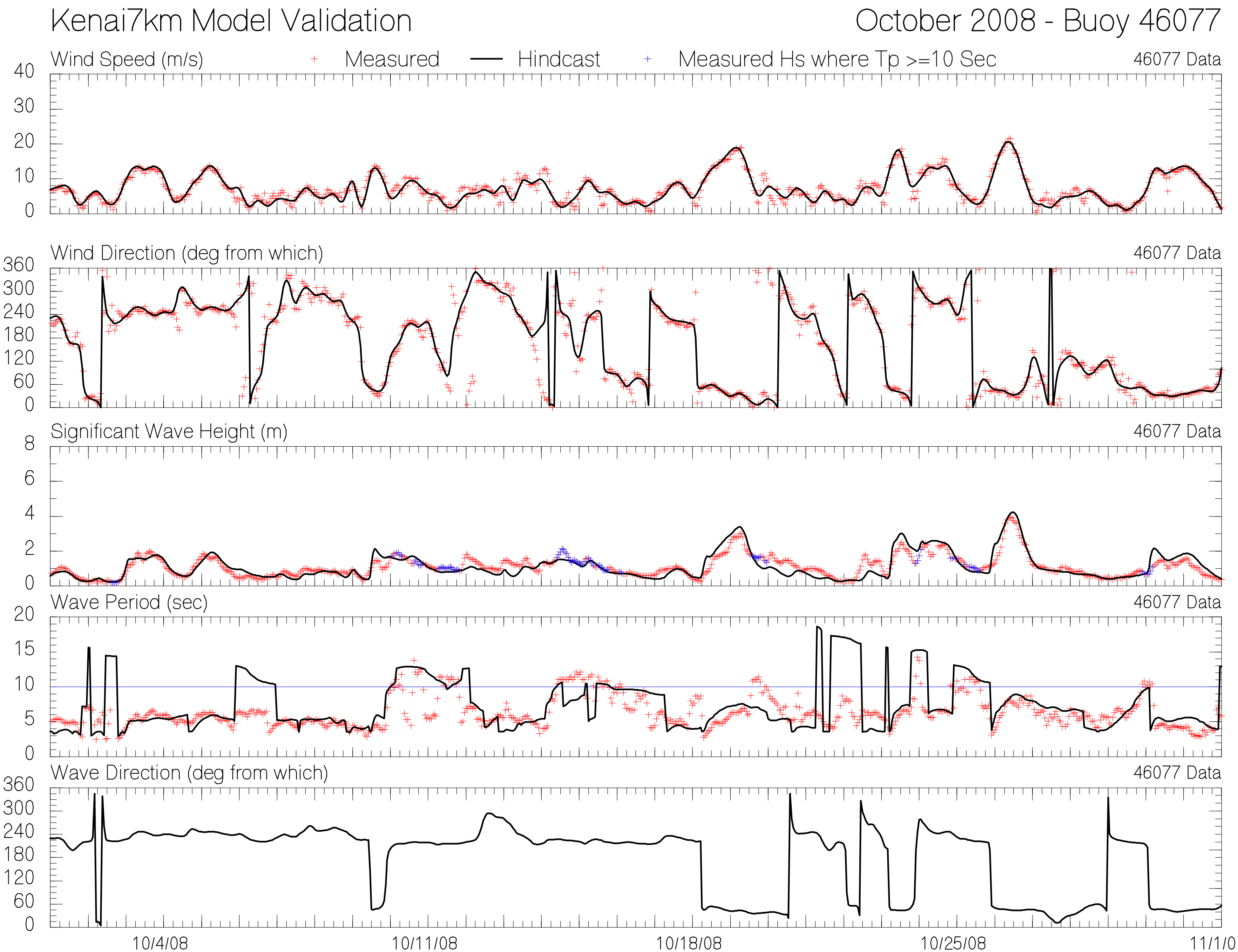
oceanweather inc.

Kenai7km Model Validation September 2008 - Buoy 46106





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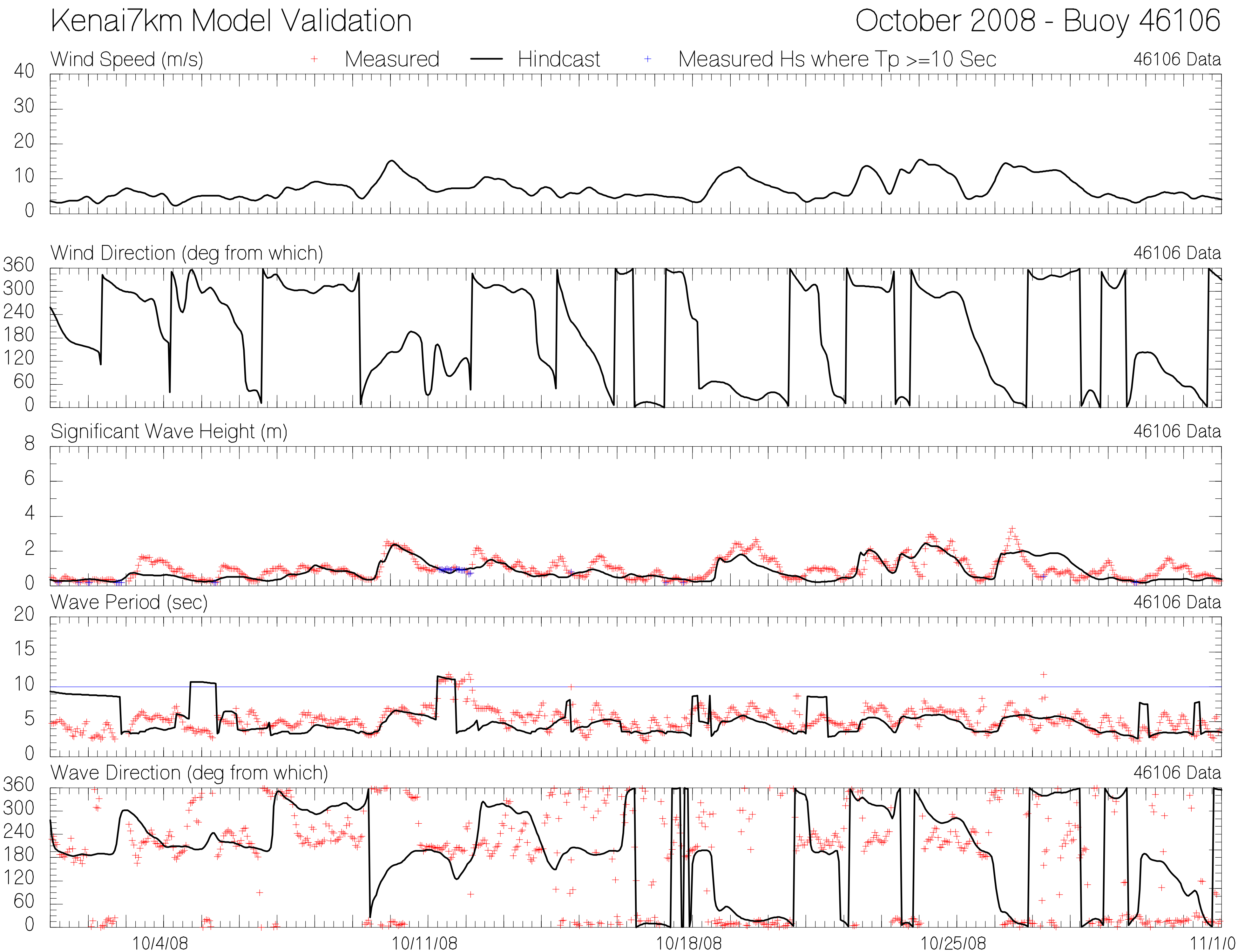
oceanweather inc.



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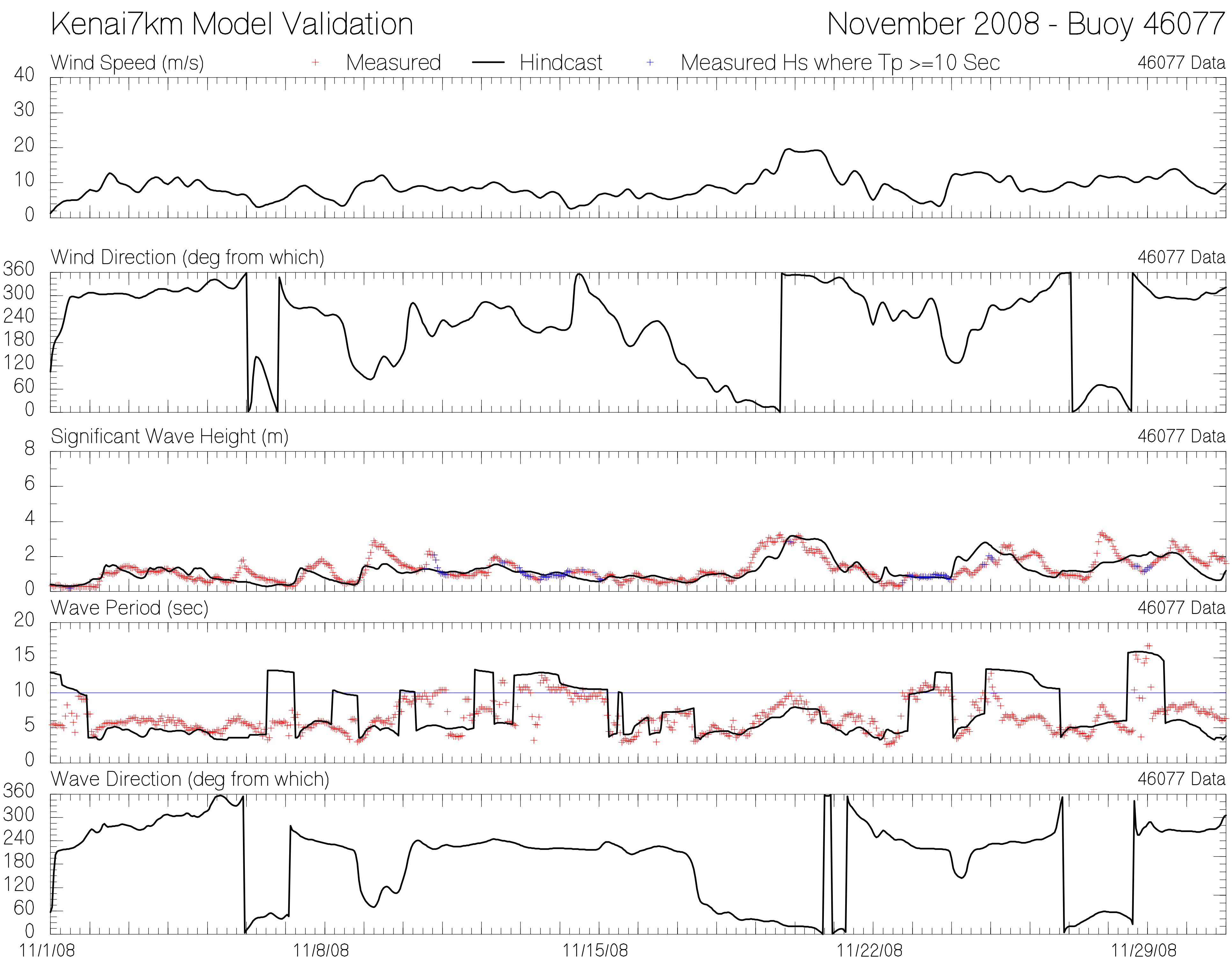
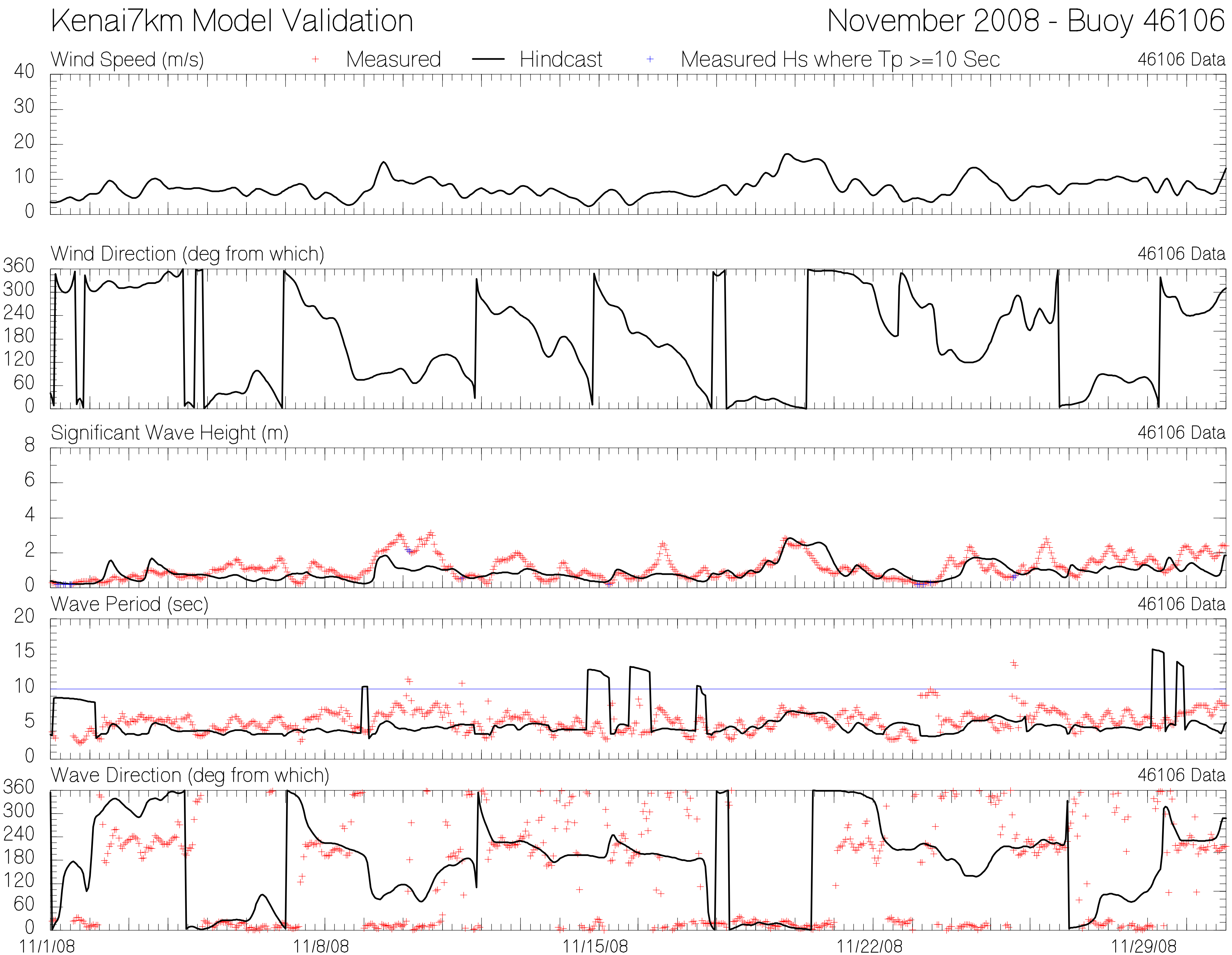

Kenai7km Model Validation
November 2008 - Buoy 46077
Wind Speed (m/s)
Measured
Hindcast
Measured Hs where Tp >=10 Sec
46077 Data
Wind Direction (deg from which)
Significant Wave Height (m)
Wave Period (sec)
Wave Direction (deg from which)
11/1/08
11/8/08
11/15/08
11/22/08
11/29/08



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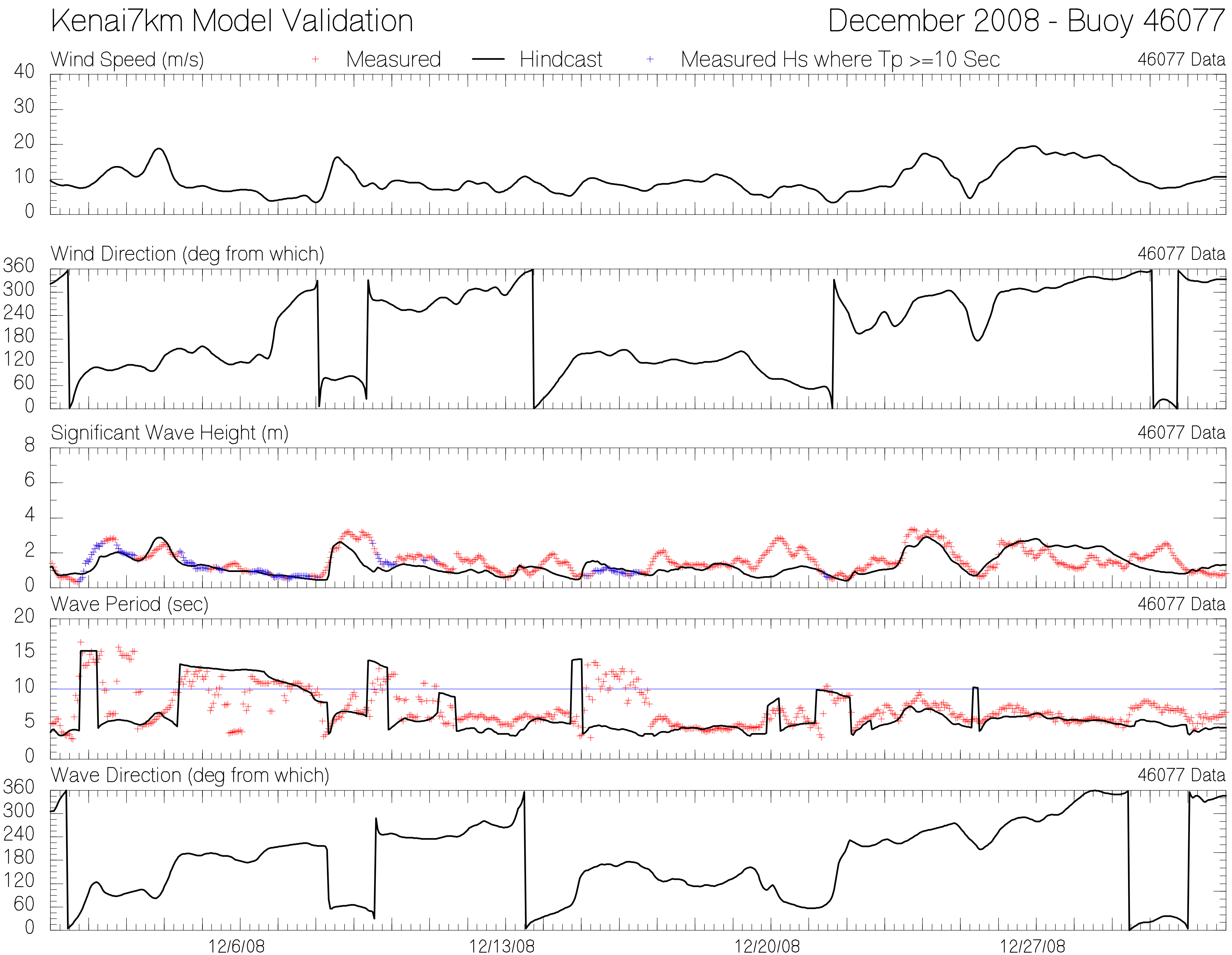

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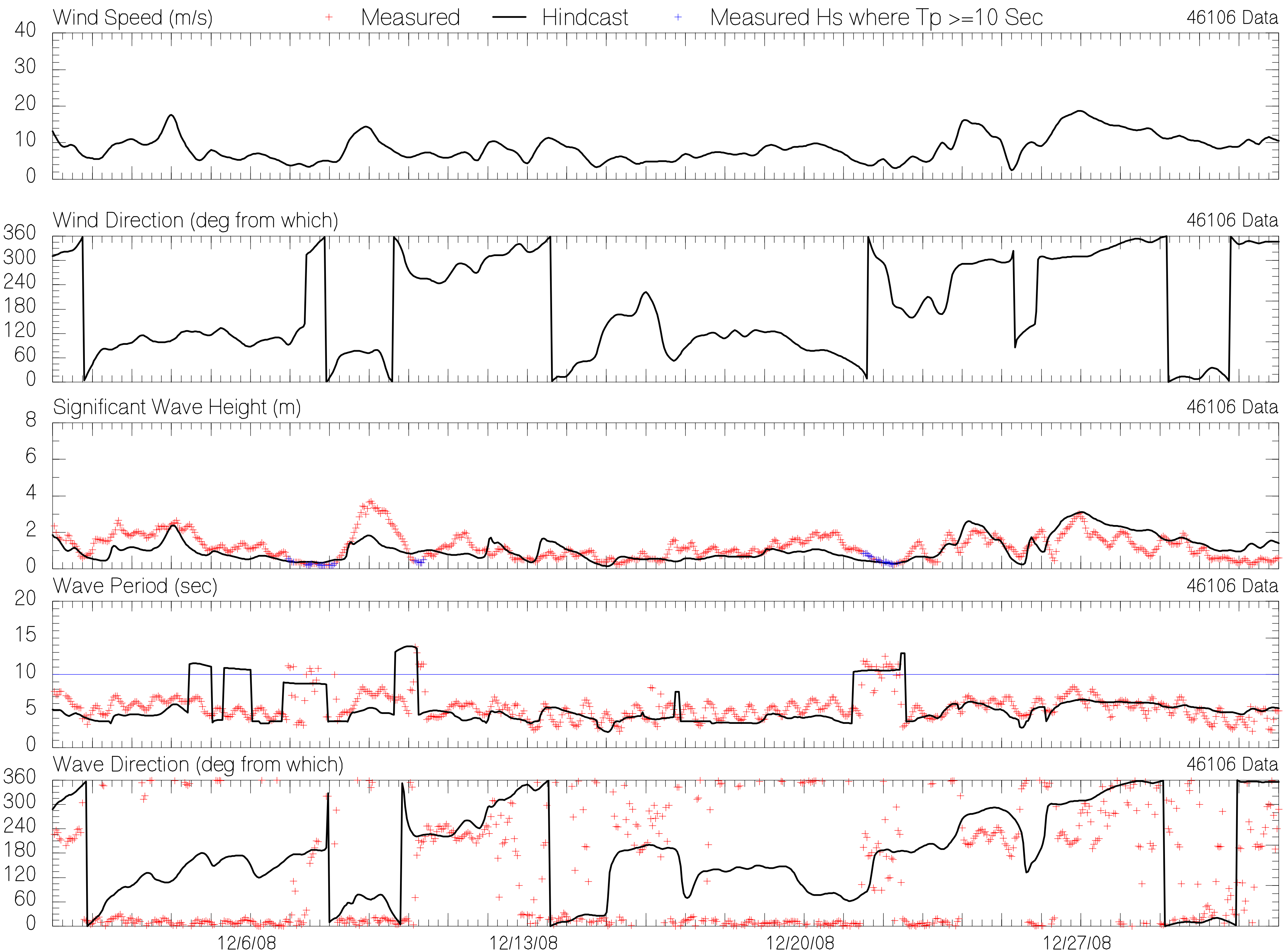
oceanweather inc.

Kenai7km Model Validation

December 2008 - Buoy 46106



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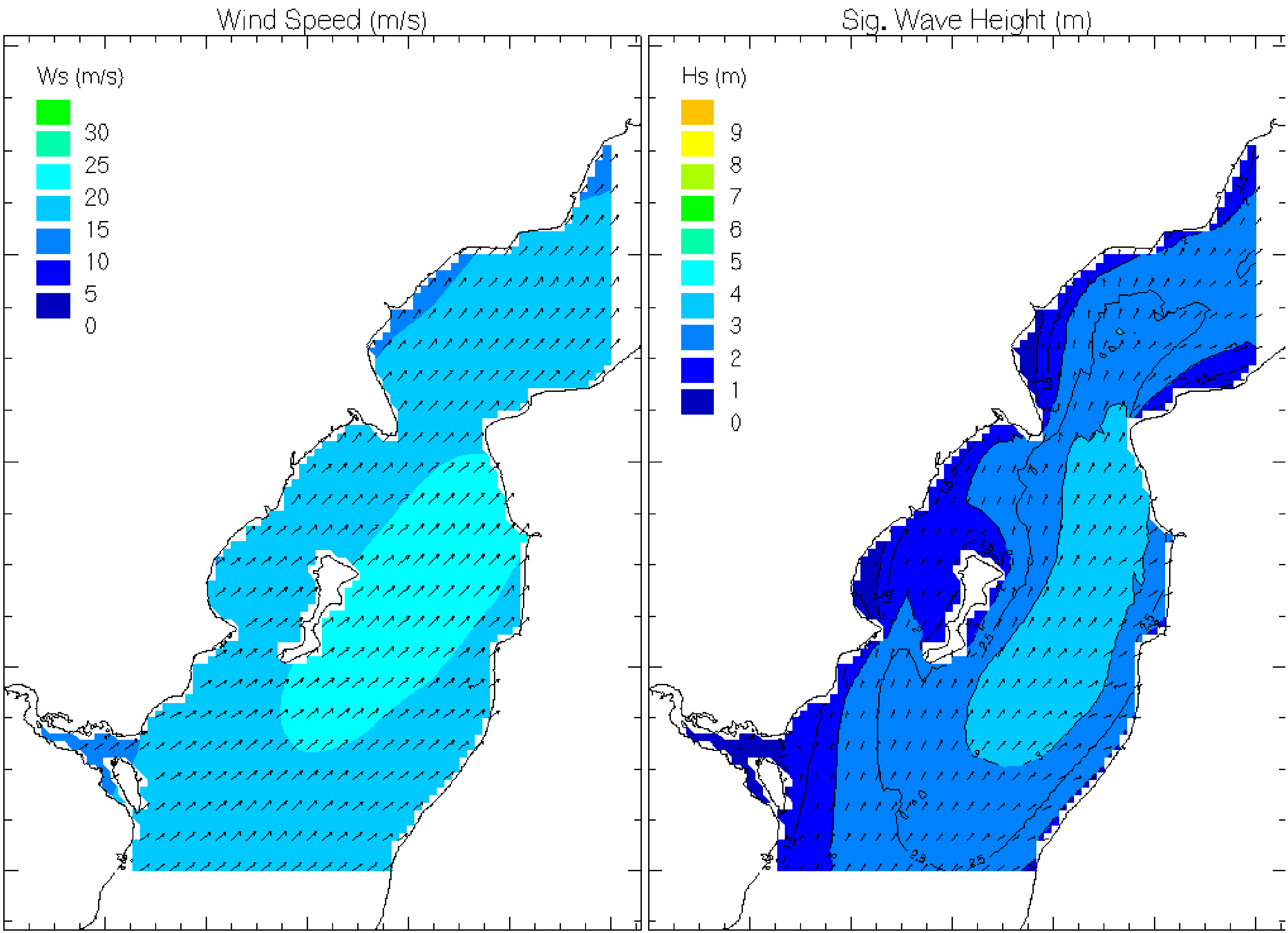
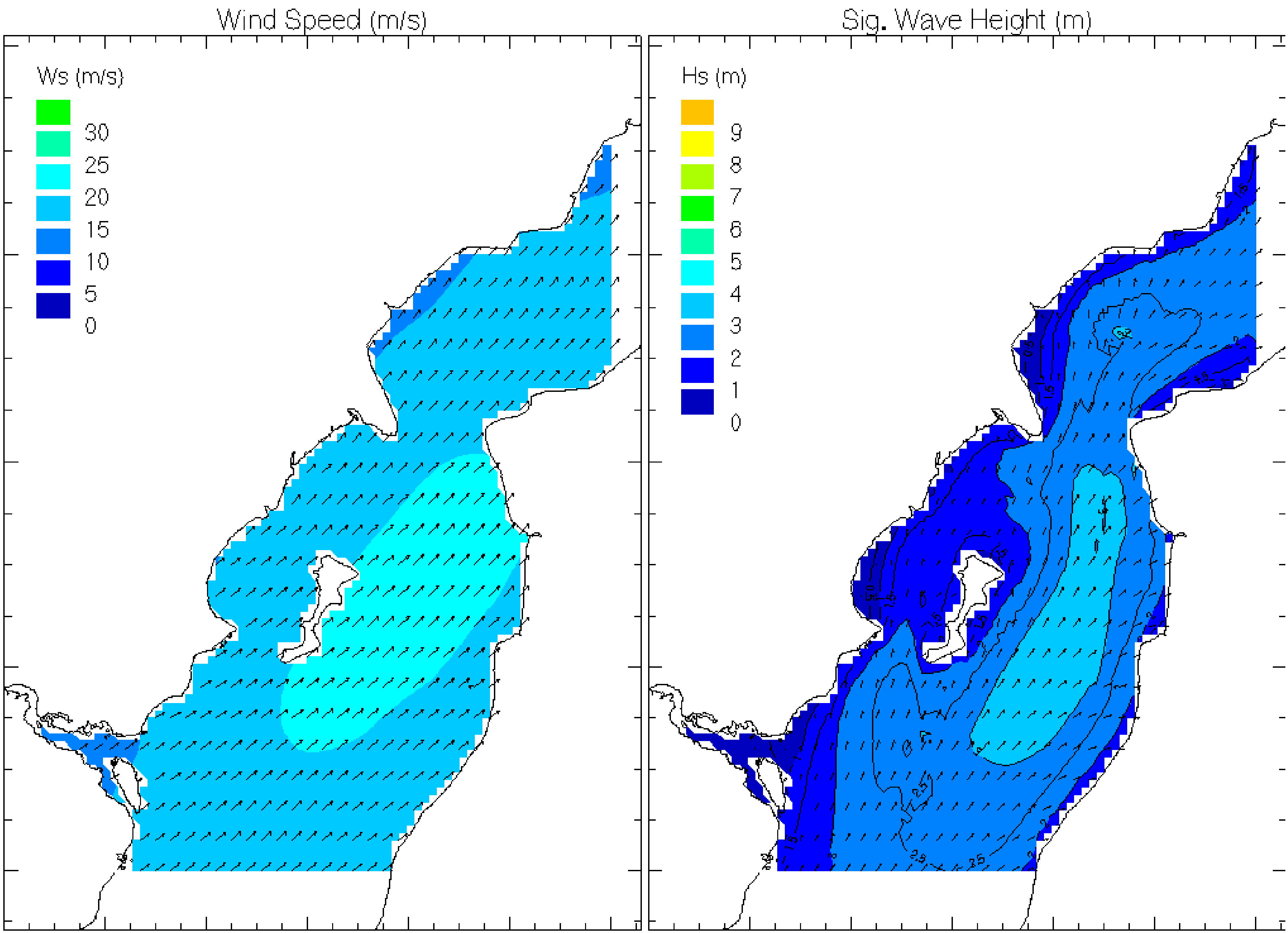
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 19730310



Kenai Maximum Hindcast Winds and Waves during 19730310



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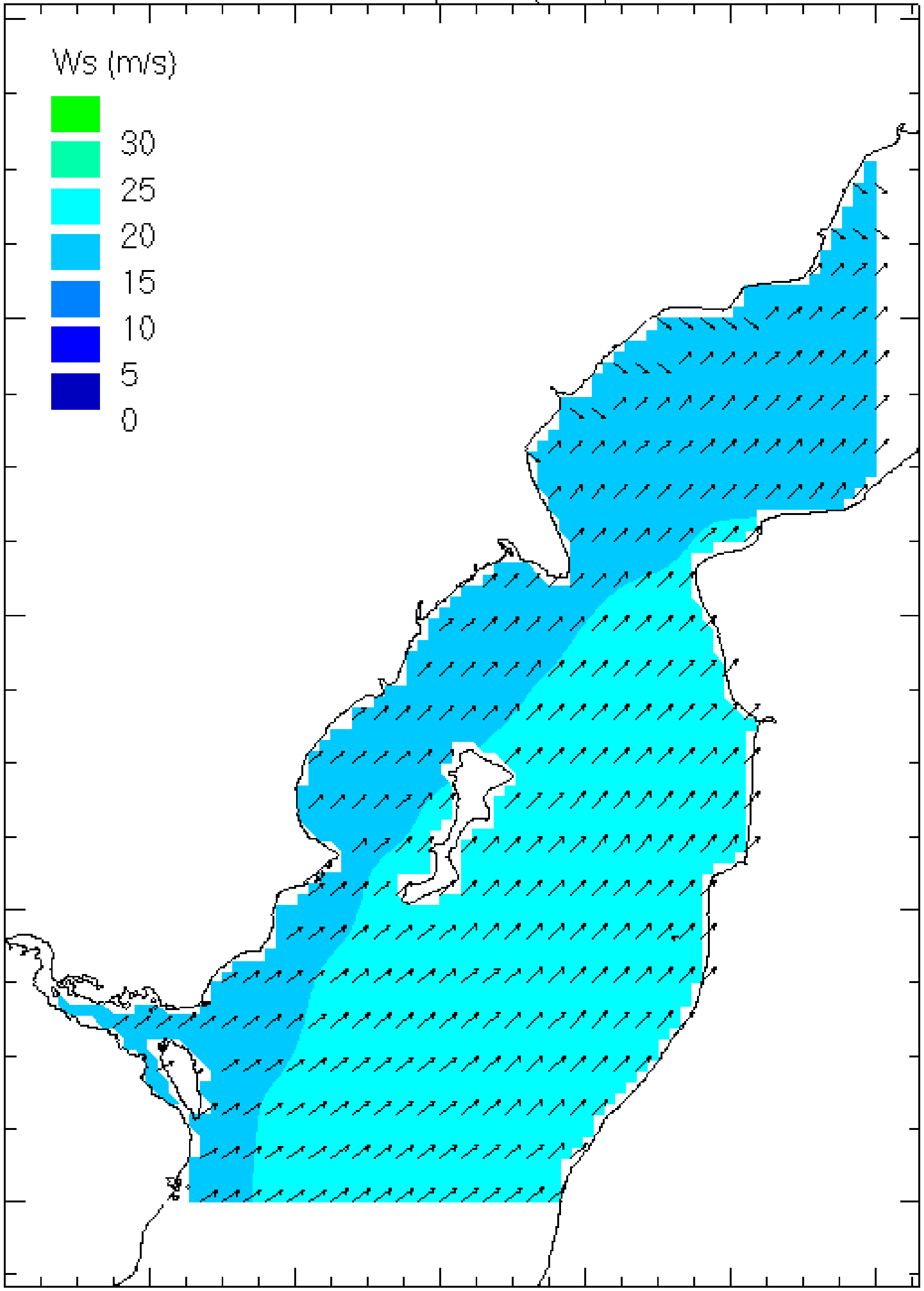
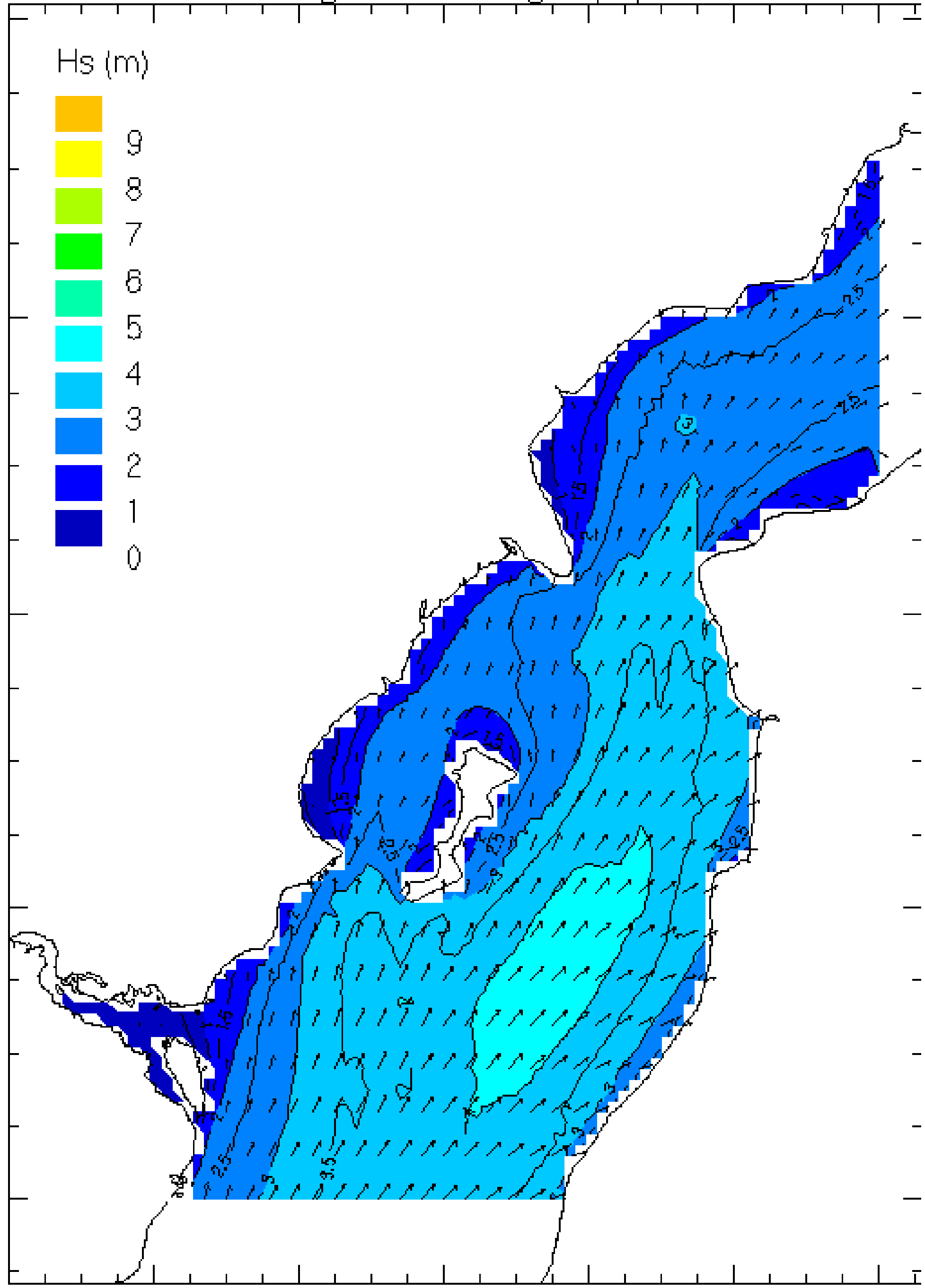
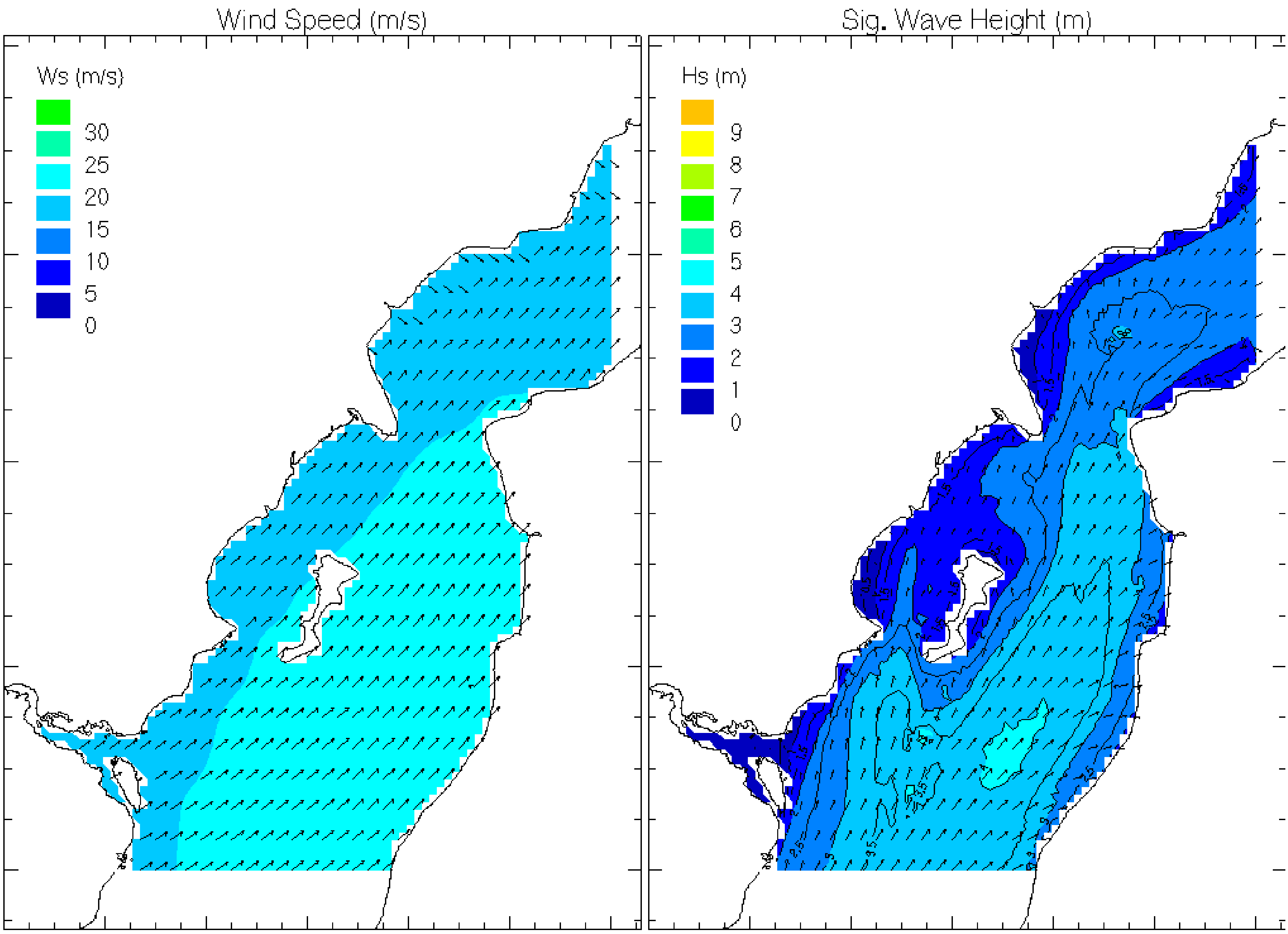
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 19740303

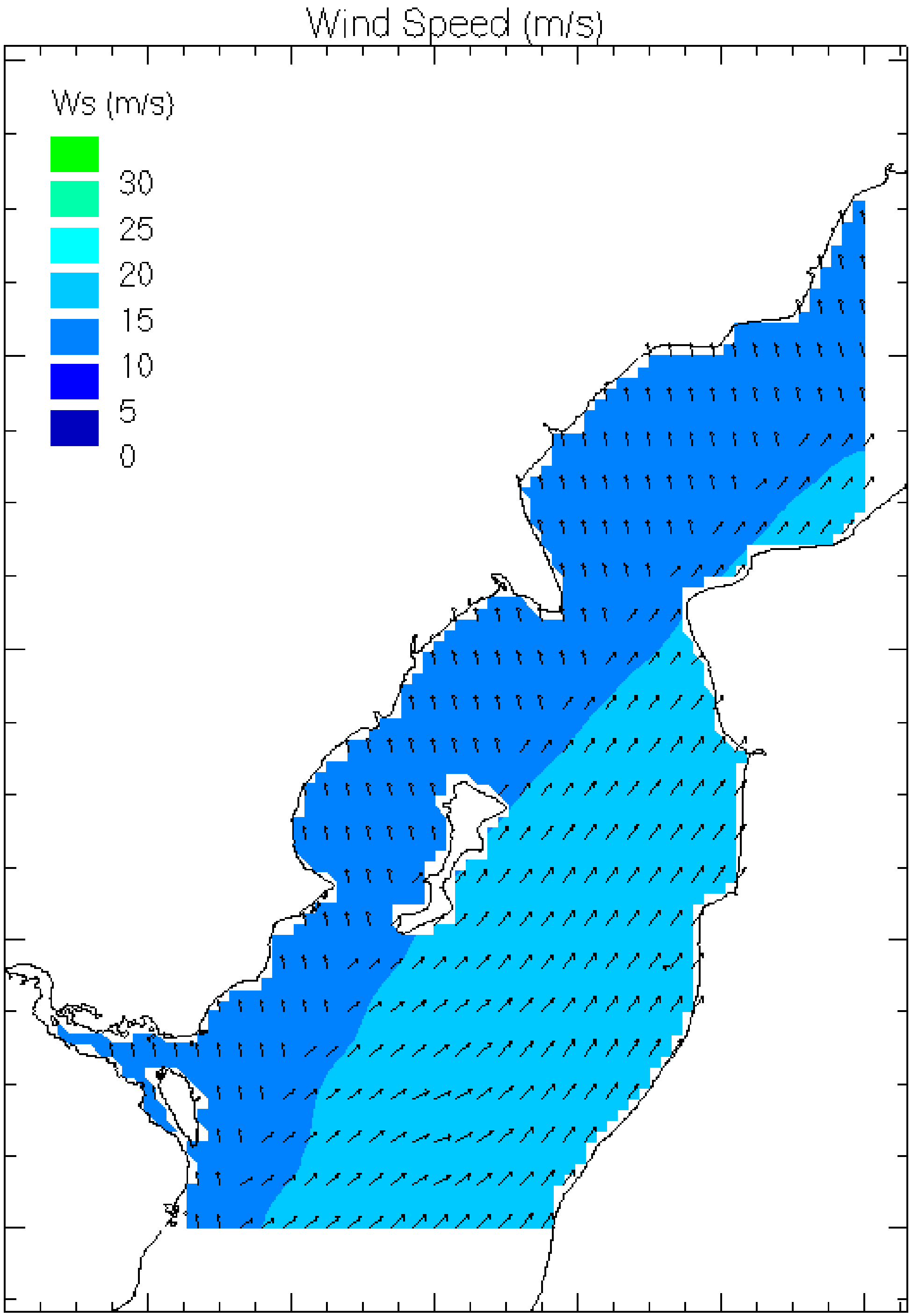


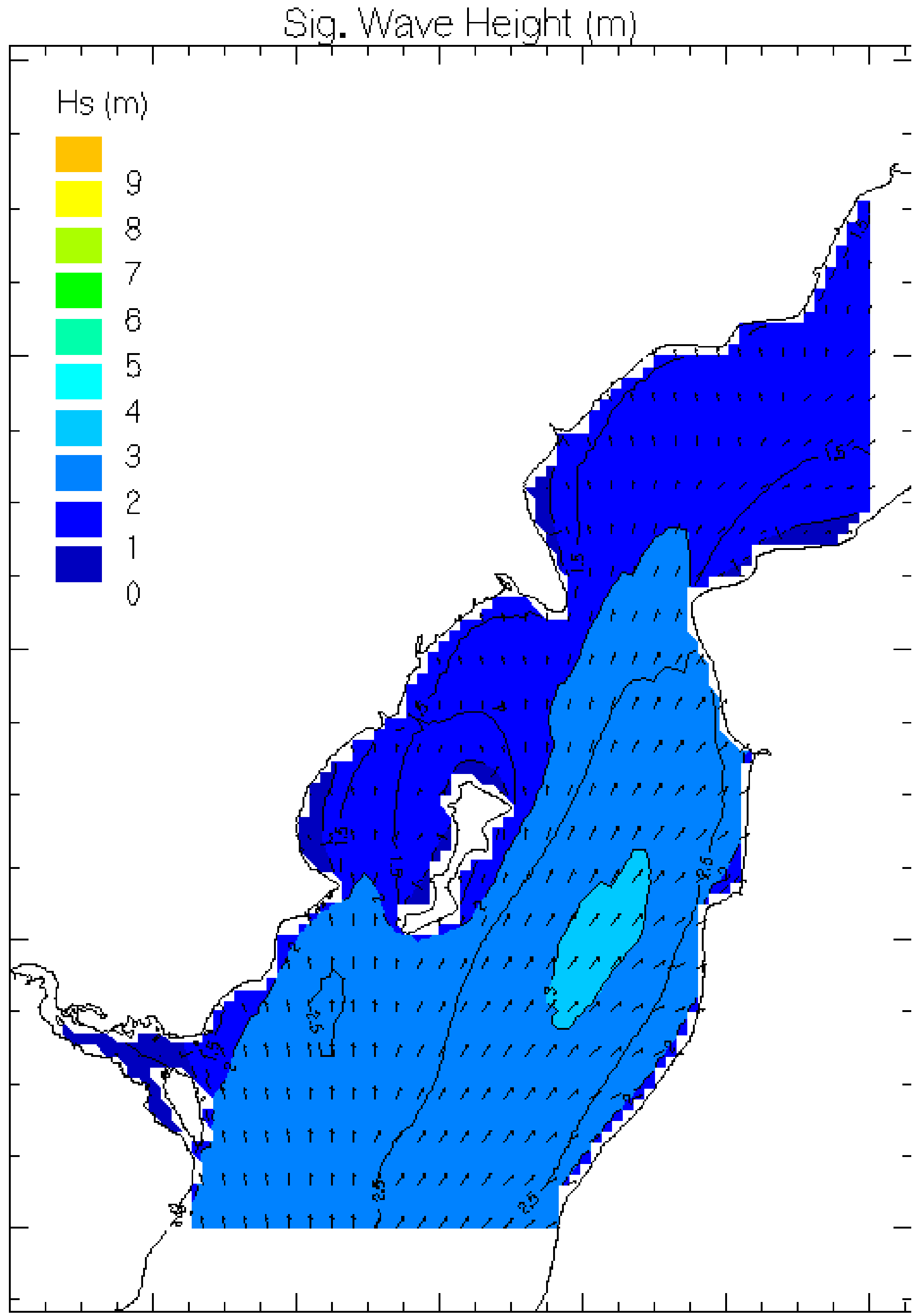


Kenai Maximum Hindcast Winds and Waves during 19740303



Kenai MTR Maximum Hindcast Winds and Waves during 19750126





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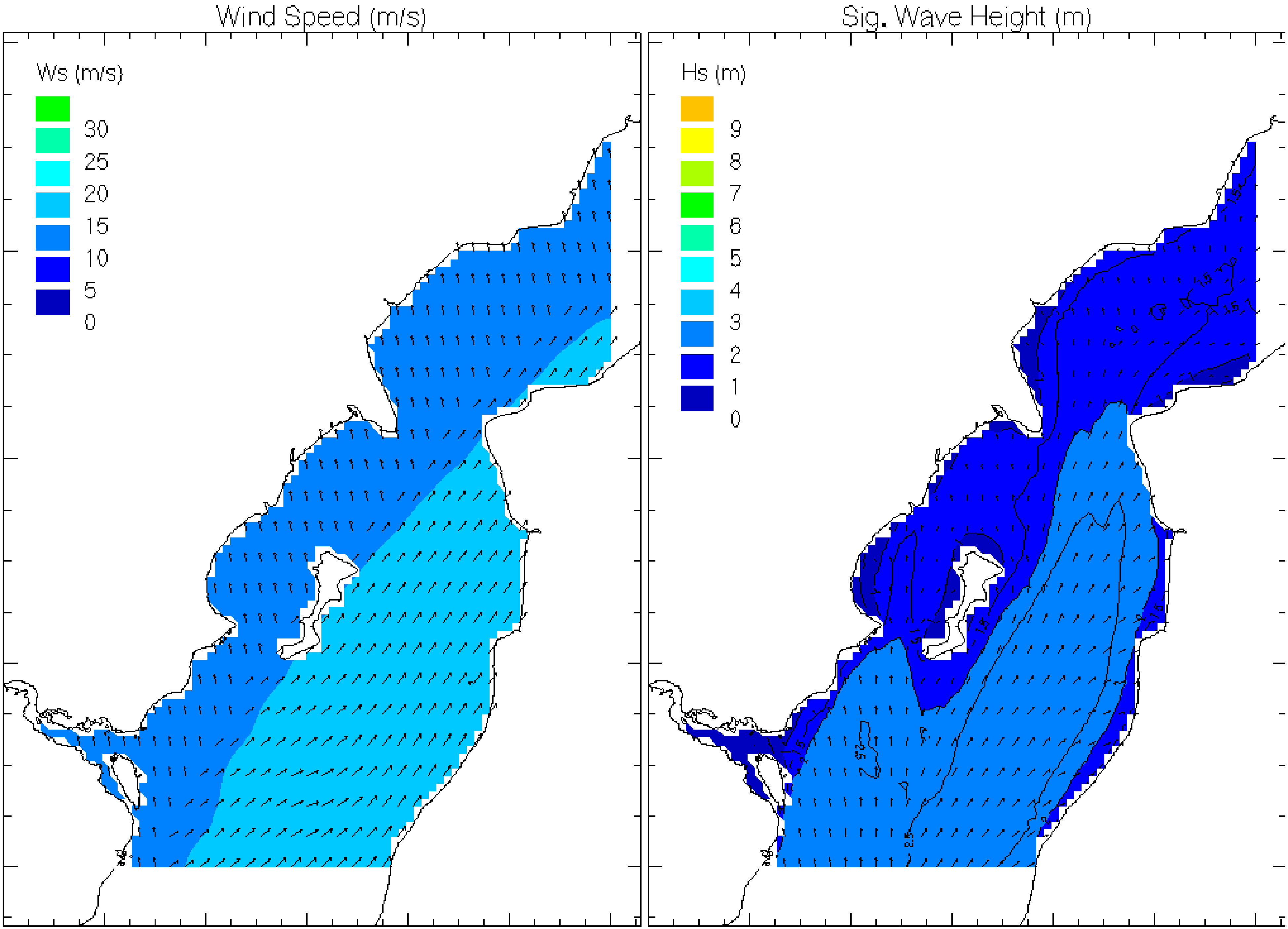
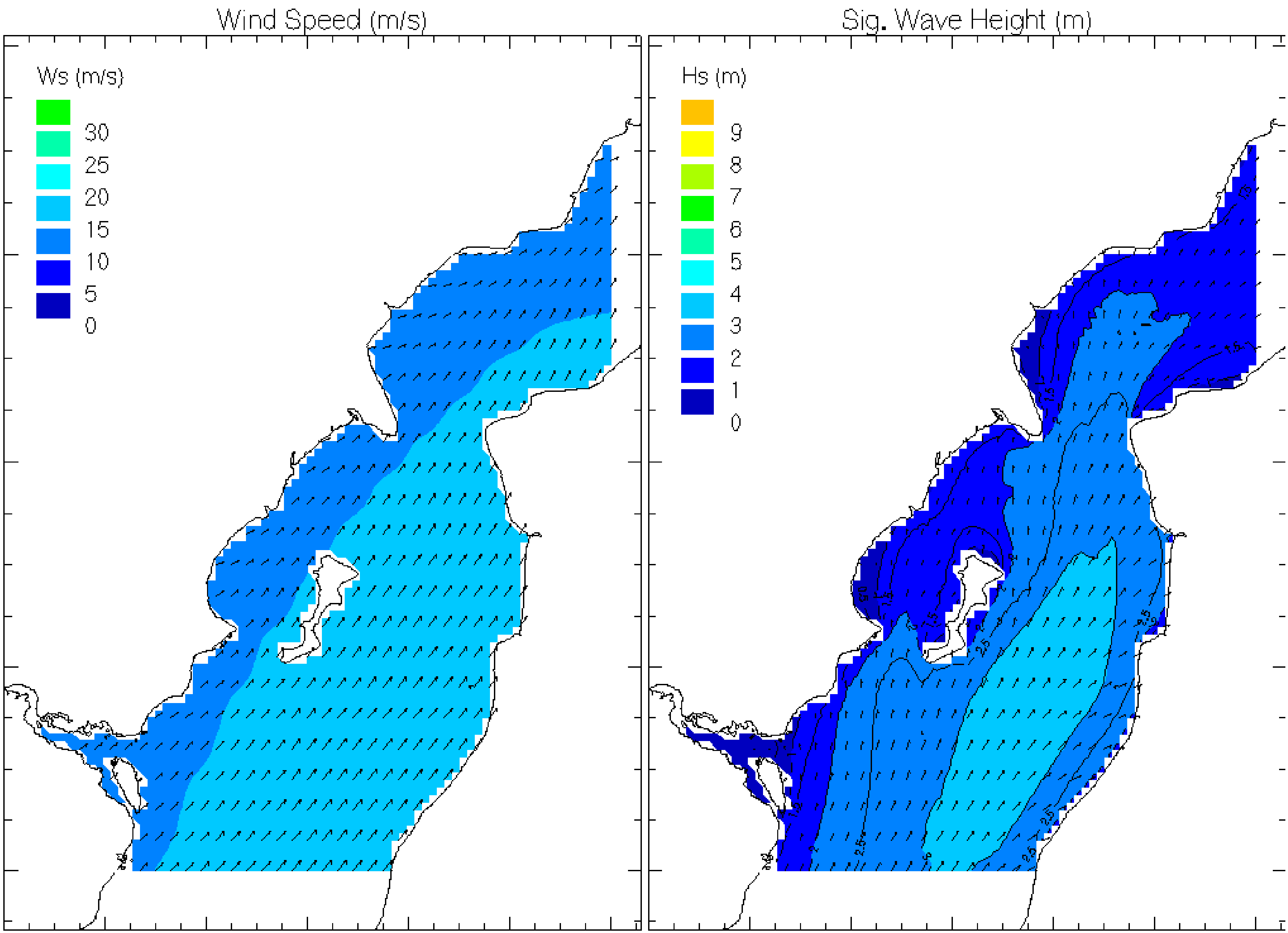
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 19750126



Kenai MTR Maximum Hindcast Winds and Waves during 19751021



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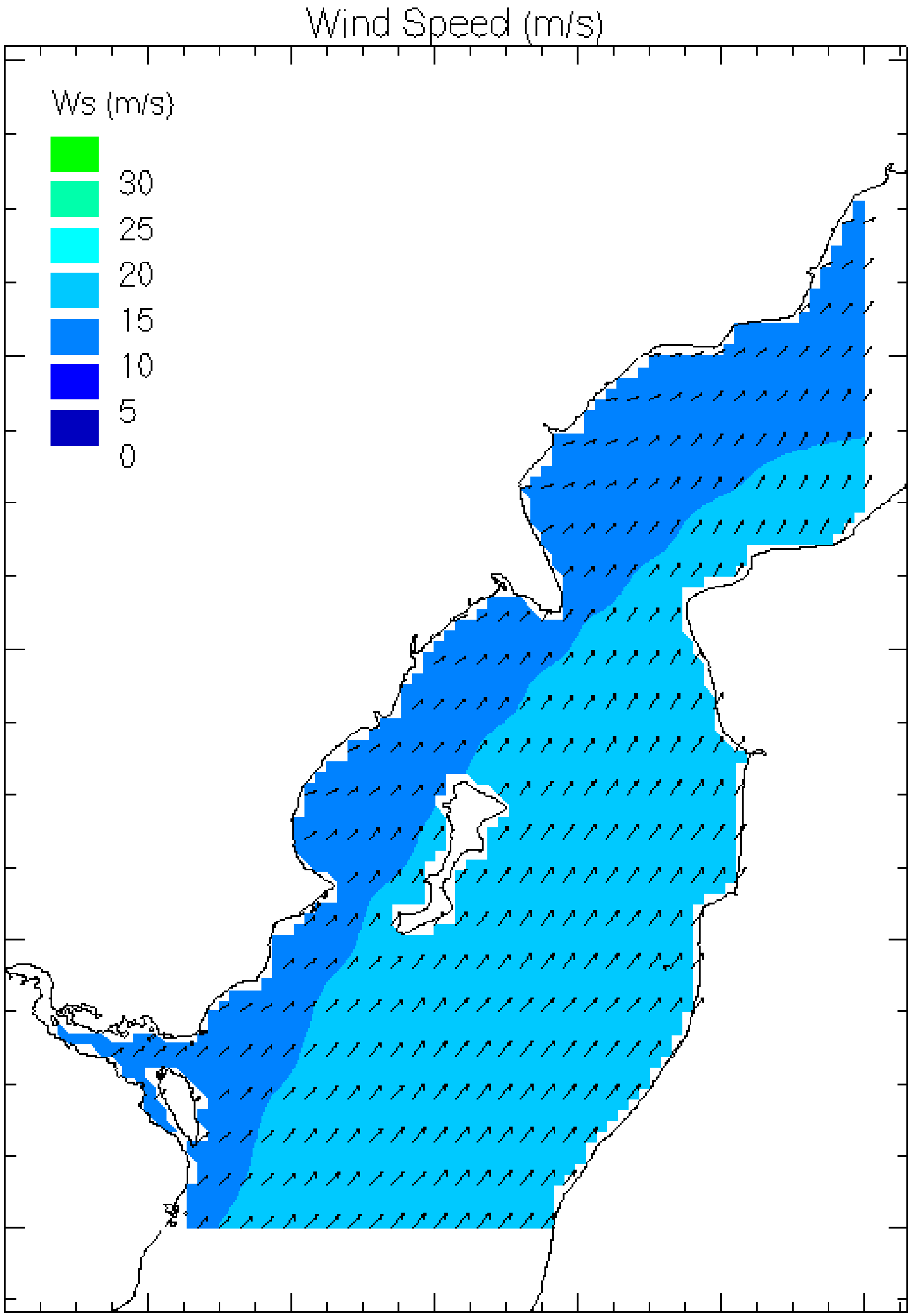
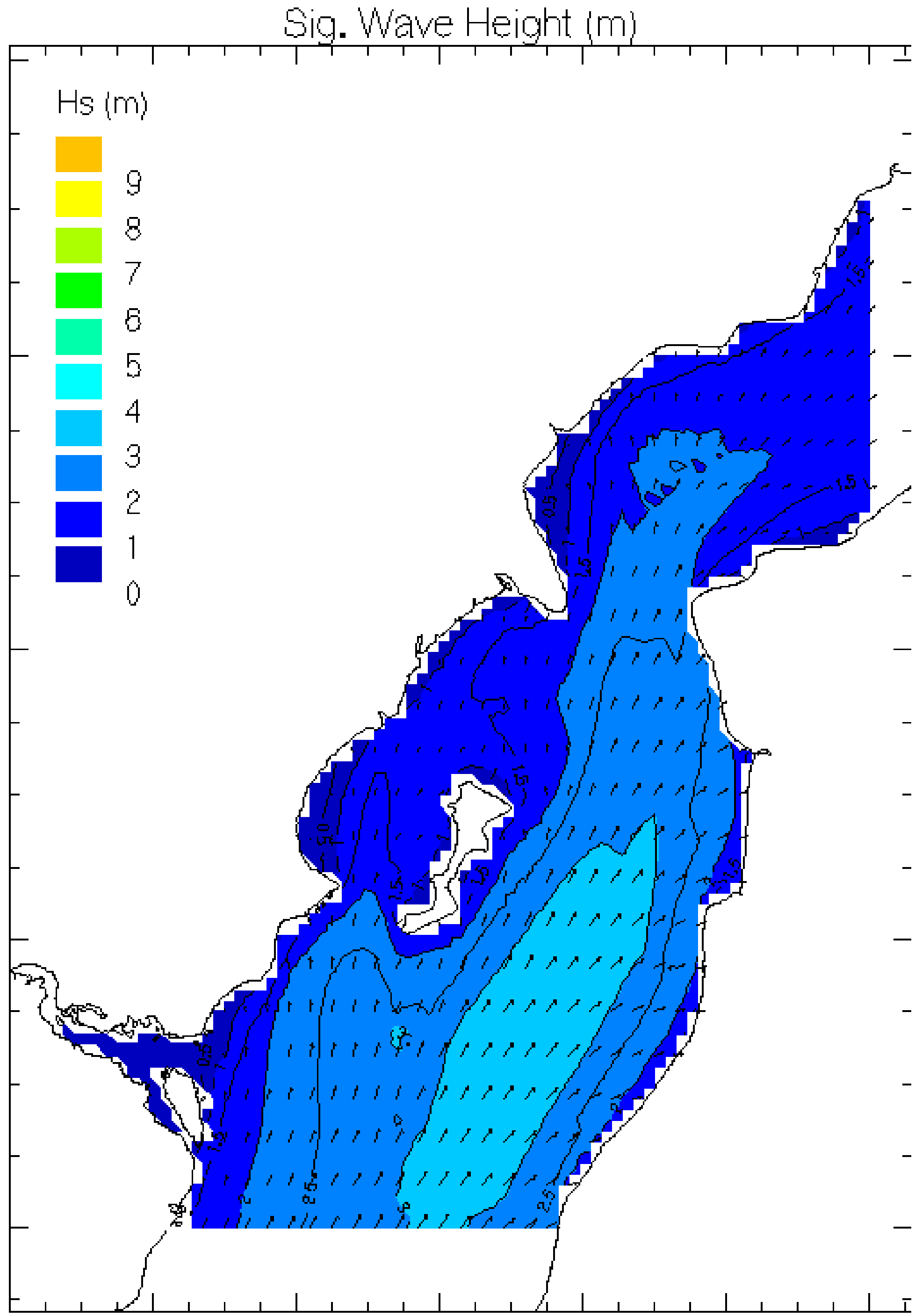
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 19751021





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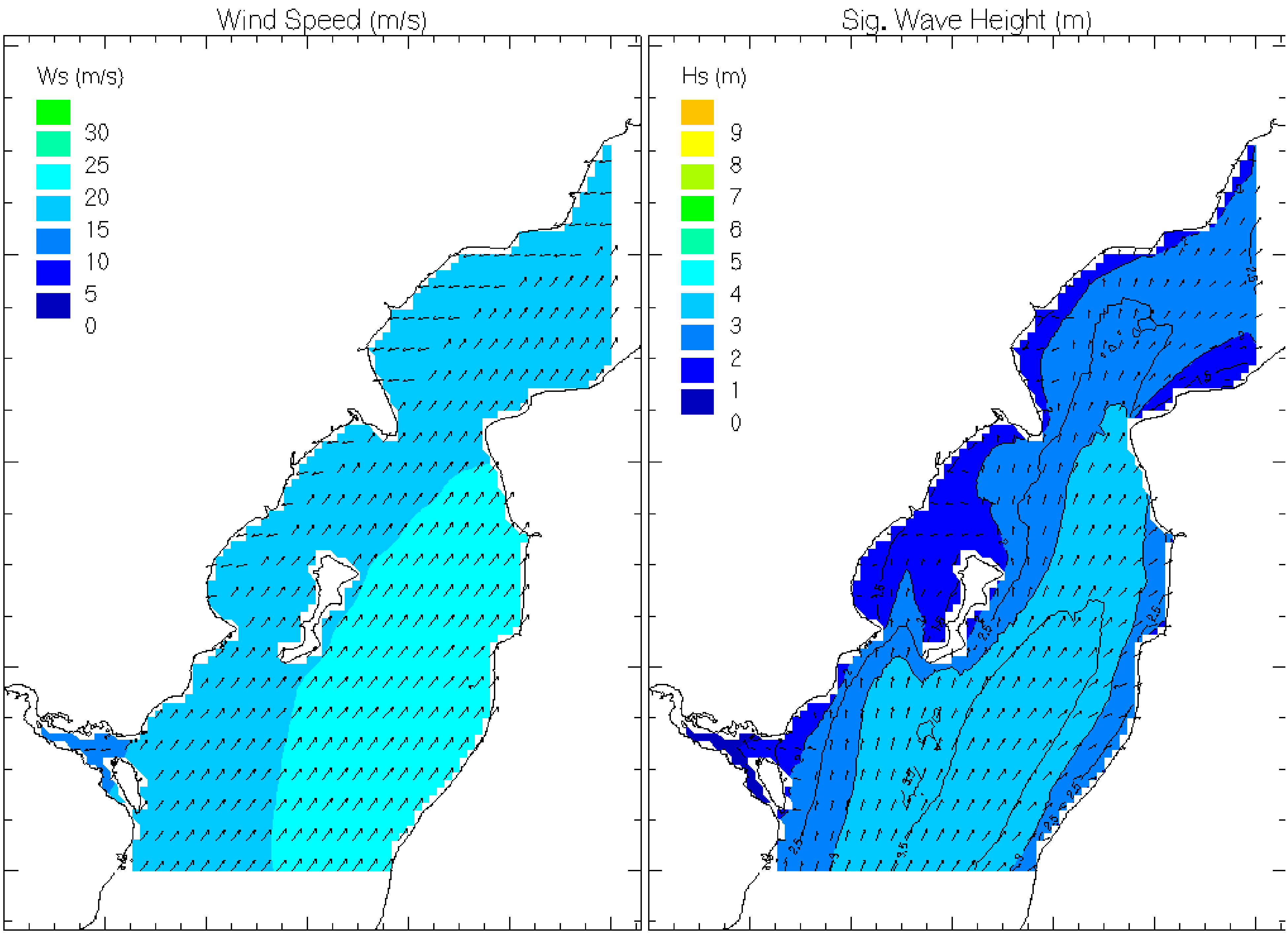
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 19760130



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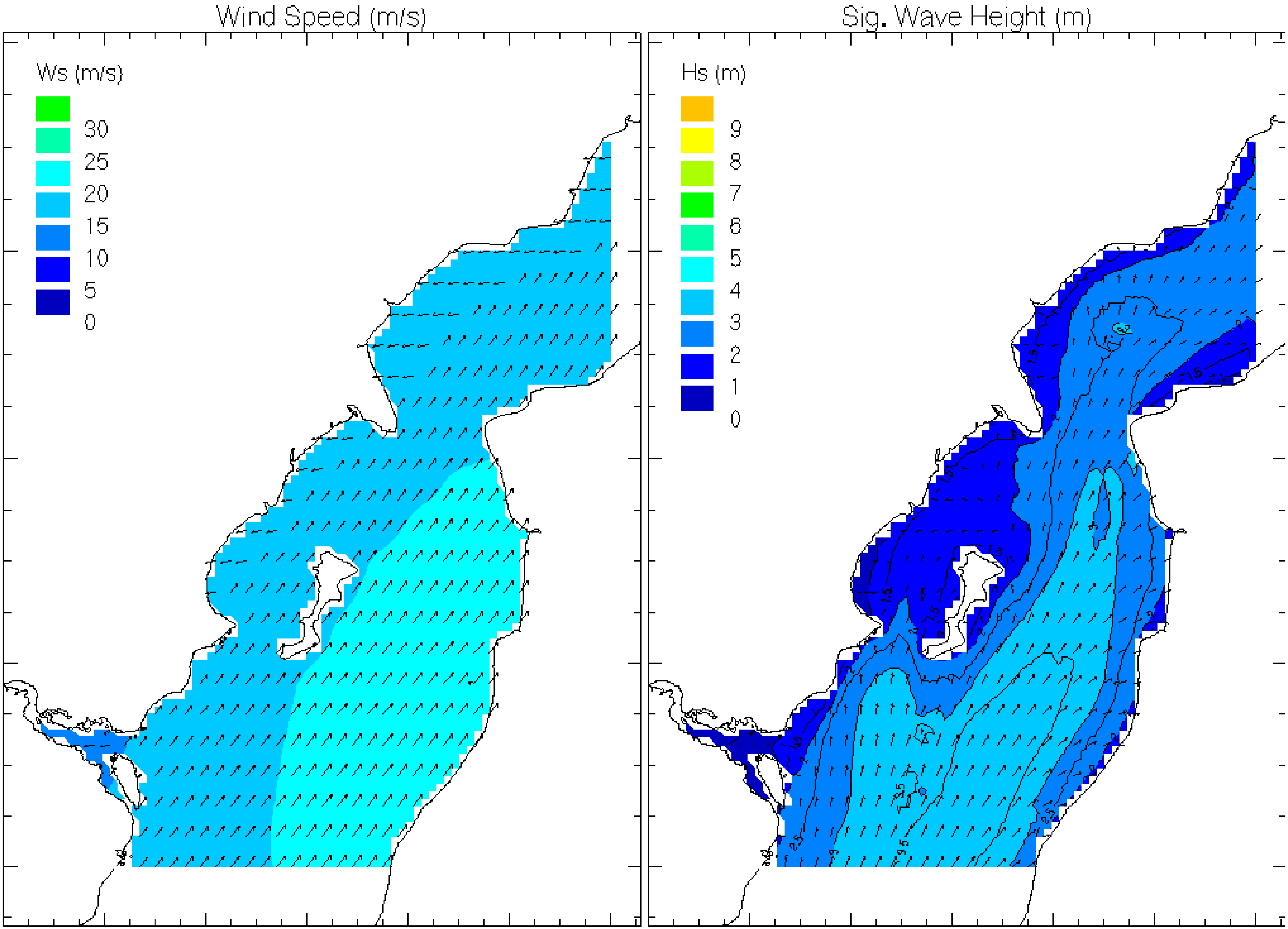
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 19760130



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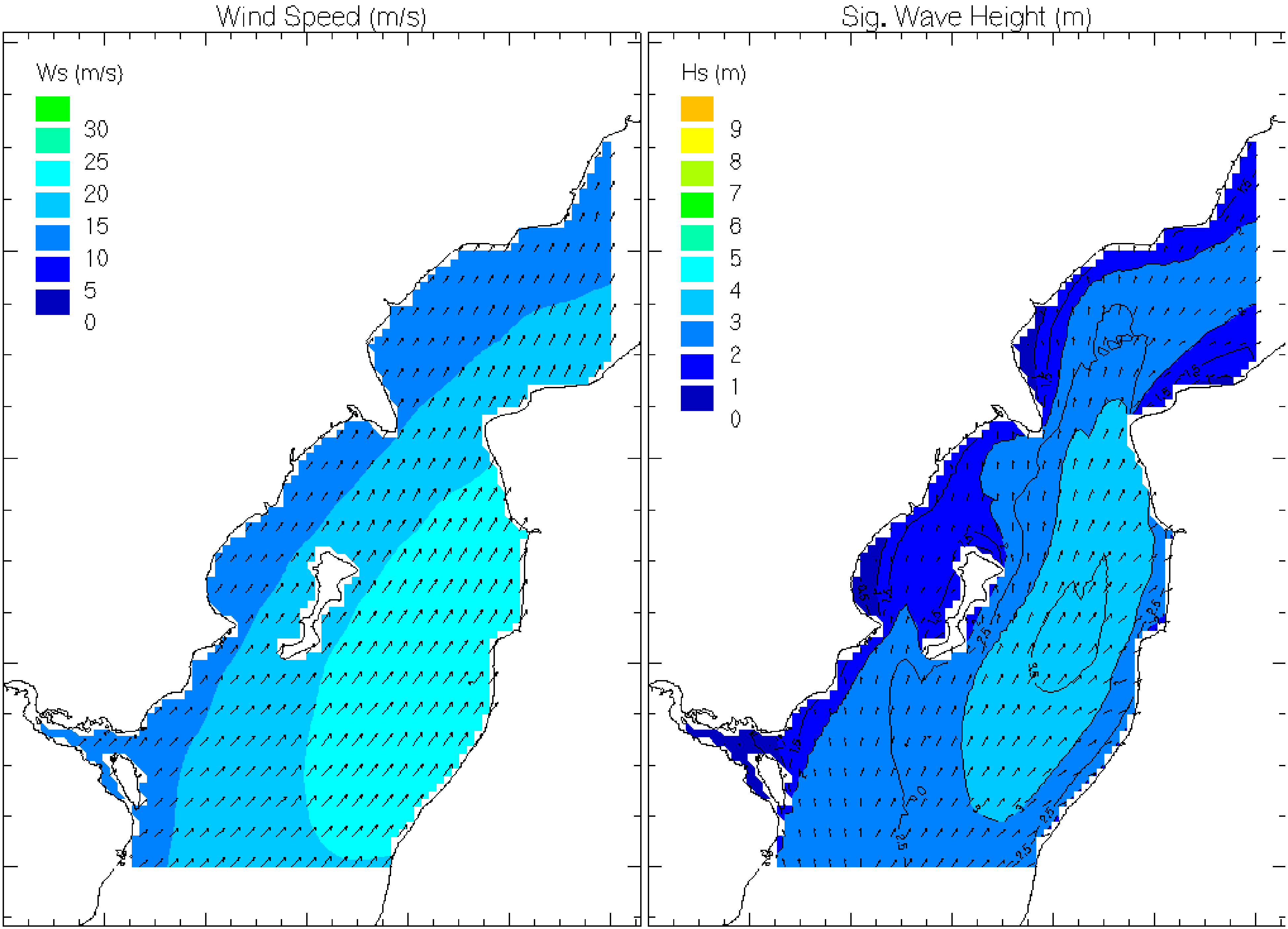
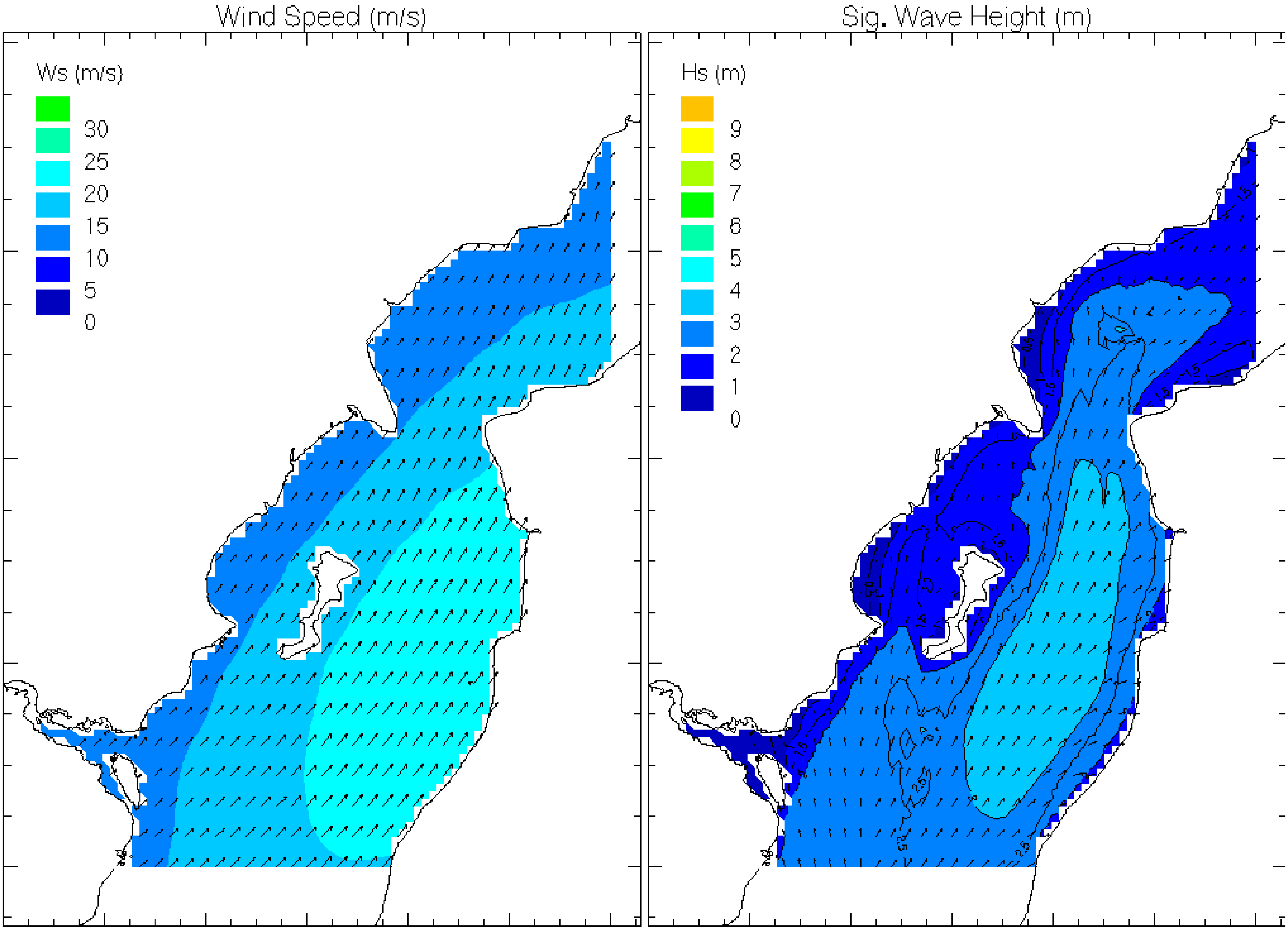
oceanweather inc.

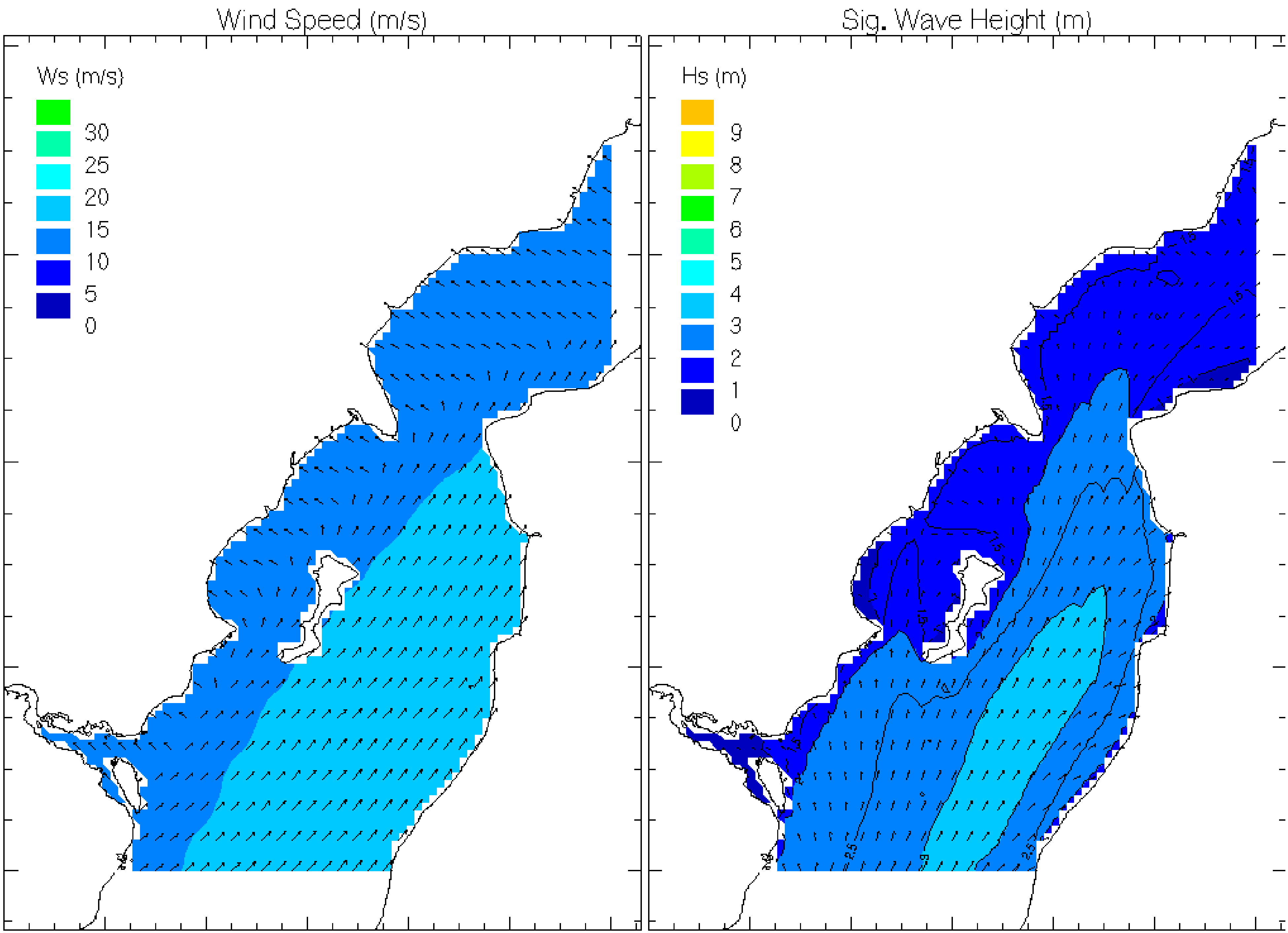
Kenai MTR Maximum Hindcast Winds and Waves during 19780820



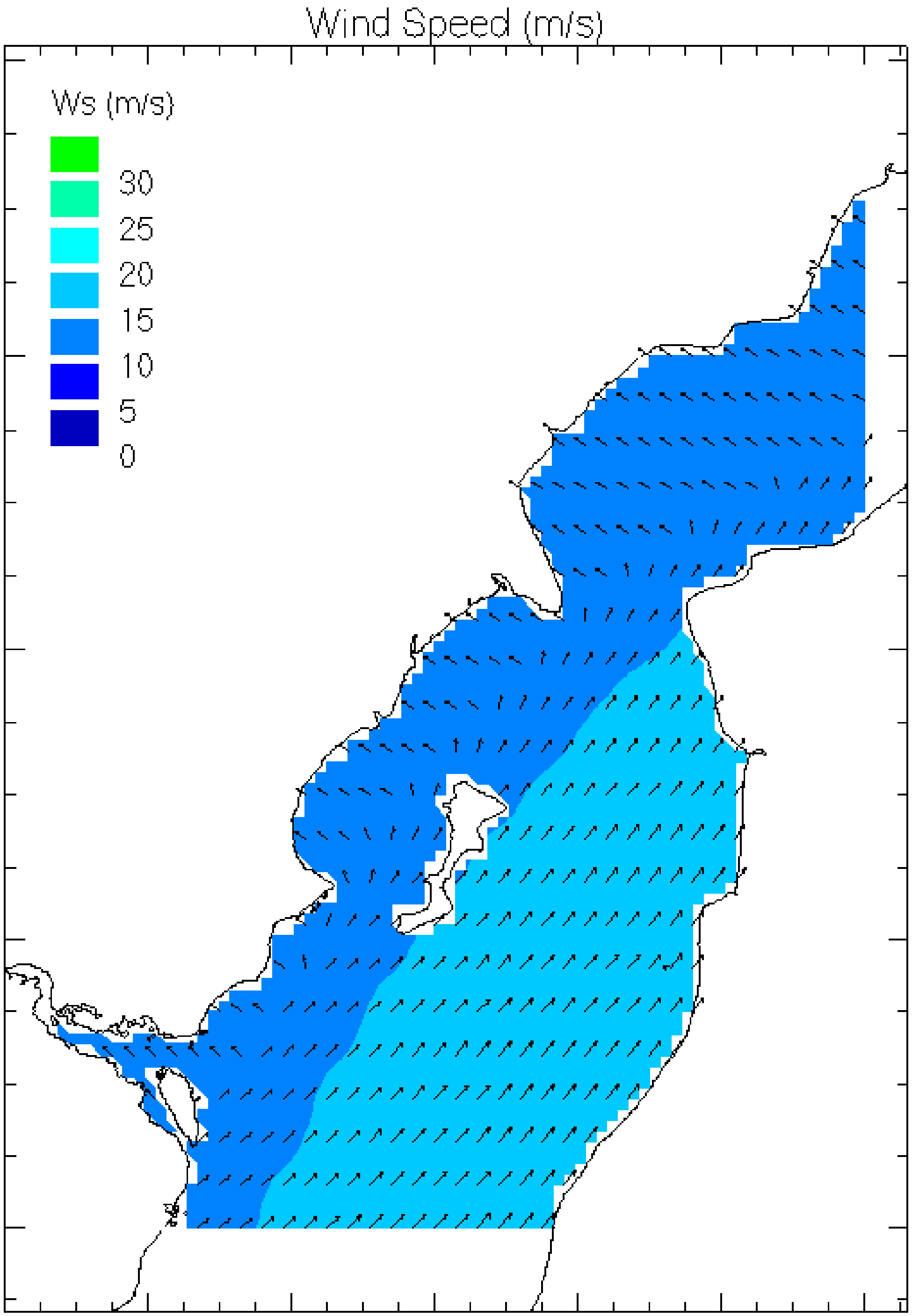
Kenai Maximum Hindcast Winds and Waves during 19780820

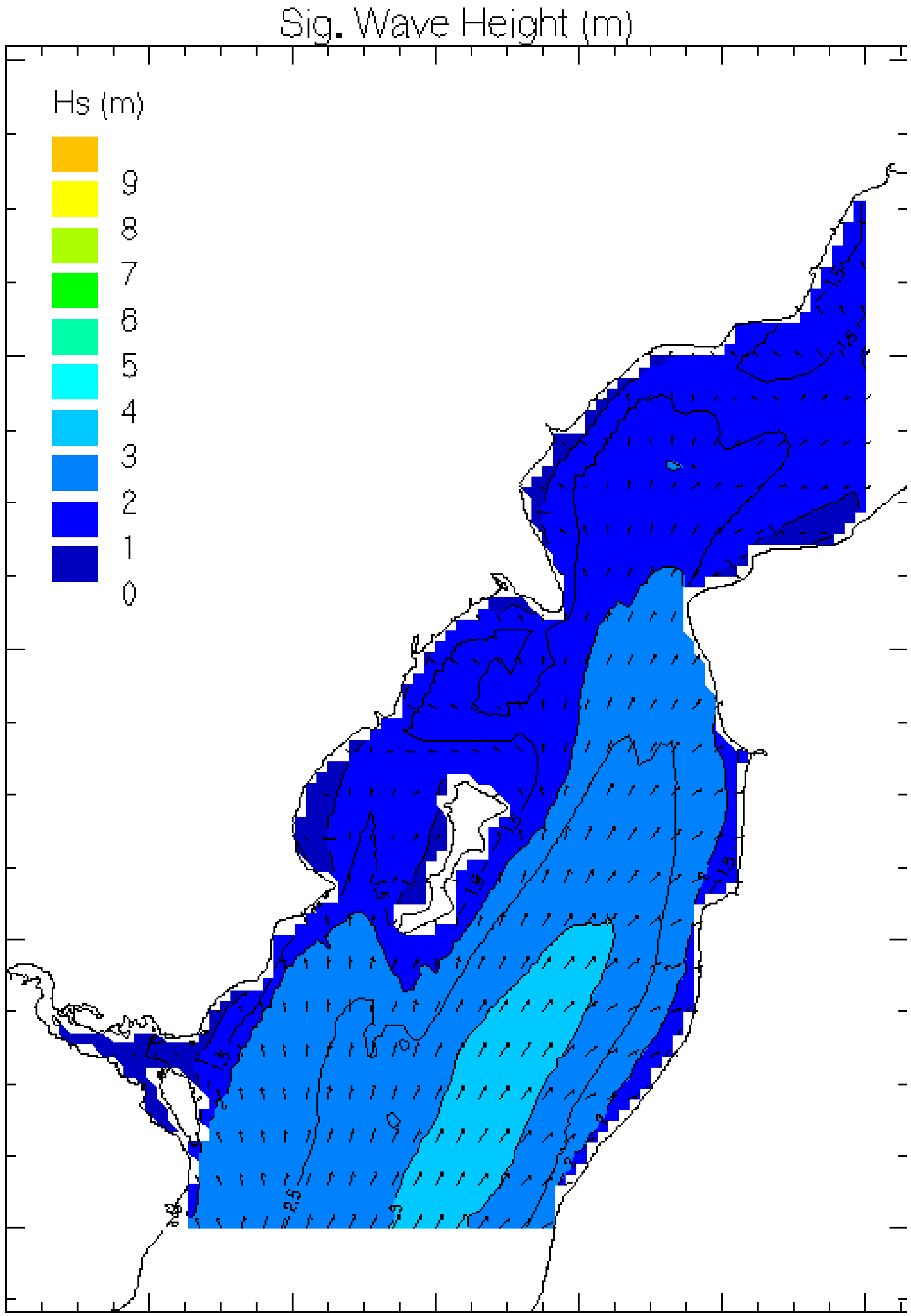


Kenai MTR Maximum Hindcast Winds and Waves during 19800207

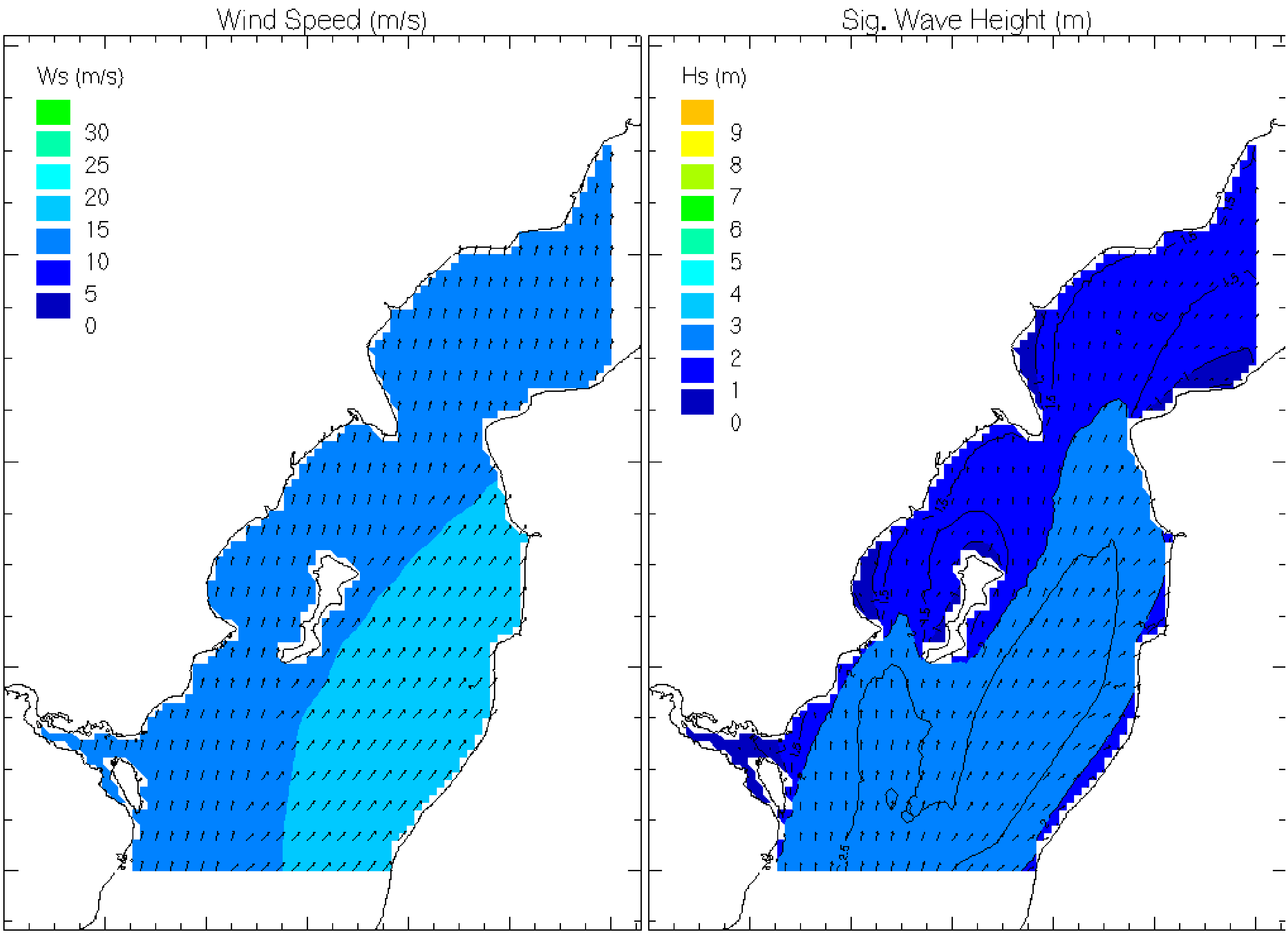


Kenai Maximum Hindcast Winds and Waves during 19800207





Kenai MTR Maximum Hindcast Winds and Waves during 19850228



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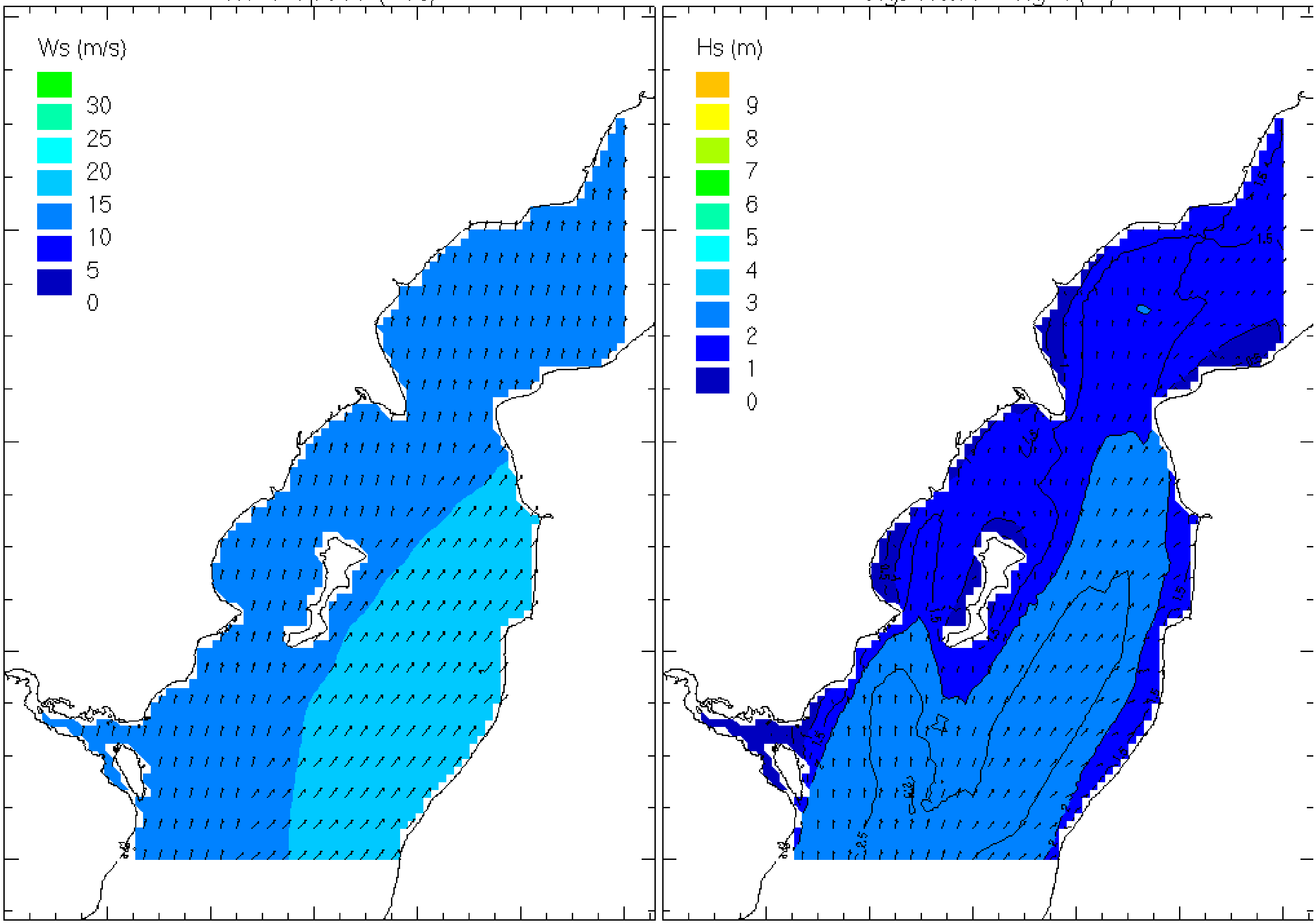
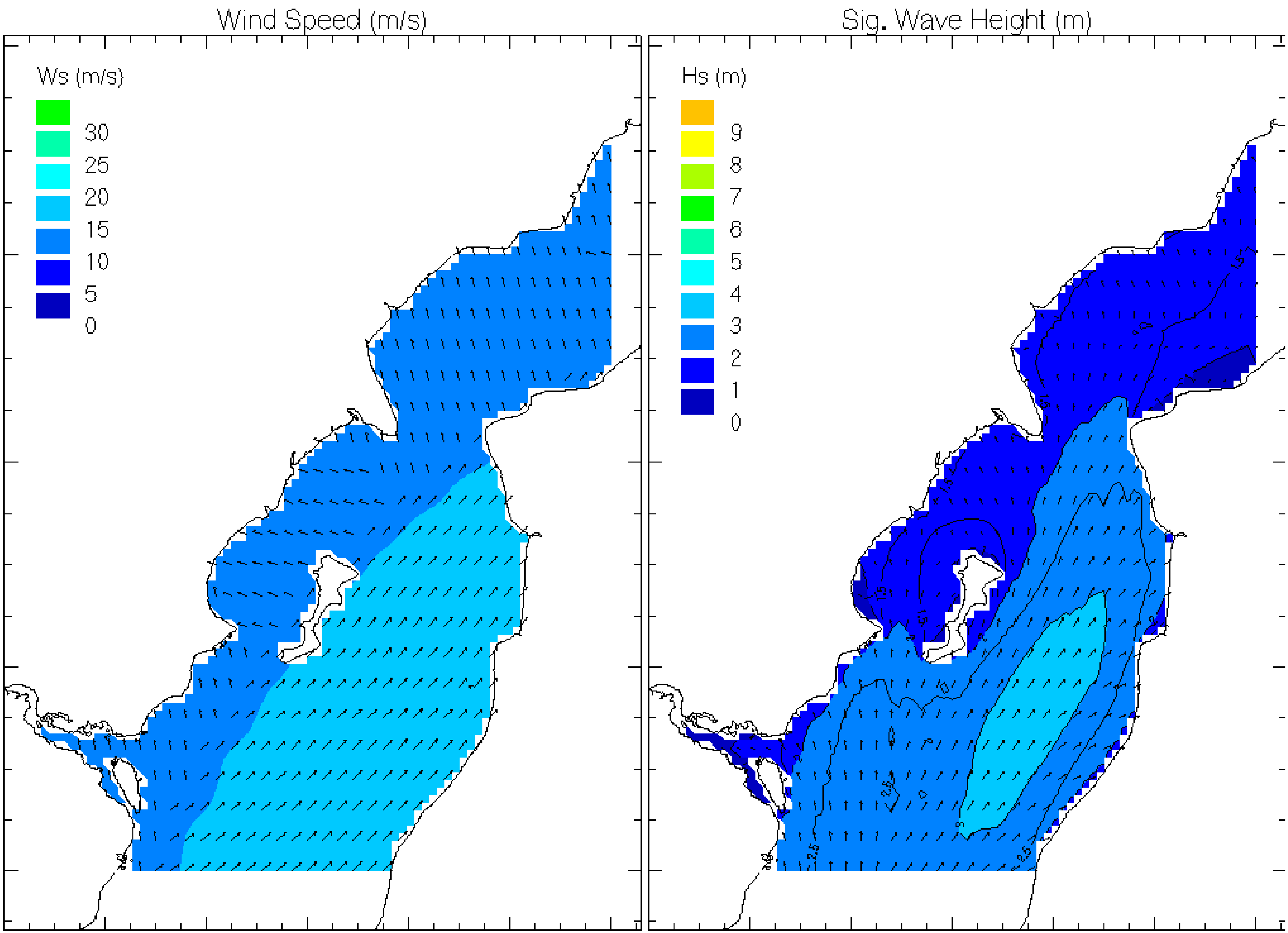
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 19850228

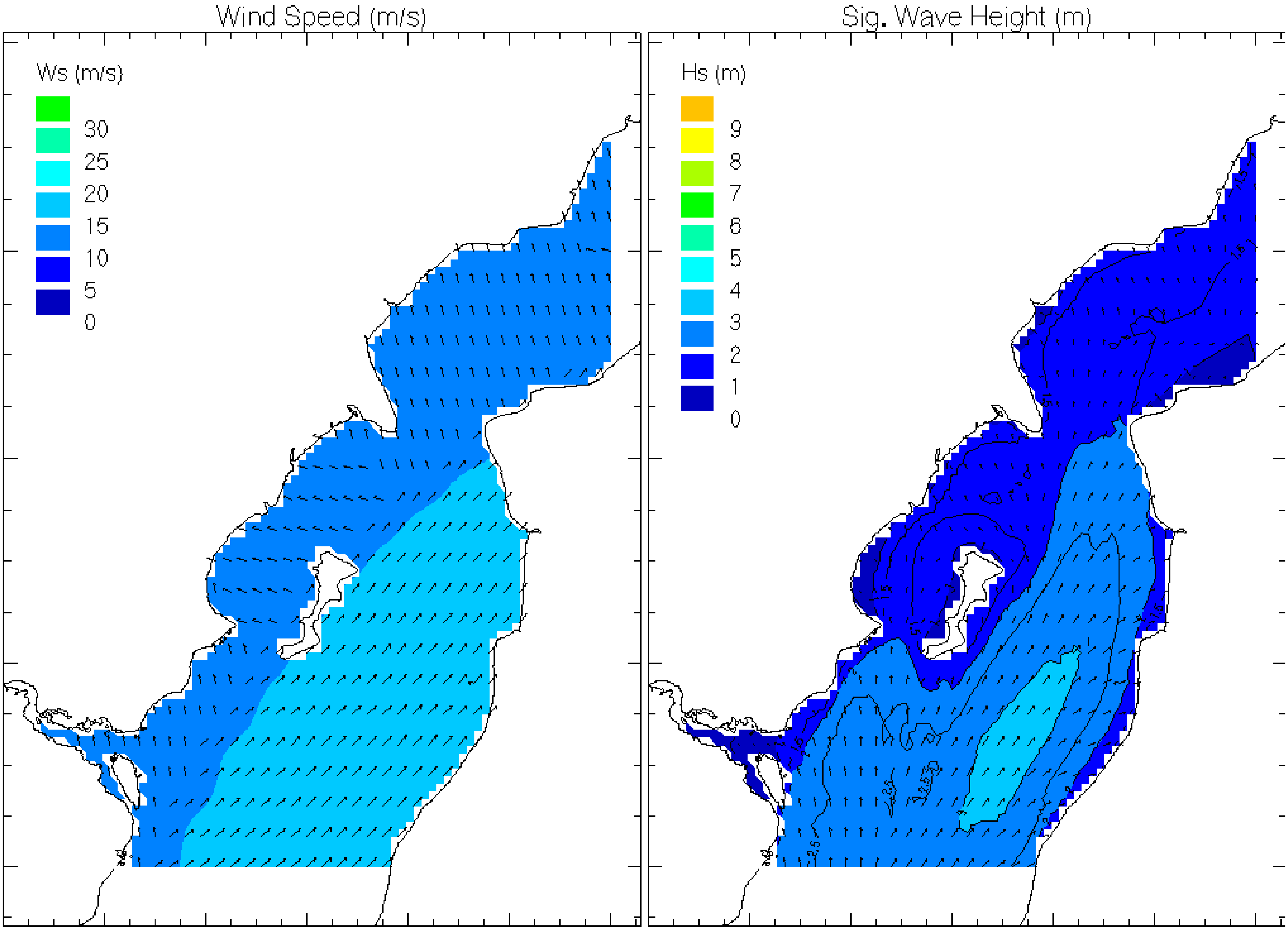
Wind Speed (m/s) Sig. Wave Height (m)



Kenai MTR Maximum Hindcast Winds and Waves during 19870222



Kenai Maximum Hindcast Winds and Waves during 19870222



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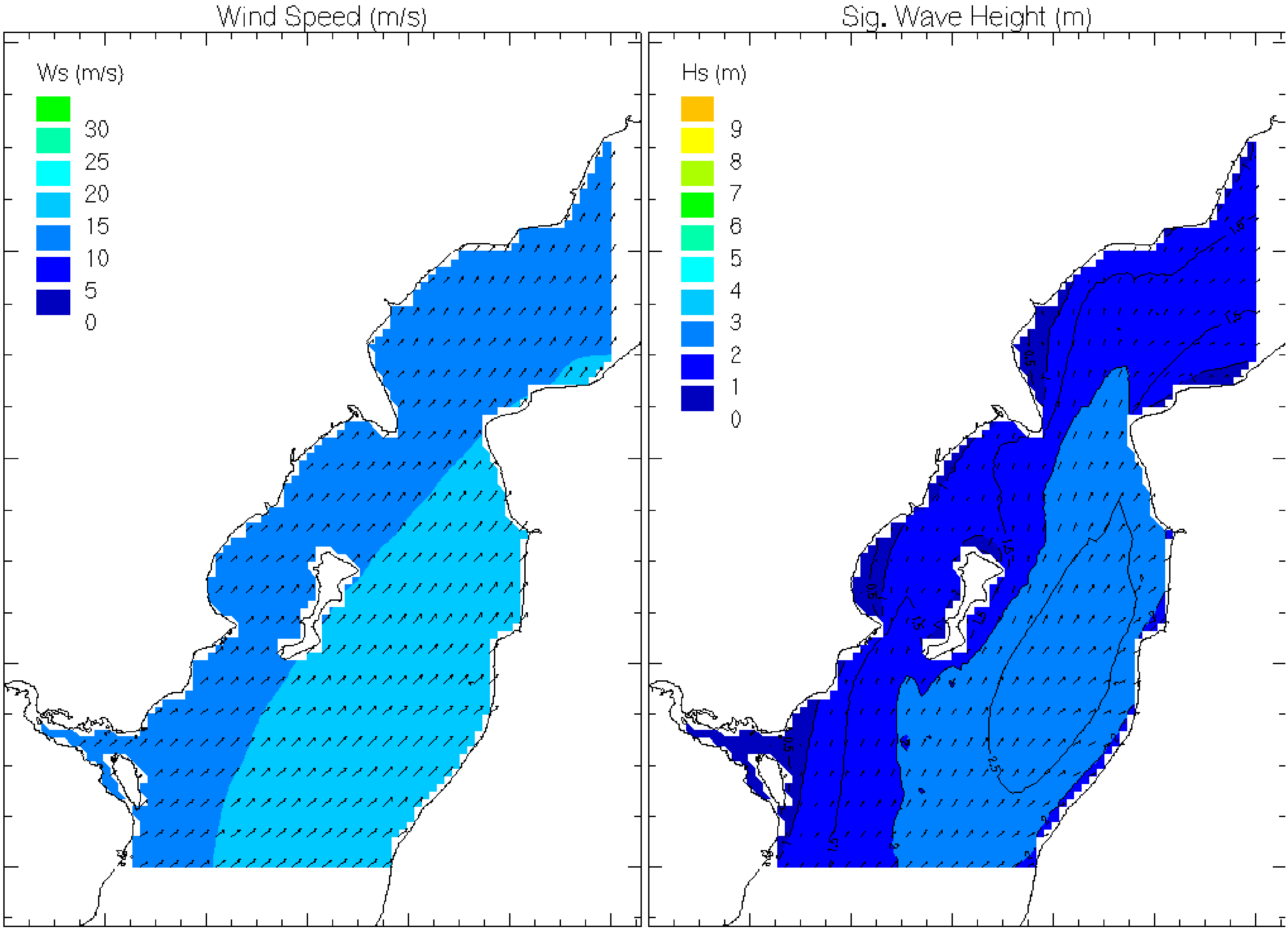
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 19900827



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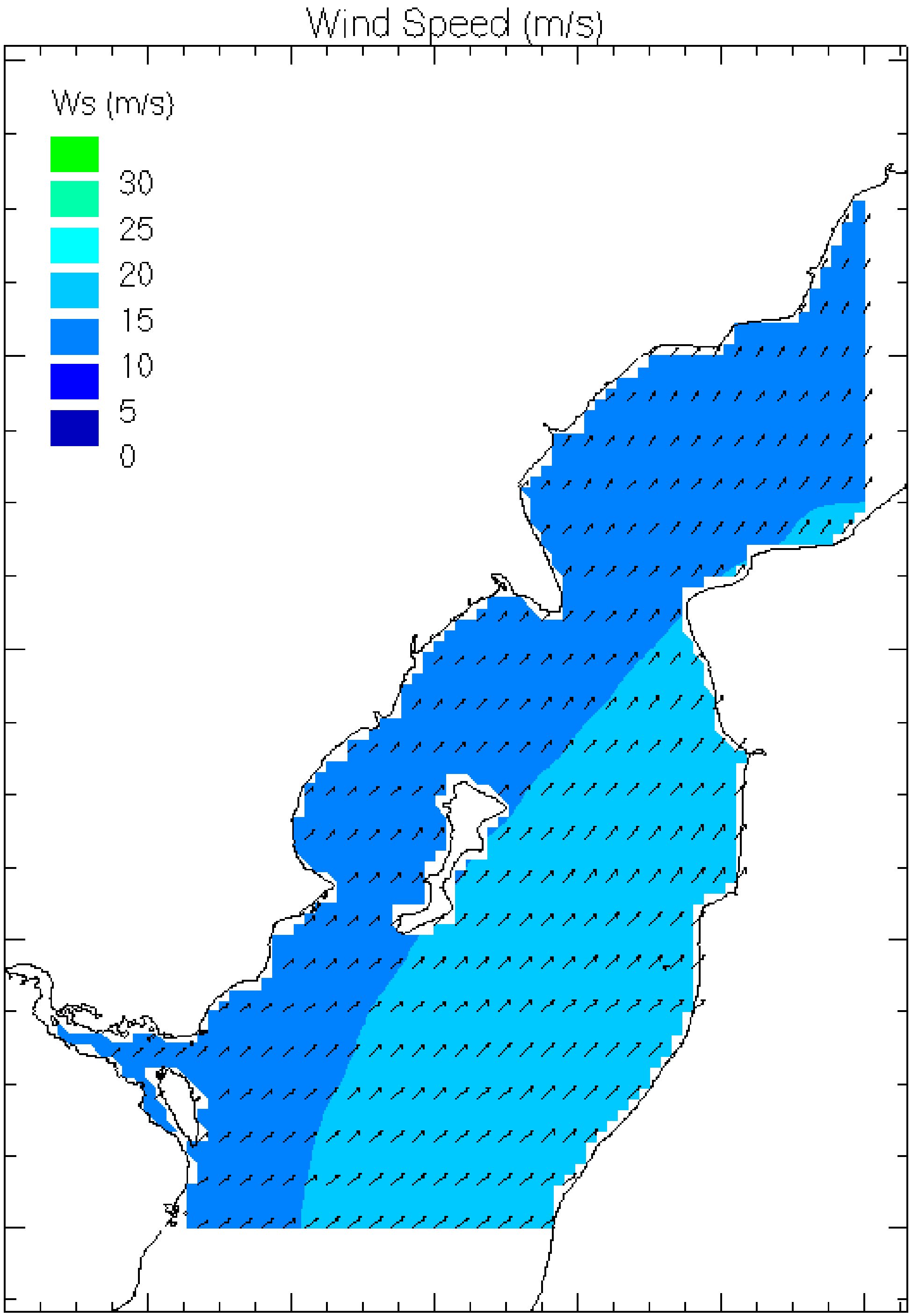
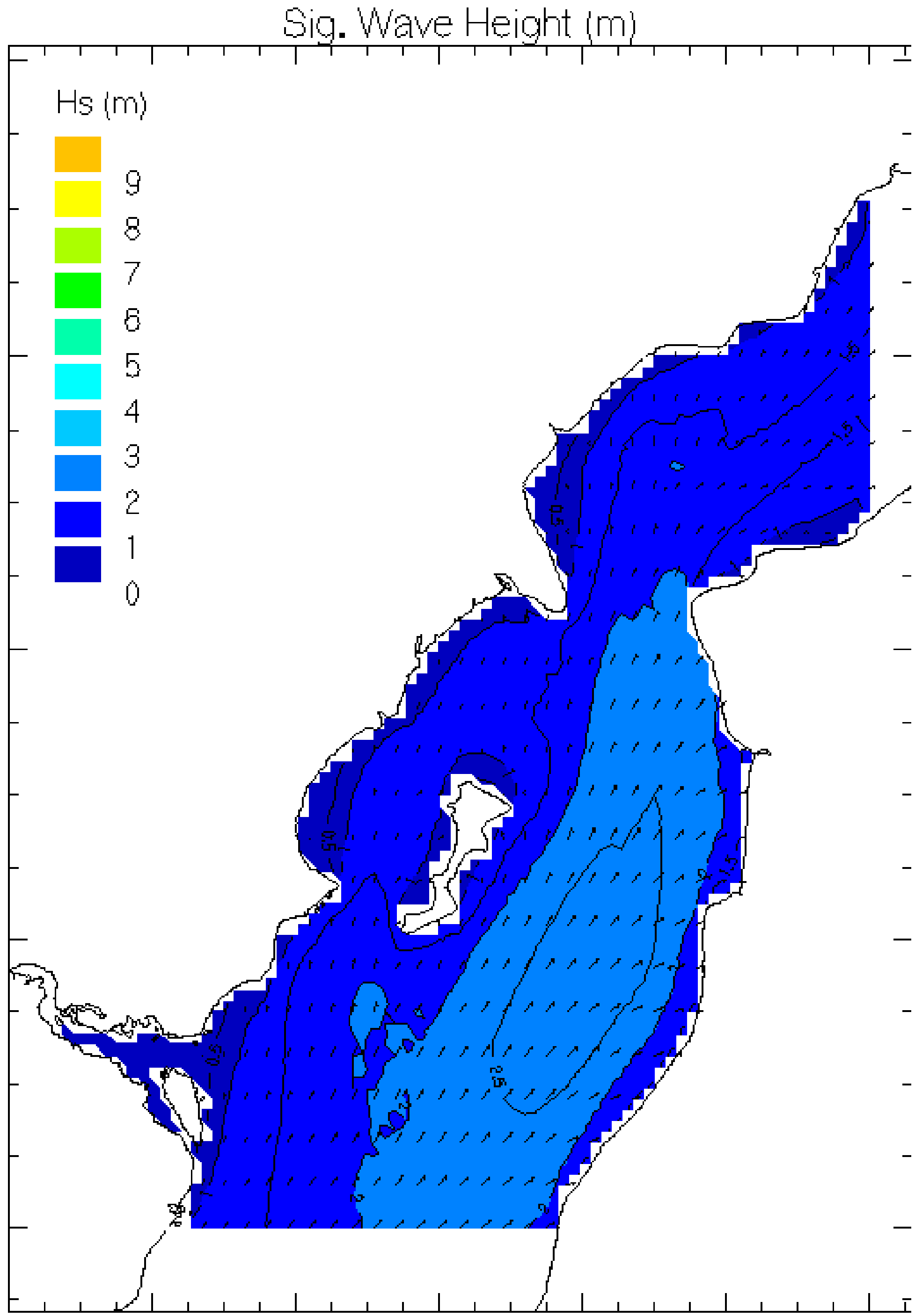
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 19900827





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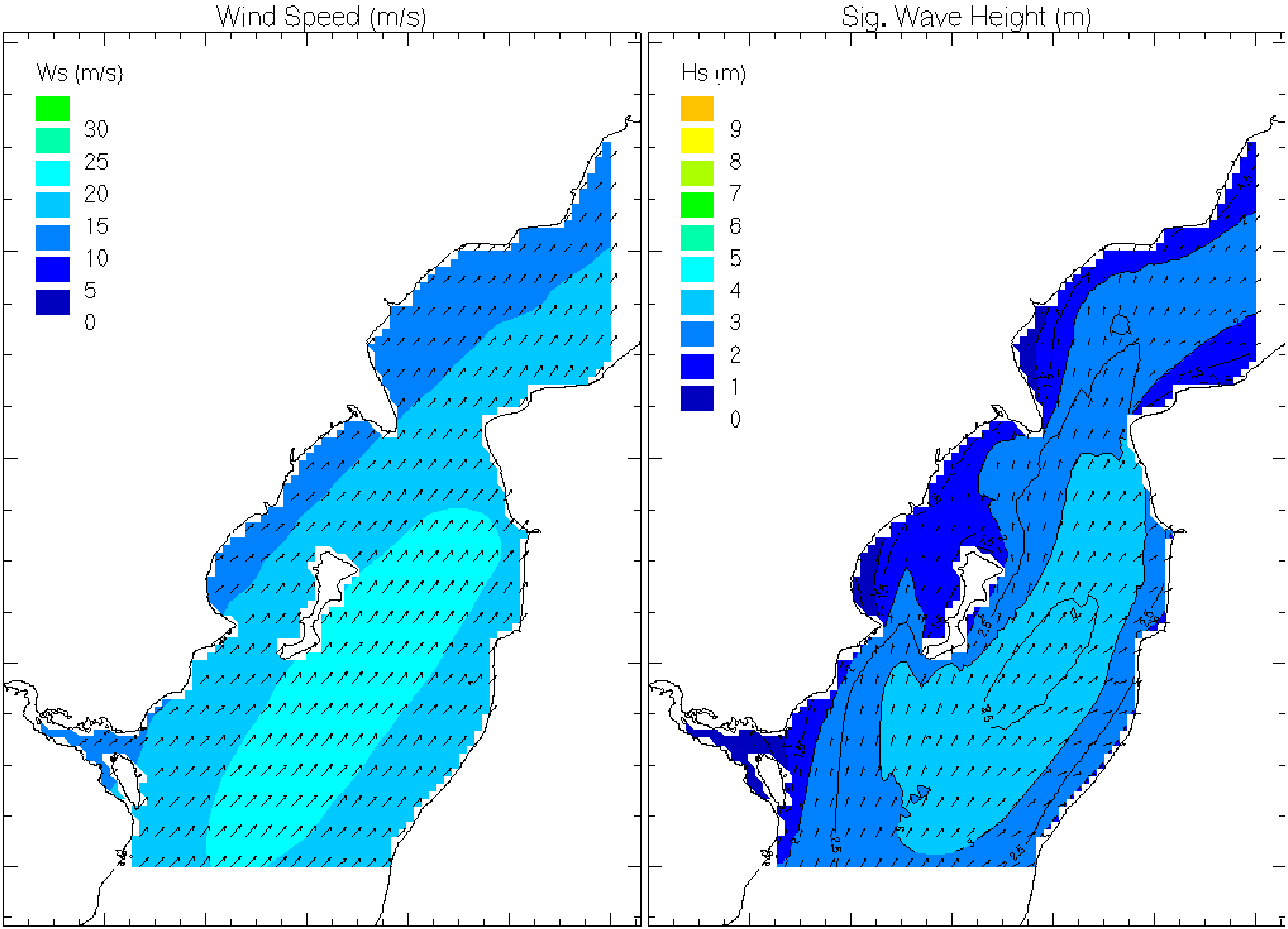

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oceanweather inc.

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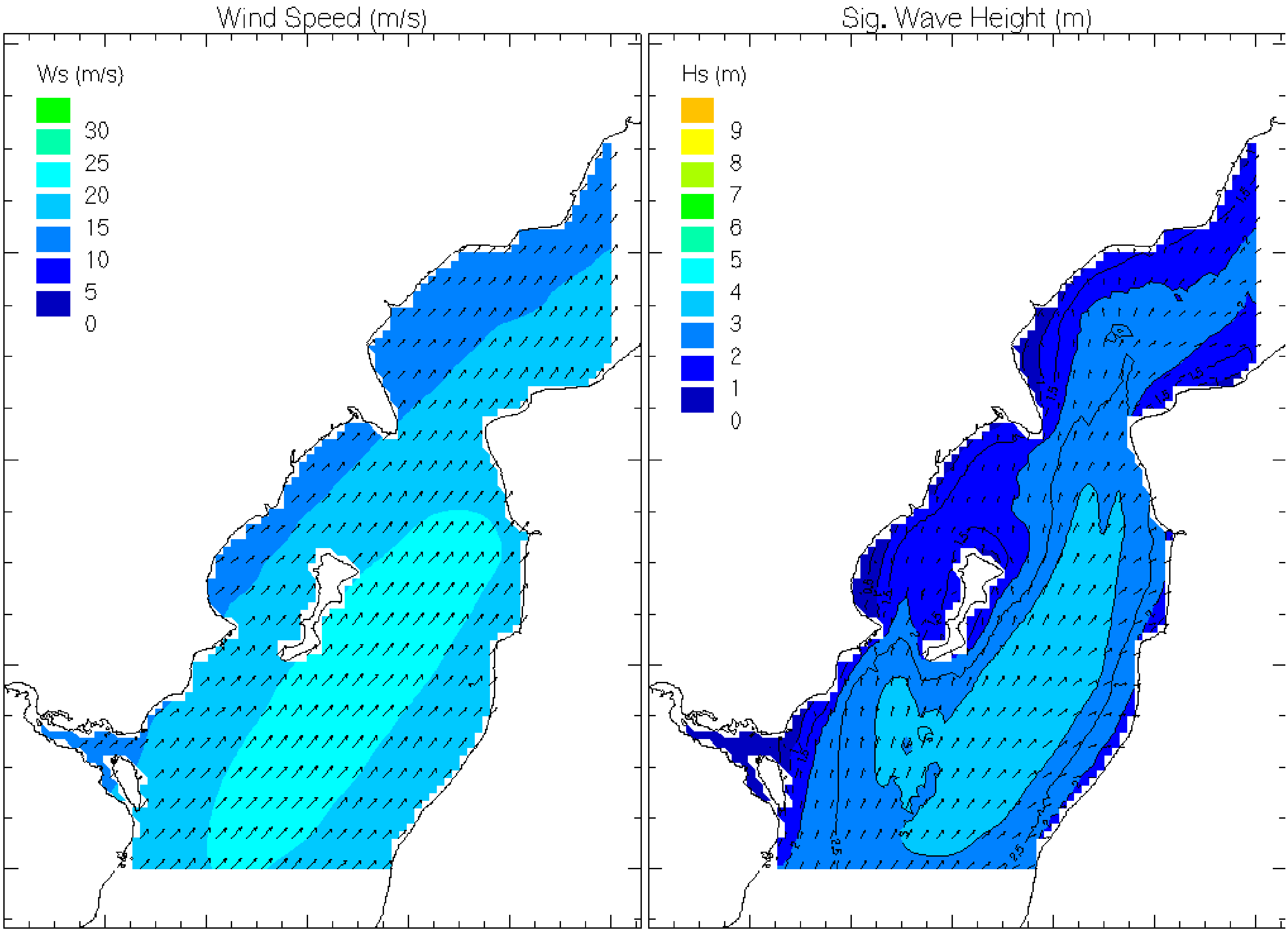
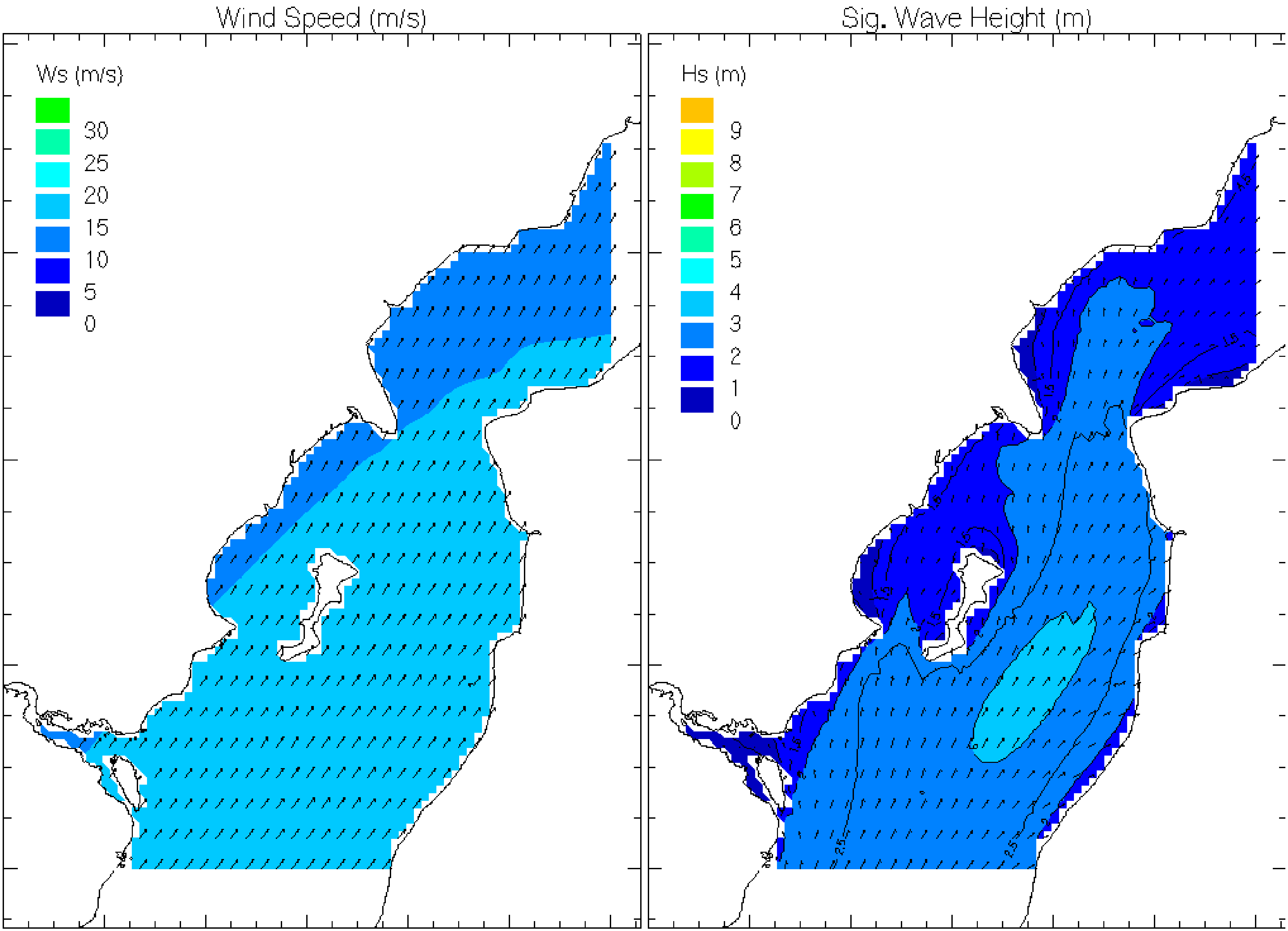
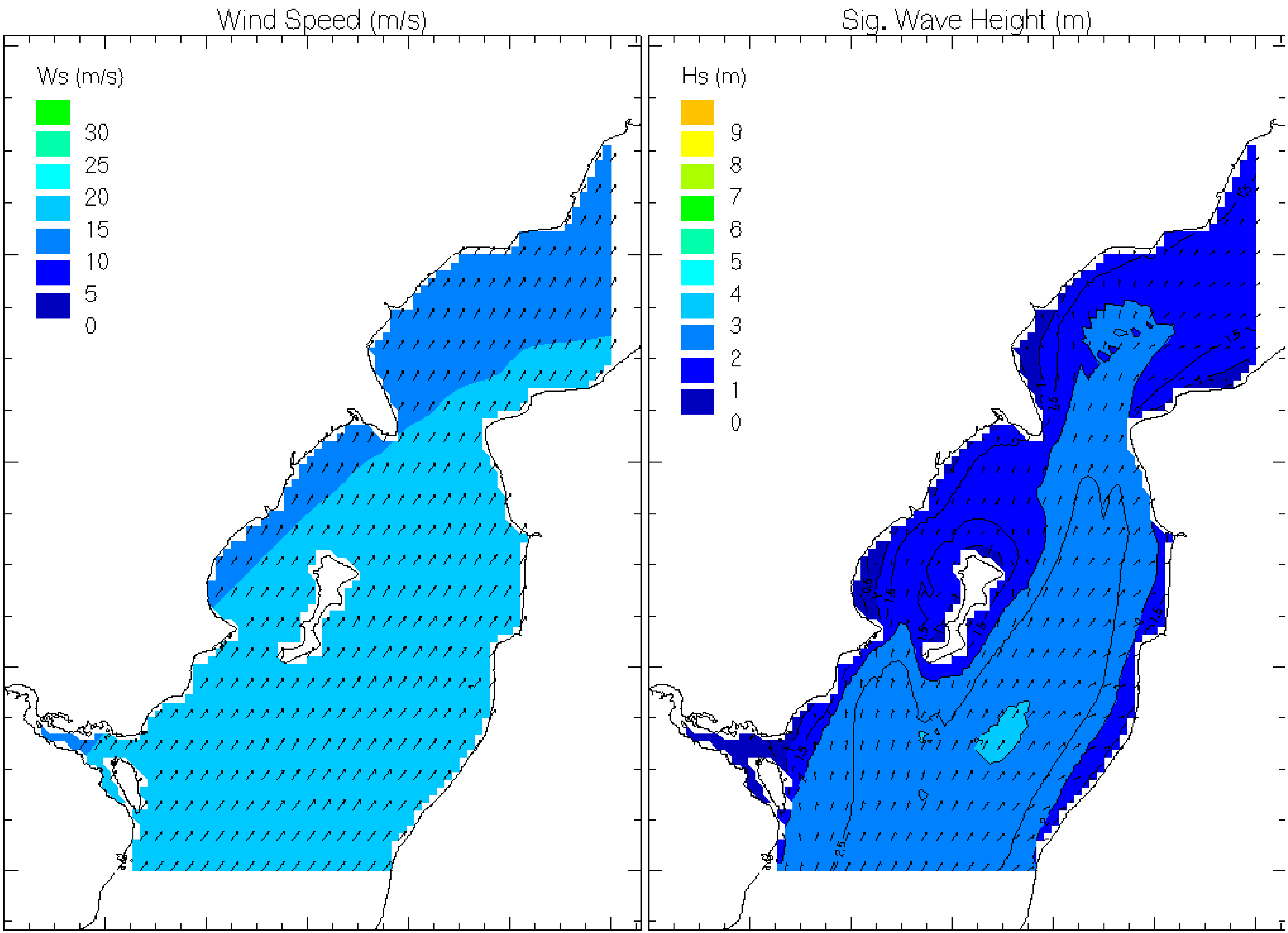


Kenai MTR Maximum Hindcast Winds and Waves during 19930921



Kenai Maximum Hindcast Winds and Waves during 19930921



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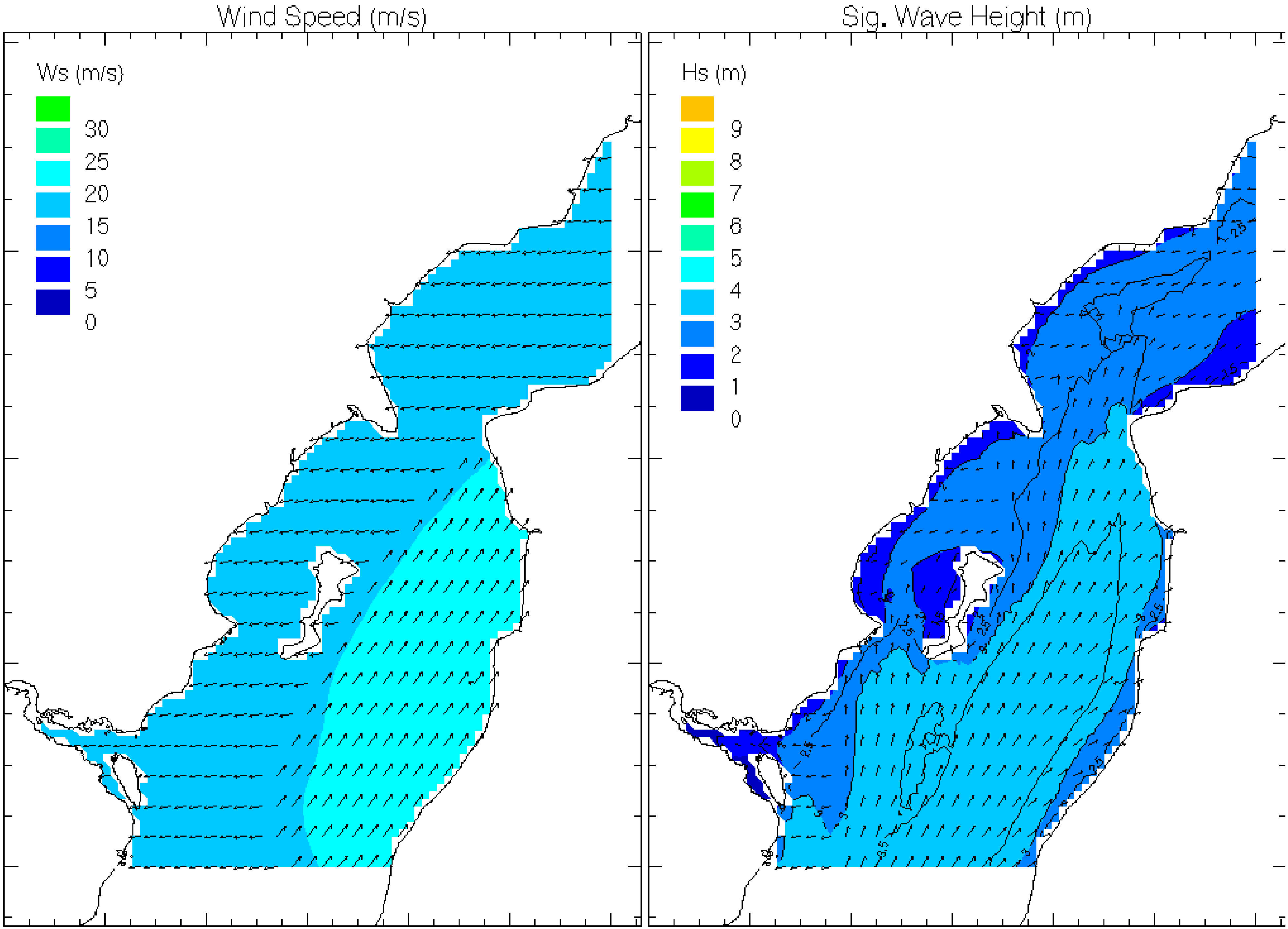
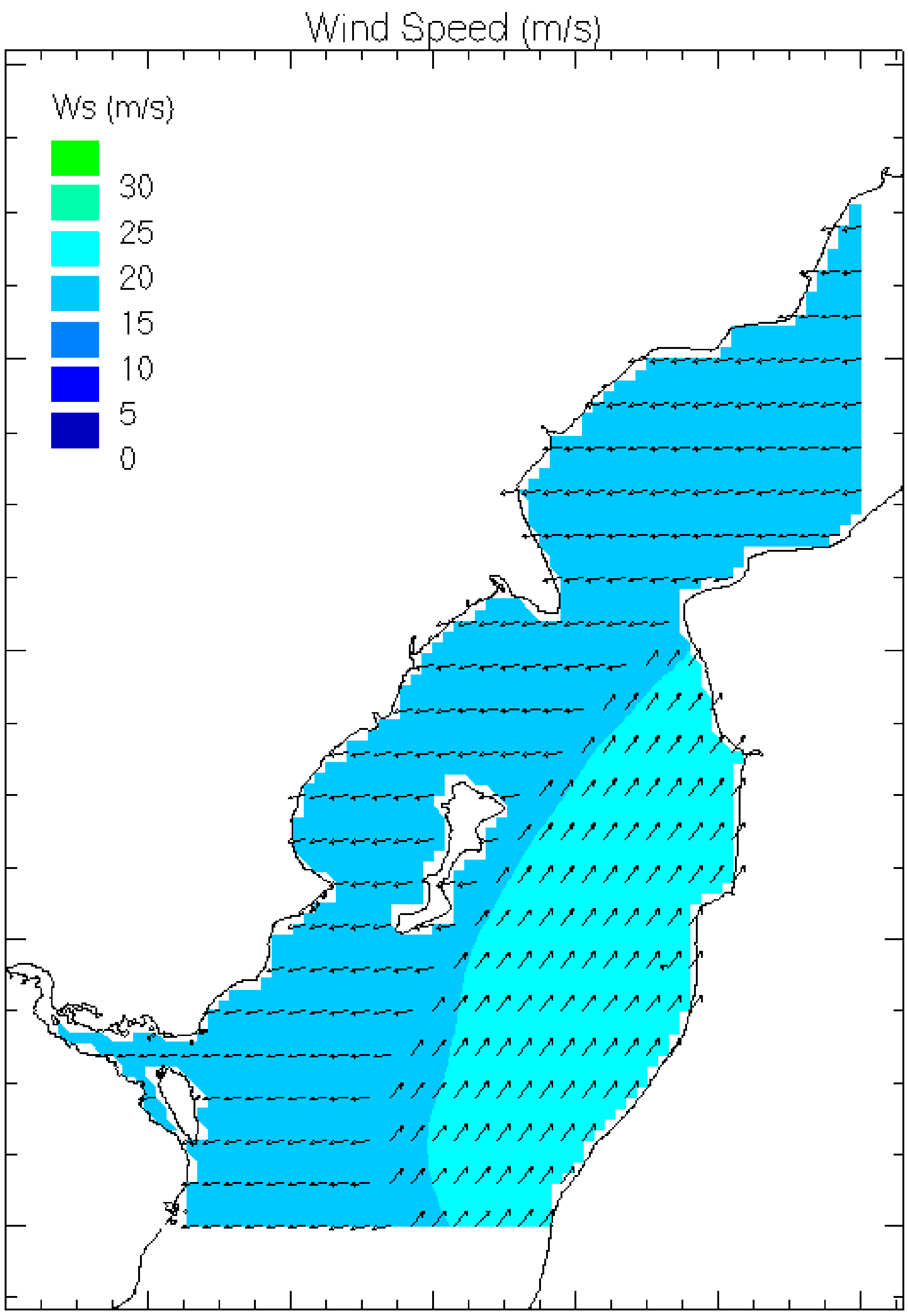
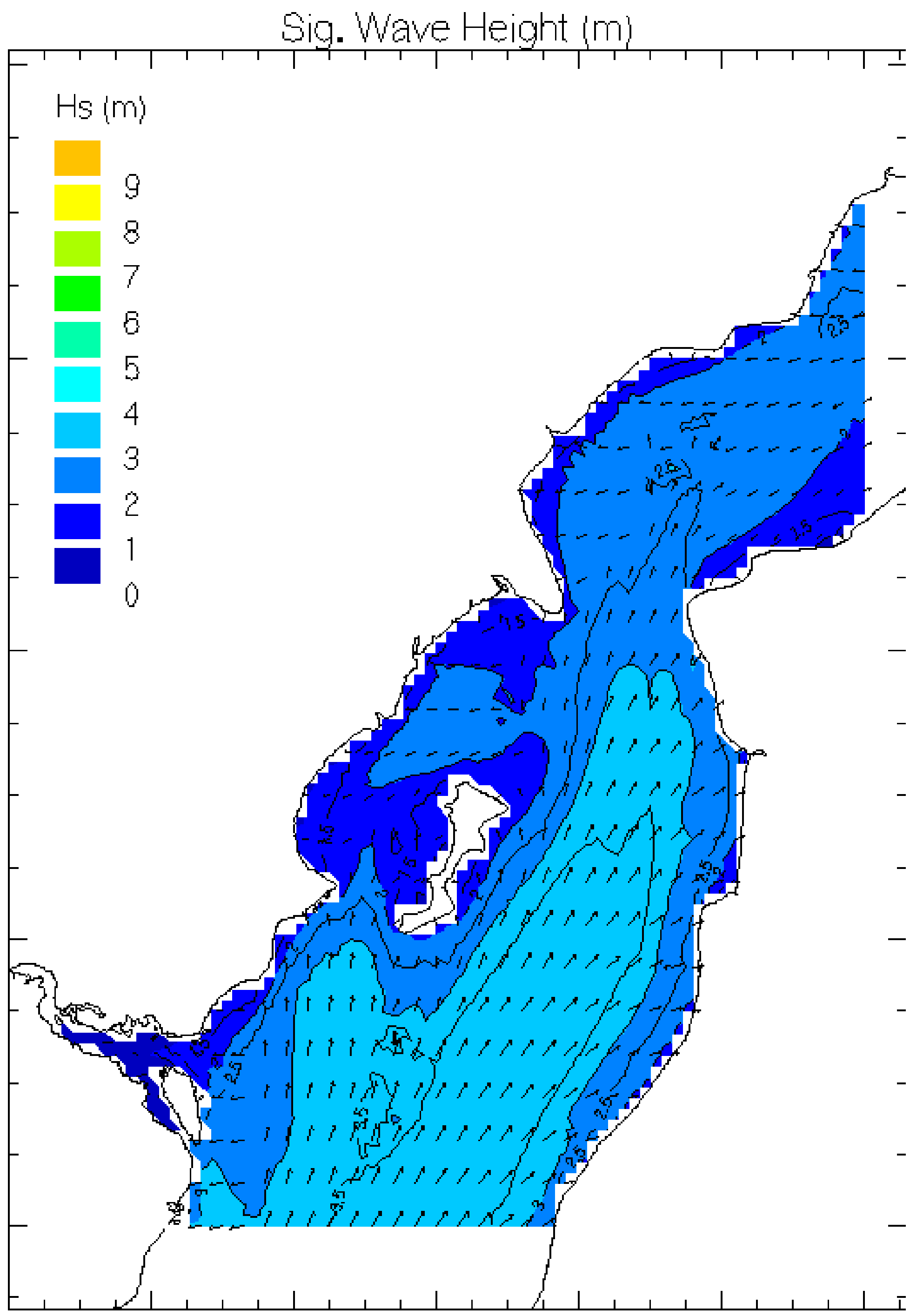
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 19960925



Kenai Maximum Hindcast Winds and Waves during 19960925





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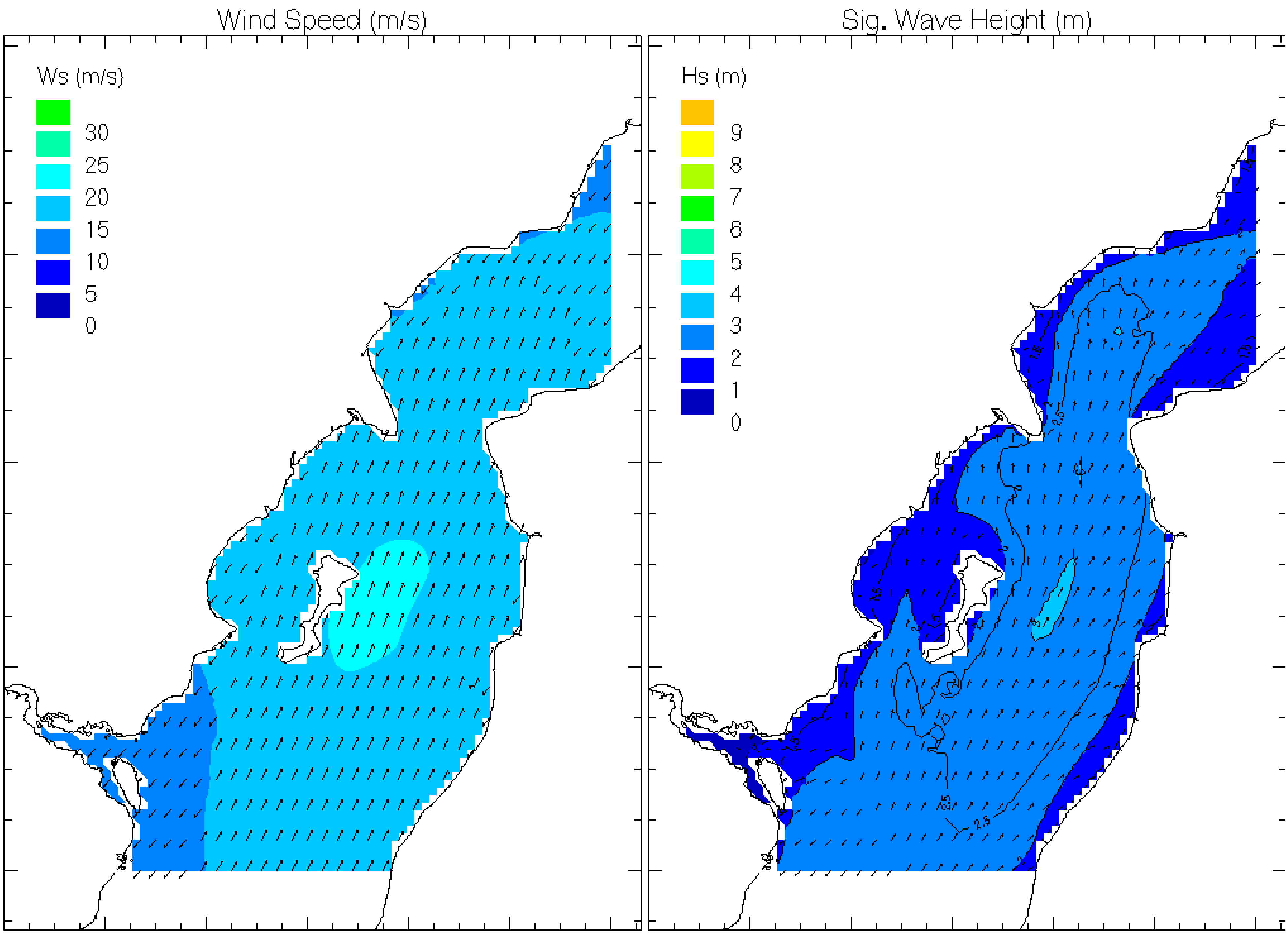
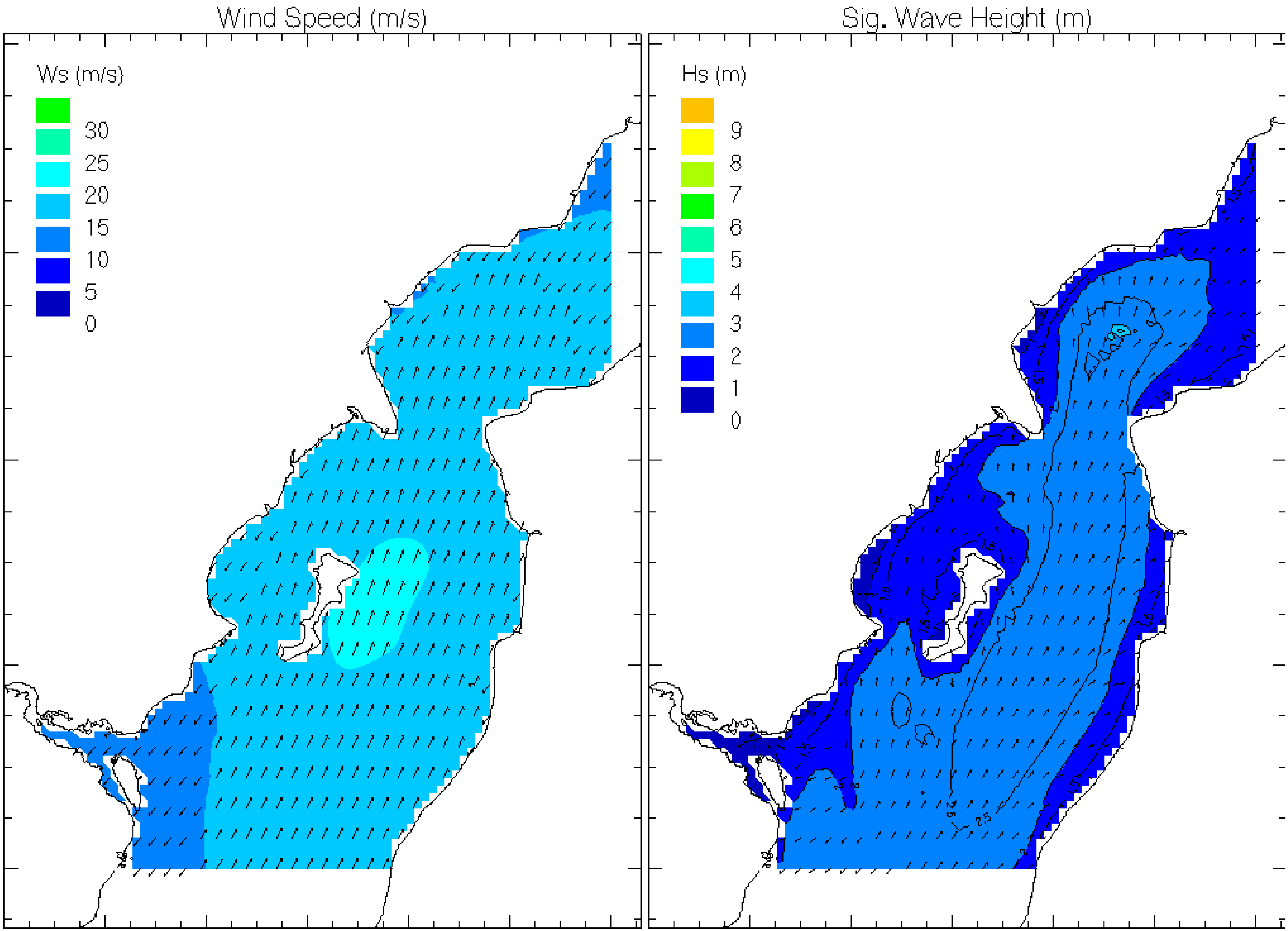
oceanweather inc.

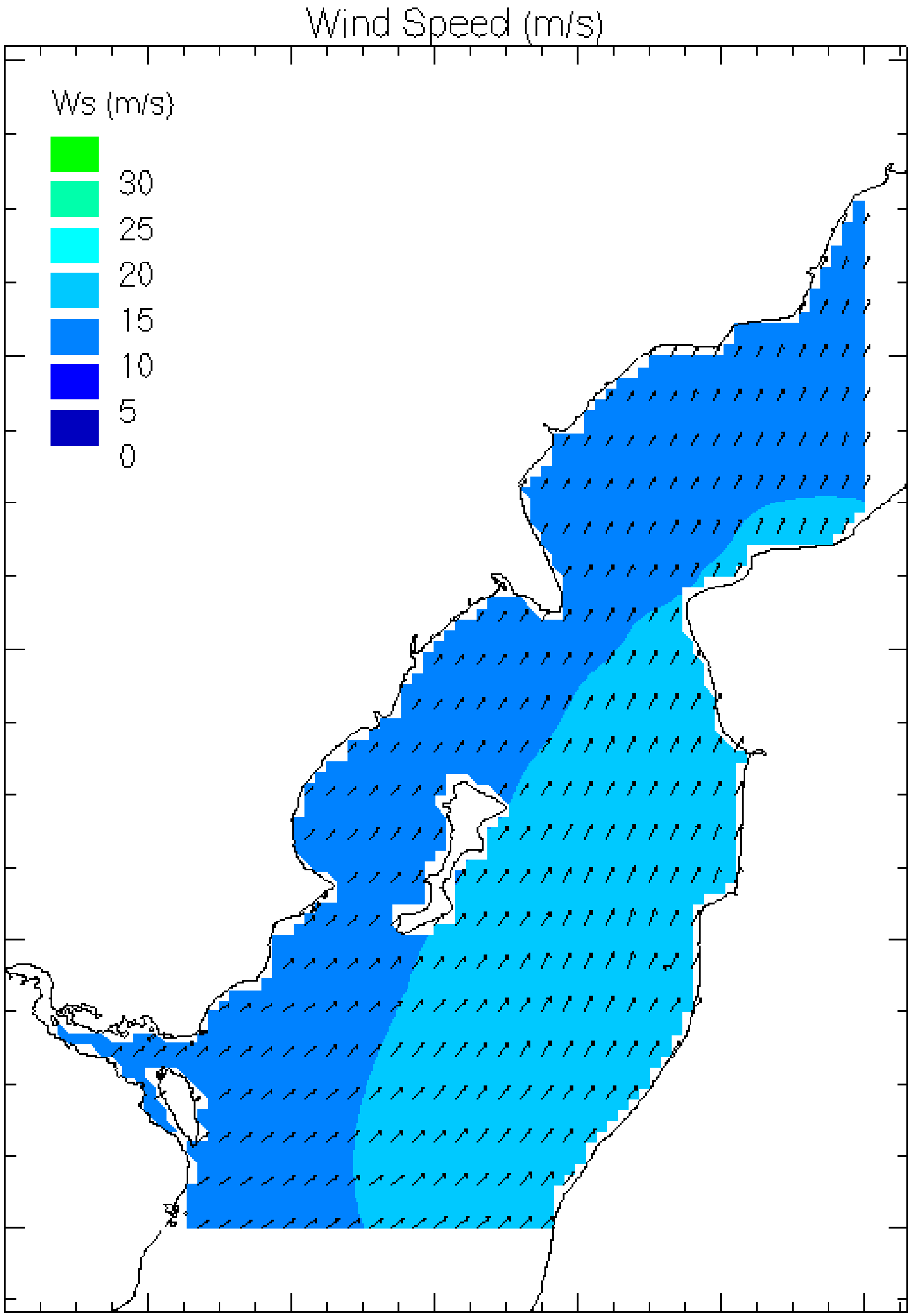
Kenai MTR Maximum Hindcast Winds and Waves during 19971229

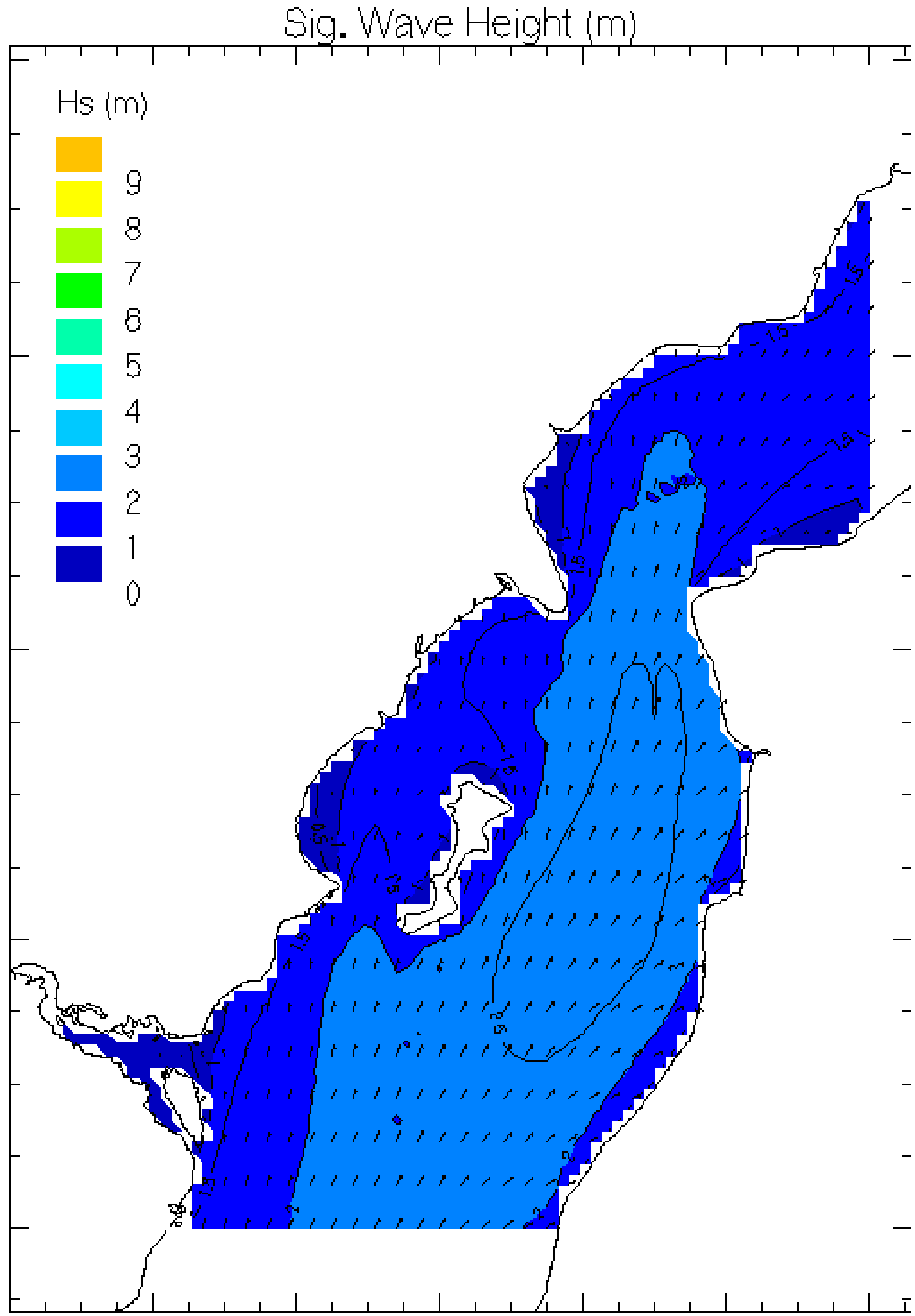


Kenai Maximum Hindcast Winds and Waves during 19971229



Kenai MTR Maximum Hindcast Winds and Waves during 19980817





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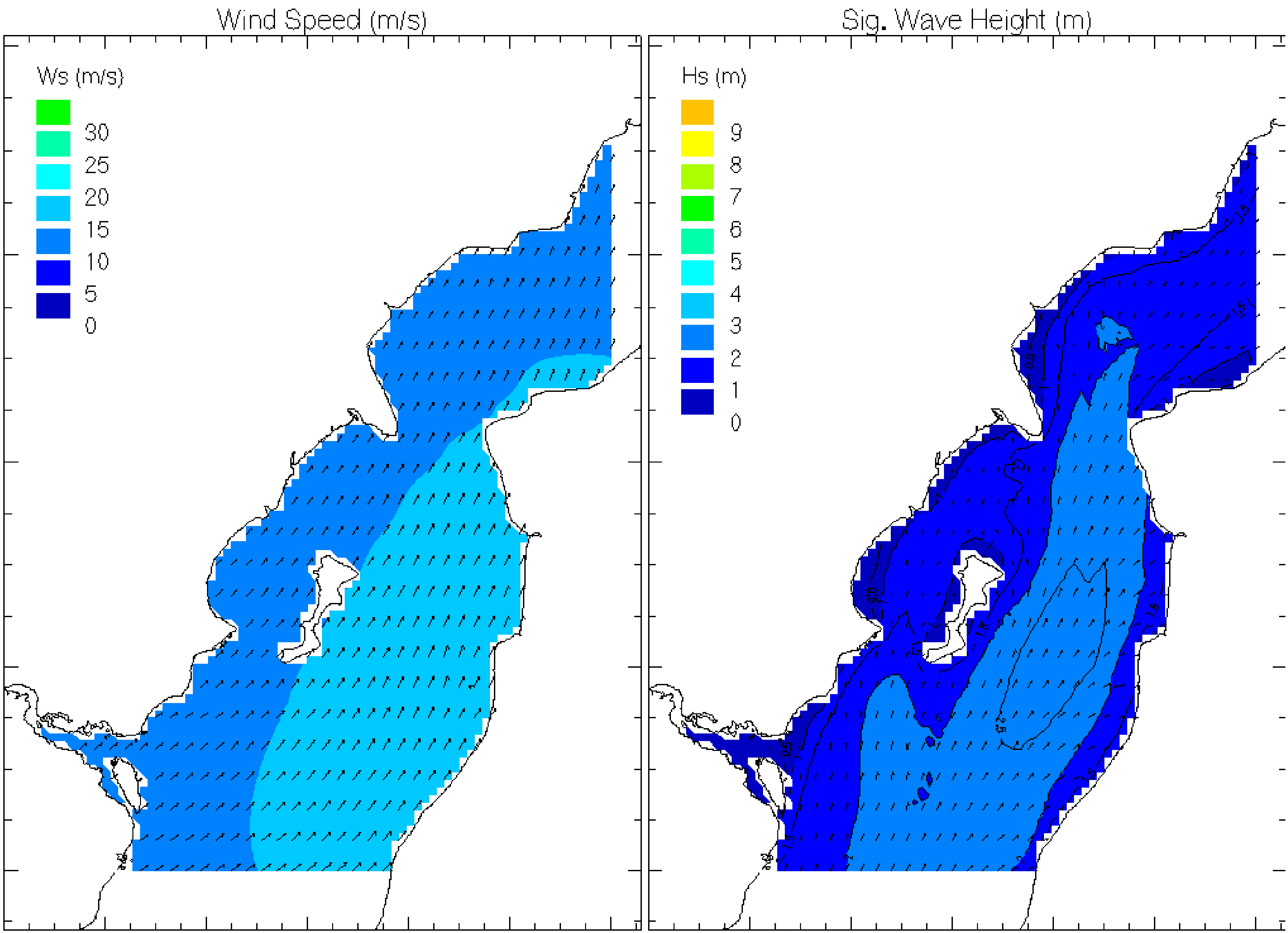
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 19980817



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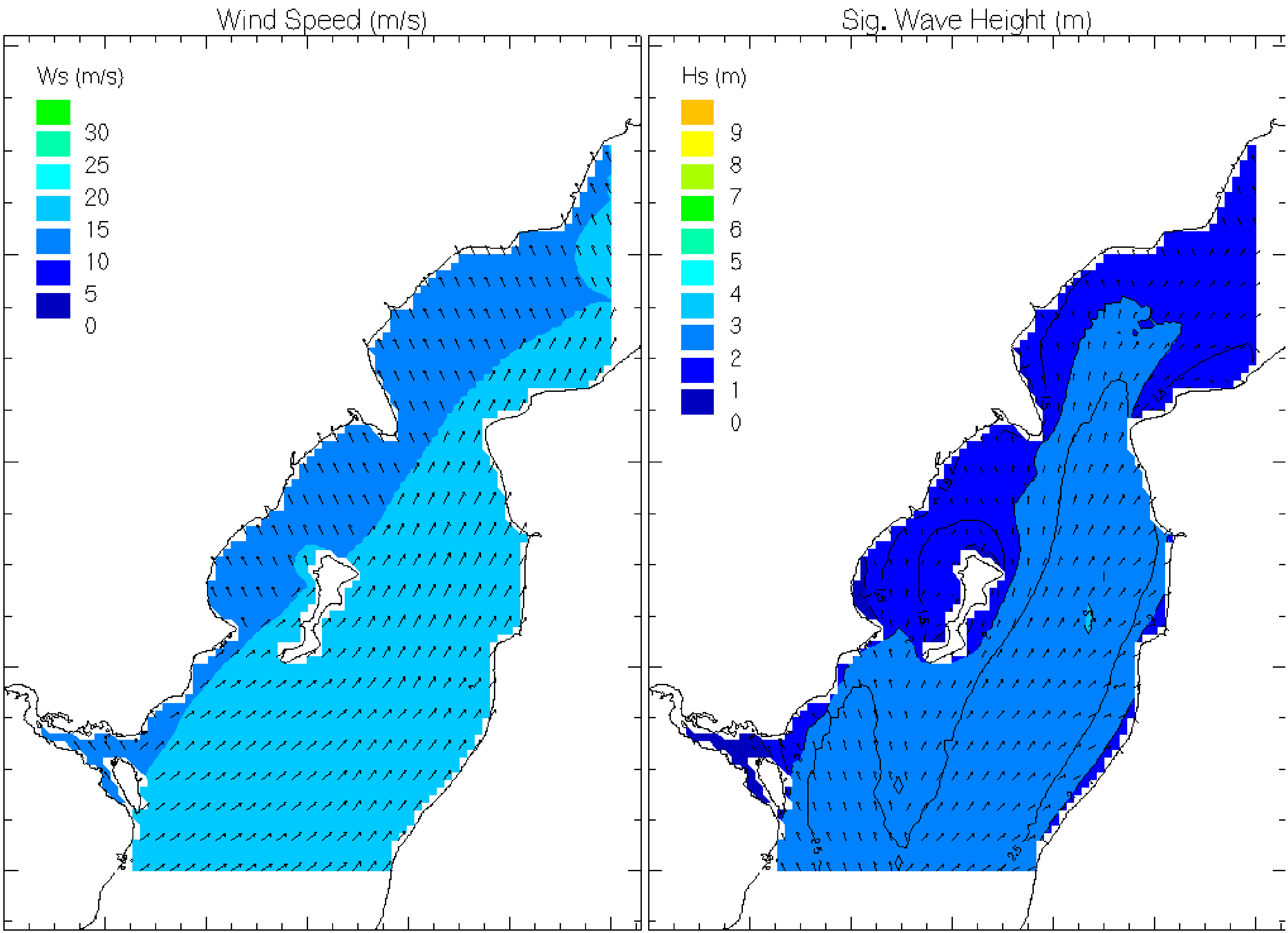
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 19991223



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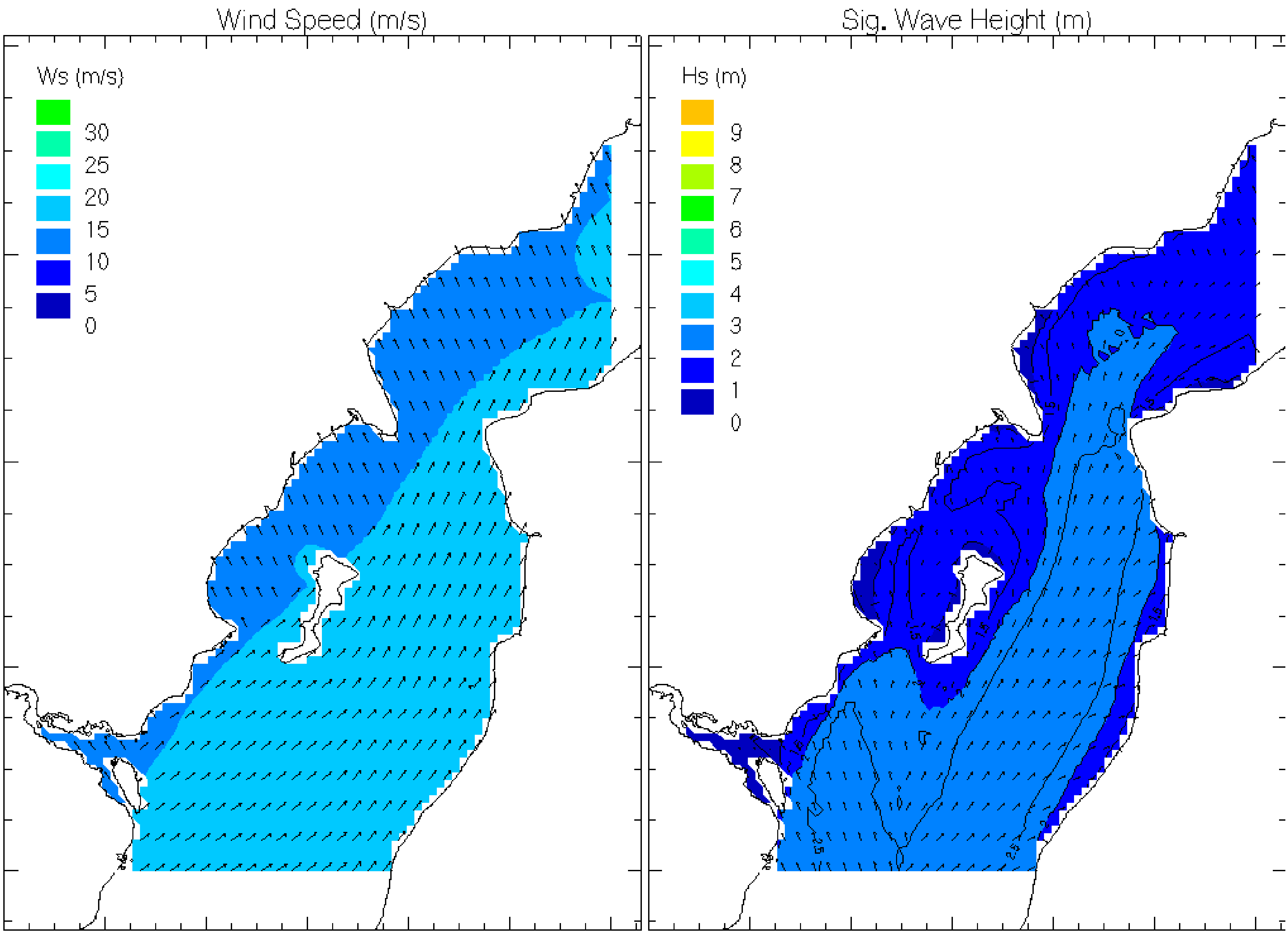
Kenai Maximum Hindcast Winds and Waves during 19991223



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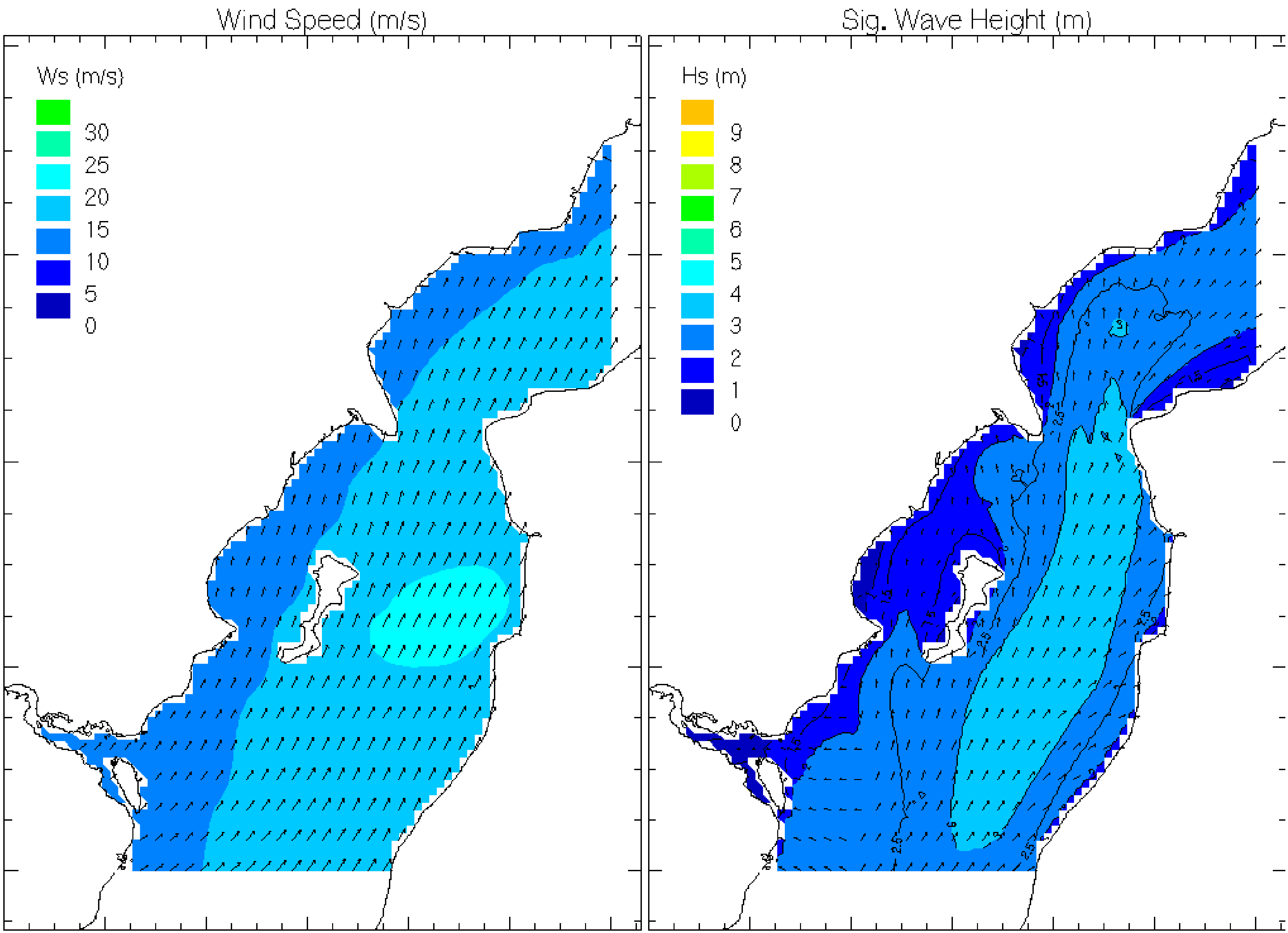
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 20000128



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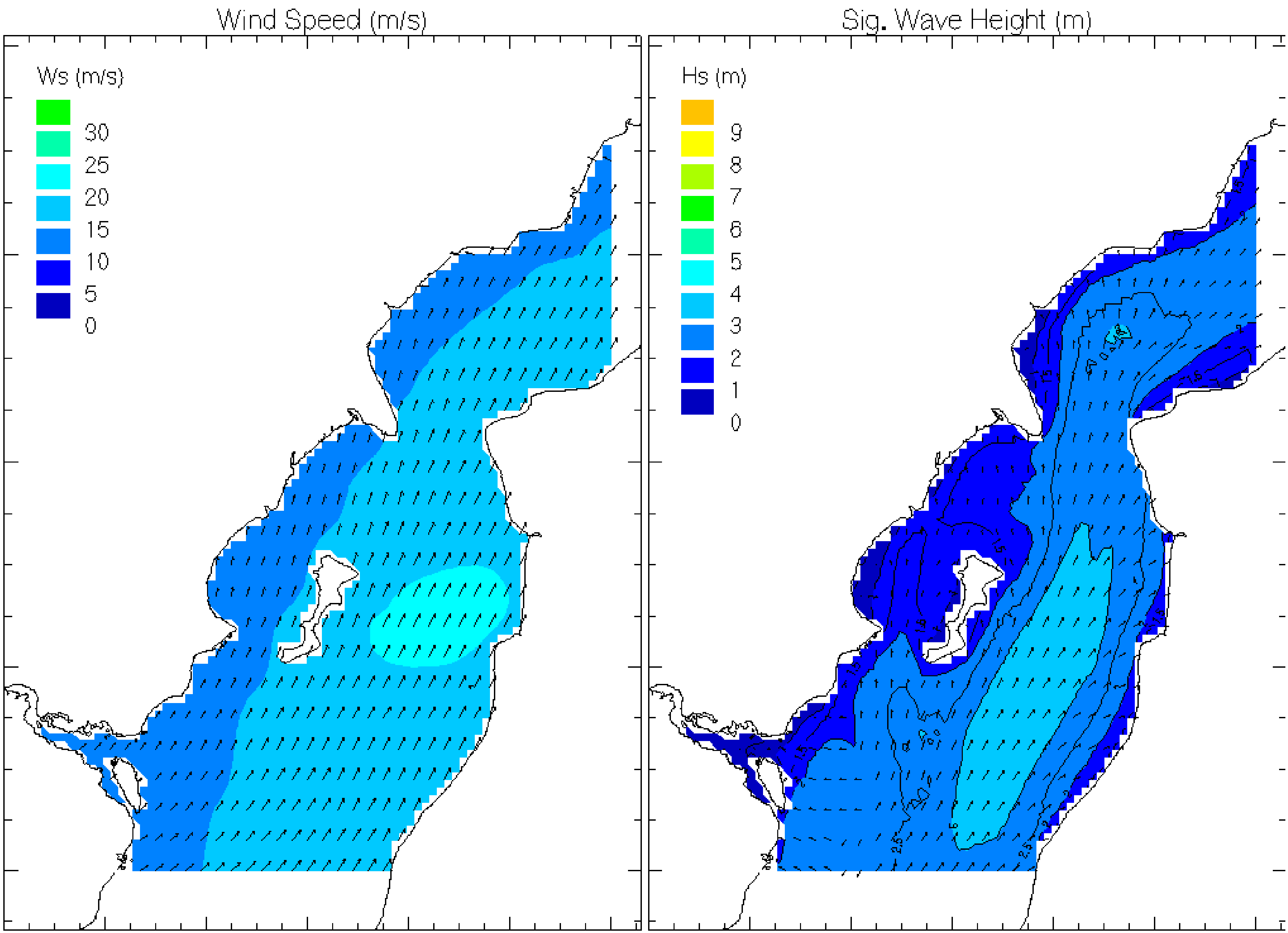
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 20000128



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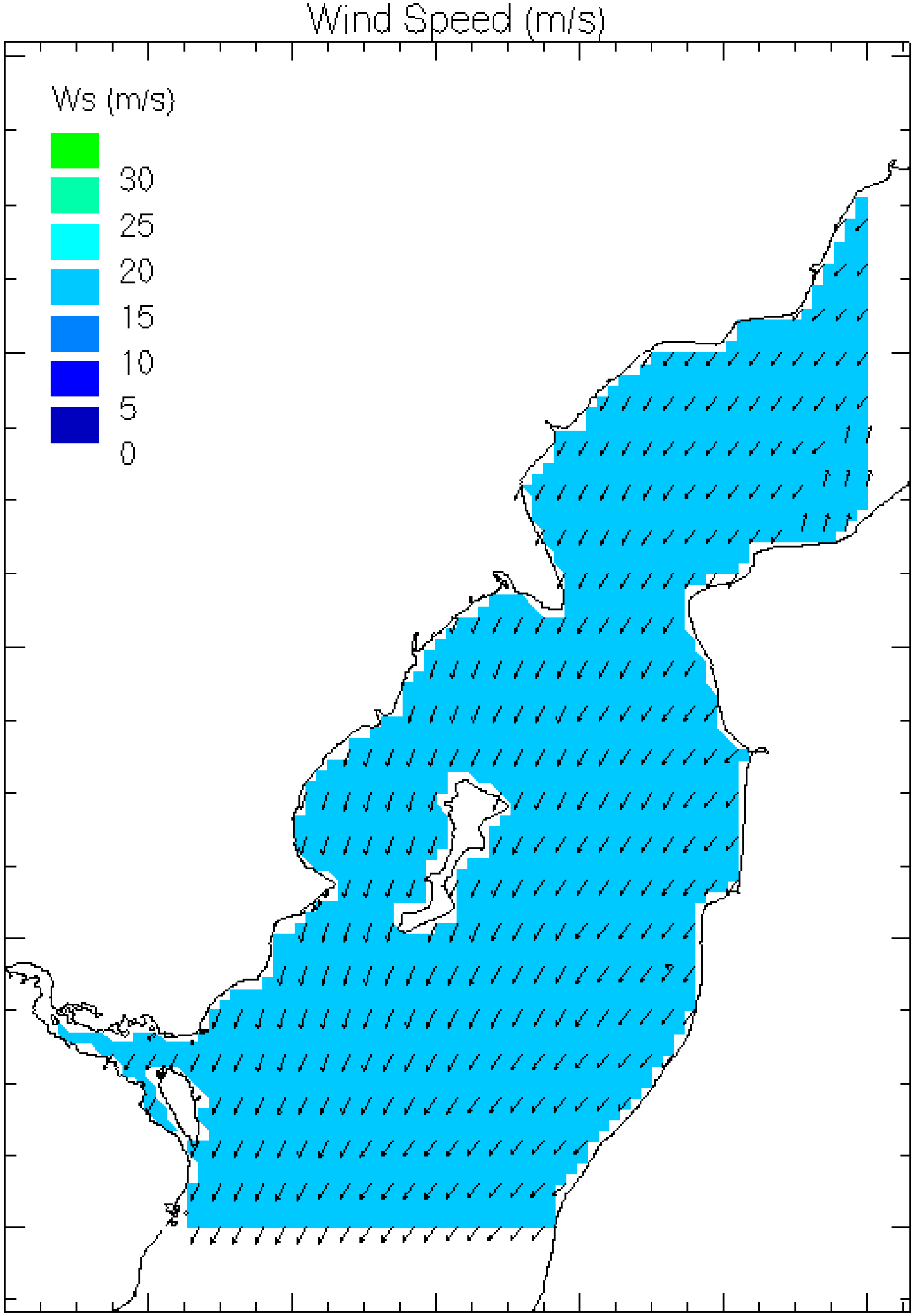
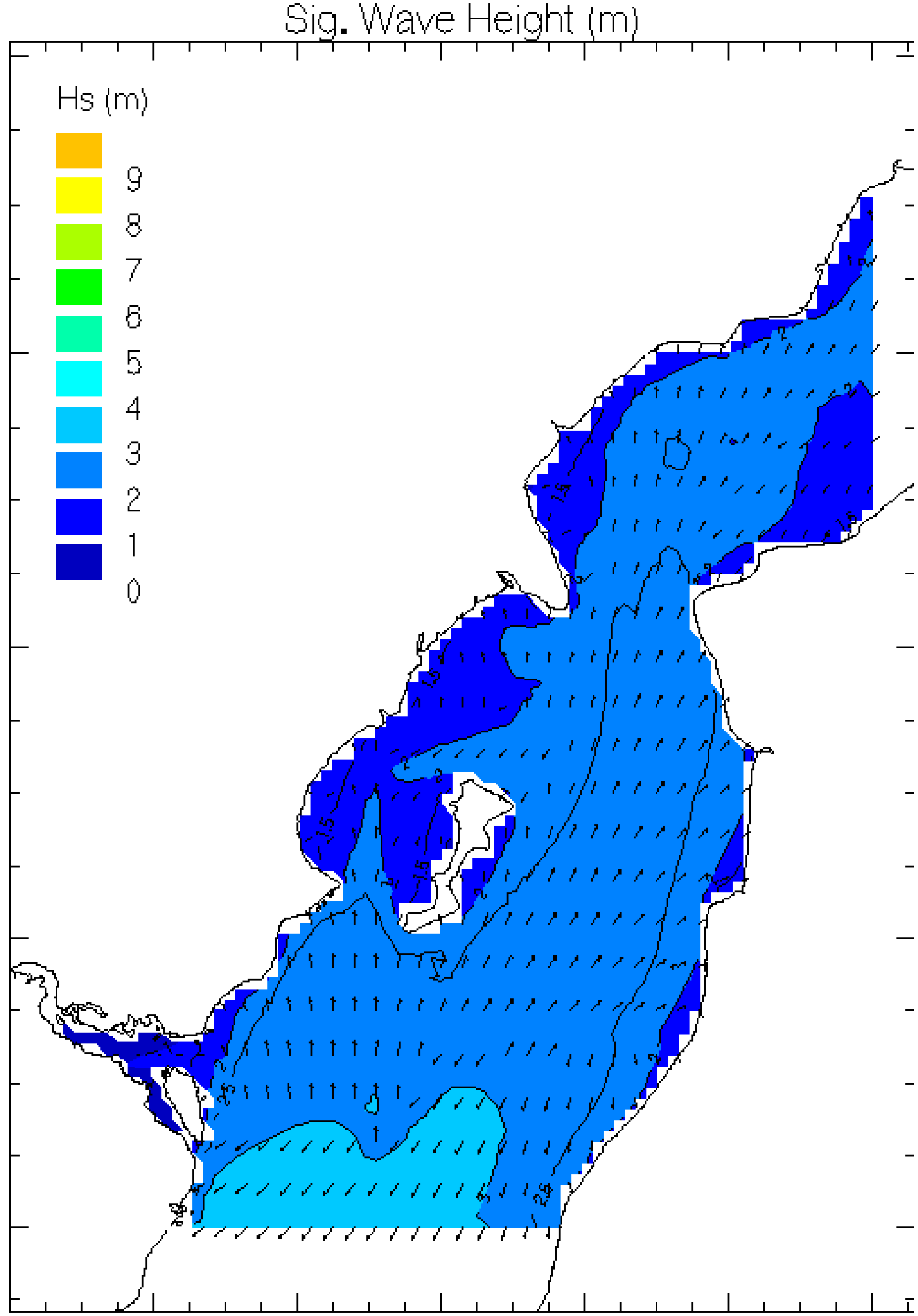
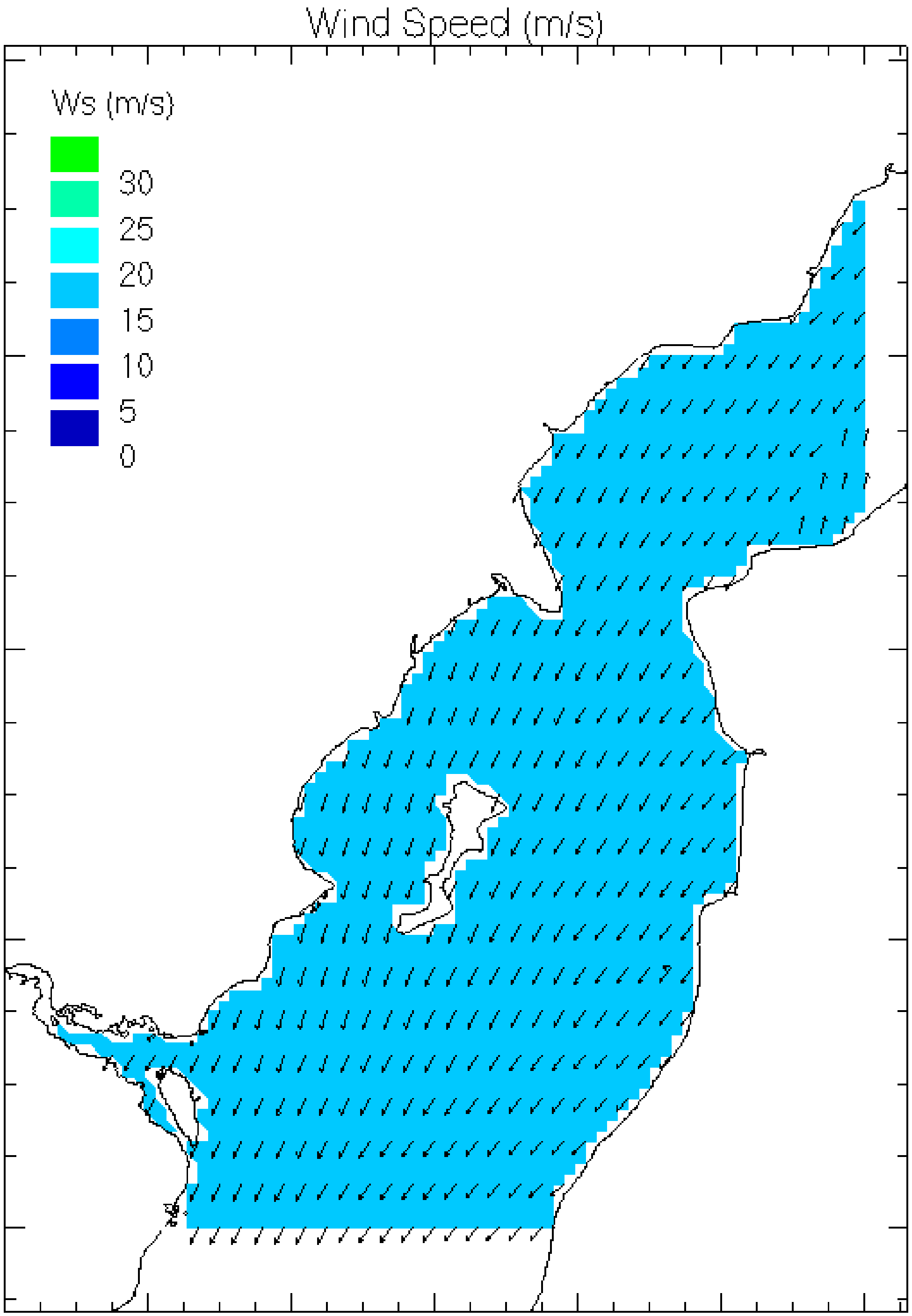
oceanweather inc.

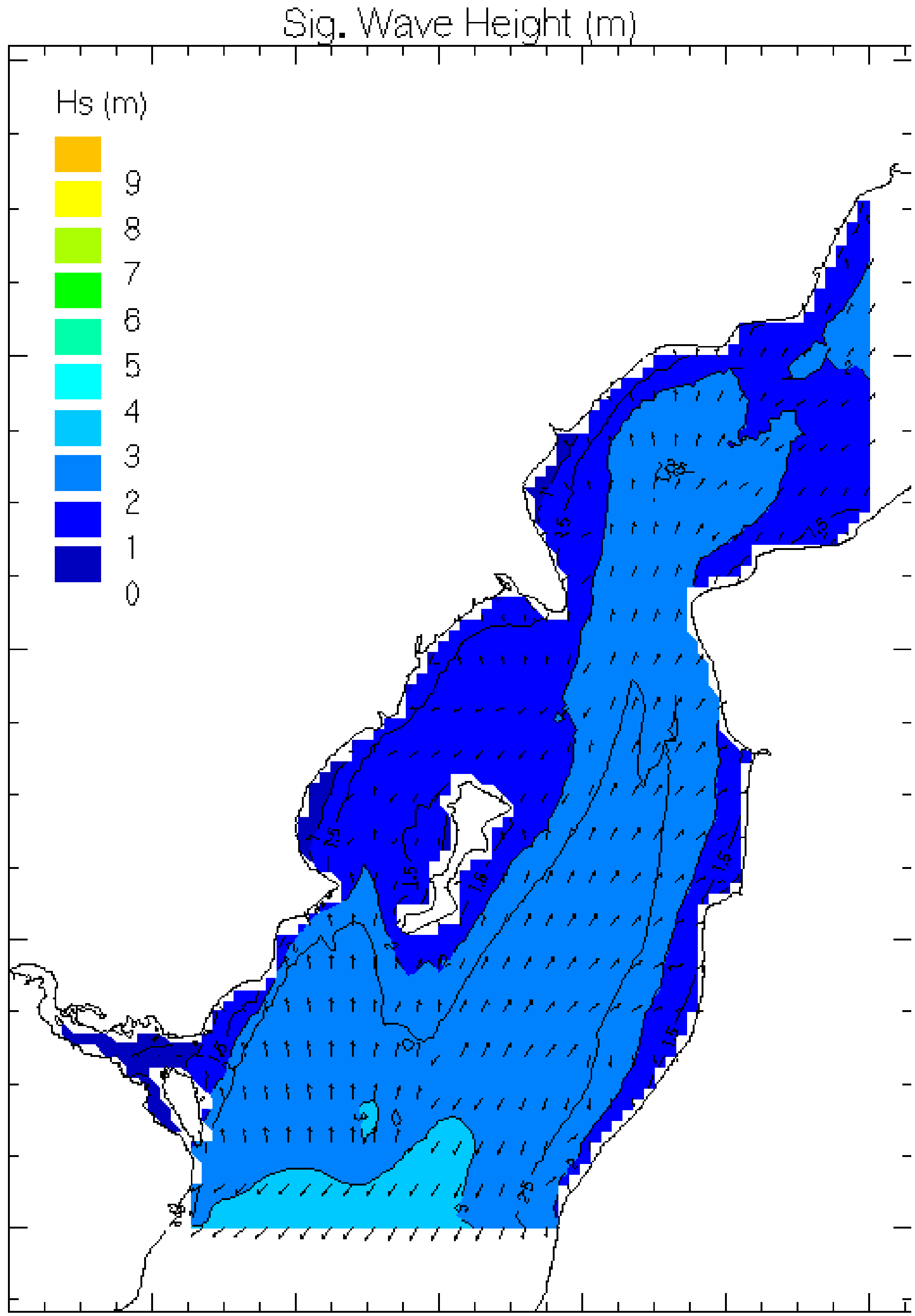
Kenai MTR Maximum Hindcast Winds and Waves during 20010228



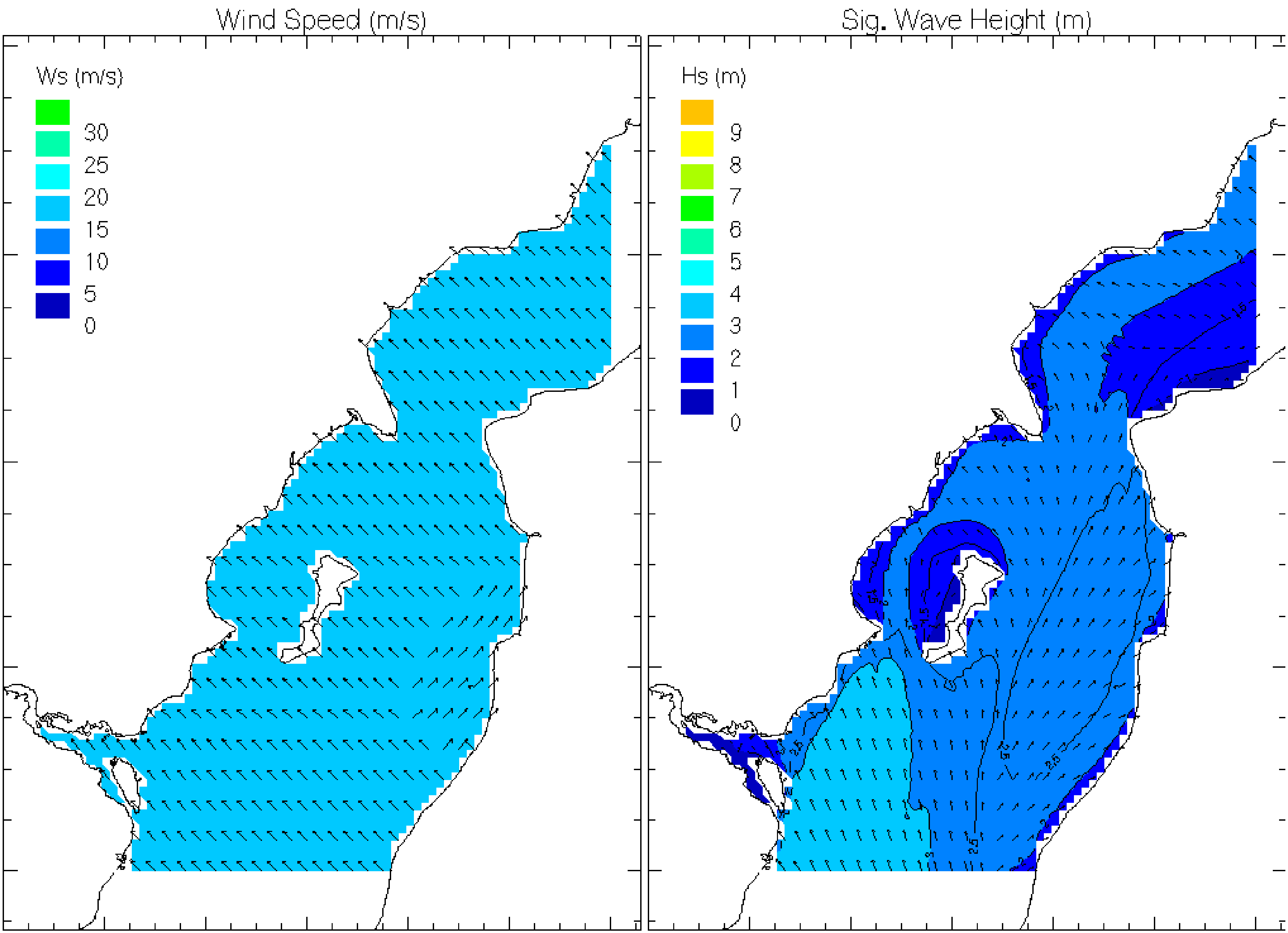


Kenai Maximum Hindcast Winds and Waves during 20010228

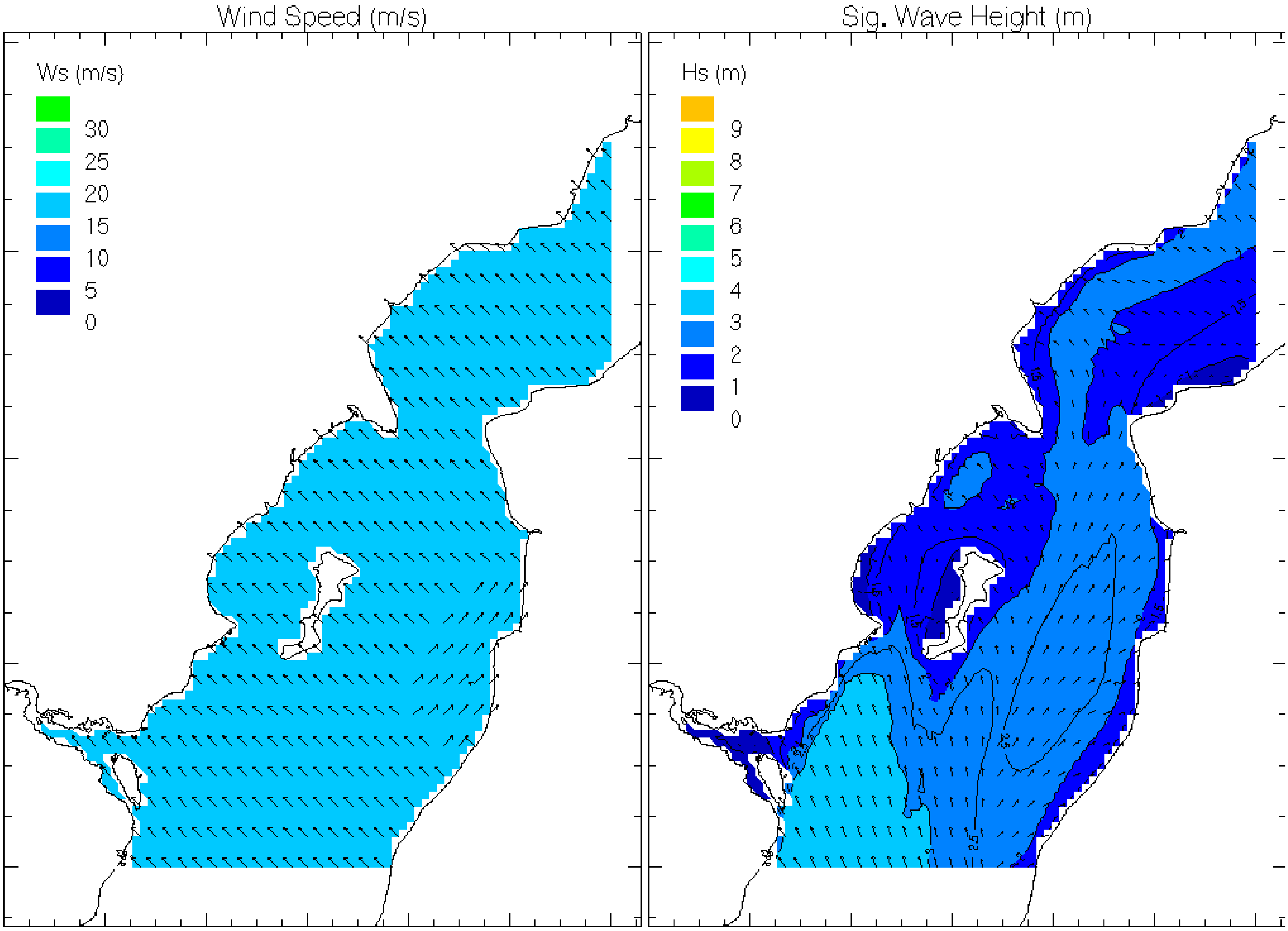




Kenai MTR Maximum Hindcast Winds and Waves during 20010404



Kenai Maximum Hindcast Winds and Waves during 20010404



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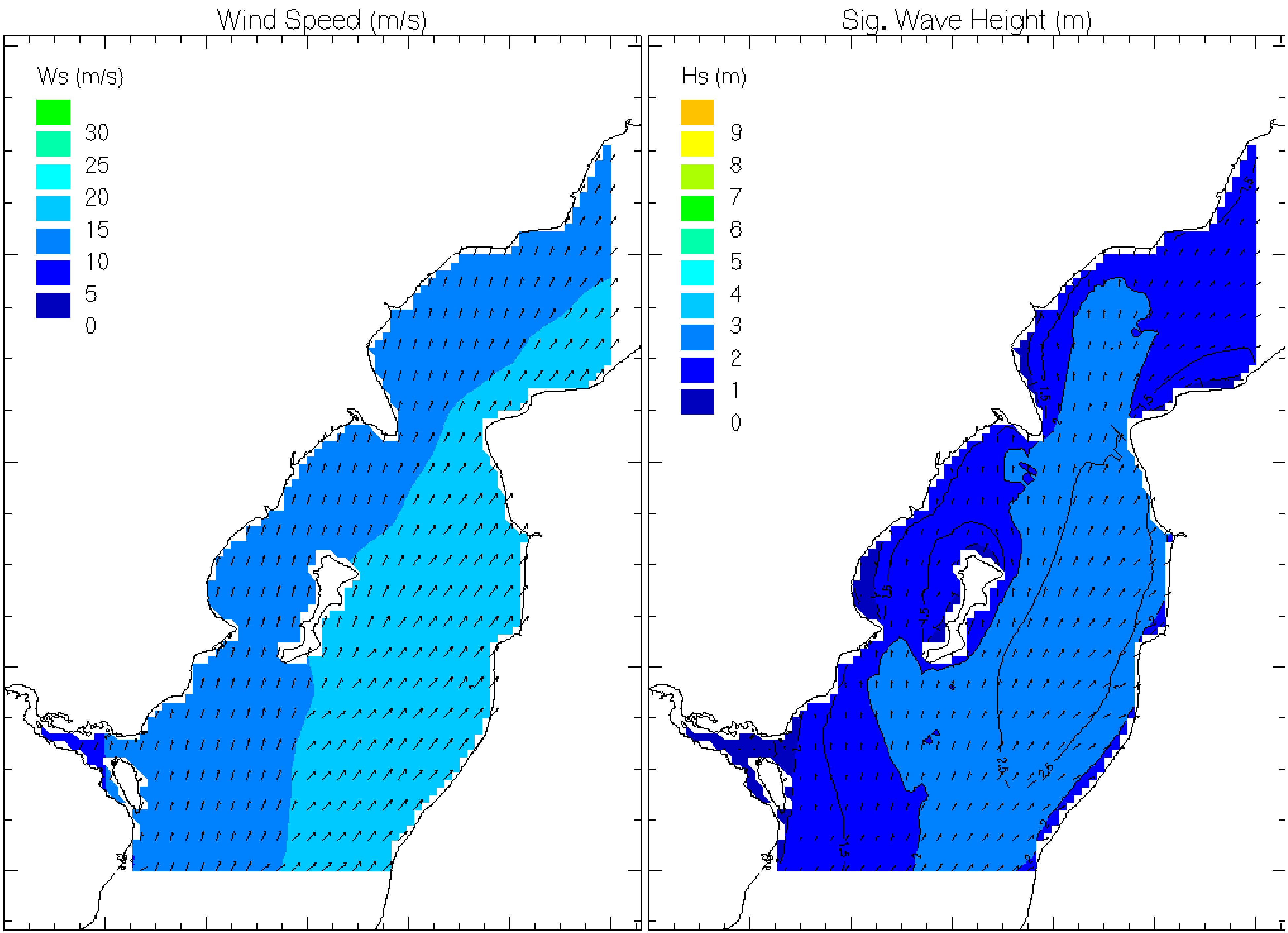
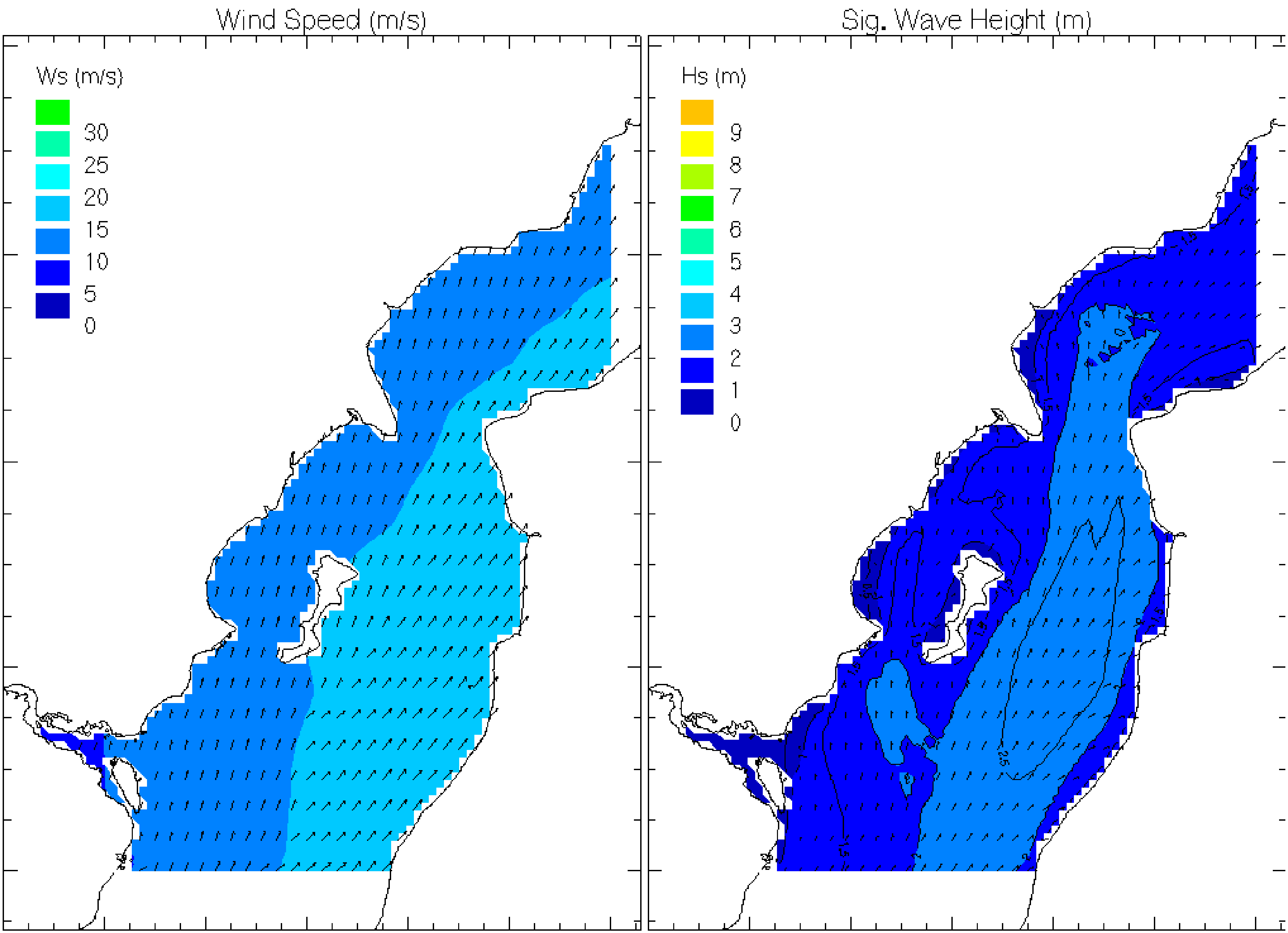
Kenai MTR Maximum Hindcast Winds and Waves during 20010502



Kenai Maximum Hindcast Winds and Waves during 20010502



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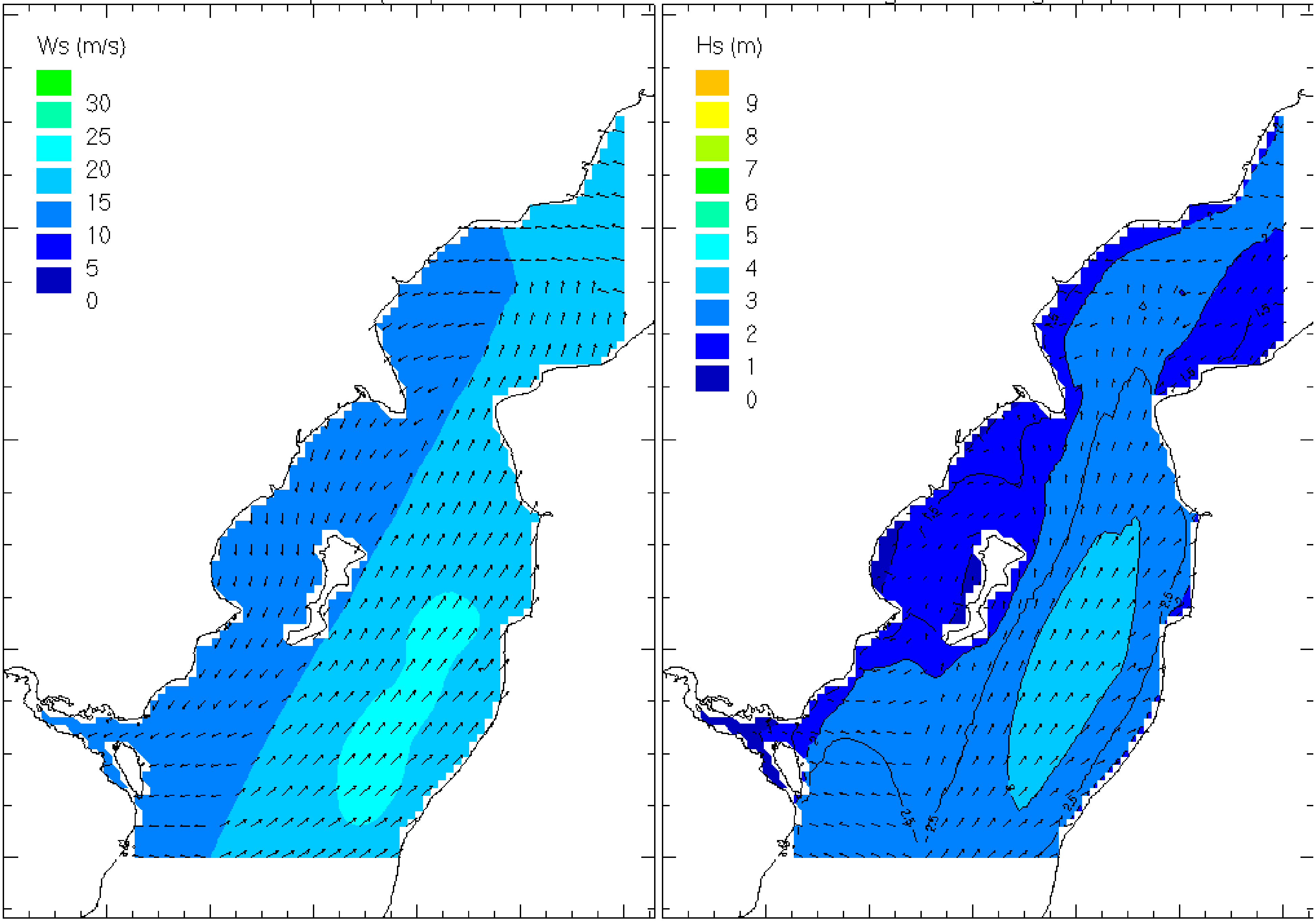
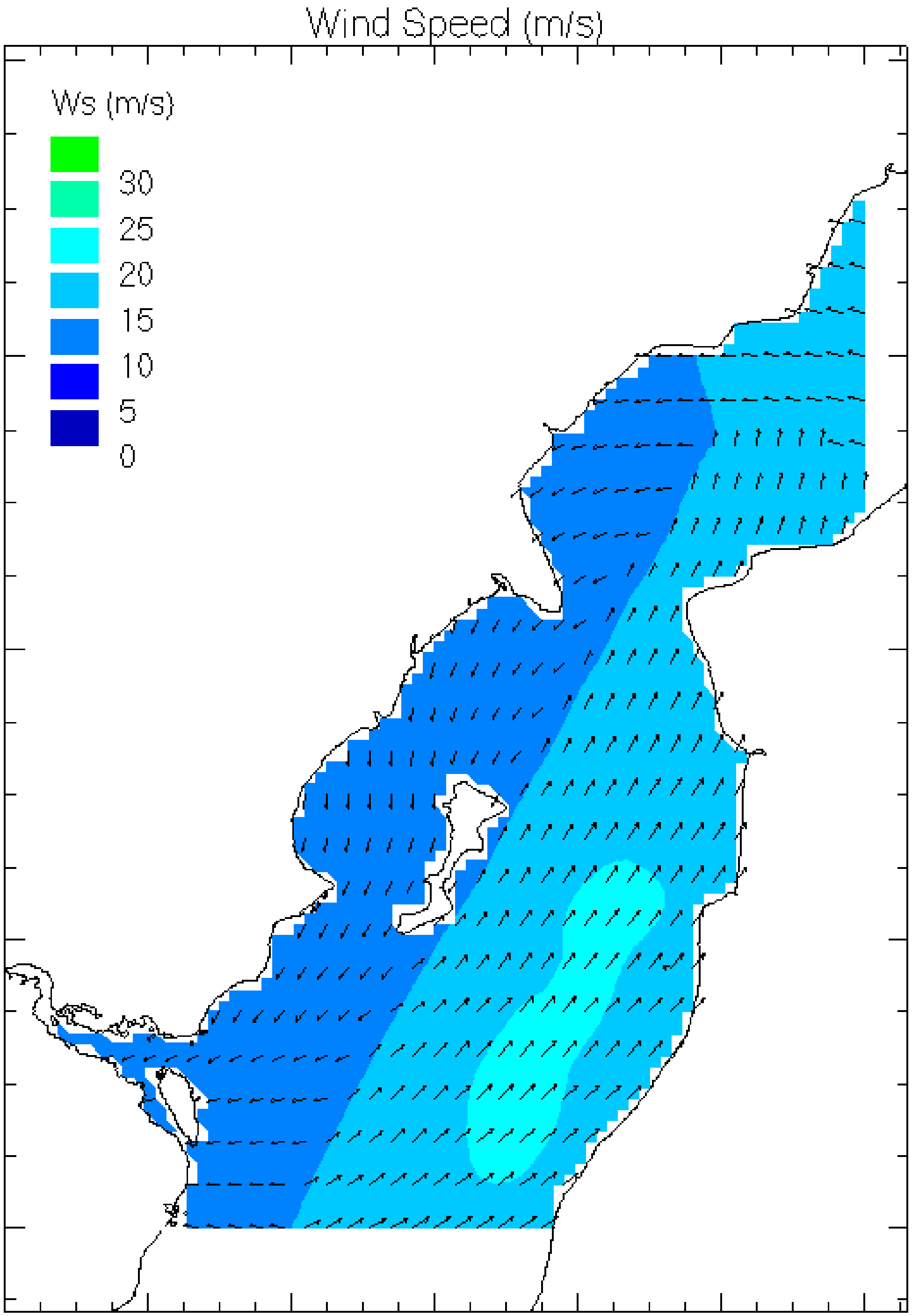
oceanweather inc.

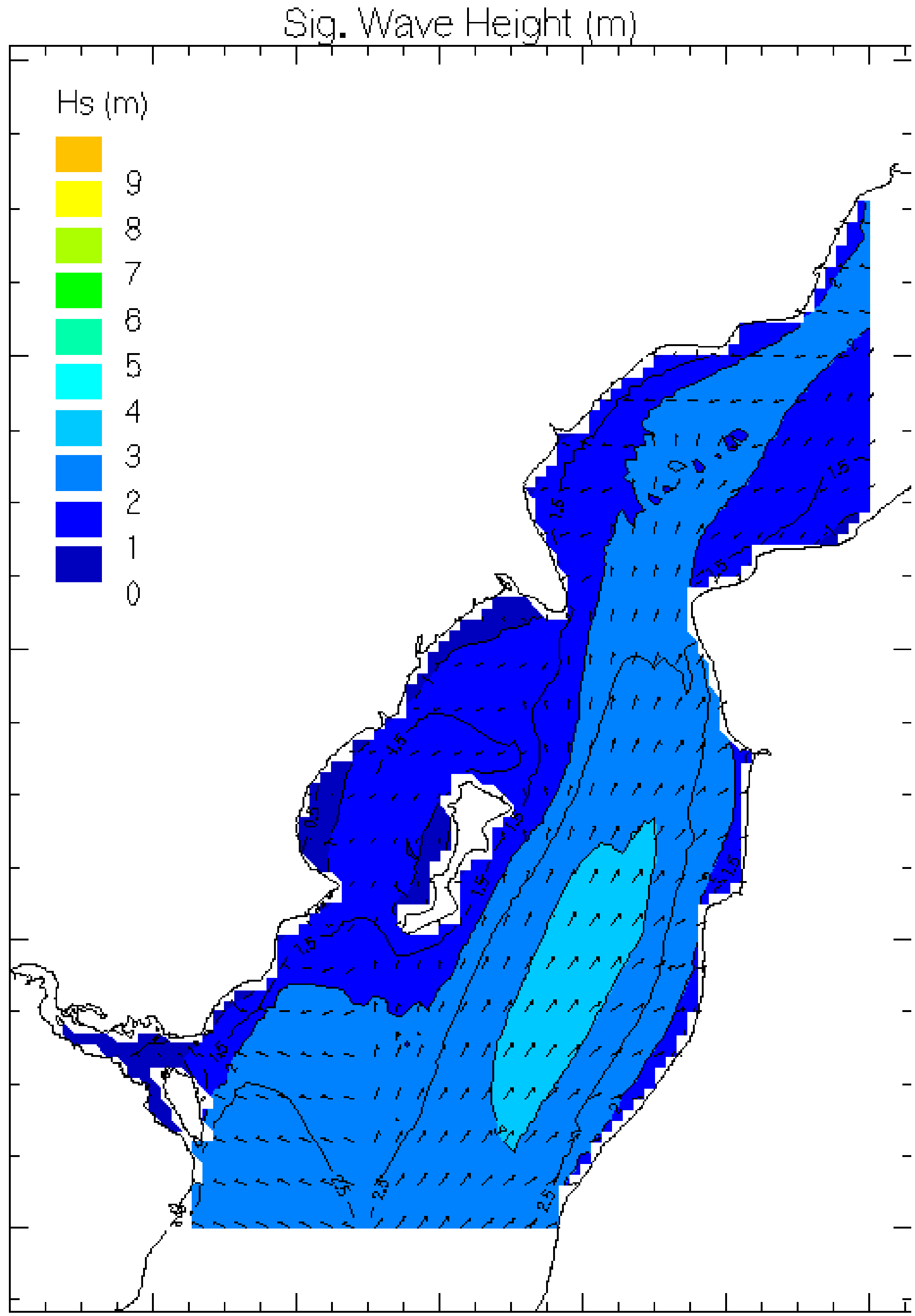
Kenai MTR Maximum Hindcast Winds and Waves during 20020213

Wind Speed (m/s) Sig. Wave Height (m)



Kenai Maximum Hindcast Winds and Waves during 20020213





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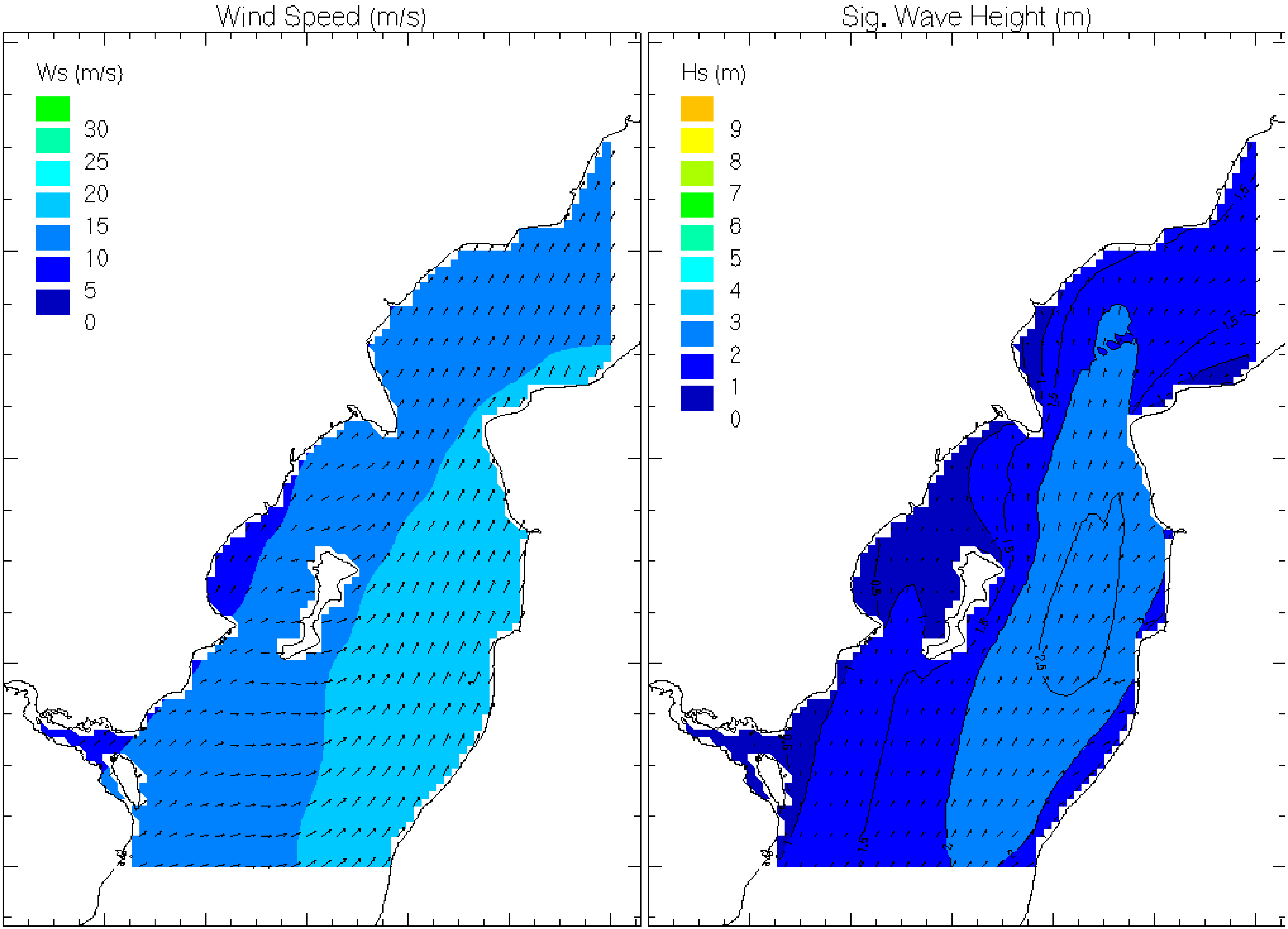
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 20020501



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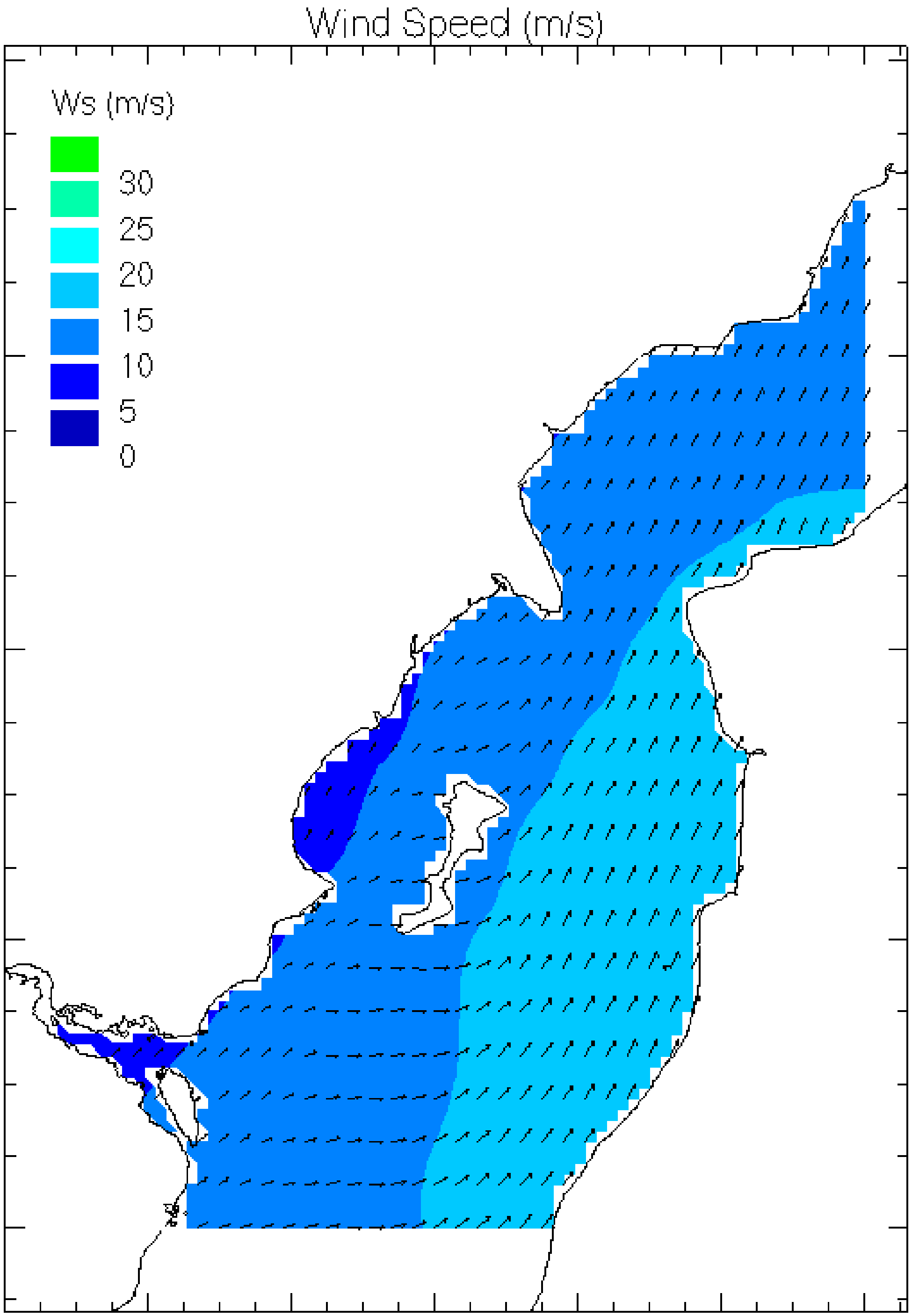
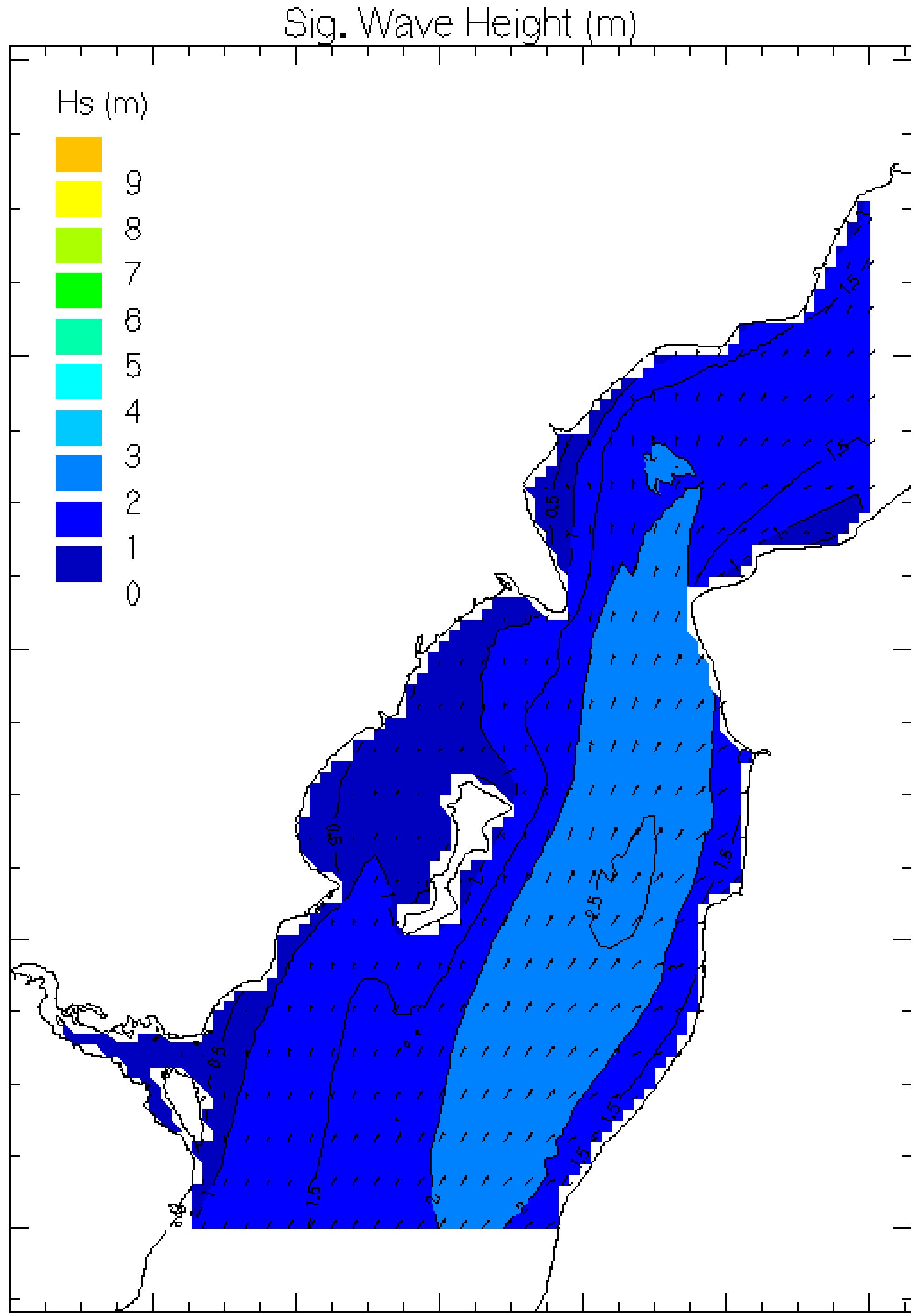
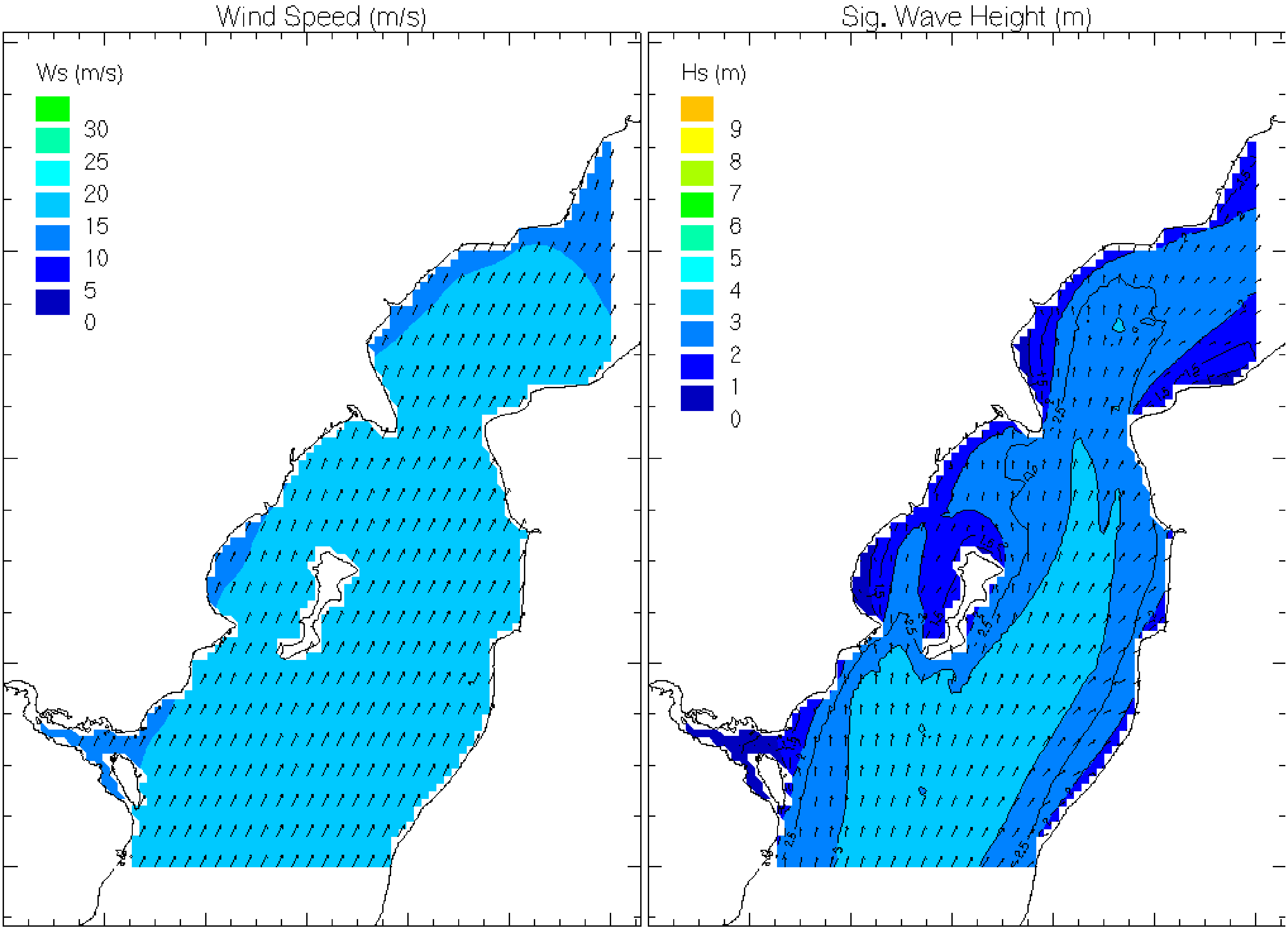
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 20020501





Kenai MTR Maximum Hindcast Winds and Waves during 20020927



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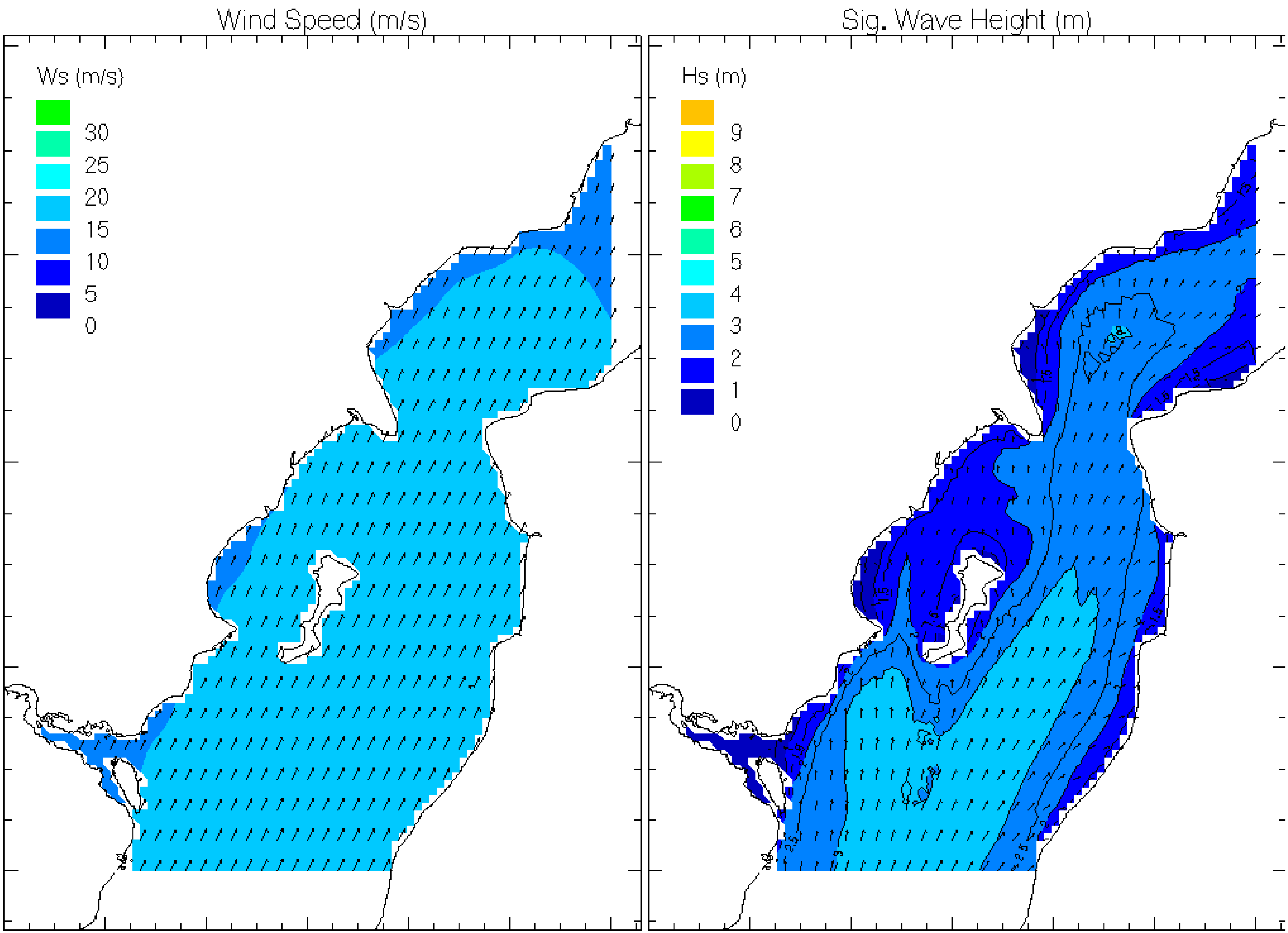
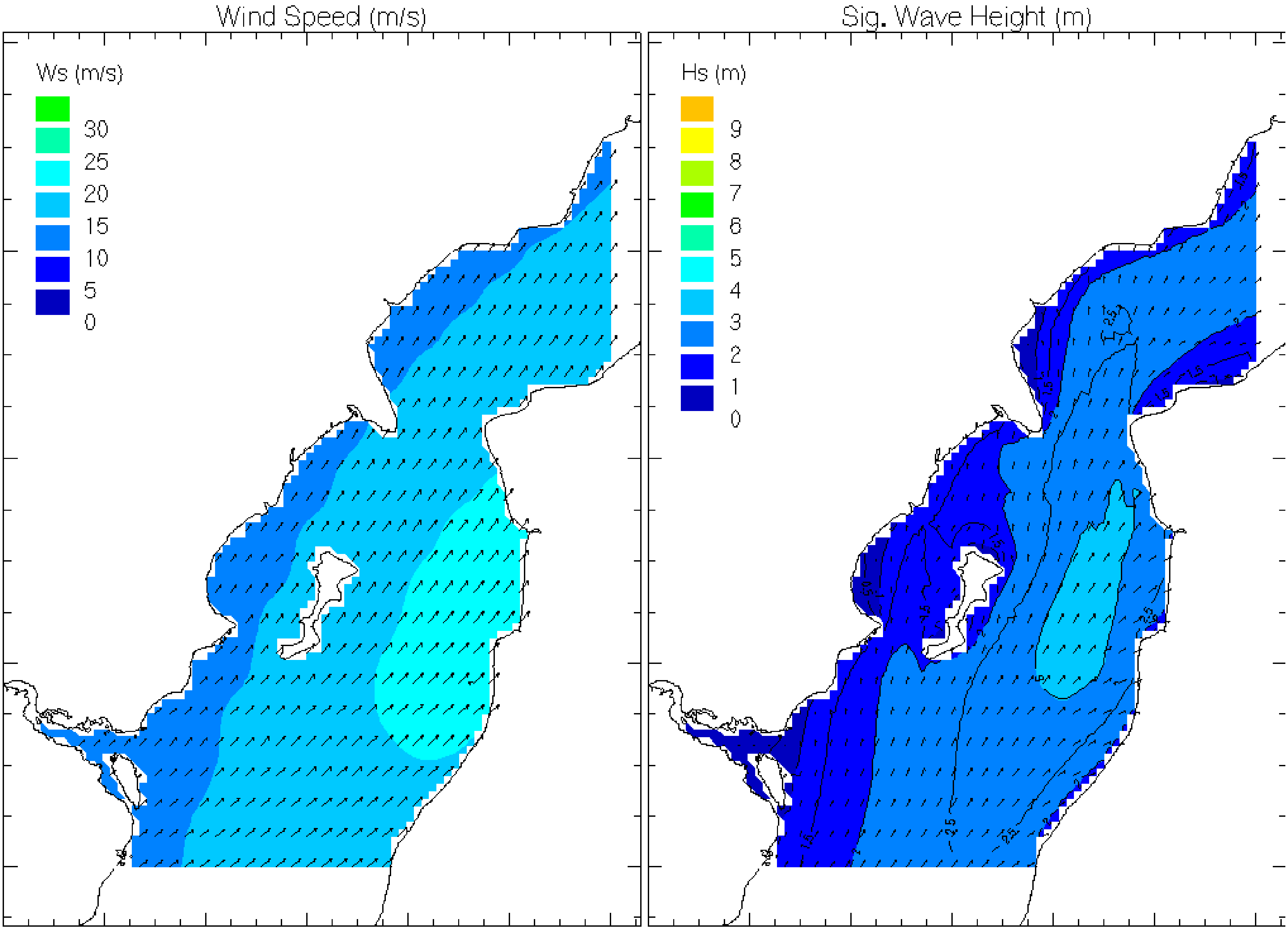
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 20020927



Kenai MTR Maximum Hindcast Winds and Waves during 20021008



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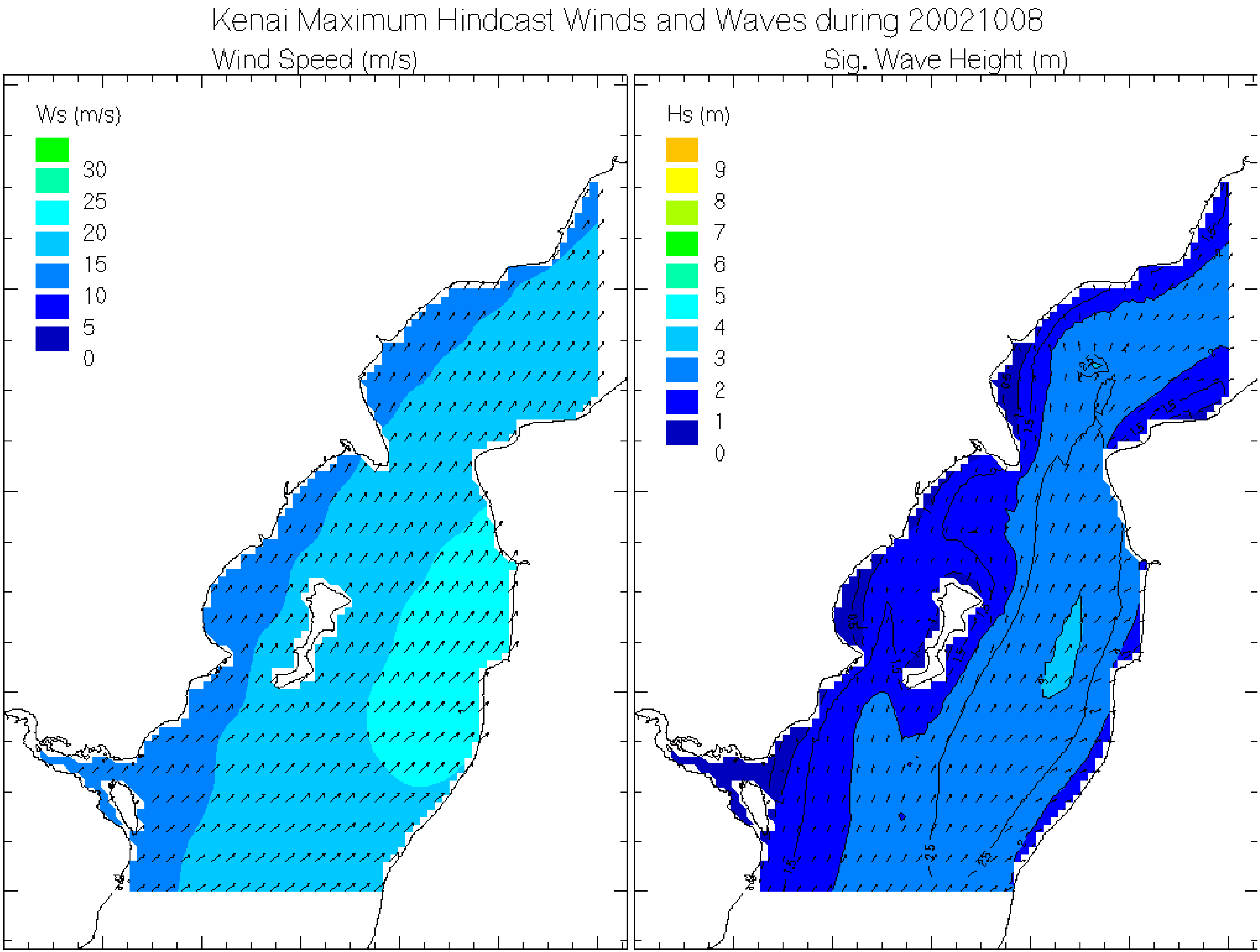
oceanweather inc.



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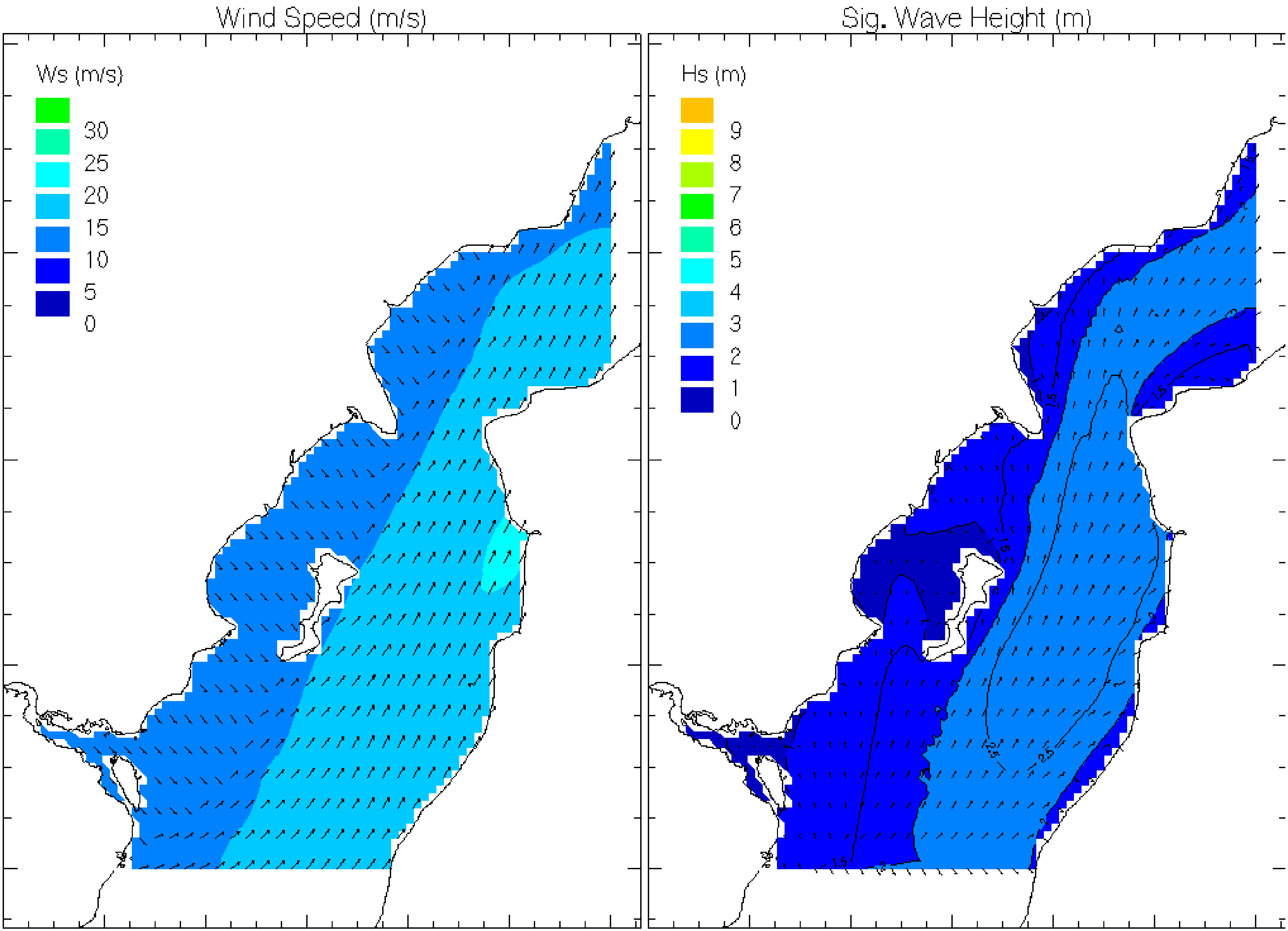
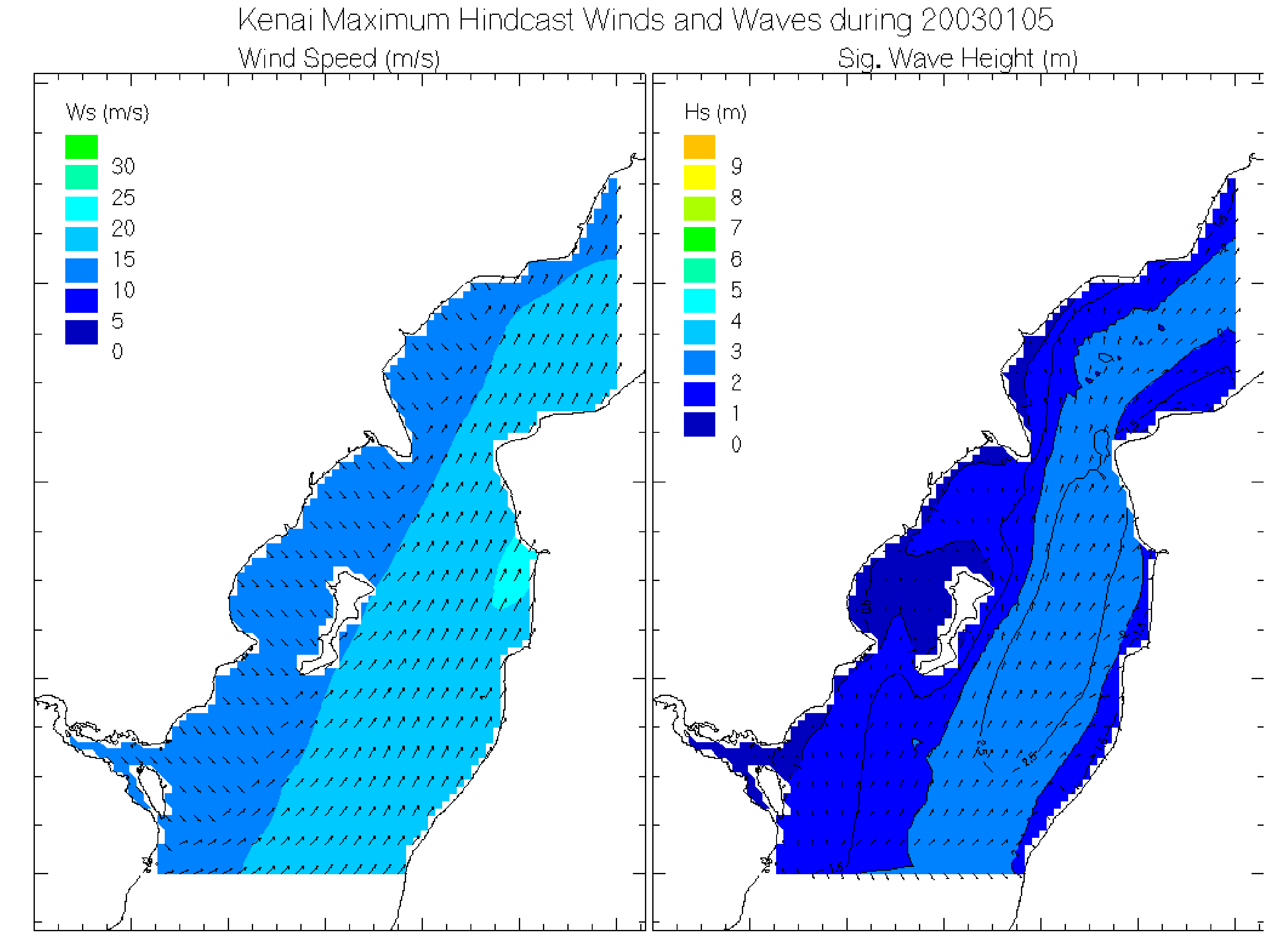
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 20030105





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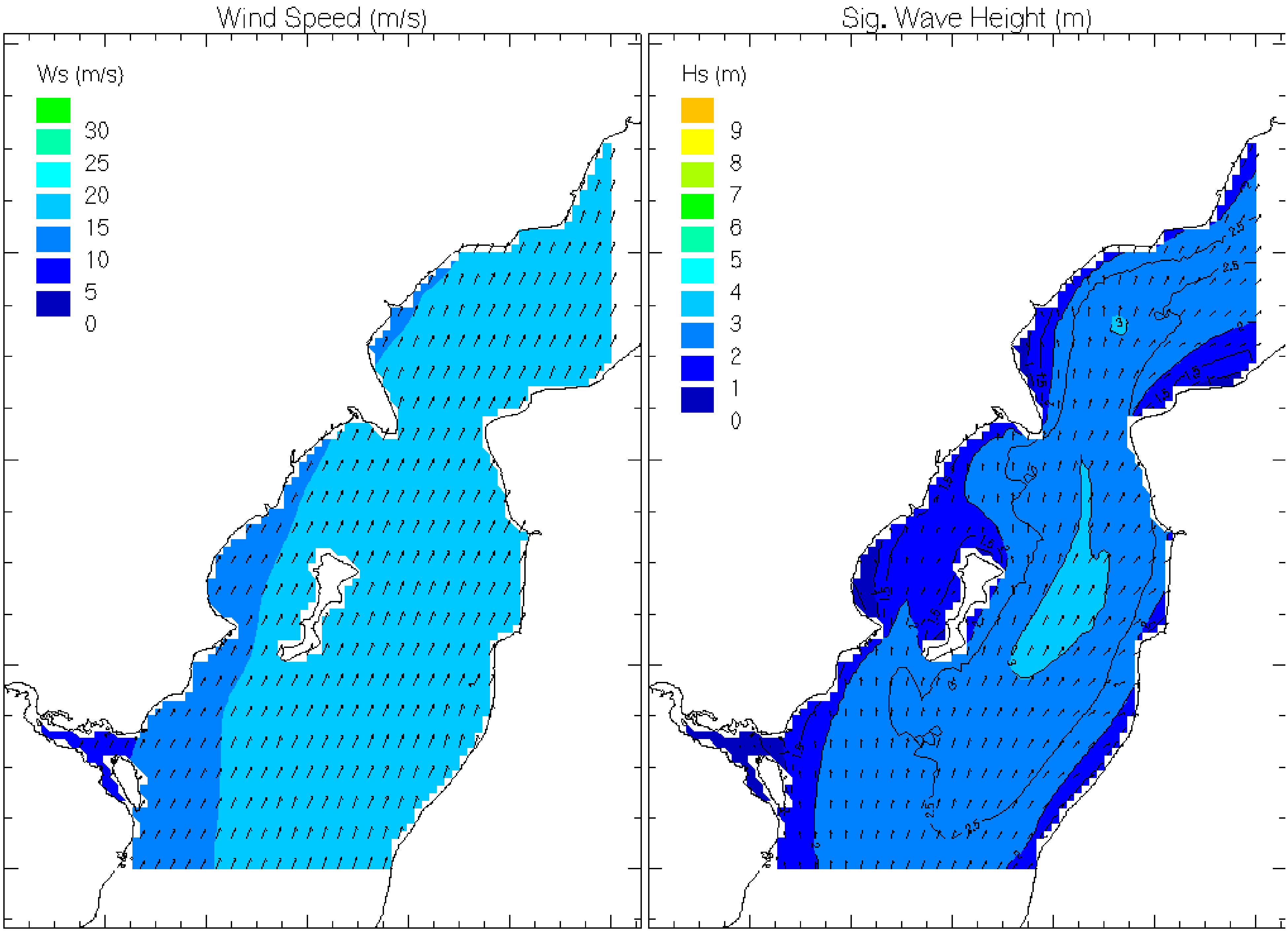
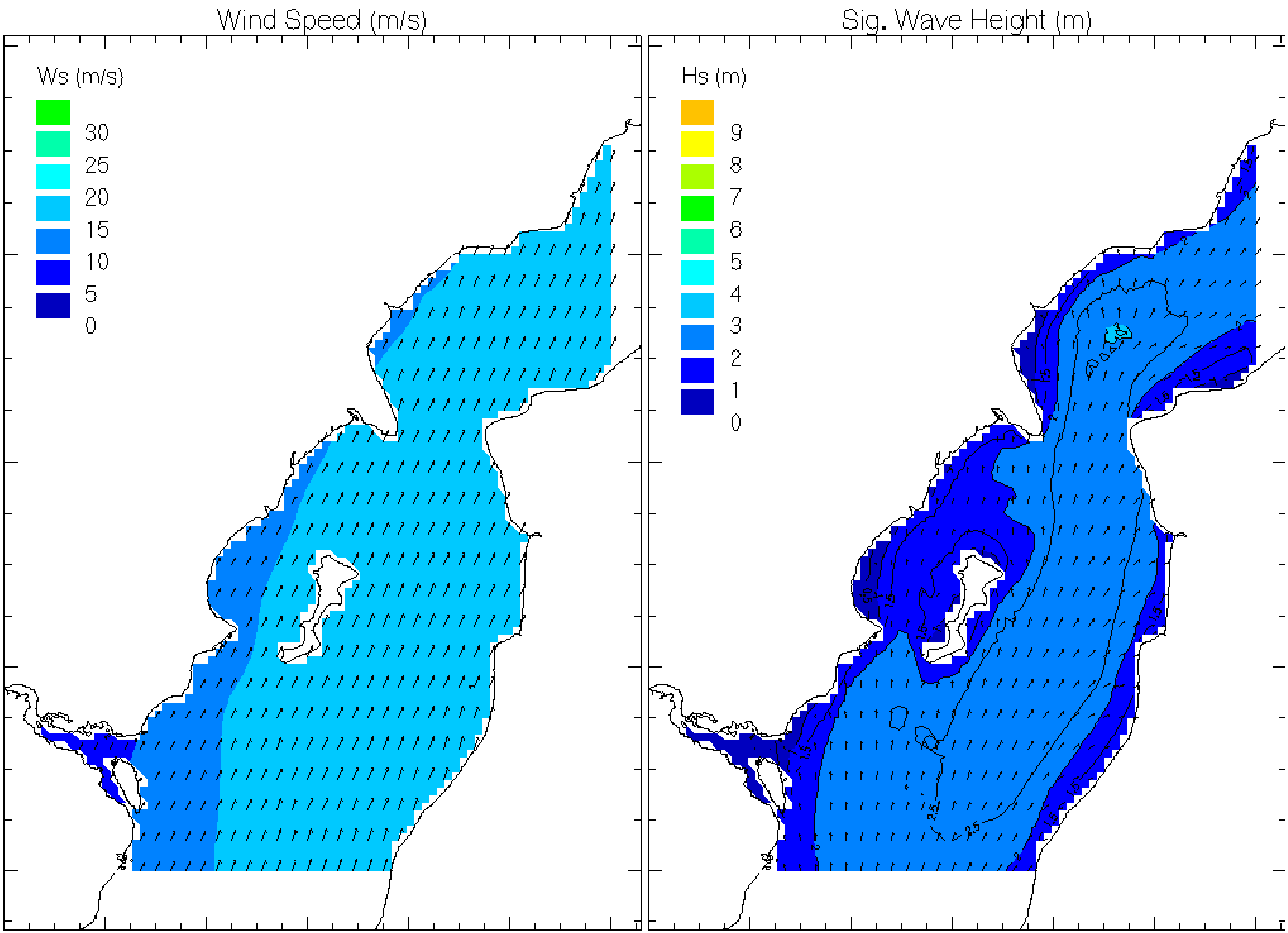
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 20030727



Kenai Maximum Hindcast Winds and Waves during 20030727



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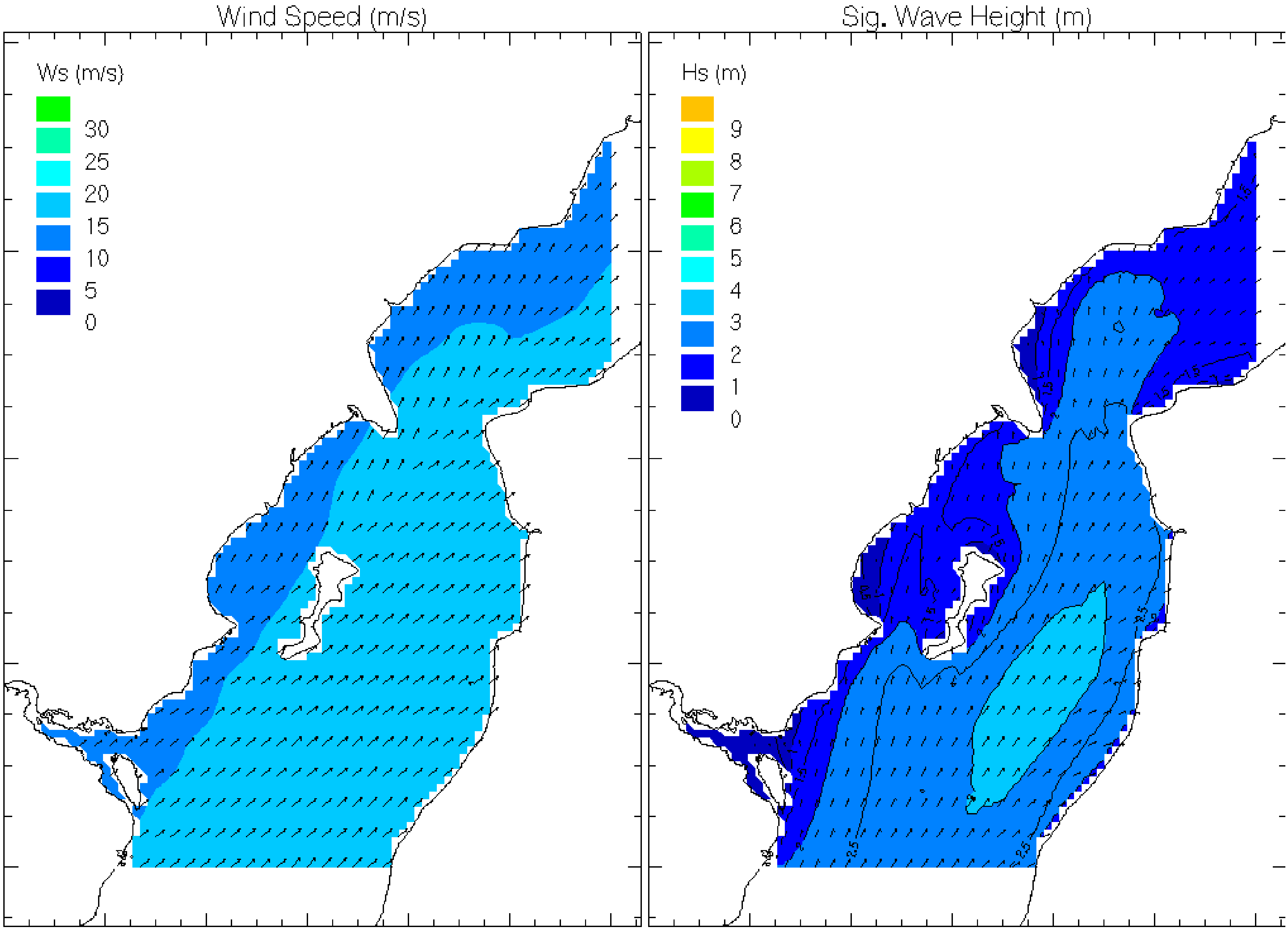
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 20050924



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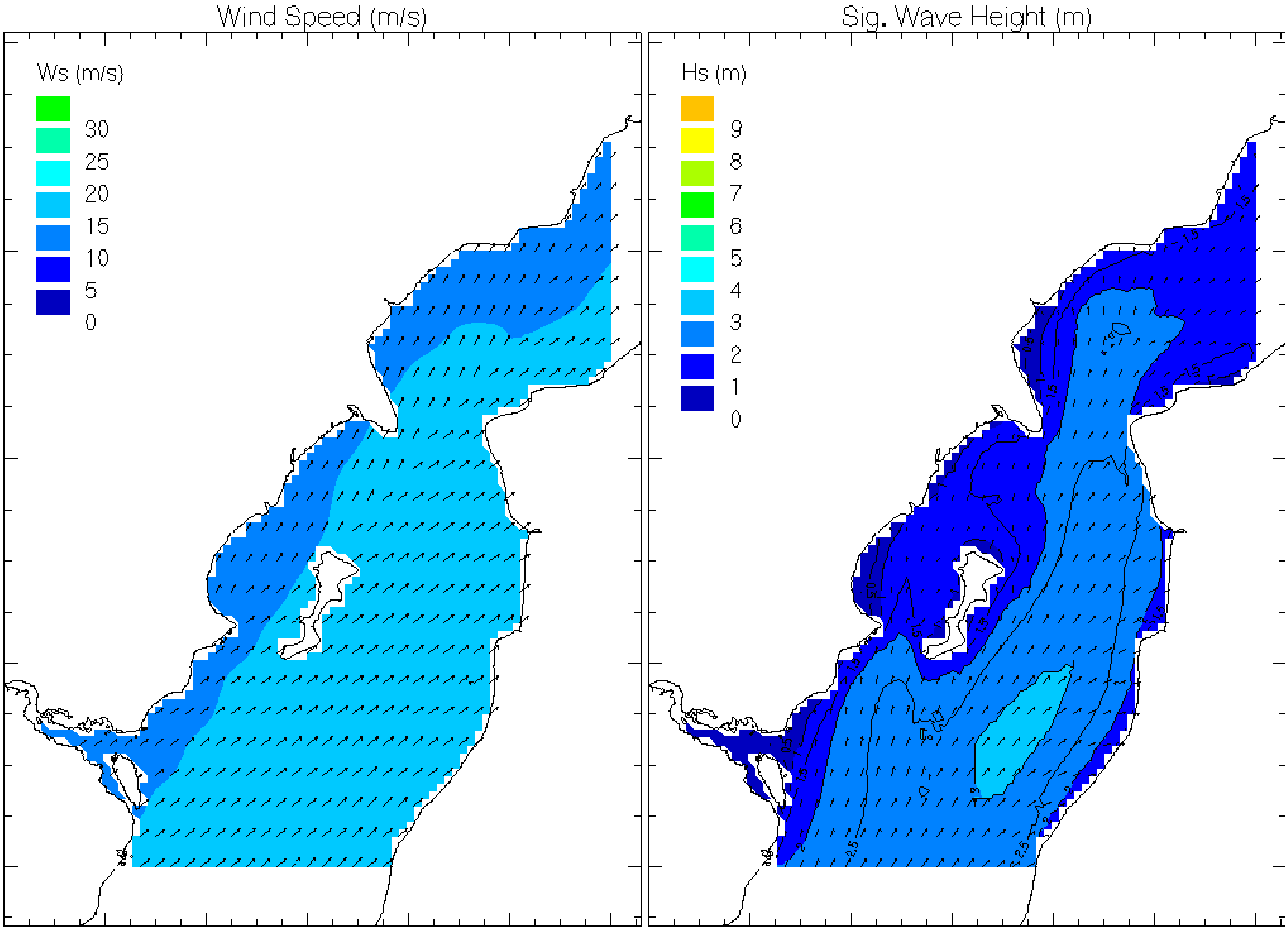
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 20050924



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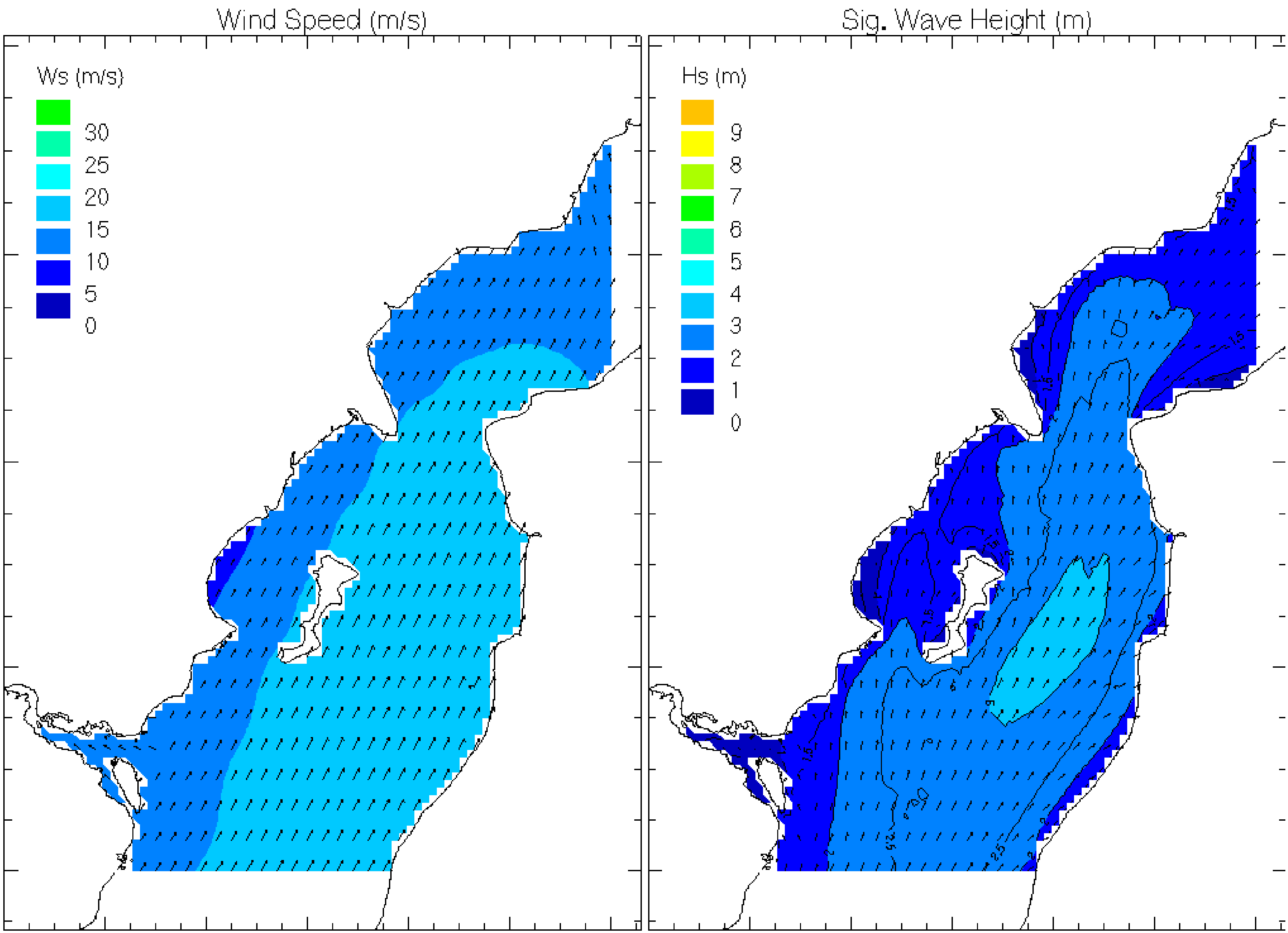
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 20051019



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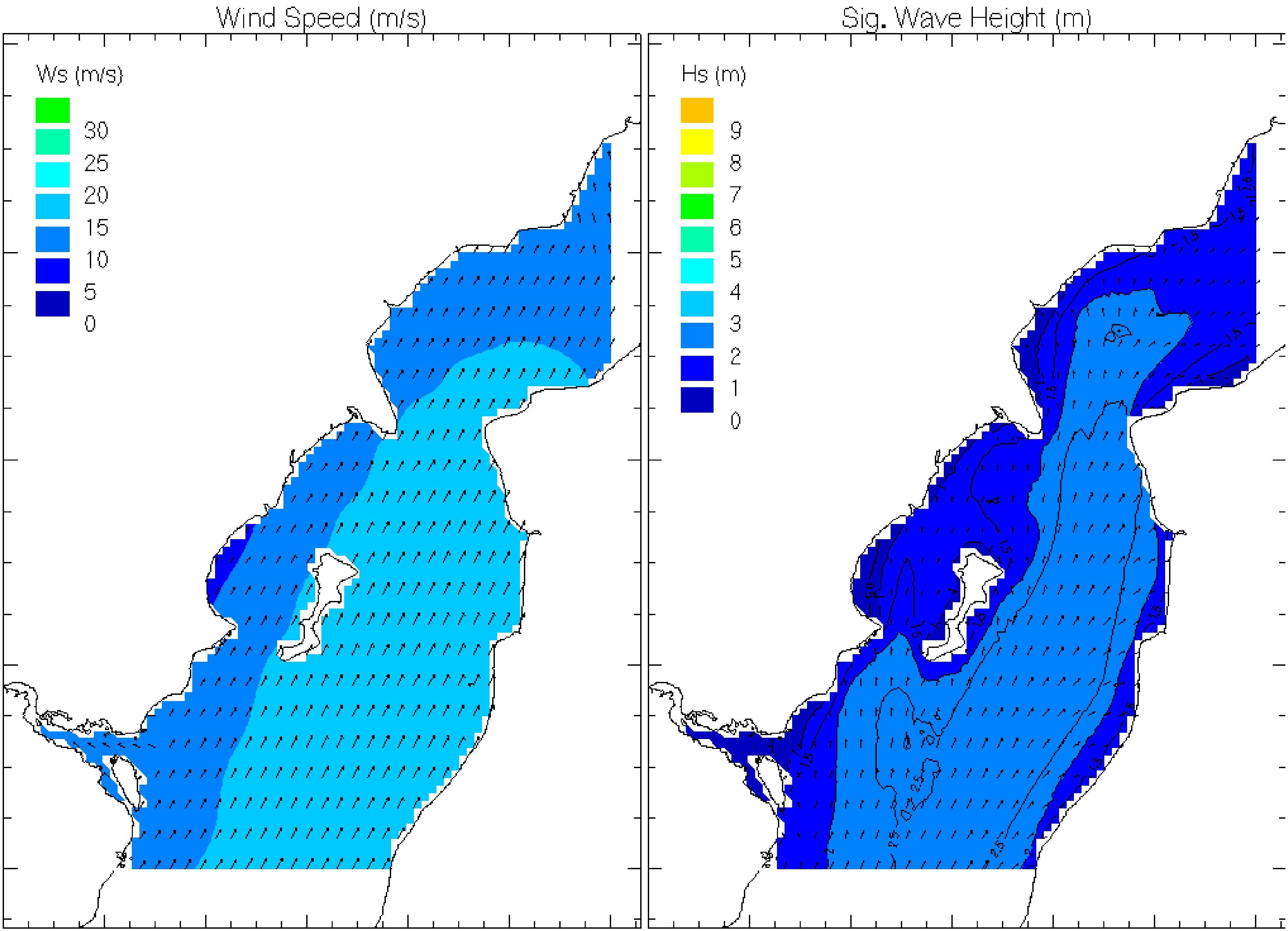
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 20051019



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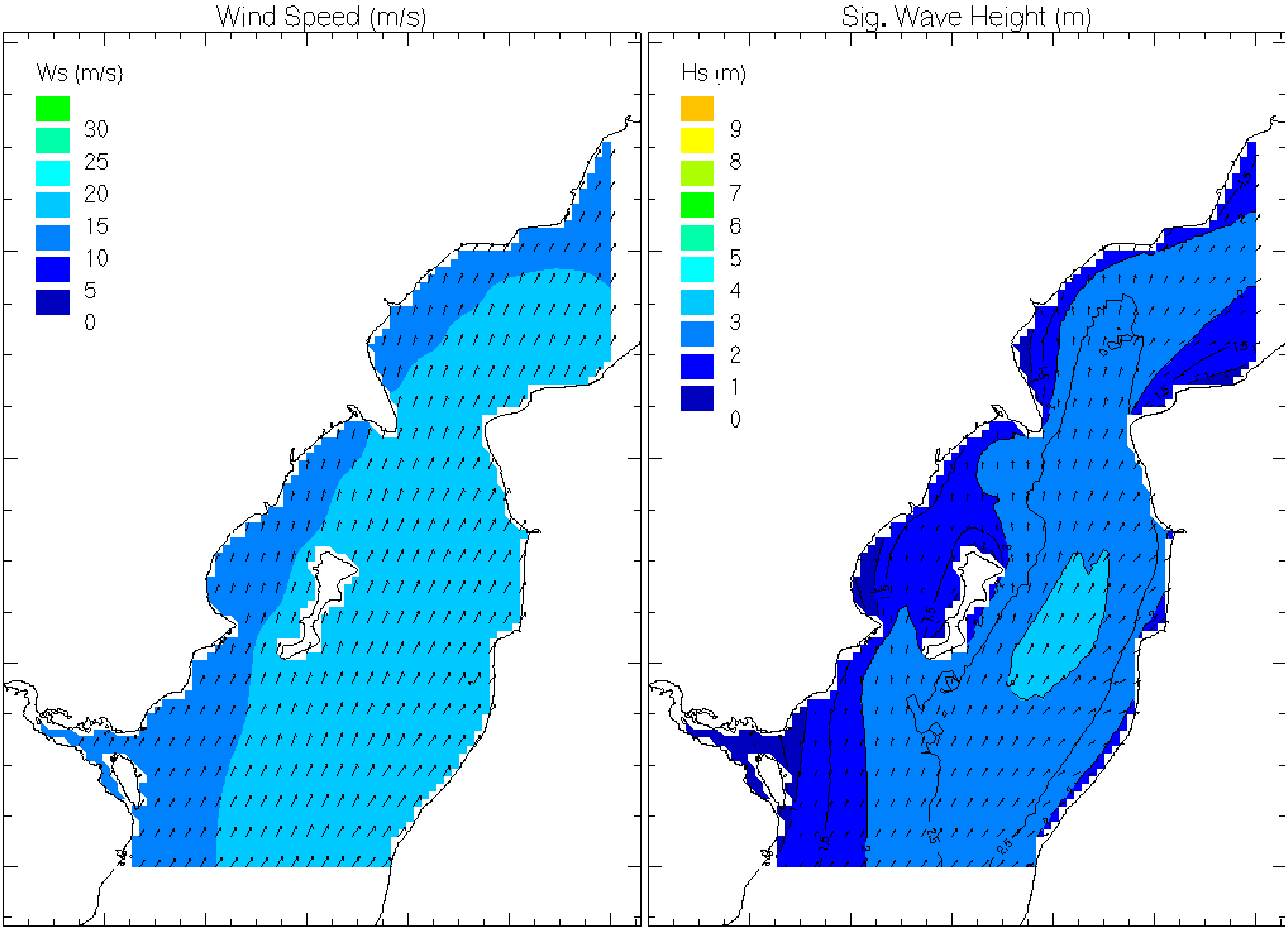
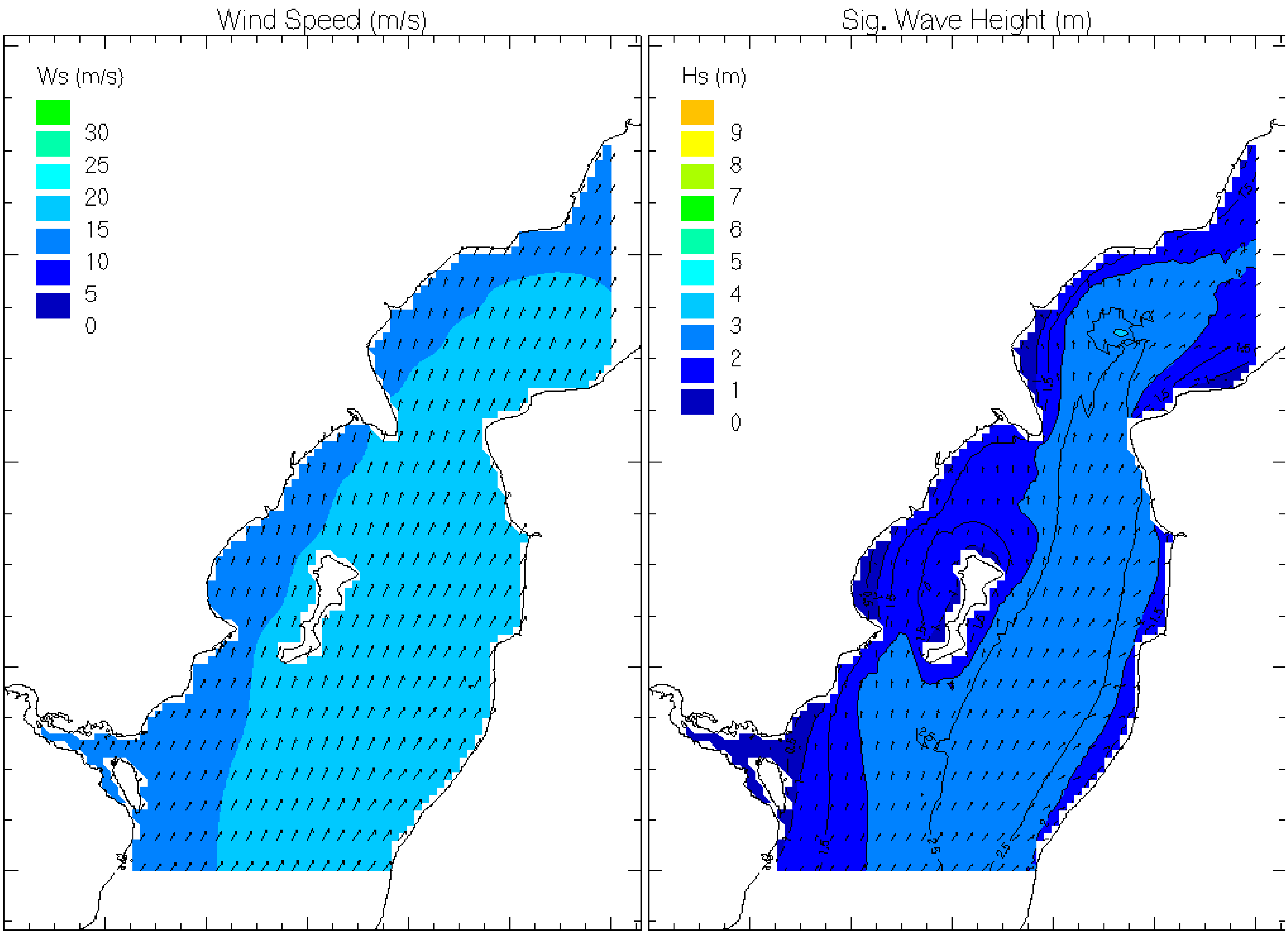
Kenai MTR Maximum Hindcast Winds and Waves during 20051124



Kenai Maximum Hindcast Winds and Waves during 20051124



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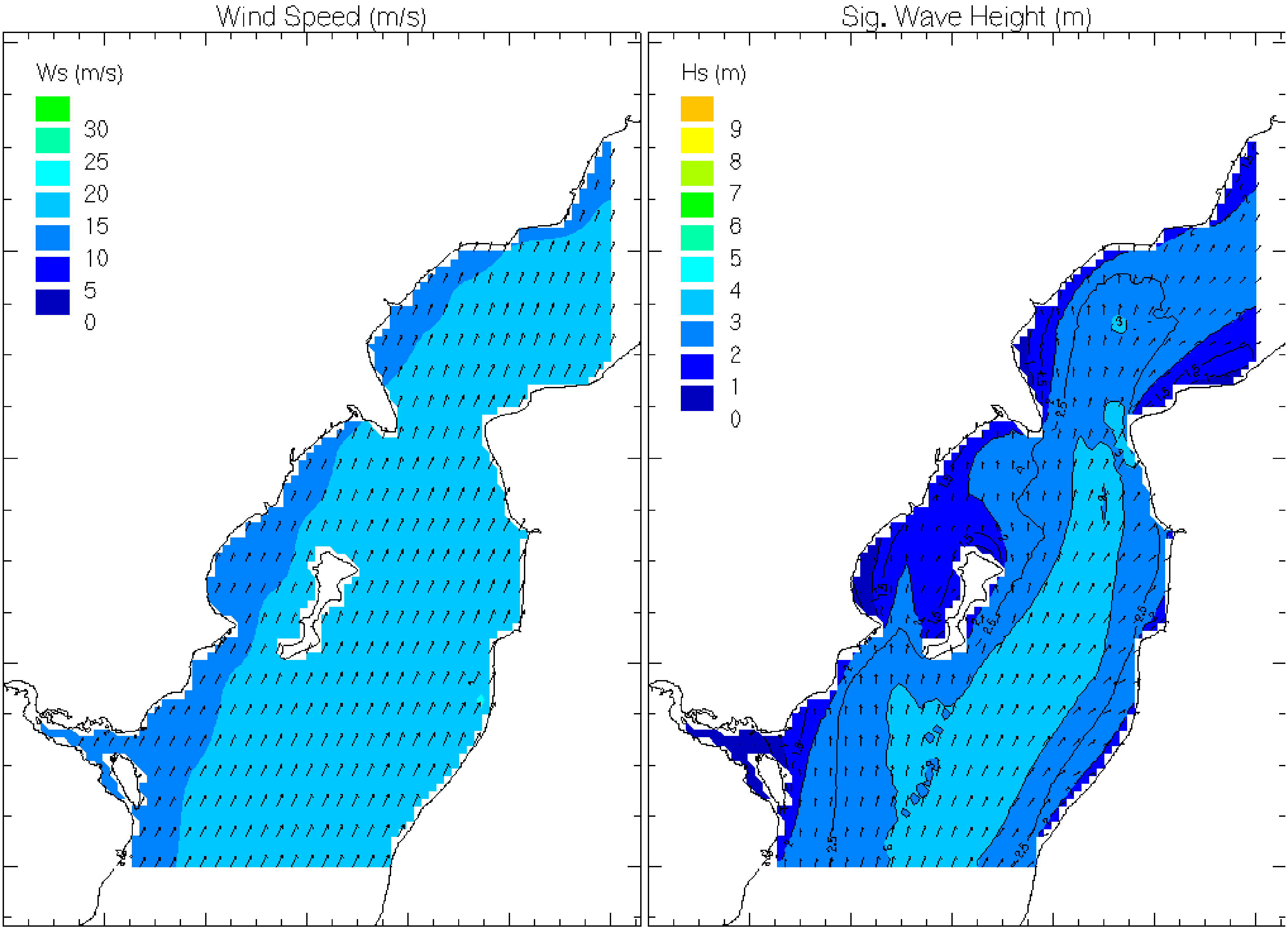
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 20060818



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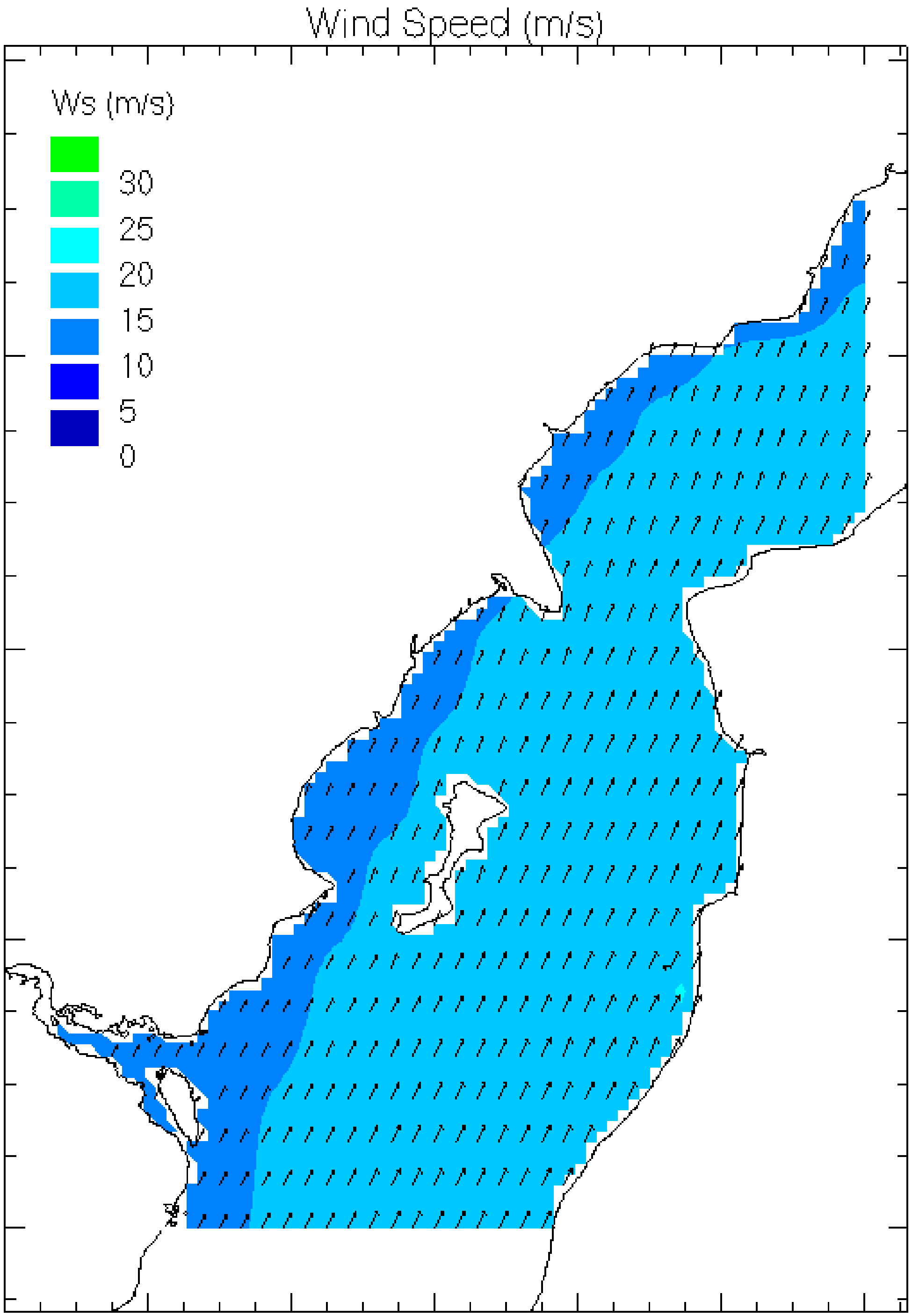
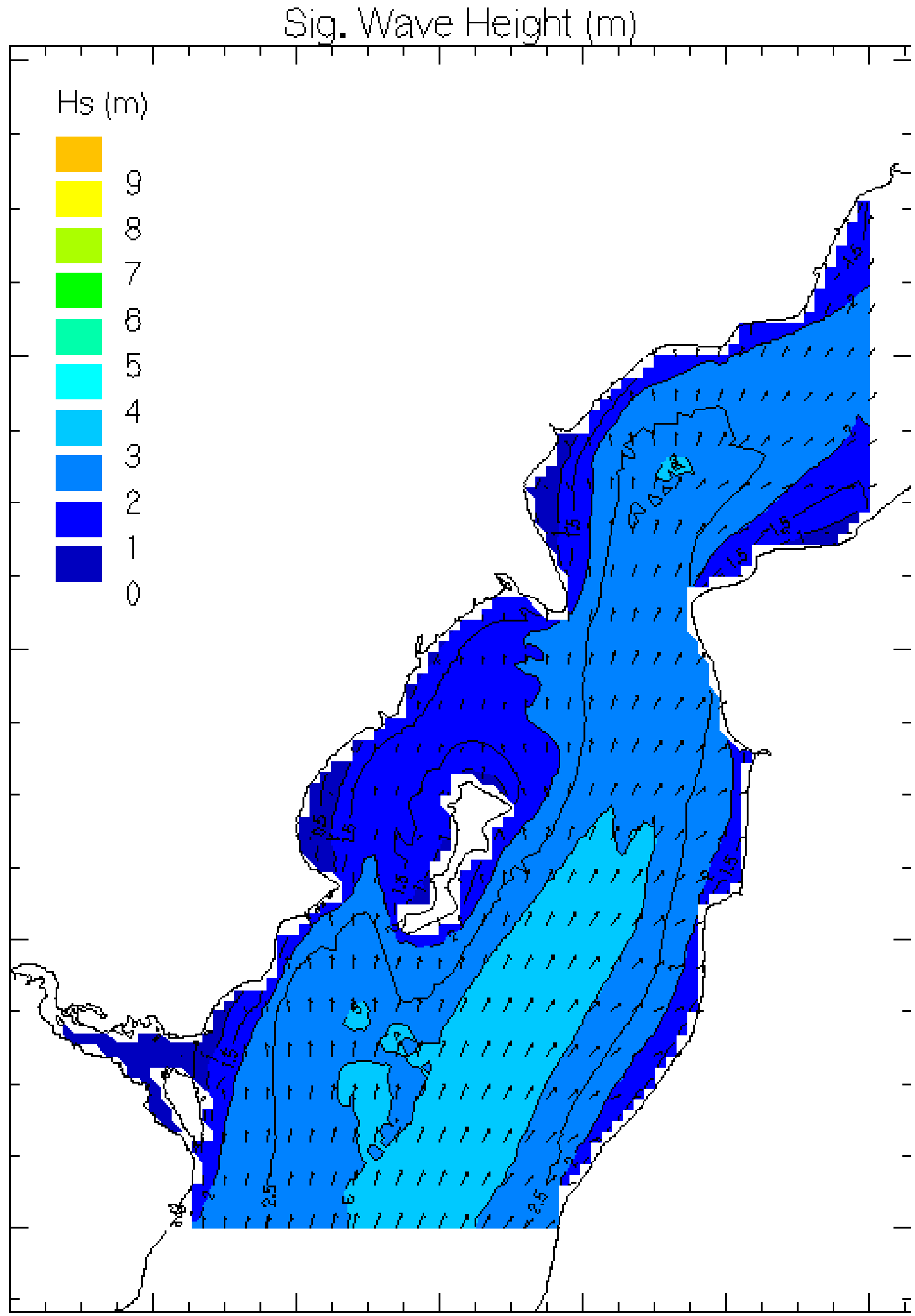
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 20060818





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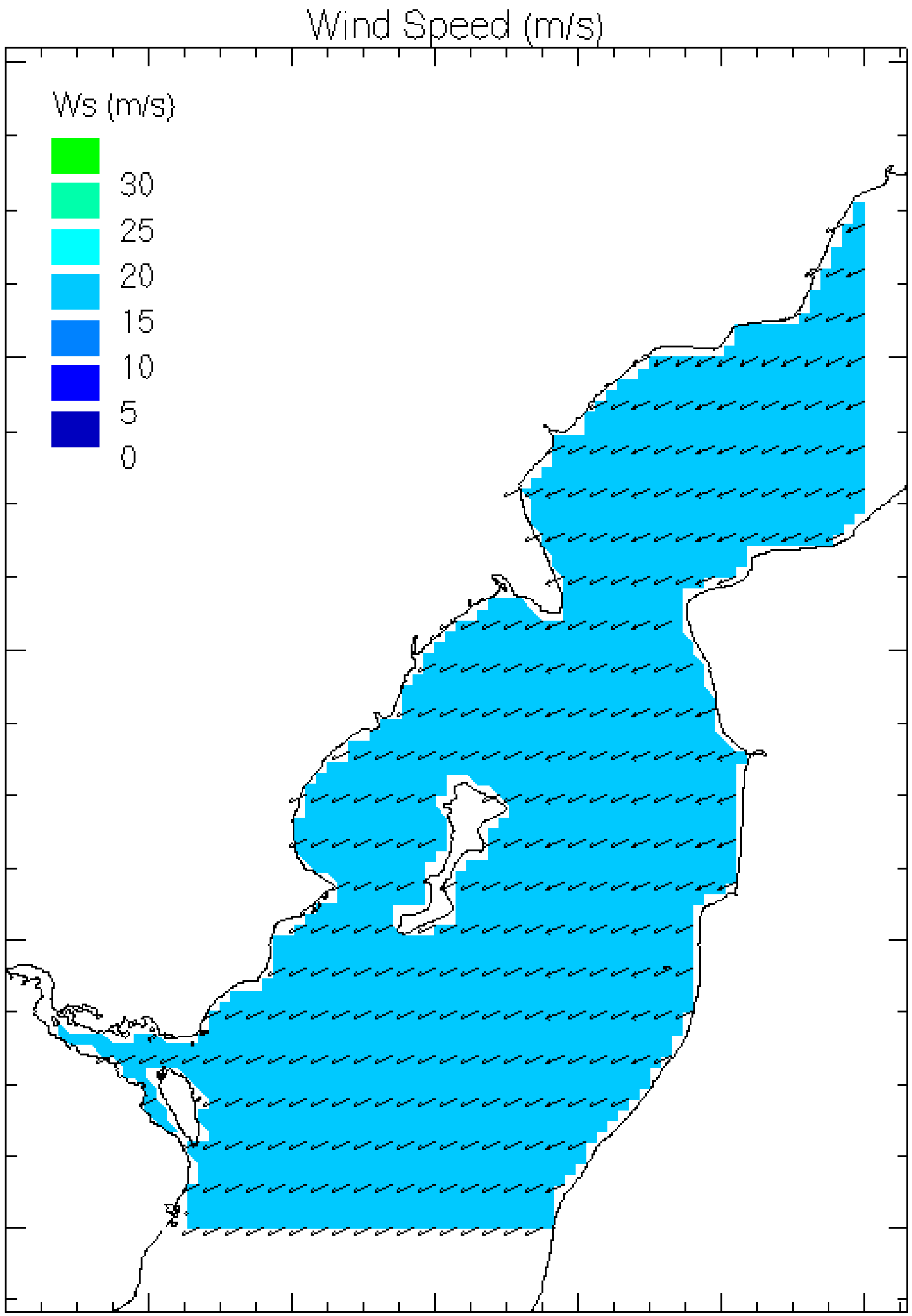
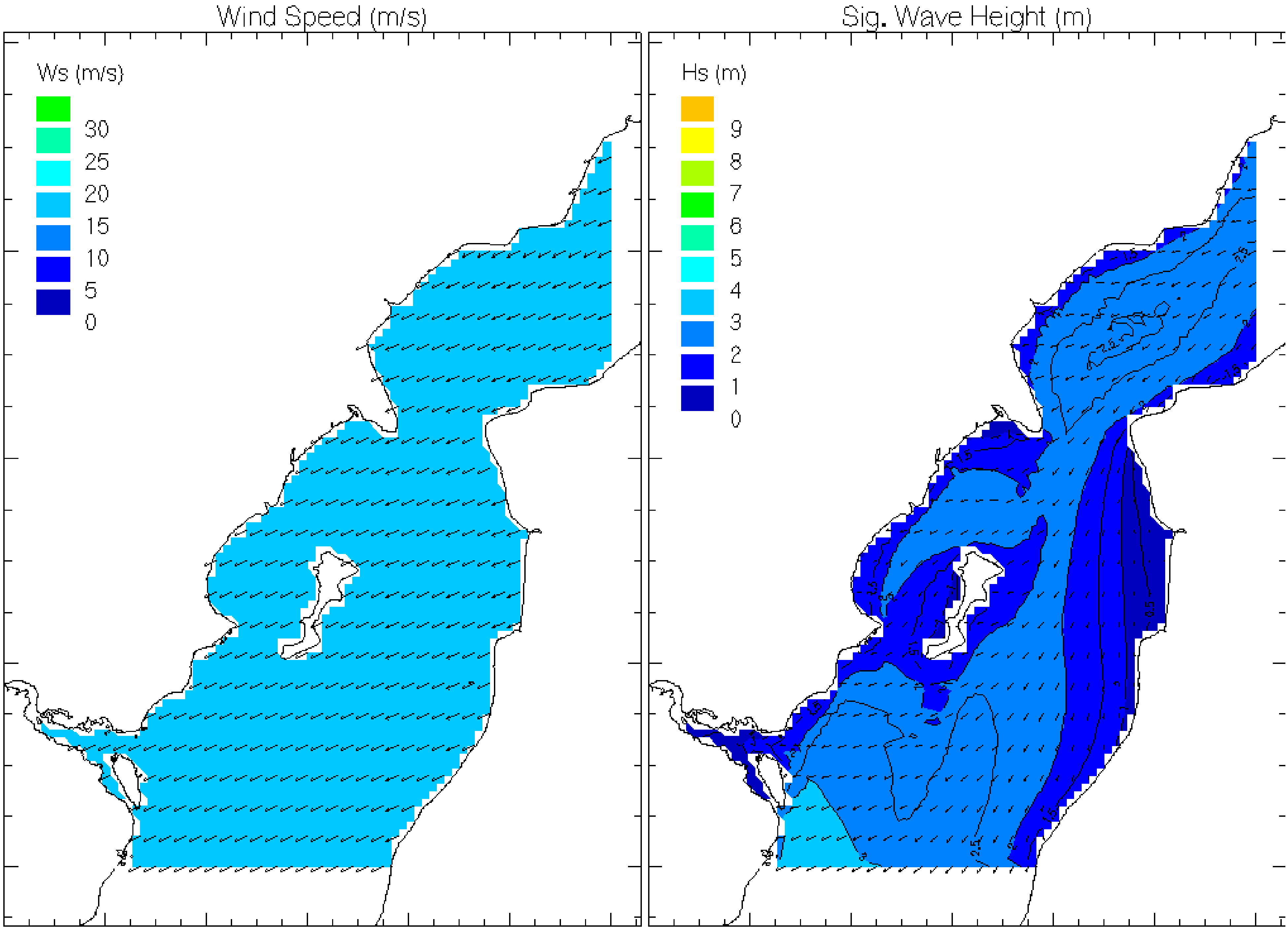
oceanweather inc.

Kenai MTR Maximum Hindcast Winds and Waves during 50Yr_ENE



Kenai Maximum Hindcast Winds and Waves during 50Yr_ENE



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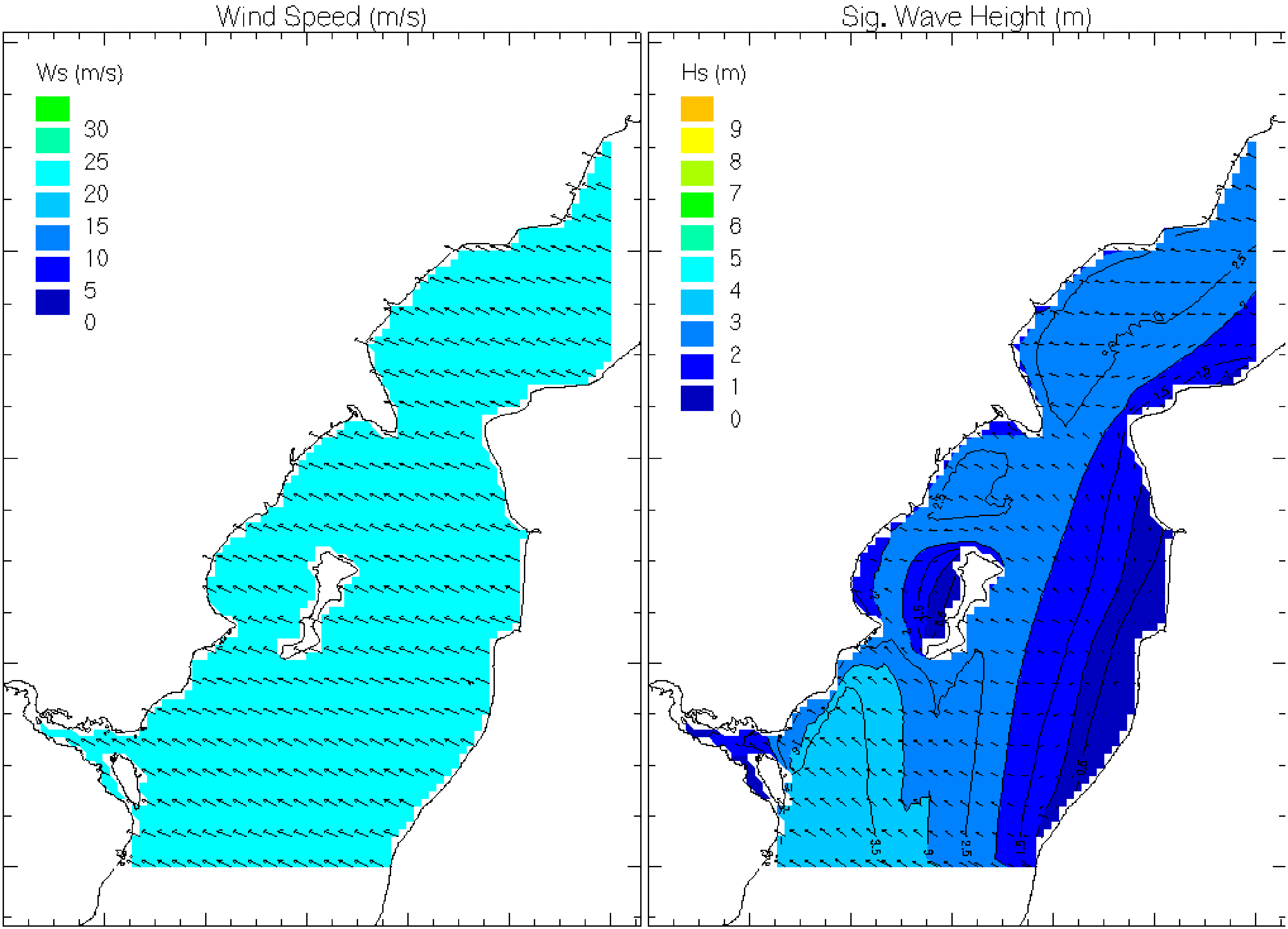
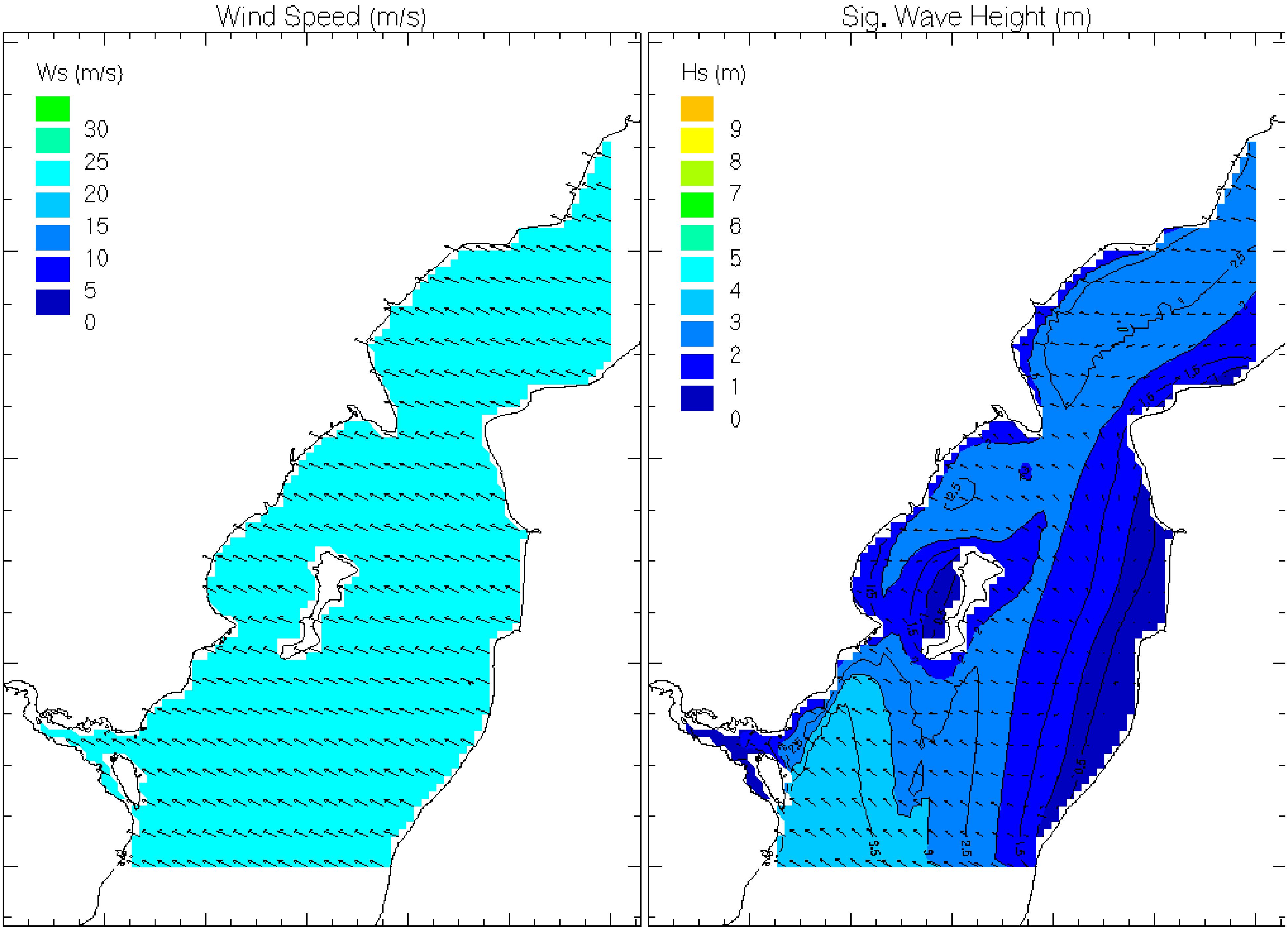
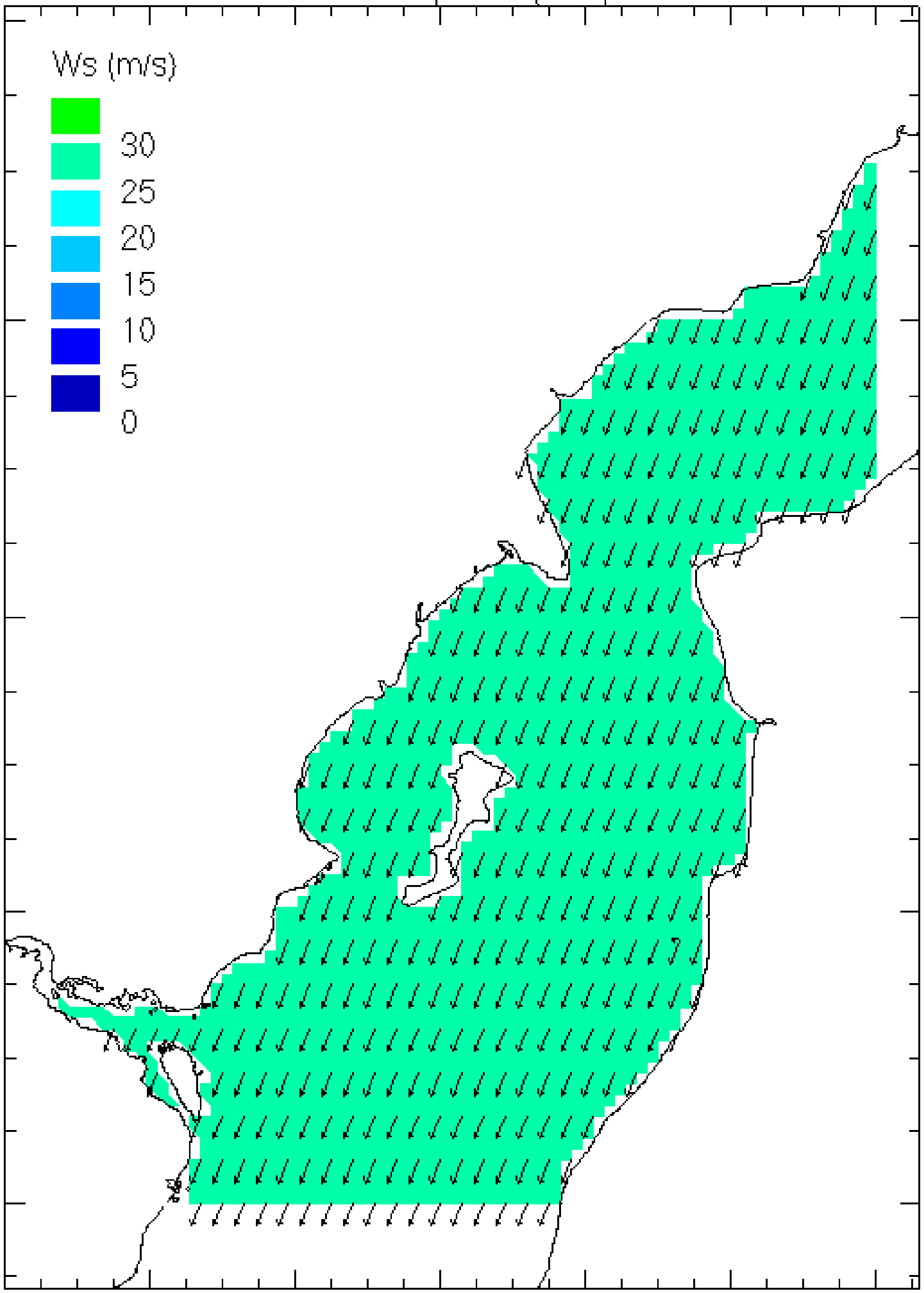
Kenai MTR Maximum Hindcast Winds and Waves during 50Yr_ESE

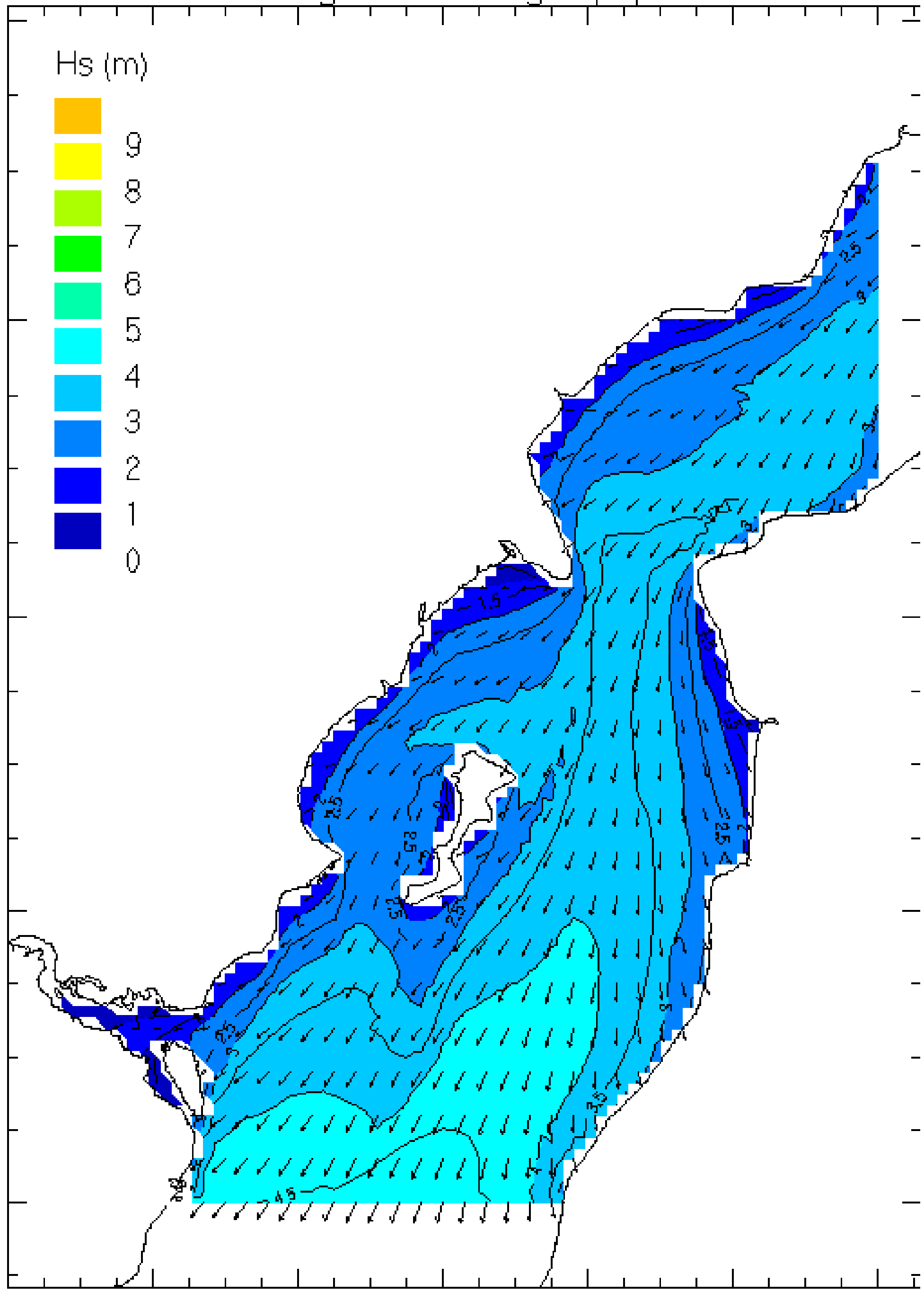


Kenai Maximum Hindcast Winds and Waves during 50Yr_ESE



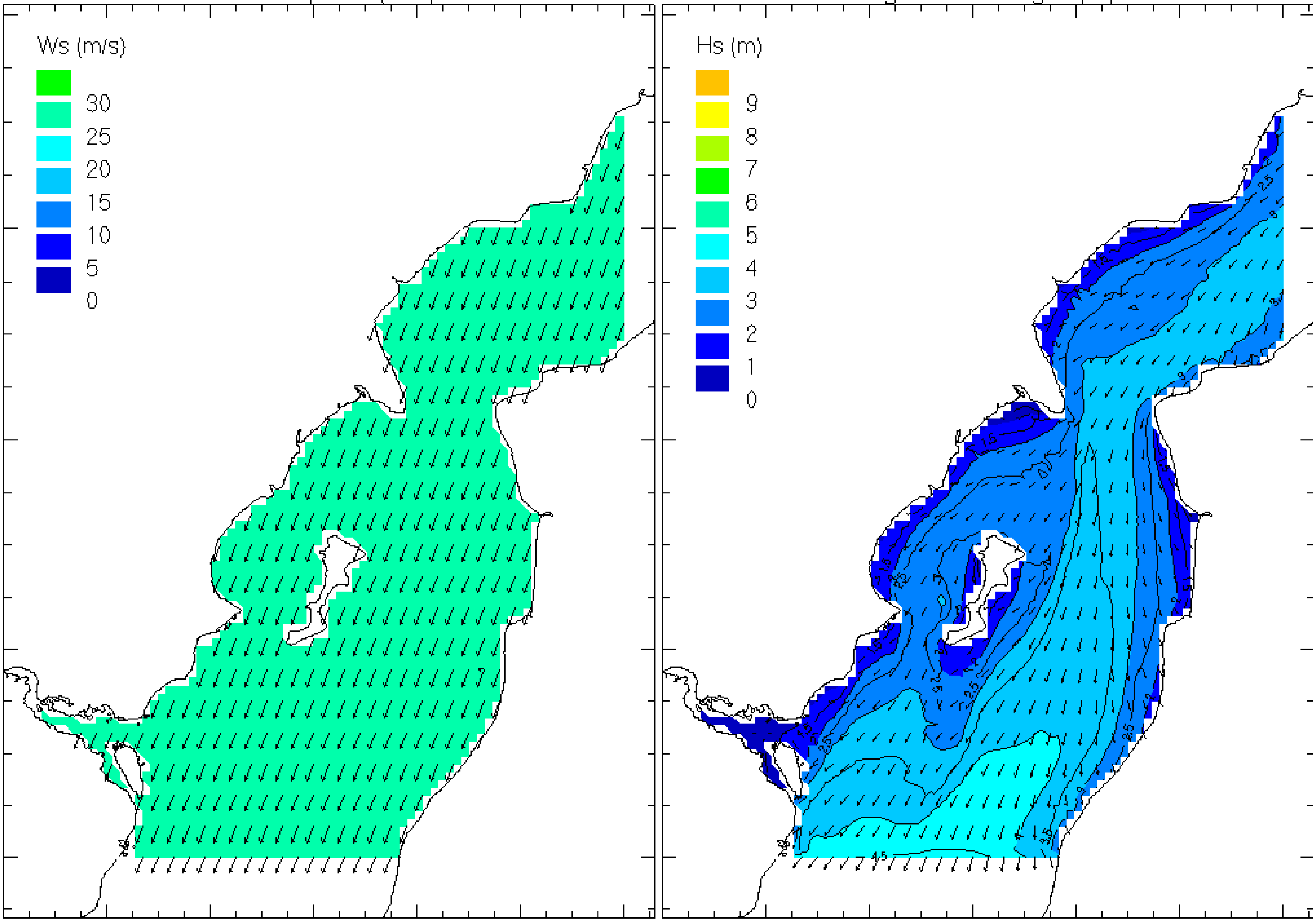
Kenai MTR Maximum Hindcast Winds and Waves during 50Yr_NNE





Kenai Maximum Hindcast Winds and Waves during 50Yr_NNE

Wind Speed (m/s) Sig. Wave Height (m)



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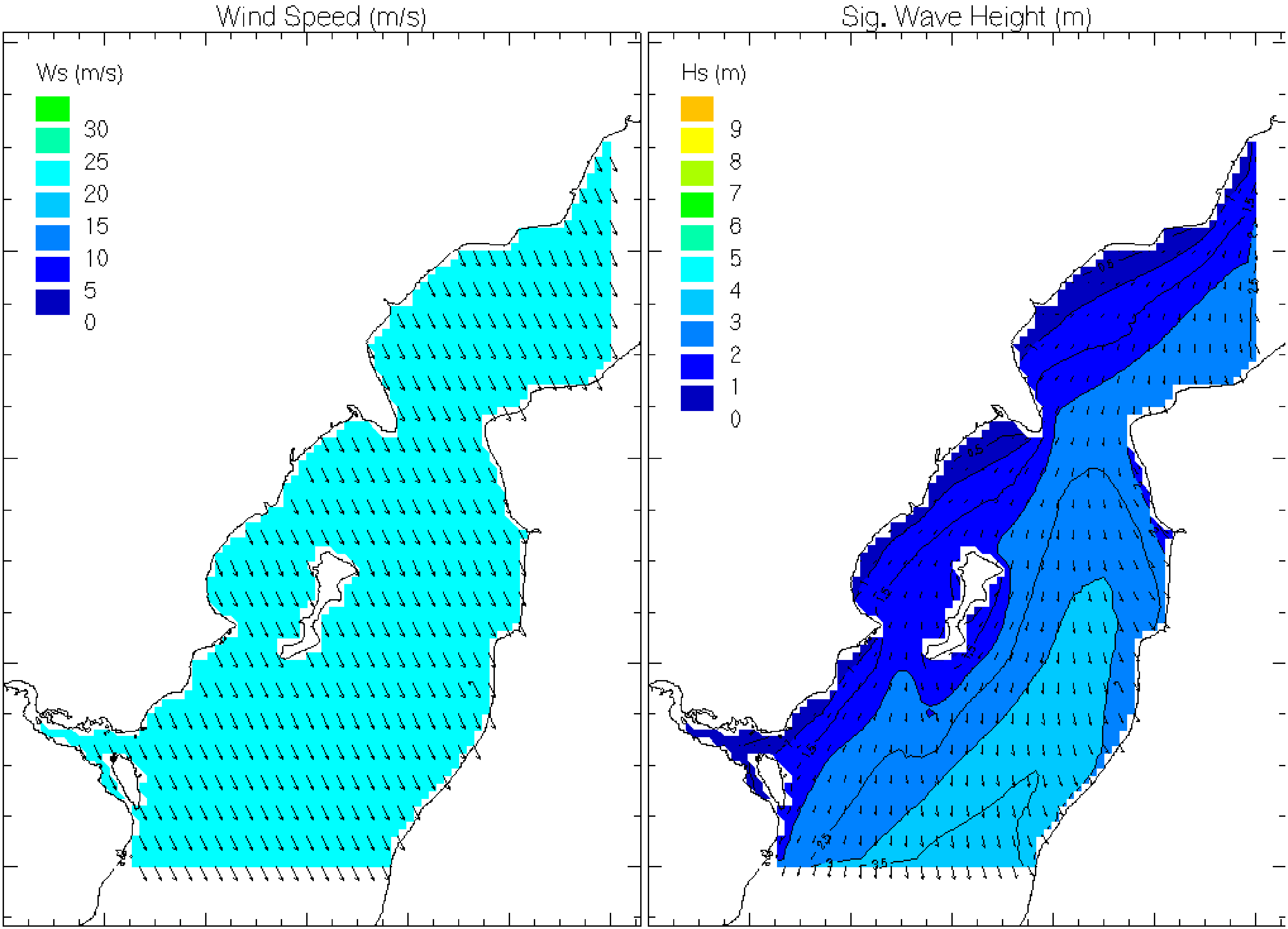
Kenai MTR Maximum Hindcast Winds and Waves during 50Yr_NNW



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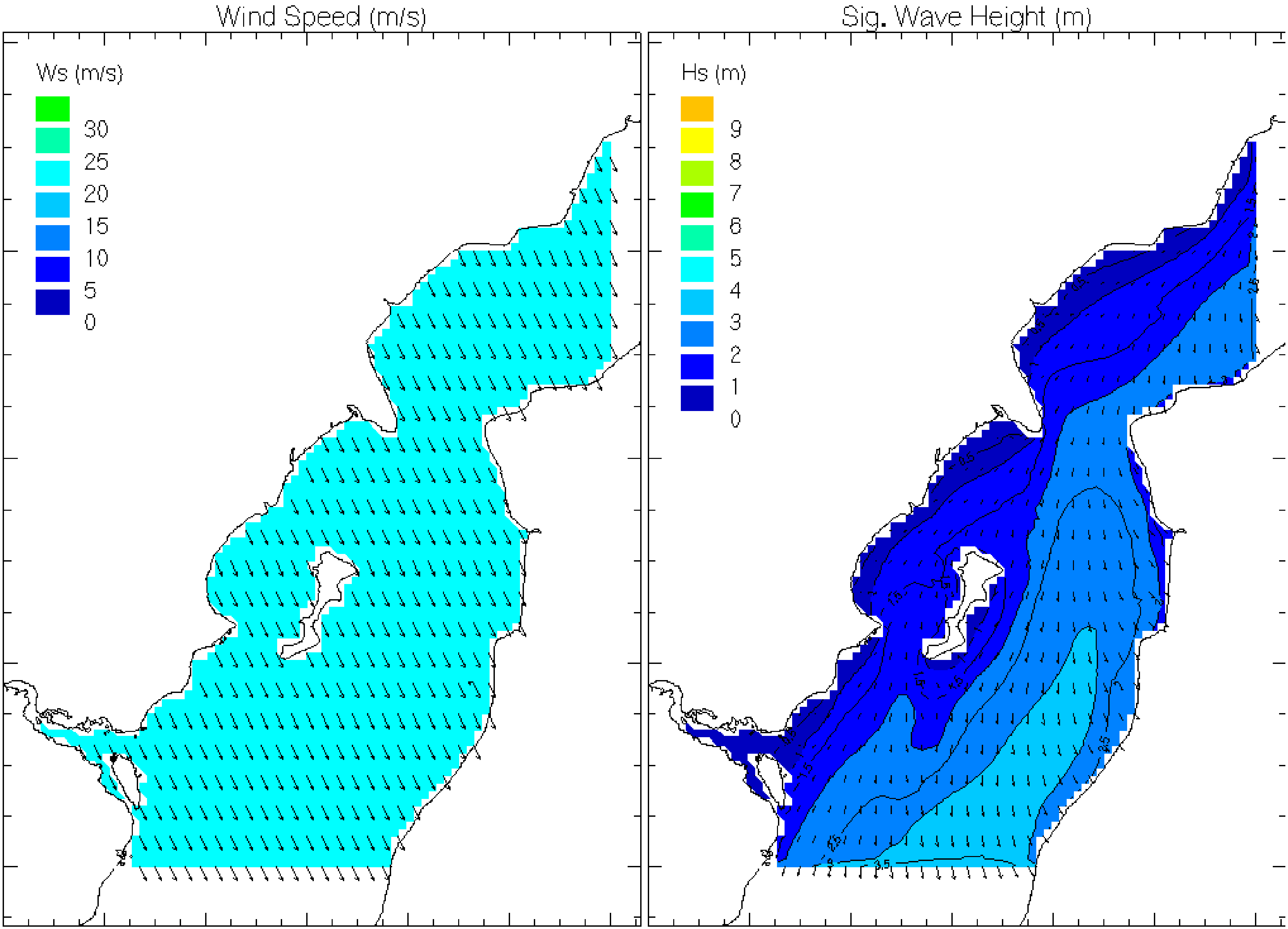
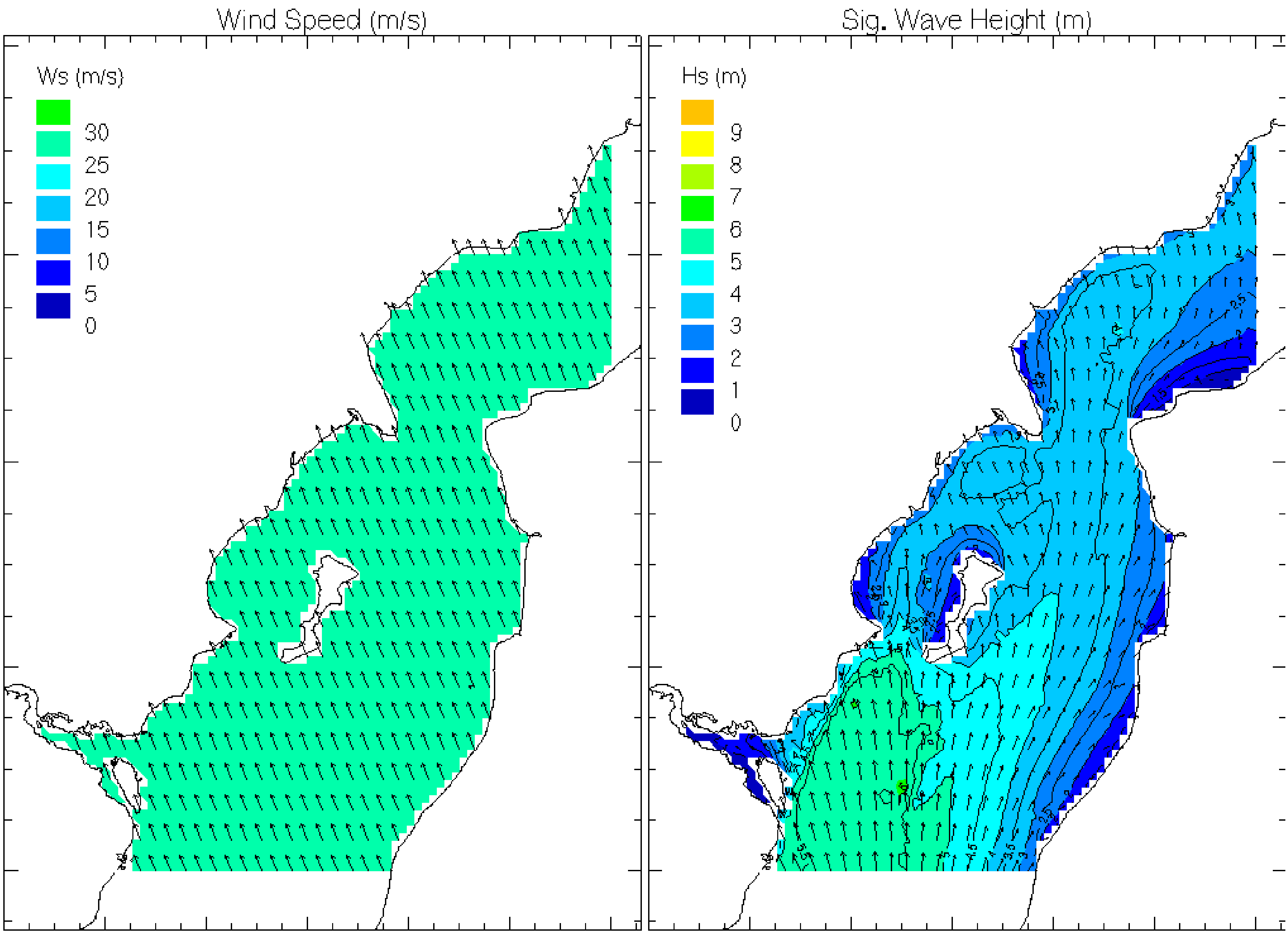
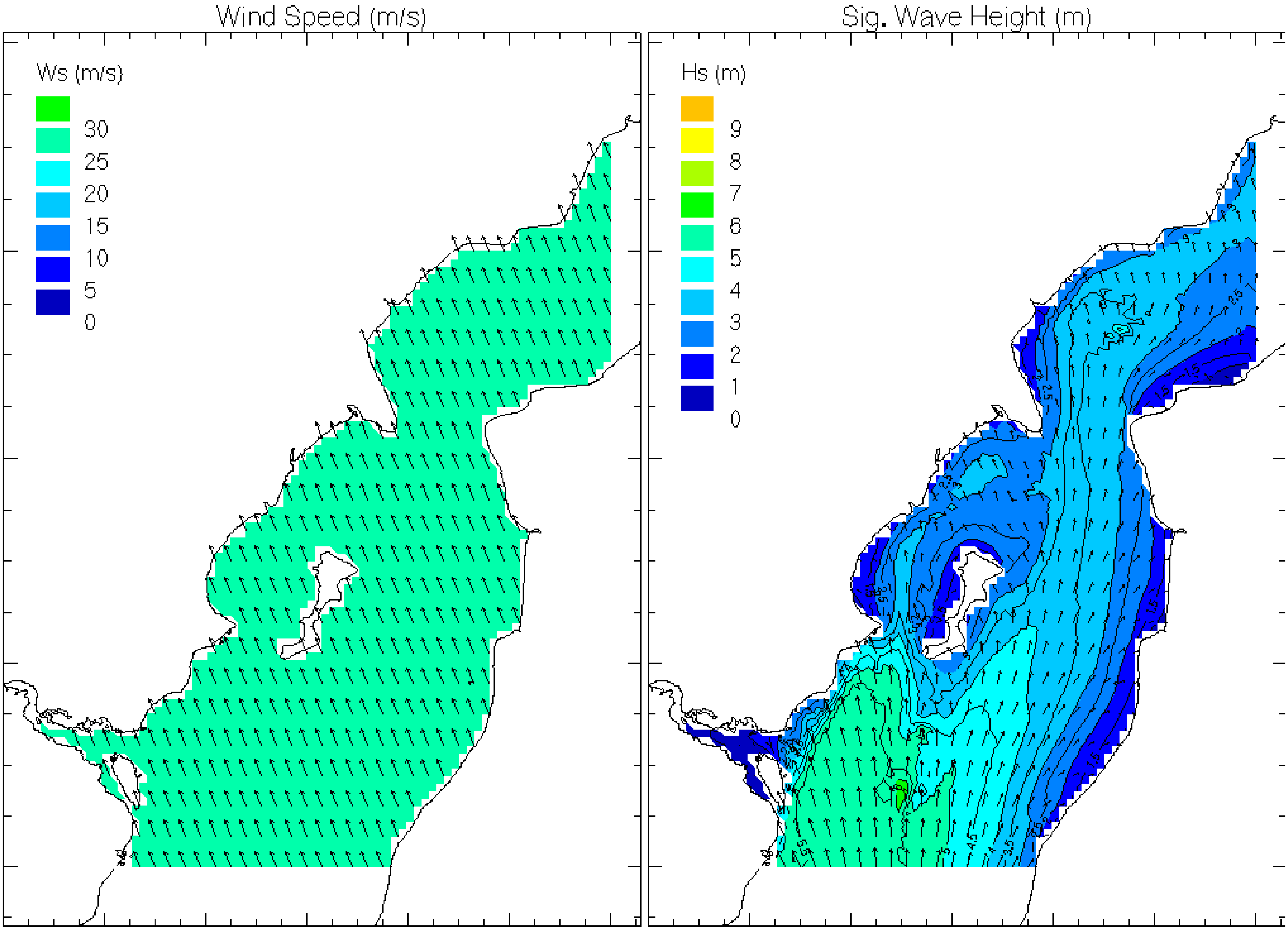
Kenai Maximum Hindcast Winds and Waves during 50Yr_NNW



Kenai MTR Maximum Hindcast Winds and Waves during 50Yr_SSE



Kenai Maximum Hindcast Winds and Waves during 50Yr_SSE



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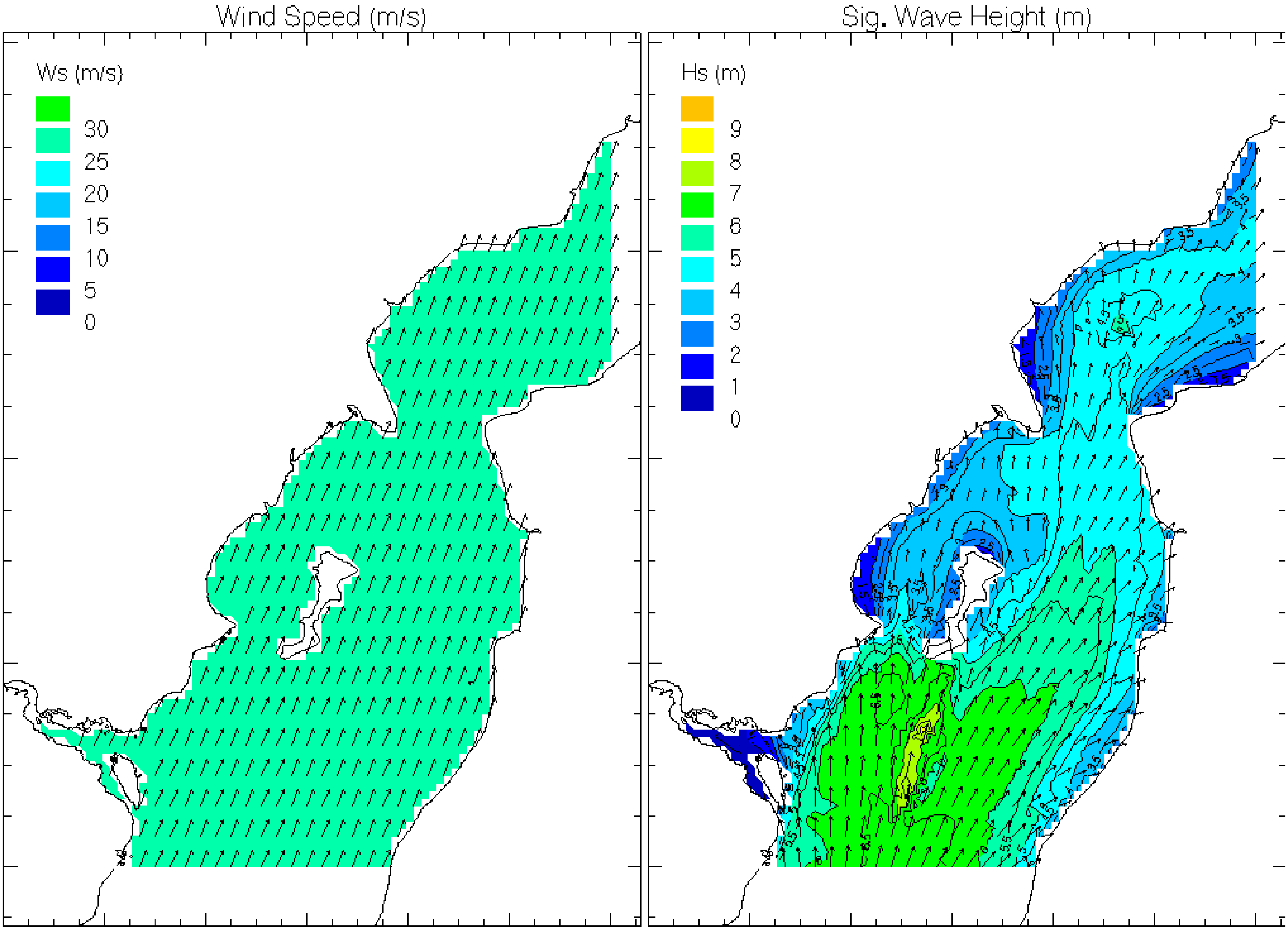
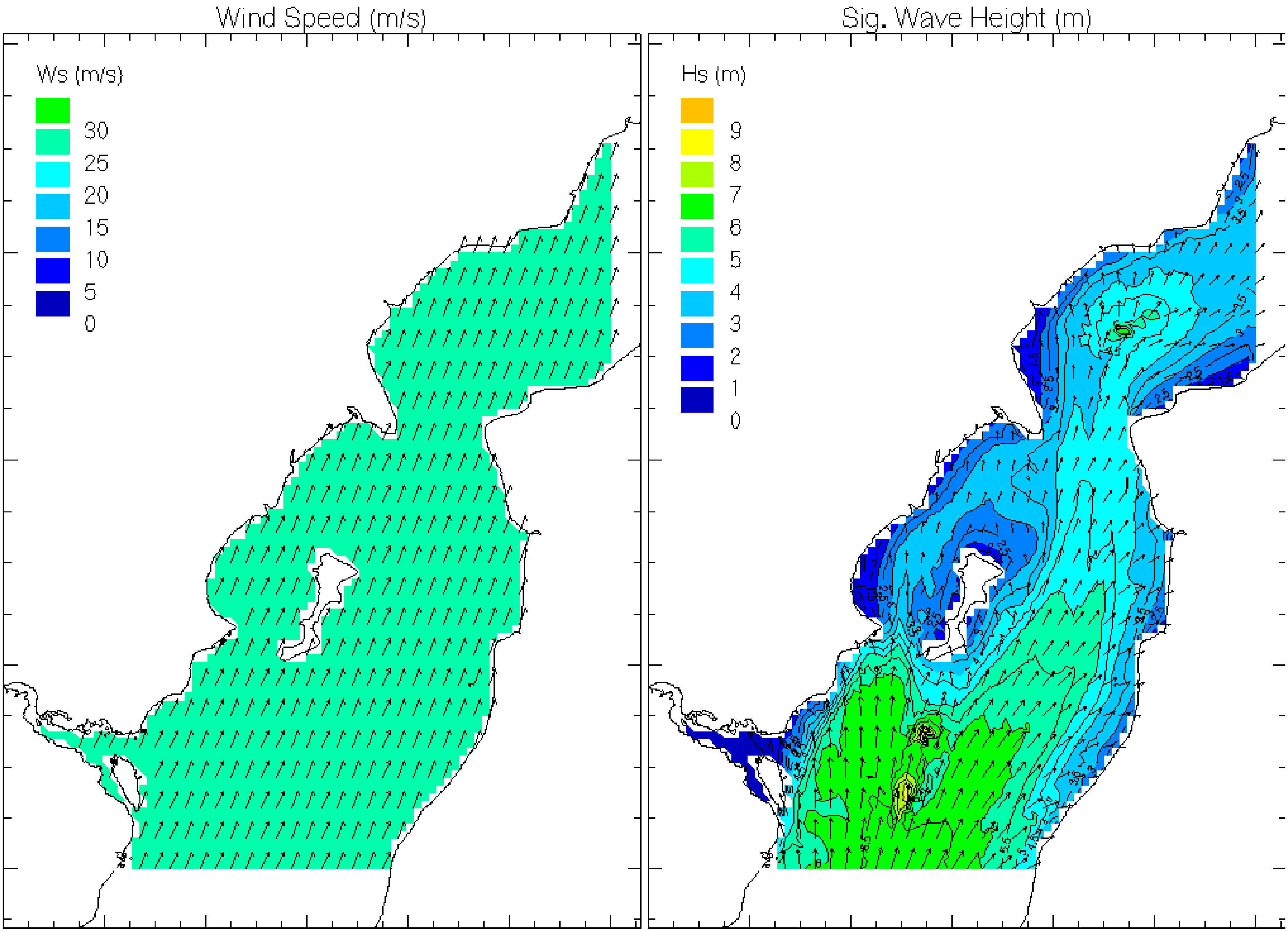
Kenai MTR Maximum Hindcast Winds and Waves during 50Yr_SSW



Kenai Maximum Hindcast Winds and Waves during 50Yr_SSW



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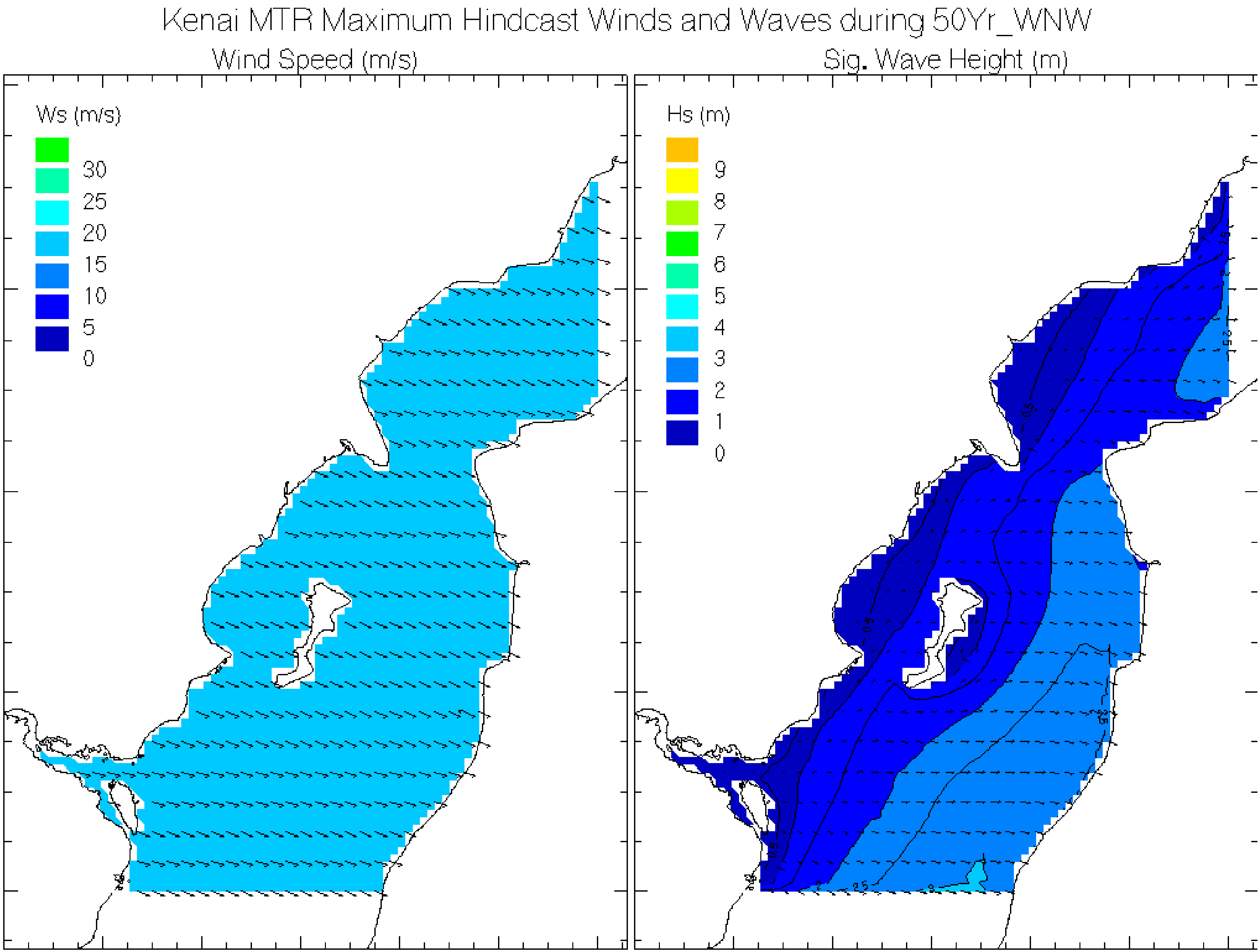

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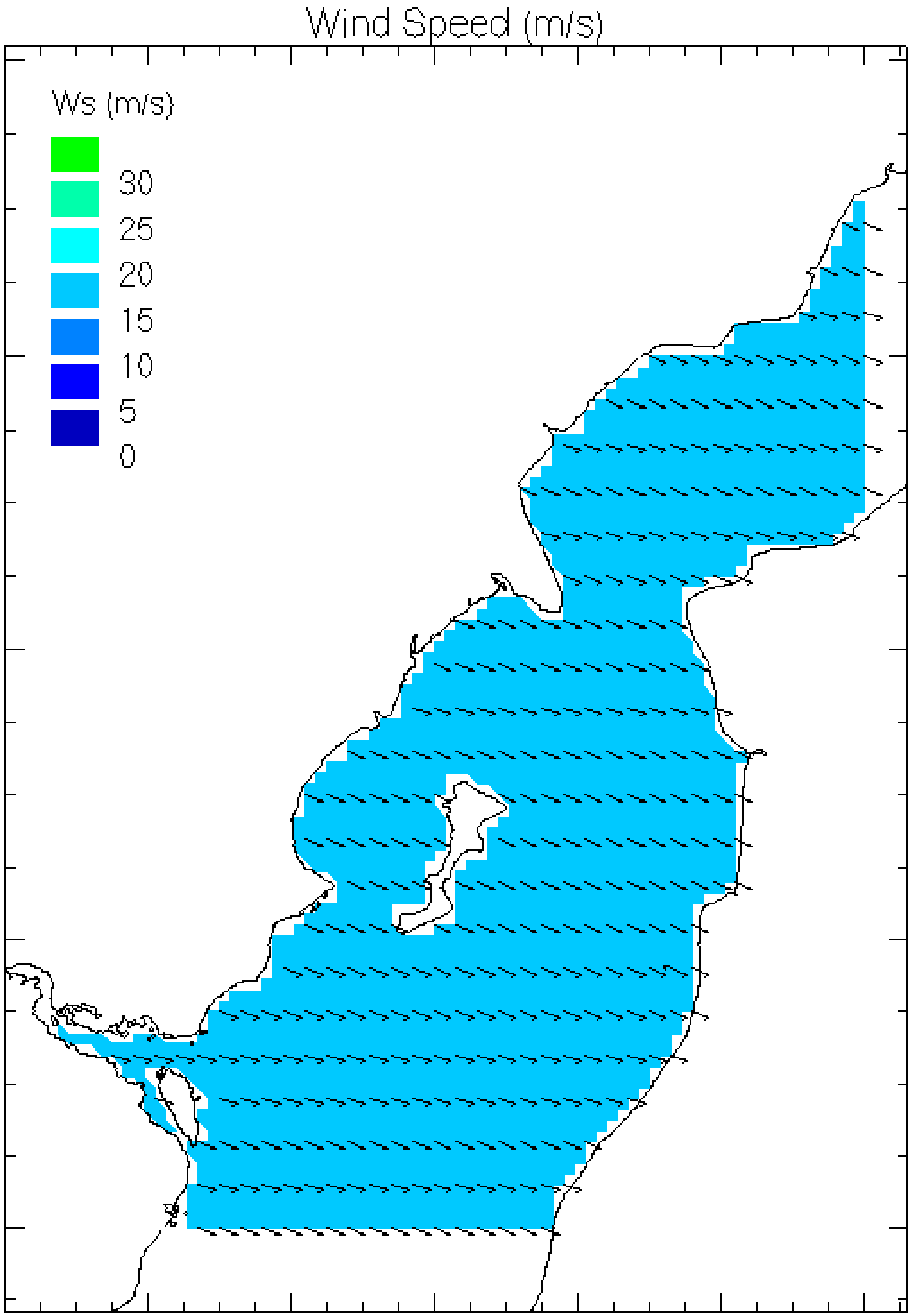
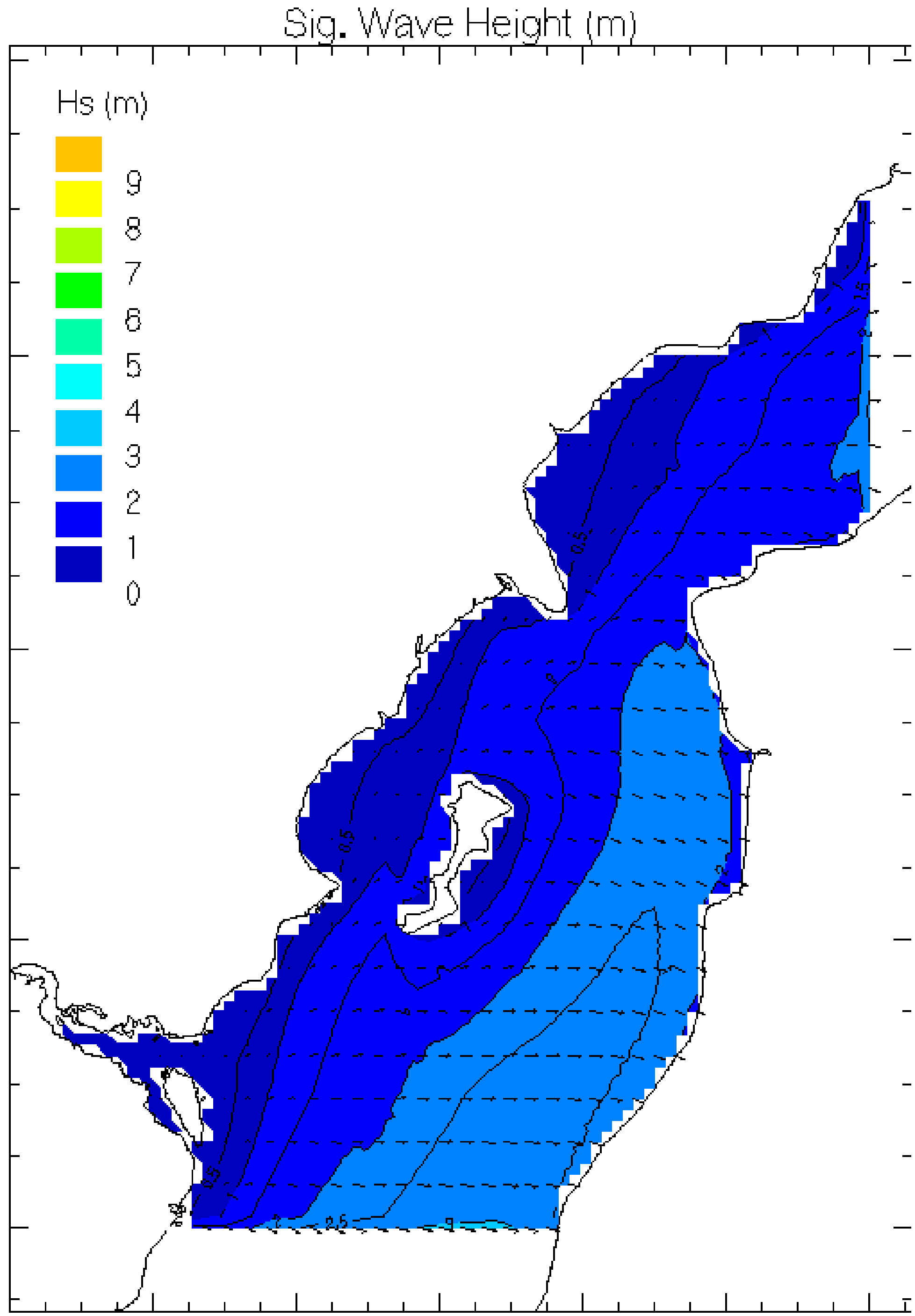
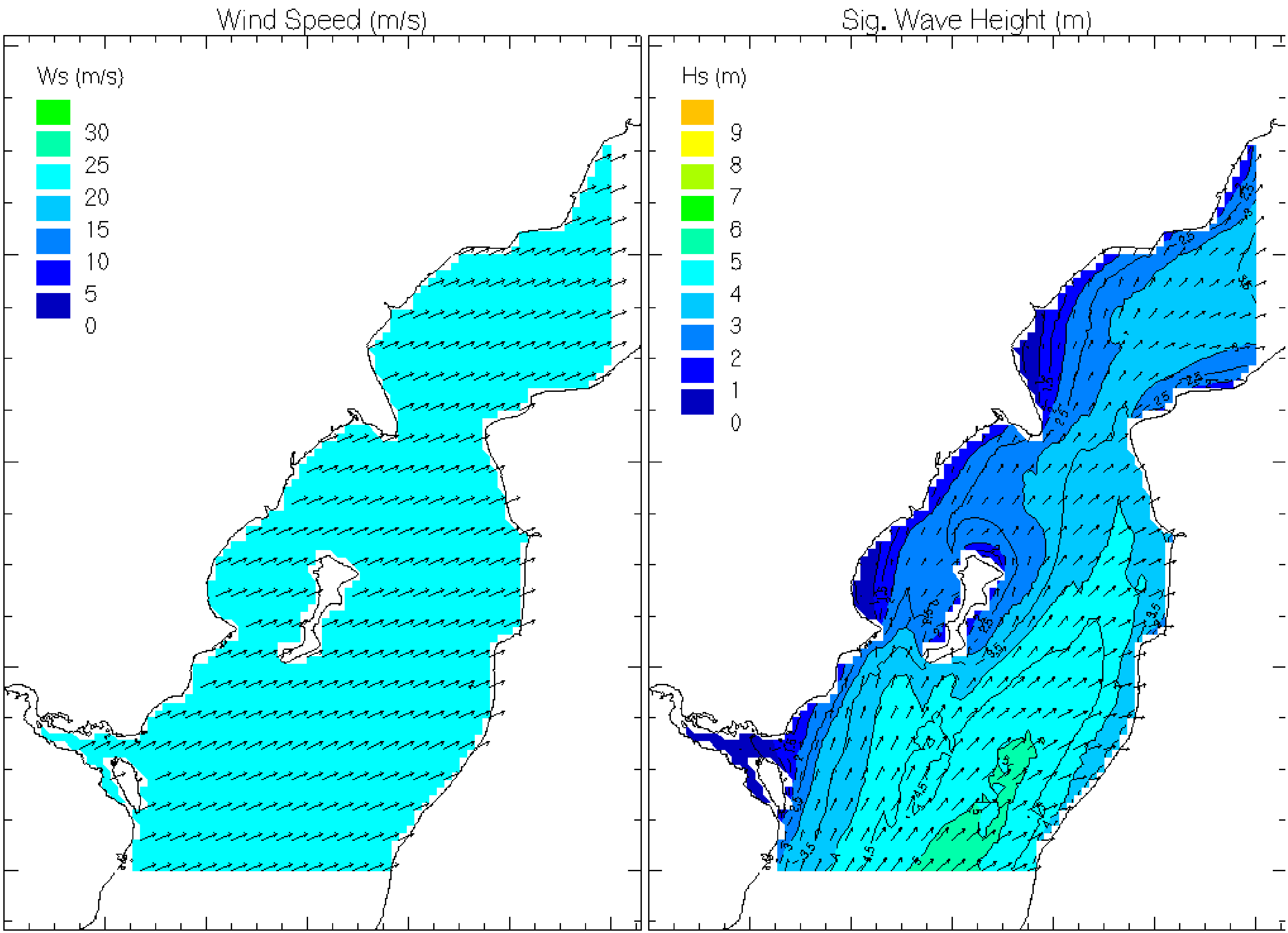
oceanweather inc.

Kenai Maximum Hindcast Winds and Waves during 50Yr_WNW

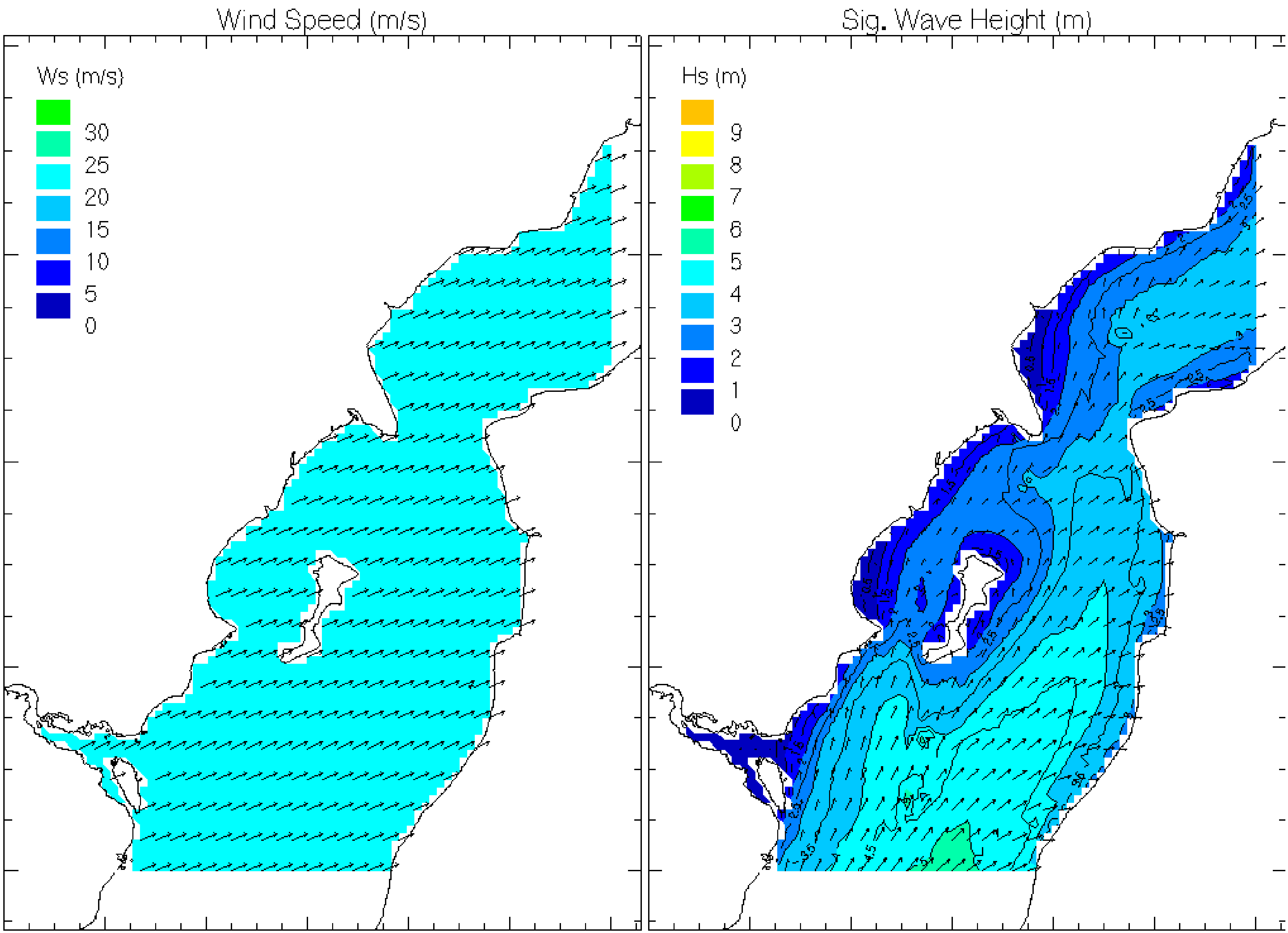




Kenai MTR Maximum Hindcast Winds and Waves during 50Yr_WSW



Kenai Maximum Hindcast Winds and Waves during 50Yr_WSW



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