Akutan Airport Marine Access Study

Prepared for
HDR Alaska, Inc.
Anchorage, Alaska

File No. 04057
July 2005

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Consulting Engineers Serving the Marine Community

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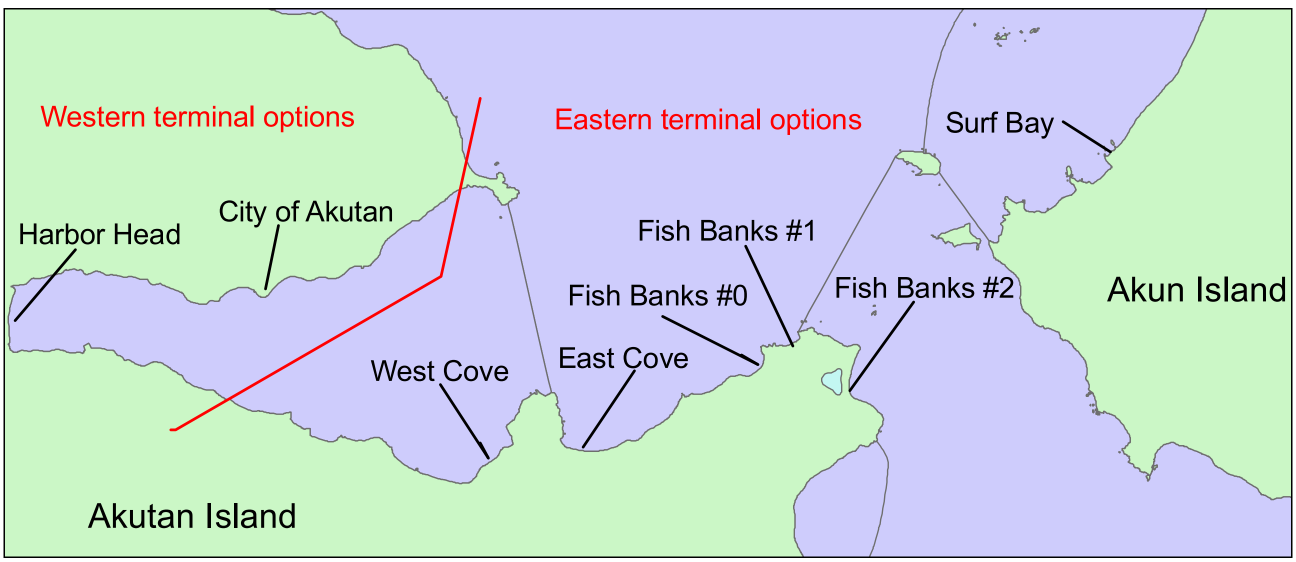
Executive Summary

This report examines the operability of potential marine routes, vessels and terminal sites for a water crossing between the City of Akutan and a proposed airport, located either near Fish Banks Lake on Akutan Island or on Akun Island south of Surf Bay.

Vessels

Three vessel types were considered for access to proposed airport sites near the community of Akutan, Alaska: landing craft, conventional ferry (with bow ramp) and hovercraft. Two western terminal locales were explored near the community of Akutan. Five eastern terminus alternatives were considered on Akutan Island and one on Akun Island.



Based on the beach environment and wave exposures, it was recommended that landing craft be eliminated from consideration. Further study was carried out for the conventional ferry and hovercraft to terminus sites on Akutan and Akun Islands.

Terminal Locations

Both western terminal locales were determined feasible for a conventional ferry or hovercraft. The hovercraft could operate from the Akutan seaplane landing pad following modifications to the sea ramps. However, the hovercraft hangar and maintenance facility would need to be located elsewhere, such as at Harbor Head. The Alaska Marine Highway System

(AMHS) dock or skiff harbor at Akutan could be modified to serve a conventional vessel, but the continued use as a skiff harbor would be compromised if it were modified to accommodate a conventional ferry..

East Cove is subject to storms, making it difficult to maintain landing facilities. East Cove was carried forward to weather operability analysis for both hovercraft and conventional ferry operations. West Cove is suitable for conventional ferry and hovercraft operations. The beaches at Fish Banks #0 and #1 were found to be too narrow to allow hovercraft landing without extensive blasting to excavate a landing space. Fish Banks #1, having a broader beach, was chosen over Fish Banks #0 for weather operability analysis. Fish Banks #2 was determined to be steep and unstable, so that it would be difficult to maintain permanent alterations to the beach necessary for hovercraft access. Fish Banks #0, #1 and #2 were found to be unsuitable for conventional ferry because of wave exposure. Surf Bay (Akun Island) could support a hovercraft terminal; however, due to the long, shallow approach to the beach, a conventional ferry could not land at this location without the building of an extensive pier.

Weather Operability

A weather operability goal of 90% was established for the hovercraft and the conventional ferry. Wind and wave climatologies were developed and the weather operability was evaluated by month. Weather operability estimates reflect both safety considerations and passenger comfort. Operability analysis indicated that a hovercraft can meet this goal in all months when operated to West Cove, East Cove or Surf Bay (Akun Island), but not to Fish Banks #1. The conventional ferry can meet this goal when operated to West Cove. A conventional ferry could not operate into East Cove during all months.

The following table summarizes hovercraft and conventional ferry feasibilities for each potential eastern terminus, based on weather operability and shore-vessel interface concerns:

Eastern Terminus	**Hovercraft**	**Conventional**
Surf Bay (Akun Island)	✓	✗
West Cove	✓	✓
East Cove	✓	✗
Fish Banks #0	✗	✗
Fish Banks #1	✗	✗
Fish Banks #2	✗	✗

Costs

Cost of a conventional ferry and hovercraft were determined in 2005 dollars. The cost of shore-vessel interface and other supporting shoreside facilities varies considerably with the choice of eastern terminus.

A conventional vessel-shore interface at West Cove will cost more than a hovercraft-shore interface.

The following table compares conventional and hovercraft costs:

Costs	**Conventional**	**Hovercraft**
System acquisition	$4.5 M to 7.2 M	$9.6M
Annual vessel operating	$640K to $1.5M	$560K to $1.0M
20-year life cycle	$11.2M to $30.3M	$15.5M to $25.1M

Recommendation

Based on an investigation of potential marine vessels, routes and terminal locations on Akutan and Akun Islands, a hovercraft to West Cove or Surf Bay (Akun Island) is recommended.

SECTION 1

Introduction

This section sets forth the questions addressed by the study, presents a general description of Akutan and describes the structure of the report.

The Alaska Department of Transportation and Public Facilities (DOT&PF), in cooperation with the Federal Aviation Administration (FAA), is exploring the feasibility of a land-based airport serving the City of Akutan on Akutan Island, Alaska. On behalf of the FAA and DOT&PF, HDR Alaska, Inc. has charged The Glosten Associates with the following tasks:

1. Identify and evaluate potential vessel types, routes and terminal sites for marine access between City of Akutan and a new airport located either on Akutan Island near Fish Banks Lake, or on Akun Island near Surf Bay.
2. Report on the feasibility of the various vessel and route combinations and the feasibility of converting existing terminal facilities at the City of Akutan.
3. Perform a weather operability analysis of the feasible vessel and route alternatives, in support of twice-daily air service.
4. Perform a cost analysis of vessel acquisition costs, operating costs and 20-year life cycle costs for the vessel alternatives.

Specifically, this study addresses the following questions:

- What vessel types are feasible for a marine crossing between the City of Akutan and the airport? What are the dimensions and carrying capacity of the vessel alternatives?
- What are the most favorable sites for landing a vessel near the proposed airport and near the City of Akutan?
- What is the anticipated weather operability of the service?
- What are the acquisition cost, annual operating cost and 20-year life cycle cost of the vessel alternatives for twice-daily service?

General Description of Akutan

Lying between Unimak Island and Unalaska Island, Akutan Island is a member of the chain of rugged, volcanic Aleutian Islands stretching westward from the tip of the Alaska Peninsula at False Pass towards the Russian coast. Akutan is approximately 763 miles from Anchorage and 35 miles northeast of Dutch Harbor on Unalaska Island.

Akutan Island is approximately 18 miles long (along an east-west axis) and 13 miles wide. Akutan Island to the west and Akun Island to the east form the boundaries of Akutan Bay (see Figure 1). Akutan Bay is open to the Bering Sea to the north. Akun Strait gives access to the North Pacific (Gulf of Alaska) to the south, but Akun Strait is shoal and subject to strong currents. Refraction around Rootok Island (southwest of Akun Strait) and shoaling and wave breaking in Akun Strait prevent most of the wave energy generated in the Gulf of Alaska from penetrating into Akutan Bay, but can cause a confused and severe breaking wave environment within Akun Strait. While these features protect Akutan Bay from Pacific swell from the south, it is subject to Bering Sea swell arriving from the north. Akutan Bay opens into Akutan Harbor extending along an east-west axis towards the west.

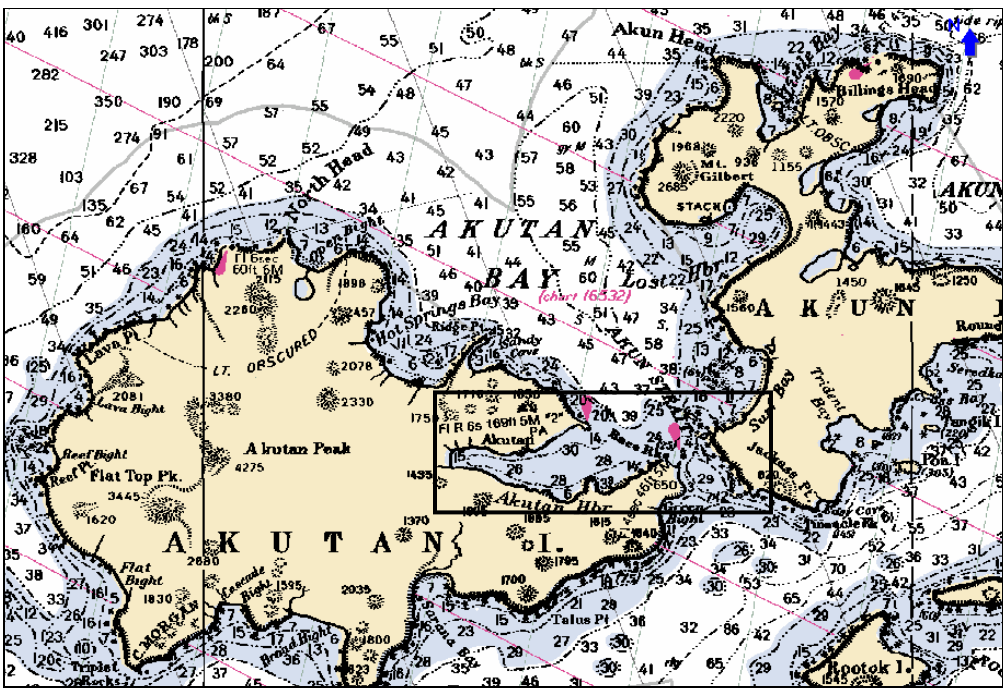


Figure 1: Akutan Island, Akun Island, Akutan Bay and Akun Strait

Akutan Harbor, shown in Figure 2, is a glacially-formed fjord about 3.9 miles long and approximately 1.8 miles wide at its mouth, narrowing to about 0.6 miles at its head. The harbor is a large and naturally deep harbor with a relatively flat bottom, and is conducive to the operations of deep-draft commercial fishing vessels. The head of the harbor is a flat valley with a gradually increasing slope, while the northern and southern shorelines are rocky and steep. The inner portion of the harbor, west of a line from Akutan Point to Big Head, is substantially sheltered from incoming Bering Sea swell.

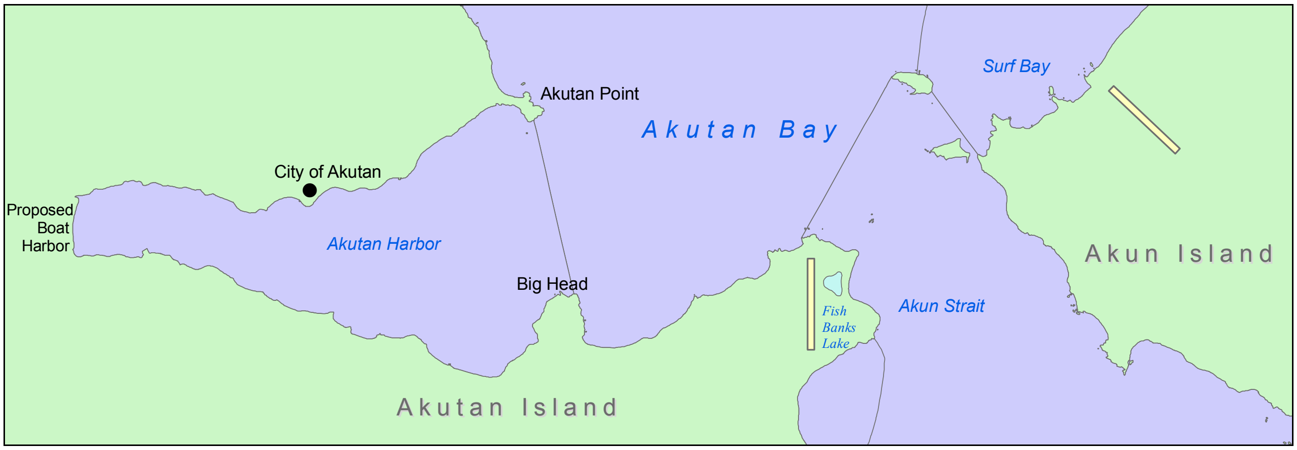


Figure 2: Akutan Harbor and surrounding landmarks

Background

The City of Akutan is located on the east side of the island, on the north side of Akutan Harbor, at approximately 54° 8' N and 165° 46' W. At present, there exists a 200-ft dock and a small-boat mooring basin at Akutan. The 200-ft dock receives seasonal use by the Alaska Marine Highway System (AMHS) ferry *Tustumena*. There is also a concrete seaplane base with two ramps located on the shoreline between the City of Akutan and the nearby Trident Seafoods plant. The seaplane base is used by the *Grumman Goose*, a twin-engine seaplane operated by PenAir, with scheduled twice-daily service between Unalaska/Dutch Harbor and Akutan. Further, there are plans to develop a new, small-boat harbor at the head of Akutan Harbor.

HDR Alaska conducted a preliminary investigation into the siting of an airport on Akutan Island and ways to enable access between the land-based airport and the City of Akutan (HDR Alaska, 2003). The access options include a road all the way around Akutan Harbor, a direct marine link and combinations of marine service and road access between potential terminal sites and the airport.

The proposed new airport identified in the initial HDR study is to be located on a north-south axis approximately 4.2 miles east-southeast of the City of Akutan, on the south side of Akutan Harbor and near Fish Banks Lake. Five potential sites on the south side of Akutan Harbor were identified for the eastern terminus. Three different types of vessels were also considered for service across the harbor: a landing craft, a conventional ferry (with bow ramps) and a hovercraft.

This study also reports on the feasibility and operability of another potential location for a land-based airport, on Akun Island southeast of Surf Bay, and a potential hovercraft terminal at Surf Bay.

The scope of work that was carried out by The Glosten Associates in the evaluation of the marine access alternatives is as follows:

- Review of relevant previous studies
- Identification of suitable vessels, including approximate vessel dimensions, capacities and weather-operability limits
- Undertaking of a field survey of potential terminal sites
- Review of available meteorological records
- Analysis of wind climatology
- Hindcast of local wave climatology
- Analysis of vessel operability
- Preparation of vessel acquisition, operating and 20-year life cycle cost estimates

The organization of the rest of this report is as follows:

- Section 2 describes the vessel alternatives.
- Section 3 examines the preliminary feasibility of the potential terminal sites and route alternatives.
- Section 4 describes the wind and wave climatology model developed for Akutan Harbor and Akutan Bay.
- Section 5 describes the weather operability analysis and presents the calculated percent operability levels for service with the feasible route-vessel combinations from Section 3.
- Section 6 presents the acquisition, operating and 20-year life cycle costs.
- Section 7 summarizes the study and presents key findings and recommendations.
- Section 8 presents a list of references.

S E C T I O N 2

Vessel Alternatives

This section recommends vessel types for operability analysis and describes the vessel alternatives.

Vessel Types

The HDR Alaska study of 2003 identified three possible vessel types to serve the Akutan route:

- conventional ferry
- landing craft
- hovercraft

Landing Craft

Landing craft is unsuitable due to wave exposure at all eastern terminus alternatives

The beaches at all potential eastern terminus sites on Akutan Island and at Surf Bay on Akun Island are exposed to waves, including transmitted Bering Sea swell. Beach materials at all Akutan Island sites consist of gravel and/or rock that would be unsuitable for repeated landings by a landing craft in waves. The beach at Surf Bay on Akun Island is sandy, but the very gentle beach slope would result in the landing craft grounding well offshore, and there would be a risk of its getting stranded on the beach through a tide cycle. For these reasons a landing craft was eliminated from further consideration.

Conventional Ferry

A conventional ferry requires good seakeeping characteristics and bow and stern ramps

Any conventional ferry serving an airport near Akutan should have a hull form conducive to good seakeeping. For most efficient loading and discharge of vehicles it is recommended that any conventional ferry be arranged with vehicle ramps at bow and stern, so that drive-through vehicle operations can be conducted. As shown in Figure 3, a ferry fitted with bow and stern vehicle ramps and arranged for drive-through roll-on/roll-off vehicle handling does not have to be a double-ended ferry with identical propulsion and rudders at each end. It is possible to achieve this desired arrangement with a single-ended ferry, provided that there is a bow thruster to assist when the ferry is docked stern to the beach.

Figure 3 shows a conventional single-ended ferry vessel of the order of 150 ft length and 40 ft beam, having an installed power of about 1,500 HP. Such a vessel would be able to carry up to 20 vehicles and 150 passengers. The vessel size is dictated not by traffic volume, but by passenger comfort and seakeeping requirements.

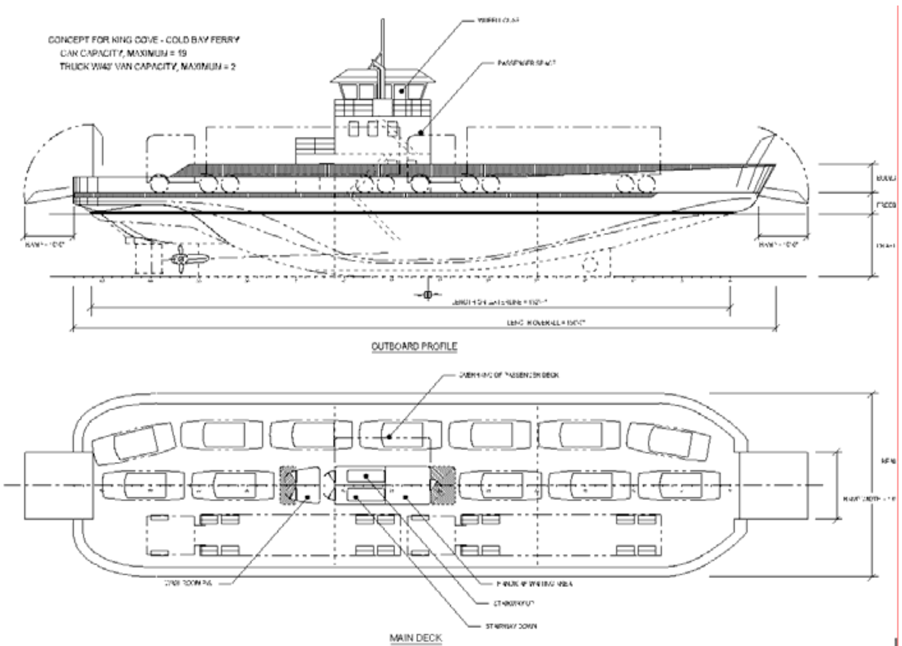


Figure 3: A conventional displacement hull single-ended vessel with bow ramp

Hovercraft Particulars

A hovercraft could be similar to that connecting King Cove and Cold Bay

Among hovercraft alternatives, the BHT 130 hovercraft is proposed for service in Akutan. Aleutians East Borough is in the process of acquiring this model hovercraft to connect King Cove with the Cold Bay airport. The proposed Cold Bay model is a "half-well" configuration with vehicle bow ramp (Figure 4) that carries approximately 50 passengers and up to four vehicles or a similar amount of freight in the open well deck. This configuration would be suitable for service across Akutan Bay and Harbor.

Figure 4: BHT 130 hovercraft

Figure 5 and Figure 6 show the outboard and inboard profiles and exterior and interior deck arrangements of the BHT 130 hovercraft and Table 1 lists its principal characteristics.

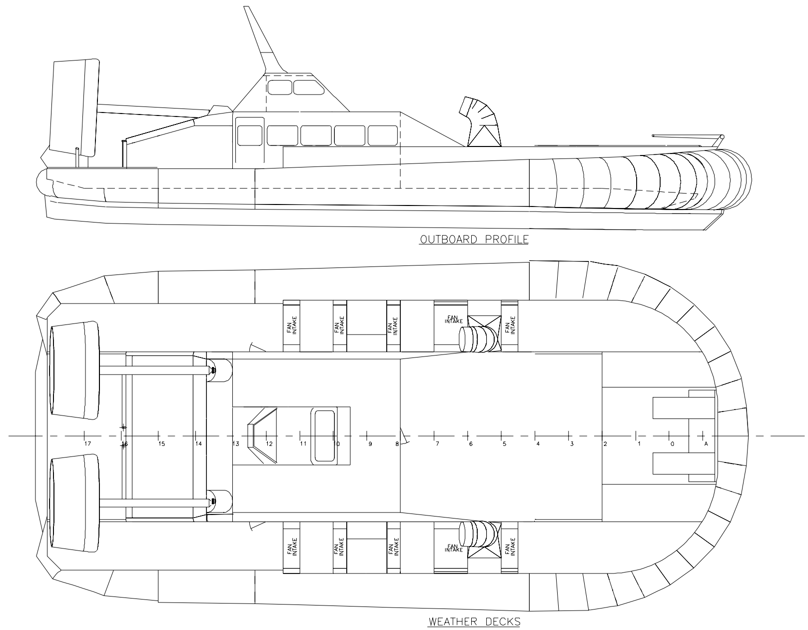


Figure 5: BHT 130 hovercraft outboard profile and exterior deck arrangement

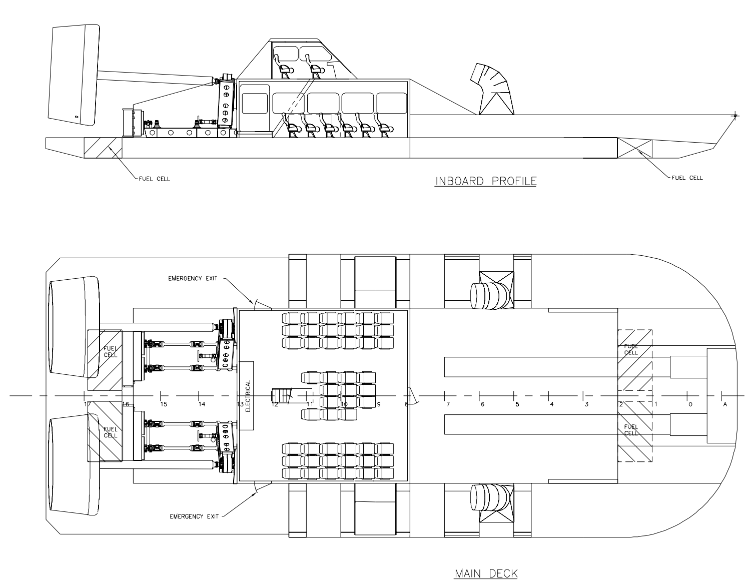


Figure 6: BHT 130 hovercraft inboard profile and interior deck arrangement

Table 1: Principal characteristics of BHT 130 hovercraft

Length	95 ft
Beam	46 ft
Skirt Depth	5.4 ft
Propellers	11.5 ft
Speed	Up to 60 knots in calm conditions*
Propulsion Power	2 x 1,300 = 2,600 HP
Lift Fan Power	2 x 1,300 = 2,600 HP

* While the BHT 130 has a claimed maximum speed of 60 knots when operating lightly loaded under calm conditions, a service speed of 40 knots has been presumed in this study for the purposes of assessing passenger motion sickness incidence, schedule and weather operability.

SECTION 3

Terminal and Route Alternatives

This section presents a preliminary assessment of the feasibility of terminal locations. The resulting routes were subjected to the weather operability analysis described in Section 5.

This section describes the potential terminal locations based on observations made during site visits. Sites are evaluated for service by a conventional ferry and by a hovercraft. The various facilities and/or site modifications necessary to support these marine operations are considered. Some sites are eliminated from further consideration on the basis of field observations, while others are carried forward into weather operability analyses described in subsequent sections of this report.

Field Surveys

As part of the current study, two site visits were conducted. In July 2004, Bruce Hutchison, P.E. of The Glosten Associates examined the five potential eastern terminal sites on the south side of Akutan Harbor, as well as the Harbor Head site on the north side.

In March 2005, the team consisted of Kate Pearson of HDR Alaska, Inc., Dan Rowley, P.E. of Aleutians East Borough, John McGrath, hovercraft operations expert, and Bruce Hutchison, P.E. The team conducted a more in-depth study of the five potential eastern terminal sites on the south side of the harbor and an additional site on Akun Island. The team also examined the two proposed western terminal sites on the north side of the harbor.

Terminal Location

Potential terminal locations were investigated near Akutan. At the western terminus near the community of Akutan, two potential terminal sites have been identified:

- At the City of Akutan
- At Harbor Head, north of the proposed small boat harbor

Five eastern terminus alternatives, near a potential airport site at Fish Banks, were considered on Akutan Island, as well as one on Akun Island:

- West Cove, approximately five miles from a proposed airport at Fish Banks
- East Cove, approximately three miles from a proposed airport at Fish Banks
- Fish Banks #0, just northwest of a proposed airport at Fish Banks
- Fish Banks #1, just north of a proposed airport at Fish Banks
- Fish Banks #2, just southeast of a proposed airport at Fish Banks.
- Surf Bay on Akun Island, just northwest of a potential airport on Akun Island.

Figure 7 shows all potential terminal sites.

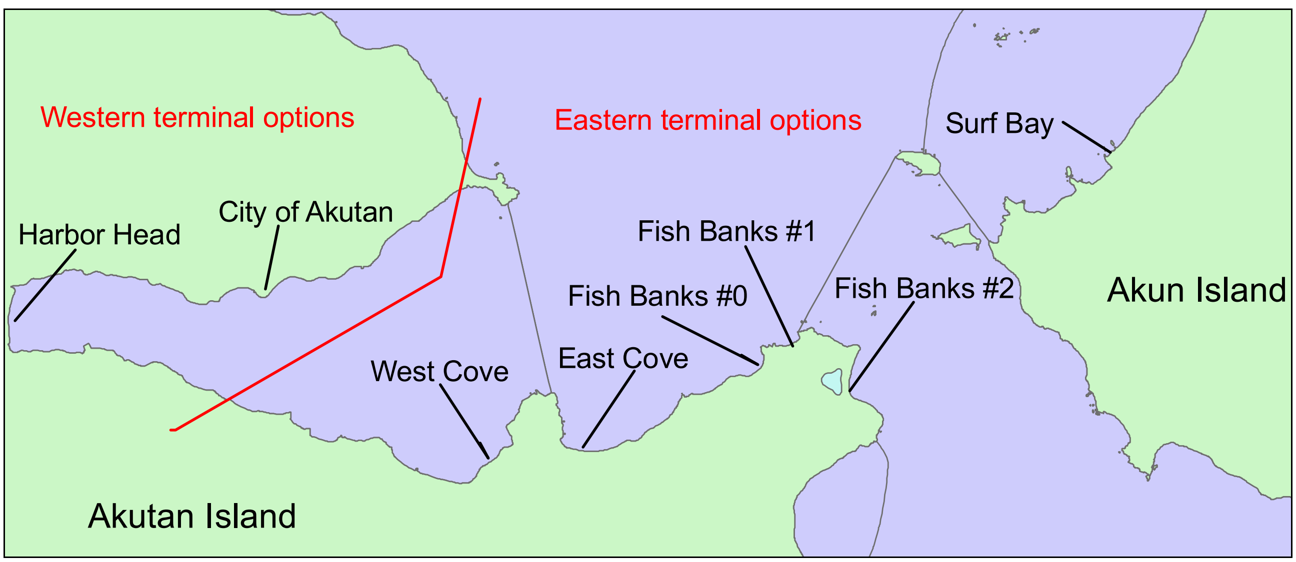


Figure 7: Map of potential terminal sites

Western Terminals

City of Akutan

City of Akutan is carried forward for weather operability analysis

There are three existing facilities of note at the City of Akutan:

- A 200-ft dock that is used by the Alaska Marine Highway System (AMHS) ferry *Tustumena*. A portion of this dock also serves as the breakwater protecting the existing skiff harbor at Akutan. With significant alteration, this dock could be modified to provide side load transfer span access to a conventional ferry serving an Akutan airport.

- The skiff harbor that is protected by the shoreward extension of the AMHS ferry dock could be modified to provide a stern or bow access ramp to a conventional ferry. Such a modification would eliminate most or all of the existing skiff moorage locations.
- The seaplane landing pad could serve as a loading and discharge site for hovercraft. Due to the size of the existing seaplane landing pad, the obstacles to enlargement, and the other uses of the pad, it would not be an appropriate site for a hovercraft hangar and maintenance facility.

Harbor Head

Harbor Head is carried forward for weather operability analysis

The head of Akutan Harbor, north of the proposed site for the new, small-boat harbor could serve as a western terminal. It is well protected from waves generated by winds acting over Akutan Bay and from Bering Sea swell. The beach is sufficiently wide, shallow and firm to be suitable for operations by hovercraft or conventional ferry.

This same site is a suitable location for a hovercraft hangar and maintenance facility.

Eastern Terminals

Proceeding from west to east, the four terminals on the south side of Akutan Harbor are increasingly exposed to Bering Sea swell arriving from the north. Fish Banks #0 and #1 are fully exposed to Bering Sea swell. Fish Banks #2 is exposed to Pacific Ocean swell. The potential terminal site at Surf Bay on Akun Island receives partial sheltering from arriving Bering Sea swell, due to rocks and islets.

West Cove

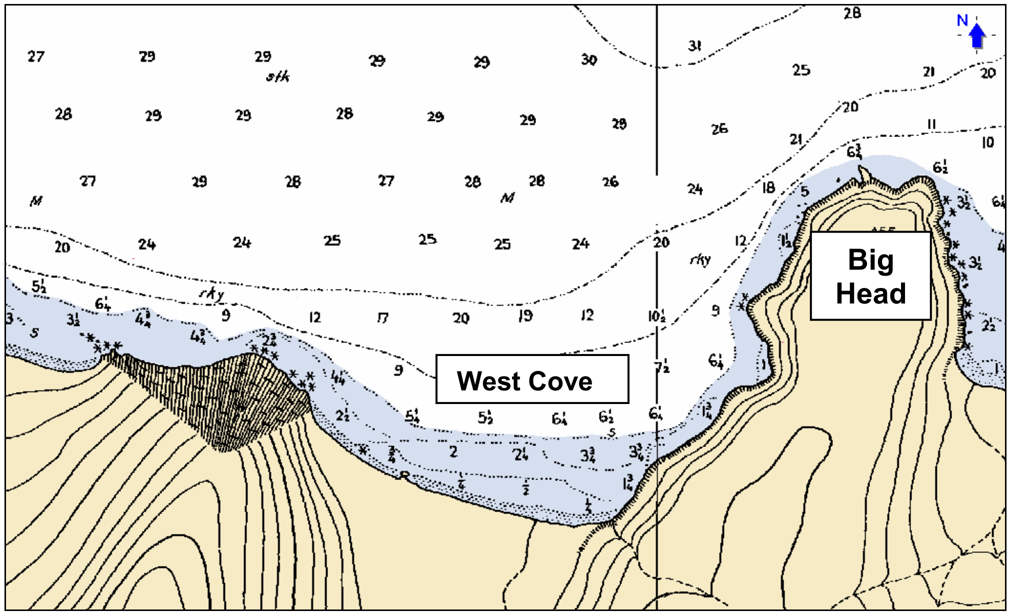


Figure 8: West Cove in Akutan Harbor

West Cove is carried forward for weather operability analysis

West Cove is located immediately to the west of Big Head on the south side of Akutan Harbor. It is about 4.9 overland miles from the proposed Fish Banks airport site and is substantially protected from Bering Sea swell by Big Head. Its beaches consist of medium gravel and some sand. West Cove provides suitable locations for a marine terminal serving a conventional ferry or a hovercraft.

East Cove

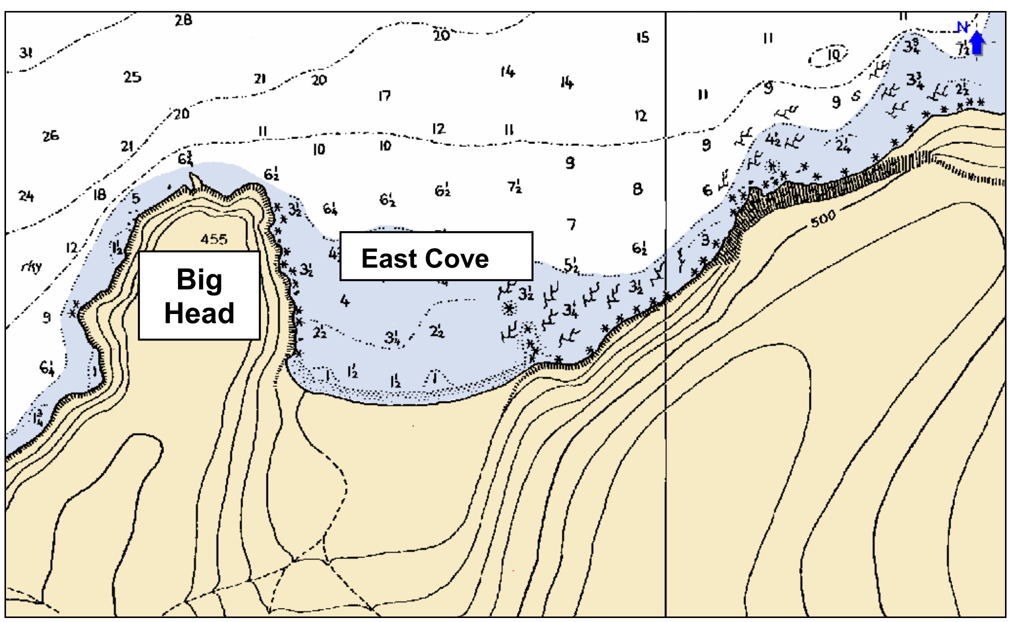


Figure 9: East Cove in Akutan Harbor

East Cove is carried forward for weather operability analysis

East Cove is located immediately to the east of Big Head on the south shore of Akutan Harbor. The Fish Banks airport would be 3.1 overland miles from an East Cove terminal. East Cove is substantially exposed to Bering Sea swell. Its beaches consist of coarse and medium gravel, and hard packed sand at lower elevations. East Cove could be used as an eastern terminus for hovercraft operations, though there is some concern that the annual and extreme storm events might damage hovercraft landing pads and facilities, requiring a degree of storm-related maintenance.

East Cove terminals may be expensive to maintain because of storms

East Cove was also considered as an eastern terminus for a conventional ferry. The annual and extreme storm events can be expected to damage the marine terminal and transfer ramp facilities used by a conventional ferry operating from this site, resulting in disruption to operability and storm-related maintenance expenses.

Fish Banks #0

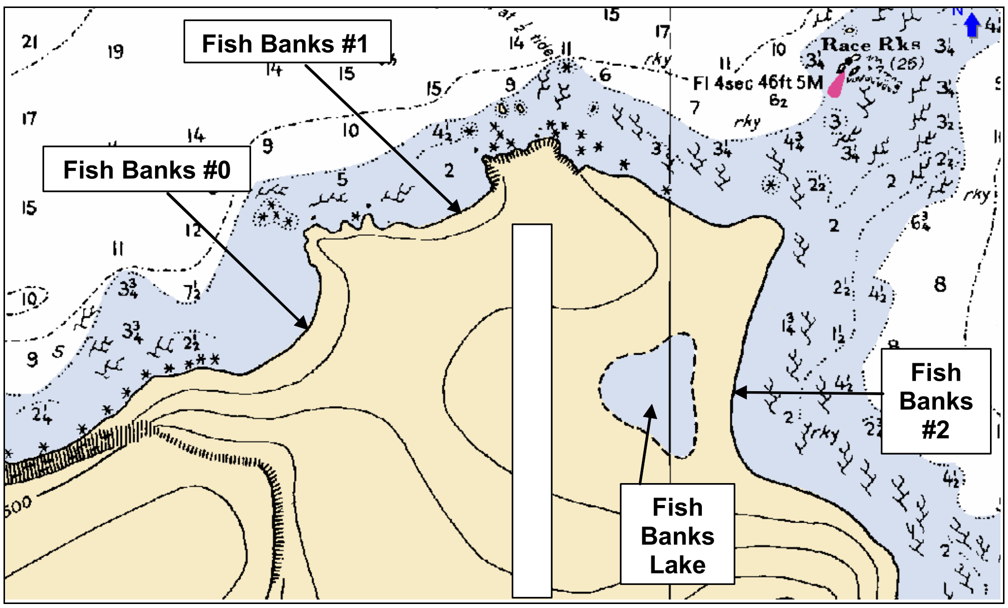


Figure 10: Location of Fish Banks #0, #1 and #2 near the proposed airport

Fish Banks #0 is unsuitable for hovercraft or conventional ferry operations due to wave exposure and poor beach configuration

The cove at Fish Banks #0 is located less than 0.5 overland miles west of the northern end of the proposed Fish Banks airport. The second field survey team unanimously concluded that it is unsuitable for either hovercraft or conventional ferry operations, due to its very short beach backed by a high steep bluff (higher than the corresponding bluff at Fish Banks #1) and minimal protection from Bering Sea swell. It is the unanimous opinion of the field survey team that Fish Banks #1 is more promising than Fish Banks #0 as a potential eastern terminus for hovercraft operations, and that there is no basis for further consideration of Fish Banks #0.

Fish Banks #1

Fish Banks #1 requires blasting a large landing area to be a feasible terminal site

The cove at Fish Banks #1 is located near the northern end of the proposed Fish Banks airport. It is fully exposed to Bering Sea swell. The beach is very narrow and consists of coarse gravel and rock. A bluff rises steeply to about 70 ft elevation from the back of the beach.

As currently configured, Fish Banks #1 is not suitable for hovercraft operations. It is conceivable that hovercraft operations could be accommodated at this site if a box canyon-like hovercraft landing area were to be blasted into the bluff. The footprint of any such landing area should extend three or more hovercraft lengths into the bluff and have a width at least 150% of the hovercraft length, thus exceeding 150 feet by 300 feet.

Fish Banks #1 is carried forward for weather operability analysis for hovercraft operation only

Fish Banks #1 is not suitable for conventional ferry operations. Not only would weather operability be well below 90%, but the site is too exposed for conventional ferry terminal and shore transfer facilities.

Fish Banks #2

Fish Banks #2 is relatively protected from Bering Sea swell by the wave dissipation processes that take place in the narrows of Akun Strait to the north. As would be expected from the bathymetry, the wave environment in Fish Banks #2 cove appeared to be dominated by swell arriving from the Pacific Ocean.

Fish Banks #2 is unsuitable for hovercraft or conventional ferry operations due to wave exposure and poor beach configuration

Access to Fish Banks #2 requires the transit of the narrows of Akun Strait, which includes many rocks and shoal features. In addition, the current runs strong through these narrows.[1] Swell from both the Pacific Ocean and Bering Sea meet in the narrows of Akun Strait, resulting in steep standing waves and clapotis. Furthermore, moving from deepwater into shoal water causes waves to steepen and perhaps break, and waves opposing the current also steepen. All evidence points to a wave environment in the narrows of Akun Strait that is characterized by steep waves, breaking waves, chaos and confusion.

The consensus judgment of the field survey team[2] was that the cove at Fish Banks #2 was unsuitable as a terminus for a hovercraft or conventional ferry operating out of Akutan Harbor. The reasons for this judgment include:

- The necessity to transit the challenging and inhospitable wave environment in the narrows of Akun Strait. This would result in

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[1] According to local reports and the U.S. Coast Pilot, currents in Akun Strait can attain an estimated velocity of 12 knots.

[2] The field survey team included a naval architect-ocean engineer, an experienced hovercraft pilot and a civil engineer, all with access to a knowledgeable local Akutan resident.

passenger discomfort greater than that on any other route, and poses additional safety hazards to a conventional ferry as further described below.

- The sense that the surging Pacific swell in the cove at Fish Banks #2 might frequently interfere with conventional ferry operations.
- The fact that the beach above the water's edge is steep and the beach morphology unstable. These features, and the surging Pacific swell, would impose challenges to implementing and maintaining modifications that would render the beach more accessible for hovercraft.

Routine passage of the narrows of Akun Strait would be particularly hazardous for a conventional ferry because of the presence of barely submerged rocks; these rocks would not present an obstacle to hovercraft operations. Furthermore, currents of the strength reported in the *U.S. Coast Pilot* would severely hamper the schedule and operations of a conventional ferry, making it difficult to coordinate a conventional ferry with flight operations.

Surf Bay (Akun Island)

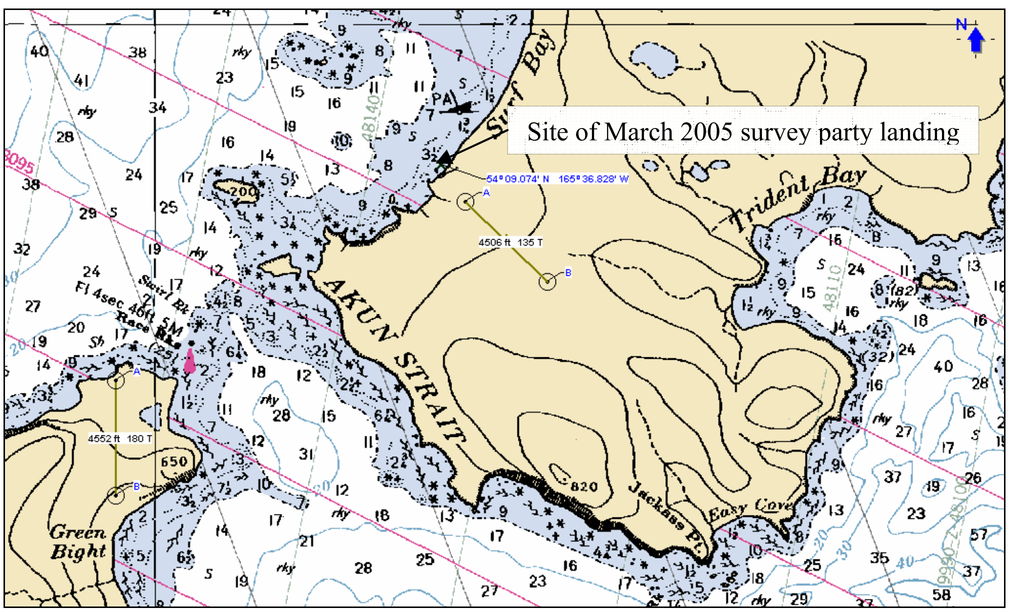


Figure 11: Proposed Akun Island terminal site southeast of Surf Bay

Surf Bay (Akun Island) is carried forward for weather operability analysis for hovercraft operation only

The Surf Bay landing site on Akun Island is partially protected from Bering Sea swell by rocks and islets to the north and, more locally, by a reef. Further, the beach is sandy with a very gentle slope (approximately 4.5°), which will result in diffused breaking of the surf resulting from the Bering Sea swell. There is adequate room to land a hovercraft – and with minimal development of the beach. Altogether, the Surf Bay beach in the area with partial protection from the reef is judged to be suitable for hovercraft landing and departure operations under all conditions in which the hovercraft can cross Akutan Bay.

The very gentle slope of the beach, while an advantage to the hovercraft, is an important reason for Surf Bay's unsuitability for conventional ferry operations. The gently sloping beach means that the water is shallow to a great distance offshore. In order to support conventional ferry operations to Surf Bay, it would be necessary to build a pier or trestle extending a great distance from the shore. This cost impact and concern is regarded as sufficient to preclude consideration of conventional ferry operations to Surf Bay.

Route Alternatives for Weather Operability Analysis

Table 2 below lists the eight potential route alternatives that were carried forward to weather operability analysis (see Section 5). The table also lists the transit distance and the nominal one-way transit time at 8 kts (for a conventional ferry) and 40 kts (for a hovercraft).

Table 2: Potential route alternatives between Akutan and a proposed airport serving Akutan

		Nominal One-Way Transit Time (min)	
Terminuses	**Distance (nm)**	8 kts (Conventional)	40 kts (Hovercraft)
City of Akutan – West Cove	1.8	13.5	2.7
City of Akutan – East Cove	2.8	21.0	4.2
City of Akutan – Fish Banks #1	3.7	*	5.6
City of Akutan – Surf Bay(Akun Island)	6.0	*	9.0
Harbor Head – West Cove	3.3	24.8	5.0
Harbor Head – East Cove	4.3	32.3	6.5
Harbor Head – Fish Banks #1	5.2	*	7.8
Harbor Head – Surf Bay(Akun Island)	7.5	*	11.3

* Conventional ferry landing not feasible at Fish Banks #1 or Surf Bay (Akun Island)

SECTION 4

Wind and Wave Climatology

This section describes the wind and wave climatology model developed for this study.

A wind and wave climatology was developed in order to predict the operability of the hovercraft and conventional ferry. The following tasks were performed to build the climatology model:

- Review of available meteorological records
- Analysis of wind data
- Hindcast of local wind-generated wave conditions
- Analysis of waves entering the operating area from the Bering Sea

Data Sources

Less than one year's data available at Akutan

The best available field data are from NOAA, National Data Buoy Center (NDBC) buoy 46032. The buoy was located in Akutan Bay northeast of Hot Springs Bay, at 54° 12' N 165° 48' W (Figure 12). The buoy was in place between 27 September 1984 and 16 August 1985. Buoy 46032 collected wind speed and direction, air and sea temperatures, and barometric pressure at sea level at three hour intervals. Wave data were not recorded. No other local data of comparable quality and relevance have been identified, though it might be possible (at considerable effort and expense) to complement the work in this report with archived wind data collected by satellite using synthetic aperture radar (SAR) technology. No other long-term direct wave measurements have been identified for Akutan Bay.

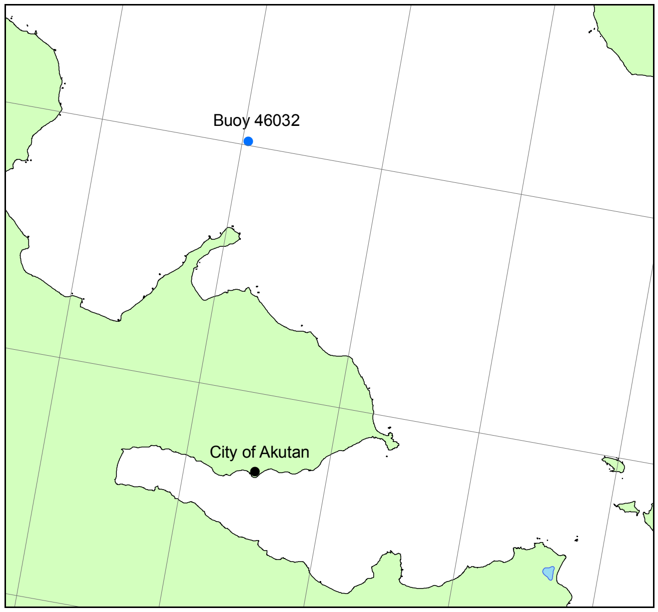


Figure 12: Location of buoy 46032 in Hot Springs Bay

Distant buoy data from different years than Akutan data

Additional data were used from NDBC buoy 46035, which is located in the Bering Sea at 57° 3' N 177° 35' W, approximately 430 n.m. northwest of Akutan (Figure 13). The record from this buoy contains many years of hourly observations of wave frequency spectra, wind speed and direction. Unfortunately, the dates for which data were collected at this buoy do not correspond with the record for buoy 46032.

Figure 13: Location of buoy 46035 in Bering Sea

Modeling of Wave Environment

Wave generation from over-the-water winds and the change in local wave conditions due to the land and underwater depth contours were calculated using the two-dimensional spectral wave growth, refraction and decay model called SWAN (Holthuijsen et al., 2004). The model takes into account the wind conditions (speed and direction), the outline of the shoreline and the bathymetry. Hydrographic survey data were collected from the National Oceanic and Atmospheric Administration (NOAA 1935-2001) Geographic Data System. The shorelines of Akutan Island and Akun Island were digitized from a *digital orthogonal quadrangle* topographic map developed by the United States Geological Survey in 1983. It is assumed that shoreline changes during the period 1983 to the present are not significant on the scale of the model resolution.

The wave conditions along the route and offshore of the proposed terminal sites were determined from an analysis of both local winds and of waves arriving from the Bering Sea. The objective of this analysis is to develop sample time series of wave height, period and direction at the route waypoints of interest. Operability analyses (topic of the next section) are based on these time series. Statistics of the combined wave height are provided in this section. The development of these time series treats the local wind-generated waves and the waves arriving from the Bering Sea as separate, independent problems. This development is discussed in the following paragraphs. The combined sea and swell are obtained by directly adding the wave energies of the two sources of waves.

Akutan Bay and Harbor Waves

Sea states were hindcast from wind

The local wind-generated waves are further divided into two components. Figure 14 shows the two systems of wind-generated waves:

(a) the outer harbor

(b) the inner harbor

Two wind-generated wave systems within Akutan Bay and Harbor

The wind speeds and directions for the two generating regions are determined from an adjustment of the winds observed at buoy 46032 (Brueser 2004). The adjustment is different for each wind speed, wind direction and season. The generation of waves in the inner and outer harbor are assumed to be independent. The two sets of wave conditions are calculated independently. The calculated wave heights of the two wave systems are then added together to define the wave conditions at each route waypoint. Figure 15 shows an example set of results for the two different wave fields.

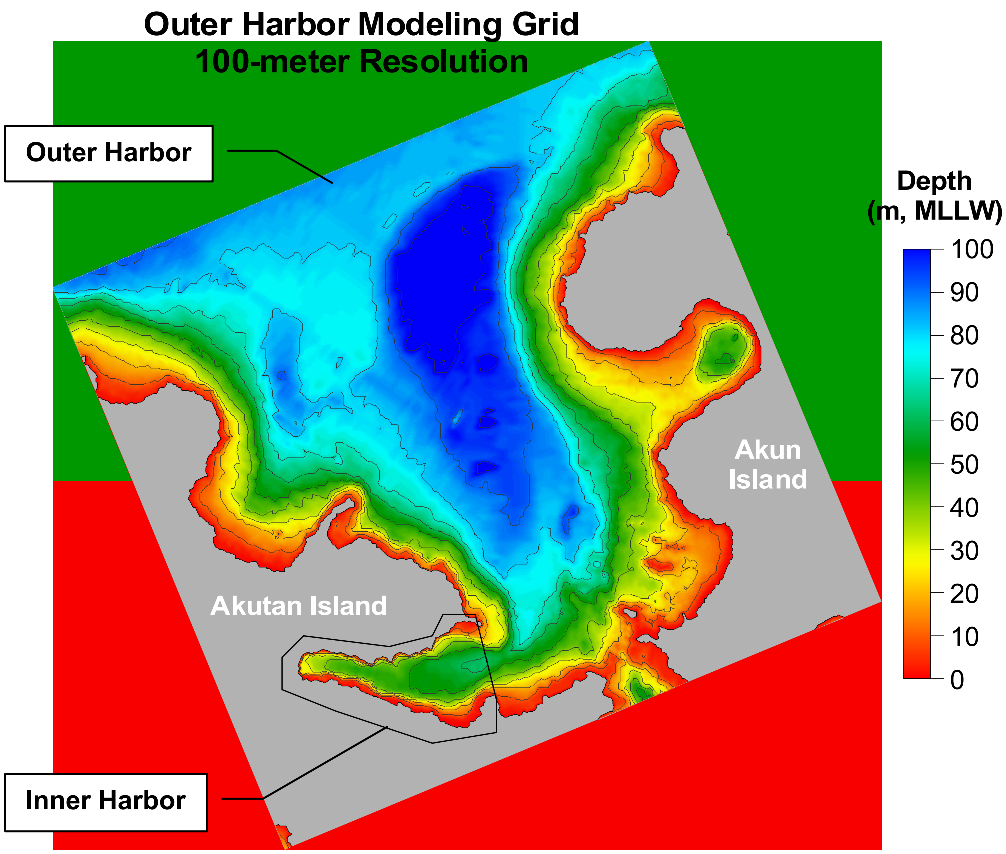
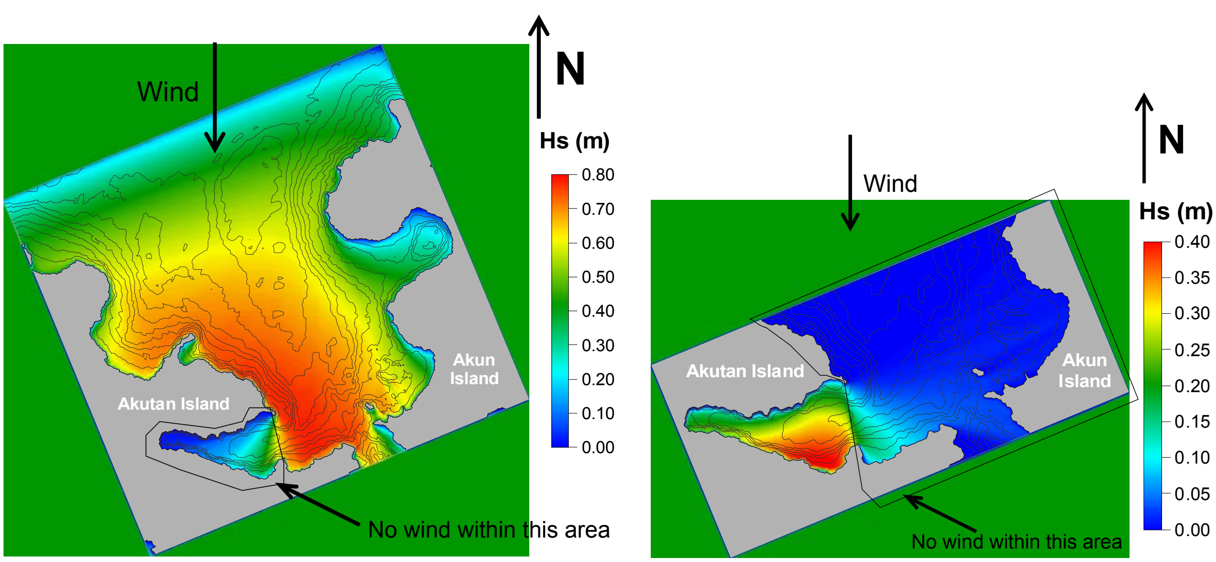


Figure 14: Inner and outer harbor domains modeled in SWAN



a) Outer harbor **b) Inner harbor**

Figure 15: Sample significant wave heights for wind 22 knots from the north

Bering Sea Waves

It is also important to determine how waves in the Bering Sea will propagate into the route and to the proposed terminal sites. For this calculation, waves coming from the Bering Sea were divided into two independent types:

- Bering Sea wind-driven waves arriving at the northern boundary of the computational model.
- Swell from distant storms in the Bering Sea, also arriving at the northern boundary of the computational model.

Bering Sea waves are transformed to the route waypoint locations

Both of these Bering Sea wave types are altered by the shoreline and bathymetry as they approach the route waypoints and locations offshore of terminal sites. The altered waves are calculated using height and direction modifiers derived by the SWAN computer model. The height and direction modifiers, also called transmission coefficients, are calculated for each location of interest. The coefficients are a function of the location of points of interest, the periods and directions of the waves as they arrive at the northern boundary of the computational model of Akutan Bay.

Combining Bering Sea and Local Waves

Determining the heights, periods and directions of the two types of waves arriving at the northern boundary of the computer model is complicated by the lack of adequate and contemporaneous data at the two nearby NOAA data buoys. The nearest buoy (46032) has a very short data record and does not have wave information. The distant buoy (46035) has a much longer record and contains both winds, waves and swell data.

Buoy 46035 is too distant from Akutan Bay to be relied upon for the local wind wave process acting within Akutan Bay or at the northern computational boundary of Akutan Bay. As described above, the winds observed by buoy 46032 are preferred for defining the local wind wave processes entering and within Akutan Bay and Harbor. As swell can propagate over long open ocean distances, buoy 46035 is regarded as the best available source for swell coming into Akutan Bay from the north. Therefore, a combination of the two data sets is used. The method is further explained in the following paragraphs.

The first type of wave from the Bering Sea is the local, wind-generated wave. Since there are no data on these waves from the nearby buoy, the wind-generated waves are calculated (also known as wave hindcasting) from the wind speeds and directions measured at buoy 46032. The wave field is assumed to be fully developed, e.g., the wind has been blowing long enough over the Bering Sea at the measured speed so that no further increase in wave height will occur. In addition, the detailed composition of the wave field can be described by the cosine-squared directionally spread Pierson-Moskowitz spectrum.

The second type of wave from the Bering Sea is swell from distant storms. The swell wave heights, periods and directions are derived from NOAA NDBC buoy 46035. However, since the wave spectra data from 46035 are a combination of both locally generated wind-driven sea and swell from distant storms, it is necessary to subtract the local wind-generated sea component acting at buoy 46035. This is done by calculating (hindcasting) the local wind-generated waves based on the wind readings at 46035. The hindcast wind-generated waves are then subtracted from the combined sea and swell total wave energy at the buoy. If the subtraction resulted in a wave energy equal to or less than zero, then the significant wave height[3] for swell is zero; otherwise the significant wave height of the swell is calculated from the residual wave energy. The direction of the swell is assumed to be the same as the wind direction. If the calculated swells do not have a component crossing the northern boundary of the SWAN computer model for Akutan Bay, they are discarded. The unidirectional Bering Sea swell is then transformed to each route waypoint using the wave period and direction-dependent transmission coefficients discussed above.

The swell time series generated as described in the above paragraph are assumed to be independent of the wind conditions in Akutan Bay as recorded by buoy 46032. Thus the swell can be directly added to the other three wind-generated waves that were calculated from the wind at buoy 46032. An advantage of this procedure is that the swell time series embodies real swell persistence properties. In order to eliminate any bias associated with the alignment of the swell time series and the wind-generated waves, the addition is repeated with random shifts of the time index of the swell time series with respect to the local wind-generated wave time series. This process is called statistical ensembling.

In each ensemble realization, all four wave system components (i.e., waves due to wind over the inner harbor, waves due to wind over the outer harbor, Bering Sea wind waves occurring at the northern boundary and Bering Sea swell) are linearly superposed[4].

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[3] Significant wave height is the average of the highest one-third of all waves and corresponds approximately to the wave height reported by a trained visual observer.

[4] Linear superposition of independent wave systems refers to linear addition of wave energies. This leads to the result that the significant wave height of the combined wave system is the square-root of the sum of the squares of the independent significant wave heights of each of the components.

Data Accuracy

Data accuracy is sufficient to evaluate wave climate at proposed terminal sites and routes

The SWAN computer model used for this study was developed with a fine mesh bathymetric grid. This small scale resolution allows us to model the waves along the route outside the surf zone to the various eastern terminus sites with accuracy sufficient to assess weather operability. The operability calculation (Section 5) includes determination of passenger comfort. However, a much finer resolution model would be required to accurately model the shoaling and breaking of the waves on the beaches at the various candidate eastern terminus sites. Such finer resolution models would be possible at sites such as West Cove, East Cove and Surf Bay on Akun Island; however this was not done. It was felt that the extreme irregularity of the bottom offshore of the Fish Banks eastern terminus sites would probably frustrate any attempt to analytically model surf at those sites. Accordingly, judgments regarding surf shoaling and breaking processes, the feasibility of siting terminals at the various candidate eastern terminus sites (Section 3), and the anticipated operability in and through the surf at these sites (Section 5) have been accomplished on the basis of general theory for surf and expert judgment by The Glosten Associates. Glosten's judgment was in turn based on field observations in the company of an experienced hovercraft operator and on descriptions of waves and surf at the various sites provided by knowledgeable local Akutan residents.

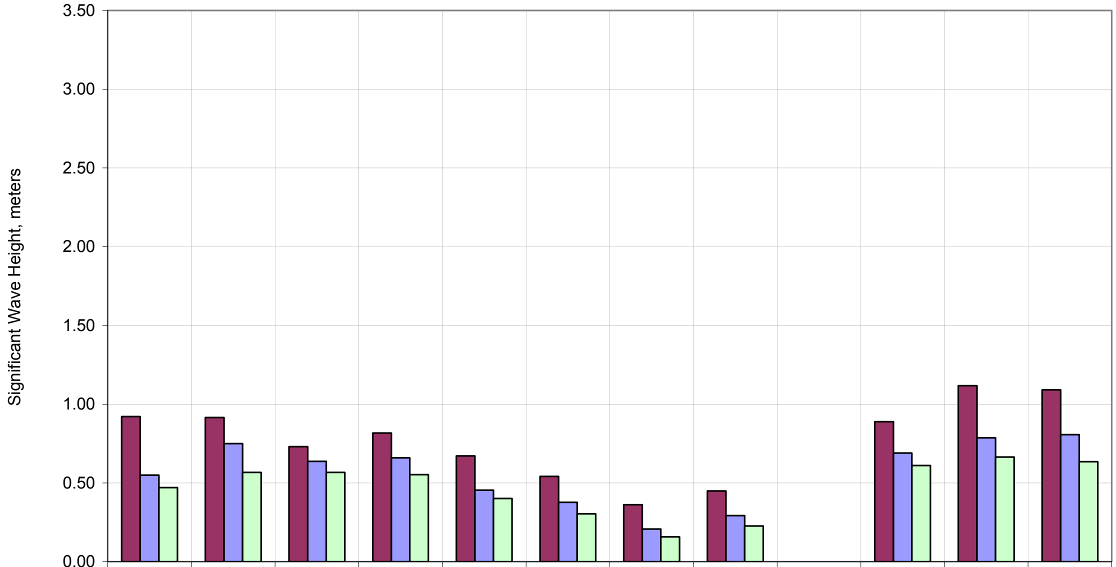
Summary Statistics of Wave Climatology

Figure 16 through Figure 19 summarize the important statistics of the encountered wave climatology along four generic route alternatives.

The summary climatologies are given for the most severe location along each route outside the near beach region where the swell builds up into surf. The summaries are by month for the combined sea and swell for three of the available Bering Sea swell data years: 1998, 2003 and 2004. These swell data years were selected because they had the most complete annual record with the fewest missing observations.

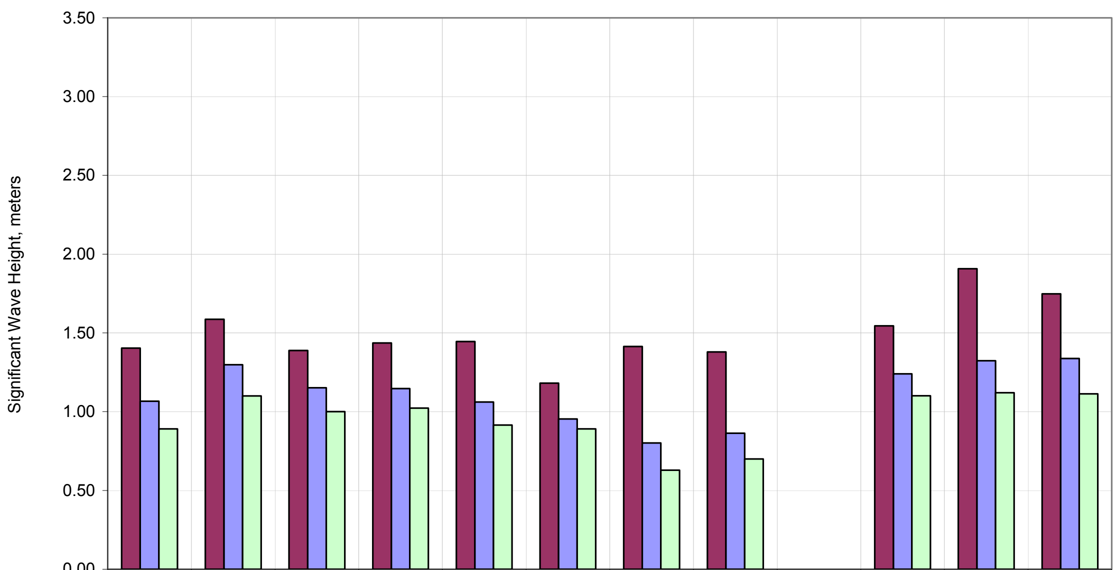
Extreme values may be much higher than the 99th percentile.

Three statistics are given for each month: the 90th percentile, the 95th percentile, and the 99th percentile. There may be extreme values that are much larger than the 99th percentile. The corresponding operating limits are shown for each route and vessel type. The values presented in Figure 16 through Figure 19 represent the average statistic using ensemble data from all three swell data years. Year-to-year variability in these statistics is on the order of ±20%. This means that the significant wave height in any particular year at the specified statistical level and month, may vary from the values shown by up to 20% (within about a 90% confidence band).



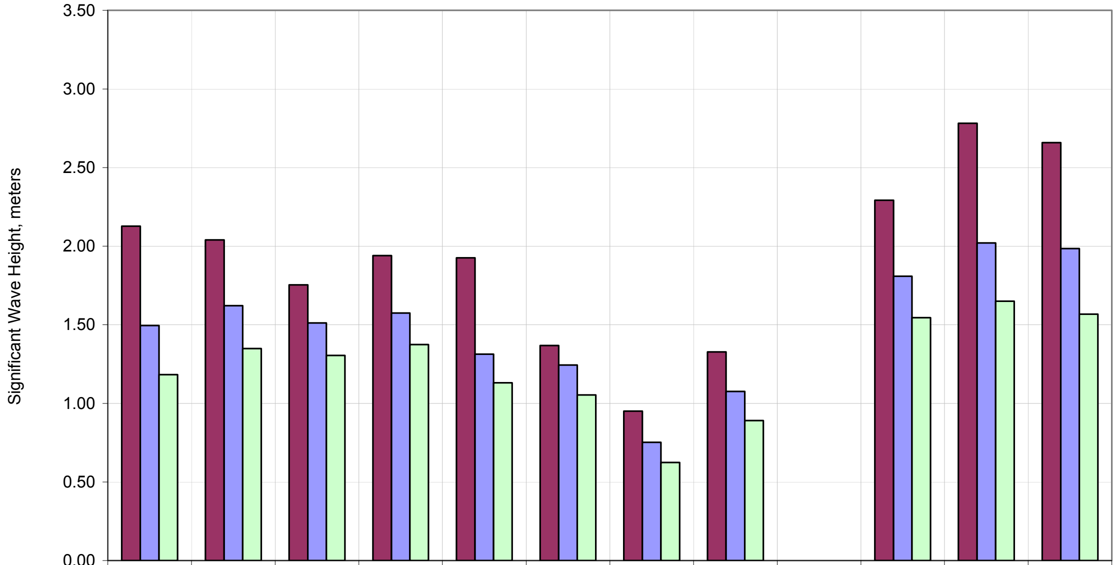
	January	February	March	April	May	June	July	August	September	October	November	December
99th %ile	0.92	0.92	0.73	0.82	0.67	0.54	0.36	0.45	Data Missing	0.89	1.12	1.09
95th %ile	0.55	0.75	0.64	0.66	0.45	0.38	0.21	0.29		0.69	0.79	0.81
90th %ile	0.47	0.57	0.57	0.55	0.40	0.30	0.16	0.23		0.61	0.66	0.63

Figure 16: Combined sea and swell: City of Akutan to West Cove terminal



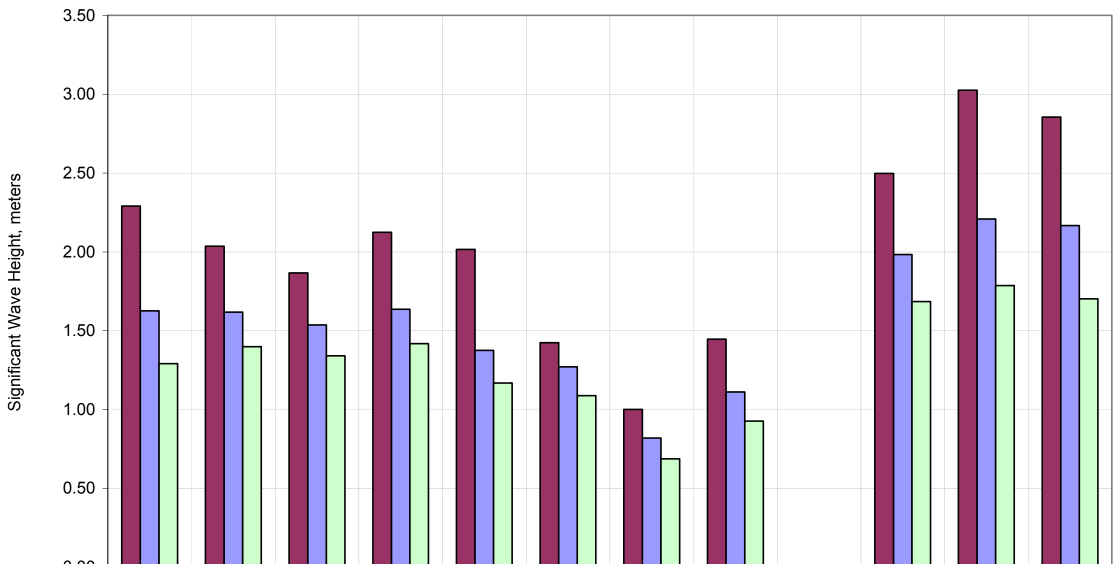
	January	February	March	April	May	June	July	August	September	October	November	December
99th %ile	1.40	1.59	1.39	1.44	1.45	1.18	1.41	1.38	Data Missing	1.55	1.91	1.75
95th %ile	1.07	1.30	1.15	1.15	1.06	0.95	0.80	0.86		1.24	1.32	1.34
90th %ile	0.89	1.10	1.00	1.02	0.92	0.89	0.63	0.70		1.10	1.12	1.11

Figure 17: Combined sea and swell: City of Akutan to East Cove terminal



	January	February	March	April	May	June	July	August	September	October	November	December
99th %ile	2.13	2.04	1.75	1.94	1.93	1.37	0.95	1.33	Data Missing	2.29	2.78	2.66
95th %ile	1.50	1.62	1.51	1.57	1.31	1.24	0.75	1.08		1.81	2.02	1.98
90th %ile	1.18	1.35	1.31	1.37	1.13	1.05	0.62	0.89		1.54	1.65	1.57

Figure 18: Combined sea and swell: City of Akutan to hovercraft terminal at Fish Banks #1



	January	February	March	April	May	June	July	August	September	October	November	December
99th %ile	2.29	2.04	1.87	2.12	2.02	1.42	1.00	1.45	Data Missing	2.50	3.03	2.85
95th %ile	1.63	1.62	1.54	1.64	1.38	1.27	0.82	1.11		1.98	2.21	2.17
90th %ile	1.29	1.40	1.34	1.42	1.17	1.09	0.69	0.93		1.69	1.79	1.70

Figure 19: Combined sea and swell: City of Akutan to hovercraft terminal at Surf Bay on Akun Island

SECTION 5

Weather Operability

This section examines weather operability for the routes selected in Section 3. Sites must meet or exceed 90% operability to be considered further.

Weather operability expresses the percentage of occasions when, for a given vessel scheduled to operate on a specified route, the weather is such that the round-trip voyage can be completed without exceeding passenger comfort goals or compromising safety. Some latitude is accorded in the time in which a voyage can be completed and still be regarded as having fulfilled the schedule expectations. If the voyage cannot be accomplished within these schedule windows, then the day is recorded as an inoperable day and the measure of weather operability is diminished proportionately.

Operability Limits

Operability was assessed for a BHT 130 hovercraft and for a 150-foot conventional ferry. Fish Banks #0 and #2 were determined to be unsuitable locations for either vessel type and were not considered for weather operability analysis. The BHT 130 hovercraft is considered to be a candidate for West Cove, East Cove, Fish Banks #1 and Surf Bay (Akun Island). The conventional ferry is considered to be a feasible candidate for operation to West Cove and East Cove. The adopted criteria limits are summarized in Table 3 below.

Operability limits are based on safety and passenger comfort

Operability for both vessel types considers safety and passenger comfort. The various phases of the operation are addressed, including transit, hovercraft operations through the surf, and loading and docking operations (shore-interface) for the conventional ferry. As set forth in Table 3, wind poses a more significant limit to hovercraft operations than to conventional ferries, provided that the conventional ferry has adequate bow thrusting capability and minimized windage.

Passenger comfort is the limiting consideration for both vessel types during the transit phase. Safety is the limiting consideration for hovercraft operations through the surf. The limitations of relative motions between the conventional ferry and the shore interface reflect both passenger safety and avoidance of damage to the ferry and/or the shore interface structures.

Table 3: Weather operability limits for the candidate vessels

		Criterion	BHT 130 Hovercraft	150-foot Conventional ferry
Transit	All Routes	Passenger Motion Sickness (MSI)	Significant Wave Height: $H_S \leq 3.00$ m	Significant Wave Height: $H_S \leq 1.25$ m
Surf	Surf Bay (Akun Is.)	Safe Operations	Significant Wave Height: $H_S \leq 3.00$ m	
	West Cove East Cove Fish Banks #1		Significant Wave Height: $H_S \leq 2.00$ m	
Shore-Interface	West Cove East Cove	Impacts and Safe Operations		Significant Wave Height: $H_S \leq 1.25$ m
Wind	All Routes	Maneuvering	$U \leq 40$ knots	

Passenger Comfort

Passenger comfort and safety limit conventional ferry operations to a significant wave height of 1.25 m during transit

Passenger comfort was measured using motion sickness incidence (MSI) indices (ISO 2631:1997(E)) subject to JONSWAP wave spectra. MSI estimates the percentage of a general population of non-acclimated passengers that will experience seasickness when exposed to a specified acceleration environment for a given duration. The usual marine standard for ferry/hovercraft operations is no more than 10% MSI. MSI increases with both the intensity of the acceleration environment and with the duration of passenger exposure to that acceleration environment. Thus, the shorter the duration of the exposure, the more intense is the permitted acceleration environment and *vice versa*. The 10% MSI limit was calculated based on systematic seakeeping analysis of the vessels.

For a 150-foot conventional ferry operating with an 8-knot service speed, a 10% MSI limit was estimated to restrict operations to conditions with significant wave height equal to or less than 1.25 m. It is the judgment of

The Glosten Associates that this same significant wave height reasonably represents the limits for vessel loading and unloading operations at an exposed shore-vessel interface. The operability of a conventional ferry designed with sufficient bow thrusting capability and minimized windage is considered to be limited in all cases by waves before being limited by wind speed.

Passenger comfort limits hovercraft operations to a significant wave height of 3.0 m during transit

The 10% MSI operability limits of a BHT 130 hovercraft were estimated presuming a 10-minute exposure to the wave-induced acceleration environment. Actual exposure time is probably less than 10 minutes. The longest exposure time, from Akutan Point to Surf Bay on Akun Island, is only about 6 minutes at 40 knots. As shown in Table 4, MSI is less than 10% at all headings and peak periods (T_P), provided that the significant wave height of combined sea and swell is less than or equal to 3.0 m. With a significant wave height of 3.5 m, there are a limited number of combinations of heading and peak period that result in exceeding the 10% MSI limit. However, as a practical matter, it should be possible for a skillful operator to continue operations when the significant wave height is 3.5 m by tacking to avoid the worst headings for the encountered wave period structure.

Table 4: Percent MSI for BHT 130 hovercraft at 40 knots with 10 minute exposure

H_S	T_P	Heading [degrees] --- 180= Following; 90= Beam; 0= Head												
[m]	[sec]	180	165	150	135	120	105	90	75	60	45	30	15	0
3.0	5	2.75%	5.43%	7.25%	6.16%	2.09%	0.23%	7.94%	5.69%	5.88%	4.72%	3.72%	3.13%	2.95%
3.0	6	4.75%	8.27%	6.30%	3.88%	1.58%	0.36%	7.26%	6.24%	6.33%	6.32%	5.81%	5.38%	5.22%
3.0	7	3.76%	5.43%	4.47%	3.06%	1.22%	0.41%	6.18%	8.78%	6.13%	6.32%	6.48%	6.41%	6.37%
3.0	8	2.78%	4.34%	3.65%	2.47%	0.96%	0.41%	5.19%	8.31%	8.32%	6.36%	6.13%	6.25%	6.30%
3.0	9	2.31%	3.63%	3.02%	2.01%	0.76%	0.39%	4.37%	7.18%	8.79%	8.38%	7.07%	6.44%	6.30%
3.0	10	1.96%	3.05%	2.52%	1.66%	0.62%	0.35%	3.70%	6.19%	7.83%	8.76%	8.72%	8.27%	8.06%
3.0	11	1.67%	2.58%	2.12%	1.38%	0.52%	0.32%	3.15%	5.36%	6.83%	7.90%	8.53%	8.74%	8.77%
3.0	12	1.43%	2.20%	1.80%	1.17%	0.44%	0.28%	2.71%	4.67%	5.99%	6.95%	7.63%	8.01%	8.13%
3.0	14	1.07%	1.64%	1.34%	0.87%	0.32%	0.23%	2.06%	3.61%	4.69%	5.47%	6.03%	6.36%	6.47%
3.0	16	0.83%	1.27%	1.03%	0.67%	0.25%	0.18%	1.61%	2.86%	3.75%	4.40%	4.86%	5.13%	5.22%
3.0	18	0.66%	1.01%	0.82%	0.53%	0.20%	0.15%	1.29%	2.30%	3.05%	3.60%	3.99%	4.22%	4.30%
3.5	5	3.21%	6.34%	8.46%	7.19%	2.43%	0.27%	9.26%	6.64%	6.85%	5.51%	4.34%	3.66%	3.44%
3.5	6	5.55%	9.65%	7.35%	4.52%	1.85%	0.42%	8.47%	7.28%	7.38%	7.37%	6.78%	6.28%	6.10%
3.5	7	4.39%	6.34%	5.22%	3.57%	1.42%	0.48%	7.21%	10.24%	7.16%	7.37%	7.56%	7.48%	7.43%
3.5	8	3.25%	5.06%	4.26%	2.88%	1.11%	0.48%	6.06%	9.70%	9.71%	7.42%	7.15%	7.30%	7.35%
3.5	9	2.69%	4.23%	3.53%	2.35%	0.89%	0.45%	5.10%	8.38%	10.25%	9.77%	8.25%	7.51%	7.35%
3.5	10	2.28%	3.56%	2.94%	1.93%	0.73%	0.41%	4.31%	7.22%	9.14%	10.22%	10.17%	9.65%	9.41%
3.5	11	1.94%	3.01%	2.47%	1.62%	0.60%	0.37%	3.68%	6.26%	7.97%	9.22%	9.95%	10.20%	10.23%
3.5	12	1.67%	2.57%	2.10%	1.37%	0.51%	0.33%	3.16%	5.45%	6.99%	8.11%	8.90%	9.35%	9.49%
3.5	14	1.25%	1.92%	1.56%	1.01%	0.38%	0.26%	2.40%	4.21%	5.47%	6.39%	7.03%	7.42%	7.55%
3.5	16	0.97%	1.48%	1.20%	0.78%	0.29%	0.21%	1.87%	3.33%	4.37%	5.14%	5.67%	5.99%	6.09%
3.5	18	0.77%	1.17%	0.95%	0.62%	0.23%	0.18%	1.50%	2.69%	3.56%	4.21%	4.66%	4.93%	5.02%
4.0	5	3.67%	7.24%	9.66%	8.21%	2.78%	0.31%	10.58%	7.59%	7.83%	6.30%	4.96%	4.18%	3.93%
4.0	6	6.34%	11.02%	8.40%	5.17%	2.11%	0.48%	9.68%	8.31%	8.44%	8.43%	7.75%	7.18%	6.97%
4.0	7	5.01%	7.25%	5.96%	4.08%	1.63%	0.55%	8.24%	11.70%	8.18%	8.43%	8.64%	8.55%	8.49%
4.0	8	3.71%	5.79%	4.86%	3.29%	1.27%	0.55%	6.93%	11.08%	11.10%	8.48%	8.17%	8.34%	8.40%
4.0	9	3.08%	4.83%	4.03%	2.68%	1.02%	0.52%	5.82%	9.58%	11.72%	11.17%	9.43%	8.59%	8.40%
4.0	10	2.61%	4.06%	3.36%	2.21%	0.83%	0.47%	4.93%	8.25%	10.44%	11.68%	11.62%	11.03%	10.75%
4.0	11	2.22%	3.44%	2.83%	1.85%	0.69%	0.42%	4.20%	7.15%	9.11%	10.53%	11.37%	11.66%	11.69%
4.0	12	1.90%	2.93%	2.40%	1.56%	0.58%	0.38%	3.62%	6.23%	7.99%	9.27%	10.17%	10.68%	10.84%
4.0	14	1.43%	2.19%	1.79%	1.16%	0.43%	0.30%	2.74%	4.81%	6.25%	7.30%	8.03%	8.48%	8.62%
4.0	16	1.11%	1.69%	1.38%	0.89%	0.33%	0.25%	2.14%	3.81%	5.00%	5.87%	6.48%	6.84%	6.96%
4.0	18	0.88%	1.34%	1.09%	0.70%	0.26%	0.20%	1.71%	3.07%	4.07%	4.81%	5.32%	5.63%	5.73%

Hovercraft Operations through Surf

Depending on the characteristics of the beach, hovercraft operations through shoaling and breaking surf may be subject to more restrictive limits than those of transit operations. As waves, particularly swell, approach a beach they slow down. The wave length decreases and the wave height increases, resulting in a steeper wave that may eventually break as either a plunging or spilling breaker, depending on the steepness of the inshore bottom up to the plunge point.

In the surf zone, safety factors limit hovercraft operations at East Cove, West Cove and Fish Banks #1 to a significant wave height of 2.0 m

The steep inshore bottoms at beaches on Akutan Island (West Cove, East Cove and Fish Banks #1) concentrate breaking surf in a narrow zone, which exacerbates the hazard of landing through the surf at those sites. At Fish Banks #1, modifications will be needed to allow landing of a hovercraft, including blasting of a box canyon landing area approximately 150' by 300'. Unless the mouth of the box canyon is very wide, the restricted maneuvering through the surf and into the narrow entrance will continue to impose a limitation to operations. For these reasons, a limit of $H_s \leq 2.0$ m is imposed at West Cove, East Cove and Fish Banks #1, as set forth in Table 3.

By contrast, the long, gently sloping inshore bottom at Surf Bay on Akun Island creates an extended breaking zone where incident wave energy is dissipated more slowly over an extended distance. In the judgment of the naval architect and experienced hovercraft pilot who participated in the March 2005 field survey, the beach at Surf Bay is highly favorable to hovercraft operations through the surf.

The operability limit for Surf Bay (Akun Island) remains a significant wave height of 3.0 m

In consideration of the gently sloping beach at Surf Bay on Akun Island and the partial protection afforded by rocks and islets offshore in Surf Bay,[5] the nominal limiting significant wave height for operations through surf at Surf Bay on Akun Island is maintained at $H_s \leq 3.0$ m.

Operability Goal for Service

90% operability is the minimum acceptable

For successful marine operations providing access to an airport serving Akutan, the vessel proposed for acquisition must have a 90% or higher weather operability along the route selected from amongst the potential routes (as per private communications with HDR Alaska). If the vessel and route were to have an operability level of less than 90%, it is likely to result in situations wherein one would be able to arrive at the land-based airport serving Akutan and *not* be able to complete the trip from the airport to Akutan. Such a situation is undesirable. Even with an operability of over 90%, there may still be situations wherein one is able to arrive at Akutan

[5] In the judgment of the naval architect and experienced hovercraft pilot who participated in the March 2005 field survey, a judgment corroborated by the knowledgeable Akutan resident providing boat service, the rocks and islets provide partial lees that could be exploited by a skilled and experienced hovercraft operator. Analytical refraction studies by Arthur as reported by Weigel (1964) also support this judgment.

airport but unable to make the marine crossing. For this reason, the construction of emergency shelter at the airport is recommended.

Service Operability Levels

Operability was assessed using the wave climatology described in Section 4. For the purposes of weather operability, there is essentially no difference between the operability for services originating at the City of Akutan or at Harbor Head.

The local, wind-generated components of the wave climatology are based on eleven months of data from 1984-85, in which wind speed and direction were sampled every three hours. There are no data for September.

In order for a day to be regarded as operable, the vessel operability limits must not be exceeded for two records between 0900 and 1500 hours:

0900 and 1200 hours

or:

0900 and 1500 hours

or:

1200 and 1500 hours

To account for swell, independent records from three data years, 1998, 2003 and 2004, were superposed on the wind-generated waves, creating three separate data sets. Maximum, mean and minimum operability was determined for each month for each of these three data sets. The minimum operability of these three data sets for each month is presented in the figures below.

Hovercraft meets 90% operability for all months to West Cove, East Cove and Surf Bay (Akun Island)

Figure 1 presents the three-year minimum hovercraft operability for destinations of West Cove, East Cove, Fish Banks #1 and Surf Bay (Akun Island). The hovercraft is more than 90% operable in all eleven months analyzed when sailing to West Cove, East Cove or Surf Bay (Akun Island). However, the hovercraft is less than 90% operable in October when sailing to Fish Banks #1.

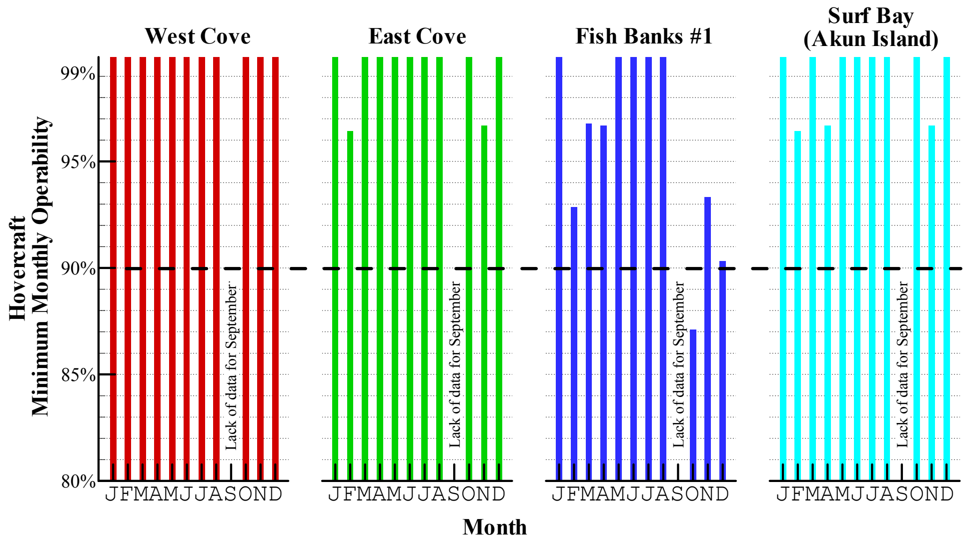


Figure 20: Hovercraft operability

Conventional ferry meets 90% operability for all months to West Cove

Figure 21 presents the three-year minimum operability of a conventional ferry to West Cove and East Cove. The conventional ferry is more than 90% operable in all months when sailing to West Cove, but less than 90% operable in three of the eleven months analyzed when sailing to East Cove.

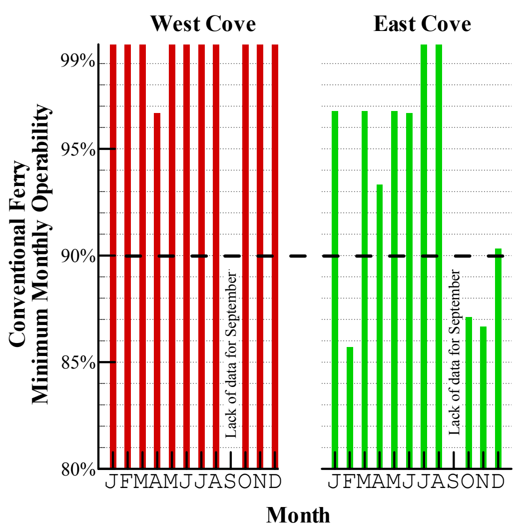


Figure 21: Conventional ferry operability

SECTION 6

Cost Analysis

This section examines the acquisition cost, operating cost and life cycle cost for the vessel alternatives.

Operating costs are evaluated on the basis of the assumption that the vessel is operated as a dayboat, i.e., the service day is limited to a contiguous twelve-hour period and the crew goes home overnight, leaving the vessel unattended in overnight layover status. Acquisition, operating and life cycle costs are presented as a range between minimum and maximum values. In some cases, the range primarily reflects estimation uncertainty, including allowances for market-price fluctuation. In other cases the range is reflective of identifiable choices under the control of the vessel owner.

The acquisition, operating, and life cycle costs for the conventional ferry and the BHT 130 hovercraft are presented in more detail in Table 5 and Table 6, respectively.

Acquisition Cost

Acquisition costs are estimated for a conventional ferry (with bow ramp) and a hovercraft. Additionally, acquisition costs are identified for ancillary equipment associated with marine operations (such as shoreside electrical power) and shoreside facilities.

The total acquisition cost of a conventional ferry (with bow ramp) is estimated to be between $4.5 million and $7.2 million (in 2005 dollars). This includes the cost of construction and acquisition program costs.

The total vessel acquisition cost for a BHT 130 hovercraft is estimated to be $9.6 million. This includes the cost of sea-trials, three months of training (an estimated $100,000), and the delivery voyage ($270,000). The vessel acquisition cost for the BHT 130 hovercraft that Aleutians East Borough is in

(text continued p. 36)

Table 5: Cost summary for service using a 150-foot conventional ferry with bow ramp (2005 dollars)

	Minimum	Maximum
System Acquisition Costs		
Vessel Acquisition Cost	$4,402,000	$7,145,000
Shoreside Electrical Power to Terminal	$50,000	$50,000
Terminal	To be determined	To be determined
Subtotal: (System Acquisition Cost)	$4,452,000 + Cost of terminal	$7,195,000 + Cost of terminal
Vessel Operating Costs		
Hull Maintenance & Pass. Services Maint.	$40,000	$50,000
Machinery Maintenance	$80,000	$120,000
Biennial Drydocking Voyage (Pro-Rated)	$20,000	$50,000
Crew Salaries	$379,500	$970,292
Fuel Costs	$26,910	$56,063
Lubricating Oil	$404	$841
Overnight Layover Expenses	$26,740	$26,740
Overhead	$34,000	$68,000
Insurance	$32,000	$208,000
Subtotal: (Annual Vessel Operating Cost)	$639,554	$1,549,936
Insurance of Shoreside Facilities	To be determined	To be determined
M&R of Shoreside Facilities	To be determined	To be determined
Other Costs of Shoreside Facilities Oper.	To be determined	To be determined
Subtotal: (Annual Shoreside Costs)	To be determined	To be determined
TOTAL: (Annual Operating Costs)	$639,554*	$1,549,936*
20-Year Life Cycle Cost		
i = 3%		
Present Value	$13,966,949*	$30,254,134*
Uniform Equivalent Annual Cost	$938,798*	$2,033,553*
i = 7%		
Present Value	$11,227,444*	$23,615,044*
Uniform Equivalent Annual Cost	$1,059,791*	$2,229,093*

* Excluding cost of terminal and shoreside facilities

Table 6: Cost summary for service using a BHT 130 hovercraft (2005 dollars)

	Minimum	Maximum
System Acquisition Costs		
Vessel Acquisition Cost	$9,547,000	$9,547,000
Shoreside Electrical Power to Terminal	$50,000	$50,000
Approach Ramp and Landing Area	To be determined	To be determined
Subtotal: (System Acquisition Cost)	$9,597,000 + Cost of terminal	$9,597,000 + Cost of terminal
Annual Operating Costs		
Maintenance and Repair	$43,125	$65,000
Biennial Drydocking Voyage (Pro-Rated)	-	-
Crew Salaries	$345,000	$517,500
Fuel Costs	$77,625	$156,000
Lubricating Oil	$1,165	$2,340
Overnight Layover Expenses	$26,740	$26,740
Overhead	$34,000	$68,000
Insurance	$32,000	$208,000
Subtotal: (Annual Vessel Operating Cost)	$559,655	$1,043,580
Insurance of Shoreside Facilities	To be determined	To be determined
M&R of Shoreside Facilities	To be determined	To be determined
Other Costs of Shoreside Facilities Oper.	To be determined	To be determined
Subtotal: (Annual Shoreside Costs)	To be determined	To be determined
TOTAL: (Annual Operating Costs)	$559,655*	$1,043,580*
20-Year Life Cycle Cost		
i = 3%		
Present Value	$17,923,253*	$25,122,835*
Uniform Equivalent Annual Cost	$1,204,724*	$1,688,649*
i = 7%		
Present Value	$15,525,993*	$20,652,701*
Uniform Equivalent Annual Cost	$1,465,544*	$1,949,469*

* Excluding cost of terminal and shoreside facilities

the process of acquiring for operations in Cold Bay, Alaska was reported in the 6 May 2005 *Daily Journal of Commerce* as being $8.8 million.

The above capital costs do not include the cost of constructing the appropriate terminals.

Operating Cost

The total annual operating cost is estimated to range between $640,000 and $1.6 million for the conventional ferry, and between $560,000 and $1.0 million for the hovercraft. This does not include the costs of operating shoreside facilities, which remain to be determined.

Life Cycle Cost

The 20-year life cycle costs (in 2005 dollars) range between $11.2 million and $30.2 million for the conventional ferry, and between $15.5 million and $25.1 million for the hovercraft. The equivalent uniform annual cost (in 2005 dollars) is between $940,000 and $2.2 million for the conventional ferry, and between $1.2 million and $1.9 million for the hovercraft. This does not include the costs of operating shoreside facilities, which remain to be determined.

SECTION 7

Summary and Recommendations

This section summarizes the key findings of this study and recommends route, vessel and terminal site candidates.

Key Findings

The vessel types, routes and terminal sites have been examined for marine service linking the City of Akutan with a proposed airport either on Akutan Island near Fish Banks Lake, or on Akun Island near Surf Bay.

A BHT 130 hovercraft and a 150-foot conventional ferry with bow ramp were selected for further consideration. Landing craft were eliminated, as all the proposed eastern terminus sites are subject to waves that would cause unacceptable pounding on the beach.

Four sites were examined as possibilities for the western terminus, three near the City of Akutan, and the fourth at the head of Akutan Harbor. In addition to a landing facility, a hovercraft requires a hangar and maintenance facility. Table 7 shows the feasibility of locations for a terminal and hangar facilities for the western terminus. Existing facilities at the City of Akutan would require modifications. There are currently no facilities at Harbor Head.

Table 7: Feasibility of western terminus sites by vessel type

Vessel Type	AMHS Ferry Terminal	Seaplane Ramp	Skiff Harbor	Harbor Head
Hovercraft	✗	✓	✗	✓
Hangar/Maintenance	✗	✗	✗	✓
Conventional	✓	✗	✓	✓

Table 8 shows the feasibility of eastern terminus sites, five on Akutan Island and one on neighboring Akun Island at Surf Bay. Feasibility of these sites is determined not only by meeting the 90% minimum weather operability criterion, but also meeting other criteria, such as sufficient space on the beach to land and sufficient beach stability to avoid high maintenance costs for permanent modifications.

Table 8: Feasibility of eastern terminus sites by vessel type

Vessel Type	Surf Bay (Akun Is.)	West Cove	East Cove	Fish Banks #0	Fish Banks #1	Fish Banks #2
Hovercraft	✓	✓	✓	✗	✗	✗
Conventional	✗	✓	✗	✗	✗	✗

Acquisition cost of a conventional ferry would be between $4.5 million and $7.2 million in 2005 dollars. Shore-vessel interface assets at Akutan and West Cove would be additional costs.

Acquisition cost of a new, U.S.-built BHT 130 hovercraft similar to that currently under construction for Aleutians East Borough is estimated to be $9.6 million in 2005 dollars. To this must be added the following costs: modifications to the seaplane landing pad at Akutan, construction of a hangar and maintenance facility (presumably at the head of Akutan Harbor), and construction of landing facilities at the eastern terminus. The cost of constructing a hovercraft terminal at the eastern terminus ranges from most expensive at East Cove to least expensive at Surf Bay.

Table 9: Acquisition costs comparison

	Conventional	Hovercraft
System acquisition cost	$4.5 M to 7.2 M	$9.6M*
Cost of terminals	TBD	TBD

* Includes cost of delivery and sea trials

Annual operating cost of a conventional ferry would be between $640,000 and $1.6 million in 2005 dollars. Annual operating costs of the BHT 130 hovercraft in this service would be between $560,000 and $1.0 million in 2005 dollars. This does not include the costs of operating shoreside facilities, which remain to be determined.

Table 10: Annual operating costs comparison

	Conventional	Hovercraft
Vessel operating cost	$640K to $1.5M	$560K to $1.0M
Shoreside costs	TBD	TBD

The 20-year life cycle costs (in 2005 dollars) range between $11.2 million and $30.2 million for the conventional ferry, and between $15.5 million and $25.1 million for the hovercraft. The equivalent uniform annual cost (in 2005 dollars) is between $940,000 and $2.2 million for the conventional ferry, and between $1.2 million and $1.9 million for the hovercraft. This does not include the costs of operating shoreside facilities, which remain to be determined.

Table 11: 20-year life cycle costs comparison

	Conventional	Hovercraft
Present value	$11.2M to $30.3M	$15.5M to $25.1M
Uniform equivalent annual cost	$940K to $2.2M	$1.2 M to $1.9M

Recommendations

Several viable marine services have been identified. The shortest distance with the most sheltered terminals would be between the City of Akutan and West Cove. That service could be provided by either a hovercraft or a conventional ferry. The shore-vessel interface structures and development necessary to support operations of a conventional ferry at West Cove will be more expensive than the corresponding developments needed to support hovercraft operations. At the City of Akutan, the structures and development necessary to support operations of a conventional ferry will not only be more expensive, but also more disruptive to established marine operations.

The other attractive marine service would be by hovercraft between the City of Akutan and Surf Bay on Akun Island. Such a hovercraft service would easily satisfy passenger comfort and weather operability goals. The modifications necessary to support hovercraft operations at the beach in Surf Bay are minimal. Required improvements at the seaplane base at City of Akutan to support hovercraft operations would likewise impose minimal cost and impact to other uses. A hovercraft hangar and maintenance facility would need to be established elsewhere, presumably at the head of Akutan Harbor.

With the exception of terminals at Fish Banks, each of the routes considered for marine links to an airport serving Akutan meets the passenger comfort and minimum weather operability established for this service. The hovercraft is a viable alternative to all viable eastern terminus sites, while the conventional ferry meets the requirements only when operating to West Cove. East Cove is less favorable than West Cove, as there would likely be a higher degree of storm-related maintenance to terminal facilities, due to annual and extreme storm events.

Ultimately the selection of a site for the airport and the associated choice of connecting marine service must be made by others, taking into account non-marine considerations. On the basis of marine operability, shore-vessel interface and system cost considerations, the recommended service would be for a hovercraft operating either to West Cove or to Surf Bay on Akun Island.

SECTION 8

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