Los Angeles County
Metropolitan Transportation Authority

Crenshaw/LAX Transit Corridor

Park Mesa Heights Grade Separation Analysis
June 2010

Metro

Park Mesa Heights Grade Separation Analysis

Crenshaw/LAX Transit Corridor Project
Advanced Conceptual Engineering
Contract E0117

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1 INTRODUCTION

The Los Angeles Metropolitan Transportation Authority (Metro) is planning a Light Rail Transit (LRT) improvement project in the Crenshaw/LAX Transit Corridor. The project is being conducted in accordance with the most recent Federal Transit Administration (FTA) guidelines for project development, and all environmental documentation prepared will satisfy the requirements of the National Environmental Protection Act (NEPA) and California Environmental Quality Act (CEQA). Metro is serving as the lead agency for the purpose of obtaining CEQA environmental clearance and the FTA is serving as the lead agency for the purpose of obtaining NEPA environmental clearance.

The preferred alignment for the project was defined in the Draft Environmental Impact Statement/Draft Environmental Impact Report (DEIS/DEIR) which was released for public comment in September of 2009. Subsequent to the issue of the DEIS/DEIR, the Metro Board selected LRT as the Locally Preferred Alternative (LPA) and authorized initiation of the advanced conceptual engineering design phase to determine the scope of the design, the extent of infrastructure required, and the most appropriate construction methods. This advanced conceptual engineering design phase will define the expected costs of the project and the extent of potential environmental impacts and appropriate mitigations needed in the project corridor in support of the final environmental documents. The Final Environmental Impact Statement/Final Environmental Impact Report (FEIS/FEIR) is planned to be completed by end of 2010.

The Crenshaw/LAX Transit Corridor is an 8.5 mile LRT system. The corridor utilizes a mix of running modes on both railroad right of way (ROW) and arterial street ROW. Currently the LPA design incorporates the following proportion of running modes:

- Street level center running – 1.4 miles
- Grade separated aerial structure – 2.0 miles
- Below grade running – 2.7 miles
- Surface running in railroad ROW – 2.4 miles

The DEIS/DEIR LPA configuration for the Crenshaw/LAX Transit Corridor Project includes two segments of underground guideway construction along Crenshaw Boulevard. Of these, one segment towards the northern section of the corridor extends on Crenshaw Boulevard from Coliseum Place to 48th Street under Leimert Park Village, and one segment extends from 59th Street on Crenshaw Boulevard to Victoria Avenue on the Harbor Subdivision ROW. These two underground segments are connected by an intermediate section of at-grade guideway.

At the time of the selection of the LPA in December 2009, the Metro Board directed that a special analysis be completed that examined the constructability, safety, environmental and economic development, and cost and schedule issues associated with a below grade segment between 48th and 59th Streets on Crenshaw Boulevard. This would create a continuous segment of 2.8 miles of underground guideway between Coliseum Place in the north and Victoria Avenue to the south. This report, defined as the Park Mesa Heights Grade Separation (PMHGS) Analysis, provides the results of this special study.

1.1 Background to the Study

This report is structured in five sections. **Section 1** presents a description of the LPA at-grade configuration in Park Mesa Heights, a description of the rationale for the LPA recommendation, and a description of several cases that represent similar operations.

Section 2 of the analysis provides a description of the PMHGS alignment, identifies potential construction methods, and the construction limits for each of these methods. The description also identifies where and how the PMHGS alignment differs from the LPA configuration.

Section 3 of the report provides an evaluation of the physical considerations on the PMHGS alignment including geology, utilities, traffic, and constructability requirements.

Section 4 provides a summary of other factors related to the PMHGS alignment including environmental considerations, costs—including construction costs and operating and maintenance costs, financial factors, and schedule impacts

The analysis identifies differences between the LPA configuration and a PMHGS alignment underground between 48th Street and 59th Street.

Section 5 presents a summary of findings for the study.

1.1.1 Description of the LPA in the Park Mesa Heights Section

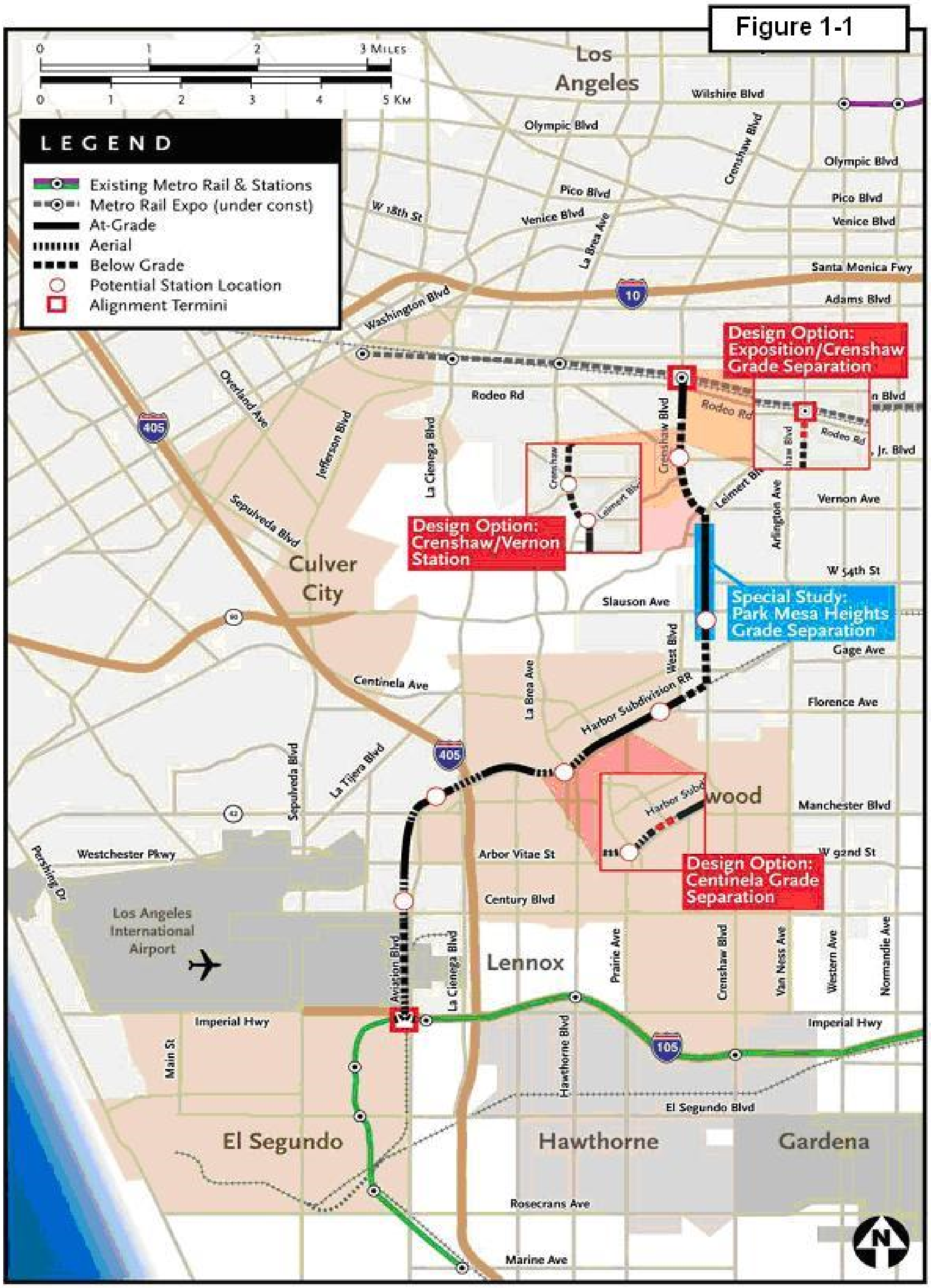
The Park Mesa Heights neighborhood lies between Leimert Park Village, a cultural center of the Los Angeles African-American community, and Hyde Park, where a community shopping center as well as schools and churches are located. Crenshaw Boulevard is the main thoroughfare that connects the Park Mesa Heights residential neighborhood with local amenities.

The study area for the PMHGS Analysis is generally north-south orientated and extends approximately one mile along Crenshaw Boulevard from 48th Street in the north to 59th Street in the south, as shown in *Figure 1-1 – Crenshaw/LAX Transit Corridor Alignment and PMHGS Area*. The study area includes portions of two local government jurisdictions: the Cities of Los Angeles and Inglewood.

The Analysis focuses on the LRT alignment between 48th Street and 59th Street. This central portion of the alignment, approximately one mile in length, supports a variety of land uses including single-family and multi-family residential, commercial, industrial, and public land.

The DEIS/DEIR LPA on Crenshaw Boulevard between 48th and 59th Streets is an at-grade alignment. The double track LRT will be located in the median of Crenshaw Boulevard in a semi-dedicated guideway. This section of at-grade guideway encompasses up to seven roadway intersections with Crenshaw Boulevard (48th, 50th, 52nd, 54th, 57th, and 59th Streets and Slauson Avenue) that are proposed as at-grade transit crossings. Vehicular and pedestrian movements across the LRT corridor at each of the signal-controlled intersections will be permitted in each case. An at-grade station will be provided at Slauson Avenue. Crenshaw Boulevard will be reconfigured by eliminating parking on one side of each of the adjacent frontage roads so that the existing roadway capacity along this portion of alignment can be maintained.

Figure 1-1 - Crenshaw/LAX Transit Corridor Alignment and PMHGS Area



1.1.2 Rationale for the Park Mesa Heights LPA At Grade Alignment

The determination of an at-grade alignment between 48th and 59th Streets followed careful analysis according to Metro's policies related to grade separation. Decisions that affect vertical alignment can be considered in two stages: determination of appropriate rail mode and determination of grade for LRT (if LRT is determined to be the appropriate rail mode). The analysis as it relates to the Crenshaw / LAX Corridor, particularly for the Park Mesa Heights section is presented below.

1.1.2.1 Determination of Mode for the Crenshaw / LAX Transit Corridor

Early in the planning process for the Crenshaw / LAX Transit Corridor Project (then called the Crenshaw-Prairie Transit Corridor Project), several potential transit modes were considered for this corridor. Transit modes considered included heavy rail transit (Metro Red/Purple lines - HRT), light rail transit (Metro Green, Blue, Gold, and Expo lines - LRT), bus rapid transit (Metro Orange line - BRT), rapid bus transit (Metro 700 series lines), and standard Metro local bus services.

In determining the "transit" mode for a corridor there are many factors considered. The factors included, but not limited to, are the following:

- Land use densities (population and employment) along the corridor and station areas.
- Physical conditions, constraints, opportunities, and composition of the possible corridor alignments being considered.
- Consideration of the "connectivity" to the transit system and to other transit modes including provisions for vehicle storage and maintenances requirements.
- Number of major regional centers within the corridor.
- Practicality of at-grade, elevated, and underground configurations of the transit mode being considered.
- The expected transit ridership per mile compared to other transit modes.
- The expected initial capital cost and cost benefit for each transit mode considered.
- The trade-offs between land use densities, ridership, capital costs, and financial attainability.

Early studies conducted for the Crenshaw-Prairie Transit Corridor (1994) did consider aerial and at-grade light rail transit (LRT) and heavy rail subway alternatives. Those studies found that both heavy rail and light rail were feasible. The heavy rail transit mode required full grade separation, requiring a capital cost that was double the light rail transit alternatives considered. The travel time of heavy rail was shorter, which produced ridership estimates 10 percent higher than the light rail alternatives. This modest gain in ridership compared to the significantly higher cost contributed to the conclusion that light rail was the more appropriate transit mode for the Crenshaw / LAX corridor. Furthermore, LRT offered the ability to potentially connect with existing LRT facilities in the corridor (e.g., the Metro Green Line).

This conclusion is supported by current studies. Based on previous and on-going corridor studies, and existing Metro Rail operations, a number of comparisons have been made related to land use densities, forecast or existing transit ridership (boardings) per mile, and capital cost per mile depending on transit mode. *Table 1-1 – Types of Corridors and Projects Applicable to Different Transit Modes* summarizes the "corridor" information and points to the type of corridors and projects that are applicable to different transit modes. Only the highest density corridors (population and jobs) would be considered for a heavy rail transit mode.

Table 1-1 - Types of Corridors and Projects Applicable to Different Transit Modes

Corridor/Line	Transit Mode	Miles	Population Density/Sq. Mile	Job Density/Sq. Mile	Transit Boardings/ Mile (existing or forecast 2025/2035)	Capital Cost/Mile $ millions	Cost comment
Existing Metro Rail Service							
Blue	LRT	22.0			3,200 (existing)	$40	When built
Green	LRT	18.0			1,800 (existing)	$40	When built
Red/Purple	HRT	15.9			8,700 (existing)	$300	When built
Gold	LRT	13.5			1,600 (existing)	$54	When built
Orange	BRT	14.6	9,500	5,500	1,700 (existing)	$25	When built
Eastside (Phase I)	LRT	5.9	17,000	15,000	4,200 (forecast)	$152	Final Cost
Studies							
Wilshire to WW	HRT	9.0	13,000	20,000	5,600 (forecast)	$425	$2009
Expo I	LRT	8.5	12,000	10,000	4,200 (forecast)	$90	$2009
Expo II	LRT	6.8	11,000	8,500	3,300 (forecast)	$190	$2009
Eastside (Phase II)	LRT	9.3	8,400	4,200	1,100 (forecast)	$190	$2009
Foothill Extension	LRT	24.5	5,900	3,000	1,200 (forecast)	$55	$2009
Crenshaw (LPA)	LRT	8.5	5,200	5,600	1,600 (forecast)	$160	$2009

1.1.2.2 Determination of Grade for the Crenshaw / LRT

Once LRT was determined to be the appropriate mode for the Crenshaw / LAX Transit Corridor, each intersection and alignment segment was analyzed to determine where it may be necessary to deviate from the typical at-grade alignment for LRT and incorporate a grade separation.

Four general categories of criteria are used to determine if and where grade separations should be included for a light rail project:

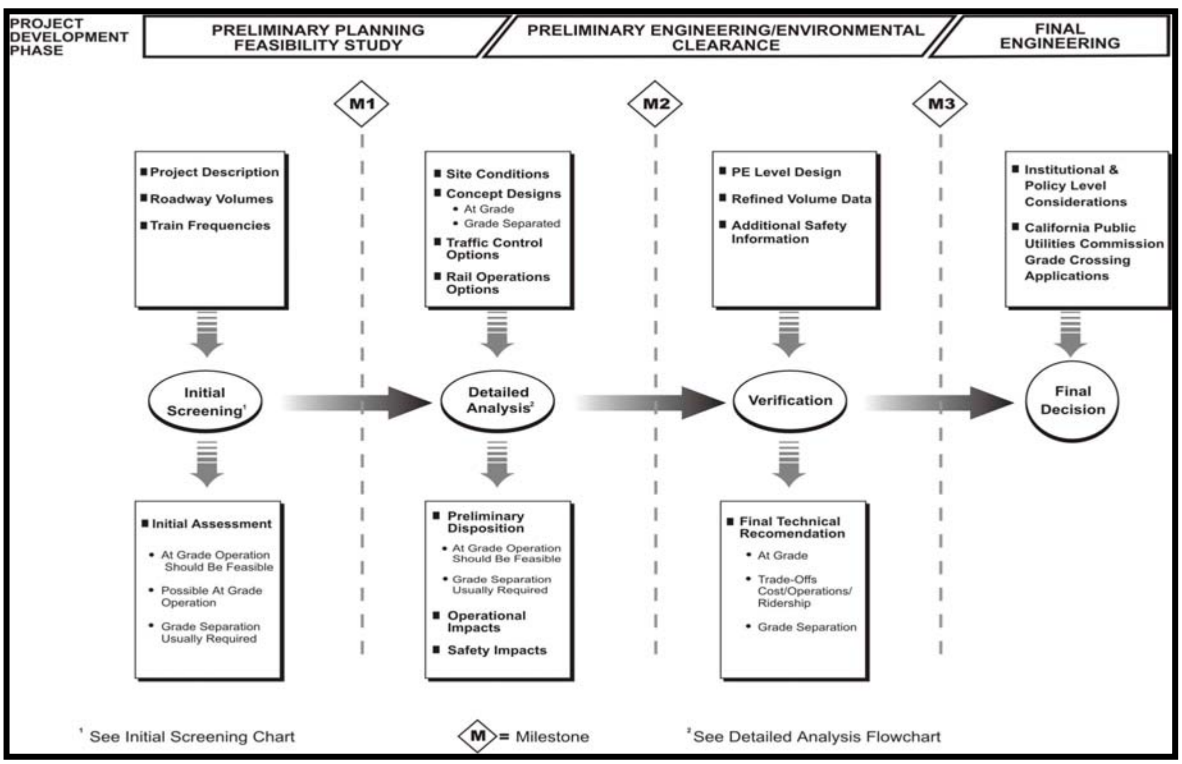
- Metro Grade separation policy.
- Environmental impacts.
- Availability of right-of-way.
- Other factors.

1.1.2.3 Metro Grade Crossing Policy

Overview

To provide a standard methodology for determining whether grade crossings along light rail lines should be grade separated or at-grade, the Metro Board adopted and published a Policy for Grade Crossings for Light Rail Transit on December 4, 2003. The policy established consistent criteria for evaluating operational, safety, institutional and financial issues. It also recognized that decisions about grade crossings are made under complex circumstances that include the interests of local, state and federal governments, the communities near the rail line, and the agency. Essentially, the policy established a process of several steps where individual grade crossings are evaluated in progressively greater detail to determine the conditions under which light rail trains may operate through a crossing efficiently and safely at-grade. The process with successive milestones is presented in *Figure 1-2 – Light Rail Roadway Crossing Review Process*.

Figure 1-2 - Light Rail Roadway Crossing Review Process



As a first step, each crossing is evaluated based on the level of traffic estimated to operate through the intersection in the horizon year (in this case, 2030) and the number of trains proposed to pass through that intersection. The data on these traffic levels is plotted against a graph as presented in *Figure 1-3 – Initial Screening Analysis for Light Rail Roadway Crossings*. Intersections which fall in the zone labeled “At Grade Operation Should be Feasible” with low traffic projections and relatively low train levels are determined to be generally feasible with at-grade crossings. These crossings are taken into further review of design features to evaluate safety features and to evaluate whether gates are appropriate safety measures as depicted in *Figure 1-4 – Evaluation Flowchart*. In street-running operation, gates are generally not used.

Intersections which fall under the zones labeled "Possible At Grade Operation" or "Grade Separation Usually Required" require additional analysis of traffic conditions, safety conditions, and rail operations to determine the appropriate operating configuration.

Figure 1-3 - Initial Screening Analysis for Light Rail Roadway Crossings

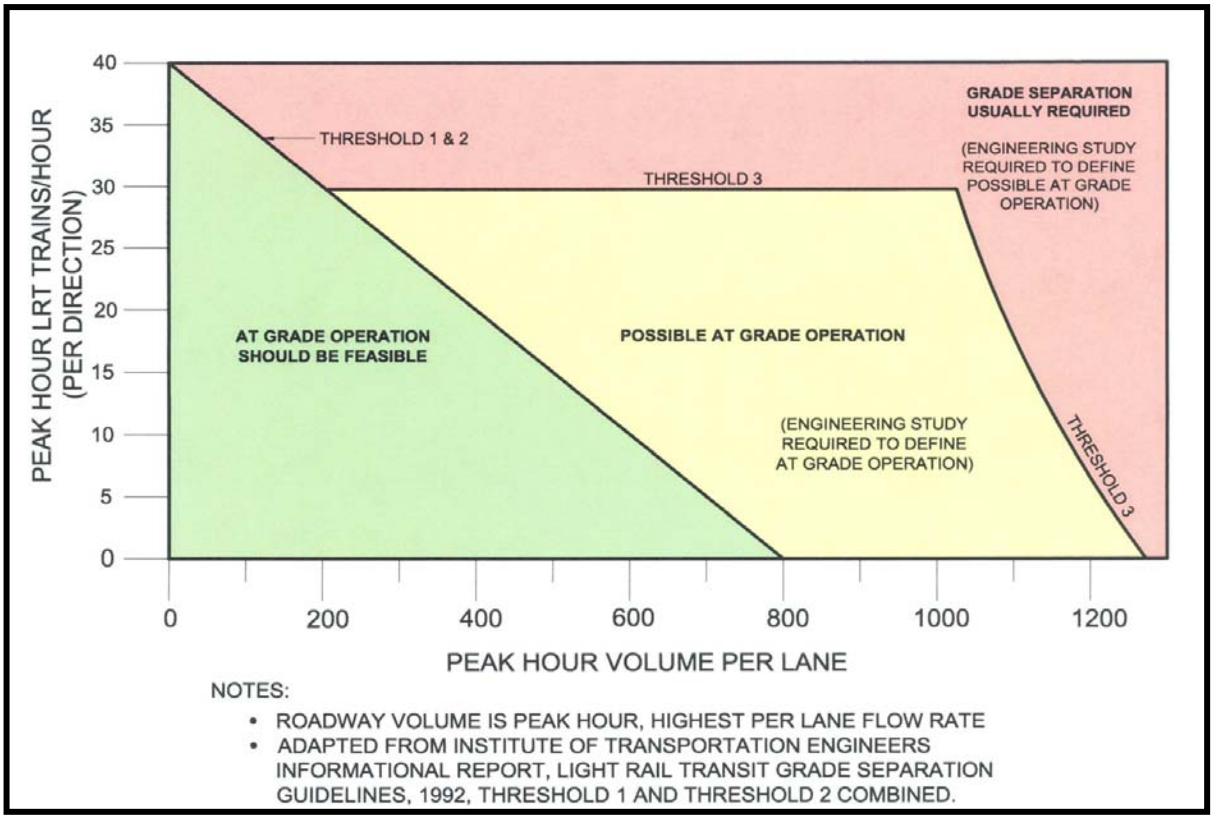
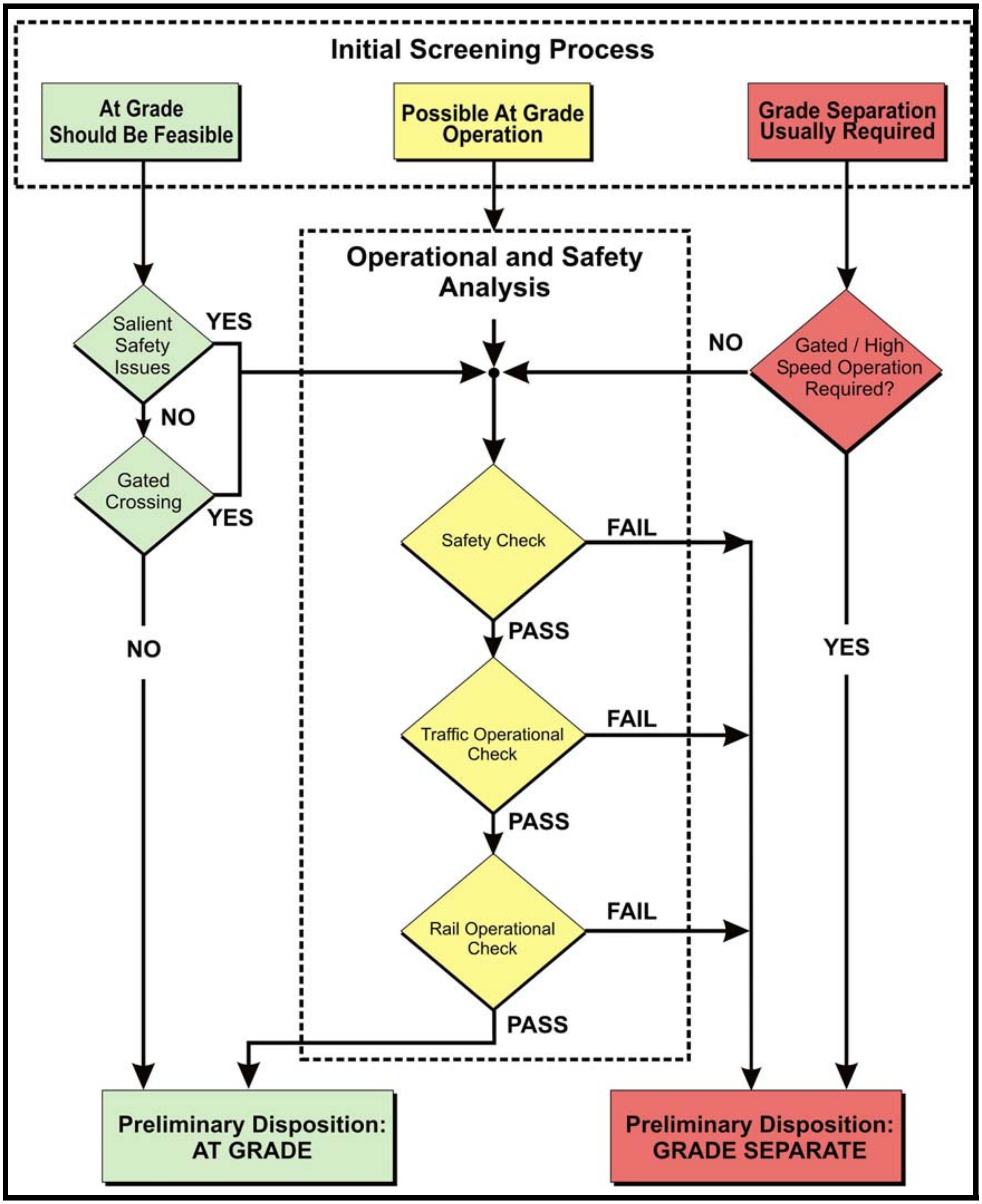


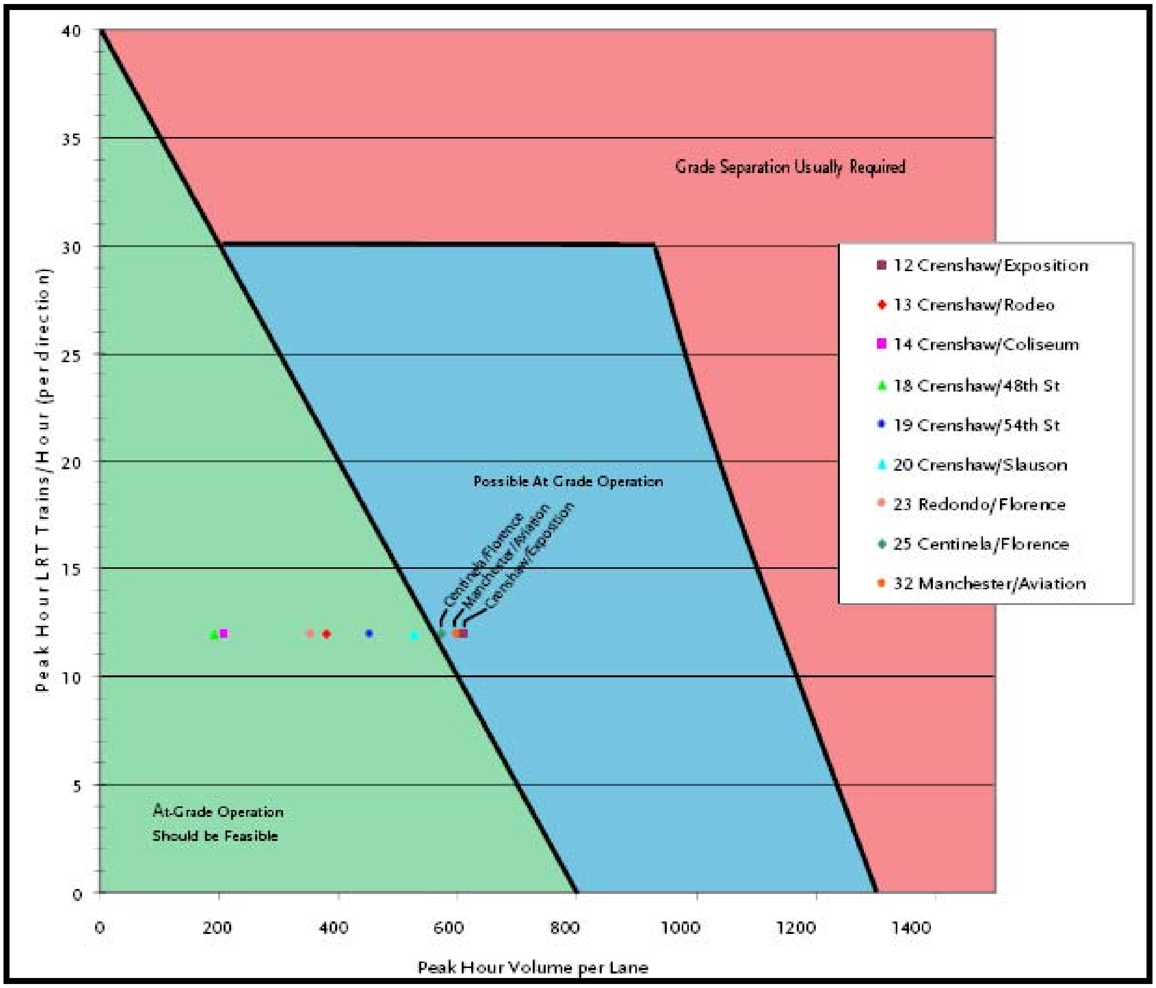
Figure 1-4 - Evaluation Flowchart



Application to Park Mesa Heights Alignment

The application of the Metro's adopted Grade Crossing Policy concluded that the Park Mesa Heights alignment does not warrant a grade separation per the policy. *Figure 1-5 – Initial Screening of Rail Crossings along the Park Mesa Heights Section* shows that of the seven intersections where there are potential automobile and train movements, all fall within the zone where "At Grade Operation Should be Feasible". Also physical conditions of these intersections do not present conditions considered out of the ordinary for the safe operation of light rail trains.

Figure 1-5 - Initial Screening of Rail Crossings along the Park Mesa Heights Section



1.1.2.4 Environmental Impacts

Overview

Another major set of criteria used in determining where grade separations may be warranted is the evaluation of environmental impacts, specifically those analyzed under the environmental review process (during the development of the EIS/EIR).

While all environmental impacts play a role in the determination of a requirement for a grade separation, the primary factors that tend to affect a grade separation decision are traffic impacts. Other factors such as visual impacts, neighborhood and community impacts, impacts to historic and cultural resources sometimes contribute to decisions related to grade separations.

Based on the analysis of traffic impacts presented in the DEIS/DEIR, traffic impacts in the Park Mesa Heights section were either insignificant or could be mitigated using the reasonable application of standard design responses to address traffic and safety impacts.

Application to Park Mesa Heights Alignment

Figure 1-6 – Initial Assessment of Traffic Impacts Assuming Exclusive Light Rail Signal Phases shows that with the initial assumption of exclusive phases for light rail three out of seven intersections, demonstrated potential traffic impacts. Based on this finding, "street-running operation" was tested. Street-running operation represents an operating configuration where light rail trains operate with traffic subject to special train signals controlling their movement. This is the standard operating configuration for most light rail systems that operate in city streets, including sections along the Metro Gold Line (Pasadena and East Los Angeles sections) and along the Metro Blue Line (in downtown Los Angeles and downtown Long Beach). Under street running operation, there are fewer significant impacts. Traffic impacts at the intersection of Crenshaw and 54th Street can be mitigated using limitations to the left turn movement across this intersection – a standard mitigation technique. Based on this traffic analysis, it was determined that there are no significant traffic impacts that would warrant deviation from at-grade street running operation. The resultant traffic impacts and the finding of no significant impact is shown in *Figure 1-7 – No Significant Traffic Impacts with At Grade Street Running Operations along Crenshaw in the Park Mesa Heights Section*.

Figure 1-6 - Initial Assessment of Traffic Impacts Assuming Exclusive Light Rail Signal Phases

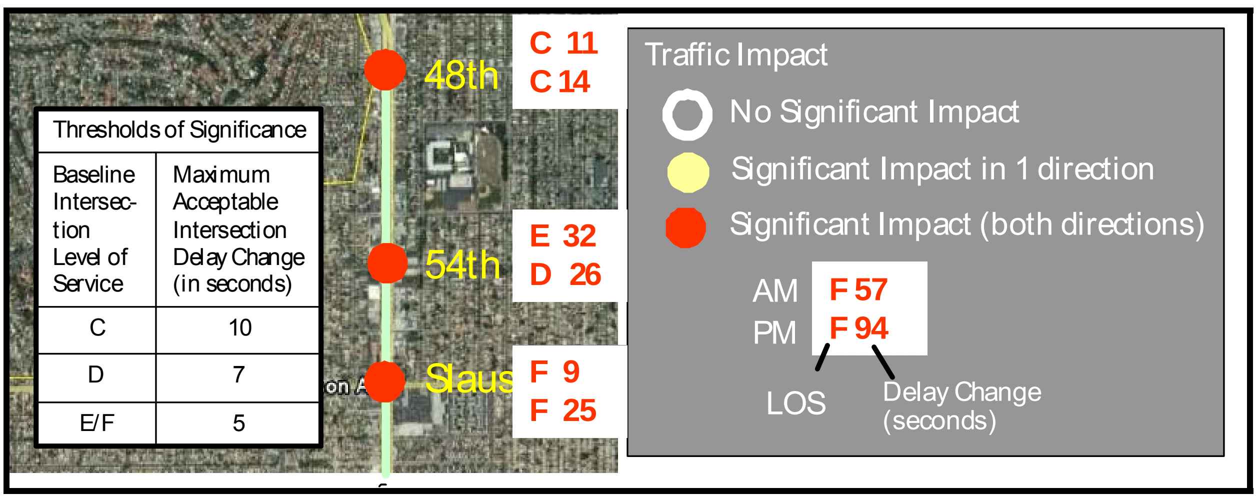
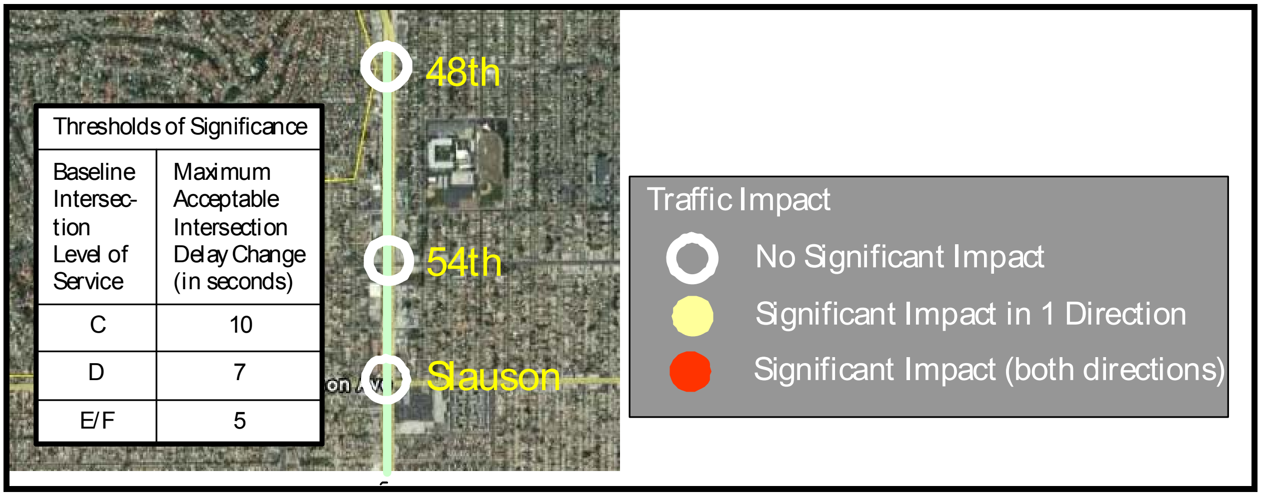


Figure 1-7 - No Significant Traffic Impacts with At Grade Street Running Operation and Mitigation Measures along Crenshaw in the Park Mesa Heights Section



Thresholds of Significance	
Baseline Intersection Level of Service	Maximum Acceptable Intersection Delay Change (in seconds)
C	10
D	7
E/F	5

The analysis of all other environmental impacts, specifically visual impacts, neighborhood and community impacts, impacts to historic and cultural resources, concluded that no significant impacts are caused by the light rail system in an at-grade configuration along this section. Therefore, no environmental criterion requires a deviation from at-grade operation of light rail in the Park Mesa Heights section.

1.1.2.5 Availability of Right-of-Way

Overview

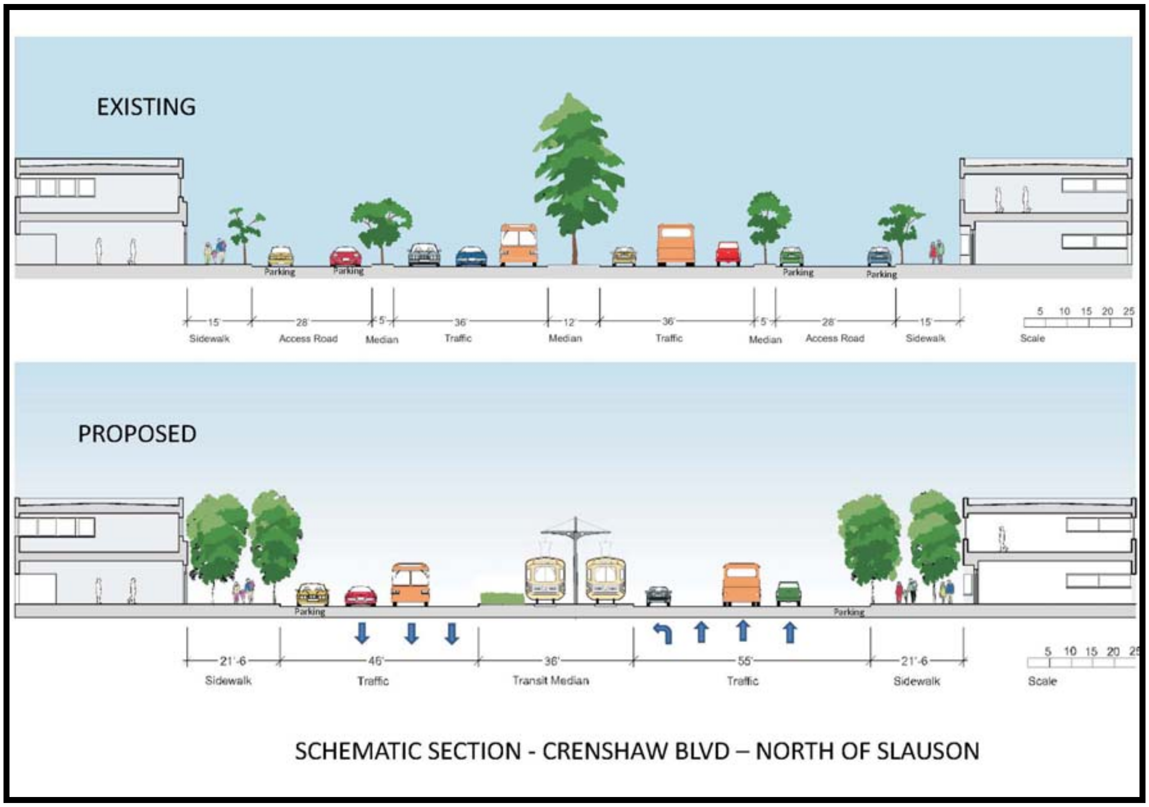
Often, decisions on grade separations are affected by the availability of right-of-way. Right-of-way is required for all sections of an LRT guideway. Often right-of-way is constrained or has specific pinch points that require grade separation. For example, the section of the alignment through Leimert Park Village demonstrates limited street right-of-way. In the Leimert Park Village section (between 39th and 48th Streets), the street right-of-way contains three through lanes, which are critical for the circulation of traffic. There is no right-of-way that can be secured without significant impacts to either traffic or displacements to one whole row of commercial businesses on one side of the street. In situations like the Leimert Park Village section, the right-of-way constraint contributed to a grade separation recommendation.

Application to Park Mesa Heights Alignment

There is no right-of-way constraint that exists along the Park Mesa Heights section that would impede the safe and efficient operation of light rail or the circulation of traffic and pedestrians in this area. In this section, the Crenshaw Boulevard is 180 feet wide from back-of-sidewalk to back-of-sidewalk, and 150 feet wide from curb-to-curb. This right-of-way width can accommodate the preservation of three through traffic lanes in each direction, all existing dedicated turn lanes (with the exception of the NB and SB left turn lanes at 54th Street), and one row of parking on both sides of the street. Retention of travel lanes will be achieved by reconfiguring frontage roads to eliminate outer parking lanes. The frontage roads provide local access to the two rows of parking in this section, but do not add to the through-capacity of the street.

The street reconfiguration (preliminary configuration shown in *Figure 1-8 – Cross Section of Crenshaw Boulevard*) accommodates the light rail guideway while preserving the essential functions of the boulevard (automobile circulation, pedestrian circulation, safety, and parking). There is no right-of-way constraint that requires the Park Mesa Heights Alignment to be grade separated.

Figure 1-8 - Cross Section of Crenshaw Boulevard



1.1.2.6 Other Factors

Overview

Often, decisions on grade separations are affected by regulatory requirements or physical conditions specific to an area. For example, adjacent to the South Runway Complex of LAX, the Federal Aviation Administration regulations require the removal of obstructions across a zone defined by the end of the runway. As another example, the elevated Metro Green Line near Aviation Boulevard and Imperial Highway requires the alignment of the Crenshaw/LAX line to be elevated to interface with the Metro Green Line. Similarly, the Metro Gold Line Eastside Expansion project included a 1.7 mile tunnel through the Boyle Heights portion of the alignment as it was felt that the narrow pre-automobile street neighborhood of Boyle Heights, perhaps Los Angeles oldest suburb, would have been substantially impacted by a surface light rail line. These other factors apply only to specific contexts and not to the entire corridor.

Application to Park Mesa Heights Alignment

There are no specific regulatory requirements or physical conditions that require the grade separation of the light rail alignment in the Park Mesa Heights section.

A comprehensive and thorough analysis of all of these factors leads to the conclusion that this section of the alignment should be at-grade to be consistent and compatible with Metro policies.

Subsequent to the publication of the DEIS/DEIR, Metro received comments from Federal, State, Regional and City Government and Agencies, from private organizations and from the general public. A number of the agency and public comments received are directly related to the study area.

Many comments expressed a strong desire that the LRT alignment be completely grade separated along the entire length of Crenshaw Boulevard. Factors raised in these comments include safety (pedestrian safety, particularly for school children and the elderly; and vehicular safety), traffic and parking (congestion at crossings and impacts of street reconfiguration), economic development, community impacts, environmental justice. A total of 283 comments are related in some form; generally or specifically to below grade alignment in the Park Mesa Heights area. (*Table 1-2 – DEIS/DEIR Comments*). Responses to all of the comments received on the DEIS/DEIR will be provided as part of the Project Final EIS/EIR.

Table 1-2 - DEIS/DEIR Comments

Topic	Number of Comments
General consideration of below grade alignments	176 (35 reference an extended below grade segment along the entire length of the alignment on Crenshaw Boulevard)
Below grade alignment in the Park Mesa Heights Area	107 (67 reference concerns about traffic and pedestrian crossings)
Total Related Comments	283

1.2 Precedent for At Grade LRT Operations in Similar Contexts

There is precedent for the type of operation and physical configuration recommended for the Park mesa Heights section of the alignment. Light rail systems operating on semi-exclusive rights of way shared with city streets provide quick and convenient access options throughout a community's residential, commercial and industrial regions. In many cities, light rail infrastructure is integrated with the existing environment of a city and urban area with operation within city streets serving adjacent land uses and development clusters directly. In these contexts, light rail systems in North American attract riders, and provide accessibility that spurs economic growth. As stated in *TCRP Report 17, Integration of Light Rail Transit into City Streets, 1996, page 7*, the LRT systems have also proven themselves to be safe systems while operating on city street right-of-way. The Cities of Sacramento, San Francisco, San Jose, Los Angeles and San Diego exemplify this success.

Existing systems in Los Angeles comparable to the Crenshaw/LAX Transit Corridor are the Metro Blue and Gold Lines.

1.2.1 Los Angeles Metro Blue Line

The Metro Blue Line, shown in *Figure 1-9 – Metro Blue Line*, runs between Downtown Los Angeles and Long Beach serving 22 Stations. This system is among the busiest in the United States with approximately 80,000 boardings per day or about 25 million passengers per year. At 22 miles, it is the longest LRT line in the Los Angeles Metro system. While the Metro Blue line utilizes former Pacific Electric Railway ROW and a short subway between Pico & 7th Street, in Downtown LA and Long Beach the tracks are at street level center running. There are 17 at-grade stations, 4 aerial stations and one underground station.

Figure 1-9 - Metro Blue Line

Source: Photo by Salaam Allah

Sections of the Metro Blue Line alignment are comparable to the Crenshaw/LAX transit Corridor. Along Washington Boulevard, the Metro Blue Line operates in the center of the street for a length of approximately 1.9 miles, utilizing embedded track in a residential, retail & light industrial area. Landscaping is incorporated along the alignment. Along Washington Boulevard the width of the street is approximately 72 feet. As the LRT tracks turn south at Washington Station, they remain center running in the median of Long Beach Avenue between two northbound and two southbound traffic lanes through an industrial area. Along Long Beach Boulevard the Metro Blue Line is also street running at the Willow Station in a landscaped median between two northbound and two southbound traffic lanes of Long Beach Boulevard, continuing in this configuration for 2.5 miles between Willow Street and 1st Street. In this section, the width of the boulevard is approximately 105 feet.

1.2.2 Los Angeles Metro Gold Line

The newest 5.8 mile extension in the Los Angeles Metro System, the Gold Line (*Figure 1-10 – Metro Gold Line*), a 19.4 miles long LRT uses a mix of surface, aerial and below grade modes to serve 21 stations. Of these stations, two are underground, one is aerial and the rest are at-grade or in freeway median. The Metro Gold Line has about 32,000 boardings per day and serves several of South California tourist attractions. *Figure 1-10* shows the Metro Gold Line at-grade median running at the landscaped East Los Angeles Civic Center Station.

Figure 1-10 - Metro Gold Line

Multiple sections of the Gold Line run at-grade in the street median. Trains run at-grade in Pasadena and South Pasadena, in Highland Park along Marmion Way, along Alameda Street and First Street in Little Tokio and Boyle Heights and along Third Street and East Los Angeles. Streetscaping and landscaping are integral with the LRT alignment and station sites to enhance the surrounding neighborhoods.

1.2.3 Sacramento Regional Transit (RT)

Sacramento RT operates a 38 route mile light rail system serving patrons with 45 stations (*Figure 1-11 – Sacramento RT*). The system runs two major routes, the Gold Line operating east and west from the city of Folsom, CA to Sacramento's downtown Amtrak station, and the Blue Line operating north to south from North Sacramento to South Sacramento. Ninety-five percent of the entire system is at-grade with the majority of the Downtown tracks within city streets on shared right of way. The system presently serves approximately 58,000 daily passengers, including a significant number of handicapped patrons who live and work in the state's capital. This system is similar to the proposed Crenshaw LRT system in that it shares city streets with vehicular traffic at intersections and serves the public with at-grade stations. This system is recognized as one of the safest LRT systems in the USA.

Figure 1-11 - Sacramento RT

1.2.4 San Diego Trolley

The San Diego Trolley system is an iconic LRT system. The "Trolley" as it is known operates 3 lines with 53 stations (*Figure 1-12 – San Diego Trolley*). The 19 route mile "Blue Line" operates between "Old Town" in downtown San Diego to the U.S./International Border with Mexico. The 21 mile "Orange Line" operates between downtown San Diego and Gillespie Field to northeast San Diego. The 19 mile "Green Line" operates between the Old Town Transit Center in San Diego to Santee Town Center. From it's beginning in 1981, the "Trolley" has been a huge component in revitalizing downtown San Diego and its surrounding communities. The Trolley is a highly popular, convenient and reliable system carrying about 110,000 riders per weekday. It also records significant ridership on weekends. Most of the San Diego "Trolley" system is surface and street running. Sections that operate in city streets have a street width between approximately 45 feet and 155 feet. The San Diego LRT system is similar to the proposed Crenshaw line in that it operates within busy city streets. It has proven to be a very safe system.

Figure 1-12 - San Diego Trolley

Source: Photography by Peter Ehrlich

1.2.5 San Jose Valley Transportation Authority (VTA)

California's Santa Clara Valley Transportation Authority (VTA) currently operates 84 track miles of light rail transit (LRT) system in Santa Clara Valley. There are 62 LRT stations in this system. VTA operates two LRT lines that serve terminals in downtown Mountain View to the west, Alum Rock in east San Jose, Santa Teresa in south San Jose and the City of Campbell to the southwest. Both lines jointly serve downtown San Jose and stop at numerous points in Silicon Valley and its residential communities. The system carries about 33,500 riders on an average weekday, and is shown in *Figure 1-13 – San Jose VTA*. VTA's system is double tracked and is 96% at-grade with grade separations only over major roads and freeways. The alignment is placed in median street running right of way or on shared use railroad corridors. This system is also very similar in character to the proposed Crenshaw Line. San Jose's Light rail system has proven to be very safe and reliable.

Figure 1-13 - San Jose VTA

Source: Photo by Steve Ewald

1.2.6 San Francisco Municipal Railway (Muni)

The San Francisco Muni system is a 143 track mile LRT system serving 84 surface stations and 9 subway stations. The systems serve about 157,000 passenger boardings per day. The SF Muni system is comparable to the combined LA Metro Blue Line, Green Line and Gold Line in track miles and daily boardings. San Francisco Muni operates an older system that has been upgraded to modern LRT standards. Both systems use street running and tunnels with street running being most prevalent. One of Muni's most heavily used lines is the N-Judah Line, which has many similarities with the proposed Crenshaw/LAX Corridor. For example the N-Judah line includes sections where it transports patrons at-grade along the Embarcadero, one of the city's busiest roads—with three lanes of vehicular traffic in each direction. As the line also passes the new SF Giants baseball stadium, there are significant numbers of pedestrian crossings of the LRT alignment. The close interrelationship between Muni, pedestrian and vehicular traffic is shown in *Figure 1-14 – Muni LRT on Embarcadero, San Francisco*.

Figure 1-14 - Muni LRT on Embarcadero, San Francisco

Source: Photograph by Peter Ehrlich

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2 DESCRIPTION OF THE PARK MESA HEIGHTS GRADE SEPARATION (PMHGS)

The PMHGS involves the construction of an additional underground segment of approximately 4,550 feet in length between 48th and 59th Streets. This underground segment would lie between two underground sections of the LPA alignment measuring 4,250 feet and 6,350 feet respectively.

Constructing the PMHGS underground would result in an extended segment of underground guideway between the limits of Coliseum Place in the north and Victoria Avenue to the south. This combined underground segment would have approximate length of 15,250 feet. The extent of this underground guideway is indicated on Figure 1-1. Plan and profile drawings showing the resulting horizontal alignment and approximate vertical profile of the PMHGS are included in Appendix A.

The PMHGS underground alignment would begin a transition from at-grade to below grade at Coliseum Place approximately in a section of open cut guideway. The below grade LRT alignment would continue south along Crenshaw Boulevard to a proposed underground station at Martin Luther King Jr. (MLK) Boulevard. Beyond Crenshaw/MLK Station the alignment would continue south under Crenshaw Boulevard.

Beyond the Crenshaw/Slauson Station site, the alignment would continue southwards under Crenshaw Boulevard to 67th Street. The tunnel alignment then would turn southwest and continue under the right of way of the Harbor Subdivision. Once the transition to the Harbor Subdivision is made, the alignment would return from below grade to at-grade at Victoria Avenue approximately, through a second section of open cut construction.

The LPA alignment includes an at-grade station between Slauson Avenue and 59th Street. Two options exist for the Crenshaw/Slauson Station associated with the PMHGS—an underground station included, or no underground station. In the event that no station is provided at Slauson Avenue, a structure will still be required in the same approximate location to provide adequate ventilation to the tunnels.

Existing ground elevation varies over the length of this underground segment, from a minimum of 137 feet at the north limit of the PMHGS analysis, Station 377+50, to a maximum of 183 feet between 54th Street and 52nd Street. Top of rail elevation is generally maintained at a minimum depth of approximately 50 feet below surface, but deepens to a maximum of approximately 80 feet within the extent of the PMHGS to provide a smooth vertical track profile and maintain passenger comfort between stations.

2.1 Description of Construction Methods

The PMHGS alignment has an overall length of 15,250 feet, comprising a southern retained cut portion of 640 feet, a central underground section of 14,200 feet, and a northern retained cut section measuring 410 feet in length. A summary of the construction methods and extents is provided and summarized in *Table 2-1 – Summary of PMHGS Option Construction Methods*.

Design studies developed during Advanced Conceptual Engineering concluded that for shorter tunnels cut and cover construction is most economical. Conversely for longer tunnels, studies confirmed that mined tunnel construction utilizing a tunnel boring machine (TBM) becomes more economical than cut-and-cover construction, as large cost items such as the procurement of the

TBM(s) can be distributed over a significant length of tunnel, maximizing efficiency and productivity, and thereby helping to minimize unit costs. For cut and cover construction, site work costs including traffic management and utility relocation become significant cost items, increasing with length and correspondingly increasing unit rates and total construction price for this form of construction.

Based upon the results of the analysis of tunneling methods and the required length of tunnel for the PMHGS, the use of TBM construction was considered for the entire length. Limited lengths of cut and cover construction will be required at each portal to allow the track profile to transition to an adequate depth to safely launch the TBM(s). It is anticipated that the length of cut-and cover tunnel required at each end of the TBM tunnels will be approximately 400 to 600 feet long. Based upon the anticipated groundwater elevations, both the TBM tunneling and the cut-and-cover construction will encounter some groundwater in the northern section of the alignment.

There are no seismic faults requiring modified construction in this area.

Table 2-1 - Summary of PMHGS Construction Methods

Description	**Length (ft)**	**Start Station***	**End Station***
Retained Cut (Victoria Avenue)	800	275+00	283+00
Cut and Cover	450	283+00	287+50
TBM	3,235**	287+50	319+85
Crenshaw/Slauson Station ***or*** Ventilation/Crossover structure	270	319+85	322+55
TBM	8,360	322+55	406+15
Crenshaw/MLK Station	270	406+15	408+85
TBM	1,015*	408+85	416+40
Cut-and-Cover	440	416+40	423+40
Retained Cut (Coliseum Place)	410	423+40	427+50
Total	**15,250**		

* - Station numbering is for reference of location along the alignment.
Units are in feet

** - includes approximately 300 linear feet of tunnel in grouted soil.

Typical cross sections for the tunnel construction methods and the underground stations are included in Appendix A. Correspondingly, the following processes have been assumed for each construction method.

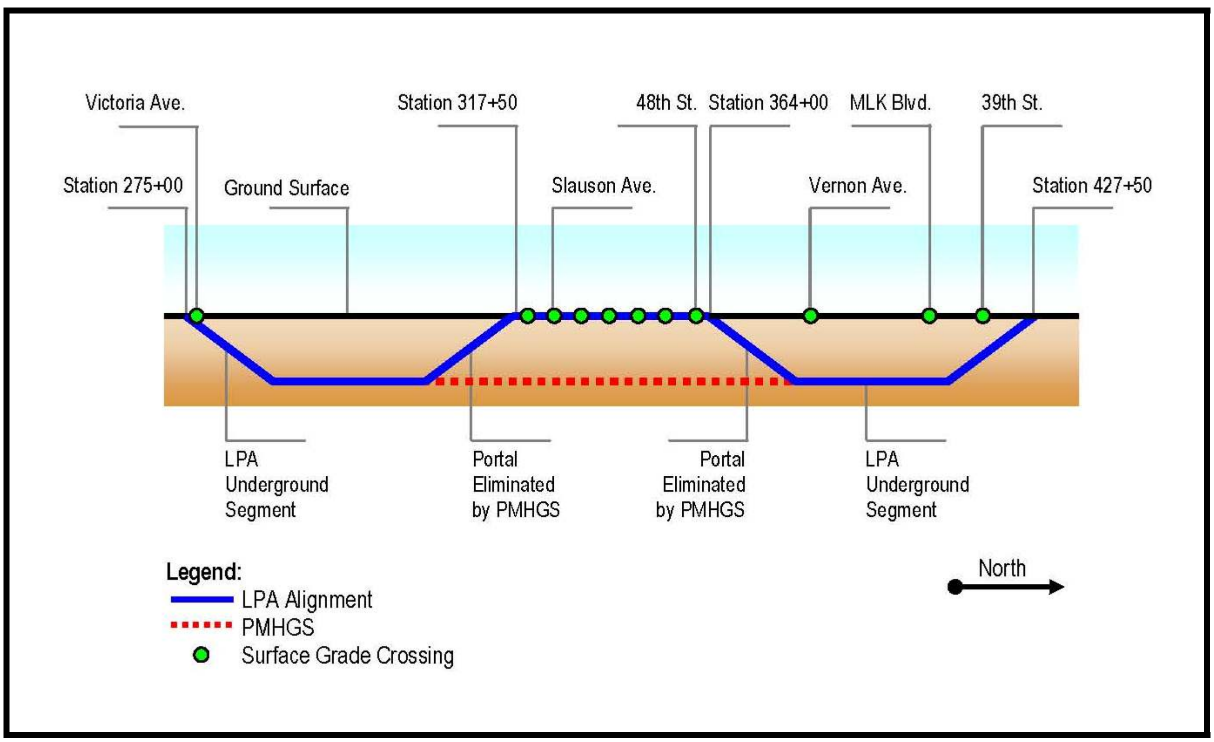
In comparison, the LPA alignment over the limits of the analyzed area would be constructed by a combination of at-grade, retained cut/cut-and-cover and TBM methods. The approximate extent of each of these construction methods is indicated in *Table 2-2 – Summary of LPA Construction Methods*.

Table 2-2 - Summary of LPA Construction Methods

Description	Length (ft)	Start Station	End Station
Retained Cut (Victoria Avenue)	800	275+00	283+00
Cut and Cover	2,950	283+00	312+50
Retained Cut (59th Street)	500	312+50	317+50
At Grade	235	317+50	319+85
Crenshaw/Slauson Station	270	319+85	322+55
At Grade	4,145	322+55	364+00
Retained Cut (48th Street)	640	364+00	370+40
Cut-and-Cover	460	370+40	375+00
TBM	3,115	375+00	406+15
Crenshaw/MLK Station	270	406+15	408+85
TBM	755	408+85	416+40
Cut-and-Cover	700	416+40	423+40
Retained Cut (Coliseum Place)	410	423+40	427+50
Total	**15,250**		

The differences between the PMHGS and the LPA are highlighted in *Figure 2-1 – Schematic of Vertical Profile for PMHGS and the LPA.*

Figure 2-1 - Schematic of Vertical Profile for PMHGS and the LPA



2.1.1 TBM

The use of pressurized face TBMs, either earth pressure balance or slurry machines, has been assumed for the running tunnels. Pressurized face TBM tunneling is recommended to avoid any requirement for dewatering along the alignment and for control of surface settlements. A minimum amount of ground cover is desirable over the TBM to provide confinement of pressurized fluids used by the machines as part of the tunneling process, to allow some arching of the ground above the tunnel for stability, and to control surface settlement. For the running tunnels, a minimum cover of one and one half diameters is desirable, and has been assumed for the purposes of this analysis. Where profile constraints dictate that less than one and one half diameters of ground cover can be provided over the TBM such as at transitions to stations, pre-excavation ground improvement such as grouting has been assumed to provide a stable medium for tunneling.

For twin bored tunnels, the ground separating the two tunnels is called the pillar. Pillar width is optimized when setting out the alignment to balance considerations of right of way and surface settlement. For this study, we have assumed that the pillar is minimized at the interface with the cut-and-cover construction, again through the use of ground improvement, and increases to approximately one tunnel diameter away from the interfaces.

An inside tunnel diameter of 18 foot-10 inches has been assumed for this analysis, based on earlier planning work, which would result in a TBM and excavation size of about 21 feet in outside diameter.

2.1.2 Cut and Cover

Based on the soils investigations conducted in the corridor in the Spring of 2010, it is not likely that the cut and cover tunnel at the south portal area will encounter groundwater during construction, whereas a perched water table is anticipated at the north portal, within the depth of the excavation. Therefore different excavation methods will be required at the cut-and-cover sections at each portal site. To the south it is likely that some form of soldier pile and lagging system can be adopted. However, at the north portal to prevent groundwater ingress into the excavation, a rigid, impermeable support of excavation system, comprising deep soil mix walls or a similar construction method will be required. It is assumed that all excavations will be internally braced. Where the excavation occurs on City streets, temporary traffic decking will be provided to maintain surface traffic.

As rigid support of excavation systems are more expensive than their more flexible counterparts, to maximize the value of the investment in this wall type it is recommended that the support of excavation be incorporated into the permanent structure at the north portal.

The permanent cut-and-cover structures would be constructed of cast-in-place concrete within the respective excavations.

2.1.3 Retained Cut

The alignment will transition from at-grade to completely underground by means of sections of retained cut construction. The construction process is similar to that described for the cut-and-cover tunnels, whereby excavation is performed within the limits of a support of excavation system, and the structure built within the excavated trench. At the south portal as described for the cut-and-cover tunnel, the excavation will be completely above the groundwater table. At the north portal the retained cut will transition from below to above the groundwater table. Therefore the excavation method can be modified accordingly to suit the specific site conditions. The permanent retained cut structures would also be constructed of cast-in-place concrete within the respective excavations.

2.1.4 Fire Life Safety

To meet the emergency egress requirements of the National Fire Protection Association (NFPA) 130 – Standard for Fixed Guideway Transit Systems, cross passages between the tunnel bores are required at 800 foot spacings to accommodate evacuation of patrons in the event of an emergency incident within the tunnel. For the PMHGS Option, a total of fifteen cross passages would be required within the extent of the TBM drive. The cross passages within the TBM drive are time consuming and expensive to construct. Due to the size of the cross passage opening, hand tools must be used for excavation, requiring extensive pretreatment of the adjacent ground.

Conversely, for the LPA Option only four cross passages are required within the TBM sections of that alignment, eleven less than for the PMHGS Option. Additional LPA cross passages are easily accommodated in cut-and-cover tunnel sections, by simply creating a door opening in the central wall separating the tracks.

Requirements for tunnel ventilation dictate that some form of ventilation structure be provided in the location in the approximate location of the Crenshaw/Slauson Station, regardless of whether a station at Crenshaw/Slauson is included. For the option with no Crenshaw/Slauson Station, the distance from the Crenshaw/MLK Station to the south portal is approximately 12,315 feet. Providing sufficient ventilation under normal and incident conditions within this tunnel segment from equipment located at the Crenshaw/MLK Station alone will be extremely difficult. Therefore, it is anticipated that for the option with no Crenshaw/Slauson Station, the construction of at least one supplemental ventilation shaft will be necessary. Also, Metro Design Criteria require a crossover within the underground alignment. This crossover could reasonably be located jointly with the ventilation structure, within the same excavation. For the purposes of the study, it is assumed that the excavation for the crossover is approximately identical to that required for the station, though ultimately the ventilation equipment rooms, electrical rooms and supply/exhaust shaft will occupy an area approximately 50% of the plan footprint of the station. To minimize any impacts with any future station construction, the plant and shaft site could be located to either side of Crenshaw Boulevard, with the purchase of additional right of way.

Cost is discussed in **Section 4.2** and a detailed cost breakdown of the PMHGS Option under the defined scenarios is provided in Appendix B.

2.1.5 Stations

With the PMHGS, if a Crenshaw/Slauson Station is provided, it would become an underground station. This analysis assumes a single entrance would be provided at the northwest corner of West Slauson Avenue and Crenshaw Boulevard. A small plaza would be created at that corner with access provided by an escalator, stairs, and an elevator to the station. Ventilation shafts would also be required. As the LRT alignment along Crenshaw Boulevard would be fully underground there would be no need for the street reconstruction associated with the LPA Option. The only visual impact would be the entrance and entrance plaza to the underground station.

As indicated in the Fire Life Safety discussion above, if the PMHGS alignment does not include a Crenshaw/Slauson Station, a ventilation structure would still be necessary in the same approximate vicinity as the proposed station location. In this case, visual impacts would be potentially associated with the ventilation shaft structures.

2.2 Description of Deviations from LPA

The PMHGS differs from the LPA configuration in terms of its alignment and construction methods. A summary of these differences or deviations from the LPA are provided below:

- Horizontal Alignment: Some modifications to the LPA horizontal alignment would be made to incorporate spiral transition curves between areas of tangent (straight) track and circular curves to provide a smoother ride for Metro patrons, these modifications are slight and do not significantly change the project footprint.
- Vertical Profile: With the introduction of the extended TBM tunnel, the vertical profile of the alignment would significantly be altered, with the resulting deletion of two portals. With the extended TBM tunnel, additional flexibility exists to deepen the alignment to avoid adverse soils conditions and to increase depth of separation over vulnerable utilities.
- It is likely for the LPA that the southern tunnel segment (between 59th Street and Victoria Avenue) would be constructed using cut and cover methods, whereas the longer northern segment (between 39th Street and 48th Street) would be principally constructed using TBM(s), with limited sections of cut and cover tunnel at the portal areas. The PMHGS, would result in an extended below grade alignment which would principally be constructed using a TBM. Environmental considerations arising from the changed construction methods are discussed in **Section 4.1**.
- Crenshaw/Slauson Station: The LPA configuration includes an at-grade station between West Slauson Avenue and West 59th Street on Crenshaw Boulevard. Access to and from the station would be provided at both ends of the platform and four street corners. Due to the need to reconfigure the streets to accommodate the LRT tracks, the streets and sidewalks would be reconstructed along the entire street running portion of the guideway with new landscaping, pavement designs and art for transit creating a fresh look along the full length of the at-grade guideway on Crenshaw Boulevard.

  With the extended tunnel, Crenshaw/Slauson Station, if constructed, would change from an at-grade station to an underground station. The station construction would be by cut and cover methods, and would result in additional right-of-way impacts (on the side of the street) for entrances, ventilation shafts and other ancillary works and potentially for an entire station box. In the event that no underground Crenshaw/Slauson Station is constructed, a mid-tunnel ventilation plant would be necessary, in the vicinity of the Crenshaw/Slauson Station location. The ventilation plant would be necessary to provide sufficient airflow within the tunnels during congested operations or during an emergency incident. The ventilation plant would be substantially located below ground, and construction methods would be similar to those proposed for the underground station. For the PMHGS with a Crenshaw/Slauson Station, an additional section of cut-and-cover construction would be required adjacent to the station to accommodate a track crossover. For the PMHGS with no station, the crossover would be accommodated within the extent of the ventilation structure.

3 EVALUATION OF PHYSICAL CONSIDERATIONS

This section of the report describes several physical conditions which must be considered as part of the analysis. These conditions include the geotechnical considerations, which determine the feasibility of the PMHGS tunnel option, the interfaces with underground sections recommended as part of the LPA, and impacts upon existing utilities, drainage and traffic.

3.1 Geotechnical Considerations

The project is generally located in the northern part of the Los Angeles Basin. The southern and central parts of the Crenshaw Corridor LRT alignment are underlain by Late Pleistocene-age sediments of the Lakewood Formation. These sediments may be overlain locally by pockets and thin deposits of younger Holocene-age alluvium, and are probably underlain at shallow depth by the Pleistocene San Pedro Formation. The northern part of the alignment is directly underlain by Holocene-age basinal and stream alluvium. Most of these materials were deposited by streams crossing the floor of the Los Angeles Basin such as Ballona Creek, and the Los Angeles, and San Gabriel Rivers. Most creeks and rivers are now confined within concrete- and rip-rap-lined aqueducts. The two sections of the alignment are separated by the hills and faults of the Newport-Inglewood structural zone, located in the Baldwin Hills area. There are no hard rocks along the project corridor. A map of the regional geology is provided in Appendix C.

3.1.1 Soils and Groundwater Regime

As of May 2010, a total of 33 soil borings have been completed between Arbor Vitae Street and Exposition Boulevard. Ten of these were completed in the area between 48th and 59th Streets. The field investigation program has been supplemented by a desk study of available existing geotechnical information. Based upon the results of the field investigations conducted to date, the general soil conditions along Crenshaw Boulevard are summarized below. The preliminary soil profile for the PMHGS area is also included in Appendix C.

- This segment is underlain by up to 20 feet of brown to olive brown, loose to medium dense, silty to clayey sand.
- The silty to clayey sand stratum is underlain by approximately 25 to over 100 feet of medium dense to very dense, brown to olive brown, silty sand to poorly graded sand. This unit also contains scattered 5 to 10 feet thick pockets of very dense, poorly graded gravel with sand and silt at approximately 40 feet below existing grade.
- Discontinuous lenses of stiff to hard clay and silt layers are prevalent throughout this portion of the alignment. In particular, between 43rd Street and Exposition Boulevard, a stiff to hard clay lens up to 20 feet thick exists at 10 to 30 feet deep below existing grade.
- Deeper layers of dark brown to olive brown, very dense to hard silt and clay were observed at depths of 60 feet and below.

During field investigations conducted along Crenshaw Boulevard in March and April of 2010, static groundwater was encountered in 10 boreholes at approximately 51 to 97 feet below existing grade. A perched condition was also observed within borings between 38th Street and Exposition Boulevard where groundwater was observed at approximately 16 to 24 feet below existing grade; in this area, a clayey unit exists near the perched groundwater elevations.

As discussed in **Section 2.1**, the soils conditions identified, while variable, are suitable for tunnel construction using either an earth pressure balance or slurry TBM. Once the field investigation has been completed and the soil profile on the LRT alignment is developed, the tunnel alignment can be adjusted to facilitate tunneling in the most advantageous soils conditions relative to the proposed TBM type. Unlike cut-and cover construction, the TBM tunnel offers the flexibility to adjust the vertical profile at no additional construction cost.

3.1.2 Hazardous Materials

A significant consideration for the TBM tunnel during construction, and in service, is the potential to encounter hazardous materials. The Crenshaw/LAX Transit Corridor passes through densely populated urbanized areas and industrial areas, including production oilfields. Therefore, the potential of encountering hazardous wastes as well as petroleum-contaminated soils and groundwater, and organic gases during tunnel excavations is always present. The potential for encountering hazardous materials during construction and operation of the LRT system will be addressed and mitigated as part of the projects risk management process. Mitigations will include gas detection equipment, appropriately designed tunnel ventilation systems, and a gasketed tunnel liner to prevent gas infiltration into the in-service tunnel.

3.2 Interfaces with Underground Sections Recommended as Part of the LPA

The creation of the single long tunnel results in the elimination of two portals, as indicated in Figure 2-1, required to transition the LPA underground segments to the adjoining at-grade section of trackwork. Correspondingly interfaces between the LPA tunnels segments and the PMHGS are created underground. However, as described in **Section 2.1**, the lengthened single tunnel alternative does not necessarily interface with the LPA tunnel segments, but could provide the opportunity to optimize the track vertical profile and the tunnel construction methods, through the maximized use of a TBM.

3.3 Constructability Considerations and Requirements

3.3.1 Requirements for Tunnel Construction and Fabrication

The feasibility of the construction of the PMHGS Option must consider the physical requirements associated with building and operating the tunnels, and the impacts of these requirements on the neighboring communities. Requirements for construction staging areas for equipment and materials—locations and sizes, requirements for delivering materials to and hauling spoil from the site, including truck routes and operating windows, and the interrelationship between LRT operations and tunnel ventilation system must all be considered.

No evaluations or decisions have been made regarding contract packaging for the LPA. The PMHGS tunnel could be procured as a single tunnel construction contract or combined with other project work. To facilitate construction, contractor staging areas will be required for contractor offices, parking storage of materials and equipment at the portal/retained cut sites and also at intermediate station or ventilation structure sites. At each site, the staging area should be adjacent to the construction. In each case an area of approximately 2 to 3 acres would be desirable. This total acreage can be a combination of on-street staging, in areas where traffic lanes are otherwise reduced to support the construction, and private property such as parking lots which can be leased or purchased as necessary. This acreage may have to be increased at the TBM launch portal depending on the type of TBM used. As indicated in **Section 2.1**, a pressurized face machine—either earth pressure balance or slurry will be required. If it is determined that a slurry machine is more suited to the anticipated ground conditions, additional staging area for slurry pumps, de-sanding and recirculation equipment will be required. The slurry can be piped to a plant remote from the tunnel site as necessary. However, as indicated in *Figure 3-1 – TBM Slurry Plant, New York City Transit, Second Avenue Subway Project, New York, NY*, the plant can be reasonably compact. This same area would also be required for the LPA tunnels, if a slurry TBM is preferred.

Figure 3-1 - TBM Slurry Plant, New York City Transit, Second Avenue Subway Project, New York, NY

In addition to the staging areas adjacent to the tunnel alignment, additional area must be found to manufacture and store the precast concrete tunnel lining segments. As this facility would be several acres in size, it may be difficult to locate appropriate space to maintain this plant close to the tunnel alignment. However, it is fairly typical that the fabrication facility can be remote from the tunnel site. For example the Traylor Shea Ghazi (TSG) Precast Plant in Littlerock near Palmdale has provided precast segments for several Los Angeles tunnel projects. A typical TBM segment production and storage area is shown in *Figure 3-2 – TBM Segment Production Facility, Palmdale, CA.*

Figure 3-2 - TBM Segment Production Facility, Palmdale, CA

While PMHGS tunneling will result in fewer surface impacts such as traffic lane closures and rerouting, and utility relocations, the continuous TBM operation will result in the generation of tunnel spoil at a relatively constant rate over a period of 16 to 20 hours per day, depending upon the contractors preferred shift arrangements for operating and maintaining the TBM.

In addition to the removal of tunnel spoil, delivery of tunnel segments must occur on a frequent basis to ensure that the TBM operation is not slowed or otherwise compromised. While some local storage space for segments will be provided adjacent to the TBM launch portal, this must be constantly replenished. Spoil removal and segment delivery is by truck. The more mined tunneling is needed, the more trucks will be needed for a longer duration.

For the PMHGS tunnel without an underground Crenshaw/Slauson Station, the distance between the south portal and Crenshaw/MLK Station is approximately 12,315 feet. This results in a single ventilation zone, which is difficult to ventilate during congested or incident operation due to the guideway length, and creates an operational issue for Metro in that per the National Fire Protection Association Standard for (NFPA 130) requires that only one train be in a ventilation zone at any one time. Therefore during a period of congested operation, or delay recovery, or should Metro wish to reduce headways, the PMHGS tunnel would become an operational constraint as only one train could be in the tunnel between the south portal and Crenshaw/MLK Station. Therefore it is considered prudent to make provision for a mid-tunnel ventilation plant, which would be located at the Crenshaw/Slauson Station site approximately. This would still require right-of-way. If an underground station at Slauson Avenue is included, the ventilation equipment would be located in the station ancillary spaces.

3.3.2 Utilities

A number of major utilities exist on or adjacent to the proposed Crenshaw/LAX LRT alignment. The most critical of these utilities, their locations, and the utility impacts for the PMHGS alignment are identified in Table 3-1. Drawings indicating the approximate location of these utilities are included in Appendix A

For the PMHGS, most of the alignment is in a section of TBM tunnel. The top of tunnel would be in most cases significantly deeper than the depth of burial of the utilities. In addition, the PMHGS results in the elimination of two portals at 59th Street and 48th Street. The removal of these portals, combined with the extended use of TBM construction, results in minimal utility impacts, as evidenced in *Table 3-1 – Potential Utility Impacts*.

Table 3-1 - Potential Utility Impacts

Utility	DEIR/DEIS Station Location	Description	Impacts to PMHGS Alignment
Storm drain	STA 310+80 to STA 320+70, 60th Street to 58th Place	21”-27” RCP 44’ west of Crenshaw Boulevard centerline between 60th Street and 58th Place. Bottom of pipe approximately 6’ below existing street grade. Pipe ties into existing 24” storm drain line in 60th Street.	None
Storm drain	STA 310+80, 60th Street	24” RCP crossing Crenshaw Boulevard 6’ north of 60th Street centerline. Bottom of pipe approximately 6’ below existing street grade. Pipe ties into existing storm drain line east of Crenshaw Boulevard/60th Street intersection.	None
Fiber Optics (LA City)	STA 310+80, 60th Street	Overhead fiber optic wires crossing Crenshaw Boulevard on south side of Crenshaw Boulevard/60th Street intersection. Wire heights have yet to be determined.	None
Sewer	STA 310+90 STA 310+90 to STA 323+30	10” RCP, +/- 7’ cover 8” RCP, +/- 6’ cover, on east and west sides of Crenshaw Boulevard	None
Telephone (Pacific Telephone & Telegraph Co.)	STA 317+20, 59th Street	Conduit crossing Crenshaw Boulevard at 59th Street centerline. Burial depth yet to be determined.	None
Gas	STA 317+70	26” H Gas, Southern California Gas crossing Crenshaw Boulevard at 59th Street intersection. Burial depth yet to be determined.	None
Cable (TW)	STA 323+90, Slauson Ave.	Overhead cable wires crossing Crenshaw Boulevard on south side of Crenshaw Boulevard/Slauson Avenue intersection. Height of wires yet to be determined.	None

Utility	DEIR/DEIS Station Location	Description	Impacts to PMHGS Alignment
Sewer	STA 310+90 to STA 323+30, STA 323+90 to STA 338+40 STA 323+90 to STA 323+40 STA 323+90	8" RCP, +/- 6' cover, on east and west sides of Crenshaw Boulevard. 8" RCP, +/- 5' cover, east side of Crenshaw Boulevard 8" RCP, +/- 5' cover, west side of Crenshaw Boulevard 8" RCP, +/- 5' cover, crossing Crenshaw Boulevard at Slauson Avenue	None
Telephone (Pacific Telephone & Telegraph Co.)	STA 323+50, between Slauson Avenue and 57th Street	Conduit crossing Crenshaw Boulevard 40' south of Slauson Avenue centerline. Burial depth yet to be determined.	None
Water (MWD	STA 330+70, 57Th Street at Crenshaw Boulevard	48" precast concrete MWD water pipe at +/- 20 feet from street surface to bottom of pipe.	Vertical alignment may have to be modified to maximize separation between tunnel and utility.
Storm drain	STA 310+80 to STA 320+70, 60th Street to 58th Place STA 323+90 to STA 330+80 STA 323+90	21"-27" RCP 44' west of Crenshaw centerline between 60th Street and 58th Place. Bottom of pipe approximately 6' below existing street grade. Pipe ties into existing 24" storm drain line in 60th Street. 24" RCP, top +/- 6' cover 27"-33" RCP Storm Drain, , approximately 5' cover over pipe, storm drain crossing Crenshaw Boulevard at Slauson Avenue intersection	None
Telephone (Pacific Telephone & Telegraph Co.)	STA 338+60, 54th Street STA 335+70 to STA 344+00 STA 342+70	Conduit crossing Crenshaw Boulevard 30' south of 54th Street centerline. No depth of conduit shown on plans. Conduit running parallel with and approx. 40' east of Crenshaw Boulevard centerline. Conduit crossing Crenshaw Boulevard approx. 380' north of 54th Street centerline	None

Utility	DEIR/DEIS Station Location	Description	Impacts to PMHGS Alignment
Cable (TW)	STA 338+90, 54th Street	Overhead cable wires crossing Crenshaw Boulevard on north side of Crenshaw Boulevard/54th Street intersection. Height of wires to be determined.	None
Sewer	STA 323+90 to STA 338+40 STA 339+50 to STA 350+80 STA 339+50 to STA 350+80	8" RCP, +/- 5' cover, on east and west sides of Crenshaw Boulevard 6" VCP, +/- 5' cover, east side of Crenshaw Boulevard 8" RCP, +/- 5' cover, west side of Crenshaw Boulevard	None
Storm drain	STA 338+90 to STA 364+00	30"-39" RCP Storm Drain, approximately 5' cover over pipe, storm drain runs parallel with and approximately 10' west of Crenshaw Boulevard centerline between 54th Street and 48th Street	None
Telephone (Pacific Telephone & Telegraph Co.)	STA 357+75, Westmont Avenue STA 354+20 to STA 366+50	Conduit crossing Crenshaw Boulevard 23' south of Westmont Avenue centerline. Depth of conduit yet to be determined. Conduit running parallel with and approx. 40' east of Crenshaw Boulevard centerline	None
Gas	STA 345+60 to STA 372+00	16" Gas, Southern California Gas, unknown depth, gas line runs parallel with and 5' west of Crenshaw Boulevard centerline, main moves to 47' E/W ROW at tunnel transition area between 48Th and Brynhurst Avenue.	None

Utility	DEIR/DEIS Station Location	Description	Impacts to PMHGS Alignment
Sewer	STA 339+50 to STA 350+80 STA 339+50 to STA 350+80, STA 350+80 STA 351+20 to STA 366+50 STA 351+20 to 364+00	6" VCP Sanitary Sewer, City of Los Angeles, approximately 5' cover over pipe, sanitary sewer runs parallel with and approximately 30' east of Crenshaw Boulevard centerline between 54th Street and point north of 52nd Street 8" RCP, +/- 5 cover, west side of Crenshaw Boulevard 8" RCP, crossing Crenshaw Boulevard 500' N/O 52nd Street 8" RCP, +/- 7' cover, west side of Crenshaw Boulevard 6" VCP Sanitary Sewer, approximately 6' cover over pipe, sanitary sewer line runs parallel with and approximately 15' east of Crenshaw Boulevard centerline between a point north of 52nd Street and 48th Street	None
Storm drain	STA 338+90 to 364+00	30"-39" RCP Storm Drain, approximately 5' cover over pipe, storm drain runs parallel with and approximately 10' west of Crenshaw Boulevard centerline between 54th Street and 48th Street	None
Telephone (Pacific Telephone & Telegraph Co.)	STA 363+80, 48th Street STA 354+20 to STA 366+50	Conduit crossing Crenshaw Boulevard 20' south of 48th Street centerline. No depth of conduit shown on plans. Conduit running parallel with and approx. 40' east of Crenshaw Boulevard centerline	None
Cable (TW)	STA 364+00, 48th Street	Overhead cable wires crossing Crenshaw Boulevard on north side of Crenshaw Boulevard/48th Street intersection. Height of wires not shown on plans.	None
Storm drain	STA 364+00 to 373+00, Leimert Boulevard	39"- 45" RCP at 24' west of Crenshaw Boulevard centerline and crossing Crenshaw Boulevard to Leimert Boulevard at STA. 370+00. Bottom of pipe approximately 9' below existing street grade. Pipe continues northerly along westerly curb of Leimert Boulevard after crossing Crenshaw Boulevard.	None

Utility	DEIR/DEIS Station Location	Description	Impacts to PMHGS Alignment
Sewer	STA 364+00 to STA 373+00 STA 351+20 to STA 364+00 STA 351+20 to STA 364+00 STA 364+00 to 373+00	8" VCP, +/- 6' cover, east side of Crenshaw Boulevard 6" VCP Sanitary Sewer, City of Los Angeles, approximately 6' cover over pipe, sanitary sewer line runs parallel with and approximately 15' east of Crenshaw Boulevard centerline between a point north of 52nd Street and 48th Street 8" RCP Sanitation Sewer City of Los Angeles, approx. 6' cover over pipe, Sanitation Sewer runs parallel with approx. 30' west of Crenshaw Boulevard centerline between a point N/O 52nd Street and 48th Street 8" VCP Sanitary Sewer, City of Los Angeles, approximately 6' cover over pipe, Sanitation Sewer line runs parallel with and approx. 35' west of Crenshaw Boulevard centerline north of 48th street	None

It can be seen from *Table 3-1*, that of the utilities along the Park Mesa Heights Section, one of the utilities has a potential impact associated with the below grade alignment.

The existing 48" Metropolitan Water District water line crossing Crenshaw Boulevard at 57th Street (Station 330+70) is significantly deeper— approximately 20 feet to the bottom of the pipe, than the majority of utilities along the Park Mesa Heights Grade Separation as noted herein. Any potential conflict between this utility and the PMHGS can be minimized by adjusting the vertical profile of the track alignment to maximize the separation between the utility and the tunnel.

3.3.3 Drainage

Based on the current vertical alignment included with this analysis, the light rail will be completely below grade between 48th and 59th Streets. Assuming that tunneling is used (as opposed to cut and cover), the grades in the area will not change as a result of undergrounding. Therefore, there will be no impact on the existing drainage and drainage patterns due to the below grade alignment in this area.

3.3.4 Traffic

A PMHGS would result in no required permanent alteration of the street profile along Crenshaw Boulevard between 48th Street and 59th Street. However, construction of the underground Crenshaw/Slauson Station, or the ventilation structure if no station is provided, would be completed using cut-and-cover methods. Therefore some temporary disruptions to traffic would occur at this location during construction.

4 EVALUATION OF OTHER FACTORS

4.1 Summary of Environmental Considerations

As with the LPA, the environmental impacts were assessed. The LPA in the Park Mesa Heights neighborhood has found to have no adverse significant impacts after mitigation.

The environmental and community impacts of the below grade PMHGS will differ from those defined in the DEIS for the LPA. A preliminary summary of potential impacts of the PMHGS is presented in *Table 4-1 – Summary of Environmental Screening*. For comparative purposes, *Table 4-1* indicates the results of a general assessment of environmental impacts of the LPA, as stated in the DEIS, and indicates impacts for the PMHGS.

Table 4-1 - Summary of Environmental Screening

Environmental Criteria	LPA Environmental Impacts from DEIS/DEIR	PMHGS Potential Additional Environmental Impacts
Land Use and Development	No adverse effect. Would improve mobility and transportation options and provide redevelopment and transportation oriented development opportunities.	No adverse effect. Would improve mobility and transportation options and provide redevelopment and transportation oriented development opportunities Potential difference in redevelopment potential based on inclusion of Crenshaw/Slauson Station.
Displacement and Relocation of Existing Uses	Potential adverse effect: some parcels may be required for parking. No adverse effect after mitigation.	Potential adverse effect: one additional property may be required for entrance to underground Crenshaw/Slauson station or ventilation shaft (SE corner of Slauson Street). No adverse effect after mitigation.
Community and Neighborhood Impacts	Potential visual impact by removing the trees in the median, removing parking spaces. No adverse effect after mitigation and replacement of trees.	Potential visual impact by removal of median trees and loss of parking spaces localized to station areas only. No adverse effect after mitigation and replacement of trees in station areas.

Environmental Criteria	LPA Environmental Impacts from DEIS/DEIR	PMHGS Potential Additional Environmental Impacts
Visual Quality	No adverse effect after mitigation. Landscape (mature trees in Crenshaw median), medians and frontage roads removed. Mitigation involves replacement of trees and landscaping along sidewalks of Crenshaw Boulevard. Fixed guideway in the middle of Crenshaw Boulevard with overhead wires and overhead contact system (OCS) poles.	No adverse effect. The LRT system would be extensively below grade. Guideway visibility and median tree removal would be limited to portal areas (none of which are in the Park Mesa Heights area). Below grade alignment and stations would minimize visual impacts (no OCS poles and wires associated with at-grade operations)
Noise and Vibration	No adverse effect. Moderate LRT pass by noise impact between 48th Street and 59th Street (which does not meet thresholds of significance)	No adverse effect: the noise source will be moved to a below grade alignment
Geotechnical/Subsurface/Seismic/ Hazardous Materials	Less than adverse effect with mitigation	Less than adverse effect with mitigation. Potential Adverse Effect if subsurface gases encountered.
Historic, Archaeological and Paleontological Resources	Less than adverse effect from potential settlement and damage that may result during excavation	Less than adverse effect from potential settlement and damage that may result during excavation
Parklands and Community Facilities	No Adverse Effect. Improves public transit access to community facilities and public services located within 0.25 mile from alignment	No Adverse Effect. Improves public transit access to community facilities and public services located within 0.25 mile from alignment

Environmental Criteria	LPA Environmental Impacts from DEIS/DEIR	PMHGS Potential Additional Environmental Impacts
Construction Impacts	No Adverse Effects with mitigation, except air quality. Temporary construction noise, vibration, street closures, cars using neighborhood streets to avoid construction, visible staging areas with equipment, stockpiles and concrete barriers, increased emissions, and pedestrian and motor vehicle access, safety, and security effects Temporary lighting may affect residential areas by exposing residents to glare from unshielded light sources or by increasing ambient nighttime light levels. Construction jobs created	Generally no Adverse Effects. There will be fewer surface impacts, such as utility relocations and traffic relocations due to use of TBM. Surface impacts to traffic and air quality are minor. Noise and vibration during construction will also be less evident due to use of TBM. Increased trucking for spoil removal and delivery of precast tunnel lining segments.
Economic Development Impacts and Benefits	No adverse effect: Additional jobs, transit operations, Increase in economic output, increase in household earnings, property tax loss	No adverse effect: Additional jobs, transit operations, Increase in economic output, increase in household earnings, property tax loss
Environmental Justice	No adverse effect	No adverse effect
Safety and Security	No Adverse Effects with mitigation Train crossings would occur with traffic signals Pedestrian and motorist gates and visual and audible warning devices may be provided if determined necessary. Stations will include monitoring equipment and be lighted to avoid shadows. Station pedestrian crossings near schools would be monitored and a crossing guard provided, if necessary during construction	No Adverse Effects with mitigation. Improved safety through grade-separation of LRT and roadway traffic. Below grade station design will comply with principles of Crime Protection Through Environmental Design (CPTED).

Further discussion of the differences between the LPA and the PMHGS is provided below:

- Land Use – Given existing land use patterns, adopted land use plans, and allowances for more growth, the LPA and the PMHGS are equivalent in their ability to support development in the corridor.
- Right-of-Way/ Displacements/ Relocations – The PMHGS will require the acquisition of additional right of way to accommodate the construction of an entrance plaza and escalator, stair, and elevator access to an underground Crenshaw/Slauson Station. Land acquisition would also include parking for Metro Operations Maintenance, Fare Collection and Security. For an option with no Crenshaw/Slauson Station, a ventilation structure would be required at this approximate location, requiring some additional right of way to accommodate a ventilation shaft.
- Community and Neighborhood Impacts – The mature trees located within the Crenshaw Boulevard median between 48th and 59th Streets would be removed for the surface light rail alignment resulting in a community impact upon the street character and visual quality. This impact would be temporary as new median landscaping along Crenshaw Boulevard would be installed to mitigate the loss of the mature trees.
- Visual – Both the LPA and the PMHGS have no adverse visual impact. The PMHGS would eliminate two portals and the overhead contact system poles and wires associated with at-grade operations. The PMHGS will be consistent with the character of the existing environment, and existing median landscaping will be largely retained, with the exception of station locations.
- Noise/Vibration – Both the LPA and the PMHGS have no adverse noise and vibration impacts. Impacts of noise and vibration during construction, and subsequent operation of the LRT system will be minimized for the PMHGS through the extended use of TBM construction methods and the lengthened underground alignment
- Geotechnical/ Subsurface/ Seismic/ Hazardous Materials – Potentially significant impacts may occur during construction of the expanded PMHGS below grade alignment with the possibility of encountering subsurface gases, contaminated soil and contaminated groundwater. Mitigation measures, such as gas detection, would be provided to minimize the impacts.
- Construction Impacts – The increase in below grade construction utilizing TBM construction methods will result in fewer surface impacts during the construction period for the PMHGS, such as impacts on existing streets, utilities, traffic and parking. However, the continuous tunneling operation will generate truck traffic over extended periods of 16 hours per day or more, depending upon the Contractors preferred work shift arrangement. Trucks will be required to remove spoil generated by the tunnel excavation, and separate trucks will be required to deliver tunnel lining segments to the work site.
- Economic Development Impacts and Benefits – Property within close proximity (½ mile) of rail transit will increase in value due to increased accessibility to employment centers, and the attraction of new and denser developments to the transit location. Both the LPA and the PMHGS will result in the construction of significant new transit infrastructure that could attract new development or redevelopment/adaptive reuse of existing properties between 48th and 59th Streets. Both options will stimulate job creation during construction as well as for the ongoing operations of the system. The intensity of development planned for this section of the corridor is of low to medium density in scale. This is reinforced by comments from the community during planning workshops conducted in March and April 2010. Both the LPA

and PMHGS, therefore, are equally supportive of planned development along this section of the alignment. Property value impacts will be similar around station areas.

- Safety and Security – Both the LPA and the PMHGS have no significant safety and security impacts. The PMHGS will not have an interface between LRT and vehicular and pedestrian traffic. It will not include seven crossings associated with the at-grade LPA configuration. For reference, the Metro Blue Line experienced a rate of accidents of 1.26 accidents per 100,000 train-miles of operation during FY 2009 (the latest full year of statistics). This figure has been steadily decreasing in the decade prior from 4.11 accidents per 100,000 train miles in FY 2000. For the street-running segments in Los Angeles and Long Beach, approximately 2.5 miles and 3.7 miles in length, respectively, the number of accidents with was 11 and 4 during FY 2009.

  All LRT systems in California are regulated by the California Public Utilities Commission (CPUC). The Commission requires strict adherence to its safety standards outlined in their General Orders. In addition, the Commission performs the State Safety Oversight of these systems that is mandated by Federal statute. All light rail systems are required to complete a rigorous "Safety Certification" program before they are sanctioned by the CPUC as safe for passenger service operations.

  Below grade stations will require design provisions to account for lower visibility and openness. Below grade station design will comply with principles of Crime Protection through Environmental Design (CPTED) to maximize opportunities for natural surveillance, and through the provision of appropriate levels of lighting.

4.2 Costs and Financial Considerations

4.2.1 Methodology

Capital cost estimates for the LPA and the PMHGS with and without a Crenshaw/Slauson Station were prepared utilizing FTA Guidelines for Standard Cost Components (SCC). Cost data where applicable has been taken from Metro's Crenshaw/LAX Transit Corridor Final Capital Cost Report dated June, 2009. Historical cost data has also been developed from similar projects. All cost data has been escalated to 2Q2010 utilizing the Engineering News Record Construction Cost Index (CCI) and allocated contingency has been applied to each cost item.

The estimate has been prepared based on preliminary plans, sketches and sections. Quantities were calculated and categorized per the FTA SCC's. The scope of work has been determined to the best extent possible at early stages of engineering design.

Capital Cost Estimate Assumptions - General

- The current base year of the estimate is 2Q2010.
- All work is to be done with typical crews without any provisions for overtime.
- Work schedules are typical for the work being performed.
- Construction indirect costs, overhead and profit are calculated as a percentage of direct costs.
- Design and construction contingency is included as part of the construction cost estimate. Allocated contingencies are applied in accordance with the Metro's Crenshaw/LAX Transit Corridor Final Capital Cost Report (June 2009), Table 3-1.

Capital Cost Estimate Assumptions – Cut and Cover Guideway

- Average depth from ground surface to the top of roof slab is 6 feet.
- Support of excavation for Segment A, where excavation limits are above the groundwater table is assumed to comprise soldier piles and lagging
- Support of excavation for Segments B and C, where excavation limits are below the groundwater table is assumed to comprise deep soil mix walls
- Wall embedment depth is assumed to be 60% of the exposed height
- Three levels of cross lot bracing are assumed at 12' spacing horizontally. Bracing member average weight is assumed to be 200 lb/ft. Continuous walers are provided to transfer ground loads to bracing. Walers also assumed to weigh 200 lb/ft average.
- Temporary traffic decking shall be provided over full extent of existing roadways.
- Average structure dimensions are assumed to be as follows:
  - Roof slab – 2 foot thick
  - Internal wall 1 foot-6 inch thick
  - Base slab 2 foot-6 inch thick
  - External wall Segment A: 2 foot-6 inch thick
  - External wall Segment B/C: 1 foot-0 inch thick, assumed integral with support of excavation
- All structural concrete is reinforced at 260 lb per cubic yard
- A 6 inch mud slab is provided under the structural base slab
- External waterproofing is provided at slabs.

Capital Cost Estimate Assumptions – TBM Options

- Two new TBMs are proposed. TBMs will excavate adjacent bores concurrently
- Construction of cross passages within a segment of the route (i.e. South Portal to Crenshaw/MLK Station will be initiated after tunneling of each segment is completed
- Crenshaw/MLK Station shell and box invert and first level primary concrete are completed before TBMs arrive. TBMs are walked though the station and relaunched. Same applies to underground Crenshaw/Slauson Station, or ventilation structure.
- Station construction is assumed to progress concurrently with tunneling.
- Tunnel internal diameter is approximately 19 foot-0 inch
- Tunnel lining shall comprise a one-pass precast concrete segmental lining. Lining thickness is approximately 1 foot-0 inch.

Unit Prices

Unit prices for the cut and cover and TBM tunnels were derived from the following sources:

- Metro's Crenshaw Transit Corridor Project Final Capital Cost Report, June 2009
- Santa Clara Valley Transportation Authority BART to San Jose Program, 65% Design Submittal, November 2008

- Transbay Joint Powers Authority, Transbay Transit Center Program, 50% Design Development Cost Estimate, prepared by Webcor/Obayashi, October 2009
- California High Speed Rail Authority Project, preliminary engineering cost model, June 2009
- LAX Airport Central Utility Plant Estimate, 30% design, September 2009.

4.2.2 Incremental Cost Results

A comparative cost evaluation for the construction was performed using the estimate basis and assumptions provided above. Order of magnitude costs for each of the alignment options are provided in *Table 4-2 – Capital Cost Comparison*.

Table 4-2 - Capital Cost Comparison

	Total Cost (39th Street to Victoria Ave) (2010 dollars)	Increment Above LPA
LPA Option	$623-million	-
PMHGS Option, No Crenshaw/Slauson Station	$790-million	$167-million
PMHGS Option, With Crenshaw/Slauson Station	$842-million	$219-million

The cost figures are inclusive of construction of guideway, systems, site work and special conditions, right of way, professional services, and contingency. The results show that the PMHGS with no underground Crenshaw/Slauson Station is $167 million more expensive than the LPA and the PMHGS including an underground Crenshaw/Slauson Station is $219 million more expensive than the LPA. Detailed order of magnitude cost estimates are provided in Appendix B.

The costs of TBM procurement, erection, launching, and removal are the same for the LPA Option and PMHGS Option. However, the principal differences in scope for the PMHGS Option relative to the LPA Option, which produce the cost differential, can be defined as follows:

Scope deletions from LPA Option:

- Deletion of two portals/retained cut sections with a net guideway length of 1,140 feet
- Deletion of a net 3,220 feet of cut and cover tunnel
- Deletion of 4,370 feet of at-grade guideway, inclusive of an at-grade Crenshaw/Slauson Station. A surface station will have a separate TPSS building that would not be required for an underground station.

Scope additions to PMHGS Option:

- Addition of 8,460 feet of TBM tunnel
- Addition of 11 cross passages in TBM drive
- Addition of underground Crenshaw/Slauson Station, or ventilation/crossover structure. Either a station or a ventilation/crossover structure results in similar construction requirements

While the PMHGS Option includes a significantly greater length of TBM tunneling, any incremental cost saving arising from the increased use of TBM is offset by the construction costs for the additional 11 cross passages between the tunnel bores, which, as indicated in **Section 2.1.4** are labor and cost intensive.

4.2.3 Operations and Maintenance Costs

Maintenance of light rail systems includes maintaining, overhead power lines, substations, station platforms, tracks and signaling systems. Obviously, maintenance access to these critical elements is much greater in surface operations as compared to subway environments. Thus, the perpetual costs of maintaining a LRT system is much lower in surface operations.

Based on the 2007 Federal Transit Administration's National Transit Database (NTD), LACMTA's annual O&M costs are projected to be between approximately $2M and $3M per mile for at-grade double track LRT or a total of between approximately $3M and $4M for the 1.39 mile long PMHGS study area. The NTD and experience from other systems supports a projected annual O&M cost of between approximately $4M and $7M for the PMHGS underground-running LRT or a net increase of between approximately 35 and 75 percent.

4.2.4 Financial Considerations

The PMHGS will result in approximately $167 million to $219 million in additional project cost (2010 dollars). The extent of the additional cost is dependent upon whether or not an underground station is constructed at Slauson Avenue.

The 2009 adopted Long Range Transportation Plan (LRTP) reserved $1.715 billion for the Crenshaw/LAX Corridor. The Board adopted LPA has an estimated cost of $1.59 billion (escalated dollars). There are three design options that are being further evaluated in the FEIS/FEIR and ACE to determine whether they need to be constructed and to refine designs and cost estimates. These options are a Centinela Grade Separation, a Crenshaw/Vernon Station, and an Exposition/Crenshaw Grade Separation. If any of these options need to be constructed, cost savings will need to be identified to fund them within the project budget. Because the PMHGS is not required, it would be an enhancement (or betterment) to the project. In the past, these types of improvements have typically been funded from sources outside the project budget, often by other parties or jurisdictions.

4.3 Travel Time and Ridership

The PMHGS also has potential impacts upon the performance of the Crenshaw/LAX line. A street-running operation typically is configured so that light rail trains operate in the same progress of green lights as the adjacent traffic (often timed at 35 miles per hour). This allows for light rail trains to offer travel time benefits to passengers. The PMHGS may allow light rail trains to achieve slightly faster speeds between stations by removing the potential for a signal delay and conflicts with vehicles and pedestrians at crossings. *Table 4-3 – Travel Times for LPA Configuration and PMHGS Configuration* presents a comparison of travel times between the LPA configuration and a configuration that modifies the LPA to include the PMHGS (with an extended below grade section). The analysis shows that the extended below grade section reduces travel times by slightly more than one minute (from 7.6 to 6.5minutes) along the section affected by the PMHGS (the section between the Crenshaw/Martin Luther King Jr. station and the Florence/West station). The total travel time for the entire Crenshaw/LAX line from the Crenshaw/Exposition station to the Redondo Beach station reduces from 29.8 minutes to 28.7

minutes. Further analysis will be carried out during the course of the project and these numbers will be refined in the future.

Table 4-3 - Travel Times for LPA Configuration and PMHGS Configuration

STATION LOCATION	Travel Time to Station from Previous Station to the North (minutes)		
	LPA	**LPA + PMHGS (with Crenshaw / Slauson Station)**	**LPA + PMHGS (no Crenshaw / Slauson Station)**
Crenshaw / Exposition			
Crenshaw / Martin Luther King Jr.	3.5	3.5	3.5
Crenshaw / Slauson	4.5	3.8	
Florence / West	3.1	2.7	5.5
Florence / La Brea	2.4	2.4	2.4
Aviation / Manchester	2.7	2.7	2.7
LAX Connection (Aviation / Century)	1.8	1.8	1.8
Metro Green Line Connection (Mariposa)	4.8	4.8	4.8
El Segundo	2.0	2.0	2.0
Douglas	2.0	2.0	2.0
Redondo Beach (Marine)	3.0	3.0	3.0
Entire Line: Crenshaw / Exposition to Redondo Beach	**29.8 min**	**28.7 min**	**27.7 min**
Crenshaw / Exposition to LAX Connection	**18.0 min**	**16.9 min**	**15.9 min**

For the version of the PMHGS that does not include an additional below grade station at Crenshaw/Slauson, the potential travel time difference is one minute less than with the station and two minutes less than the LPA. This is due to the lack of dwell time at that station and the ability for trains to reach higher speeds due to the longer distance between the Crenshaw/Martin Luther King Jr. station and the Florence/West station. This station distance is similar to several station pairs in the Metro Rail system such as along Lankershim Boulevard between North Hollywood and Universal City.

The slight differences in travel time and differences in physical configuration contribute to similarly slight differences in ridership. New ridership estimates were developed based on an expanded transportation network enabled by Measure R. The new travel demand model's network includes all new transit and highway projects to be developed by 2035. This includes several projects that interline with or connect with the Crenshaw/LAX LRT line, notably the South Bay Metro Green line extension, the Exposition Line (Phases I and II), the Metro Green line to LAX, Los Angeles World Airports Automated People Mover, and the Regional Connector. *Table 4-4 – Ridership for LPA Configuration and PMHGS Configuration* shows the estimates for ridership as well as a comparison with previous ridership estimates. The estimates of ridership with the expanded Measure R network and corrections to the travel demand model show a 60 percent increase in ridership for the LPA in accordance with the travel times listed above.

When comparing the LPA with scenarios that include the PMHGS, estimates show that PMHGS results in slight gains at two major terminal connection stations for the Exposition line (at Exposition / Crenshaw Station) and the Metro Green Line (at Aviation/Century Station). Increases at these stations are approximately six percent and four percent, respectively. The Crenshaw / Martin Luther King Jr. Station experiences a four percent increase. Increases at all other stations are minor and expected to be no greater than three percent. Between Exposition/Crenshaw and the Redondo Beach (Marine) stations, total ridership increases by less than four percent. Ridership at stations along the South Bay Metro Green Line Extension are not included for all scenarios, however, total line ridership would reflect a higher amount with those stations included.

Without the Crenshaw/Slauson station, ridership is expected to increase at the stations immediately to the north and to the south of that station: Crenshaw/Martin Luther King Jr. and Florence/West, respectively. While these stations experience an increase in ridership, overall line ridership decreases slightly due to the loss of some patrons associated with the Crenshaw/Slauson station. Overall, the ridership impacts reflect varying allocations of ridership to stations and some minor increases in the number of passengers transferring at the major connections with the Exposition Line and the Metro Green Line.

Table 4-4 – Ridership for LPA Configuration and PMHGS Configuration

	Original No Build (does not include Measure R projects)	Revised No Build (includes all Measure R projects by 2035)		
	Horizon Year 2030	Horizon Year 2035		
STATION LOCATION	**DEIS/DEIR LRT Alternative**	**LPA**	**LPA + PMHGS (with Slauson Station)**	**LPA + PMHGS (no Slauson Station)**
Crenshaw / Exposition	3,100	6,050	6,420	6,420
Crenshaw / Martin Luther King Jr.	1,390	1,270	1,290	1,430
Crenshaw / Slauson	1,000	1,400	1,390	
Florence / West	720	1,500	1,420	1,820
Florence / La Brea	1,450	2,140	1,990	1,990
Aviation / Manchester (optional)**	750	-	-	-
LAX Connection (Aviation / Century)	1,390	4,170	4,340	4,340
Station connections from Metro Green Line: Mariposa-Redondo Beach (Marine)	2,830	3,680	3,740	3,740
Crenshaw / LAX Line Ridership* (Crenshaw / Exposition to Redondo Beach)	**12,630**	**20,210**	**20,970**	**20,150**

Horizon Year 2035 forecast assumes all Measure R projects completed by 2035, notably Exposition, Phase II, South Bay Metro Green Line Extension, Metro Green Line to LAX and Los Angeles World Airports Automated People Mover, and the Regional Connector.

* Does not include:

- Ridership at stations along South Bay Metro Green Line Extension
- Likely upward adjustments to account for airport passengers

** Note that ridership at optional stations at Crenshaw/Vernon and Aviation/Manchester is not included in these summaries. These stations are estimated to generate ridership of near 800 and 2,200, respectively with associated reductions at adjacent stations. The rise in the estimate at Aviation/Manchester reflects interactions with South Bay Metro Green Line Extension.

4.4 Project Implementation Schedule Impacts

The adoption of the PMHGS has the potential to impact the implementation schedule for the Crenshaw/LAX Transit Corridor LRT Project, both in terms of the Environmental Process and the duration of construction. There are many variables which could ultimately impact the implementation schedule for the project. These potential schedule impacts are discussed in the following sections of the report.

4.4.1 Environmental Process Impacts

The adoption of the PMHGS will result in the need for additional environmental review to document the project change with the Federal and State regulatory agencies. The extent of the environmental process impacts will be based upon a determination if the project changes arising from the adoption of the PMHGS result in significant changes to the impacts associated with the project or if there are significant new circumstances or information relevant to environmental issues. The determination of the extent of the environmental impacts and the process to document the impacts must be agreed between Metro and the Federal Transit Administration as lead agencies.

Based upon the extent of the project changes, and differing environmental impacts of the PMHGS, Metro and FTA must determine whether to address the change as a supplement to the Environmental Impact Statement (EIS), as an addendum to the EIS, or as a mitigated negative declaration. The potential schedule impact of each of these reporting processes is discussed below:

- Supplement to the EIS: If the changes to the project configuration resulting from the adoption of the PMHGS are believed to result in significant environmental impacts not evaluated in the EIS, then a Supplemental EIS (SEIS) may be required for the project. The duration of the SEIS will be dependent upon the magnitude of the project change. For instance, the San Francisco Municipal Transportation Authority (SFMTA) recently prepared a Supplemental EIS for their Central Subway Project. The Notice of Preparation of the EIS was filed with the City of San Francisco in June of 2005, and the US Department of Transportation Record of Decision (ROD) was granted in November of 2008. However, this SEIS was the result of a very significant change—the project alignment changing from Third Street to Fourth Street. For environmental clearance via supplement approximately 18 months is often cited as an initial time to budget. However, the final process can take more or less time depending on the project, comments, etc.
- Addendum to the EIS: Issuance of an addendum is appropriate to provide additional information or analysis that does not substantially change the analysis of significant impacts and alternatives in an existing environmental document. Environmental addenda can be adopted by the Metro Board at their public meetings without further need for public outreach. Depending on the nature of the design refinement being addressed, addenda can take two to six months to prepare, review and approve.
- Mitigated Negative Declaration: A Negative Declaration is authorized when the Lead Agency determines that changes to the project or other mitigation measures are imposed such that all potentially significant environmental effects are avoided or reduced to a level of insignificance. For initial scheduling purposes, a mitigated negative declaration could be assumed to take between 6-12 months to complete. This timeframe is shorter than the supplemental EIS process due to the shorter public comment period. Again, depending on other factors, this timeframe could be adjusted.

Therefore based upon the Metro/FTA determination, it is likely that the process to complete the environmental documentation in support of the PMHGS could take anywhere from two to eighteen months.

The impact of this range of durations upon the Preliminary Engineering schedule is discussed in the following paragraphs.

As design studies will be required in support of the SEIS clearance process, it is anticipated that design of the PMHGS Option could continue concurrently with the development and approval of the environmental documentation, However, any design of the PMHGS Option would be 'at-risk' until such time as an approval was awarded.

If it is assumed that Preliminary Engineering (PE) commences in November of 2010, and has a duration of 12-18 months, and if it is also assumed that the development of the environmental documentation is initiated concurrently with the PE, then obtaining the necessary environmental approvals to facilitate the adoption of the PMHGS Option could delay the overall completion of PE by the durations indicated in *Table 4-5 – Environmental Review Schedule Delay*.

Table 4-5 - Environmental Review Schedule Delay

PE Duration	Net Implementation Schedule Delay		
	EIS Supplement	EIS Addendum	Negative Declaration
12 months	6 months	No impact	No impact
18 months	No impact	No impact	No impact

From the table it can be seen that with an eighteen month PE schedule, none of the environmental process options should adversely impact the project implementation schedule. For scenarios with the shorter twelve month PE duration, only the supplemental EIS approach may exceed the PE duration, with an estimated maximum schedule impact of six months.

Any potentially adverse schedule impact of the supplemental EIS could be mitigated in part by initiating the process in advance of the PE phase of the project.

4.4.2 Construction Sequencing Impacts

Various scenarios exist for the construction packaging of the Crenshaw/LAX Transit Corridor project. These must be investigated to arrive at an optimal construction solution in terms of cost and schedule. The project could either be awarded as a single procurement, or broken into a number of smaller contracts. One scenario could evolve separate procurements for each of the major civil structures. Thereafter contracts could be awarded for track and systems work, and for surface finish works – streets and landscaping, either as a combined contract or as separate procurements.

If the same construction sequencing assumption is adopted for both the LPA and the PMHGS, that At Grade trackwork and systems can be initiated anytime, but track and systems cannot be installed in the tunnels until such time as the tunnel contracts are complete, then the tunnel construction durations form much of the critical path for the project construction and operation.

As individual procurements, the construction of the Below Grade sections of the LPA alignment identified in *Table 2-2*, would be expected to be completed within a timeframe of approximately

31 to 37 months. This duration assumes that procurement and award of both contracts is simultaneous, which may be difficult to accomplish from an administrative or cash flow perspective, particularly if the same potential bidders are sought for each contract.

Based upon the assumptions provided herein, the construction of the PMHGS is estimated at approximately 37 to 45 months. This duration has three critical elements – the construction of the portal to launch the TBM, the TBM tunnel construction, and the subsequent completion of the reception portal structure after removal of the TBM. If the duration of each of these tasks can be assumed to vary by between 2 and 3 months each, then as a worst case scenario the construction duration would take 8 months longer. Based upon the approximate construction durations it can be seen that the PMHGS adds between six and fourteen months to the construction duration of the LPA best case.

A major schedule variable for the construction of the PMHGS is the number of tunnel boring machines procured. Two machines have been assumed in the development of the schedule duration. Additional machines typically shorten schedules. However, schedule savings must be weighed against the cost/benefit of purchasing additional TBMs. Additional measures to minimize the potential schedule difference in the PMHGS and LPA can also be investigated as part of the contract packaging process through the adoption of advance construction or procurement packages. Such measures could include the following:

- Advance procurement of tunnel boring machines by Metro. By procuring the TBMs in advance the machines would be available to the contractor at or shortly after construction NTP. The contractor would still have to construct a limited portal area, sufficient to launch the machines.
- Advance precast tunnel liner procurement. In conjunction with the advance purchase of the machines, the advance procurement of the fabrication of the tunnel liner will allow mining to begin immediately after machine set up.
- Advanced contract for portal utility relocation and portal excavation. Such a contract can prepare the portal area for the delivery of the TBMs.

With the incorporation of these or other measures, it is likely that the delay in the aforementioned completion of the PMHGS could be reduced by 4-6 months. If a four month reduction in the schedule duration of the PMHGS is assumed, then the schedule for The PMHGS is reduced from 37 to 45 months to approximately 33 to 41 months

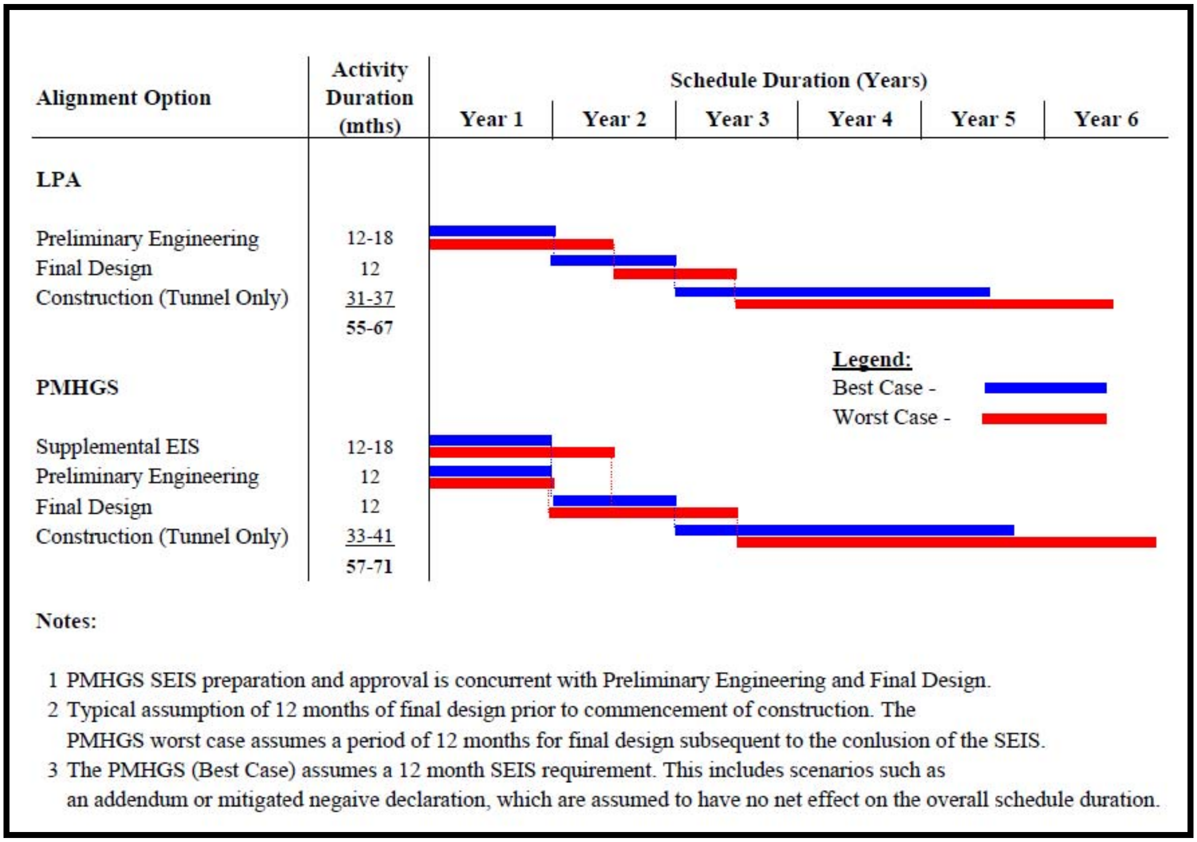
The potential combined impacts of the environmental process and construction sequencing are presented in *Figure 4-1 – Potential Schedule Impacts*. The figure is only a comparison of the relative schedule duration differences between the LPA and PMHGS. The figure is not intended to represent the overall project schedule. Durations for subsequent track, systems and finishes installation contracts, and a testing and commissioning period are not included. The figure provides both best case and worst case scenarios for the LPA and PMHGS based upon the discussion in this section.

Based upon the approximate environmental review and construction durations it can be seen that the PMHGS will take longer to construct and will add time to the schedule. If the LPA takes the minimum indicated time the PMHGS will add at least two months to the total project schedule. Comparing the worst case for both the LPA and the PMHGS, the PMHGS takes 4 months longer. The worst case for the PMHGS is 16 months longer than the LPA best case.

To summarize, assuming that the environmental process can be completed before the end of final design, the PMHGS may add 2 to 16 months to the best case LPA schedule, but on average it is most likely that the PMHGS would take approximately 2 to 4 months longer to construct than the

LPA. As indicated above, if the environmental process is extended beyond the completion of final design, the net delay may be longer.

Figure 4-1 - Potential Schedule Impacts



5 SUMMARY

Using the Metro Policy for Grade Crossings for Light Rail Transit as a basis, it was determined as part of the DEIS/DEIR evaluation that the grade separation of Crenshaw Boulevard between 48th and 59th Streets was not required.

The Metro Board has requested that an analysis of placing the LRT guideway between 48th and 59th Streets in a below grade configuration be performed, and evaluated against the LPA Option in terms of issues associated with constructability, safety, environmental and economic development benefits, cost and schedule.

The analysis has resulted in the following findings;

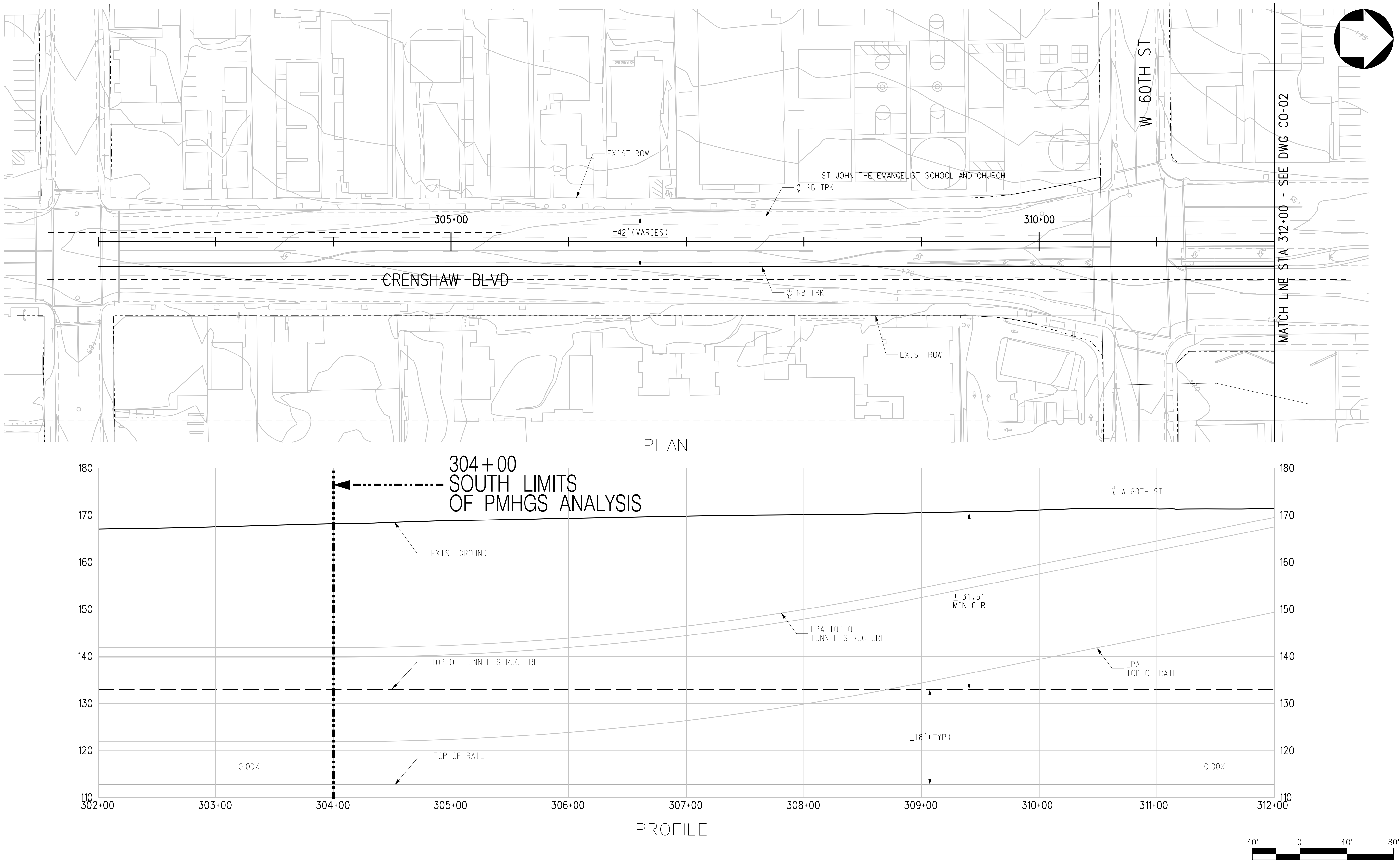
- Constructability: The PMHGS results in the connection of two underground sections of the LPA option, forming a continuous tunnel between limits of Coliseum Place on Crenshaw Boulevard to Victoria Avenue on the Harbor Subdivision Railroad. Based upon the anticipated ground conditions, the construction of the continuous tunnel is feasible and would be undertaken primarily by TBM methods.
- Safety: The PMHGS removes the street interface between the LRT, roadway vehicles and pedestrians. As noted in Section 1.2, LRT systems operate safely and successfully at-grade in cities across California and North America. The at-grade recommendations for the LPA Option resulted in no significant safety impacts. The determination of safety impact for both options is the same.
- Environmental: As the LPA's at-grade recommendation was determined to have no significant environmental impacts, the PMHGS results in no change to the determination of environmental impacts. The PMHGS will not require reconfiguration of Crenshaw Boulevard resulting in fewer temporary impacts associated with construction at-grade (traffic, air quality, noise, and vibration). The PMHGS does remove operating trains and any associated noise from the street surface. If a Crenshaw/Slauson station is included, temporary environmental impacts would be experienced at the construction site and permanent displacement would occur due to the need to purchase right-of-way for the station.
- Economic Development: Both the LPA and the PMHGS will result in the construction of significant new transit infrastructure that could attract new development or redevelopment/adaptive reuse of existing properties between 48th and 59th Streets. Both options will stimulate job creation during construction as well as for the ongoing system operations. The intensity of development planned for this section of the corridor is of low to medium density in scale. This is reinforced by comments from the community during planning workshops conducted in March and April 2010. Both the LPA and PMHGS, therefore, are equally supportive of planned development along this section of the alignment. Property value impacts will be similar around station areas.
- Cost: The construction cost of the PMHGS Option is higher than the LPA. The PMHGS with no underground Crenshaw/Slauson Station results in an increased project cost of $167 million (2010 dollars). With the Crenshaw Slauson Station, the increased cost of the PMHGS is $219 million (2010 dollars) above the recommended LPA. These cost estimates reflect construction efforts combined with adjacent underground sections.
- Travel time and Ridership: Impacts of the PMHGS to travel time and ridership are minimal. The PMGHS potentially reduced travel time up to 1 or 2 minutes compared to the LPA,

depending on whether a below grade station at Crenshaw/Slauson is included or not. Ridership also shows minor changes. The ridership for the entire line with the PMHGS is estimated to increase ridership between three and four percent. Without a Crenshaw/Slauson station, ridership for the entire line will remain roughly the same (with increases at many stations and the loss of riders at the Crenshaw/Slauson station itself.)

- Schedule: The adoption of the PMHGS may delay the completion of the project, as a result of the time required to obtain approval of the Supplemental Environmental Review (with a Supplemental Final Environmental Impact Statement/Supplemental Final Environmental Impact Report), and based upon a longer construction duration for the PMHGS tunnel than for the LPA. Additional time and budget for the procurement or contract modifications for environmental analysis services would also be required. Assuming the current schedule for the project implementation holds, the potential impact on the project completion schedule for the tunnel section can vary between two and sixteen months. The 16-month estimate represents the worst case scenario. Likely impacts may be less.

These findings do not change the LPA recommendation that the LRT alignment should be at-grade to conform to Metro's policies related to grade separation.

Appendix A
Drawings



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CRENSHAW/LAX TRANSIT CORRIDOR PROJECT

PMHGS ANALYSIS PLAN & PROFILE STA 302+00 TO STA 312+00

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DRAWING NO CO-01
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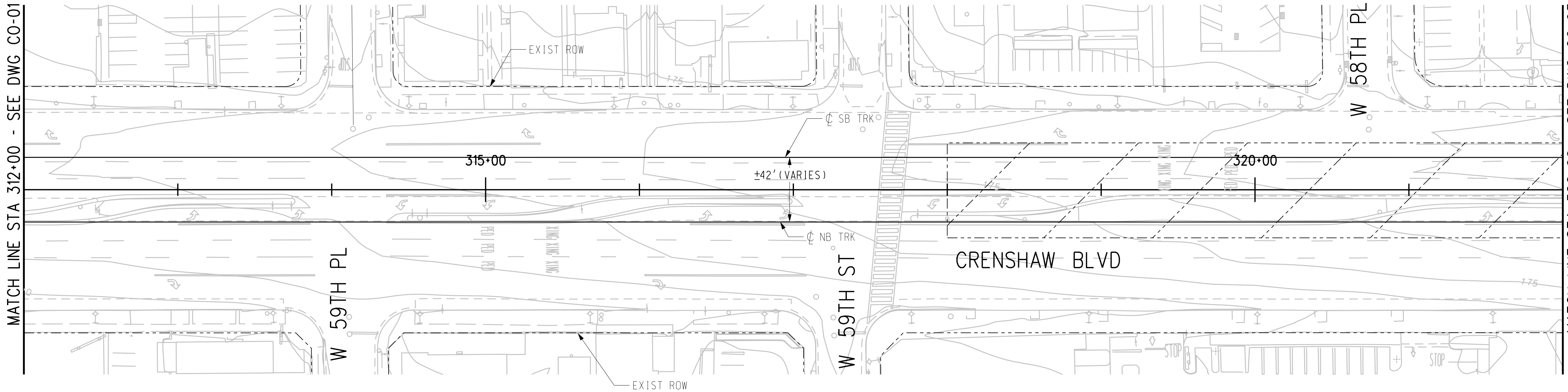

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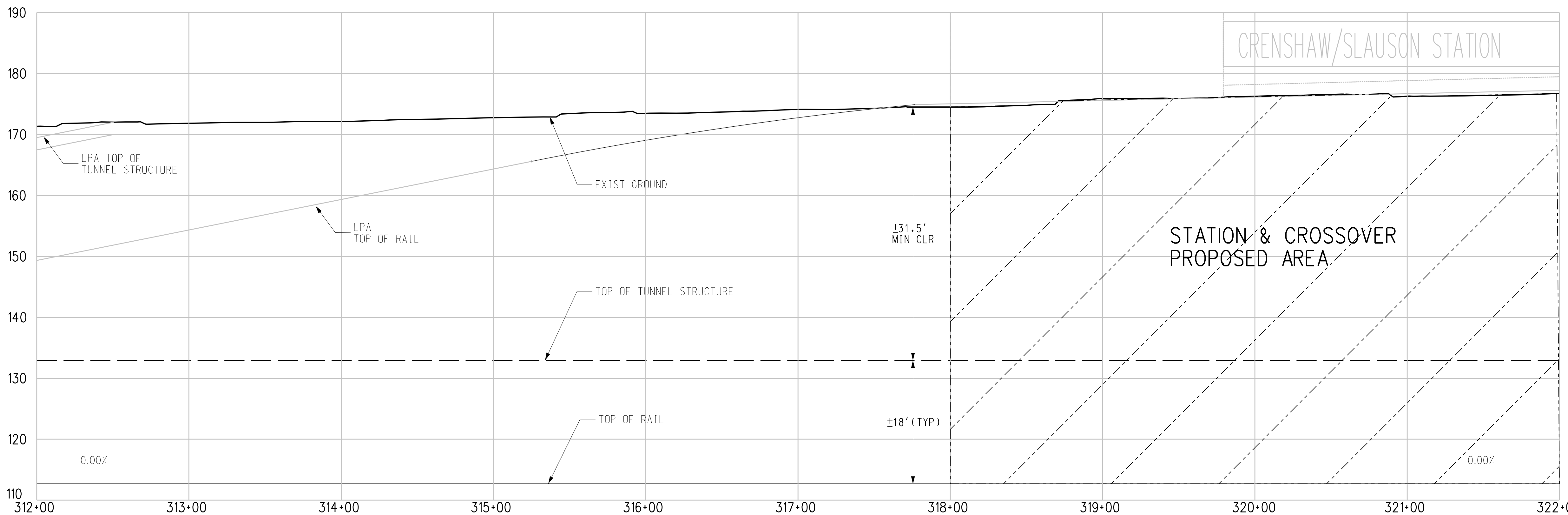

PROFILE

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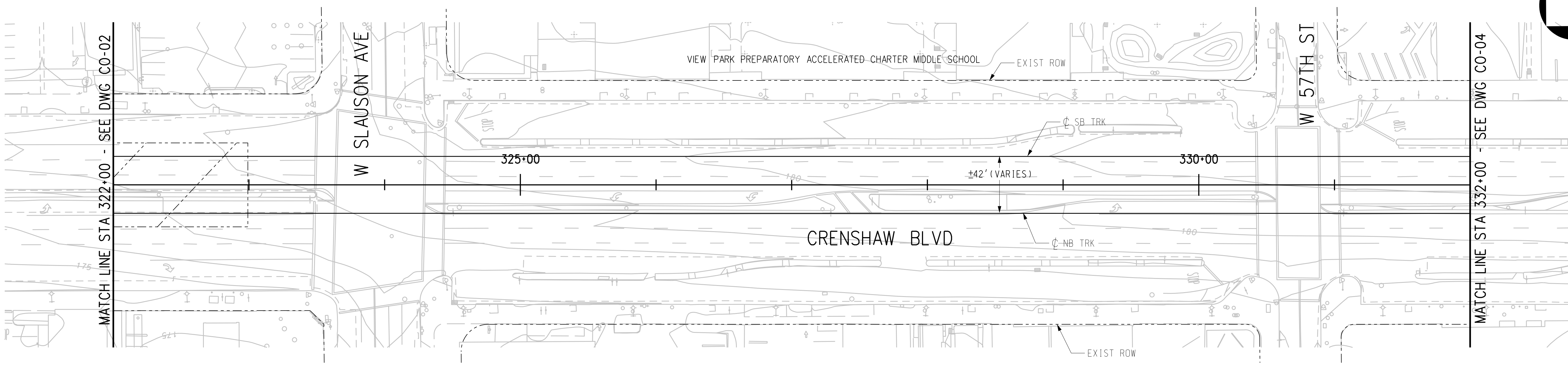

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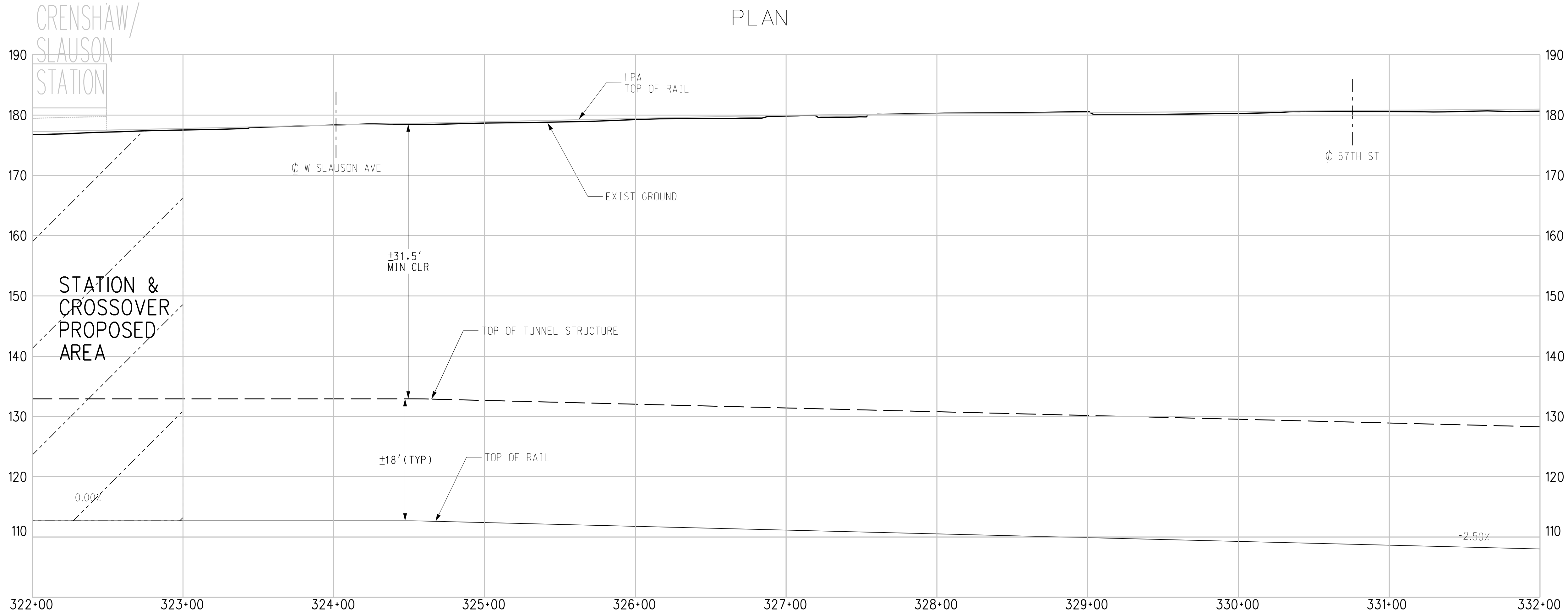

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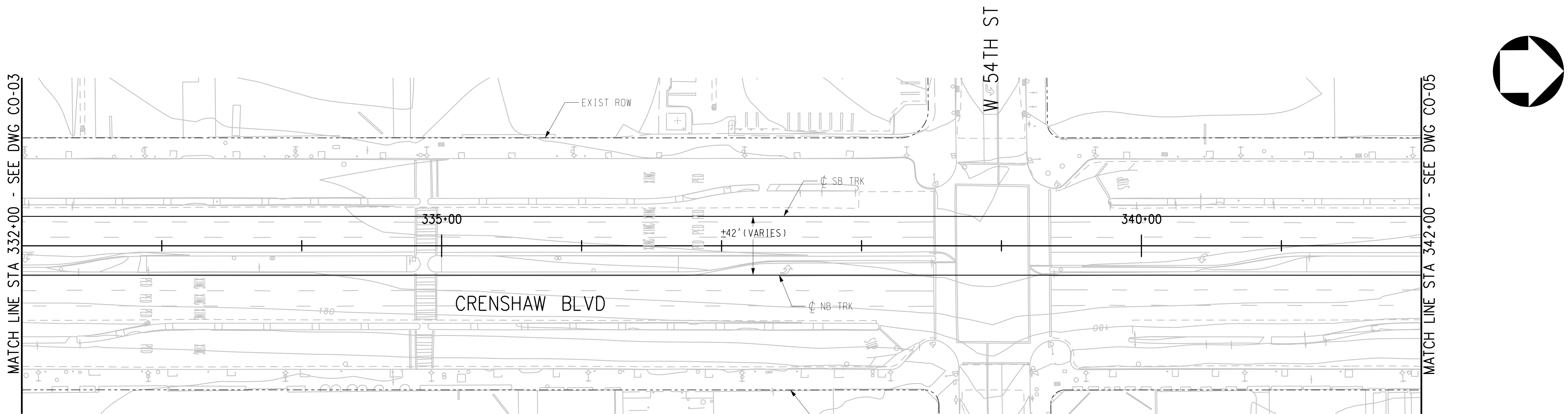

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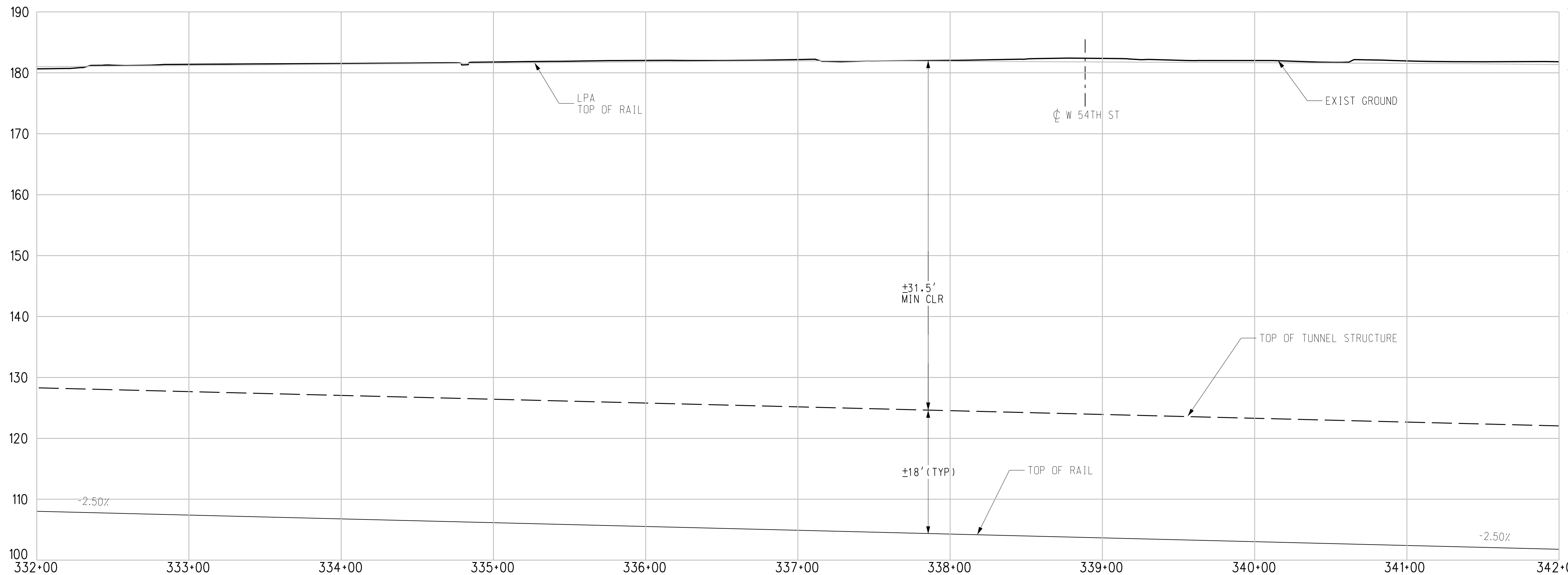

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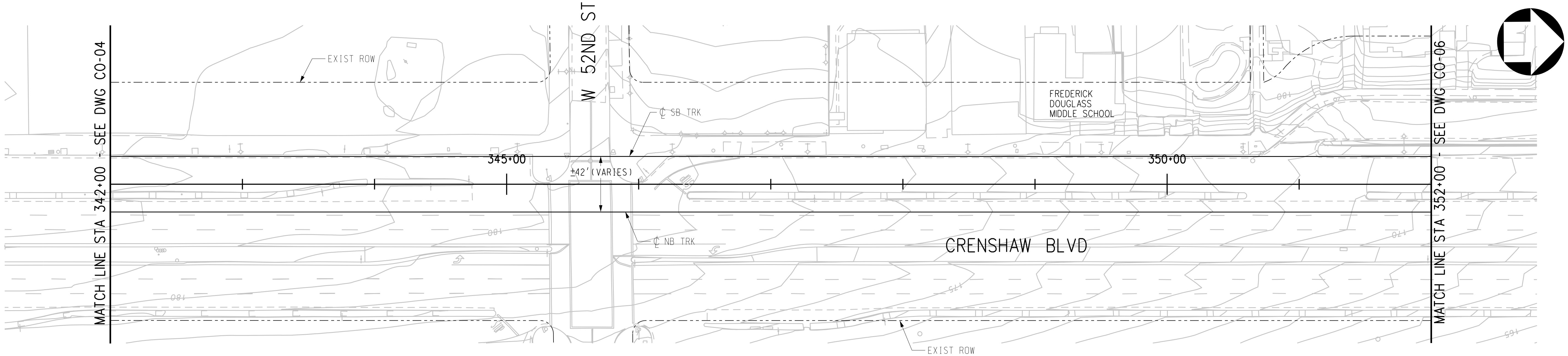

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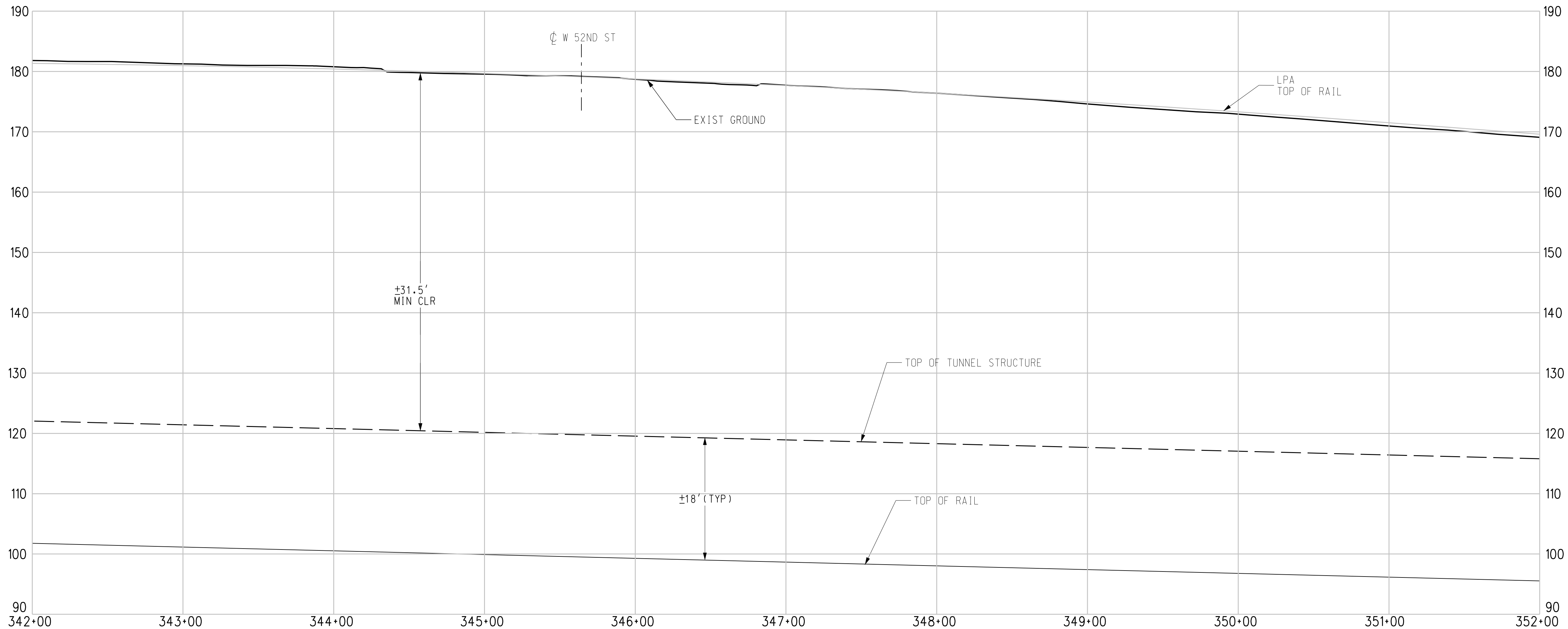

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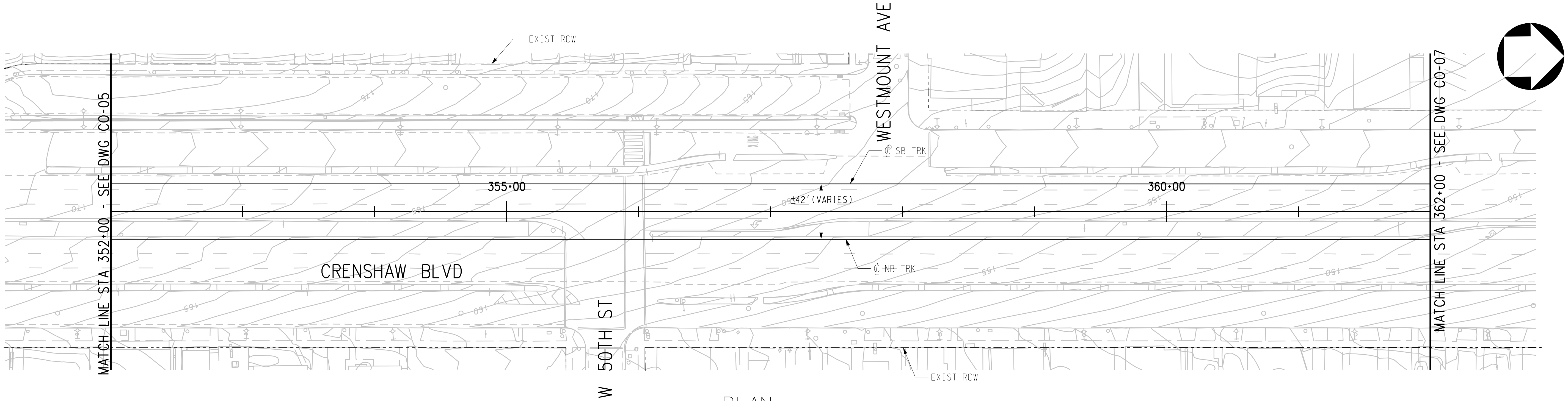

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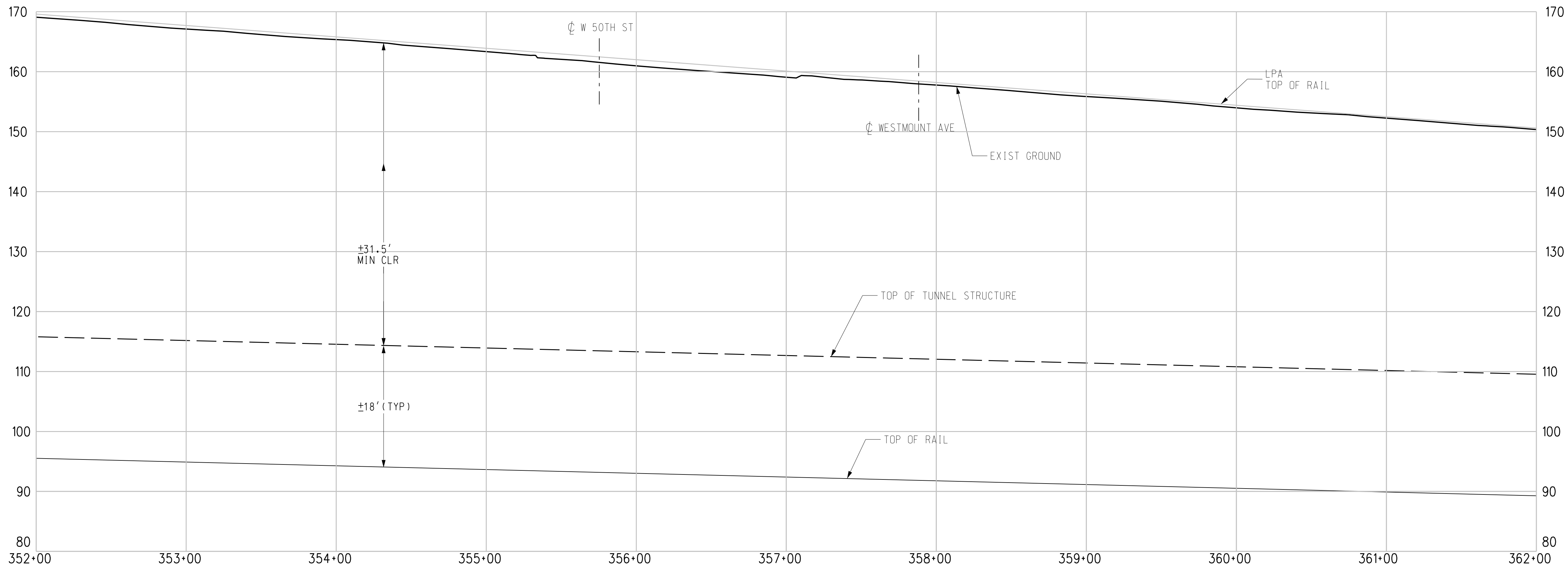

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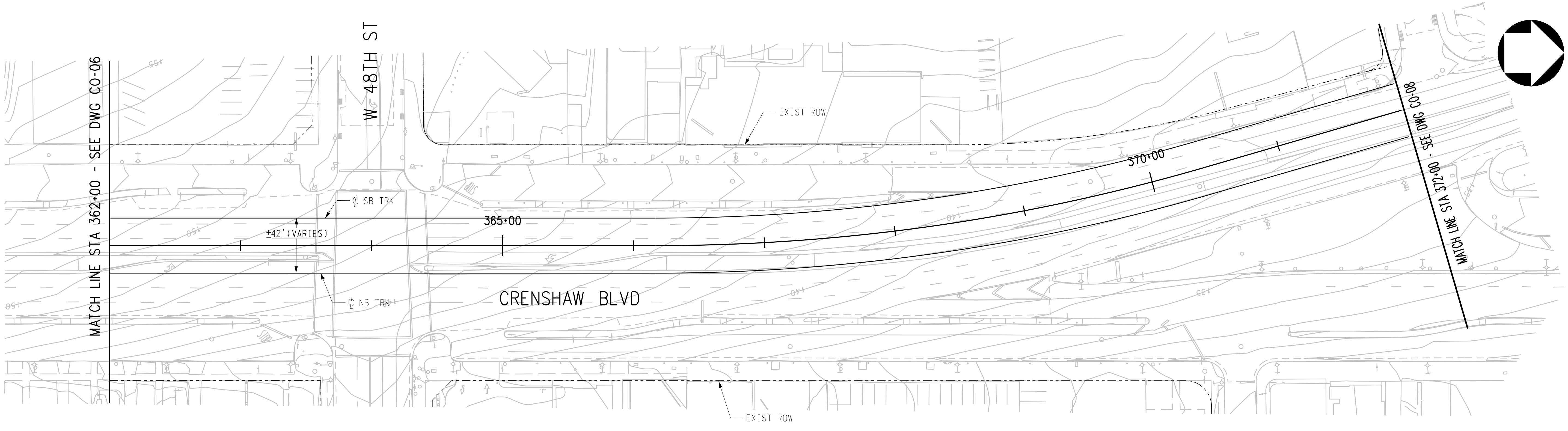

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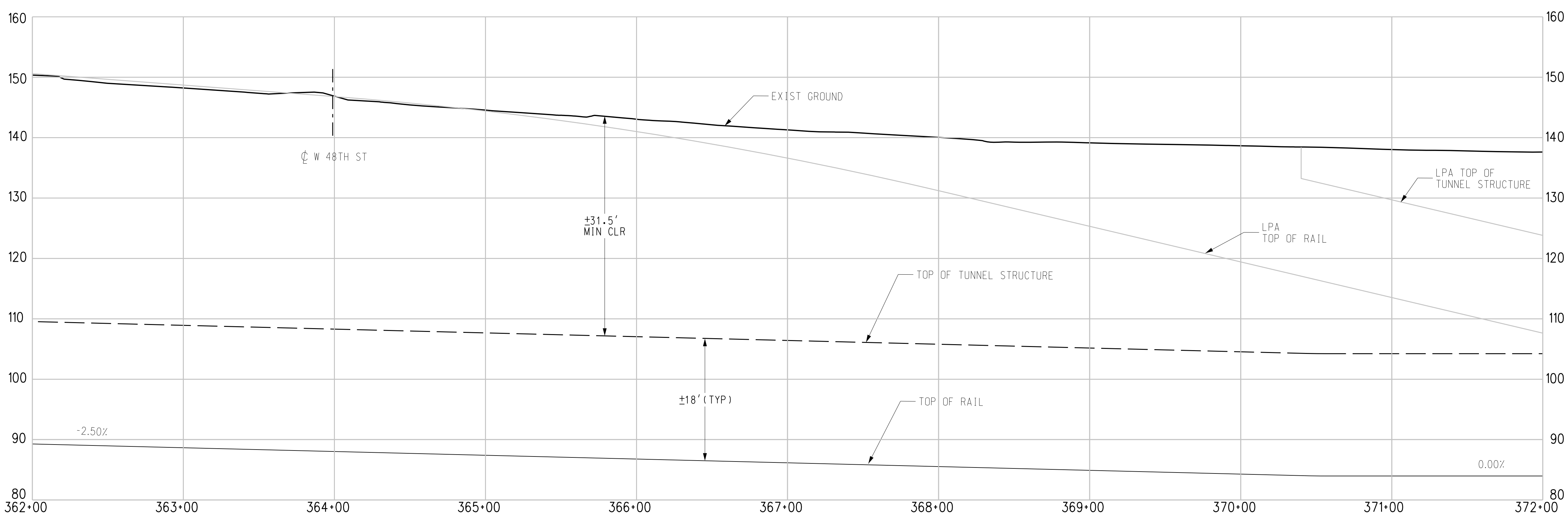

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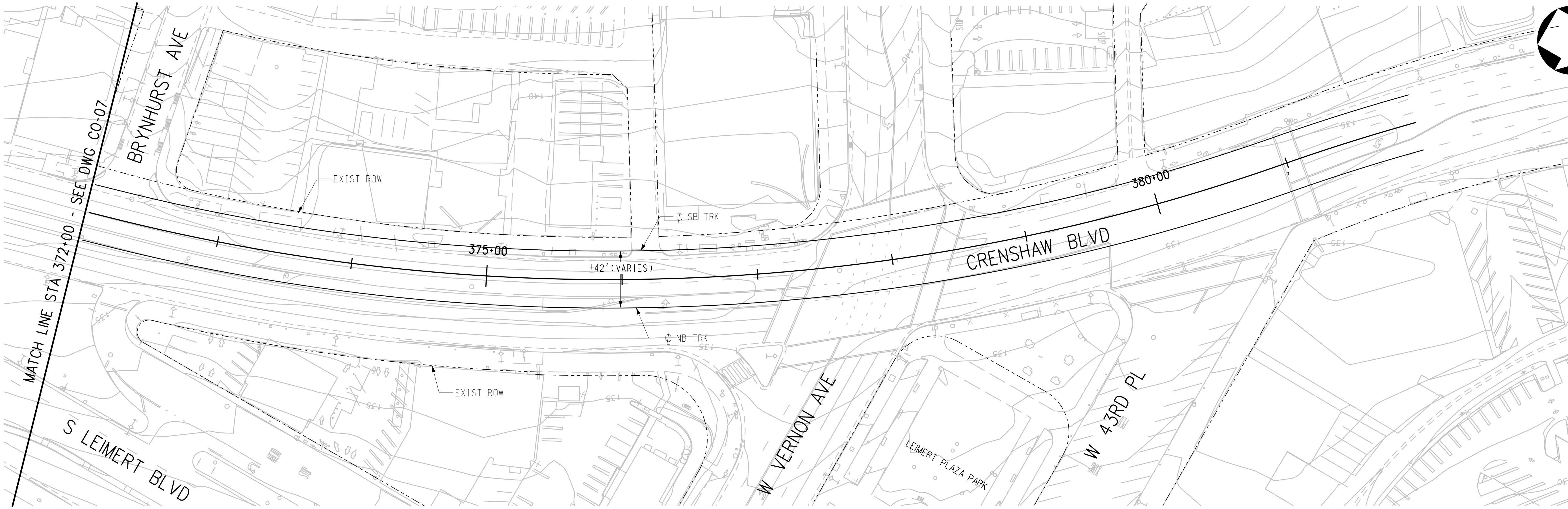

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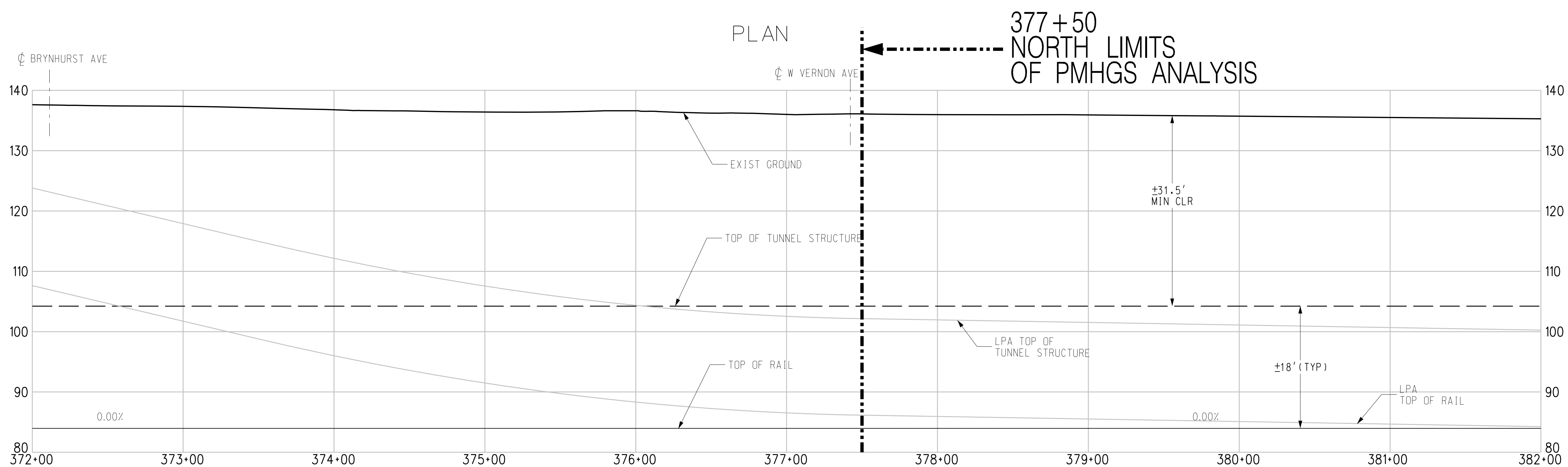

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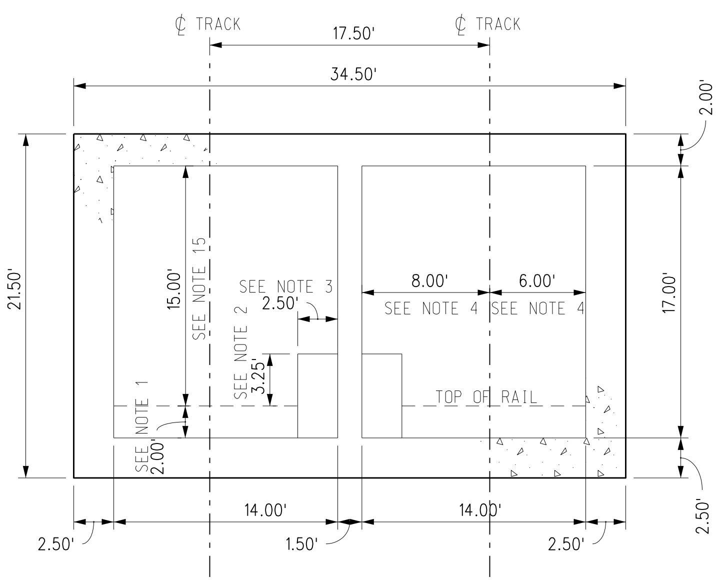
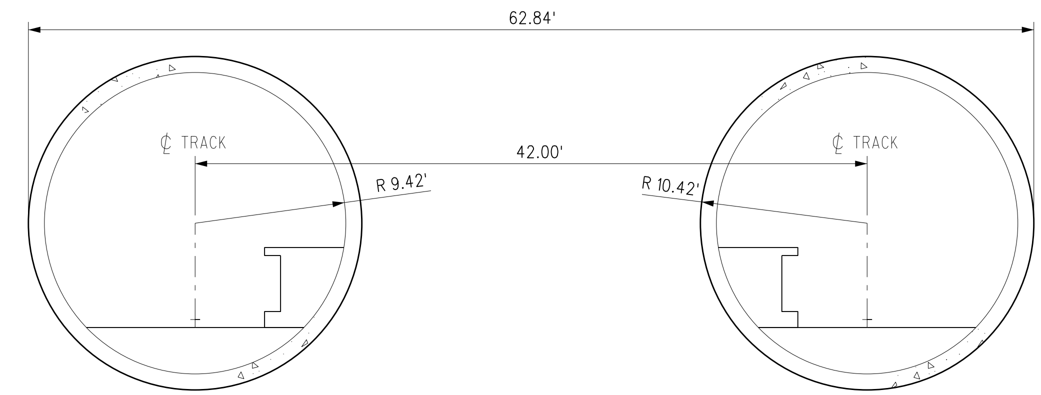
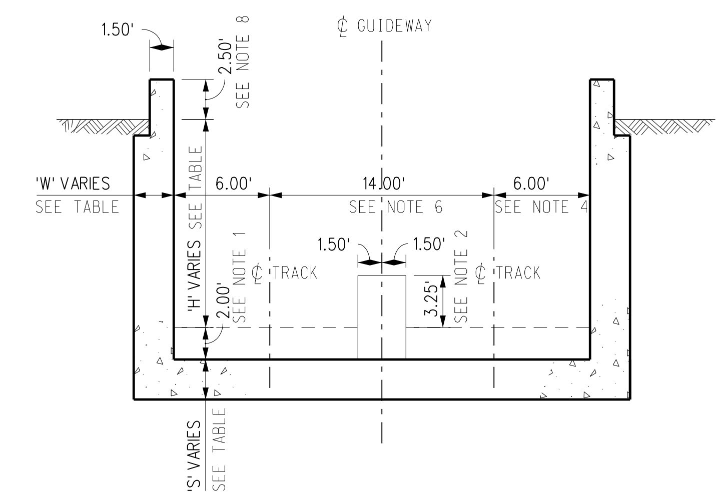


CUT&COVER TUNNEL – TYP CROSS-SECTION



TYPICAL SECTION



RETAINED CUT – TYP CROSS-SECTION

NOTES:

1. TRACK STRUCTURE DEPTH TO BE DETERMINED. 2'-0" IS AN ASSUMED DIMENSION
2. PER METRO DESIGN CRITERIA, SECTION 4, ITEM 4.1.3.3.A.
3. PER METRO DESIGN CRITERIA, SECTION 4, ITEM 4.1.3.3.G.
4. PER METRO DESIGN CRITERIA, SECTION 4, ITEM 4.1.3.3.H.
5. PER METRO DESIGN CRITERIA, SECTION 4, ITEM 4.1.3.4.
6. PER METRO DESIGN CRITERIA, SECTION 4, ITEM 4.1.3.3.H.6, ASSUMING A CENTER WALKWAY, WITHOUT CENTER OCS POLES
7. PERMANENT METRO ROW SHALL BE ON A VERTICAL PLANE, 5'-0" BEYOND THE OUTSIDE FACE OF THE PERMANENT STRUCTURE PER METRO DESIGN CRITERIA, SECTION 3, ITEM 3.H.3.A.3.
   BARRIER CONFIGURATION IS INDICATIVE ONLY. ACTUAL SOLID AND OPEN.
8. BARRIER HEIGHT AND CONFIGURATION SHALL BE DETERMINED IN ACCORDANCE WITH METRO DESIGN CRITERIA, SECTION 3, ITEM 3.5.3.

RETAINED CUT DIMENSION TABLE

DESIGN HEIGHT 'H' (FT)	WALL THICKNESS 'W' (FT)	BASE SLAB THICKNESS 'S' (FT)
5-10'	1'-6"	2'-0"
10-15'	2'-0"	2'-6"
15-20'	2'-6"	3'-0"
20-25'	3'-0"	3'-6"
>25'	3'-6"	4'-0"

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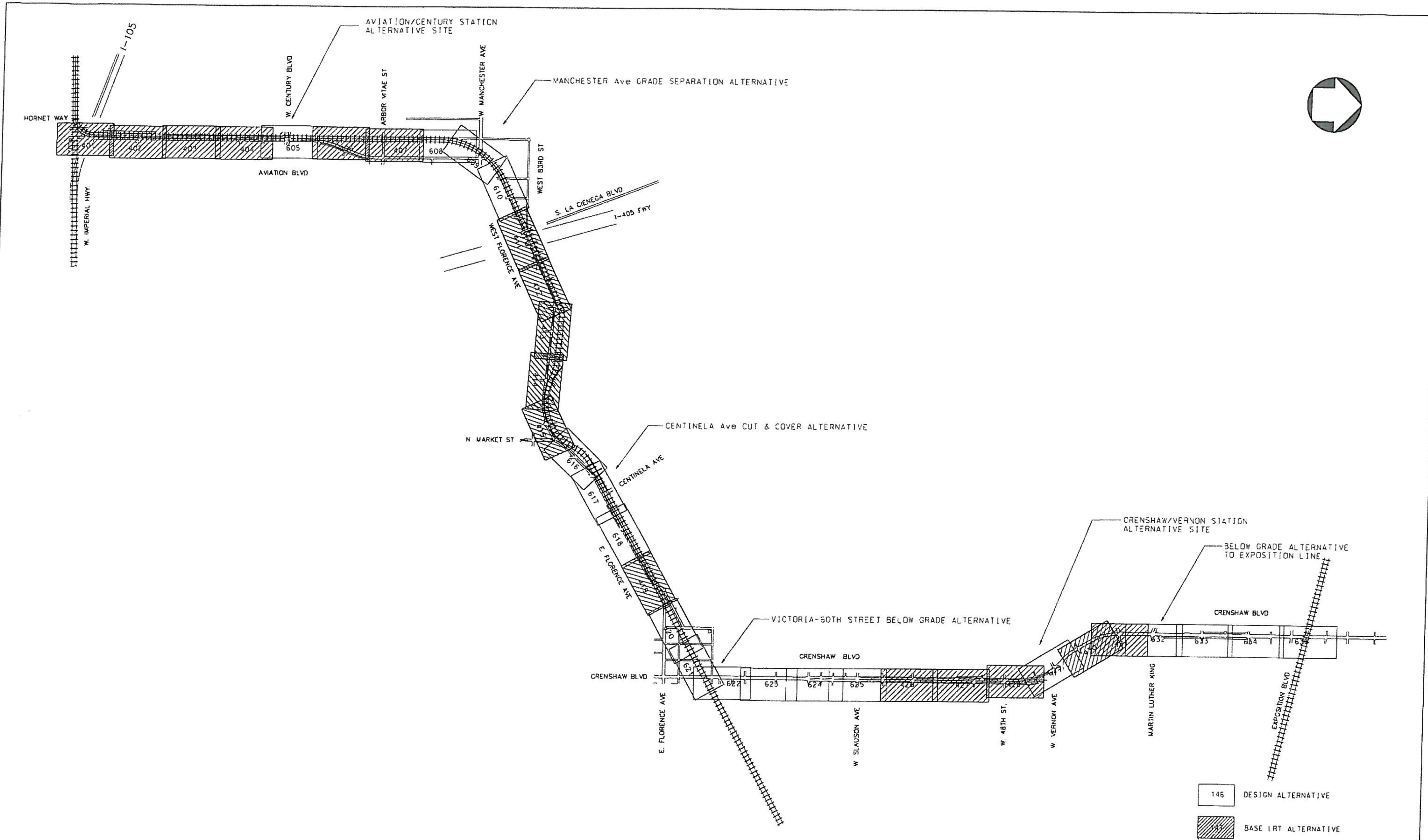
PMHGS ANALYSIS PROPOSED TUNNEL
TYPICAL SECTIONS

CONTRACT NO E0117
DRAWING NO TS-01
REV
SCALE 1:60
SHEET NO



THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL TRANSIT ADMINISTRATION (FTA), UNDER THE FEDERAL TRANSIT ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV	DATE	BY	APP	REG NO	EXPIRES	SEAL HOLDER	DESCRIPTION

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DRAWN BY
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Metro
LOS ANGELES COUNTY METROPOLITAN TRANSPORTATION AUTHORITY
Crenshaw-Prairie Transit Corridor Project

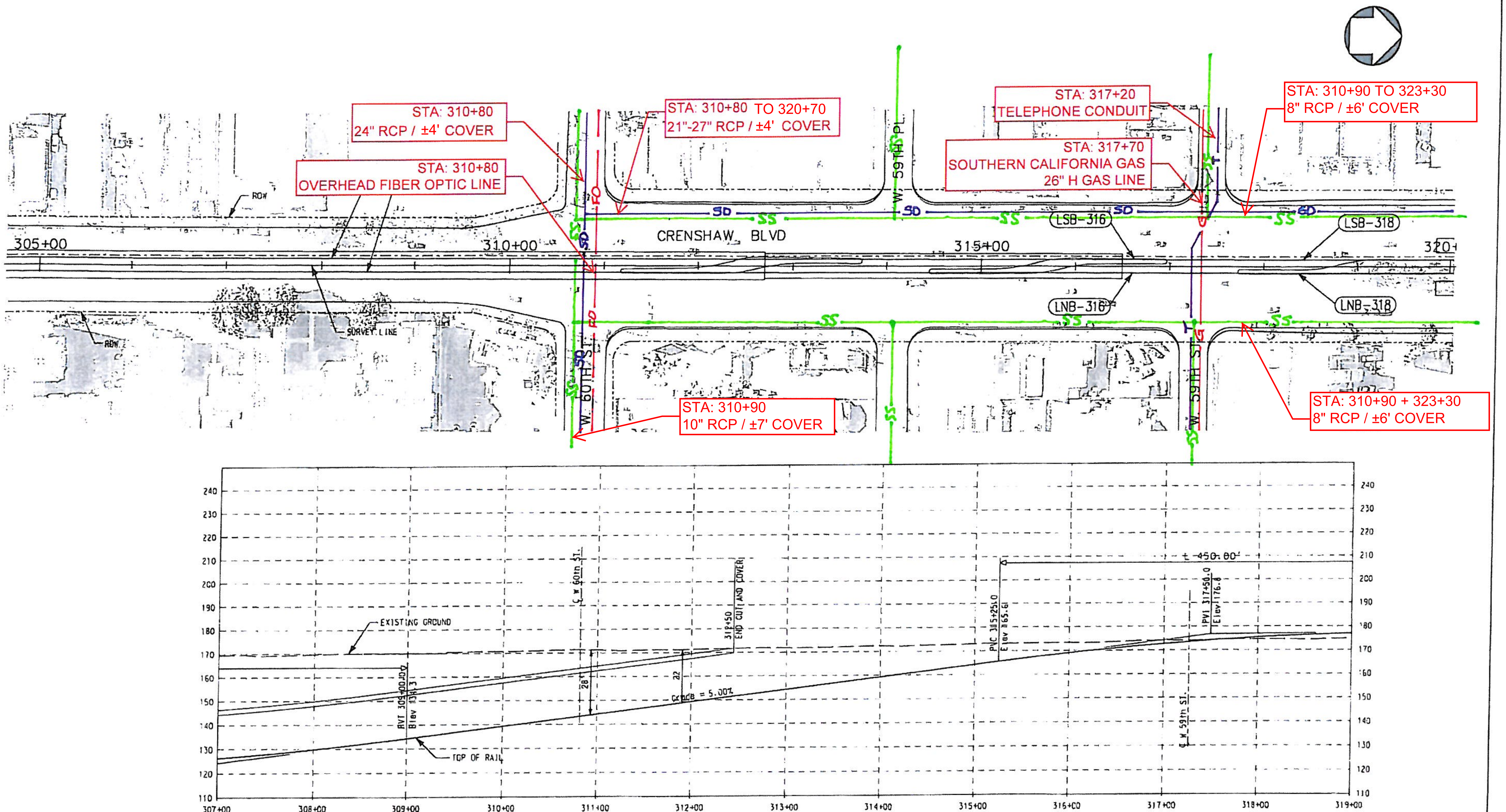
Parsons Brinckerhoff
In Association with
Jenkins Gales Martinez, Inc.

PROJECT MANAGER

LIGHT RAIL TRANSIT DESIGN ALTERNATIVE KEY MAP

CONTRACT NO PS-4330-1968
DRAWING NO C-600
REV 0
SCALE NOT TO SCALE
SHEET NO

04/27/2010



THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL TRANSIT ADMINISTRATION (FTA), UNDER THE FEDERAL TRANSIT ACT OF 1964, AS AMENDED AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA	REV	DATE	BY	APP	REG NO	EXPIRES	SEAL HOLDER	DESCRIPTION

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Crenshaw-Prairie Transit Corridor Project

PB Parsons Brinckerhoff
In Association with Jenkins Gales Martinez, Inc.

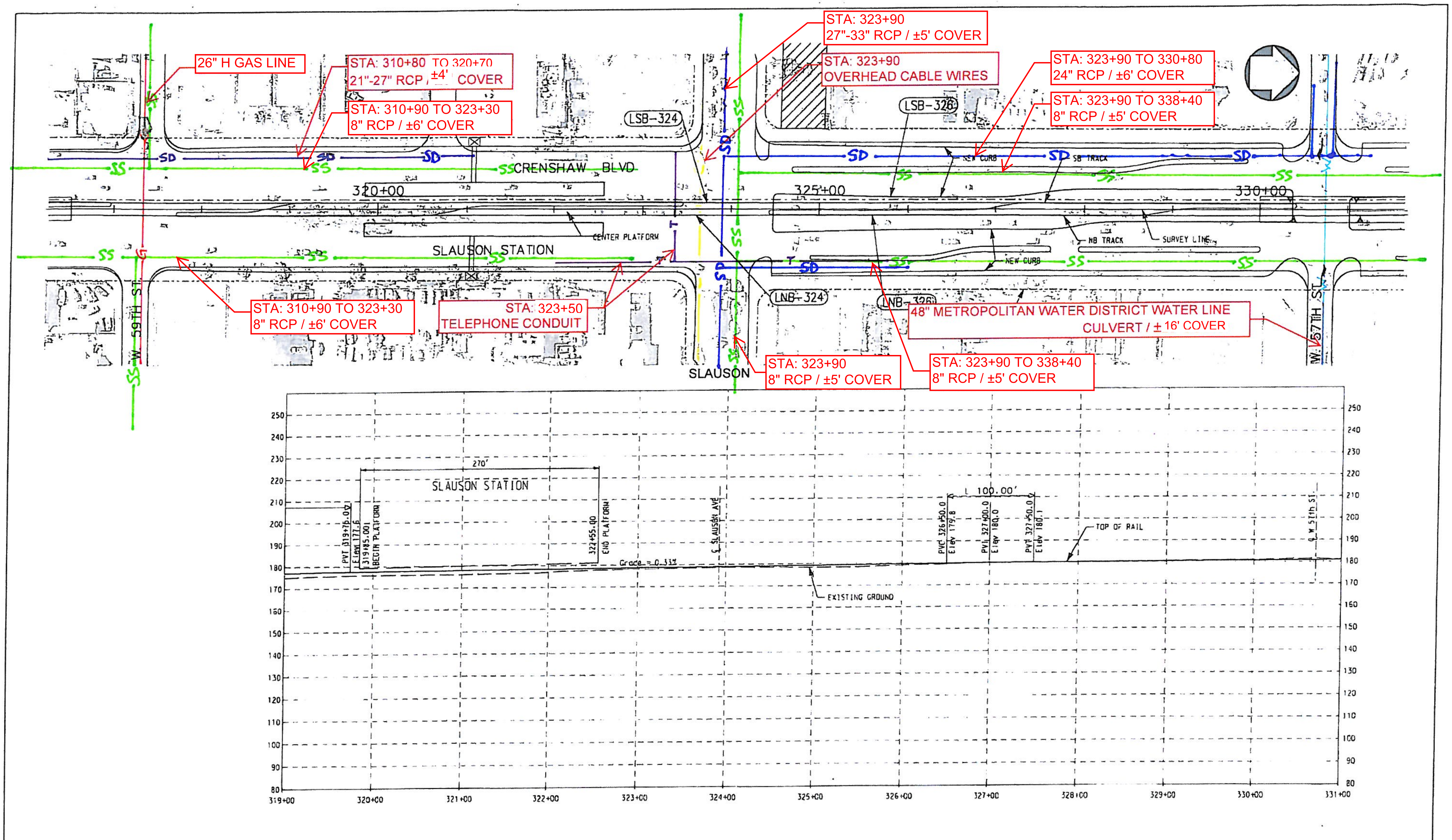
PROJECT MANAGER

LIGHT RAIL TRANSIT
VICTORIA-60th STREET BELOW-GRADE ALTERNATIVE
PLAN & PROFILE
STA 307+00 TO STA 319+00

CONTRACT NO PS-4330-1968
DRAWING NO C-624
REV 0
SCALE HORIZ: 1" = 100' VERT: 1" = 40'
SHEET NO

NOTE: UTILITY NOTES WERE ADDED TO OLD "CONCEPTUAL ENGINEERING" BASE MAPS

04/27/2010



THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL TRANSIT ADMINISTRATION (FTA), UNDER THE FEDERAL TRANSIT ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA.

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Crenshaw-Prairie Transit Corridor Project

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Parsons Brinckerhoff
In Association with
Jenkins Gales Martinez, Inc.

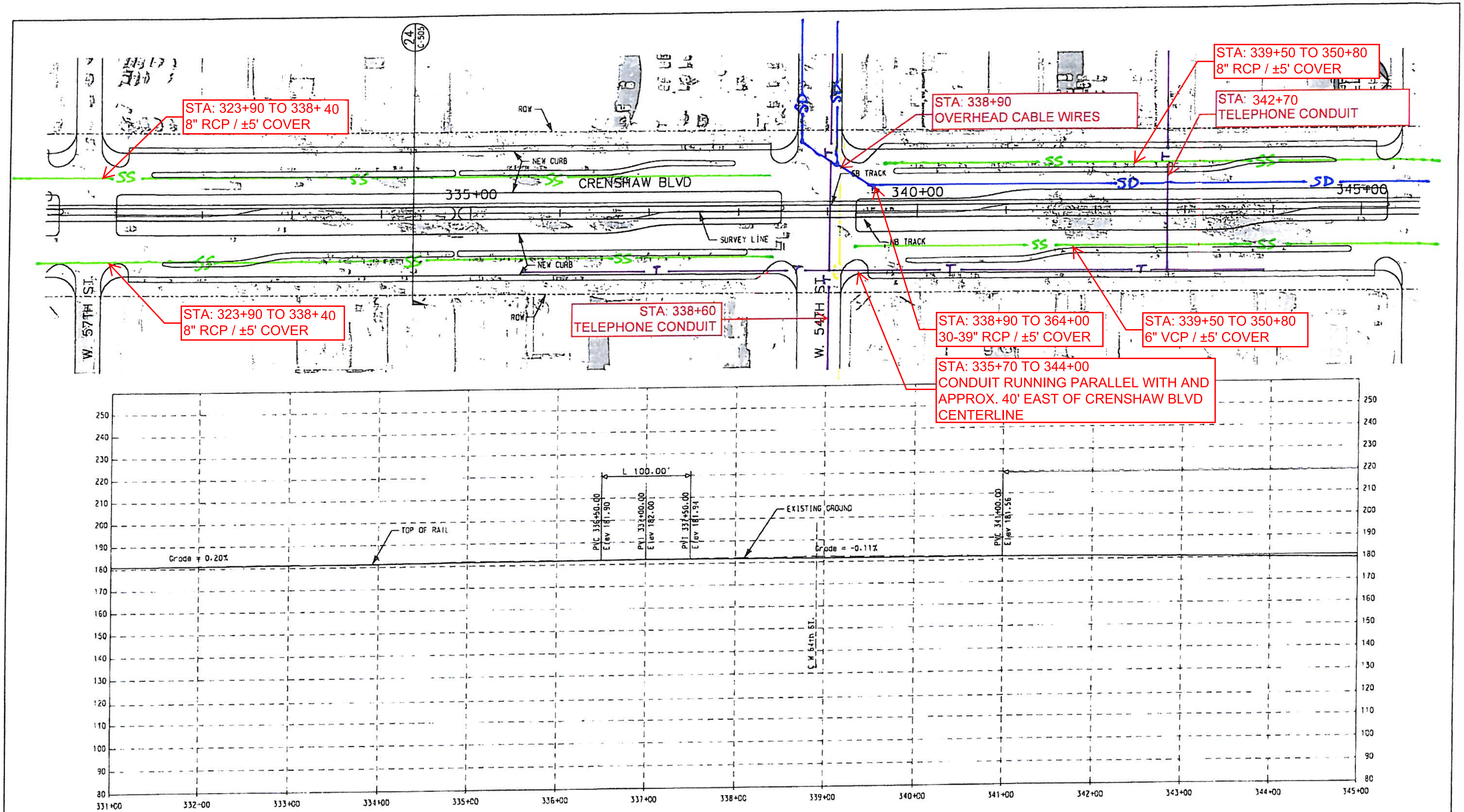
PROJECT MANAGER

LIGHT RAIL TRANSIT
VICTORIA-60th STREET BELOW-GRADE ALTERNATIVE
PLAN & PROFILE
STA 319+00 TO STA 331+00

CONTRACT NO PS-4330-1968
DRAWING NO C-625
REV 0
SCALE HORIZ: 1" = 100'
VERT: 1" = 40'
SHEET NO

04/27/2010

NOTE: UTILITY NOTES WERE ADDED TO OLD "CONCEPTUAL ENGINEERING" BASE MAPS



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LOS ANGELES COUNTY METROPOLITAN TRANSPORTATION AUTHORITY
Crenshaw-Prairie Transit Corridor Project

Parsons Brinckerhoff
In Association with
Jenkins Gales Martinez,Inc.

PROJECT MANAGER

LIGHT RAIL TRANSIT

PLAN & PROFILE
STA 331+00 TO STA 345+00

CONTRACT NO PS-4330-1968
DRAWING NO C-426
REV 0
SCALE HORIZ: 1" = 100' VERT: 1" = 40'
SHEET NO

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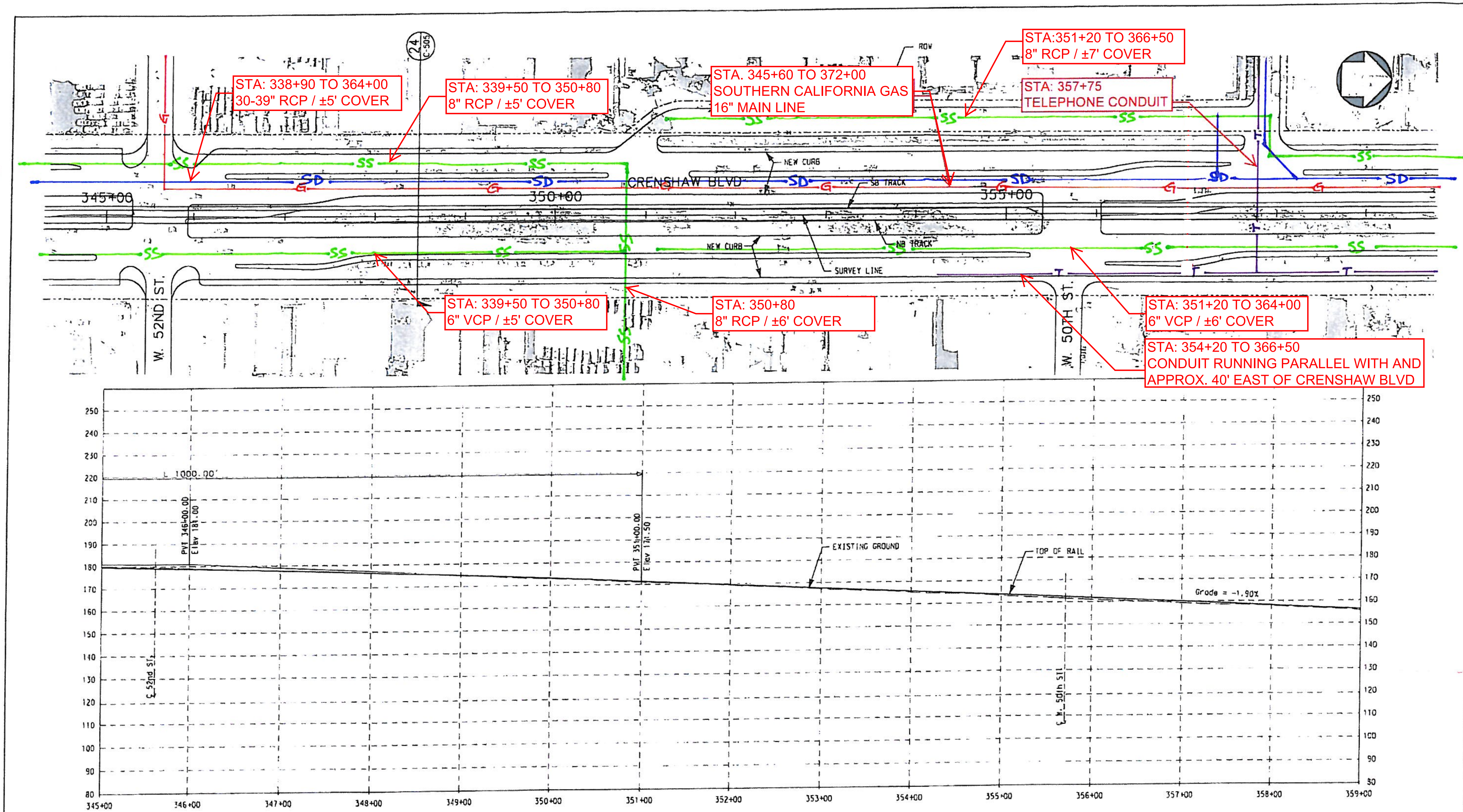

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL TRANSIT ADMINISTRATION (FTA), UNDER THE FEDERAL TRANSIT ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV	DATE	BY	APP	REG NO	EXPIRES	SEAL HOLDER	DESCRIPTION

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Crenshaw-Prairie Transit Corridor Project

Parsons Brinckerhoff
In Association with
Jenkins Gales Martinez, Inc.

PROJECT MANAGER

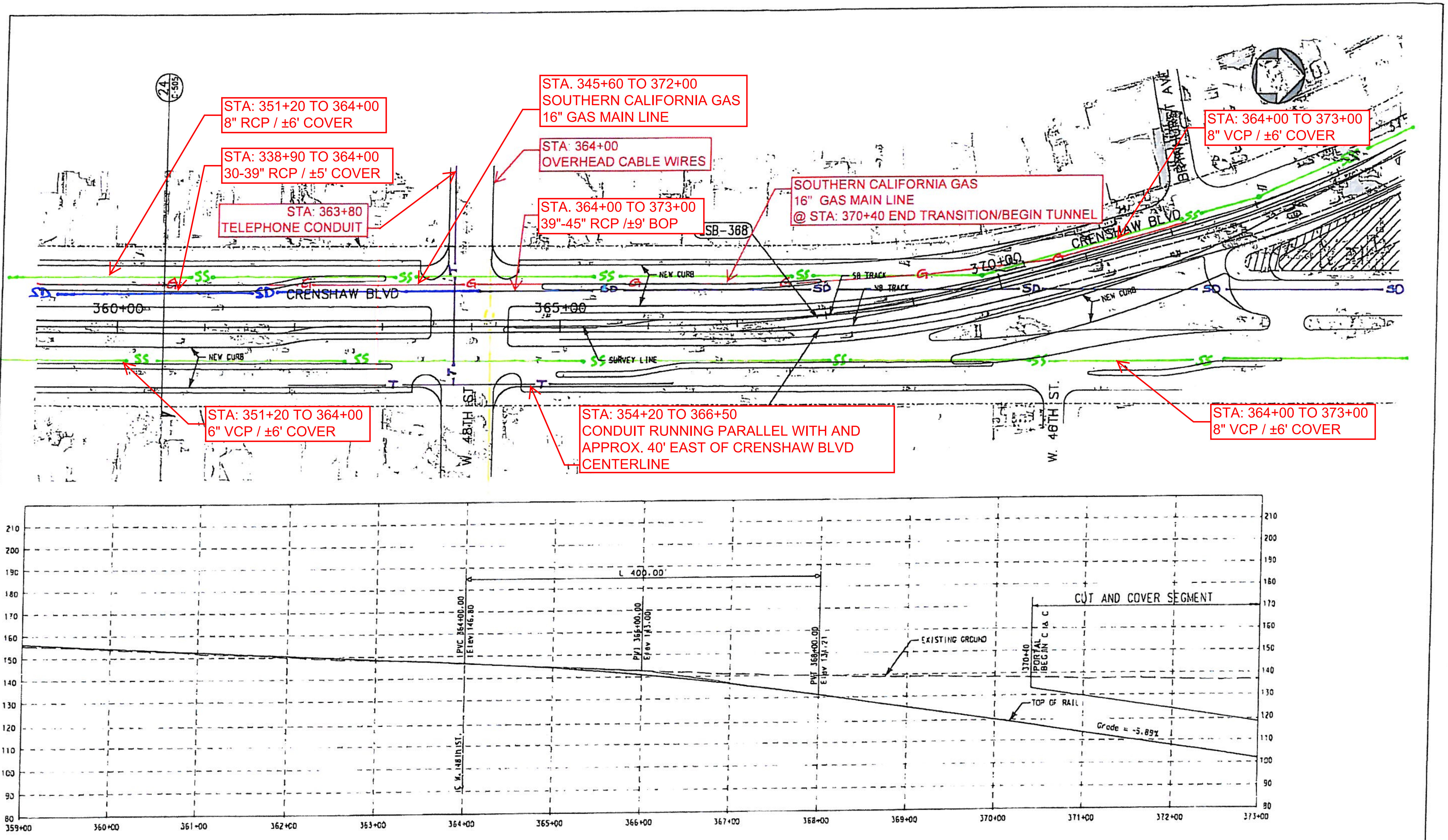
LIGHT RAIL TRANSIT

PLAN & PROFILE
STA 345+00 TO STA 359+00

CONTRACT NO PS-4330-1968
DRAWING NO C-427
REV 0
SCALE HORIZ: 1" = 100'
VERT: 1" = 40'
SHEET NO

04/27/2010

NOTE: UTILITY NOTES WERE ADDED TO "OLD CONCEPTUAL ENGINEERING" BASE MAPS



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Crenshaw-Prairie Transit Corridor Project

PB Parsons Brinckerhoff
In Association with Jenkins Gales Martinez, Inc.

PROJECT MANAGER

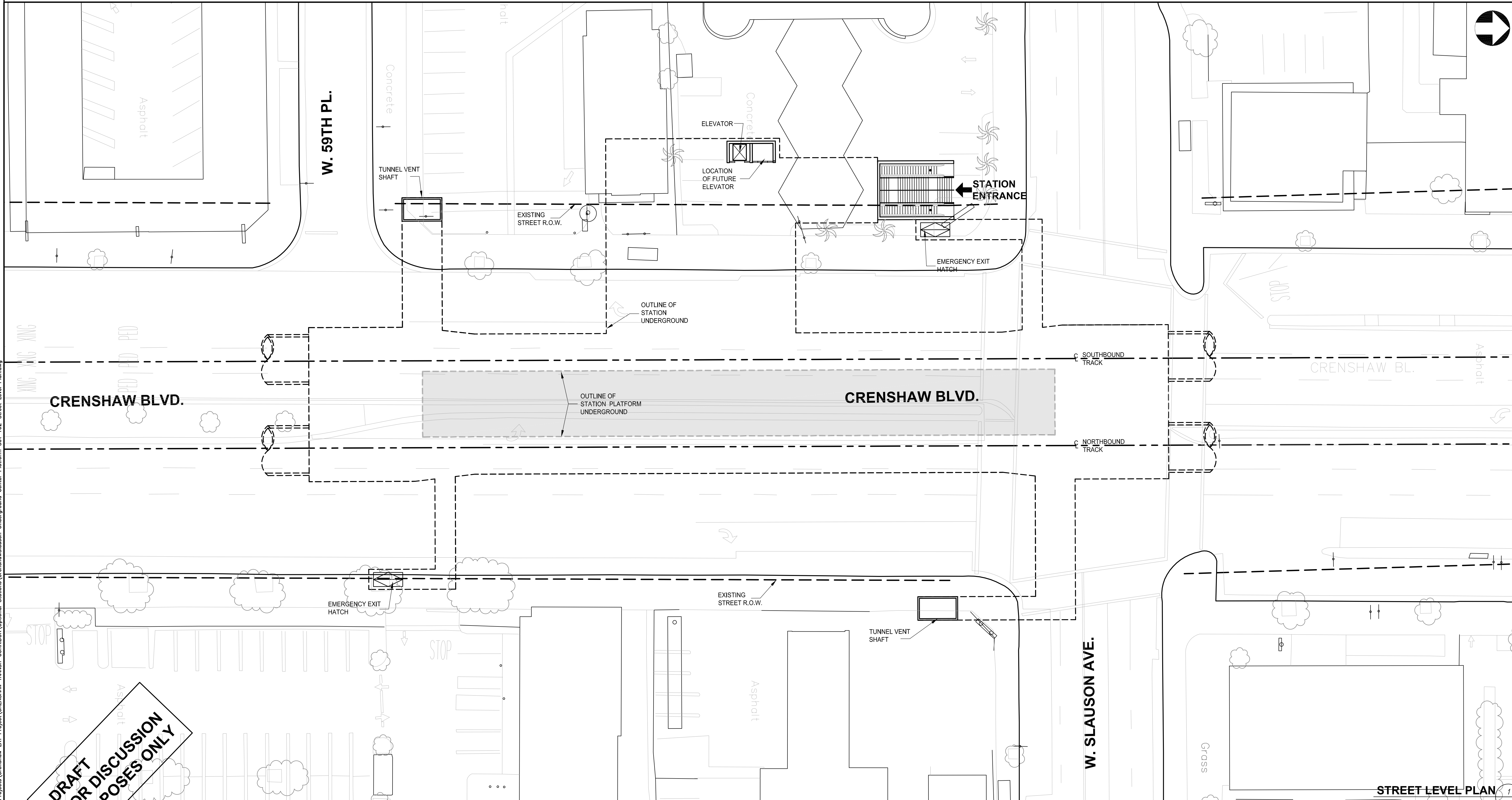
LIGHT RAIL TRANSIT

PLAN & PROFILE
STA 359+00 TO STA 373+00

CONTRACT NO PS-4330-1968
DRAWING NO C-428
REV 0
SCALE HORIZ: 1" = 100' VERT: 1" = 40'
SHEET NO

NOTE: UTILITY NOTES WERE ADDED TO OLD "CONCEPTUAL ENGINEERING" BASE MAPS

04/27/2010



20' 0' 20' 40'

GRAPHIC SCALE

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LOS ANGELES COUNTY METROPOLITAN TRANSPORTATION AUTHORITY

Metro

Crenshaw - Prairie Transit Corridor Project

Hatch Mott MacDonald
6151 W. Century Blvd. Suite 800
Los Angeles, CA 90045
Phone: 310-337-0500
Fax: 310-337-0042

Anil Verma Associates, Inc.

LIGHT RAIL TRANSIT

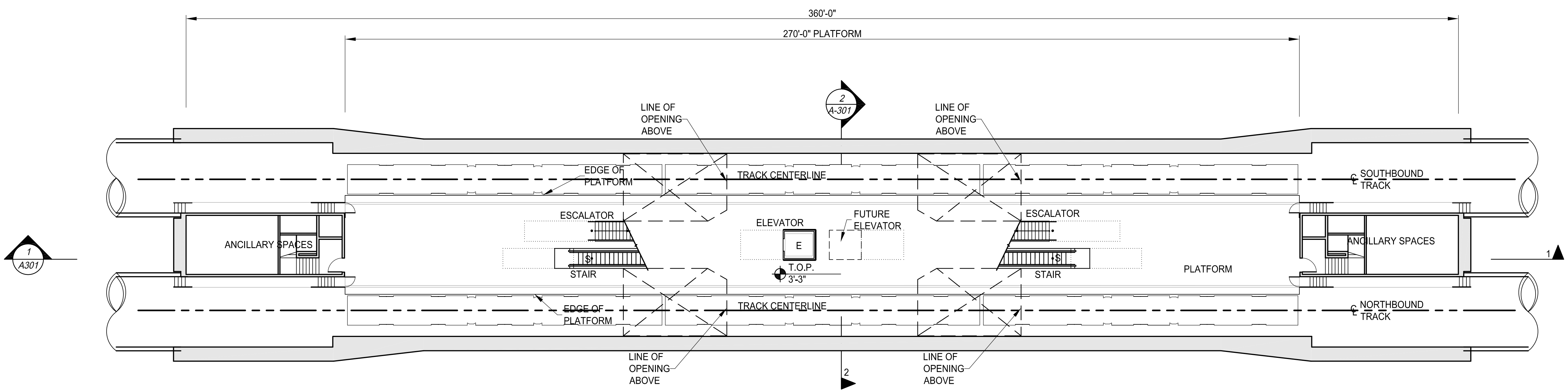
SLAUSON UNDERGROUND CENTER
PLATFORM STATION OPTION 1
STREET LEVEL PLAN

CADD FILENAME

SIZE | SCALE

CONTRACT NO. | REV.

AREA CODE | SHEET NO. | PAGE NO.



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FOR DISCUSSION
PURPOSES ONLY

PLATFORM LEVEL PLAN 1/—

16' 0' 16' 32'

GRAPHIC SCALE

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Anil Verma Associates, Inc.
444 SOUTH FLOWER STREET, SUITE 1688
LOS ANGELES CA 90071
PH: (213) 624-6908, Fax: (213) 624-1186,
anilverma@earthlink.net, www.anilverma.com

LIGHT RAIL TRANSIT
SLAUSON UNDERGROUND CENTER
PLATFORM STATION OPTION 1
PLATFORM LEVEL PLAN

CADD FILENAME
SIZE | SCALE
CONTRACT NO. | REV.
AREA CODE | SHEET NO. | PAGE NO.

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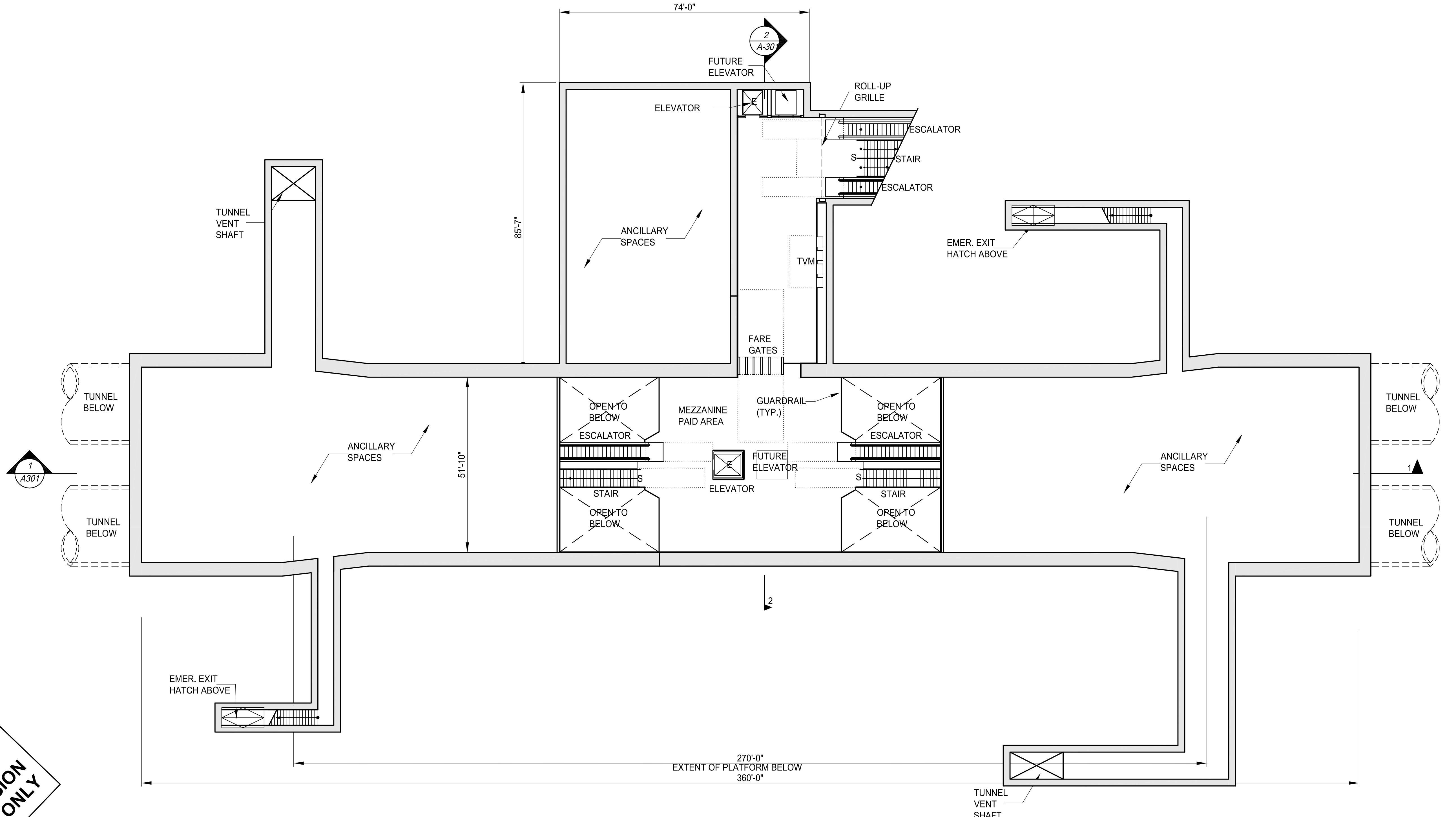

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MEZZANINE LEVEL PLAN
1
—

16' 0' 16' 32'
GRAPHIC SCALE

Apr 28, 2010 – 8:42am G:\Current Projects\Crenshaw LRT Project\CRENSHAW TRANSIT CORRIDOR\Optional Stations\CrenshawSlauson Underground Center Platform SIA-104–Mezzanine Level Plan–SIMPLIFIED.dwg
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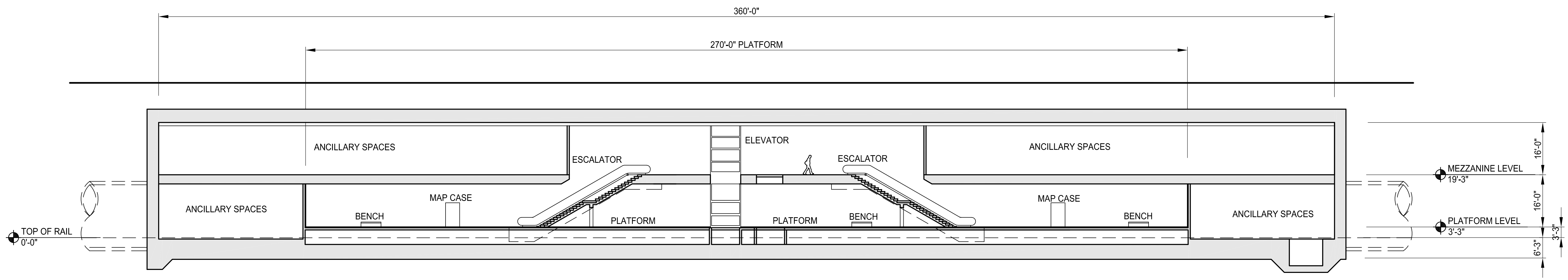
Anil Verma Associates, Inc.

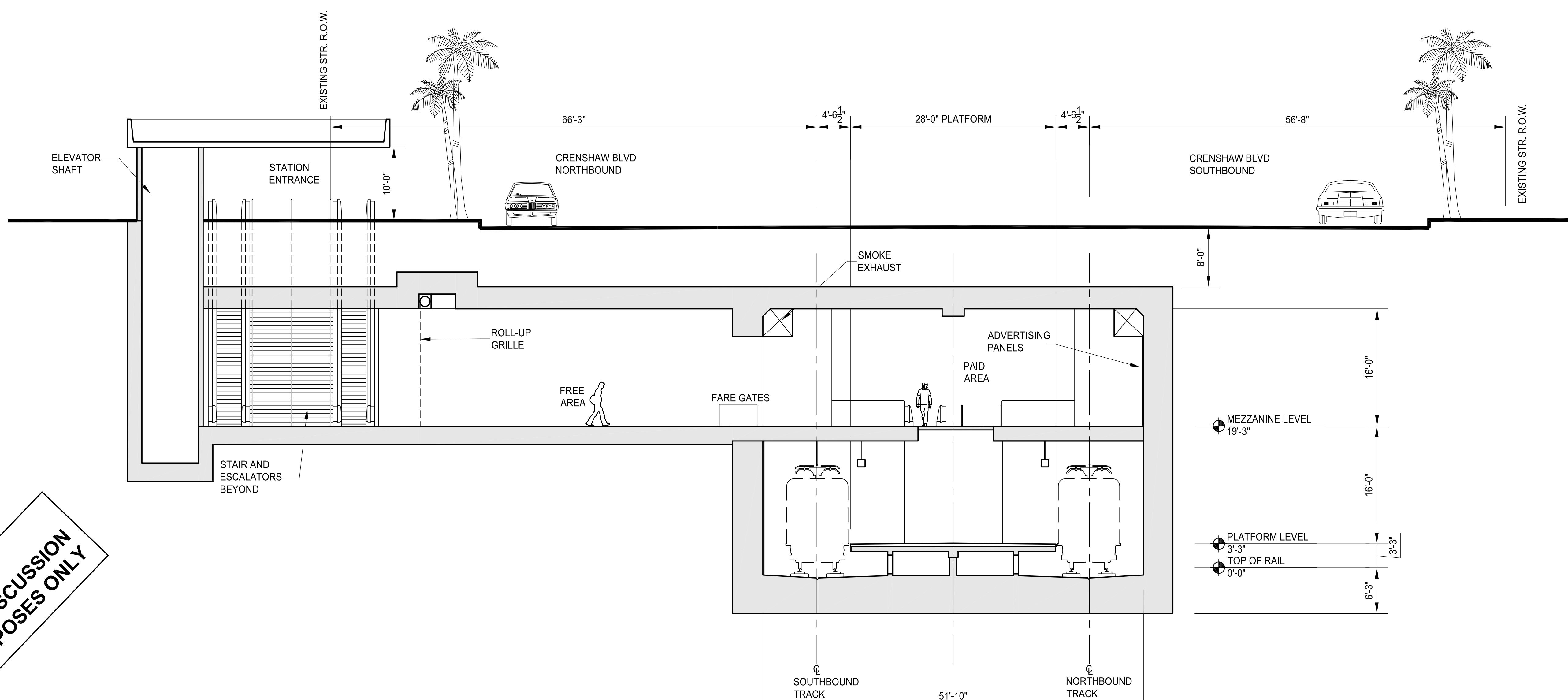
LIGHT RAIL TRANSIT
SLAUSON UNDERGROUND CENTER
PLATFORM STATION OPTION 1
MEZZANINE LEVEL PLAN

CADD FILENAME
SIZE | SCALE
CONTRACT NO. | REV.
AREA CODE | SHEET NO. | PAGE NO.



LONGITUDINAL SECTION 1

16' 0' 16' 32'
GRAPHIC SCALE



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CROSS SECTION 2

8' 0' 8' 16'
GRAPHIC SCALE

georgiyl Apr 28, 2010 – 8:47am G:\Current Projects\Crenshaw LRT Project\CRENSHAW TRANSIT CORRIDOR\Optional Stations\CrenshawSlauson Underground Center Platform SIA-202-Section-SIMPLIFIED.dwg

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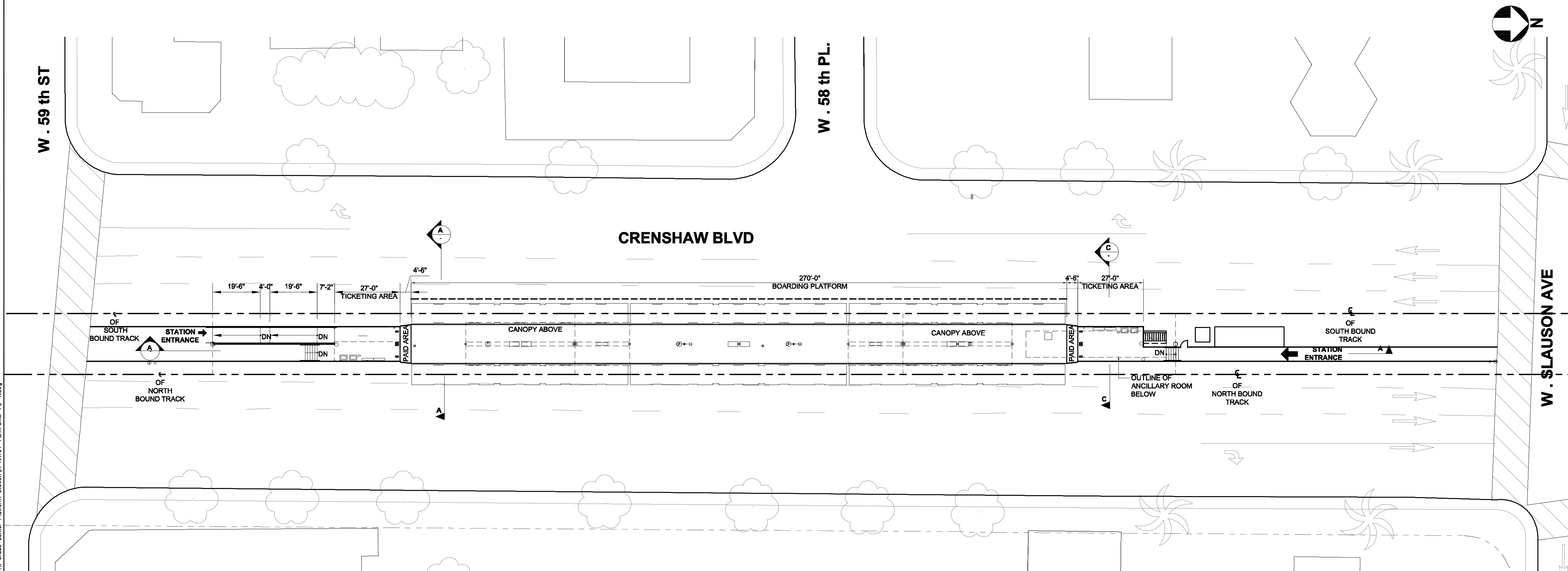
LIGHT RAIL TRANSIT
SLAUSON UNDERGROUND CENTER
PLATFORM STATION OPTION 1
SECTION

CADD FILENAME
SIZE SCALE
CONTRACT NO. REV.
AREA CODE SHEET NO. PAGE NO.



SITE PLAN 1/-

DRAFT FOR DISCUSSION PURPOSES ONLY

20' 0' 20' 40'

GRAPHIC SCALE

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Metro
Crenshaw - Prairie Transit Corridor Project

Hatch Mott MacDonald
6151 W. Century Blvd. Suite 800 Los Angeles, CA 90045 Phone: 310-337-0500 Fax: 310-337-0042

Anil Verma Associates, Inc.

LIGHT RAIL TRANSIT
SLAUSON AT GRADE CENTER PLATFORM STATION
SITE PLAN

CADD FILENAME
SIZE SCALE
CONTRACT NO. REV.
AREA CODE SHEET NO. PAGE NO.

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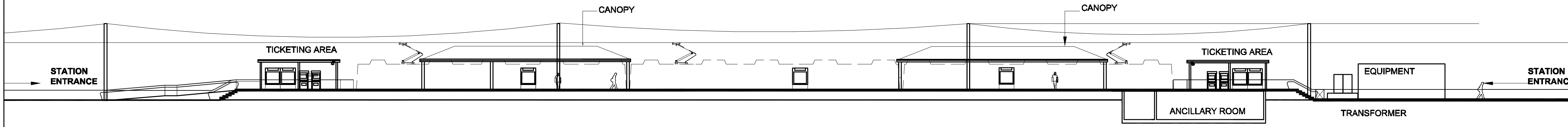
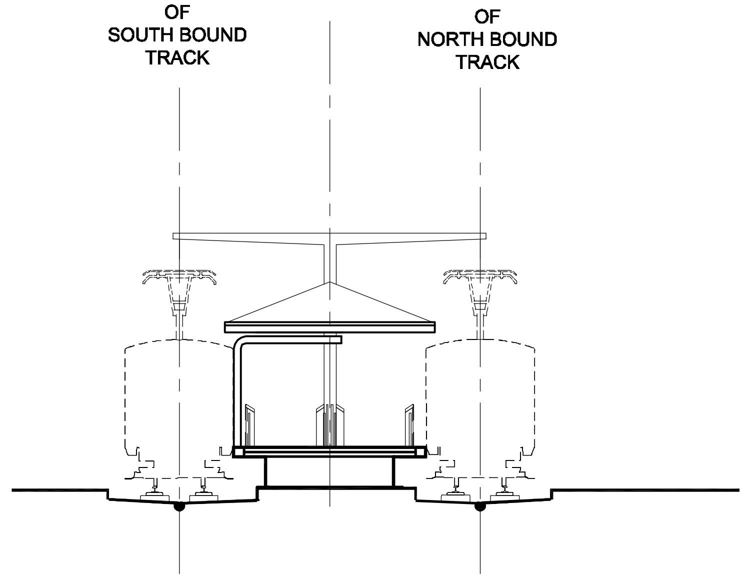


SECTION "A"

16' 0' 16' 32'
GRAPHIC SCALE: 1/16"=1'-0"



SECTION "B"

8' 0' 8' 16'
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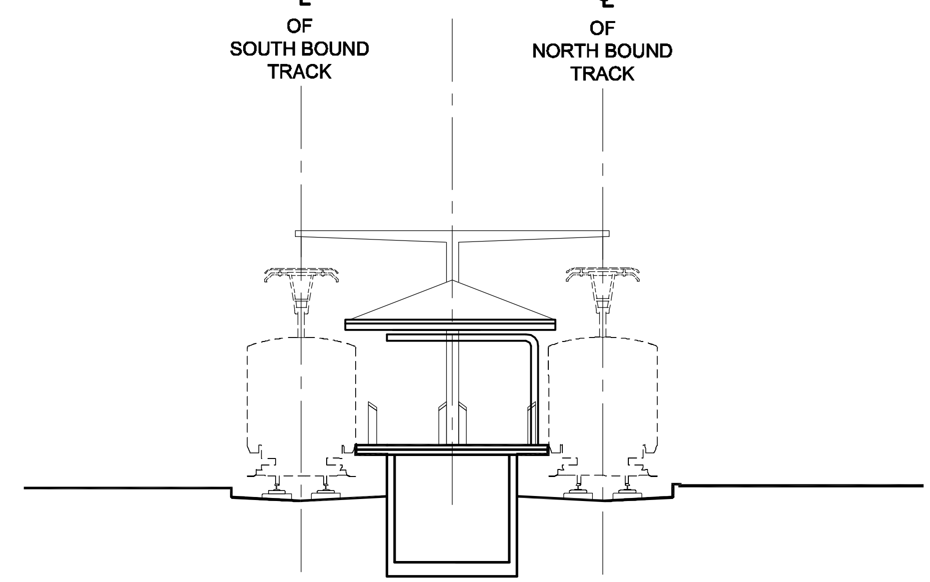

SECTION "C"

8' 0' 8' 16'
GRAPHIC SCALE: 1/8"=1'-0"

8' 0' 8' 16'
GRAPHIC SCALE

16' 0' 16' 32'
GRAPHIC SCALE

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Metro
Crenshaw - Prairie Transit Corridor Project

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Fax: 310-337-0042

Anil Verma Associates, Inc.

LIGHT RAIL TRANSIT
SLAUSON AT GRADE CENTER PLATFORM STATION
SECTIONS

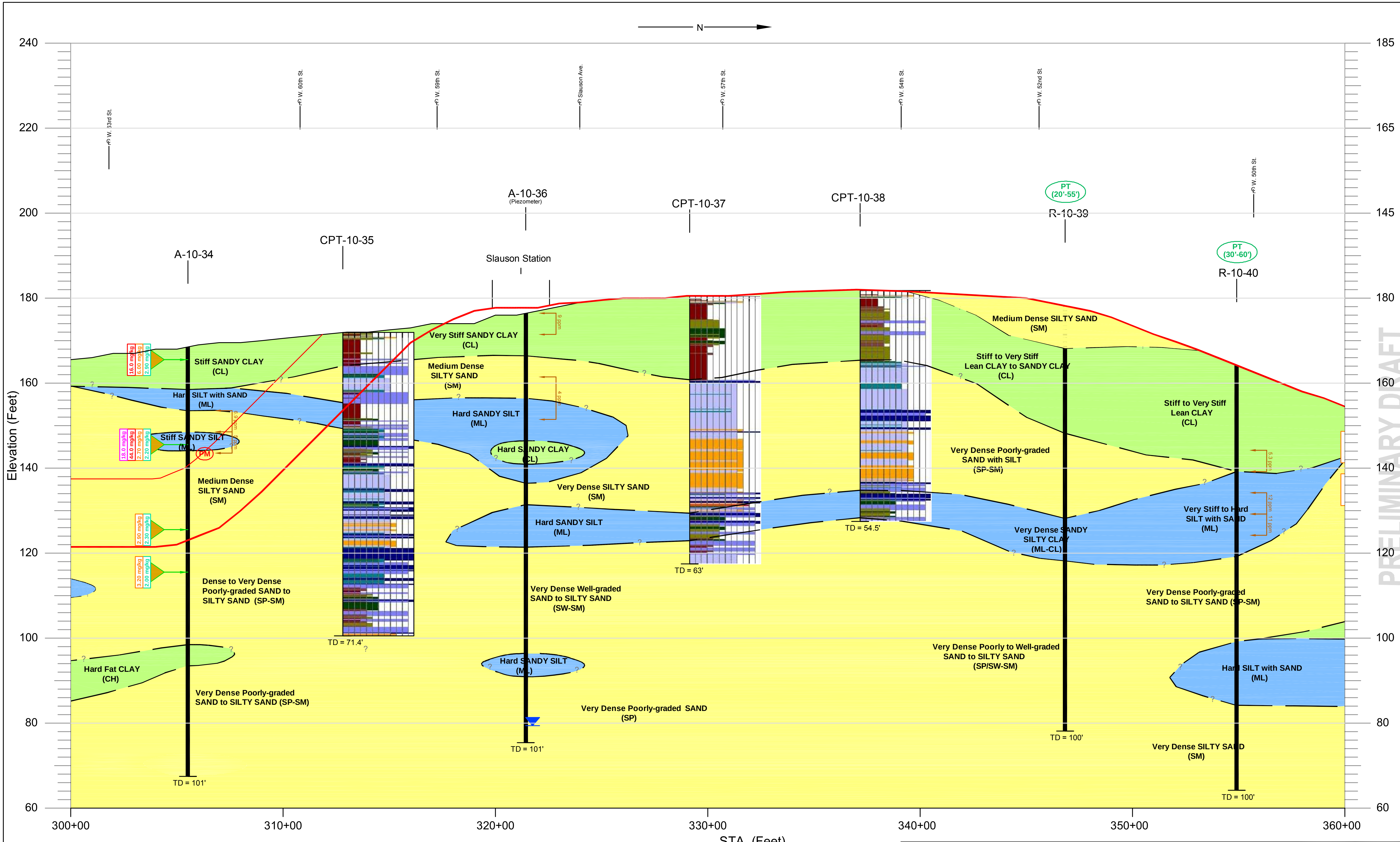
CADD FILENAME
SIZE | SCALE
CONTRACT NO. | REV.
AREA CODE | SHEET NO. | PAGE NO.

Appendix B
Cost Data

Crenshaw/LAX Transit Corridor Project
Park Mesa Heights Grade Separation Analysis Caital Cost Estimate

					LPA		PMHGS			
							No Slauson Station		Slauson Station	
SCC Code		Description	Units	Unit Price ($)	Qnty	Total Cost ($)	Qnty	Total Cost ($)	Qnty	Total Cost ($)
	Guideway, Trackwork & Special Trackwork									
	10.01	Guideway: LRT At-Grade Exclusive Right-of-Way	RF	522	4,370	2,281,140	-	-	-	-
	10.06	Guideway: Undergound Cut and Cover	RF	31,434	2,950	92,730,300	-	-	-	-
	10.06	Guideway: Undergound Cut and Cover (Below GWT)	RF	31,900	1,160	37,004,000	-	-	-	-
	10.06	Guideway: Undergound Cut and Cover (Deep @TBM)	RF	36,685	-	-	890	32,649,650	1,160	42,554,600
	10.07	Guideway: Underground Tunnel (Regular)	RF	22,113		-		-		
	10.07	Guideway: Underground Tunnel (Wet & Gassy)	RF	22,113	4,420	97,739,460	12,610	278,844,930	12,340	272,874,420
	10.08	Guideway: Retained Cut and Fill	RF	6,394	2,350	15,025,900	1,210	7,736,740	1,210	7,736,740
	10.09	Track: Direct Fixation	RF	782	15,250	11,929,313	15,250	11,929,313	15,250	11,929,313
	10.12	Double Crossover	EA	730,100	4	2,920,400	2	1,460,200	2	1,460,200
	10.13	Track: Vibration & Noise Damping	%	Item 10.09	10%	1,192,931	10%	1,192,931	10%	1,192,931
	Stations, Stops, Terminals & Intermodal							-		
	10.01	At-Grade Stations	EA	4,693,500	1	4,693,500		-		-
20	20.03	Underground Stations	EA	70,000,000	1	70,000,000	1	70,000,000	2	140,000,000
	20.07	Elevators	EA	429,660	2	859,320	2	859,320	4	1,718,640
	20.07	Escalators	EA	521,500	4	2,086,000	4	2,086,000	8	4,172,000
30	**Support Facilities: Yards, Shops, and Administration Buldings**									
	30.04	Ventilation Structure	EA	45,000,000	-	-	1	45,000,000	-	-
	Sitework and Special Conditions							-		
	40.01	Demolition, Clearning , Earthwork	RF	156	6,460	1,010,667	2,640	413,028	2,640	413,028
	40.02	Utility Relocation, Heavy	RF	305	6,460	1,970,801	2,640	805,405	2,640	805,405
	40.03	Hazardous Materials, Contaminate Soil Removal and Mitigation, and Groundwater Treatment	MI	709,240	1.2	851,088	0.4	283,696	0.4	283,696
40	40.04	Environmental Mitigation	MI	915,407	1.2	1,098,489	0.4	366,163	0.4	366,163
	40.05	Site Structures, including Retaining Walls	RF	614	6,460	3,965,148	2,100	1,288,980	2,100	1,288,980
	40.06	Pedestrian/Bike Access & Accommodation, Landscaping	MI	625,800	1.2	750,960	0.4	250,320	0.4	250,320
	40.07	Civil: Median/Sidewalk Reconstruction	RF	261	6,460	1,684,445	2,100	547,575	2,100	547,575
	40.07	Civil: Driveway and Access Roads	EA	15,645		-		-		-
	40.08	GC Mobilization, Demobilization, Temporary Facilities, Overhead & Profit	%	Items 10-50, excl 40.08	10%	37,966,402	10%	48,381,326	10%	51,577,622
	Systems							-		
	50.01	Train Control and Signals	RF	300	15,250	4,575,000	15,250	4,575,000	15,250	4,575,000
	50.02	Traffic Signals and Crossing Protection	EA	625,800	7.5	4,699,426	1.0	647,134	1.2	730,337
	50.03	Traction Power Supply: Substation	EA	2,557,500	3.08	7,866,855	3.08	7,866,855	3.08	7,866,855
50	50.04	Traction Power Supply: Catenary	RF	450	15,250	6,862,500	15,250	6,862,500	15,250	6,862,500
	50.05	Communication	MI	1,101,408	2.89	3,181,150	2.89	3,181,150	2.89	3,181,150
	50.06	Fare Collection Equipment: TVM	EA	153,450	2	306,900	2	306,900	2	306,900
	50.06	Fare Collection Equipment: Gates	Entry	713,000	4	2,852,000	4	2,852,000	4	2,852,000
	50.07	Central Control	MI	625,800	2.89	1,807,472	2.89	1,807,472	2.89	1,807,472
	Right of Way, Land and Existing Improvements							-		
	60.01	Purchase and Lease of Real Estate	Acre	1,534,500	7	10,741,500	7	10,741,500	7	10,741,500
	60.02	Relocation of Existing Households and Businesses	%	Item 60.01		-		-		-
		Subtotal Construction				428,371,927		542,936,088		578,095,347
		Design and Construction Contingency	%	Items 10-50		-		-		-
		Total Construction				**428,371,927**		**542,936,088**		**578,095,347**
	Professional Services		%							
	80.01	Preliminary Engineering	%	Items 10-50	3%	12,528,913	3%	15,965,838	3%	17,020,615
	80.02	Final Design	%	Items 10-50	7%	29,234,130	7%	37,253,621	7%	39,714,769
80	80.03	Project Management for Design/Construction	%	Items 10-50	10%	41,763,043	10%	53,219,459	10%	56,735,385
	80.04	Construction Administration and Management	%	Items 10-50	5%	20,881,521	5%	26,609,729	5%	28,367,692
	80.06	Legal, Permits, Fees etc	%	Items 10-50	1%	4,176,304	1%	5,321,946	1%	5,673,538
	80.07	Surveys, Testing, Investigation & Inspection	%	Items 10-50	2%	8,352,609	2%	10,643,892	2%	11,347,077
	80.08	Start-Up and Agency Force Account Work	%	Items 10-50	5%	20,881,521	5%	26,609,729	5%	28,367,692
90	**Unallocated Contingency**		%	Items 10-80	10%	56,618,997	10%	71,856,030	10%	76,532,212
		Total Segment Cost				**622,808,965**		**790,416,332**		**841,854,328**

Appendix C
Regional Geology and PMHGS Soil Profile

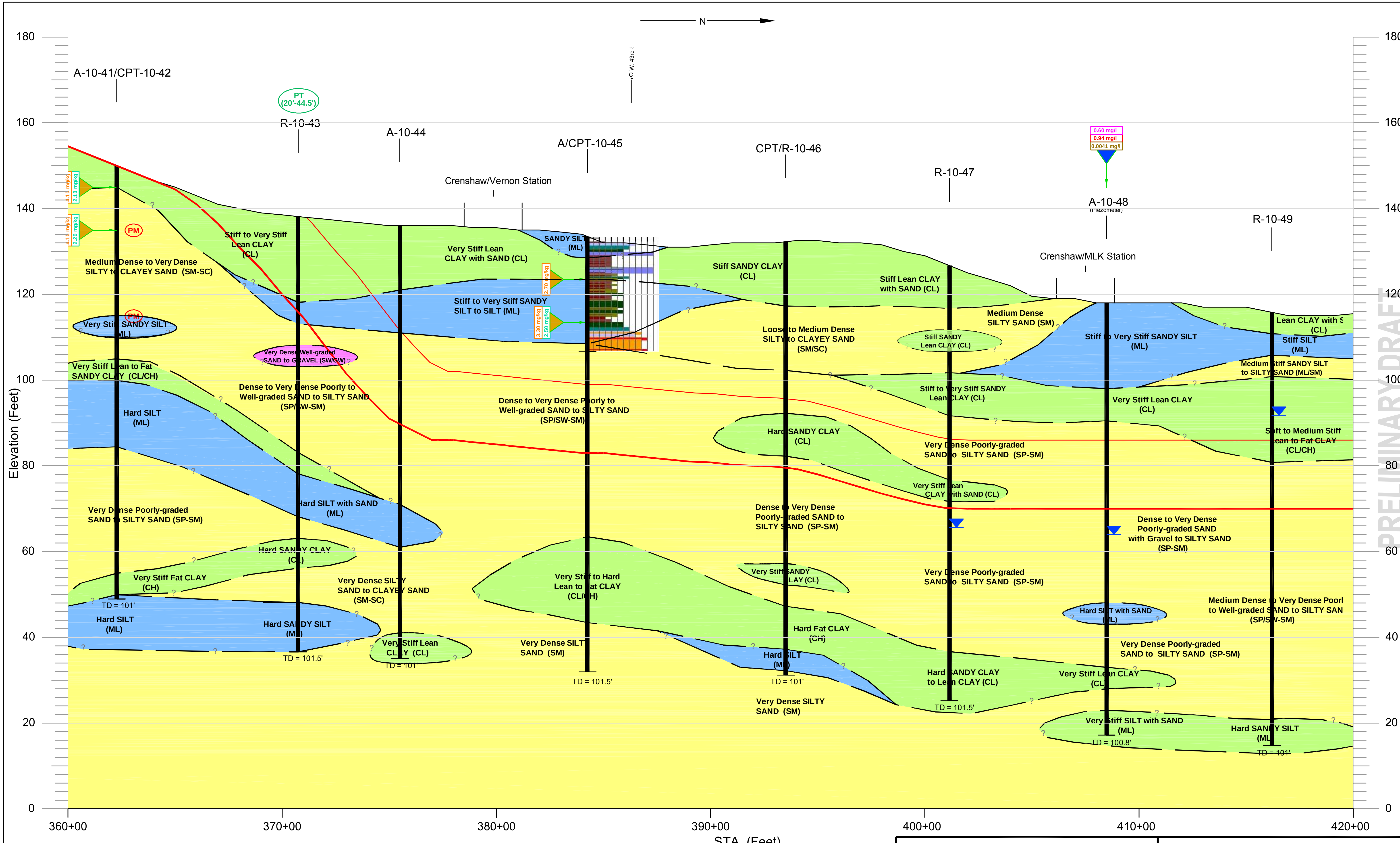


Scales:
Hor. 1"=400'
Ver. 1"=20'

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Crenshaw-Prairie Transit Corridor Project
Subsurface Cross Sections

SHEET 6 OF 8



Scales:
Hor. 1"=400'
Ver. 1"=20'

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Crenshaw-Prairie Transit Corridor Project
Subsurface Cross Sections

Clay (consistency)

Silt (consistency)

Sand (consistency)

Gravel (consistency)

Top of Rail

Top of Tunnel

Soil Contact, queried where uncertain

Observed Groundwater Depth

PT (20'-55') Packet Test (Depth Interval)

Environmental Soil Tests

12.0 mg/kg DRO C13-C-23 (Reporting Limit = 5mg/kg)

11.0 mg/kg ORO C24-C-44 (Reporting Limit = 5mg/kg)

7.00 mg/kg EFH C13-C44 (Reporting Limit = 5mg/kg)

6.10 mg/kg EFH C10-C28 (Reporting Limit = 5mg/kg)

4.10 mg/kg Arsenic (Reporting Limit = 5mg/kg)

3.20 mg/kg Lead (Reporting Limit = 5mg/kg)

Environmental Water Tests

1.20 mg/l DRO C13-C-23 (Reporting Limit = 0.5mg/l)

0.65 mg/l ORO C24-C-44 (Reporting Limit = 0.6mg/l)

0.94 mg/l EFH C13-C44 (Reporting Limit = 0.5mg/l)

50.0 mg/l EFH C10-C28 (Reporting Limit = 50mg/l)

0.0041 mg/l Methane (Reporting Limit = 0.001mg/l)

P.I.D. (ppm)

PM Pressure Meter Test Location

CONE PENETROMETER TESTING LEGEND

1 - sensitive fine grained	4 - silty clay to clay	7 - silty sand to sandy silt	10 - gravelly sand to sand
2 - organic material	5 - clayey silt to silty clay	8 - sand to silty sand	11 - very stiff fine grained (*)
3 - clay	6 - sandy silt to clayey silt	9 - sand	12 - sand to clayey sand (*)

*L&C = Law and Crandall
*TBD = To Be Drilled

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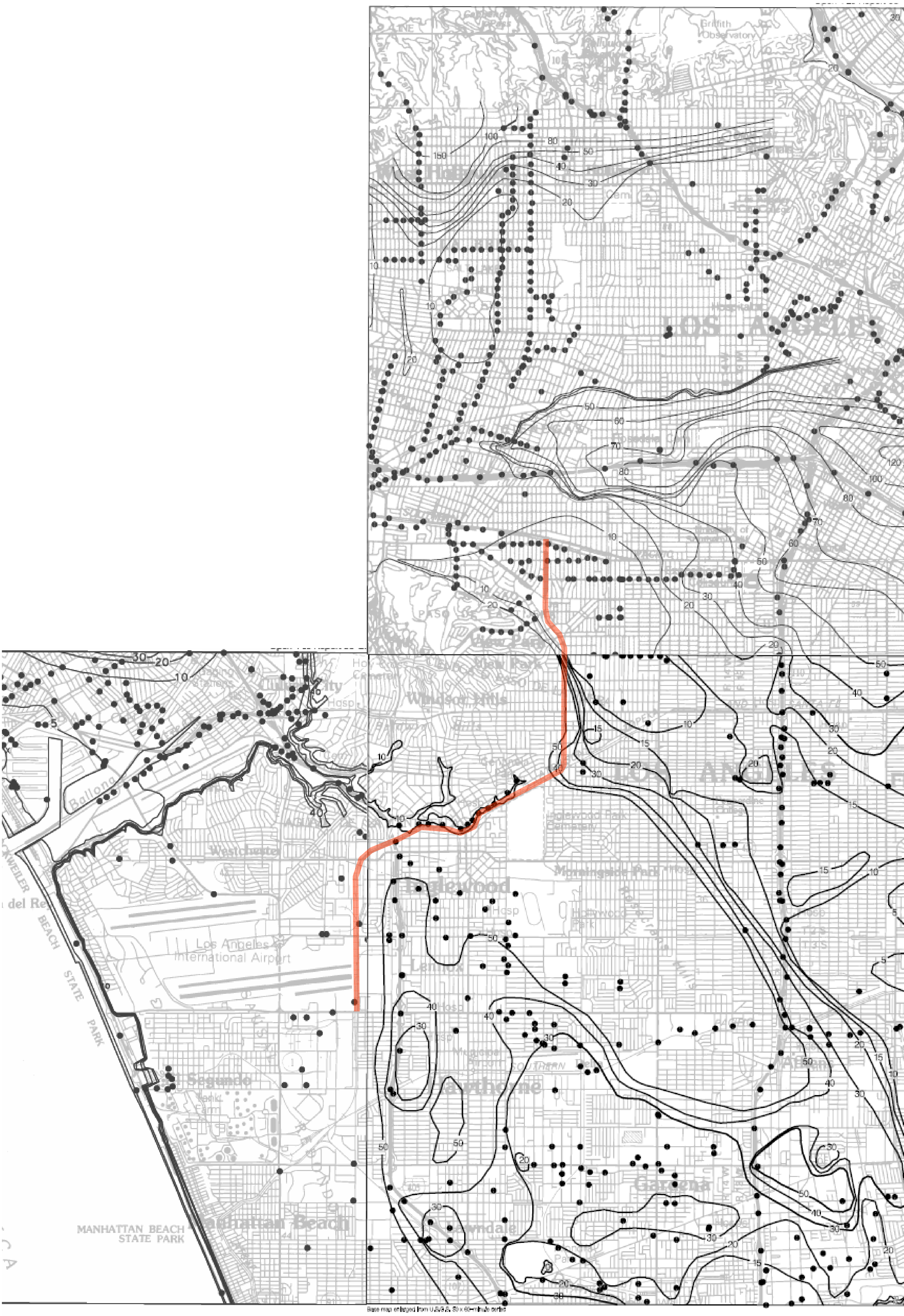
Subsurface Cross Section Legend

CRENSHAW/LAX TRANSIT CORRIDOR PROJECT

Project No. 10-101 | Date: April, 2010



und Water Contours and Borehole Log Data Locations, Venice Quadrangle.

e — 30 — Depth to ground water in feet

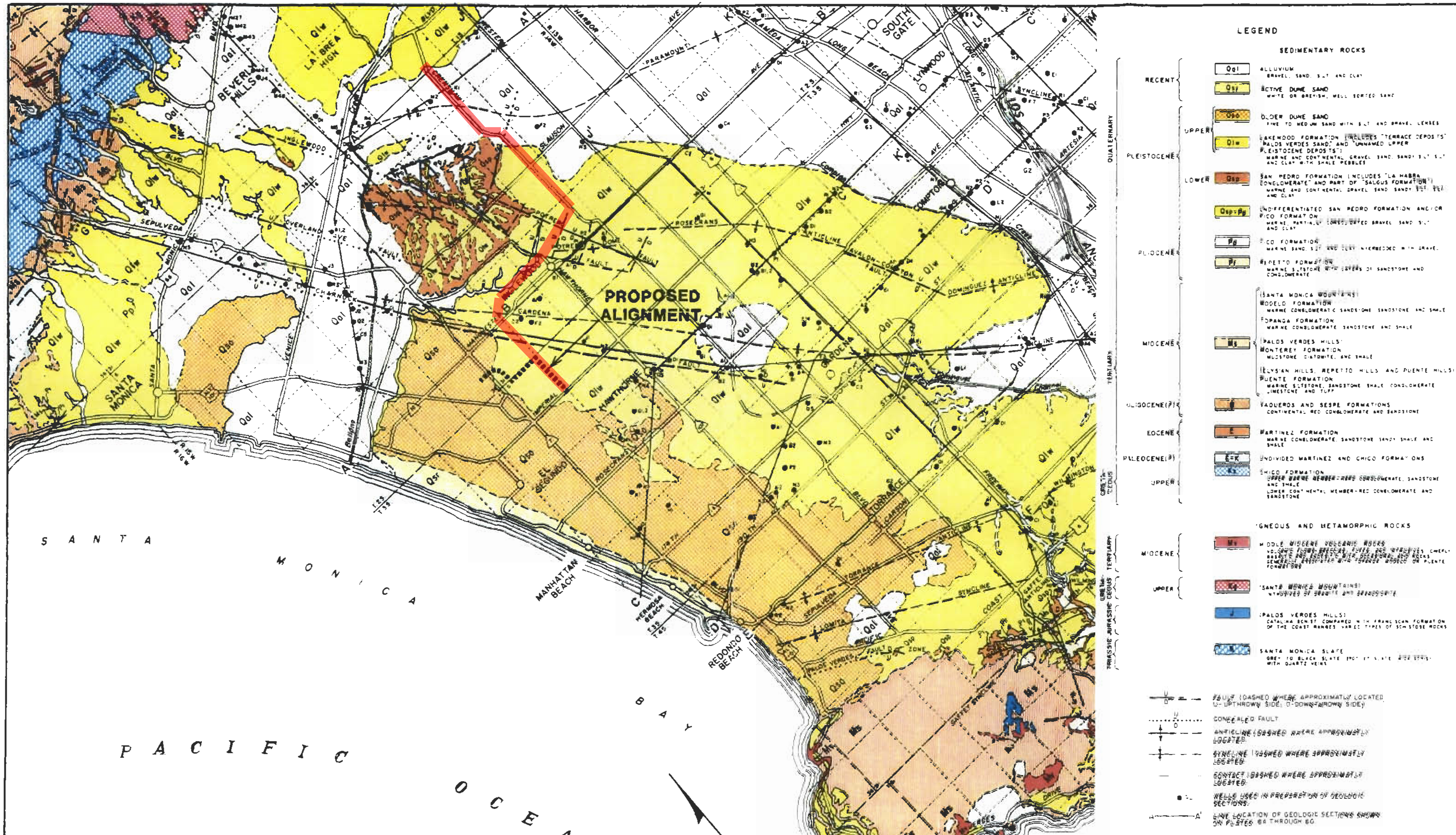
e-generated liquefaction. See "Areas of Past Liquefaction" discussion in text.

ONE MILE
SCALE

Plate 1.2 Historically Highest Ground Water Contours and Borehole Log Data Locations, Inglewood Quadrangle.

● Borehole Site — 30 — Depth to ground water in feet

ONE MILE
SCALE



REGIONAL GEOLOGY

LAW/CRANDALL, INC.

PLATE 4.1

JOB 1-9046?.AE0 DATE 6-12-91 DR. JULIANA O.E. CHKD.