Corral Bottom Road Bridge over the Trinity River
Replacement vs. Rehabilitation Study

Bridge No. 05C-0162

Prepared for:

County of Trinity

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Prepared by:

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Registered Civil Engineer Stamp

This Replacement vs. Rehabilitation Study Report has been prepared under the direction of the following registered civil engineer. The registered civil engineer attests to the technical information contained herein and the engineering data upon which recommendations, conclusions, and decisions are based.

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TABLE OF CONTENTS

REPLACEMENT VERSUS REHABILITATION STUDY

The primary decision to be made during this preliminary engineering phase is whether to replace the existing bridge, or to rehabilitate and widen it. We call these types of studies Rehabilitation Studies, wherein we compare the cost of replacing the existing bridge with the cost of keeping it in place and performing necessary rehabilitation and widening work. A flowchart depicting the necessary studies is shown as **Exhibit 1.** Included in this Rehabilitation Study are seismic and hydraulic studies, as well as preliminary design and cost estimates.

Existing Bridge Facts

- Built in 1960; 53 yr old
- Functionally Obsolete
- Seismically Deficient
- Fracture Critical

EXECUTIVE SUMMARY

This Replacement vs. Rehabilitation Study for the Corral Bottom Road Bridge includes a detailed Seismic Assessment, Hydraulics Study, Structure Preliminary Geotechnical Report, and a Life Cycle Cost Analysis. The conclusion of this Study indicates that Bridge Replacement Alternative 2, which consists of replacing the existing bridge with a three span CIP/PS Concrete Box Girder, is the most cost-effective option. However, life-cycle costs are relatively close for all three bridge replacement alternatives, while the Seismic Retrofit/Rehab/Widen Alternative is the most expensive option.

Alternative	Prorated Present Value Cost
Replacement Alternative 1	$6.38 Million
Replacement Alternative 2	$6.10 Million
Replacement Alternative 3	$6.38 Million
Retrofit/Rehab/Widen Alternative	$6.90 Million

The life-cycle cost for the Seismic Retrofit/Rehab/Widen Alternative is estimated at $8.23 Million. The life-cycle cost for Bridge Replacement Alternative 2 is $6.10 Million. The Rehab cost represents approximately 113% of the Replacement cost. Due to the high cost of rehab and widening compared to the replacement cost, and since the bridge is 53 years old and has been in service for approximately 70% of its 75 year design life, we recommend the bridge be replaced based on the following:

Alternatives	Structurally Deficient	Functionally Obsolete	Seismically Deficient	Substandard Approach Roadway	Hydraulics Compatibility (Overtopping)	Scour Critical	Fracture Critical	Bridge Life
Existing Bridge (Do Nothing Option)	–	✓	✓	✓	–	–	✓	22 years remaining
Bridge Seismic Retrofit Only	–	✓	–	✓	–	–	✓	22 years remaining
Bridge Rehab including Seismic Retrofit and Widening	–	–	–	✓	–	–	–	15 to 30 years remaining
New Bridge Replacement	–	–	–		–	–	–	75 years

BACKGROUND

The existing 1960 structure, located 0.1 Mile south of SR 299, carries local traffic over the Trinity River. The structure consists of four spans (37'+109.5'+109.5'+80'), all simply supported, with a total length of 342'±feet and a width of 19.5'± (edge of deck to edge of deck). The curb to curb width is 14'. Span 1 (south end of the bridge) consists of a reinforced concrete Double Tee-Beam system. Spans 2, 3, and 4 consist of two welded steel plate girders. The bridge deck consists of a non-continuous, reinforced concrete section throughout the entire bridge length. All piers consist of solid rectangular concrete columns founded on spread footings. Abutment 1 (the southern abutment) consists of a reinforced concrete wall founded on a spread footing and Abutment 5 (the northern abutment) consists of reinforced concrete portal frame in transverse direction founded on pipe piles.

According to Caltrans' Bridge Inspection Report dated 09/20/2012, the structure has a Sufficiency Rating of 68.3. However, the structure is Functionally Obsolete (FO) due to its substandard clear width of 14'. The average ADT as shown in that same report is 300 with 5% truck ADT.

Generally, bridges that have a Sufficient Rating (SR) between 50 and 80 are only eligible for rehabilitation to bring the bridge up to current standards. Assuming the County/Caltrans is interested in rehabilitating the bridge, all deficiencies under the rehabilitation will need to be addressed as noted below. Even if all deficiencies are mitigated, the bridge will need to be widened to add deck width to eliminate the FO flag. The existing deck width is obviously very substandard, with only a 19'-6" width from edge of deck to edge of deck and a clear width of only 14'-0".

This bridge is located in a rural setting with low traffic volumes, (ADT of 300 listed on SI&A). The road is classified as a local rural road and carries only one lane of traffic at the bridge.

RELEVANT ISSUES

As noted in the Caltrans maintenance reports, the existing structure has several deficiencies that need to be addressed. A primary consideration is the condition of the existing bridge. In order to retain the existing structure in the final project, the following work or considerations should be evaluated:

1. **Sub-Standard Width/Functionally Obsolete Classification:** The existing bridge is designated as Functionally Obsolete due its substandard clear width of only 14' between railings. The existing bridge would have to be widened to provide sufficient width for two lanes of traffic plus shoulders in accordance with current AASHTO standards.

   Assuming a Design Year ADT of 400 to 1500 (Design Year 20 years from date of construction), Table 5-1 of the 2011 AASHTO Standards (AASHTO) indicates that an appropriate design speed would be 40 MPH for this project. Table 5-5 of the AASHTO Standards lists the minimum width of the traveled way as 20 feet, and Table 5-6 of the AASHTO Standards indicates that for a design speed of 40 MPH, the minimum clear width for new or reconstructed bridges is the width of the traveled way plus 3 feet on each side. The resulting AASHTO minimum clear width is 26'-0" between the bridge rails.

2. **Approach Roadway Geometrics:** The south approach to the existing bridge has a sag vertical curve with a design speed of approximately 25 MPH. This sag vertical curve begins approximately 280' south of the southerly abutment, where the tangent slope is approximately -10%, and ends near the south abutment where the tangent slope is approximately +3%.

Although rehabilitating and widening the existing bridge would require widening the approach roadway, it would not be feasible or cost effective to reconstruct the south approach in order to increase its design speed. Under the rehab and widening scenario, the profile grade of the existing structure could not be altered sufficiently to improve the vertical alignment at the south end of the bridge.

With the bridge replacement option, the vertical alignment is not constrained by the existing structure. Therefore, the horizontal and vertical alignment of the replacement bridge and new approaches can be designed to meet the 40 MPH design speed.

3. **Scour Repair and/or Countermeasure Work:** A Caltrans Bridge Inspection Report dated September 20, 2012 states, "Some of the material on the column side of the cofferdam at Pier 3 (shown as Pier 2 on as-built plans) has been scoured away. The upstream sheet pile is exposed on the column side to a depth of 2.5'. The downstream sheet pile is exposed on the column side to a depth of 1'."

   A hydraulic field review by Caltrans on October 29, 2004 concluded that "…all the footings are founded on competent rock that is non-scourable. The bridge is not considered scour critical at this time."

   The Structure Preliminary Geotechnical Report (SPGR) prepared by Taber Consultants dated May 20, 2013 states, "Based on our preliminary observations, the unconsolidated channel bedload deposits and alluvium within and along the channel banks are considered subject to scour. The underlying rock is considered scour resistant. Rock that is scour resistant is not scour proof. Some minor rock scour would be expected to occur over the life of the bridge but the amount of scour would likely not affect bridge foundation elements established within the rock."

4. **Seismic Analysis and Retrofit:** In rehabilitating a structure, it is important to be sure that the existing structure meets current seismic standards. Any widening scenario must consider the costs of retrofitting the existing structure in the evaluation. The performance of the existing structure was assessed, and retrofit strategies were developed to ensure that the retrofitted structure meets the "no collapse" performance standard for the design earthquake. The Corral Bottom Road Bridge was constructed before modern bridge seismic codes had been developed. Bridges constructed during this time typically were designed for low lateral seismic load levels, and not designed to have the displacement ductility that is currently required. The seismic issues will have to be addressed due to the fact that the existing structure is fracture critical and offers no structural redundancy in case of a seismic event.

   4.1 Analysis Description and Findings

   The dynamic behavior of the as-built structure was investigated using CSiBridge for the prescribed seismic loading. A three dimensional model was used in order to evaluate the seismic demand in both longitudinal and transverse directions. The girders and concrete deck were modeled as a spine beam with equivalent stiffness and mass of the entire section. In addition, a rocking analysis for footings was performed. In order to determine the maximum lateral seismic loads each pier can carry, and push-over analysis was performed for the overall structure to determine displacement capacity of the whole as-built system taking into account the effective stiffness of the abutments as well as stiffness reflecting rocking at footings. The as-built structural analysis results and findings are summarized below.

(a) Shear Connectors – There is a lack of shear connectors on the steel girders to transfer lateral seismic loads from the concrete deck to the structural components below. The requirement for the shear connection is stipulated in Section 4.8 of "Guide Specifications for Seismic Design of Steel Bridges" by Caltrans dated December 2001. For the purpose of determining the seismic demand on the rest of the structural elements, it was assumed that adequate shear connection is available between the steel girders and concrete deck.

(b) Lateral Steel Bracings - Both intermediate and end diaphragm bracing members in Spans 2 to are insufficient to resist the anticipated compression forces resulting from transverse seismic loads (D/C=1.3, diagonal member in intermediate bracing; D/C=2.0, diagonal member in end diaphragm bracing)

(c) Anchor Bolts at Bearings – Anchor bolts for the bearings at Abutment 5 are insufficient for shear force in longitudinal direction (D/C=1.5). The anchor bolts at all other bearings have sufficient capacities to resist the anticipated seismic loads.

(d) Shear in Abutments and Piers – All pier columns and abutment walls have sufficient shear capacities in both transverse and longitudinal directions to resist anticipated seismic loads.

(e) Pile Foundation - The piles at Abutment 5 are insufficient to resist the anticipated seismic loads in longitudinal direction (D/C=1.13), but sufficient transversely (D/C =0.67).

(f) Spread Footings – The rocking analysis results for all pier footings indicate that rocking will occur but the structure is stable during rocking. It is noted that rocking would occur prior to yielding or plastic hinging of all pier columns, thus the piers will remain elastic and the lateral seismic load demand at piers is governed by the demand rocking shear instead of plastic moment of column. An overstrength factor of 1.2 is applied to the rocking demand force before applying it as shear demand for columns, bearings and bracing. Due to the lack of as-built information concerning footing reinforcement, the flexural and shear capacity of spread footings cannot be accurately determined. However, it is likely that the footings at Piers 2 and 3 may fail in shear and retrofit with a top mat may be required at these locations. The cost to retrofit spread footings is not included the cost estimate.

(g) Displacement – An overall pushover analysis in the longitudinal direction indicates that the structure has sufficient displacement capacity (D/C=0.6); Transverse displacement is not critical. Due to the lack of as-built information concerning reinforcement in pier columns, a range of steel ratios was tested and it was determined that the displacement capacity is not very sensitive to the steel ratio because of lack of confinement typical for 1960's reinforced concrete structures.

The D/C ratio tables are included in Appendix D.

4.2 Retrofit and Rehabilitation Measures

Based on the identified vulnerabilities of the as-built structure above, and the requirement to bring the structure up to functional as well as fracture non-critical, the following are the recommended retrofit and rehabilitation measures:

(a) Install shear studs on top of steel girders and end cross beams by removing portion of concrete deck, welding steel studs to top steel flanges and pouring repair concrete. The total shear capacity of the studs will be sufficient to resist seismic shear demand of 0.35g.

(b) Replace existing bracing members and gusset plates with new bracing members and gusset plates that can carry the anticipated lateral seismic loads.

(c) Provide transverse shear keys and longitudinal catcher blocks at all piers and abutments to ensure shear transfer in transverse direction and allow the structure to move longitudinally while preventing it from unseating.

(d) Enlarge the existing pile cap and provide 24" CIDH piles to increase the shear capacity of the foundation in longitudinal direction.

(e) Widen the bridge by 16' to provide two 10-ft lanes, two 3-ft shoulders, one 6-ft sidewalk and two Type 80 concrete barriers, to bring the structure to functional status. The widening includes adding two steel plate girders for Spans 1 to 3 and two T-beams for Span 4. It also involves adding new pier columns adjacent and similar to the existing ones, as well as widening the existing abutments to accommodate the widened superstructure. As a result of widening, the existing fracture critical condition is removed due to the presence of additional steel girders. The bridge widening will be designed such that the mass and stiffness will be approximately the same as the existing structure.

The Retrofit and Rehabilitation Alternative is shown in Appendix B.

5. **Repairs, including deferred maintenance items**: In order to maximize the remaining service life of the existing structure, consideration should be given to necessary structural repairs and maintenance. The deferred maintenance items currently outstanding according to Caltrans 2012 Inspection Report include: replacing joint seals at Piers 2 and 4, cleaning and painting of girders where the paint is damaged by the water drained from the deck, providing drainage away from steel girders, and removing debris from around Pier 3 and repairing the steel sheet piling.

6. **Bridge Railing Replacement**: The existing bridge railings are substandard, as documented on Caltrans' Structure Inventory and Appraisal (SI&A) form. This means that the railings need to be replaced as part of the rehabilitation project.

   Therefore, as part of this project, the existing barrier rails will need to be removed and replaced with current crash tested railings rated for the design speeds expected.

7. **Bridge Deck Overlay:** Based on field visits as well as reviewing the latest Caltrans maintenance reports, the existing deck appears to be in good condition. However, under the widening/retrofit scenario, portions of the existing bridge deck would have to be removed so that shear studs could be welded on top of the existing steel girders. After the shear studs are installed, the deck would then be patched. A portion of the existing bridge deck would be overlaid with polyester concrete in order to provide a standard 2% crowned section over the bridge.

8. **Traffic Compatibility:** The existing structure must be compatible with the proposed traffic handling sequence proposed for construction.

9. **Hydraulic Compatibility:** The existing conditions flood hydraulics were analyzed by Pacific Hydrologic, Inc. (PHI). PHI has completed preparation of the existing condition backwater model for Corral Bottom Road over the Trinity River. With a drift assumption, the following water surface elevations (NAVD88) were estimated by PHI's backwater model at a location a short distance upstream of the existing bridge (86-feet):

   - 100-year flood, 1214.80-feet
   - Flood of record, 1213.14-feet
   - 50-year flood, 1212.08-feet

   According to PHI, "The flood of record occurred December 22, 1964 and had a peak flow estimated to be 68700-cfs at Corral Bottom Road (Q50 = 61000-cfs, Q100 =75600-cfs)." PHI ignored flood records prior to construction of Trinity Dam except for model calibration with no bridge.

   Caltrans and FHWA recommend that the minimum soffit elevation be the greater of the following:

   - 50-year flood plus appropriate clearance for drift
   - Flood of record (FOR) plus appropriate clearance for drift
   - 100-year flood with "soffit dry"

   The appropriate clearance for drift at this location is 3-feet. Based on the results of the existing condition backwater analysis, the water surface elevation of the FOR plus 3-feet will be the governing criteria for meeting the minimum recommended requirements of Caltrans and FHWA.

10. **Load Capacity:** According to the latest Caltrans maintenance report, the existing structure is capable of carrying both HS-20 design vehicles as well as a P-13 permit vehicle.

11. **Fracture Critical Status:** Based on the latest fracture critical inspection by Caltrans, which was completed on 10/04/2011, the existing steel girders and connections appear to be in good working condition. However, this latest fracture critical inspection reported that there is flame nicking on the transition butt welds on the tension flanges of the girders in all spans. According to the 9/20/2012 Bridge Inspection Report, flame nicking will be monitored in future fracture critical inspections which are on a 24 month inspection cycle. Bridge widening would require additional steel girders which would be connected to the existing girders in such a way that the resulting superstructure would no longer be fracture critical.

12. **Paint System:** The existing steel members seem to have a good painting system applied protecting the girders.

As expected, the existing bridge paint includes lead. Lead was used in most paints until the mid-1950's and was banned in amounts in excess of 0.06% by weight in 1978. Please note that the Seismic Retrofit/Rehab/Widen Alternative includes cleaning and painting of portions of the steel elements of the existing structure.

13. **Bridge Life:** The standard bridge life normally assumed to be at most 75 years. Since this bridge was built in 1960, it is nearing its assumed bridge life. Although there are bridges that stay in service well beyond the 75 years design life, it should be noted that fatigue becomes a serious issue when a steel bridge has been in service for so long. What tends to happen is that the steel members tend to start showing serious signs of distress and welds tend to start cracking, webs start to crack, etc. which are very costly to repair.

    Typically once steel bridges reach their design life, maintenance costs start escalating quickly due to issues associated with fatigue of the steel components.

14. **Bridge Replacement Alternatives:** Due to the length of a detour (125 miles), closing the existing bridge during construction is not an option. Therefore, the new bridge will need to be built either on a new alignment adjacent to the existing bridge, or constructed in stages.

    Alignment Alternatives:

    Due to the steep slope located on the southwest side of the existing bridge, DHA determined that the new bridge would have to be located east of the existing bridge. A new alignment ("CBR" Line) was developed that conforms to Corral Bottom Road approximately 600 feet south of the existing bridge. The "CBR" alignment intersects State Route 299 opposite the intersection of Ranger Station Road. The "CBR" alignment has a long sag vertical curve at the south end and a horizontal curve with superelevation. The "CBR" alignment is located a sufficient distance east of the existing bridge to allow the construction of the replacement bridge to occur in a single stage. The design speed for the new "CBR" alignment is 40 MPH per 2011 AASHTO Standards. A byproduct of moving the alignment to the east is that it will improve the site distance along this stretch of roadway since the existing slope will not impact the vision of motorists.

    If the replacement bridge were constructed in two stages (Alternative No. 3), the new road alignment could be closer to the existing bridge. With staged construction in mind, a second alignment alternative ("CBR-2") was developed. The "CBR-2" alignment is similar to the "CBR" alignment in that it also has a 40 MPH design speed. The "CBR-2" alignment is closer to the existing right-of-way, which would reduce right-of-way acquisition, approach fill volumes, and retaining wall construction. However, the additional cost for staged construction would outweigh any potential savings. Also, constructing the bridge in two stages would extend the duration of construction to two construction seasons.

    Span Configuration:

    Price Creek flows into the Trinity River near the southeast corner of the existing bridge. In order to avoid obstructing the flow of Price Creek, the south abutment of the new replacement bridge on the "CBR" alignment would have to be located approximately 70 feet south of the existing bridge. This would result in the new bridge having a length of approximately 450 feet, which is considerably longer than the existing bridge.

If the replacement bridge were constructed in two stages (along the "CBR-2" alignment), the new bridge would be approximately 390 feet long.

Given an overall length of either 450 feet or 390 feet, and considering that the County of Trinity would like to avoid having permanent supports within the low-flow portion of the Trinity River (permanent supports are obstacles to rafters), a three-span configuration was determined to be best suited for the site.

Three Replacement Alternatives (shown in Appendix C) were considered for the site. The replacement alternatives range in cost from $6.10 million and $6.38 million**.** The preferred replacement alternative is Alternative No. 1. Alternative No. 1 (at $6.38 million) is slightly more costly than Alternative No. 2 (at $6.10 million). However, Alternative No. 1 will not require falsework in the low-flow portion of the river which is a significant benefit in terms of potential environmental concerns. Falsework in the low-flow portion of the river could also pose a hazard to recreational uses such as rafting. Alternative No. 1, with its vee-shaped piers and slender superstructure, is more aesthetically pleasing than Alternative No. 2. Alternative No. 1 does not require falsework in the low-flow portion of the river. And, Alternative No. 1 represents the best combination of structure type, foundation type, span lengths, construction techniques and aesthetics to produce an appropriate and cost effective bridge for the project.

Replacement Alternative	Structure Type	Depth/Span Ratio	Bridge Depth	Comments
1	Cast-in-Place Post-Tensioned Box Girder w/ Drop-In Span 2 and Vee-Shaped Piers	0.040	5-0"	Does not require falsework in the river. Construction is more complicated and more expensive than Alternative No. 2. Most aesthetically pleasing structure type.
2	Cast-in-Place Post-Tensioned Box Girder	0.040	6'-3"	Most cost-effective alternative. Requires falsework in the river. Less aesthetically pleasing than Alternative No. 1.
3	Stage Constructed Cast-in-Place Post-Tensioned Box Girder	0.040	6'-0"	Requires least amount of approach roadway work and right-of-way acquisition. Shortest bridge length. Requires two construction seasons to complete.

15. **Summary of Life-Cycle Cost Analysis:**

Alternative	Prorated Present Value Cost
Replacement Alternative 1	$6.38 Million
Replacement Alternative 2	$6.10 Million
Replacement Alternative 3	$6.38 Million
Retrofit/Rehab/Widen Alternative	$6.90 Million

16. **Highway 299 Improvements at Corral Bottom Road Intersection:**

If bridge replacement is the selected alternative, it would be advantageous if Corral Bottom Road were realigned so that it intersects Highway 299 opposite from Ranger Station Road. Also, a left turn lane for eastbound Highway 299 traffic would be required to improve safety. A conceptual layout of the resulting new intersection of Highway 299/Corral Bottom Road/Ranger Station Road is shown in Appendix M. The conceptual layout, entitled "HWY 299 LEFT TURN EXHIBIT", shows road widening to accommodate the new left turn lane, intersection widening per Figure 405.7 of the Caltrans Highway Design Manual, and additional paving for a bus stop.

Left Turn Lane Cost Estimate:

Area of Pavement Widening	Unit Cost	Total
17,000 s.f.	$50.00/s.f.	$850,000

17. **Environmental Issues:**

An Environmental and Permitting Feasibility Study has been prepared by North State Resources, Inc. and is included in Appendix K. The Environmental and Permitting Feasibility Study evaluates the four bridge design alternatives. Please refer to Appendix K for further details.

The findings of the Environmental and Permitting Feasibility Study are summarized in the following Environmental Issues Alternatives Matrix:

Corral Bottom Road Bridge (No. 05C-0162) over the Trinity River Replacement Project
Environmental Issues Alternatives Matrix

Environmental Issue	**Replacement Alternative 1** Cast-in-Place Post-Tensioned Box Girder with Drop-in Span 2 and V-Shaped Piers	**Replacement Alternative 2** Cast-in-Place Post-Tensioned Box Girder	**Replacement Alternative 3** Staged Constructed Cast-in-Place Post-Tensioned Box Girder	**Seismic Retrofit / Rehabilitation / Widening Alternative**
Hydrology	Improved hydrological conveyance due to removal of existing in-channel piers and location of new piers outside of the low-flow channel	*Long-term:* Improved hydrological conveyance as described for Alternative 1 *Short-Term:* Temporary falsework in active river channel during construction would affect hydrology	*Long-term:* Improved hydrological conveyance as described for Alternative 1 *Short-Term:* Temporary falsework in active river channel for two construction seasons would affect hydrology	Existing in-channel piers will remain and need to be widened; bridge height will stay the same – this could raise the base floodplain elevation and result in an increased risk of flooding
Jurisdictional Waters	Removal of existing in-channel piers would result in a net increase in riverine habitat	*Long-term:* Net increase in riverine habitat as described for Alternative 1 *Short-term:* Temporary falsework in active river channel during construction will result in greater temporary impacts to jurisdictional waters	*Long-term:* Net increase in riverine habitat as described for Alternative 1 *Short-term:* Temporary falsework in active river channel for two construction seasons will result in a greater temporary impact to jurisdictional waters	Existing in-channel piers will remain and be widened which will result in greater impacts to riverine habitat; beneficial impact of removing the existing piers will not be achieved as they would under any of the replacement alternatives
Fisheries	Removal of existing in-channel piers would result in a net increase in riverine habitat which will improve fish passage; pile-driving will be required at a similar level for all alternatives.	*Long-term:* Net increase in riverine habitat and improved fish passage as described for Alternative 1 *Short-term:* Temporary falsework in active river channel during construction will result in greater temporary impacts associated with fish passage; pile-driving will be required at a similar level for all alternatives.	*Long-term:* Net increase in riverine habitat and improved fish passage as described for Alternative 1 *Short-term:* Temporary falsework in active river channel for two construction seasons will result in greater temporary impacts associated with fish passage and may complicate the Endangered Species Act consultation with NMFS; pile-driving will be required at a similar level for all alternatives.	Existing in-channel piers will remain and be widened which will result in greater impacts associated with fish passage; beneficial impact of removing the existing piers from the active low-flow channel will not occur as it would under any of the replacement alternatives; pile-driving will be required at a similar level for all alternatives.

T&E Species Trinity Bristle Snail	Most impact, due to realignment of road. Potential need for an Incidental Take Permit from the California Department of Fish and Wildlife.	Less impact, alignment closer to existing road. Potential need for an Incidental Take Permit from the California Department of Fish and Wildlife.	Less impact, alignment on existing road. Potential need for an Incidental Take Permit from the California Department of Fish and Wildlife.	Less impact, alignment on existing road. Potential need for an Incidental Take Permit from the California Department of Fish and Wildlife.
Recreation	Removal of the existing in-channel piers will improve river conditions and increase public safety associated with in-river recreationists (e.g., rafters, kayakers, fishermen)	*Long-term:* Improved river conditions and increased public safety as described for Alternative 1 *Short-term:* Temporary falsework in active river channel during construction will result in greater temporary impacts to in-river recreationists due to safety concerns	*Long-term:* Improved river conditions and increased public safety as described for Alternative 1 *Short-term:* Temporary falsework in active river channel during two construction seasons will result in greater temporary impacts to in-river recreationists due to safety concerns	Existing in-channel piers will remain and be widened which will result in greater impacts to in-river recreational activities; beneficial impact of removing the existing piers from the active low-flow channel will not occur as it would under any of the replacement alternatives
Aesthetics	Removal of the existing bridge piers within the active channel will improve the overall aesthetic, particularly for recreational users moving through the river corridor	*Long-term:* Improved aesthetics along the river due to removal of existing piers as described for Alternative 1 *Short-term:* Temporary falsework in active river channel during construction will result in greater temporary aesthetic impacts to in-river recreationists	*Long-term:* Improved aesthetics along the river due to removal of existing piers as described for Alternative 1 *Short-term:* Temporary falsework in active river channel during two construction seasons will result in greater temporary aesthetic impacts to in-river recreationists	The long-term benefit of removing the existing bridge pier to improve the local aesthetics, particularly for in-river recreationists, will not be achieved as it would under the replacement alternatives
Wild & Scenic River	See comments made above under Fisheries, Recreation and Aesthetics	See comments made above under Fisheries, Recreation and Aesthetics	See comments made above under Fisheries, Recreation and Aesthetics	See comments made above under Fisheries, Recreation and Aesthetics; it is anticipated that this alternative would be the least desirable to the U.S. Forest Service, the river manager for this segment of the Trinity River

County of Trinity
Trinity River Bridge 5C-0162
Bridge Improvements
Rehab/Replace Flowchart

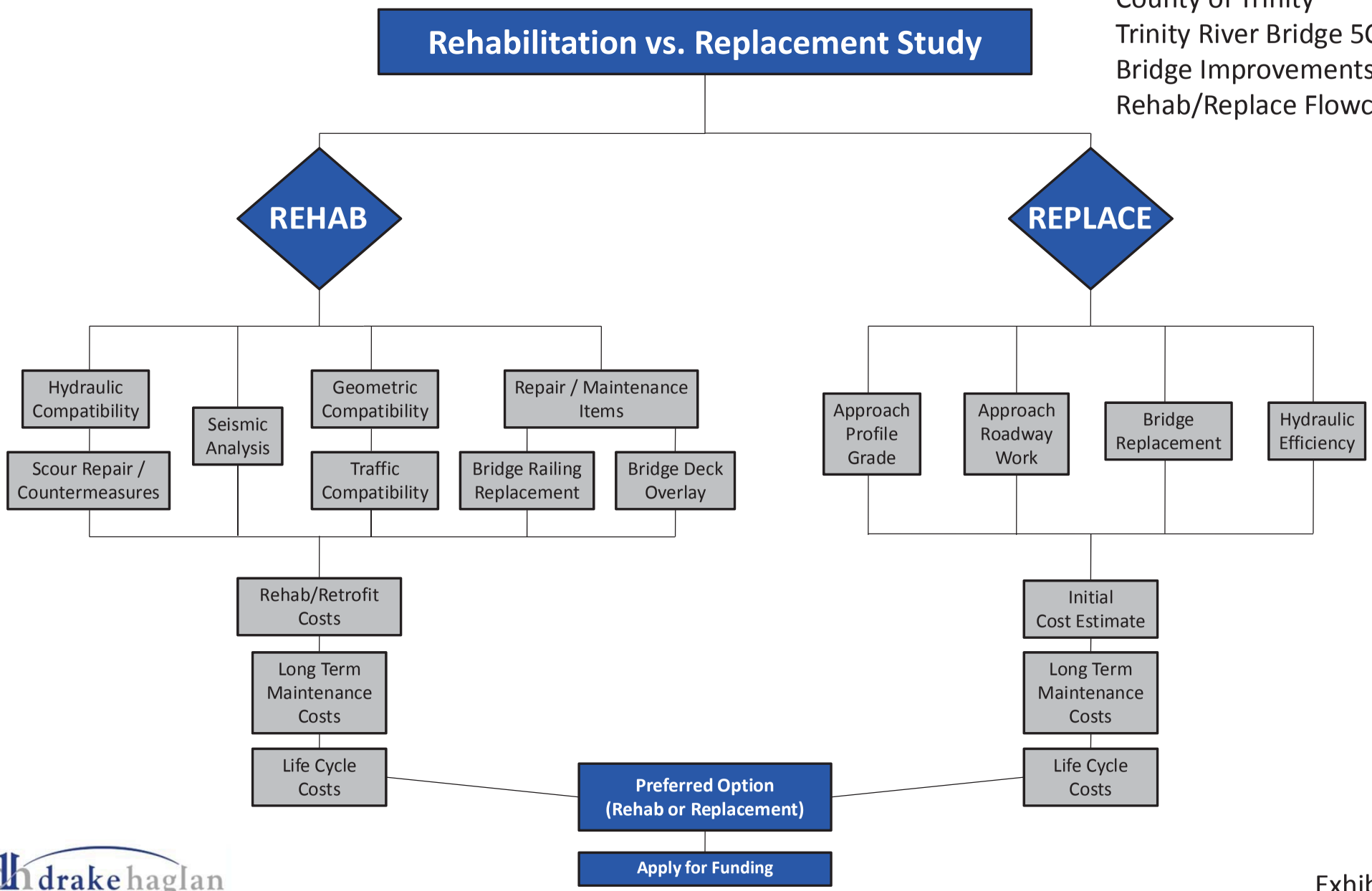

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Exhibit 1

APPENDIX A

LIFE-CYCLE COST ANALYSIS

Corral Bottom Road Bridge over the Trinity River (05C-0162)
Life-Cycle Cost Analysis

Drake Haglan and Associates (DHA) performed a life-cycle cost analysis for the Corral Bottom Road Bridge to evaluate three bridge replacement alternatives and a seismic retrofit/bridge rehabilitation and widening alternative. The results concluded the following:

Assuming a discount rate of 4% and a construction cost inflation rate of 5%

- The life-cycle cost analysis shows that Bridge Replacement Alternative 2, replacement of the existing structure with a three span CIP/PS Concrete Box Girder, is the most cost effective option.
- The life-cycle costs are relatively close for all three bridge replacement alternatives while the seismic retrofit/bridge rehabilitation and widening alternative is the most expensive option. See prorated present value costs shown below.
    - **Seismic Retrofit/Rehab/Widen Alternative - $6.90 Million**
    - **Bridge Replacement Alternative 1 - $6.38 Million**
    - **Bridge Replacement Alternative 2 - $6.10 Million**
    - **Bridge Replacement Alternative 3 - $6.38 Million**

Life-Cycle Cost Analysis Assumptions

DHA performed a life-cycle cost analysis to determine the present value cost in today's dollars associated with the bridge replacement and seismic retrofit/bridge rehabilitation/widening options. The following assumptions were used:

- The expected service life is assumed to be 75 years for a new bridge.
- The expected remaining service life of the existing bridge, which was constructed in 1960, is approximately 20 years if the bridge is rehabilitated. As part of the life cycle cost analysis, the assumed remaining service life parameter for the rehabilitated bridge was varied from 15 to 30 years to study the effect on the present value costs.
- The analysis period for the replacement options is 75 years which is the assumed expected service life of the new structure. The analysis period for the seismic retrofit/rehabilitation/widening option is to the end of the expected service life after the rehabilitated structure is replaced with a new bridge. It is assumed that the widened portion will remain in service and that just the rehabilitated 1960 structure is replaced. For example, an analysis period of 95 years is used if it is

assumed that the existing rehabilitated portion of the bridge will be replaced in 20 years. The present value costs are prorated to account for the difference in analysis periods.

- The future bridge replacement cost for the Seismic Retrofit/Rehabilitation/ Widening Alternative is based on using an estimated cost in today's dollars and then escalating this cost to future dollars based on using an assumed value for the construction cost inflation rate. Attachment B contains the bridge construction cost index that Caltrans has compiled since 1940.[1] Construction costs rose sharply starting in 2004 through 2008, before sharply decreasing in 2009 and staying at similar levels in 2010 and 2011. Starting last year, construction costs have started increasing again. The average bridge cost index for the last 8 years was compared to that of previous 8 year periods to better adjust for the extreme fluctuations that have occurred recently. Based on the available data, a construction cost rate of 5% was used as the baseline value for the life-cycle cost analysis. Please note that this parameter was also varied from 3% to 6% to study the effect on the present value costs.
- The Seismic Retrofit/Rehabilitation/Widening Alternative involves replacing the 1960 rehabilitated structure in approximately 20 years when it has reached the end of its design life. It is assumed that the widened portion will remain in service and that just the rehabilitated 1960 structure is replaced. A square foot cost of $350 is used based on using a steel girder superstructure for this newly widened portion to match the rest of the structure. This cost represents the total project costs (not just the bridge costs) and includes minor roadway approach work and items such as traffic control and water pollution control. A square foot cost of $30 is used for the removal of the existing steel girder structure.
- The discount rate is the interest rate by which future costs will be converted to present value. Discount rates typically range from 3% to 5%. Caltrans currently uses a discount rate of 4% in the life-cycle cost analysis of pavement structures.[2]
- Annual maintenance costs of $1000 are assumed for the replacement alternatives which consist of replacing the existing bridge with a concrete box girder or I-girder superstructure. Annual maintenance costs of $3500 are assumed for the rehabilitation alternative since a more time consuming inspection will need to be performed to check all of the connection details for the steel girder superstructure. Application of a touch-up/overcoat for the painting system of the steel girders is assumed to occur every 25 to 30 years using an assumed cost of $1 per square foot of steel surface area.

[1] Construction Statistics, State of California, Department of Transportation, 2012
[2] Life-Cycle Cost Analysis Procedures Manual, State of California, Department of Transportation, November 2007, Updated August 2010

Life-Cycle Cost Analysis Results

Shown below are the prorated present value costs for the different options assuming a discount rate of 4% and a construction cost inflation rate of 5%:

- **Seismic Retrofit/Rehab/Widen Alternative - $6.90 Million**
- **Bridge Replacement Alternative 1 - $6.38 Million**
- **Bridge Replacement Alternative 2 - $6.10 Million**
- **Bridge Replacement Alternative 3 - $6.38 Million**

Since the present value costs are dependent on the assumed discount rate and construction cost inflation rate, life-cycle cost calculations were also performed to determine the effect that varying these parameters had on the present value costs. Table 1 depicts the present value costs assuming a construction cost inflation rate of 5% and a varying discount rate. Table 2 depicts the present value costs assuming a discount rate of 4% and a varying construction cost inflation rate.

Table 1 – Prorated Present Value Life-Cycle Costs, Construction Cost Inflation Rate = 5%

Discount Rate	2%	3%	4%	5%
Retrofit/Rehab/ Widen Alt	$8,281,489	$7,496,519	**$6,899,236**	$6,432,633
Replacement Alt 1	$6,398,677	$6,389,702	**$6,383,680**	$6,379,485
Replacement Alt 2	$6,118,677	$6,109,702	**$6,103,680**	$6,099,485
Replacement Alt 3	$6,398,677	$6,389,702	**$6,383,680**	$6,379,485

Table 2 – Prorated Present Value Life-Cycle Costs, Discount Rate = 4%

Construction Cost Inflation Rate	3%	4%	5%	6%
Retrofit/Rehab/ Widen Alt	$6,076,399	$6,445,101	**$6,899,236**	$7,465,314
Replacement Alt 1	$6,383,680	$6,383,680	**$6,383,680**	$6,383,680
Replacement Alt 2	$6,103,680	$6,103,680	**$6,103,680**	$6,103,680
Replacement Alt 3	$6,383,680	$6,383,680	**$6,383,680**	$6,383,680

The present value cost of the Seismic Retrofit/Rehabilitation/Widening Alternative is heavily dependent on both the discount rate and construction cost inflation rate since it has a significant lump sum cost expenditure in the future when it is assumed that the 1960 rehabilitated portion of the bridge will be replaced. As shown in Table 1, the present value costs of the replacement options are not really affected by the assumed discount rate since the yearly maintenance costs are minimal compared to the initial replacement costs.

Another parameter that will have a significant effect on the present value costs for the Seismic Retrofit/Rehabilitation/Widening Alternative is the amount of remaining service life that the existing bridge will have after it is rehabilitated. Since the bridge was built in 1960, it is assumed that the rehabilitated portion of the bridge will have approximately 20 years of service life remaining.

To take the analysis a step further, present value costs are determined for the Seismic Retrofit/Rehabilitation/Widening Alternative using an assumed remaining service life of 15, 20, 25 and 30 years for the existing bridge. The analysis period for each of these cases is based on the remaining service life of the retrofitted structure plus the assumed 75 year design life of the new structure built after that. The present value costs are then prorated so they can be compared to the replacement options. For example, the present value costs for the rehab option with an assumed service life of 20 years will be multiplied by a factor of 75/95 to account for the analysis period of 95 years for the rehab option versus 75 years for the replacement options.

Table 3 shows the prorated present value life-cycle costs assuming a discount rate of 4% and a construction cost inflation rate of 5%. The prorated costs for the rehab option decrease as the remaining service life of the retrofitted bridge increases.

Table 3 – Prorated Present Value Life-Cycle Costs, Discount Rate = 4%, Construction Cost Inflation Rate = 5%

Remaining Service Life of Retrofitted Bridge	15 years	20 years	25 years	30 years
Retrofit/Rehab/ Widen Alt	$7,162,578	**$6,899,236**	$6,667,382	$6,462,782
Replacement Alt 1	$6,383,680	**$6,383,680**	$6,383,680	$6,383,680
Replacement Alt 2	$6,103,680	**$6,103,680**	$6,103,680	$6,103,680
Replacement Alt 3	$6,383,680	**$6,383,680**	$6,383,680	$6,383,680

Conclusions

- Bridge Replacement Alternative 2, which involves replacing the existing bridge with a three span CIP/PS Concrete Box Girder, is the most cost effective option.
- The life-cycle costs are relatively close for all three bridge replacement alternatives, while the seismic retrofit/bridge rehabilitation and widening alternative is the most expensive option.
- Due to the large lump sum future cost of replacing the retrofitted structure for the Seismic Retrofit/Rehabilitation/Widening Alternative, the assumed parameters (discount rate, construction cost inflation rate, and remaining service life of retrofitted structure) have a huge effect on the present value cost.