Discussion of Potential Trench Issues

Keith Reckdahl
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These are my personal opinions, not necessarily those of XCAP or the City of Palo Alto
Potential Trench Issues

• These slides discuss the potential issues for the Charleston/Meadow Trench
  • While the AECOM trench analysis highlights these issues, it does little to determine their solvability

• Potential Issues:
  • Cost
  • Construction duration
  • Creek interference
  • Groundwater leaking/pumping
  • Interference with groundwater flow
  • Tiebacks
Trench Cost

- AECOM’s cost estimate for the South Palo Alto trench is $800-950 million
  - However, this cost estimate is inconsistent with other trench projects
  - Also note that these trenches are all much wider than the Palo Alto trench

<table>
<thead>
<tr>
<th>Rail Trench Project</th>
<th>Total Price (millions $)</th>
<th>Completion Date</th>
<th>Length (ft)</th>
<th>Road Overpasses</th>
<th>Creeks</th>
<th>Trench in Water Table?</th>
<th>Cost/linear foot (thousands $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Palo Alto</td>
<td>800-950</td>
<td>2025 (est)</td>
<td>6,000</td>
<td>2</td>
<td>2</td>
<td>Yes</td>
<td>133-158</td>
</tr>
<tr>
<td>Reno ReTRAC</td>
<td>282</td>
<td>COMPLETED Dec 2005</td>
<td>10,560</td>
<td>11</td>
<td>0</td>
<td>Yes</td>
<td>27</td>
</tr>
<tr>
<td>San Gabriel CA</td>
<td>293.7</td>
<td>COMPLETED Sept 2018</td>
<td>7,920</td>
<td>4</td>
<td>2</td>
<td>Yes</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Alameda Corridor East)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carlsbad CA (Short Design)</td>
<td>224</td>
<td>2030 (est)</td>
<td>6,000</td>
<td>6</td>
<td>??</td>
<td>Yes</td>
<td>37</td>
</tr>
<tr>
<td>Carlsbad CA (Long Design)</td>
<td>335</td>
<td>2030 (est)</td>
<td>8,400</td>
<td>7</td>
<td>??</td>
<td>Yes</td>
<td>40</td>
</tr>
<tr>
<td>Phoenix Sky Harbor</td>
<td>441</td>
<td>2025 (est)</td>
<td>12,000</td>
<td>1</td>
<td>0</td>
<td>??</td>
<td>37</td>
</tr>
</tbody>
</table>

Note that costs are not necessarily in same-year dollars

A $300 million trench estimate would change the Palo Alto trench conversation
The Carlsbad Feasibility Study includes a cost analysis which adjusts the trench construction costs into 2016 dollars. These costs only include the actual construction, not design/etc.

### Table 10.2: Comparison of CVDT Proposed Cost with Recently Completed Similar Trench Structures in 2016

<table>
<thead>
<tr>
<th>Project</th>
<th>Total Construction Cost ($ millions)</th>
<th>Max. Trench Height (ft)</th>
<th>Trench Width (ft)</th>
<th>Trench Length (ft)</th>
<th>Adjusted 2016 Cost / LF of Trench ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reno Transportation Rail Access Corridor¹</td>
<td>$171 (2002)</td>
<td>33</td>
<td>54</td>
<td>10560</td>
<td>$39,803</td>
</tr>
<tr>
<td>San Gabriel Trench Grade Separation²</td>
<td>$173 (2012)</td>
<td>30</td>
<td>51</td>
<td>7920</td>
<td>$33,681</td>
</tr>
<tr>
<td>CVDT Long Trench (With 30% Contingency)</td>
<td>$226 (2016)</td>
<td>32</td>
<td>55</td>
<td>8100</td>
<td>$27,852</td>
</tr>
<tr>
<td>CVDT Short Trench (With 30% Contingency)</td>
<td>$155 (2016)</td>
<td>32</td>
<td>55</td>
<td>5700</td>
<td>$27,263</td>
</tr>
</tbody>
</table>

*From Carlsbad Village Double Track – Railroad Trench Alternative Economic Analysis and Feasibility Study (January 2017)*
Construction Duration

- AECOM estimates that the Charleston/Meadow trench will require 6 years of construction

- Comparisons:
  - The Reno trench was constructed in 3 years
    - The Reno trench is 75% longer and about twice as wide as Palo Alto’s
    - Reno has 11 overpasses compared to Palo Alto’s 2 overpasses
    - Reno has similar ground-water constraints
    - Reno’s trench was constructed in the middle of an urban environment
    - Reno’s excavation was complicated by the removal of large boulders
  - The Alameda trench was completed in less than 4 years

A 6-year construction estimate for Charleston/Meadow trench seems generous
Creek Interference

• Adobe Creek is located ~1200 feet from Charleston Road
  • This makes it difficult for the trench to rise above the creek
  • Some interference with the creek likely is unavoidable

• The current AECOM design dams the creek, pumping the water over the trench
  • It is possible that Valley Water may choose to disallow this design

• Other option is bring creek under the trench using either passive or powered siphons
  • Passive siphons are simpler, but can accumulate sediment
  • Active siphons require backup power, but are less prone to sediment

• Siphons likely would solve creek interference, however they add complexity
  • Siphons would require approval of Valley Water
Mitigations for Creek Interference

• To the first order, creek interference is acceptable provided sufficient the cross-sectional area is maintained
  • While not ideal, sometimes a reduced cross-sectional area is still acceptable if creek geometry allows enough backup to increase pressure

• Cross-sectional area can be increased by widening the creek and/or deepening the creek under the rail
  • The creek flow is currently limited by its culvert under Alma

• The amount of creek interference can also be somewhat reduced by varying the trench’s vertical curves
  • Designing the vertical curve to increase the slope at Charleston, results in a more-rapid rise from Charleston to Adobe Creek
  • Raising the track south of Adobe Creek can also reduce creek interference by decreasing the amount of levelling-out that occurs between Charleston and Adobe Creek
  • Reducing the bridge-deck thickness at Charleston reduces creek interference

• The creek interference can also be greatly reduced by increasing the allowable curvature of the rail’s vertical curve
  • XCAP should request Caltrain Grade Separation Study to evaluate this topic
Groundwater Leakage

• The current Charleston/Meadow trench design allows groundwater to leak into the trench, requiring continual pumping
  • Pumping permanently lowers the local water table
  • Groundwater pumping must be treated for pollutants

• Conversely, the Reno, Alameda, and Carlsbad trenches all seal the trench from the surrounding groundwater
  • The Carlsbad Feasibility Study compared construction techniques and found that four met their groundwater control criteria

• The trench still requires pumps to eliminate rainwater
  • Stormwater pumping operation/maintenance is approx. $4000-$8000 per year

Table 6.1: Wall System Evaluation Summary

<table>
<thead>
<tr>
<th>Wall Type</th>
<th>Applicability to Soil Conditions</th>
<th>Groundwater Control</th>
<th>Bridge Abutment Loading</th>
<th>Construction Duration and Impact</th>
<th>Utility/ROW Conflicts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secant Pile Wall</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Slurry-Diaphragm Wall</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Deep Soil Mixing (DSM) Wall</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cantilever Wall without Shoring</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Cantilever Wall with Sheetpile Shoring</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Soil Nail Wall</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Soldier Piles and Lagging</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>MSE Walls</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
</tbody>
</table>

Legend: ✓ Criteria satisfied  X Criteria not satisfied

From Carlsbad Village Double Track – Railroad Trench Alternative Economic Analysis and Feasibility Study (January 2017)
Groundwater Flow

• One concern is that the 30-foot trench will interrupt the flow of groundwater
  • The groundwater depth in Charleston/Meadow is 15-20 feet

• However, consider the number of development at San Antonio and along El Camino
  • The parking/foundations of these developments are much deeper than 30 feet
  • My lay opinion: most groundwater flow is already being constrained to deeper than 30 feet

• However, the trench’s impact on groundwater flow should be determined by a groundwater analysis
Trench Tiebacks

- Tiebacks prevent the trench walls from caving inward
  - Tiebacks would likely require easement for the homes on the west side of the tracks
  - Tiebacks also prevent trees from being planted near the trench

- Some construction techniques (such as slurry walls) produce a much stiffer wall, which reduce (but not necessarily eliminate) the need for tiebacks

- The Alameda and Carlsbad trenches could not use tiebacks due to the close proximity of utilities and right-of-way boundaries
  - Those trench projects instead support the wall using struts at the top of the walls
  - The struts are installed in compression to counteract the lateral soil pressure

- The choice of struts/tiebacks depend on a geotechnical soil analysis

Struts may reduce/eliminate the need for trench tiebacks
Trench Tiebacks (cont’d)

Picture of Alameda Corridor East (ACE) Trench showing:

• Overhead struts
• Three sets of tracks
• Double-stack rail cars
Summary

- The Charleston/Meadow trench has many engineering challenges
  - My lay opinion: these engineering challenges won’t be easy but (from the current data) they don’t appear to be show stoppers
- The cost estimates for the Charleston/Meadow trench are not consistent with other rail trench projects
  - The community would be well-served if the City consults with the companies that successfully completed the Reno/Alameda rail trench projects and/or are planning the Carlsbad trench

The potential benefits of the trench alternative warrants refined analysis