Appendix S

Movable Bridge Report

KETCHIKAN GRAVINA ISLAND ACCESS

Movable Bridge Report

HP-NCPD-922(5) / 67698 / 19752

A Gateway to the Future
Gravina Access

Prepared for:

Department of Transportation and Public Facilities
Southeast Region

Prepared by:

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January 2009

Gravina Movable Bridge Report

January 2009

Introduction

A preliminary scoping investigation was performed with the specific goal to determine if a movable bridge could be designed and constructed the *Tongass Narrows* navigational channel at a cost of under $150 million. The first step was to determine what the basic cross sections would be for movable spans which can meet the desired requirements for large ship transit of the channel.

There are three types of movable bridges; bascule, swing and vertical lifts.

Bascule bridges are composed of a steel truss span that pivots about a trunnion and are balanced by a counterweight. Bascule bridges are built as either single or double leaf designs. The maximum practical span length for each leaf is approximately 150-feet. The double-leaf bascule design will not provide the necessary navigational opening that is required over *Tongass Narrows*.

Swing bridges consist of a truss span that rotates about a center pivot pier. The swing spans can be either steel or concrete, with concrete being by far the heavier structure. Swing spans are generally up to 350 feet in length. Two swing spans could be used to meet the navigation channel width requirements. The challenge with swing spans across the narrow channel is the lack of room for the backspan portion of the swing span. A variant of the swing span (bobtail swing) has unequal length arms. This variant would be very challenging for the desired bridge alignment.

A vertical lift structure is a span that is lifted between two towers. These towers guide the movable span and provide support for the counterweight system used to balance the span. The movable span is connected to its counterweights by cables (wire ropes). Large cable sheaves are mounted on the top of the towers such that as the span is raised, the counterweight is lowered (generally within the envelope of each tower. Vertical lift bridges have been constructed with navigation channel clearances of 600 feet and under-clearance of 250 feet.

With a swing bridge, a free channel clearance of 500-feet can be provided. This clearance is less than desired by the cruise industry, but acceptable to the AMHS. Construction of a swing bridge requires that the tracklines will have to be moved to the east in order to accommodate the backspan. A lift bridge can be centered on the trackline, but the towers will encroach into the FAA Part 77 airspace, which is not expected to be a major issue.

Movable bridges also require an operator to open and close the span for marine traffic. In addition, specific ongoing maintenance is required. Maintenance costs are greater than a fixed bridge and require limited expertise with mechanical and electrical systems.

Bridge Configuration
A configuration assuming twin swing spans will provide for a 500 foot clear channel. An alternative approach would be to have a single swing span with two 230 foot channels on with side of the pivot pier. This second option is substantially less expensive but results in smaller navigation channels. A concrete superstructure (approximately 20 million pounds) and a steel superstructure (approximately 4 million pounds) were examined below.

Additionally, a lift span was also analyzed, using two concrete towers with a steel frame, and an almost 600 foot steel deck truss for the span across the trackline. The truss section will weigh approximately 6 million pounds and span the 550-foot navigational channel.

It is understood that the Department prefers concrete due to maintenance considerations, but concrete is not a preferred material for movable bridges due to its weight.

<u>Concrete Twin Swing Spans</u>

Pivot Pier	130'x 45' diameter	qty: 2
Superstructure	565' x 50' 9" wide x 43' deep	qty: 2
Bridge Machinery System		qty: 2
Bridge Electrical System		qty: 2
Approach Spans		470'
Pier Protection System		
Roadway Lighting System		

<u>Steel Truss Twin Swing Spans</u>

Pivot Pier	130' x 45' diameter	qty: 2
Superstructure	550' x 50' 9" wide x 43' deep	qty: 2
Bridge Machinery System		qty: 2
Bridge Electrical System		qty: 2
Approach Spans		500'
Pier Protection System		
Roadway Lighting System		

<u>Single Concrete Swing Span</u>

Pivot Pier	130' x 45' diameter	qty: 1
Superstructure	565' x 50' 9" wide x 43' deep	qty: 1
Bridge Machinery System		
Bridge Electrical System		
Pier Protection System		
Roadway Lighting System		

Vertical Lift Span

Foundations (drilled shafts, concrete pier cap and cofferdam)	qty: 2
Towers (concrete and steel frame)	qty: 2
Span (steel truss and deck)	
Bridge Machinery System	qty: 2
Bridge Electrical System	
Approach Spans	800’
Pier Protection System	
Roadway Lighting System	

Estimated Costs

Pivot Pier Costs

Assume 45’ diameter x 130’ tall = 4,500 CYs of concrete @ $1,000 per CY = $10,000,000

Superstructure Costs

The costs for the superstructure are the single largest component for the bridge.

Concrete 565’ long x 50’ 9” wide x 43’ deep
Approximately 4,750 CYs at $2,000 each = $ 9,500,000 each

Steel Truss 550’ long x 50’ 9” wide x 43’ deep
Approximately 4,000,000 pounds at $5.00 per pound = $ 20,000,000 each

Bridge Machinery System

Span Operating Machinery	$ 3,000,000
Span Lock Machinery	$ 1,000,000
Lift Machinery	$14,000,000

Bridge Electrical System

Incoming Service	$ 1,500,000
Back up Generator	$ 1,000,000
Bridge Control System	$ 1,000,000
Submarine Cables	$ 2,000,000

Pier Protection System

Cell Structures	$ 2,000,000
Fender System	$ 1,000,000

Roadway Lighting System

Poles and wiring	$1,000,000

Approach Spans and Piers
It is assumed that the cost of the approach spans (concrete box sections will be proportional to the movable spans adjusted for length). The cost of the approach piers will be equal to the span costs.

Concrete Approach spans, 470 feet = $ 8,000,000
Concrete Approach spans, 500 feet = $ 8,500,000
Concrete Approach Spans, 1035 feet = $ 17,600,000

Twin Concrete Swing Spans (550')

Pivot piers		$ 20,000,000
Superstructure		$ 19,000,000
Bridge Machinery		$ 9,000,000
Bridge Electrical		$ 11,000,000
Pier Protection		$ 20,000,000
Roadway Lighting		$ 1,000,000
Approach Spans		$ 8,000,000
Approach Piers		$ 8,000,000
	Subtotal	$ 96,000,000
	Contingency 25%	$ 24,000,000
	Total	$ 120,000,000

Twin Steel Swing Spans (500')

Pivot Piers		$ 20,000,000
Superstructure		$ 40,000,000
Bridge Machinery		$ 8,000,000
Bridge Electrical		$ 11,000,000
Pier Protection		$ 20,000,000
Roadway Lighting		$ 1,000,000
Approach Spans		$ 8,500,000
Approach Piers		$ 8,500,000
	Subtotal	$ 117,000,000
	Contingency 25%	$ 29,000,000
	Total	$ 146,000,000

Single Concrete Swing Span (250')

Pivot Pier		$ 10,000,000
Superstructure		$ 9,500,000
Bridge Machinery		$ 5,000,000
Bridge Electrical		$ 5,500,000
Pier Protection		$ 15,000,000
Roadway Lighting		$ 1,000,000
Approach Spans		$ 17,600,000
Approach Piers		$ 17,600,000
	Subtotal	$ 81,200,000
	Contingency 25%	$ 20,300,000
	Total	$101,500,000

Vertical Lift Span (600')

		M1	M2
Foundations		$ 23,268,000	$ 23,268,000
Towers		$ 58,500,000	$ 58,500,000
Span		$ 30,980,000	$ 30,980,000
Approach Spans (800')		$ 13,600,000	$ 19,550,000
Approach Piers		$ 13,600,000	$ 19,550,000
Pier Protection		$ 21,500,000	$ 21,500,000
Bridge Machinery		$ 64,360,000	$ 64,360,000
Bridge Electrical		$ 6,200,000	$ 6,200,000
Roadway Connection		$ 20,000,000	$ 33,170,000
Roadway Embankment			$ 675,000
Roadway Lights		$ 1,250,000	$ 1,250,000
	Subtotal	$253,258,000	$279,003,000
	Contingency 25%	$ 63,315,000	$ 69,750,750
	Total	$316,573,000	$348,753,750
	Say:	$316,600,000	$348,800,000

Maintenance and Operations

In additional to normal and routine roadway and bridge maintenance, moveable bridges require a full-time ongoing operational staff to insure unimpeded shipping on *Tongass Narrows*, and continuous access between Revilla and Gravina islands. The following are estimated costs for the annual operation of a movable structure:

Bridge Operators (5 people @ $60k plus benefits)		$ 450,000
Routine Maintenance (32 hrs/month @ $25/hr+$5k materials)		$ 30,000
Operating Expenses (electricity)		$ 120,000
Annual Repairs (assume $10k per month)		$ 120,000
	Subtotal (say)	$ 750,000
Annual Roadway Maintenance		$ 300,000
	Total	$1,050,000

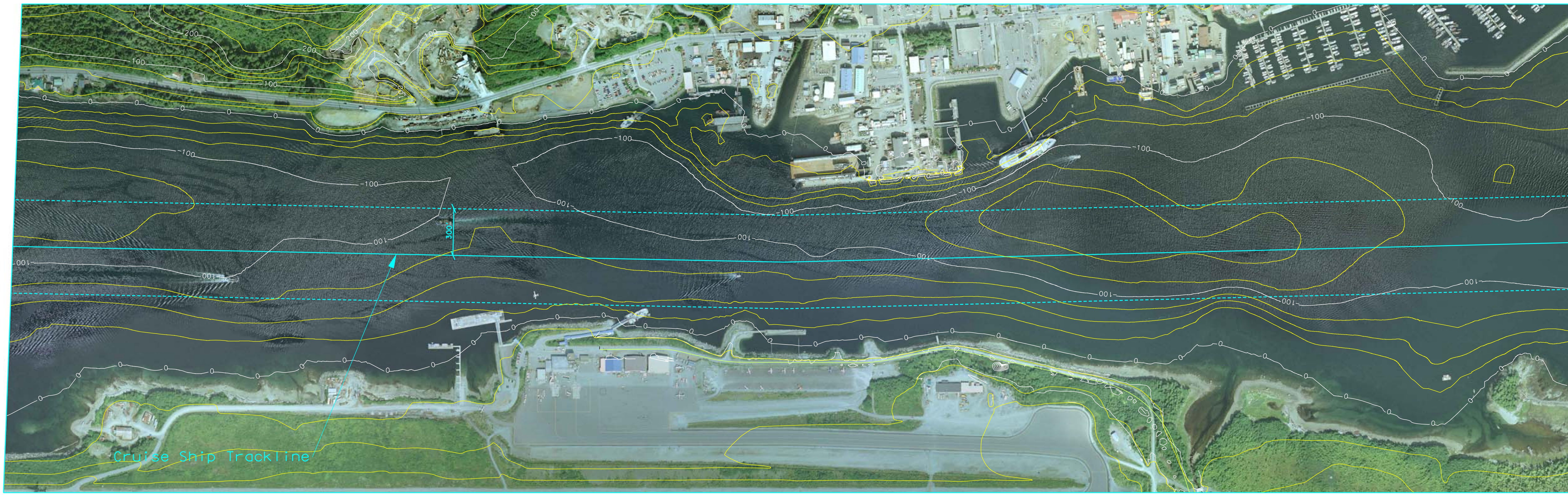
One approach that clients are beginning to implement is to remotely operate the movable bridge such that a dedicated bridge operator is not required. This approach can significantly reduce costs.

Life-cycle Costs

A life-cycle cost was prepared for the vertical life spans using the NIST *BridgeLCC* software. In 25 years, rehabilitation will be required on the structure which is expected to cost approximately $5 million. In 50 years a major rehabilitation will be required, at about $35 million. For a 75 year anticipated life beginning in 2013, the expected life-cycle costs are between $388 and $445 million.

Summary

A double leaf bascule bridge could only provide about a 300-foot opening; not the minimum desired opening for *Tongass Narrows* large shipping, and was immediately discarded. Swing bridges can provide a navigational opening of 500-feet (and even greater), but their major negative is they must be a balanced structure, and the backspan length is difficult to provide in the narrow channel opening. The most feasible structure will be a vertical lift span. This bridge can provide a span opening of 550-feet, centered on the cruise ship trackline.


300'
Cruise Ship Trackline

Movable Bridge M-1
K = 101.63
300.00 VC
PVI STA.=0+01.45
PVI ELEV.=40.00
PVC STA.=10+50.00
PVC ELEV.=40.00
PVI STA.=12+00.00
PVI ELEV.=40.00
PVT STA.= 13+50.00
PVT ELEV.=35.57
PVI STA.=16+37.00
PVI ELEV.=27.10
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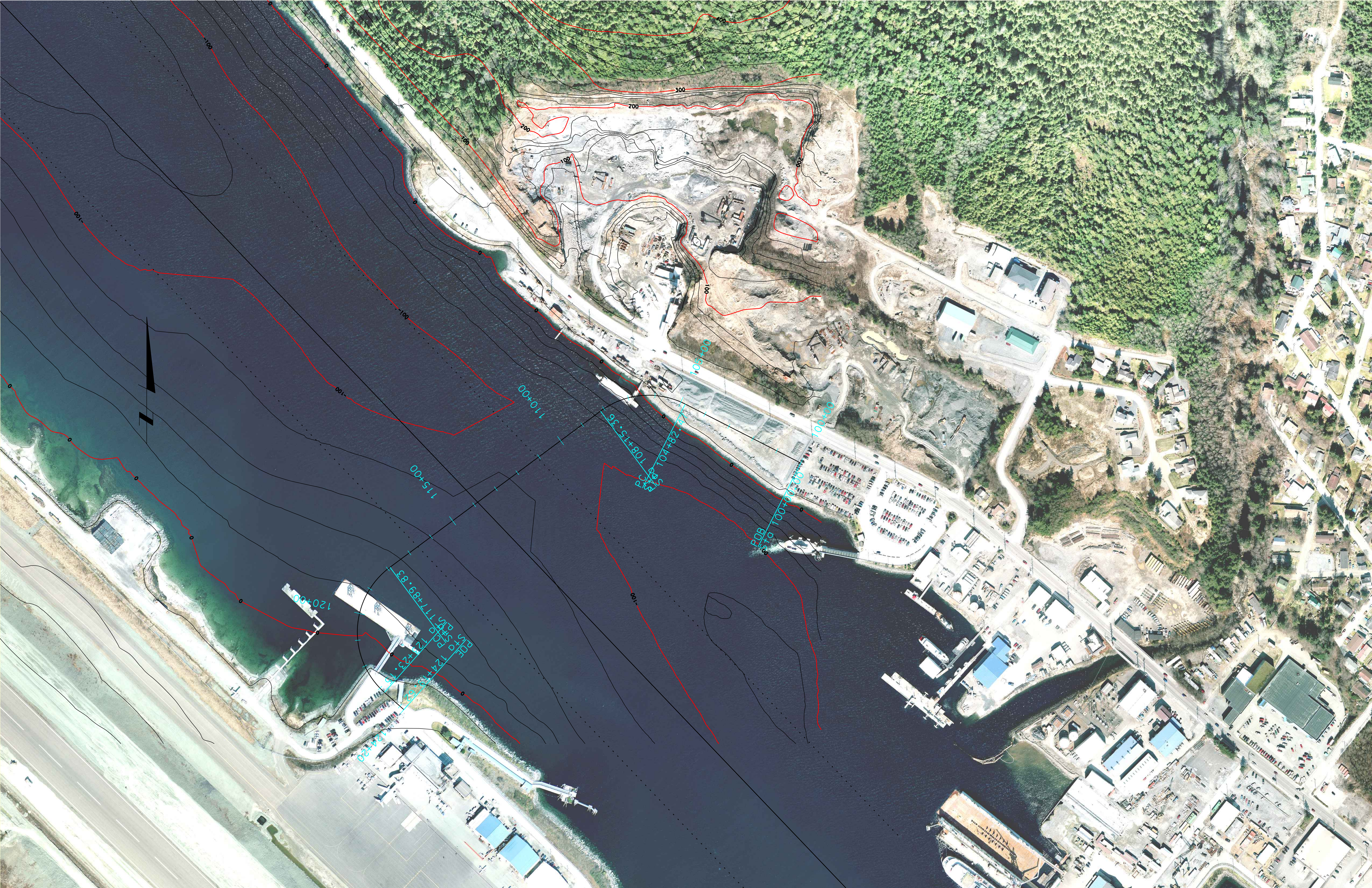
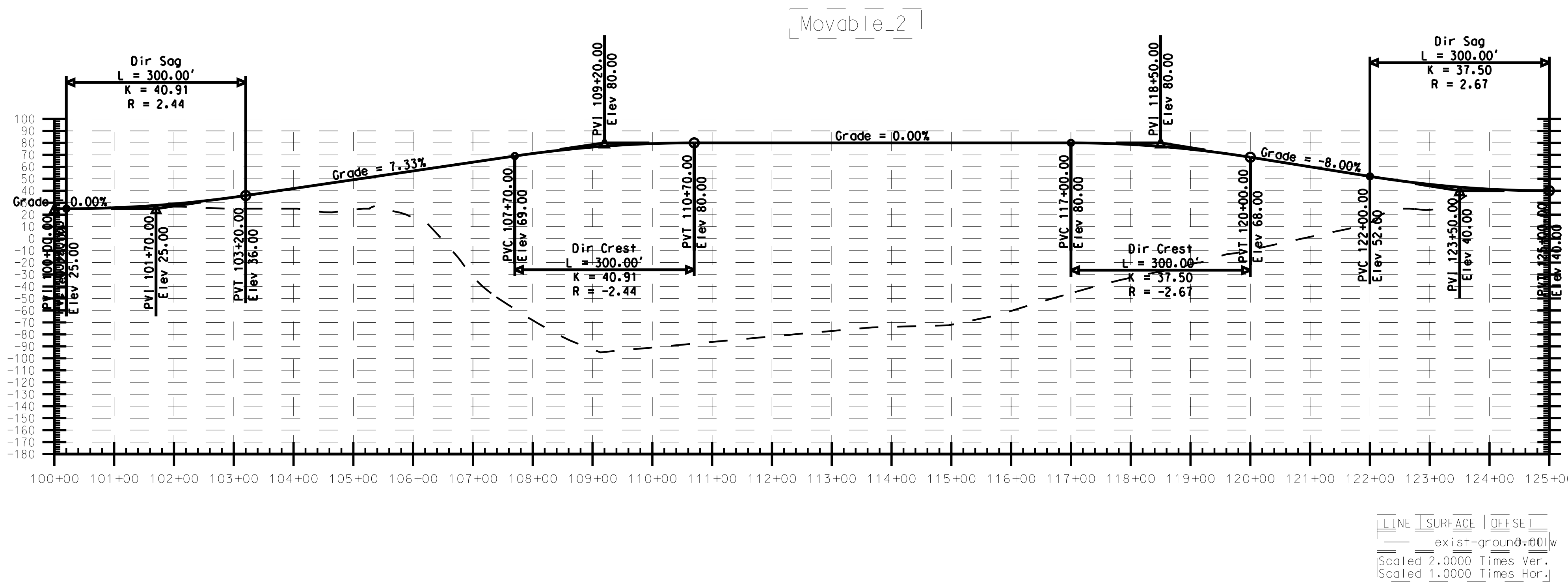
-2.95%
Sta 16+37.46
Sta 15+66
15+00
10+00
5+00
0+00



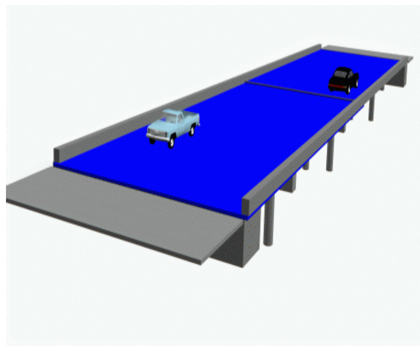
300
200
100
-100
0
110+00
115+00
120+00
108+15.36
117+89.83


Movable_2
Dir Sag
L = 300.00'
K = 40.91
R = 2.44
Grade = 0.00%
Grade = 7.33%
PVI 109+20.00
Elev 80.00
Grade = 0.00%
PVI 118+50.00
Elev 80.00
Grade = -8.00%
Dir Sag
L = 300.00'
K = 37.50
R = 2.67
PVI 100+00.00
Elev 25.00
PVI 101+70.00
Elev 25.00
PVT 103+20.00
Elev 36.00
PVC 107+70.00
Elev 69.00
Dir Crest
L = 300.00'
K = 40.91
R = -2.44
PVT 110+70.00
Elev 80.00
PVC 117+00.00
Elev 80.00
Dir Crest
L = 300.00'
K = 37.50
R = -2.67
PVT 120+00.00
Elev 68.00
PVC 122+00.00
Elev 52.00
PVI 123+50.00
Elev 40.00
PVT 125+00.00
Elev 40.00
100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180
100+00 101+00 102+00 103+00 104+00 105+00 106+00 107+00 108+00 109+00 110+00 111+00 112+00 113+00 114+00 115+00 116+00 117+00 118+00 119+00 120+00 121+00 122+00 123+00 124+00 125+00
LINE SURFACE OFFSET
exist-ground 0.00 lw
Scaled 2.0000 Times Ver.
Scaled 1.0000 Times Hor.

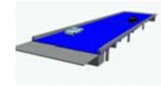
BridgeLCC 2.0
Reports

Ketchikan Gravina Island Access -- M and T Alignments

02/11/2009



Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD



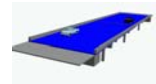
Analysis: Summary of Life-Cycle Costs

02/11/2009

	Name	**Base Case**	**Alternative #1**	**Alternative #2**
	Total Life-Cycle Cost	**$388,208,335**	**$442,183,826**	**$445,097,447**
By Cost Bearer:	Agency Costs	$388,208,335	$442,183,826	$445,097,447
	User Costs	$ 0	$ 0	$ 0
	Third-Party Costs	$ 0	$ 0	$ 0
By Cost Timing:	Initial Construction Costs	$335,514,454	$354,766,017	$369,540,473
	OM&R Costs	$ 52,693,881	$ 87,417,809	$ 75,556,974
	Disposal Costs	$ 0	$ 0	$ 0
By Cost Component:	Elemental Costs	$388,208,335	$442,183,826	$445,097,447
	Non-elemental Costs	$ 0	$ 0	$ 0
	New-Technology	$ 0	$ 0	$ 0

Data: Project Parameters

02/11/2009



Study Period

Base Year	2008
Length of period	80
Last Year	2088

Currency

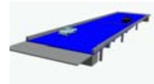
U.S. Dollars ($)

Interest Rates

Inflation	2.05%
Real Discount	2.80%

Elements

#1	Bridge
#2	Tunnel
#3	Paved Road
#4	Gravel Road
#5	
#6	Non-elemental
#7	New technology



M1 (20' to 200')

Lanes on	2	Length of roadway (ft)	1,640.00
	0	Length of bridge (ft)	1,400.00

Alignment M1. Provide a flat low-profile minimal-clearance (20-foot) movable bridge (600-foot vertical lift span) over Tongass Narrows between the existing ferry terminals on Revilla and Gravina islands. Span will open to provide 200 feet of vertical and 550 feet of horizontal navigational clearance.

T1

Lanes on	2	Length of roadway (ft)	25,314.00
	0	Length of bridge (ft)	3,200.00

Alignment T1. Provide a tunnel under Tongass Narrows between Peninsula Point on Revilla Island and Lewis Point on Gravina Island. Connect with a new paved road from Lewis Point portal up the hill to the Seley Road. Upgrade and pave the Seley Road, pave the Lewis Reef Road and Airport Access Road to the KTN passenger terminal. Channel will provide 550 feet of horizontal navigational clearance, and 40 feet of vessel draft at MLLW.

M2 (60' to 200')

Lanes on	2	Length of roadway (ft)	2,720.00
	0	Length of bridge (ft)	1,700.00

Alignment M2. Provide a curvilinear low-clearance (60-foot) movable bridge (600-foot vertical lift span) over Tongass Narrows near the existing ferry terminals on Revilla and Gravina islands. Span will open to provide 200 feet of vertical and 550 feet of horizontal navigational clearance.

Item	Event	Start Year	End Year	Frequency	Qtty	Unit of Measure	Unit Cost	Total	Remarks
Base Case									
Agency									
Initial Construction									
Construction cost	<no event>	5	5	1.0000	1.000	LS	$374,700,000	$374,700,000	.
Disposal									
Disposal cost	<no event>	80	80	1.0000	1.000	LS	$ 0	$ 0	.
O, M, and R									
M&O Bridge	<no event>	5	80	1.0000	1.000	LS	$ 1,050,000	$ 1,050,000	
M&O Paved Road	<no event>	5	80	1.0000	1640.000	LS	$ 4	$ 7,052	
M&O Gravel Road	<no event>	5	80	1.0000	34408.000	LS	$ 4	$ 147,954	
Inspection Above Ground	<no event>	7	80	2.0000	1.000	LS	$ 40,000	$ 40,000	
Inspection Underwater	<no event>	10	80	5.0000	1.000	LS	$ 40,000	$ 40,000	
Guardrail Bridge	<no event>	10	80	5.0000	1400.000	Length of	$ 23	$ 32,200	
Guardrail Paved Road	<no event>	10	80	5.0000	100.000	LS	$ 117	$ 11,700	
Guardrail Gravel Road	<no event>	10	80	5.0000	3441.000	LS	$ 117	$ 402,597	
Replace Pavement Bridge	<no event>	15	80	10.0000	1400.000	Length of	$ 102	$ 142,800	
Replace Pavement Road	<no event>	15	80	10.0000	200.000	LS	$ 102	$ 20,400	
Anode Replacement	<no event>	15	80	10.0000	1.000	LS	$ 100,000	$ 100,000	
Joint Gland Replacement	<no event>	15	80	10.0000	1.000	LS	$ 500,000	$ 500,000	
Signs/Illumination Bridge	<no event>	20	80	15.0000	1400.000	Length of	$ 5	$ 7,000	
Signs/Illumination Paved	<no event>	20	80	15.0000	100.000	LS	$ 5	$ 500	
Signs/Illumination Gravel	<no event>	20	80	15.0000	6882.000	LS	$ 5	$ 34,410	
Joint Assembly Replacement	<no event>	30	80	25.0000	1.000	LS	$ 1,400,000	$ 1,400,000	
Bridge Rehabilitation	<no event>	30	80	25.0000	1.000	LS	$ 5,000,000	$ 5,000,000	
Bridge Major Rehabilitation	<no event>	55	80	50.0000	1.000	LS	$ 35,000,000	$ 35,000,000	
Alternative #2									

Item	Event	Start Year	End Year	Frequency	Qtty	Unit of Measure	Unit Cost	Total	Remarks
Agency									
Initial Construction									
Construction Cost	<no event>	5	5	1.0000	1.000	LS	$412,700,000	$412,700,000	
O, M, and R									
M&O Bridge	<no event>	5	80	1.0000	1.000	LS	$ 1,800,000	$ 1,800,000	M&O=2800/1640
M&O Paved Road	<no event>	5	80	1.0000	2720.000	Length of	$ 4	$ 11,696	
M&O Gravel Road	<no event>	5	80	1.0000	34408.000	LS	$ 4	$ 147,954	
Inspection Above Ground	<no event>	7	80	2.0000	1.000	LS	$ 40,000	$ 40,000	
Inspection Underwater	<no event>	10	80	5.0000	1.000	LS	$ 40,000	$ 40,000	
Guardrail Bridge	<no event>	10	80	5.0000	1700.000	Length of	$ 23	$ 39,100	
Guardrail Paved Road	<no event>	10	80	5.0000	1360.000	LS	$ 117	$ 159,120	
Guardrail Gravel Road	<no event>	10	80	5.0000	3441.000	LS	$ 117	$ 402,597	
Replace Pavement Bridge	<no event>	15	80	10.0000	1700.000	Length of	$ 102	$ 173,400	
Replace Pavement Road	<no event>	15	80	10.0000	1020.000	LS	$ 102	$ 104,040	
Anode Replacement	<no event>	15	80	10.0000	1.000	LS	$ 100,000	$ 100,000	
Joint Gland Replacement	<no event>	15	80	10.0000	1.000	LS	$ 500,000	$ 500,000	
Signs/Illumination Bridge	<no event>	20	80	15.0000	1700.000	Length of	$ 5	$ 8,500	
Signs/Illumination Paved	<no event>	20	80	15.0000	510.000	LS	$ 5	$ 2,550	
Signs/Illumination Gravel	<no event>	20	80	15.0000	6882.000	LS	$ 5	$ 34,410	
Joint Assembly Replacement	<no event>	30	80	25.0000	1.000	LS	$ 1,400,000	$ 1,400,000	
Bridge Rehabilitation	<no event>	30	80	25.0000	1.000	LS	$ 5,000,000	$ 5,000,000	
Bridge Major Rehabilitation	<no event>	55	80	50.0000	1.000	LS	$ 35,000,000	$ 35,000,000	
Disposal									
Disposal Cost	<no event>	80	80	1.0000	1.000	LS	$ 0	$ 0	

Alternative #1

Agency

Item	Event	Start Year	End Year	Frequency	Qtty	Unit of Measure	Unit Cost	Total	Remarks
Initial Construction									
Construction cost	<no event>	5	5	1.0000	1.000	LS	$396,200,000	$396,200,000	.
O, M, and R									
M&O Tunnel	<no event>	5	80	1.0000	1.000	LS	$ 1,500,000	$ 1,500,000	
M&O Paved Road	<no event>	5	80	1.0000	23514.000	LS	$ 4	$ 101,110	
M&O Gravel Road	<no event>	5	80	1.0000	16714.000	LS	$ 4	$ 71,870	
Inspection Above Ground	<no event>	7	80	2.0000	1.000	LS	$ 40,000	$ 40,000	
Inspection Underwater	<no event>	10	80	5.0000	1.000	LS	$ 40,000	$ 40,000	
Guardrail Paved Road	<no event>	10	80	5.0000	11057.000	LS	$ 117	$ 1,293,669	
Guardrail Gravel Road	<no event>	10	80	5.0000	1671.000	LS	$ 117	$ 195,507	
Replace Pavement Tunnel	<no event>	15	80	10.0000	3200.000	Length of	$ 102	$ 326,400	
Replace Pavement Road	<no event>	15	80	10.0000	22114.000	LS	$ 102	$ 2,255,628	
Anode Replacement	<no event>	15	80	10.0000	1.000	LS	$ 100,000	$ 100,000	
Joint Gland Replacement	<no event>	15	80	10.0000	1.000	LS	$ 500,000	$ 500,000	
Signs/Illumination Tunnel	<no event>	20	80	15.0000	3200.000	Length of	$ 5	$ 16,000	
Signs/Illumination Paved	<no event>	20	80	15.0000	11057.000	LS	$ 5	$ 55,285	
Signs/Illumination Gravel	<no event>	20	80	15.0000	3343.000	LS	$ 5	$ 16,715	
Joint Assembly Replacement	<no event>	30	80	25.0000	1.000	LS	$ 1,400,000	$ 1,400,000	
Tunnel Electrical	<no event>	5	80	1.0000	1.000	LS	$ 550,000	$ 550,000	
Tunnel Repairs and	<no event>	5	80	1.0000	1.000	LS	$ 200,000	$ 200,000	
Disposal									
Disposal cost	<no event>	80	80	1.0000	1.000	LS	$ 0	$ 0	.

Gravina Access Project
Movable Bridge Alternative Technical Memorandum

Agreement No: 36893013
DOT&PF Project No: 67698
Federal Project No: ACHP-0922(5)

Prepared for:

State of Alaska
Department of Transportation and Public Facilities
6860 Glacier Highway
Juneau, Alaska 99801

Prepared by:

HDR Alaska, Inc.
712 West 12th St.
Juneau, AK 99801

February 2000

Table of Contents

1.0 Introduction

The Alaska Department of Transportation and Public Facilities (DOT&PF) has initiated the Gravina Access Project to study ways to better connect the City of Ketchikan and Revillagigedo Island with Ketchikan International Airport and Gravina Island. As part of this project the DOT&PF is considering bridge, ferry, tunnel, and tube crossings of Tongass Narrows. This memorandum describes and evaluates one type of bridge option under consideration—a bridge with a movable span, also known as a fixed movable bridge.

The fixed movable bridge is under consideration because it would allow cruise ships to pass through Tongass Narrows and it would not penetrate the airport clearance zone to the degree that a high-level bridge would. High level bridges in this area are constrained by the dimensions of the navigational channel and by the airspace requirements of the Ketchikan International Airport. Some high-level bridge options under consideration, options that would allow passage of two way cruise ship traffic, would be so high that they would penetrate the airport navigational clearance zone and would require special approval from the Federal Aviation Administration. A movable bridge would provide a span that would be raised to allow for passage of cruise ships, and therefore, it would not affect the operations of the airport in the same manner as would a high bridge. The fixed movable bridge's towers and raised lift span could penetrate the airport clearance zone, but the rest of the bridge would not. However, a movable bridge could interfere with floatplane operations on Tongass Narrows, depending on its exact alignment.

This memo describes a bridge with a movable span of 237.7 m (780 ft) to accommodate a navigational channel of 228.6 meters (750 ft). It would also be possible to construct a low-level fixed bridge with no movable span, but this would block Tongass Narrows to large cruise ships, those with an air draft of 37 meters (121 ft) or more. With a fixed, low-level bridge, cruise ships and other large vessels would be forced around Gravina Island, as described in the document titled "Reconnaissance of Vessel Navigation Requirements" (Glosten October 1999). The financial and other impacts of this scheme have not yet been determined. An evaluation of a fixed movable bridge, including proposed alignment, clearance requirements, types of movable bridges (including the preferred vertical lift bridge), operations requirements of a lift bridge, and cost, is included in the following sections.

2.0 Alignment

The alignment chosen for the movable bridge is that noted by Option "D" in the "Gravina Access Project Practicable Alternative Development Memorandum" (HDR 1999). Figures 1 and 2 depict the plan and profiles of the Option D alignment. This alignment crosses Tongass Narrows at the airport near the existing ferry terminal. The channel width at this location is 600 meters (2,000 ft) and the maximum water depth is 20 meters (66 ft). The total length of elevated structure for this alignment is 1,060 meters (3,500 ft).

3.0 Clearances

To minimize traffic interruptions due to vessel traffic, a vertical clearance of 36.58 meters (120 ft) above mean higher high water (MHHW) was assumed for the bridge in the closed position. This clearance would allow Alaska Marine Highway System vessels to pass under the bridge without requiring an opening of the span (Glosten October 1999).

When the bridge is in the open position, a vertical clearance of 64 meters (210 ft) above MHHW was assumed (HDR January 2000). This vertical clearance would allow for the passage of the cruise vessels that frequent and are anticipated in Tongass Narrows. In addition, as discussed in the "Gravina Access Project Navigational Clearances Memo" a horizontal clearance of 228.6 meters (750 ft) and a draft of 12.2 meters (40ft) were assumed (HDR 2000).

4.0 Design Considerations

Movable bridges, like other bridge types, must be designed for structure and traffic loads, earthquake loads, ship impact loads (if navigation protection is not provided), and wind loads. Of special concern for a movable bridge is the wind loading. The Ketchikan area experiences wind speeds in excess of 100 MPH. A movable bridge, because of the nature of the structure, typically has larger members, which catch more wind force. Also, in the open position, the continuity of a fixed span is lost, and therefore individual piers must take larger wind forces. For these reasons, a movable bridge design is more influenced by wind forces, having more impact on member and pier sizes, appearance, and cost. Special wind studies at the selected crossing site would be accomplished to provide accurate wind data to design the bridge, if a bridge is the selected crossing option.

5.0 Types of Movable Bridges

Three types of movable bridges were considered at the Option D alignment. They are discussed in more detail below.

<u>Vertical lift bridge.</u> A vertical lift movable bridge is composed of a simple span structure with lifting towers at the supports. Each end of the span is elevated with cables that run from the span over sheaves in the towers. The other ends of the cables are connected to counterweights that are almost equal to the weight of the structure. The counterweights reduce the amount of horsepower required to lift the bridge. Both ends of the bridge are lifted simultaneously to ensure that the span remains level at all times. Because the spans

of a movable bridge must be lifted, the lifted span is typically fabricated from structural steel. For spans in this range, a steel truss is the only structure type that is viable. For this movable bridge type, a 237.7 meter (780 ft) simple span steel truss would be supported by braced steel towers at each end. The depth of the superstructure would vary from 15 meters (50 ft) at the supports to 20 meters (65 ft) at midspan.

Bascule bridge. A bascule bridge is composed of a cantilever span that pivots about a trunnion and is balanced by a counter weight. Cantilever spans are typically steel trusses. The steel trusses may be either a decked truss or a through truss. The maximum reasonable span for each cantilever leaf of a double-leaf bascule is approximately 46 meters (150 ft), for a 92 meter (300 ft) total main span. This is less than the required 228.6 meters (750 ft) horizontal clearance requirement so the bascule bridge was eliminated from further consideration.

Swing bridge. A swing bridge is a double balanced cantilever structure that pivots about a center pivot pier. The cantilever spans are constructed as continuous steel trusses. Two 122 meter (400 ft) double cantilever swing spans would be required to provide the required horizontal clearance for a swing bridge option. The maximum reasonable span for each cantilever leaf of a double-leaf bascule is approximately 61 meters (200 ft). A 122 meter (200 ft) double cantilever swing span is not feasible; hence, the swing bridge was eliminated from further consideration.

This brief review of movable bridge types indicates that only the vertical lift span would be structurally feasible; therefore, it is the only type considered in the following discussion.

6.0 Operation of a Lift Bridge

The operating cycle for raising a 237.7 meter (780 ft) long span 27.4 meters (90 ft) as shown in Figure 3 would be 23 to 35 minutes. The simple steel lift span could be raised and lowered in 4 to 5 minutes. However, vessel passage can take between 15 to 25 minutes depending on the size of the vessel. This amount of time is needed because a vessel will not maneuver toward the bridge until the bridge is completely open. To account for a malfunction during the raising of the span, a vessel will either be stationary or far enough away from the bridge that it will be able to stop if the bridge is not fully raised. Allowing for vessel passage times of 15 to 25 minutes results in a bridge closure of 23 to 35 minutes. According to the "Gravina Access Project Navigational Clearances Memo" (HDR January 2000) cruise ships stop in Ketchikan an average of five times a day during the May through September tourist season. Thus, the bridge would be closed to traffic for two to three hours a day.

In addition, the lift towers of the movable bridge would be 91.4 meters (300 ft) above MHHW. These lift towers, therefore, would penetrate the Federal Aviation Regulations

(FAR) Part 77 surface for the airport and would be considered an obstruction to navigation. The deviation into the Part 77 surface would require an approval from the FAA.

7.0 Construction, Operation, and Maintenance Costs

The table below presents the costs of a movable bridge span of 259 meters (850 ft) with segmental prestressed concrete bridge approaches of 808 meters (2,650 ft), and a fixed span bridge of 1,060 meters (3,500 ft). Construction costs for a lift span portion of the bridge are estimated to be significantly higher than that of a fixed span. Initial conceptual costs were based on per square foot construction costs from other recent projects. Costs of $800/sf of a movable bridge and $100/sf for a segmental post tensioned bridge from Lower 48 prices were increased 25% for Alaska, 30% for deep foundation conditions, and 12.5% for inflation from the base 1998 year to 2002. In addition, the movable bridge costs were increased 30% because that cost data was for shorter span bridges.

Operational labor costs for a movable bridge were obtained by assuming a staff of five required for the five month tourist season and a staff of two for the remainder of the year. An annual average salary of $40,000 was assumed with a 2.5 multiplier. In addition, $150,000 was assumed for annual maintenance and repairs. The annual maintenance costs include painting the steel superstructure, changing the bridge lighting, monitoring and servicing the navigation lighting system, testing the operation of the electrical and mechanical back up systems, performing routine lubrication of the machinery bearings, rotating elements, monitoring and lubricating the wire as necessary, suspending and operating ropes on the bridge, and replacing worn or broken parts.

The operation and maintenance costs for a fixed span bridge were obtained assuming a staff of one for the entire year, and a maintenance and repair costs of $25,000 per year.

Costs

	Movable bridge span	***Fixed bridge***
Initial construction cost	$104,000,000	$30,700,000
Annual operations cost	$475,000/ year	$125,000/ year

8.0 Conclusion

While the initial and annual costs of a movable bridge are significantly higher than that of a fixed span bridge, the economic and operational impacts associated with the increased travel time of cruise ships around Gravina Island due to a fixed span has yet to be analyzed. The operation cycle to open and close the bridge would be lengthy and would cause delays at the airport. Construction and operational costs would be much higher for a movable bridge span than for a fixed span bridge. Until that analysis is complete, a fair comparison of alternatives cannot be made. Therefore, the movable bridge alternative may be a viable alternative for the crossing of Tongass Narrows and will continue to be considered at this time.

9.0 References

The Glosten Associates. October 1999. "Gravina Access Project: Reconnaissance of Vessel Navigation Requirements." For the Alaska Department of Transportation and Public Facilities.

HDR Engineering. January 4, 2000. "Gravina Access Project Navigational Clearances Memo." For the Alaska Department of Transportation and Public Facilities.

HDR Engineering. 1999. "Gravina Access Project Practicable Alternative Development Memorandum." For the Alaska Department of Transportation and Public Facilities.