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California Highway 1 Improvement Project Northern Monterey County, CA

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SANTA CLARA UNIVERSITY

Department of Civil Engineering

I hereby recommend that the
SENIOR DESIGN PROJECT REPORT
prepared under my supervision by

MARIE ADAMS

NICHOLAS GEORGE

&

SHAUN SHAPIRO

entitled

CALIFORNIA HIGHWAY 1 IMPROVEMENT PROJECT
NORTHERN MONTEREY COUNTY, CA

Be accepted in partial fulfillment of the requirements for the degree of

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

Advisor

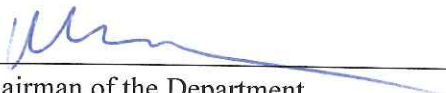
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06/10/14



6/12/14



California Highway 1 Improvement Project
Northern Monterey County, CA

Final Report

by
Marie Adams
Nick George
Shaun Shapiro

Spring 2014

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Abstract

This project focuses on improving traffic flow and safety on a 4-mile segment of California Highway 1 between Moss Landing and Castroville in Monterey County. Improvements include partial widening, signalization, and intersection upgrades.

Acknowledgements

We would like to thank our advisors Dr. Rachel He of the Civil Engineering Department at Santa Clara University and Professor Roxanne Rashedi of the English Department at Santa Clara University for the many hours they spent reviewing our project, presentation and thesis paper. We would also like to thank our families, friends and professors for their support and encouragement they have shared with us the past 9 months and everything they have done to help us reach the milestone of college graduation.

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Introduction

California's Highway 1 is a heavily travelled route that runs along the entire coast of the state. The road varies from remote, narrow two-lane roads to six-lane freeways. There is a particular section of two-lane undivided highway in northern Monterey County which connects two freeway sections between the cities of Castroville and Watsonville, traversing the harbor town of Moss Landing. The area is notorious for long traffic backups and dangerous driving conditions, even though it is the primary route between the Santa Cruz and Monterey regions. This project

will improve traffic conditions on the southern portion of this stretch, a 4 mile section between Dolan Road in Moss Landing and State Route 156 in Castroville. Due to an inability to obtain as-builts from Caltrans for the project site, the scope of this project was limited to three intersections along Route 1: Dolan Road, Moss Landing Road and Merritt Street.

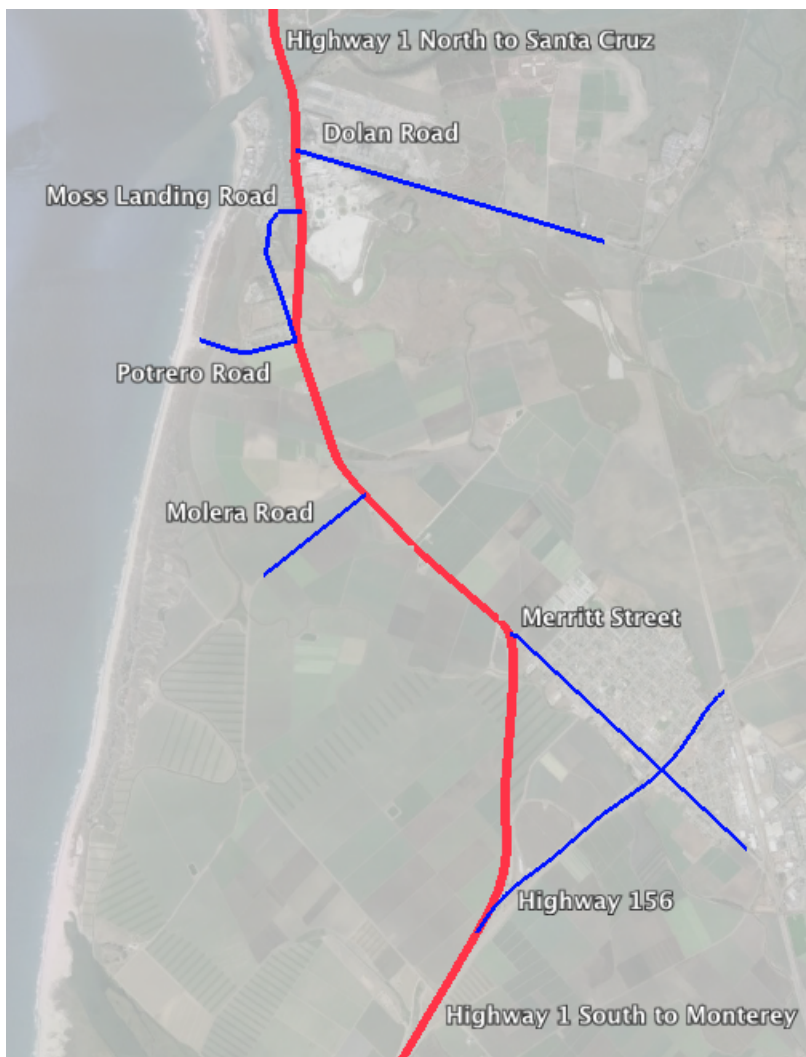


Figure 1: Map showing the segment of Highway 1 (red) between Moss Landing and Castroville, and its intersecting roads. (North up)

Existing Conditions and Need for Project

Between the towns of Moss Landing and Castroville, Highway 1 is an undivided, two lane rural highway, with a speed limit of 50 miles per hour. There are three major at grade intersections

(Dolan Road, Moss Landing Road, and Merritt Street) and two smaller local intersections (Potrero Road and Molera Road). Traffic on Highway 1 flows unimpeded through each of these intersections, and the minor streets meet the highway with simple stop signs. Currently, there are no restricted turns from any of the side streets, meaning both left and right turns are allowed. There is one exception to this, at Merritt Street, where traffic cannot turn left onto Highway 1 South, due to the close connection to the South via Highway 156. Traffic turning to and from each of these streets must cross mainline highway traffic, often travelling at speeds of 50-60 miles per hour.

Table 1: Summary of existing conditions on this segment of Highway 1.

Segment Length	2.9 miles
Speed Limit	50 mph
Major Intersections	Dolan Road Moss Landing Road Merritt Street
Minor Intersections	Potrero Road Molera Road
Unsignalized Intersections	5
Signalized Intersections	0
Number of Lanes	2
Lane Width	12-15 feet
Right of Way Width	100-250 feet
Shoulder Width	6-13 feet
Terrain	Flat/Rolling

Most of the traffic here consists of locals and tourists. Moss Landing is a harbor town and a local tourist destination, with a number of boating operations, boutique shops and restaurants, as well as a large research center operated by the Monterey Bay Aquarium. Moss Landing also offers access to a number of state beaches. Castroville, on the other hand, is a small town that is mostly residential and doesn't attract a lot of outside traffic. In between the two towns, there are large agricultural fields on both sides of Highway 1.

On Highway 1 in Moss Landing, the T-intersections of Dolan Road and Moss Landing Road are closely spaced, at about 1,500 feet apart. For turning traffic, sight lines are severely limited by buildings and trees placed close to the roadway. While performing traffic counts at this location,

we actually witnessed a minor accident, where a city bus passing through the intersection at Moss Landing Road scraped the front of an RV that was trying to make a left turn across traffic. Witnessing this helped to reinforce the need for improvements here.



Figure 2: Existing conditions at Highway 1 at Moss Landing Road in Moss Landing. (North up)



Figure 3: Existing conditions at Highway 1 at Dolan Road in Moss Landing. (North up)

The existing configuration of Highway 1 at Merritt Street includes an at-grade T-intersection. Traffic on Highway 1 is unimpeded, while traffic turning to and from Merritt Street is forced to cross a lane of traffic travelling at 50 to 60 miles per hour. To add to the danger here, Highway 1 is on a curve, which has a private residence and many trees in its apex. This limits the clear line of sight and increases the risk of an accident occurring.

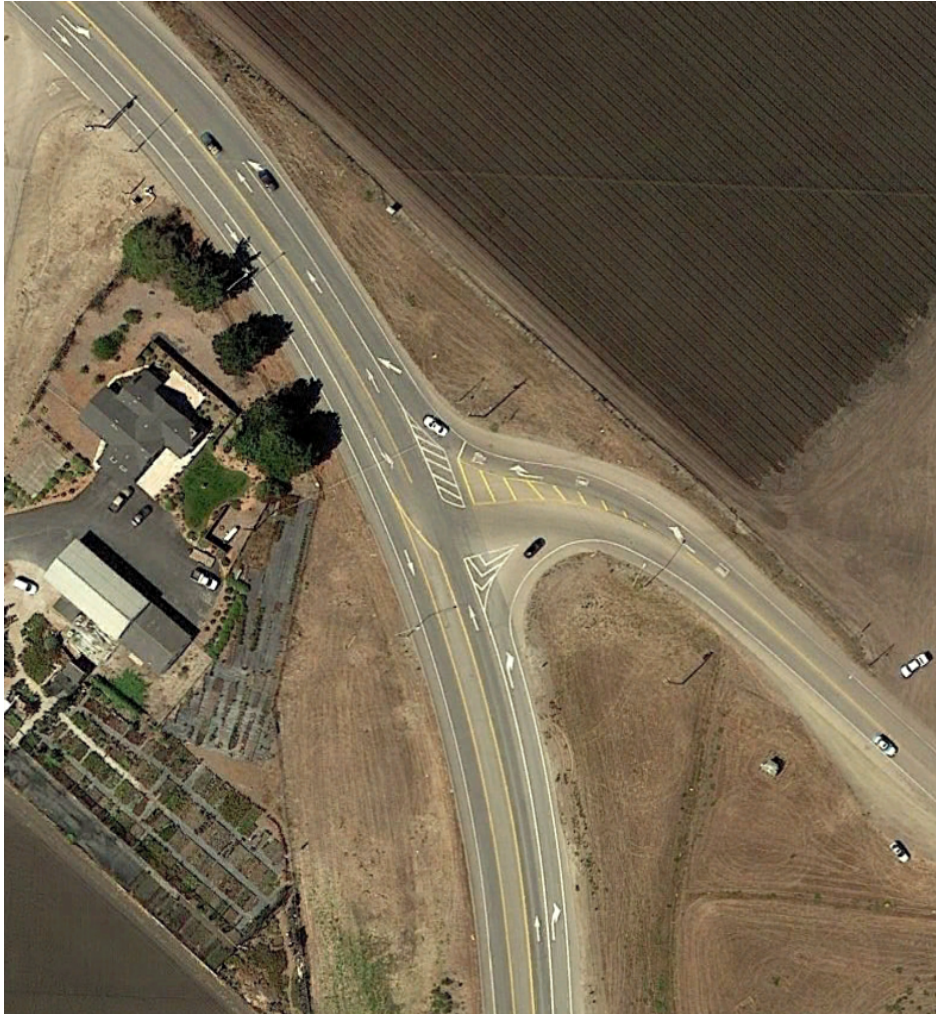


Figure 4: Existing conditions at Highway 1 at Merritt Street in Castroville. (North up)

According to a 2009 CalTrans Transportation Planning Fact Sheet, the accident rate on this 4 mile stretch of Highway 1 between Castroville and Moss Landing was 1.01 accidents per million miles travelled, which was higher than the state average of 0.85 for a highway of similar conditions (CA, 2009). Another notable statistic is the fatality and injury collision rate, which was measured at 0.35 accidents per million miles travelled. The state average for a similar facility is actually slightly *higher*, at 0.41. There is a good reason for this discrepancy. Most of the accidents occurring on this stretch of Highway 1 are low-speed “fender benders”, as it is unlikely to have a major injurious crash when the road is jammed up with traffic. However, many safety issues still exist: high-speed traffic conflicts, line of sight limitations, and outdated intersections.

Design Criteria and Resources

The primary source of design criteria and standards will be the California Department of Transportation (CalTrans) Highway Design Manual, revised in June 2013 (CA, 2013). These standards will supercede the standards of Monterey County since this is a state maintained and operated facility.

Many resources will be required to accomplish the project. The Highway Capacity Manual (HCM) will be a primary reference in design and analysis of the site. It will provide many of the formulas and data required. Several studies, including the Monterey Bay Aquarium Research Institute (MBARI) Master Plan Update: Traffic Impact Analysis, and the Moss Landing Community Plan, will provide background information for the current conditions at the location and what options are already being considered.

Software used for the project will include AutoCAD for geometric design, and Synchro for intersection and traffic signal analysis.

Quality Control Protocol

Our team has scheduled weekly meetings to compile and revise work before submission and discuss the upcoming steps for the project. This includes the division of work and scheduling of other meetings if necessary. To assist in quality control measures related to document submission we have created a Excel document and shared it with Google Drive. The Excel document contains a list of all due outs, who they are due to, the date they are due, the date a draft is due to the team for revision and the date we will be meeting with Professor Rachel He, our advisor. This due date tracker will help track performance not only of document submissions, but of project stages as the design progress continues.

Alternatives Considered

For each intersection three options were considered. At Dolan Road and Moss Landing Road the alternatives included installing a traffic signal, installing a roundabout and to leave the site in its existing condition. In both cases the traffic signal was chosen. For the third location at Merritt Street a signalized intersection, flyover and leaving the site in its existing condition were considered. A flyover was chosen as the best option for Merritt Street. For information regarding the details of the traffic signals and the flyover, see *The Final Design*.

Roundabouts were considered at Dolan Road and Moss Landing Road for their decrease in conflict points compared to a signalized intersection or an uncontrolled intersection, as is the current route set up. The Federal Highway Administration and Institute of Transportation

Engineers found that most roundabouts are actually safer than signalized or uncontrolled intersection in a 2004 report (US, 2004). Roundabouts are more efficient than other types of intersections, however, they do take up more space and can have a higher upfront cost. A typical roundabout could be anywhere from 150 - 200 feet inscribed circle diameter with two lanes on the exterior of the measured circle (US, 2000). The speeds of these roundabouts are usually 25 or 30 mph (US, 2000). Since Route 1 currently has a speed limit of 50 mph, it may not be the best or safest option to decrease the speed by 20 mph when local drivers are not familiar with roundabouts.

A signalized intersection was not chosen for Merritt Street, as the current lines of sight are near the minimum standard at that intersection. Of the three intersections Merritt Street has the highest rate of traffic, a high amount of semi-trucks pass through it and the proximity to highway 156 on ramp is incredibly close.

Leaving the site as is could be a valid option for two reasons: if the cost of implementing any change greatly outweighs the need for the change, and if the alternatives do not prove to be viable. These were not found to be the case for the current conditions at any of the three intersections.

The Final Design

Overview:

Signalization at Dolan Road and Moss Landing Road

- *Synchronized traffic signals on Highway 1 at Dolan Road and Moss Landing Road:* These intersections are approximately 1,500 feet apart, so these two signals will prioritize through traffic on Highway 1 to experience green lights most of the time. Traffic on the minor streets will have loop detectors that will trigger the signals to change.
- *Additional through lane in each direction:* The additional capacity between these two intersections will help to alleviate the extra traffic that is stopped at the newly implemented signals when red. Also, this will allow for safe passing of slower-moving vehicles.

Geometric Changes at Merritt Street

- *Flyover ramp from SB Highway 1 to Merritt Street:* This will eliminate the primary at-grade conflict at this intersection by separating exiting southbound traffic from northbound through traffic.
- *At-grade ramp from NB Highway 1 to Merritt Street:* Separate ramp with wider radius allows cars to exit Highway 1 at higher speeds, minimizing braking on the mainline and reducing backups.
- *Elimination of the left turn from Merritt Street to SB Highway 1:* This particular traffic count was very low. SB Highway 1 can still be accessed from the nearby interchange with Highway 156.
- *Improved horizontal and vertical curvature:* Increases safety by maximizing sight distances and increasing driver comfort levels.

Potrero and Molera Intersections

- *No action at this time:* Due to the low traffic counts at these two intersections, it was deemed unnecessary to make any changes during the initial stages of this improvement project.

Signalization at Dolan Road and Moss Landing Road:

Converting an un-signalized highway intersection into a signalized one is a major change to traffic flow and commuter expectation, as well as an expensive and time consuming process. It must be proven that converting the intersection as such will result in improved traffic flow and/or safety of the intersection. The Highway Design Manual outlines eleven warrants – criteria that can be used to build a strong argument for inserting a stoplight into the intersection. The warrants most relevant to this project are warrants 1, 2, and 6. Warrant 1 outlines the minimum amount of vehicles that must travel through the intersection per hour on both the major and minor street, for any 8 hours out of a typical day. If an intersection meets this warrant, the general flow of the intersection is proven to be busy and may suffer as a result. Warrant 2 is similar to Warrant 1, but its focus is on large differences in traffic flow between the major and minor street of the intersection. For example, if the traffic flow on Highway 1 is very high, but the traffic flow on Dolan Road is very low, Dolan Road may suffer additional delays. Lastly, Warrant 6 describes criteria related to accident rate of the area. This warrant is met if other measures do not solve the problem, if there are at least 5 accidents per year that involve damage to property or personal injury, if warrants 1 and/or 2 are met at least 80% of the way, and if installation of a signal will not interrupt traffic flow.

The traffic count data taken at Dolan Road and Moss Landing Road as shown in in Table 2 was used in determining whether these warrants were met. Warrant 1 was met at Moss Landing,

however it was not satisfied at Dolan simply due to a slightly lower volume of vehicles on Dolan Road than required. However, these traffic counts were not obtained during peak hours, and if more data were acquired it would be guaranteed that Warrant 1 would be met for Dolan Road as well. Warrant 2 was satisfied at both intersections, as the traffic flow on Highway 1 was significantly higher than that of both Dolan Road and Moss Landing Road. Warrant 6 was satisfied due to accident data of the area and personal experience. The high rate of fender benders and observed accidents witnessed in the area on a regular basis meets the 5 accident per year requirement, and no other alternative to this particular intersection would work as well as adding a stoplight. Warrants 1 and 2 were satisfied over 80% of the way, and no significant impacts to traffic flow were found when simulating a signalized intersection at these locations.

Table 2: Recorded traffic count data at the site location.

	Vehicles/Hour on Highway 1	Vehicles/ Hour on Cross Street (1 Direction, Higher Value)
Dolan Road/ Highway 1 intersection	2196	140
Moss Landing / Highway 1 Intersection	2232	168

Table 3: Warrant 1: Minimum vehicular volume

# Lanes (Major ST)	# Lanes (Minor ST)	Vehicles/Hr (Major, Both Directions)	Vehicles/Hr (Minor, Both Directions)
1	1	500	150
2+	1	600	150
1	2	500	150
2+	2	600	150

Table 4: Warrant 2: Interruption of continuous traffic

# Lanes (Major ST)	# Lanes (Minor ST)	Vehicles/Hr (Major, Both Directions)	Vehicles/Hr (Minor, Both Directions)
1	1	750	75
2+	1	900	75
1	2	750	100
2+	2	900	100

The traffic count data from the two intersections was used to simulate optimized signal timings at Dolan Road and Moss Landing Road. Using an overlay from Google Maps, a scaled overhead map of the intersection was created, and the existing intersections created accordingly, complete with traffic flow data. The Level of Service (LOS), a rating system that describes the performance of an intersection with a grade ranging from A through F, was determined to be an F at both intersections under current conditions; that is, without any traffic signals installed. When optimized traffic signals were added to Dolan and Moss Landing, the LOS increased to B and C, respectively. When an additional lane was added to either side of Highway 1, the LOS for both intersections jumped to an A rating.



Figure 5: Current LOS Conditions at Moss Landing and Dolan Road

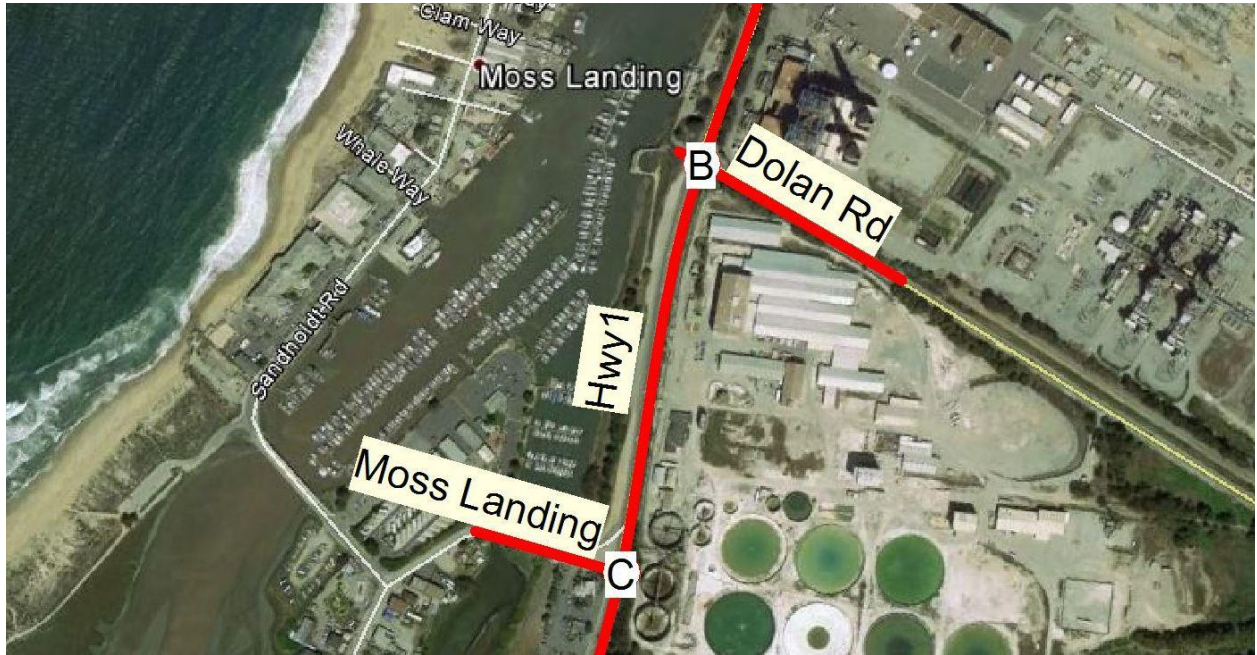


Figure 6: LOS Conditions at Moss Landing and Dolan Road with optimized stoplights



Figure 7: LOS Conditions at Moss Landing and Dolan Road with optimized stoplights and additional lanes on Highway 1.

Geometric Changes at Merritt Street:

The major changes at Merritt Street and Highway 1 will be dominated by a new flyover structure that connects Southbound traffic from CA-1 to Merritt Street and points further south. Northbound through traffic on CA-1 will travel underneath the flyover, completely eliminating the at-grade conflict that exists here. Southbound through traffic on CA-1 will travel through the redesigned interchange on its existing path, with only minor changes to curvature. For traffic coming from Merritt Street, there will be a straightened ramp that connects to Northbound CA-1. As mentioned in earlier sections, traffic destined for destinations South of Castroville will use Highway 156 as they would currently. Lastly, Northbound traffic exiting at Merritt Street will use a new ramp with a much wider radius than what exists now. Table 5 summarizes the curvature details, including curve speeds and superelevation rates obtained from section 202.2 of the Caltrans HDM (CA, 2013).

Table 5: Curvature and speed limit details at the CA-1 Merritt Street Interchange.

Curve	Radius	Speed Limit	Superelevation Rate
Southbound CA-1	1300 feet	50	0.08
Northbound CA-1	800 feet	50	0.10
Exit Ramp to Merritt Street from NB CA-1	250 feet	30	0.10

Throughout the entire project, 12 foot lane widths will be maintained. There will be a minimum of a 4 foot shoulder on the left, and a 10 foot shoulder on the right, including on the flyover structure. For the flyover, the ascending and descending grades do not exceed 4%, allowing comfortable traversing at 50 mph for passenger cars and heavy vehicles alike. The vertical clearance underneath the flyover is 18 feet; larger than the minimum of 16 feet required by the CalTrans HDM, section 309.2 (CA, 2013). While a structural design hasn't been done as part of this project, 4 feet of vertical clearance has been allocated between the roadway surface of the flyover and the bottom of the structure, where the 18 foot clearance was measured from. New drainage grates will be provided throughout, to avoid any runoff into local farms or creeks. The interchange has been designed to accommodate a future widening of Highway 1 to a 4 lane expressway. Figures 8-11 show different views of the redesigned interchange. See the Appendix for detailed engineering drawings of this interchange.

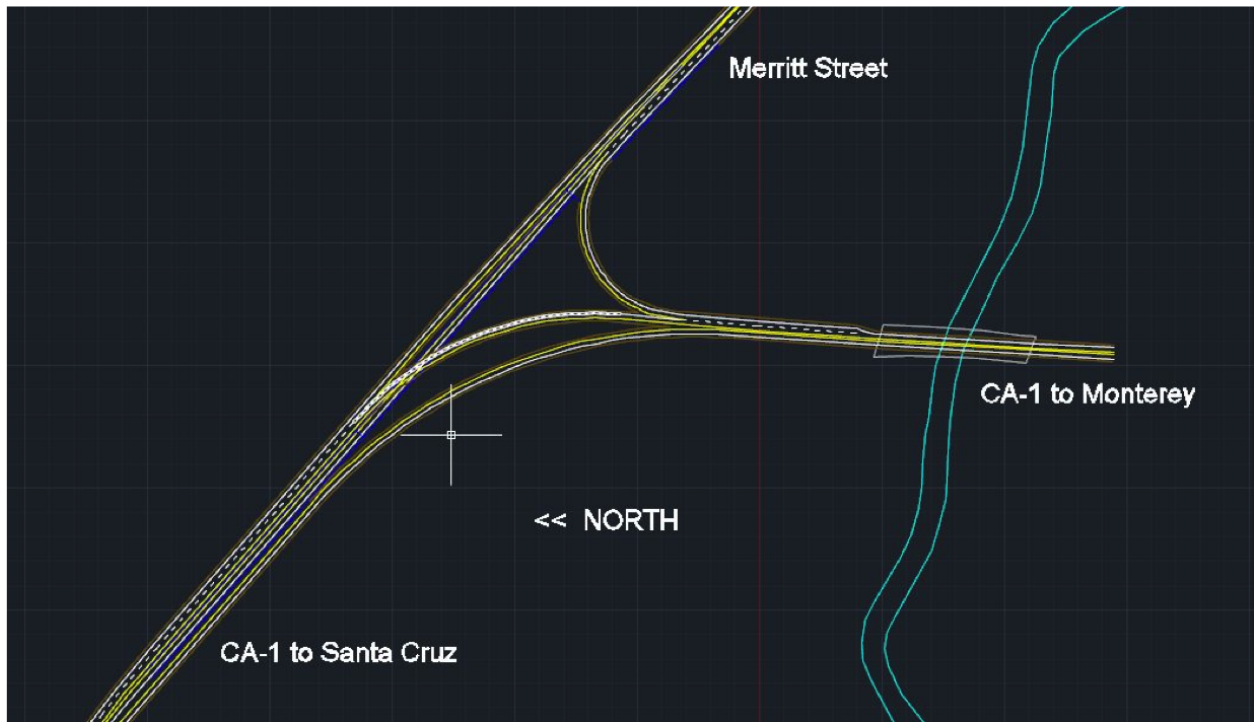


Figure 8: New interchange configuration at CA-1 and Merritt Street; plan view.

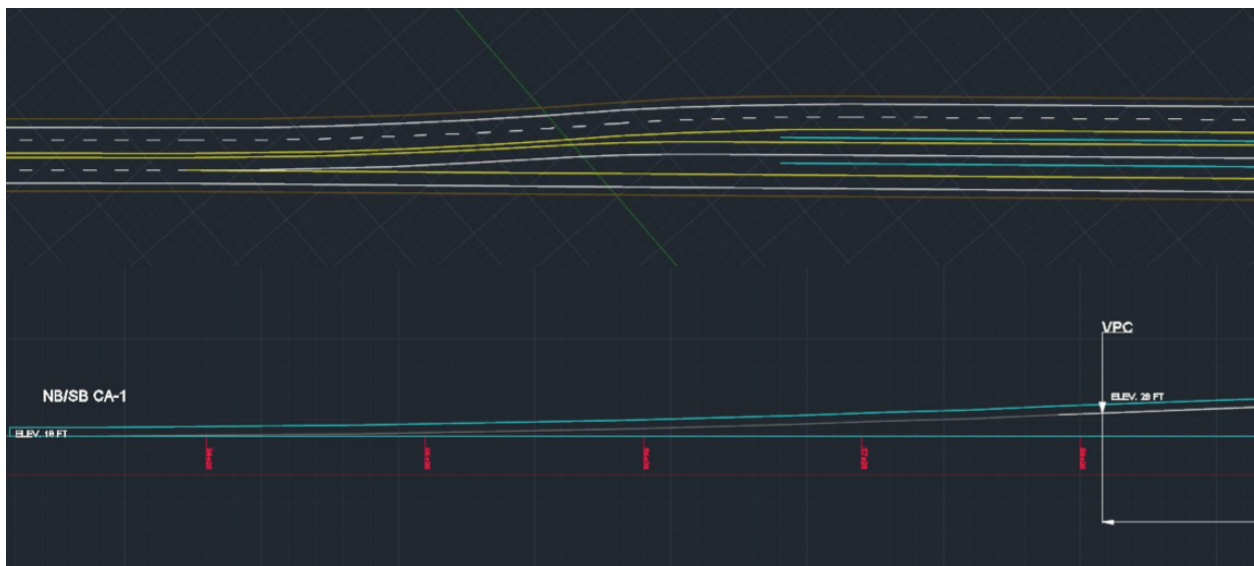


Figure 9: New flyover structure approach; plan and profile views.

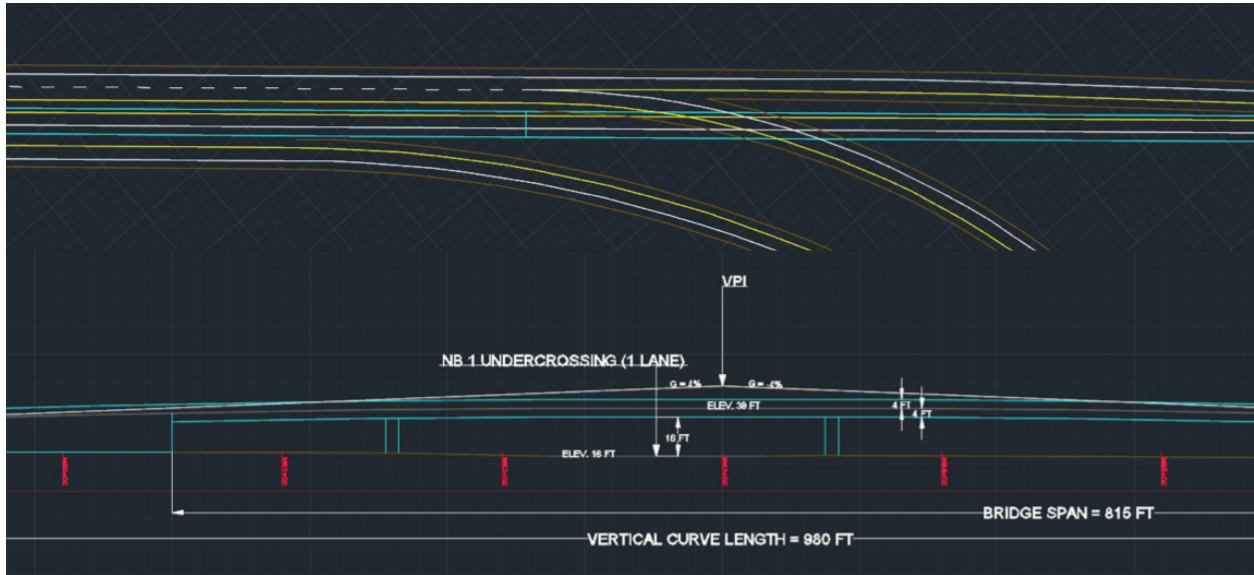


Figure 10: New flyover structure crest; plan and profile views.

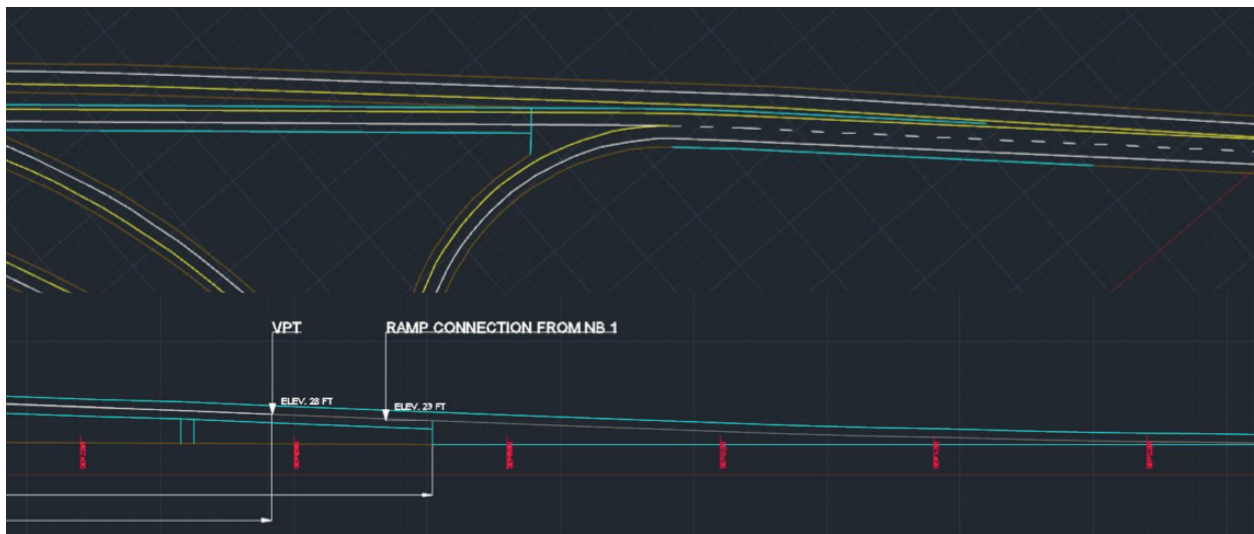


Figure 11: New flyover structure descent; plan and profile views.

Environmental Considerations

Environmental considerations include wildlife, farmland, water sources, local human impacts, hazardous waste, noise and air pollution. No environmental reports were conducted for this project site in recent years, so when this project is conducted a new environmental report will need to be conducted in accordance with the Environmental Protection Agency (EPA), National Environmental Policy Act (NEPA), Farmland Protection Policy Act (FPPA), California Environmental Quality Act (CEQA), California Coastal Act (CCA), Clean Water Act (CWA) and other applicable laws and regulations. To determine if there were any environmental

impacts this project should be concerned about two similar projects in the region were looked at and compared to the current project site. These environmental impact reports include *Initial Study with Mitigated Negative Declaration/Environmental Assessment with Finding of No Significant Impacts* (May 2006) and *State Route 1/Rio Road to Carmel Valley Road Operational Improvement Project* (July 2011).

Between the two reports only one endangered or special-consideration plant or animal was found, the California Red-Legged Frog. One California Red-Legged Frog was found in 2001 near a fire suppression pond (US, 2006). This sighting was not found to need special consideration, because no alterations were planned for the fire suppression pond, although it was within the project limits (US,2006). There are no similar ponds in the construction area for the current project that need to be considered, but an eye should be kept out for the California Red-Legged Frog during a thorough environmental impact report.

Farmland runs adjacent to the current project site and the two study project sites. As the project designs do not utilize farmland, the only consideration that will need to be made will be with regards to preventing runoff from flowing into the crop fields. Chemicals used in road construction can be harmful to farm crops and ranch animals.

At the southern end of the current project site for Route 1 is the Tembladero Slough. Tembladero Slough feeds into Old Salinas River and then drains into the Pacific Ocean. The construction site expands to the bridge that goes over the slough, so runoff must be considered to prevent harming native wildlife. A storm water pollution prevention plan will be implemented to mitigate this risk. This may include bioswales, pipes, ditches and vegetated channels to filter the water or bring it to a local facility where the water can be treated (US, 2006 and CA, 2011). These alternatives for filtering runoff will be left in place during and after construction.

Human environment considerations include: land use and community planning, parks and recreational facilities, and utility and emergency services. This project is consistent with local land use and community plans for Dolan Road as outlined in the Moss Landing Community Plan (Monterey County, 2012). There are no parks and recreational facilities in the project site, so no consideration needs to be taken. Emergency services will not be affected during or after construction. Lastly, all utility services will be contacted to ensure that their pipes and lines are marked and plans for adjustments are made if the lines or pipes need to be moved.

There are two hazardous waste sites within a mile of project site. Both of these hazardous wastes sites occur near the junction of Dolan Road and CA-1 at the northern end of the project site. The first is Dynegy Moss Landing at the junction who require corrective action. The second is just under a mile away along Dolan Road at Duke Energy Moss Landing LLC. This site currently has an operating permit for hazardous waste. The implications to the project will include soil

testing, special care and considerations if dewatering is needed, an emergency response plan and identify potential risks and ways to mitigate them for worker and the environment (CA, 2009).

There are no negative impact noise related issues that need to be addressed. If CA-1 is expanded from a two-lane to a four-lane, the traffic noise level should still be in the 3-A difference between indoor and outdoor noise based on the Carmel Valley Road Improvement Project (CA, 2009). During construction there will also be short-term noise increases due to the project and transportation of the workers to the site (CA, 2009). If the big trucks and equipment are left at the site overnight the commuting noise is lessened and fuel is saved. The noise level during site work will comply with local and federal regulations. If work on the sites is limited to normal business hours this will respect local residents and comply with noise level regulations.

Air quality does not need any special considerations as normal construction measures cover the short-term effects and no long-term effects are created (CA, 2009). Taking a sustainable approach to individual tasks and the overall project will reduce gas-powered equipment where possible.

Ethical Considerations

This project must follow a strict adherence to local, state, and federal regulations, including (but not limited to):

- Highway design standards and regulations (California Dept. of Transportation Highway Design Manual, 2013)
- Ordinances for city and county planning and development (Monterey City Code Chapters 1-38, Monterey County Ordinances, Titles 12 - Vehicles and Traffic, and 16 - Environment)
- Immediate environmental effects (traffic rerouting, noise control, dust control, runoff, among others)
- Environmental laws relating to long-term project effects (Cal EPA, CEQA)
- Eminent domain limitations
- Earmarks and restrictions for sources of funding (taxes, bonds, other investments)

One of the largest ethical considerations comes with regards to the procurement of land; specifically the property located at 10178 Merritt St., Castroville, CA, as seen in Figure 12. If Caltrans or the State of California currently owns this plot of land, then there are no issues and the project can proceed as planned. If it is not then there are two options: to negotiate with the owner or to take it under eminent domain laws. Ethically, the best and recommended way to first approach this issue is to start by negotiating directly with the owner. This plot of land is currently empty, so there are no extra considerations that would need to be taken if it was a working business or farmland. The State of California should explain to the owner the project proposal and why they need this property over another nearby property. They should then offer to buy the

land for fair market value. If the owner declines to sell the property, then Caltrans can proceed to step two.



Figure 12: Location of 10178 Merritt St., Castroville, CA along Route 1

The last alternative is to obtain the parcel by eminent domain laws. The 5th Amendment to the Constitution notes that land can be taken for public use if the owner is justly compensated (US Constitution, Amendment 5). In addition, Caltrans offers a Relocation and Assistance Program to assist the owners in finding and purchasing new property (CA, 2009). Executive Order 13406, executed on June 23, 2006, added that the use of the land must solely benefit the general public and not an individual or corporation (Executive Order 13406, Section 1). Since this project will increase the safety of travellers and potentially increase the capacity of Route 1 if extra lanes are added, it fulfills the requirement for the benefit of the general public. The project has no ties to individuals or businesses, so it is not unethical for Caltrans and the State of California to use eminent domain if they deem it necessary after having negotiated directly with the owner.

Cost Estimates

The following estimates are rough values that are based on similar projects along Highway 1.

- Signalization at Dolan Road and Moss Landing Road: \$5,000,000*
 - Equipment and Supplies: \$4,000,000
 - Construction Cost: \$1,000,000
 - *Based on project at Highway 1 and Rio Road in Carmel, CA.
- New Interchange at Merritt Street: \$30,000,000**
 - Equipment and Supplies: \$20,000,000
 - Construction Cost: \$10,000,000
 - **Based on project at Highway 1 and Salinas Road in Watsonville, CA.

Conclusion and Future Recommendations

This project seeks to solve the main issues with this segment of Highway 1 by improving the existing intersections that cause traffic bottlenecks. However, there is more that can be done to further improve efficiency and safety. Ultimately, the logical next step would be to widen Highway 1 to a 4 lane expressway between Salinas Road in Watsonville and Highway 156 in Castroville; a 7 mile stretch. This would remove the last portion of 2 lane, undivided road on CA-1 between Santa Cruz and Monterey, and greatly improve the facility for long-term regional growth.


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APPENDIX

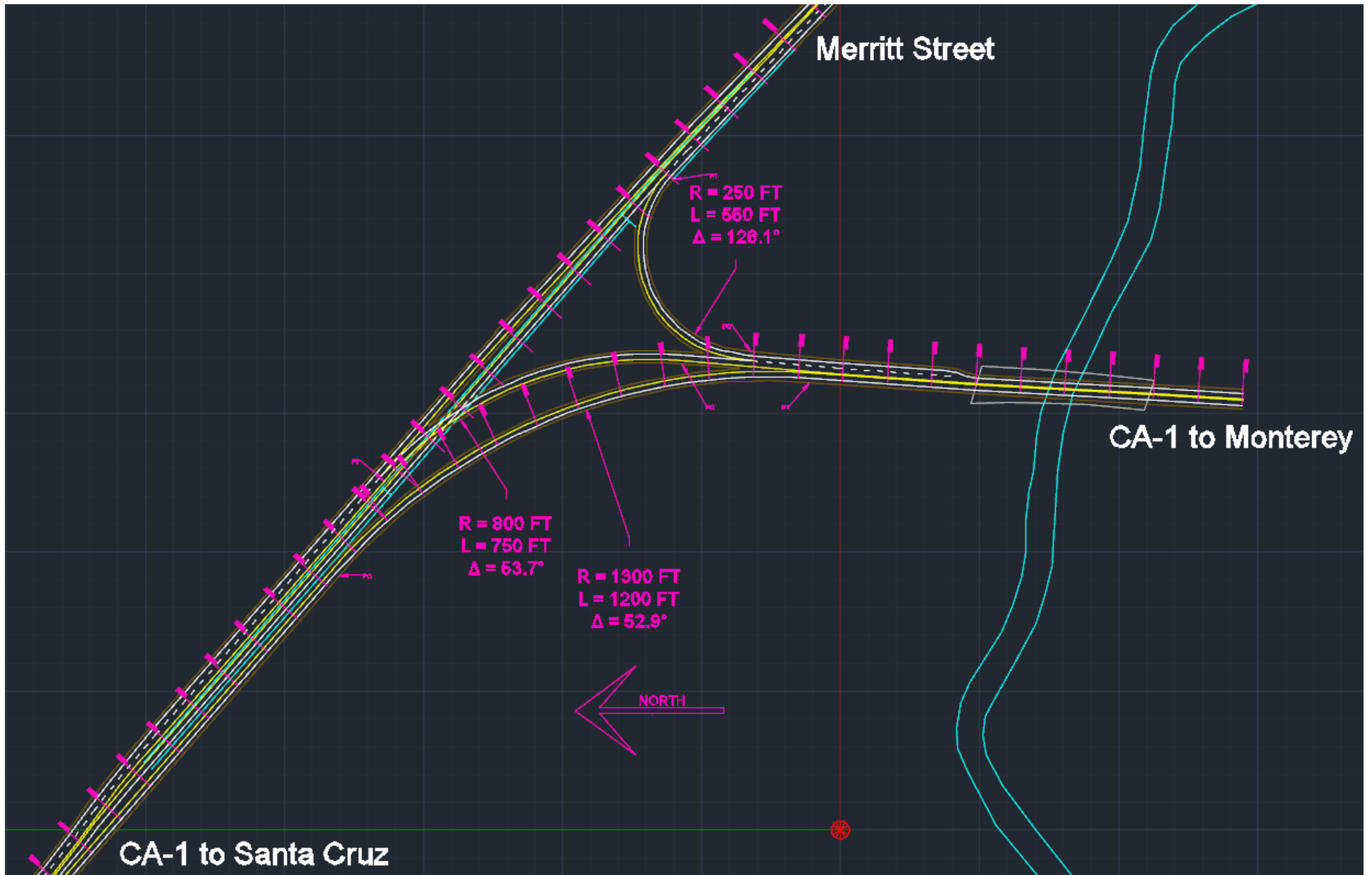


Figure A1: Overview of new interchange design at Highway 1 and Merritt Street.

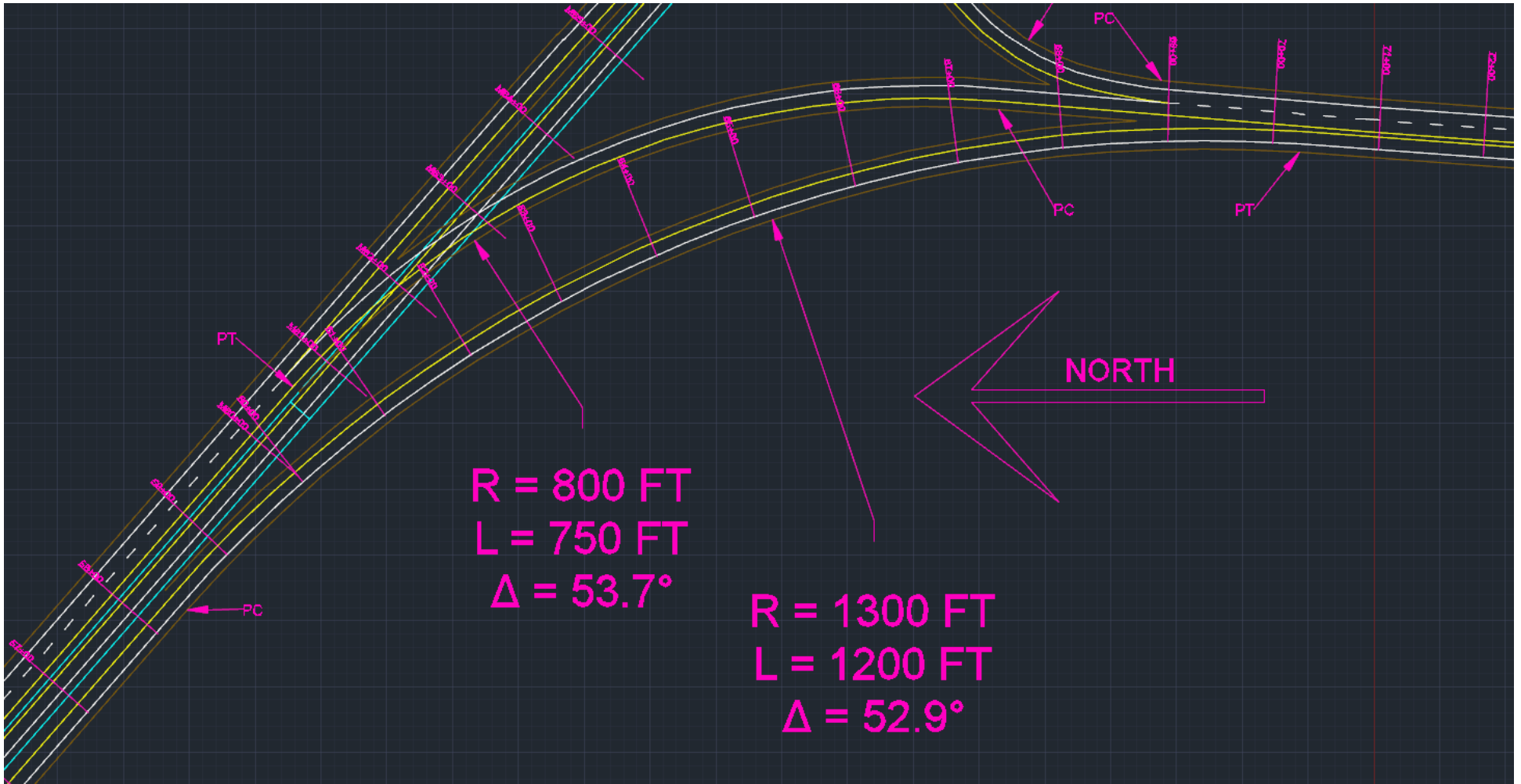


Figure A2: Detail of two curves on Highway 1 at Merritt Street.

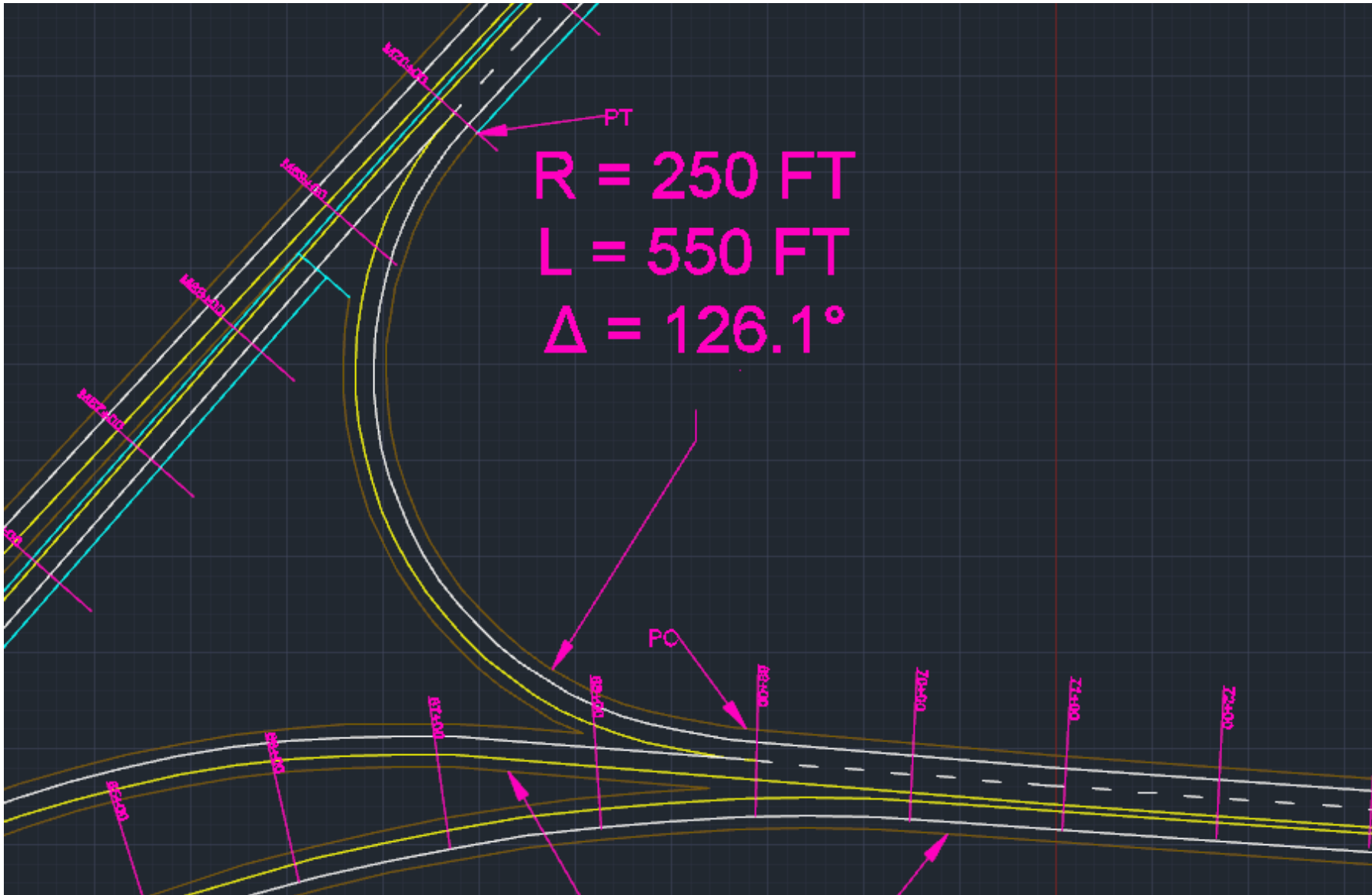
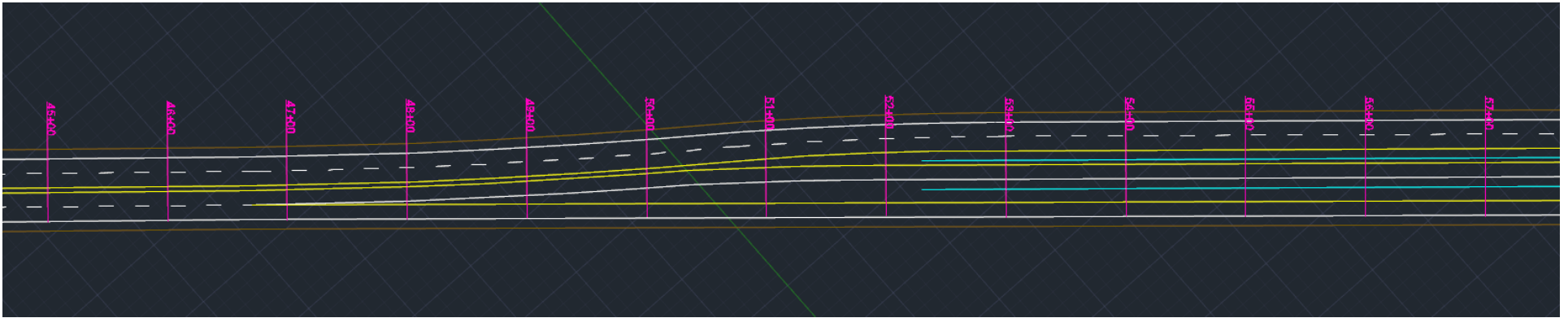
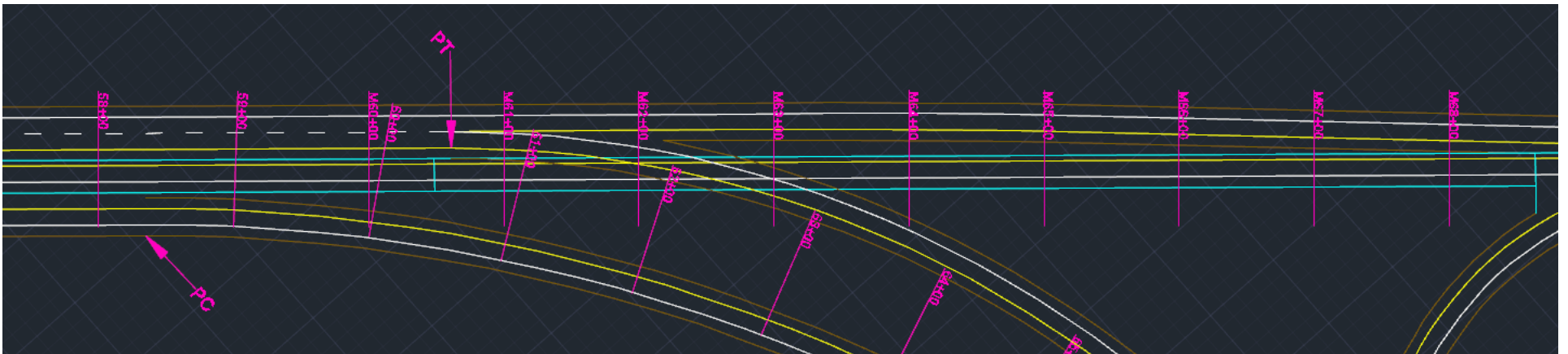


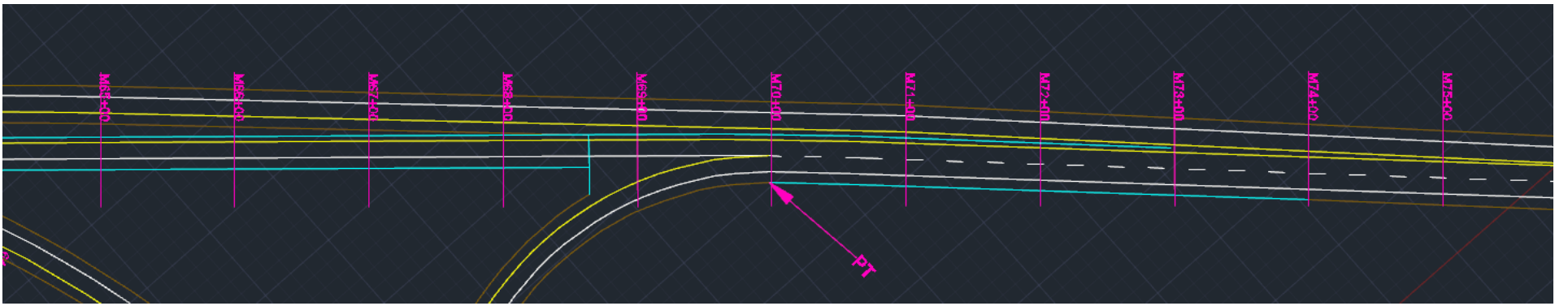
Figure A3: Detail of curve from Highway 1 North to Merritt Street.



<< CA-1 North to Santa Cruz



Crest of Flyover Ramp



To Merritt Street >>

Figure A4: Detail of flyover ramp connecting Highway 1 South to Merritt Street.

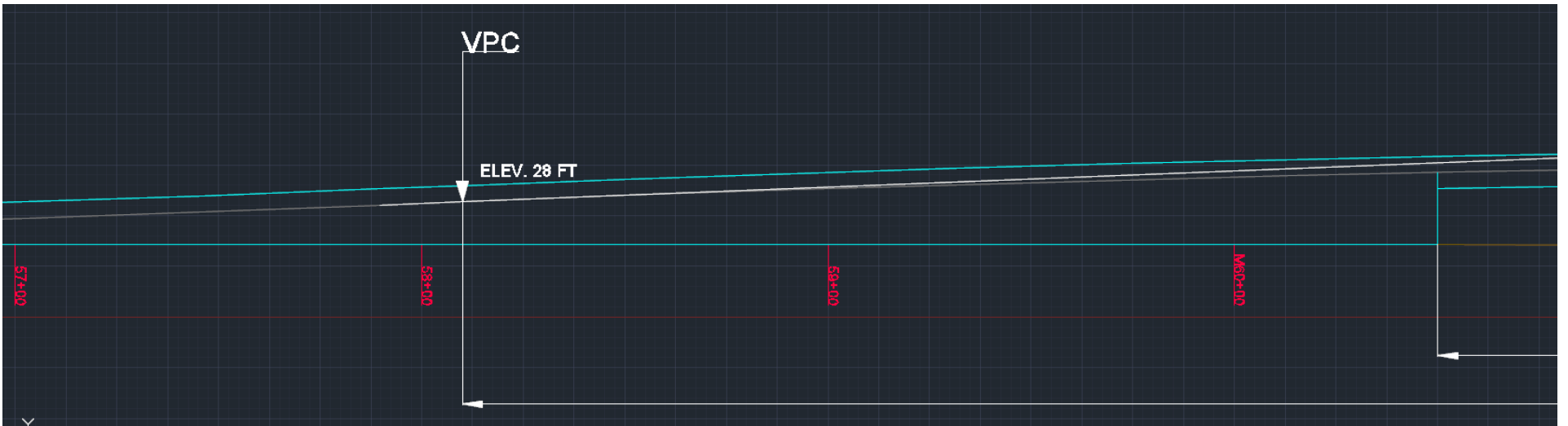
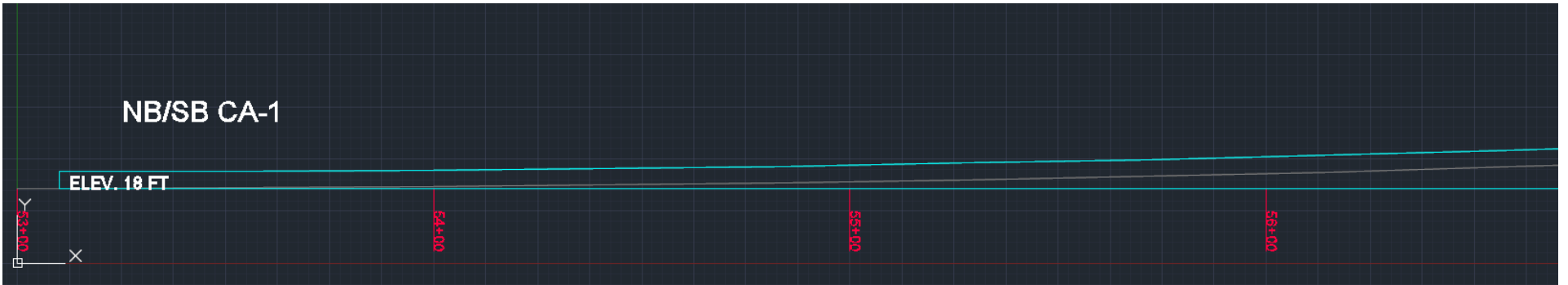


Figure A5.1: Profile view of flyover ramp (53+00 to M60+00).

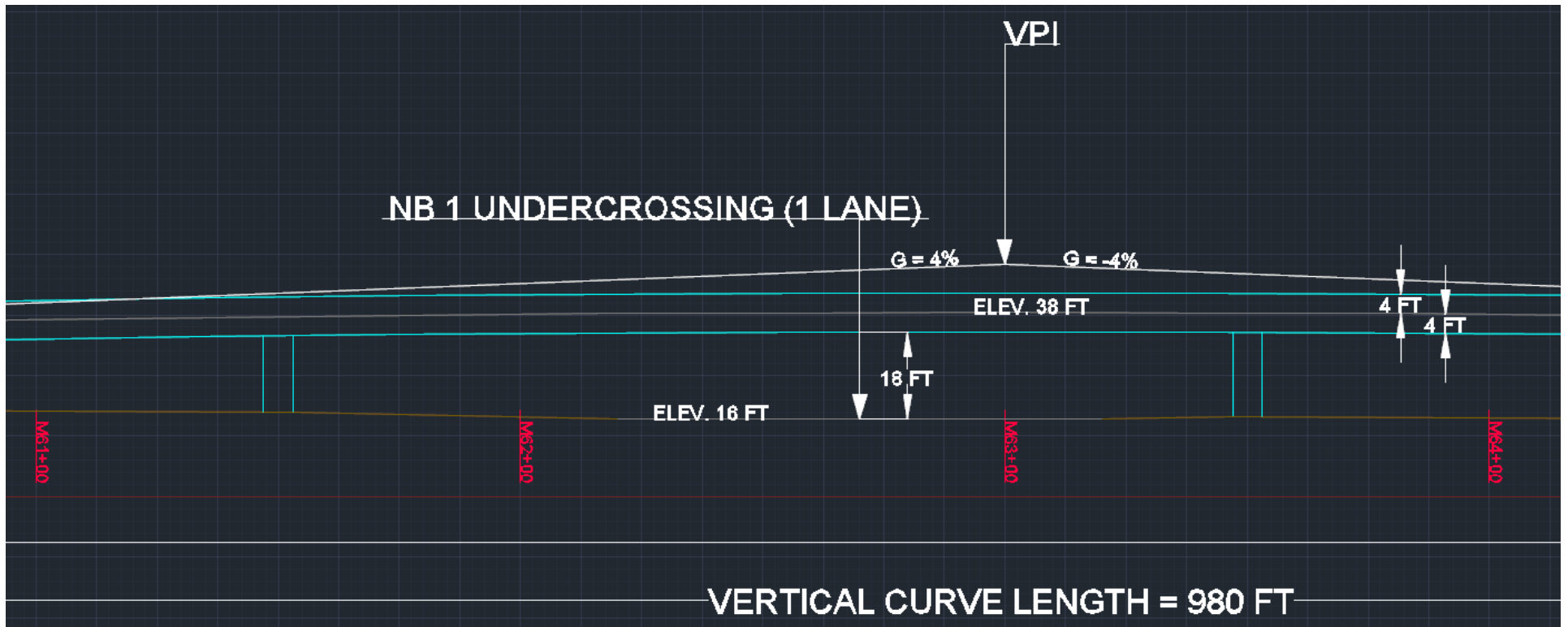


Figure A5.2: Profile view of flyover ramp (M61+00 to M67+00).

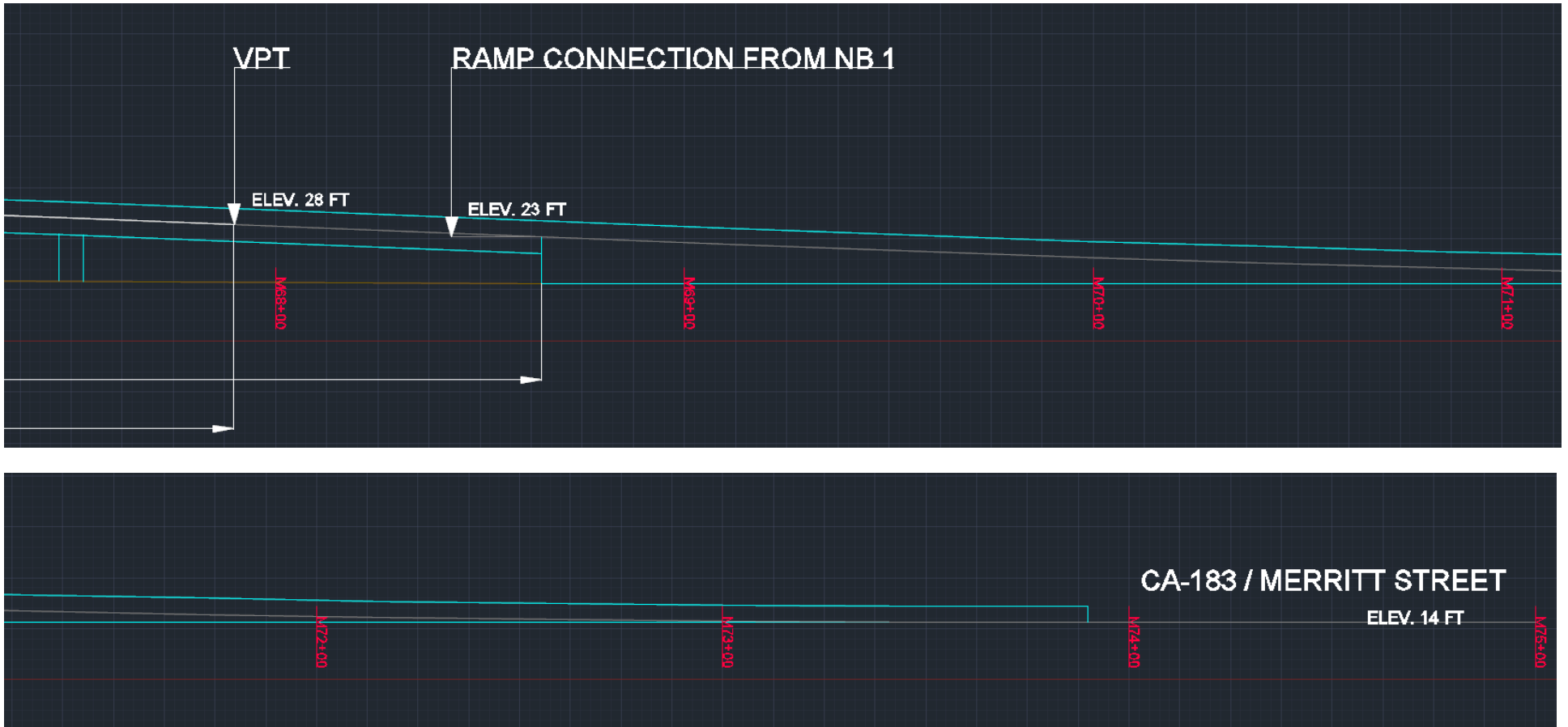


Figure A5.3: Profile view of flyover ramp (M68+00 to M75+00).

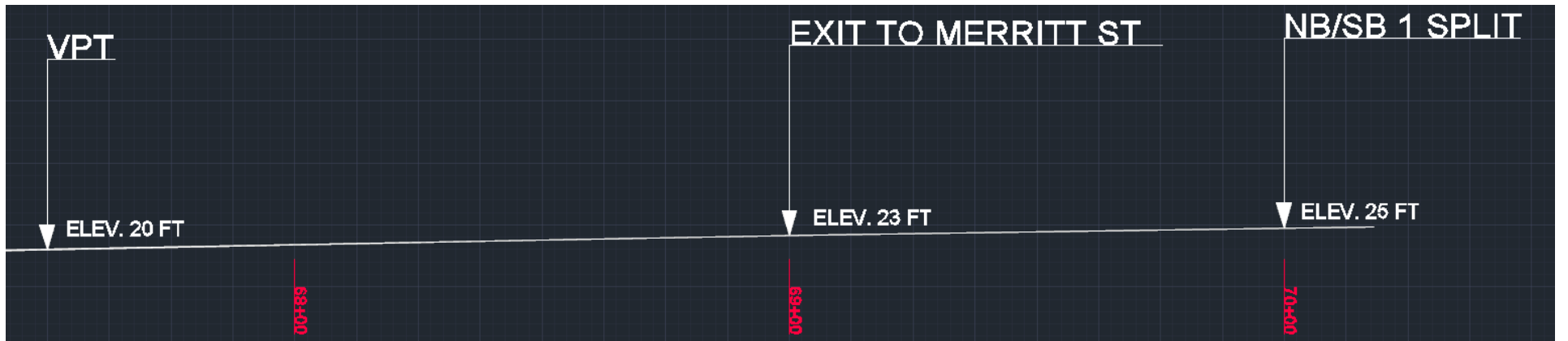
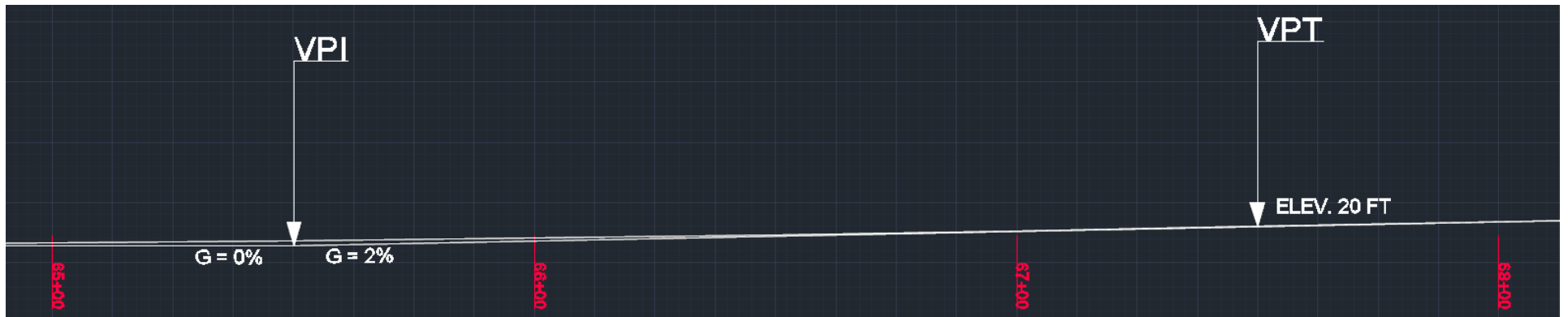
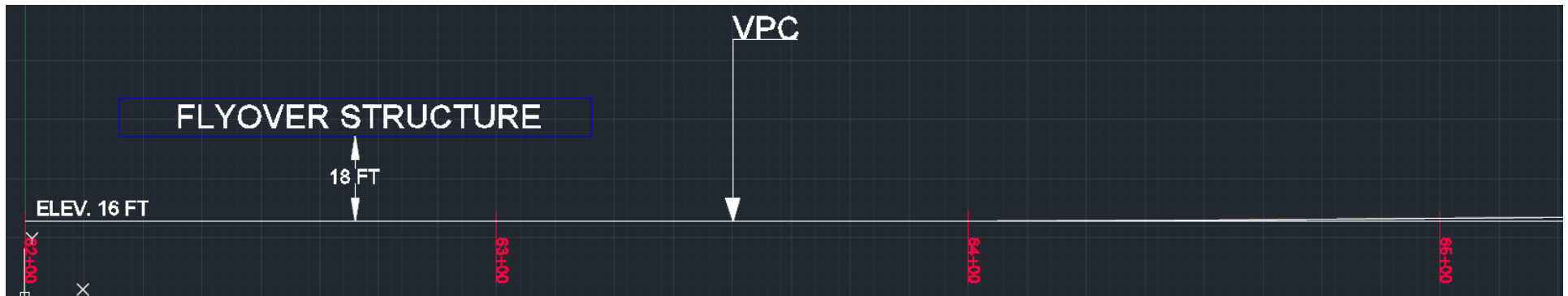


Figure A6: Profile view of the Highway 1 North undercrossing (62+00 to 70+00).