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April 5, 2005

Mr. Edward Smith
Raft Island Improvement Association, Inc.
P. O. Box 332
Gig Harbor, WA 98335-0332

RE: Raft Island Bridge Condition Evaluation
Project No.: A04208.00

Dear Mr. Smith:

Attached is the final report of the work that we have performed for you on the Raft Island Bridge. We are presenting the results of our inspection and load rating as well as our suggested long term maintenance and replacement for the bridge. All of your comments and requests have been incorporated. Thank you for letting us assist you with this project.

Respectfully,
Sargent Engineers, Inc.

Monte Jay Smith
Principal

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Introduction

The Raft Island Bridge connects Raft Island to Rosedale near Gig Harbor. The 788 foot long bridge has a curb to curb with of 20 feet. The bridge has an asphalt concrete surface with a membrane under the asphalt protecting the concrete deck of the bridge. The deck is composed of inverted bathtub units that are reinforced with reinforcing steel and prestressing steel (this is steel that is pretensioned before the concrete is cast). The deck is supported by timber pile bents spaced at 17 feet. There is one span that is 23 feet long.

In 1996 we performed an in depth inspection of the bridge. During that inspection, we observed all of the bridge at a close enough distance to identify cracks and deterioration in the bridge. We also sampled the concrete and timber in the bridge to determine the condition of the concrete and timber. At the time, the Association (Raft Island Improvement Association) had been repairing the timber piles as needed. From our investigations, we identified a high concentration of chlorides in the concrete deck units. The chlorides come from the salt water below the concrete units. These chlorides deteriorate the protective chemical reaction that protects the steel in the concrete units. Given enough time, these units will deteriorate due to this high chloride content.

Scope of Work

We performed the following work:

Detailed Inspection

We performed a hands on inspection of the bridge. This means that we were at a close enough distance to all of the members of the bridge that we could touch them. This enabled us to detect cracks or other deterioration in the structure.

For the lower portions of the bridge, we walked under the bridge and climbed the piers to inspect the timber in the piers. The marine growth on the piles was cleaned off in spots. The piers were sounded with a hammer to detect hollow spots. Suspect spots were drilled and the material from the pile sampled to find any decay. The holes from this drilling were plugged with preservative treated plugs. All deteriorated portions of the pile bents were documented.

The upper portions of the bridge was inspected with an under bridge inspection truck provided by Al Ferris Contracting. This truck makes it possible for the inspector to go under the bridge and get a close look at all of the concrete members in the bridge. One lane of the bridge was closed for this inspection. The concrete members were sounded with a hammer to detect deteriorated areas. The deteriorated areas were documented for this report.

The asphalt was visually inspected for deterioration. This deterioration included cracking, rutting, and creep.

The expansion joints were visually inspected for debris, water containment, and proper movement. Any deterioration in the dams and seals was documented.

Proposed Maintenance

Once the inspection was completed, then future required maintenance was projected. This projection included the year that the maintenance will probably be required as well as its cost. The maintenance included, pile replacements or repairs, concrete repairs, timber brace and cross beam replacement, and repairs to the asphalt and membrane. This proposed maintenance plan assumes that the bridge will never be replaced.

Bridge Replacement

A proposed replacement bridge was sketched up and costs for the design and construction of the bridge developed. Per the *Stormwater Management Manual for Western Washington*, the new bridge has to treat any stormwater coming from the bridge. Therefore, the bridge profile has to be changed from its present configuration.

Bridge Load Rating

A bridge load rating indicates the current ability of the bridge to carry truck loads. The current load rating for the bridge was reviewed and updated. The bridge load rating was projected into the future based on the proposed maintenance plan.

Bridge Preservation Strategy

Several different strategies were developed for the preservation of the bridge. These strategies included consideration of the current condition of the bridge, the replacement cost of the bridge, the current and projected load rating, and the projected maintenance of the bridge. Potential strategies included:

- Maintain the bridge without replacement. This included sealing the deck on the top and bottom to keep water from corroding the steel, repair or replacement of piling as they decay, and replacement of selective deck panels as they deteriorate. These items will all occur at different times in the life of the structure.
- Maintain the bridge with replacement in 20 years.
- Maintain the bridge with replacement in 10 years.
- Replace the bridge in two years.

Present day cost estimates were developed for all of these scenarios for comparison.

Report

A report was prepared for the Association to use to plan for future maintenance and revenue raising. The report presents the results of the inspection, the proposed maintenance items, a proposed replacement bridge, the current load rating, and the proposed strategies.

Detailed Inspection

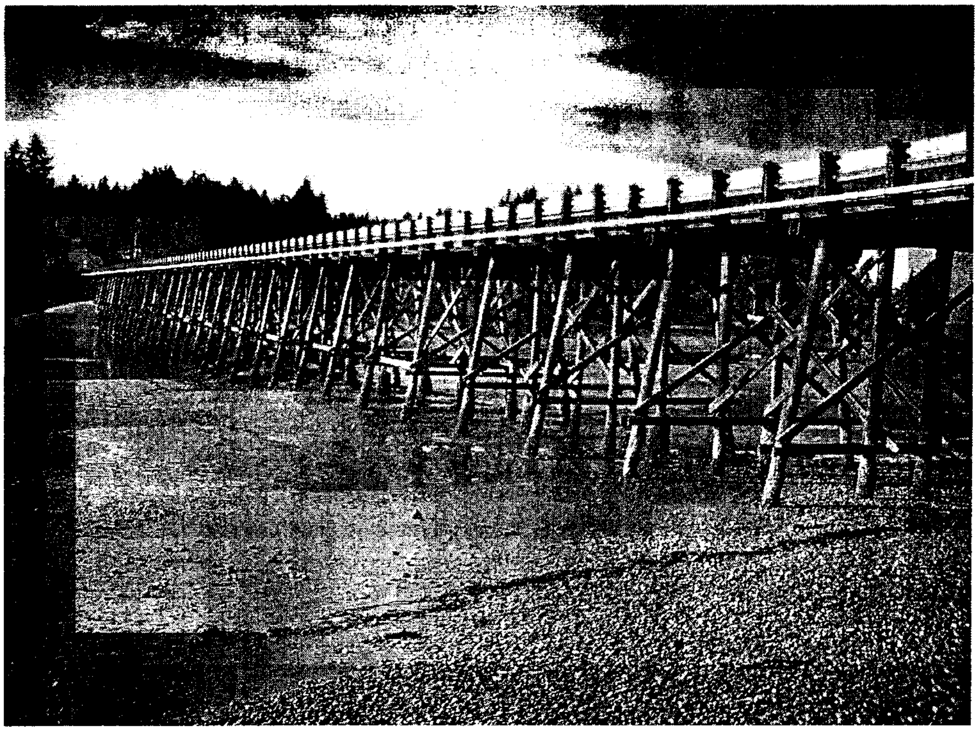
On October 5, 2004, Charles Mayhan and Jessica Soward of Sargent Engineers, Inc. performed a visual and tactile evaluation of the superstructure and upper portions of the substructure with the aid of an under bridge inspection truck (UBIT) provided and operated by Al Ferris Contracting. On October 23, 2004, Mr. Mayhan, accompanied by Kirk Ketter of Sargent Engineers, Inc., completed a similar evaluation of the timber substructure elements.

At the time of the UBIT inspection, the tide was approximately +7 feet, whereas, the substructure evaluation was conducted at +1 to +2 foot tide. Although the substructure evaluation can be conducted at these tidal flows, a minus tide, i.e., typically occurring during the month of June would permit access to the entire member. As such, we were unable to examine conditions at the mud line on many of the piles.

Bridge Description

The Raft Island Bridge is the sole vehicle access to Raft Island and its residents. The bridge is 788 feet long and consists of 47 – 17 foot spans and one 23 foot span. The 23 foot span serves as the primary passage for vessels traversing the waterway. The structure was built in 1957 and was designed for an H15-44 design load. The structure has a timber trestle substructure supporting a superstructure made up of precast prestressed concrete inverted bathtub deck units. There are expansion joints at the abutments and at bents 16 and 32 and the deck has an asphalt concrete overlay with a membrane protective system. For the purpose of this report the spans are numbered from the south end of the structure.

Looking South along the Bridge



East Side View of Bridge

Superstructure

We have assigned a "fair condition rating" as the overall condition of the superstructure, i.e., slab units, expansion joints, and asphalt overlay. Our 1996 evaluation of the bridge included chloride testing of the precast prestressed deck units to evaluate the potential for corrosive deterioration due to chloride contamination. That evaluation established that there are high chloride concentrations in the deck units, making them very susceptible to deterioration through corrosive deterioration of the reinforcing steel, i.e., mild steel reinforcement and prestressing strands. This corrosive deterioration appears to be advancing as evidenced by the increasing number of spalled and delaminated areas, cracking with rust staining along the bottoms of the webs in some areas, and corrosion of the exposed reinforcing bars. The delaminated concrete is typically found surrounding the spall areas.

We did not observe any exposed prestressing strands, however, the September 2003 report did identify a few areas of prestressing exposure that have since been patched. It is extremely difficult to arrest corrosion in the prestressing strand once the process has started due to the makeup of the strands. Thus, these areas are highly susceptible to accelerated, progressive deterioration.

We did observe many areas of exposed transverse reinforcing bars throughout. In general, concrete cover over these bars is on the order of ½" to ¾" which we would consider inadequate considering the severe exposure to contaminates, (chlorides, marine growth, etc.) at the site.

The following is a summary of the specific findings of our evaluation of the superstructure:

Spans 2 and 3 – a number of exposed transverse reinforcing bars were observed on the underside of the exterior slab units. Some further delamination of the surrounding concrete is occurring. Earlier areas of deterioration have been patched in span 3.

Spans 6, 10, 11, 15, 18, 19, 21, 22, 24, 26, 27, and 28 – areas of exposed transverse reinforcing on the underside of the west exterior slab unit. In many cases, there is delamination of the surrounding concrete at the perimeter of the spall.

Spans 20, 25, 26 and 28 – areas of exposed transverse reinforcing on the underside of the east exterior slab unit. Some have delamination in evidence at the perimeter of the spalled areas.

Spans 7 and 9 – areas of patching on the underside of the west exterior slab units.

Spans 16, 23, and 25 – areas of patching on the underside of the east exterior slab units.

Spans 24, 26, and 32 – Span 24 beam #5 stem has been patched along the lower portion of the stem. Span 26 beam #3 stems have been patched to repair the lower portions of the stems. Span 32 beams #3 and #4 stems have been patched to repair the lower portions of the stem. These are the locations of exposed prestressing as identified in the September 2003 report. These elements should be flagged or color coded in some manner and monitored for further evidence of strand deterioration.

Span 28 – the bearing corner of beam #2 west stem has a shear crack extending up the stem. We recommend sealing the crack using epoxy injection. Beam #5 east stem near bent # 29 is delaminated and concrete will soon begin to spall off.

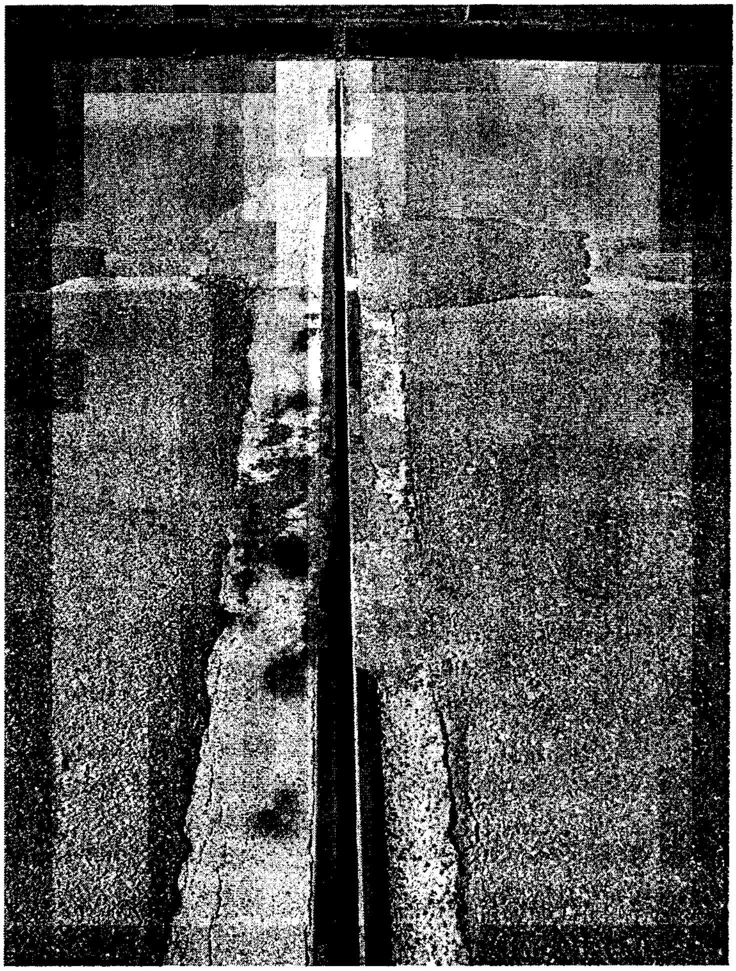
Span 34 – concrete on the underside of the west deck unit is beginning to spall.

Span 36 – a wide flange 10 x 33 Section (approx.) has been installed on the underside of the west exterior deck unit to strengthen the member. The wide flange member was painted with primer and is now rusting. The member has timber shims at the top between the wide flange and the underside of the deck unit. The east stem of this deck unit is cracked.

Span 40 – beam #7 stems have spalled rock pockets.

Span 42 – a wide flange 12 x 26 Section (approx.) has been installed on the underside of the west exterior deck unit to strengthen the member. The wide flange member paint is in good condition and the member has a grout bearing surface cast, over the full length of the member, between the top of the wide flange and the underside of the concrete deck unit. Beam #5 has a longitudinal crack at the center of the deck unit that extends throughout the full length of the deck unit.

The asphalt surface is in fair condition with a majority of the defects occurring adjacent to the expansion joints. Some spalling of asphalt immediately adjacent to the compression seal joint has been repaired in the past and is breaking up again. Concrete headers at the joints have been patched and are beginning to show some distress again. The metal joint elements appear to be adequately anchored and are not showing any significant distress at this inspection.

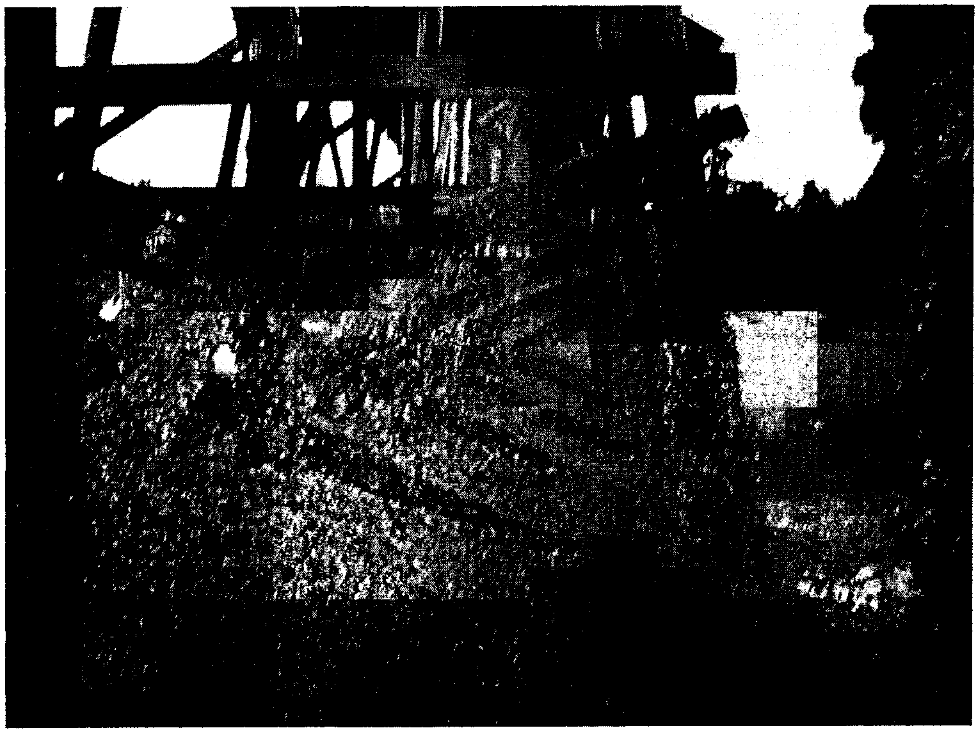


Expansion Joint on Bridge with Asphalt Patches

Substructure

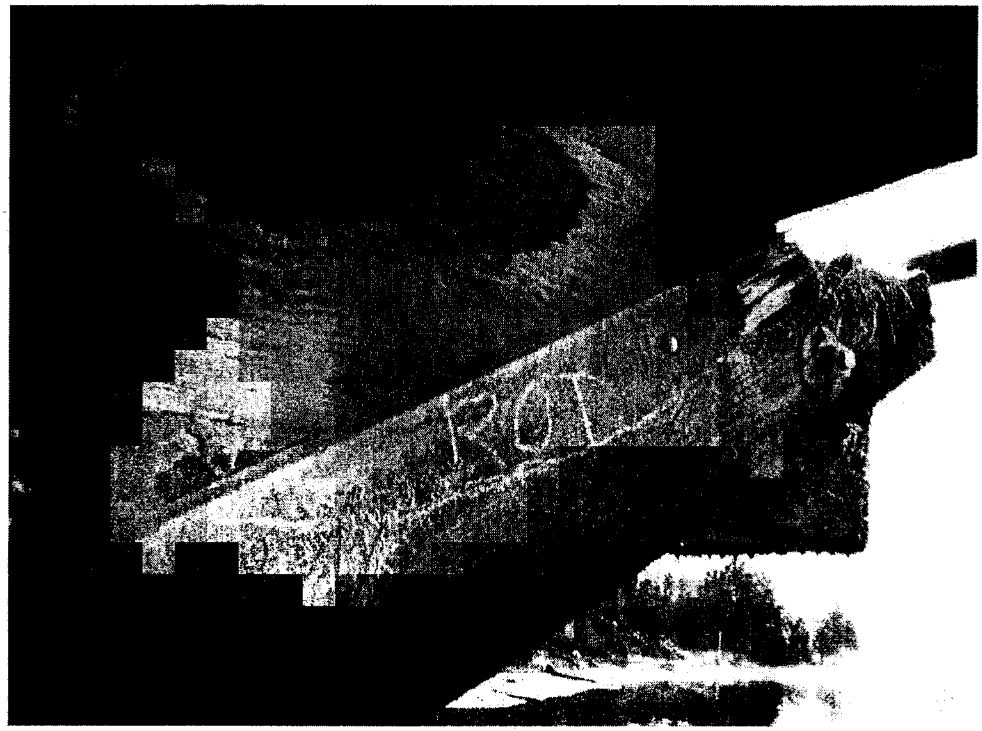
We have assigned a "fair condition rating" as the overall condition of the substructure, i.e., piles, caps, and bracing. The substructure evaluation consisted of a visual inspection and members were sounded with a hammer to determine soundness of the material. Only limited boring of piles was done as the results showed sound wood to the core. Although 20 to 25 percent of the piles have checks large enough to produce a rebound sound, none were found to have any rot, except at bents 8 and 31 (see below).

Barnacle accumulation under the bridge throughout the tidal area is such that the critical mud-line area of the pile is obscured and difficult to expose for proper evaluation. This accumulation also conceals the lower portions of some of the bracing. To perform a thorough evaluation of this highly susceptible area of the piles would require removal of this accumulation of barnacles.



Buildup of Barnacles at Piers

Many of the bracing members are splitting at the ends, typically extending through the bolt at the connection to the pile or beyond. Some have rot developing in these areas as well.



Cross Brace with Decayed End

Bent with Missing Brace

The following is a summary of the specific findings of our evaluation of the substructure:

Bents Nos. 11, 13, 18, 20, 21, 23, 25, 28, 30, 32, 34, 36, 39, 40, and 41 – each of these bents have had one or more piles replaced as follows:

> Deteriorated pile was cutoff near the bottom of the pile and a barrel or other metal can placed over the remaining pile stub. A new section of pile was then moved into position to bear on the pile stub at the bottom and on the underside of the pile cap at the top. Metal straps were placed on either side of the cap to pile connection and secured with lag screws or possibly through bolts. Concrete was placed inside the barrel or can at the base of the pile to complete the pile splice.

A total of 21 piles have been repaired in this manner. Each of the above bents have one such pile replacement, except that bent #21 and #24 have two piles replaced and bent #32 has had all four piles replaced. These replacement piles appear to be functioning well.

Bent Nos. 8 and 31 – the east pile in each of these bents have some beginning center rot near the ground line and at the top of the pile.

Bent Nos. 24, 27, 38, and 40 – end of bracing is broken and rotten or an end is rotting at each of these bent locations. Typically at one end only. Some are at the west side and others at the east side of the bent.

Bent Nos. 30, 31, 34, 36, 39, 40, and 42 – ends of bracing is splitting and typically extending through the bolt at the connection to the pile or beyond the connection. Typically at one end only.

Proposed Maintenance

The following proposed maintenance should be performed to preserve the condition of the bridge.

1. Spalled areas on the underside of the precast prestressed deck unit should continue to be patched. The surrounding delaminated concrete should be removed to sound concrete and the reinforcing steel should be sand blasted clean in preparation for patching. Exposed reinforcing steel, (mild or prestressed), should be coated with epoxy immediately prior to applying patching material. Patching material should be a low slump mixture of fine aggregate with an epoxy binder that can be troweled and worked into the spall areas. Patching material may be prepackaged or a design mixture specified by the epoxy manufacturer and applied as directed by manufacturer.
2. Cracks in the precast prestressed deck unit webs should be sealed by epoxy injection. Web concrete in the vicinity of the web cracking should be sounded and any loose or severely delaminate concrete should be removed prior to injecting with epoxy. Any exposed reinforcement, (mild or prestressed), should be cleaned by sandblasting and the concrete section restored to its original configuration with patching material described in Item 1.

3. Areas of previously exposed prestressing strand in spans 24, 26, and 32 should be monitored for further spalling and deterioration. Where corrosion has established itself in the prestressing strands, it is extremely difficult to arrest the corrosion process. These areas are highly susceptible to ongoing deterioration.
4. Beam 2, Span 28 – the shear crack at the bearing area of the west beam should be repaired by epoxy injection. Also the concrete in the east stem is delaminating near bent 29. The delaminated concrete should be removed and the area repaired as described in Item 1 above.
5. The steel wide flange member placed under the west exterior deck unit in Span 36 was painted with primer only and is now rusting. This member should be sand blasted to remove rust areas and repainted with a base primer and a protective finish coat. We also recommend removing the wood shims and forming and pressure grouting between the top of the wide flange section and the underside of the deck unit similar to the wide flange section in Span 42.
6. Beam 5, Span 42 has a longitudinal crack at the center of the deck unit full length, this crack should be sealed by epoxy injection.
7. Deck surface – the asphalt surface adjacent to the expansion joints will continue to require periodic patching. It is important that these areas adjacent to the joints be maintained to minimize impact forces in the surrounding elements, i.e., steel joint elements, concrete deck units, etc.
8. Rotting and splitting timber cross-bracing elements in Bents 24, 27, 30, 31, 34, 36, 38, 39, 40, and 42 should be replaced.
9. The barnacle accumulation under the bridge throughout the tidal area precludes inspection of the critical mud-line area of the pile. This growth eventually will decay the piles in the bridge. Consideration should be given to removal, redistribution, etc. of this material.

Maintenance for the Next Ten Years

The following is a summary of the specific items that should be repaired or replaced over the next ten (10) years:

Raft Island Maintenance	
Item	**Description**
Remove Barnacle Accumulation	A significant accumulation of barnacles in the tidal area precludes visual and tactile inspection of piles and cross bracing at timber bents in this area. Barnacles should be removed to the mud line.
Pile Replacement	Replace east pile at bent nos. 8 and 31. Piles have center rot at the mudline and at the top of the pile.
Repair or Replace Cross Bracing	Repair or replace damaged or deteriorating cross bracing at bent nos. 24, 27, 30, 31, 34, 36, 38, 39, 40 & 42.

Raft Island Maintenance	
Item	**Description**
Repair/Patch Concrete Deck Units	Spans 2 & 3 East & West Exterior slab units. Spans 6, 10, 11, 15, 18, 19, 21, 22, 24, 26, 27, 28, & 34 West Exterior slab units. Spans 20, 25, 26, & 28 East Exterior slab units. Remove delaminated concrete around exposed rebar on underside of exterior slab units and repair as described in Item 1 above. Beam #5 near Bent #29: Remove delaminated concrete from stem, clean & patch deteriorated area
Prior Prestressed Strand Exposure	Span 32 beams #3 & #4: Monitor these beams for further deterioration. Repair as necessary.
Epoxy Crack Injection – Concrete Deck Units	Span 28 beam #2: Seal crack at bearing using epoxy injection. Span 42 beam #5: Seal crack at center of deck unit extending full length of member using epoxy injection.
Steel Beam WF10x33	Span 36 @ West Exterior Deck Unit: Remove timber shims at top of beam, sand blast to clean the steel member, grout between top of beam and slab unit similar to WF Section in span 42. Paint with base primer and protective finish coat.
Deck Surface	Maintain asphalt surfacing adjacent to expansion joints to minimize impact forces.

These specific maintenance needs were identified at the last inspection and should be addressed within 2 to 5 years.

As a general comment, any utilities supported on the structure should be maintained to prevent leakage, general deterioration, etc. that would compromise the function of the utility or present a hazard to the public or environment.

Replacement Bridge

Various options were compared for the replacement of the bridge. They include a bridge that spans the entire channel, a causeway to replace the bridge, and partial length bridges combined with a causeway. At the north end of the bridge, it appears that you have a 60 foot right of way width with the bridge centered in that width. On the south you have a 62 foot right of way width with 24.57 feet taken out of the west side near the water. Therefore, if you need to move the bridge it may have to be to the east. Both of the property descriptions go to a meander line at the water and state that you also have the tide lands that adjoin the property. Only a detailed survey of the bridge with respect to all boundaries will confirm the exact location of the bridge.

We can replace the entire bridge with a causeway. If we do this, we will displace tidal land that is important for aquatic life. The Corps of Engineers will probably ask you to mitigate this in one fashion or another. This usually includes finding another site that can be developed in habitat. The following estimates reflect the cost for constructing a causeway. They do not include any funds for mitigation if it is necessary.

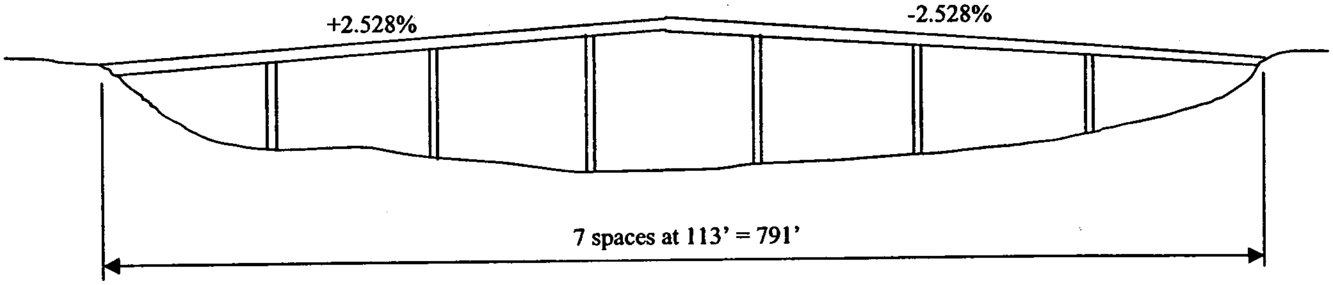
Replace Bridge with Road Fill Six Feet Lower at Center of Crossing

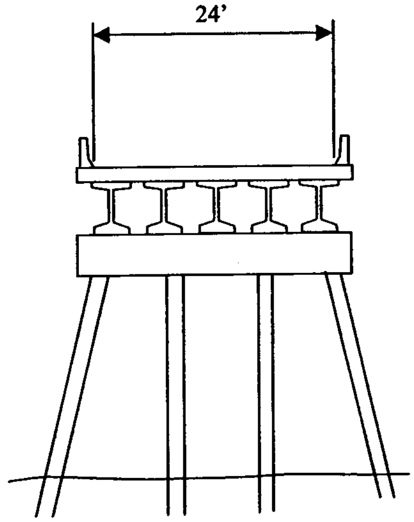
Item	Unit	Quantity	Unit Cost	Item Cost
Mobilization	LS	1	$160,957.69	$160,958
Fill	CY	45326.67	$25.00	$1,133,167
Compaction	CY	45326.67	$2.00	$90,653
Base Course	Ton	280.1778	$20.00	$5,604
Top Course	Ton	233.4815	$20.00	$4,670
Asphalt	Ton	233.4815	$70.00	$16,344
Barrier	LF	1576	$40.00	$63,040
Anchors	Each	4	$1,800.00	$7,200
Traffic Control	LS	1	$2,500.00	$2,500
Drainage	LS	1	$50,000.00	$50,000
Remove Bridge	SF	15760	$15.00	$236,400
Contingencies	0.2			$354,107
Taxes	0.08			$169,971
Construction Total				$2,294,613
Property Acquisition	SF	43134	$11.00	$474,474
Design Engineering	0.15			$344,191.92
Permitting	0.04			$91,784.51
Construction Engineering	0.1			$229,461.28
Grand Total				$3,434,525

Replace Bridge With Road Fill at its Present Elevation

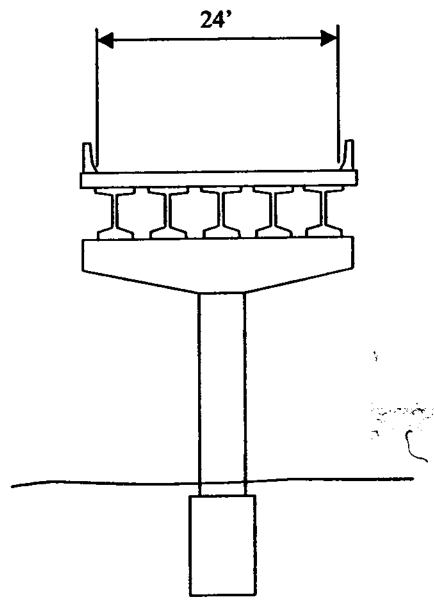
Item	Unit	Quantity	Unit Cost	Item Cost
Mobilization	LS	1	$194,760.38	$194,760
Fill	CY	56860.37	$25.00	$1,421,509
Compation	CY	56860.37	$2.00	$113,721
Base Course	Ton	560.3556	$20.00	$11,207
Top Course	Ton	466.963	$20.00	$9,339
Asphalt	Ton	466.963	$70.00	$32,687
Barrier	LF	1576	$40.00	$63,040
Anchors	Each	4	$1,800.00	$7,200
Traffic Control	LS	1	$2,500.00	$2,500
Drainage	LS	1	$50,000.00	$50,000
Remove Bridge	SF	15760	$15.00	$236,400
Contingencies	0.2			$428,473
Taxes	0.08			$205,667
Construction Total				$2,776,504
Property Acquisition	SF	52730	$11.00	$580,030
Design Engineering	0.15			$416,475.59
Permitting	0.04			$111,060.16
Construction Engineering	0.1			$277,650.39
Grand Total				$4,161,720

A preliminary layout for a new bridge was prepared. The new bridge will have seven spans of approximately 113 foot length with concrete piers supporting the new spans. The concrete piers can be either composed of a large diameter shaft or multiple piles. The new bridge has a crest in the middle of it to carry runoff water to each end of the bridge. The runoff water will then have to be treated per the requirements of Pierce County at the time the bridge is replaced. The cost for this treatment is not included in this report. The relative costs of a bridge supported by shafts or piles cannot be determined without a geotechnical investigation.





Pile Bent Alternate



Drilled Shaft Alternate

New Bridge Layout

Cost of New 791 Foot Bridge

Item	Unit	Quantity	Unit Cost	Item Cost
Roadway Items	LS	1	$414,722.00	$414,722
Bridge Items	LS	1	$1,984,532.00	$1,984,532
Drainage	LS	1	$50,000.00	$50,000
Contingencies	0.2			$489,851
Taxes	0.08			$235,128
Construction Total				$3,174,233
Property Acquisition	SF	16351	$11.00	$179,861
Design Engineering	0.15			$476,134.98
Permitting	0.02			$63,484.66
Construction Engineering	0.1			$317,423.32
Grand Total				$4,211,137

Another option would construct a roadway fill with a 143 foot bridge to provide the same waterway opening that exists now. The cost for that follows:

Cost of New 143 Foot Bridge

Item	Unit	Quantity	Unit Cost	Item Cost
Mobilization	LS	1	$208,355.29	$208,355
Fill	CY	47421.19	$25.00	$1,185,530
Compaction	CY	47421.19	$2.00	$94,842
Base Course	Ton	459.3778	$20.00	$9,188
Top Course	Ton	382.8148	$20.00	$7,656
Asphalt	Ton	382.8148	$70.00	$26,797
Barrier	LF	1576	$40.00	$63,040
Anchors	Each	4	$1,800.00	$7,200
Traffic Control	LS	1	$2,500.00	$2,500
Drainage	LS	1	$50,000.00	$50,000
New Bridge	SF	4004	$100.00	$400,400
Remove Bridge	SF	15760	$15.00	$236,400
Contingencies	0.2			$458,382
Taxes	0.08			$220,023
Construction Total				$2,970,313
Property Acquisition	SF	44098	$11.00	$485,078
Design Engineering	0.15			$445,546.95
Permitting	0.04			$118,812.52
Construction Engineering	0.1			$297,031.30
Grand Total				$4,316,782

Another option looks at a longer 584 foot bridge with approach fills. The cost for that follows:

Cost of New 584 Foot Bridge

Item	Unit	Quantity	Unit Cost	Item Cost
Mobilization	LS	1	$228,513.63	$228,514
Fill	CY	10259.81	$25.00	$256,495
Compation	CY	10259.81	$2.00	$20,520
Base Course	Ton	145.0667	$20.00	$2,901
Top Course	Ton	120.8889	$20.00	$2,418
Asphalt	Ton	120.8889	$70.00	$8,462
Barrier	LF	1576	$40.00	$63,040
Anchors	Each	4	$1,800.00	$7,200
Traffic Control	LS	1	$2,500.00	$2,500
Drainage	LS	1	$50,000.00	$50,000
New Bridge	SF	16352	$100.00	$1,635,200
Remove Bridge	SF	15760	$15.00	$236,400
Contingencies	0.2			$502,730
Taxes	0.08			$241,310
Construction Total				$3,257,690
Property Acquisition	SF	9282	$11.00	$102,102
Design Engineering	0.15			$488,653.55
Permitting	0.04			$130,307.61
Construction Engineering	0.1			$325,769.04
Grand Total				$4,304,523

Except for the lower fill, all of the crossing options cost approximately $4,300,000. Throughout the rest of this evaluation this will be the cost used for comparison purposes.

Bridge Load Rating

The bridge is currently load rated for the following:

Truck	16 Tons
Tractor & Semi	26 Tons
Truck & Trailer	30 Tons

A new load rating was prepared for the bridge. Our evaluation shows that the limiting member is the timber pile cap at each end of the 23 foot span, see the following load rating report. In addition, given the heavy chloride contamination and increasing rate of deterioration of the precast prestressed concrete deck units, we made an analysis assuming that future deterioration may render the lowest prestressing strand in each leg ineffective. The reduced capacity of the deck units still exceeds the capacity of the pile cap, thus the pile cap continues to be the controlling structural element. The updated load rating is essentially the same as the load rating that was performed earlier. We do not expect this to change until the concrete superstructure deteriorates significantly. This load rating does not change with either one or two lanes on the bridge. The cap still controls.

Bridge Preservation Strategies

The Raft Island Bridge is the sole vehicular access to Raft Island and its residents. Therefore, the Raft Island Association desires to maintain this access route for personal access as well as for commercial and emergency vehicles servicing the island residents. The following considers various strategies for preserving or replacing the existing bridge:

Maintain Bridge Without Replacement

As noted above, the bridge has an overall "fair condition rating". The concrete deck units are heavily contaminated with chlorides and 20 to 25 percent of the piles have relatively large checks, exposing the unprotected center of the piles to decay. The detrimental effects of chloride contamination is manifesting itself in many of the concrete deck units in the form of delaminated and spalled concrete due to the expansive pressures exerted by the corroding reinforcement. This deterioration is irreversible and will progress at an accelerated rate with time.

Considering the present condition of the bridge, an aggressive ongoing maintenance and member replacement effort will be required to maintain an acceptable level of service. With that in mind, we have developed a maintenance and member replacement schedule based on a 25-year plan with ongoing maintenance for the following 25 years. The projected cost of this plan is $4,138,400. Details of the plan follow:

The structure has been in service for about 46 years, and although we typically consider the service life to be approximately 75 years, this structure is in a severe environment and timber structures in western Washington frequently do not achieve the projected 75-year service life. Therefore, the following schedule assumes a schedule that would essentially replace all of the primary elements and their supporting components over a 25-year period. The end product is a bridge with a new superstructure supported on a substructure with some members that are 25 years old. Thus, maintenance and replacement of substructure elements would be on going. All piling will be spliced to the original piles at or just below the mud-line.

Year	Member	No. Replaced	Unit Cost	Total Cost	Cumulative Total
2010	Replace Timber Piles Incl. X-Bracing	12	$4,000	$48,000.00	
	Replace Timber Caps	4	$3,500	$14,000.00	
	Patch/Repair Deck Units	26	$1,500	$39,000.00	
				$101,000.00	$101,000.00
2015	Replace Timber Piles Incl. X-Bracing	24	$4,000	$96,000.00	
	Replace Timber Caps	8	$3,500	$28,000.00	
	Patch/Repair Deck Units	51	$1,500	$76,500.00	
				$200,500.00	$397,500.00
2020	Replace Timber Piles Incl. X-Bracing	36	$4,000	$144,000.00	
	Replace Timber Caps	11	$3,500	$38,500.00	
	Patch/Repair Deck Units	76	$1,500	$114,000.00	
				$296,500.00	$694,000.00
2025	Replace Timber Piles Incl. X-Bracing	47	$4,000	$188,000.00	
	Replace Timber Caps	15	$3,500	$52,500.00	
	Patch/Repair Deck Units	101	$1,500	$151,500.00	
				$392,000.00	$1,086,000.00
2030	Replace Timber Piles Incl. X-Bracing	59	$4,000	$236,000.00	
	Replace Timber Caps	11	$3,500	$38,500.00	
	Replace Deck Units w/ 4'-0" Units	288	$2,500	$720,000.00	
	Replace Bridge Railing per L.F.	1576	$60	$94,560.00	
				$1,089,060.00	$2,175,060.00
2035	Replace Timber Piles Incl. X-Bracing	12	$4,000	$48,000.00	
	Replace Timber Caps	4	$3,500	$14,000.00	
				$62,000.00	$2,237,060.00
2040	Replace Timber Piles Incl. X-	24	$4,000	$96,000.00	

Year	Member	No. Replaced	Unit Cost	Total Cost	Cumulative Total
	Bracing				
	Replace Timber Caps	8	$3,500	$28,000.00	
				$124,000.00	$2,361,060.00
2045	Replace Timber Piles Incl. X-Bracing	36	$4,000	$144,000.00	
	Replace Timber Caps	11	$3,500	$38,500.00	
				$152,500.00	$2,513,560.00
2050	Replace Timber Piles Incl. X-Bracing	47	$4,000	$188,000.00	
	Replace Timber Caps	15	$3,500	$52,500.00	
				$240,500.00	$2,754,060.00
2055	Replace Timber Piles Incl. X-Bracing	59	$4,000	$236,000.00	
	Replace Timber Caps	11	$3,500	$38,500.00	
				$274,500.00	$3,028,560.00
	Mobilization		10.02%	$303,500.00	$3,332,000.00
	Taxes		8.8%	$266,565.00	$3,598,600.00
	Design Engineering		17.8%	$539,800.00	$4,138,400.00

Assume pile deterioration progresses at 1.2% per year, i.e., 6% in 2010, 12% in 2015, 18% in 2020, & 24% in 2025, & 30% in 2030.

Assume deck unit deterioration progresses at 1.5% per year thru 2010, or 7.5% in 2010, 1.5% thru 2015 or 15% in 2015, 1.5% thru 2020 or 22.5% in 2020, 30% in 2025, replacement in 2030

Assume pile cap deterioration progresses at same rate as the deck units, except replace the remaining 11 caps in 2030.

Maintain Existing Bridge and Replace in 20 Years

This strategy will require an aggressive maintenance program of repair and crack sealing of the concrete deck units to keep them serviceable for the 20-year period prior to replacement of the structure. Similarly, many of the timber substructure elements will require replacement during the period leading up to replacement. The estimate for the maintenance over the 20 year period follows:

Year	Member	No. Replaced	Unit Cost	Total Cost	Cumulative Total
2010	Replace Timber Piles Incl. X-Bracing	12	$4,000	$48,000.00	
	Replace Timber Caps	4	$3,500	$14,000.00	
	Patch/Repair Deck Units	35	$1,500	$52,500.00	
				$114,500.00	$114,500.00
2015	Replace Timber Piles Incl. X-Bracing	24	$4,000	$96,000.00	
	Replace Timber Caps	8	$3,500	$28,000.00	
	Patch/Repair Deck Units	50	$1,500	$75,000.00	
				$199,000.00	$411,000.00
2020	Replace Timber Piles Incl. X-Bracing	36	$4,000	$144,000.00	
	Replace Timber Caps	11	$3,500	$38,500.00	
	Patch/Repair Deck Units	76	$1,500	$114,000.00	
				$296,500.00	$707,500.00
2023	Replace Timber Piles Incl. X-Bracing	22	$4,000	$88,000.00	
	Replace Timber Caps	3	$3,500	$10,500.00	
	Patch/Repair Deck Units	10	$1,500	$15,000.00	
				$113,500.00	$821,000.00
	Mobilization			$82,100.00	$903,100.00
	Taxes			$72,248.00	$975,348.00
	Design Engineering			$135,500.00	$1,110,848.
2025	Replace Bridge			$4,300,000.00	$5,411,000

Assume pile deterioration progresses at 1.2% per year, i.e., 6% in 2010, 12% in 2015, 18% in 2020, & 11% in 2023

Assume deck unit deterioration progresses at 1.5% per year thru 2010, or 7.5% in 2010, 1.5% thru 2015 or 15% in 2015, 1.5% thru 2020 or 22.5% in 2020, & 1% per year for the last 3 years or 3% in 2023

Assume pile cap deterioration progresses at same rate as the deck units, except at 2% for the last three years or 6%.

Maintain Existing Bridge and Replace in 10 Years

The program associated with maintenance of the concrete deck units will continue to require a reasonably aggressive effort over the 10-year period leading up to replacement of the bridge. Fewer timber substructure elements will have to be addressed, primarily due to the shorter term of required maintenance. The costs for this scenario is:

Year	Member	No. Replaced	Unit Cost	Total Cost	Cumulative Total
2010	Replace Timber Piles Incl. X-Bracing	12	$4,000	$48,000.00	
	Replace Timber Caps	4	$3,500	$14,000.00	
	Patch/Repair Deck Units	25	$1,500	$37,500.00	
				$99,500.00	$99,500.00
2013	Replace Timber Piles Incl. X-Bracing	9	$4,000	$36,000.00	
	Replace Timber Caps	3	$3,500	$10,500.00	
	Patch/Repair Deck Units	10	$1,500	$15,000.00	
				$61,500.00	$161,000.00
	Mobilization			$16,100.00	$177,100.00
	Taxes			$14,200.00	$191,300.00
	Engineering			$26,600.00	$217,900.00
2015	Replace Bridge			$4,300,000.	$4,518,000.

Assume pile deterioration progresses at 1.2% per year, i.e., 6% in 2010, & 1.5% per year in for the last 3 years or 4.5% in 2013

Assume deck unit deterioration progresses at 1.5% per year thru 2010, or 7.5% in 2010, & 1% per year for the last 3 years or 3% in 2013

Assume pile cap deterioration progresses at same rate as the deck units, except at 2% for the last three years or 6%.

Replace Existing Bridge in 2 Years

Assuming replacement in 2 years, the concrete deck units would require only minimal effort, primarily monitoring to address any further exposure of prestressing strand or significant cracking. With regard to the timber substructure, we recommend only selective replacement of the most heavily deteriorated cross-bracing members.

Year	Member	No. Replaced	Unit Cost	Total Cost	Cumulative Total
2005	Replace Selected Timber X-Bracing	4	$1,500	$6,000.00	
	Monitor/Repair Deck Units	5	$1,500	$7,500.00	
				$13,500.00	$13,500.00
	Mobilization			$1,400.00	$14,900.00
	Taxes			$1,200.00	$16,100.00
	Engineering			$2,200.00	$18,300.00
2007	Replace Bridge			$4,300,000.00	$4,318,300.00

Several of the cross-brace members are cracked or rotting to the extent that they provide little lateral restraint. These should be selectively replaced to restore lateral restraint at the bents.

With regard to the concrete deck units, we recommend they be monitored and any significant structural deficiencies be repaired to maintain the rated capacity until the new bridge is in service.

It is probable that much of the projected cost shown for the deck units may never be realized in the 2 year period leading to replacement.

Recommended Strategy

A summary of the costs for each of the strategies follows:

Strategy	Construction Cost	Structure Life	Cost per Year
Maintain Bridge with no Replacement	$4,138,400	50 years	$82,800
Maintain Bridge for 20 years before Replacement	$5,411,000	70 years	$77,300
Maintain Bridge for 10 years before Replacement	$4,518,000	60 years	$75,300
Replace bridge in 2 years	$4,318,300	52 years	$83,000

So based on the different scenarios considered, replacement of the bridge in the next ten years makes the most economic sense. The primary reason for this is the cost for the ongoing maintenance of the timber piles.