

Work Plan No.: B.21-01 - Silicon Valley Berryessa Extension Tunnel Seismic Assessment

Scope:

2.0 SCOPE OF SERVICES

This project shall include the following scope of work:

1. Review the as-built design documents (design criteria, drawings, specifications, geotechnical reports, photos etc.). Review drawings of tunnel, pump station, expansion joint construction, and Foundation Recommendation Report, as provided by BART. per the original Silicon Valley Berryessa Extension Project design criteria using BART standards
 2. Review the existing Sierra Lundy Tunnel Foundation Recommendations Appendix C on the Racking Study analysis and results. Geotechnical engineer and structural engineer will review the subsurface profile soil layer properties, ground motions, the SSI models, the FLAC 2D and FLAC 3D analyses results and etc. as shown in the Appendix C in order to determine if the racking displacement results from the FLAC analyses are appropriate as the basis to study the structural performance of the existing tunnel structure. per the original Silicon Valley Berryessa Extension Project design criteria using BART standards
 3. A Tech Memo will be submitted outlining the methodology and procedure of the Seismic Assessment for BART's review and approval prior to commencing the Geotechnical/Structural analysis and the Initial Draft Seismic Assessment Report (Tasks 5 to 12).
 4. Conduct a site visit to verify general conformance with record drawings and gather any other necessary information from BART as required. The site visit is limited to 2 HDR staff engineers. 1 watchperson will be provided for the site visit. BART to provide access and safe environment for the site visit of the engineers. The verification is limited to visual verification only for accessible areas, without any excavation or removal of any items. Field photos and observation notes will be included in the Initial Draft Seismic Assessment Report. No field and inspection report and geotechnical subsurface investigation are proposed.
 5. **Verify Seismic Joint Design between Tunnel and Pump Station in the Longitudinal Direction.**
 - Perform a preliminary evaluation of the performance of expansion joint between pump station and tunnel under design seismic event per the original Silicon Valley Berryessa Extension Project design criteria using BART standards.
 - Perform an initial assessment of the longitudinal relative movement between the tunnel and pump station based on the racking displacement described in the existing Foundation Recommendations.
 - Review the existing Sierra Lundy Tunnel Foundation Recommendations Appendix C on
-

the design criteria, soil parameters, assumptions, time histories and soil structure interaction model in order to determine if the original racking analysis is too conservative. If the results are too conservative, and the seismic expansion joint between the tunnel and the pump station structure does not have the deformation capacity to accommodate the longitudinal movement per the original racking analysis reviewed under Item 2 above, perform the **Optional Task A** with new 3D racking SSI analysis for the pump station to further investigate the seismic joint design (see Task 6 below).

6. **Optional Task A** – Perform new racking analysis of the pump station.

- Perform PLAXIS3D analysis to further investigate the performance of the seismic expansion joint between the tunnel and the pump station structure using (3) time histories. This is similar to the original design. The existing Sierra Lundy Tunnel Foundation Recommendations Appendix C specified (3) sets of time histories for the SSI analysis.
- Dynamic non-linear finite element analysis will be performed. Create 3D structure model of the pump station with the as-built properties of the concrete elements.
- The 6" compressible Geofom material between the tunnel and the pump station structures would not be included in the 3D model as the large number of the small mesh to model the 6" gap is not feasible for the computer runtime.
- The relative longitudinal movement between the tunnel and the pump station will be based on the results of the pump station new PLAXIS3D analysis and the tunnel FLAC3D analysis in the existing Sierra Lundy Tunnel Foundation Recommendations Appendix C .

7. **Verify Tunnel Strength Design in the Transverse Direction.**

- Evaluate whether the as-built tunnel satisfies the transverse direction racking analysis requirement per the original Silicon Valley Berryessa Extension Project design criteria using BART standards.
- If the original racking result does not meet the design requirement, perform **Optional Task B**.
- Perform 2D pushover analysis to compare the demand and capacities of the tunnel slab and wall members. If the tunnel members strength design in the transverse direction satisfies the original design criteria, the Tunnel Strength Evaluation is complete. However, if the tunnel members strength design in the transverse direction does not satisfy the original design criteria, proceed to **Optional Task C**.

8. **Optional Task B** – Perform a new SSI PLAXIS2D analysis in the transverse direction

- Create one 2D model of the tunnel to perform dynamic non-linear finite element analysis in the transverse direction. The pump station configuration and its stiffness will be considered in the evaluation of the racking results. However, the analysis of the pump station and the model of the pump station is excluded in the scope of work.
- Perform a new SSI PLAXIS2D analysis in the transverse direction based on the original project criteria. Similar to the SSI analysis in existing Sierra Lundy Tunnel Foundation Recommendations, the racking analysis ground motions is based on the design acceleration response spectra (ARS) curves previously developed and modified to incorporate the site conditions. The (3) sets of response spectra compatible time histories will be used with the structural model of roof and invert slab, exterior and interior wall .
- Perform a new SSI PLAXIS2D analysis in the transverse direction using response

spectrum per the Safety Evaluation Earthquake (SEE) requirements per AASHTO LRFD Road Tunnel Design and Construction Guide Specifications, 1st Edition, 2017.

- o Following Caltrans SDC criteria, the SEE spectrum will be based on a 5% probability exceedance in 50 years or 975-year return period. Spectrum will be provided by BART.

9. **Optional Task C** - If the tunnel strength design does not meet the design requirements per the original Silicon Valley Berryessa Extension Project design criteria, perform Optional Task B and determine if the as built condition meets the Safety Evaluation Earthquake (SEE) requirements per AASHTO LRFD Road Tunnel Design and Construction Guide Specifications, 1st Edition, 2017.

- If the as built condition does not meet the above design requirements per AASHTO, determine the seismic level (i.e., the % exceedance with the recurrence period in number of years) that the existing design can meet the Safety Evaluation Earthquake (SEE) requirements using the design capacity calculated per the above AASHTO criteria.

10. **Optional Task D – Determine Groundwater Inflow Rate**

- As directed by BART, based on the performance of the expansion joint evaluated above, determine the groundwater inflow rate into the tunnel per the design ground water level per the original Silicon Valley Berryessa Extension Project design criteria using BART standards.

11. **Optional Task E – Provide Conceptual Repair Details**

- As directed by BART, provide conceptual repair details or retrofitting approach for the (1) tunnel strength deficiency and (2) the expansion joint movement deficiency. The conceptual repair details will be presented in the Seismic Assessment Report.
 - o ROM constructions estimate of the repair and retrofit is not included in this scope.
 - o The repair or retrofit of the 18" storm drainpipe at the tunnel and pump station is not included in this scope as it is not considered as a life safety design.

12. Response and resolve BART comments on all the deliverables.

13. The Final Assessment Report will contain the following main sections (at minimum):

- Executive summary
- Project description
- Methodology
- Assumptions
- Summary of results
- Recommendations
- Detailed calculations
- Photos

Assumptions:

- Geotechnical data required to perform the FE modeling will be provided by BART. The

methodology and design criteria for the structures will be based on the criteria defined in the scope above. The time histories from the Foundation Recommendation Report (in digitized format) to be provided by BART or the geotechnical consultant that completed the report. Engineering judgement will be used to develop our best estimate of the missing engineering input parameters.

- "HDR's review of the as-built conditions and design documents for the project does not make HDR responsible for such conditions and design; including any errors, omissions or deficiencies therein; which remain the sole responsibility of the contractor(s) and/or designer(s) that performed construction and design work for the project.
- HDR scope doesn't include claim support or acting as an expert witness.

Prime: HDR

Subconsultant: None

Work Plan Value: \$403,461