A Vision of Electrified Rail in Southern California: Los Angeles to the Inland Empire

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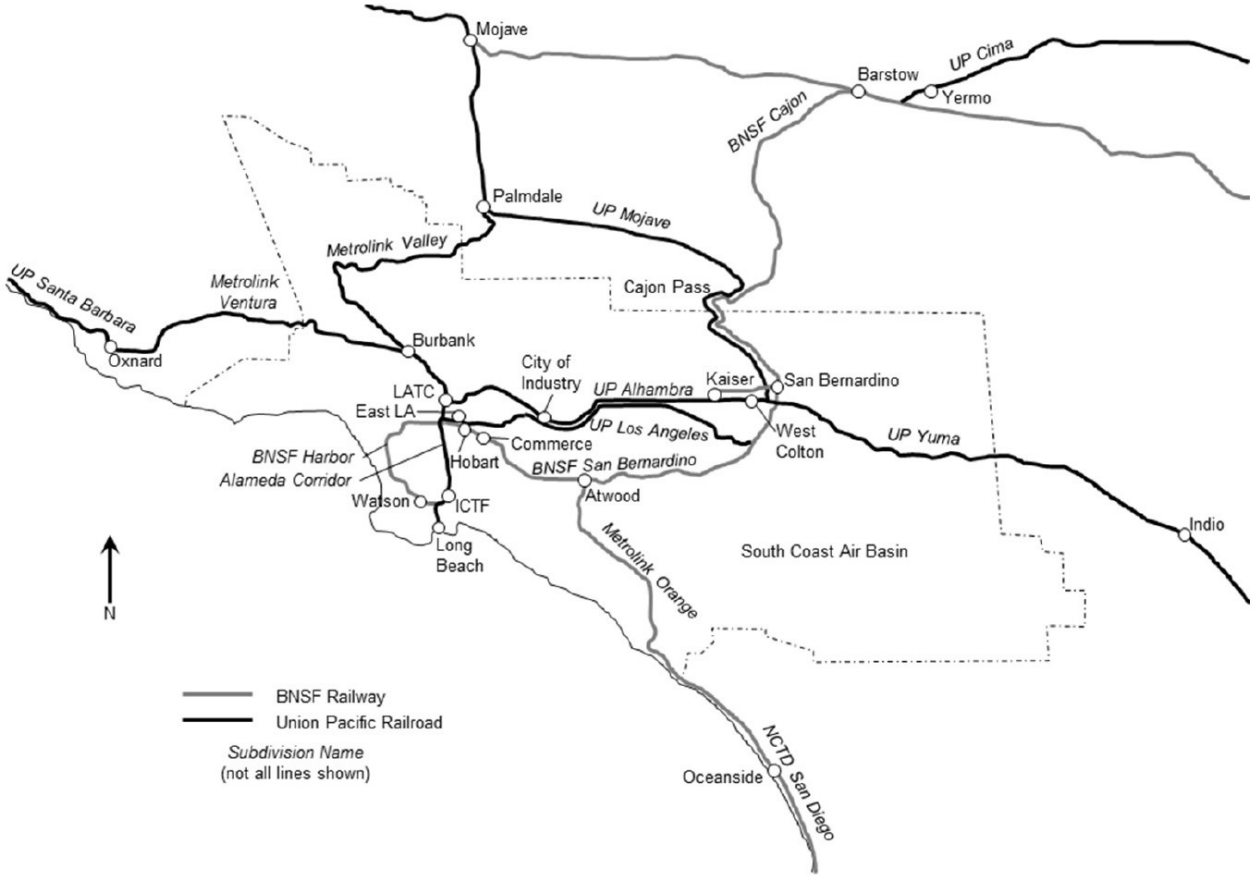
BNSF trains, just south of Santa Ana River crossing,
with San Bernardino Mountains and Southern California Edison Vista Substation behind
(photos by Brian Yanity)

The railroad tracks of Southern California carry some of the nation's busiest freight rail traffic, and a substantial number of passenger trains as well. This could all grow with added capacity and improvements such as electrification. Southern California needs a regional rail network with frequent passenger service and ample freight capacity.



Map of line-haul freight rail network in Southern California (Figure 3-2 from 2016 report by University of Illinois Urbana-Champaign RailTEC for California Air Resources Board: *Transitioning to a Zero or Near-Zero Emission Line-Haul Freight Rail System in California: Operational and Economic Considerations*)

Rail Electrification

There is a great need to reduce emissions from the high number of diesel-powered trains in Southern California, especially as increased track capacity leads to a far greater number of trains using the lines in the future. Electrification of many of these trains (regional if not long-haul) would eliminate a source of local particulate, smog-forming and greenhouse-gas emissions. Southern California is losing the battle against smog and particulate emissions, turning back years of progress. Rail electrification needs to be part of the solution.

Used successfully all over the world, electric locomotives produce zero emissions, are quieter, and have better acceleration than the diesel locomotives that Metrolink, Amtrak and freight railroads currently use. Not only does electrification make service faster, but it enables more stops to be served in the same amount of time. The faster acceleration of electric locomotives will enable fast, short-haul regional freight trains to run at higher speeds than typical U.S. freight trains, enabling them to be more competitive with trucks. State and local government should also emphasize conventional overhead wire electrification for interregional rail, instead of hydrogen locomotives, which are not a proven technology and have very limited range compared to conventional diesel locomotives.

The electrification of the Caltrain corridor between San Francisco and San Jose (and subsequent California High Speed Rail plan) provides a national model for passenger and freight rail electrification, by providing experience in electrification construction, implementation and operations. In Southern California, electrification and other upgrades to the Burbank-LA-Anaheim corridor by the California High Speed Rail Authority (CHSRA), in collaboration with those made by other public agencies and BNSF, would be a great public benefit to both passenger and freight rail service. The heavy train traffic of this corridor would lead to improved economics and higher utilization of electric rail infrastructure, if used by both electric passenger and freight trains sharing the corridor.

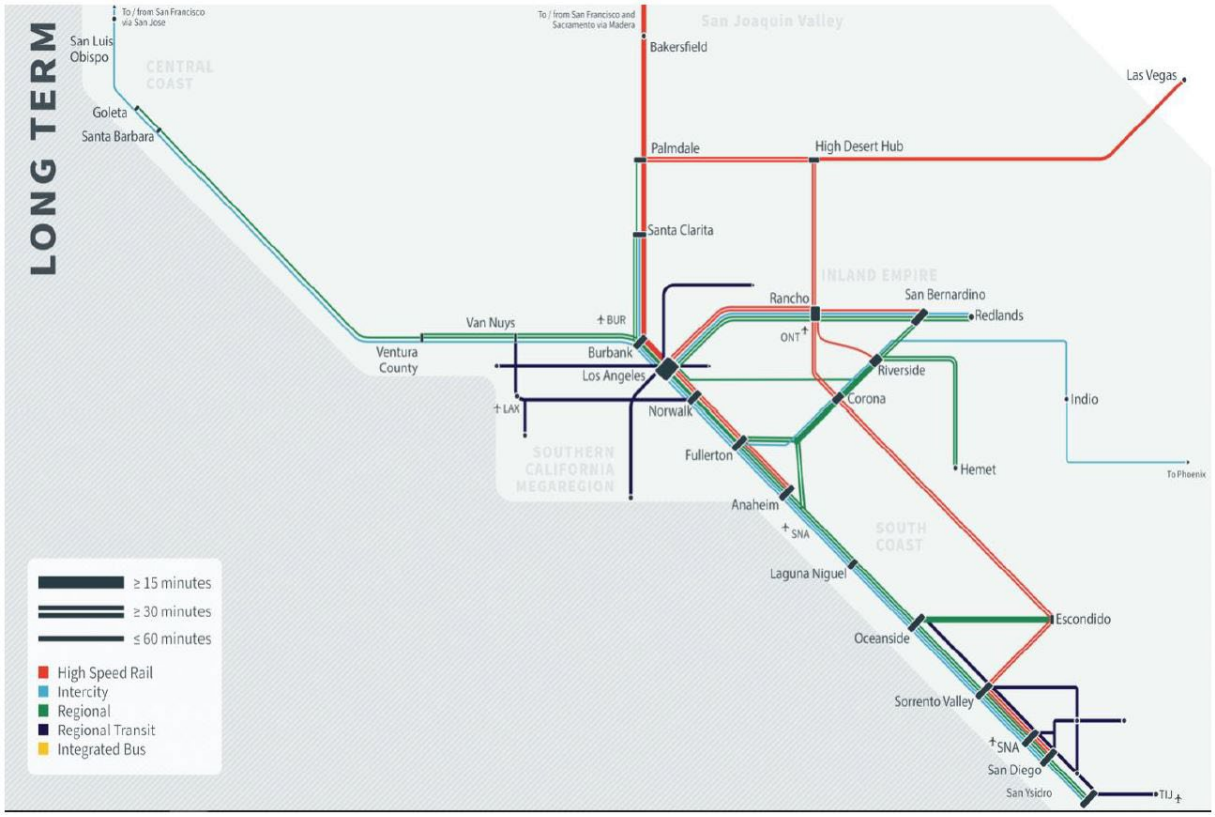
The ‘blended’ CHSRA Burbank-Los Angeles-Anaheim-Irvine corridor could serve as a catalyst for electric regional passenger and freight rail for the rest of Southern California. An existing model for “blended services”, combining electrified higher-speed / high-speed passenger trains and express freight trains, can be found in Germany and other countries. Freight trains in Germany operate in mixed traffic with commuter, regional, long distance, and high-speed passenger trains on lines with maximum speeds of up to 150 mph. Electric freight trains in Germany typically operate at 60-70 mph. German 90 mph freight trains were common in the past, but that speed was found to be too costly to be beneficial to the commercial service. California high-speed rail infrastructure can be shared with lightweight express freight trains running late at night or other off-peak times on HSR tracks. U.S. freight railroads have mostly given up on short haul service and expedited delivery.

Rail electrification is an industrial process that requires large-scale manufacturing. CHSRA and Brightline West need to encourage the manufacture of rail electrification infrastructure within the state of California, including by setting standards for green sourcing to ensure that out-of-state offers do not have an advantage due to not being subject to environmental regulations. This would enable a statewide ‘economy of scale’, enabling joint procurement contracts with CHSRA and other agencies, and even competing bids to bring down electrification costs.

A steady volume of rail electrification activity over the long term allows development and retention of skill-set and manufacturing capability for rail electrification. Developing expertise and experience over a period of years the costs will fall and the rate of infrastructure installation can increase. There is a large pool of vendors and manufacturers worldwide for heavy rail all-electric catenary rail technology. Cost-effective construction techniques of overheard catenary wire is well-understood around the world.

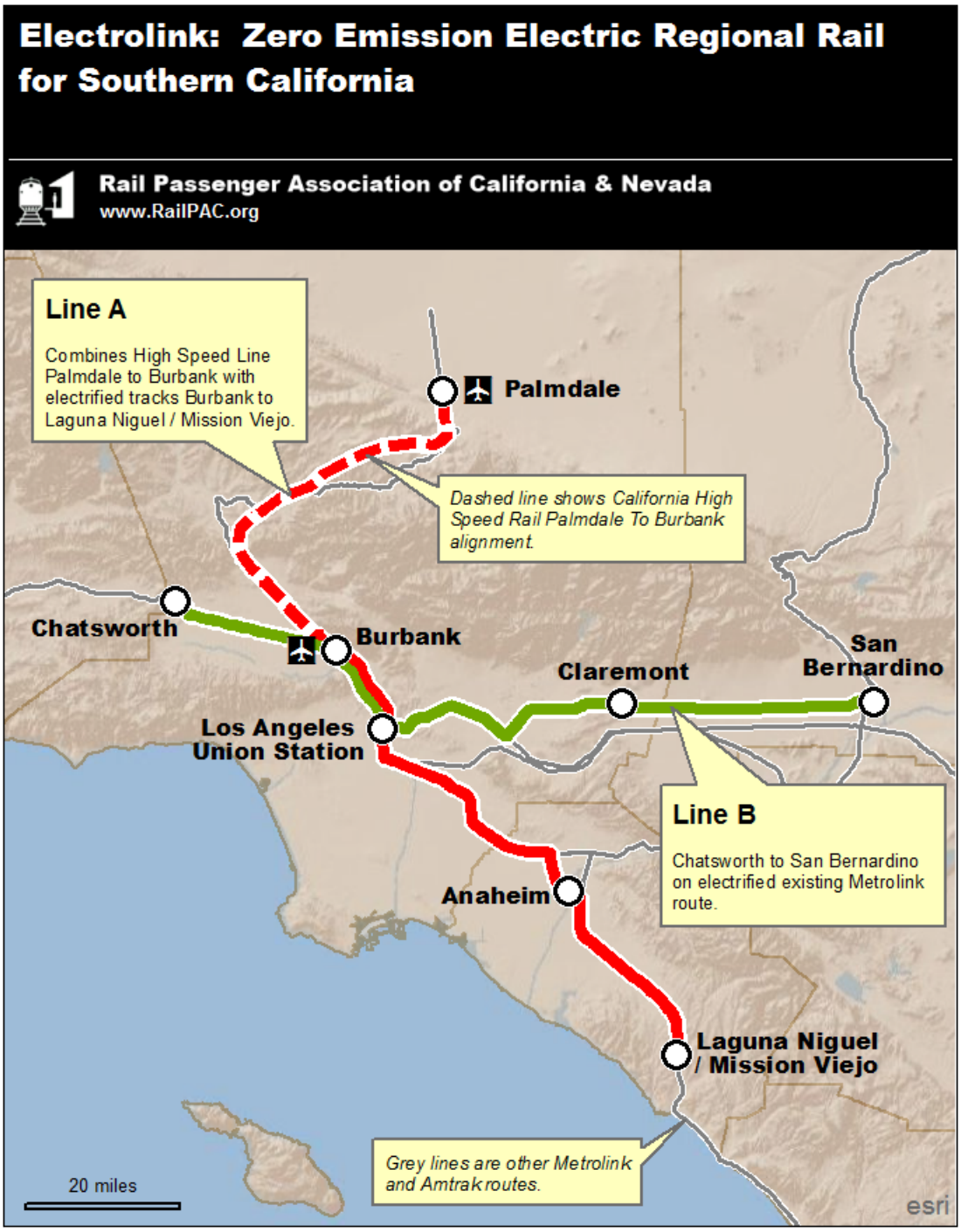
Good rolling stock is necessary for electric freight and passenger rail to be a success. Reinvented electric locomotives or electric multiple units (EMUs) specific to Southern California are not needed. Standard European designs can be used (with slight modifications for the American market) and are already being manufactured in the U.S. Additionally, catenary-battery hybrids are being developed by Wabtec, Stadler, Alstom and others.

As mentioned above, electric trains accelerate faster than the diesel locomotives currently used by all freight and Amtrak trains in California. Regional rail (commuter) lines with semi-frequent stops which share tracks with freight, such as Metrolink's Orange County Line and 91/Perris Valley and Inland Empire-Orange County lines along the BNSF San Bernardino Subdivision, would be sped up. Electrification would also mean more frequent service. Ridership would increase dramatically, taking tens of thousands of cars off the freeways each day. The 2018 State Rail Plan called for planning for "development of future electrified regional services and phased implementation of HSR across Southern California, including the BNSF San Bernardino Subdivision and the Inland Empire." The map below is from the draft 2022 State Rail Plan, showing a long-term passenger rail service vision for the Southern California region.



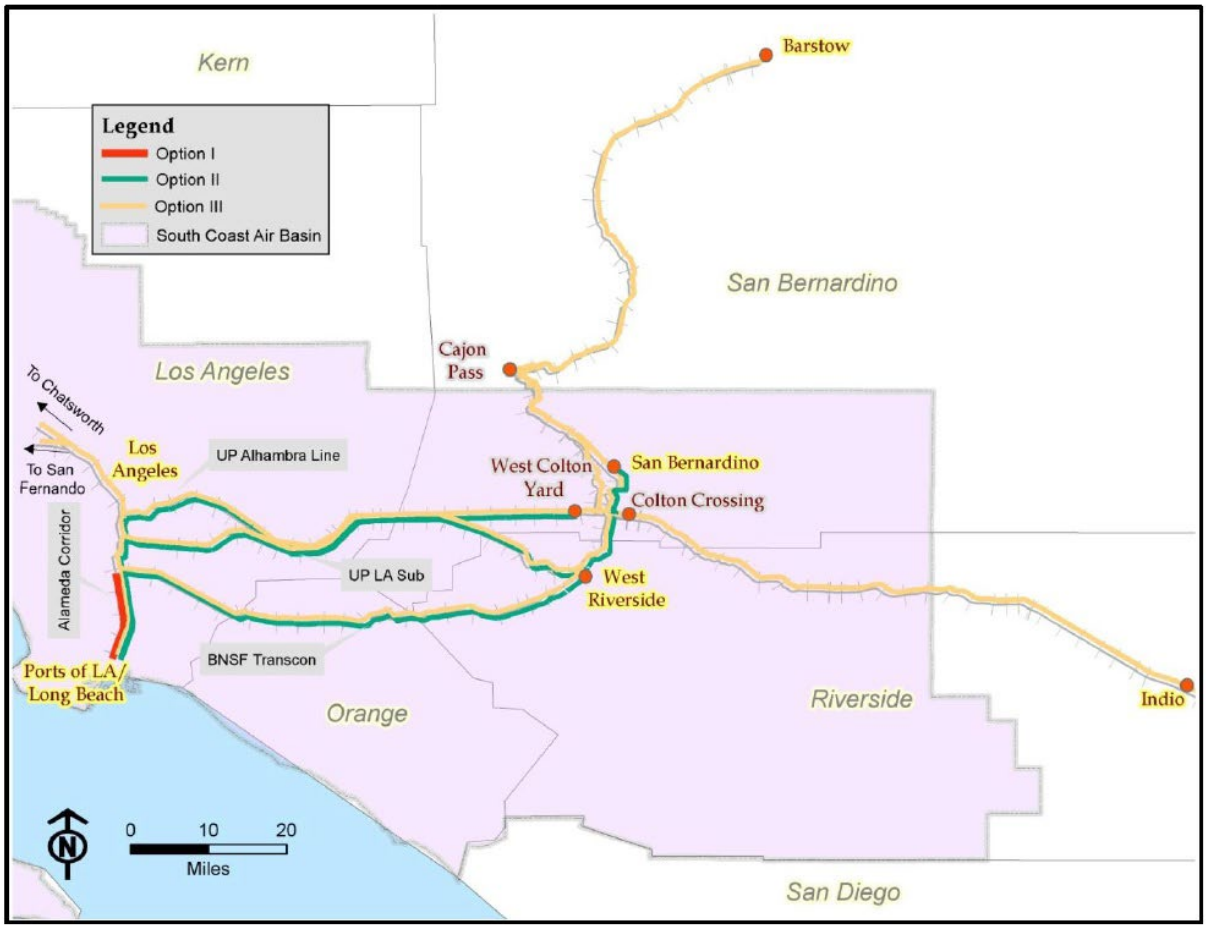
2022 State Rail Plan long term passenger rail vision for Southern California

In addition, below are a 2014 map of proposal Metrolink electrification, or "Electrolink", by the Rail Passenger Association of California and Nevada (RailPAC), and a 2012 map of a regional rail electrification scenarios from a Southern California Association of Governments study.



RailPAC 'Electrolink' regional passenger rail electrification proposal from 2014

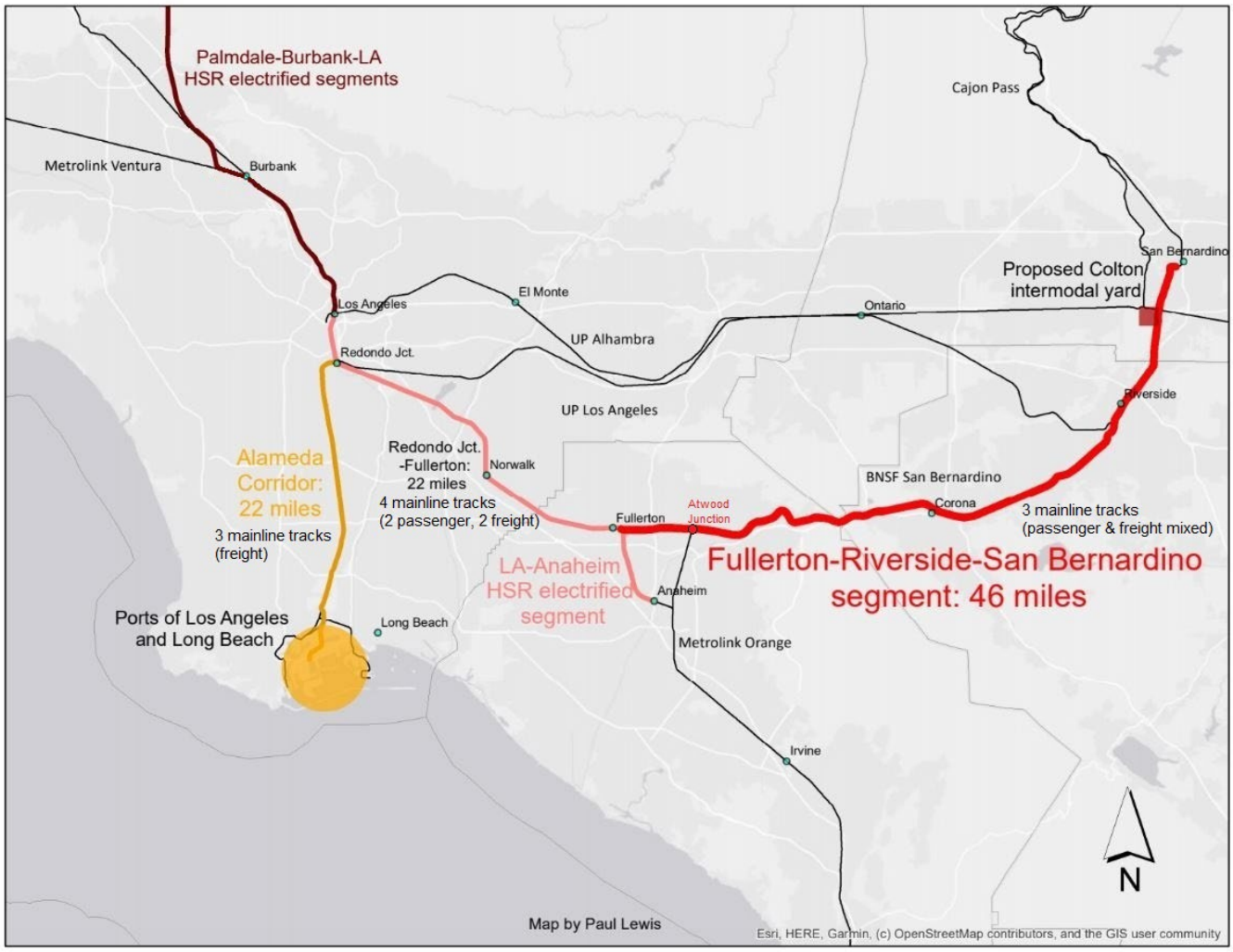
Figure 4.3 Regional Electrification Options and the SCAB Boundary



Freight rail electrification scenarios in the South Coast Air Basin, as proposed by 2012 SCAG report (Background map: *Task 8.3: Analysis of Freight Rail Electrification in the SCAG Region (Final Technical Memorandum),* prepared by Cambridge Systematics, Inc. for Southern California Association of Governments, April 2012, pg. 4-24)

BNSF San Bernardino Subdivision

The BNSF Railway's San Bernardino Subdivision runs for a length of nearly 70 miles between Los Angeles and San Bernardino. Passing through Los Angeles, Orange, Riverside and San Bernardino counties, it is one of the busiest freight and passenger railroad corridors in the United States. It is the westernmost segment of BNSF Southern Transcon between Los Angeles and Chicago. Roughly 20 million people live within 50 miles of the BNSF San Bernardino Subdivision. With capacity upgrades (including additional mainline and siding tracks) and performance improvements such as electrification, the line will become an even more important transportation axis for the Southern California region and the nation. Its strategic location between population centers, and large amount of freight and passenger traffic, make it worthy of large capital investments which will bring tremendous public benefits for decades to come. Many road-rail grade separations have been completed in recent years along the BNSF San Bernardino Subdivision, and more grade separations are in the works.



Note: number of mainline tracks shown on map are at full build out of planned capacity projects on the BNSF San Bernardino Subdivision

Fullerton-Riverside-San Bernardino 3rd Main Track

A third mainline track between Fullerton, Riverside and San Bernardino is currently in various stages of planning and environmental review, but is not yet fully funded for construction. Part of the LOSSAN/ Metrolink SCORE program in collaboration with BNSF, the project will increase capacity, improve reliability, and reduce passenger-freight train congestion conflicts on one of the nation's busiest freight rail corridors shared with passenger trains. On the 46 miles between San Bernardino and Fullerton, BNSF has currently two main tracks for 31 miles and about 15 miles of third mainline track.

Full completion of the remaining 31 miles of third mainline track (along with sections of fourth mainline track at Corona and La Sierra) is currently in planning and environmental review by RCTC, using funds from the 2018 SB1 Metrolink SCORE grant by BNSF. The study is led by Metrolink and BNSF as they will actually oversee design and construction of the track. The project was estimated by the 2018 Metrolink SCORE proposal to cost $566 million, and to be completed in the 2024-2028 timeframe. However, a more recent Riverside County Transportation Commission (RCTC) estimate, shown at the end of Appendix A, gave an estimated cost of $146 million for the 29 miles of third mainline track

construction on the BNSF San Bernardino Subdivision within Riverside County. An initial portion of third mainline track east of Fullerton between Atwood (junction east of Fullerton) and Esperanza in Orange County is moving forward thanks to a federal grant received by Metrolink. This project is a first phase of the larger Fullerton Junction Interlocking capacity enhancement project.

Passenger trains operating on the Fullerton-Riverside-San Bernardino segment include Amtrak (*Southwest Chief*) and Metrolink (91/Perris Valley Line, Riverside Line and Inland Empire Orange County Line). The Amtrak *Sunset Limited* and the proposed LA-Coachella Valley and LA-Arizona services may use this segment in the future. In 2018 there were 25 one-way Metrolink and 2 one-way Amtrak *Southwest Chief* trips on the Atwood-Riverside segment, for total of 27 passenger train slots. This compares to an average of 34 one-way daily freight trips on Atwood-Riverside in 2018. RCTC's current (1992) agreement with BNSF allows for 36 Metrolink train slots on the Atwood-Riverside segment of the San Bernardino Subdivision, but up to 58 if the entire segment had three mainline tracks. When this additional planned capacity is completed, and factoring in PTC train dispatching, the Fullerton Junction project, and LA-Fullerton 4th track, RCTC and the other public agencies could be in a position to negotiate with for a much greater number than 58 daily passenger trains between Fullerton and Riverside.

Electrification of the Fullerton-Riverside-San Bernardino Corridor

All-electric high speed rail passenger trains are already planned to serve Fullerton and Anaheim at speeds up to 125 mph, with the inauguration of the California High Speed Rail service. Electrification of the LA-Anaheim corridor (which includes 22 miles of the BNSF San Bernardino Subdivision) is proposed for the Phase 1 of California High Speed Rail, combined with the capacity upgrade of the LA-Fullerton corridor to four mainline tracks.

Electrification of the Fullerton-Riverside-San Bernardino segment would build upon the CHSRA LA-Anaheim plans for electrification. Doing so would enable 'higher speed' electrified Metrolink service, at speeds over 100 mph, which would be a game changer in improving passenger and freight rail service for this densely-populated corridor.

From Fullerton Junction to the San Bernardino BNSF yard, it is a distance of 46 route miles on the BNSF San Bernardino Subdivision. Assuming $3 million per route mile (covering 3 to 4 tracks), OCS infrastructure (overhead catenary wire and structures) would cost just ~$150 million (including contingency). This is average by global standards, but about half of Caltrain costs. Other assumptions for this rough cost estimate for electrification infrastructure include:

- Overhead catenary structures will be wide enough for a minimum of three mainline tracks the entire length between Fullerton Junction and San Bernardino, even in sections which are currently still have only two tracks. The catenary structures will be wide enough for four mainline tracks in the sections where this is proposed such as in Corona and La Sierra.

- A contact wire height of 7.6 m (25') above the top of rail, which is assumed to be sufficient clearance for 50 kV wire above the tallest double-stack 'high cube' train cars. However, it is also assumed that no bridge structures or at-grade crossings will be modified (See Appendix C). If a significant interference issue were to be caused by the overhead catenary structures and wire at the locations of bridges and at-grade crossings, then it is assumed there will be a neutral section 'gap' in the catenary at these locations.

- An OCS voltage of 50 kV, 60 Hz would have lower overall cost, and greater energy efficiency and power capacity. Due to the heavy freight traffic of the line, it is assumed that a majority of electric power capacity (a rough average of 200 MVA[1] power capacity) would be consumed by freight trains, and a minority (~100 MVA) by passenger trains along the Fullerton-Riverside-San Bernardino segment. 50 kV requires fewer traction power substations and switching stations than 25 kV and so supporting infrastructure cost is less. There is also better train performance due to less voltage drop and less energy loss. Locomotives moving at speed can transition between 50 kV and standard 25 kV 60 Hz AC, electrification system, to be installed in future by CHSRA on the LA to Fullerton segment of the San Bernardino Subdivision.

- The total power capacity of the 46-mile Fullerton-Riverside-San Bernardino OCS electrification segment will be 300 MVA. This amount would be more than sufficient to power both passenger and BNSF freight trains (the heaviest of which consumer up to 25 MVA each). Two traction power substations, each with a transformer capacity of 150 MVA, will provide 50 kV power solely to the 46-mile electrified segment. Each will be located about 5 miles from either end of the electrified segment and will serve as the electric utility interconnections for the OCS system. A switching station will be located roughly mid-way in between the two traction power substations, and six to eight smaller paralleling stations will be built along the 46-mile segment. The traction power substations, including utility interconnection lines, switching station and paralleling stations have a combined ROM installation cost of $200 million (including continency).

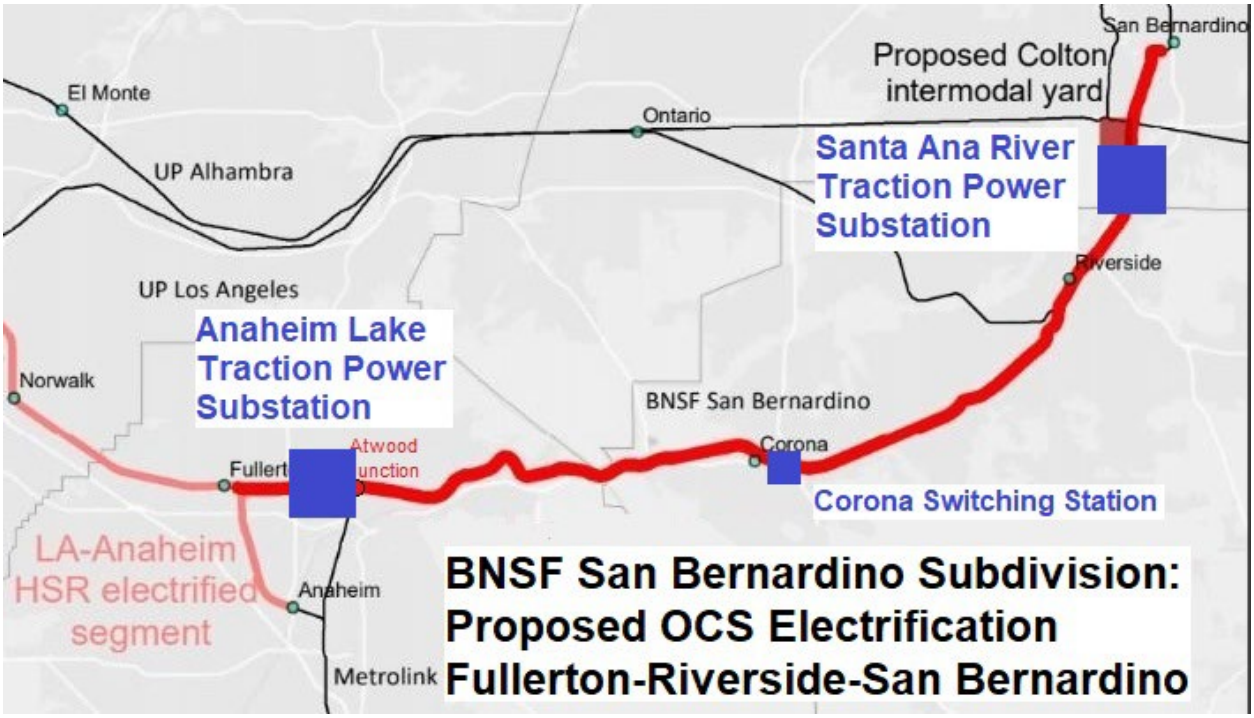
- There are many existing electric utility substations adjacent the BNSF San Bernardino Subdivision, the existing infrastructure of Southern California Edison (SCE), Anaheim Public Utilities (APU) and Riverside Public Utilities (RPU) is mostly in place to handle the amount of power needed (up to roughly 300 MW total) to be delivered to an electrified San Bernardino Subdivision.

- The installation of the remaining 31-mile gap in third mainline track (with sections of four mainlines) between Fullerton, Riverside and San Bernardino will be completed before or concurrently with electrification construction. Having three mainline tracks instead of two will enable two mainlines to remain open to normal train traffic while one track is closed for OCS construction. The costs of constructing the third mainline track, discussed above, are included in the ROM cost for electrification.

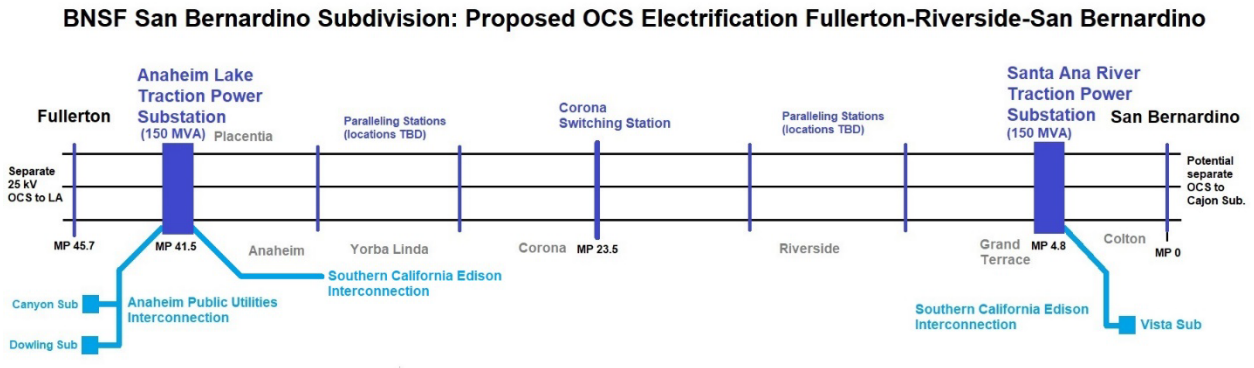
- For the proposed BNSF Colton intermodal facility, the exact routing of new track connecting this facility to the BNSF mainline from has not yet been determined. However, the track distance from Fullerton to the Colton intermodal facility would be several miles less than the Fullerton-San Bernardino distance.

ROM cost estimate of electrification (OCS catenary, traction power substations, and all other infrastructure) of 46 miles of the BNSF San Bernardino Subdivision between Fullerton, Riverside and San Bernardino, is **~$350 million, or $7.6 million per route mile.**

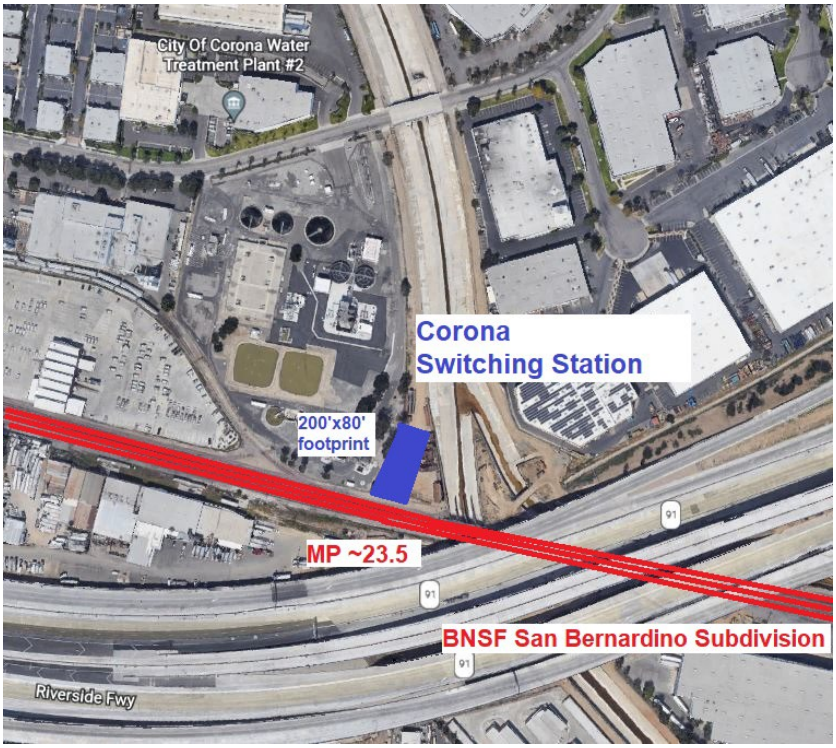
[1] Mega Volt Amps (MVA) ratings are used as this is the electrical industry standard for ratings of transformers and substations, and are slightly greater than the Megawatt (MW) real power capacity of the same equipment.



The most feasible locations for the two traction substations are ‘Anaheim Lake’ (connected to potentially both Anaheim Public Utilities and Southern California Edison) near the western end, and ‘Santa Ana River’ (connected to Southern California Edison) near the eastern end. These and other alternative locations for traction power substations are discussed in Appendix B.

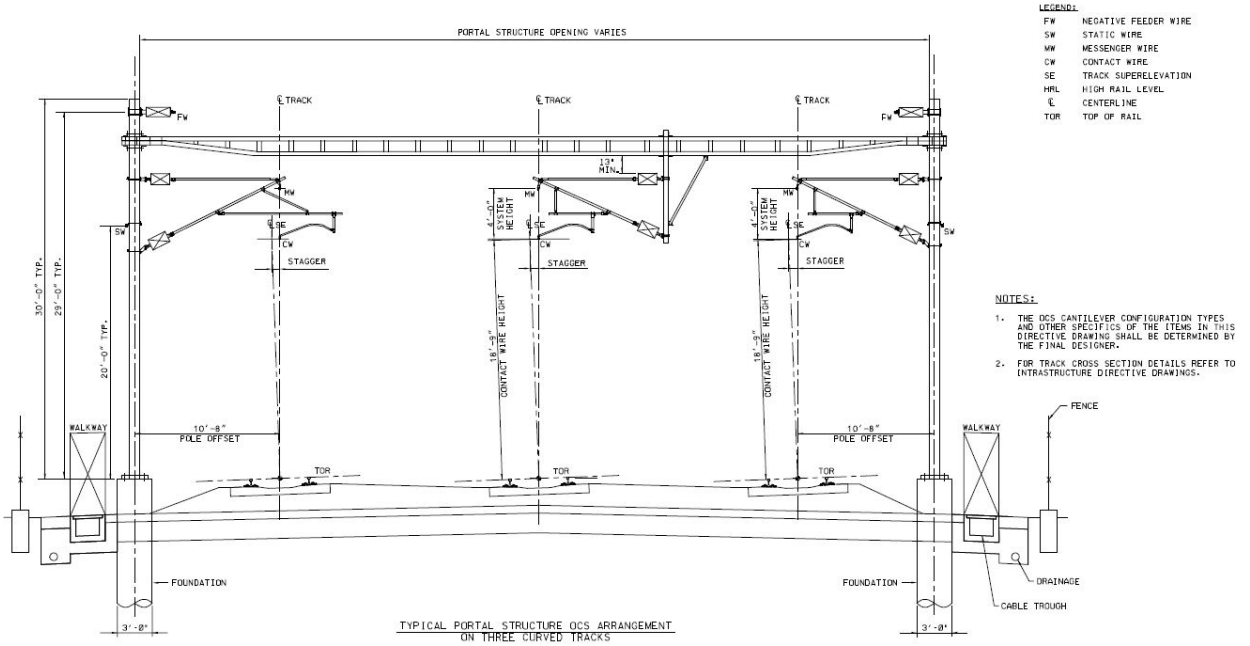



Placentia
BNSF San Bernardino Subdivision
Anaheim Lake laydown area
MP ~41.5
Distance
1.2 mi
100' x 1000' footprint
300' x 300' footprint
Existing SCE transmission line
Options for
Anaheim Lake
Traction Power Substation
50 kV AC, 150 MVA
APU Canyon Sub
The Adventure Lagoo
APU Dowling Sub
Kaiser Permanente
Anaheim Kraemer...

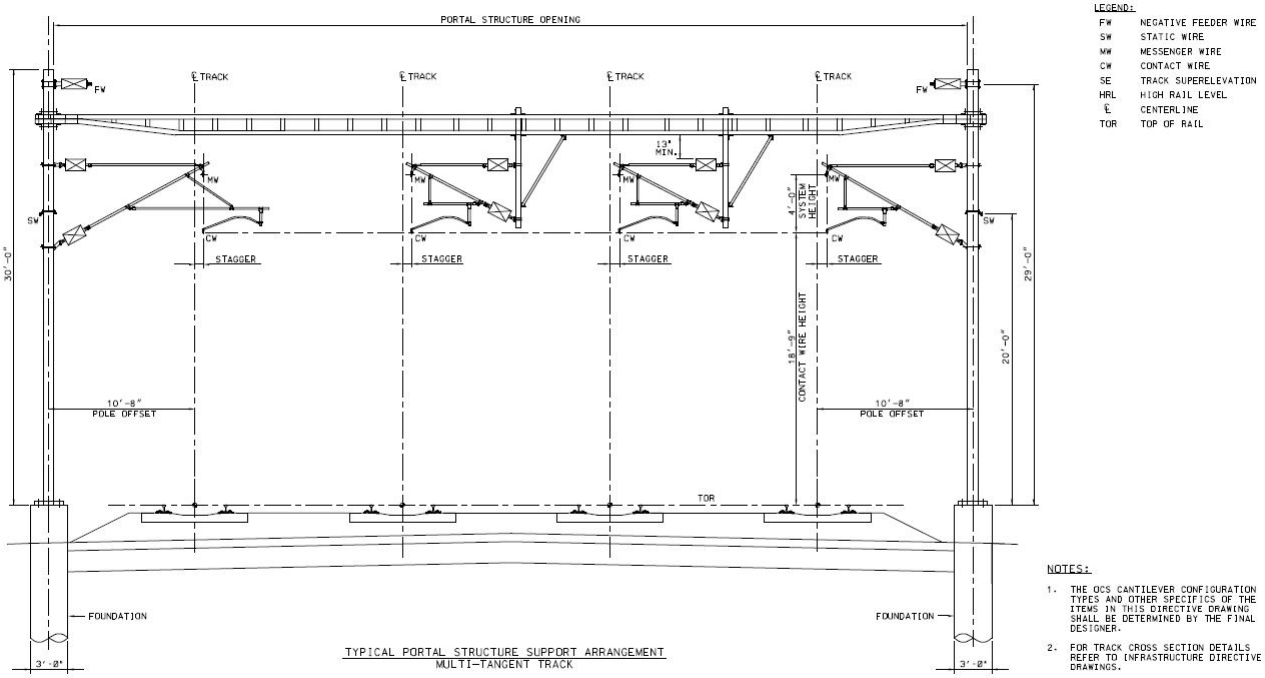

City Of Corona Water
Treatment Plant #2
Corona
Switching Station
200'x80'
footprint
MP ~23.5
BNSF San Bernardino Subdivision
Riverside Fwy
91

Examples of OCS configuration of three-track mixed use, similar to Fullerton-Riverside-San Bernardino-

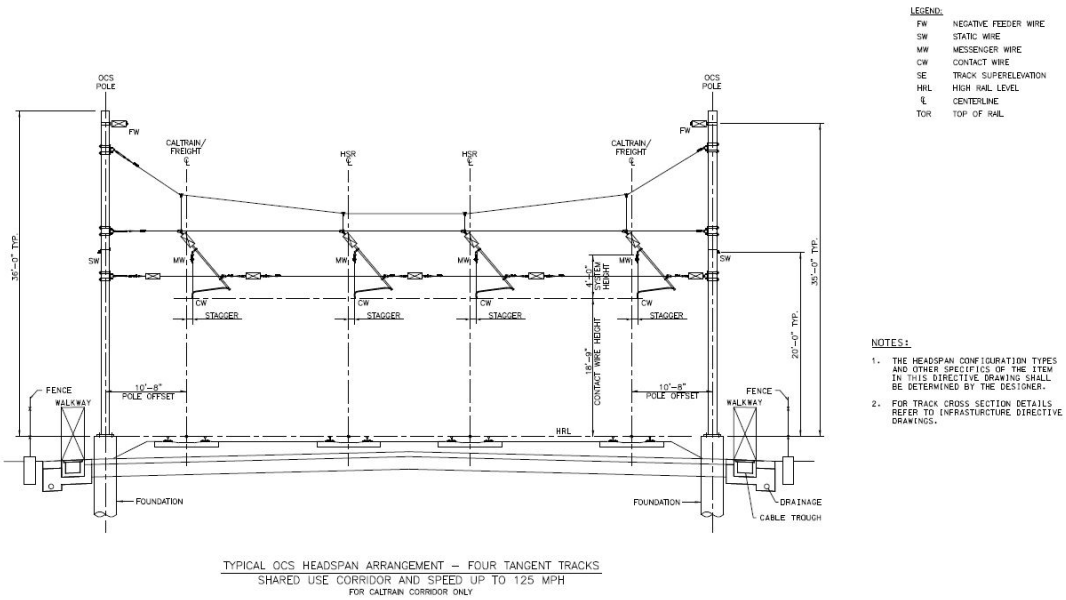
Note that the three reference 'directive drawings' shown below from the *Technical Memorandum (TM) 3.2.1 – OCS Requirements,* for California High Speed Rail Authority by Parsons Brinkerhoff, October 2010, are for 25 kV OCS with an overhead clearance of 16'9" above the top of rail, or lower than needed for double-stack container trains. The structure and wire heights would be higher (contact wire height of 25' above the top of rail) for a 50 kV Fullerton-Riverside-San Bernardino OCS, due to the need to accommodate double-stack container trains, and a higher voltage.



"Typical portal structure OCS arrangement on three curved tracks, speed up to 125 MPH",
Drawing TM 3.2.1-F from *Technical Memorandum (TM) 3.2.1 – OCS Requirements,*
for California High Speed Rail Authority by Parsons Brinkerhoff, October 2010



"Typical portal structure arrangement, multi-tangent track, speed up to 125 MPH",
Drawing TM 3.2.1-G from *Technical Memorandum (TM) 3.2.1 – OCS Requirements,*
for California High Speed Rail Authority by Parsons Brinkerhoff, October 2010



"Typical OCS headspan arrangement, four tangent tracks shared use corridor, speed up to 125 MPH", Drawing TM 3.2.1-M from *Technical Memorandum (TM) 3.2.1 – OCS Requirements,* for California High Speed Rail Authority by Parsons Brinkerhoff, October 2010

Bridges-

There are 26 road bridges (considering multi-bridge freeway overhead crossings one 'unit') and 5 pedestrian bridges at stations, and one railroad overpass between Fullerton and San Bernardino. Google Earth maps and photos of the bridges are cataloged in Appendix C, with one example shown below, 'qualitatively' judged to have the least amount of overhead clearance of those observed. The good news is that all of them appear to be sufficiently high enough for 50 kV (with neutral sections, special insulators, etc. at the lowest bridges), without modifications to the bridge or track. A lot of them looked like they were built in the past 30 years or so, in the era of the double-stacked container train.

Laydown Areas-

Logistical support, and convenient equipment and material storage at ample laydown areas (storage yards) is important for keeping construction costs down, and work completed on schedule. The ideal sites are as close as possible to the track, while also being close to existing key roads and streets for convenient truck access. Potential laydown areas adjacent to the track are shown in Appendix B. Preferably they should also be located in industrial areas to minimize construction noise and traffic impact on residential areas. Thankfully, much of the corridor alongside the BNSF San Bernardino Subdivision has long been industrialized, and there are other vacant lots not far from the track. So there should be more than enough optimal laydown area sites along the Fullerton-Riverside-San Bernardino rail electrification construction project corridor. For a central, 'main headquarters' construction depot, areas around the San Bernardino Metrolink and BNSF yards should be investigated, due to the presence of existing rail maintenance/construction equipment and facilities.

BNSF Cajon Subdivision

The Cajon Pass between San Bernardino and Victorville represents a particularly important opportunity for energy and emissions savings through freight rail electrification. The steep grade between San Bernardino (1,053') to Cajon Pass (3,777') climbs over 2,700' in net elevation over a track length of less than 26 miles. The ruling grade is 2.2%. Such a grade is well-suited to an electric locomotive's many advantages in mountainous terrain, including better adhesion, greater power at low speeds, and regenerative braking. The two rail subdivisions through the Cajon Pass, UP Mojave and BNSF Cajon, together represent 256,000 MWh annually of 'at-wheel' locomotive energy, or about 60% of all energy consumed by freight locomotives in Southern California[2]. This electrical load, powered by an OCS system, would approximately be an overall average load of about 30 MW. An average of about 90 freight trains per day traverse Cajon Pass, making it the rail section in California which would have the greatest emissions and energy-use reductions with electrification. In addition, routing new electric transmission lines along railroad corridors to the desert, such as Cajon Pass, would provide more transmission corridors between solar energy development areas and the Los Angeles Basin.

BNSF's massive Barstow International Gateway is under development on the west side of Barstow: https://bnsfcalifornia.com/barstow-international-gateway-project/
This proposed 'inland port' is heavily tied to the Ports of LA/Long Beach freight traffic, and the concept of "short-haul freight shuttle" trains between the Barstow area and the ports. This would be a prime pilot application for electric freight trains. The business model depends on the contents of international 40' containers to/from the ports being transloaded to 53' containers going to the rest of the USA. About 10 miles east of Barstow, on the BNSF Needles Subdivision, is SCE's decommissioned Coolwater coal power plant. This site now has two major substations, undergoing expansion, and is an important transmission hub for the regional power grid. Large solar generation and energy storage facilities have been developed just to the east of Coolwater. Due to its proximity to the BNSF mainline tracks, this existing SCE substation site would be a good location for a rail traction power substation.

[2]*Transitioning to a Zero or Near-Zero Emission Line-Haul Freight Rail System in California Operational and Economic Considerations, Final Report.* Prepared for State of California Air Resources Board by University of Illinois at Urbana-Champaign Rail Transportation and Engineering Center (RailTEC), Spring 2016, pg. 48: https://www.arb.ca.gov/railyard/docs/uoi_rpt_06222016.pdf

UP Alhambra and Los Angeles Subdivisions

UP's mainlines through San Gabriel Valley are the parallel Alhambra and Los Angeles subdivisions. The Alhambra Subdivision is not used for passenger rail except Amtrak's *Sunset Limited*, which runs three days a week in each direction. Improvements proposed for the Alhambra Sub include completion of a second main track from South Fontana to CP Reservoir Road in Pomona. The Los Angeles Subdivision is used by the Metrolink Riverside Line, though it has only six daily roundtrips on weekdays (plus a seventh train inbound to LA Union Station).

Metrolink San Bernardino Line

The San Bernardino Line, primarily owned by both Los Angeles and San Bernardino counties, is Metrolink's busiest route in terms of both ridership and frequency. Although it is used primarily by Metrolink passenger trains, there are a few daily freights by both BNSF and UP to serve customers along the route.

Currently, Metrolink is advancing several double-tracking and siding extension projects on the San Bernardino Line in the process of being environmentally cleared: the Marengo Siding Extension, the El Monte Siding Extension, and the Rancho Cucamonga Siding Extension. Additionally, LA Metro's CP Lone Hill to CP White in the cities of San Dimas and La Verne and SBCTA's between CP Lilac to CP Rancho in the cities of Rialto and San Bernardino, have been environmentally cleared and ready for final design and construction. Also, the Etiwanda Avenue grade separation project in Rancho Cucamonga is fully funded and is in the pre-construction phase. Taken together, these improvements will improve schedule reliability and enable the implementation of service which is on a more frequent schedule than at present. Thus electrification would be more economically justified.

RailPAC has long supported electrification of the San Bernardino Line, as shown on the Electrolink proposal on page 5.

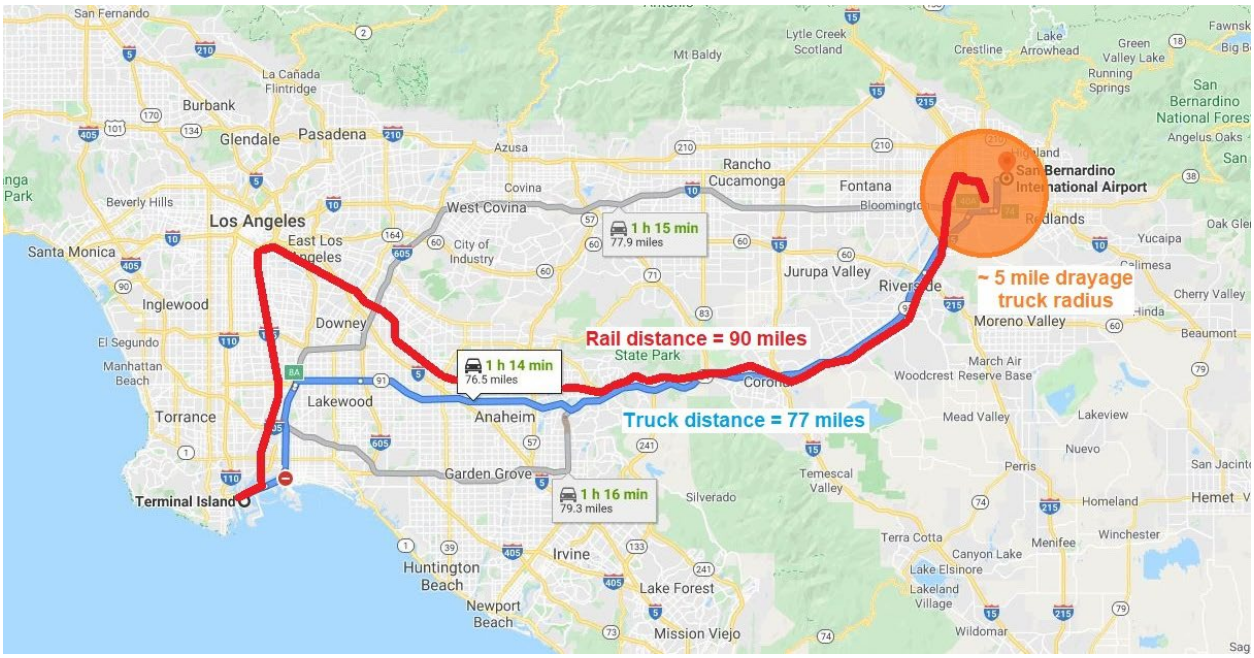
Southern California Short-Haul Freight Rail Network

The Ports of Los Angeles and Long Beach together the busiest container port in North America, handle about 40% of all containerized U.S. imports. Nearly 20 million twenty-foot-equivalent units (TEUs) of intermodal container traffic passed throught the San Pedro Bay ports in 2021. Close to 30% of this containerized import cargo moving through the San Pedro Bay ports left the docks by rail, and about 70% by truck. The San Pedro Bay Ports are responsible for approximately tens of thousans of daily regional truck trips, many of which are for moving containers.

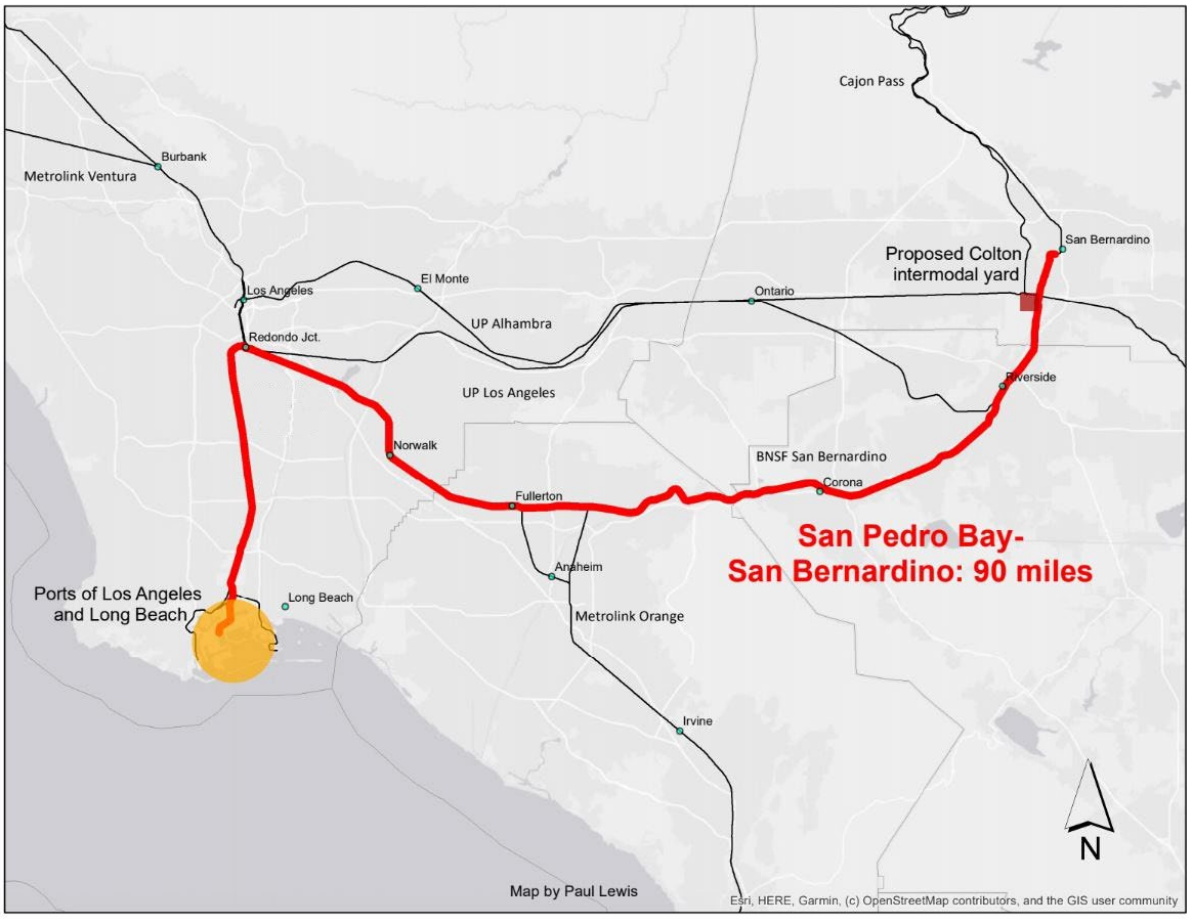
The Southern California region has at least 1.5 billion square feet of warehouse and distribution space, or roughly 1/8th that of the entire U.S. About a third of all containerized imports that move through the Los Angeles and Long Beach harbors, go by truck to warehouses and distribution centers in the "Inland Empire" region of San Bernardino and Riverside counties. This represents thousands of daily truck trips of a distance less than 80 miles one-way. If the Inland Empire (San Bernardino and Riverside Counties) were its own container port, the region would rank 4th busiest in the U.S. (just behind combined Port of New York and New Jersey), and in the top 25 in the world.

Alternatives to conventional truck transportation are much needed in the Los Angeles metro area, which is afflicted by the worst highway congestion and air quality in the nation. To address pollution and

congestion, a mode shift of more freight from truck to rail is critical in Southern California. There will be major environmental and energy-savings benefits from short-haul freight rail service within the region. Moving a ton-mile of freight by rail uses 1/3rd to 1/5th the energy (using 1/3rd to 1/5th the fuel and producing 1/3rd to 1/5th the emissions), compared to truck. This is true whether comparing diesel truck to a diesel train or an electric truck to electric train. California's goals to reduce greenhouse gas emissions are dependent on cleaner freight transport, and more rail must be part of the solution.



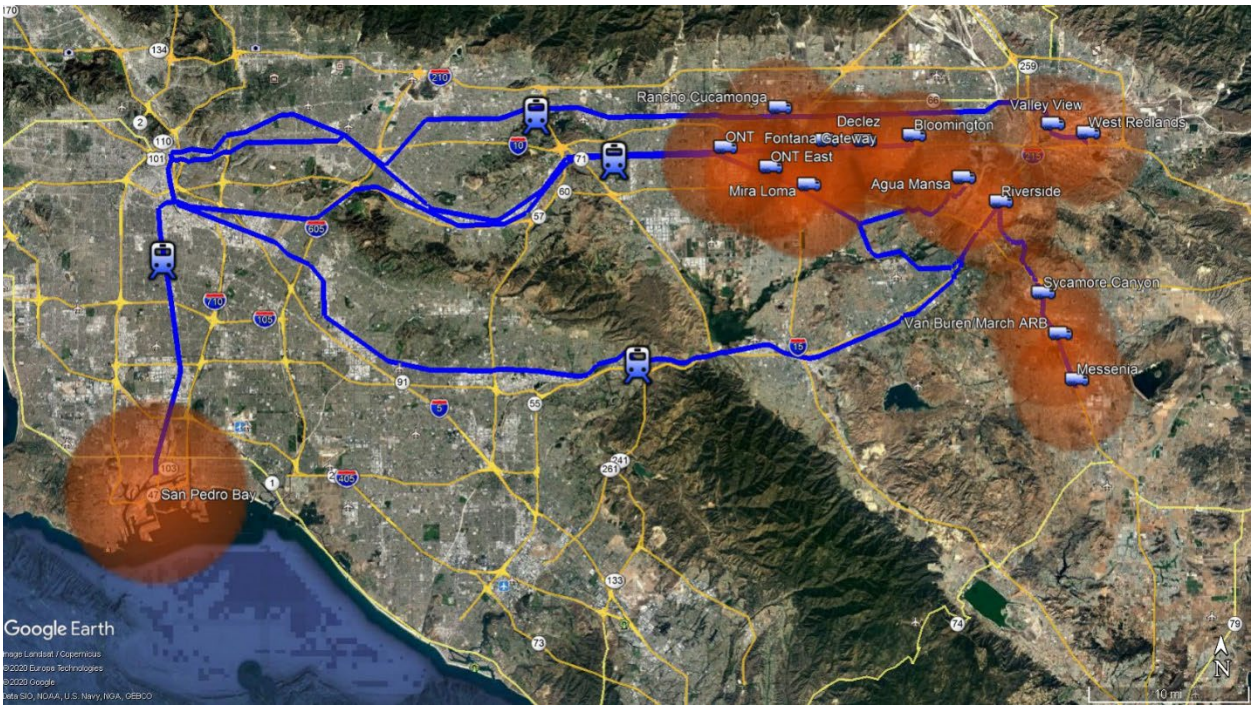
Comparison of truck vs. rail distance for drayage between the Ports of LA&LB to San Bernardino



Fully electrified rail corridor between from Ports of LA & Long Beach to San Bernardino on the Alameda Corridor and the BNSF San Bernardino Subdivision

The map above shows a potential electrified 90-mile corridor between the Ports of LA and Long Beach and San Bernardino. Combined with electrification of the Alameda Corridor, this would enable not only electric Metrolink trains to the Inland Empire, but also short-haul electric freight trains from the Ports of LA/LB to the Inland Empire. This would provide a far more energy efficient, zero-emissions alternative to trucks on the highway. European-style short, faster freight shuttle trains using new rapid-load/unload intermodal technologies would be more competitive with trucking than conventional double-stack container cars or trailer-on-flatcars.

The proposed BNSF Colton intermodal yard might want to incorporate relevant design and operational features to allow last mile train operations, in and out of the rail yard, using electric traction.



Proposed network for San Pedro Bay-Inland Empire short-haul freight rail
(5-mile truck drayage radius shown around each proposed inland intermodal terminal)

Financing Rail Electrification

The experience of rail electrification around the world has shown that not only is the capital cost is justified with high enough frequency of trains, but that the lower operating and maintenance costs of electric locomotives will result in lower costs over the long run. The high upfront capital costs for rail electrification need to be viewed in the context of the several-decade lifespan of the infrastructure investment, the cumulative avoided cost of diesel fuel, locomotive maintenance and the pollution impacts of diesel locomotives over the same period.

The amortization period of the catenary infrastructure is typically up to 30 years. However, the structures and equipment can last much longer. A proper economic analysis of a rail infrastructure capital project looks at a lot of different numbers to determine benefit/cost ratio and return on investment: time value of money, interest rates, inflation, locomotive unit cost, operation and maintenance costs, how often components have to be replaced, rail traffic projections, etc.

If we can envision over 1,000 containers a day moving on electric short-haul fast freight trains between the San Pedro Bay Ports and the Inland Empire or the Barstow area (a fraction of the several thousand that are now trucked each day), most likely we could work out some favorable economics for combined freight/rail electrification. Passenger traffic between LA, Orange County and the Inland Empire is also heavy and projected to increase in the years ahead.

The electrification of the BNSF mainline between Fullerton and San Bernardino, and the Metrolink San Bernardino Line, and other freight/passenger shared tracks in Southern California, are all opportunities for public-private partnerships. These could leverage CHSRA's planned electrification investments in the region.

In his February 2021 *Railway Age* commentary "Don't Dismiss Rail Electrification" Jim Blaze challenged AAR assertion that freight rail electrification is a bad idea that is not necessary https://www.railwayage.com/news/dont-dismiss-freight-rail-electrification/:

> "Why challenge AAR's professional conclusion that we should stick to Tier 4 or higher EPA-rated diesel-powered locomotives? Because the AAR conclusion appears, at least on its surface, too simplistic. It dismisses previous rail industry business-case studies for electrification.
>
> In contrast, previous [U.S.] railroad company reports have shown cases where overhead electrification could work and be financed with reasonable internal rates of return. They have demonstrated that specific route studies are the best determinants of a business case for alternate fuels. That analytical approach has been true for longer trains, heavy-axle loadings and overhead-clearance business case evaluations. It should therefore be true for electrification or selective-route battery locomotive applications.
>
> Where is the case history documentation review by the AAR that showed a favorable business case for full freight rail electrification? AAR does not acknowledge that a positive business case existed. However, the possibility of feasible financial returns for electrification was in fact seriously examined.
>
> …studies examined into the 1980s the potential to electrify parts of the Powder River Basin Wyoming/Montana low-sulfur coal routes. There were some favorable structured project terms evaluated, then negotiated, and very close to execution. Why? Because there were favorable joint railroad right-of-use aspects for the utility companies and available funding. The internal rates of return for a partnership of utility/railroad/financing had back then a projected rate of return greater than 25%. This was the same period when overall railroad ROI on assets was less than 10-12%.
>
> The financing venture terms in part looked like this: A partnership would spread the risks over multiple parties, not just the railroad company. A financial organization or a bank would initially have been a limited partner. The railroad company would have invested only a token amount of capital and then gradually acquired the partnership from the lenders.
>
> The joint venture structure back then was offering to absorb the initial building cost of the catenary, the power (electricity) distribution and the power generation as a package, with the railroad to pay like a trucker does for road use. It was to be a railroad trains pay-as-you-go deal. Electric locomotive energy regeneration—putting power back into the grid through regenerative dynamic braking—was part of the cost-benefit analysis calculations.
>
> Therefore, four decades ago, innovative railroads and outside parties were structuring interesting feasible deals for electrification.
>
> .. So, why did the parties back then walk away from a projected rail freight electrification project with a favorable outlook? Probably because some people or persons in charge at the railroad headquarters or board level clearly had a negative outlook for the rail industry. "

Benefits to Electric Utilities

Electric utilities must be involved in planning for rail electrification from the outset. It is the electric utilities who will provide the electric energy, build up new substation infrastructure to service electrified track, and construct or upgrade distribution and transmission lines. While there would be a need to construct new electric power infrastructure to serve electrified freight rail lines, electric utilities could see the new loads from freight trains as a business opportunity.

Utility-scale battery energy storage system connected to electric rail catenary, and trackside charging systems for locomotives with batteries, could be located at passenger train stations and along freight railroads. A sufficient level of energy storage along a rail line could provide backup power in case of a local or regional power outage.

These rail energy storage systems could provide a new business opportunity for electric utilities. Under utility control, these distributed energy storage systems could be charged at off-peak hours, provide power to the local distribution grid during periods of peak demand, and provide ancillary services such as voltage and frequency support, reactive power, or aid integration of distributed solar energy systems. California utilities should consult the experience of other countries with both extensive electric rail and high percentage of renewable energy generation, such as Germany and Spain. Both of these nations have populations greater than California's, meet more than one-third of their overall electricity needs from renewable sources (excluding large-scale hydroelectric), and have a rail system electrification rate of at least 60%.

Next step: An OCS Electric Rail Demonstration Site in Southern California

To evaluate and advance rail electrification expertise, public agencies, railroads, electric utilities and other stakeholders need to work to develop an OCS electric rail pilot project or demonstration site in Southern California. This could be an OCS system installed on a short section of track, perhaps a yard siding, close or adjacent to an existing railroad facility. The OCS system should be capable of both 25 kV and 50 kV operation, and tall enough (25' above top of rail) for the tallest freight cars. The facility could also serve as a future training facility for construction, operation and maintenance of overhead line electrification systems.

Appendix A:

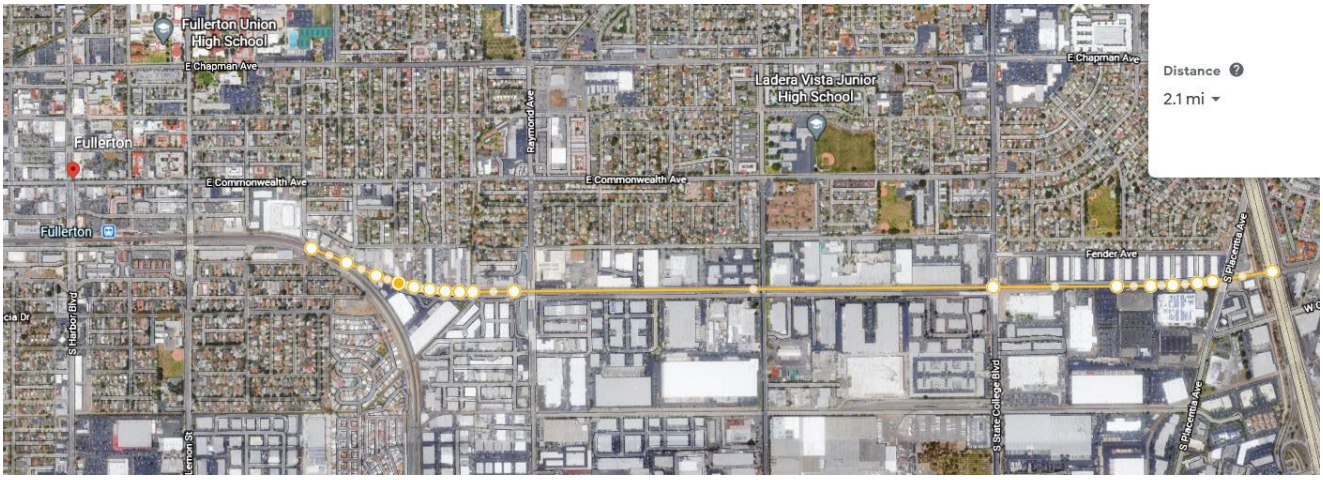
Fullerton-Riverside-San Bernardino

Track Segment Summary

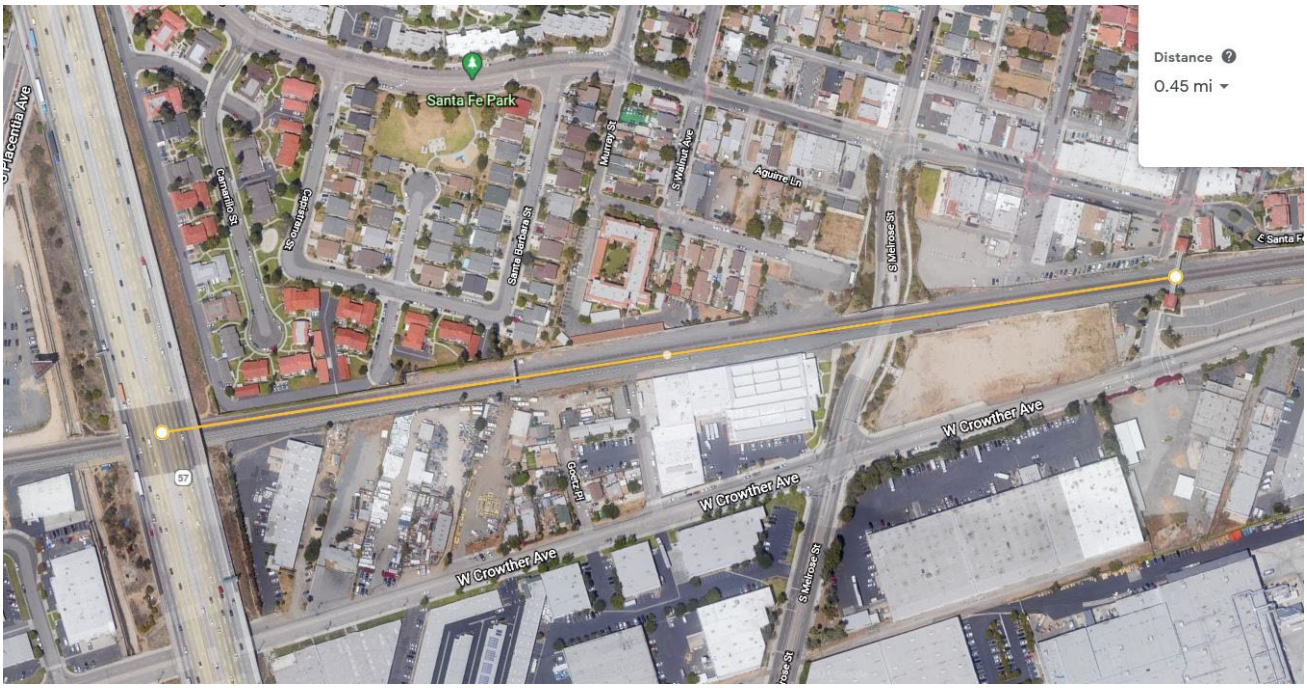
	Segment	Length (miles)
1	Fullerton Junction-SR57	2.1
2	SR57 to Placentia	0.5
3	Placentia to Orangethorpe	1.2
4	Orangethorpe to Tustin	0.5
5	Tustin Ave. to Lakeview Ave.	1.4
6	Lakeview Ave. to Imperial Hwy	1.7
7	Imperial Hwy to Fairmount Blvd	0.8
8	Fairmount Blvd to Yorba Linda Blvd	1.7
9	Yorba Linda Blvd to Via Lomas De Linda	2.3
10	Via Lomas De Linda to Crestridge Dr.	3.7
11	Crestridge Dr. to SR91	0.3
12	SR91 , Green River to Palisades	1.7
13	SR91 Palisades to West Corona	0.8
14	West Corona to N Lincoln Ave	2.0
15	N Lincoln Ave to Corona-North Main	1.1
16	Corona-North Main to I15	1.0
17	I15 to S. Promenade Ave	0.7
18	S. Promenade Ave to Magnolia Ave	2.1
19	Magnolia Ave to La Sierra	2.0
20	La Sierra to Ivy St.	7.0
21	Ivy St. to Riverside-Downtown	1.2
22	Riverside-Downtown to SR 60-215	1.5
23	SR 60-215 to Columbia Ave	0.8
24	Columbia Ave to Iowa Ave	0.6
25	Iowa Ave to 215	1.4
26	215 to Santa Ana River	1.3
27	Santa Ana River to Colton Crossing	1.4
28	Colton Crossing to San Bernardino Station	3.7
	Total length (miles)	46.5

Appendix A: Fullerton-Riverside-San Bernardino track segments

1. Fullerton Junction to SR57 (Fullerton)
2.1 miles



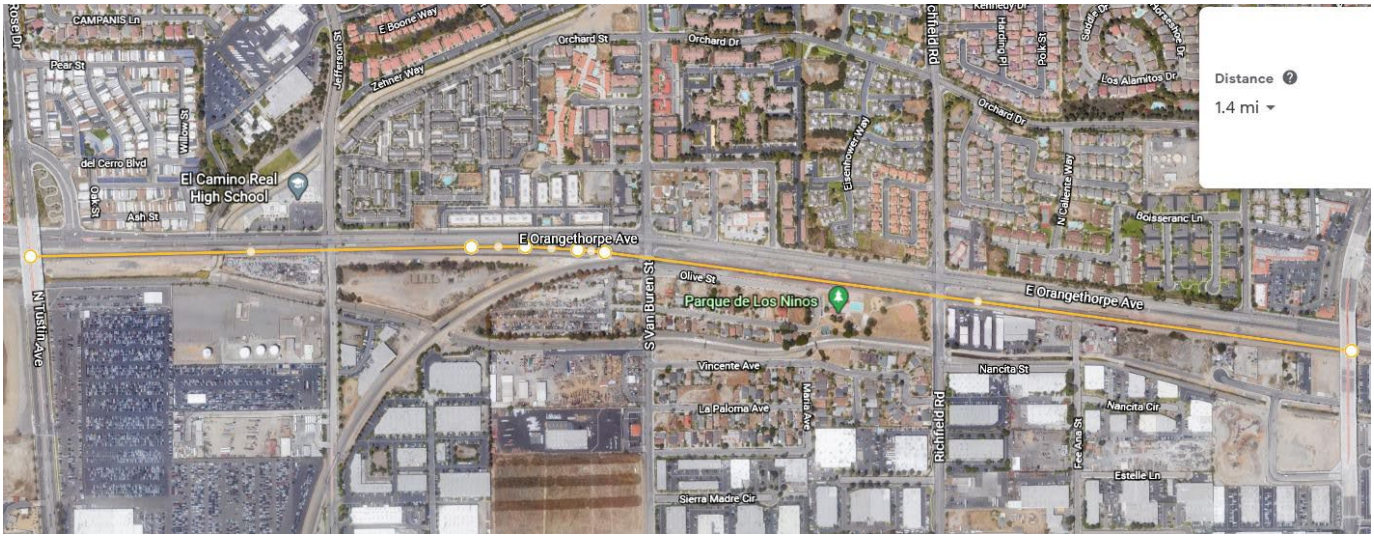
2. SR57 to Downtown Placentia pedestrian bridge (future Metrolink station)
0.5 miles



3. Downtown Placentia pedestrian bridge to E. Orangethrope Ave. (Anaheim)
1.2 miles

4. Orangethrope Avenue to North Tustin Avenue (Anaheim)
0.5 mile

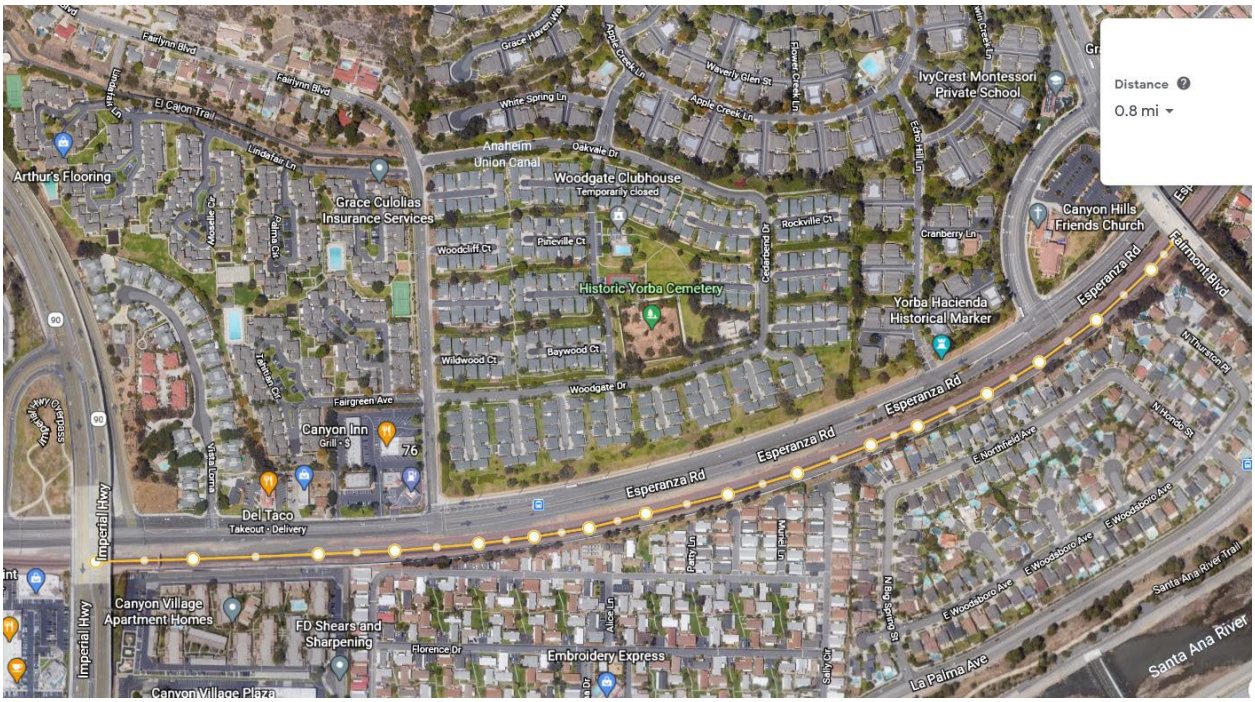
5. North Tustin Avenue (Anaheim) to Lakeview Avenue (Placentia)
1.4 mile



6. Lakeview Avenue (Placentia) to Imperial Highway (Anaheim/Yorba Linda)
1.7 miles

7. Imperial Highway to Fairmont Blvd. (Yorba Linda)

0.8 miles



8. Fairmont Blvd. to Yorba Linda Blvd. (Yorba Linda)

1.7 miles

9. Yorba Linda Blvd. to Via Lomas De Linda (Yorba Linda)

2.3 miles

10. Via Lomas De Linda to Crestridge Drive (Corona)

3.7 miles

11. Crestridge Drive to SR91 'Green River' (Corona)

0.3 Miles

12. SR91 'Green River' to SR91 'Palisades' (Corona)

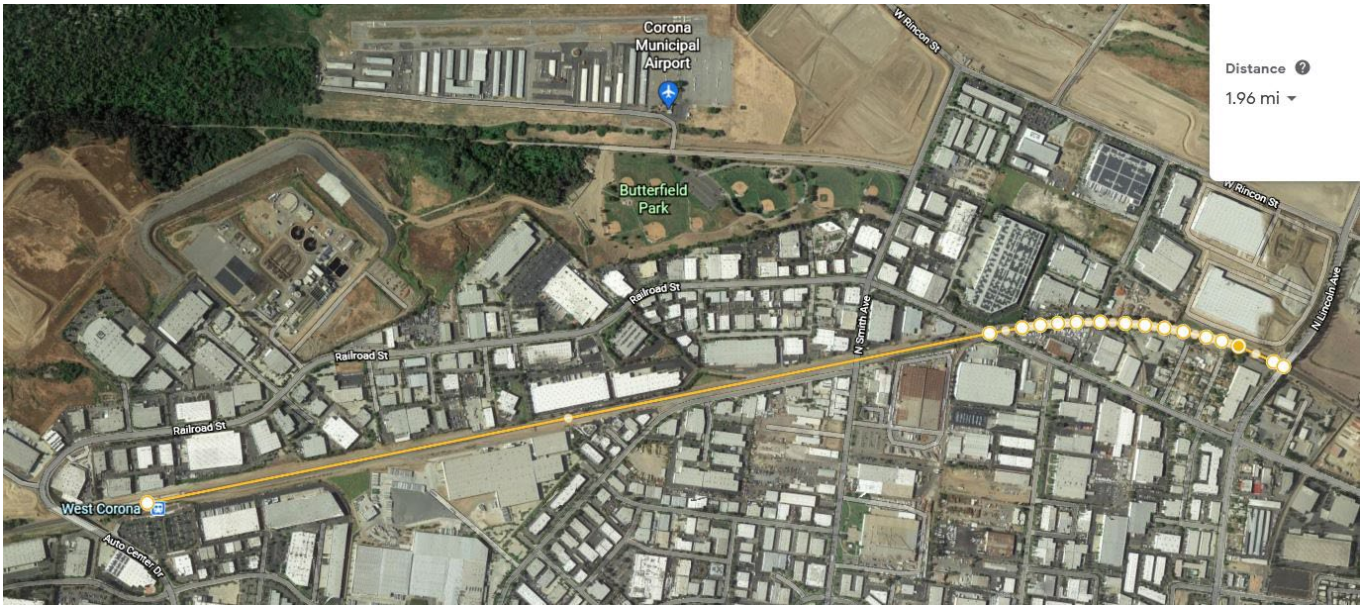
1.7 miles

13. SR91 'Palisades' to West Corona

0.8 miles

14. West Corona to North Lincoln Ave. (Corona)

2.0 miles

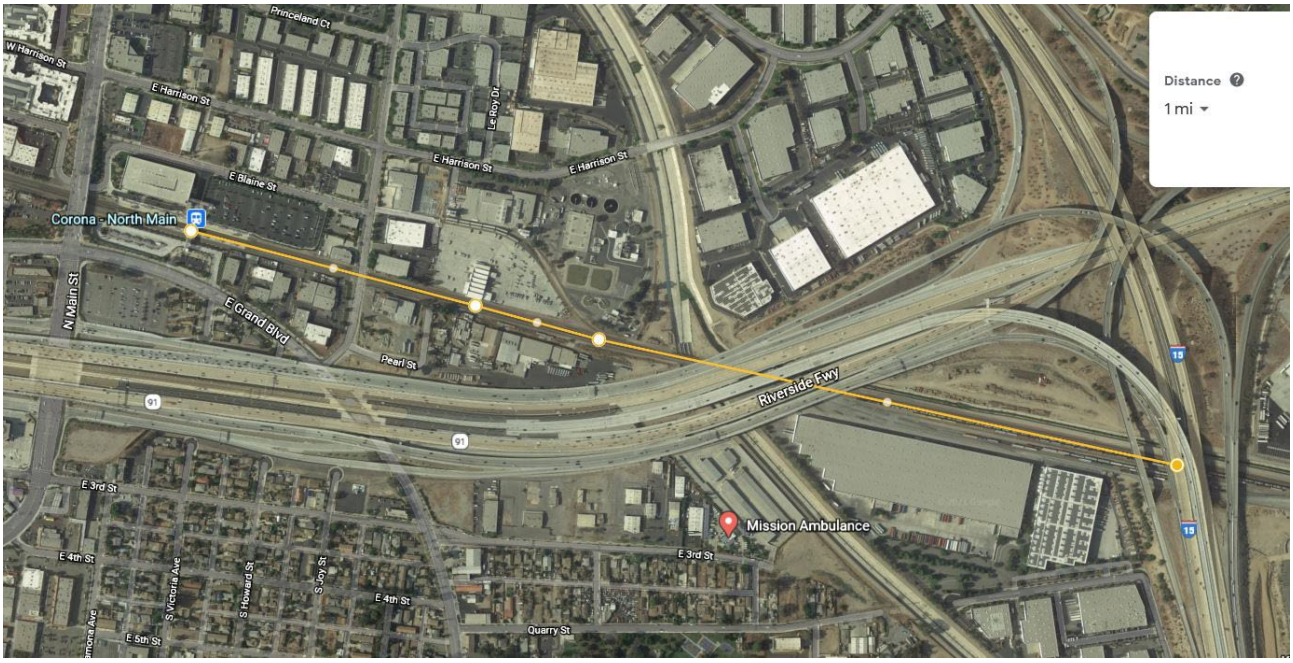


15. North Lincoln Ave. to Corona – North Main

1.1 miles

16. Corona – North Main to I-15

1.0 mile

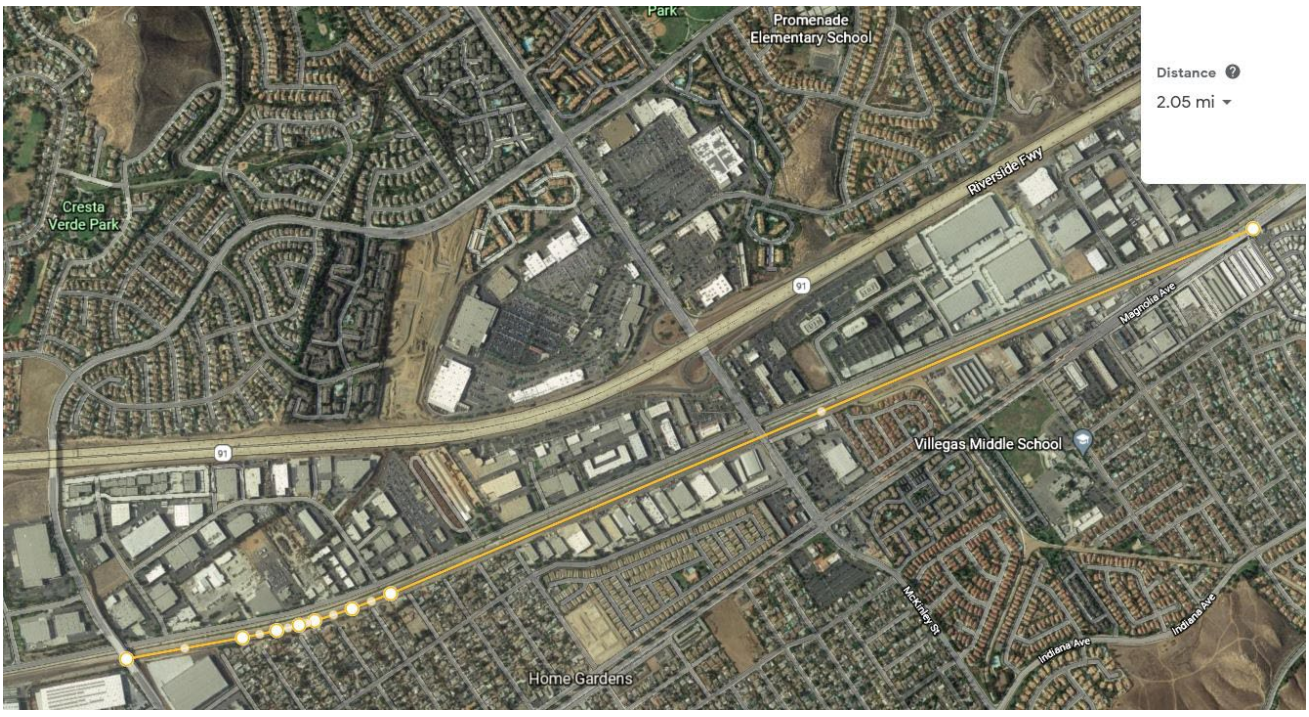


17. I-15 to South Promenade Ave. (Corona)

0.7 mile

18. South Promenade Ave. to Magnolia Ave. (Corona/Riverside)

2.1 miles

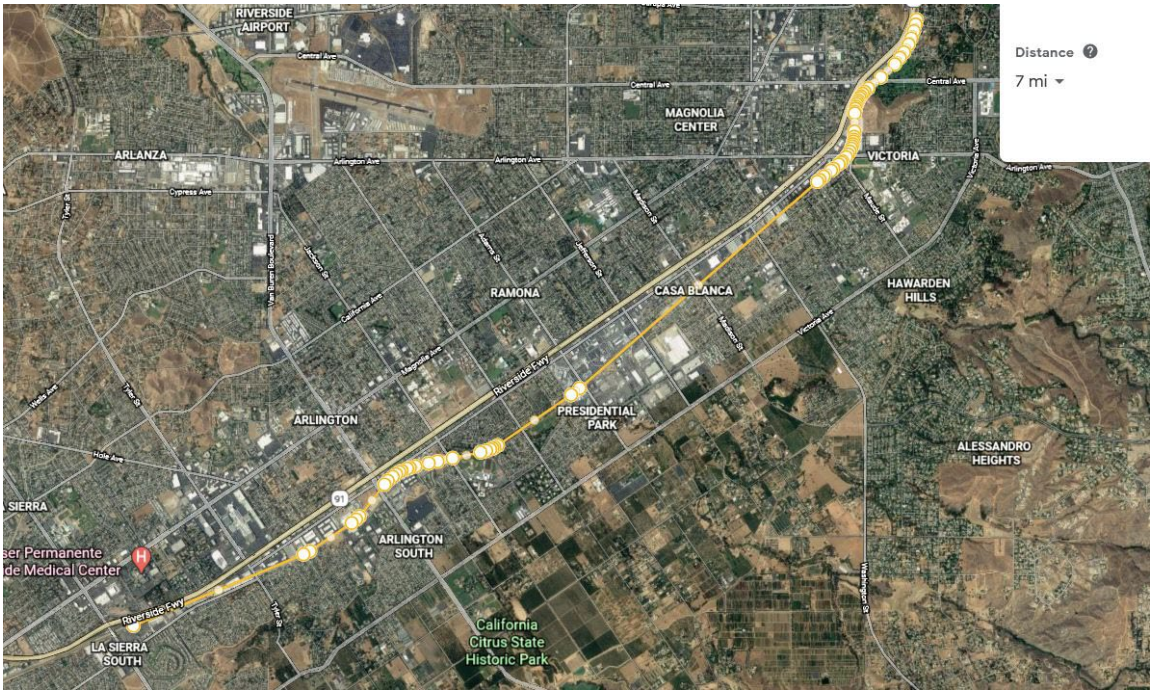


19. Magnolia Ave. to La Sierra Ave. (Riverside)

2.0 miles

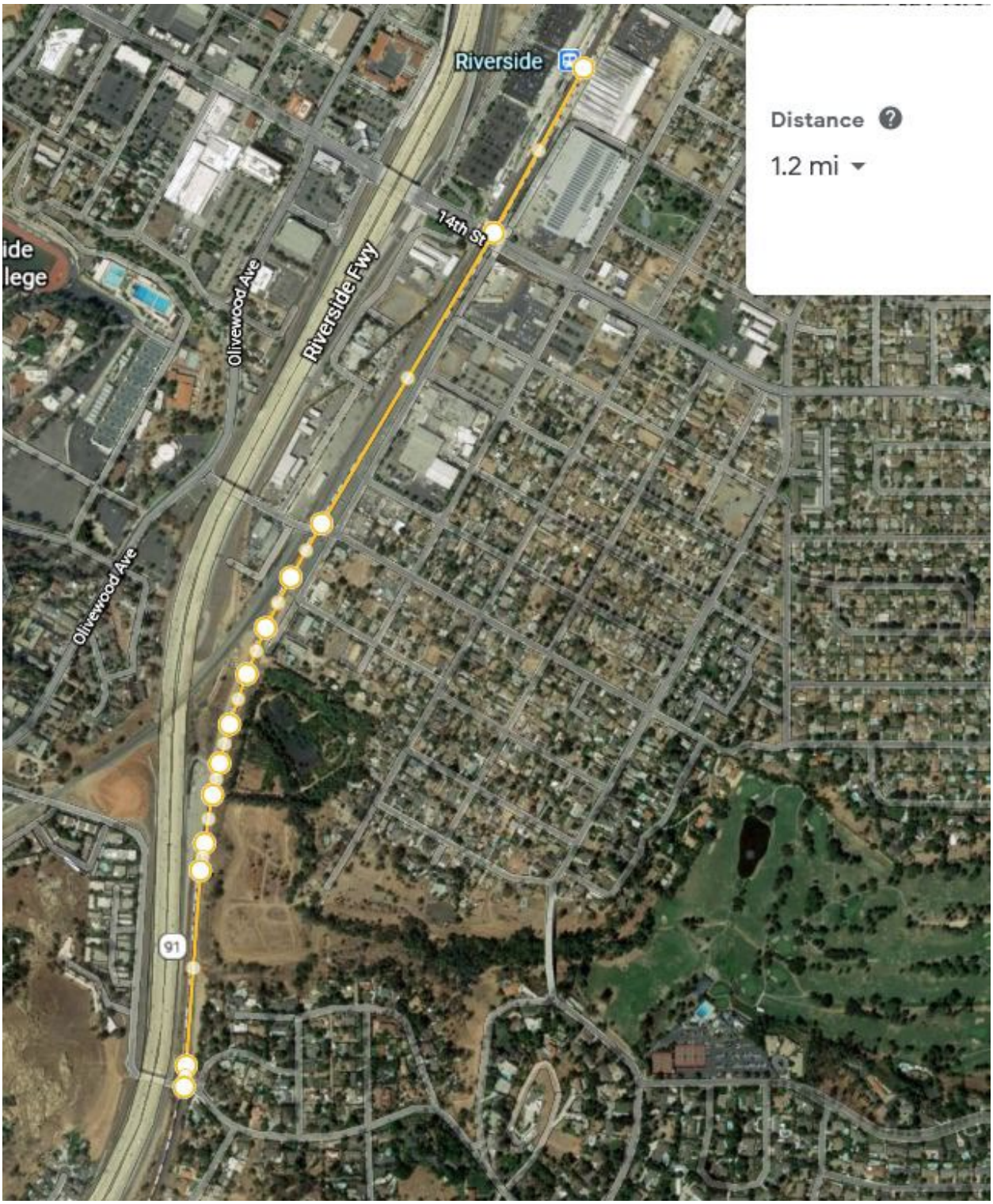
20. La Sierra Ave. to Ivy St. (Riverside)

7.0 miles



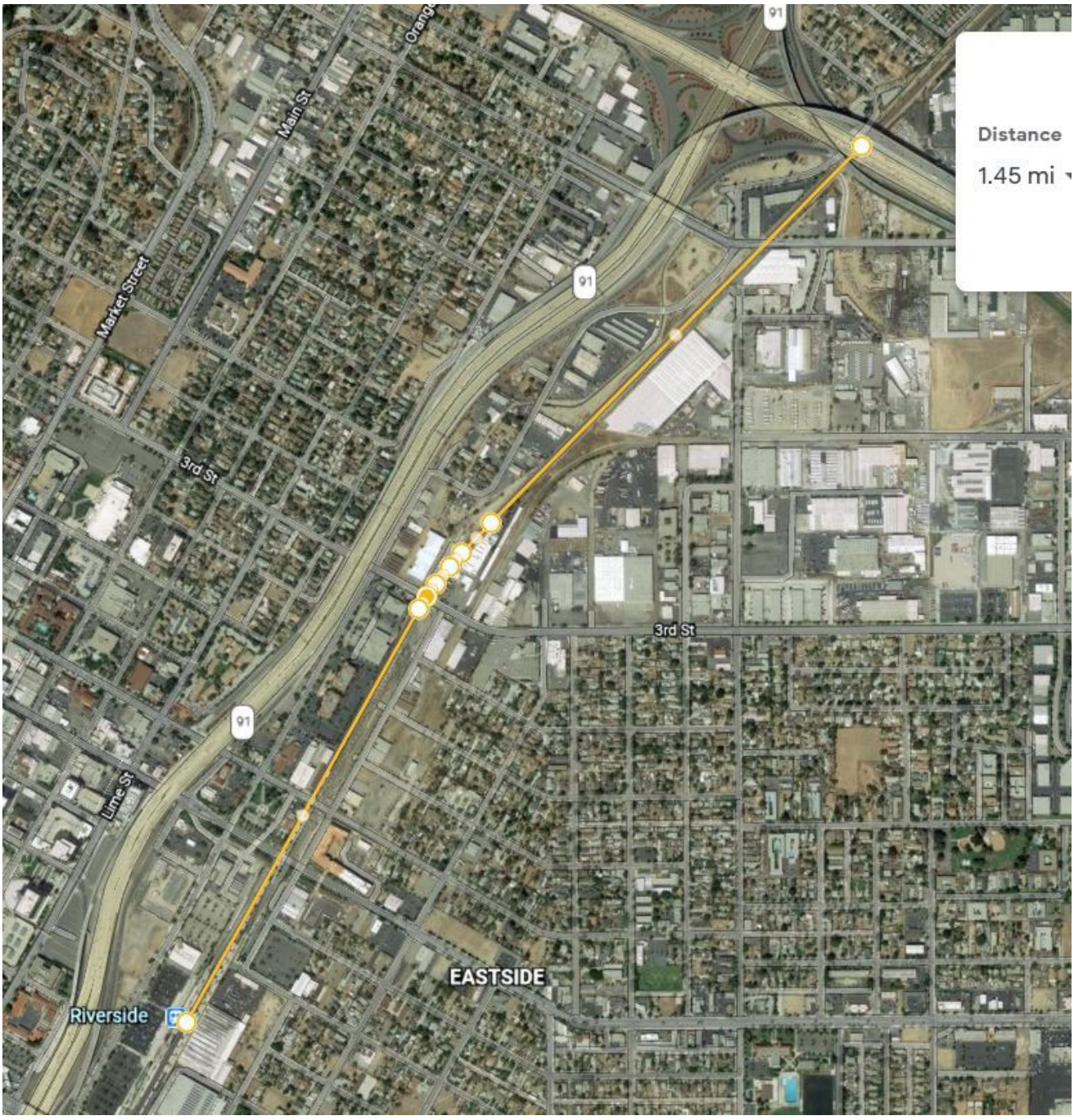
21. Ivy St. to Riverside-Downtown station

1.2 miles



22. Riverside-Downtown station to SR 60/215

1.5 miles



23. SR 60/215 to Columbia Ave. (Riverside)

0.8 miles

24. Columbia Ave. to Iowa Ave. (Riverside)

0.6 miles

25. Iowa Ave. to I-215 (Grand Terrace)

1.4 miles

26. I-215 to Santa Ana River (Grand Terrace)

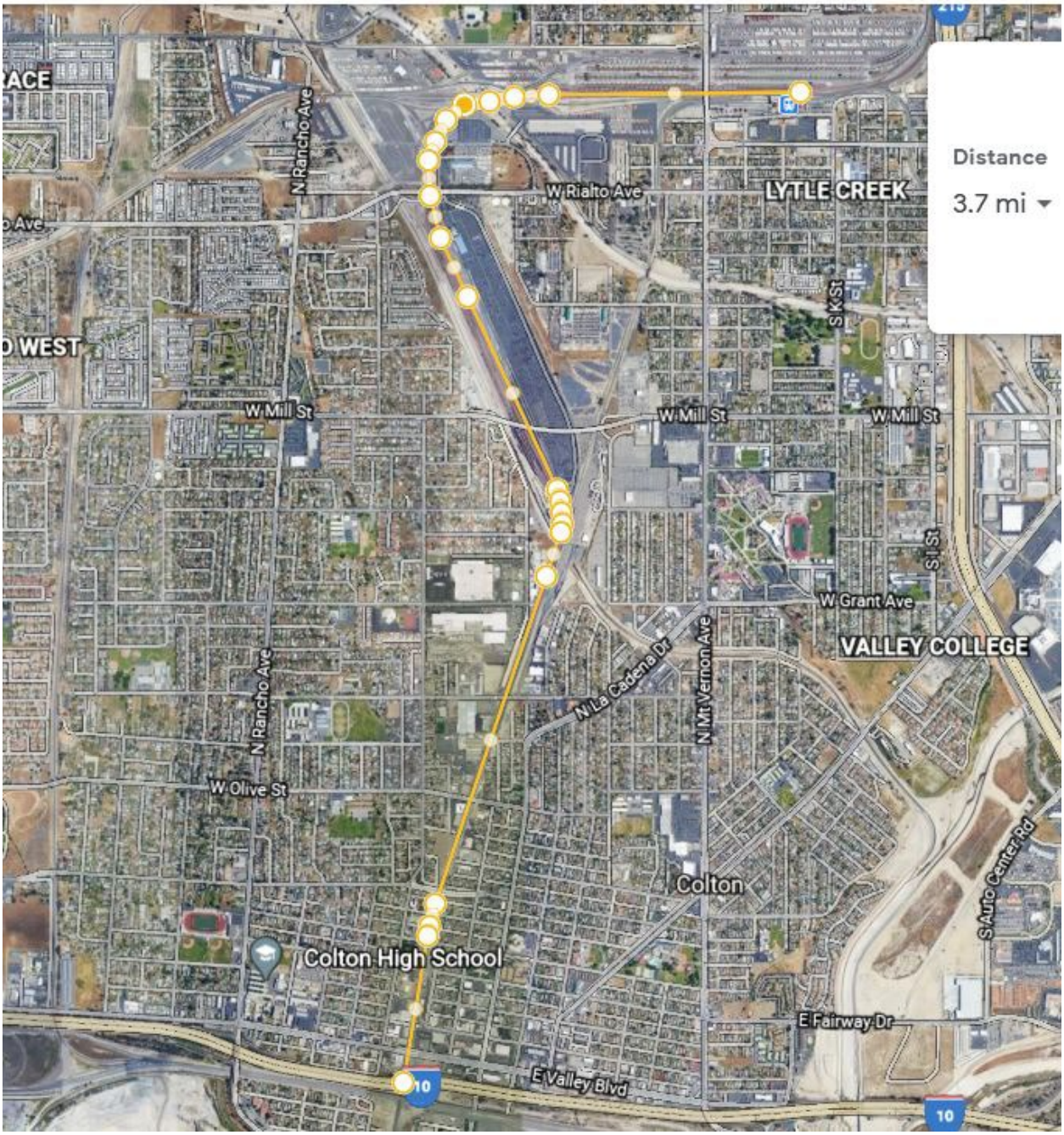
1.3 miles

27. Santa Ana River to Colton Crossing

1.4 miles

28. Colton Crossing to San Bernardino station/BNSF yard

3.7 miles



Riverside County Transportation Commission Cost Estimates for Completion of Third Mainline Track Within Riverside County

Completion of BNSF Triple Track Fullerton to Riverside

Draft 12/1/21

Currently, the triple track project Fullerton to Prado Dam is fully funded with an existing SCRRA CRISI Grant.

The remaining sections from Prado to Riverside have been identified and estimated in three sections as Project Study Reports.
The entire 3rd track section from Prado to Riverside is needed for additional passenger trains under existing agreements.

Section 1 - Prado Dam (MP 29.4) to East Porphyry (MP 4.3/East of Corona)
Third Track - 6.9 miles, Fourth Track - 2,640 track feet

PSR's Project Cost Estimate by Task:

Task Name	Task #	Estimated Cost	
Project Management & Detailed Work Plan	1	$	2,657,003
Final Design and NEPA/CEQA	2	$	17,713,355
Construction	3	$	66,425,082
Project Closeout	4	$	1,771,336
	Total Project Cost	$	88,566,776

Section 2 - East Porphyry (MP 22.50) to La Sierra (MP 17.50)
Third Track - 5 miles, Fourth Track - 5,280 track feet

PSR's Project Cost Estimate by Task:

Task Name	Task #	Estimated Cost	
Project Management & Detailed Work Plan	1	$	1,349,387
Final Design and NEPA/CEQA	2	$	8,995,912
Construction	3	$	33,734,672
Project Closeout	4	$	899,591
	Total Project Cost	$	44,979,562

Section 3 - Riveside-La Sierra (MP 17.50) to CP Ontario (MP 10.60/Riverside Downtown)
Third Track - 6.9 miles, no Fourth Track proposed

PSR's Project Cost Estimate by Task:

Task Name	Task #	Estimated Cost

Project Management & Detailed Work Plan	1	$	1,695,517
Final Design and NEPA/CEQA	2	$	11,303,448
Construction	3	$	42,387,931
Project Closeout	4	$	1,130,345
	Total Project Cost	$	56,517,241

Combined Section Totals

PSR's Project Cost Estimate by Task:

Task Name	Task #	Estimated Cost	
Project Management & Detailed Work Plan	1	$	5,701,907
Final Design and NEPA/CEQA	2	$	38,012,716
Construction	3	$	142,547,684
Project Closeout	4	$	3,801,272
	Total Project Cost	$	190,063,579

Combined Project Development	$ 43,714,623
Combined Construction/Cloesout	$ 146,348,956

Project Elements

New or modified: tracks, ballast, switches, signals, crossovers, bridges, culverts, industry track, grade crossings, pedestrian crossings, passenger platforms, passenger bridges, parking modifications, etc.

Appendix B:
Fullerton-Riverside-San Bernardino
Existing Electric Utility Substations and
Potential Construction Laydown Sites

May 8, 2022

The existing utility substations and potential laydown areas shown this appendix are all adjacent to the BNSF San Bernardino Subdivision mainline tracks in Orange, Riverside and San Bernardino counties. The two different sites are shown grouped together in this appendix because they are both important for co-mobilization of construction activities of the rail electrification of resources. The traction power substations, adjacent to the existing utility substations, will be large construction projects in and of themselves. So large laydown, storage and staging areas will be required on each substation construction site.

The utility substations shown are owned by Anaheim Public Utilities (APU), and Riverside Public Utilities (RPU), Southern California Edison (SCE). The substations shown in this appendix are located next to the tracks, but also appear to be surrounded by enough free space for a new, adjacent rail traction power substation to be built (typically 150’ x 200’ minimum footprint). Paralleling and switching stations, also needed along the line, each take up a smaller space than a traction power substation. Switching station compound dimensions are typically 80’ x 160’; paralleling station compound dimensions are typically 40’ x 80’.

Paralleling stations have a typical average spacing of about 6 to 10 miles (between paralleling stations and/or switching and traction stations). Switching stations are typically located mid-way between traction power stations.

For the 46 miles of the Fullerton-Riverside-San Bernardino electrified segment it is anticipated that the line will need two to three traction power substations, one to two switching stations, and between six and eight paralleling stations. It is not anticipated that it will be difficult to find a sufficient number of sites along the corridor for switching and paralleling stations given their smaller land footprint. Sites designated as construction laydown areas could also be sites for some of the paralleling and switching stations. Land ownership of the laydown areas, and some areas adjacent to the existing electrical substations, has not yet been determined.

Appendix B: FUL-RIV-SBD Existing Electric Utility Substations and Potential Construction Laydown Sites

Taking into account the exiting electric substation sites described below, the most likely candidate site area for traction power substations are:

1. Anaheim Lake (Anaheim)
   - 1 mile to APU Canyon sub
   - 1.2 miles to APU Dowling Sub

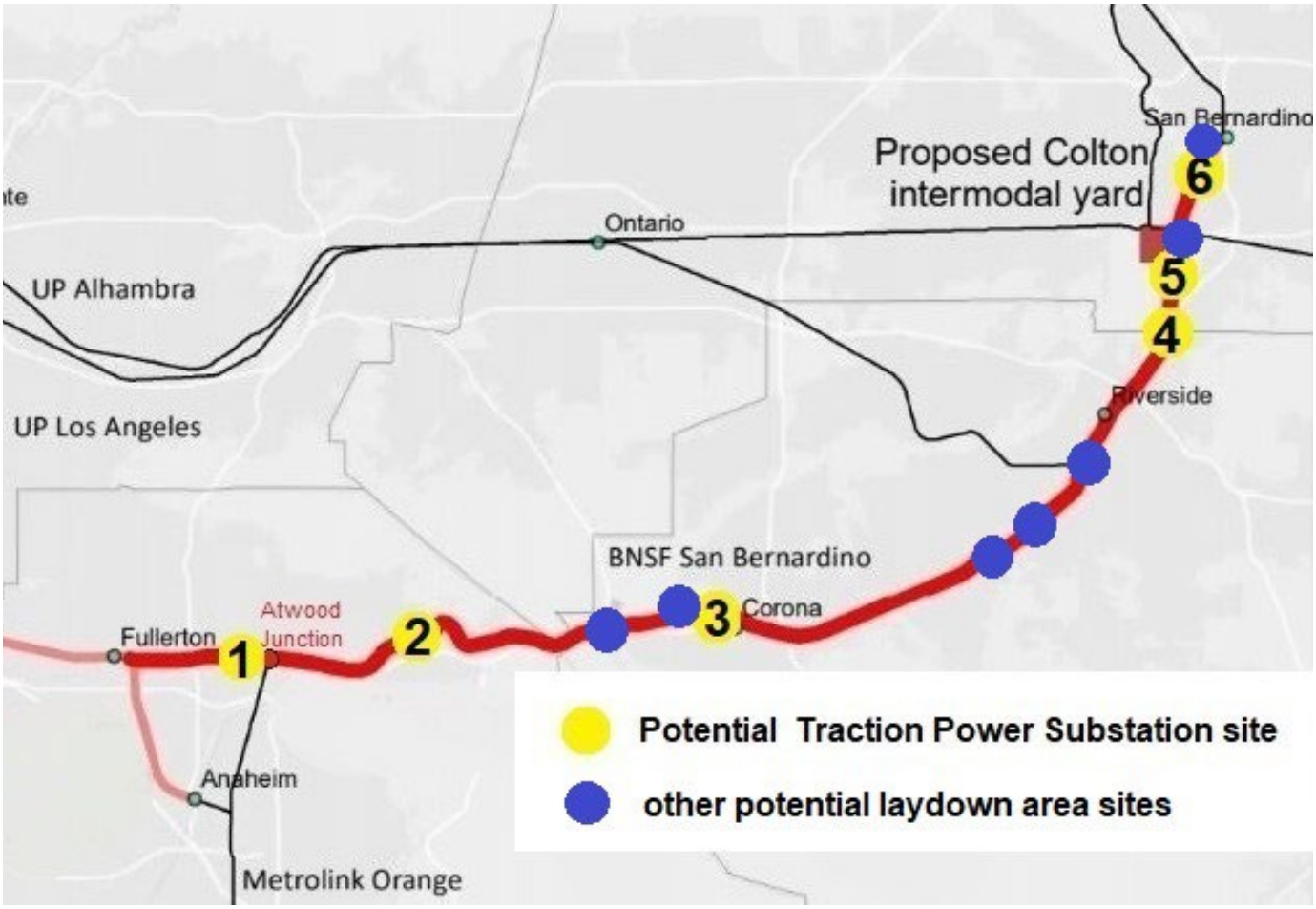
2. Esperanza/Weir Canyon (Anaheim)
   - 0.5 miles to SCE Canyon Sub

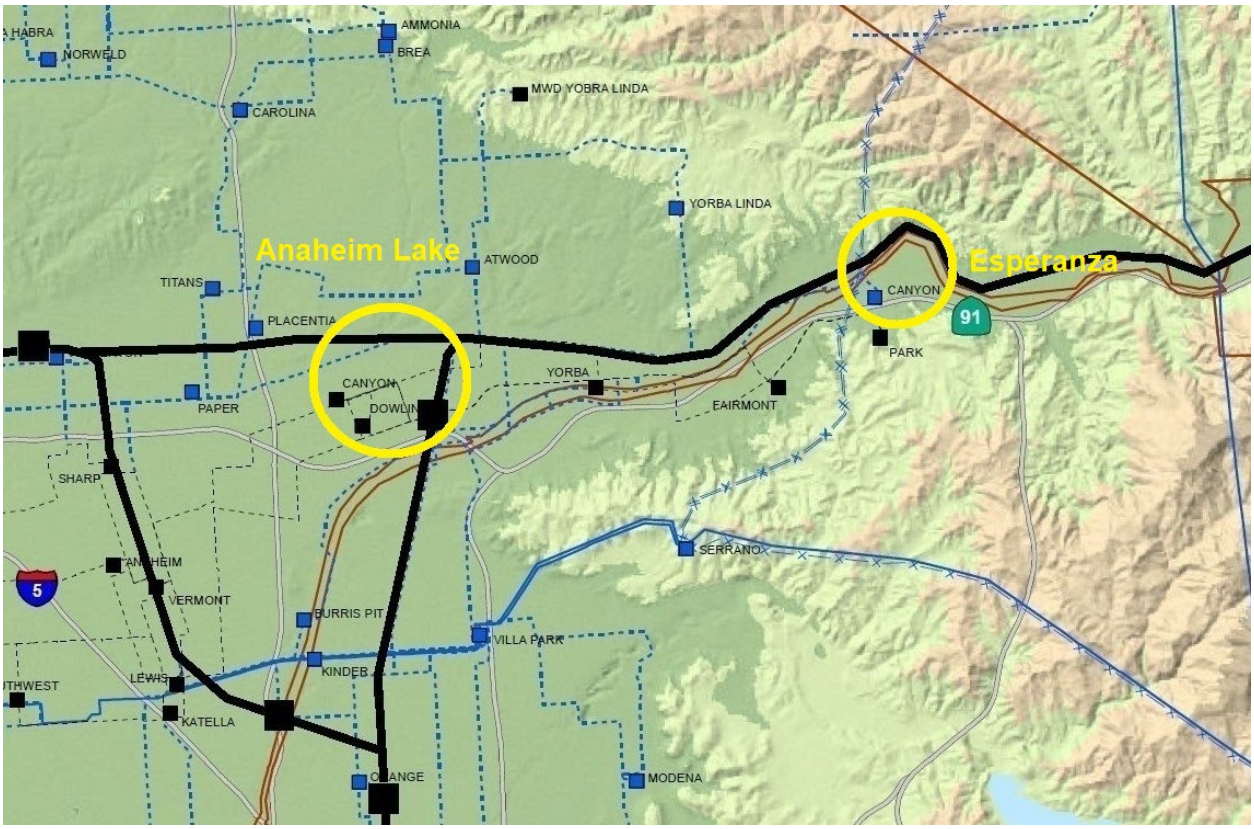
3. SCE Corona Sub (Corona)

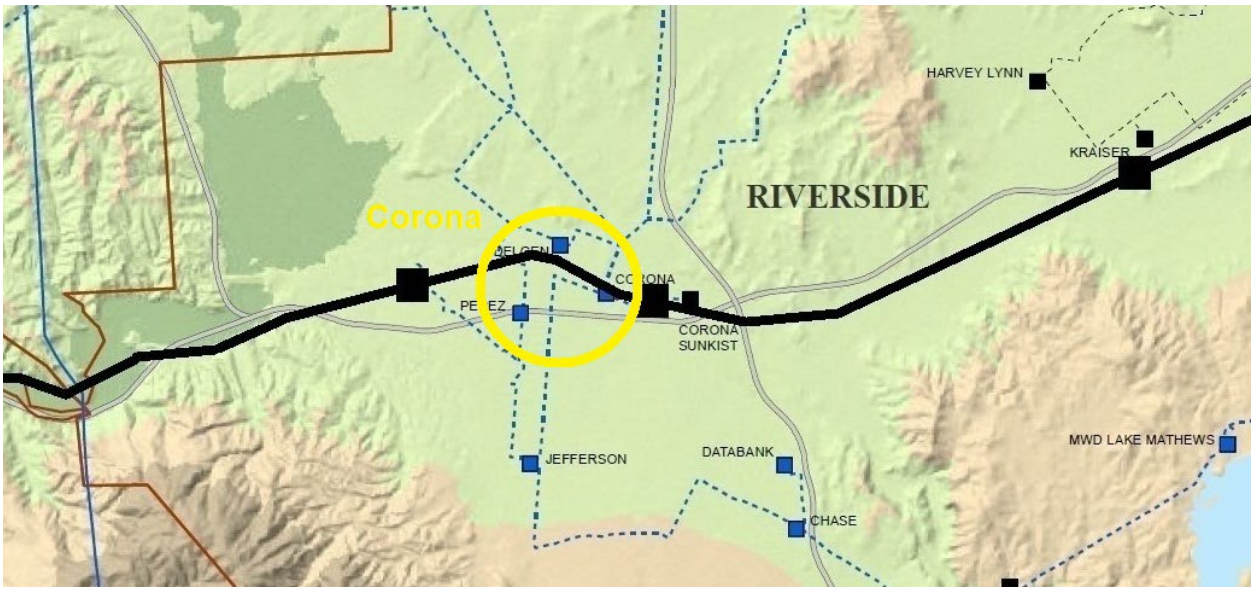
4. SCE Highgrove Sub (Grand Terrace)

5. Santa Ana River/Vista (Grand Terrace)
   - 0.6 miles to SCE Vista Sub

6. Calectric/Metrolink EMF
   - 0.5 miles to SCE Calectric Sub

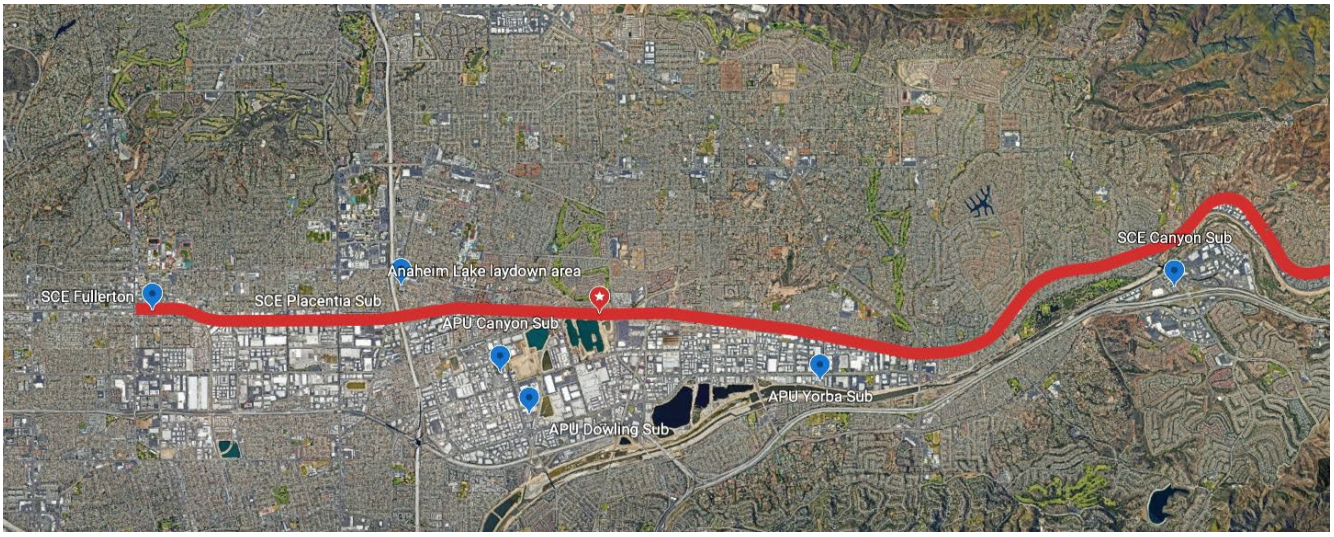




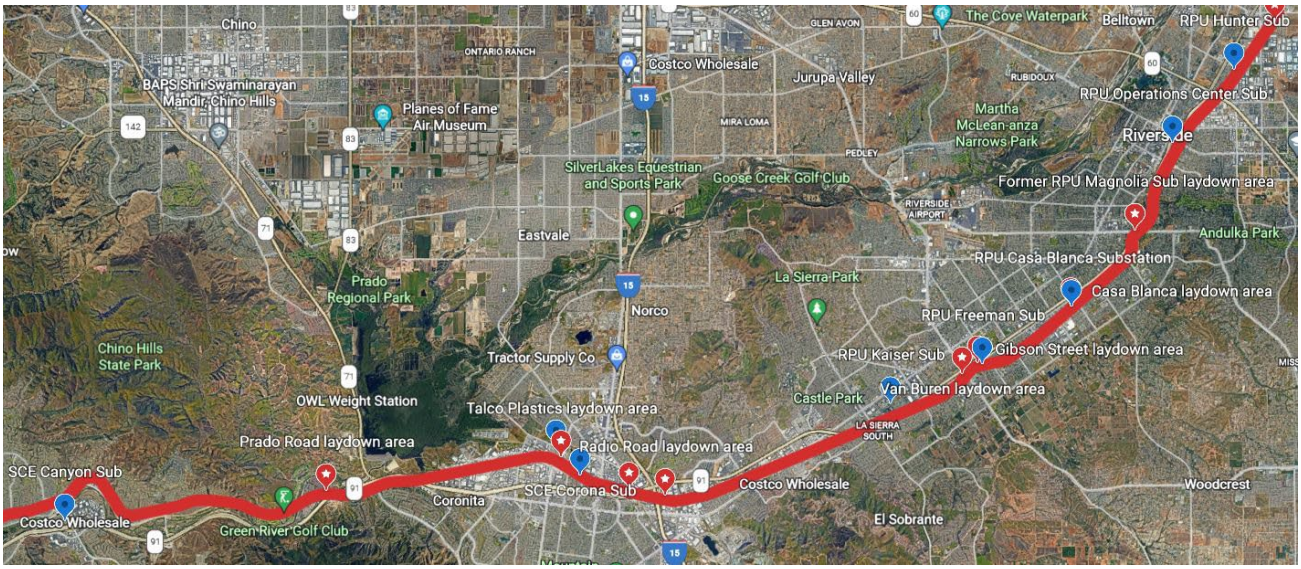


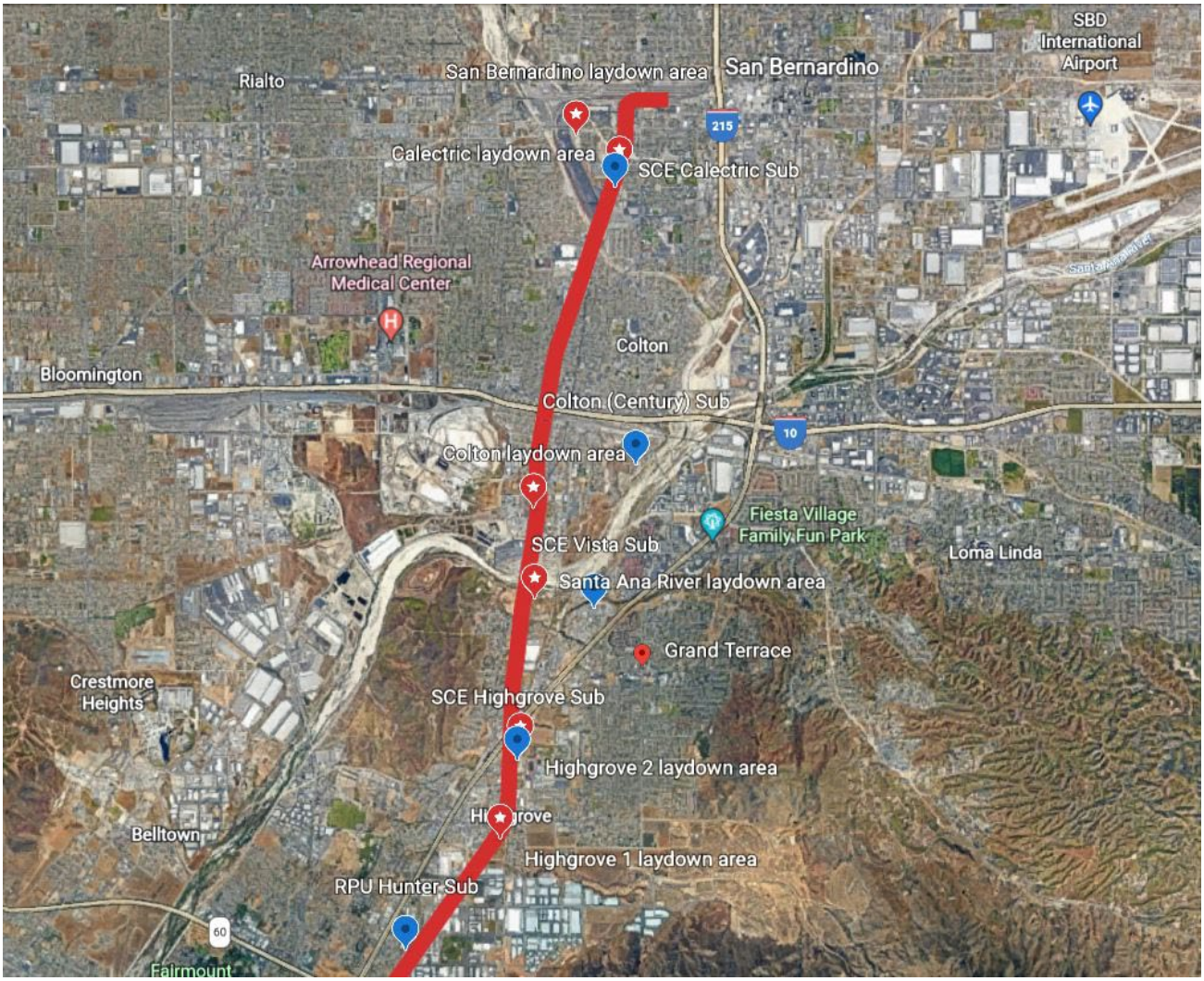
(above maps are from California Energy Commission, annotated by author)

Appendix B: FUL-RIV-SBD Existing Electric Utility Substations and Potential Construction Laydown Sites



Appendix B: FUL-RIV-SBD Existing Electric Utility Substations and Potential Construction Laydown Sites



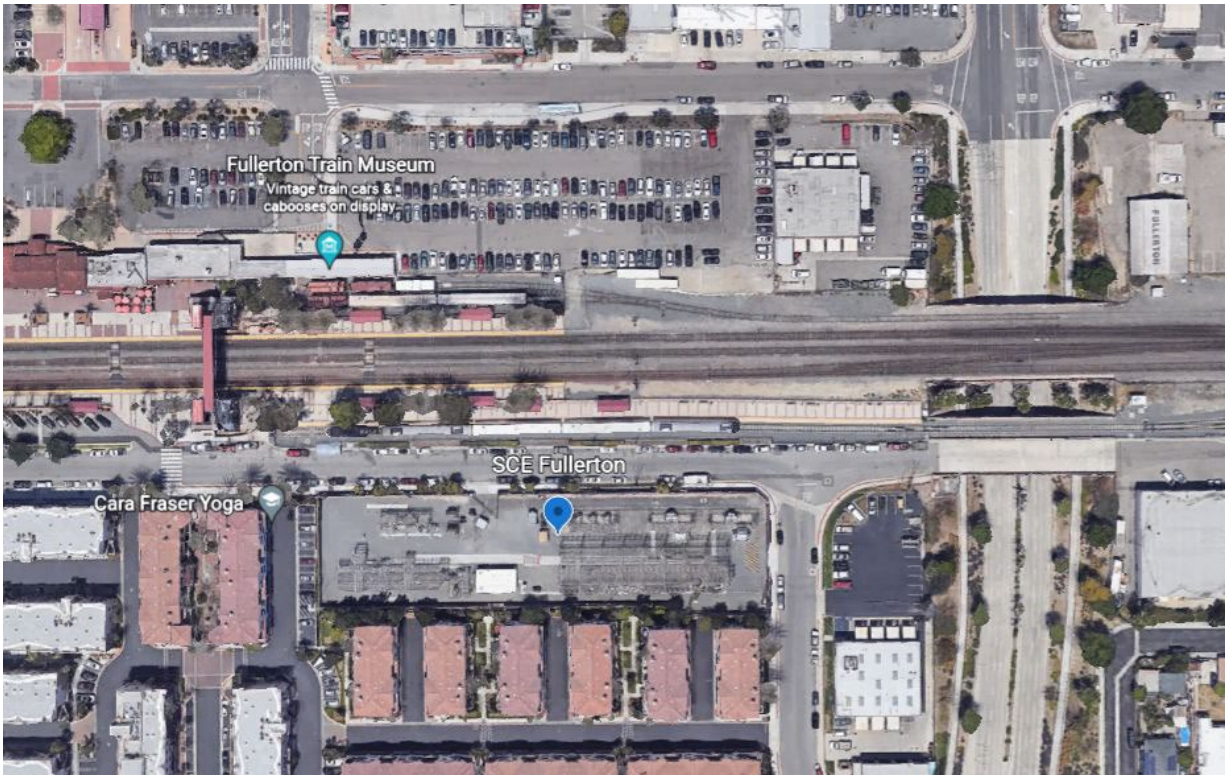


SCE Fullerton Sub

MP ~46

280 E Walnut Ave, Fullerton, CA 92832

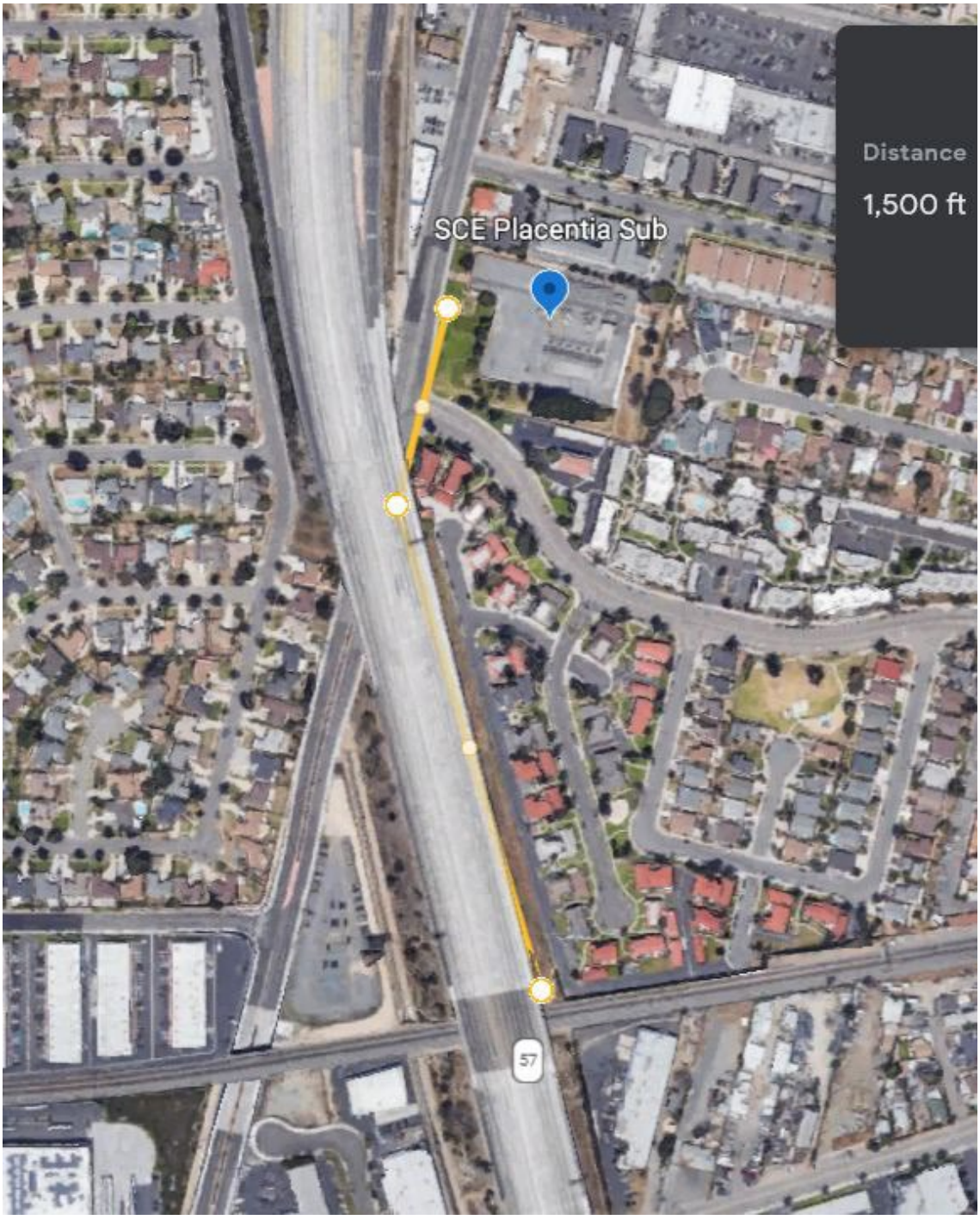
Located across the tracks from the Fullerton passenger train station, about 1/3 west of Fullerton Junction



SCE Placentia Sub

MP ~43.2

220 S Placentia Ave, Placentia, CA 92870
Located about ¼ mile north of tracks.



Anaheim Lake laydown area

MP ~41.5

925 E Crowther Ave, Anaheim, CA 92806

Located about one mile from two major APU substations: Canyon and Dowling, this is a likely traction power substation location. There is also an existing SCE transmission line passing the site, shown on California Energy Commission maps as 66 kV. The site, located between the BNSF tracks and Atwood Channel, is about 1000’ long x 100’ wide. It should be feasible to build bridge structures over Atwood Channel, and extend the usable width of some of the site to about 150’. Concrete walls and a higher-elevation pad would be needed to protect against possible flooding. Another potential laydown or substation site, about 300’ x 300’ in size, is located further south along N. Tustin Ave, is currently being used as a staging area for construction of a City of Anaheim groundwater treatment plant.

An existing 69 kV APU transmission line goes north from Dowling Sub along the Carbon Canyon Diversion Channel north to Miraloma Avenue. Another 69 kV APU line goes from the Canyon gas-fired generating station eastward along E. Miraloma Avenue. A new transmission line to the traction power substation could also go along these routes.

Anaheim Lake site from Orangethorpe overpass, and existing 66 kV SCE overhead line (May 4, 2022 photo)

Anaheim Lake site from Orangethorpe overpass, showing Atwood Channel and existing 66 kV SCE overhead line (May 4, 2022 photo)

Anaheim Lake site from N. Tustin Ave. overpass, showing Atwood Channel (May 1, 2022 photo)

Construction staging site for City of Anaheim wastewater plant on N. Tustin Ave. (May 1, 2022 photo)

Looking north along Carbon Canyon Diversion Channel and 69 kV APU overhead line (May 4, 2022 photo)

Looking south along Carbon Canyon Diversion Channel and 69 kV APU overhead line towards APU Dowling Sub (May 4, 2022 photo)

APU Dowling Sub (May 4, 2022 photo)

APU Yorba Sub

MP ~39.1

1000 Kellogg Drive, Anaheim, CA 92899

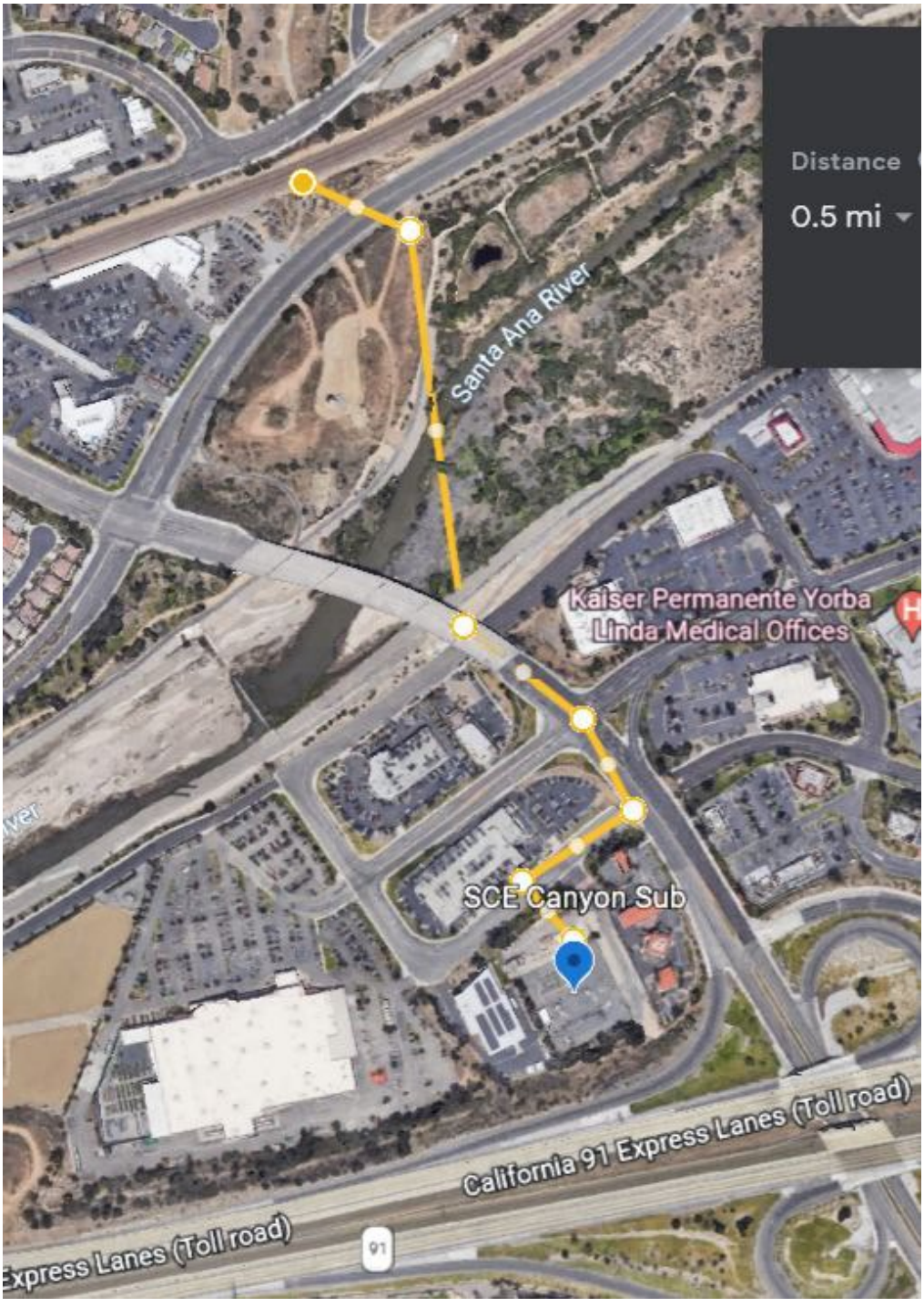
About ½ mile south of track

SCE Canyon Sub

MP ~35.8

1002 Old Canal Road, Anaheim, CA 92807

About ½ mile from CP Esperanza



Prado Road laydown area

MP ~29.7

4600 Prado Road, Corona, CA 92880

Potential Prado Road laydown area (May 1, 2022 photo)

SCE Corona Sub and Talco Plastics laydown area

SCE Corona Sub-

MP ~24.5

1000 West Rincon Street, Corona, CA 92880

Talco Plastics laydown area-

MP ~25.0

1000 West Rincon Street, Corona, CA 92880

Potential Talco Plastics laydown area (May 1, 2022 photo)

Van Buren laydown area

MP ~16.7

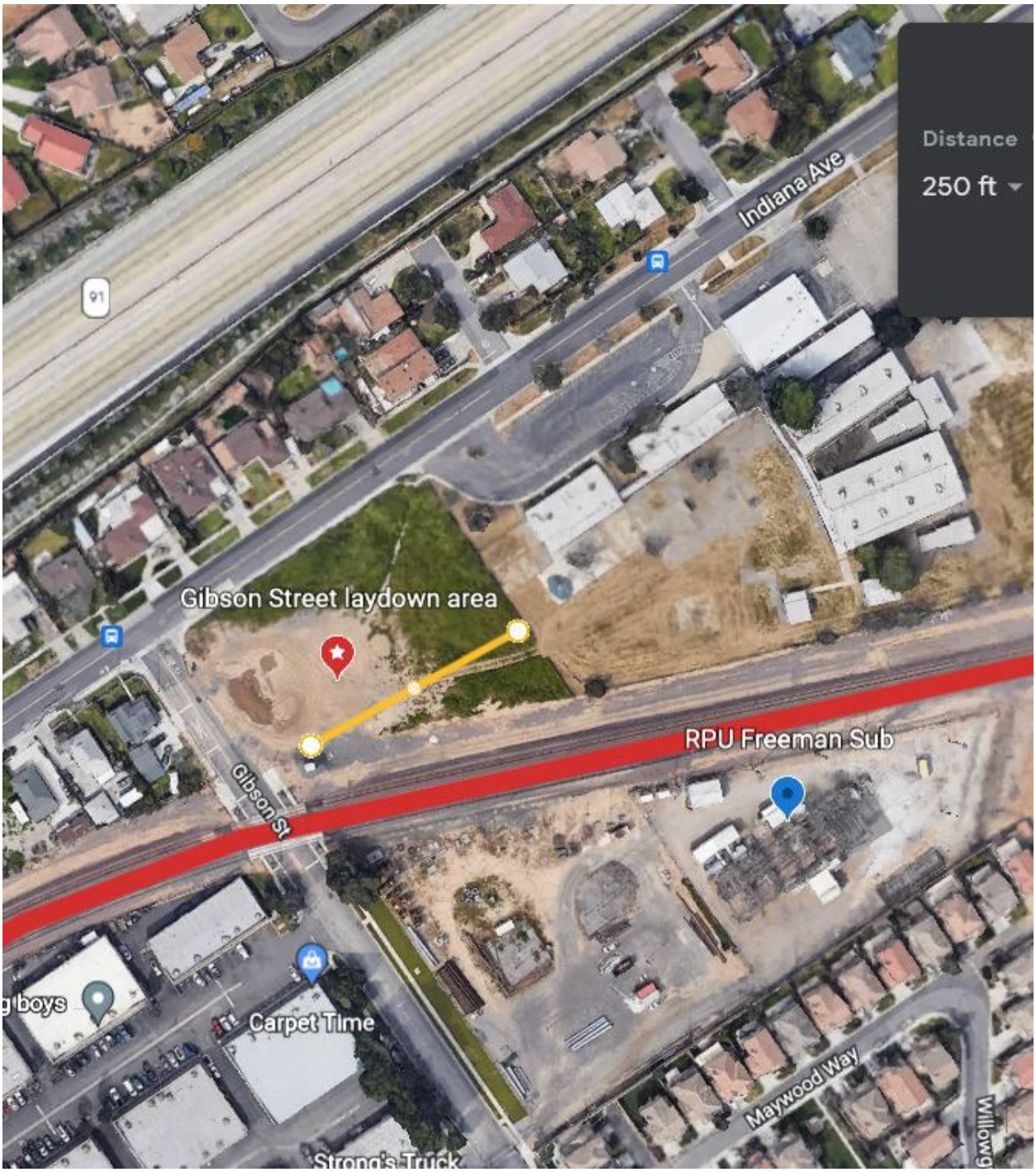
9560 Indiana Avenue, Riverside, CA 92503

Potential Van Buren laydown area (May 1, 2022 photo)

RPU Freeman Sub and laydown area

MP ~16.3

Laydown area:
3377 Gibson Street, Riverside, CA



RPU Freeman substation and potential Gibson Street laydown area (May 1, 2022 photo)

RPU Casa Blanca substation and laydown area

MP 14.0

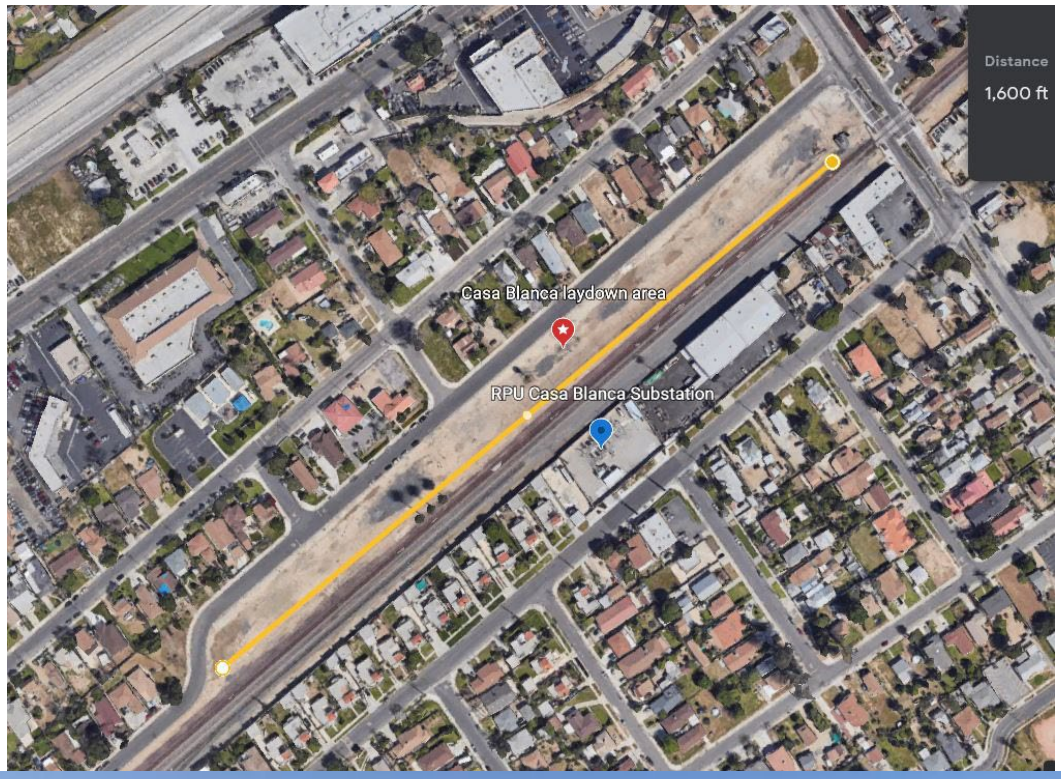
RPU Casa Blanca substation

7605 Evans St, Riverside, CA 92504

Laydown area (located at CP Casa Blanca):

7600 Railroad Avenue, Riverside, CA 92504

The potential laydown area site is reported to become an affordable housing complex.



RPU Casa Blanca substation and potential laydown area (May 1, 2022 photo)

Former RPU Magnolia Sub laydown area

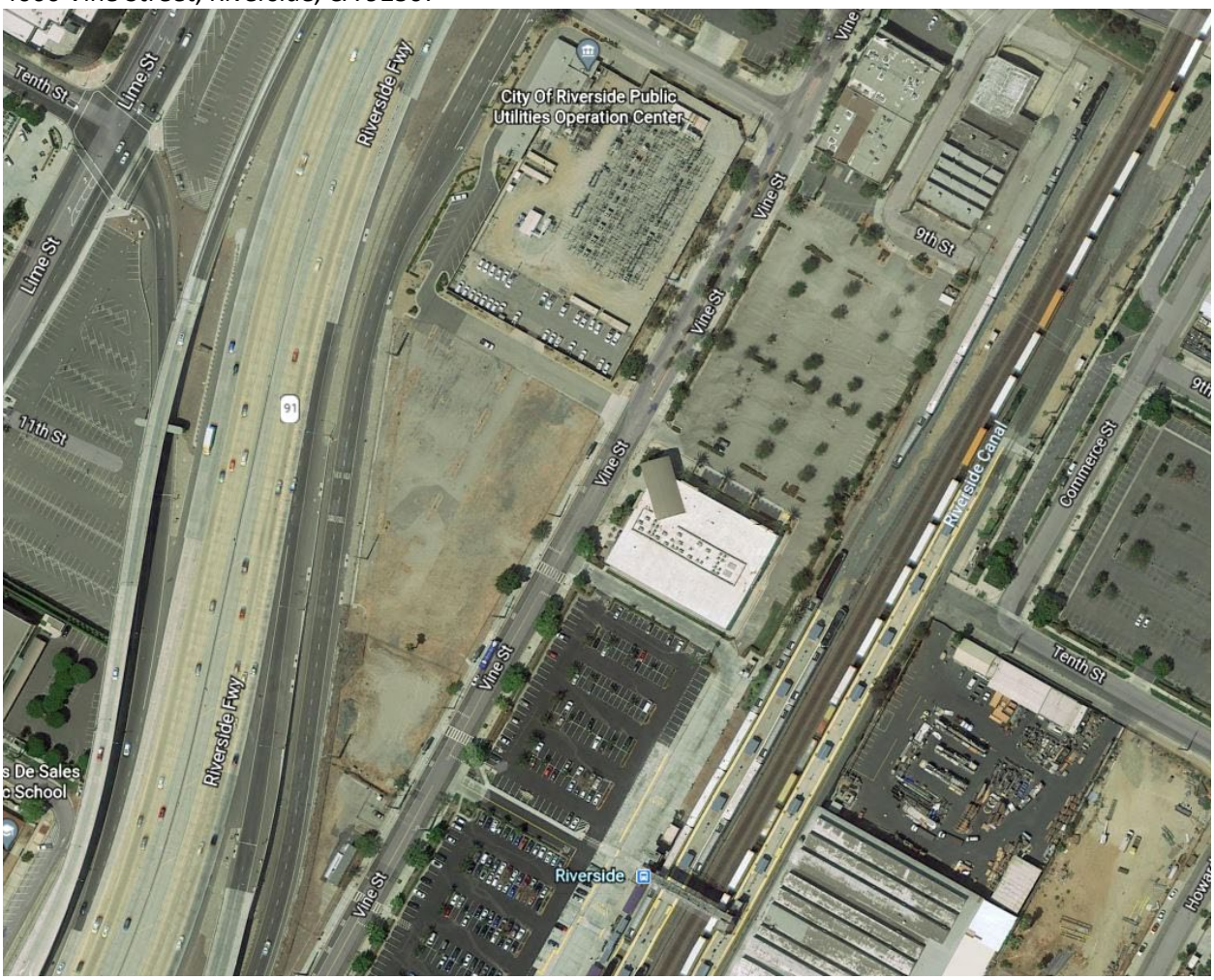
MP ~11.0

3350 Central Avenue, Riverside, CA 92506

Riverside station and RPU Operations Center Sub

MP 9.8

4066 Vine Street, Riverside, CA 92507



RPU Hunter Sub

MP 8.0

1450 Chicago Avenue, Riverside, CA 92507

RPU Hunter Substation (May 1, 2022 photo)

Perris Valley Junction / "Highgrove 1" laydown area

MP 7.1

1050 Villa Street, Riverside, CA 92507

The laydown area is located at the Perris Valley Junction

Perris Valley Junction laydown area, looking south from Villa Street (May 1, 2022 photo)

Perris Valley Junction laydown area, looking south from Villa Street (May 1, 2022 photo)

SCE Highgrove Sub and laydown area

MP 6.3

12700 Taylor Street, Grand Terrace, CA 92313

SCE Highgrove Sub is located at CP Highgrove (MP 6.3)

The empty fields north of SCE Highgrove Sub are clear, but appear to be drainage basins.

The closest classroom buildings of nearby Grand Terrance High School are about ¼ mile (1200') from the "Highgrove 2" laydown area.

SCE Vista substation and Santa Ana River laydown area

MP 4.8

21000 Vivienda Avenue, Grand Terrace, CA 92313

Preferred location for a traction power substation is on the south banks of the Santa Ana River, north of transmission lines going to the Vista Substation. Concrete walls and a higher-elevation pad would be needed to protect from possible flood damage.

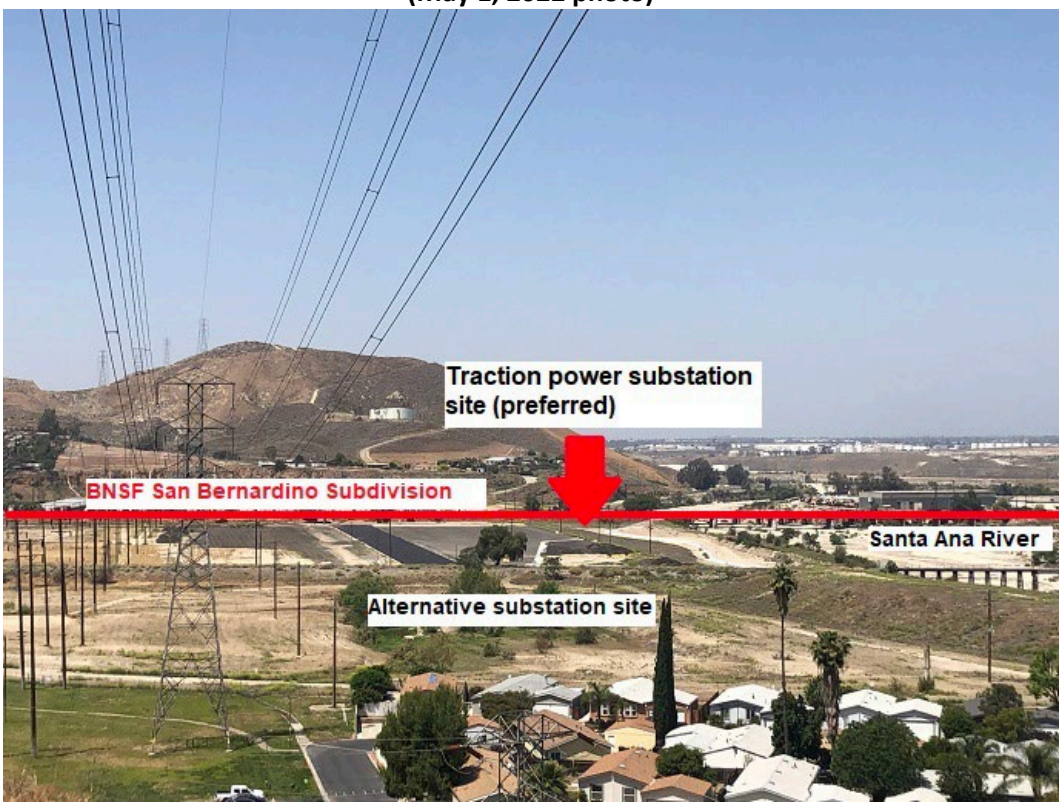
As of May 2022, the much of the site is under construction as a large asphalt parking lot for trucks and trailers going to a new large warehouse on the other side of the tracks and across S. La Cadena Drive.

The parking lot, parts of which could be used as a laydown area, is about 1100’ wide.

Looking east from potential Santa Ana River substation site towards Vista Substation (May 1, 2022 photo)

Looking south from potential Santa Ana River substation site (May 1, 2022 photo)

Looking north towards potential Santa Ana River substation site from Vivienda Ave. (May 1, 2022 photo)

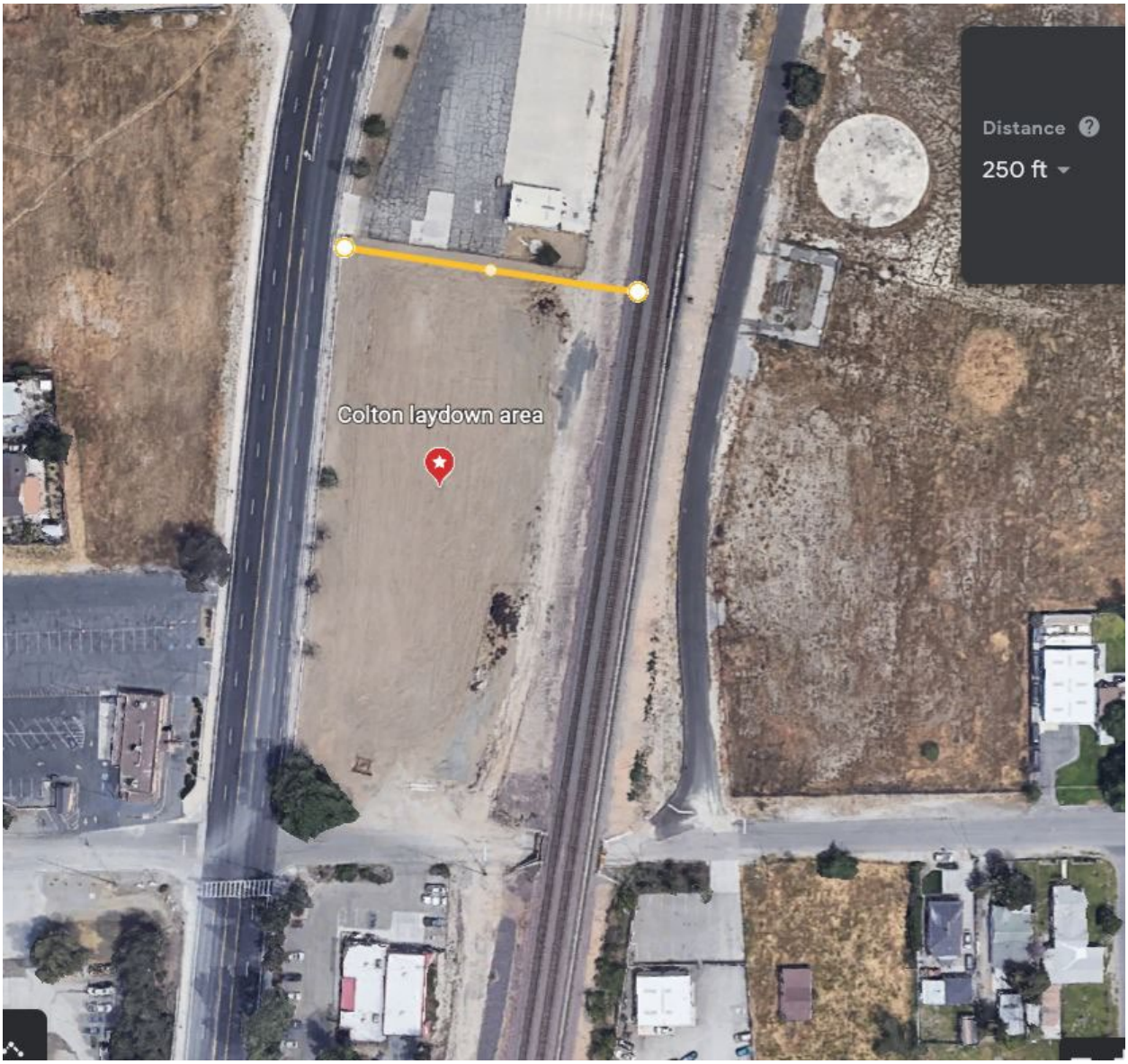


Looking west towards potential Santa Ana River substation site from SCE Vista Substation (Grand Terrace Road (May 1, 2022 photo)

Colton laydown area

MP 4.0

1080 South La Cadena Drive, Colton, CA 92324



To the south of the site, across Fogg Street, is City of Colton Fire Station 213.

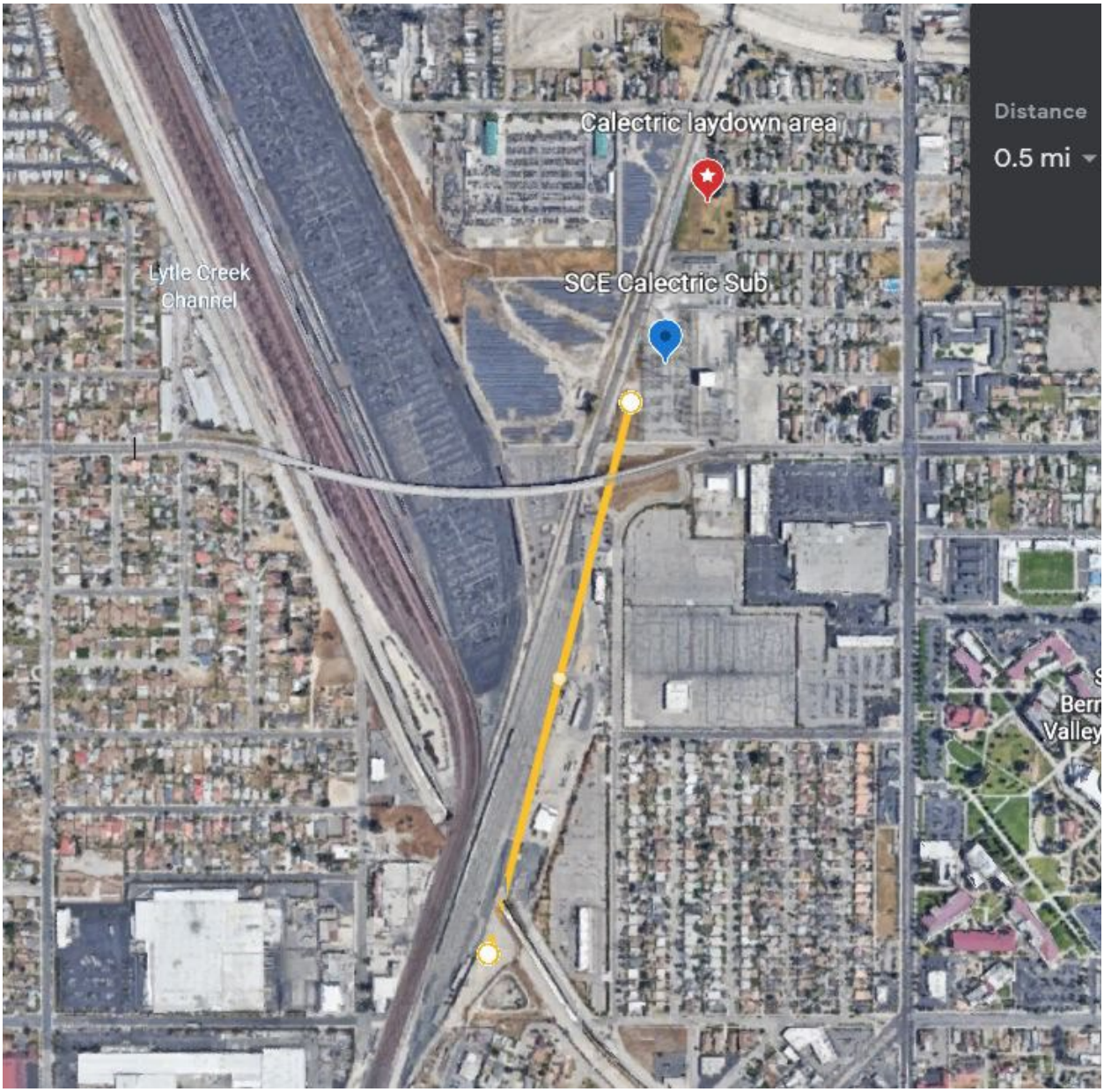
Colton potential laydown area (May 1, 2022 photo)

SCE Calectric Sub and laydown area

MP 1.1

1370 Chestnut Street, San Bernardino, CA 92410

Located at CP Mill, just east of the Inter Rail Transport automobile transport railyard facility, south of BNSF San Bernardino yard and J.B. Hunt intermodal yard.

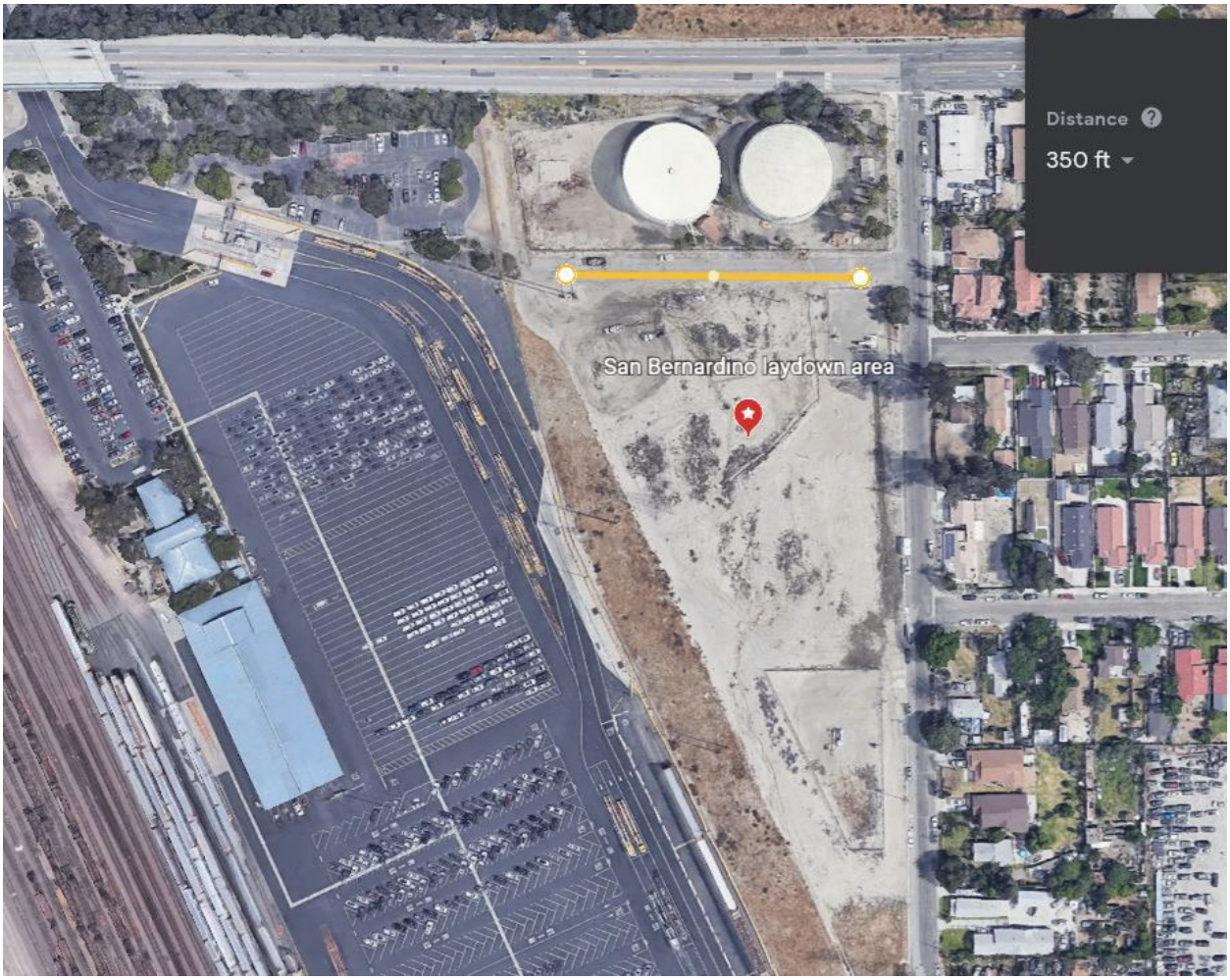


SCE Calectric substation and potential laydown area (May 1, 2022 photo)

San Bernardino laydown area

MP ~0.5

145 S. Muscott Street, San Bernardino, CA 92410



Potential laydown area in San Bernardino (May 1, 2022 photo)

Appendix C:

Fullerton-Riverside-San Bernardino

Bridges over BNSF Mainline

There are 26 road bridges (considering multi-bridge freeway overhead crossings one 'unit') and 5 pedestrian bridges at stations, and one railroad overpass between Fullerton and San Bernardino. Photos of the bridges listed below were all taken on April 17, 2022, except for the photos of the railroad bridge over I-215 (which were taken on May 22, 2022). All of them appear to be sufficiently high enough for 50 kV (with neutral sections, special insulators, etc at the lowest bridges), without modifications to the bridge or track. A lot of them looked like they were built in the past 30 years or so, in the era of the double-stacked container train.

1. **SR57 (Fullerton)**
2. **Downtown Placentia pedestrian bridge**
3. **E. Orangethorpe Ave. (Anaheim)**
4. **N. Tustin Ave. (Anaheim)**
5. **Lakeview Ave. (Placentia/Anaheim)**
6. **Imperial Highway (Anaheim/Yorba Linda)**
7. **Fairmont Blvd. (Yorba Linda)**
8. **Yorba Linda Blvd. (Yorba Linda)**
9. **Via Lomas De Yorba (Yorba Linda)**
10. **Crestridge Drive (Corona)**
11. **SR91 Green River (Corona)**
12. **SR91 Palisades (Corona)**
13. **Auto Center Dr. and West Corona pedestrian bridge (Corona)**
14. **N. Lincoln Ave. (Corona)**
15. **North Main St. and Corona – North Main pedestrian bridge (Corona)**
16. **SR91 Temescal Wash (Corona)**
17. **I-15 (Corona)**
18. **S. Promenade Ave. (Corona)**
19. **Magnolia Ave. (Corona/Riverside)**
20. **La Sierra Ave. and La Sierra pedestrian bridge (Riverside)**
21. **Ivy St. (Riverside)**
22. **Riverside Downtown-pedestrian bridge**
23. **SR60-I215 (Riverside)**
24. **Columbia Ave. (Riverside)**
25. **Iowa Ave. (Riverside)**
26. **Railroad bridge over I-215(Grand Terrace/Colton)**
27. **Barton Rd. (Colton)**
28. **Colton Crossing and I-10 (Colton)**

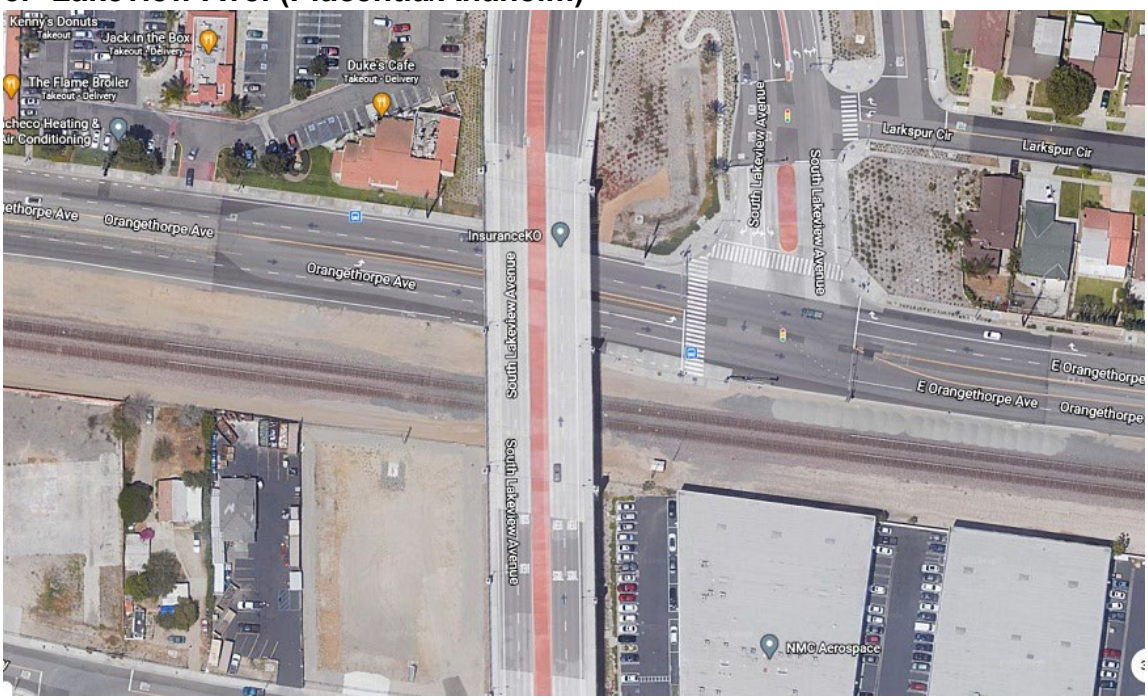
1. SR57 (Fullerton)

2. Downtown Placentia pedestrian bridge

3. E. Orangethorpe Ave. (Anaheim)

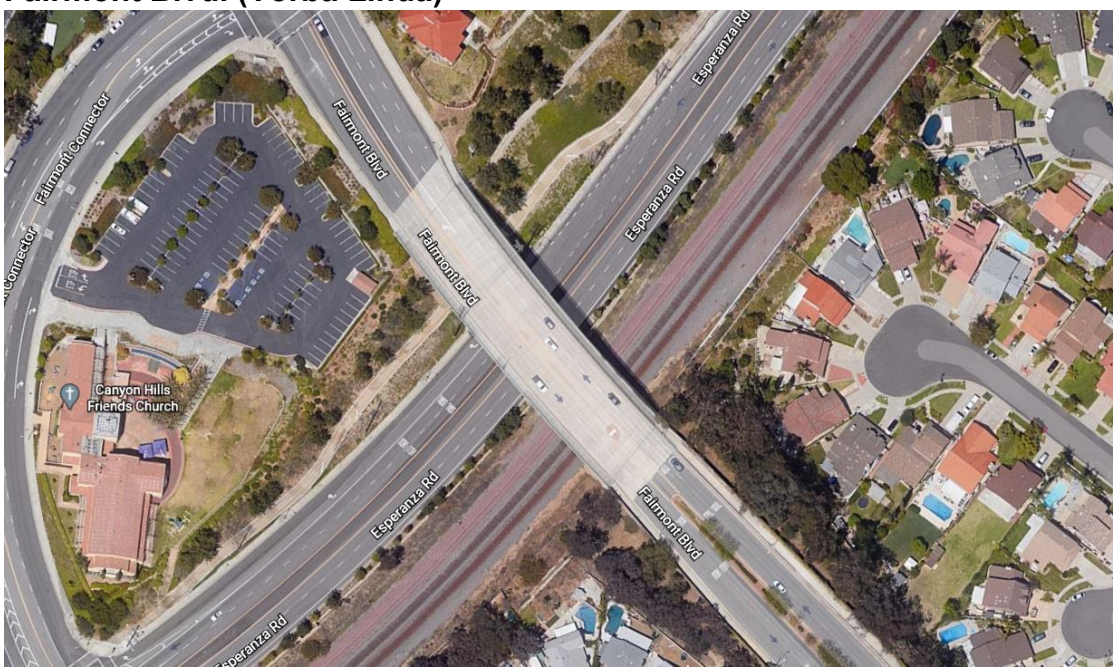
4. N. Tustin Ave. (Anaheim)

5. Lakeview Ave. (Placentia/Anaheim)



6. Imperial Highway (Anaheim/Yorba Linda)

7. Fairmont Blvd. (Yorba Linda)



8. Yorba Linda Blvd. (Yorba Linda)

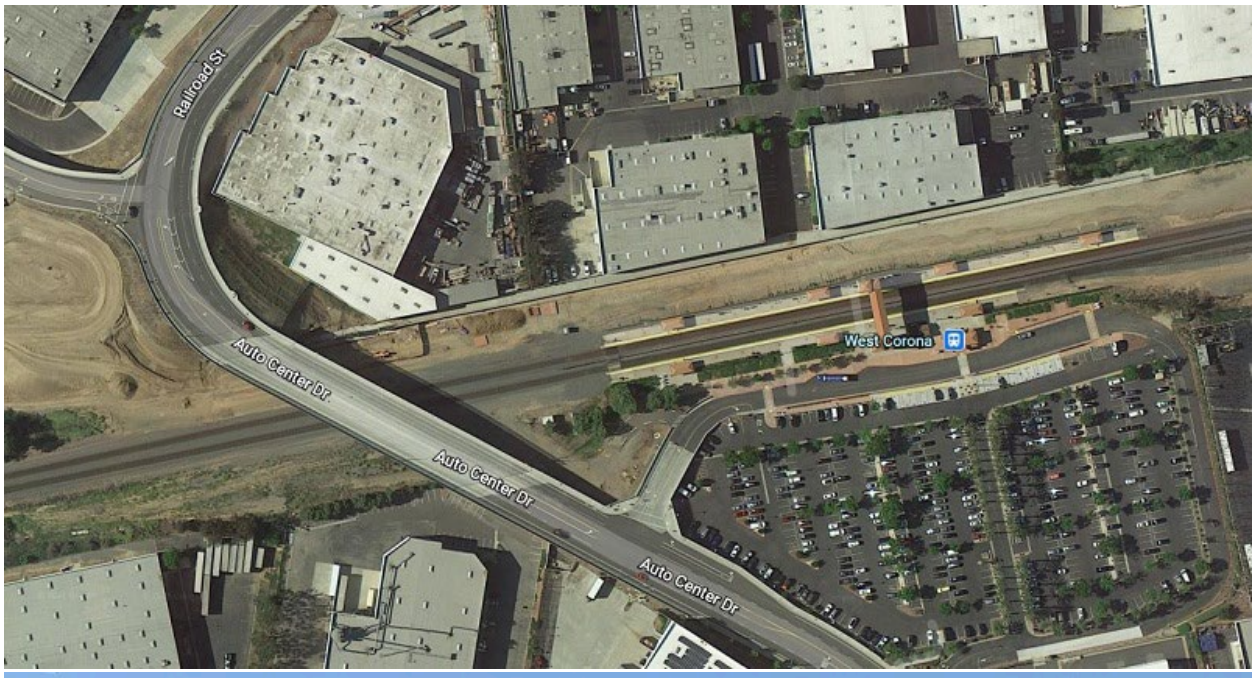
9. Via Lomas De Yorba (Yorba Linda)

10. Crestridge Drive (Corona)

11. SR91 Green River (Corona)

12. SR91 Palisades (Corona)

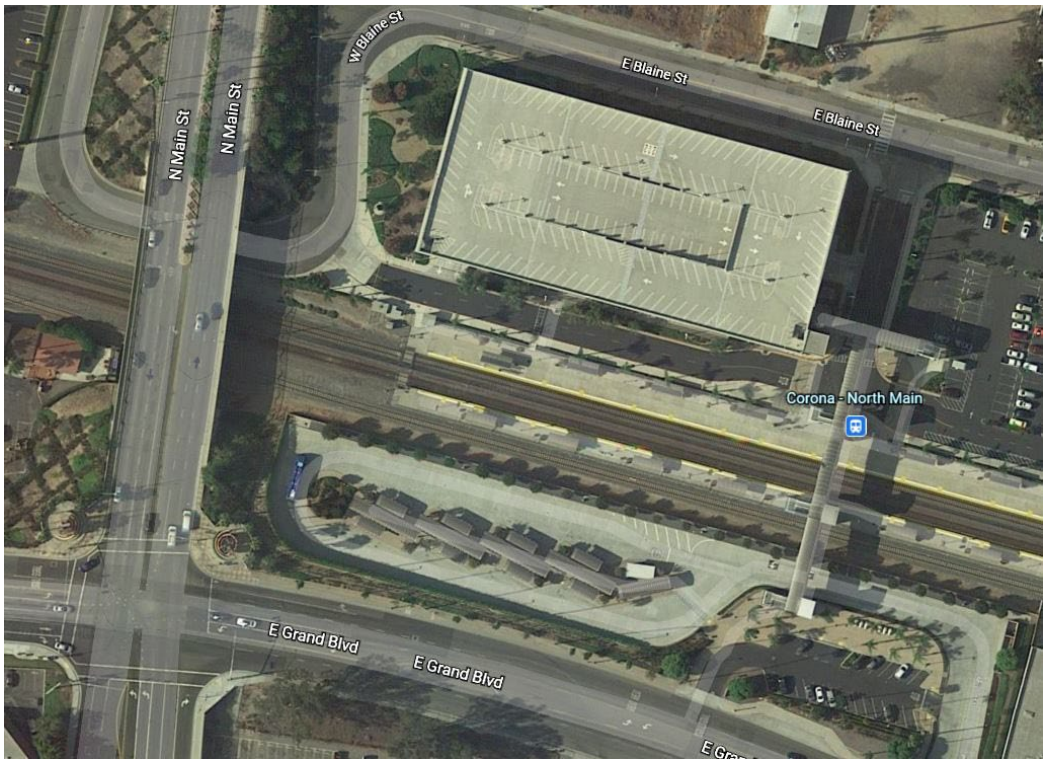
13. Auto Center Dr. and West Corona pedestrian bridge (Corona)



Appendix C: Fullerton-Riverside-San Bernardino bridges over the BNSF mainline

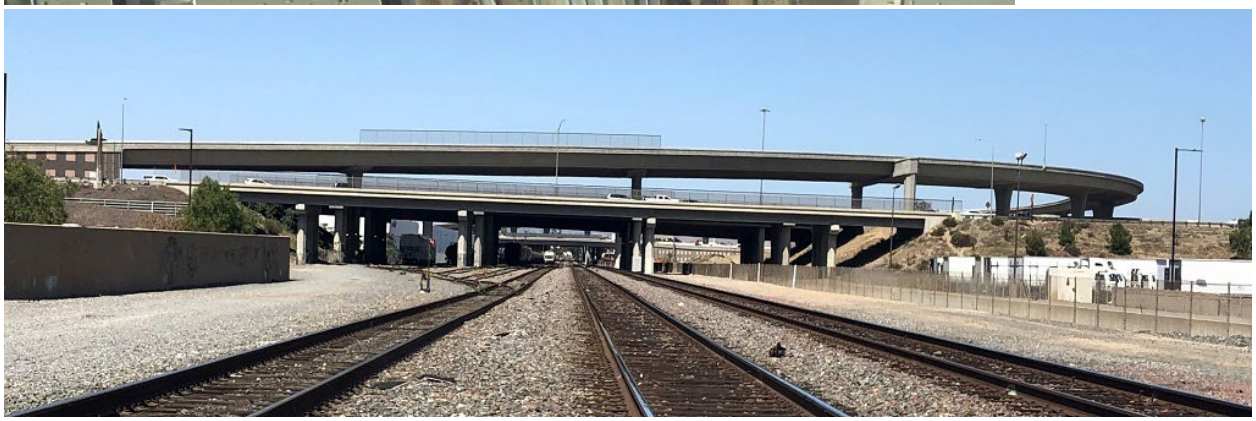
14. N. Lincoln Ave. (Corona)

15. North Main St. and Corona – North Main pedestrian bridge (Corona)



16. SR91 Temescal Wash (Corona)

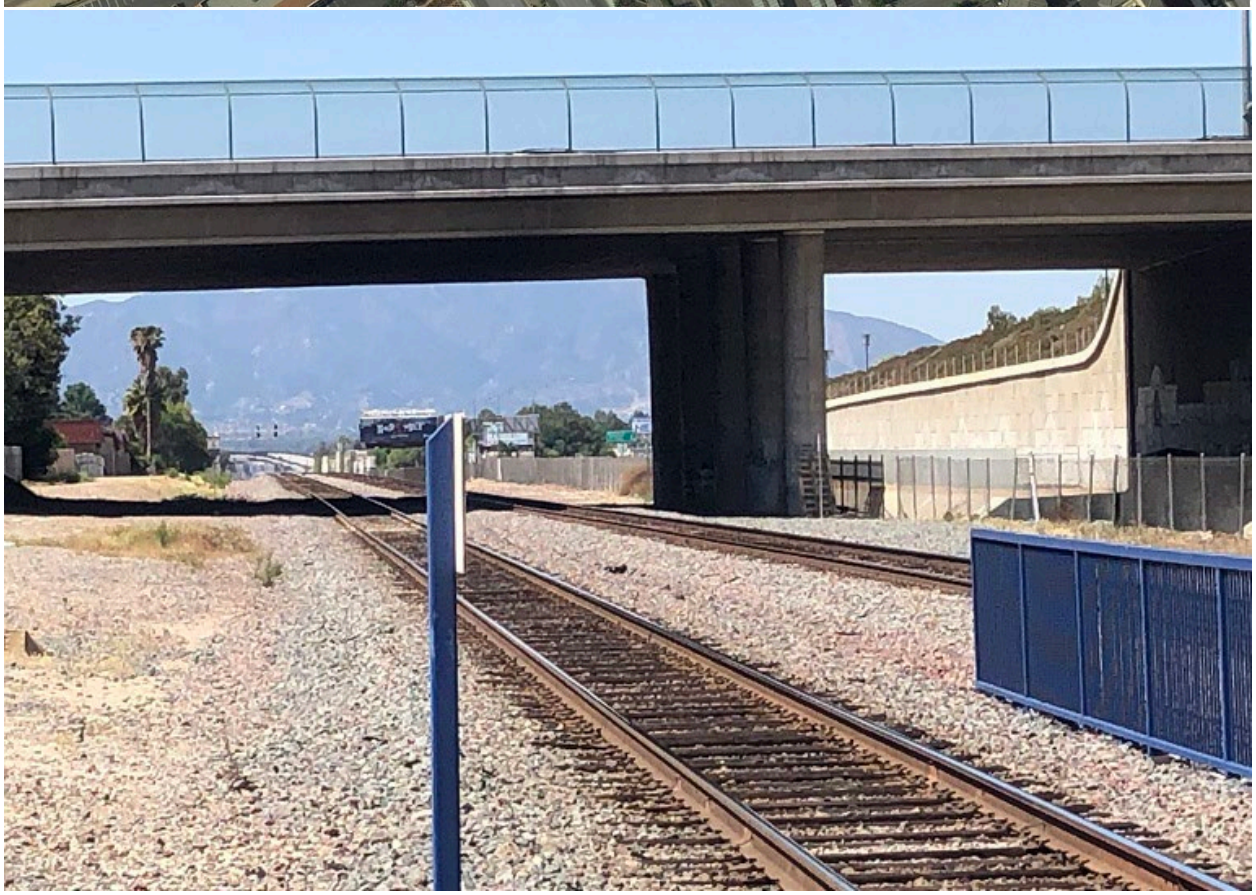
17. I-15 (Corona)



18. S. Promenade Ave. (Corona)

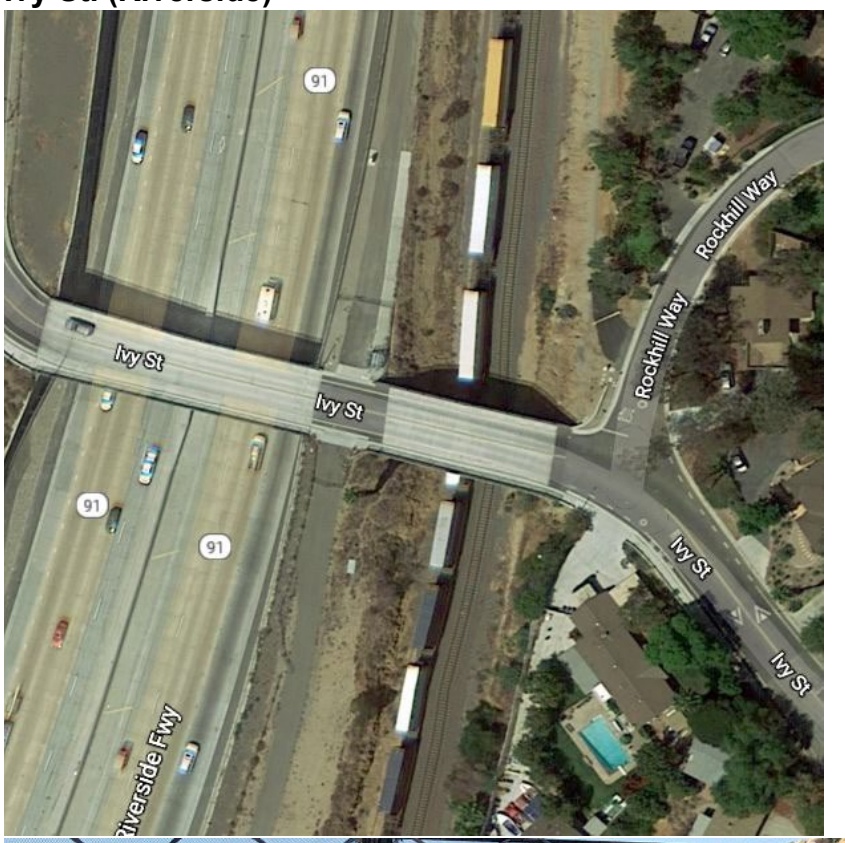
19. Magnolia Ave. (Corona/Riverside)

20. La Sierra Ave. and La Sierra pedestrian bridge (Riverside)

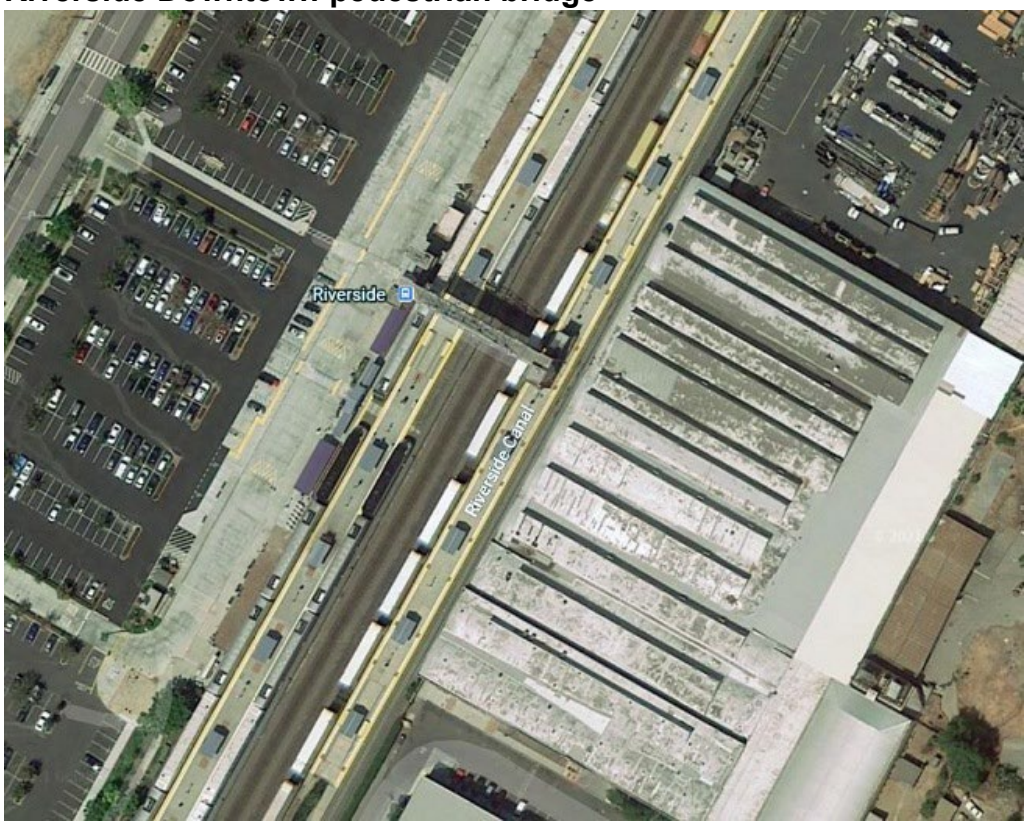


Appendix C: Fullerton-Riverside-San Bernardino bridges over the BNSF mainline

21. Ivy St. (Riverside)



22. Riverside Downtown-pedestrian bridge

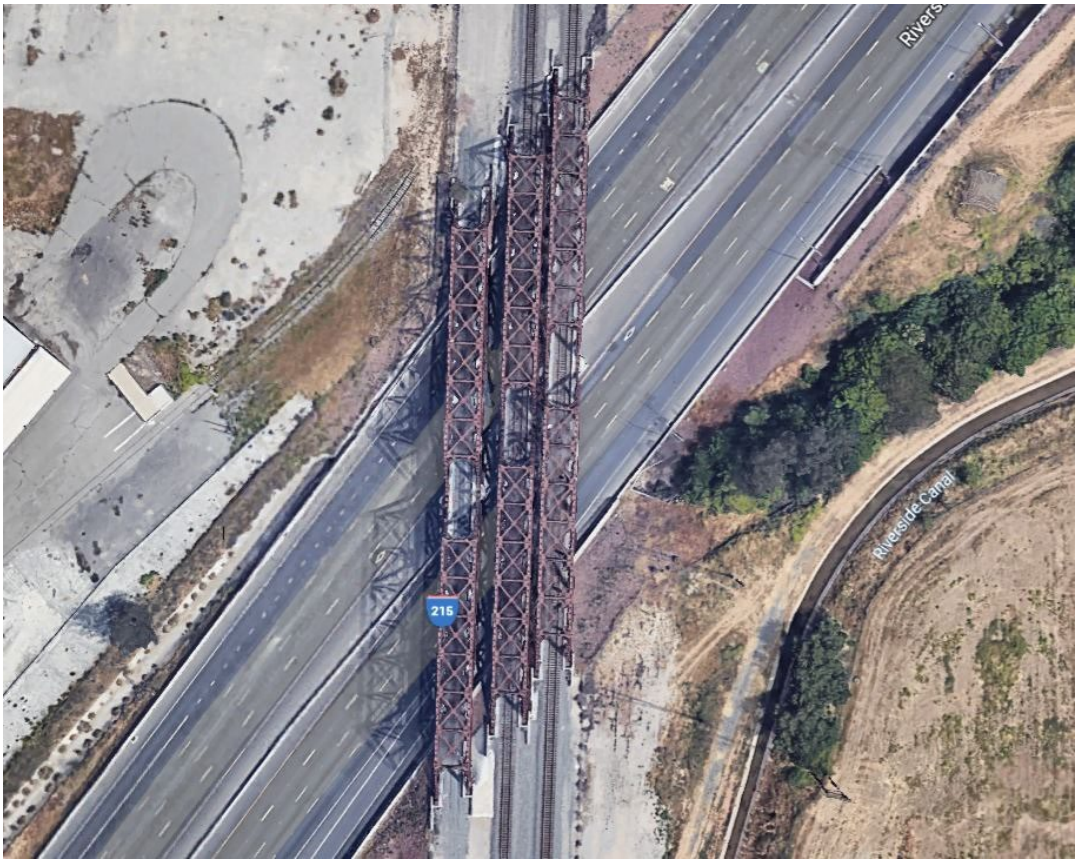


23. SR60-I215 (Riverside)

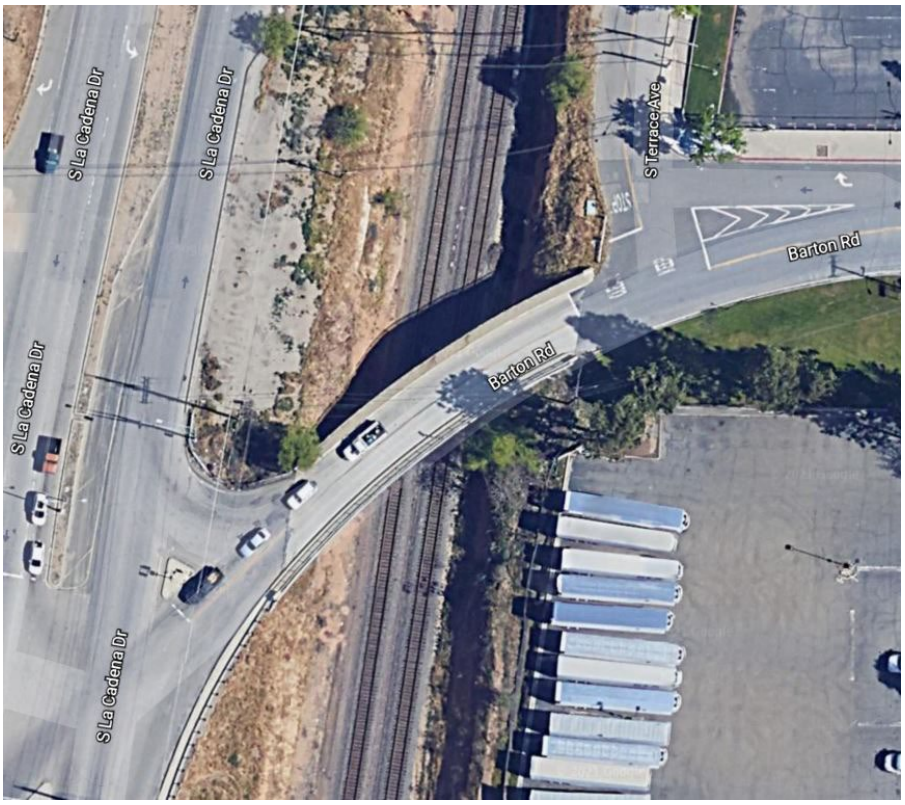
24. Columbia Ave. (Riverside)

25. Iowa Ave. (Riverside)

26. Railroad bridge over I-215 (Grand Terrace/Colton)



27. Barton Rd. (Colton)



Appendix C: Fullerton-Riverside-San Bernardino bridges over the BNSF mainline

28. Colton Crossing and I-10 (Colton)