

December 18, 2019

XCAP Meeting

Item #3: Discussion: Update from Technical Working Group Regarding Review of New Ideas/Iterations with Volunteer Civil Engineers and AECOM

Overview of Attachments for this Item:

Item #3 has three (3) attachments, each with sub-attachments. The list of attachments and sub-attachments is included below:

Attachment 1: Memo from Nadia Naik with Technical Working Group Summary Notes

Attachment 1a: Memo from AECOM to the Technical Working Group from Dec. 5, 2019

Attachment 2: Email Memo from Retired Civil Engineer, Joe Teresi

Attachment 2a: Copy of the South Palo Alto Tunnel Fact Sheet

Attachment 2b: Regulatory Status of Local Creeks (from Joe Teresi)

Attachment 3: Email Memo from XCAP Member, Phil Burton

Attachment 3a: Palo Alto Design Criteria Report

Attachment 3b: Phil's Calculations for Vertical Curve

Attachment 3c: Design Standards for Vertical Clearances for Caltrain Electrification Project

If you have any questions, please contact staff at transportation@cityofpaloalto.org.

Attachment 1

To: Expanded Community Advisory Panel (XCAP)
From: Nadia Naik, Chair
Date: December 12, 2019
Subject: Notes and Update from Technical Working Group Regarding Review of New Ideas/Iterations with Volunteer Civil Engineers and AECOM
Agenda Item: This relates to Agenda Item #3 on the December 18 XCAP Agenda

XCAP Summary Meeting Notes

Date: December 5, 2019
Location: City Hall-1st Floor-City Council Conference Room

Attendees:

City Staff: Ed Shikada, Philip Kamhi, Chantal Gaines

AECOM: Ety Mercurio, Millette Litzinger, Peter DeStefano, John Maher

Hexagon (Traffic): Gary Black

Volunteer Civil Engineers: Sreedhar Rao, Joe Teresi, Edgar Ugarte, Ron Owes

XCAP Tech Working Group: Tony Carrasco, Phil Burton, Keith Reckdahl, Larry Klein, Nadia Naik

The XCAP Technical Working Group, the volunteer Civil Engineers and the AECOM team discussed with City Staff the new ideas previously presented at the XCAP meeting. In addition to the information presented in AECOM's memo (see attached), the group had the following observations:

South Tunnel At-Grade Concept (Roland Lebrun)

The idea was ultimately considered an iteration on an existing alternative/idea which has already been studied by AECOM. The group noted that if the XCAP/City Council recommended pursuing the South Palo Alto Tunnel option further, more detailed evaluation of the benefits presented by this iteration could be considered at that time.

Embarcadero / Alma Roundabout and Viaduct (Tony Carrasco)

This proposed idea was considered a new alternative with two options:

Option 1: placing a viaduct above the existing Embarcadero grade separation and using today's existing structure to create a roundabout.

Option 2: removing the existing Embarcadero grade separation, filling in the underpass, creating a new on-grade roundabout and building a viaduct over the roundabout.

Both options require a viaduct and would either a) require rebuilding the existing Embarcadero grade separation (Option 1) or b) demolishing the existing Embarcadero grade separation and filling in the underpass (Option 2).

The on-grade roundabout (Option 2) would require further study (for design, capacity) but could provide significantly more flexibility in mitigating traffic in the area.

It was noted that this concept could be considered for further study, but the cost of either option would likely be higher than the cost of each of the existing Churchill alternatives (viaduct and closure).

Churchill Crossing Concept (Mike Price)

This concept was considered a new alternative that, if technically feasible, could be a cheaper alternative than a viaduct, but more expensive than the closure of Churchill.

There were some technical concerns related to road geometry (can it be engineered to allow enough space for buses to turn; is there enough space on the road; etc.) that need further evaluation. AECOM will try to come back with these quick checks prior to the December 18, 2019 XCAP Meeting.

Charleston/Meadow Underpass Concept (Elizabeth Alexis)

This concept was considered a new iteration on an idea that was previously discarded (underpass). The group recognized that this concept requires further work to flesh out key components, but that it should be studied due to the potential benefits.

Significant cost savings compared to other alternatives are possible given that the train tracks do not move, thereby potentially eliminating the need for shoofly tracks. The AECOM engineers pointed out, however, that in the past, even on projects where only excavation under the tracks was done (such as Jefferson Ave. in Redwood City), there was still a shoofly track needed for safety reasons of excavating beneath an active rail line. Further information regarding the need for shoofly tracks for this concept would be needed to compare the potential cost of this concept relative to the existing alternatives proposed for Meadow and Charleston.

This alternative could potentially have a shorter construction period and have less disruption overall relative to other alternatives being considered.

Additional information relating to traffic patterns in the area of Meadow, Charleston and Alma would be necessary to evaluate whether this concept could work and whether there could be any property impacts.



AECOM
100 West San Fernando
San Jose, CA 95113
aecom.com

Project name:
Palo Alto Rail Program Management

Project ref:
60577356

From:
Milette Litzinger

Date:
December 4, 2019

DRAFT

To:
Ed Shikada, City Manager
City of Palo Alto
250 Hamilton Avenue
Palo Alto, CA 94301

CC:
Etty Mercurio, AECOM
John Maher, AECOM
Peter DeStefano, AECOM
Gary Black (Hexagon)

Memo

Subject: "New Ideas" from XCAP Technical Working Group

The Expanded Community Advisory Panel (XCAP) received and screened new ideas from the community at their November 13, 2019 Special XCAP meeting. In this meeting, they received New Ideas from five (5) community members. The XCAP voted to push forward ideas from four (4) of the presenters to their Technical Working Group for further review. The New Ideas that were pushed forward are listed below. Full descriptions of the New Ideas can be found under the "November 13, 2019 XCAP Special Meeting" at <https://connectingpaloalto.com/presentations-and-reports/>

- South Tunnel At-Grade Concept (Roland Lebrun)
- Embarcadero/Alma Roundabout and Viaduct (Tony Carrasco)
- Churchill Crossing Concept (Michael Price)
- Charleston/Meadow Underpass Concept (Elizabeth Alexis)

Below is a description of the distinguishing characteristics that AECOM used to review each New Idea and notable impacts related to the following categories:

- Geometrics/Structures
- Right of Way Requirements
- Groundwater/Stormwater Impacts
- Traffic/Access Circulation
- Safe Routes for Ped/Bikes
- Cost Effectiveness

South Tunnel At-Grade Freight Concept (Roland Lebrun)

This concept is a variation of the South Palo Alto Tunnel At-Grade Freight alternative already being studied. Variations include:

- Begin tunnel 200 feet north of Matadero Creek.
- Reduce spacing between twin bore tunnel to 30 feet.
- Split the two freight tracks, one to each side of the trench/tunnel section

Geometrics/Structures

- Extensive jet grouting would be required to accommodate the reduced spacing between the twin bore tunnels. impacting underground utilities. A geotechnical investigation is required to define ground improvement measures.
- Construction complications/inefficiencies due to restricted access for portal and boring construction activities.
 - a. The CPUC will not allow private at-grade crossings of the northbound track for construction and maintenance access.
 - b. Caltrain will not allow access across tracks during revenue hours.
- The permanent southbound freight trackway is within 3-feet of the western Caltrain right-of-way line and private properties (homes/backyards). There will be permanent freight train noise and vibration.

Right of Way Requirements

- Similar to the other South Palo Alto Tunnel alternatives, subsurface acquisitions are required for ground anchors for the trench retaining walls and right of way acquisitions will be required to construct pump stations.

Groundwater/Stormwater Impacts

- Adobe Creek will be impacted. Matadero Creek will not be impacted.
- Extensive jet grouting will impact ground water flow and containment of existing contaminated plumes.
- Pump station required to dewater the trench and tunnel.
- Numerous regulatory agency approvals required for creek diversions.

Traffic/Access Circulation

- Alma St. permanently reduced to three lanes at the South Portal.

Safe Routes for Ped/Bikes

- Pedestrian and bicyclists are separated from passenger train traffic only.

Cost Effectiveness

- This alternative will still be in the billions of dollars range (greatest level of local funding) and will not eligible for grade separation funding as the at-grade crossing for freight would remain.

Embarcadero/Alma Roundabout and Viaduct (Tony Carrasco)

This concept includes a roundabout at the Embarcadero/Alma, allowing all turning movements to/from Embarcadero and Alma.

Geometrics/Structures

- The rail has to be raised 20+ feet over its current elevation over Embarcadero, creating a 3-level “interchange”. As a result, the rail impacts extend about 1,000 feet further north than the Churchill viaduct.
- The existing rail and road bridges over Embarcadero would have to be demolished and reconstructed to accommodate a wider structure needed for a roundabout.
- The aforementioned wider structure would likely require lowering of Embarcadero itself (doable, but added cost).

Right of Way Requirements

- Right-of-way impacts on the west side are likely (at Palo Alto High School and the Town and Country shopping center).

Groundwater/Stormwater Impacts

- New pump station required at Embarcadero.

Traffic/Access Circulation

- Queues from the left turns onto Kingsley (from SB Alma) could back up into the circulatory roadway of the roundabout, impacting the roundabout itself, in addition to this being a safety issue too (sudden, unexpected stopping of vehicles).
- A private driveway would have to be accessed from the circulatory roadway of the roundabout (done in some cases, but certainly not desirable).
- Merging from the roundabout onto WB Embarcadero is problematic (sight distance is limited, plus there's not much distance to weave into the adjacent lane to make a left turn into the high school).

Safe Routes for Ped/Bikes

- Big roundabouts are typically difficult for ped/bikes to navigate.

Cost Effectiveness

- We have another alternative (the intersection at Kingsley/High) to address traffic circulation at Embarcadero/Alma that functions better and costs much less.

Churchill Crossing Concept (Michael Price)

This concept partially closes Churchill Avenue, but preserves access to Alma.

Geometrics/Structures

- The “split” of the roadway on NB Alma and EB Churchill introduces a fixed object in the road (end of the retaining wall), but we should be able to design this so that it's not a safety hazard.
- The retaining walls on Alma will be tall (~20 feet Max) and will have a tunnel-effect. Providing left and right shoulders would be ideal, especially 8 to 10-foot right shoulders for disabled vehicles, but we may not have room for that.
- Need to evaluate a profile on Churchill to see if there's an impact to the Churchill/Paly/Castilleja intersection. At first glance, it appears we can avoid lowering this intersection.
- Since there are no ped/bikes on Alma and Churchill (under the tracks), we can be more aggressive with the road profile and use 10-12% Max. This will help reduce the construction limits and cost.
- The bridge geometry and lane configurations need to be hashed out. We'll need two through lanes on NB Alma.

Right of Way Requirements

- Potentially none except for Temporary Construction Easements.

Groundwater/Stormwater Impacts

- Pump Station will be needed to drain the lowered Churchill/Alma intersection.

Traffic/Access Circulation

- This concept will create circuitous routes for some and introduce more traffic on residential streets.
- Several traffic movements are eliminated... likely to cause driver confusion for those not familiar with the configuration:
 - a. Traffic from WB Churchill must turn right onto NB Alma
 - b. No thru-movement allowed on Churchill
 - c. Traffic from SB Alma cannot make a left onto EB Churchill
 - d. Traffic from NB Mariposa cannot access Churchill (vehicles would have to turn around). Residents on Mariposa (south of Churchill and north of Miramonte) would be forced to travel south, generating more traffic on other Southgate neighborhood streets (Castilleja Ave and Miramonte Ave).
 - e. One private driveway on Churchill (between Castilleja and Mariposa) will front a one-way “frontage” road (traveling north), which will force them to travel north and make a right onto Mariposa to exit the Southgate neighborhood.
 - f. Left turns not allowed from WB Churchill onto Mariposa (same condition as today).

Safe Routes for Ped/Bikes

- Grade separation for motor vehicles is not ped/bike friendly, so need a separate undercrossing for ped/bikes (similar to the current Option 1 for the Churchill closure). Need more information on the proposed bike/ped at grade concept in this idea.

Cost Effectiveness

- This idea is more costly than a closure of Churchill, but potentially less costly than the Churchill viaduct.

DRAFT: For Discussion Only

Charleston/Meadow Underpass Concept (Elizabeth Alexis)

This concept provides a grade separation at Charleston and Meadow without raising the tracks.

Geometrics/Structures

- The east/west through movements would pass under two structures (one for the railroad, one for Alma St), similar to Embarcadero today.

Right of Way Requirements

- The presentation infers no property impacts, but the width needed to accommodate the turning movements (the u-turn bay, for example) for truck/buses will likely require sliver takes (at the very least) or complete property acquisitions.
- Slide 8 does not show standard merge distances, so the footprint (along M/C) would likely be much larger than presented on this slide.

Groundwater/Stormwater Impacts

- Same as other underpass options... a pump station will be needed to drain the lowered roads.

Traffic/Access Circulation

- A circuitous route is proposed for EB vehicles on Charleston and Meadow.
- Road geometry would have to be hashed out to ensure queuing of vehicles (for the u-turn movement, for example) does not impact through movements.

Safe Routes for Ped/Bikes

- The "split" of Meadow and Charleston will create a conflict between peds/bikes and motor vehicles, i.e., peds would be on the outside of the road approaching the railroad, but then cross one lane of (moderately high speed) traffic to get to the inside lane (to enter the underpass section of M/C).

Cost Effectiveness

- The property impacts will likely make this concept more costly than the Hybrid alternative, and thus, potentially cost prohibitive.

Attachment 2

Gaines, Chantal

From: jtnia@comcast.net
Sent: Friday, December 6, 2019 5:20 PM
To: 'Nadia Naik'; Gaines, Chantal
Subject: Follow-up comments from yesterday's Technical Working Group meeting
Attachments: Factsheet_PA_South_Tunnel_Opt_1_Nov2019.pdf; Regulatory Status of Local Creeks.docx

Nadia,

It was great to meet you and the other Working Group members at yesterday's meeting. Here are a few follow-up comments based on my work experience and knowledge of the City's creeks and storm drain system:

1. The project alternatives that include the obstruction of one or more of the City's creeks are not necessarily fatally flawed, but they introduce large technical challenges and increased risk of threats to public safety (flooding).
2. Although the City's storm drain system includes eight pump stations (the ninth station that I mentioned yesterday is actually owned and maintained by Santa Clara County [Oregon Expressway Underpass]), these involve flows that are an order of magnitude smaller than either Matadero or Adobe Creeks. The largest storm water pump station pumps a 96-inch diameter storm drain into San Francisquito Creek downstream of Highway 101 at a peak rate of 300 cubic feet per second (cfs). As a comparison, the estimated peak (1% or 100-year) flow on Matadero Creek is 2500 cfs and the peak flow on Adobe Creek is 2000 cfs. Storm water pump stations typically handle flows from a localized low point (e.g. a roadway underpass) or a relatively small storm drain tributary area (i.e. up to around 1,500 acres), whereas a creek drains an entire upstream watershed of multiple square miles.
3. The idea of an inverted siphon to carry either creek under a new railroad tunnel or trench is more practical than a pump station, although there are several downsides/risks inherent in this approach. The enormity of the pump station(s) that would be needed to pump the full flow rate of either creek is overwhelming, particularly due to the constrained site conditions in the narrow railroad corridor. A properly-designed inverted siphon would work hydraulically, but it has many downsides. A small pump station to periodically dewater the siphon would likely still be necessary from a maintenance standpoint. The inverted siphon would likely present a difficult maintenance challenge, as it would tend to fill up with debris and sediment that may not be able to be pumped out, but rather would require periodic removal by maintenance crews. There could also be odor problems and accumulation of stagnant anaerobic water, although that could be controlled by periodically pumping out the contents of the siphon. There is also the increased risk due to the potential blockage or other failure of the siphon, which could result in large-scale flooding of upstream areas. The flood risk is exacerbated by the presence of the railroad embankment which prevents the flow of surface waters towards the Bay and has the potential to impound deep ponded water behind it. Impounded water could also potentially find its way into the railroad tunnel, which could overwhelm the relatively small dewatering pumps likely envisioned in the tunnel design. There is some historical precedent that reinforces the concept of this flooding risk. Namely in 1998, there was significant flooding (including the filling of an underground parking structure) along Park Boulevard just south of Page Mill Road that was caused by the overflow of either the storm drain system or Matadero Creek upstream of the railroad tracks. Some of the impounded flood waters also found their way into the Oregon Expressway underpass, worsening the flooding of that facility.

4. Another large challenge to the creek siphon concept would be the permitting & approval process. Needless to say, placing a regional creek into an inverted siphon although not unprecedented is certainly not standard practice. There will likely be strong resistance from the owner of the two subject creeks – the Santa Clara Valley Water District. As was mentioned by the AECOM reps yesterday, the initial response to the idea of an inverted siphon from District staff was negative, and there was a preliminary suggestion that if such a plan were implemented that the District would defer maintenance (and likely liability) to the City. Besides the District, the rerouting of the creek would also require approvals/permits from the Federal Emergency Management Agency, US Army Corps of Engineers Section 404 permit, State Department of Fish and Wildlife Stream Alteration Agreement, and Regional Water Quality Control Board Section 401 Water Quality Certification. I am not sure how these multiple agencies would respond to such a non-standard design concept. There would likely be water quality, flood risk, as well as fish & wildlife concerns expressed. FEMA is very averse to any flood control mechanism that is subject to failure. At the very least, they would require the submittal of a robust and fully-funded Operations and Maintenance Plan to show how a potential blockage of the siphon would be detected and corrected in such a way as to avoid flooding. Several areas along Adobe and Matadero Creeks upstream of the railroad tracks were removed from the FEMA-designated floodplain in the late 1980's-early 1990's as a result of Santa Clara Valley Water District flood control projects. Any risk of returning these areas to the floodplain (which results in federally-mandated flood insurance and restrictions to building improvements/remodels) would create a huge public outcry. Even though there is not a lot (if any) fish & wildlife habitat in the concrete channels of Matadero and Adobe Creek in the vicinity of the railroad tracks, the resource agencies have published "listings of beneficial uses" for these two creeks that will limit the ability to make any design changes that could threaten fish & wildlife habitat. The attached document includes the "listed beneficial uses" for the two creeks in the Regional Board's San Francisco Bay Basin Plan.
5. I have also included an annotated version of the South Palo Alto Tunnel Fact Sheet showing creek segments that closely parallel the railroad tracks and storm drain pipelines and box culverts that either closely parallel the tracks or cross beneath them. I highlight these in order to make AECOM aware of them as potential design challenges (e.g. could these create the need for additional protective shoring during construction and/or additional siphons to accommodate existing flow patterns?). These are in addition to all the other challenges that will be encountered in addressing other utility conflicts with the myriad existing water, gas, sanitary sewer, electric, telephone/cable/communications, fiber optic facilities in the project vicinity.

I hope that this information is helpful to the group. If anyone has questions regarding the City's storm drain system or the local creeks, I would be happy to attempt to answer them as best as I can. Thanks for the opportunity to contribute to the review of this monumental challenge/opportunity facing the City and its residents.

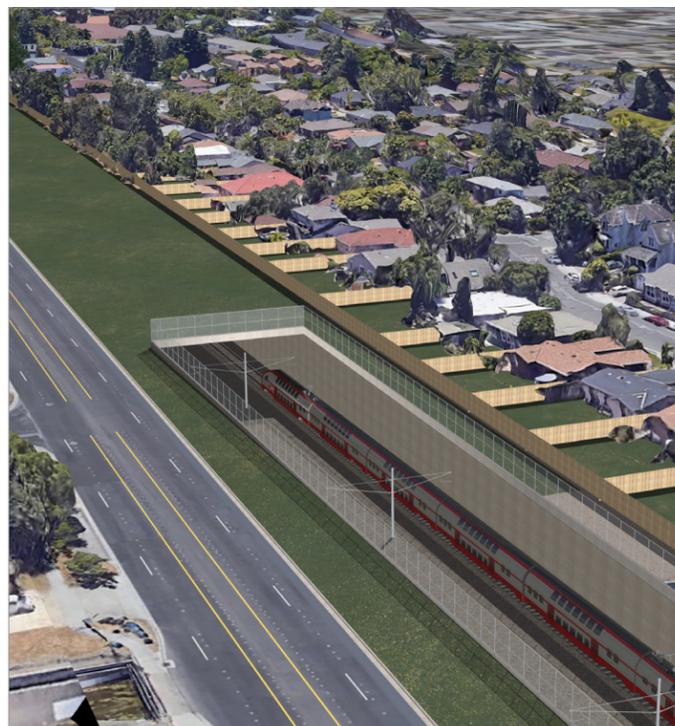
Cheers,
Joe Teresi
Retired Civil Engineer
Retired City of Palo Alto employee

RAIL FACT SHEETS

South Palo Alto Tunnel – Passenger & Freight



Proposed Ground Level View - Looking Southwest Charleston Road Intersection



Proposed Tunnel Aerial View - Looking South



Proposed Backyard View - Looking East Typical Property West of Tracks

What is a tunnel with passenger and freight?

For the tunnel alternative, the railroad tracks will be lowered in a trench south of Oregon Expressway to approximately Loma Verde Avenue. The twin bore tunnel will begin near Loma Verde Avenue and extend to just south of Charleston Road. The railroad tracks will then be raised in trench to approximately Ferne Avenue. The new electrified southbound railroad tracks will be built at the same horizontal location as the existing railroad track, however, the northbound track will be moved to the east within the limits of the tunnel to accommodate the spacing required between the twin bores. The railroad tracks will carry both passenger and freight trains as it does today.

The roadways at Meadow Drive and Charleston Road remain at their existing grade and will have a similar configuration that exists today with the addition of Class II buffered bike lanes on Charleston Road. This will require expanding the width of the road to maintain bike lanes through the overpass of the railroad.

By the numbers

- Diameter of twin bores is 34 feet.
- Railroad track is designed for 110 mph.
- Meadow Drive and Charleston Road are designed for 25 mph.
- Maximum grade on railroad is 2%.
- Travel lane widths are 10-12 feet.
- Bike lane widths are 5-6 feet.
- Construction period is approximately 6 years.

Engineering Challenges

- A non-standard grade of 2% will be required on tracks. Caltrain's preferred maximum grade is 1%.
- Lowering of the tracks will require diversion of Adobe and Matadero creeks, resulting in the need for lift stations/siphons and numerous regulatory agency permits/approvals. Negotiations with the regulatory agencies will be lengthy and difficult since there are other "least impacting" alternatives that could be considered.
- Pump stations will also be needed for dewatering since the tunnel will be below the ground water level.
- Increased long term maintenance costs and risk of flooding due to pump stations.
- Major utility relocations are required for the lowered railroad.

Neighborhood Considerations

- During construction, Alma Street will be reduced to one lane in each direction from south of Oregon Expressway to Ventura Avenue. From Charleston Road to Ferne Avenue, there will only be one southbound lane.
- The train tracks will be approximately 60 feet below the existing grade in the tunnel section. A high fence will be required along trench walls.
- With grade separations at Meadow Drive and Charleston Road the traffic at nearby intersections is expected to improve.

Cost Breakdown

Roadway & Railroad Items	\$764M to \$1,146M
Right-of-way & Utilities	\$6M to \$10M
Support Costs	\$236M to \$353M
Escalation from 2018 to 2025 dollars	\$212M to \$318M
TOTAL PROJECT COSTS	\$1,218M to \$1,827M

Preliminary and subject to change. Maintenance costs and relocation of fiber optic lines not included.



Milan Metro Line, Italy

For more Rail Fact Sheets visit:
<https://connectingpaloalto.com/fact-sheets/>

Evaluation with City Council-Adopted Criteria

Facilitate movement across the corridor for all modes of transportation

Meadow Drive and Charleston Road will be grade separated from the railroad for all modes and will remain open.

Reduce delay and congestion for vehicular traffic at rail crossings

With construction of the grade separation, the railroad crossing gates and warning lights at Meadow Drive and Charleston Road will be removed. Thus, the traffic will not be interrupted by railroad crossing gates.

Provide clear, safe routes for pedestrians and cyclists crossing the rail corridor, separate from vehicles

Pedestrians/cyclists will be separated from train traffic.

Support continued rail operation and Caltrain service improvements

A temporary railroad track will be required at the boring pit areas to the north and south. A siding track will be relocated north of the California Avenue Caltrain Station. Due to the pump stations, there will be potential risks to train operations due to flooding.

Finance with feasible funding sources

The tunnel will require the greatest levels of local funding in the form of fees, taxes or special assessments, the feasibility of which are still being studied in the context of overall citywide infrastructure funding needs.

Reduce rail noise and vibration

Train horn noise and warning bells will be eliminated with the replacement of the at-grade crossings with grade separations. Utilizing electric engines instead of diesel engines will also reduce noise. In the trench section, train noise could reflect off walls and impact properties farther away, which can be mitigated. In the tunnel section, train wheel noise will be contained.

Minimize visual changes along the corridor

Railroad tracks will be below grade with high fencing at-grade in the trench section. Landscaping options will be limited to plants with shallow roots in areas where ground anchors are required for the trench section.

Maintain access to neighborhoods, parks, and schools along the corridor while reducing regional traffic on neighborhood streets

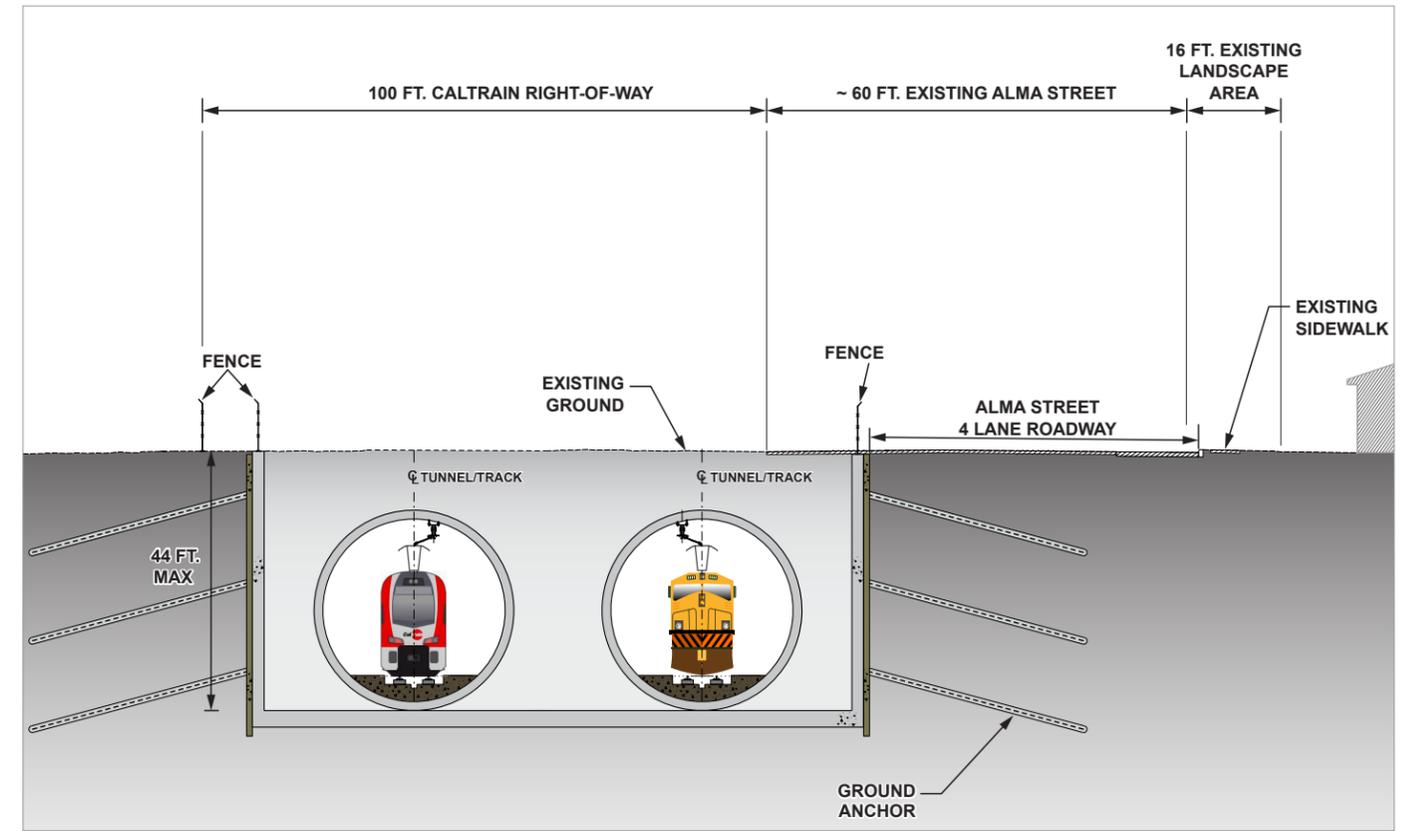
No diversion of regional traffic with construction of a grade separations.

Minimize right-of-way acquisition

Subsurface acquisitions will be required for the ground anchors for the trench retaining walls and right of way acquisitions will be required to construct pump stations.

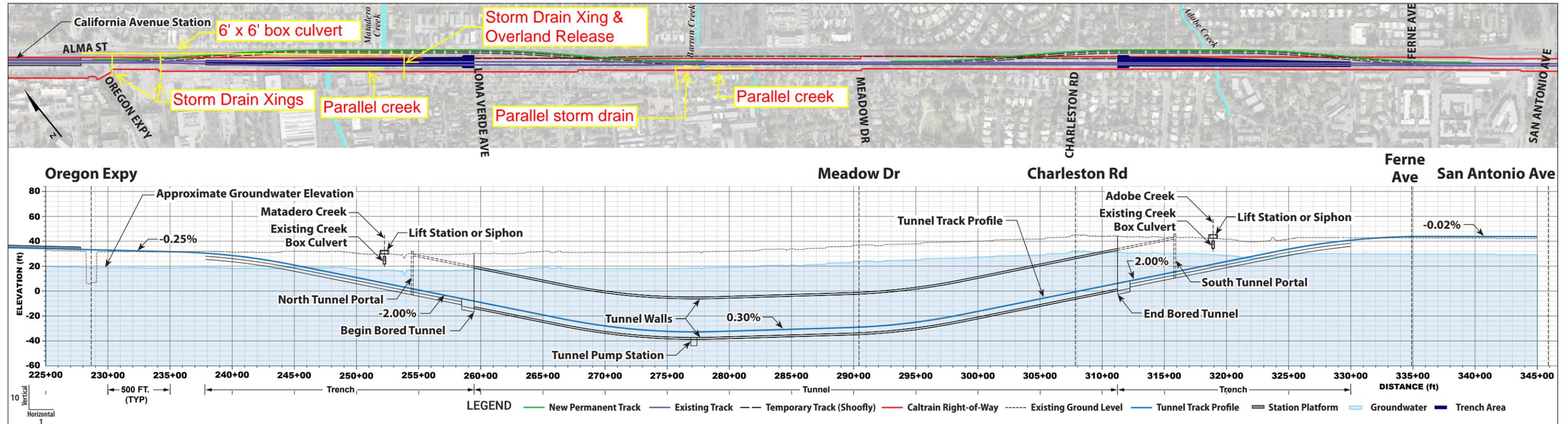
Minimize disruption and duration of construction

Extended lane reductions on Alma Street are required. Construction would last for approximately 6 years.



Example Section - South Portal Tunnel - Looking North

Concept Plan and Profile



Regulatory Status of Local Creeks

Document provided by Joe Teresi, December 2019

Matadero Creek – Existing Beneficial Uses

- Cold Freshwater Habitat (COLD)
- Warm Freshwater Habitat (WARM)
- Fish Migration (MIGR)
- Fish Spawning (SPWN)
- Preservation of Rare and Endangered Species (RARE)
- Wildlife Habitat (WILD)
- Water Contact Recreation (REC-1)
- Noncontact Water Recreation (REC-2)

Adobe Creek – Existing Beneficial Uses

- Cold Freshwater Habitat (COLD)
- Warm Freshwater Habitat (WARM)
- Wildlife Habitat (WILD)
- Water Contact Recreation (REC-1)
- Noncontact Water Recreation (REC-2)

Permitting Agencies for Channel Modifications

- Federal Emergency Management Agency
- Santa Clara Valley Water District
- State Department of Fish & Wildlife Stream Alteration Agreement
- Regional Water Quality Control Board Section 401 Water Quality Cert
- US Army Corps of Engineers Section 404 Permit

Attachment 3

Gaines, Chantal

From: Phil Burton <philip-b@comcast.net>
Sent: Thursday, December 12, 2019 12:32 PM
To: 'Nadia Naik'; Gaines, Chantal
Subject: for agenda item #3 - vertical curve and vertical clearance issues
Attachments: Palo Alto Design Criteria 20190807_FINAL.PDF; Vertical Curve calculations.xlsx; Design Standards for Vertical Clearances for Caltrain Electrification Pr....docx

Chantal,

This email and the attachments should be part of item 3 of the agenda for the next meeting.

The vertical curve issue is the length of the transition between a level grade and a grade of 1% or 2%, as examples. According to the attached document, Palo Alto Design Criteria, Caltrain uses different formulas to calculate the vertical curve transition for passenger and freight trains. The attached spreadsheet, Vertical Curve calculations.xlsx, shows the required transition lengths for passenger trains at 110 mph and freight trains at 50 mph. Note that for a 2% grade, the required transition length is 578' for passenger trains and 1075' for freight trains, almost twice the length required for passenger trains.

At a freight train design speed between 35 and 40 mph, the required freight train transition length would be the same as for passenger trains at 110 mph. While 50 mph may be a reasonable design speed for fast, high-value freight trains operating for long distances, the freight service on the Peninsula is "local" traffic of mostly low-value bulk commodities with some container traffic, and a reasonable lower speed through Palo Alto would not create a big impact on overall running times. It is not even clear that current Union Pacific freight trains even operate over 35 or 40 mph on Caltrain tracks. Temporary or permanent speed restrictions due to local conditions are common on the US rail network.

The issue here is that all the alternatives under consideration, for all three grade crossings, require vertical curve transitions. If the transitions can be shortened to the passenger train length, there could be considerable construction savings. In addition, shoofly track lengths could be shortened. For the South Palo Alto tunnel, it is possible (but I have not verified) that a revised design might avoid the creeks, especially in combination with a smaller tunnel inner diameter

The vertical clearance issue is much harder to pin down because I have not been able to find a single source for this design standard for the spacing between top of rail and the overhead contact wire for power distribution.

I have created a document, Design Standards for Vertical Clearances for Caltrain Electrification, to summarize what I have been able to learn about vertical clearance standards. Clearly the CPUC standard of 34' is not controlling.

Caltrain standard is to design for AAR Plate H, for a max car height of 20' 3".(Association of American Railroads.) A "plate" is a cross-section of a freight car, for various kinds of cars, to ensure that certain kinds of

cars, e.g. normal boxcars or “double stack” shipping container cars, can operate over all most of the mainline freight lines in the US.

In the absence of a Plate H requirement, Caltrain would effectively be operating according to Plate B, a maximum of 15’ 1”. 15’ is also the approximate height of the EMUs that Caltrain is planning to order for electrified service. (need verification of this point). Plate B is sufficient for the hopper and container cars that constitute freight service on Caltrain tracks. Even Plate F may be overdesign for freight train operation on Caltrain tracks.

However, due to existing clearance restrictions and the nature of current rail traffic, it isn’t clear that current freight traffic can even allow double-stack container cars, only normal container cars. Even if clearances were not an issue, there would still be considerable investment at container car loading/unloading locations to support double-stack container shipments. Shipment volumes would probably not justify such investments.

A 5’ reduction in vertical clearance would result in construction cost savings for the Meadow/Charleston trench alternative, and for the South Palo Alto tunnel alternatives due to a potentially smaller tunnel diameter. Further, for all alternatives, the poles needed to support the catenary structure that holds the overhead power contact wire could be lower, with cost and visual impacts.

see p. 5 for vertical curves - differences
between pax and frt.

FINAL

Preliminary Engineering

Grade Separations

Design Criteria

Palo Alto Rail Program
Management Services

AECOM Project Reference: 60577356
City of Palo Alto Contract Number: C18171057

August 7, 2019

Revision History

Revision	Revision date	Details	Authorized	Name	Position
0	10/8/2018	Draft	10/8/2018	Millette Litzinger	Deputy Project Manager
1	8/7/2019	Final	8/7/2019	Ety Mercurio	Project Manager

Distribution List

# Hard Copies	PDF Required	Company Name / Contact
	X	City of Palo Alto/Ed Shikida, Chantal Gaines
	X	Caltrain/Melissa Reggiardo, Jim Lightbody
	X	AECOM/Ety Mercurio, John Maher, Elliot Wong
	X	AECOM/Millette Litzinger, Peter DeStefano

Prepared for:

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Ed Shikida, City Manager
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1. Introduction

The City of Palo Alto is conducting technical analysis of alternatives coupled with a comprehensive community and stakeholder engagement process aimed at identifying and implementing locally-preferred alternatives for modification to the four existing at-grade crossings in Palo Alto. The four existing at-grade crossings are located at Palo Alto Avenue, Churchill Avenue, Meadow Drive and Charleston Road in Palo Alto.

2. Terms and Definitions

This section provides standardized definitions for the terms used in this Design Criteria document. It also identifies frequently used abbreviations and acronyms.

2.1 Acronyms

AASHTO	American Association of State Highway and Transportation Officials
APN	Assessor's Parcel Number
AREMA	American Railway Engineering and Maintenance-of-Way Association
CAD	Computer Aided Design
CBC	California Building Code
CBDA	Caltrans Bridge Design Aids Manual
CBDD	Caltrans Bridge Design Details Manual
CGP	Construction General Permit
CHSTP	California High-Speed Train Project
CL	Center line
CPUC	California Public Utilities Commission
CS/SC	Curve-Spiral/Spiral-Curve
CSDC	Caltrans Seismic Design Criteria
DOC	Degree of Curve
EIR/EIS	Environmental Impact Report/Environmental Impact Statement
EP	Edge of Pavement
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration

GAD	Geometric Approval Drawings
GO	General Order
HST	High-Speed Train
PCJPB /JPB	Peninsula Corridor Joint Powers Board
ML	Main Line
MP	Milepost
MSE	Mechanically Stabilized Earth
PC	Point of Curvature
PS	Point of Switch
PT	Point of Tangency
ROW	Right-of-Way
RWQCB	Regional Water Quality Control Board
STA	Station/Stationing
TBD	To be Determined
TCE	Temporary Construction Easement
TOR	Top of Rail
TS/ST	Tangent-Spiral/Spiral-Tangent
UPRR	Union Pacific Railroad

3. Design Criteria

3.1 Railroad Design Standards

Caltrain has jurisdiction over the railroad right-of-way through the project corridor. UPRR has freight operating rights on the tracks through an agreement with the JPB. The design will comply with the following standards, including all addenda, specifications and recommended practices:

- **Caltrain Design Criteria Manual**
- Caltrain Standard Drawings
- Caltrain Standard Specification
- **Caltrain CADD Manual**
- California Public Utilities Commission General Orders
- American Railway Engineering and Maintenance-of-Way Association Manual for Railway Engineering

- **Federal Railroad Administration Track Safety Standards, Part 213**
- Federal Highway Administration Railroad-Highway Grade Crossing Handbook – for all At-Grade Crossings
- **Union Pacific Railroad Engineering Track Standards – for all Main Line Track Improvements**
- **Union Pacific Railroad Technical Specifications for Construction of Industrial Tracks – for all Industry Track Improvements**

3.2 Railroad Design Criteria

The preliminary track design and any temporary track work will be in conformance with **Caltrain Design Criteria Chapter 1 – Design Guidelines, Chapter 2 – Track, Chapter 3 – Station and Facilities**, and not to preclude the California High-Speed Train Project technical memoranda **TM 1.1.21 – Typical Cross Sections for 15% Design, TM 2.1.2 – Alignment Design Standards for High-Speed Train Operation, and TM 2.1.3 Turnouts and Station Tracks** when feasible.

Track alignment, at a minimum, shall be designed for **110 mph for Caltrain EMU**, which corresponds to FRA Class 6 track standards. Upon completion of the track construction, Caltrain will determine the appropriate operating speed. Various railroad design elements will be based on the following design speeds, whichever governs:

- a. **50 mph for freight operations**
- b. 79 mph for passenger operations with existing Caltrain fleet.¹
- c. 110 mph for High Speed Rail passenger operations when feasible.
- d. 110 mph for passenger operations with future Caltrain EMU fleet.

No curves with a degree of curvature less than 30 minutes shall be used unless the curve length is greater than 500’.¹ Overbalance shall be avoided as much as possible considering the four operating scenarios above.

Where physical restrictions prevent the use of the above preferred standards, the design speed will be determined on a case-by-case basis by considering primarily rail car design and safety of operations **with passenger comfort as the secondary consideration**. The design shall meet Federal and State minimum requirements and with approval from the Caltrain Deputy Director of Engineering.

3.2.1 Horizontal Track Geometry

3.2.1.1 Track Spacing

The horizontal alignments for main line tracks are stationed along the centerline of track MT1 from San Francisco to San Jose/Lick. Main tracks are spaced a minimum of **15 feet** from track centerline to track centerline.^{2 3}

Temporary (shoofly) tracks are spaced a minimum of 14 feet from track centerline to track centerline plus an additional 2 inches per degree of curvature on curves with the same superelevation. Shoofly track spacing from the existing mainline tracks will vary along the shoofly alignment.

3.2.1.2 Horizontal Tangents

Minimum horizontal tangent lengths between reverse curves are based on the formula, $L = 3V$, as prescribed by Caltrain’s design criteria in Chapter 2, Table 2-2, where L is the tangent length and V is the design speed in miles per hour (mph). For V = 90 mph, $L_{min} = 270$ feet. For V = 110 mph, $L_{min} = 330$ feet.

3.2.1.3 Curve Length

Horizontal Curves shall be designed for 110 mph for Caltrain EMU, which corresponds to FRA Class 6 track standards⁴. A higher future design speed of 110 mph shall be considered wherever practicable without being cost

¹ [Caltrain Design Criteria](#) page 2-9.

² [Caltrain Design Criteria](#) page 2-11.

³ California High-Speed Rail Authority [Technical Memorandum 1.1.21](#) (August 20, 2013) page 11

⁴ [Caltrain Design Criteria](#) page 2-9

prohibitive, that is, requires additional right-of-way or impacting existing improvements. **The absolute minimum length of circular curve allowed on the main line tracks is 100 feet.**⁵

3.2.1.4 Superelevation

The equilibrium superelevation shall be determined by the following equation:

$$E_e = 0.0007 D_c V^2$$

where: E_e = total superelevation required for equilibrium, in inches.

V = maximum design speed through the curve, in miles per hour (mph)

D_c = degree of curvature, in degree

The total superelevation is expressed as follows:

$$E_e = E_a + E_u$$

where: E_a = actual superelevation that is applied to the curve

E_u = unbalanced superelevation (amount of superelevation not applied to the curve)

The actual superelevation shall be rounded to the nearest 1/4 inch by the formulas above. For any curve, a 1/2-inch (minimum) superelevation shall be specified. **Super elevation above 5 inches** should be avoided when possible.

Slower speed tracks, such as yard and non-revenue tracks, and curves within special trackwork shall not be superelevated.

Curves within station and grade crossings shall be avoided. They may be superelevated only with the approval from the Caltrain Deputy Director of Engineering.

3.2.1.5 Spirals

The standard type of spiral used for all horizontal curves is the **clothoid** type spiral. **Spirals are required for all curves.** Spiral lengths are determined by the maximum of the following formulas and rounded to the nearest 5-feet⁶:

$$L_s = 62 * E_a$$

$$L_s = 1.63 * E_u * V$$

Where:

L_s = Length of spiral

E_a = Actual superelevation ($E_a \leq 5.0$ inches)

E_u = Unbalanced superelevation

E_u , Freight = 2.0 inches

E_u , Passenger = 3.0 inches

For Caltrain design speeds > 79 mph,

$E_u \leq 4.5$ inches is acceptable

$E_u \leq 6$ inches may be used with Caltrain approval

V = Design Speed in mph

⁵ Caltrain Design Criteria page 2-12 to 2-14.

⁶ Caltrain Design Criteria page 2-18.

Note: For the design of $V > 79$ mph, if the above formula creates excessively long spiral that pose challenges due to available ROW, existing infrastructure, etc.; then the following criteria may be considered:

$$L_s > 82.7 * E_a$$

$$L_s > 0.41 * (E_u + 1.5) * V$$

3.2.1.6 Shoofly

For the temporary shoofly, the horizontal track geometry will be designed for a maximum operating speed in accordance with Table 2-4, as prescribed in the Caltrain Design Criteria⁷ and the current JPB timetable.

3.2.2 Vertical Track Geometry

The vertical alignment is defined by the top of rail profile. The profile represents the top of rail (TOR) elevation of the grade rail of track MT1. The TOR elevation of track MT2 is equal to the TOR elevation of track MT1 at points extended from MT1 radially and/or perpendicularly. Grades and lengths of vertical curves vary slightly in order to accommodate the differences in curve lengths of horizontal curves.⁸

3.2.2.1 Maximum Profile Grade

The preferred maximum continuous grade along the main line track is 1%. The maximum design gradient, with curve compensation at 0.04% per degree of curve if applicable, for grades up to 2% may be implemented with the approval of the Caltrain Deputy Director of Engineering.

At station platforms, a level gradient is preferred with a maximum grade of up to 1% permitted.

3.2.2.2 Vertical Tangents

Mix of pax and firt trains

The minimum length of vertical tangent between vertical curves shall be 330 feet as defined by the following formula⁹:

$$L = 3V$$

Where:

$$V = 110 = \text{Design speed in mph}$$

3.2.2.3 Vertical Curve Lengths

Minimum vertical curve lengths shall be determined per the 2014 AREMA Manual for Railway Engineering, Chapter 5, Section 3.6 – Vertical Curves (2002), based on the equation below:

$$L = (D * V^2 * K) / A$$

Additionally, the following equations from CAHSRA Technical Memoranda 2.1.2 shall be considered when determining minimum vertical curve lengths:

$$L = 200 * D$$

$$L = 4.55 * V \text{ (See Note)}$$

Note: $3.52 * V$ is minimum and $2.64 * V$ is exceptional and requires Caltrain approval.

Where

$$A = \text{Vertical acceleration, in ft/s}^2$$

⁷ Caltrain Design Criteria page 2-13 Table 2-4

⁸ Caltrain Design Criteria page 2-19

⁹ Caltrain Design Criteria page 2-19.

= 0.10 for Freight Train and

= 0.60 for Passenger Train

= 0.90 for High Speed Rail

D = Absolute value of the difference in grades expressed in decimal.

K = 2.15 conversion factor to convert units of L into feet

L = Length of vertical curve in feet

V = Speed of train in mph:

= 50 mph for Freight

= 79 mph for Caltrain with existing fleet

= 110 mph for High Speed Rail

= 110 mph for Caltrain with future EMU fleet

Example:

For an incoming grade of +0.6% and an outgoing grade of -0.7%,

$D = |+0.006 - (-0.007)| = 0.013$, the minimum length of vertical curve (L) shall be the greater of:

$$L_{\min} \text{ for Freight} = 0.013 * (50)^2 * 2.15 / 0.10 = 699 \text{ feet} \leftarrow \text{Governs}$$

$$L_{\min} \text{ for Caltrain} = 0.013 * (90)^2 * 2.15 / 0.60 = 377 \text{ feet}$$

$$L_{\min} \text{ for High Speed Rail} = 0.013 * (110)^2 * 2.15 / 0.90 = 376 \text{ feet}$$

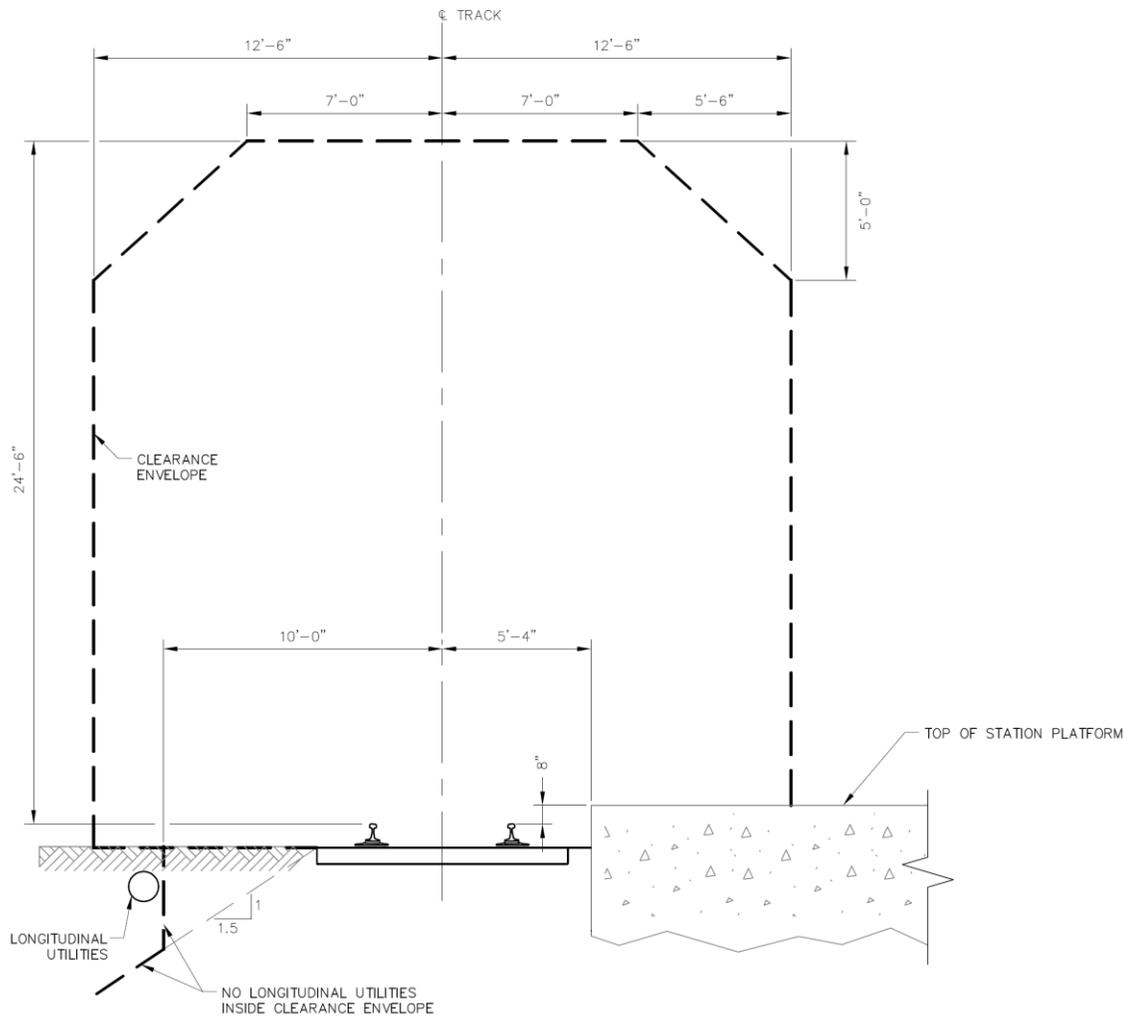
The absolute minimum length of vertical curve shall be 100 feet. And no vertical curves shall be placed within the limits of special track work, such as turnouts and crossovers.

3.2.3 Horizontal and Vertical Railroad Clearance

Horizontal clearances shall meet the requirements of California Public Utilities Commission (CPUC) General Order 26-D. Caltrain has additional clearance requirements beyond that of the CPUC, but some allowances will be considered for temporary track conditions (shoofly track) as described in the following sections.

3.2.3.1 Horizontal Clearances

The Caltrain standard horizontal track clearance requirements **for structures** shall be 12'-6" from track center line to the face of a temporary or permanent structure as shown in the figure below.



CLEARANCE REQUIREMENTS FOR STRUCTURES

1. ALL SIDE CLEARANCE DIMENSIONS ARE FOR TANGENT TRACKS. SIDE CLEARANCE FOR CURVE TRACK 2 DEGREE OR SHARPER SHALL BE 1'-0" GREATER.

Figure 1 – Clearance Requirements for Structures

3.2.3.2 Temporary Horizontal Clearance

Temporary track alignments (Shoofly track) on a tangent may use 10'-0" as the minimum clearance from track centerline to the face of any temporary or permanent structures. Temporary curved track alignments may use 11'-0" as the minimum clearance from track centerline to the face of any temporary or permanent structures.

3.2.3.3 Vertical Clearance (Underpass)

The minimum vertical clearance required from the surface of the roadway pavement to the soffit (bottom) of the grade separation structure shall be a minimum of 15'-6"¹⁰.

3.2.3.4 Vertical Clearance (Overhead)

The vertical clearance required from the top of rail to the bottom of the grade separation structure is dictated to be 24'-6" per the Caltrain Design Criteria¹¹. The figure below from the California High-Speed Train project technical memorandum TM 1.1.21 demonstrates the required vertical clearance needed above top-of-rail (TOR).

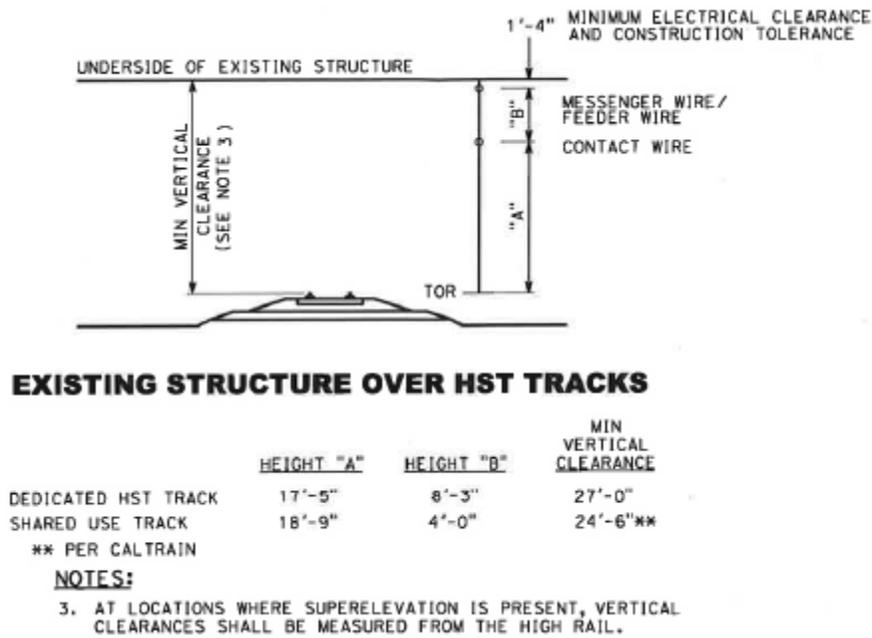


Figure 2 - Required Vertical Clearance over Railroad

¹⁰ PCJPB Standards for Design and Maintenance of Structures, Section 2.4.2, Issue Date: 2003.

¹¹ Caltrain Design Criteria page 3-9

3.2.4 Track Roadbed

The required track roadbed to support the train loads is summarized in Table 1 below

Table 1. Track Roadbed Criteria

Criteria	Requirement	Caltrain Reference
Ballast Depth	9" Min.	Std. Dwg SD-2151
Subballast Depth	6" Min.	Std. Dwg SD-2151
Ballast Shoulder	12" Tangent 18" Superelevation	Std. Dwg SD-2151
Subballast Shoulder	2' Min.	Std. Dwg SD-2151
Subgrade Cross Slope	2%	Std. Dwg SD-2151
Embankment Slopes	2:1 Max.	Std. Dwg SD-2151
Cut Slopes	2:1 Max.	Std. Dwg SD-2151
Track Ditch Bottom Width	12" Min.	Std. Dwg SD-2151
Track Ditch Depth	2' Below Subgrade	Std. Dwg SD-2151

3.2.5 Caltrain Stations

There are three existing stations within the City of Palo Alto city limits:

- Palo Alto Caltrain Station at University Avenue
- California Avenue Station
- Stanford Home Games Train Station

The alignment of the track geometry may impact these stations and could require these stations to be adjusted and/or re-built with the track work. The design requirements with regards to the track and roadway design are located herein.

3.2.5.1 Horizontal & Vertical Clearances

The California Public Utilities Commission (CPUC) General Order #26-D mandates the minimum clearances required. **Caltrain has additional clearance requirements which are more stringent than those mandated by the CPUC.** The more stringent clearance criteria for Caltrain stations are as follows as detailed in the Caltrain Design Criteria.¹²

¹² Caltrain Design Criteria page 3-5 to 3-10

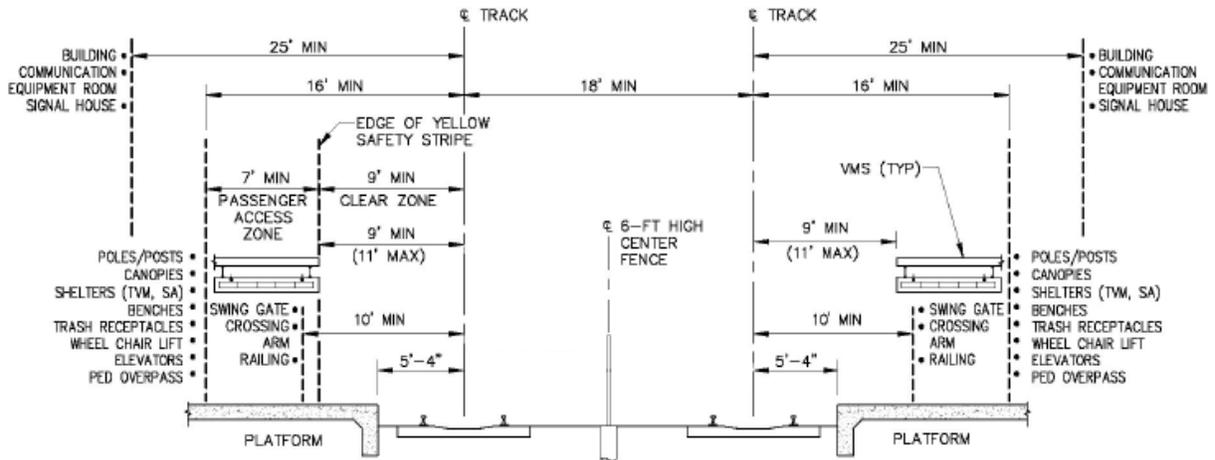


Figure 3 - Caltrain Minimum Clearances at Station Platforms – Outboard Platforms

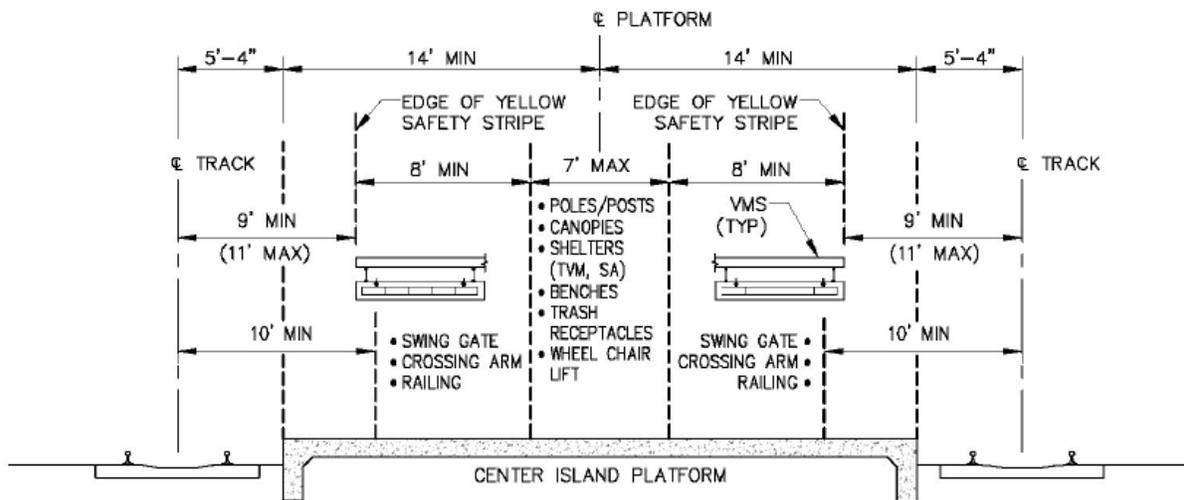


Figure 4 - Caltrain Minimum Clearances at Station Platforms – Center Island Platforms

The Caltrain minimum horizontal clearances listed below are measured from the **centerline** of the closest track:

- a. Permanent Structures: 25 feet
- b. Minor and Auxiliary Structures at Stations: 16 feet
- c. At-grade Pedestrian Crossings: 10 feet
- d. Signal Houses: 16 feet minimum, 25 feet preferred
- e. Variable message signs: 9 feet
- f. Return fence at the ends of a station platform: 9 feet
- g. Right-of-way fence: 12 feet.
- h. Center Fence: 9 feet.

Caltrain minimum vertical clearance (to a structure or obstruction over tracks):¹³

- a. 24 feet – 6 inches from the top of rail

3.2.5.2 Station Configuration

There are two preferred layout alternatives for Caltrain station platforms as seen in **Figure 3** and **Figure 4** above. Center island platforms and outboard platforms are defined as:

- a. Center island platforms: Single platforms which service tracks that are located on either side of the platform.
- b. Outboard platforms: Outboard platforms are located on the outside of tracks MT1 and MT2. The two platforms which are located on opposite sides of the main line track from each other service one track each.

3.2.5.3 Platform Dimensions

The platforms are set at 8 inches above top of rail. The edges of the platforms are located 5 feet 4 inches from the centerline of the nearest track. The criteria for platform dimension are as follows:

- a. **Platform length:** Caltrain train consists are composed of different cars and locomotives, necessitating additional platform lengths. The standard platform length shall be **875 feet** to accommodate a **10-car Electrical Multiple Units (EMU)** consist. See **Figure 3-5** for station "footprint" requirements and platform configurations. Platform design shall consider or not preclude a possible expansion of platform length to **1,000 feet** to accommodate future longer car train consists. At the San Francisco and San Jose Diridon terminal stations, the station platforms shall be designed to accommodate **two 10-car EMU consists**.
- b. **Platform width:** The platform shall be a minimum of 18 feet (20 feet preferred) wide for an outboard platform and a minimum of 28 feet (32 feet preferred) wide for a center island platform. The wider center platform is needed to accommodate stairway, ramps, and/or elevator, shelters, and passenger access and circulation safety. A minimum clear walkway width of 7 feet from the edge of the yellow safety stripe shall be maintained for the entire length of the platform for **outboard** platforms.

However, for center island platform, the clear walkway width shall be increased to a minimum 8 feet from the edge of the yellow safety stripe to the platform structures (stairways, elevators).

- c. **Platform longitudinal slope:** The station platforms shall be on a track segment that is tangent and have the same grades as the tracks served. Track grades through station of more than 1 percent shall not be considered.
- d. **Platform cross slope:** This slope is required for **drainage** purposes. The slope shall generally be 1 percent (2 percent maximum, in accordance with ADA Standards) and shall be **sloped away from** the tracks, to minimize the risk for persons in wheelchairs of natural rolling effects toward the tracks. This will also aid in track drainage, by directing the surface water away from the track

¹³ Caltrain Design Criteria page 3-10.

structure. At center island platforms, an underdrain shall be provided at the center of the platform width.

- e. Platform curve: **Curved track** through the station, either horizontally or vertically curved, shall be **avoided**. If unavoidable, the curve shall be as shallow a curve as possible, to no more than 1 degree and 30 minutes, and at either end of the platforms. Platforms on curves shall require prior approval from the Caltrain Deputy Director of Engineering.
- f. Track centers: Track centers at station platforms shall be expanded to a minimum of 18 feet to accommodate **center** fencing, so that the fence is at least 8 feet 6 inches clear from the track center. The center fence shall extend a minimum of 100 feet beyond the ends of the platforms. If there are at-grade pedestrian crossings at the stations, then the fence shall continue to the edge of the crossings, and extend a minimum of 100 feet beyond the at-grade pedestrian crossings.

3.2.5.4 Temporary Station

A temporary station is required to be constructed in order to maintain Caltrain service during the construction of the grade separation as part of the construction staging. The temporary platform and final platform minimum design requirements are similar except for two exceptions:¹⁴

- a. The minimum platform length is 500 feet, with a minimum platform width of 12 feet. This platform length allows for the functional operation of a five-train consist. Additional platform length will be required to accommodate longer train sets when service level is increased in the future.
- b. The platform may be constructed of asphalt concrete to expedite construction. ADA-compliant warning tactile is required at the boarding edge of a platform, except at a holdout rule station. The selected warning tactile material shall be compatible with the material used for platform construction.

3.3 Roadway Design Criteria

3.3.1 Design Speed

Roadway geometric features of Palo Alto Avenue, Churchill Avenue, Meadow Drive and Charleston Road will be designed for a speed (V) of **25 mph**.

For V = 25 mph, the minimum **Stopping Sight Distance is 150 feet**.

3.3.2 Cross Sectional Elements

Design criteria for cross sectional elements (lane widths, shoulder widths, sidewalk widths, etc.) will be based on the **City of Palo Alto Standard Drawings 201, 201A and 201B (last updated in 2018)**.

This project shall use the following for collector or local streets:

Lane Width = **10 feet** (Minimum) +1 **foot shy distance adjacent to curb or wall**, 12 feet (Preferred)

Right Shoulder/Parking Width (with no bike lane) = 8 feet (measured from Edge of Traveled Way (ETW) to flow line of gutter or face of barrier)

Sidewalk Width = **5.5 feet** (Minimum, includes curb width) adjacent to road, 5 feet (Minimum) with landscape buffer from road

Bicycle Lane Width= 5 feet (Minimum), 6 feet (Preferred)

Crosswalk Width = 10 feet

¹⁴ Caltrain Design Criteria page 3-15

The minimum roadway cross slope will be based on the City of Palo Alto Standard Drawings 201, 201A and 201B.

3.3.3 Vertical Clearance of Underpasses

Minimum Vertical Clearance of Railroad Structure over Local Roads = 15'-6"

Minimum Vertical Clearance of Railroad Structure over Pedestrian/Bicycle Path = 10'-0"

3.3.4 Profile Grade

The maximum profile grade of the roadway shall be 8%. The minimum profile grade of the roadway shall be 0.2%. The maximum profile grade of a separate bicycle/pedestrian path, where the path does not follow the profile of the roadway, shall be 5%.

3.3.5 Crest Vertical Curves

Crest vertical curves will be designed based on the design speed and sight distance described in Section 3.3.1. A driver's eye height of 3.5 feet and an object height of 6 inches will be used.

3.3.6 Sag Vertical Curves

Sag vertical curves will be designed for driver comfort in lieu of headlight sight distance. Lighting on all sag vertical curves is expected and assumed. AASHTO's formula for passenger comfort on sag vertical curves is:

$$L = A \cdot V^2 / 46.5$$

Where

L = Length of Vertical Curve

V = Design Speed in mph

A = Absolute Value of Algebraic Grade Difference of the incoming/outgoing grades (in percent)

$$k = L/A = V^2/46.5 = 25^2/46.5 = 13.44$$

Example:

For an incoming grade of -8% and an outgoing grade of +8%, $A = |-8 - 8| = 16\%$, the minimum length of vertical curve (L) shall be:

$$L_{\min} = k \cdot A = 13.44 \cdot 16 = 215 \text{ feet}$$

3.3.7 Minimum Vertical Curve Length

No vertical curves shall be less than 50 feet.

3.3.8 Permanent and Temporary Signing & Pavement Delineation

Signing, pavement delineation and temporary traffic control devices will be designed in accordance to the November 7, 2014 edition of the California MUTCD.

3.3.9 Other Roadway Design Criteria

The cut/fill slope will be 1:2 or flatter.

Americans with Disabilities Act (ADA) curb ramps will be designed as shown on City of Palo Alto Standard Drawings 101, 102, 103, and 104.

Storage/Turn Length = As per Traffic Operations Analysis Report

Design Turning Vehicles = Fire Truck (Pumper), Garbage Truck (Heavy)

Driveways will be based on the City of Palo Alto Standard Drawings 121 to 125.

Curb return radius = As per truck turns and intersection needs

3.4 Structural

Structures and bridges supporting railroad shall be designed according to the PCJPB Standard for Design and Maintenance of Structures, and the AREMA Manual for Railway Engineering.

3.4.1 Structure Depth

Roadway profiles will be based on an assumed structure depth of 5 feet for Railroad¹⁵ bridge structures. Railway profiles will be based on an assumed structure depth of 5 feet for Roadway¹⁶ bridge structures. Structure Depth for other structures such as drainage culverts will be evaluated on a case-by-case basis and will be based on initial geotechnical evaluation of the site conditions.

3.5 Railroad Signals

The alternative analysis may require the adjustment of the existing signals to match the changes in elevation of the tracks required to achieve the grade separation. More detailed criteria, such as for **Positive Train Control** and revised braking calculations, would need to be developed during the next phase of design.

3.5.1 Signal Placement

Ground signals are 22 feet in height measured from the existing grade to the top of the signal. Signal cantilever and bridge structures are designed to have a 28 feet clearance from TOR. **Dwarf signals** have a horizontal clearance of 6' from the centerline of the closest track. Although the CPUC general orders allow dwarf signals 36 inches or less above TOR, the Caltrain Design Criteria mandates the dwarf signals to be 34 inches or less above the TOR.¹⁷

For Ground Signal foundation and signal placement, Standard Drawings SD-5108 and SD-5201 will be used.

For Signal Bridge placement, Standard Drawing SD-5209 will be used.

For Signal Cantilever placement, Standard Drawing SD-5210 will be used.

3.6 Construction Staging

Construction of the grade separation will require temporary shoofly tracks around the limits of the construction zone in order to keep all Caltrain tracks fully operational at all times and shall cause no interruption to the **Caltrain/UP/HSR** operation during construction, except for approved construction windows during cut over operations.

The shoofly tracks will include a temporary at-grade crossing at Palo Alto Avenue, Churchill Avenue, Meadow Drive and Charleston Road.

Retaining walls and/or temporary shoring shall be used, where required, to prevent any conflicts between the construction activities of the track structures and the active shoofly tracks.

¹⁵ For the purpose of this document, the structure depth is defined as the dimension from top of rail to the bottom of soffit.

¹⁶ For the purpose of this document, the structure depth is defined as the dimension from top of roadway surface to the bottom of soffit.

¹⁷ Caltrain Design Criteria page 5-7.

Traffic handling of vehicular traffic on the local streets will be evaluated for the preferred alternative. Existing turning movements, access to existing properties will be considered and maintained to the greatest extent possible.

3.7 25 kV AC Railroad Electrification System

3.7.1 General Requirements and Definitions

Caltrain is undertaking the Peninsula Corridor Electrification Project, which will electrify the portion of the Caltrain Corridor between San Francisco and San Jose (approximately between San Francisco milepost (MP) 0.0 to the Southbound Home Signals at C.P. Lick, Caltrain MP 50.94/Union Pacific MP 51.64).

- All grade separation alternatives shall assume the 25 kV AC Electrification Systems will be in operation during construction. Considerations shall be given to the **planning-level cost estimates to** maintain continuous operations of the live electrified railroad with minimum impacts.
- **25 kV AC Electrification System:** The Overhead Contact System, Negative Feeders, and Traction Power Return System used to power electrified trains in the Electrified JPB Rail Right-of-Way. Traction power Substations, Switching Stations, Paralleling Stations and electrical supply stations are also included in this definition.
- **Overhead Contact System (OCS):** The OCS comprises the aerial supply system that delivers 25 kV traction power from the Substations to the Pantographs of the electric trains, and includes the Catenary System Messenger and Contact Wires, feeder, auxiliary wires and hangers, associated Supports and structures (including poles, portals, headspans and their foundations), manual and/or motor operated isolators, insulators, Phase Breaks, conductor terminations and tensioning devices, downguys, and other overhead line hardware and fittings.

3.7.2 Clearances

Clearances for the OCS, per SED-2 CPUC requirements for Caltrain Electrification are as follows:

- Structure Limit: 6'-0" minimum clear from the back (field side) of OCS Pole the face of any structure
- Vegetation Growth Limit: No vegetation shall overhang beyond the vegetation trim lines (as shown in Figure 3) or exist within 10'-0" of OCS or other electrical equipment.
- Track Clearance: Horizontal clearance shall be between 10' (minimum) and 12' (preferred) as measured from the track centerline to the face (track side) of OCS poles or other OCS and electrical equipment.
- Contact Wire Height: The contact wire height will be 22 feet above the top of rail.

There are further clearance requirements set forth in SED-2 beyond those listed above. The entirety of the SED-2 shall be taken into consideration during design.

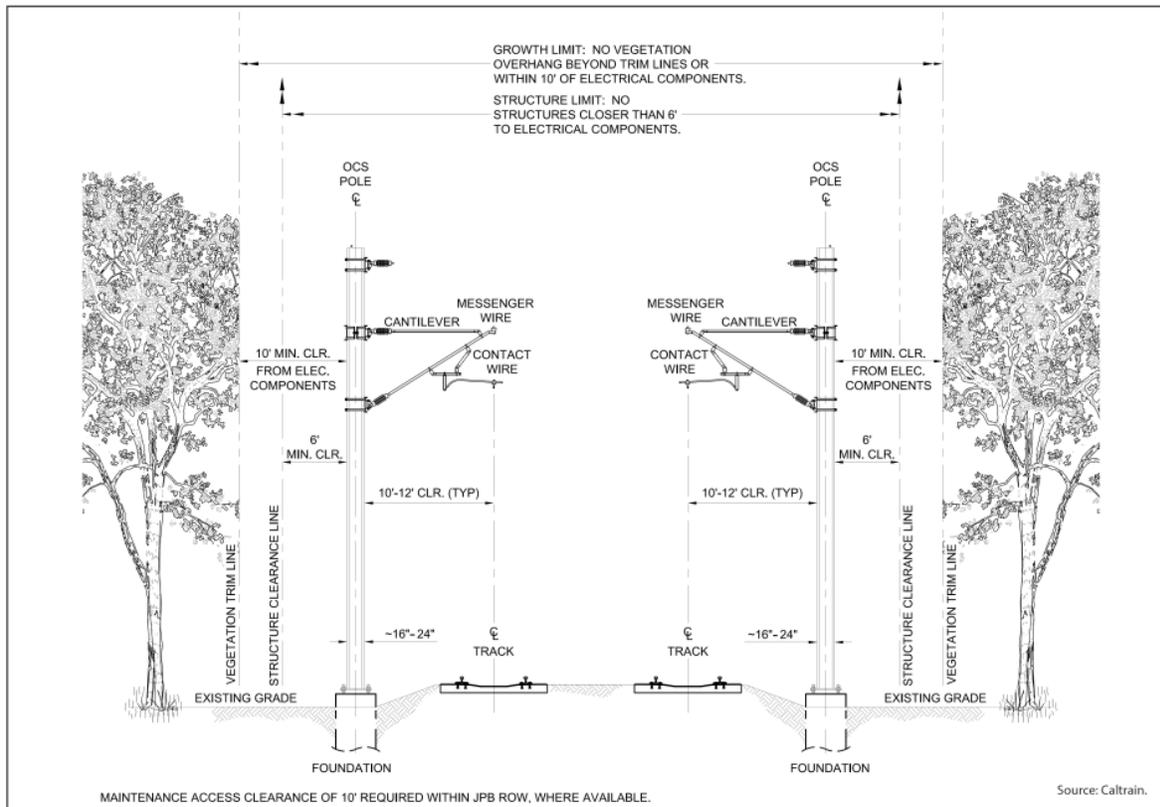


Figure 5 - Caltrain OCS Clearances

Vertical Curve Calculations By Phil Burton

$$L = (D * V_{\text{squared}} * K) / A$$

Ref: Palo Alto Design Criteria 20190807_FINAL.pdf, p. 13

At 2.0% vertical grade

	D	V (mph)	Vsquared	K	A-passenger	A-freight	L-passenger	L-freight
passenger	0.02	110	12100	2.15	0.9		578	
freight @ 50 mph	0.02	50	2500	2.15		0.1		1075
freight @ 40 mph	0.02	40	1600	2.15		0.1		688
freight @ 35 mph	0.02	35	1225	2.15		0.1		527

At 1.4% vertical grade

	D	V (mph)	Vsquared	K	A-passenger	A-freight	L-passenger	L-freight
passenger	0.014	110	12100	2.15	0.9		405	
freight @ 50 mph	0.014	50	2500	2.15		0.1		753
freight @ 40 mph	0.014	40	1600	2.15		0.1		482
freight @ 35 mph	0.014	35	1225	2.15		0.1		369

At 1.0% vertical grade

	D	V (mph)	Vsquared	K	A-passenger	A-freight	L-passenger	L-freight
passenger	0.01	110	12100	2.15	0.9		289	
freight @ 50 mph	0.01	50	2500	2.15		0.1		538
freight @ 40 mph	0.01	40	1600	2.15		0.1		344
freight @ 35 mph	0.01	35	1225	2.15		0.1		263

Design Standards for Vertical Clearances for Caltrain Electrification Project

AAR Plates (plates not shown do not exist)

AAR Plate	Car Max Height	Notes
B	15' 1"	Unrestricted interchange service standard
C	15' 6"	Limited interchange service standard (will clear 95% of total rail mileage)
D	--	information for obtaining the maximum allowable width of cars, other than at the centerline of the car, to allow for unrestricted Plate B and limited Plate C, H, J and K interchange service.
E	15' 9"	Limited interchange service
F	17' 0"	Limited interchange service
H	20' 3"	Limited interchange service Double-stack container cars
J		Limited interchange service Conventional 19' autorack cars
K	20' 3"	Limited interchange service 20' 3" autorack cars
	15' 1"	Unrestricted* diagram for single loads, without end overhang, on open top cars. Presumably flat cars and gondola cars

A post on the Caltrain website, **Engineering Standards 2011**, includes a drawing for AAR Plates F and H. The Caltrain drawing SD-2001 for Plates F and H adds a 6" cushion to the AAR Plates.

For most of the freight cars operating in current Union Pacific freight services, plate B and (no letter) apply.

Relevant Caltrain Standards

Note that existing overpasses impose a ___ clearance.

CPUC Order 95 standards for vertical clearance. See line 2. Note that Caltrain will be electrified at 25 KV 60 Hz. See Column F.

TABLE 1: CPUC GENERAL ORDER 95 BASIC MINIMUM ALLOWABLE VERTICAL CLEARANCE OF WIRES ABOVE RAILROADS, THOROUGHFARES, POLES, BUILDINGS, STRUCTURES OR OTHER OBJECTS

CASE NO.	NATURE OF CLEARANCE	A SPAN WIRES (OTHER THAN TROLLEY SPAN WIRES) OVERHEAD GUYS AND MESSENGERS	B COMMUNICATION CONDUCTORS (INCLUDING OPEN WIRE, CABLES & SERVICE DROPS), SUPPLY SERVICE DROPS OF 0-750 VOLTS	C TROLLEY CONTACT, FEEDER AND SPAN WIRES, 0-5,000 VOLTS	D SUPPLY CONDUCTORS OF 0-750 VOLTS & SUPPLY CABLES	E SUPPLY CONDUCTORS & SUPPLY CABLES, 750-22,500 VOLTS	F SUPPLY CONDUCTORS & SUPPLY CABLES, 22.5-300 KV	G SUPPLY CONDUCTORS & SUPPLY CABLES, 300-550 KV (mm)
1	CROSSING ABOVE TRACKS OF RAILROADS WHICH TRANSPORT OR PROPOSE TO TRANSPORT FREIGHT CARS (MAXIMUM HEIGHT 15-FT, 6-INCH) WHERE NOT OPERATED BY OVERHEAD CONTACT WIRES.	25-FT	25-FT	22.5-FT	25-FT	28-FT	34-FT	34-FT
2	CROSSING OR PARALLELING ABOVE TRACKS OF RAILROAD OPERATED BY OVERHEAD TROLLEYS.	26-FT	26-FT	19-FT	27-FT	30-FT	34-FT	34-FT
3	CROSSING OR ALONG THOROUGHFARES IN URBAN DISTRICTS OR	18-FT	18-FT	19-FT	20-FT	25-FT	30-FT	30-FT

From the Wikipedia article https://en.wikipedia.org/wiki/Electrification_of_Caltrain.

Contact wire height is planned to vary between 16 to 23 feet (4.9 to 7.0 m), depending on overhead clearance required, with the messenger wire another 2 to 5 feet (0.61 to 1.52 m) above that, and pole height will vary between 30 to 50 feet (9.1 to 15.2 m). Nominal clearance under the contact wire will be 23 feet (7.0 m) to accommodate freight and non-electrified passenger rail service.

From the Caltrain website,

http://www.caltrain.com/Assets/Peninsula+Rail+Program/Electrification+2025/EA-DEIR-04-2004/Chapter_2_WEB.pdf

Clearances for maintenance and operation of the OCS will be designed to allow for existing freight railroad clearances and operations; the OCS, however, may have to be de-energized at some overhead bridge locations in order to operate certain freight trains over the JPB-owned portion of the right-of-way during non-passenger revenue hours. OCS installation on the segments of the UPRR-owned right-of-way would be designed to provide clearance parameters to permit American Association of Railroads (AAR) Plate H freight operations at all times under the energized conductors. (See Figures 2.3-1 through 2.3-3)