Appendix C
BEAVER CREEK CORRECTION ANALYSIS FORM

Natural Systems Design

Correction Analysis Form

Site Information (measurements in feet)

Project Name: ***Beaver Creek Culvert Replacement*** *SRFB Project #:* *Date:* ***March 31, 2021***

Bankfull Width (outside influence of culvert): **12.9 ft** Utilities Crossing: ☒ Yes ☐ No ☐ Unknown

Road Fill at Culvert Invert: **3.7 ft** Road Width: **14.8 ft**

Road Description/Condition (mainline, spur road, driveway/access): **Private driveway (asphalt) connecting parking lot (west side) to access road for other buildings on the property (east side) which splits after crossing the creek. Road drops longitudinally approximately 3 ft across the existing culvert (see Photo 1).**

Evaluator Information

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Upstream Habitat/Channel Description

Channel Slope (outside of culvert influence): **0.9 – 1.0%** Re-grade Potential (streambed US – streambed DS in feet): **0.95 ft**

Dominant Substrate: ☐ Sand (<1/5") ☒ Gravel (1/5"–3") ☐ Cobble (3"-12") ☐ Boulder (>12") ☐ Bedrock

Additional Upstream Information, Habitat Description, Other Site Conditions or Concerns, Including Potential Re-Grade Impacts Relative to Channel Stability And Habitat: **Channel is fairly uniform width and meanders mildly through the project reach. Channel banks are well vegetated for the most part with good root mass from riparian vegetation and steep or overhanging banks in several areas (see photo 2). Riparian corridor is narrow, but well vegetated and mainly composed of alder, red-osier dogwood, and maple with small woody material (mostly alder) present in the channel in several locations upstream of the culvert (see photos 3 and 4). Slope is fairly consistent upstream of the culvert; substrate immediately upstream of the culvert is primarily small gravel and sand; substrate becomes gravel-dominant several hundred feet upstream of the culvert. Regrade potential through the new channel is fairly limited due to relatively uniform slope upstream and downstream of crossing. For the replacement channel bed, it may be necessary to oversize material for stability with the anticipation that the smaller sediment typical of existing conditions will fall out over time. Similarly, if the steep banks of the existing channel upstream and downstream are to be replicated through the crossing the use of boulders to create steep banks may be necessary.**

Downstream Habitat/Channel Description

Channel Slope: **0.9 – 1.0%** (outside of culvert influence)

Additional Downstream Information, Habitat Description, Other Site Conditions or Concerns: **Downstream of the culvert, the channel is heavily vegetated with riparian shrubs and small trees (see photo 5). Channel geometry including width and bank heights are generally consistent with upstream channel geometry. Approximately 40 feet downstream of the existing culvert outlet the channel enters a wide meander, turning toward river right and then back toward river left over a length of approximately 3 bankfull widths. The meander downstream of the culvert has an active floodplain with an obvious high flow channel cutting across the floodplain bar near the left side of the ravine. Small woody material in the channel immediately downstream of the high flow channel inlet likely directs some portion of flow during regular high flows (1- to 2-year events) into the high flow channel (see photo 6). Slope and sediment composition downstream of the culvert are similar to conditions upstream of the culvert. The gradual slope extends downstream of the Chiwawa Loop Road crossing before gradient increases again for the lowest 0.2 RM of Beaver Creek upstream of the confluence with the Wenatchee River (see Figure 1).**

Downstream of the culvert several utilities are present which will require at least temporary relocation during construction. Several overhead utility lines cross the creek downstream of the existing culvert and tie into a nearby junction box before continuing in multiple directions underground. A utility locate conducted prior to site survey indicated that buried power and phone lines are present on the east side of the existing culvert; based on discussions with the landowner it is likely that a buried domestic water line and a buried phone line are present on the west side of the creek and cross toward the east at the existing culvert; neither buried line was identified on the utility locate. The landowner also suggested that a fiber line exists overhead, crossing the creek overhead before joining the nearby junction box and continuing underground in an unknown direction; the presence of the fiber line has not been confirmed. The utility pole and associated junction box (see photo 7) will at a minimum require temporary relocation to

accommodate construction; if the buried water and phone lines do in fact exist, the design will have to incorporate a means of allowing the utility lines to cross the creek.

Approximately 8 ft downstream of the existing culvert outlet an 18" diameter irrigation pipe crosses the creek channel. The pipe crosses the channel above ground and is exposed to natural elements; a protective covering is included on the pipe through the exposed crossing. The irrigation pipe is owned and operated by the Wenatchee-Chiwawa Irrigation District (WCID). The pipe conveys irrigation water from west of the creek across the creek to the east side of the creek (see photo 8). This pipe will likely be within the limits of earthwork for the replacement structure; at a minimum, this pipe will require special care while conducting earthwork and at worst the pipe may require temporary removal and replacement during construction if work cannot be conducted with the pipe in its current location; if required this work will be coordinated with WCID.

Correction Options and Preferred Alternative

Options to Consider – Provide up to Three Site-Appropriate Correction Alternatives.

Option 1: **Replace existing culvert with precast modular concrete bridge (18 ft span).**

Option 2: **Replace existing culvert with precast concrete split box culvert (18 ft span).**

Option 3: **Replace existing culvert with bottomless aluminum box culvert (18 ft span).**

Preferred Alternative - Provide a 1- or 2-paragraph Recommendation for this Site. Include any Site-Specific Concerns that Will Need to be Addressed During Design and Construction: **The preferred alternative for this project is a modular concrete bridge used to replace the existing undersized culvert. The Stream Simulation design approach outlined in the Washington Department of Fish and Wildlife (WDFW) Water Crossing Design Guidelines (WCDG) was used to develop this design option. The replacement structure is sized based upon the minimum opening size for the field verified and agreed upon bankfull width of 12.9 ft using the standard 1.2 x Bankfull width plus an additional 2 ft which gives 17.5 ft and is rounded up to the next whole foot. Site constraints, particularly the longitudinal slope across the culvert, as well as estimated construction cost played a role in determining the preferred alternative. Chelan County Code requirements for freeboard will require some raising of the existing drivable surface. The landowner has expressed their desire to minimize the profile adjustment of the road to the extent practicable. That being said, both Options 1 and Options 2 provide similar improvements hydraulically and geomorphically while minimizing the vertical adjustment to the driving surface necessary to accommodate minimum freeboard requirements and the structure itself. The modular bridge option is anticipated to cost less (approximately 11%) than the precast split box culvert and is therefore considered the preferred alternative. Plan and profile drawings of the preferred alternative are provided in Figure 2. It is important to note that a geotechnical investigation has been scoped for this effort, but has not yet been conducted. If weak soils are discovered it is likely that design option 1 would become infeasible and design option 2 would become the preferred alternative. At this time the working assumption of the design is that soils will be adequate to allow for independent footings (i.e. a modular bridge is feasible) and therefore design option 1 remains the preferred alternative until the results of the geotechnical analysis are available.**

A bottomless aluminum box culvert meeting the minimum span requirements was briefly considered as a third option. Due to the minimum fill required over the aluminum box culvert, the vertical profile adjustment necessary to accommodate this type of structure is simply too severe to be considered a viable option. This option was included on Figure 3 for illustrative purposes only.

Cost Estimates

Rough Cost Estimate* - Attach Detailed Cost Breakdown Using the Appropriate Cost Estimate Template, Provided Separately.

Option 1: **$333,800 (plus additional $42,000 for temporary bridge)**

Option 2: **$370,800 (plus additional $42,000 for temporary bridge)**

Option 3: **N/A (not feasible)**

For all cost esimates, a line item was included for a temporary bridge to allow for traffic to cross the creek near the existing culvert. Depending on coordination efforts with the landowner, this cost may be reduced if an alternate access to the far side of the creek can be achieved through other means.

A determination regarding the need to include wingwalls has not been made at this point in the design. Wingwalls would add a significant cost to the project if constructed of concrete (~$50K - $60K) but would provide the best embankment protection and aesthetically would match the look of the replacement structure itself. If wingwalls are determined to be necessary a lower cost alternative would be to construct them using boulders.

Lastly, the cost to temporarily or permanently relocate utilities included in the cost estimates should be viewed as a very rough estimate. This cost could vary significantly depending on the actual number and type of utilities present as well as the nature of the relocation (permanent versus temporary); the prices included in the cost estimates are approximate at best.

*This is a rough approximation of project costs; actual costs may vary depending on specifications identified during final project design.

Photo 1. Looking west across existing culvert crossing.

Photo 2. Steep, well-defined and vegetated banks typical of channel in project reach.

Photo 3. Narrow riparian corridor upstream of existing culvert.

Photo 4. Small woody material present in channel upstream of culvert.

Photo 5. Riparian conditions downstream of existing culvert.

Photo 6. Small woody material downstream of existing culvert.

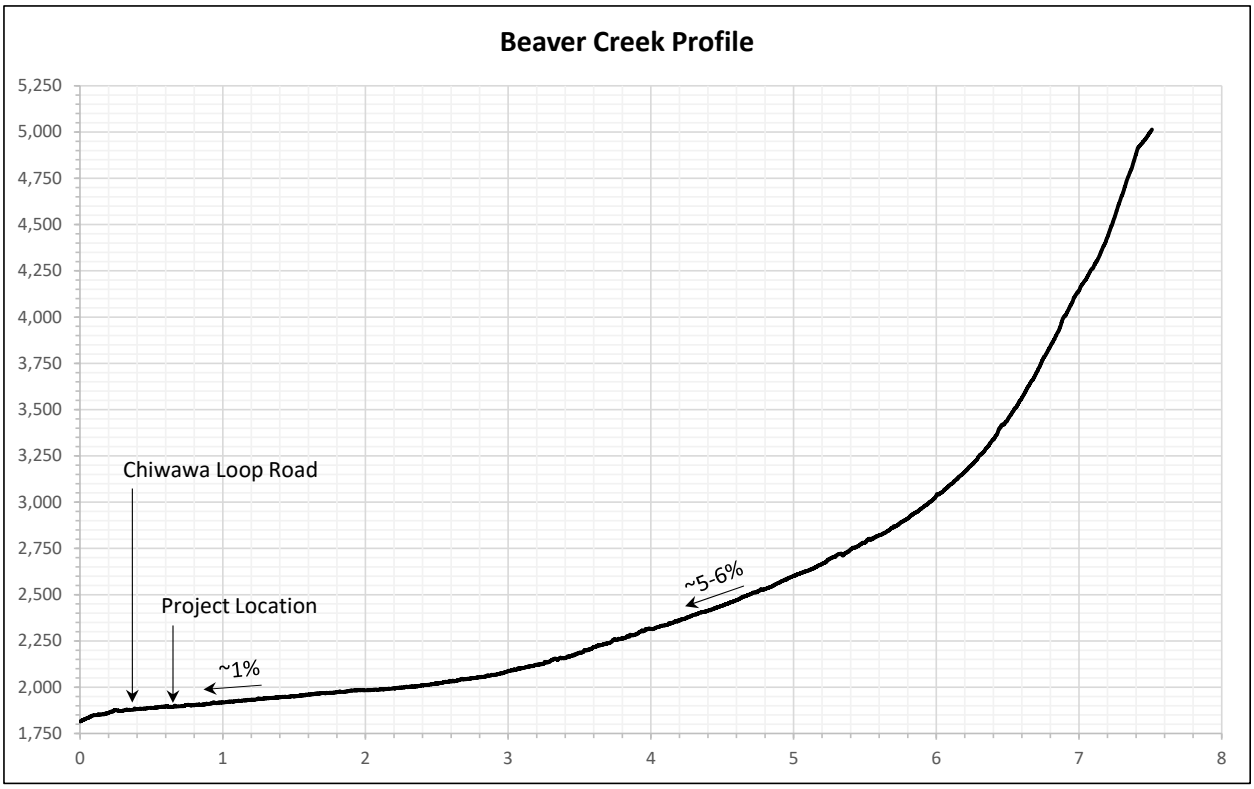
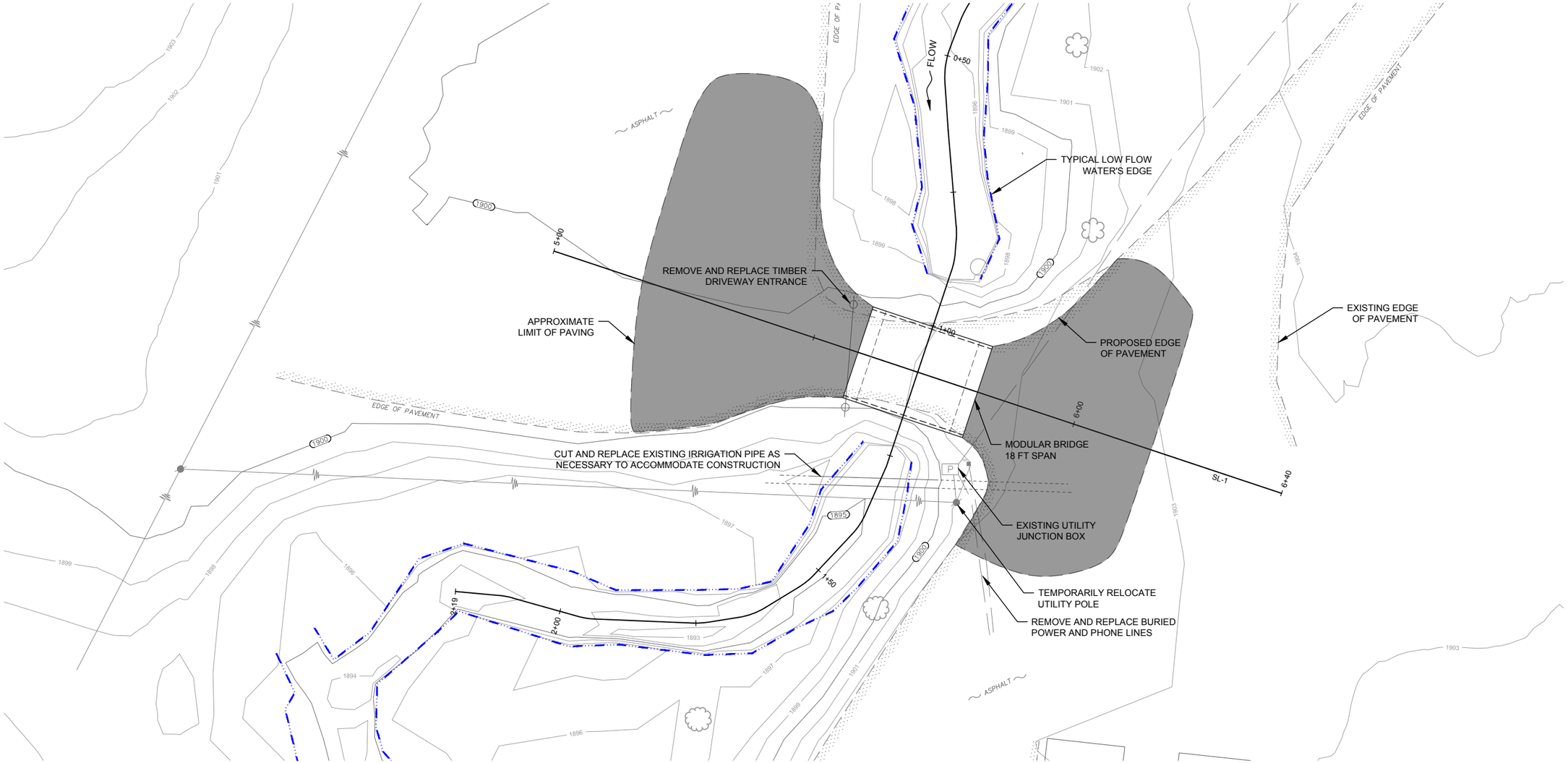


Figure 1. Longitudinal profile of Beaver Creek indicating typical slopes and project location.

Photo 7. Looking downstream at utility pole and associated junction box near the existing culvert.

Photo 8. Existing irrigation pipe which crosses Beaver Creek above channel downstream of existing culvert.

DESIGN OPTION 1: MODULAR BRIDGE OPTION 18 FT SPAN



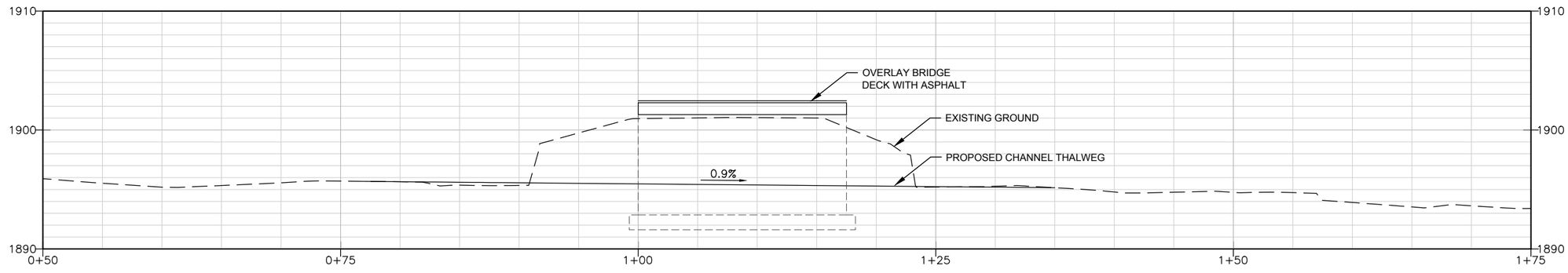


FIGURE 2. PLAN AND PROFILE VIEW OF PROPOSED CONDITIONS FOR PREFERRED ALTERNATIVE

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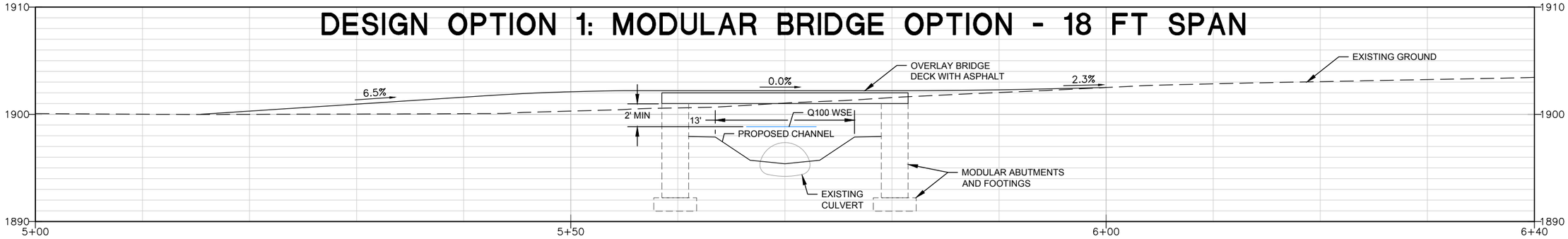

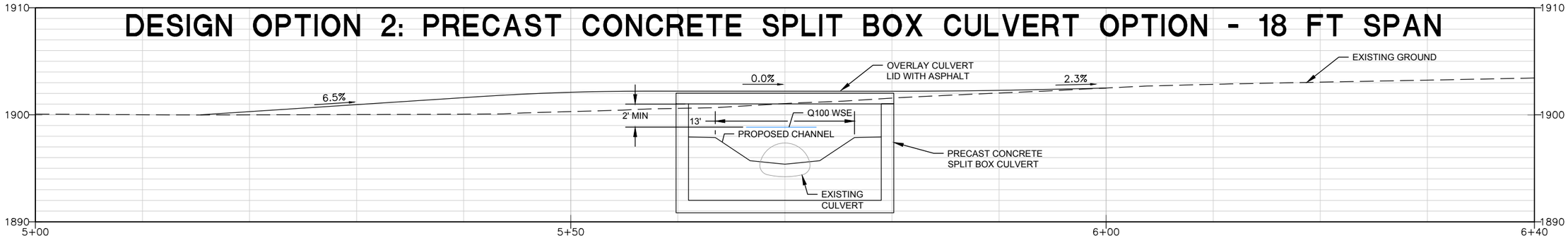

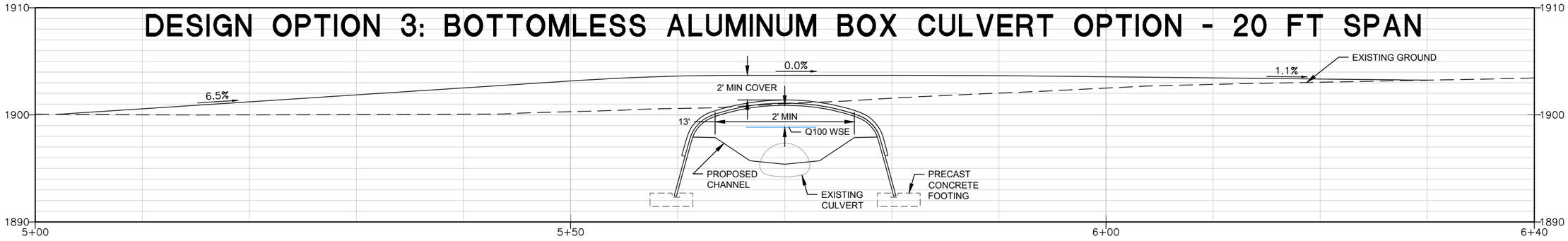

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FIGURE 3. TYPICAL SECTION VIEWS FOR DESIGN OPTIONS CONSIDERED