METROLINK

SCRRA DESIGN CRITERIA MANUAL

FINAL

March 2024

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1.0 FOREWORD

1.1 PURPOSE

This Southern California Regional Rail Authority (SCRRA) Design Criteria Manual (DCM) serves to define the criteria that govern the design of projects for SCRRA. The Design Consultant shall use this DCM together with SCRRA's referenced standards, codes, specifications, guidelines, and manuals. Strict compliance with this DCM is required to facilitate completion of design work in a timely manner.

This is a controlled manual and as such will be updated on a periodic and as-needed basis. Any deviation from the minimum standards presented herein must be approved in advance by SCRRA (see Section 3.2.2).

Review and acceptance of submittals by SCRRA shall not relieve the Design Consultant of responsibility to provide a design that meets the professional standard of care.

The design criteria contained in this DCM are the property of SCRRA and intended for SCRRA approved uses only. SCRRA shall not be responsible for any use of these criteria for non-SCRRA work. The selection and use of this design criteria is the sole responsibility of the user and should not be used without consulting a registered professional engineer. Anyone making use of the information in this DCM for non-SCRRA work shall assume all liability arising from such use.

1.2 CHANGES/UPDATES

The date shown in the lower right-hand corner of each page is the effective date of this DCM. The DCM with the most recent effective date shall supersede all previous versions. Users of the DCM shall be solely responsible for checking the web site www.metrolinktrains.com and using the latest version. Any suggested changes or updates to this DCM should be forwarded to the SCRRA Engineering and Construction Department for consideration.

Those individuals who regularly use this DCM can provide valuable assistance in identifying needed updates and improvements. Forward any suggested changes or suggestions to this DCM to the SCRRA Engineering and Construction Department for consideration. Suggested changes or suggestions should be submitted in writing. Each suggested change will be reviewed and responded to by a committee of SCRRA managers. If SCRRA agrees with the suggested change, the DCM will be updated to reflect the change in the next revision.

The current effective date of this DCM shall be June 2022.

1.3 TERMS AND DEFINITIONS

Technical terms used in this DCM are defined in Appendix A.

1.4 ABBREVIATIONS AND ACRONYMS

Abbreviations and acronyms used in this DCM are defined in Appendix B.

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2.0 SOUTHERN CALIFORNIA REGIONAL RAIL AUTHORITY

2.1 INTRODUCTION

In August 1991, SCRRA was formed as a regional Joint Powers Authority (JPA). Its purpose is to plan, design, construct, operate, and maintain regional commuter rail lines serving the counties of Los Angeles, Orange, Riverside, San Bernardino, and Ventura. Today, SCRRA operates one of the fastest growing commuter rail systems in the country. SCRRA's rail system operates in what can be typically categorized as an urban and suburban environment. SCRRA is one of the nation's largest commuter rail systems based on route miles and annual ridership.

SCRRA's mission statement declares that SCRRA will provide a safe, efficient, dependable and on-time transportation service that offers outstanding customer experience and enhances quality of life. SCRRA provides reliable transportation and mobility for the region, leading toward more livable communities.

SCRRA is committed to and characterized by the following values:

- Safety: Safety is foundational.
- People: Everything we do demonstrates an appreciation for quality of life, and every act values the lives of our employees, contractor co-workers, customers, and communities.
- Quality: We operate on best practices and principles with a continued focus on providing high-quality service to our customers every day on every ride.
- Efficiency: As responsible stewards of public funds, we embrace innovative solutions and continuous improvement for the lowest cost and most efficient operations.
- Growth: We continuously seek creative, progressive, and collaborative solutions to promote investment, develop partnerships, and increase capacity to improve the mobility of Southern Californians.

2.1.1 The SCRRA System

The SCRRA system began operation in October 1992 with three lines: San Bernardino, Antelope Valley, and Ventura. The Riverside Line started in June 1993, and the Orange County Line, which extends 19 miles into northern San Diego County, started in March 1994. The sixth line, Inland Empire-Orange County, started in October 1995. SCRRA initiated service on the 91 Line (Riverside-Fullerton-Downtown Los Angeles) in May 2002. This line was extended by 24 miles to the City of Perris in 2016, becoming the 91/Perris Valley Line. Most recently, the San Bernardino Line was extended from San Bernardino Depot Station to San Bernardino-Downtown Station in 2018.

Today, SCRRA operates service on the following seven lines:

- Ventura County Line
- Antelope Valley Line
- San Bernardino Line
- Riverside Line
- Orange County Line
- Inland Empire-Orange County Line
- 91/Perris Valley Line

With the exception of the Inland Empire-Orange County Line, all services extend from the terminal station to Los Angeles Union Station. Figure 2-1 shows the SCRRA system, including stations and connecting rail transit lines.

FIGURE 2-1. METROLINK SYSTEM MAP

2.1.2 Services

As of the issue date of this DCM, trains run Monday through Friday, with Saturday and Sunday service on the San Bernardino, Antelope Valley, Orange County, 91/Perris Valley, and Inland Empire-Orange County lines. The Ventura County and the Riverside Line trains run Monday through Friday. Additional special event trains may be operated on some weekends. SCRRA may run Sunday services on some holidays.

Hours of operation vary by line. Scheduled passenger services are shown on the most recently issued passenger schedule, which may be obtained from SCRRA's website at www.metrolinktrains.com.

2.1.3 SCRRA Facilities and Infrastructure

SCRRA operates on conventional railroad track and right-of-way (ROW), which are owned either by one of the county transportation agencies or by a private freight railroad company that has conveyed operating rights to SCRRA.

The design, and maintenance of the SCRRA system are governed by Federal Railroad Administration (FRA) regulations and California Public Utilities Commission (CPUC) General Orders (GOs).

SCRRA owns a fleet of locomotives and coaches that are maintained at the maintenance facilities listed below. Vehicle inspection and light repair are also performed at various layover sites throughout the system.

Maintenance Facilities:

Central Maintenance Facility (CMF)
1555 N San Fernando Road
Los Angeles, CA 90065

Eastern Maintenance Facility (EMF)
1945 Bordwell Street
Colton, CA 92324

Keller Yard
720 Keller Street
Los Angeles, CA 90012

Additional Layover locations:

- Lancaster Layover
- Moorpark Layover
- Ventura-East Layover
- Riverside Layover
- South Perris Layover
- Stuart Mesa Yard (NCTD)

Train operations are dispatched from the Dispatch and Operations Center (DOC) located at 2704 North Garey Avenue, Pomona, CA 91767. The DOC is manned 24 hours per day, 365 days per year. Secondary dispatch center is the Metrolink Operations Center (MOC) located at 2558 Supply Street, Building A, Pomona, CA 91767.

2.1.4 Operations

In addition to supporting SCRRA's commuter rail service, SCRRA tracks are shared by two major freight rail carriers, BNSF and UP, as well as the intercity passenger carrier Amtrak. In turn, SCRRA operates on tracks owned by its member agencies, BNSF, UP, and North County Transit District (NCTD).

2.2 ORGANIZATION

SCRRA consists of five county transportation agencies:

- Los Angeles County Metropolitan Transportation Authority (METRO)
- Orange County Transportation Authority (OCTA)
- Riverside County Transportation Commission (RCTC)
- San Bernardino County Transportation Authority (SBCTA)
- Ventura County Transportation Commission (VCTC)

SCRRA is governed by a board of directors, consisting of eleven members representing the five counties that comprise the agency. An executive staff manages the operation of the SCRRA system. Refer to www.metrolinktrains.com for more detail about the organization.

2.3 FUNDING

SCRRA receives operating and capital funding from many sources. SCRRA fare box returns fund the largest portion of the system's operating revenue. Constituent counties provide additional funds through operating subsidies, which are calculated relative to the service miles in each county. Other sources of operating funds include utility easement fees, advertising revenue, and railroad user charges.

Capital funding is received from several sources and can vary from year to year, and from project to project. The primary source of capital funds is SCRRA's constituent counties. Other capital funding comes from federal sources and the State of California. SCRRA also obtains funds from third parties whose contracts require certain work to be performed by SCRRA forces. This is referred to as recollectable work.

2.4 ASSETS

The real estate holdings maintained and operated by SCRRA are owned by the individual counties that comprise the SCRRA JPA. The fixed improvements and equipment are owned collectively by the counties that are partners in the SCRRA JPA. Asset ownership is presented in Table 2-1.

TABLE 2-1. REAL PROPERTY OWNERSHIP

Real Property	Owner	
Ventura County Line	In Los Angeles County: In Ventura County:	METRO and UP VCTC and UP
Antelope Valley Line		METRO
River Corridor (Taylor to Soto)		METRO
San Bernardino Line	In Los Angeles County: In San Bernardino County:	METRO SBCTA
Riverside Line	Riverside Terminal: Remainder of Riverside Line:	RCTC UP
Orange County Line	Los Angeles to Fullerton: Fullerton to San Clemente: In San Diego County:	BNSF OCTA METRO NCTD
IEOC Line	Riverside to Atwood: Atwood to Orange:	BNSF OCTA RCTC SBCTA
91/Perris Valley Line	Perris to Riverside Riverside to Los Angeles	RCTC BNSF
Central Maintenance Facility		SCRRA
Eastern Maintenance Facility		SCRRA
Pomona Campus		SCRRA
Passenger Stations	Varies; however, station sites are typically owned by the local municipality.	
Keller Yard		SCRRA
Layover Yards		
Lancaster		METRO
Riverside		RCTC
Perris Valley		RCTC
Moorpark		VCTC
Ventura		VCTC
Marine Way Maintenance Yard		OCTA

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3.0 DESIGN STANDARDS

3.1 SCOPE

The basic requirement for railroad design is to provide a track structure that is consistent with safe, regulatory-compliant, economical, and efficient train operation. SCRRA, as a commuter operation, places a high priority on passenger safety and on minimum travel times.

The criteria presented herein follow accepted engineering practices used on operating Class 1 railroads, including Amtrak, BNSF, and UP.

Project scope shall always allow for a review of the SCRRA system needs for rehabilitation. The vicinity of projects shall be checked to determine if there are upcoming or concurrent rehabilitation projects. This check shall be noted in the project's design submittal report.

3.2 STANDARDS AND CODES

The Design Consultant shall adhere to the standards and codes listed in Appendix A. This list is by no means comprehensive and other standards may apply.

The design shall meet all applicable parts of the State of California general laws, California Public Utilities Commission (CPUC) requirements, Federal Railroad Administration (FRA) safety requirements, Federal Transportation Administration (FTA) requirements, American with Disabilities Act (ADA) requirements, and any specific project requirements. Where any conflict in criteria exists, the stricter criteria shall govern.

Unless specifically noted otherwise in these criteria, the latest edition of the standard, code, or guideline that is applicable at the time the design is initiated shall be used. If a new edition of or amendment to a standard, code, or guideline is issued before the design is issued for bid, the design shall conform to the new requirements to the extent approved or required by the agency enforcing the standard, code, or guideline changed.

3.2.1 SCRRA Standards

SCRRA has developed standard plans, specifications, and manuals all of which shall be applied to projects on SCRRA's system. Standard plans and specifications shall be used wherever possible to reduce engineering and construction costs and to maintain uniformity and consistency throughout the SCRRA system. What follows is a partial list:

- SCRRA Bridge, Culvert, and Tunnel Safety Management Program
- SCRRA CADD Manual
- SCRRA Configuration Change Control Procedure
- SCRRA Configuration Identification Plan
- SCRRA Configuration Management Plan (CMP)
- SCRRA Database Configuration Management Plan
- SCRRA Hardware Configuration Management Plan (HCMP)

- SCRRA Composite Maps
- SCRRA Design Criteria Manual
- SCRRA Design Procedures Manual
- SCRRA Design Quality Assurance Plan
- SCRRA Document Control Plan
- SCRRA Engineering Standards
- SCRRA Facilities Management Plan
- SCRRA Highway-Rail Grade Crossing Design Standards and Criteria Manual
- SCRRA Instructions Governing Installation, Maintenance, Inspection, and Testing of Signal Apparatus and Signal Systems
- SCRRA Rolling Stock (Locomotive and Passenger Car) Management & Maintenance Plan
- SCRRA Signal Maintenance Manual
- SCRRA Standard Operating Procedures (SOPs)
- SCRRA Standard Specifications
- SCRRA Timetable
- SCRRA Track Charts
- SCRRA Track Maintenance Manual

3.2.2 Deviations from SCRRA Preferred Criteria

All standards, manuals, and guidelines shall be adhered to throughout the project. Some criteria are noted as either preferred or minimum criteria. Whenever practical, preferred criteria shall be used. Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration per the SCRRA Design Procedures Manual (DPM), Section 5.2.4.

3.2.3 Limitations and Disclaimers

These Criteria are not intended for use as a textbook and shall not be used as a substitute for engineering knowledge, experience, or judgment. The criteria, information, and analysis methodologies presented in these Criteria have been developed in accordance with recognized engineering principles and in accordance with railroad industry practice. SCRRA does not warrant the accuracy or completeness of these Criteria or that the Criteria are free from errors and omissions. Users of these Criteria shall promptly notify SCRRA of any discrepancies or inconsistencies discovered in the course of utilizing these Criteria.

3.3 CLIMATE CHANGE VULNERABILITY AND ADAPTATION

Consideration of future climate conditions is essential for project planning, design, and delivery to safeguard future investments in SCRRA assets over their useful life, which ranges from 20 to 100+ years. As part of the design process, the designer must utilize SCRRA's Climate Vulnerability Assessment and Adaptation Plan or Climate Vulnerability Dashboard to assess the vulnerability of the project site and its assets to current and future changes in the climate. If the assets to be installed at that location are found to be vulnerable to climate hazards, adaptation strategies must be incorporated to address the vulnerabilities. It is required as part of the Design Compliance process (Appendix E of the DCM) to produce:

(a) a summary of the project's climate vulnerabilities, and if vulnerable,

(b) a summary of the adaptation strategies to be incorporated

The process for performing these steps is provided below.

3.3.1 Project Vulnerability Assessment

Step 1: Review project scope to determine the asset type: Identify key project elements/assets such track, station/facilities, bridges, tunnels, culverts, communication, or signals.

Step 2: Determine Planning Horizon / Climate Projection to Use: Climate vulnerabilities were assessed for mid-century (2040–2069) and late-century (2070–2099) timeframes as part of the CVA. Use the Table 1 below to identify which timeframe is appropriate, based on the project/asset anticipated lifespan. For example, a bridge project expected to last more than 50 years should review expected vulnerability for the late-century planning horizon.

TABLE 3-1 Planning Horizon and Example Asset Types

Planning Horizon (time frame)	**Example Asset Types** (grouped by anticipated lifespan of project)
Mid-century (2040–2069)	▪ Electrical, HVAC, and mechanical components ▪ Most building retrofits (substantial improvements) ▪ On-site energy equipment (e.g., fuel tanks, emergency generators) ▪ Stormwater detention systems ▪ Concrete paving ▪ Infrastructural mechanical components ▪ Track ▪ Signals ▪ Communications ▪ Culverts
Late-century (2070–2099)	▪ Bridges ▪ Tunnels ▪ Stations ▪ Structures ▪ Facilities (EMF, DOC, etc.) ▪ Retaining walls

Note: Areas with historical record of impacts (sun kinking, 100-year floodplain) should implement recommended strategies regardless of timing of vulnerability.

Step 3: Review climate hazards

Review Table 2 to identify hazards that are likely to affect project type and understand future trends and impacts.

TABLE 3-2. Summary of Hazard Projections and Potential Impacts

Hazard	Future Trends	Example Impacts
Sea level rise	Hazard increasing though late-century, coastal areas only.	Erosion, corrosion, temporary flooding, and potential damage to track structure and stations from wave runup
Flooding	Precipitation depth during major storms projected to increase system-wide, especially for watersheds on San Gabriel, Valley, and Ventura subdivisions. More extreme swings between wet and dry years, but no substantial change in annual averages.	Damage or service delays because of the exposure of bridges, rail lines, stations, or other facilities to temporary inundation and/or high velocity flows. Erosion and scour of foundations, pilings, footings from overland flow. Additional stress on drainage and pumping systems.
Extreme Heat	Substantial increase in annual maximum temperatures through late-century. Highest temperatures (exceeding 115°F) will be inland (Riverside and San Bernardino counties, Palmdale/Lancaster).	Rail buckling, mandatory slowdown orders, unhealthy platform temperatures for riders, stress on air conditioning systems, electrical equipment failure or reduced efficiency and power outages, material degradation, pavement softening.
Wildfire	Substantial increase of wildfire hazards in mountainous wildland areas across the region, especially around Simi Valley and between Santa Clarita and Palmdale.	Damage or destruction of rail line, communications infrastructure or other facilities, and power outages. Wildfire smoke may cause degraded air quality, which may affect passenger safety and comfort at outdoor stations and crews working in outdoor locations.
Drought	Increase in frequency and severity system-wide through late-century.	Damage to track and/or facility foundations, or on natural systems that prevent flooding/heat. Drought may indirectly increase exposure to other hazards. For example,

Hazard	Future Trends	Example Impacts
		prolonged drought can increase wildfire hazards, and areas cleared of vegetation by wildfire are more prone to landslides.
Landslides	Increased wildfire frequency and changing precipitation patterns could exacerbate landslide hazards where they already exist.	Washed out rail lines, destruction of track and other facilities, and derailment. Landslide and mudslide hazards are local and can affect only Metrolink assets where they are near steep, unstable slopes.
Earthquakes	Hazard currently is high across Southern California. Climate change is not anticipated to have a substantial influence on seismic impacts.	Damage or destruction of track, bridges, tunnels, stations, and other facilities and assets.
Electrical outages	Short-term peak in frequency of both intended and unintended outages followed potentially by reduction as service providers upgrade utility infrastructure.	Unintended interruptions caused by direct climate impacts (i.e., a spike in power consumption causing a brown out during an extreme heat day) or PSPS that are planned outages (usually to avoid starting wildfires during dry/windy weather conditions).

Step 4: Determine if the assets are vulnerable to climate hazards at that project site: This can be performed utilizing either (A) the CVA document or (B) the CVA Dashboard. Direction for each approach is provided below:

Step 4.A) Use CVA document: The results of the CVA were summarized in vulnerability maps for mid-century (CVA pages 29-43) and vulnerability profiles for each asset type developed which include a chart showing the vulnerability rating by hazard, a table to identify assets vulnerable to multiple hazards, and a list of all assets considered to have high vulnerability (CVA pages 44-66). Review the vulnerability profile(s) of the asset type(s) included in the project (CVA pages 44-66) to see if project asset(s) are specifically identified as vulnerable to each of the hazards assessed. Further study or cost benefit analysis may be carried out to confirm the vulnerability and benefit. For example, Figure 1 (CVA, p49, Bridge Vulnerability Profile) identifies bridges that are highly vulnerable to flooding by mid-century and Figure 2 (CVA, p46, Track Vulnerability Profile) identifies track segments with high vulnerability to multiple hazards by mid-century.

FIGURE 3-1: Bridges identified as having High Vulnerability to flooding by mid-century.

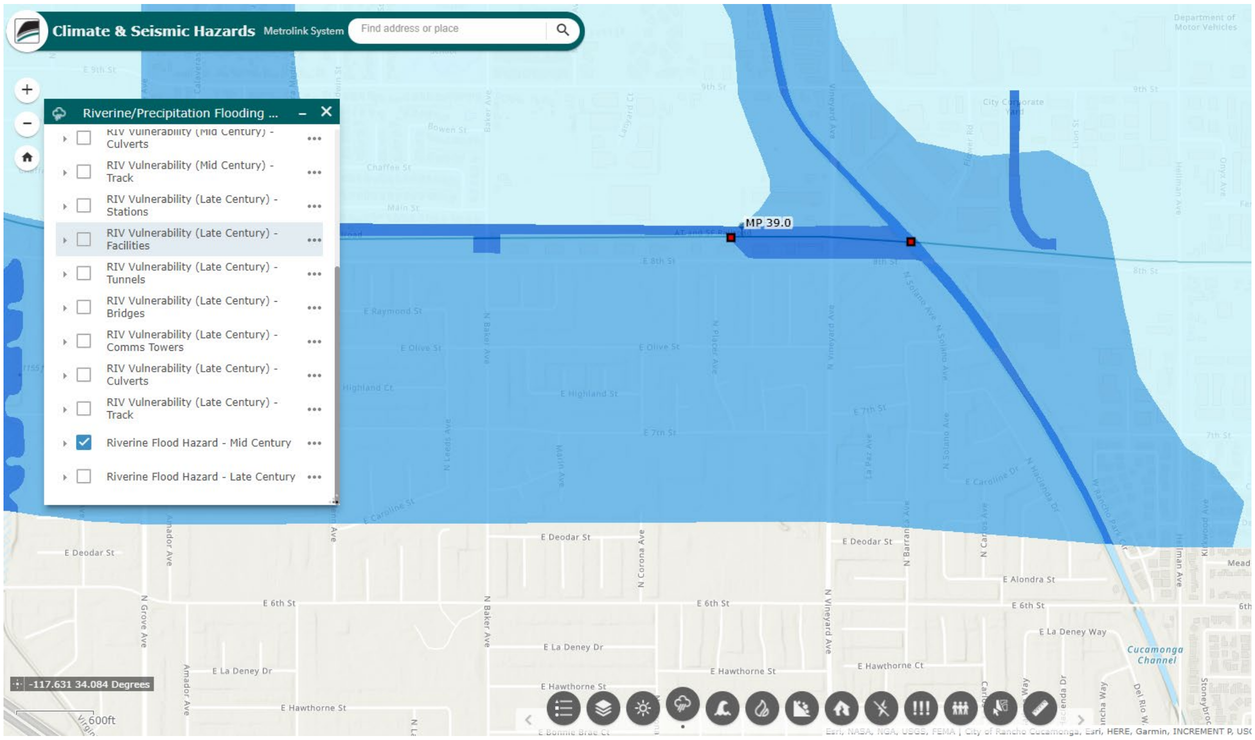
Bridge	Subdivision	County	Score
Sea Level Rise (Mid-Century)			
No bridges have high vulnerability to sea level rise			
Flooding (Mid-Century)			
30.940-MT	Valley	Los Angeles	15
436.960-MT	Ventura	Ventura	15
38.900-MT	San Gabriel	San Bernardino	15
39.200-MT	San Gabriel	San Bernardino	15
428.630-MT	Ventura	Ventura	12
41.260-MT	Valley	Los Angeles	12
0.800-LT2, ST	River	Los Angeles	12
192.800-ST	Orange	Orange	12
858-MT	Perris Valley	Riverside	12
84.980-MT	Perris Valley	Riverside	12
173.600-MT2	Orange	Orange	12
188.500-MT2	Orange	Orange	12
446.400-MT	Ventura	Los Angeles	10

FIGURE 3-2 Track segments identified as having High Vulnerability to multiple hazards by mid-century.

MP Beg	MP End	Sub	County	SLR	Flooding	Heat	Wildfire	Landslides	Seismic
25	26	Valley	Los Angeles	Low	Low	Medium	Low	High	High
33	34	Valley	Los Angeles	Low	Low	Medium	Low	High	High
34	35	Valley	Los Angeles	Low	Low	Medium	Low	High	High
32	33	Valley	Los Angeles	Low	High	Medium	Low	Medium	High
31	32	Valley	Los Angeles	Low	High	Medium	Low	High	Medium
438	439	Ventura	Ventura	Low	High	Medium	Low	High	Medium
437	438	Ventura	Ventura	Low	High	Medium	Low	High	Medium
29	30	Valley	Los Angeles	Low	High	Medium	Low	High	Medium
202	203	Orange	Orange	High	Medium	Low	Low	High	Medium
203	204	Orange	Orange	High	Medium	Low	Low	High	Medium
204	205	Orange	Orange	High	Medium	Low	Low	High	Medium
207	Sub end	Orange	Orange	High	Medium	Low	Low	High	Low

Step 4.B) Use the CVA Dashboard: The CVA Dashboard is an interactive interface that can be used to identify if the project site is located in a climate hazard area in (high, medium, or low) and to identify the related vulnerability of project assets (e.g., track, stations, signals, communications, bridges) to climate hazards (sea level rise, riverine flooding, extreme heat, wildfires, drought, landslides/mudslides, earthquakes, and electrical outages). Mid- and Late-Century timeframes can be selected with the dashboard see Figure 3-3.

FIGURE 3-3 Screenshot from CVA Dashboard tool showing two bridges with high vulnerability to flooding by mid-century.



Step 5: Summarize vulnerability: Produce a short summary identifying the vulnerability by hazard for each asset type that will be part of the project as required in the Design Compliance Checklist in Appendix E.

3.3.2 Adaptation Strategies

If the assets to be installed at that location are found to be vulnerable to climate hazards, adaptation strategies must be incorporated to address the vulnerabilities. Within the CVA document strategies are organized as a toolkit by hazard type, with applicability of the strategy for each asset type highlighted (CVA pages 110-131). Potential locations where the strategy may be suitable to reduce vulnerability to a specific hazard are included (based on the vulnerability assessment).

These strategies have been added into the relevant sections of this DCM. If the asset / new project is in an area of vulnerability, the adaptation strategies must be integrated into project design or a reason given why they are not needed. Additional studies may be required to inform a particular project (such as detailed flood modelling or a drainage study to inform flood barrier extent and height or stormwater conveyance sizing).

A summary and discussion of strategies to be included in the project design must be provided as listed in the Design Compliance Checklist in Appendix E.

Example strategy types

Sea level rise strategies protect assets through barriers (such as sea walls) or the elevation and/or enclosing of assets.

Extreme heat strategies aim to reduce the heat island effect, likelihood of outages and improve passenger comfort through use of shading (trees or canopies), cooling devices or light-colored materials. Passive solar cooling and ventilation design can maintain lower internal facility temperatures with less air conditioning. Providing additional or redundant ventilation systems can cool electrical equipment. Providing a range of electricity back up options depending on criticality of a facility load to ensure continuity of supply.

Flooding strategies improve drainage potential through material choice, nature-based solutions or conveyance improvements to reduce flood likelihood; or through raising or enclosing of assets in flood prone areas.

Wildfire strategies reduce the likelihood of flames reaching assets through vegetation clearance or providing fireproof casing; or through provision of improved filtration to reduce impacts from wildfire smoke within facilities.

4.0 CLEARANCES

4.1 SCOPE

The design criteria for critical horizontal and vertical clearance dimensions between SCRRA rolling stock and fixed facilities adjacent to and over the tracks are discussed below. The goal is to provide safe and adequate running clearances between moving trains and fixed facilities for the protection of passengers, maintenance personnel, operating personnel, and equipment.

4.2 STANDARDS AND CODES

CPUC Minimum legal clearance standards are described in CPUC GO No. 26. Design variances shall not be granted that do not meet these legal minimum clearances.

Required clearances on mainline tracks, secondary tracks, and yard tracks are described in SCRRA ES 2101 through ES 2104.

All standards and manuals shall be adhered to throughout the project. Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

4.3 TRACKS

4.3.1 General

The SCRRA standard clearance envelope is shown in ES 2101. All new permanent construction must comply with these clearance requirements. During construction, temporary clearances shown in ES 2101 can be used for formwork or other temporary construction, which will be removed prior to final completion.

The CPUC minimum legal clearances are shown in ES 2102. No special design considerations will be considered if they do not comply with the requirements of CPUC GO No. 26. For curved track, the CPUC minimum legal horizontal clearance shall be one foot greater than the minimum legal horizontal clearance listed in CPUC GO No. 26.

At all times, minimum approved clearances shall be maintained. If the facility is on another railroad’s property, the clearances specified by the specific railroad at that location shall be followed. At clearance locations where superelevation is present, horizontal clearance shall be measured perpendicular to the plane across the top of both rails and vertical clearance shall be measured from the high rail.

4.3.2 Structural Clearances

Piers, abutments, and columns also affect track spacing and must comply with the requirements in Chapter 12, Grade Separation Criteria of this DCM and the AREMA Manual for Railway Engineering, Chapter 8. New piers, abutments, and columns shall not be permitted on the ROW.

4.4 ROLLING STOCK

4.4.1 Cars

Various types of railroad cars operate over all SCRRA's lines. SCRRA operates coach cars, cab cars, locomotives and in the near future Multiple Units as either DMU's or ZMU's. Amtrak and privately-owned passenger cars also operate over all SCRRA lines and have varying dimensions.

Freight cars, weighing up to 286,000 pounds on four axles, including double-stack container well cars, are in general interchange service and will operate over all SCRRA lines except for clearance restrictions at Los Angeles Union Station and the tunnels on the Ventura County and Antelope Valley lines. Specific extra dimension and/or extra weight cars are moved on all lines except at Union Station with prior SCRRA approval.

4.4.2 Locomotives

SCRRA uses several different locomotives; manufacturer's drawings are included in Appendix C-4. The common lengths of the locomotives are shown in Table 4-1, but other relevant dimensions are as shown in the manufacturer's drawings:

TABLE 4-1. LOCOMOTIVE LENGTHS

Model	Length
F40PH-2	56 feet 2 inches over coupler faces
F59PH	58 feet 2 inches over coupler faces
F59PHI	58 feet 7 inches over coupler faces
F59PHR	58 feet 2 inches over coupler faces
MP36PH-3C	68 feet 0 inches over coupler faces
EMD F125, Tier 4	69 feet 0 inches over coupler faces
Multiple Units (DMU, ZMU)	163 feet 0.6 inches (min trainset)

Complete specifications of each model may be found in the respective owner's manual. These manuals should be consulted for locomotive data.

Amtrak, BNSF, and UP locomotives will operate over all mainline tracks and sidings of SCRRA tracks. Many of these locomotives operate in multiple unit consists in general freight operation.

5.0 TRACK GEOMETRY

5.1 SCOPE

The design criteria for the geometric alignment of the SCRRA system trackage are discussed below. The goals are optimum safety, minimum travel times, passenger comfort, and minimized long-term maintenance costs, based on accepted railroad industry engineering practice and the experience of conventional mixed traffic railroad systems.

5.2 STANDARDS AND CODES

Detailed alignment design information is available in SCRRA ES 2201 through ES 2209. The values and formulae for design parameters presented in this chapter are to be used throughout the SCRRA system. Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

5.3 DESIGN SPEED

The design speed for all primary tracks shall be 90 mph on all lines except the Orange County Line from Santa Ana to San Clemente, where the design speed shall be 110 mph. The maximum design speed for all freight tracks is 60 mph.

Shoofly tracks (temporary detour tracks) shall be designed to match the current maximum authorized operating speed. Where physical constraints make achievement of these design speeds difficult or costly, the designer may propose alternative design speeds for approval. Physical constraint elements should be defined with the proposed alternative and will be considered, typical constraints include ROW, topography, and existing adjacent structures.

The designer shall confirm the design and operating speeds for the subdivision on which the project resides. The designer shall note that design speeds may be higher than current train operating speeds.

Actual train operating speeds will be evaluated and approved by SCRRA, considering the alignment, grade, braking distance, station proximity, PTC overspeed limit, and other factors.

5.4 HORIZONTAL ALIGNMENT

SCRRA standards will govern track design. All track construction must comply with SCRRA Track Construction Standards which exceed the FRA Track Safety Standards, Part 213, Subpart C, and CPUC GO No. 26 minimum legal clearances.

For consistency of relating design plans to subdivision milepost (MP), stationing of track centerlines shall follow the milepost of the subdivision on which the project is located. For example, if the project begins at MP 2.0, the stationing at MP 2.0 shall start at Station 105+60.

MP 2.0 x 5280 ft/1 mile = 10,560 ft x 1 Station/100’ = 105+60

Stationing and geometrics shall be denoted along the centerline of the left track in the direction of increasing stationing. Independent stationing and geometries for each track are required when the tracks are not parallel or where parallel tracks have independent profiles.

5.4.1 Components

The preferred horizontal track alignment shall be defined as a continuous series of tangents and circular curves, connected with transition spirals as required. All circular curves shall be connected to tangents by transition spirals except in yards at speeds below 20 mph or if the spiral offset (p) is less than ¼ inch. Compound circular curves may be used; however, transition spirals between such curves shall be used and approval must be obtained from SCRRA.

Circular curves shall be connected by a minimum tangent length unless the designer is retrofitting an existing alignment with inadequate spirals and tangents where alternatives for correcting the condition do not exist and where SCRRA has approved the use of modified design tables ES 2204-03 and ES 2204-04.

5.4.2 Curves and Superelevation

Horizontal curvature shall be designed in accordance with ES 2202 through ES 2204. The designer shall choose a degree of curvature that will meet the subdivision speed criteria. If a curve must become the speed-limiting factor for the subdivision because of ROW or other concerns, the designer shall advise SCRRA so that appropriate guidance can be issued.

General guidance for design of curves and superelevation is that freight speed will be designed to accommodate 2-inch unbalanced superelevation and passenger speed will be designed to accommodate 3.5-inch unbalanced superelevation. Track curvature design alignment will be checked to verify that the underbalance for maximum freight speed using the actual superelevation selected for passenger operation will result in an underbalance of between 1 and 2 inches.

In ES 2204, tables with the suffix "M" specify track geometry criteria for the maintenance and rehabilitation of certain existing segments of SCRRA routes that have spiral lengths that are considered too short by current criteria. These tables shall not be used for new construction, unless approved by SCRRA.

Curves should be designed to maximize speeds. The minimum curve radius, for mainline tracks, is 573 feet (D=10 degrees), and the maximum actual elevation is 5 inches. The minimum curve radius for non-mainline track is 479 feet (D=12 degrees). Certain combinations of super-elevation and curvature are prohibited, as specified in ES 2204. The curve speed, unbalanced elevation, and actual elevation shall be designed based on criteria shown in SCRRA Engineering Standards ES 2203 and values shown in tables shown in ES 2204. Actual elevation greater than five inches is not permitted without prior approval of SCRRA.

A closely spaced group of curves should be considered as a unit, with a common design speed that optimizes train dynamics and minimizes running time.

Curved alignment through grade crossings should be avoided when possible. If tracks are superelevated through the crossing, both the track and road profiles may need to be modified to provide a smooth road profile over the crossing.

Turnouts and other special trackwork shall not be placed in horizontal curves unless approved by SCRRA.

Yard tracks shall be designed for 20 mph. Yard and secondary tracks and special trackwork shall not be superelevated.

5.4.3 Track Spacing

Preferred mainline track spacing is 25 feet with a minimum of 15 feet, see also ES 2207. Bridges, tunnels, and stations will also impact the allowable minimum track spacing. Shared corridors add complexity to design and operations for the different rail modes. Track spacing for shared corridors are discussed in further detail in Chapter 30 of this Manual.

Mainline/Siding Tracks

The minimum track spacing is 15 feet, measured from centerline of track to centerline of adjacent track (centerline to centerline). Centerlines of mainline and siding tracks shall be spaced as defined on ES 2207.

Preferred track spacing between mainline and other mainline/siding tracks is 25 feet, centerline to centerline, to allow unencumbered train operations on an adjacent track during maintenance operations.

Where possible, the designer should review the relevant strategic plans for the track segment such that the current design is consistent with future plans.

Yard/Industry Tracks

The SCRRA preferred spacing between a mainline track and an adjacent yard/industry track is 25 feet, centerline to centerline, the minimum is 15 feet. Other safety improvements to compensate for less than 25-foot track centers may be required, but in no case will less than 15-foot track centers be allowed.

Tracks within a Yard

If movement of servicing equipment is not required between or adjacent to two tracks, the minimum track spacing for newly constructed yard tracks is 15 feet. For existing yards, where interior tracks have been constructed at 14-foot track centers, a special design consideration may be granted if it is not possible for tracks to be reconstructed at 15-foot track centers. Alternatively, if movement of servicing equipment is required between or adjacent to two tracks, the minimum track spacing may be 25 to 35 feet, depending on the dimensions of the service equipment to be used. Verification of anticipated service equipment dimensions and turning radii is required to ensure that there is adequate clearance between and adjacent to yard tracks.

5.4.4 Spirals

Spiral length is defined in the following:

- ES 2203
- ES 2204-01
- ES 2204-02

Spiral length shall be selected to satisfy the degree of curve requirement for the maximum subdivision speed. Even if the proposed maintenance operating track speed and resulting required superelevation will be less, the designer shall select the longer spiral length so that in the future, the track speed can be more easily increased. In the interim, the lower superelevation can be constructed into the entire spiral at a lower rate of change. The designer should consider the maximum possible superelevation for degree of curve to help select the longest possible spiral curve length. Existing curvature and spiral length on the Ventura County and Antelope Valley lines may require application of shortened spiral lengths (M) depicted in ES 2204-03 and ES 2204-04 to accommodate the required track speeds on these converted former freight branch lines. Shortened design spirals may be used if approved by SCRRA.

The designer shall note that a track segment currently designed as a siding track may become a second mainline track in the future; therefore, design of siding spiral curves shall accommodate future speeds and resulting superelevation and spiral lengths for mainline operation.

Note that spirals long enough for future higher speeds per this section may be needed to allow future speed changes without curve realignment. Curves designed to these higher speeds will have superelevation constructed appropriate for the present operating speed.

5.4.5 Tangents

Tangents between curves shall be equal to 3 times the maximum design speed, in miles per hour, or 100 feet, whichever is greater.

Standards regarding tangent lengths between curves and between curves and other track components are shown in ES 2203. These required tangent lengths shall not be shortened unless the design is tying into an existing subdivision where tracks were originally designed with shorter requirements. In such a case, shortened tangent lengths may be necessary but will only be allowed after it can be demonstrated that a solution that meets current standards and design requirements is not practical or available and must be approved by SCRRA.

5.5 VERTICAL ALIGNMENT

5.5.1 General

The profile grade shall represent the elevation of the top of the low rail for the primary mainline track. Additional tracks, including additional mainline and siding tracks, shall be constructed roughly parallel to and slightly lower than the mainline track in accordance with the cross-slope and offsets (15- to 25-foot track centers), as illustrated on ES 2001 and ES 2002.

When the top of low rail profile is given for one track only, the top of low rail elevations of the other tracks are to be calculated based on ES 2001, ES 2002, or a job-specific template cross slope.

Gradients and lengths of vertical curves shall vary accordingly (slightly) to accommodate the differences in lengths through horizontal curves.

5.5.2 Grades

Maximum Gradient

Maximum gradient for mainline and siding tracks, with gradient compensation, shall not exceed the existing maximum ruling grade for that subdivision. Gradient compensation shall be calculated as 0.04 percent equivalent grade per degree of curve. Gradient compensation shall be satisfied by either extending the reduction in allowable grade through the entire gradient or through the entire circular curve, both spirals and for a length into the tangents on either end of the circular curve.

$$G_c = G - 0.04D$$

Where

G = gradient before compensation, expressed in percent
D = degree of curve, expressed in decimals of degrees
G_c = compensated gradient, expressed in percent

Minimum Length of Constant Profile Gradient

For mainline track, the desired length of constant profile grade between vertical curves shall be determined by the following formula, but shall not be less than 100 feet (minimum):

$$L = 3V$$

Where

L = minimum tangent length, feet
V = maximum design speed, mph (which may be a future, higher speed)

Short grades up to 3.0 percent may be designed with the approval of SCRRA. Grades shall be minimized in siding tracks where trains meet or pass and shall be uniform at station platforms unless approved by SCRRA. Gradients shall be designed to prevent roll-out in yard tracks, especially where cars are stored, and yard track bowl grade shall not exceed a maximum gradient of 0.2 percent.

Platform Maximum Gradient

The maximum allowable gradient along a station platform shall not exceed the existing maximum ruling grade for that subdivision or 1.5 percent, whichever is flatter.

5.5.3 Vertical Curves

Vertical curve design standards are shown in ES 2201.

Vertical curves shall be designed per the recommended practices in the AREMA Manual for Railway Engineering, as modified and shown in the following formula:

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

Where

A = vertical acceleration in feet/second²

D = absolute value of the difference in rates of grades expressed as a decimal

K = 2.15 conversion factor to give LVC in feet

LVC = length of vertical curve in feet

V = speed of train in miles per hour

The recommended value for vertical acceleration is 0.10 foot/second/second for freight traffic and is 0.60 foot/second/second (0.02 g) for passenger traffic for both sags and summits. The minimum length of a vertical curve is 100 feet.

Vertical curves are not permitted in the platform area and shall begin or end no less than 100 feet from the ends of the platform unless approved by SCRRA. Likewise, vertical curves are not permitted in turnouts and other special trackwork.

Complex profiles, such as more than three grade changes exceeding 1.0 percent, each within a distance of 3000 feet, should be avoided as this may cause excessive dynamic forces and handling problems on the train. SCRRA may require train performance simulations to verify that proposed vertical profiles will not produce unacceptable dynamic in-train forces.

5.6 TURNOUTS

5.6.1 Location of Turnouts

Turnouts and crossovers shall be located to allow suitable placement of switch machines or switch stands and associated CPUC walkways, and with consideration of the placement and visibility of control signals.

Turnouts shall be located:

- At least 60 feet from any curve
- At least 20 feet from curves without superelevation and within yard tracks
- At least 100 feet from the edge of the traveled roadway or back of sidewalk, if a sidewalk is present
- Facing point turnout spacing shall adhere to ES 2209

Crossovers shall be located:

- On tracks with 15-foot minimum spacing unless existing yard track centers have 14-foot spacing
- With no curves between opposing frogs

Switch machines for power-operated crossovers shall be located on the outside of the mainline track.

5.6.2 Speeds through Turnouts

Maximum speeds through turnouts are defined in ES 2208. The designer shall select turnouts based on operating speeds. The turnout shall be laid out to allow the higher speed and tonnage operation to traverse the normal switch position (straight side) of the turnout.

5.6.3 Turnout Size and Type Selection

There are various types of turnouts used on SCRRA's system and the type used is dependent on the usage of the track. Refer to Chapter 6, Section 6.2.3 for criteria for selection of turnout type.

5.7 YARDS

For the configuration of turnouts and reverse curves in yards, the designer shall consider the following:

- Reverse curves, including turnouts, should have at least 50 feet minimum of tangent, if possible.
- Upon approval tangents between reverse curves used in slow speed (10 mph or less) and low-use turnouts to be reduced to a minimum tangent of 20 feet. Additional protection measures may be required by SCRRA.
- Placement of switch-stands shall provide walkway clearance per CPUC GO No. 118 and shall be in compliance with ES 2105.
- Placement of access/fire road crossings shall not be within 100 feet of any turnouts.

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6.0 TRACKWORK

6.1 SCOPE

This chapter provides criteria for the selection of track components and materials necessary to construct, remove, repair, modify, and rehabilitate railroad tracks.

All standards and criteria shall be adhered to throughout the design of the project. Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

Detailed specifications for CWR, OTM, special track work, ballast, sub-ballast, concrete ties, wood ties, elastic fasteners, and precast concrete grade crossing are available in SCRRA's Standard Specifications, which should be reviewed for additional information.

The project site must be assessed for climate vulnerability (see Section 3.3) to ensure any work is designed to be resilient to future climate conditions.

6.1.1 Standards and Codes

Track construction shall at all times meet the SCRRA Standards and minimum FRA standards for Class 5 track or higher, as required in 49 CFR 213 - Track Safety Standards and CPUC GOs No. 26 and No. 118. At no time may track be designed or operation allowed on track that fails to meet FRA standards required for operation in that class.

See the standards and codes listed in Appendix A.

6.2 TRACKWORK

6.2.1 Track Classification

<u>Primary Track</u>

Primary Track is track constructed for vehicles in revenue service (carrying revenue passengers). This includes mainline, siding, and station tracks.

<u>Secondary Track</u>

Secondary Track includes all other track that is constructed for the purpose of switching, storing, or maintaining vehicles not in revenue service. Excluding track maintained by third parties.

<u>Freight and Other Track</u>

Freight and Other Track includes all tracks that are constructed and/or maintained by SCRRA for use by freight railroads to serve their industrial clients, not generally used by SCRRA passenger equipment.

6.2.2 Track Construction Types

Ballasted track is the standard for track construction. Ballasted track, except where allowed elsewhere in this section, shall be constructed with continuous welded rail (CWR).

Direct-fixation track shall not be designed for use except in special circumstances on Secondary Track where special inspection pits, wash racks, fueling facilities, or other environmental and or maintenance needs require consideration of this track construction type.

In areas where a short stretch of track is exposed or will be exposed in the future to flooding or overtopping, consider the use of berms, raising the channel walls, or widening flood channels. To protect sensitive components of track structure in flood zones where track is above grade and where high velocity flow occurs, the subgrade and sub-ballast will be protected by riprap or other materials. Design linear swales along flood-prone track to direct water away from the track bed. This strategy could be coupled with sub ballast armoring and elevation of sensitive mechanical/electrical equipment to create multiple lines of defense.

For stretches of track identified as vulnerable to sea level rise and storm surge, improved revetment (large rocks armor size, more gradual slope, high crest) will be constructed where rail is exposed to excessive runup and overtopping from waves during the 100-year storm or high tides. Refer to Chapter 9 Hydraulics regarding countermeasure design for coastal environment and SCRRA Engineering Standard ES 2003 for roadbed section with exposure to ocean surf.

A ditch or perforated high-density polyethylene underdrain shall be installed in areas where groundwater is anticipated to interfere with stability of the track, roadbed, and side slopes.

The proposed embankment will be designed with additional width to accommodate long term erosion but permitting increased width of ballast section.

Primary Track

Typical Primary Track construction is new 136-pound (RE), head-hardened CWR fixed with elastic fasteners on concrete ties situated on a roadbed of ballast and sub-ballast. Primary Track construction employs the use of fully welded insulated joint plugs, to the extent possible, to eliminate in-track joints. Track sections and fastener details are shown in the appropriate SCRRA Engineering Standards.

Secondary Track

Typical Secondary Track construction is new 136-pound (RE) new or secondhand rail (as directed by SCRRA). New 136-pound (RE) rail shall be head-hardened rail.

On all lead and moderate/high-use Secondary Tracks, CWR shall be used. When connecting rail of differing sizes in lead tracks, transition rails shall be used, as presented in SCRRA ES 2372 and ES 2373. With CWR, transition rails with welds and fully welded joint plugs shall be used. Compromise welds, welds used to connect two different-sized rails, shall not be used.

Secondary Track may consist of either timber or concrete ties. When concrete ties are used, elastic fasteners shall be used to attach rails to ties. When timber ties are used, new screw fasteners, steel tie plates, elastic fasteners, and anchors shall be used. Track sections and fastener details are shown in the appropriate SCRRA Engineering Standards.

Freight and Other Track

Typical Freight and Other track construction is the same as Secondary Track construction. Secondary Track standards shall be maintained for use in major lead tracks. Track sections and fastener details are shown in the appropriate SCRRA Engineering Standards.

6.2.3 Turnouts

Primary Track

Turnouts shall be fully welded with elastic fasteners, timber ties, or concrete ties, as directed. Turnouts will be insulated and interlocked. Lateral turnout geometry shall be used unless the use of equilateral turnout geometry is warranted and approved by SCRRA.

Secondary Track

Turnouts shall be insulated and interlocked for any lead tracks or tracks that may be equipped with automated switch machine operations. Non-insulated turnouts are acceptable for lower-use tracks that will never be remotely controlled or operated with power switch machines or incorporate track circuits. Insulated joints in the closure rail may be poly-insulated joint bars. Primarily wood or standard turnouts will be selected for use.

Freight and Other Track

Turnouts shall be installed per the Secondary Track standard.

SCRRA has engineering standards for both construction of new turnouts (ES 2800 Series) and for maintenance of existing turnouts (ES 2900 Series). The type of turnouts selected will be as noted in the sections below. For locations of turnouts, refer to Section 5.6.1.

New Construction

For new track design and construction, concrete turnouts consisting of welded spring manganese (WSM) frogs using tangential geometry with hollow steel switch movement ties, shall be used as per ES 2800 Series Engineering Standards. Spring rail frogs will be used for No. 10 turnout if the turnout side (diverging traffic) is not used for meeting or passing of through trains or if the diverging traffic is less than 30 percent of the main line traffic. Wood turnouts consisting of rail-bound manganese (RBM) frogs using tangential geometry may be used for No. 10 turnouts as per ES 2802 Series Engineering Standards.

Equilateral turnouts are not allowed unless approved by SCRRA. Double slip turnouts shall be used only at Los Angeles Union Station.

All turnouts shall be installed with an HMA underlayment per ES 2105. All criteria for the geometry and materials specified in the engineering standards and standard specifications shall be adhered to throughout the design.

Turnout Construction Pads per ES 2005 shall be incorporated into the design to facilitate turnout fabrication and installation during short, preplanned outage windows. If construction in accordance with standards is not feasible due to spatial constraints, a construction area workplan shall be prepared and approved by SCRRA.

Maintenance

Maintenance standards (ES 2900 Series) shall only be used for the replacement of parts of existing turnouts that utilize the maintenance standards. For the replacement of the entire existing turnout, new construction turnout standards (ES 2800 Series) will be used.

Minimum Turnout Size

The minimum new turnout size shall be selected based in Table 6-1.

TABLE 6-1. MINIMUM TURNOUT SIZE

From	To	Minimum Turnout Size
Main/Siding	Main/Siding	No. 14
Main/Siding	Yard/Industry	No. 10
Yard/Industry	Yard/Industry	No. 10

6.2.4 Highway-Rail Grade Crossings

The design of highway-rail grade crossings of Primary Track shall incorporate precast concrete panels. Running rail through the crossing area shall be electric flash-butt welded, and the cross ties shall be 10 feet long timber ties. 10-foot-long timber ties shall extend beyond each end of the crossing panel limits a minimum of 24 ties at 19.5 inches center to center spacing, see ES 4201 for further details. Highway-rail grade crossings shall be located in tangent track wherever possible. No exothermic rail welds, insulated joints, or bonds shall be placed in crossings or within 10 feet of a crossing. No turnouts or crossovers shall be located within 100 feet of a crossing. SCRRA standards on grade crossings are presented in ES 4001 through ES 4201.

Traffic pavement markings and striping information is presented in Chapter 8.0, Grade Crossings.

6.2.5 Derails

Derails shall be located so that they derail equipment in a direction away from the primary track. Derails shall be located beyond the clearance points of converging tracks. Switch-point derails may be installed at locations as directed by SCRRA, including locations where operating locomotives are stored and where cars are moved or switched by non-railroad personnel. SCRRA standards on derails are presented in ES 2601 through ES 2614.

All new industrial or spur track designs shall include an electric lock/come-out signal and appropriate split switch-point derail, as required below, that is controlled by and connected to the signal system for the adjacent mainline track. This would include new industrial spur tracks constructed on an existing lead track. The lead track, which will now have a new industrial spur, must also include in the design the appropriate double switch-point derail and electric lock/come-out signal where the modified lead track connects with the mainline.

Blue flag derails are required to protect workers on service tracks per 49 CFR 218 and to protect the unloading of hazardous materials per 49 CFR 172.

Primary Track

Derails shall be used to prevent unintended roll-outs of rail vehicles to adjoining or adjacent Primary Tracks. All new derails shall be double switch-point derails except when the prevailing grade on secondary or industrial tracks descends away from the Primary Track with a gradient of 0.5 percent or greater; see ES 2601 for additional information regarding use of derails. Double switch-point derails are required if an industry has its own locomotive or trackmobile, regardless of the grade.

Secondary Track

Derails shall be used to prevent unintended roll-outs of vehicles to adjoining or adjacent Primary or Secondary Tracks. Derails shall be installed per the same standard as Primary Tracks (see ES 2601).

Freight and Other Track

Derails shall be used to prevent unintended roll-outs of rail vehicles to adjoining or adjacent lead tracks. On freight lead tracks, derails shall be installed per the same standard as primary and Secondary Track derails.

6.2.6 Bumping Posts/Earthen Bumpers

Bumping posts shall be installed at the end of each stub-ended track. A preferred distance of 10 feet and a minimum distance of 3 feet shall be provided from the train stopping position to the face of the bumping post. The face of the bumping post shall be located a minimum distance of 8 feet from the end of the track.

Where space is available, earthen bumpers may be used at the end of each stub-ended track as directed by SCRRA. Earthen bumpers shall be pyramid shaped with a 16 foot by 16 foot base (centered over the track), four foot by four foot top (centered over the base), and sloped at 1.5:1. A red flag shall be placed on the slope of the earthen bumper facing the track.

6.2.7 Railroad (Diamond) Crossings

New Railroad diamond crossings are not allowed on SCRRA system.

For the replacement of the existing diamonds where the speed of train on the Secondary Track is set to slow speeds flange bearing crossing frogs shall be used. HMA underlayment shall be required for any diamond replacements.

6.2.8 Inner Guard Rails

The purpose of inner guard rails is to reduce the likelihood that derailed wheels strike a structural bridge component above the deck and/or improve the likelihood that derailed equipment remains on the deck until the derailed train is stopped. However, inner guard rails reduce the ability for maintenance crews to surface track and correct minor surface irregularities and therefore should only be installed as noted:

- Inner guard rails on bridges shall be required for all spans where exposed structural steel is present above T/R and is subjected to structural damage by derailed equipment. Inner guard rails shall be installed on bridges where individual spans are over 100 feet in length or where the entire structure is over 800 feet in length and at least one span crosses over a waterway that normally contains water at least 15 feet deep. Inner guard rails shall extend 50 feet beyond the span or spans to be protected.

- Inner guard rails shall be installed on any other bridge as directed by SCRRA.

SCRRA standards for inner guard rails associated with bridges are presented in ES 2302 and ES 2304.

6.3 TRACK MATERIALS

6.3.1 Rail

Primary Track and Secondary Track shall be 136-pound (RE), head-hardened rail meeting current SCRRA standard specifications and AREMA “Specifications for Steel Rail.” Industrial tracks (not maintained by SCRRA), such as yard body tracks, storage tracks, and spurs, may be 115-pound (RE) section, jointed rail.

All CWR shall be welded into continuous lengths by the electric flash-butt welding process except for certain field welds that may be exothermic welds. The exothermic welding process may be performed when joining strings in the field and insulated joint plugs, transition rails, frogs, closure rails, and other special trackwork. No compromise welds are allowed.

CWR shall be manufactured on-site by welding rail sections in nominal 80-foot lengths into 1,400-foot strings. Field welding of CWR strings shall be as per Standard Specification 34 72 30, Field Welding Rail.

6.3.2 Ties

Concrete ties with elastic fasteners shall be used for new primary track construction. Concrete tie construction shall conform to SCRRA Standard Specification 34 11 33, Concrete Railroad Ties. Timber ties shall be used for road crossing ties and for turnout construction except for premium turnouts, as designated by SCRRA, specifically designed for concrete ties. Timber ties may be used to construct temporary shoofly track and to rehabilitate existing timber tie track. Timber tie construction shall conform to the requirements of SCRRA Standard Specification 34 11 34, Wood Railroad Ties.

Transition ties shall be used where track modulus changes abruptly from concrete to timber, particularly at ends of turnouts, road crossings, open deck bridges, and other wood-to-concrete tie interfaces. SCRRA standards for transition tie sections, including quantity and spacing requirements, are presented in ES 2351. Transition ties shall be new 10-foot timber ties.

In areas where ties are prioritized for replacement per Metrolink Rehabilitation Plan (MRP), replace wood ties with concrete ties.

If wood ties are not to be replaced with concrete ties based on SCRRA preference, install elastic rail fasteners and provide 12” of shoulder ballast. In areas with wood ties secured by standard plates with cut spikes and rail anchors, in sections replace failed and marginal ties secured to the rail with elastic rail fasteners.

Steel ties may be used as directed by SCRRA and in non-CTC controlled locations of substandard ballast depth or in locomotive service areas.

6.3.3 Other Track Material

Other track material (OTM) shall conform to current SCRRA and AREMA standards and specifications. Resilient fastening system shall be used for all new construction. Standard fastening system shall be used only for maintenance of the existing track constructed with cut spikes. Rail anchors shall also be used if cut spikes are used. Required fastener types are presented in ES 2361 through ES 2368.

The designer shall call for approved tie pads and insulators on concrete ties in the project specifications. SCRRA standards for approved tie pads and insulators are presented in ES 2360-01 through ES 2360-03.

Refer to SCRRA's Standard Specification 34 11 15, Other Track Materials and 34 11 36, Elastic Rail Fasteners for additional information on OTM.

6.3.4 Special Trackwork

Special Trackwork shall conform to current SCRRA Engineering Standards and Standard Specifications Section 34 11 23, Special Trackwork and AREMA recommended practices.

6.3.5 Ballast

Primary Track ballast shall conform to SCRRA standard specification 34 11 26, Ballast, ES 2109 and AREMA recommended practices. Secondary Track ballast, where maintenance personnel are likely to walk while inspecting or maintaining equipment, shall be yard ballast.

Standard ballast sections are presented in ES 2001 and ES 2002 see also walkway standards ES 2109.

In the problem areas immediately adjacent to a project area where identified by ballast scan data, replace, re-tamp and stabilize ballast to increase ballast density and review and resolve subgrade issues as necessary.

6.3.6 Sub-Ballast

Sub-ballast material shall conform to SCRRA standard specification 34 11 27, Sub-Ballast and Aggregate Base and AREMA recommended practices. The aggregate shall consist entirely of crushed rock with a minimum of 75 percent of the material having at least two fractured faces. No reclaimed asphalt or concrete shall be included in this material. The sub-ballast for all tracks shall consist of a uniform minimum 6-inch layer, or more as determined by geotechnical analysis, placed and compacted over the entire width of the roadbed following the profile and cross section of the roadbed. Final design shall consider the use of a thicker sub-ballast section or geotextiles when subsoil conditions dictate, as presented in ES 2001 and ES 2002.

Design of subgrade and sub-ballast for relocated and transition sections shall consider the condition of the existing ballast and sub-ballast. Unless the existing ballast is contaminated with fines or organic material, or is not adequately drained, the existing ballast and sub-ballast may be used to support relocated and transition track segments.

6.3.7 Joints and Welds

Primary Track

All CWR shall be welded into continuous lengths by the electric flash-butt welding process except for certain field welds that may be exothermic welds. The exothermic welding process may be performed when joining strings in the field and insulated joint plugs, transition rails, frogs, closure rails, and other special trackwork. No compromise welds are allowed. All field welds must comply with the SCRRA Track Maintenance Manual.

No joints or field welds are allowed in road crossings.

Permanent joints shall be welded. Temporary joints, pending welding, should not have bolts installed or holes drilled on the center two holes of six-hole bars.

Secondary Track

All leads where track is CWR shall be welded into continuous lengths by the electric flash-butt welding process except for certain field welds that may be exothermic welds. No compromise welds are allowed. All field welds must comply with the SCRRA Track Maintenance Manual. Compromise bars and poly-insulated joint bars may be used on jointed rail track.

6.3.8 Insulated Joints

Permanent insulated joints shall be installed by insulated joint plugs fully welded in Primary Track. Poly-insulated bars may be used in jointed Secondary Track and closure rail of turnouts used in jointed Secondary Track. No compromise welds are allowed.

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7.0 STATIONS

7.1 SCOPE

The stations design criteria is an instrument to inform the design consultant and associated stakeholders on the guidelines, practices, and policies that reflect current regulations, proven and accepted technological developments, and best available rail industry design practices. The design consultant and associated stakeholders shall apply these standards toward the development of station designs in planning and during construction. These station design criteria provide the preferred and in some cases the minimum requirements for the design and planning of new or rehabilitated stations.

SCRRA intends to apply these station design criteria when new stations or improvements to existing stations are proposed. It is not intended that the requirements be applied retroactively to existing stations unless there are proposed major physical or use changes.

All standards and manuals shall be adhered to throughout the project. Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

Station designs shall provide a safe and enjoyable transit experience that promotes ridership growth, integrates with other public transportation systems for the convenience of the passengers, and encourages development opportunities in adjacent areas.

The design of a SCRRA commuter train station is typically site-specific and reflects the surrounding community. However, the functionality of SCRRA stations must be practical and consistent in order to effectively serve SCRRA trains and passengers. The criteria set forth in this Design Criteria Manual (DCM) is intended to ensure that a station is designed to meet the minimum requirements for a SCRRA commuter train station as well as to create elements of continuity throughout the system.

The site and passenger access for the station must be assessed for climate vulnerability (see Section 3.3) to ensure it is designed to be resilient to future climate conditions, and to provide passengers with amenities to protect them as appropriate for current and future extreme weather events.

Numerous SCRRA trains serve stations located throughout Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Counties, as shown in Table 7-1. For the most current information refer to https://www.metrolinktrains.com/rider-info/general-info/stations/.

TABLE 7-1. STATION LOCATIONS

Station	Address	City
Anaheim (ARTIC)	1750 S. Douglas Rd.	Anaheim
Anaheim Canyon	1039 N. Pacificenter Dr.	Anaheim
Baldwin Park	3825 Downing Ave.	Baldwin Park

TABLE 7-1. STATION LOCATIONS		
Station	**Address**	**City**
Buena Park	8400 Lake Knoll Drive	Buena Park
Burbank Downtown	201 N. Front St.	Burbank
Burbank Airport – South (VC Line)	3750 Empire Ave.	Burbank
Burbank Airport – North (AV Line)	3600 N. San Fernando Blvd.	Burbank
Auto Club Speedway (Seasonal)	8894 Calabash Avenue	Fontana
Cal State LA	5150 State University Dr.	Los Angeles
Camarillo	30 Lewis Road	Camarillo
Chatsworth	10046 Old Depot Plaza Road	Chatsworth
Claremont	200 W. 1st St.	Claremont
Commerce	6433 26th St.	Commerce
Corona – North Main	250 E. Blaine St	Corona
Corona – West	155 S. Auto Center Dr	Corona
Covina	600 N. Citrus Ave.	Covina
El Monte	10925 Railroad St.	El Monte
Fontana	16777 Orange Way	Fontana
Fullerton	120 Santa Fe. Ave.	Fullerton
Glendale	400 W. Cerritos Ave.	Glendale
Industry	600 S. Brea Canyon Road	City of Industry
Irvine	15215 Barranca Parkway	Irvine
Jurupa Valley / Pedley	6001 Pedley Rd.	Riverside
Laguna Niguel/Mission Viejo	28200 Forbes Road	Laguna Niguel
Lancaster	44812 N. Sierra Highway	Lancaster
Montclair	5091 Richton St.	Montclair
Montebello/Commerce	2000 Flotilla St.	Montebello
Moorpark	300 High St.	Moorpark
Moreno Valley / March Field	14160 Meridian Parkway	Riverside
Newhall	24300 Railroad Ave.	Santa Clarita
Northridge	8775 Wilbur Ave.	Northridge
Norwalk/Santa Fe Springs	12700 Imperial Highway	Norwalk
Oceanside	235 S. Tremont St.	Oceanside
Ontario - East	3330 E. Francis St.	Ontario
Orange	194 Atchison St.	Orange
Oxnard	201 E. Fourth St.	Oxnard
Palmdale	39000 Clock Tower Plaza Drive	Palmdale

TABLE 7-1. STATION LOCATIONS		
Station	**Address**	**City**
Perris – Downtown	121 South C Street	Perris
Perris – South	1304 Case Road	Perris
Pomona - Downtown	101 W. 1st St.	Pomona
Pomona - North	205 Santa Fe St.	Pomona
Rancho Cucamonga	11208 Azusa Court	Rancho Cucamonga
Rialto	261 S. Palm Ave.	Rialto
Riverside-Downtown	4066 Vine St.	Riverside
Riverside – Hunter Park / UCR	1101 Marlborough Avenue	Riverside
Riverside-La Sierra	10901 Indiana Ave.	Riverside
San Bernardino – Downtown	174 South E Street	San Bernardino
San Bernardino Depot	1170 W. 3rd St.	San Bernardino
San Clemente	1850 Avenida Estacion	San Clemente
San Clemente Pier	615 Avenida Victoria	San Clemente
San Juan Capistrano	26701 Verdugo St.	San Juan Capistrano
Santa Ana	1000 E. Santa Ana Blvd.	Santa Ana
Santa Clarita	22122 Soledad Canyon Road	Santa Clarita
Simi Valley	5050 Los Angeles Ave.	Simi Valley
Sun Valley	8360 San Fernando Road	Sun Valley
Sylmar/San Fernando	12219 Frank Modugno Dr.	Los Angeles
Tustin	2975 Edinger Ave.	Tustin
Union Station	800 N. Alameda St.	Los Angeles
Upland	300 E. A St.	Upland
Van Nuys	7720 Van Nuys Blvd.	Van Nuys
Ventura - East	6175 Ventura Blvd.	Ventura
Via Princessa	19201 Via Princessa	Santa Clarita
Vincent Grade/Acton	730 W. Sierra Highway	Palmdale

7.2 STANDARDS AND CODES

For standards and codes that apply refer to Section 3.2 of this Design Criteria Manual and Part 2 of Appendix A. For a listing of third-party permits, see Section 5.8.3 of the DPM.

7.2.1 Definitions

For definitions, see Part 1 of Appendix A.

7.2.2 Station Standard Drawings

Se ES 3000 Series for station standard drawings.

7.3 SCRRA REQUIREMENTS

7.3.1 Design

The station design, calculations, submittals, estimates, and review process and procedures shall be as per SCRRA's Design Procedures Manual. The drawings shall be as per SCRRA's CADD Manual.

To design a new SCRRA station or modifications to an existing station, a station owner may use its own architectural/engineering firm or enter into a cost -reimbursement agreement with SCRRA to use the services of one of SCRRA's design consultants. In either case, SCRRA must be actively involved in the development of any station design that SCRRA services.

7.3.2 SCRRA Station Equipment

For a typical station, SCRRA may provide the following equipment:

- Ticket vending devices (TVDs) with the installation. SCRRA shall be consulted regarding the number of TVDs since mobile ticketing may reduce the number of TVDs required.
- Procurement of precast station dual -tenant communications shelter.
- Procurement of SCRRA passenger information phone. Installation and commissioning by Contactor on site.
- Design and construction of signal work including any needed intermediate signals at stations.

These services and equipment items must be specially ordered for each station and must be funded by the project sponsor.

7.3.3 Agreements

Before any designs can be finalized and before any construction work can begin, a construction and maintenance (C&M) agreement must be executed by SCRRA and the project sponsor and any other outside parties participating in the funding or maintenance. The C&M includes a detailed work description; specifies the method of payment; assigns responsibility for design, construction, funding, and maintenance; provides cost estimates of the SCRRA work; and specifies the form, duration, and amount of insurance and liability. As part of the C&M agreement, the project sponsor shall notify SCRRA within five working days in advance of any maintenance activity, and within 30 days in advance of any construction activity, that will occur within the ROW. The project sponsor shall be required to reimburse SCRRA the actual cost and expense incurred by SCRRA for all services and work performed in connection with the project, including a computed surcharge (overhead) representing SCRRA's costs for administration and management.

7.4 STATION SITES

To establish a sense of "place" of the station and to instill a feeling of ownership by the community, station layout, station elements (canopies and fence), and architectural features should be reviewed with the local public agency(ies) and neighborhood community organizations. For new station construction, the architect should evaluate emerging transit-oriented development that can complement the station to promote and increase ridership. The design engineer should initiate and coordinate with the community to limit local traffic impacts and minimizes disruption during and after the implementation phase. For existing station rehabilitation and renovation, the architect should complement the existing architectural elements.

Station sites will be identified jointly by station owner staff and SCRRA staff in accordance with project goals. Site selection must be approved by SCRRA engineering and operations staff in writing, who will seek to place and locate stations to maintain a train schedule competitive with driving time. SCRRA cannot guarantee that all trains will stop at every station. The suggested station spacing is five track miles. Cities are encouraged to consider the station site as an opportunity to create community intermodal centers with other transportation modes and create opportunities for active transportation.

Operational considerations, including train and automobile sight distances, the ability of a location to accommodate future expansions, and site-specific train and passenger safety concerns, will be reviewed with SCRRA.

Areas with tangent track are preferred for a station site. Curved track through the platform should be avoided if at all possible. If a station platform is located on a curve, the platform should be on the inside of the curve. Platforms on the outside of a curve are discouraged as it prevents the train engineer and conductor from seeing all of the cars and doors to ensure that all passengers have safely boarded or alighted before closing the doors. If a platform on a curve is unavoidable, it should be as shallow a curve as possible, and the degree of curve shall be no more than 1 degree and 30 minutes. Platforms located on a curve shall require prior approval from SCRRA. Superelevation in the track should be eliminated if possible, but in the worst case should be no more than 1.5 inches.

Track centers where two tracks are present at station platforms should allow for an inter-track fence. This will require a minimum spacing of 19.25 feet between the centerline of tracks. See ES 2004. The expanded track centers and the inter-track fence should extend a minimum of 150 feet beyond the end of the platform plus possible future platform extensions at each end of the station.

Proposed station sites should be evaluated to determine if the location causes train operations to be affected by the "Train Delayed Within a Block" rule (General Code of Operating Rules [GCOR] 9.9). If Delayed in Block would result, the station project shall include modifications to the signal system to avoid such a delay. This is usually accomplished by adding signals or re-spacing automatic block signals.

Proposed sites will be evaluated based on their impact on freight and commuter railroad operations. All sites are subject to the approval of the owner of the railroad ROW and SCRRA.

A license/lease agreement from a SCRRA member agency and a C&M agreement (with SCRRA, the station owner, and the station maintainer) are both required for a new station. If an existing station is being modified and does not already have a C&M agreement in place, the project sponsor is required to facilitate one for the parties involved before the project begins construction.

Pedestrian crossings shall have good visibility both for pedestrians and drivers.

Enhanced concrete paving, pavers, and other decorative paving materials shall be considered for providing an inviting pedestrian experience, enhancing the aesthetics, and reinforcing a sense of direction that is associated with functional areas such as drop-offs, pick-up, other transit stops, as well as accessible access. Landscaping should effectively reinforce pedestrian circulation. An open area, with enhanced paving treatment, shall be provided to collect pedestrians from the major walkways and allow a queuing area adjoining the entry or exit from the station. Changes in texture or color of the vehicular paving at pedestrian crossings should be considered.

Barriers shall be provided to either discourage or prevent pedestrians from crossing vehicular traffic at locations where unsafe conditions would otherwise result. Pedestrian barriers may consist of railing, fencing, walls or landscaping that are architecturally harmonious with the site.

A direct and safe approach for pedestrians shall be provided from adjacent streets and bus drop-off areas to the station entrance. Pedestrian walkways shall be provided to avoid conflicts with vehicular traffic. Walkways may be provided to minimize pedestrian use of an automotive drive aisle, or provided to minimize locations at which pedestrians can cross automobile traffic lanes. Where pedestrians approach the station from various destinations and major intersections, consideration shall be given to the provision of a walkway with a direct route to the platform. Passenger underpasses will be assessed for and protected against current and future flooding.

7.4.1 Emergency Egress Analysis

The National Fire Protection Association (NFPA) 130 standard specifies fire protection and life safety requirements for underground, surface, and elevated fixed guide-way transit and passenger rail systems. All stations shall at a minimum conform to NFPA 130 Requirements. This includes providing passenger egress calculations that depict exiting all passengers from the platform within 4 minutes and illustrating the minimum distance requirements between an exit and the most remote point on a platform. Additionally, station designers shall at a minimum comply with the CBC, maximum travel distance of 300 feet from the most remote point to an exit/vertical circulation element.

7.5 STATION PARKING

The minimum number of parking spaces at new stations shall be coordinated with station owner and SCRRA. Parking considerations shall be made for determining the minimum number of parking spaces. Parking at SCRRA stations shall be free and/or by SCRRA permitted unless approved by SCRRA. Parking may displace other land uses and surface parking may be repurposed for future transit-oriented development. Account for approximately 360 square feet per parking space for circulation (drive aisles) or approximately 120 cars per acre. The minimum number of parking will be for 500 cars unless a lesser amount is approved by SCRRA, station owner, and the City where the station is located. Stations also have the opportunity to share parking facilities for sites with existing infrastructure such as L.A. Union Station. The total number of spaces allotted for the station and the number of access points will determine the minimum number of accessible and van spaces as per CA Title24 requirements. All Accessible spaces shall have an accessible route to the station platform and shall be placed as close to the station platform as possible.

Existing stations that are being modified shall at the direction of the SCRRA PM perform an ADA deficiency analysis for the parking lot/structure, platform, transit connections, station buildings, (up to the street access point) and identify and correct all deficiencies that are not compliant with current ADA and CA Title 24 requirements.

The parking lot should be configured to separate bus movements from passenger vehicle circulation. A traffic engineer should determine the best flow for vehicles entering, exiting, and circulating the station parking lot. It is recommended that the number of entrances and exits to a station be minimized while still remaining compliant with local traffic requirements. The reduced number of entrances/exits allows for better security monitoring and control of the parking lot. The parking lot layout should be designed to reduce conflicts between vehicles traveling up and down vehicle drive lanes and vehicles backing out of parking stalls. Station exit lanes with adequate stacking space, as determined by a traffic engineer, are recommended to provide for controlled exiting.

In locations projected to experience extreme heat, and where feasible, plant shade trees within the station parking lot area. Trees should be heat and drought-tolerant, low maintenance native plant species. Other architectural shading canopies should be considered, including solar photovoltaic panels for energy generation.   Increase pavement reflectance by using reflective aggregate, a reflective or clear binder, or a reflective surface coating to further reduce the heat island effect.

In locations projected to experience flooding and where geological conditions are appropriate, use permeable pavers, and bioretention or nature-based features to reduce stormwater run-off volumes for parking lot surfaces.

An area should be designated to pick-up and drop- off passengers (Kiss-n-Ride). The area must be compliant with Accessibility guidelines and should be located to prevent conflicts with buses or vehicles traveling down parking stall lanes.

The design of pedestrian approaches from parking areas to the station entrances shall be contingent upon the location of other, more primary station area pedestrian walkways serving the station area and the location of potential transit area development. Parking pattern shall be designed so the pedestrians walk down the parking aisles toward the station, minimizing traffic crossings, or along a major walkway.

Crosswalks shall be well defined and have clear visibility for both pedestrians and drivers. Pedestrian path of travel shall be provided with slip-resistant surfaces with a static coefficient of friction not less than 0.6 when tested in accordance with ASTM C1028.

A monument sign identifying SCRRA with their logo shall be provided at the station entrance to identify the station parking area (see ES 3305). Other vehicular directional signs should be provided to direct motorists to the accessible parking, EV parking, and Kiss-n-Ride areas as needed.

New station layouts will include provisions to allow maintenance-of-way and signal and communications trucks to access the ROW on both sides of the station. If this access is to be provided from the public parking or driveway areas, a locked gate will be used to keep unauthorized vehicles from entering the ROW. Existing stations shall be evaluated for maintenance needs and access points with SCRRA and confirm requirements for the station going forward based on the new configuration proposed. Bollards may be used to control vehicular access or to deter unsafe pedestrian movements. When bollards are used as traffic barriers where SCRRA maintenance access may be required, bollards shall be retractable or removable and lockable. For bollards used as traffic barriers see ES 5107.

Fire lanes shall be provided, from a public street to the station, through parking lots. Fire truck access shall be provided to all building structures and station entrances. Access roads and parking lot perimeter roads shall accommodate fire trucks. Confirm lane widths, turning radius and access requirements with the local fire department.

7.6 INTERMODAL ISSUES

SCRRA encourages the provision of intermodal connections at stations. These may take the form of alternate rail mode connections (Amtrak/DMU/HSR/LRT/NCTD), regular transit bus service, bike paths, dedicated walkways, and pedestrian-friendly paths of travel. If existing intermodal transportation in the surrounding context doesn’t exist, consider providing connections to feasible and possible future intermodal connections.

Every effort should be made to separate pedestrian paths of travel from bus circulation routes. It is recommended that dedicated bus loops be used to reduce the chance of conflicts between buses, automobiles, and pedestrians. Bus stops located within the station must be accessible and have an accessible route to all other accessible elements on the site and the adjacent public sidewalk. If bus service is located on the street outside of the station, an accessible path of travel from the nearest bus stop(s) to the station platform must be provided. Bus loading areas shall have adequate clear space to allow for the deployment of a wheelchair lift from either the front or rear bus doors. Provide a continuous unobstructed loading zone along the entire length of the bus berth curb. Zone shall be an area from the face of the curb to a minimum of 8 feet back from the curb. The designer shall verify requirements with the bus transit system.

7.7 PLATFORMS

In designing the station platforms, consideration should be given to possible future platform extensions for longer train consists. New stations will be constructed with a minimum 680-foot-long platform (longer where Amtrak service exists). Where an additional track will be added in the near-term, a temporary platform can be constructed in the location of the future track with a permanent platform behind.

A side platform should be a minimum of 16 feet wide (see ES 3201). A center platform should be a minimum of 30 feet wide (see ES 3202). Additional width should be provided at side platforms, if possible, for canopies and overcrossing or undercrossing structures. The center platform may need increased width to allow for an undercrossing or overcrossing tower with its vertical circulation elements, and crash walls. SCRRA prefers pedestrian undercrossings instead of overcrossings at all stations due to elevator maintenance challenges. The platform layout shall be efficiently designed to reduce obstructions, such as exploring attaching equipment to light poles instead of installing separate poles for equipment.

A pedestrian bridge should be considered for center platforms with deep undercrossing to limit length to cross the platform above the accessible ramps. Evaluate Underpass corner shape to increase pedestrian site distance at the corners.

All side platforms should slope away from the track a minimum of 1 percent and no more than 2 percent for accessibility. Platforms sloped away from the track provide roll-back away from the track enhancing safety for users. At center platforms, water should be treated and discharged to the municipal storm drain system. Area drain grates within the platform must be accessible by maintenance personnel, and be installed with an ADA compliant grate. See chapter 9 for overall drainage requirements. To enhance the effectiveness of the drainage at the station area, the track bed shall be constructed with 6-inch-thick hot mixed asphalt concrete through the platform area and 10 feet beyond the limits of the platform (see ES 2004). If there is an existing station at-grade crossing, the hot mixed asphalt concrete shall extend through the at-grade crossing and 10 feet beyond the limits of the station at-grade crossing. All new pedestrian crossings to side platforms and center platforms shall be grade-separated.

The preferred platform height shall be at an elevation 8 inches above the top of the adjacent rail, and the platform edge shall be 5 feet 4 inches from the centerline of the track (see ES 3201 and 3202). Platform height may require an ADA level board waiver through FTA. Platforms shall be constructed of concrete with a flush vertical wall on the track side. Designers shall consult with SCRRA on the final profile for the track and will establish the platform grade to match the final track grade (following any rehabilitation or modifications to the track.) Track grade shall be at a consistent slope through the platform, and the project shall move any vertical curves to be outside the platform limits.

Ends of platforms shall be a minimum of 120 feet from the edge of any at-grade crossing per ES 3002 and ES 3003 to avoid the train being within the crossing island circuit. Where stations are near an adjacent highway-rail at-grade crossing, placement of platforms shall consider the possibility of planned roadway widening or sidewalk realignment that may cause the island circuit to be moved closer to the platform.

All station platforms, structures, and equipment must be designed at minimum to meet the minimum clearance requirements of CPUC GO 26-D.

For new or altered stations serving local communities, commuter, intercity, or high-speed rail lines or systems, in which track passing through the station and adjacent to platforms is shared with existing freight rail operations and the railroad proposes to use a means other than level-entry boarding, the railroad is required to meet the following requirements:

Perform a comparison of the costs (capital, operating, and life-cycle costs) of car-borne lifts and the means chosen by the railroad operator, as well as a comparison of the relative ability of each of these alternatives to provide service to individuals with disabilities in an integrated, safe, timely, and reliable manner.

Submit a plan to FRA and/or FTA, describing its proposed means to meet the performance standard at that station. The plan shall demonstrate how boarding equipment or platforms would be deployed, maintained, and operated; and how personnel would be trained and deployed to ensure that service to individuals with disabilities is provided in an integrated, safe, timely, and reliable manner.

Obtain approval or a waiver from the FTA (for commuter rail systems) or the FRA (for intercity rail systems). The agencies will evaluate the proposed plan and may approve, disapprove, or modify it. The FTA and the FRA may make this determination jointly in any situation in which both a commuter rail system and intercity or high-speed rail system use the tracks serving the platform.

7.7.1 Mini-High Platform

SCRRA and FTA/FRA will review the proposed method to ensure that the railroad provides reliable and safe services to individuals with disabilities in an integrated manner.

To provide for level boarding of the train through the use of a bridge plate, a mini-high platform is required. The mini-high platform landing is centered 60 feet from the station end closest to Los Angeles Union Station for stations with a single mini-high. For stations with a mini-high at both ends, they shall be placed at opposing ends of the platform per standards. Coordinate with SCRRA staff to determine the number of mini-high platforms required. See ES 3101-01 and ES 3101-02 for details.

7.7.2 Surface

Platforms must be firm, stable, and slip resistant; therefore, finishes shall meet Accessibility standards and static coefficient of friction (SCOF) as recommended by the Department of Transportation in 49 CFR Part 37, Commuter Rail Cars and Systems. Slip resistance shall be a minimum SCOF of 0.6 for steps, floors and platform surfaces and a SCOF 0.8 for ramp surfaces.

7.7.3 Detectable Warning Strip

A detectable warning strip 2 feet wide and associated paint striping are required at the rail side of the platform. The stripe is required for the entire length of the platform. A one-inch-wide black contrast stripe is required at the back of the detectable strip. Detectable warning dome size, dome spacing, contrast, resiliency, and color shall meet the provision of CBC 11B-705.1.

- Color: Yellow conforming to AMS STANDARD 595A COLOR AMS-STD 33538.
- Dome spacing: domes shall have a center to center dimension of 2.3 inches minimum to 2.4 inches maximum.

The pattern for detectable warning at platform edges shall be per the US DOT Federal Transit Administration – ADA Circular (FTA C 4710.1), which allows for the 45 degree or staggered pattern depicted on ES 3203.

<u>Paint Striping</u>

A painted 4-inch-wide yellow stripe shall be applied on the platform located 3 feet 2 inches from the rail edge of the platform with 4-inch high block letters per ES 3203. See “Alternate A” on ES 3203 for joint use platform striping.

7.7.4 Detectable Directional Texture

Detectable directional texture shall be required at every boarding platform side per ES 3203. This surface shall be placed directly behind the yellow warning stripe and aligned with the doors of the transit vehicles where passengers will embark (see ES 3203). To avoid confusing patrons, the detectable directional texture will not need to be placed for the entire length of the platform and shall only be placed to accommodate the daily maximum number of cars (and as constrained by platform length) for the particular line on which the station is located. Detectable directional texture, texture size, texture spacing, contrast, resiliency, and color shall meet the provisions of CBC 11B-705.2.

- Color: Yellow confirming to AMS Standard 595A Color AMS-STD 33538
- Width: 48 inches
- Depth: 36 inches

7.7.5 Stairs/Ramps/Walkways

Accessible walkways should clearly define the path of travel to each platform. Walkways and ramps to and from platforms should be a minimum of 8 feet wide. If Amtrak baggage cart service is provided at that station, the minimum width shall be 10 feet wide. When platforms are placed above or below parking lot elevations, access to the platforms should be by stairs and ramps. The placement of these should be carefully planned to be convenient for passengers. Ramps, which are defined as a walking surface that has a running slope steeper than a 5 percent slope, shall comply with accessibility requirements. All accessible circulation elements shall meet current ADA Standards for Accessible Design.

7.7.6 Guardrails/Handrails

Handrails shall be provided to meet accessibility and ingress/egress requirements, including a smooth uninterrupted surface. Stainless steel handrails shall be used to reduce station maintenance requirements. Handrails should be designed to discourage/deter skateboarding on them (consider proximity to walls, large ground boulders at the end of them, etc.).

7.7.7 Other Design Considerations

Some stations will have both Amtrak, SCRRA service or others. This introduces several design issues for the station platform. Amtrak may require a longer platform than SCRRA, usually a minimum of 850-1,000 feet long. Amtrak may also require the use of baggage carts on the platform, so baggage cart circulation/turnaround and secured cart storage/recharging area must be considered and turning templates performed at any undercrossings. If Amtrak requires the use of baggage carts, a private Amtrak only at-grade crossing with an automatic gate in place of an inter-track fence or underpass structure may be considered.

It is recommended that hose bibb connections be placed at interval locations, not to exceed 100 feet on-center or 50 feet from the end of the platform, for complete coverage of the platform during power washing. Hose bibb connections shall be placed in recessed floor boxes of stainless steel construction. Water point-of-connection may share services with irrigation meter if approved by the local agency. If recycled water is utilized, approval by the department of public health is required as well and boxes will be required to follow recycled water requirements with purple lids, ID tags, and approved warning signage.

7.8 PEDESTRIAN CROSSINGS

SCRRA must approve the final design of pedestrian crossings at stations, regardless of the ownership of the station. SCRRA requires new stations to have grade-separated pedestrian access only to separate platforms from each operating track, with an inter-track fence between the tracks to prevent patrons from crossing between platforms at-grade. All new pedestrian crossings must be approved by the California Public Utilities Commission (CPUC) through a formal application process. Refer to SCRRA's Highway-Rail Grade Crossings Design Standards and Criteria Manual for at-grade pedestrian crossings design and construction see Chapter 8 Grade Crossings. Refer to SCRRA's Grade Separation Criteria, Chapter 12 Section 12.4.4 Pedestrian Grade Separations for detail information on pedestrian overheads and underpasses. Pedestrian crossings shall be accessible in compliance with ADA and CA Title24.

7.8.1 Station Overheads

Where the track is at or below grade, then an overhead crossing may be used. A permanent minimum vertical clearance of 24 feet 6 inches shall be provided for all Overhead Structures, measured from the top of the high rail to the lowest point of the structure, the overcrossing tower structure shall not be closer than 14 feet from the centerline of the track, per ES 2101. For horizontal clearances see the Clearances section in 12.4.2 Overhead.

Access to the overcrossing can be provided through the use of ramps, or elevators complying with Accessibility requirements. If an elevator is chosen, additional vertical circulation element, should be designed for use by passengers. If alternative access is not feasible, dual elevators should be provided to provide redundancy.

Fencing on overcrossings is required to prevent large objects from being dropped onto passing trains.

Due to reliability and maintenance cost issues related to elevators, overcrossings are not preferred or recommended. Exterior maintenance of an overcrossing is also difficult and costly. The long-term maintenance of an overhead crossings will be addressed in the C&M agreement during the design and discussed with the station owner who will be responsible for maintaining the overhead crossing. Additionally, the relatively long travel distance of an overcrossing makes it undesirable to the public and ADA users.

Overpasses shall be constructed of "fire resistive materials". Finishes of overpasses shall be durable and maintenance-free. Drainage of the walking surface shall be designed so that water does not flow over the side edges, but is channeled into an internal system.

7.8.2 Station Underpasses

Where the track is at-grade or elevated on an embankment, the use of an underpass becomes the preferable alternative to an overcrossing. If used, the minimum inside clear dimensions (including drainage site treatments, signage, aesthetic surface treatments and lighting) of the pedestrian underpass structure shall not be less than 14 feet wide by 9 feet high. The underpass should have as open an aspect as possible at each side. Accessibility can be provided through the use of elevators or ramps. Ramps/stairs are preferred due to the reliability and maintenance cost issues of elevators. If elevators are used, alternate access or dual elevators should be designed for use in the event of elevator failure.

Provisions for electronic security systems should be included in an undercrossing. Depending on the site configuration and slopes, a sump pump may be required to drain the underpass during a rain event. Also, a barrier system, such as gates or vertical rolling door, should be included at each end of the undercrossing if the station owner wishes to secure the facility at night. In addition to a vertical rolling door, an emergency access/egress door shall be provided. Provision should be made for an emergency lighting system in the event of a power outage, size and capacity of emergency backup power to be developed in coordination with local agency.

Provisions for public art should be considered for underpasses along with a graffiti resistant design or coating along all underpass walls.

The entire underpass enclosure structure shall be waterproofed on the exterior surface. The surface drainage system of area drains or trench drains shall prevent surface water from entering pedestrian undercrossings.

Overpasses shall be constructed with "non-combustible materials". Finishes of overpasses shall be durable and maintenance-free.

If underpass is in an area that will be vulnerable to future sea level rise, storm surge or wave run-up, or is within the current 100year flood zone, ensure appropriate flood protection is designed to eliminate flooding.

7.9 PLATFORM AMENITIES

7.9.1 Canopies

The preferred canopy coverage is 50 percent of the platform length, however canopies shall cover a minimum of 30 percent of the platform length to accommodate passenger usage. Additionally 15 percent of the total platform square footage shall be covered. It is suggested that the structural supports be set at the back of the platform clear of the 16--foot minimum side platform width and in the center of the canopy for center platforms. Canopy configuration is at the discretion of the station designer.

The purpose of platform canopies is to provide weather protection for passengers. Side and back panels may be needed to provide adequate protection from wind (where high wind is present), sun, and rain. Semi-transparent vertical sun shades/screens should also be considered in addition to the canopies for all new platforms to ensure all day shading can be provided, whatever the orientation of the platform.

Misters should be provided in all stations identified as highly vulnerable to extreme heat in the CVA, wherever an air-conditioned waiting room is not available. Heaters may be considered in areas with extreme cold temperatures.

The canopies shall have lighting and include conduits for SCRRA's customer information system (CIS) and video surveillance system (VSS). Roof drainage at canopies should connect to a subterranean storm drain system with proper cleanouts.

At the station Owner and project sponsor's option, provisions can be made to provide drinking fountains and public charging outlets/stations on the platform.

All canopies to provide a clear zone allowing accessible use at minimum 48 inches by 36 inches.

Canopies are required above all exterior TVD's. The TVD canopy shall have lighting, provisions for passenger information, communications equipment, and electronic security systems.

The canopy height shall accommodate passenger information, communications equipment, and electronic security systems

7.9.2 Platform Furniture

All platform furniture (benches and trash receptacles) should be located in compliance with accessibility standards. All platform furniture shall be designed to be securely anchored or built into the platform. Platform furniture placed in the facility shall be designed in such a way as to prevent them from causing damage in a blast. Anchoring objects made of blast resistant, reinforced materials to the ground will make them less likely to act as projectiles and cause secondary damage, and designed to redirect blast force safely, whenever possible.

Bench selection is at the discretion of the station designer. Benches may be integral to the design of the platform. Benches should be vandal-resistant and designed to discourage sleeping on the benches. Benches must be securely fastened to the platform. When benches are provided, they must meet accessibility requirements. The preferred number of benches is one per canopy plus one bench per every one hundred feet of platform edge that is not covered by a canopy.

Trash receptacles should be provided at regular intervals on the platform. Trash receptacle selection should consider a mesh-type to prevent the placement of hidden explosive devices. Trash receptacles must be securely fastened to the platform. Recycling containers should be placed off of the platform near beverage vending machines. The preferred number of trash receptacles is one per platform bench, at a minimum provide one trash receptacle per every two platform benches.

7.10 OFF-PLATFORM AMENITIES

7.10.1 Information Kiosk/Display Cases

An information kiosk or display cases are required at stations to provide a location to display SCRRA and local information.

Kiosks and display cases are typically not internally illuminated, so they must be placed in a well-lit area or the vicinity of the TVD area if provided. Display cases may be located directly under the platform canopy.

Kiosks and display cases must be accessible.

7.10.2 Food and Beverage Vending Machines

The installation of vending machines is at the discretion of the station owner. Separate vending machine areas shall be constructed off of the platform.

Vending machines, if provided, must be accessible.

7.10.3 Emergency Telephones

If emergency telephones are provided at a station, they must comply with accessibility guidelines and have an alternate power source such as solar or battery backup, capacity of such backup system to be developed in coordination with local agency.

7.10.4 Bike Lockers and Racks

Bike storage, bike lockers, and racks should be provided near, but not on the platform. It is recommended that the station owner establish a system to regulate the use of bike lockers to prevent unauthorized long-term storage.

Bikeways shall be designed to provide a direct, convenient connection between the station and any existing or proposed bike routes throughout the community.

7.10.5 Passenger Information Phone

SCRRA provides, installs, and maintains an accessible passenger information phone on each station platform that connects directly to the SCRRA customer service center. No conduits are required for these phones because they are cellular and solar-powered.

7.10.6 Hydration Stations

The installation of hydration stations (water fountain and spout for filling water bottles) is at the discretion of the station owner, but are recommended in locations that have been identified as vulnerable to extreme heat.

7.10.7 Restroom Facilities

The installation of station restrooms is at the discretion of the station owner. Restrooms are available onboard trains for passengers. If station restrooms are provided for passengers, they shall meet accessibility requirements and meet or exceed requirements for low-flow faucets, toilets and urinals. Consider installing a hydration station as part of the station restroom infrastructure (see above 7.10.6).

A locked unisex restroom may be considered for station security personnel. If the station is also a bus layover, the transit agency may request restroom facilities for bus operators. Staff only and bus operator restrooms must be accessible.

7.10.8 Ticket Vending Device Area

SCRRA shall determine the number of TVDs (typically two) and future accommodations to be located at a station. A TVD area must be provided at a minimum of one platform entrance point. It is preferable to have the TVD located off of the platform at primary locations before entering the platform area. The TVD area requires a 12-inch-thick concrete pad for installation of the TVDs.

It is preferable to have the face of the TVDs oriented to the north to minimize screen glare throughout the day. Accessible area and queuing space shall be provided in front of each TVD.

The TVD area should not have benches or trash receptacles or other obstructions to TVD accessibility.

Installation of information display cases near the TVD area is preferred.

See ES 3405-01 and 3405-02 for TVD pad details. The station owner is responsible for providing power and MPLS conduits/cable connections to all TVDs. SCRRA will install communications cables for all ticket vending equipment. SCRRA will place the final MPLS order with the local provider. Coordination with SCRRA and station owner is required regarding ticket vending.

7.11 RECOMMENDED ILLUMINATION LEVELS

Recommended illumination levels are shown in Table 7-2.

TABLE 7-2. STATION ILLUMINATION LEVELS

Location	Average Illumination Level
Platforms	5 foot candles
Canopies	5 foot candles
Overheads and Underpasses	10 foot candles (may be adjusted per existing light levels – see below note pertaining eye adjustments)
Stairways and Ramps	5 foot candles
Walkways	5 foot candles
TVD areas	5 foot candles
Parking lots	Minimum 1 foot candle or per local requirements

Designer to implement separate day and night levels in the overheads and underpasses, to help with eye adjustments. The use of security cameras at a station may require that these levels be adjusted. Platform lights should not “blind” engineers as trains enter the station. Lighting control shall be designed to use energy efficiently. Light fixture selection and layout shall conform to Dark Sky and Title 24 code requirements. Automatic and manual control arrangements shall ensure efficient use of energy and maintenance procedures. All exterior site areas shall be illuminated by a photocell with time clock and manual override.

7.12 FENCING

Where two or more tracks serve a station, an inter-track fence shall be provided for the full length of the platform and at least 150 feet beyond each end. The fence shall be 6 feet high; however, within 150 feet of an at--grade pedestrian crossing, the fence height drops to 4 feet for improved sight distance at the crossing as required by CPUC General Orders. See ES 5102 for details of the inter-track fence.

Permanent ROW fencing shall be 6 feet high welded wire mesh per SCRRA ES 5105. ROW fencing within 150 feet of any crossing shall be 4 feet high per SCRRA ES 5106 and in compliance with SCRRA. Walkway fencing will be designed to provide a positive experience for pedestrians and motorists.

Wherever the railroad ROW can be used as a shortcut to the station, ROW fencing shall be installed to prevent trespassing onto the ROW

The station owner may consider perimeter fencing to better secure the parking area. An entrance gate should be installed if the station owner would like to close the parking lot overnight. Perimeter fencing shall be at the discretion of the designer and should be integral to the overall station design, adjacent context, or existing infrastructure.

7.13 SIGNAGE

Refer to Chapter 31 Signage, Section 31.8 for station signage design criteria.

7.14 LANDSCAPE CONSIDERATIONS

Refer to Chapter 26 Landscaping Design. See Sections 26.4 and 26.4.2

7.15 ARTWORK

Artwork should be evaluated as an installation away from the platform. For artwork installed on the platform, consideration should be made for having dedicated spaces under the canopies for artwork installations. Artwork should be under the ownership of the station owner. Artwork and aesthetic finishes shall be considered for ramp and stair walls.

7.16 STATION COMMUNICATIONS INFRASTRUCTURE

See Chapter 20 Communications Systems, Section 20.14 Passenger Station Communications Infrastructure.

7.17 STATION SECURITY

7.17.1 Security Systems

Station design should consider electronic security systems as part of the station’s physical security measures. Electronic security systems should be designed to provide maximum detection coverage with a minimum of false and nuisance alarm occurrences. These systems can be used in combination with other access management tools to provide an efficient and dependable security system. Security systems may include card access control to allow entry by authorized staff into secure areas, intrusion detection that consists of motion detectors and position monitoring of gates (automated or manually operated), roll-down doors, and pedestrian emergency exit doors. The card access and intrusion events should be video recorded and assessed in real-time using remote video surveillance cameras. Refer to the FTA Transit Security Design Considerations for additional security system criteria.

When designing a remote video surveillance system, it is important to consider positioning cameras to avoid potential obstacles, such as structural columns and sharp corners that may prevent full surveillance coverage of the intended target. Where a single camera cannot capture the entire area, multiple cameras can be positioned to provide overlapping coverage areas. Various types of cameras should be considered for each specific camera location depending on the intended target. Typical camera type for stations include: stationary, pan/tilt/zoom ability multi-image sensor 360-degree/180-degree wide angle. All cameras should consist of high definition resolution, produce a clear image in very low light, and suitable for the environment in which the camera is installed. SCRRA shall be consulted on types and placements of security cameras. The mounting height of the cameras should be such that it is unreachable by any pedestrian. The surveillance video may be sent back to the local authority’s monitoring station, however, SCRRA shall be able to request access to any recorded video and shall be provided the exported video within 72 hours of the request. Video storage requirements, quantity, quality and duration, to be coordinated per individual project requirements.

SCRRA station standards include sufficient conduit on the platform to support the electronic security systems equipment. If desired by the station owner, project sponsor, member agency, and/or SCRRA, electronic security measures at stations shall be designed and installed to maintain passenger and staff security.

7.17.1 Crime Prevention through Environmental Design

Ensure the station design aligns with the principles of Crime Prevention through Environmental Design (CPTED). CPTED Principles include natural surveillance, natural access control, territorial reinforcement and maintenance. Table 7-3 provides a high level overview of each concept.

TABLE 7-3. Crime Prevention through Environmental Design

CPTED Principle	Reference
Natural Surveillance	The placement of physical features, activities, and people in a way that maximizes visibility.
Natural Access Control	Control access to a site by physically guiding activity through space by the strategic design of streets, sidewalks, building entrances, and landscaping.
Territorial Reinforcement	The use of physical attributes that express ownership such as fencing, pavement treatments, signage, and landscaping.
Maintenance	Allow for the continued use of the station for its intended purpose. Serves as an additional expression of ownership.

7.18 CONSTRUCTION

Similar to station design, a station owner may bid and award a contract to construct a new SCRRA station or make modifications to an existing station or may enter into a cost reimbursement agreement with SCRRA to have SCRRA award and manage a construction contract. In either case, SCRRA must be actively involved in the management of any SCRRA station construction.

7.19 STATION MAINTENANCE

Upon acceptance of a station project, the station owner is responsible for the operation, maintenance, and security of the station.

7.19.1 SCRRA Maintenance

SCRRA will be responsible for the ongoing operation and maintenance of the ticket and information systems, platform and ROW signage, and station communications shelter.

7.19.2 Station Owner Maintenance

The station owner’s responsibilities include, but are not limited to housekeeping and maintenance of the station and related parking facilities not listed above.

Maintenance shall be performed on an “as-needed” basis to keep the station improvements in good order, condition, and repair at all times.

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8.0 HIGHWAY-RAIL GRADE CROSSINGS

8.1 SCOPE

SCRRA highway-rail grade crossings are operated under relatively dense (> 50 daily) mixed commuter, multiple units, LRT, freight, and inter-city passenger train traffic, with relatively high levels of motor vehicle, pedestrian, and bicycle traffic.

This chapter provides the Grade Crossing Designer with criteria necessary for the development of a new or enhanced Highway-Rail Grade Crossing. For additional information about Highway-Rail Grade Crossings see the SCRRA Grade Crossing Manual and chapter 12 of the DCM.

8.1.1 Purpose

The purpose of this chapter is to mitigate challenges associated with highway-rail grade crossing design by providing guidelines to address potential design or planning flaws that may arise.

Applying the design standards and criteria in this chapter will enhance the safety and efficiency of the highway-rail grade crossing and result in a highway-rail crossing that reflects "best practices" on a national basis. When considering the standards and criteria in this chapter, all design teams must exercise sound judgment and take into consideration the unique conditions that exist at each highway-rail grade crossing.

8.1.2 Design Standards and Criteria

The standards and criteria provided in this chapter shall be applied when:

- A significant physical change or traffic volume increase (rail, vehicle, pedestrian) is proposed, or occurs, to an existing highway-rail grade crossing, inclusive of motor vehicle highway and non-motor vehicle pedestrian and bicycle approaches.
- A significant change in use is proposed, or occurs, to the highway-rail grade crossing; especially changes in use resulting in significant increases in vehicle, pedestrian, bicycle, train traffic, or changes in traffic patterns.

All existing grade crossings being modified shall go through the steps in Chapter 12 Grade Separation Criteria, Subsection 12.3 before being modified at-grade.

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

8.1.3 SCRRA Policy on New Highway-Rail Grade Crossings

SCRRA's Board (Board) has passed Resolution 91-3 and Resolution 98-21 (See Appendix I) pertaining to the establishment of a new highway-rail grade crossing on SCRRA's system. SCRRA's policy, as well as State and National policy, strongly discourages the construction of new highway-rail grade crossings and seeks to reduce the number of active highway-rail grade crossings by promoting grade separation or closure of existing highway-rail grade crossings. In accordance with Resolution 98-21, a new, additional highway-rail grade crossing is not allowed unless the member agency of SCRRA sponsors the request to construct it and the SCRRA Board approves the request. This resolution also requires the member agency to sponsor the closure of a nearby existing and in-service highway-rail grade crossing(s) in order to open a new highway-rail grade crossing, so there will not be a net increase in the number of highway-rail grade crossings on SCRRA's commuter rail system.

New highway-rail crossings should only be permitted when the following can be demonstrated:

- Where there is a clear and compelling public need (other than enhancing the value or development potential of the adjoining property for new highways or streets)
- Grade separation cannot be economically justified, i.e., benefit-to-cost ratio on a fully allocated cost basis is less than 1.0 (when the crossing exposure exceeds 50,000 in urban areas or exceeds 25,000 in rural areas)
- There are no other viable alternatives to provide access

If a crossing is permitted, the following conditions should apply:

- Whenever a new highway-rail crossing is constructed, consideration should be given to closing one or more adjacent crossings
- If it is a main track, the crossing should be equipped with active devices with gates
- The plans and specifications will be subject to the approval of SCRRA, CPUC, and the highway authority having jurisdiction over the roadway, and any other diagnostic stakeholders
- All costs associated with the construction of the new crossing should be borne by the party or parties requesting the new crossing, including providing financially for the ongoing maintenance of the crossing surface and traffic control devices where no crossing closures are included in the project
- Whenever new public highway-rail crossings are permitted, they should fully comply with all applicable provisions herein

8.1.4 Closure or Separation

The first alternative that should always be considered for a highway-rail crossing is elimination, which can be accomplished by the following:

- Replacing the crossing with a grade separated facility
- Closing the crossing to highway traffic and removing the roadway crossing surface
- Closing the crossing to railroad traffic through the abandonment or relocation of the rail line and removal of the railroad tracks

Closure of a crossing provides the highest level of crossing safety compared to other alternatives, because the point of intersection between highway and railroad is removed. However, the effects of closure on highway and railroad operations may not always be completely beneficial. The major benefits of crossing closure include reductions in certain types of collisions and decreased delays to highway and rail traffic, as well as lowered maintenance costs.

Decisions about whether a crossing should be eliminated or simply improved depends upon safety, operational, and cost considerations. However, federal regulation (23 CFR 646.214(c)) specifies that "all crossings of railroads and highways at grade shall be eliminated where there is full control of access on the highway (a freeway) regardless of the volume of railroad or highway traffic." (See 8.5.9 and Chapter 12).

8.2 HIGHWAY-RAIL GRADE CROSSINGS

At-grade highway-rail grade crossings, also known as “level” crossings or highway-rail grade crossings, are locations where trains intersect with other modes of transportation, including motor vehicles, pedestrians, and bicycles. In order to provide for safety at the highway-rail grade crossings, warning devices such as vehicle gates, flashing lights, bells, signage, medians, and pavement markings are incorporated to warn users of the highway-rail grade crossing of approaching trains.

8.2.1 Public Highway-Rail Grade Crossings

In this chapter, the term “highway-rail grade crossing” will be used to mean rail-grade crossing, rail crossing, at-grade crossings, or crossing. The term “highway” will be used to mean highway, road, or approach road. A large majority of SCRRA’s highway-rail grade crossings are categorized as public highway-rail grade crossings.

8.2.2 Private Highway-Rail Grade Crossings

In many cases, SCRRA, or the member agency, provides access to private property under an agreement between the property owner and SCRRA member agency. These highway-rail grade crossings are prevalent where a highway or driveway is used as the means of accessing private property that would otherwise be landlocked. A private highway-rail grade crossing might also be used in cases where the railroad intersects private property and the private crossing allows necessary access between sections of the private property divided by the railroad (e.g., farmland). All private active or passive highway-rail grade crossings shall be subject to the standards and criteria that are applied to permanent highway-rail grade crossings in this chapter.

8.2.3 Temporary Construction Crossings (Not Used by the Public)

Temporary construction crossings shall be approved by SCRRA. Temporary construction crossings will only be considered by SCRRA where it is shown that extreme hardship and/or unusual conditions exist that justify the crossing.

Temporary construction crossings shall not be open to the public and shall be designed and constructed in accordance with SCRRA ES 4302.

Temporary construction crossings shall be secured, gated, and locked with an SCRRA lock to ensure no access is possible when not in use. Access across temporary construction crossings shall be controlled by an SCRRA Roadway Worker In Charge (RWIC) and shall only be used when an SCRRA RWIC is present at the worksite.

Whistling point signs per SCRRA ES 5216 shall be installed 1,320 feet (0.25 mile) from the centerline of the temporary construction crossing in each direction along the track and shall remain in place for the duration that the temporary construction crossing is in place. Whistling point signs shall be removed once the temporary construction crossing is removed.

Temporary construction crossings in place for 6 months or more will require a Department of Transportation (DOT) number assigned to the crossing. SCRRA will provide the DOT number upon request. Emergency Notification System (ENS) Signs per SCRRA ES 8270 shall be posted at the temporary construction crossing for the duration the crossing is in place.

8.2.4 Temporary Highway-Rail Grade Crossings (Used by the Public)

A temporary highway-rail grade crossing occurs when the highway, railroad, or both is temporarily relocated to a new location. The temporary relocations can be due to the construction of a grade separation, a railroad line change, or some other major construction project that requires the relocation of road or track. Relocated or temporary highway-rail grade crossings shall be subject to the standards and criteria that are applied to permanent highway-rail grade crossings in this Manual.

8.2.5 Highway

The overall design and requirements of the highway is set forth in the standards and criteria of the highway agency, AASHTO Publications, CPUC General Orders, CA MUTCD, and Caltrans Standards, and shall be consistent with the requirements of this chapter. In most cases, the highway agency has jurisdiction over the highway, outside of the immediate area of the crossing. SCRRA and highway agency jurisdictional limits are generally defined by CPUC GO 72 and covered in more detail in the C&M Agreement.

The overall quality of the constructed highway, including approaches to the highway-rail grade crossing and the crossing itself, shall be sufficient to:

- Provide for a smooth ride for motor vehicles at the posted speed limit.
- Provide a smooth ride for train traffic at the designated operating speeds.
- Provide safe stopping sight distances (in accordance with the posted speed limit).
- Provide adequate highway and adjacent intersection capacity or mitigate/control the queue such that motor vehicles do not queue on the tracks.
- Include the display of appropriate signing and pavement markings and in compliance with the CA MUTCD.
- Provide for ADA compliance for pedestrians through the crossing.
- Minimize or eliminate sight restrictions for highway users and train operations.

- Allow highway users to make clear and informed decisions that will minimize traffic congestion and the potential for conflict.
- Comply with the standards and criteria in this chapter.

On the approaches to a crossing, the characteristics of the approach highway, traffic signals, and approach sidewalks are an extremely important factor in developing an effective design of the highway-rail grade crossing. Grade Crossing criteria in this chapter as well as in the ES 4000 series shall be adhered to.

8.2.6 Highway and Railroad Geometry

As applied to highways and railroads, geometry defines the horizontal and vertical curvature. “Crossing geometry” refers to the geometrical relationship between the alignment of the crossing highway and the railroad. This horizontal relationship may be perpendicular or skewed. The vertical relationship may include “humps”/profile deficiencies or vertical curves. These geometric features can affect traffic operations at a highway-rail grade crossing. Additional geometric concerns, such as the elevation of the crossing and the number of lanes, are also aspects that shall be considered during the design of the crossing. The geometric characteristics of a highway-rail grade crossing greatly affect the visibility of the crossing to users—motorists, bicyclists and pedestrians alike.

Sight distance shall be considered to the extent possible within the design of the highway-rail grade crossing geometry and provide horizontal and vertical curves that provide an unobstructed view of the crossing. The horizontal and vertical alignment of the highway at the approaches to the crossing, in addition to the geometry of the railroad tracks, are major factors in considering sight distance and overall visibility at the crossing.

8.2.7 Highway-Rail Grade Crossing Geometry

It is SCRRA’s policy, wherever possible, to have the highway intersect the railroad at a right angle. When a right-angle highway-rail grade crossing cannot be achieved due to physical constraints, the interior angle shall be designed as close to 90 degrees as practical, but shall not be less than 75 degrees.

Active warning devices shall be installed 15 feet from the centerline of the track, as measured from the center of the mast, at new or existing highway-rail grade crossings.

For skewed crossings, highway active warning devices shall be installed perpendicular to the highway and 15 feet from the centerline of the track, as measured from the either the center of gate mast or tip of the gate (whichever is closer). See ES 4011 through ES 4016.

In cases where space is limited, gates may be placed at a minimum of 12.0 feet from the centerline of track and/or parallel with the track with approval from SCRRA.

Configurations that will minimize pedestrian travel time between pedestrian gates over the highway-rail grade crossing, while providing pedestrian gate arms of minimum length shall be developed.

A. Level of Service

The term “Level of Service” (LOS) is normally used to describe the performance of the roadway network in terms of its operational ability to meet traffic volume demands. Factors that characterize LOS include vehicle speed, travel time, freedom to maneuver, traffic interruptions, and convenience. LOS is a mechanism used by highway departments, or highway agency, to determine if a road is operating at ideal, average, or poor efficiency. The LOS relates the quality of traffic service to given traffic volumes. The Transportation Research Board Highway Capacity Manual defines six levels of service, designated A through F, with A being the highest (free flow) and F the lowest (unacceptable and extreme congestion). At all highway-rail grade crossings that SCRRA owns and maintains, any major modification to the crossing should allow the crossing to perform at a level of service rating of “D” or higher.

Factors other than LOS will affect the overall operation of traffic at a highway-rail grade crossing. To accommodate traffic-related issues, the design of a highway-rail grade crossing should include all aspects affecting the flow of traffic—regardless of LOS.

The traffic flow is affected by warning devices and signage associated with highway-rail grade crossings. Also, the LOS may directly affect the progression of traffic between traffic signals at adjacent intersections with the highway-rail grade crossing signaling system.

B. Highway Design Vehicles

Both the highway horizontal and vertical design criteria and the design vehicles are established by the highway agency having jurisdiction over the highway. The highway authority, with CPUC concurrence, needs to establish the typical design vehicle for the grade crossing based on current or expected use. For SCRRA highway-rail grade crossings the following design criteria shall be used:

AASHTO WB-65 semi-tractor-trailer

Long wheelbase vehicles or trailers with low ground clearance.

The highway design vehicle used for horizontal highway geometry design at highway-rail grade crossings and grade crossing approaches. In locations where the WB-65 vehicle may be prohibited access, the mere posting of signage restricting access to a highway, such as “NO TRUCKS OVER 3 AXLES” or “NO TRUCKS OVER 3 TONS”, should not be considered a reliable deterrent for controlling truck access to a SCRRA highway-rail grade crossing. Therefore all vehicles that may utilize the crossing shall be considered, regardless of posted signs prohibiting access.

Highway-rail grade crossing vertical profiles shall be analyzed with the Low-Ground Clearance Vehicle template to determine the clearance for this vehicle type. The Low–Ground Clearance Vehicle template has a nominal six inch ground clearance. Highway-rail grade crossings should provide a minimum clearance of three inches between the street surface and the lowest point on the Low-Ground Clearance Vehicle template. Vehicle template should be chosen in coordination with SCRRA.

In the event site conditions do not allow for the design to meet the Low-Ground Clearance design vehicle template, consider installing a W10-5 low-ground-clearance sign (as specified in the CA MUTCD) on each approach to the highway-rail grade crossing sufficiently in advance of the crossing to allow low-ground clearance vehicles to turn around in advance of the highway-rail grade crossing. In addition, as recommended by the CA MUTCD, a supplemental message such as “Ahead,” “Next Crossing,” or “Use Next Crossing” (with appropriate arrows) should be placed at the nearest intersecting road where a vehicle can detour, or at a point on the highway wide enough to permit a U-turn.

C. Horizontal and Vertical Alignment

The horizontal and vertical geometry of the highway approaches and adjacent intersections (immediately upstream and downstream of the highway-rail grade crossing) shall safely accommodate all anticipated traffic movements and required clearances of the highway design vehicle.

D. Proximity to Adjacent Traffic Outlets

The design must consider highway-rail grade crossing proximity to highway intersections, alley intersections, and driveways, and the impact of adjacent traffic control devices on the operation of the highway-rail grade crossing. Refer to Section 8.2.9 Driveways for additional information on driveways.

E. Highway Pavement

The pavement within 50 feet of the highway-rail grade crossing should be designed to high standards in terms of thickness, materials, and quality of construction, in order to minimize or prevent the need for future repairs or rehabilitation. The need for a high quality, low maintenance pavement is particularly important where any exit gate loop detectors are located. Asphalts shall conform to Caltrans or Greenbook specifications and asphalt lifts shall be a minimum of 2 inches and a maximum of 4 inches to allow for proper compaction to ensure a quality pavement section.

F. Design Speed

The design speed of the highway-rail grade crossing highway is usually equal to or slightly above the posted speed limit that is set by the highway agency. The highway agency having jurisdiction over the highway-rail grade crossing shall be consulted to determine the design speed over the highway-rail grade crossing.

G. Highway Horizontal Curves

Horizontal curves in the highway may create overall visibility challenges. In cases where existing horizontal curves in the highway affect the overall visibility of the crossing, the following process shall be adhered to:

- Analyze the sight distance through the approaches to the highway-rail grade crossing, utilizing highway design criteria defined by the agency having jurisdiction over the highway.

- Determine the feasibility of highway geometry modifications to enhance the visibility of the crossing.
- Use additional signaling or warning devices as necessary to mitigate the effects of horizontal curves on visibility.

H. Vertical Profile of the Highway and Highway Cross Slope

The following items shall be followed when developing the design of the vertical profile of the highway:

- The approach grades to the highway-rail grade crossing shall be minimized. A steeper slope on the approaches to the highway-rail grade crossing will increase the acceleration time and, consequently, will increase preemption time for the traffic signals related to the crossing. Transitions of the edges of the pavement (EP) of the highway-rail grade crossing approach highway—from the normal 2 percent cross-fall (from centerline to EP) to the track grade (where both halves of the highway will slope to match the profile of the railroad track) —shall be accomplished in a manner that will not create any abrupt changes in the highway. Refer to SCRRA Grade Crossing Manual for additional guidance.
- Vertical curves within the highway at a Highway-Rail Grade Crossing shall not be allowed. Vertical curves outside of the Highway-Rail Grade Crossing should meet the Stopping Sight Distance requirements from the latest editions of the Caltrans Highway Design Manual, or AASHTO publication entitled A Policy on Geometric Design of Highways and Streets.
- At highway-rail grade crossings with multiple tracks, the tops of the rails for all tracks shall be in the same plane. The intersection of highway and railroad shall be as level as possible.
- The highway vertical profile grade at lip of gutter pan should be zero percent within 10 feet of the centerline of the nearest track and the grade can be increased to 1.11 percent up to 37.50 feet from the centerline of the nearest track. Beyond 37.50 feet from the centerline of the nearest track, the grade on the approach to the highway-rail grade crossing shall be minimized, with due respect for low-ground-clearance vehicles, to allow maximum acceleration by heavy trucks. Refer to SCRRA ES 4001 for additional details.

I. Truck Movements

The design of improvements to the highway-rail grade crossing must factor in all likely means by which the highway-rail grade crossing shall be traversed. The design shall allow for the free movement of the design vehicle throughout the highway-rail grade crossing envelope and downstream intersections. The turning radius of the horizontal design vehicle shall be applied for all allowable turning movements, superimposing the vehicle wheel paths and vehicle body paths onto the proposed highway-rail grade crossing design. This shall be accomplished using the appropriate truck turning template software.

Curb return radius, and the location and length of raised medians may need to be refined based on the design vehicle for that crossing. In some cases, the installation of additional traffic control methods such as raised medians may not be required if the raised median (or other control measure) would prevent a design vehicle from safely traversing the crossing and/or adjacent intersection.

Effective ingress and egress shall be provided for the typical design vehicle traversing the crossing. The following steps shall be followed during the design process:

- Analyze the turning radius of the WB-65 design vehicle within the proposed design.
- Mitigate the effects of insufficient turning radius within the design.
- Submit a drawing demonstrating that the design vehicle successfully navigates into and through the designed highway-rail crossing.

J. Railroad Geometry and Condition of Railroad Facilities

If the railroad geometry and facilities in the vicinity of the highway-rail grade crossing do not meet current SCRRA standards, or the railroad facilities are not in acceptable condition, the railroad facilities shall be reconstructed to correct any deficiencies. Designer is encouraged to review geometry and condition of the railroad 1000 feet either direction from the project limits.

A review and analysis of the railroad geometry is particularly important if the highway-rail grade crossing is located within, or near, a railroad curve; or if other special railroad facilities exist near the crossing such as special trackwork (turnouts and crossovers), a passenger station, or a railroad bridge.

Additionally, the location of special trackwork, station platforms, bridges, wayside signals, signal or communication houses, pull boxes, longitudinal utilities (both surface and underground), and the location of all existing active warning devices should be determined.

After the survey of the existing railroad geometry and facilities is conducted, the necessary engineering and condition analysis to determine the changes and modifications required to bring the railroad facilities into compliance with current SCRRA standards and criteria shall be performed with input from SCRRA.

K. Highway Approaches

Highway approaches to a highway-rail grade crossing shall, at a minimum, be designed to meet the requirements set forth in CPUC GO 72. The following highway-rail grade crossing requirements are contained in CPUC GO 72:

- Part III, Width of Public Crossings:

  [Highway-rail] grade crossings shall be a width not less than the traveled approach portions of the adjacent sections of road, highway or street, including usable shoulders and sidewalks [pedestrian pathways].

- Part IV, Minimum Width:

  [Highway-rail grade] public crossings hereafter constructed shall not be less than twenty-four feet wide in effective roadway width measured at right angles with the centerline of the roadway.

- Part V, Deceleration and Acceleration Lanes:

  Deceleration and acceleration lanes for vehicles required to stop at railroad [highway-rail] grade crossings should be provided wherever public agencies [highway agencies] determine such lanes are necessary. Deceleration and acceleration lanes should also be provided on roadways adjacent to the grade crossing to address safety concerns for vehicles turning towards the grade crossing or departing the grade crossing area and needing to merge into the flow of traffic on the adjacent roadway. Without proper acceleration lanes on the adjacent roadway and at un-signalized intersections, vehicles could queue back onto the grade crossing while waiting for a gap in traffic. If acceleration lanes cannot be provided, a traffic signal may be warranted to mitigate safety concerns. Refer to CA-MUTCD, Part 4 for Traffic Signal Warrant 9 – Proximity to a Grade Crossing.

- Part X, Surface of Crossings:

  At the time of construction, the surface of the highway shall be installed to conform to the plane of the rails for the entire area between rails, between tracks, and to two feet outside the rails.

  Where crossings involve two or more tracks, the top of rails for all tracks shall be brought to the same plane where practicable. The surface of the highway shall be at the same plane as the top of rails for a distance of at least two feet outside of rails for either multiple or single-track [highway-rail grade] crossings. The top of rail plane shall be connected with the grade line of the highway each way by vertical curves of such length as is required to provide riding conditions and sight distances normally applied to the highway under consideration.

- Part XI, Approach Grades:

  Approach grades not in excess of six percent are desirable, but where not reasonably obtainable due to local topographical conditions, the gradients in the vicinity of the rails shall be kept as low as feasible.

Should the Project Lead modify an existing highway rail crossing that has more than six percent approach grades, the Project Lead should modify the approach grades to meet CPUC GO 72. Refer to Crossing Profile –Vertical Alignment section of U.S. Department of Transportation, Federal Railroad Administration Highway-Rail Crossing Handbook for additional useful information and recommendations on vertical curves.

The approach grades are defined to be 30 feet from the outermost rail.

It is important that vehicles traversing the highway-rail grade crossing be given a clear avenue of escape after, or downstream of, the highway-rail grade crossing. To clarify, a vehicle entering the footprint of the highway-rail grade crossing shall have an unimpeded means of clearing the crossing. In cases where there is an intersection adjacent to the crossing, it may be necessary to add a refuge in the cross-traffic direction to allow a design vehicle to clear the intersection and move onto the cross street without constraining the movement of cross traffic.

L. Highway and Railroad Interface

Sidewalks and pavement approaches to the highway-rail grade crossing shall be constructed using hot mix asphalt concrete between the crossing panels and a distance of ten feet from the centerline of the track.

8.2.8 Median Islands

A. General

Installing raised medians on approaches to highway-rail grade crossings is an effective way to channelize motorists and discourage RR warning device gate circumvention, U-turns movements and motorist access to/from adjacent driveways which could impede safety at the highway-rail grade crossing.

B. Design Requirements

Design of median islands shall conform to the latest SCRRA Engineering Standards as well as criteria from the AASHTO publication titled “A Policy on Geometric Design of Highway and Streets”.

Raised median islands shall be used on both approaches where possible to the highway-rail grade crossing to constrain undesirable traffic movements

On each approach to the highway-rail grade crossing, the raised median shall begin 10 feet from the centerline of the nearest track. The end of the median adjacent to the highway-rail grade crossing shall be square, with a six-inch radius on the corners to discourage motorists from making left or U-turns on the grade crossings, between the raised median islands.

The preferred length of the median as measured from the highway-rail grade crossing gate shall be 100 feet. When not feasible a minimum of 60 foot raised median is required to channelize automotive traffic. The width of the median shall be ten feet minimum if a warning device is installed in the median and four feet if no warning device is installed in the median. The minimum width of the median may be two feet with the approval of SCRRA and the highway agency. Raised median height shall be eight inches.

It is preferable that the median island width remains a minimum of 10 feet for the entire length of the median. However, in circumstances where ROW is limited or channelization for left turn lanes downstream is required, the median width must remain a minimum of 10 feet for a distance of 20 feet beyond the warning devices, to allow adequate room for SCRRA’s signal forces to maintain the RR warning devices.

The height of the median curb is recommended to be 6” by FRA. CPUC recommendation is to use 8” high median curb. The median curb height will be 8” for all SCRRA system grade crossings.

Table 8-1 shall be used in the selection and design of raised medians.

TABLE 8-1. STANDARD SCRRA APPLICATIONS OF RAISED MEDIANS

Design Conditions	Option 1	Option 2	Notes
Adjacent driveways	Install Raised medians to extend past driveway	Raised medians extending past the driveway, and shaped to limit vehicular movements	The use of the raised median shall effectively control vehicular activity at the driveway
Multiple lanes	Install raised medians for additional highway-rail grade crossing gates	N/A	Raised medians are mandatory in instances where additional gates and lights are needed for proper lane coverage
Light traffic or rural area	Install raised medians	N/A	The use of the median shall effectively control vehicular activity
Limited highway right-of-way	Install raised medians	Install raised delineators, upon approval of roadway owner	The installation of medians may require the acquisition of additional highway right-of-way
Insufficient truck turning radius	Extend median to the maximum length that still accommodates truck movements	Consider exit gates	Insufficient Truck turning radius may be a defining component on the use of exit gates instead of raised medians
Insufficient right-of-way for a raised median	Acquire additional right-of-way for the installation of the raised median	Use surface mounted channelizers , if right of way acquisition is not possible	The installation of surface mounted channelizers or other devices between traffic directions should be considered if the acquisition of additional right-of-way is possible

In addition to preventing vehicles from driving around gates, well designed medians limit movements into and out of driveways near highway-rail grade crossings, as discussed in Section 8.2.6, thus minimizing vehicle queuing hazards associated with cross-traffic vehicle movements.

The primary median width requirement, per CPUC, is that there shall be a minimum horizontal clearance of two feet between any part of the median installed railroad warning device (typically the RR flasher backplate) and the face of the curb.

C. Median Landscaping

In general, trees, shrubbery, and similar view obstructing landscaping are not allowed on highway approaches within 150 feet of a highway-rail grade crossing or in the median within 150 feet of the crossing. Low maintenance stamped concrete, pavers, decomposed granite, ballast rock or other hardscape materials shall be the standard landscape treatment for median islands and sidewalk approaches to grade crossings.

8.2.9 Driveways

The location of driveways, alleys, or similar facilities (with respect to the highway-rail grade crossing) can significantly affect the safety associated with highway-rail grade crossing operations.

New driveways (private or public) shall not be located within 100 feet of the nearest highway-rail grade crossing active warning gate. Existing driveways within 100 feet of the nearest highway-rail grade crossing active warning gate shall be removed or appropriately reconfigured to achieve safety objectives such as increased safety of automotive and pedestrian traffic.

Table 8-2 shall be consulted for the design of mitigations when driveways are located adjacent to the crossing:

TABLE 8-2. DRIVEWAY MITIGATIONS

Driveway Location	Raised Medians	Signage	Warning Gates
Near-side	Install	Install R3-5 (RT) “Right Turn Only” sign at the driveway; one-way signage installed in the raised median	Installed at entrance quadrant
Far-side	Install raised island at the driveway to prohibit left turns toward the tracks	Install R3-5 (RT) “Right Turn Only” sign at the driveway; one-way signage installed in the raised median	Installed at entrance quadrant. Consider exit gates if there is a possibility of unsafe access through the raised median

Driveways adjacent to a highway-rail grade crossing which require vehicle reversing (backing) movements shall not be allowed and the highway agency shall prohibit the reversing moves. If the driveway can only be accessed by a backing movement by the design vehicle, then this driveway will need to receive one of the following mitigations to eliminate any reversing movements near the grade crossing:

- Relocate the driveway away from the grade crossing to provide sufficient turning capability for the design vehicle.

- Modify the loading/unloading area/location to provide sufficient turning capability for the design vehicle so that a reverse movement into the driveway is not required.
- Widen the highway so the design vehicle can exit the travelled way and provide sufficient turning capability for the design vehicle.

The design and actual usage of the driveway shall not allow the reverse movement of vehicles through and over the highway-rail grade crossing while entering or exiting the driveway.

In such instances, the roadway owner shall endeavor to close the near-side driveway or work with the adjacent property owner to control this access to address the unsafe vehicle movements. Special traffic signage and other traffic control devices shall be installed to control undesirable traffic movements, especially reverse or slow movements into or out of driveways near tracks.

8.2.10 Visibility

It is SCRRA's policy to work jointly and responsibly with highway agencies, and other adjacent private property owners, to ensure that proper visibility is maintained at the highway-rail grade crossing. Buildings, fences, walls, billboards, highway geometry, trees, vegetation, natural or man-made embankments, or other man-made structures will play a significant role in the overall visibility at the highway-rail grade crossing, and these features will become important in the geometric design process. The CA MUTCD requires that all advance warning signage, pavement markings, and highway-rail grade crossing warning devices be clearly visible to the approaching motorist.

Horizontal and vertical curves within the highway near, or at, the highway-rail grade crossing create additional concerns. In cases where the sight distance is not sufficient to allow adequate braking prior to the crossing, the need for active/RR-interconnected advance warning devices should be examined.

Of particular concern is stopping sight distance near and across the highway-rail grade crossing. Refer to the Vertical Profile of the Highway and Highway Cross Slope Section 8.2.7-I Highway and Railroad Geometry, for highway geometry that impacts stopping sight distance. All aspects of the highway geometry shall be examined and follow the Caltrans Highway Design Manual or AASHTO publication titled "A Policy on Geometric Design of Highways and Streets" requirements for stopping sight distance. During the design phase, all measures for improving visibility at crossings shall be examined and any detected hazards shall be mitigated.

The following actions shall be taken during the design of a grade crossing to preserve and improve visibility at highway-rail grade crossings:

- Prohibit new trees at highway-rail grade crossing approaches and medians, and ensure existing trees are trimmed on a regular basis by the highway authority for proper visibility.
- Prohibit new ground covers or shrubs within 150 feet of the near rail crossing, and ensure the existing trees are trimmed for proper visibility.
- Investigate the possibility of mitigating the effects of adjacent development on overall visibility at the crossing, related to location of structures, signage and other features.

- Ensure stopping sight distances are per the Caltrans Highway Design Manual or the AASHTO publication titled "A Policy on Geometric Design of Highways and Streets".
- Prohibit Vehicle parking within 100 feet of the highway-rail grade crossing, as measured from the furthest automatic warning device from the tracks.

8.2.11 Sight Triangles

It is SCRRA's policy to work jointly and responsibly with highway agencies, and other adjacent private property owners, to ensure that improvements to properties adjacent to the railroad corridor, and particularly at highway-rail grade crossing, are designed so as to mitigate the effects of the development on highway-rail grade crossing safety. See Railroad-Highway Grade Crossing Handbook published by FHWA Chapter 2 Engineering Treatments.

8.2.12 Passive Traffic Control Devices

Passive warning devices are traffic control warning devices not activated by trains, vehicles, or pedestrians. Passive warning devices provide static messages of warning, guidance, and (in some instances) mandatory action for the motorist, bicyclist, or pedestrian. Passive warning devices placement shall be consistent with and not conflict visibility of active traffic warning devices. The application of passive warning devices is defined in Part 8 of the CA MUTCD.

A. Signage

See Design Criteria Section 31.7 Highway Rail Grade Crossing Signage for Signage criteria at highway-rail grade crossings.

B. Roadway Striping and Pavement Markings

Striping and pavement markings are defined within Part 8 of the CA MUTCD and SCRRA ES 4006. The configuration and location of striping shown in Chapter 8 of the CA MUTCD and SCRRA ES 4006 shall be adhered to.

SCRRA has defined additional striping and delineation requirements that apply to highway-rail grade crossings where SCRRA is jointly responsible with the highway agency. These measures include the following:

- White edgeline striping with raised pavement markers along edge of travel way: (SCRRA ES 4011 through 4017)
- Yellow median striping with raised pavement markers between raised medians: (SCRRA ES 4011 through 4017)
- 24" white RR Stop Line, located 8' (min) in advance of nearest RR flasher
- White "KEEP CLEAR" pavement markings: (CA MUTCD Section 3B.17 and Caltrans Standard A24E)
- White "WAIT HERE" pavement markings: (Caltrans Standard A24D)
- Turn Arrows upstream of the crossing are prohibited

The highway agency is responsible for approving the use of highway pavement markings. This will require coordination with the highway agency. Maintenance responsibilities for pavement markers, channelization/traffic control features, striping and pavement markings are the responsibility of the highway agency, unless defined otherwise in the C&M agreement.

8.2.13 Active Traffic Control Devices

All SCRRA public highway-rail grade crossings shall be equipped with active warning devices to warn roadway users of a train on approach to the crossing, in accordance with CPUC GO 75, this chapter, and the CA MUTCD. Furthermore, it is SCRRA's policy that any new SCRRA private highway-rail grade crossing shall be equipped with standard active equipment at the private owner's expense and maintenance costs (subject to annual increases) of the standard equipment shall be borne by the private owner for the life of the crossing.

A. Design Requirements

The placement of active warning devices is an important factor in the overall design process. Baseline criteria have been developed to use for guidance in the placement of the highway-rail grade crossing devices. It is SCRRA standard to provide flashing lights for each traffic lane approaching the highway-rail grade crossing. For more detailed information on the location, dimensions, selection of warning devices, and how the railroad signaling system works in conjunction with the warning devices, refer to SCRRA's Engineering Standards for Signals and Communications.

Each warning device is constructed on a substantial foundation required for the safe support of the device. These foundations may require a large footprint and must be considered in the placement of the device. The utilities and drainage associated with the highway-rail grade crossing shall be considered when developing the overall layout of the devices. Additionally, the position of present and future foundations must be taken into account when considering utility encroachment—it may be necessary to relocate utilities and other facilities that could interfere with these foundations. Conflicts with overhead utility wires and gate arms should also be considered during the development of the overall device layouts.

For additional information on the various types of warning devices, refer to CPUC GO 75 and SCRRA Engineering Standards. In addition to the crossbuck, a sign indicating the number of tracks (if two or more tracks are present) at the crossing is mounted on each RR Warning Device to indicate the presence of multiple tracks at the crossing.

Some applications of RR flashing lights include backlights mounted on the mast in addition to the standard flashing signal configuration. SCRRA's policy is to not use backlights on exit gates and median mounted entrance gates to avoid motorist confusion.

When a Standard No. 9 Gate is used, the flashing light mounted on the mast shall provide warning for the curb and the traffic lane. If there is more than one lane, and highway width is greater than the maximum length of the single gate arm, an additional device on a raised median will be required. Additionally a No. 9-A cantilever signal may be used for flasher placement over additional travel lanes.

Where pre-signals are installed, the locations of both the railroad and traffic signals shall be evaluated to ensure the combination of traffic lights and highway-rail grade crossing warning lights is coordinated and do not conflict with one another, thus mitigating possible confusion for motorists approaching the tracks. A line of sight evaluation should be conducted to ensure visibility of all devices. Final configuration and types of proposed warning devices is subject to approval by SCRRA.

B. Crossing Gate Systems

i. Entrance Gate System

Standard RR gate systems utilize entrance gates installed in the approach quadrant of the highway-rail grade crossing and in the approach median when necessary. Also depicted here are optional Pedestrian Gates. (Figure 8-1).

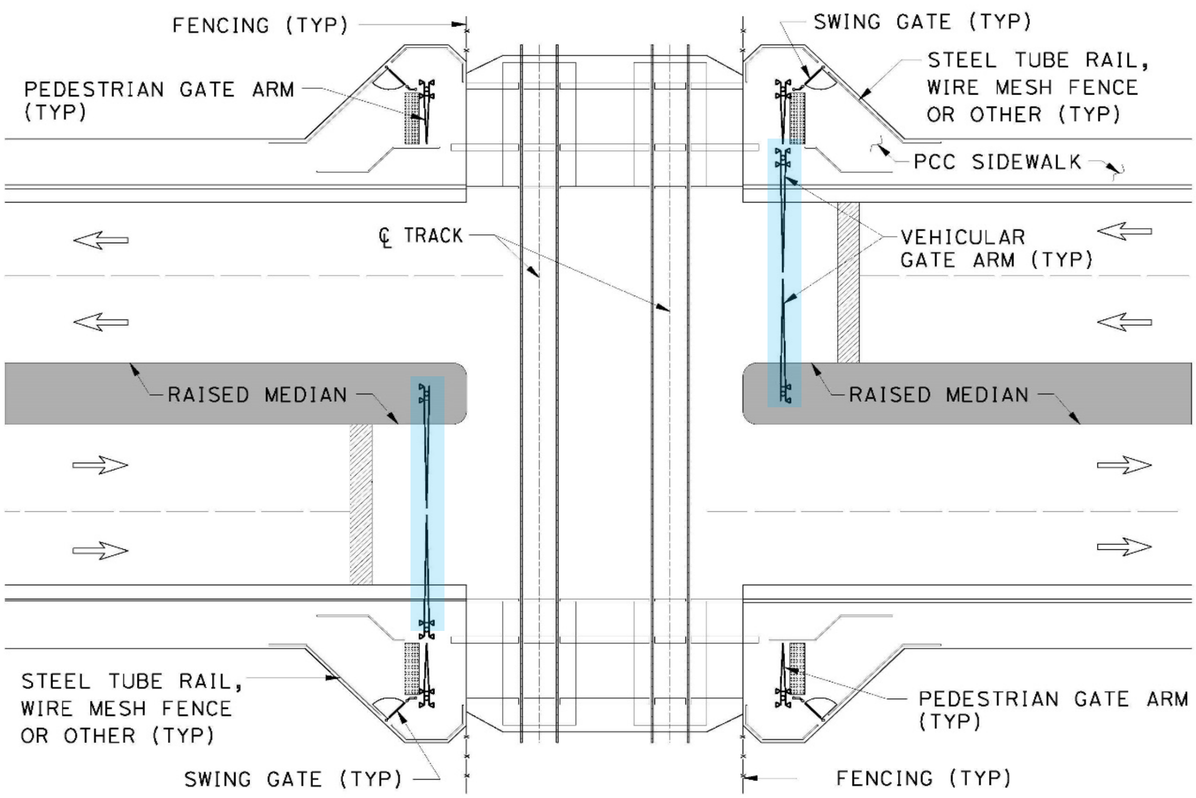


FIGURE 8-1. ENTRANCE GATE SYSTEM

ii. Exit Gate System

Exit gates are gates installed on the downstream quadrant of the highway-rail grade crossing and in the downstream median when necessary. They are installed in conjunction with the standard entrance gate system as an additional safety measure, see Figure 8-2. Exit gates shall only be used when all other options to mitigate gate circumvention have been exhausted (including the use of raised medians as discussed in Section 8.2.8 in this chapter) and an exit gate system is the only feasible option. With the exception noted in Section 8.2.13-D in the section named

Intersections of Highways Adjacent and Parallel to Rail Corridor exit gates shall require SCRRA approval. If used, exit gates shall be perpendicular to the roadway.

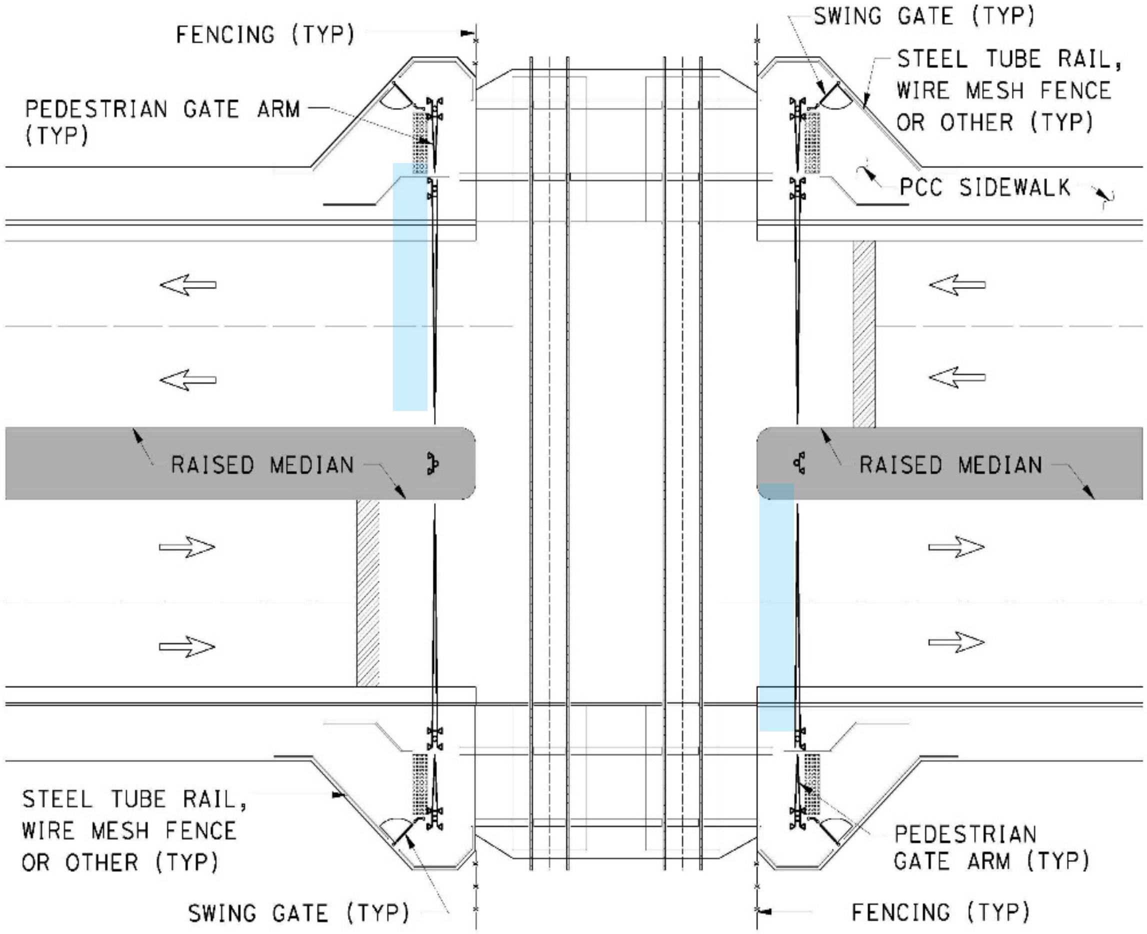


FIGURE 8-2. EXIT GATE SYSTEM

The inclusion of exit gates requires the installation of induction loops that are part of the vital crossing signal system within the pavement. It is SCRRA's policy to maintain these loops when they are integrated into the vital railroad signal system. Refer to SCRRA ES 8405 for further discussion on the use of induction loops.

The following protocols shall be observed during the engineering and construction of these induction loops:

- SCRRA ES 8405 shall be referred to for placement of induction loops through the crossing.
- SCRRA ES 8405 shall be referred to as a minimum standard for the pavement structure through the crossing; shall verify the pavement section through appropriate engineering analysis; and enhance the specifications as necessary to meet the needs of the design. Low maintenance high quality pavement sections shall be installed within 50 feet of the highway-rail grade crossing as noted in the Highway Pavement section of Section 8.2.7-F.

- A mandate that the contractor shall not install pavement within the limits of the highway-rail grade crossing and the induction loops without the review and approval of SCRRA shall be included within the construction specifications.
- The highway agency having jurisdiction over the highway shall execute a Construction and Maintenance Agreement defining the induction loops, as well as the division allocation of maintenance responsibilities and costs regarding the crossing.

Table 8-3 can be a used as a general reference for the installation of gates.

TABLE 8-3. SCRRA STANDARD FOR ENTRANCE GATE INSTALLATIONS TWO-WAY TRAFFIC

Number of Approach Lanes	Raised Median	Option 1	Option 2	Option 3
1	No	Two No. 9 devices	N/A	N/A
1	Yes	Two No. 9 devices	N/A	N/A
2	No	Two No. 9-A devices	N/A	N/A
2	Yes	Two No. 9-A devices	Four No. 9 devices	Two No. 9
3	Yes	Two No. 9-A devices Two No. 9 devices	N/A	N/A
4	Yes	Two No. 9-A devices Two No. 9 devices	N/A	N/A

C. <u>Measures to Counter Potential Gate Circumvention</u>

When analyzing a highway-rail grade crossing for gate placement, it is important to assess the opportunities that motorists will have to drive around the lowered gate, see Figure 8-3. Many conditions exist that promote such opportunities. Several of these conditions are listed below:

- Higher traffic counts, and the resulting delays at the gates.
- In locations, or at times when there is light traffic, presenting less restrictions to gate violation.
- In locations where the vehicle crossing is adjacent to a station where dwell times within the station cause longer gate down time.
- The proximity of driveways or intersections that provide opportunities for gate violations.

The project location shall be analyzed to assess the need to install median islands, lengthen existing median island(s), or to include exit gate(s) in order to counter potential or observed gate circumventions.

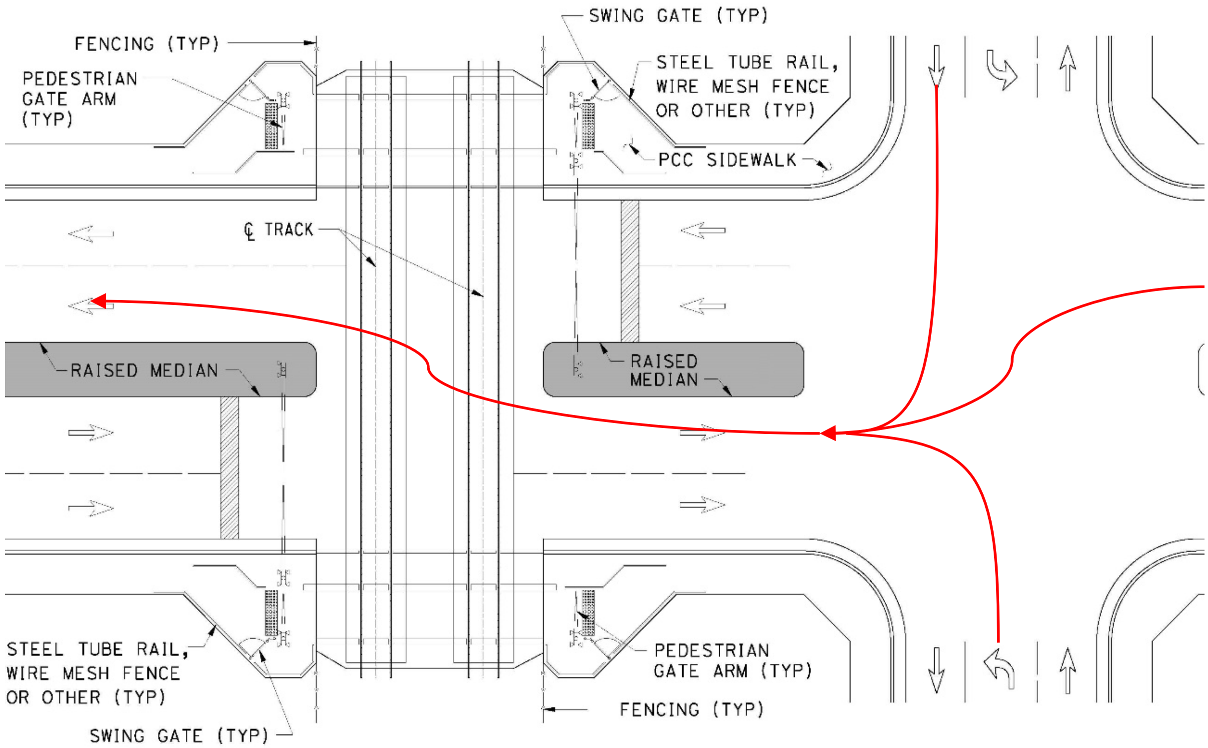


FIGURE 8-3. POSSIBLE ILLEGAL GATE CIRCUMVENTION PATHS AT INTERSECTIONS WITH HIGHWAY ADJACENT TO RAIL CORRIDOR

D. Intersections of Highways Adjacent and Parallel to Rail Corridor

At an intersection with a highway that runs parallel with the rail corridor, there is a possibility for vehicles to circumvent the standard entrance gate configuration by utilizing the far-side lanes of opposing traffic; where the opposing traffic has been halted by the entrance gate of the opposing lanes, creating a clear, but unsafe and illegal path across the tracks.

For highway intersections within 100 feet of the highway-rail grade crossing with multiple main tracks, an exit gate system should be considered to discourage vehicular movements from accessing the track area.

8.2.14 Adjacent Crosswalks

Pedestrian crosswalks parallel and adjacent to highway-rail grade crossings are strongly discouraged. Pedestrians using these crosswalks may cause vehicles to queue over the highway-rail grade crossing without an avenue of escape. Active measures should be taken to prohibit access using signage and barricades. Any new proposed crosswalks that are adjacent to a highway-rail grade crossing will require SCRRA approval. If they are used, these crosswalks shall be accessible for the cross slope.

8.2.15 Adjacent Highway-Rail Grade Crossings

The location of adjacent highway-rail grade crossings should generally be noted and analyzed with the operation of the subject highway-rail grade crossing.

At locations where there is a possibility of vehicles queuing over a highway-rail grade crossing, the design shall be coordinated with the owners and operators of both highway-rail grade crossings to develop a solution to avoid vehicles being trapped between the highway-rail grade crossings or over either highway-rail grade crossing.

8.2.16 Traffic Signals

Several factors shall be considered when deciding on the inclusion of a traffic signal into highway-rail grade crossing system, some of which are listed below. In addition, queuing studies and diagnostic reviews should be conducted during traffic peak-hours to accurately assess actual traffic conditions at the project site.

- Traffic congestion should be minimized when possible along the highway that crosses the railroad tracks. Various factors can affect the operation of traffic at the highway-rail grade crossing and can cause traffic to queue over the tracks. Motorists should be encouraged to use grade separations instead of grade crossings wherever possible.
- The presence of a traffic signal downstream of the highway-rail grade crossing may tend to generate long traffic queues that could back up over the tracks, depending on proximity to the grade crossing, cycle length of the traffic signal, amount of green time given to the movement of traffic downstream of the track and vehicle platooning. Even traffic signals at intersections upstream of the grade crossing can impact traffic operations at the grade crossing and need to be reviewed and evaluated.
- CA MUTCD, Section 8C.09, "Traffic Control Signals at or Near Highway-Rail Grade Crossings" recommends the preemption of traffic signals located within 200 feet of the highway-rail grade crossing. In addition, Section 8C.09, Paragraph 05 suggests preemption may be appropriate for longer distances, depending upon vehicle queuing. Refer to Section 8.2.17 Preemption, of this chapter for additional information on preemption.
- The location of a nearby pedestrian crosswalks whether controlled or uncontrolled may cause traffic to back up into the highway-rail grade crossing, especially during peak traffic hours. If possible, consider removal of pedestrian crosswalks immediately downstream of grade crossings to avoid vehicle-pedestrian conflicts.

Some commonly used mitigation measures are as follows:

- Traffic signal coordination between traffic signals along the highway corridor
- Installation of pre-signals, queue-cutter signals, hybrid pre-signals, hybrid queue-cutter signals, operated in a way to provide queue prevention at the grade crossing,
- Vehicle detection systems to control vehicles from queuing on the grade crossing
- Turning movement prohibitions towards the grade crossing and/or downstream of the grade crossing.

E. Adjacent Stop Controlled Intersections

All-way stop-controlled intersections should generally be avoided in all instances adjacent to grade crossings. Vehicles traversing the highway-rail grade crossing should have a clear path over the crossing that is unimpeded by vehicular cross traffic. Consider changing the intersection control to remove the stop control for the movement clearing the track or determine if a traffic signal is warranted.

The location of a nearby stop controlled intersection downstream of the grade crossing may tend to cause traffic to back up into the highway rail grade crossing, especially during peak traffic hours. Depending on the proximity of the downstream intersection and the length of the design vehicle, regular queuing could occur on or past the grade crossing. If possible, consider removing the stop control condition for vehicles clearing the grade crossing. Consider replacing the stop control with a preempted traffic signal.

F. Design Scope

The design shall specify all traffic signal equipment, including: traffic signal controller assemblies and software, the railroad interconnection system, railroad interface panel, vehicle detection systems, battery backup systems, emergency vehicle preemption systems, video monitoring systems (if applicable), blank-out signs (if needed), lighting for the intersection and the grade crossing , sign illumination systems, communication devices and systems.. The design shall incorporate equipment that has been proven to be reliable, durable, and effective on SCRRA or other major Class 1 inter-city passenger or commuter railroad systems, and already is or can be readily incorporated in current SCRRA System active warning devices. In order to provide this, the designer shall coordinate with SCRRA forces for advice/direction regarding this matter.

The design shall incorporate features and equipment that are familiar to SCRRA Engineering, Construction and Maintenance staff and contractors and that will contribute to the inspection, testing, repair operations, and maintenance of the traffic signal system. Any new testing procedures, or methods required by new equipment, must be identified and submitted to SCRRA and the highway agency for consideration and approval before implementing the new equipment and procedures.

G. Traffic Signal Standards

Traffic signal systems shall be designed in accordance with the standards and practices of the highway authority having jurisdiction over the specific traffic signal system. The most current version of the applicable standards in effect at the time of proposal submission shall be used.

The design shall adhere to the latest version of CA MUTCD and the highway authority’s design criteria for traffic signals, or to a separate criterion specifically established by the highway agency. Any new or modified traffic signal system shall be coordinated and integrated into the civil and track design to provide a seamless interface between the design disciplines.

H. Traffic Signal Design

As per the CA MUTCD, if railroad preemption is provided at a signalized intersection, the normal sequence of traffic control signal operation shall be interrupted by the railroad (preempted upon the approach of a train). The sequence of traffic signal and railroad warning system operations during the interruption shall avoid entrapment of vehicles on the highway-rail grade crossing (entrapments that might result from conflicting displays in which the traffic control signals are green, even while the railroad active warning flashing-light signals are active). During the preemption hold interval, the traffic signal indications shall prevent vehicles from moving toward the track area while displaying a green protected movement signal for traffic to move off the tracks and away from the crossing. All turning movements toward the highway-rail grade crossing that are currently permitted shall be prohibited during the signal preemption sequences. A blank-out, changeable message sign, appropriate highway signal indication, or other similar control shall be used to prohibit turning movements toward the highway-rail grade crossing during preemption. Turn prohibition blank-out signs that are associated with preemption shall be visible only when the highway-rail grade crossing restriction is in effect. For signalized intersections that display a red indication during preemption to restrict all movements across the tracks, a R10-11 blank-out sign may be used.

The R3-1 (NO RIGHT TURN), R3-2 (NO LEFT TURN), and R5-1 (DO NOT ENTER) blank-out signs are typically placed to easily be seen by the motorist intending to make a turn. The R3-1 signs should be placed on the near side of the intersection (adjacent to the right-turn lane) and on the far side of the intersection (to be visible to the motorist at the stop line of the intersection, prior to making the right turn towards the grade crossing). The R3-2 should be placed over the highway in line adjacent to the left-turn signal indications if possible. . The R5-1 should be placed to keep motorists from entering the restricted area. .

Per the CA MUTCD, Section 4D.27, “Preemption and Priority Control of Traffic Control Signals”, whenever a traffic signal is provided with emergency vehicle preemption and railroad preemption, the railroad preemption shall have priority. In the event of a demand for emergency vehicle preemption during the time the intersection is operating on railroad preemption, the railroad preemption sequence shall continue unaffected until completion. In the event of a demand for railroad preemption during emergency vehicle preemption operation, the railroad preemption function shall immediately assume control of intersection operations.

Traffic signals may be used to enhance the control of highway users at highway-rail grade crossings. A detailed analysis shall be conducted for any planned signalized intersection to properly define the lane geometry and configuration.

Traffic signal system design shall incorporate input from the highway authority having jurisdiction over the traffic signal system. A traffic signal system plan shall be prepared for each new or modified traffic signal system. The traffic signal system plan shall be in a format acceptable to the highway authority having jurisdiction over the traffic signal system and shall be prepared by a professional Civil Engineer registered in the State of California.

The following general criteria shall apply to designs of traffic signals:

- Traffic signals, pedestrian signals, and any special signs required shall be designed and installed in accordance with the highway authority’s specifications.
- Where there are existing conductors, interconnecting traffic signal and railroad signal system, they may be reused if in good condition and adequate for the desired type of

interconnection. See Section 8.4.1 for information on interconnection circuitry. New traffic signals shall be integrated into the existing or modified system, as appropriate, in accordance with the highway agency's standards and specifications, and SCRRA requirements. In particular any traffic signal work performed that affects a crossing with an existing preemption interconnection shall require that the interconnection configuration be brought to current SCRRA standards.

- The designer shall be responsible for coordinating with the appropriate local utility company to determine the source of power and the utility company's requirements for each new or modified traffic signal and safety lighting system.
- The design and placement of vehicle detection loops within 25' of the tracks shall be coordinated with SCRRA.
- Where the traffic signal system design requires the removal of existing traffic signal equipment, the existing traffic signal system shall be kept operable until the new equipment has been installed, tested, and put into service. During periods when the existing traffic signal is inoperable, the intersection shall be flagged in accordance with the requirements of the highway authority. In cases where the operation of the existing traffic signal would cause vehicle queuing onto the adjacent grade crossing, the highway authority or project owner shall provide roadway flagging at the grade crossing and discuss the need for railroad flagging with SCRRA.
- For modifications of existing traffic signals, new and modern signal equipment shall be installed as approved by the Public Agency.

I. Left-Turn Movements

A traffic study shall be conducted to determine the need and length for left-turn lanes and protected left movements at existing signalized intersections that are preempted by trains, which do not have left-turn lanes and/or protected left-turn signal indications (green arrows). All legs of the intersection shall be evaluated to determine the appropriateness of the left turn protection. In addition, the length of the left-turn lane shall be evaluated for proper application according to traffic demands. The left-turn protection (green arrow) shall provide the following criterion during the preemption sequence:

- Provide sufficient green time for the left-turn movements traveling away from the highway-rail grade crossing to clear any queues over the railroad tracks.
- Restrict conflicting left-turn movements toward the tracks. In cases where an existing left-turn lane is not provided with a signal head equipped with a protected left-turn arrow, the traffic signal shall be modified to provide a protected left-turn arrows or no-left-turn blank-out signs restricting the left-turn movement towards the tracks.
- Allow non-conflicting left-turn movements away from the tracks during railroad preemption.

The designer shall analyze the length of left-turn lanes in association with the overall crossing. A left-turn lane configuration extending across the tracks should be avoided.

If a left-turn lane extending across the tracks is required, SCRRA approval is required and shall include countermeasures to warn motorists not to stop on the tracks, such as traffic signals, striping, and signing. An engineering study shall be performed to evaluate the traffic movements associated with adding or modifying a left-turn lane through the highway-rail grade crossing. The study shall recommend appropriate mitigations to avoid the trapping of vehicles across the highway-rail grade crossing that shall be included in the design, such as:

- Install an interconnected traffic signal at the highway intersection to allow the clearance of the left-turn lane upon the arrival of a train.
- Install a queue-cutter signal or pre-signal to provide queue prevention at all times at the grade crossing.

J. Pre-Signals

Pre-signals are traffic signals that control traffic approaching a highway-rail grade crossing, in conjunction with the traffic system of an adjacent downstream highway intersection, to prevent queueing over the highway-rail grade crossing.

Refer to CA MUTCD, Section 8C.09, “Traffic Control Signals at or Near Highway-Rail Grade Crossings” for requirements associated with pre-signals. Whereas existing traffic signal preemption is mandated to clear queued vehicles from the crossings upon arrival of trains, a pre-signal is intended to prevent queuing across the highway-rail grade crossings during each traffic signal cycle, regardless of the presence of a train on the approach. A pre-signal does not eliminate the need for preemption, but it does significantly reduce the likelihood that vehicles are within the minimum track clearance distance and clear storage distance, at the onset of the track clearance green time (see Section 8.2.16-K for an explanation of these terms).

To mitigate the possible confusion of conflicting signal directions between the pre-signal and railroad crossing warning signal, a Standard No. 9-A cantilever shall not be used as or used to mount a pre-signal. In locations where both a pre-signal and a cantilever are already present or are typically required; installation of the pre-signal only should be considered, when possible, to avoid motorist confusion; the final determination shall be made by SCRRA’s Director of Communications and Signals. This installation allows the railroad warning gates and lights to operate in conjunction with the traffic pre-signals to send the appropriate message to the motorist.

Pre-signals and all associated signage installed in front of a railroad crossing gate shall be positioned to not interfere with the visibility of the railroad flashing-light signals or other traffic control signals.

A pre-signal shall be considered in the following cases:

- Where the clear storage distance is 50 feet or less.
- At approaches where high percentages of long-length vehicles (i.e. semi-trucks with trailer, buses, recreation vehicles, etc.) are evident and the clear storage distance is less than 75 feet. A vehicle classification study should be conducted to determine the types of vehicles using the crossing.

- Where the clear storage distance is greater than 50 feet or 75 feet (depending on the highway vehicle design length), but less than 120 feet, and an engineering study determines that vehicle queuing regularly extends near, at or past the grade crossing. Where the clear storage distance is 200 feet or less. An engineering study should be made to evaluate the various elements involved in a pre-signal including the need for the pre-signal.

K. Pre-Signal Location

There are two primary alternative locations for placement of traffic signal heads at the crossing. Pre-signals can be placed on mast-arm poles placed ahead of the highway-rail grade crossing (upstream), or between the highway-rail grade crossing and the intersection (downstream). Downstream placement of the pre-signal mast-arm pole is the preferred position, so the stopping position of the vehicular traffic is close to the crossing. Where the pre-signal pole is placed upstream of the highway-rail grade crossing with multiple approach lanes, a pole shall be placed on the sidewalk and on the median. In all cases, pre-signal poles shall be positioned to maintain visibility of the railroad flashing lights.

CA MUTCD, Section 4D.11, “Number of Signal Faces on an Approach” states that a minimum of two signal faces shall be provided for the major movement on the approach to an intersection. At least one and preferably both signal faces shall be located as follows:

- Not less than 40 feet beyond the stop line, unless a supplemental near-side signal face is provided.
- Not more than 150 feet beyond the stop line, unless a supplemental near-side signal face is provided.
- As near as practical to the line of the driver’s normal view, if mounted over the highway.

L. Downstream Pre-Signals

As specified in CA MUTCD, Section 8B.28, “Stop and Yield Lines”, the stop line should be placed no closer than 15 feet from the nearest rail, and eight feet from the railroad gates (if present). It is desirable to utilize this same stop line for the pre-signal indications, if possible. Placement of the traffic signal stop line at the same location as the railroad warning gate stop line has two advantages:

- Transit vehicles and trucks required to stop at crossings would not be subject to a double stop.
- Motorists will have one place to stop with every traffic signal cycle

If clear storage distance is 50 feet or less, and if it is possible to use the near-side intersection signal heads as a pre-signal, the stop line of the pre-signal should be at the same location as the railroad warning gate stop line. The far-side intersection signal heads shall be equipped with programmed-visibility heads or louvers to restrict visibility of the intersection signal displays to drivers at the pre-signal stop line.

If the clear storage distance is more than 50 feet, and if it is possible to locate a pre-signal between the highway-rail grade crossing and the intersection, the pre-signal faces should be located such that the stop line of the pre-signal is at the same location as the railroad warning gate stop line.

M. Upstream Pre-Signals

When traffic signal faces are located near the railroad warning devices, the stop line must be located a minimum of 40 feet ahead of (upstream) the signal faces to allow for visibility of the traffic signal heads per CA MUTCD requirements. If the stop line distance is shortened, a low mount pre-signal head and a “STOP HERE ON RED” (R10-6) sign shall be installed to warn approaching traffic of the traffic control signal. The far-side intersection signal heads should be equipped with programmed-visibility heads or louvers to restrict visibility of the intersection signal displays to the drivers at the pre-signal stop line.

N. Signs and Markings for Pre-Signals

If there is a nearby, signalized intersection with insufficient clear storage distance for a design vehicle, or if the highway-rail grade crossing does not have gates, an “NO RIGHT TURN ON RED” (R10-13A (CA)) or “NO LEFT TURN ON RED” (R13B(CA)) sign shall be installed for the approach that crosses the railroad track as per Chapter 8C, Section 09 in CA MUTCD.

STOP HERE ON RED (R10-6) signs

If the distance between the stop line and the upstream signal faces is less than 40 feet, the ‘STOP HERE ON RED (R10-6) sign shall be installed to provide warnings to incoming traffic of the traffic signal as per Chapter 8C, Section 09 in CA MUTCD. It is also prudent to have this sign installed where there is frequent violation of stop line or where it may not be clear for drivers regarding where to stop.

WAIT HERE pavement markings

A Stop line needs to be installed before the railroad crossing where the vehicles need to be stopped. It should be at a distance of minimum 15 feet from the railroad tracks or 8 feet from the gates as per Figure 8B-6(CA) in CA MUTCD.

A limit line will be added for the pre-signal prior to the grade crossing. Per CA MUTCD Section 8B.28 Standard 01, “On paved roadways at grade crossings that are equipped with active control devices such as flashing-light signals, gates, or traffic control signals, a stop line shall be installed to indicate the point behind which highway vehicles are or might be required to stop.”

O. Pre-Signal Operations

The pre-signal intervals should be progressively timed with the downstream intersection signal intervals, providing adequate time for vehicles to clear the minimum track clearance distance and continue through the clear storage distance area and downstream intersection. Vehicles that are required to make mandatory stops (such as school buses and vehicles hauling hazardous materials) should be considered when determining the preemption timing design parameters. Unless otherwise defined, the design vehicle for the design of a pre-signal shall be the AASHTO WB-65 semi-tractor-trailer.

Where the clear storage distance is inadequate to store the design vehicle clear of the minimum track clearance distance, consideration should be given to the installation of vehicle detection loops within the clear storage distance. This could prevent vehicles from being trapped within the minimum track clearance distance by extending the track clearance green time. Pre-signals shall display a red signal indication during the transition into the preemption control portion of a signal preemption sequence. This shall prohibit additional vehicles from crossing the railroad tracks.

P. Queue-Cutter Signals

Another solution to traffic queuing onto the tracks, and an alternative to a pre-signal, is the use of an automated queue-cutter traffic signal upstream of the highway-rail grade crossing. Preemption form will be required for Queue-Cutter as well since pre-emption timing will be in conjunction with the queue cutter.

A queue-cutter signal differs from a pre-signal in that if the clear storage distance is greater than 50 feet or 75 feet for roadways that is regularly used by multi-unit vehicles; any traffic signal heads located at a highway-rail grade crossing should be considered to be a separate, mid-block highway-rail grade crossing (a “queue-cutter”) signal and not a pre-signal as per Chapter 8C, Section 09 in CA MUTCD. The queue-cutter signal can be utilized in conjunction with R8-8 signs (“DO NOT STOP ON TRACKS”), as per CA MUTCD requirements. The queue-cutter traffic signal can be activated by vehicle detection (typically induction loops) on the far-side of the highway-rail grade crossing to detect a growing queue between the highway-rail grade crossing and the downstream highway intersection. The queue detection location relative to the adjacent track shall be evaluated to prohibit queue build up while traffic signals are in transition once a queue is detected. Queue-cutter signals must be interconnected to the railroad crossing warning system to allow a red traffic signal to be displayed when a train is approaching. A queue-cutter signal typically operates independently of the downstream traffic signal, depending on traffic progression during different times of day.

Q. Hybrid Pre-Signals

Another queue management technique is the use of a hybrid pre-signal. Hybrid pre-signals control traffic approaching a highway-rail grade crossing, in conjunction with the traffic system of an adjacent downstream highway intersection, to prevent queuing over the highway-rail grade crossing.

A hybrid pre-signal is typically used at locations where the highway-rail grade crossing is located within 250 feet from the traffic signal and queuing is a concern. A hybrid pre-signal is appropriate to install when vehicles stop on the tracks due to proximity to a signalized intersection. The hybrid pre-signal controls vehicles from encroaching into the track area during normal and preempted signal operations. The intersection signal would provide clearance so that the track area is kept clear, but vehicles may remain in the clear storage distance area. The hybrid pre-signal provides the opportunity for vehicles to remain in the clear storage distance thru traffic signal operations between the presignal and the downstream intersection signal. The hybrid pre-signal should have queue detection to extend the duration of the downstream intersection green time after the hybrid pre-signal cycles to red during normal operations. .

R. Hybrid Queue-Cutter Signals

Another solution to traffic queuing onto the tracks, and an alternative to a pre-signal, is the use of a hybrid queue-cutter traffic signal upstream of the highway-rail grade crossing.

A hybrid queue-cutter signal is typically used at locations where the highway-rail grade crossing is located between 200 and 500 feet from the traffic signal and queuing on track is a concern. A hybrid queue cutter signal can operate independently or dependently on the downstream signal. The hybrid queue-cutter signal is tied to the grade crossing warning system and actuated when a queue is detected near to the tracks or on the train approach. Upon actuation, the hybrid queue cutter signal will turn red requiring motorists to stop in advance of the grade crossing. The hybrid queue cutter signal will provide a green indication when the vehicle queue is no longer detected, and the crossing warning system is inactive. During certain times of day or certain times of the year, the queue buildup between the downstream traffic signal and the grade crossing could be too fast for the queue detection and traffic signal system to react in order for the queue cutter signal to provide queue prevention. During those times, the queue cutter signal can operate in coordinated operations with the downstream traffic signal, but at all other times operate as an independent queue cutter traffic signal.

S. Traffic Signal Controller Units

There are two types of traffic signal controller units: those that are designed to NEMA specifications and those that are Type 170/2070 Controller Units (discussed below). Traffic signal controller units manufactured according to older NEMA TS 1 standards do not have internal preemption. These units are generally not capable of accommodating preemption without special external control processes. The current industry standard for both pre-timed and actuated traffic signal controller units-the NEMA TS 2 standard-includes provisions for internal preemption. NEMA TS 1 controllers shall be replaced with traffic signal modification work to NEMA TS 2 controllers.

The Model 2070 Controller Unit includes various provisions for internal preemption; these depend on the specific software packages being run by the microprocessor. Depending on software, the Model 2070 can be an open platform advanced transportation controller (ATC) that completely separates hardware from application software by defining a common controller unit hardware on which multiple applications from multiple developers can operate.

The preemption capabilities of traffic signal controller units vary from manufacturer to manufacturer. It is very important to be familiar with the preemption operation provided in each controller unit being used in the field.

The IEEE 1570 standard for the interface between the railroad active warning system and the traffic signal controller unit is a digital communications interface. Designed according to both fail-safe and closed-loop principles, it provides equivalent functions while maintaining the required safety attributes at the highway-rail grade crossings. Application of the IEEE 1570 interface shall be explored for all new highway-rail construction and modifications. Serial interconnection shall only be explored if requested by the City traffic agency. The standard interconnection scheme preferred by SCRRA is a supervised cable interconnection configured as outlined in AREMA 16.30.10. For more information on the IEEE 1570 standard, consult the IEEE Standard for the

Interface Between the Rail Subsystem and the Highway Subsystem at a Highway Rail Intersection (IEEE publication no. 1570-2002).

The traffic signal controller unit shall be able to meet the following minimum functions and requirements:

- Receive multiple preemption inputs and provide multiple routines on a priority basis, at least one of which shall be assigned to railroad preemption. Per CA MUTCD, the railroad preemption shall have priority at a traffic signal provided with emergency vehicle preemption and railroad preemption.
- The preemption feature shall have either an electrical circuit based upon the closed-circuit principle, or a supervised interconnect circuit (preferable) between the control circuits of the railroad active warning system and the traffic signal controller unit.
- Detect broken wires/cables and respond as programmed. One possible programming alternative is to first clear the tracks and then display all-way flashing red signal indications.
- Remotely notify the responsible highway agency as soon as a detectable problem is known to exist at the highway-rail grade crossing.
- Provide an indication, via health check circuit, to the railroad active warning system cabinet when the traffic signals are in flashing mode, on battery backup, or “dark” (without power) condition.
- Provide a backup power system for the traffic signal controller in the event of a commercial power outage, and remote notification to the highway agency responsible for maintenance of the controller.

T. Standby Power

In accordance with FRA rules and requirements, railroads install backup power systems to provide power to flashing light signals during commercial power failures. Backup or standby power systems shall be required at all traffic signals interconnected with railroad signals.

8.2.17 Preemption

The design of preemption for a highway-rail grade crossing owned or maintained by an agency other than SCRRA shall be in accordance with the standards used by that agency. The resulting design must be consistent with, or more stringent than, the standards and criteria in this chapter or other applicable SCRRA Standards.

In establishing preemption operations at highway-rail grade crossings adjacent to signalized highway intersections, the highway agency shall coordinate with SCRRA and the CPUC. The need for preemption, type of preemption, preemption time, right-of-way transfer time, queue clearance time, track clearance green time, etc., for preemption shall be determined by the highway agency and SCRRA and must be agreed to by SCRRA.

A. Highway-Rail Grade Crossing Elements that Affect Railroad Preemption

The following highway-rail grade crossing and intersection elements affect preemption timing calculations and/or highway-rail grade crossing operations and should be evaluated carefully to determine their impact:

- Intersection geometry.
- Highway-rail grade crossing geometry:
  - Track clearance distance (track clear zone).
  - Clear storage distance; distance from clear track zone to intersection.
- Approaches to the highway-rail grade crossing
- Travel times to clear the intersection or crossing.
- Vehicle volumes.
- Train type and speed
- Frequency of train movements.
- Train stops within the approach to the highway-rail grade crossing (especially for sidings and stations).
- Vehicle queue lengths and dissipation rates.
- Design vehicles and special classes of vehicles, and their operating abilities through the intersection.
- Signal timing
- Types and locations of active warning devices.
- Pedestrian activity.
- Location and length of pedestrian crosswalks
- RR Stop Line location

Refer to SCRRA's Grade Crossing Manual for additional information on preemption elements.

B. Preemption Operational Sequence

FHWA and ITE publications (see Appendix A for references) have tables and charts that help identify different phase sequence at the intersection preemption can trigger during phased operation. These tables and charts indicate the phase sequence that would be activated, depending on what phase was active when preemption input was received. Each highway-rail grade crossing is unique; an engineering study should be conducted for each signalized intersection near a highway-rail grade crossing to determine the most appropriate preemption operational sequence and the preemption parameters to be implemented.

It is however SCRRA's policy for designers to use the "LADOT Railroad Preemption Form" spreadsheet to determine the amount of advance preemption and track clearance green time needed at preempted traffic signals near highway-rail grade crossings. The Texas Department of Transportation Traffic Signal Preemption at Highway-Rail Grade Crossings form may also be used. Total Approach Time for highway-rail grade crossing warning systems shall not exceed 50 seconds. An example of the LADOT Railroad Preemption Form is included in Appendix E-8, while an electronic version is available from SCRRA upon request.

All requests for additional traffic signal preemption time will be submitted, through a special design consideration (see Section 3.2.2), to SCRRA's PTC, C&S Engineering Services Department for review and approval.

The traffic signal controller unit shall enter into preemption operation as soon as the interconnect circuit from the railroad active warning system is activated. Some controller units may incorporate a delay time to verify the continuity of the preemption call.

Railroad preemption results in a special traffic signal operation; depending on the location of the railroad tracks to the intersection, the number of phases in the traffic signal, and site-specific traffic conditions. Preemption ensures that the actions of the traffic control devices complement, rather than conflict, with the railroad warning system devices. There are three basic elements to railroad preemption:

1. Right-of-way transfer into preemption control
    a. Termination of normal operation
2. Preemption control
    a. Track clear/clear storage interval
    b. Hold/dwell interval
3. Transition to normal operation
    a. Exit phases
    b. Transition to coordination, if applicable

i. Right-of-Way Transfer into Preemption Control

There are many possible transition scenarios, depending upon which interval in the traffic signal control cycle is operational when preemption is initiated. Upon receiving a preemption call, right-of-way transfer of the traffic signal should provide the following basic sequence of operation:

- The length of yellow change and red clearance intervals shall not be altered by preemption for any signal phase
- Phases that are in the green interval when preemption is initiated, and which shall be green during the track clearance interval, shall remain green, unless doing so creates a yellow trap condition. In that case, they must be terminated normally and then restarted after a brief all-red period.

ii Preemption Control

TRACK CLEAR/CLEAR STORAGE INTERVAL

During preemption, there are various scenarios that could occur with the pedestrian walk interval or the pedestrian clearance time, depending on the highway agency's requirements and crossing users:

- Shortening or termination of the pedestrian walk interval, while allowing the pedestrian clearance interval to follow the normal time.
- Immediate termination of the pedestrian walk, with full or partial truncation of the pedestrian clearance.

The signal phase (or phases) controlling traffic over the railroad tracks should be green during the track clearance interval. A yellow change interval shall be provided if a green signal indication was provided during the track clearance interval.

Right-of-way transfer time (RWTT) is the maximum traffic signal timing required for the transition to track clearance green. RWTT can vary, depending on the programmed phasing and timing of the controller when the preemption call is established. The maximum right-of-way transfer time (RWTT) is used in the calculation of preemption time. This set of circumstances is sometimes referred to as "worst case" scenario.

The RWTT is zero if the preemption call is received when the traffic signal controller is already in the phase that is used as the track clearance green time (queue clearance phase). This scenario is usually known as the "best case" scenario. These variations in traffic signal operations can be unsafe if not properly recognized in the timing and design of simultaneous and advance preemptions. The "worst case" scenario shall be used in the determination of maximum preemption time, while the variety of traffic phasing and timing both scenarios shall be accounted for in the design of any preemption sequence.

Track clearance time ensures that the railroad crossing is cleared of all vehicles when the pre-emption is activated by the detection of oncoming rail. The gate down circuit is a mechanism which ensures that the track clearance time terminates when the gates go down. Based on current design practice, a gate-down circuit should be used on all new interconnected grade crossings. The gate-down circuit provides two benefits:

1. It eliminates preempt trap by making sure that the track clearance time does not terminate before the gate comes down;
2. It ensures that the track clearance time is not unnecessarily long when maximum right-of-way transfer time is needed.

HOLD/DWELL INTERVAL

Hold/Dwell Interval (also known as Limited Service) shall be used for traffic signals interconnected to SCRRA RR Signal System. . The transition into preemption hold occurs after the queue clearance time and separation time (track clearance interval) have been completed and continues while the train is occupying the crossing. Preemption hold shall remain in effect until the preemption input to the controller unit is removed. The purpose of the preemption hold interval is to allow those movements that do not conflict with the occupancy of a train in the crossing to proceed.

TRANSITION TO NORMAL OPERATION/EXIT PHASES

There are many possible scenarios for the transition from preemption control to normal operation; they depend on the type of intersection control that was in effect at the time of preemption (e.g., running free, actuated [semi or full], recalls, coordinated, etc.).

The user can define the exit phases that shall operate after the preemption call has been released. Most controllers shall run the normal split time for the exit phases, and then, depending on user-programmed parameters and time of day, the controller may attempt to resynchronize with the defined offset.

Some controller software has the capability to monitor the coordinated cycle during preemptions so that upon release of preemption, the transition to normal operation is right in step with the coordinated background cycle. The designer should be aware of the highway agency's preferred operation.

C. Preemption Timing Parameters

The highway-rail grade crossing elements that affect railroad preemption (as defined in Section 8.2.17) help calculate the timing parameters defined in this section. Refer to SCRRA's Grade Crossing Manual for preemption timing parameters that should be evaluated carefully and calculated for each appropriate sequence of preemption operation.

- Maximum RWTT
- Minimum RWTT
- Queue clearance time
- Separation time
- Maximum highway traffic signal preemption time
- Advance preemption time (as defined in Appendix A)
- Total approach time (as defined in Appendix A)

D. Preemption Timing Scenarios

The highway agency shall complete preemption calculations to help determine the preemption time that is needed at that location. The evaluation shall consider all feasible approaches to the highway-rail grade crossing. The highway authority shall select the preemption calculation methodology using one of these standard forms: Los Angeles Department of Transportation (LADOT) (preferred by SCRRA as mentioned in Sub-Section B above), Texas Department of Transportation (TXDOT) or Caltrans. The highway agency shall also submit a preemption calculation exhibit, detailing the key measurements used in the preemption. In addition, the agency shall complete SCRRA's Highway-Rail Grade Crossing Traffic Signal Preemption

Request Form (see Appendix E-7), detailing the types of interconnection and preemption times, and submit to SCRRA for review and approval.

E. Preemption Trap and Potential Solutions

Preemption trap is the condition wherein the queue clearance or the track clearance green time ends before the railroad flashing-light signals start to flash and the gates start to descend. Many motorists will continue to cross the tracks until the railroad gates actually begin to descend. Some motorists will even try to squeeze under the descending gate. Therefore, the downstream traffic signals should display a queue clearance green indication until at least the gates have descended. To properly define the preemption parameters, a thorough understanding of the capabilities of the traffic signal controller that is to be used is required.

The following factors can also create a preemption trap:

- Warning time variation that is different from the value used in the preemption calculations and programming of the traffic signal controller (if it is implemented without a gate down circuit input).
- A longer advance preemption time that is different from the value used in the initial preemption calculation and programming of the traffic signal controller (if implemented without a gate down circuit input).

These variations in time create a preemption trap.

Under simultaneous preemption, the railroad warning lights start to flash at the same time the preemption notification is received by the traffic signal controller. Therefore, the queue clearance green interval does not begin before the lights start to flash.

The evaluation of the maximum highway traffic signal preemption time should evaluate all possible approaches to determine the maximum right-of-way transfer time. Potential solutions for the preemption trap shall be considered and implemented. The following are some of the methods that may be used to avoid preemption traps:

- Increase the queue clearance green interval in the traffic signal controller unit. The queue clearance green interval should be displayed at least until the gates start to descend, and ideally until the gates block the path of approaching vehicles. The use of older traffic signal controllers cannot guarantee that the gates will be down when the queue clearance green interval terminates. Increasing the track clearance green time may not be the best option, because an increased overall delay to the signalized intersection can cause other congestion-related problems, especially if train volumes are high.
- Use a controller that is capable of dynamically calculating the RWTT and adding the difference to the QCT to account for the variations in allocated (versus used) green time for the conflicting movements.
- Use a “gate down” circuit to guarantee that the queue clearance phase terminates only after the gates are down. This is the preferred method. Refer to Section 6.1.2 for more information on “gate down” circuits.

- The highway agency should consider changing its traffic signal controller unit specifications, selecting a unit that has the ability to adjust the queue clearance green interval based on variations in the time allocated versus the green time used for the conflicting movements.
- The traffic signal controller should also have the functional ability to recognize a second preemption call during the initial preemption sequence in order to maintain the preemption hold state.
- Consider the potential of conditional service solutions/controller logic to prevent the preemption trap.

F. Other Preemption Considerations

Multiple Tracks

Multiple tracks at highway-rail intersections introduce two problems that must be considered when designing a preemption timing plan:

- Additional clearance distance is required during the queue clearance time. The additional clearance distance increases the track clearance green time and thus increases the total approach time required for preemption.
- The possibility that a second preemption call could be sent to the controller unit, immediately after the first preemption input, is removed. This occurs when a train traveling on the second track approaches a crossing right after a train on the first track has left the highway-rail grade crossing area.

Older traffic signal controller units cannot recognize a second preemption call that was received while the first preemption was being serviced; the first preemption sequence had to time out first. Typically, the older traffic signal control units would then continue in the hold state even though the railroad gates had risen. If the railroad gates were to rise before the traffic signal controller unit recognized the second preemption call, it could lead to skipping the clear track interval and potentially trapping vehicles on the tracks.

Provisions to avoid this problem may include use of an “extended hold” to keep the highway-rail grade crossing gates down until the second train has arrived, as well as use of traffic signal control logic that ensures that a second track clearance can be provided in the event the gates have been raised prior to the arrival of a second train.

When pedestrian clearance time becomes a driving factor for long preemption times and affects levels of service at an intersection, consideration should be given to providing a separate pedestrian input to the traffic signal controller, which will require SCRRA approval.

This is particularly true when there is a station stop in the approach to the highway-rail grade crossing or when switching may occur regularly within the crossing approach.

The determination whether to include extra preemption time for vehicle gate interaction time shall be determined jointly by the railroad and highway agency. Among the factors to be considered are whether the highway-rail grade crossing has a history of broken gates, RR approach distance/system capabilities, the opportunity to solve the broken gate concern another way (extending flash-only operations prior to gate descent, for instance) and the impact on the additional preemption time to the intersection level of service.

Multiple Intersections

Where a highway-rail grade crossing is located between two closely spaced signalized intersections, the two highway traffic signals must be interconnected. Further, their preemptions must be coordinated to permit the tracks to be cleared in both directions.

When the railroad diagonally crosses two interconnected highway intersections, it is normally necessary to clear out traffic on both highways prior to the arrival of the train, requiring approximately twice the preemption time computed for a single approach. An example of this condition is shown in Figure 8-4. Both railroad warning systems shall be designed to operate concurrently to prevent the traffic signals and railroad warning systems from falling out of coordination with each other, in this scenario, a single pre-emption call could be sent to the City controller. Activation of either crossing would initiate pre-emption activation for BOTH intersections. When the railroad warning system is activated, traffic leaving the intersection and approaching the highway-rail grade crossing may queue back into the intersection and block traffic if there is not adequate storage for those vehicles between the highway-rail grade crossing and the intersection. Traffic turning at the intersection toward the other highway-rail grade crossing may also be unable to proceed due to stopped traffic. When this occurs, the following recommended solutions could be used:

- Utilization of advance preemption
- Activating one highway-rail grade crossing before the other
- Extension of gate delay time and minimum warning time
- Use of blank-out turn restriction signs

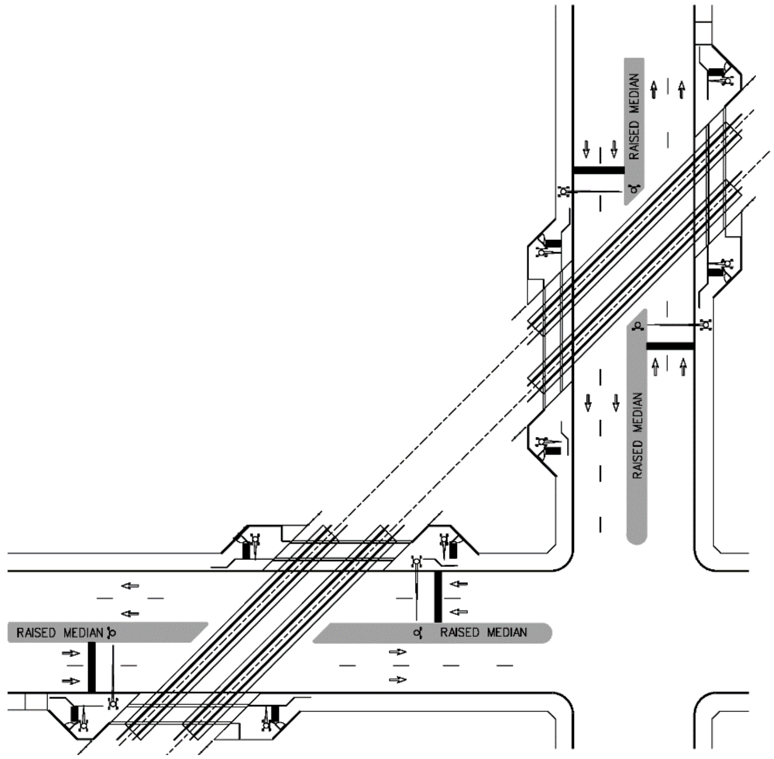


FIGURE 8-4. RAILROAD DIAGONALLY CROSSING TWO INTERCONNECTED HIGHWAY INTERSECTIONS

G. <u>Preemption Form with Gate Interaction</u>

It is SCRRA's policy for designers to use the "LADOT Railroad Preemption Form" spreadsheet to determine the amount of advance preemption and track clearance green time needed at preempted traffic signals near highway-rail grade crossings. The Texas Department of Transportation Traffic Signal Preemption at Highway-Rail Grade Crossings form may also be used. Total Approach Time for highway-rail grade crossing warning systems shall not exceed 50 seconds. An example of the LADOT Railroad Preemption Form is included in Appendix E-8, while an electronic version is available from SCRRA upon request.

The LADOT Preemption Form also provides a graphical depiction of the timeline of events occurring prior to train arrival at the highway-rail grade crossing to help the user visualize the effects of changes in preemption timing. It was designed to simplify the process of determining specific preemption timing values, and to enable the user to experiment with different scenarios based upon engineering judgment. The form computes the necessary times based upon input data regarding specific geometric, signal timing, and railroad equipment parameters. As data is entered into the form, a timeline is updated to show the effect of each entry. Once all the entries are completed, the timelines can be reviewed to determine whether the settings are appropriate for the crossing. This gives the user the ability to experiment with different timings and immediately see the result of those changes.

8.2.18 Railroad Features

A. Gate Operations Near Stations

Most stations function as both near-side and far-side stations (relative to the highway-rail grade crossing and the travel direction of the trains).

The station scenarios described below are ideal; however, each situation is unique and should be carefully examined during the diagnostic analysis and design in order to address the challenges at the highway-rail grade crossing and station interface.

i. Near-Side Station

A station functions as a near-side station when a passenger train stops at the station before proceeding through the highway-rail grade crossing. In cases where the station is within the highway-rail grade crossing detection circuitry, but not directly adjacent to the crossing, it is desirable to have the highway-rail grade crossing gates remain raised until the train is ready to depart (assuming there is sufficient distance between the highway-rail grade crossing and the station to allow this protocol). When stations are very near vehicular crossings, it may be preferable to have the gates remain down while the train is waiting in the station to depart. This is particularly important at a multiple-track station adjacent to a crossing, where the train stopped at the station may block the view of a second oncoming or overtaking train in the far track.

ii. Far-Side Station

A stations function as far-side station when passenger trains proceed through the highway-rail grade crossing before stopping at the station. The highway-rail grade crossing gates should recover immediately after the train proceeds through the highway-rail grade crossing unless a second train is approaching on another track, in which case the gates shall react and remain down as required.

B. Track Structure

The track structure within the highway-rail grade crossing is defined from the subgrade up through the highway surface. All components of the track structure shall be designed in accordance with SCRRA Engineering Standards.

In the design of the track structure, the existing conditions at the highway-rail grade crossing shall be thoroughly examined to detect any indications of failure of the surface or structure. The track structure at highway-rail grade crossings shall follow SCRRA design standards and meet the following criteria:

- No exothermic rail welds, insulated joints, or bonds shall be placed in highway-rail grade crossings or within 10 feet of a crossing.
- No turnouts or crossovers shall be located within a crossing.
- The highway-rail grade crossing structure shall be designed to permit drainage of the track structure

  - Where drainage conditions dictate, construct underdrains within the vicinity of the highway-rail grade crossing to maximize the highway-rail grade crossing life.
- Under no circumstances shall street surface or gutter runoff be permitted to flow into the track structure.

C. Multiple Tracks

Multiple, parallel tracks within the highway-rail grade crossing create additional concerns that need to be addressed. The following concerns shall be mitigated during design of the crossing:

- The curvature of the railroad tracks and the resulting superelevation of the tracks shall be evaluated and addressed within the design.
- The path for a pedestrian to traverse the highway-rail grade crossing shall be designed for the shortest `path across the crossing, preferable perpendicular to the tracks.
  - This is especially important with skewed crossings that inherently increases the width of a crossing.
- Visibility of a second train approaching on an adjacent track shall be considered.
- Visibility of all active tracks, where a train may be temporarily stopped or spotted on the adjacent track, shall be considered.
  - This is especially important when the adjacent track is a siding or industrial lead where locomotive and railroad cars may be stored for long durations.
- Refer to DCM Chapter 12 for issues related to consideration of grade separation based on multiple tracks at the crossing.

D. Geometry

Where highway-rail grade crossings are located within a superelevated curve, the surface of the highway plane should be in the same plane as the top of rails of the superelevated curve. The Highway Agency should review the roadway interface at the crossing and determine if traffic speed on the approaches and through the crossing should be reduced due to the undulations of the railroad superelevation.

At multiple-track crossings involving concentric superelevated curves, the inside rails for each track may be at equal elevations, while the outside rail are also at equal elevations. The elevations of the four individual rails create an uneven surface through the highway-rail grade crossing.

To avoid this situation, multiple tracks shall be brought to the same plane to provide a smooth and level highway-rail grade crossing plane for the highway.

This may not always be possible due to railroad vertical profile constraints; therefore, highway vertical profiles should be designed on either side of the highway-rail grade crossing to provide as smooth a transition as feasible, and to provide the proper clearance for the lowest vertical clearance design vehicle. See Chapter 31 Signage for low clearance signage.

E. Special Trackwork

Highway-Rail Grade Crossings located in close proximity to special trackwork shall not be allowed.

The point of switch for turnouts and crossovers shall be located a minimum of 100 feet from the edge of traveled roadway or sidewalk, if present. When turnouts and crossovers are close to the Highway-Rail Grade Crossing, the designer shall consult SCRRA about the railroad's need for special trackwork and shall refer to SCRRA Communications and Signal Engineering Standards (ES 8000 series).

F. Utilities

See DCM Chapter 10 for Utilities.

8.2.19 Future Improvements

Enhancements to the highway-rail grade crossings, such as median islands, traffic signal systems, signal preemption, roadway widening, pedestrian and bike facilities, should be designed and constructed, such that future railroad improvements, second or more track(s), and/or other railroad improvements can be accommodated without the need to completely modify the current elements of the crossing. The designer should be cognizant of the potential to improve the highway-rail grade crossing system for future SCRRA tracks and other facilities. The design should incorporate the necessary accommodation of future railroad improvements.

8.3 PEDESTRIAN-RAIL GRADE CROSSINGS

8.3.1 General

Pedestrians at highway-rail grade crossings present unique challenges. Many of the same considerations given to motor vehicles – such as channelization, signs, and warning lights – also apply to pedestrians as crossing users. This section will discuss and define the components and treatments that together, all or in part, comprise a pedestrian-rail grade crossing and then will describe the applications at the different types of pedestrian-rail grade crossings.

The design of pedestrian-rail grade crossings and installation of pedestrian treatments shall be in accordance with the process in Section 8.3.7 and the Pedestrian-Rail Grade Crossing Design Consideration Flowchart in ES 4004. This process shall be similar for any type of pedestrian-rail grade crossing and defines SCRRA's required approach to the application of pedestrian treatments at pedestrian-rail grade crossings. Design of a pedestrian-rail grade crossing should include the following features:

- A smooth, easily traversed surface that does not impede individuals with disabilities, strollers, or carts, incorporated into the adjacent sidewalk topography.
- Clear striping and signage that avoids confusing directions or features, a relatively straight path that is clearly marked and easily accessible throughout the footprint of the crossing and a readily accessible means of exiting the crossing.

- Deterrents such as signage, fences, and gates that minimize trespassing into prohibited areas of the railroad right-of-way.

8.3.2 Pedestrian-Rail Grade Crossing Types

The design of a pedestrian-rail grade crossing should provide an environment that provides ample opportunities for pedestrians to observe and comply with the warning devices and stay clear of any approaching train traffic. The decision to select passive and active warning devices depends upon the four types of crossing noted below.

- Pedestrian-Rail Grade Crossings at Highway-Rail Grade Crossings
- Pedestrian-Rail Grade Crossings at Highway-Rail Grade Crossings and Adjacent to Rail Passenger Station
- Pedestrian-Rail Grade Crossings at Stations
- Pedestrian-Rail Grade Crossings

With each type, the following factors need to be considered:

- The number of tracks, type of tracks (i.e. main, siding, industry lead), and track speeds
- Type of train traffic (commuter, transit, long distance passenger, freight)
- The proximity to rail passenger stations
- The proximity to other rail facilities such as sidings, yards, industry spurs
- The skew and vertical profile across the crossing
- Establishment of quiet zones
- Travel distance across tracks to reach a location clear of the train dynamic envelope
- Visibility restrictions
    - Sight distance for pedestrians (as well as motorists) viewing approaching trains and conversely for trains viewing approaching or waiting pedestrians/vehicles.
- Existing and future pedestrian and bicycle activity
- Type of path (pedestrian only or combined pedestrian and bicycle)
- The volume and pattern of pedestrian activity
- Type of pedestrian activity (i.e., school, transit, hospital)
- Current and future development (including transit service and transit-oriented development) in close proximity to the pedestrian-rail crossing
- Right-of-way constraints

A. Pedestrian-Rail Grade Crossings at Highway-Rail Grade Crossings

Most pedestrian-rail grade crossings on SCRRA's system are of the type where the pedestrian-rail grade crossing is a part of the highway-rail grade crossing and is located on one or both sides of the highway.

When beginning the design for modifications to a highway-rail grade crossing, the designer should determine whether the highway agency allows pedestrians along the highway and to what degree pedestrian facilities are already in existence. A flowchart detailing the decision process for determining the type of pedestrian treatments warranted for a highway-rail grade crossing is provided in ES 4104.

B. Pedestrian-Rail Grade Crossings at Highway-Rail Grade Crossings and Adjacent to Rail Passenger Stations

Combined pedestrian-rail grade and highway-rail grade crossings near rail stations are considerably more complex and represent a special case of pedestrian-rail grade crossings. Some of the complicating factors are as follows:

- These pedestrian-rail crossings may be used by large groups of commuter rail patrons accessing the platforms and by pedestrians crossing the tracks.
- The level of pedestrian activity at a station crossing is directly associated with the departure and arrival of passenger trains and other transit modes such as buses and shuttles; it is also associated with the presence of parking lots.
- The stopping patterns and dwell times of trains affect the operating characteristics of the active warning devices.

The designer shall follow the same design process used for a pedestrian-rail grade crossing adjacent to a highway-rail grade and determine the appropriate pedestrian treatments as provided in Section 8.3.7.

C. Pedestrian-Rail Grade Crossings at Stations

Pedestrian-rail grade crossings at stations (not located at highway-rail grade crossings) are primarily used by commuter rail patrons accessing the platforms; however, in some circumstances they may also be used by pedestrians to cross the rail corridor.

As noted in Section 8.3.2-A, the level of pedestrian activity at a station crossing is directly associated with the departure and arrival of passenger trains. New station pedestrian-rail grade crossings shall provide full pedestrian treatments.

- Signage
- Channelization
- Active pedestrian warning devices
- Pedestrian gates
- Pedestrian swing gates

- Fencing

Pedestrian-rail grade crossings shall not cross more than two tracks.

Currently, there are two types of pedestrian-rail grade crossing configurations at stations on SCRRA's system:

1. Pedestrian-rail crossings at any location on the platform
   - Due to safety concerns and operating restrictions, new pedestrian-rail grade crossings at any location on platforms shall not be allowed.
   - Reconstruction of existing stations that have a pedestrian-rail grade crossing at any location on the platform shall relocate the pedestrian-rail grade crossing beyond the ends of the platform.
   - If the pedestrian-rail grade crossing cannot be relocated beyond the ends of the platform, then a pedestrian grade separation (Overhead or Underpass) shall be constructed.
2. Pedestrian-rail grade crossings located past the ends of platforms
   - New station pedestrian-rail grade crossings shall be constructed 60 feet from the ends of the platform and include full pedestrian treatments. See ES 4021.
   - It is desirable to have the gates recover during normal station dwell time.
   - Fencing or metal hand railing shall properly channelize pedestrians across the tracks at the pedestrian-rail grade crossing and deter the public from taking a "short cut" and trespassing across the tracks in prohibited areas.

PEDESTRIAN-RAIL GRADE CROSSING VS. GRADE SEPARATION AT STATIONS

Pedestrian-rail grade crossings are discussed in chapter 12 section 4.4.

D. Pedestrian-Rail Grade Crossings (for Pedestrians Only)

Pedestrian-rail grade crossings are crossings for pedestrians only. Pedestrian-rail grade crossings shall follow the same design process as a pedestrian-rail grade crossing at highway-rail grade crossings in Section 8.3.2-A.

Any new pedestrian-rail grade crossings shall not be allowed.

Pedestrian-rail grade crossings are typically associated with walking paths and bike trails adjacent to the railroad right-of-way. Pedestrians may be tempted to take shortcuts and trespass rather than use the designated pedestrian crossings. This behavior shall be considered when designing the crossing and place the proper fencing and channelization to address this undesirable behavior.

8.3.3 Americans with Disabilities Act

The Americans with Disabilities Act Accessibility Guidelines (ADAAG) govern the design and construction of any features associated with pedestrian crossings. ADA Accessibility Guidelines must be incorporated into the overall design for pedestrian-rail grade crossings. Designers should also review CBC chapter 11B division 4.

A. Detectable Warning Strips

The ADAAG requires that detectable warning be placed on approaches to hazardous vehicular areas, which includes highway-rail grade crossings (ADAAG 4.29.5). Detectable warning strips shall be installed on the sidewalk ahead of the warning device in order to show pedestrians where to stop when a train is approaching. The width of the detectable warning strip shall be 3 feet wide as prescribed by the ADAAG. See also CBC 11B-705 Detectable warnings and detectable directional texture

The detectable warning strip shall also be placed in front of the pedestrian swing gates to warn people that there is a hazardous vehicle area beyond the swing gate.

The placement of the detectable warning strip shall follow the standards outlined in SCRRA's Engineering Standards.

B. Flangeway Gap

The track structure is made up of many components. The component that most affects the pedestrian-rail grade crossing is the flangeway.

The ADAAG limits the width of the flangeway gap to a maximum of two and a half inches (ADAAG 10.3.1). The surface of the crossing shall be level and flush with the top of the rail at the outer edge and between the rails. Freight railroads require a three-inch flangeway gap at installation to allow for wear of about one inch in regular use. To accommodate both ADA and freight requirements, SCRRA standards call for a rubber flangeway filler for all new or improved crossings. The rubber filler allows a two-and-a-half-inch gap to be maintained for ADA requirements while providing flexibility to provide a three-inch gap by being compressed to provide an extra half inch as wheels of the freight train pushes against the rubber filler as it crosses over the concrete panel. After the freight train passes over the concrete panels, the rubber filler will return to its undisturbed shape and maintain the two-and-a-half-inch gap. See ES 4201.

8.3.4 Visibility

Visibility between trains and pedestrians shall be considered during the diagnostic analysis and design of the crossing. The design should provide the pedestrian reasonable visibility of a train upon its approach and departure. This is especially important when dealing with a multi-track crossing, when the view of an approaching train may be blocked by an additional train. In general, the installation of active warning devices including automatic gates and appropriate fencing will mitigate the lack of visibility. During the initial site assessment, all features in and around the crossing that could impede pedestrian visibility shall be examined. Pedestrian gates shall be equipped with two-way warning lights, for all pedestrian approaches, aimed at the pedestrian path.

The overall visibility at the crossing shall be considered from the pedestrian's perspective and deficiencies that could diminish the intrinsic safety of the crossing shall be mitigated. During the diagnostic analysis and inventory, the diagnostic team shall consider the following and take appropriate action:

- Diagram the crossing to show the obstructions to pedestrian visibility and incorporate solutions/mitigations into the design of the crossing.
- Examine each of the features at the crossing, and thoroughly explore the risk arising from those features. Include recommendations to remove a feature that is severely impeding pedestrian visibility.
- Additional devices or signage may be necessary to offset the lack of visibility created by the obstructions; however, placement of each of these devices should be carefully examined for compatibility with existing features.

8.3.5 Warning Devices for Pedestrian Crossings

Warning devices warn pedestrians of approaching trains and dictate the pedestrian to not cross the tracks. As with highway-rail grade crossings, there are two types of warning devices for pedestrian-rail grade crossings:

- Active Warning Devices
- Passive Warning Devices

A. Active Warning Devices

Active warning devices applicable for pedestrian-rail grade crossings are usually similar to those for vehicles. Active pedestrian warning devices include pedestrian gates, which is a variation of the CPUC Standard No. 9, with the main difference being that they have shorter gate arms and no counterweight. The active pedestrian warning devices also have an additional pair of flashers focused on pedestrian pathways facing the tracks. Refer to SCRRA ES 8308 and 8309 for pedestrian gate standards.

Active warning devices that are used to aid pedestrians take on a variety of configurations. Refer to SCRRA ES 4011 - 4021 for examples of these configurations.

Active warning devices for pedestrian-rail grade crossings should be installed at the preferred 15 feet from the centerline of the track, as measured from the center of the mast at new or existing crossings.

B. Passive Warning Devices

The following passive warning devices shall be used in conjunction with Active Warning Devices at all new pedestrian crossings.

i. Signage

Signage is utilized throughout a crossing to guide pedestrians. Of particular note, are the signs warning pedestrians of multiple tracks, and the possibility of multiple trains at the crossing. These signs should be used at the approaches to the crossing. The potential presence of a second train is an important consideration when applying signage to the crossing. See Chapter 31 Signage.

ii. Pavement Markings

Pavement markings for pedestrian-rail grade crossing should generally consist of white striping, similar to crosswalk striping for highways. Refer to the SCRRA ES 4006 and ES 4011 - 4021 for details on pavement markings. All pavement markings shall be thermoplastic per SCRRA ES 4006.

iii Swing Gates

Pedestrian swing gates have two distinct functions: they can serve as an entry/exit swing gate, or strictly as an emergency exit gate, as explained in further detail below:

- As an entry/exit swing gate, the swing gate is intended, when not used with a pedestrian-rail grade crossing gate, to slow pedestrians and encourage them to stop, look both ways down the track for approaching trains, and then pull the swing gate open to safely cross the tracks. A “LOOK” sign, as detailed in SCRRA ES 4002, shall be mounted on the approach side on the swing gate or on a separate post next to the swing gate. Particularly at pedestrian-only crossings without active warning devices and automatic gates, the pedestrian must determine if there is sufficient time to cross the tracks in front of an approaching train. The design of the crossing should provide the pedestrian with adequate visibility. Appropriate “Push Gate To Open” signs on the track side and “Pull Gate To Open” signs on the approach side shall be mounted on the entry/exit swing gates.
- As an emergency exit gate, the swing gate is incorporated with an active warning device, so pedestrians shall have an escape route in the event of occupying the crossing during the time when a crossing gate is activated. The gate shall only swing away from the crossing, with clearly marked “Push Gate to Open” signage on the track side. The approach side of the swing gate shall have signage marked as “Exit Only” to deter pedestrians from using the gates and entering the crossing while the active warning gates are activated.

Refer to SCRRA ES 4002 for details on the swing gates and signs.

8.3.6 Pedestrian Channelization

The design of pedestrian-rail grade crossings shall provide clear, well-defined traveled-ways throughout the crossing and should discourage improper pedestrian movement, such as circumventing the gates, walking onto the railroad Right-of-Way, or walking onto the highway. Fencing or railing shall be provided along the sidewalk to direct pedestrians along the proper path. Coordination with the SCRRA Signal Department is required to ensure this railing, to the extent possible, does not block or impede maintenance access to railroad signal devices and does not interfere with the location of the devices used for sealing the corridor. This channelization device can be tubular steel railing, ornamental fencing, or welded wire mesh fencing. The type of channelization device to be used shall be discussed and agreed upon with the highway agency.

Additional controls shall be used to identify the pedestrian travel-way such as striping per Pavement Markings in Section 8.2.12-B. Bold, white striping is used to delineate the pedestrian's path across the crossing. Refer to SCRRA ES 4011 - 4021 for examples of these treatments.

A. Influencing Pedestrian Line of Sight

The channelization of pedestrians is particularly effective when attention can be directed along a given line of sight. By controlling the direction taken by pedestrians approaching a crossing, pedestrians may be influenced to look in a given direction. For example, the creation of a zigzag pedestrian path forces the pedestrian to look along both approaches of the crossing, maximizing the likelihood that the pedestrian will notice trains approaching from either direction.

B. Trespass Prevention

Pedestrians sometimes trespass into prohibited areas of the railroad right-of-way. This problem requires special consideration. Traditional designs have often used fencing to keep pedestrians out of protected areas. "No Trespassing" signs, complete with warnings about enforcement and prosecution, have also been used. During the diagnostic review, the team should review pedestrian access to the railroad right-of-way and develop safe and effective solutions to prevent trespassing.

C. Inter-Track Fence

An inter-track fence is a fence between two tracks, typically at a station, that prevents pedestrians from unsafely crossing the tracks to get from one platform to the other platform. At stations, track centers shall accommodate the inter-track fence clear of any component of the inter-track fence, including sliding gates. Track centers shall not exceed more than 25 feet to accommodate an inter-track fence.

The fence shall extend the full length of the platform and channelize the passengers to crossings at the ends of the platforms. See ES 4020 and ES 4021.

The height of the inter-track fence shall not exceed four feet within 150 feet of any crossing (station or highway) to ensure that proper visibility is maintained between the train and motorist/bicyclist/pedestrian. Where tracks cannot be widened to accommodate an inter-track fence, proper signage should be installed to deter pedestrians from crossing the tracks except at the proper and designated locations.

D. Refuge Areas

SCRRA standard pedestrian channelization include a refuge area that pedestrian can utilize as a means of exiting the crossing when the pedestrian gates are activating, and a train is approaching. This refuge area is not intended as a location where a pedestrian can wait for the train, but rather as a safe harbor if the pedestrian is between a downed gate and the track. Refer to SCRRA ES 4011 - 4021 for examples of these refuge areas. The refuge area shall incorporate a swing gate to allow pedestrians to exit the refuge area away from the tracks.

8.3.7 Design Process and Consideration Table

Pedestrian-rail grade crossings should, in combination with the horns on locomotives, provide adequate warning devices which allow pedestrians and bicyclists to be warned of approaching trains and take appropriate action. During the design of the pedestrian-rail crossing see ES 4004 for Pedestrian Crossing Design Consideration Table.

8.4 RAILROAD ACTIVE WARNING AND TRAFFIC SIGNAL SYSTEM INTERCONNECTION CIRCUITS

8.4.1 Interconnection Design

A. Background

The field of traffic signal preemption continues to evolve. Before designing a traffic signal preemption circuit, the designer should review the latest guidelines regarding traffic signal preemption as prepared by the Institute of Transportation Engineers, AREMA, CA MUTCD, CPUC, and other knowledgeable parties. Circuits described below are based on fail-safe closed loop methodology. A vital serial data circuit in accordance with IEEE Standard 1570-2002 may be used in lieu of the referenced circuits. Design and testing of traffic signal preemption interconnection circuits must be coordinated with the railroad and the agency having jurisdiction.

B. Interconnection Circuits

Older style Traffic Signal Interconnection schemes used a simple two wire circuit between the traffic signal cabinet and the railroad crossing warning equipment to notify or issue a call for traffic signal preemption. This scheme was generally used with simultaneous preemption and a very basic traffic management program. Modern Traffic Signal Interconnect designs use multiple circuits to provide a cable integrity check, system health status and the position of Entrance gate mechanisms.

C. Short/Cut Circuit Interconnection Fault Protection

It is important that a potential short or cut in the interconnection circuit between the railroad and traffic signal equipment be detected. The states of the two inputs can be monitored by the traffic signal equipment in the form of an “Exclusive-OR” logic, which can detect if there is a short or cut in the interconnection circuit. As shown in Table 8-4, the “true” states are the normal and preempt operations, while the “false” states are the other states of the input, which are considered “fault” conditions that will set the traffic signal into an “all-red-flashing” operation.

TABLE 8-4. SUPERVISED PREEMPTION CIRCUIT LOGIC

Inputs		Traffic Signal Operation
Primary	Secondary	
High	Low	Normal
Low	High	Preempt
High	High	Fault
Low	Low	Fault

In order to detect a shorted or open interconnection circuit, two additional wires are used to provide a supervised circuit. The energy source originates at the traffic signal controller: two wires provide a return path, verifying the railroad preemption control relay is energized and there is no call for preemption. The two additional wires verify circuit integrity when the railroad issues a call for preemption. The circuit logic is “Exclusive OR.” One circuit must be energized and the other de-energized. If both circuits are shown to be energized or both appear de-energized, it indicates a problem with the interconnect circuit. In that case, the traffic signal controller should assume a state known to be safe and issue a notification that there is a circuit deficiency.

D. Gate-Down Circuits

A preemption trap condition occurs when the track clearance green time ends too soon, prior to the motorist clearing the grade crossing area.

One of the solutions to avoid preemption trap is to use a “gate down” circuit as required by the CA MUTCD, Section 8C.06 (16). The purpose of the “gate down” circuit is to prevent the traffic signal from leaving track clearance green time until it is determined that all gates on approach to the grade crossing are fully lowered. The “gate down” circuit notifies the traffic signal controller unit when the gates controlling access over the tracks on the approach to the intersection have either fully lowered or the train has occupied the crossing. At the beginning of preemption, the traffic signal controller unit will transition to track clearance green as usual, but shall dwell in the track clearance green time until the “gate down” confirmation is received, or until a user-defined maximum time has expired. Traffic Signal Health Check Circuits

A health check circuit provides an indication to the railroad active warning system cabinet when the traffic signals are in red flash (such as when the controller is in failure) or when dark (due to loss of power). This health check circuit requires additional wires/cables between the traffic control signal cabinet and the railroad active warning system cabinet. Consideration should be given to a fail-safe design for the health check circuit so that there shall be no case in which the circuit shall remain energized while the traffic signals are flashing or dark.

E. Interconnection Circuits

Jointly the Highway Agency and SCRRA will collaborate and determine the specific Traffic Signal Interconnection circuit to be used at specific crossing locations. The design of the interconnection circuits shall be reviewed and approved by the Highway Agency and SCRRA before any new systems are installed or changes to existing systems are made.

F. Total Approach Time for Traffic Signals

Total Approach Time for traffic signals, shall be limited to a maximum time of 50 seconds. Second Train Logic

Where there is more than one track, a second train can approach at any time. If there is an advance preemption interconnection between the traffic signals and the railroad, the appearance of a second train can hold the traffic signals in preemption and have the gates rise momentarily, allowing vehicles to pull up onto the tracks. Where second train logic is employed, if a second train is detected on the outer approach, the gates shall remain down until after the second train passes. Second train logic may be employed where no traffic signals are present if circumstances warrant.

8.5 SPECIAL ISSUES

8.5.1 Adjacent Freight, Transit Tracks, or other Tracks

The responsibility of installing and maintaining warning devices at the crossing will fall on the railroad that owns and operates the part of the crossing on which the warning devices are required. In such cases, there may be two separate crossing warning systems, one from SCRRA and one from the foreign railroad, at the crossing that must be interconnected to work in conjunction with each other. Coordination with the foreign railroad must be done throughout the design stages to ensure that adequate warning devices are installed at the highway-rail grade crossing and will work in conjunction with one another.

See Chapter 30 Shared Corridors for additional information about LRT, High Speed Rail, and other adjacent uses.

8.5.2 Adjacent Development

Redevelopment and new developments have afforded the opportunity to control the location of driveway approaches that are close to the highway-rail grade crossing (see Section 8.2.9). The designer shall review the development plans, coordinate with the highway agency, and ask the highway agency to impose “conditions for development approval” relative to development street access.

Adjacent residential and commercial development to highway-rail grade crossings may substantially increase the volume of highway traffic over a crossing. This may occur during certain times of day, such as during peak rush hour periods, or during certain times of the year. Schools near highway-rail grade crossings may generate increased volumes of vehicular and pedestrian traffic before and after school hours. Likewise, certain entertainment/sporting venues may increase vehicular and pedestrian traffic before, and after, an event. Observations of a highway-rail grade crossing during different times of the day and year should take place to understand how the dynamics of adjacent development affect a highway-rail grade crossing. The selection of appropriate traffic control/warning devices shall be installed to mitigate these affects.

8.5.3 Landscaping

It is important that landscaping not decrease the level of safety at a highway-rail grade crossing by impeding the visibility of any active or passive warning signals or signage for motorists, bicyclists, pedestrians, or train engineer.

Refer to Chapter 26, Landscaping Design for landscaping during design, construction, and maintenance on and adjacent to SCRRA railroad right-of-way.

As mentioned in Section 8, within 150 feet of a highway-rail grade crossing or in the median within 150 feet of a highway-rail grade crossing, stamped concrete, or other hardscape materials, infill for median islands shall be used as the standard landscape treatment for median islands.

8.5.4 Bikeways and Trails

The addition of bikeways and trails within, or adjacent to, the railroad right-of-way presents a challenge to both the highway agency and railroad operators. Of particular concern to SCRRA is the activity of pedestrians and bicyclists within the right-of-way. Also, the incorporation of a bike path that is adjacent to the highway-rail grade crossing intersection introduces another element to be accounted for within the analysis and determination of preemption requirements for the highway-rail grade crossing. Refer to Chapter 27 for Rail-With Trail design criteria. The highway agency shall follow this procedure in the development of the trail, including improvements to site within and adjacent to the railroad right of way, and may include the installation of additional fencing and channelization, modified traffic signals, pedestrian treatments, and additional highway-rail grade crossing warning devices. The initiating agency shall facilitate a diagnostic review and highway-rail grade crossing design process to mitigate these effects.

8.5.5 Right of Way Fencing and Security Gates

The design of the SCRRA Right of Way shall incorporate adequate fencing to limit access by trespassers onto SCRRA railroad right-of-way.

This fence shall be tubular steel fencing or other non-cuttable fencing as per SCRRA Engineering Standards. The fence shall be located at the edge of the trail and along the railroad right-of-way.

A three split-rail fence, in combination with landscaping that can serve as a positive barrier between the track and any bike/pedestrian trail, may be used in rural or environmentally sensitive areas, if approved by SCRRA and the member agency. Since newly planted landscaping may take a few years before it becomes an effective barrier, suitable temporary measures may be required until the landscaping has sufficiently matured. Any landscaping must be maintained so it does not impede the visibility of any active or passive warning devices or traffic control devices —by trains, pedestrians or engineers.

It is SCRRA's policy to maintain access along its right-of-way for maintenance and inspection. The right of way fencing shall not be constructed so as to limit this access. Should access points be necessary, the fencing shall incorporate gates at locations as per SCRRA Engineering Standards or locations requested by SCRRA maintenance crews. These gates shall be secured with SCRRA locks. The highway agency shall install "No Trespassing" warning signs, as per SCRRA ES 5214.

The height of the fence within 150 feet of highway-rail grade crossings shall be 4 feet. The height of the fence in the balance of the right-of-way shall be at least 6 feet.

All access points to SCRRA rights-of-way at highway-rail grade crossings shall utilize a chain link gate in accordance with SCRRA ES 4011 – ES 4016. These gates are to be installed in accordance with these drawings, as follows:

- The gate shall be placed to allow a maintenance vehicle to safely park off the highway, prior to opening the gate.
- Gate swing shall not foul tracks.
- The installation of the gate shall be incorporated into the proposed fencing plan to adequately secure the right-of-way.
- Bollards, K-Rails, or other substantial barriers shall be used with the right-of-way gates to provide a maximum level of security.

8.5.6 Lighting

The highway authority shall provide and maintain lighting for the travel-way to maintain a safe environment for all crossing users. Local, state, and federal guidelines, as well as industry standards for lighting, shall be incorporated into the design. For lights installed within SCRRA Right-of-Way, electric power supplied to these lights must not utilize the same electric meter service or power source as that supplied to the railroad grade crossing warning equipment. All lighting equipment, including light poles and foundations must be installed to provide a minimum of thirty feet clearance between the light foundation and the nearest running rail of the track and such that no part of the lighting system will block access to the railroad Right-of-Way.

8.5.7 Vital Equipment Placement and Maintenance Access

Whenever a highway-rail grade crossing is being modified, placement of vital equipment and maintenance access must be considered and evaluated. When evaluating the crossing to place vital equipment, such as signal houses and cabinets, the highway geometry should be reviewed to determine which quadrant would be the best to place vital equipment to avoid being damaged from errant vehicles. Vital equipment, such as a signal house, should be placed in the least accident-prone quadrant of the highway-rail grade crossing, when possible. If vital equipment is placed in a location that has a high potential of being hit by errant vehicles, the vital equipment shall be protected with bollards or guard-railing to prevent or minimize damage to the vital equipment.

Maintenance access to the railroad signal devices and railroad right-of-way must also be provided whenever a highway-rail grade crossing is modified, to allow SCRRA’s maintenance forces to perform maintenance (either at the grade crossing, signal houses, or along the track). Providing maintenance access can be a challenge with pedestrian channelization devices due to limited Right-of-Way. Coordination with the SCRRA is required to ensure that the pedestrian channelization devices, to the extent possible, does not block or impede maintenance access to railroad signal devices and railroad right-of-way.

A. Maintenance Access to Railroad Warning Devices

All pedestrian channelization devices must be designed to provide a minimum of 24 inches of clearance between any part of the railing structure and any active warning devices.

B. Maintenance Access to Railroad Right-of-Way

Maintenance access to the railroad right-of-way must be provided outside the limits of the crossing gates to allow safe entry of maintenance personnel to the railroad right-of-way. Maintenance access to the railroad right-of-way can be either a driveway that meets the Highway Agency's standard or a 4-inch mountable curb with proper transition to full height curb as noted in SCRRA's Engineering Standards. An access gate, wide enough to accommodate a maintenance vehicle, shall also be provided to seal off the railroad ROW from the public, while allowing access to only authorized personnel. See SCRRA ES 4011 – ES 4016 for examples of maintenance access at highway-rail grade crossings.

8.5.8 Positive Train Control Critical Features

Positive Train Control (PTC) is a system that automatically stops a train to prevent certain accidents from occurring, such as:

- Train to Train Collisions
- Excessive Speed
- Train Movements onto Unauthorized Tracks/Work Zones

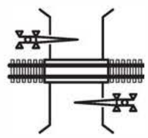
PTC does not prevent accidents that may occur with vehicles at highway-rail grade crossings. Even though the operation of a highway-rail grade crossing is not affected by the PTC system, there are certain features associated with a highway-rail grade crossing that affects the PTC system. These features that affect the PTC system are known as PTC critical features. Any modifications to a highway-rail grade crossing that includes modification to existing or addition of new PTC critical features shall be coordinated with SCRRA's PTC Technical Services Group. Refer to CHECK B4 U CHANGE Figure 8-5 that shows items that are considered PTC critical features.

CHECK B4 U CHANGE

- ☐ CHANGE COORDINATION BOARD APPROVED*
- ☐ COORDINATION IN PLACE

* IF UNSURE, CHECK WITH YOUR MANAGER

CHANGES TO A GRADE CROSSING

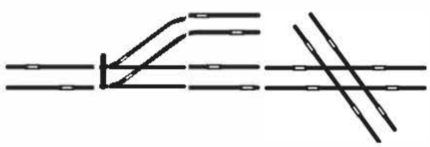


- STREET WIDENED
- NEW PANELS
- CHANGES TO GATES – INCLUDING PEDESTRIAN GATES
- QUIET ZONE
- APPROACH TIMING
- TRAFFIC SIGNAL & INTERCONNECTION

CHANGES TO SIGNALS & WAYSIDE DETECTORS

- TYPE OF SIGNAL
- OPERATION OF SIGNAL
- SIGNAL ASPECTS
- NUMBER OF HEADS AND LOOPS
- SIGNAL PROGRAMS
- LOCATION OF SIGNAL
- ABSOLUTE SIGNAL
- NUMBER PLATED
- P–PLATE
- ANY CHANGES TO A CP

CHANGES AT A TURNOUT / DIAMOND



- ADDING OR REMOVING A TURNOUT OR DERAILS
- CHANGING INSULATED JOINTS**
- REPLACING POINTS**
- ANY CHANGES TO THE GEOMETRY
- CHANGES TO TYPE OF SWITCH:
  - a. POWERED
  - b. ELECTRICALLY LOCKED
  - c. HAND OPERATED
  - d. WITH LEAVING SIGNAL
  - e. NON–CLEARING
- TYPE OF DERAIL
- EMERGENCY REPAIR, PROCEED WITH REPAIR AND CONTACT 1–888–446–9715 AS SOON AS COMPLETE. NOTE PTC COMPONENT CHANGED OR MODIFIED.

CHANGES TO SIGNS

- SPEED SIGNS
- LIMIT SIGNS
- MILE POST
- WHISTLE SIGNS
- DAMAGE OR REMOVE TRACK MARKING

CHANGES TO TRACK/GEOMETRY

- ALIGNMENT
- SUPERELEVATION
- REMOVAL OR MOVING**

CHANGES TO SPEEDS

- PASSENGER OR FREIGHT
- TONS PER OPERATIVE BRAKE
- SUBDIVISION SPECIAL SPEED RESTRICTIONS

ANY & ALL CHANGES TO THE PHYSICAL CHARACTERISTICS

* EMERGENCY REPAIR, PROCEED WITH REPAIR AND CONTACT 1–888–446–9715 AS SOON AS COMPLETE. NOTE PTC COMPONENT CHANGED OR MODIFIED

FIGURE 8-5. CHECK B4 U CHANGE

C. Commissioning of PTC with Changes to PTC Critical Features

Prior to placing a new or modified highway-rail grade crossing into service, the physical characteristics of the crossing must be surveyed and incorporated into the PTC Subdivision (Subdiv) file. The changes to the Subdiv file must then be verified by on-site measurement and verification per the SCRRA prescribed Verification and Validation (V&V) Process. The Subdiv file must also be verified by lab testing through SCRRA's PTC Technical Services Group. Only after these processes have been successfully completed and documented can the crossing commissioning process be moved forward. The designer responsible for the crossing design must coordinate with SCRRA's PTC Technical Services Group in order to establish schedule and budget for accomplishing these sub-tasks.

8.5.9 Closing Crossing

Highway-rail grade crossings that are to be closed shall require coordination with all active users of the crossing. Stakeholders shall be informed of the pending closure per state and municipal requirements. A crossing that is to be closed shall at minimum meet appropriate municipal requirements for a dead end, cul-de-sac or other road closure method. The designer is directed to the FHWA Grade Crossing Handbook, third edition, Chapter 2 Engineered Treatments – Closure or Separation section for guidance on closing a crossing.

9.0 DRAINAGE AND GRADING

9.1 SCOPE

The design criteria for drainage facilities and grading located within SCRRA ROW and for other drainage facilities located outside SCRRA ROW that are affected by SCRRA construction are discussed below. In general, modification or relocation of existing drainage facilities belonging to an agency other than SCRRA shall be "replacement in kind" or "equal construction," unless conditions of flow, loading, or operation are altered. If conditions are altered, designs shall conform to the design criteria and the standards of the agency involved.

These drainage design criteria are intended to protect SCRRA facilities from storm water damage and to drain the ROW within a reasonable amount of time to minimize risk of damage. Local water accumulation weakens the track subgrade, interferes with walkways, and increases vegetation. Good drainage practices that follow industry standards for design also protects SCRRA from liability from damage to other property due to storm water flows caused by the construction of SCRRA improvement.

The site must be assessed for flood related climate vulnerability (see Section 3.3) to ensure it is designed to be resilient to future climate conditions.

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

9.2 GENERAL DRAINAGE DESIGN REQUIREMENTS

Criteria for design of SCRRA system drainage facilities are provided in the sections below. In some cases, other more stringent criteria may govern the design. The designer shall evaluate whether criteria by FHWA, FEMA, Caltrans, the city, the county, the reclamation board, the flood control district, or the local FEMA floodplain administrator, or other regional or local jurisdictional limits apply. If so, the more stringent design criteria shall be adopted by the designer.

If the site is in a location projected to be exposed to increased depth of 100-year flooding or identified in the CVA as highly vulnerable to flooding, the designer shall consider alternative design and obtain SCRRA approval. Partnerships should be explored with local flood control districts to identify and solve localized flooding to Metrolink tracks where it originates from overtopped flood control channels.

Pumps are required in tunnels or depressed grade separated crossings capable of 24/7 pumping out storm and ground water will be updated and/or replaced with readily available inexpensive pumps that can be quickly replaced if failure occurs. The size of pump required shall be reviewed for adequacy and have back-up pumps available.

9.3 PERMITTING

On behalf of SCRRA, and unless directed otherwise by SCRRA, the design consultant shall coordinate with floodplain development and environmental permitting agencies, obtain and submit all permit applications, and track progress of each permit. The design consultant shall submit draft permit applications and all accompanying data to SCRRA for review and approval prior to submittal to the agencies. When all permits have been obtained, the design consultant shall transmit a "Permit Completed" letter, complete with the original and one copy of the permit documents, to SCRRA for handling with construction forces. Permit letters shall conform to the following:

1. Permit letters shall identify what SCRRA proposes to do, what additional information is included, a request for permit determination, and where additional information can be obtained or questions answered.
2. Requests for permits shall be made to all agencies that have jurisdiction. Some agencies will request notification only and have no formal permit requirements.
3. All permits and forms shall be completed and signed by the design consultant acting on behalf of SCRRA.
4. One letter shall be used to notify as many agencies as practical.
5. All required figures, tables, and supporting information, as well as a photograph of existing structures, shall be included with the permit letter.
6. Where permits require payment of fees, supporting forms and documents shall be submitted in completed form and payment made by the design consultant.
    a. Prior to payment, the design consultant shall notify SCRRA Project Manager of fees that have not been accounted for in the project or if the fees exceed the amount budgeted for the project.
7. Where permitted, the design consultant shall sign all permit correspondence on behalf of SCRRA. All draft and final correspondence will be copied and provided to SCRRA.

Upon receipt of permit approvals from all agencies, the design consultant shall transmit a final permit letter to SCRRA stating that all permit activity is completed and provide copies and summaries of all permits.

9.3.1 Non-SCRRA Drainage Facility Connection to SCRRA Drainage Facilities

Non-SCRRA drainage facilities being designed to interconnect with SCRRA drainage facilities shall conform to the drainage criteria of this chapter. Upon completion of construction, as-built drawings shall be provided to SCRRA. This applies to SCRRA projects as well as any Third-Party Projects.

Third Party Project teams are encouraged to reach out to SCRRA early in the design process to avoid delays and design changes during the Right-of-Entry Permit process. Standard plan review fees will apply, refer to the latest Right-of-Way Encroachment process on Metrolink's Engineering & Construction webpage at www.metrolinktrains.com.

9.4 HYDROLOGY

9.4.1 Design Storm Frequency

Table 9-1 provides guidelines on the storm frequency to use in developing design discharge rates for SCRRA drainage facilities. In some cases, other more stringent criteria may govern the design.

The engineer shall evaluate whether criteria by FHWA, FEMA, Caltrans, the city, the county, the reclamation board, the flood control district, or the local FEMA floodplain administrator, or other regional or local jurisdictional limits apply. If so, the more stringent design criteria shall be adopted by the design consultant. In locations identified as highly vulnerable to flooding in the CVA increase the design storm frequency required to account for larger expected flow rates.

TABLE 9-1. DESIGN STORM FREQUENCIES*

Drainage Area	Storm Frequency
All culverts and drainage crossing the SCRRA mainline and mainline siding tracks	low chord/soffit = 50-year subgrade = 100-year***
All culverts and drainage crossing industrial leads, yards, and customer-owned or third-party tracks**	low chord/soffit = 25-year subgrade = 50-year
All new or replacement conduit in all off-track cases where drainage is picked up by means of a head wall, and where inlet or outlet conditions control the hydraulics	10-year
Track Roadbed Ditches (to top of subballast)	10-year
Main storm drains	10-year
Parking lots	10-year
All longitudinal drains or subdrains that could flood the roadbed	10-year
All sump condition areas (defined as a low area which prevents the free passage of water with consequent flooding of streets of Private property).	50-year
All other areas	50-year

* Where an established FEMA -mapped floodplain exists, bridges, culverts, and channel improvements shall also comply with the requirements of the NFIP as administered by the local FEMA floodplain administrator.

** If a drainage structure crosses under both mainline and non-mainline tracks, the most restrictive criteria shall apply.

***Regardless of whether the structure is in a FEMA -designated floodplain, the 100-year water surface elevation of any replacement opening shall be compared with the existing condition 100-year water surface elevation, and the waterway shall be sized such that impacts on the water surface profile conform to SCRRA, FEMA, or other local water surface or freeboard criteria, whichever is more restrictive.

9.4.2 Hydrologic Methodology

Design flow rates shall be determined by the design consultant using the most current, local appropriate methods accepted by the industry as applicable for the particular watershed conditions that drain to the design point. In most cases, methods that provide peak instantaneous flow rates rather than hydrographs are appropriate.

Many methods are available for use by hydraulic engineers in estimating peak flow rates for design, including those in the AREMA Manual for Railway Engineering, Chapter 1, Part 3. Some agencies, such as Caltrans, provide hierarchical lists for selection of methods while other local jurisdictions may have mandates for methods that need to be used. As noted above, design methods in common use by other local designers should be researched and applied, with documentation provided justifying the designer’s selection. The final choice of method is left to the discretion of, and appropriate application by, the responsible hydraulic design engineer acting in full compliance with industry standards and local jurisdictional requirements. Future climate change conditions should be incorporated into the engineer's methodology.

- Unless governed by local jurisdictions, peak flow and hydrograph procedures described in FHWA HDS No. 2, "Highway Hydrology," as adopted or amended by Caltrans, are considered fully applicable to determining design discharges for SCRRA facilities.

For tidal areas, it is assumed that hydrology can be obtained using the same methods as for non-tidal sites. If in the judgment of the designer, further refinement is required, the designer will so recommend and obtain approval from SCRRA before proceeding.

Many government agencies have developed storm water management master plans that include peak flow estimates at various locations within their jurisdiction. These generally include existing condition as well as ultimate development flow rates developed using the most current and watershed-appropriate methods. The designer should verify the downstream facilities have been upgraded to the ultimate development as shown in the storm water management master plan. Where published flow rates exist, the designer should adopt the published values unless justification in support of alternative flow rates is approved by SCRRA.

Design for existing condition flows is allowed unless use of previously published ultimate development flows is mandated by flood control districts or other jurisdictions that will require a permit application. In the presence of published ultimate development rates but the absence of mandates for their use, the designer should apply methods that incorporate only those future developments that can be reasonably predicted. Where less than ultimate development rates are suggested, the designer shall provide his/her recommendation to SCRRA and receive approval from SCRRA before proceeding. Flow rates published in FEMA flood insurance reports are generally not recommended for design, but this is left to the discretion of the designer.

Storm scenario shall be based on future precipitation/flood projections.

9.4.3 Critical Storms for Rainfall--Runoff Methods

Some procedures for developing peak flow rates for various recurrence frequencies require conceptualizing a design storm for the selected frequency; this is then transformed into a design hydrograph or peak flow rate. Unless restricted by local jurisdictions or industry standards, the designer may assume that the frequency of the peak flow rate resulting from a rainfall-runoff method matches that of the design storm. Because many storm conceptualizations have the same recurrence frequency, consideration of the storm that produces the most critical peak flow is recommended.

9.5 HYDRAULICS

9.5.1 Cross-Track Bridge and Culvert Hydraulic Design Methods

Bridges and culverts that pass water from one side of the tracks to the other shall be designed by using detailed topographic contour maps or surveyed cross sections and existing structure geometry information to develop models of water-surface profiles for both the low chord/soffit and subgrade events along the stream and through the structures, both for the existing conditions and proposed new or replacement conditions. Water-surface profiles shall be computed by the latest version of public-domain backwater profile software, and results shall document the version used.

Some jurisdictions, particularly cities or counties that have implemented the NFIP and created detailed-study regulatory Zone AE floodplains and floodways, may require analysis of the proposed SCRRA facility impacts using the same software used in mapping the floodplains. In such cases, it will be acceptable for the designer to complete the design and perform the required before-and-after comparison using the agency model.

Adverse backwater effects of under-sized non-SCRRA facilities downstream of new or replacement cross-track or off-track SCRRA structures may occur if the facilities have lower flood passage capacities than SCRRA standards. These limited-capacity facilities may result in unreasonable costs in order to meet the criteria discussed in Section 9.3. If the limiting structure is likely to be replaced with an appropriately matched structure in the near term, the design can proceed, upon SCRRA approval, as though the condition is improved. Regardless, the backwater shall be assessed, and one alternative meeting SCRRA criteria shall be provided. The alternative may include a relief structure within SCRRA ROW to preclude inundation of the track, protect the downstream pipe, or protect downstream property owners. Care shall be exercised in designing junctions between larger culverts and smaller pipes to avoid an abrupt change of cross section, which might cause deposition of debris and clogging of the drain.

SCRRA system bridges and culverts conveying cross-track flood flows shall be designed to freely pass low flows and accommodate high-water conditions as follows:

1. Drainage facilities for the SCRRA system shall be designed with no increase of water levels on developed properties and no increases in erosion, sedimentation, or other adverse impacts on downstream developments.
2. For all cases, the opening will be sized so that the water surface for a low chord/soffit event will rise no higher than the lowest low chord of the bridge or soffit (crown) of the culvert.
3. For all cases, the opening will be sized so that the energy grade line for a subgrade event will not rise above the adjacent subgrade elevation (defined as 2.81 feet below top of rail elevation).
4. Both SCRRA criteria and local regulatory flood passage criteria shall be evaluated. The SCRRA criteria shall be adopted unless FEMA or other applicable flood regulations are more restrictive.
5. If the opening does not meet the criteria, a larger opening will be proposed provided that changes do not impact downstream development or violate other applicable flood regulations. For bridges, this enlargement will be lateral to the extent possible, and for culverts, the enlargement will be the fewest and largest culverts practicable to fit the existing channel width while meeting structural cover and spacing requirements and construction constraints.
6. If it is found that insufficient channel area exists to meet the criteria, even with maximum widening, consideration will be given to adding relief structures on the overbank floodplain, raising the SCRRA grade, or other reasonable alternatives.
7. The design of any drainage facility shall incorporate all applicable requirements to reduce erosion and control sedimentation caused by the drainage facility or construction activities.

8. Any requests for incorporating designs with surcharge at culverts for the low chord/soffit event will be considered for an above-soffit variance only if the surcharge amounts do not exceed FHWA, Caltrans, city, county, reclamation board, flood control district, or other regional or local jurisdictional limits on the surcharge ratio of headwater depth to culvert opening height. In all cases, the surcharged water level for the low chord/soffit event must not exceed 0.5 foot below subballast.
9. Replacement structures shall generally be steel beam spans, double-cell concrete box girders or slab girders, concrete box culverts, or circular corrugated metal pipe culverts (a minimum of 24-inch diameter under mainline and mainline siding tracks). Unless otherwise specified, replacement structures will be per SCRRA standards, including roadbed sections for track construction, prestressed concrete trestles, corrugated metal pipe culverts, and reinforced concrete box culverts.

Many SCRRA projects include parallel track construction, adding a second mainline or siding track alongside an existing mainline. The designer should initially design the drainage structure for the new track to match the hydraulics of the existing structure assuming it will remain unchanged, regardless of whether or not the existing condition meets the criteria discussed in Section 9.4. For adjacent non-SCRRA structures, the impacts of the new SCRRA structure on the adjacent non-SCRRA structure should be evaluated and any modification needed to the non-SCRRA structure should be included in the recommendations for the new SCRRA structure. The agency or municipality responsible for ownership and/or maintenance of the non-SCRRA structure should also be consulted prior to selection of the final structure type.

On a case-by-case basis, SCRRA may request analysis of the waterway opening and structure size that would be required for both existing and proposed structures to meet the criteria discussed in Section 9.4 and may choose in the interim to install the recommended structure for the second track assuming that the existing structure might be eventually replaced to match. On a case-by-case basis, increase hydraulic openings in bridges and culverts to accommodate the predicted increase in runoff during a peak rainstorm. Rainfall in mountain areas may increase as much as 25% (as per Caltrans) in some areas which would potentially increase runoff in streams close to hillsides.

9.5.2 Hydraulic Design of Storm Drains, Ditches, and Off--Track Drainage Facilities

In the case of ditches, the design consultant can recommend that the design storm return period be increased to balance the planned life and development potential of the structure or area to be protected. Drainage facilities that remove water from the surface of bridge decks, the track, and adjacent ground shall have adequate capacity to safely discharge it to the adjacent conveyance facility.

In all off-track cases where drainage is picked up by means of a head wall, and where inlet or outlet conditions control the hydraulics, the new or replacement conveyance conduit shall be designed as a culvert but using the design storm, or higher if required by other jurisdictions, as the low chord/soffit design storm.

Where a pipe or other closed conduit is part of a storm drain system and crosses the track or track bed, it shall be designed as a storm drain with the same design storm as the remainder of the system to which it is connected.

Ditches providing open channel conveyance of runoff generally parallel to the track should be designed to accommodate the design storm per Table 9-1 and should be protected against erosion or scour up to the design storm.

Trapezoidal-shaped ditches are preferred due to their higher hydraulic efficiency and ease of maintenance. Triangular shapes require less ROW but are not as readily maintained with a grader. Rectangular shapes are generally used in rock areas.

Wherever avoidable, transverse ditches shall not intersect parallel ditches at right angles. Transverse ditches shall join parallel ditches at an angle of approximately 30 degrees or less as allowed by the site condition to minimize confluence bed and bank scour and sedimentation.

Scour Design and Mitigation Criteria Scour is the engineering term for erosion caused by flowing water excavating and carrying away bed and bank material. Scour is the most common cause of bridge failure. Scour at bridges consists of three components: (1) long-term aggradation or degradation of the stream channel (natural or human-induced), (2) contraction scour due to constriction or the location of the bridge, and (3) local scour. Bridge design must appropriately account for the scouring effects of the design storm, at a minimum. Scour analysis and countermeasure methods have been studied extensively. Some of the most commonly accepted methodologies have been presented by the Federal Highway Administration in various Hydraulic Engineering Circulars. Table 9-2 presents a number of these circulars and the subjects applicable to railroad structures.

TABLE 9-2. SCOUR TOPIC LOCATIONS

Circular	Assessing Long Term Degradation	Scour Analysis at Bridges	Scour Analysis at Culverts	Counter-measure Selection	Counter-measure Design Guidance	Counter-measure Design for Coastal Environment
HEC-11				X	X	
HEC-14		X		X	X	
HEC-18	X	X	X			
HEC-20	X					
HEC-23				X	X	
HEC 25						X

Coastal revetment design improvements shall address inadequate armor layer, inadequate underlayer, flanking, toe scour, and overtopping splash as discussed in the Federal Highway Administration Hydraulic Engineering Circular 25 Chapter 7 Coastal Revetment. Riprap revetments are a common method of protection for coastline track embankments, culvert outlets, abutments and embankments at bridges. Grouting of riprap is a common practice where there is a need to reduce the total thickness of a stone revetment. Where grouted rock riprap is planned for scour or erosion protection, the design shall comply with the grouted rock specifications included in SCRRA Standard Specifications, Section 34 80 11, Stone Revetment (Riprap). Any modification to the riprap requirements above for a specific crossing or situation shall require approval from SCRRA.

For 100-year velocities over 14 feet per second in metal culverts, SCRRA requires that the culvert invert be paved with concrete to prevent abrasion.

9.6 DRAINAGE SYSTEM FEATURES

9.6.1 General

A portion of SCRRA ROW exists in urban areas where drainage cannot be accomplished using open ditches or channels with culverts under the tracks connecting flow from these open ditches or channels. At some locations, existing roadways do not allow for adequate railroad drainage or block drainage. Inlets, manholes, and storm drain piping may be necessary to provide adequate drainage of the ROW.

9.6.2 Culverts

General

A culvert is defined as a drainage structure crossing under a track or roadway embankment and connecting with open channels at both ends. Culvert sizing for drainage under track shall be designed in accordance with the hydraulics and hydrology requirements discussed in Sections 9.1 through 9.5.

- Culvert lengths shall be per ES 6302-01 and ES 6302-02.
- Culvert inlet and outlet headwalls shall be per ES 6003-03, ES 6003-04 and ES 6301 through ES 6310.
- Headwalls 4 feet in height or within 20 feet of the nearest track require handrails per ES 6301 and CPUC GO No. 118.

Minimum Size

The minimum diameter of pipe for culverts under tracks shall be 24 inches, and the minimum diameter of pipe for culverts not under tracks shall be 18 inches.

Design Considerations

Where headroom is restricted, box culverts or a circular pipe with a buried invert shall be considered. A pipe arch may be considered as an alternative. An acceptable procedure for selecting a pipe arch is to determine the required circular pipe and then to select the equivalent pipe arch. If an arch pipe is selected, a low-cement-content flowable fill or similar material for backfill under the haunches shall be provided.

Abrupt changes in direction or slope of pipe shall be avoided. Where such abrupt changes are required, an inlet or manhole shall be placed at the point of change.

The minimum culvert grade shall be 0.35 percent. Grade shall be computed as a straight line between the inlet and outlet elevations. Culverts shall be placed on the most economical slope and at the most economical depth but must meet the height of cover requirements detailed in the AREMA Manual for Railway Engineering, Chapter 8, Part 16, for reinforced concrete box culverts. Height of cover requirements for smooth steel and corrugated steel pipes must adhere to ES

6340, Tables 1 and 2 respectively. Cover requirements for structural steel plate pipes must adhere to Chapter 1, Part 4, Section 14.

Material

- Smooth steel, corrugated steel, and structural steel plate pipes passing beneath tracks or railroad maintenance roadways shall be aluminized Type II coated metal pipe in accordance with SCRRA Standard Specifications, Section 33 42 00, Culvert and Drainage Pipe and the latest ES 6340.
- Reinforced concrete box culvert material shall be in accordance with ES 6003-01 and ES 6003-02.
- Culverts under tracks and railroad access roads shall meet gage, wall thickness, corrugation, and joint coupling requirements shown in the latest SCRRA Pipe Culvert Standards.
- If using jacking and boring as an installation method, smooth steel material may be used in accordance with SCRRA Standard Specifications, Section 33 42 00, Culvert and Drainage Pipe.

Cover

Culverts under tracks shall have a minimum cover of 4 feet or half the diameter of the culvert, whichever is greater, measured from the top of culvert to bottom of track tie unless specifically designed for less cover with approval from SCRRA. Culverts not under tracks shall have a minimum of 4 feet of cover within 45 feet of the track centerline and a minimum of 3 feet of cover elsewhere.

Debris Control

Culverts and waterways shall be sized with sufficient headroom to accommodate all debris contained within the maximum design flow. For SCRRA system drainage structures receiving flow from open channels and areas that may contribute debris, static inlet head shall not be used in determining the size of the opening.

If the drainage structure is protected from debris by existing conditions upstream, or if the structure is part of an enclosed storm drain system with all grated or protected inlets, static head may be considered in computing the capacity. The static head on the entrance to the culvert and the water-surface elevation in the system at peak conditions shall not be higher than can safely be contained by headwalls, ditch banks, and tributary drainage systems. Trash racks or screens for culvert-inlet protection shall not be provided. Where culvert headroom is required for debris, the design shall not allow headwater and tail water depths to exceed 80 percent of the culvert diameter or height. Draw down at the entrance to this depth shall not be construed as meeting this requirement unless it can be shown that the draw down allows free passage of all debris. The use of a transition flume is the preferred method of satisfying this requirement.

9.6.3 Drop Inlets

Drop inlets and manholes shall conform to Caltrans Standard Plans except when, in special circumstances, they are located outside SCRRA ROW, where local agency standards apply. Drop inlet capacities for specific types of drop inlets under various conditions shall be calculated in accordance with Caltrans HDM Chapter 837 and FHWA HEC No 22. Manholes shall conform to APWA Standard Plans for Public Works Construction or local agency standards, as applicable.

Drop Inlet Location and Spacing

Drop inlets on continuous grade, in track ditch, shoulder, or swale areas or in a depressed median between tracks where water is trapped, may be depressed in a drainage dike with side slopes of 8:1 to increase capacity.

If the capacity of the waterway portion of the track ditch, shoulder, swale, or depressed median between tracks where water is trapped exceeds the inlet capacities, the drop inlet capacities shall govern the spacing of drop inlets.

If the capacity of the allowable waterway portion of the track ditch, shoulder, swale, or depressed median section between tracks where water is trapped is less than the drop inlet capacities, the capacity of this portion of the track ditch, shoulder, swale, or depressed median section between tracks where water is trapped shall govern the spacing of drop inlets.

On shoulder (without swale) sections, the maximum spacing of drop inlets shall not exceed 450 feet. Inlet spacing in depressed median sections between tracks where water is trapped and in shoulder or swale areas shall not exceed 900 feet. If analysis of drop inlet capacities results in a spacing of less than 100 feet, then consideration shall be given to re-spacing the drop inlets by allowing channel flow to bypass the inlets.

In general, a 10-year storm of 5-minute duration shall be used for spacing drop inlets. Drop inlet spacing may be generally determined from inlet capacity, giving due consideration to the percentage of water bypassing the inlet and along tracks, the maximum amount of ponded water safe for the track structure and trains.

When there is a change in pipe size in the inlet, the elevation for the top of pipes shall be the same, or the smaller pipe shall be higher. A minimum drop of 4 inches shall be provided in the inlet between the lowest inlet-pipe invert elevation and the outlet-pipe invert elevation.

Handrails

Inlet and storm drain headwalls at inlets and outlets exceeding 4 feet in height or within 20 feet of the nearest track require handrails per ES 6301 and CPUC GO No. 118.

9.6.4 Storm Drains and Manholes

Storm drains are typically used to pass storm water from one side of the ROW boundary to the other side of the ROW boundary. In addition, they may be used for SCRRA facilities such as station platforms, parking lots at stations, and under paved roadways to such facilities. Manholes are placed to facilitate grade and direction changes of storm drains as well as to provide locations for access and clean-outs. Manholes for non-SCRRA storm drains shall not be located on SCRRA ROW unless approved by SCRRA and included as part of the real estate agreement for such facility.

Minimum Size

The minimum diameter of storm pipe for storm drains not crossing under tracks, including connections to inlets, shall be 18 inches. Where possible, storm drains that can connect to culverts shall meet the requirements in Section 9.6.2. When not possible, storm drains shall pass under the tracks as carrier pipes protected by casing pipes.

Material

Culverts and drains with an 18–inch diameter or less under platforms or in station areas not under tracks or roadways may be Schedule 40 polyvinyl chloride (PVC) or high-density polyethylene (HDPE) pipe. If under roadways, Schedule 80 PVC or HDPE pipe may be used if adequate cover meeting design loading parameters is provided.

Manholes shall conform to APWA Standard Plans for Public Works Construction or local agency standards, as applicable.

9.6.5 Underdrains

Perforated underdrains shall be located in areas where it is anticipated that groundwater may interfere with the stability of tracks, roadbeds, and side slopes or where ROW constraints make the standard V-ditch unfeasible. The use of underdrains shall be supported by thorough field explorations prior to design and may occur in the following places:

- Along the toe of a cut slope to intercept seepage where ditches will not serve the same purpose (with ditch on uphill side of track)
- Between tracks at locations of outside station platforms
- At low points in the profile and 100 feet on each side of a low point
- Across the track or roadway at the downhill end of a cut
- Along the periphery of any paved area under which groundwater is likely to collect

Underdrains may also be provided to collect track surface drainage along tracks, in retained cuts, on retained embankments, or where several sets of tracks are adjacent, such as in yards.

Underdrains draining soils on SCRRA ROW shall outlet into culverts, storm drain piping, or other drainage facilities.

Minimum Size

The minimum size of underdrains shall be 6 inches with the pipe designed to run no more than half full. If the under drain is within 20 feet of the track or under the track, the minimum size shall be 8 inches. Actual size and perforations shall be determined by the design consultant based on anticipated groundwater flows to be addressed. The top of under drainpipe shall be a minimum of 15 inches below the bottom of ballast. Riser cleanouts shall be provided at the beginning of all under drain runs and at 300-foot intervals.

Filter Material

Underdrain pipe shall be wrapped in permeable geotextile fabric and bedded in aggregate filter material. Geotextile fabric and filter material gradations for fine and coarse aggregates shall be based on the findings of the soils engineering investigation.

Underdrain Material

Under drains located under tracks or within 20 feet of a track shall be HDPE with perforations. Gage, loading and corrugations shall be per the latest SCRRA Pipe Culvert Standards. Underdrain not located under tracks or within 20 feet of the track may be HDPE or PVC perforated piping with thickness and strength to be determined by the design consultant based on height of cover and location of roads or other permanent features.

Slope

The preferred underdrain pipe slope shall not be less than 0.5 percent, with a minimum slope of not less than 0.2 percent.

Underdrain System Separation

Offsite surface water shall not be captured and flow into underdrain system, such flows shall be routed in a separate drainage system.

9.6.6 Pump Stations

The use of pump stations shall be avoided. The use of a pump station shall be based on a comprehensive analysis of initial outlays for gravity drainage versus pumping, and future maintenance and operating costs of a pump station. A thorough economic analysis must be made to justify the use of pump stations. If the pump station alternative is selected and recommended to SCRRA, it shall conform to the details contained in Chapter 17.

9.7 GRADING

9.7.1 General

Ditches and other drainage features shall be graded to drain as shown in the plans. Water shall not pond on SCRRA ROW. Linear swales shall be designed along flood prone track to direct water away from the track bed.

9.7.2 SCRRA Maintenance Vehicle Access

Maintenance vehicle access, particularly to turnouts, signals, and curve lubricators, shall be provided. These typically create berms or “ditch blocks” across drainages. The designer shall provide culverts or storm drains, including the use of drop inlets and manholes, as necessary to provide continuous drainage on SCRRA ROW.

9.7.3 Surface Grading and Drainage

The following are guidelines for surface drainage design associated with SCRRA projects in areas beyond the trackway drainage.

- Pedestrian Areas:

- Comply with ADA criteria in pedestrian areas.
- Minimize surface water level and velocity to maintain a safe walking surface.
- Minimum grade shall be 0.5 percent and maximum grade shall be 2.0 percent in open plaza areas. Special drains shall be installed as necessary.
- Maximum water surface over drains shall be 0.5 inch.
- Maximum water velocity in pedestrian areas shall be 2 feet per second.

- Parking lots:
  - General
    - Asphalt parking stalls shall have the following limits on steepness and flatness of slope:
      - Steepness: 4 percent preferred slope (5 percent maximum) in any direction in a non-ADA parking stall
      - Flatness: 1.5 percent preferred slope (1 percent minimum)
    - Asphalt parking traveled area shall have a preferred slope of not more than 5 percent with a 6 percent maximum slope in any direction in a traveled area
    - Asphalt parking shall have a preferred slope of not more than 1.5 percent with a maximum of 2 percent slope in any direction
    - Asphalt parking 0.5 percent minimum slope in any direction
  - Driveway Slopes and Ramps
    - 20 percent maximum slope on driveway or ramp
    - 10 percent maximum cross slope of a driveway or ramp
    - Transition slopes are required when the slope of the driveway of ramp exceeds 12 percent
  - Comply with ADA criteria regarding slopes at parking spaces and access aisles designated for accessible parking. Accessible parking spaces shall be located at an optimum location within the parking lot, to provide easy access to the station.
  - Remove storm water by overland flow to a gutter or curb and gutter, then to an inlet where the water will enter a closed drainage system.
  - Overland flow shall be a minimum of 1 percent grade and shall not run for more than 175 feet before being intercepted by a drainage structure such as a gutter or a drain.
  - The maximum flow distance in the gutter in a parking area shall not exceed 120 feet" before being collected in a drainage system.
- SCRRA Right-of-Way Streets
  - General
    - Maximum 6 percent slope
    - Desirable 5 percent slope

    - Minimum 0.5 percent slope
    - Desirable 1 percent slope
    - Cross-slope 2 percent
    - Crown cross section except on curves where 2 percent continuous cross-slope toward center of curve may be used
  - Maximum Grade Differentials:
    - Crest Vertical Curve 9 percent
    - Sag Vertical Curve 6.5 percent
    - Crest and sag curves at top and bottom of ramps without parking may exceed these differentials, but must use a vertical curve 20 feet in length or more.
  - Keep the water surface below top-of-curb and from flowing more than 0.5 inch deep in the traveled way.
  - The traveled way can be described as the lane that begins eight feet away from the face of curb.
  - Water surface elevation shall be controlled by adding catch basins as necessary.

9.7.4 Grade Crossings

All surface drainage along the roadway approaches to the roadway-rail grade crossing and across the crossing itself shall be channeled away from the roadway-rail grade crossing to minimize opportunities for hydroplaning within the roadway-rail grade crossing and approaches. In particular, the following conditions shall apply to surface drainage within the area of roadway-rail grade crossings:

- All surface runoff within the roadway-rail grade crossing shall be collected by appropriate drainage devices outside the limits of the track structure. Minimize surface flow from entering the track section.
- For all approaches to the roadway-rail grade crossing, a roadway cross-fall and cross-slope transition at a nominal 2 percent to the highway gutter shall be considered.
- Sufficient drainage and cross-flow shall be provided within the design drawings.
- Roadway and track drainage systems shall be continuous within the limits of the crossing.

9.7.5 Vegetation

SCRRA is required to maintain its ROW clear of vegetation that is a fire hazard or may harbor vermin. Ground cover cannot be presumed to control erosion, except as provided for in SCRRA Standard Specifications, Section 32 91 00, Soil Erosion, Sediment Control, Topsoil and Seeding. Refer to Chapter 26, Landscaping Design Criteria for the design, construction, and maintenance of vegetation.

Plant drought tolerant vegetation that stabilizes slopes and contributes to erosion prevention in areas that can support vegetation without irrigation while also minimizing wildfire risk.

9.7.6 Construction

Positive drainage of all portions of all construction sites must be maintained in order to avoid saturation of the track embankment or deposition of silt in track ballast.

Linear swales shall be designed and constructed along flood prone track to direct water away from the track bed.

9.8 POST CONSTRUCTION STORMWATER QUALITY

9.8.1 References

The latest edition of the following references and guidelines shall be considered for use in the design of SCRRA facilities to address post construction stormwater quality.

- Post-Construction Water Balance Performance Standard; related information is included in Appendix 2 of Construction General Permit (https://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/constpermits/wqo_2009_0009_app_2.pdf); the corresponding Post-Construction Water Balance Calculator is now provided electronically in Stormwater Multiple Application and Report Tracking System (SMARTS) (https://smarts.waterboards.ca.gov/smarts/faces/SwSmartsLogin.xhtml)
- California Stormwater Quality Association (CASQA) Industrial & Commercial Best Management Practice (BMP) Online Handbook (https://www.casqa.org/resources/bmp-handbooks/industrial-commercial/industrial-commercial-bmp-online-handbook); requires subscription
- California Stormwater Quality Association (CASQA) Municipal Best Management Practice (BMP) Online Handbook (https://www.casqa.org/resources/bmp-handbooks/municipal-bmp-handbook)
- California Stormwater Quality Association (CASQA) New Development & Redevelopment Best Management Practice (BMP) Online Handbook (https://www.casqa.org/resources/bmp-handbooks/new-development-redevelopment-bmp-handbook)
- California Phase II Low Impact Development (LID) Sizing Tool (http://owp-web1.saclink.csus.edu/LIDTool/Start.aspx)
- Low Impact Development Manual for Southern California: Technical Guidance for Site Planning Strategies (https://www.casqa.org/sites/default/files/downloads/socallid-manual-final-040910.pdf)
- State, regional, or local standards, ordinances, codes, and design criteria as applicable

9.8.2 General

Criteria for design of SCRRA system post construction stormwater quality facilities are provided below. The post construction phase is synonymous with operations and maintenance and will be used interchangeably in this section. In some cases, other more stringent criteria may govern the design. The design consultant shall evaluate whether criteria by State Water Resources Control

Board (SWRCB), Regional Water Quality Control Board (RWQCB), the city, the county, or other regional or local jurisdictional limits apply. If so, the more stringent design criteria shall be adopted by the design consultant.

There are two main factors that trigger compliance with post construction stormwater quality requirement. The first factor is the addition of or impact to impervious surfaces such as, but not limited to, pavements, building envelopes (i.e. stations, maintenance facilities, etc.), platforms, access roads, closed deck bridges, signal houses, slope paving, etc. When no local jurisdictions apply, the default post construction stormwater quality requirement is the post construction stormwater performance standard of the Construction General Permit (CGP), Order no. 2009-0009-DWQ (NPDES no. CAS000002) and amendments.

The second factor is related to project features that are part of an industrial activity as defined by the federal government, such as layover yards, maintenance facilities, etc. The related requirement is covered in the Industrial General Permit (IGP), Order no. 2014-0057-DWQ (NPDES no. CAS000001) and amendments. Complying with applicable post construction stormwater quality requirements normally requires demonstration that project runoff is treated so as to filter applicable pollutants of concern generally associated with rail use. This compliance also requires that drainage impacts (i.e., peak flow, volume, etc.) are also mitigated.

For any introduced impervious surface, the mitigation is normally two-fold. The first is to mitigate for the drainage (flood control) impact (the major portion). The second is to mitigate for the stormwater quality impact (the minor portion). Both of these elements are related as there is overlap and needs to be coordinated during the design process.

Compliance with local conditions and/or coordination with a Phase II permittee may override or overlap the above requirements.

9.8.3 Water Quality Requirements

As stated in Section 9.8.2 General, the default post construction stormwater quality requirement is imposed statewide by the SWRCB which is the post construction stormwater performance standard of the CGP, or the IGP for any industrial activity. The CGP specifies runoff reduction requirements for all sites not covered by a Phase I or Phase II MS4 NPDES permit, to avoid, minimize and/or mitigate post-construction storm water runoff impacts. These requirements are identified in Section XIII Post-Construction Standards of the CGP Order. They are summarized as follows:

1. For water quality impacts, use non-structural controls. If infeasible, use structural controls.
2. Perform a post construction water balance calculation for the 85th percentile storm event and demonstrate no adverse condition between the pre-project and post-project phases.
3. Implement BMPs to reduce pollutants in post construction phase.
4. The related calculations may be a separate document, included as part of the online PC water balance calculations in SMARTS, and/or both.

For projects that involved activities of an industrial nature (i.e., layover, maintenance facilities, etc.), the statewide Industrial General Permit (IGP) applies during operations and maintenance. The Statewide General Permit for Stormwater Discharges Associated with Industrial Activities, Order 2014-0057-DWQ implements the federally required stormwater regulations in California for stormwater associated with industrial activities discharging to waters of the U.S. The IGP regulates discharges associated with 10 federally defined categories of industrial activities. The IGP requires the implementation of BMPs, a site specific SWPPP, and monitoring plan. The IGP also includes criteria for demonstrating no exposure of industrial activities or materials to stormwater and no discharges to waters of the U.S.

Multiple Separate Storm Drain System (MS4) permits were issued in two phases:

- Under Phase I, which started in 1990, the RWQCBs adopted NPDES stormwater permits for medium (serving between 100,000 and 250,000 people) and large (serving 250,000 or more people) municipalities. Many local agencies within the jurisdiction of SCRRA have been issued a Phase I MS4 permit as a group.
- On April 30, 2003, as part of Phase II, the SWRCB issued a General Permit for the Discharge of Stormwater from Small MS4s (Order No. 2003 0005 DWQ) to provide permit coverage for smaller municipalities (population less than 100,000), including non-traditional Small MS4s, which are facilities such as military bases, public campuses, prisons, and hospital complexes. The Phase II Small MS4 General Permit covers Phase II Permittees statewide. On February 5, 2013, the current Phase II Small MS4 General Permit (Order No. 2013 0001 DWQ) was adopted and became effective July 1, 2013.

One of the non-traditional Small MS4 categories included in the permit are local transportation planning agencies, such as Bay Area Rapid Transit, CalTrain, Golden Gate Bridge (Highway and Transportation District), High Speed Rail, MTS, North County Transit District, and Valley Transportation Authority. These latest categories and agencies are reflected in Attachment B (conformed unofficial draft) of the permit. SCRRA was not included in the permit as a non-traditional Small MS4. However, SCRRA does currently overlap non-traditional Small MS4 permittees such as the following:

1. California State University, Los Angeles – the San Gabriel Subdivision crosses this jurisdiction; includes the Cal State LA station (the station is owned and operated by City of Los Angeles)
2. March Air Force Base – the Perris Valley Subdivision crosses this jurisdiction; the Moreno Valley/March Field station is located here (the station is owned and operated by RCTC)

Even though SCRRA is not a non-traditional Small MS4 permittee, SCRRA does need to coordinate with those entities. The above permittees either have or are currently preparing the guidance (compliance) documents that specify the stormwater runoff controls to reduce the discharge of pollutants and the post construction stormwater standards.

9.8.4 Coordination with Local Conditions

The requirements discussed thus far assume proposed improvements occur in SCRRA right-of-way and compliance with local conditions is not required. However, the following instances may invoke compliance with additional post construction stormwater quality requirements:

1. Local conditions apply such as acquiring ministerial/discretionary permits for, but not limited to, storm drain connections, encroachment, utility work/connection, grading, building construction, etc. In this case, the project would need to meet compliance with local ordinances and municipal codes.
2. A 401 Water Quality Certification is required as part of the environmental permit process and this certification requires post construction stormwater quality documentation consistent with the local entity.

In either one of these two cases, compliance with the local Phase I or II permit and corresponding post construction stormwater quality guidance documents will be required provided the specific thresholds are met and exemptions are not applicable. The local entity will normally have a template available to base the project-related post construction stormwater quality checklist document. Each local agency has a different name for this template (e.g., water quality management plan, water quality technical report, stormwater quality management plan, LID report, post construction stormwater management plan, etc.). This document will describe the approach and proposed BMPs and include tables, figures, calculations, worksheets, and other attachments. In addition, this document includes information on the maintenance responsibility of proposed BMPs.

These thresholds typically includes addition of new or reconstruction of existing impervious surface beyond a minimum area (e.g., 5,000 square feet, etc.). Or the proposed improvements may meet certain exemptions (e.g., maintenance activity, emergency work, etc.) from complying with the conditions. This local evaluation also requires that the project be associated with a particular category of development such as New Development, Redevelopment, Commercial/Industrial, Parking Lots, etc. The mitigation measures may apply within and/or outside the SCRRA right-of-way depending on local conditions or environmental process requirements.

Replacement of impervious surfaces that are part of a routine maintenance activity would normally not trigger compliance with the local MS4 permit requirements. These activities may include the following:

1. Replacing roof material on an existing building (e.g., maintenance building, etc.)
2. Rebuilding a structure to original design after damage from earthquake, fire or similar disasters
3. Restoring pavement or other surface materials affected by trenches from utility work (may be at grade crossings)
4. Resurfacing existing roads (grade crossing) and parking lots, including slurry, overlay and restriping
5. Grade crossing improvements within street right-of-way

Typical SCRRA projects that may require compliance with local conditions are the following (assuming they have an impact on impervious surface):

1. Stations
2. Platforms

3. Parking lots
4. Maintenance yards
5. Closed deck bridges
6. Mainline, spur or siding improvements

9.8.5 BMP Design

In the absence of any guidance from the local agency having jurisdiction, prioritize the selection of BMPs to remove storm water pollutants, reduce storm water runoff volume, and beneficially use storm water to support an integrated approach to protecting water quality and managing water resources in the following order of preference:

1. Infiltration systems
2. Capture and use
3. Biofiltration/Bioretention systems
4. Other BMP type (structural)

Each type of BMP shall be implemented to the maximum extent feasible when determining the appropriate BMPs for a project. BMPs may be volume or flow based. Refer to CASQA Industrial/Commercial, Municipal, or New Development & Redevelopment Handbooks for additional information on design criteria.

Pollutants of concern (POC) associated with railroad use is similar to highway/roadway/freeway use. Those POC's include heavy metals, organic compounds, sediments, trash and debris, and oil and grease.

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10.0 UTILITIES

10.1 SCOPE

These design criteria govern new utility construction exclusive of buildings, and the support, maintenance, protection, relocation, and restoration of utilities affected by construction activities within SCRRA ROW. Consideration shall be given to the needs of the SCRRA system, the requirements, and obligations of the public or private utility owner, and the service needs of adjoining properties when designing a new or modifying an existing utility encroachment.

The site must be assessed for climate vulnerability (see Section 3.3) to ensure it is designed to be resilient to future climate conditions.

10.2 STANDARDS AND CODES

The design shall meet all applicable parts of the State of California general laws, California Public Utilities Commission (CPUC) requirements, FRA safety requirements, and the specific project requirements. Where any conflict in criteria exists, the stricter criteria shall govern.

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

See the standards and codes listed in Appendix A.

10.3 GENERAL REQUIREMENTS

The objective of utility pre-construction activities is to obtain and properly incorporate pertinent utility information into the contract documents. This information shall include but not be limited to:

- Design and installation requirements
- Protection of utilities and maintaining service during construction
- Safety and regulatory requirements

Information to be acquired includes the following:

- Owner
- Type
- Size
- Condition
- Easement
- Location
  - Horizontal
  - Vertical

Information pertains to all utilities within the existing ROW of existing and proposed utilities affected by construction within SCRRA ROW. Including the disposition of utilities within proposed ROW, easements, or TCE's to be acquired by SCRRA. The following shall be clearly identified with information provided on the contract drawings:

- Utilities to be supported and maintained in place during construction and to be maintained in service following construction
- Utilities to be reconstructed in place
- Utilities to be temporarily relocated and maintained and then to be restored in the original location upon completion of the SCRRA improvements
- Utilities to be permanently relocated beyond the limits of SCRRA construction
- Utilities to be abandoned or removed

The requirements of Chapter 15, Excavation Support, shall apply to all trenches and excavations.

- In excavations and trenches, compacting and backfilling should be to 95 percent maximum dry density as defined in ASTM D698. Clean, suitable backfill material should be designated.

Utility service to adjoining properties shall not be interrupted except for brief temporary interruptions for new connections and only with written notice to, and written agreement by, the adjoining property owners. Replacements for existing sewers, storm drains, or water mains shall, at a minimum, be designed to provide service equal to that provided by the existing facilities. No capacity changes or betterments shall be incorporated unless agreed to in writing by the utility owner and SCRRA prior to final design.

- No utilities shall be routed through existing culverts or existing underground structures.
- No utilities shall be attached to structures carrying railroad loading or structures owned by SCRRA without specific written approval.
- Utility attachments to structures not owned by SCRRA shall be allowed only with prior written approval of the agency who owns the structure and SCRRA.
- Utilities that run underneath roadways below railroad structures on SCRRA Member Agency-owned ROW are permissible, but separate real estate agreements with SCRRA's Member Agency must be obtained for each utility.

- In order to help ease climate vulnerability for electrical energy, potential partnerships with Southern California Edison, Los Angeles, Water and Power, and other local providers in the Southern California area, will be developed for increased access to renewable energy/diversified power sources. Similarly, partnerships will be developed with local flood control districts to identify and solve localized flooding to Metrolink tracks when it originates from overtopped flood control channels.

10.4 UTILITY AGREEMENTS

Existing utility encroachments are typically covered by a real estate agreement between SCRRA Member Agencies and the utility owner. These agreements, in the form of a license, lease, easement, or permit, govern how changes to the utility installation may be made and must be referenced. In the case of conflict between the utility real estate agreement and SCRRA procedures and design criteria, the procedures and design criteria shall govern unless otherwise approved by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

Applicants for ROW utility encroachments shall follow SCRRA's "Encroachment Right-of-Way Process, SCRRA Form No. 36." This includes a written statement of the request for encroachment, a completed Encroachment Application Form (available online at www.metrolinktrains.com).

10.5 RELOCATION OF EXISTING UTILITIES

Existing utilities that are potentially affected by construction within SCRRA ROW shall be identified through the procedures identified in Section 5.8.1 Utilities in the SCRRA Design Procedures Manual.

The responsibility for the design and relocation of the affected utilities shall be determined based upon review of the utility agreements and in consultation with the SCRRA PM. In general, the design and construction of affected public utilities will be the responsibility of the Design Consultant and contractor, and third-party utilities will be the responsibility of the utility owner. Public utilities will be designed per the public utility standards and requirements as well as the requirements identified below. Third party utilities will be designed per the third-party utility owner's standards and requirements as well as the requirements identified below. New and relocated third party utilities will be coordinated with the affected existing utilities and any proposed new utilities so that impacts between new and relocated utilities are avoided.

10.6 UTILITY MARKERS AND SIGNAGE

The presence of utility lines, including drains and culverts crossing SCRRA ROW below ground, shall be identified on the site by markers placed at points where the centerline of the utilities intersect the boundaries of the ROW. Electrical utility markers shall follow NESC standards. See ES 5229.

Markers shall identify each utility, its owner, a phone number to call in case of emergency, the SCRRA milepost, the survey station, and the depth. All markers shall be installed and maintained by the utility owner.

Typically, markers should be placed just inside SCRRA ROW, with the face of targets parallel to and facing the adjacent track. They shall not encroach on safety walkways, clearance areas, ditches, and service roads.

When circumstances do not allow markers to be placed on the centerline of the utility, they shall be placed as close to the centerline as practicable with the direction and offset from the marker to the utility indicated.

Existing utility markers are to be protected in place when feasible or relocated along with the utility relocations in accordance with the Utility Marker requirements described in this section.

If it is determined during the development of the design of a project that a utility marker sign is missing, then the marker will be replaced as part of the proposed project improvements in accordance with the Utility Marker requirements described in this section. The utility owner is responsible for the replacement of the missing utility marker and the information that is to be displayed on the utility marker. The missing utility marker shall be reported to the utility owner whose marker is missing. Utility owner contact information can be obtained from the utility markers in the field. If there are no available utility markers with contact information, then a search of Dig Alert and the associated utility agreements can be used to identify contact information for the utility owner with the missing utility marker.

10.7 PIPELINE UTILITY CROSSINGS

Pipelines crossing beneath the track shall conform to the AREMA Manual for Railway Engineering, Volume 1, Chapter 1, Part 5, Pipelines. In addition, pipelines across or along SCRRA ROW shall conform to ES 5001 and ES 5002.

Casing pipes shall include seals and vents as noted in ES 5001 and ES 5002 and in the AREMA manual. Where the SCRRA system is adjacent to other railroad tracks and pipelines, and casing pipes are continuous beneath both tracks, seals and vents shall be provided at the ends of the continuous system. The designer shall coordinate the design with the adjacent railroad.

Uncased gas pipeline installed across SCRRA ROW shall conform to the AREMA Manual for Railway Engineering, Chapter 1, Part 5, Pipelines, Section 5.2, and ES 5002. Installation of gas lines without casing must be approved by SCRRA through a Request for Special Design Consideration (see Section 3.2.2) and submitted with the crossing application.

All reinforced concrete pipes shall be encased per requirements of ES 5001. Where the track is constructed above un-encased utilities that are to remain in service, the utilities shall be uncovered and encased before track is placed or replaced by a new system. To accommodate future track construction, temporary or permanent track relocation, and/or construction and maintenance activity on SCRRA ROW, pipeline encasement shall extend as per requirements in ES 5001 and ES 5002.

Where utility owner requirements meet or exceed SCRRA requirements, those requirements shall apply. This would include but not be limited to safety, clearances, walkways, casing thickness, etc.

10.8 JACKING AND BORING, TUNNELING, AND HORIZONTAL DIRECTIONAL DRILLING

Jacking, tunneling, and drilling operations shall be as discussed in this section and in Chapter 15, Excavation Support, and as provided in ES 5001 and ES 5002. All pipe installed under this section shall use the dry bore process. Water jetting or puddling are prohibited during jacking, boring, or horizontal directional drilling operations. A minimal amount of fluid to lubricate cutter and pipe during the boring or drilling operation is considered dry bore.

Jacking or boring, tunneling, and horizontal directional drilling operations shall not be permitted closer than 25 feet from the centerline of the nearest track.

Jack and Boring/Tunneling:

- Installation will not be permitted at locations with boulders, buried debris, or excessive groundwater.
  - Soils shall be sampled by a geotechnical engineer at locations specified by SCRRA at all sites proposed for jacking and boring or tunneling when the pipe is greater than 48 inches in diameter and the depth from top of pipe to base of rail is between 5 feet 6 inches and 10 feet.
  - Granular material or high-water tables shall be identified in the geotechnical report, including recommendations to prevent failure of the jack and bore or tunneling procedure.
- Pipes equal to and greater than 48 inches nominal diameter:
  - Will not be allowed when cover from base of rail to top of pipe is less than one and one-half times the pipe's nominal diameter.
  - Will require that rail elevations be monitored in compliance with ES 5001 and ES 5002.
- Pipes greater than 72 inches nominal diameter shall not be allowed unless otherwise approved by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

Horizontal Direction Drilling (HDD):

The following requirements apply specifically to pipelines installed via HDD.

- All liquid or gas pipelines shall be steel pipe across SCRRA ROW. The pipe may be used as a carrier pipe or a casing pipe.
- For fiber optics or electrical installations, plastic (PVC or HDPE) pipe may be installed without steel casing per ES 5001 when the nominal diameter is 6 inches or less and the depth to base of rail is 12 feet or greater.
- All pipelines carrying flammable, hazardous, or highly volatile substances shall have minimum cover of 25 feet from base of rail to top of pipe.
- A dry bore method for a pipeline not carrying liquids and with a nominal diameter of 6 inches or less shall have a minimum cover of 6 feet from base of rail to top of pipeline.
- A dry bore method for a pipeline carrying liquids or with a nominal diameter of more than six inches shall have a minimum cover of 12 feet from base of rail to top of pipeline.
- 3rd Party Utility applicants must provide:
  - Pipe specifications that comply with ES 5001 and ES 5002, as well as AREMA recommendations and all applicable government and industry regulations.
  - Drilling contractor qualifications including specific instances of previous successful experience in drilling under sensitive surface facilities
- Prior to commencement of drilling, contractor must provide:
  - Installation Plan that includes:

- Anticipated rig capacity
- Proposed equipment
- Method for advancing through anticipated soil conditions
- Angles, depth and exact location of exit ditch
- Pilot hole diameter
- Proposed reaming plan including the number and diameter of pre-reams/ back reams and the diameter of the final reamed borehole
- Contingency equipment and plans for dealing with soil conditions that a soil engineer could reasonably expect to encounter during HDD installation
- Anticipated hours of operation
- Minimum number of personnel and their responsibilities on-duty and off-site during the HDD operations

- Detailed Fracture Mitigation Plan that includes:
    - Method of monitoring and capturing the return of drilling fluids with particular attention to preventing the inadvertent release of drilling fluids that could undermine the railroad tracks
- Borehole Location Monitoring Plan that includes:
    - An establish Survey Grid Line
    - Method for monitoring and documenting the actual location of the borehole during drilling operations

- During the HDD drilling operations, the following is required:
    - A railroad observer and a 3rd Party Utility applicant inspector are required to monitor the ground, ballast, and track for movement during the drilling, reaming and pullback processes.
    - The installation process and all train movement must be immediately stopped if movement is detected.
    - All work within the Railroad right-of-way must be coordinated with the SCRRA Roadway Worker in Charge (RWIC).
    - The damaged area must be immediately reported to the Railroad and immediately repaired subject to Railroad review and approval.
    - The installation process must be reviewed and modified before the installation may continue to proceed.
- Upon completion of the HDD the contractor is to provide:
    - Accurate as-built drawings of the installed HDD segment
    - As-Built drawings are to include both horizontal and profile plans.

10.9 WIRELINE UTILITY CROSSINGS

Clearance to overhead wireline crossings shall conform to ES 2104. All other aspects of the design and construction of overhead wireline crossings shall conform to CPUC GO No. 95, and as outlined in these design criteria.

All underground wireline crossings shall conform to CPUC GO No. 128 and as outlined in these design criteria.

In the case of conflict between the utility license agreement, ES 2104, and these design criteria, these design criteria shall govern for new or modifications to existing crossings unless otherwise approved by SCRRA.

New or relocated electrical wireline utility crossings shall be located such that they do not interfere with any existing utilities, such as SCRRA signals, communications, PTC fiber optic, etc. See Section 10.10 for specific depth and horizontal requirements for fiber optic systems including clearance requirements from electrical utilities.

For proposed electrical lines crossing tracks, SCRRA may request that an inductive interference study be performed at the expense of the utility owner. Inductive interference from certain lines has the potential to disrupt the signal system in the track, causing failures in the track signals and grade crossing warning devices. SCRRA will determine the need for a study on a case-by-case basis.

10.9.1 Underground Wireline Crossings

Table 10-1 identifies specific requirements for underground wireline crossings that are to be used when designing new and relocated wireline crossings. These requirements are in addition to the requirements identified in CPUC GO No. 128. Where the criteria are different, the more stringent criteria shall be utilized by the engineer.

TABLE 10-1. UNDERGROUND WIRELINE UTILITY CROSSINGS

Wireline Type*	Wireline Encasement Length	Depth of Cover** (Natural Ground)	Depth of Cover** (Below Base of Rail)	Warning Tape Requirement	Wireline Crossing Location
Underground Less than 750 V	Extend 50 feet from the centerline of each main track, or to the ROW line, whichever is less.	3 Feet (4 Feet under ditch bottom)	5 Feet-6 Inches	6-inch, 2 Feet below ground and 3 feet below base of rail	50 Feet from the end of any Bridge, Culvert of Switching Area
Underground Greater than 750 V	Across the entire ROW	4 Feet	5 Feet-6 Inches	6-inch, 2 Feet below ground line and 3 Feet below base of rail	50 Feet from the end of any Bridge, Culvert of Switching Area

TABLE 10-1. UNDERGROUND WIRELINE UTILITY CROSSINGS

Wireline Type*	Wireline Encasement Length	Depth of Cover** (Natural Ground)	Depth of Cover** (Below Base of Rail)	Warning Tape Requirement	Wireline Crossing Location
Non-Electrical Wirelines	Extend 50 feet from the centerline of each main track, or to the ROW line, whichever is less.	3 Feet (4 Feet under ditch bottom)	5 Feet-6 Inches	6-inch, 2 Feet below ground and 3 feet below base of rail	50 Feet from the end of any Bridge, Culvert of Switching Area

Notes:

* Wireline encasement for underground lines shall be in rigid metallic conduit.

** The casing and carrier must be a minimum of 2 feet below any fiber optic line, and installation must be hand excavated when within 5 feet of the fiber optic line.

10.9.2 Overhead Wireline Crossings

ES 2104 and CPUC GO No. 95 identifies specific requirements for overhead wireline crossings that are to be used when designing new and relocated wireline crossings. Where the criteria is different, the more stringent criteria shall be utilized by the engineer.

10.10 FIBER OPTIC SYSTEMS

In general:

- Overhead crossings of the track by the fiber system shall comply with SCRRA ES 2104.
- Underground crossings of the track by the fiber system shall comply with CPUC GO No. 128.
- Underground crossings of the track by the fiber system shall comply with SCRRA ES 5001. Plastic (PVC or HDPE) pipe may be installed without a steel casing pipe per ES 5001 when the nominal diameter is 6 inches or less and the depth to base of rail is 12 feet or greater.
- For trench installations, a detector wire shall be installed with all buried fiber optic cables and warning tape shall be placed above the buried facility.
- The fiber system be encased over the top of any culvert on SCRRA ROW in accordance with Table 10-2.
- The fiber system shall be attached to SCRRA bridges or other SCRRA structures with rigid conduit.

Horizontal Installation Requirements Include:

- Install near the outer limits of SCRRA ROW.

- Keep the system's running line as straight as possible while maintaining a consistent distance from centerline of the nearest track.
- Install on the field side of all SCRRA structures, including bridges, signal facilities, buildings, and platforms.
- Shall not be laid out to be installed within the slope of cut or fill sections, and any cut or fill sections should not be benched.
- Shall be located over the top and on the field side of the back-slope of a cut section whenever possible.
- Shall be located a minimum of 5 feet beyond the toe of outer most ditch slopes if located beneath a ditch.
- Fiber optic cable shall not be installed within 5 feet horizontally of underground power or signal lines, unless suitably insulated.

Hand Holes, Splice Boxes, and Manholes Design Requirements Include:

- Location should not be within 100 feet of existing SCRRA signal or communication buildings or facilities.
- Include Cooper E80 live load surcharge if within 15 feet of centerline of nearest track in addition to all other loads
- Include current AASHTO live load surcharge in addition to all other loads if greater than 15 feet from centerline of nearest track

Table 10-2 provides fiber optic system depth requirements.

TABLE 10-2. FIBER OPTIC INSTALLATION DEPTH REQUIREMENTS

Fiber Optic Location	Depth Requirement
Under natural ground	3 Feet 6 inches Minimum**
Under an existing signal or communication structure	10 Feet Minimum under natural ground*
Under existing signal or communication lines	2 Feet Minimum vertical separation
Under all culverts on SCRRA ROW	5 Feet Minimum below the bottom of the culvert
Under all ditches	5 Feet Minimum below the bottom/ flow line of the cleaned out ditch***

Notes:

* This extra depth may also be required in "signal sensitive areas," such as interlocking or control points.

** In the event that local ground conditions prohibit the placement of the fiber system at a depth of 3 feet 6 inches, the fiber system shall be encased, and approval by SCRRA is required. If rock is encountered and prevents a depth of 3 feet 6 inches, the fiber system should be cut into the rock at a depth of 18 inches or greater, provided proper grouting and cable protection is used. Cutting the rock and installing the fiber system less than 18 inches requires permission from SCRRA.

*** Placement of the fiber system at extra depth and/or in protective casing should be considered for protection during ditch cleaning maintenance. Also, placement of the warning tape should be designated so that it would not be disturbed during regular maintenance cycles.

1. For HDD requirements see section 10.8

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11.0 STRUCTURES

11.1 STANDARDS AND CODES

The design and construction of railroad bridges and other civil structures supporting rail live loads shall be in accordance with the current edition of the AREMA Manual for Railway Engineering. If SCRRA is operating on any portion of BNSF or UP ROW, the guidelines for design and construction for the appropriate railroad host, BNSF or UP, shall govern.

This DCM provides clarification of SCRRA's use of AREMA guidelines, identifies SCRRA special design considerations to AREMA guidelines, and describes SCRRA's philosophy and criteria for aspects of bridge and structure design that are not specifically addressed by AREMA. Where this DCM is silent, the AREMA and/or BNSF/UP guidelines shall apply.

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

Bridge designers are expected to familiarize themselves with the AREMA Manual for Railway Engineering, Chapters 7, 8, 9, and 15, regardless of the material(s) being implemented in a specific bridge. The designers should recognize that the AREMA Manual for Railway Engineering contains provisions within these individual chapters that may also govern the design of seemingly unrelated materials.

The site for a bridge, underpass, retaining wall, culvert or other infrastructure must be assessed for climate vulnerability (see Section 3.3) to ensure it is designed to be resilient to future climate conditions.

11.2 DESIGN METHODOLOGY

The design methodology for the various bridge components and other civil structures supporting rail live loads shall be in accordance with AREMA recommended practices unless specified otherwise herein.

All bridge spans shall be simply supported.

Concrete civil structures and concrete elements of a bridge shall be designed using the Load Factor Design method.

The design of steel structural shapes or members that are not covered by AREMA guidelines shall be designed using Allowable Stress Design in accordance with the latest edition of the American Institute of Steel Construction (AISC) Steel Construction Manual and modified as necessary to be equivalent to AREMA allowable stresses and safety factors.

Seismic design methodology shall be in accordance with AREMA guidelines contained in the Manual for Railway Engineering, Chapter 9.

The overall design process shall follow the steps defined in the SCRRA Design Procedures Manual (DPM), which defines the required submittals, deliverables, and reviews. The manual also defines the development of specifications and estimates. The design shall incorporate existing SCRRA standards, plans, and specifications to the extent possible.

11.3 GENERAL DESIGN GUIDELINES

11.3.1 Minimum Clearances

Minimum vertical clearance below underpass structures supporting railroad loading shall be in accordance with the Chapter 12.0, Grade Separation Criteria, of this DCM. Minimum vertical clearance from tracks to overpass structures shall be in accordance with Chapter 12.0 Grade Separation Criteria of this DCM.

Minimum horizontal clearances shall be 8 feet 6 inches from the centerline of the track to the face of any handrail and 6 feet 6 inches from the centerline of the track to the nearest face of any ballast curb. Minimum horizontal clearances for “through” structures shall be 9 feet 0 inches. These minimum clearances shall be adjusted in accordance with AREMA and SCRRA guidelines for curved tracks.

Parallel, separated structures shall have a minimum separation of 5 feet 0 inches between each structure to provide access for maintenance work and inspection.

Minimum horizontal clearance between bottom flanges of steel girders and steel beams shall be 12 inches for members 45 inches and less in depth and shall be 18 inches for members greater than 45 inches in depth.

In addition, new structures shall consider ease of inspection and inspection access as part of the design. This may include inspection walkways between girders, fall protection foot holds and tie off points along caps or girders or safety lines attached between girders, and ladders integral with the structure. Details shall be such that all exposed parts will be accessible for inspection, cleaning and painting.

11.3.2 Bridge Decks

All new bridges shall have ballasted decks.

Bridge decks shall be steel plate for all bridge types with the exception of the standard precast concrete double box beams and slab beams described in SCRRA ES 6001 and ES 6002, respectively.

Bridge decks shall have a minimum longitudinal grade of 0.2 percent to longitudinal deck drain collection points to provide positive drainage. If the track grade is less than 0.2 percent, the difference shall be made up with additional ballast depth and installing spans on a 0.2 percent longitudinal grade.

The structural portion of bridge decks shall be level, with no transverse cross-slope.

Two 4-inch-inside-diameter galvanized metal conduits shall be provided at each side of the bridge deck adjacent to the ballast retainers, as shown in Appendix C-1, Sheet 7 of 7.

Longitudinal deck drains shall be used for bridges where deck waterproofing is required. Water shall be collected and piped off of the bridge at the low end abutment behind the backwall. Long bridges may require intermediate collection points. These intermediate collection points shall be near piers and piped to daylight, tied into a curb and gutter system, or tied into a storm sewer system. The deck drainage shall be independent and shall not connect to the subdrainage system.

Longitudinal deck drains shall not be placed within the live load distribution area. The maximum ballast design depth shall be used to determine the limits of this area. If possible, longitudinal deck drains shall be placed between tracks and access roads on multiple-track bridge structures.

Waterproofing shall be used on all steel decks and on bridge decks over roadways and paths.

Hot-mix asphalt (HMA) shall be placed on the decks of all concrete bridges with a minimum thickness of 2 ½ inches and a maximum thickness of 4 inches.

The HMA shall be crowned with a 1 percent cross slope. When multiple longitudinal deck drains are needed for wide bridges, the HMA shall be crowned between longitudinal deck drains.

A minimum ballast depth below tie shall be 12 inches. When HMA is used, 8 inches of ballast shall be provided. The minimum total thickness of the HMA and ballast shall be 12 inches.

Ballast curbs shall be a minimum of 24 inches in height above the structural deck (not the HMA). Ballast curb heights shall be increased as necessary to accommodate a superelevated track or increased ballast depth due to the required minimum 0.2 percent longitudinal grade.

The deck configuration for steel beam and Deck Plate Girder (DPG) spans shall match the Steel Beam Span configurations shown in Appendix C-1.

11.3.3 Handrail and Walkways

Handrail and walkways shall be provided on both sides of the bridge. The location of the handrail shall provide a minimum clearance of 8 feet 6 inches from the centerline of the track to the nearest point of the handrail. Additional clearance shall be provided for tracks on a curve in accordance with the AREMA Manual for Railway Engineering, Chapter 28, Section 1.1.

Bridges with multiple tracks and independent superstructures for each track shall have a walkway between superstructures for tracks having centerline spacing less than 25 feet. Tracks having centerline spacing equal to or greater than 25 feet may have separate walkways with handrails between tracks.

Walkways and handrails shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Sections 8.5.2 and 8.5.3. Platform, walkway, and handrail requirements when a bridge is at or near a station are provided in Chapter 7.0, Stations, of this DCM. Standard bridges using ES 6001 and ES 6002 shall use the handrail approved for these standards. For culvert headwalls, handrails shall be provided and designed in accordance with ES 6330 and the AREMA Manual for Railway Engineering, Chapter 15, Sections 8.5.2 and 8.5.3.

Walkways other than the ballast deck shall be concrete or galvanized serrated steel bar grating. Handrails shall have a minimum of three horizontal rails. The horizontal rails can be made of round tubular sections. Walkways and handrails shall be simple designs requiring minimum maintenance. Standard walkway and handrail configurations are shown in ES 6001 and ES 6002. Grade separation structures shall follow Chapter 12.0, Grade Separation Criteria, of this DCM for walkway and handrail requirements.

11.3.4 Geotechnical Subsurface Investigation

Geotechnical subsurface investigations shall be conducted in accordance with the AREMA Manual for Railway Engineering, Chapter 8.

Additionally, a formal Geotechnical Report, signed and sealed by a geotechnical engineer licensed in California, shall be provided. The report shall include the following investigation results:

- General geologic setting
- Specific site subsurface conditions and groundwater levels
- Soil types and classifications (include boring logs, test pit records, and lab results in appendices; make sure ground surface elevations at boring locations are provided and datum noted; soil borings shall extend at least 10-ft below the recommended pile or shaft tip elevation)
- Evaluation of site for potential accelerated corrosion issues
- Possible presence of hazardous materials
- Geologic hazards
- Site seismicity, including:
    - Fault rupture potential
    - Seismic design parameters as required per Chapter 14 Seismic Design Potential for liquefaction, seismic settlement, lateral spreading, slope failures or landslides, and any other secondary seismic hazards
- Anything special about the site based on the geotechnical engineer’s experience or observations in the immediate area

The report shall also include the following design recommendations:

- Recommended railroad embankment side slopes and required compaction (2:1 side slopes preferred)
- Estimated settlements, including:
    - Embankments
    - Foundations
    - Down drag on foundations
    - Lateral spreading
- Feasible and recommended foundation type(s) for bridges and miscellaneous structures for the project, including retaining walls. For each recommended foundation type, include the following:
    - Axial capacity charts for Cast-in-Drilled Hole (CIDH) pile foundations and recommended bearing/bottom elevation and material
    - Axial capacity charts for driven pile foundations and recommended bearing/bottom elevations and material including rock sockets, if needed
    - Recommended allowable bearing pressure for spread footings (service and seismic)

- Recommended design acceleration response spectra (ARS) curves for each level of earthquake (AREMA level 1, 2, and 3, which are approximately equivalent to 100-year, 475-year, and 2,475-year return periods) and Caltrans maximum credible earthquake (MCE)
- Recommended p-y curves for fill and in-situ soils
- Recommended soil profile and properties for use in lateral CIDH or pile analysis (service and seismic)
- Recommended design earth pressures for active, at-rest, and passive conditions (for passive, consider ½-inch, 1-inch, 2-inch, and maximum deformations into the soil behind each abutment, both native and fill)
- Recommended design seismic earth pressures for active and passive conditions
- Recommended allowable bearing pressure for retaining walls on spread footings (service and seismic)
- Potential constructability issues, such as:
    - Groundwater
    - Shoring
    - Cobbles
    - Drivability of piles
- Corrosion mitigation recommendations for new steel and concrete elements exposed to severely corrosive soil and/or brackish water conditions.
- Recommendations for surface and subsurface drainage

11.4 LOADING

11.4.1 Loads and Forces

Bridges and other civil structures supporting rail live load shall be designed for all loads specified in the AREMA Manual for Railway Engineering, Chapters 8, 9, and 15, and as modified below.

Dead Load

In addition to the actual self-weight of the structure, the following dead loads shall be applied as applicable:

Track rails, inside guard rails and their fastenings	200 lbs per linear foot per track
Ballast	120 lbs per cubic foot
HMA	140 lbs per cubic foot
Earth-filling materials	120 lbs per cubic foot
Waterproofing and protective covering	Estimated weight
Future utilities	5 lbs per square foot of deck

Dead load for bridges shall include a minimum of 18 inches and a maximum 25 inches of ballast from top of deck to top of tie, including HMA when required.

Increase in grades for flood protection can impart significant surcharge on the underlying utilities and underground structures. Prior to increasing grades, the load carrying capacities of utilities and structures shall be evaluated.

Live Load

All structures subject to rail live load shall be designed for AREMA Cooper E80 loading except steel superstructures that are governed by the AREMA Alternate Live Load on 4 Axles.

For multiple track structures, the track shall be allowed to be placed anywhere on the structure. The number of tracks on the structure shall be determined using a minimum track spacing of 13 feet 0 inches on center (to generate a conservative load).

Impact Load

Impact load shall be in accordance with AREMA guidelines.

The impact load prescribed by AREMA shall be used for the material under design. For example, concrete impact load shall be used for a concrete bent cap, and steel impact load shall be used for the supporting steel pile above the ground line, regardless of superstructure type.

11.4.2 General Load Distribution

Live load distribution to supporting superstructure elements shall be in accordance with AREMA guidelines.

The live load shall be distributed transversely on ballasted deck bridges using an 8-foot-3-inch-long tie that is 8.5 inches in depth. The following load cases should be considered:

- A minimum of 12 inches of ballast below the tie, including HMA when required
- A maximum of 16 inches of ballast below the tie, including HMA when required

The HMA shall be considered as an additional ballast depth in determining the live load distribution to the deck.

11.4.3 Longitudinal Force Distribution

Longitudinal force on bridges shall be distributed in accordance with AREMA guidelines. The longitudinal superstructure deflection due to the longitudinal force shall not exceed 1 inch. Vertical reactions at girder bearings resulting from the applied longitudinal force and associated force couples (if any) shall be considered in the substructure design. Appendix F provides detailed methodology for distributing longitudinal force to the substructure element.

For simultaneous loading on two or more tracks, the proportion of longitudinal force per track shall be used in conjunction with the specified live load in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Section 2.2.3.c(6). Bridges containing more than two tracks shall develop a project-specific design criteria to address the potential that more than one track may be subject to a longitudinal force event in the same direction and at the same time.

11.5 SEISMIC DESIGN CONSIDERATIONS

Seismic design for railroad bridges shall be in accordance with Chapter 14.0, Seismic Design of this DCM.

11.6 STRUCTURE TYPE SELECTION

11.6.1 Structure Selection Analysis and Report

SCRRA requires that a structure selection analysis be performed for all structures. A structure selection report shall then be developed that includes the results of the structure selection analysis and that includes all backup information in the report appendices.

The analysis shall include, at a minimum, the following:

- Required span lengths
- Structure
  - Span types
  - Substructure types
  - Foundation types
- Number of tracks
- Track alignment
  - Vertical
  - Horizontal
- Geometry of feature being crossed
- Drainage
  - Hydraulic requirements (see Chapter 9.0, Drainage and Grading, of this DCM)
  - Hydraulic opening requirements for waterways
  - Deck
  - Discharge
  - Erosion potential of side slopes
  - Highway and street drainage and discharge methods
- ROW
- Subsurface conditions
  - Geology
  - Seismicity
  - Soil reactivity
  - Water table

  - Hazardous materials
  - Scour potential in water courses
- Required clearances
- Physical constraints near the structure
  - At-grade crossings
  - Overhead structures
  - Turnouts (switches)
  - Stations
  - Utilities
- Environmental Issues
  - Within 1 mile of the coast
  - Wetlands
  - Threatened and endangered species
  - Noise
  - Allowable working hours
  - Mitigation requirements
  - Aesthetics
  - Saltwater and brackish water
  - Potential for increased water flow during extreme storm events
  - Potential for damage from wildland fires
  - Potential for increased temperatures and thermal effects
  - Potential for increased wind speeds and loading
  - Changes to stream bed hydraulics
- Constructability
  - Shoring needs
  - Under rail traffic
  - Equipment access and material staging
  - Phased construction
  - Work windows
    - Quantity
    - Duration
  - Offline construction

    - Shoofly
    - Permanent track realignment

- Maintenance
  - Painting
  - Channel cleaning
  - Damage (vehicular hits, derailments, floods, seismic, etc.)
    - Track down time
    - Repair costs
- Project cost
  - Short term (construction)
  - Long term (maintenance)
- Project schedule
  - Fabrication times
  - Work windows
  - Environmental non-disturbance times for threatened and endangered species

The analysis shall do the following:

- Compare structure types (including spans, substructures, and foundations) and their impacts on the project cost and schedule.
- Compare structure types (including spans, substructures, and foundations) and their impacts on the environment and their impacts on existing physical constraints.

The result of the analysis shall be a recommended structure type that balances the impacts on costs (short term, including impacts on physical constraints and track outages for construction, and long term, including maintenance and track outages for possible damage), schedule, and the environment. It is not acceptable to recommend a structure type that deviates from SCRRA standards solely due to cost.

11.6.2 Substructure and Foundation Types

Each structure site poses a unique set of circumstances for substructure and foundation type selection.

Abutments should not be skewed to the track. Variable beam lengths shall be used in approach spans when piers are skewed. When high abutments are necessary due to site constraints and are skewed, the abutment backwall shall be designed to eliminate the skew at the backwall to provide the track a uniform transition and support from the approach embankment to bridge deck.

Open and encased pile substructures shall have a minimum of three piles per transverse row of pile. Concrete piers shall have a minimum of two columns. Wall-style piers are also acceptable.

Special consideration shall be made to keep excavations to a minimum adjacent to active tracks. An example to reduce the excavation depth is using a top-down construction method such as columns or piles that can be constructed and then exposed later when the bridge is in service, thus requiring an initial excavation depth only to construct the pier caps.

Special consideration shall also be made for construction under rail traffic. Foundation and substructure elements shall be positioned and designed in such a manner to reduce their impact on rail traffic when constructed. Precast elements should be considered to speed construction and reduce impact on rail traffic. Examples of this include locating a pile being driven through an existing bridge deck such that it does not interfere with the existing rail, or adding precast riser blocks to pier caps such that the pier cap can be constructed initially below the existing low chord.

The following foundation types are preferred:

- Driven steel H pile
- Precast/Prestressed concrete pile
- Cast-in-Steel Shell (CISS) pile
- Cast-in-Drilled Hole (CIDH) pile (also known as drilled shaft)
- Spread footings

These foundation types have no order of preference; the preferred type has a direct correlation with the site geology, potential for scour in stream beds, and seismicity.

When using ES 6001 and ES 6002, driven steel H-pile (in accordance with these standards) is the preferred foundation type with precast concrete pile caps as the preferred substructure type.

The CISS pile is usually a driven pipe pile filled with concrete, reinforced, or unreinforced. The pipe may be used as a sacrificial form in brackish and saltwater areas or in corrosive soils.

CIDH piles are holes drilled to a bearing strata and then filled with reinforced concrete. The holes may have to be kept open with slurry, temporary casing, permanent casing, or a combination of these. Rock sockets may be required to achieve bearing requirements. CIDH piles below ground shall be larger in diameter than the columns above ground (Type II) to meet the detailing requirements in Chapter 14.0, Seismic Design, of this DCM.

Spread footings shall not be used to support structures in a stream or river environment without protection from undermining.

Properly designed riprap shall be stockpiled near bridges and culverts known to be exposed to scour or high velocity flows.

11.6.3 Superstructure Types

The following are the allowed superstructure types in order of preference based on span length:

1. Standard double -box beams per ES 6001 (20- to 35-foot span lengths)
2. Standard slab beams per ES 6002 (9- to 22-foot spans)
3. Steel beam spans (30- to 69-foot spans) (see Appendix C-1 for typical details)

- SCRRA has adopted the superstructure style and details of UP standards "W36 and W40 Beam Span, 31' to 69' Lengths." The intent is to use these standard beam span configurations on SCRRA rail lines.
- Modifications to the ballast retainer support and handrail bracket can be made to accommodate non-standard bridge widths.
- W44 beams can be added to accommodate multi-track bridges.
- The design engineer will provide checked design calculations that show that the bridge design meets SCRRA design criteria requirements.
- All details required for the bridge construction shall be included in drawings.
- SCRRA Standard Specifications will be used for the fabrication and erection of the beams. These Standard Specifications can be modified by project Special Provisions, if needed, on a project-by-project basis.
- The bearing details were not designed for seismic events. The bearings will need to be designed and detailed as required per SCRRA seismic design criteria.
- The deck drainage will need to be modified to accommodate the waterproofing and longitudinal drainage system.

4. Non-standard precast prestressed double cell box beams, 42" deep (35- to 50-foot span lengths)
5. Non-standard precast prestressed single cell box girders, up to 80" deep (50- to 80-foot span lengths) with transversely post-tensioned tie rods
6. DPG spans with steel deck (up to 180-foot spans)
7. Through-Plate Girder (TPG) spans with steel deck (up to 180-foot spans)

Span erection offline should be considered when constructing under rail traffic. Offline erection may require rolling in the new span and/or rolling out the old span or picking and placing a complete span. Grade separation projects being constructed for a third party shall not be constructed under rail traffic.

A bridge does not have to use all the same span types. The bridge can consist of different span types. While the main span may need to be a DPG span, the approaches could be standard double box beams.

Section 8.4, Structure Selection Criteria of Chapter 12.0, Grade Separation Criteria, of this DCM provides further direction on structure type selection for underpass grade separation structures.

11.7 CONCRETE STRUCTURES

11.7.1 Materials

Material requirements shall be in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Part 1, and SCRRA Standard Specifications. The Standard Specifications may be amended by Special Provision on a project-by-project basis for material that is not specifically included in the Standard Specifications.

Concrete, when subjected to wetting by or submersion in brackish or salt water, shall be made of the mix designated for that use in the SCRRA Standard Specifications. The reinforcing steel in this concrete shall be epoxy coated, stainless steel, or fiberglass (if approved by SCRRA). No un-protected ferrous metal shall be embedded in concrete that is subject to wetting by, or submersion in, brackish or salt water.

Self-consolidating concrete (SCC) will be allowed for fabrication of plant-cast, precast and/or prestressed members.

11.7.2 Concrete Substructure Requirements

The minimum compressive strength (f'_c) shall be 4,000 psi at 28 days.

Minimum wall thickness for high abutments, at the base, shall be 0.2 times the height of the abutment (footing or pile cap to seat).

Permanent casing shall be provided for CIDH piles within the limits of live load surcharge influence from adjacent active tracks during construction. Chapter 15.0, Excavation Support Criteria, of this DCM provides limits of live load surcharge.

Positive drainage shall be provided behind abutments. The drainage system shall remove free water as close to the bottom of the abutment as practical.

The drainage system shall collect the water from behind the abutment using a drainage blanket and perforated pipe not less than 8 inches in diameter. The drainage blanket can be made from granular material. The drainage system shall be piped to daylight, tied into a curb and gutter system, or tied into a storm sewer system.

Weep holes not less than 6 inches in diameter can be used if the drain water will not have any detrimental impacts on what is in front of the abutment. Weep holes shall have a positive connection to adjacent weep holes and shall be spaced not greater than 10 feet on center.

For older bridges where pile/column foundations are shallow, replace them with deep foundations that extend into non-scourable bedrock. For bridges vulnerable to overtopping, consideration will be given to pier modifications to reduce flood water surface elevation immediately under a bridge crossing. For bridges where abutments/approaches are within the flood plain, add riprap revetments, concrete erosion protection, or other armoring to protect abutments from scour.

11.7.3 Concrete Superstructure Requirements

Concrete superstructures shall be in accordance with ES 6001 and ES 6002.

11.8 STEEL STRUCTURES

11.8.1 Materials

Material requirements shall be in accordance with SCRRA Standard Specifications. The Standard Specifications may be amended by Special Provision on a project-by-project basis for material that is not specifically included in the Standard Specifications.

Steel member material shall be as follows:

Rolled Beams	ASTM A709 Gr. 50W T1	F_y=50,000 psi

Girder Web, Bottom Flange, End Floor Beam	ASTM A709 Gr. 50W F1	F_y=50,000 psi
Girder Top Flange, Bearing Stiffeners	ASTM A709 Gr. 50W T1	F_y=50,000 psi
Intermediate Floor Beams	ASTM A709 Gr. 50W T1	F^y=50,000 psi
Deck Plates (Galvanized)	ASTM A709 Gr. 36 T1	F_y=36,000 psi
Cover Plates (Galvanized)	ASTM A36	F_y=36,000 psi
Walkway Checkered Plates	ASTM A786 Gr. 36, Galv.	F_y=36,000 psi
Handrail	ASTM A847	F_y=50,000 psi
Drain Pipe Downspouts	ASTM A53 Gr. B	F_y=35,000 psi
Bearings		
Pins	ASTM A576 Gr. 1018	F_y=36,000 psi
All other Material	ASTM A588	F_y=50,000 psi
Anchor Rods	ASTM F1554 Gr. 36	F_y=36,000 psi
H-Piling	ASTM A572 Gr. 50	F_y=50,000 psi
	ASTM A588	F_y=50,000 psi
Pipe Piling	ASTM A53 Gr. B	F_y=35,000 psi
	ASTM A252 Gr. 2	F_y=35,000 psi
	ASTM A252 Gr. 3	F_y=45,000 psi
	ASTM A500 Gr. B	F_y=42,000 psi
	ASTM A500 Gr. C	F_y=46,000 psi
Steel Sheet Piling	ASTM A328	F_y=39,000 psi
	ASTM A690	F_y=50,000 psi
All other Structural Steel	ASTM A588	F_y=50,000 psi

11.8.2 Design and Detailing Requirements

Deck composite action shall not be used for strength requirements but may be used for deflection requirements.

All steel structures within 1 mile of the coast, or low-level water crossings as specifically directed by SCRRA, shall have corrosion resistant material and protective coatings designed for marine environments. Cathodic protection can be used when authorized by SCRRA.

If the structure will be painted or galvanized, non-weathering steel shall be substituted for the material being painted or galvanized.

All new bridges at locations where deck elevation is constrained, consider through girder or truss designs over deck/box girder designs.

Superstructure connection bolts shall be ASTM A325 minimum 7/8 inches in diameter, slip critical, and the bolt type shall be consistent with the material being connected. Contact surfaces of bolted parts shall be designated as Class A in accordance with the AREMA Manual, unless otherwise required by design.

All other steel-to-steel connection bolts shall be ASTM A325 minimum 3/4 inches in diameter.

All other bolts shall be ASTM A307.

Coping of members carrying railroad live load shall not be allowed. Stripping of flanges without modifying the web may be allowed.

Fatigue prone details shall be avoided. Fracture critical members (FCMs) shall use bolted connections to the extent practical. FCMs shall be identified on the design plans and meet minimum notch toughness requirements per the AREMA Manual.

All intermediate stiffeners shall have a bolted connection to the web.

All intermediate stiffeners acting as floor beam or transverse diaphragm connections shall be bolted to the bottom flange on only one side of the web.

Intermediate stiffeners on plate girders located within a distance equal to the depth of the girder from the bearing need to be bolted to the bottom flange.

All end floor beams shall be designed to allow jacking of the span for bearing maintenance. The jacking load used for design shall be at least one half of the maximum dead load of the span, including superstructure, ballast, walkways, and track.

11.9 TIMBER STRUCTURES

Timber shall not be used for any bridge or culverts. Existing timber bridges and structures shall be replaced as soon as feasible.

11.10 BRIDGE BEARINGS

Bridge bearings shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Part 5.

Material requirements shall be in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Part 5, and SCRRA Standard Specifications. The Standard Specifications may be amended by Special Provision on a project-by-project basis for material that is not specifically included in the Standard Specifications.

Bridge bearing selections shall be based on the AREMA Manual for Railway Engineering, Section 5.1.5, Bearing Selection Criteria.

Fiber-reinforced elastomeric bearing pads can be selected in the same manner as plain or reinforced elastomeric pads. The requirements for sizing a fiber-reinforced elastomeric bearing pad are provided below.

Random oriented fiber (ROF) reinforced elastomeric bearing pads may be used as bridge bearings without steel reinforcing layers up to 2 inches in thickness. Design of ROF pads shall be in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Steel Structures, Part 55, Bearing Design, for “plain” elastomeric bearings with the following exceptions:

1. Modifying factor: $k = 1.0$
2. Allowable compressive stress in psi $f_a \leq 1000 + 100(S) \leq 1500$ psi
3. Allowable compressive deflection, $d_c \leq 0.15\ (T) \leq 0.2”$
4. Allowable rotation, $L\ (a_L) + W\ (a_W) \leq 0.30\ (T)$

See the AREMA Manual for Railway Engineering, Chapter 15, Section 55.6.3.3, Notations, for variable definitions.

Bridge bearings may be supplemented by additional shear resisting devices mainly to help transfer seismic lateral forces provided that the movement required to engage the shear resisting devices does not cause failure of a bearing device itself under the Level 1 seismic event.

11.11 WATERPROOFING

The HMA will act as the main waterproofing for concrete bridge decks. When the joints between spans need to be waterproofed, such as over a roadway, a detail similar to the Bridge Deck Joint Details provided in Appendix C-2, shall be used.

A waterproofing membrane in accordance with SCRRA Standard Specifications shall be required on all steel bridge decks. A detail similar to the Bridge Deck Joint Details provided in Appendix C-2 shall be used at all steel bridge deck joints.

11.12 CULVERTS

11.12.1 Materials

Material for culverts shall be in accordance with the AREMA Manual for Railway Engineering, Chapter 1, Part 4; Chapter 8, Part 1; and SCRRA Standard Specifications. The Standard Specifications may be amended by Special design consideration on a project-by-project basis for material that is not specifically included in the Standard Specifications.

Reinforced concrete pipe culverts shall not be used, unless approved by SCRRA, when crossing below tracks and within the typical track section with 2:1 side slopes.

11.12.2 Design and Detailing Requirements

Culverts shall be sized in accordance with Chapter 9.0, Drainage and Grading, of this DCM.

Pipe culverts shall be in accordance with ES 6004.

Guidance on jacking and boring limitations for culvert installation is provided in Chapter 10.0, Utilities, of this DCM.

Precast concrete box culverts shall be in accordance with ES 6003. Precast concrete box culverts outside the limits of these standards shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Part 16.

Cast-in-place concrete box culverts shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Part 16.

All culverts shall have a headwall at the upstream end. If right-of-way limits permit, a headwall at the downstream end of the culvert may be omitted. The headwalls shall generally have 45 degree flared wingwalls in accordance with ES 6003 or 30 degree flared wingwalls in accordance with ES 6004. However, square precast concrete headwalls and/or cutoff walls may be allowed in situations where drainage ditching or right-of-way precludes flared headwalls.

Energy dissipaters shall be in accordance with Chapter 9.0, Drainage and Grading, of this DCM and the Hydraulic Recommendation report developed for the culvert.

11.13 PERMANENT RETAINING WALLS

Retaining walls with tracks above shall not be placed closer than 12 feet from the front of wall to the centerline of the nearest track. This clearance may need to increase to allow for construction adjacent to a live track. Additional information is provided in Chapter 15.0, Excavation Support Criteria, of this DCM.

The retaining wall design shall account for the presence of multiple tracks and associated lateral loading onto the wall. The retaining wall deflection under live loading shall be limited to 1 inch per 10 feet of wall height.

Retaining walls adjacent to tracks shall provide a minimum clearance of 12 feet from the front face of the wall to the centerline of the nearest track. This clearance may need to increase to allow for construction adjacent to a live track. Additional information is provided in Chapter 15.0, Excavation Support Criteria, of this DCM.

Utilities shall not be attached to retaining walls.

Geotechnical subsurface requirements are discussed in Section 11.3.4.

Temporary shoring requirements are provided in the Chapter 15.0, Excavation Support Criteria.

11.13.1 Wall Type Selection

Each site for a retaining wall poses a unique set of circumstances for retaining wall type selection. The wall type selection should take into account the following:

- Subsurface conditions
- Constructability
- Loading conditions
- Aesthetics
- Maintenance
- Project cost
- Adjacent watercourses

Concrete wall types are preferred due to their corrosion resistance and minimum maintenance requirements.

Mechanically Stabilized Earth (MSE) wall types are not allowed for use in supporting railroad loading. However, MSE wall types may be allowed to support non-railroad loading, on a case by case basis. Special detailing, specifications, and construction requirements will be necessary to extend the design life of an MSE retaining wall.

Special precast concrete T-type retaining walls are allowed to support railroad loading.

Retaining walls comprised of lightweight cellular concrete fill with precast concrete facing panels are allowed to support railroad loading, particularly where relatively tall and narrow railroad embankments are required.

11.13.2 Retaining Wall Details

<u>Tie Backs</u>

Tie backs, when required to run below the track structure, shall be a minimum of 5 feet 0 inches below top of rail and shall be below top of subgrade.

Tie backs shall be protected from corrosion. Acceptable methods are fully grouting the tie backs and wrapping the tie backs in a bituminous coating system.

Drainage

Positive drainage shall be provided behind retaining walls. The drainage system shall remove free water as close to the bottom of the retaining wall as practical.

The drainage system shall collect the water from behind the retaining wall using a drainage blanket and perforated pipe not less than 8 inches in diameter. The drainage blanket can be made from granular material. The drainage system shall be piped to daylight, tied into a curb and gutter system, or tied into a storm sewer system.

Weep holes not less than 6 inches in diameter can be used if the drain water will not have any detrimental impacts on what is in front of the retaining wall. Weep holes shall have a positive connection to adjacent weep holes and shall be spaced not greater than 10 feet on center.

11.13.3 Mechanically Stabilized Earth Retaining Walls

MSE walls shall be designed in accordance with AREMA and AASHTO guidelines.

MSE walls shall not be used as a barrier adjacent to water flow path due to susceptibility to scour and erosion.

The maximum wall height shall be 30 feet.

The design life shall be 100 years.

Limiting differential settlements for wall facings are provided in Table 11-1.

TABLE 11-1. LIMITING DIFFERENTIAL SETTLEMENTS FOR MSE WALLS

Facing Type	Joint Width	Limiting Differential Settlement (in/ft of wall)
Precast concrete panel, 5 feet by 5 feet	0.75 inch	1/100
Precast concrete panel, 5 feet by 5 feet	0.50 inch	1/200
Precast concrete panel, 5 feet by 5 feet	0.25 inch	1/300
Full height concrete panel	0.50 inch	1/500
Segmental block	—	1/200
Wire mesh face	—	1/50
Geosynthetic wrap face	—	1/50

Differential settlements greater than the values shown in Table 11-1 and total settlements greater than 6 inches shall require ground improvements to reduce the differential settlements and total settlements to the required minimums.

Steel reinforcement shall be designed to have corrosion resistance/durability for the 100-year design life of the wall. Galvanized steel, in accordance with AASHTO specifications, shall be used for reinforcement. PVC coatings, epoxy coatings, and resin bonded epoxy coatings shall not be used on reinforcement. The sacrificial thickness of steel reinforcement shall be in accordance with AASHTO guidelines using the electro-chemical criteria for backfill soils in the AASHTO guidelines.

Geosynthetic reinforcement shall be designed using the appropriate reduction factors for a 100--year design life. The chemical and biological degradation factor (RF_D) shall be obtained from the product--specific data. The other reduction factors shall be in accordance with AASHTO guidelines. The creep reduction factor (RF_{ID}) and the chemical and biological degradation factor (RF_D) shall not be less than 1.1. The backfill shall be in accordance with AASHTO guidelines for electro-chemical criteria for backfills and geosynthetic reinforcements.

Backfill for MSE walls shall be free draining and shall meet the gradation requirements provided in Table 11-2.

TABLE 11-2. MSE WALL BACKFILL GRADATION

U.S. Sieve Size	Percentage Passing for Steel Reinforcements	Percentage Passing for Geosynthetic Reinforcements
4 inches	100	100
¾ inch	—	100
No. 40	0-60	0-60
No. 200	0-3	0-3

A subdrainage system shall be provided to collect and drain water from behind the MSE walls. The system shall be piped to daylight or tied into a storm water system.

11.14 SLOPE STABILIZATION

Deploy slope stabilization strategies to areas near track burned by wildfire. Implement slope stabilization (vegetation or engineered) where bridge foundations or supports are located within landslide exposure areas. Address active landslides near at the source with retaining walls, shortcrete, etc. Perform landslide debris removal after material has stopped moving to ensure that removing debris does not inadvertently exacerbate slope failure. Complimentary site work such as soil retention systems, internal/surface drainage, and erosion control BMPs are required as applicable.

11.15 MAXIMUM LOAD RATING

Maximum load ratings shall be performed for all new bridge structures. The ratings shall be calculated in accordance with Chapter 13.0, Load Rating of this DCM. The ratings shall be calculated for the bridge as designed and not for the as -built condition. A maximum rating shall be performed for no speed restriction and for a reduced speed of 10 mph. The Maximum Load Rating for each case shall be reported on the front sheet of the bridge drawings.

SCRRA has adopted the FRA definition of a bridge structure, which is defined as any structure with a deck, regardless of length, that supports one or more railroad tracks, and any other underground structure with an individual span length of 10 feet or more located at such a depth that it is affected by live loads.

12.0 GRADE SEPARATION CRITERIA

12.1 SCOPE

A “grade separation” is a means of separating vehicle or pedestrian traffic from railroad tracks. This may be accomplished with an underpass or overpass. Other than crossing closure, this is the most effective means of eliminating hazards at grade crossings.

The purpose of the grade separation design criteria is to inform and provide current criteria for the design and construction of, or modifications to, grade separation structures that affect SCRRA track and right-of-way. The term Project Sponsor, as used within this chapter, refers to the agency, such as a roadway authority such as a city, county, or state agency that is taking the lead role in progressing the design and construction of a grade separation project.

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

The design of a structure owned or maintained by a Project Sponsor other than the SCRRA and not supporting SCRRA tracks or trains shall be constructed and maintained in accordance with the standards used by that Project Sponsor, and shall be consistent with SCRRA operating and maintenance requirements. Structures not supporting SCRRA tracks or trains that are owned or maintained by Caltrans, or by any jurisdiction adopting the standards of that Project Sponsor, shall be designed in accordance with Caltrans criteria and SCRRA operating and maintenance requirements.

12.2 GENERAL REQUIREMENTS

SCRRA’s Board (Board) Resolution 91-3 and Resolution 98-21 (See Appendix I) pertain to the establishment of a new highway-rail grade crossing on SCRRA’s system. SCRRA’s policy, as well as State and National policies, strongly discourage the construction of new highway-rail grade crossings and seek to reduce the number of active highway-rail grade crossings by promoting grade separation or closure of existing highway-rail grade crossings. These policies shall be adhered to during the design of highway-rail and pedestrian-rail grade crossings and grade separations.

12.2.1 Jurisdiction

California Public Utilities Commission (CPUC) Code Sections 1201-1220 have rules and regulations regarding railroad crossings. Section 1201 requires that no public road, highway, or street shall be constructed across the track of any railroad corporation at-grade without having first secured the permission of the Commission. Section 1202 says that the CPUC has the exclusive power (a) to determine and prescribe the manner, including the particular point of crossing, and terms of installation, operation, maintenance, use, and protection of each Grade Crossing, (b) to alter, relocate, or abolish by physical closing any such crossing, and (c) to require, where in its judgment it would be practical, a separation of grades at any crossing and prescribe the terms upon which such separation shall be made and the proportions in which the expenses shall be divided.

CPUC jurisdiction is limited to public crossings. Any grade separation for a private roadway typically would not be subject to the Rules and Procedures of the CPUC.

12.2.2 Approval

CPUC application for authority to construct a new public highway-rail grade crossing, major alteration to an existing crossing, or a grade separation is necessary per CPUC Code Sections 1201-1205. However, CPUC General Order (GO) No. 88-B and/or a Form G provide for an informal process for modifying grade separations or converting existing at-grade crossings to grade separations that close one or more highway-rail grade crossings.

Evidence of agreement is required to be submitted with a GO 88-B by all stakeholders. If agreement is not obtained, the applicant would be required to submit a formal application to the CPUC.

12.2.3 Funding

The Project Sponsor interested in developing a Grade Separation is responsible for securing all funding for the project.

Federal and State Section 190 funding (partial) is available for Grade Separation projects that eliminate one or more Highway-Rail Grade Crossings. CPUC is responsible for establishing priority lists of projects that are in need of funding for separation. These lists are determined on the basis of criteria established by the CPUC. California Streets and Highways (S&H) Code Section 2450-2461 has rules and regulations regarding funding for Grade Separations. Refer to S&H website www.leginfo.legislature.ca.gov/ for further information on codes.

For a State-funded project, and per CPUC Section 1202.5 requirements, the railroad shall pay ten (10) percent of the cost of the Grade Separation project where it will directly result in the elimination of one or more existing Highway-Rail Grade Crossings, located at or within a reasonable distance from the Grade Separation. For a Federally funded project, and as per U.S. Department of Transportation, Federal Highway Administration, Code of Federal Regulations, Title 23, Part 646, Section 646.210, the railroad shall pay five (5) percent of the cost of the Grade Separation project. The railroad’s share of the cost shall be based on the costs for preliminary engineering; Right-of-Way and construction within the limits where a Grade Crossing is eliminated by a Grade Separation; and the structure and approaches required to transition to a theoretical highway profile, which would have been constructed if there were no railroad present; and for the number of lanes on the existing highway in accordance with current design standards of the State highway agency (Caltrans).

12.3 GRADE SEPARATION EVALUATION CRITERIA

12.3.1 Evaluation Criteria

The large number of SCRRA highway-rail grade crossings, combined with high and increasing levels of train traffic, motorized vehicles, additional modes, crossing lengths, and pedestrian/bicycle traffic, has driven the need for SCRRA to develop a grade separation evaluation criteria. When considering changes and modifications to existing grade crossings, a new grade crossing, new SCRRA service, or a new mode, the Project Sponsor shall follow SCRRA's grade separation evaluation criteria shown in this chapter.

As the population of Southern California continues to grow, demand for alternate public transportation modes, such as Light Rail Transit (LRT), Diesel Multiple Units (DMU), Electric Multiple Units (EMU) or Zero Emission Multiple Units (ZEMU), LRT Trams, High-Speed Rail (HSR) systems, and other modes have increased to help relieve the congestion on freeways. With much of the land in Southern California developed, these alternate transportation modes are constrained to using existing railroad corridors to provide an efficient and practicable route. Currently, SCRRA's System includes a limited LRT system on the SCRRA Pasadena Subdivision that does not share tracks with Metrolink trains, but with the demand for alternate public transportation modes increasing, there is consideration being given for an LRT, DMU, EMU/ZEMU, LRT Trams, HSR system, or other mode to utilize any of SCRRA's other subdivisions along with SCRRA/Freight/Amtrak trains. All planned and future shared corridors with alternate train modes will be subject to all of the standards and criteria of this Design Criteria Manual and SCRRA standards.

Due to the safety concerns of intermixing different modes of rail, the FRA and FTA issued a joint policy statement on how agencies will coordinate their safety authority. This joint policy can be found on the Federal Register, Vol. 65, No. 132, Monday, July 10, 2000, pp. 42526-42528.

LRT, DMU, EMU/ZEMU, LRT Trams, HSR systems, and other modes operate very differently from commuter, long distance and freight rail systems. The close proximity of these LRT, DMU, EMU/ZEMU, LRT Trams, HSR systems, and other modes to SCRRA's system warrants special attention at highway-rail grade crossings due to various factors that affect the safety and operation through the crossing for both rail vehicles, highway vehicles and pedestrians.

The technical decision to proceed with a grade separation will be made through three key steps. These three steps include: Step 1 - Initial Factors Form, Step 2 – Detailed Analysis Report, and Step 3 - Risk, Indemnification, and Liability.

SCRRA Grade Separation decision process flow chart is shown in Figure 12-1. The Project Sponsor will follow this process for all public at-grade crossings proposed in the project limits. The process and the steps are described in the details below.

SCRRA concurs with the key conclusions of the FRA Guidance on Pedestrian Crossing Safety At or Near Passenger Stations, dated April 2012, which can be downloaded at http://www.trb.org/Main/Blurbs/167049.aspx. In particular, SCRRA concurs with this statement found within this document stating, “FRA recommends that railroads with busy passenger stations located on multi-track rail lines (particularly those with three or more main tracks) with frequent freight service should investigate the application of a high-capacity grade separation structure to carry large volumes of pedestrians to and from their busy passenger platforms, separated from the potential hazards of crossing a multi-track railroad at-grade.”

Before implementing, modifying, improving, or expanding an at-grade crossing, consider a crossing closure or full/partial grade separation of the new rail mode’s tracks and/or pedestrians.

12.3.2 Step 1 - Initial Factors Form

All SCRRA and third party projects shall complete the Step 1 Form when implementing, modifying, improving, or expanding an at-grade crossing. The results of Step 1 will be valid for a period of two years after completed for 5% design to be complete as defined by the SCRRA Design Procedures Manual. If a project experiences significant delays and after the 5% design level or major changes in the Step 1 assumptions, the Project Sponsor shall obtain current information and resubmit the Step 1 Form for SCRRA approval and signature. The Project Sponsor shall resubmit the Step 1 Form if any assumptions change and cause a new category to be “Yes” instead of “No” in the Step 1 Form.

Factors that affect the selection of the crossing alternatives are summarized in Table 12-1. This table will be completed as a part of Step 1 and will be submitted to SCRRA.

This Form is broken into two parts, Part A and Part B. Part A considers proximity of adjacent grade crossing(s), overall crossing length, distance between proposed tracks, overlap with any other future projects/adjacent crossing projects, train volume, new modes, formal applications, accident history, and vehicle ADT. Part B considers pedestrian traffic, gate down time, and any other issues of importance.

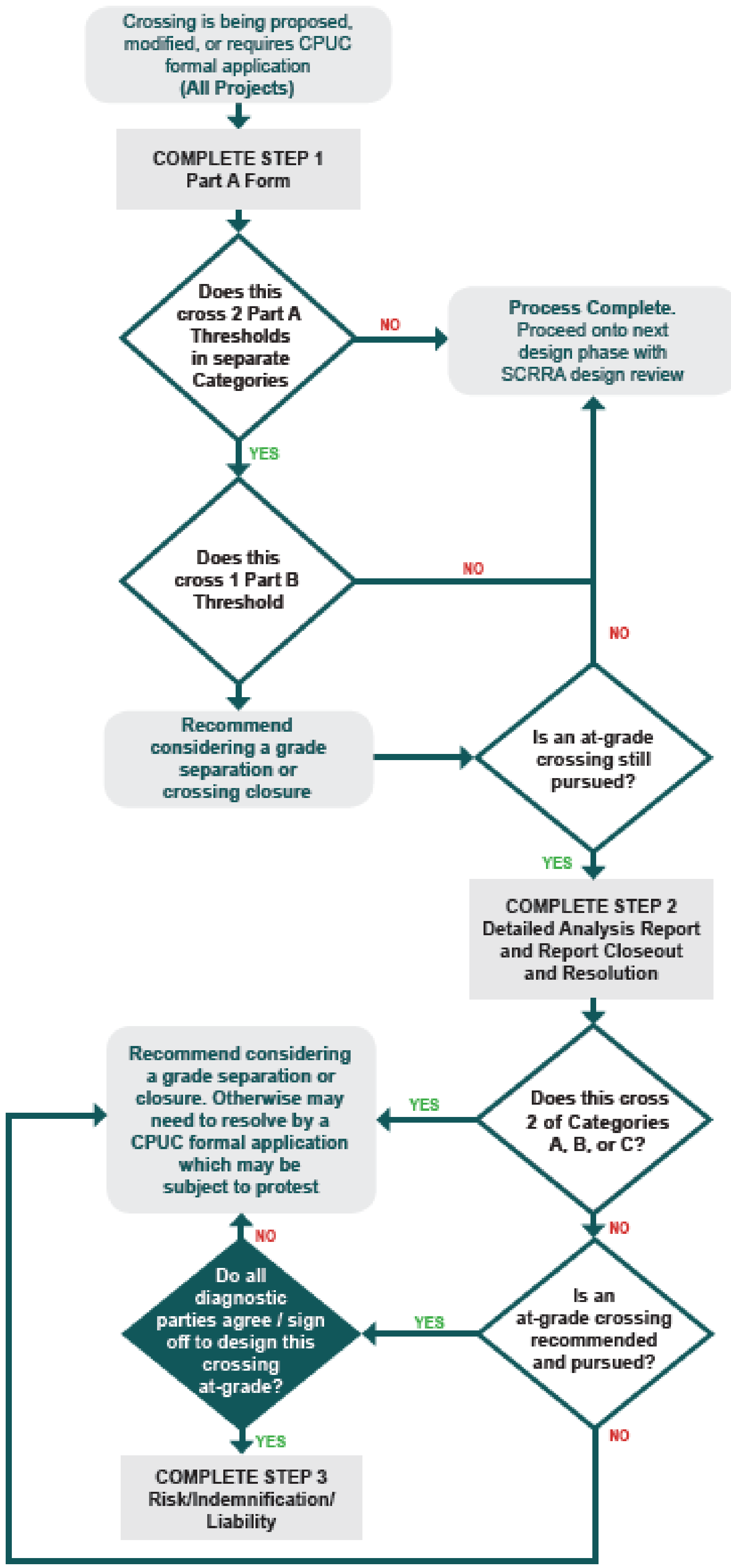

FIGURE 12-1. SCRRA GRADE SEPARATION EVALUATION FLOWCHART

TABLE 12-1. INITIAL FACTORS FORM

Project Name: ____
Crossing Street:________________City/County:________DOT#:______
Subdivision:____________________Mile Post:__________

Category No.		Description	Yes	No
PART A				
Proximity of Adjacent Grade Crossing(s), Overall Crossing Length, and/or Distance between Proposed Tracks Is there an adjacent crossing with tracks within 200 feet of the proposed crossing track(s) based on inside track centers? Distance: ft (If yes, then Categories **1 through 6** need to account for all data combined at BOTH crossings. If no, then utilize only the crossing data at the crossing under evaluation)				
Does this project overlap with any other future projects/adjacent crossing projects at this location by any related entity including, but not limited to: SCRRA SCORE, HSR, cities, transportation agencies, etc.? If yes, please list the project(s). ____				
Category 1 Projected Number of Trains	a.	Are there more than 75 trains/day projected for the design year (or 20 years from now)? ______ Trains/day		
	b.	Are there more than 10 trains/peak hour projected for the design year (or 20 years from now)?______ Trains/peak hour		
	NOTE: Part a and b should factor in projects like SCORE, alternate modes, regional rail projects, etc. This category should also consider major planning documents such as the SCRRA 10-Year Strategic Plan and any SCRRA member agency planning for other train modes.			
Category 2	Are new train modes being introduced to this crossing? If yes, which modes are proposed?__________________________________			
	NOTE: This should factor in projects like SCORE, additional future modes, etc. This category should also consider major planning documents such as the SCRRA 10-Year Strategic Plan and any SCRRA member agency planning for other train modes.			
Category 3	Is overall crossing length more than 66 feet for the Minimum Track Clearance Distance (MTCD)? _________ft			
	NOTE: The MTCD is defined to be the distance (in feet) from the railroad warning device limit line or gate to a point 6 feet past the far rail.			
Category 4 Formal Application	Does this project require a CPUC formal application for at-grade implementation (such as a new crossing, adds more than 1 mainline tracks, etc.)? If yes, how many mainline vs. siding tracks are proposed at-grade? _____Mainline and _____Siding			
Category 5 Accident History	a.	Have there been 2 or more FRA-reportable accidents in the last 5 years? ______ Accidents in the last 5 Years		
	b.	Have there been 2 or more highway authority reported accidents in the last 5 years within 200 feet of the crossing including at any nearby adjacent intersections? ______ Number of accidents in the last 5 years within 200 feet		

TABLE 12-1. INITIAL FACTORS FORM

Project Name: ____
Crossing Street:_______________City/County:________DOT#:______
Subdivision:__________________Mile Post:_________

Category No.		Description	Yes	No
Category 6 Future Vehicle ADT	a.	Is the Future ADT above 20,000 as projected 20 years from now? ________ Future vehicles/day		
	b.	Is the Future Peak Hour volume on the crossing street above 3,000 as projected 20 years from now? ______ Future vehicles/peak hour		
	NOTE: If the vehicle ADT is below 3000, consider a crossing closure instead.			
PART B				
Only fill out Part B, Categories 7-8 if there are 2 Yes answers from 2 separate categories (#1-6) on Part A. If Part A was not met, then proceed to signature line at the bottom to submit to SCRRA.				
Category 7 Pedestrian & Bicycle Counts	a.	Does the peak hour pedestrian volume at the crossing exceed 50? _______pedestrians/peak hour _______bicycles/peak hour		
	b.	Does the daily pedestrian volume at the crossing exceed 300? _______pedestrians/day _______bicycles/day		
	(NOTE: Include in a and b the bicycle volume if there are no separate bicycle facilities such Class I, II, or III bike paths. If Class I, II, or III bike path exists, only analyze further in Step 2 – Detailed Analysis Report)			
Category 8 Gate Down Time	a.	Does the gate down time in the peak hour exceed 15 minutes? _____ minutes/peak hour		
	b.	Does the gate down time for the daily total exceed 2 hours? _____ minutes/day		
		NOTE: For rough order of magnitude, user can assume 1 minute per passenger train and 2 minutes per freight train. If a station is impacting the dwell time, assume 3 minutes per train in the direction after the station and consider the dwell time and distance from the station. This is an estimate for basic analysis purposes.		
Category 9	Any other key/unique factors that need to be considered for this location? (SCRRA fills out) _______			

If any Part B thresholds are crossed including subparts, recommend to "consider" a rail and/or pedestrian grade separation or crossing closure. If multiple Part B thresholds are crossed, then recommend to heavily consider a vehicle and/or pedestrian grade separation or crossing closure. However, if an at-grade crossing is still pursued, then proceed to Step 2 Detailed Analysis. If no Part B threshold is crossed, then proceed with at-grade design with SCRRA approval of design in conformance with CPUC GO-88B and Formal Application processes.

TABLE 12-2. INITIAL FACTORS FORM

Project Name: ____
Crossing Street:_______________City/County:________DOT#:______
Subdivision:__________________Mile Post:_________

Step 1 Reference Notes:

- Proximity of adjacent crossings/crossing length: 200 feet was selected based upon engineering judgment of a WB-65 having the possibility to be trapped between 2 crossings or potential to create 1 large crossing with 2 crossings in close proximity.
- Category 1 values were selected based upon FHWA 2019 Highway-Grade Crossing Handbook and modified to best reflect intent herein.
- Category 2, 4, 6, 7, 8 values were selected based upon engineering judgment.
- Category 3 value was selected based upon engineering judgment and in connection with a 4-track crossing at 15-foot track centers with the gate offset at 15 feet plus 6 feet past the far rail = 66 feet at 90 degrees.
- Category 5 value was selected based upon engineering judgment and in connection with the MUTCD's definition of 200 feet defining an adjacent intersection for pre-signals.

Step 1 Form Signatures:

Step 1 Form Completed By:

Project Sponsor Signature:________________________________ Date:_______

Name: _______________________ Organization/Title:__________________________

SCRRA Approval of Step 1 Form:

SCRRA Signature: _____________________________________ Date:_______

Name:_______________________ SCRRA Title:________________________

12.3.3 Step 2 – Detailed Analysis Report

If the thresholds from Step 1 are met, detailed analysis shall be performed to ensure that the safety is maintained for all crossing users and there are minimal delays to operations and travel times.

The latest FHWA Railroad-Highway Grade Crossing Handbook should be used as a reference while going through the detailed analysis report process.

The results of Step 2 will consider a full or partial grade separation of vehicles and/or pedestrians or if the crossing should be closed.

Full grade separations of all rail modes from all highway and pedestrian crossings is always the recommended alternative as it provides the highest level of crossing safety. If the analysis of an at-grade crossing shows indications that the at-grade crossing cannot be operated safely, effectively, and efficiently and a full grade separation is not implemented, then at a minimum, a partial grade separation of new mode tracks or pedestrians/bicyclists shall be considered. An example of a partial grade separation can be found on the SCRRA Pasadena Subdivision, SCRRA San Gabriel Subdivision, Bay Area Rapid Transit (BART) system between Oakland and Fremont, where the new passenger tracks are grade-separated over a highway crossing and the freight tracks remain at-grade.

If there are large pedestrian volumes over 50 per peak hour or 300 per day, consider a partial grade separation of the pedestrians if the vehicles are not grade-separated.

If a partial grade separation of additional train mode track(s) are implemented, the design of the partial grade separation shall consider a possible future full grade separation of all tracks and of all rail modes with the location of the abutments placed far enough from the roadway to allow a future full grade separation. A future full grade separation shall be evaluated through a preliminary design to ensure that a future full grade separation will not be extremely cost prohibitive due to the partial grade separation taking into account constructability issues, such as the need to construct shoo-flies for the existing rail service.

<u>At-Grade Evaluation Criteria</u>

Evaluation criterion, approved by SCRRA and the highway authority, shall be established to evaluate the safety and operation of each at-grade crossing. The evaluation criteria shall include all of the scope in the following pages, but not be limited to these factors. The evaluation criteria shall include fair and reasonable thresholds, as approved by SCRRA, to determine:

- If a full or partial grade separation is warranted of vehicles and/or pedestrians;
- If the crossing should be closed;
- If the crossing can safely remain at-grade with acceptable impacts to ALL diagnostic stakeholders and SCRRA on the operation of all rail, vehicular, and pedestrian modes utilizing the crossing.

The trade-offs between the cost and benefit of at-grade and grade-separated options should be reviewed and a Final Technical Recommendation for at-grade or grade separation operation should be made.

One report per grade crossing shall be developed evaluating all criteria included in the scope herein. If there are multiple crossings on a project that pass the Step 1, Part B thresholds, then a cumulative summary report shall also be prepared analyzing the cumulative impacts of these outcomes at-grade, grade-separated, or closed. The cumulative summary report will also include calculating and ranking adjacent crossings within project limits using the following methods:

- CPUC Section 190 Grade Separation Program formula – input the same cost values for all crossings such that these can be compared based on the other factors within this formula
- USDOT hazard index formula

If a crossing is not closed, a conceptual five (5) percent design alternative of both an at-grade crossing configuration and a grade-separated crossing will be included for each grade crossing that goes through the Detailed Analysis Report process. The five (5) percent design shall be per the SCRRA Design Procedures Manual requirements.

The final Detailed Analysis Report shall be signed and stamped by a licensed Professional Engineer.

Scope of Grade Crossing Analysis

The following scope should be used when evaluating the highway-rail grade crossing.

1. FHWA Closure Thresholds

Highway-rail crossings should be considered for closure and physically removed from the railroad right-of-way whenever one or more of the following apply:

1.1. An engineering study determines a nearby crossing otherwise required to be improved or grade-separated already provides acceptable alternate vehicular and pedestrian access

1.2. If an engineering study determines any of the following apply:

- Average Annual Daily Traffic (AADT) less than 3,000
- Acceptable alternate access across the rail line exists within one (1) mile measured along the track
- The median trip length normally made over the subject crossing would not increase by more than 2.5 miles

1.3. If railroad operations will occupy or block the crossing for extended periods of time on a routine basis and it is determined that it is not physically or economically feasible to either construct a grade separation or shift the train operation to another location, and an engineering study determines that such a crossing should be closed to vehicular and pedestrian traffic. Such locations would typically include the following:

- In or adjacent to rail yards and locations near industrial spur tracks where trains pick up or set out blocks of cars or switch local industries

- Passing tracks primarily used for holding trains while waiting to meet or be passed by other trains
- Locations where train crews are routinely required to stop for crew changes or for cross traffic on intersecting rail lines
- In the proximity of stations where trains dwell for extended periods of time and block the crossing

It may be advisable to investigate whether to construct alternative roadway access in conjunction with closing the crossing when the subject crossing is currently the only access to a community.

2. FHWA Grade Separation Thresholds

Highway-rail grade crossings should be considered for grade separation or otherwise eliminated across the railroad right-of-way whenever one or more of the following conditions exist:

2.1. The posted highway speed equals or exceeds 55 mph

2.2. AADT exceeds 30,000 in urban areas or 20,000 in rural areas

2.3. Maximum authorized train speed exceeds 79 mph

2.4. An average of 30 or more trains per day

2.5. An average of 75 or more passenger trains per day in urban areas or 30 or more passenger trains per day in rural areas

2.6. An average of 150 or more transit trains per day in urban areas or 60 or more passenger trains per day in rural areas

2.7. Freight Train Crossing Exposure (the product of the number of trains per day and AADT) exceeds 900,000 in urban areas or 600,000 in rural areas

2.8. Passenger Train Crossing Exposure (the product of the number of passenger trains per day and AADT) exceeds 2,250,000 in urban areas or 600,000 in rural areas

2.9. Transit Train Crossing Exposure (the product of the number of transit trains per day and AADT) exceeds 4,500,000 in urban areas or 1,200,000 in rural areas

2.10. The expected accident frequency for active devices with gates, as calculated by the USDOT Accident Prediction Formula including five-year accident history, exceeds 0.5 (per year). If the highway is a part of the designated National Highway System, the expected accident frequency for active devices with gates, as calculated by the USDOT Accident Prediction Formula including five-year accident history, exceeds 0.2 (per year).

2.11. Vehicle delay exceeds 30 vehicle hours per day with consideration for cost effectiveness

2.12. Whenever a new grade separation is constructed, whether or not it replaces an existing highway-rail crossing, consideration should be given to the possibility of closing one or more adjacent crossings. In addition, the railroad should be consulted prior to starting design to determine the railroad's future clear span requirements for the tracks crossed.

2.13. Utilize Table 12-3 for LRT separations.

TABLE 12-3. LRT GRADE SEPARATION THRESHOLD

Trains per Hour	Peak-Hour Volume (Vehicles Per Lane)
60	200
40	400
20	600

3. Vehicle Movements

3.1. Existing and Future ADT Volumes

3.1.1. Future Volumes Need to Consider Traffic a Minimum of 10 Years After Project Completion

3.1.2. Recent or Future Planned Developments Near the Crossings that will Affect Future Traffic Volumes at the Crossings

3.1.3. Immediate and Near Future (Post-Construction) Impacts and Changes to Traffic Patterns at and Near the Crossings

3.2. Existing and Future Peak-Hour Volumes

3.2.1. Future Volumes Need to Consider Traffic a Minimum of 10 Years After Project Completion

3.2.2. Recent or Future Planned Developments Near the Crossings that will Affect Future Traffic Volumes at the Crossings

3.2.3. Immediate and Near Future (Post-Construction) Impacts and Changes to Traffic Patterns at and Near the Crossings

3.3. Vehicle Delay Times/Gate Crossing Down Time

3.3.1. Effects of Warning Devices from Trains Dwelling at a Station

3.3.2. A gate down analysis will be required for both peak hour and daily total time. Analysis shall factor in crossing operations for multiple trains on approach and if the gates will remain down between trains. If gates will only ascend for a few seconds before descending again, then assume the worst-case and include the gate down time between train approaches

3.4. Future Delay Times (peak hour and per day)

3.5. Distances Between Existing and Current Traffic Signal Locations/Storage Lengths for Design Vehicles

3.6. Traffic Queues, Queue length, and Impacts of Upstream and Downstream Intersections, including traffic simulation and modeling

3.7. Available storage length

3.8. Effects on Level of Service

3.8.1. Effects Due to Gate Down Time: A longer gate down time would degrade an adjacent intersection vehicle level of service at some locations and should be included in this analysis. This will also affect a pedestrian's ability to continue along their route without being delayed.

3.9. Special Route Through Crossing:

3.9.1. School Route

3.9.2. Transit and School Bus Routes

3.9.3. Truck Route

3.9.4. Hazardous Material Truck Route

3.9.5. Emergency Services Route

3.10. Geometric Configuration of Approaches
   3.10.1. Number of vehicular lanes
   3.10.2. Vehicular crossing length
   3.10.3. Vehicle Circulation Through Crossing
   3.10.4. Proximity of Lane Additions/Reduction to Crossing
   3.10.5. Right-Turn Only Lanes Through Crossing

3.11. Vehicle Circulation Through Crossing
   3.11.1. Evaluation of Sight Distances: Stopping Sight Distance, Clearing Sight Distance, Corner Sight Distance

3.12. Deploy video to observe crossing for seven (7) days and analyze violations, behavior, near misses, etc.

4. Pedestrian Movements and Associated Walking Times

4.1. Existing and Future Pedestrian and Bicyclist Volumes and consideration of station proximity on volumes
   4.1.1. Future Volumes need to Consider Pedestrian and Bicyclist Volumes a Minimum of 10 Years after Project Completion
   4.1.2. Pedestrian and Bicyclist Volumes from Adjacent or Nearby Transit Stations/Bus Stops
   4.1.3. Recent or Future Planned Developments Near the Crossings that will Affect Future Traffic Volumes at the Crossings
   4.1.4. Immediate and Near Future (Post-Construction) Impacts and Changes to Traffic Patterns at and Near the Crossings

4.2. Pedestrian Circulation Through Crossing
   4.2.1. Evaluation of Crossing Times to Cross All Tracks or Reach a Refuge Area
   4.2.2. Walking speed shall be calculated using 3.5 feet/second unless slower moving pedestrians are anticipated at the crossing which warrants a slower walking speed of 2.8 feet/second.
   4.2.3. Walking Speed for crossings shall be evaluated independently for each individual crossing and shall consider facilities in proximity of the crossing that generate pedestrians with slower walking speeds.
   4.2.4. Length of Crossing Between Pedestrian Gates
   4.2.5. Need for Refuge Areas Between Tracks

5. Train Operations – all train modes

5.1. Number of Tracks

5.1.1. Evaluate the complexity of designing a safe crossing as each additional track is added and the ability to operate it safely, efficiently, and effectively.

5.2. Number of Trains

5.3. All of Train Modes (LRT, LRT Trams, HSR, Commuter, Freight, DMU, EMU/ZEMU, Long Distance Passenger Trains (Amtrak), etc.)

5.4. Frequency of Trains and string line diagrams/train operations modeling

5.4.1. Including lowest planned design headways for all train modes

5.5. Speed of All Train Modes (Min, Max, Average)

5.5.1. Including future express service potential and lowest planned design headways for all train modes

5.6. Distances Between Tracks

5.7. Train Stopping Characteristics Between Each Rail Mode

5.8. Consider proximity of adjacent stations, yards, and switching moves to the crossing and additional crossing activations as well as longer gate down time. Include in the analysis how this impacts a driver's crossing perception and impatience.

5.8.1. The nature of new mode operations places stations in closer proximity to each other than commuter rail operations. As such, a new mode train may be stopped at a station while commuter operations continue to pass by. The lead Engineer shall analyze crossings near and adjacent to stations, where new modes and SCRRA operations are closely related yet mutually exclusive, for safety, efficiency, and effectiveness of remaining at-grade.

5.9. Evaluation of the gate down time for the longest, worst-case train arrival sequence based upon current schedules and anticipated future schedules.

5.10. Additional safety devices shall be considered when multiple trains are passing simultaneously, including, but not limited to: additional signage such as a "second train coming" activated blankout sign, use of channelization with gates, preemption of traffic signals, extended advance warning times, pedestrian gates, extra channelization for pedestrians, etc.

6. Positive Train Control (PTC), Rail Signal and Communications

6.1. Ability to Safely and Effectively Operate PTC or the equivalent for LRT, DMU, EMU, and/or HSR

6.2. Grade Crossing Near-side Signal Stop

6.3. Simultaneous Approach of 2 or More Trains at the Crossing

6.4. Sequential Approach of 2 or More Trains at the Crossing

6.5. Differences in Approach Warning Detection for Prediction (Fixed Distance vs. Constant Warning Time)

7. Safety Factors

7.1. Accident History including an Analysis of all FRA reportable Accident History

7.2. Trespassing History

7.3. ROW Security

7.4. Performance and Reliability of Active Warning Devices with Increased Volume of Crossing Activations (75 activations/day).

7.5. Illumination Levels

7.6. Possible Confusion/Impatience of Motorists/Pedestrians of Long Gate Down Times Due to Multiple Train meets at Crossing once you exceed 15 minutes in the peak hour and 20 minutes in non-peak hours.

7.7. Sight Distances for Motorist, Pedestrians, and Cyclists to all Warning Devices, Traffic Signals and Approaching Trains

7.8. Pedestrian and Vehicular Warning times

8. Community Factors

8.1. Right-of-Way Impacts

8.2. Existing Infrastructure that Generate Pedestrian Movement Near the Crossing: Schools, Hospitals, Medical Clinics, Senior Facilities, Shopping Centers, Recreation Centers, Parks, and Stations/Bus Stops

8.3. Quality of Life with Increased Train Traffic and Horns/Bells at the Crossing

8.4. Cost analysis showing the full costs to grade-separate all tracks, costs of grade separating only the new LRT or HSR tracks, and the cost-benefit analysis to maintain an at-grade crossing for the next 50+ years compared to the grade separation costs. This cost analysis should include a conceptual plan and profile of all tracks and a plan and profile of the roadway to accompany the cost analysis.

9. Economic Benefit-Cost Analysis

Perform an economic benefit-cost analysis in accordance with the FHWA Highway-Rail Crossing Handbook (2019 or latest). Benefit-cost analysis requirements are contained in 23 CFR 924. The benefit-cost analysis should be performed using a Life-Cycle (25+ years from today) Basis, which considers both the initial cost to construct the at-grade or grade-separated crossing as well as its ongoing operating and maintenance costs.

23 CFR 924: (https://www.fhwa.dot.gov/legsregs/directives/fapg/cfr0924.htm)

An economic analysis may be performed to determine possible alternative improvements that could be made at a highway-rail crossing. The FHWA Highway Safety Benefit Cost Analysis Guide and companion Highway Safety Cost Analysis Tool and support material available at the FHWA Highway Safety Improvement Program (HSIP) website can add guidance while preparing the benefit-cost analysis portion of the Detailed Analysis Report.

FHWA Highway Safety Benefit Cost Analysis Guide:
(https://safety.fhwa.dot.gov/hsip/docs/fhwasa18001.pdf)

Highway Safety Cost Analysis Tool:
(https://safety.fhwa.dot.gov/hsip/docs/bcatool030118_finalv2.0.xlsm)

FHWA Highway Safety Improvement Program (HSIP) website:
(https://safety.fhwa.dot.gov/hsip/planning.cfm)

Practitioners need to assemble information on the following elements, using the best available facts and estimates:

- Collision costs
- Service life
- Initial improvement costs
- Maintenance costs
- Salvage value
- Traffic growth rates

Other considerations include the effectiveness of the improvement in reducing collisions and the effects on travel, such as reducing delays.

The selection of collision cost values is of major importance in economic analyses. Considerable care should be used in establishing values for these costs. The following are the two most common sources of collision costs:

- National Safety Council (NSC)
- National Highway Traffic Safety Administration (NHTSA)

The NSC costs include wage losses, medical expenses, insurance administrative costs, and property damage. The NHTSA includes the calculable costs associated with each fatality and injury plus the cost to society, such as consumption losses of individuals and society at large caused by losses in production and the inability to produce. Many states have developed their own state-specific values. Whichever is selected, the values should be consistent with those used for other safety improvement programs. An appropriate method of discounting should be used to account for inflation and opportunity cost. The selected discount rate should be informed by current practices and should be documented as part of the analysis.

The service life of an improvement should be equal to the time that the improvement can affect collision rates. Both costs and benefits should be calculated for this time. Hence, the service life is not necessarily the physical life of the improvement. For highway-rail crossings, however, it is a reasonable assumption that the improvement would be equally effective over its entire physical life. Thus, selecting the service life equal to the physical life would be appropriate.

The selected service life can have a profound effect on the economic evaluation of improvement alternatives; therefore, it should be selected using the best available information.

Project costs should include initial capital and maintenance costs and should be considered life-cycle costs; in other words, all costs are distributed over the service life of the improvement. The installation cost elements include the following:

- Preliminary engineering
- Labor
- Material
- Lease or rental of equipment
- Miscellaneous costs

The maintenance costs are all costs associated with keeping the system and components in operating condition.

The salvage value may be an issue when a highway is upgraded or relocated, or a railroad line is abandoned. Salvage value is defined as the dollar value of a project at the end of its service life and, therefore, is dependent on the service life of the project. For crossing signal improvement projects, salvage values are generally very small. Due to the characteristics of crossing signals and control equipment as well as the liability concerns that arise from deploying signal equipment that has already been used, it is assumed that there is zero salvage value after ten (10) years.

10. Federal Railroad Administration GradeDec Software

Perform an analysis with the FRA GradeDec Software per FHWA Highway-Rail Crossing Handbook (2019 or latest) Chapter 3: Treatment Selection Guidance – FRA GradeDec Software.

FRA developed the GradeDec.NET (GradeDec) highway-rail grade crossing investment analysis tool to provide grade crossing investment decision support. The GradeDec provides a full set of standard cost-benefit metrics for a rail corridor, a region, or an individual grade crossing. Model output allows a comparative analysis of grade crossing alternatives designed to mitigate highway-rail grade crossing collision risk and other components of user costs, including highway delay and queuing, air quality, and vehicle operating costs. The online application can be accessed via FRA's Website at https://gradedec.fra.dot.gov/. More information can be found in the FHWA Highway-Rail Crossing Handbook (2019).

<u>Step 2 Report Resolution</u>

Based on the results of Steps 1 and 2, if a crossing has "yes" answers for 2 of the categories below, the Project Sponsor should <u>consider</u> a grade separation. If it has "yes" answers in all 3 of the categories below, the Project Sponsor should <u>strongly</u> consider a grade separation.

- Category A – Does it meet any of the FHWA criteria for grade separation in the 2019 FHWA Highway-Rail Grade Crossing Handbook, Chapter 3, Treatment Selection Guidance - Technical Working Group Guidance (which were evaluated during the Step 2 Detailed Analysis Report scope)?
- Category B – Will this crossing have additional passenger train modes beyond SCRRA and Amtrak? Freight traffic already exists on all SCRRA subdivisions.

- Category C – Are there 4 "yes" answers from 4 separate categories in Step 1 - Initial Factors Form (cumulative total from both Part A and Part B)?

The City(ies), Project Sponsor, SCRRA, Member Agency, Key Project Stakeholders, etc. must:

- Review and participate in collaborative project team comment resolution sessions together.
- **Sign off:** Comment review meetings shall be required on the draft analysis performed and all diagnostic team stakeholders (SCRRA, Highway Authority(ies), CPUC, other operating railroads, FRA, etc.) must be present. **All** diagnostic team stakeholders are required to formally sign off on the outcome of the report, whether the crossing will be at-grade or grade-separated via signature page(s).
- CPUC must be provided a copy of the report and diagnostic team Step 2 signature page(s).
- If agreement of the involved parties cannot be obtained, then a formal Application must be filed with the Commission's Docket Office to gain Commission approval for the proposed modifications.
- All of this must occur prior to proceeding with the final design on the project.

The final decision on the crossings will be based upon all of the technical input into the process including the Final Technical Recommendation; however, SCRRA recognizes that the ultimate decision will involve institutional consideration of the proposed crossing treatments and will require third party approvals, primarily consisting of approval of the crossings by the CPUC under the provisions of all CPUC General Orders.

12.3.4 Step 3 – Risk, Indemnification, and Liability

Agreements including those to obtain necessary right-of-way, and for identifying any sharing of construction and/or maintenance costs will need to be addressed as part of this analysis.

Upon a decision for the crossing, should the crossing remain at-grade, the key parties (SCRRA, the highway authority and/or member agency) need to address the risk, indemnification, and liability within the C&M agreement for this crossing.

The location of adjacent track(s) owned and operated by another railroad company creates conditions that need to be evaluated during the design of warning devices for vehicles and pedestrians. The responsibility of installing and maintaining warning devices at the crossing will fall on the railroad that owns and operates the part of the crossing on which the warning devices are required. In such cases, there may be two separate crossing warning systems, one from SCRRA and one from the new rail mode, at the crossing that must be interconnected to work in conjunction with each other. Coordination with the new rail mode must be done throughout the design stages to ensure that adequate warning devices are installed at the highway-rail grade crossing and will work in conjunction with one another.

12.4 GRADE SEPARATION DESIGN CRITERIA

12.4.1 General Design Criteria

The design of Grade Separation projects shall be performed by the Project Sponsor. SCRRA Signal and Communications Engineering Section prepares, at Project Sponsor's cost, the design for the active railroad control system including the train detection circuits. The railroad signal and communications design may be done by SCRRA approved consultants if requested by the Project Sponsor and approved by SCRRA.

The policy of the SCRRA is that the construction and removal of a Grade Separation shall not temporarily or permanently reduce the utility of the Operating System. Aspects of utility to be preserved include: future track expansion of at least one additional track; opportunity to build additional track(s) identified in future plans including but not limited to SCRRA's Strategic Plan; clearances, and sight lines for signals and road crossings; maintenance access to track and/or signals; drainage of the track; speed of train operations; reliability of train operations; and economy and reliability of operation and maintenance of the Operating System. SCRRA's reviews of Grade Separation submittals for design and work plans shall be guided by this policy of not diminishing the utility of the Operating System. The Project Sponsor's design documents and design and construction submittals shall demonstrate that the utility of the Operating System is not diminished.

Grade Separation projects are undertaken based on schedule and funding that may change in the course of implementation. It is possible that the design will be completed ahead of the funding, and the actual construction will start at a later date with considerable (24 months) gap between the design and the construction. If this happens to any project, the design shall be revised to meet current standards, requirements, and Criteria of SCRRA and other agencies.

Design of Grade Separation Structures shall be reviewed by SCRRA and/or SCRRA's outside consultant at the expense of the Project Sponsor. Prior to any review, a DSA shall be executed by the Project Sponsor agreeing to pay all review costs for the design and construction phases of the project. Review expenses shall include all costs for in-house personnel and/or consultants retained by SCRRA. The original estimated costs would not be the upper limit of the costs but provide a guideline for budgeting purposes. Regardless, all costs incurred by SCRRA during plan review process and construction-monitoring phase of the work shall be fully recoverable from the Project Sponsor.

Engineer in Responsible Charge shall prepare design calculations for Underpass bridge structures. These calculations shall be checked by another independent person who was not involved in the original design. SCRRA may engage the services of an outside consultant at the expense of the Project Sponsor for the independent check of the calculations.

For Overhead Structures, a demolition plan indicating the method of track protection, the sequence of demolition, and a description of the procedure and equipment to be used during demolition shall be submitted to SCRRA for review and acceptance.

All Overhead Structures shall provide horizontal and vertical clearances for: anticipated future track(s); changes in track alignments; raising track(s) for maintenance purposes; location of access roads; location and size of drainage facilities; and location of existing or relocated utilities. SCRRA shall be contacted prior to finalizing the clearances. All requests for information regarding future track requirements shall be formally submitted to the SCRRA. At all times, minimum CPUC and SCRRA clearances shall be maintained. If the facility is on another railroad, the clearances specified by the specific railroad at that location shall be followed, if greater. At clearance locations where super elevation is present, vertical clearances shall be measured from the high rail.

Construction activities that impact SCRRA trains must be coordinated with SCRRA. The proposed staging and phasing must be reviewed and accepted by SCRRA at the concept stage and re-reviewed during development of detailed plans. See the Construction Section 12.4.4 of these Criteria for construction track window discussion requirements. A proposed construction sequence for all aspects of the work for Grade Separations affecting SCRRA operations, including agreed upon construction track windows, shall be incorporated into the construction documents and annotated on the Contract drawings. Special Provisions shall include SCRRA coordination requirements in order to make the Contractor aware prior to letting of the proposed Grade Separation. During construction, the Contractor shall submit a final Site Specific Work Plan (SSWP) incorporating the construction sequences, phasing, including track windows accepted during the design phase.

Grade separation projects required coordination with different stakeholders and their design, construction, safety, material, acceptance, accounting, submittal, reporting, funding, and scheduling procedures. During the design and prior to construction, the Consultant will outline all applicable requirements and then select the most applicable one in concurrence with all stakeholders. During construction, the design and construction team will carry out advance planning and constant communications among the stakeholders to prevent surprises and delays.

<u>Dimensions and Units</u>

All dimensions and calculations of interest to SCRRA shall be in English units. Dual dimensions with English units in parenthesis are acceptable for projects that require the use of Metric units as per State or Federal requirements. SCRRA shall reject any and all drawings and reports if dual dimensions are not shown or not shown properly.

If required, Dual dimensions shall be shown as a minimum for the following:

- Horizontal and Vertical clearances.
- Underground and Surface utilities.
- Drainage patterns and Drainage facilities.
- Track spacing, SCRRA and other Railroad Right-of-Way, and track stationing.
- Span length, width, and depth of Superstructure elements.
- Size and limits for barrier rails or splashboards and fences.
- Location and elevation of underground or aerial utilities and their relocation adjustments if required.
- Size, elevation, and location of pier or abutment footings for spans adjacent to track(s).
- Size of structure supports.
- Size and elevations of pier protection wall.

- Shoring and Falsework locations and their limits, if required.
- Top-of-Rail elevation under structure and grade profile.
- Size and location of drainage structures and ditches.
- Temporary construction vertical or horizontal clearances.

Operational Requirements

The proposed construction be performed without interference to railroad operations. The most effective method for reducing interference to SCRRA operations for construction of grade separation projects is to use an Overhead structure and avoid an Underpass structure.

Access Road

The design shall include adequate access to existing railroad facilities along and/or within the Right-of-Way. Access road, access road bridge, or access road turnaround with a minimum of 50 feet radius is to be provided. Access road requirements and location shall be verified at the concept stage of the proposed grade separation project. Minimum access road width shall be 12 feet and the centerline of the access road shall be located a minimum of 20 feet from the centerline of the nearest existing or future track.

Excavation Support

All temporary excavation required for construction or demolition of a Grade Separation and other facilities shall comply with SCRRA Excavation Support Criteria, Chapter 15.0. The design of permanent retaining walls and other systems of permanent earth retention adjacent to SCRRA track(s) is addressed in the SCRRA Design Criteria Manual and applicable reference materials. Shored excavations within 15 feet of a track (including both a shoofly or permanent track) will typically require the track structure include a hot mix asphalt (HMA) sub-ballast, eight (8) inches thick for temporary track and 12 inches thick for permanent track, 12 feet wide (centered about the track centerline) and extending 20 feet past the shored excavation. Refer to Section 8.15 for permanent track and structure HMA requirements.

Exception and Waiver Requests

All standards and manuals shall be adhered to throughout this project unless waived in writing (see Request for Special Design Consideration DPM-13 in Section 3.2.2) by SCRRA.

12.4.2 Overhead

The design and construction of Overhead Structures shall be in compliance with the criteria shown on standard drawings, ES 2101 and ES 2104.

The structure, at a minimum, shall meet the specifications and design standards of AASHTO and Caltrans, and shall comply with all applicable Federal, State, and Local laws.

Expansion or hinge joints for the Overhead Structures shall not be located over any track(s) or within the SCRRA Right-of-Way.

Loading

Overhead Structures shall be designed to carry dead, live, impact or dynamic, wind, seismic, and other loads and forces. All new and replacement highway bridges shall be designed to carry not less than AASHTO HL-93 live load.

Clearances

Horizontal

Design for the Overhead Structure shall have all piers and abutments located outside of the SCRRA Right-of-Way. If this is not feasible and an exception is granted by SCRRA, then all piers and abutments shall be located a minimum of 25 feet from the face of pier to the centerline of the nearest track or identified future track.

Horizontal clearances are for tangent track(s) and correspond to the perpendicular distance from the centerline of the track to the face of support or pier protection wall. The horizontal clearances shall be increased per AREMA and CPUC requirements when any part of the Overhead is located within 80 feet of curved track.

Vertical

A permanent minimum vertical clearance of 24 feet 6 inches shall be provided for all Overhead Structures, measured from the top of the high rail to the lowest point of the structure, in accordance with ES 2101.

Additional vertical clearances may be required for features beyond those shown in the Engineering Standards, such as: correction of sag in the track(s); track raise; construction requirements; and future track raises [within the next five years]. The elevation of the existing top of rail shall be verified prior to beginning construction. All discrepancies shall be brought to the attention of SCRRA prior to construction.

Temporary

A temporary minimum horizontal clearance of 12 feet from the centerline of track(s) (including temporary falsework) shall be provided for all Overhead Structures.

A temporary minimum vertical clearance of 22 feet 6 inches above the top of the rail shall be provided for all Overhead Structures in accordance with ES 2101.

Safety Barriers

Safety barriers for Overhead Structures shall be provided to retain and redirect errant vehicles. Concrete barrier (Type 842) as per Caltrans Standard Plan RSP B11-82 with a height of 42 inches shall be provided on both sides of all Overhead Structures. Other barriers that provide equivalent strength and protection may be considered and will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

Safety Fences

Overhead Structures shall provide means of protecting SCRRA facilities and the safety of their employees below from objects being thrown from above by pedestrians or passing motorists.

Chain link railing (fencing) (Type 7) per Caltrans Standard Plan B11-52 or Type 3 per Caltrans Bridge Standard xs16-160 shall be provided on both sides of all Overhead Structures. The Type 7 railing shall be installed when there are no sidewalks or pedestrian pathways present and the Type 3 railing shall be installed when there is a sidewalk or pedestrian pathway present (see Sheet GSG-07 in Appendix C-5). The Type 3 railing shall be modified to be installed on top of the safety barrier (without the pipe handrailing) at a minimum height of 8 feet from the flowline of the curb to the top of the railing. The limits of protective fence shall extend to the full length of the SCRRA Right-of-Way or a minimum of 25 feet beyond the centerline of the outermost track, identified future track or access road; whichever is greater. Ornamental fencing with a maximum gap of four inches may be considered and will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

Parallel structures, which are up to two feet apart, shall not require safety fence at their interface, but the gap shall be covered with a 3/16 of an inch minimum thickness galvanized steel plate. Overhead Structures, which are more than two feet apart, shall be treated as individual structures and the required safety protective fence shall be provided.

Abutment Slopes

To prevent embankment material from sloughing and drainage waters from undermining track subgrade, end slopes of abutments adjacent to tracks shall be protected with paved slopes.

Paved slopes should extend two feet past the outside face of abutment wall and terminate with either a curb or gutter to divert runoff. Paving shall consist of a prepared sub-base and filter fabric with a minimum of four inches thick reinforced concrete or grouted rip-rap placed on prepared sub-base and filter fabric. Toe of slopes should terminate at the bottom of drainage ditches and shall have a cut-off wall as required to protect slope from drainage erosion. The toe of slope shall be below the finished track or roadway subgrade and provide a ditch for positive drainage.

If the layout of the abutment interferes with the existing drainage ditches, suitable means of handling the longitudinal drainage shall be provided with drainage modification plans and supporting calculations to SCRRA.

Piers

Piers and abutments shall be located outside of the SCRRA Right-of-Way. All piers or columns shall be located so that they do not interfere with the drainage ditches or the natural drainage features of the area. If the layout of piers or columns interferes with the drainage ditches, suitable means of handling the longitudinal drainage shall be provided along with drainage modification plans and supporting calculations to SCRRA.

Tops of pier footings within 25 feet of track centerlines shall be a minimum of six feet below the base of rail. Pier footings shall not restrict SCRRA from modifying the longitudinal drainage system in the future or from providing unobstructed area for placing signal, fiber optic lines, or other buried utilities.

Pier Protection

All new, replacement, or modified Overhead Structures will comply with the AREMA manual recommended practices for pier protection.

To limit damage by the redirection and deflection of railroad equipment, piers supporting Overhead Structures over SCRRA track(s) and with a clear distance of less than 25 feet from track centerlines shall be of heavy construction or shall be protected with a reinforced concrete crash wall. Crash walls for piers from 12 to 25 feet clear from the centerline of track shall have a minimum height of six feet above the top of rail. Piers less than 12 feet clear from the centerline of track shall have a minimum crash wall height of 12 feet above the top of rail. Piers shall be considered of heavy construction if they have a cross-sectional area equal to or greater than that required for the crash wall and the larger of its dimensions is parallel to the track.

The necessity of a pier protection wall for piers greater than 25 feet from the track centerline shall be discussed with SCRRA prior to design and construction. Factors such as horizontal and vertical alignment of the track, embankment height, and an assessment of the consequences of serious damage in the case of collision will be considered.

Design of pier protection shall comply with the recommended practices outlined in AREMA Chapter 8, Part 2, and Section 2.1.5.1. Examples of protection walls are shown in the AREMA Manual Figure C-8-2-1. In locations where pier columns and protection walls interfere with drainage, openings must be provided in the wall for drainage to ditches, or drainage facilities must be provided to collect and dispose water to the drainage system. Opening in the pier protection wall must be lower than the track subgrade elevation and must drain away from the track(s).

A pier protected with a crash wall shall either be (1) anchored to the overhead bridge footing and columns, with the overhead bridge designed accordingly with the added mass or (2) installed separate from the overhead structure and accommodated for seismic displacements by providing an adequate gap between the two structures.

The crash wall shall be at least two foot six inch thick and at least 12 feet long. When two or more columns compose a pier, the crash wall shall connect the columns and extend at least one foot beyond the outermost columns parallel to the track. The crash wall shall extend to at least four feet below the lowest surrounding grade.

The crash wall shall be designed to accommodate future track(s). For example, if there is one existing track, the location, height, width, and other design features of the crash wall shall be designed to accommodate future track.

<u>Foundation</u>

Drilled piles and piers/shafts within the influence line shown on the SCRRA Excavation Support Criteria, Chapter 15.0, shall be designed with temporary casing to protect track against cave-in, subsidence, and/or displacement of surrounding ground. Casing shall be designed for live load due to the railroad surcharge in addition to all other loads. Drilled shafts or piling shall be designed to allow the drilling or pile driving to proceed without impacting the SCRRA Operating System.

Drilling of piles, piers/shafts, or shoring construction for footings within influence of railroad surcharge shall not proceed without acceptance from SCRRA. For limits of the Railroad Zone of Influence, refer to the SCRRA Excavation Support Criteria, Chapter 15.0.

Drainage

Drainage plans and hydrology report prepared as per local city, county, and SCRRA criteria (Design Criteria Manual, Chapter 8), shall be submitted for SCRRA review and acceptance.

Drainage from the structure shall be diverted away from the SCRRA Right-of-Way at all times. Scuppers from structure deck shall not be permitted to discharge water onto the track or roadway areas at any time. If drainage of deck uses downspouts in the columns, then they shall be connected to the storm drain system or allowed to drain into drainage ditches away from SCRRA Right-of-Way. Concrete splash block or aggregate ditch lining shall be provided at the discharge area of downspouts. Downspouts shall be behind the face of the piers.

Lateral clearances shall provide sufficient space for construction of the required standard ditches parallel to the standard roadbed section. When the proposed construction shall change the quantity and/or characteristic of flow in the existing ditches, the ditches shall be modified as required to handle the increased runoff. The size of the ditches should vary depending upon the flow and terrain and should be designed accordingly.

Lights

All Overhead Structures exceeding 80 feet of Superstructure width shall be provided with a lighting system. Lighting shall also be provided for structures of less than 80 feet width in areas where switching is performed, where high vandalism or trespassing has been experienced, or as directed by SCRRA.

An average of one (1) foot-candle of power shall be provided under the structure. Fixtures shall be installed on column walls or caps of the Overhead Structure without reducing the minimum clearances. The maintenance of lights shall be the responsibility of the Project Sponsor.

Falsework

For Overhead Structures, those carrying traffic over SCRRA track, the falsework design and construction shall meet the rules and requirements of Caltrans Falsework Manual and Caltrans Standard Specifications Section 51-1.06. Falsework installation and removal methods and procedures shall be submitted for SCRRA review and acceptance. Temporary collision posts set in six (6) feet of concrete and extending not less than 16 feet above the top of the rail shall be installed on both sides of the falsework bents and located 10 feet clear of the centerline of the nearest track and approximately 100 feet in advance of the falsework. Collision posts shall preferably be steel I-girders with web parallel to the track. Falsework shall be sheathed solid on the side adjacent to track between three and 17 feet above the top of the rail. Sheathing shall consist of plywood not less than 5/8 inch thick or lumber not less than one inch thick. Collision posts and sheathing shall not be required if horizontal clearances to falsework are 25 feet or greater.

Falsework design and construction shall not obstruct the clear view of SCRRA's wayside train signals that may be located on either side of the falsework. If it is necessary to temporarily or permanently relocate the wayside signals, the cost of the relocation shall be the responsibility of the Project Sponsor requesting the falsework installation.

Where falsework is within 2,000 feet of an existing railroad signal, the falsework shall be placed in a manner that provides the locomotive engineer an unrestricted view of the railroad signals. The lowest point of the falsework shall provide a minimum clearance of two feet from the locomotive engineer's line of sight. The two feet distance shall be calculated based on the actual height of the highest lens of the railroad signal(s) from the top of the rail, at a distance of 2,000 feet from the railroad signal(s), and with the locomotive engineer's eye-line at 11 feet 6 inches from the top of the rail. See Figure 12-2, Falsework Signal Clearance.

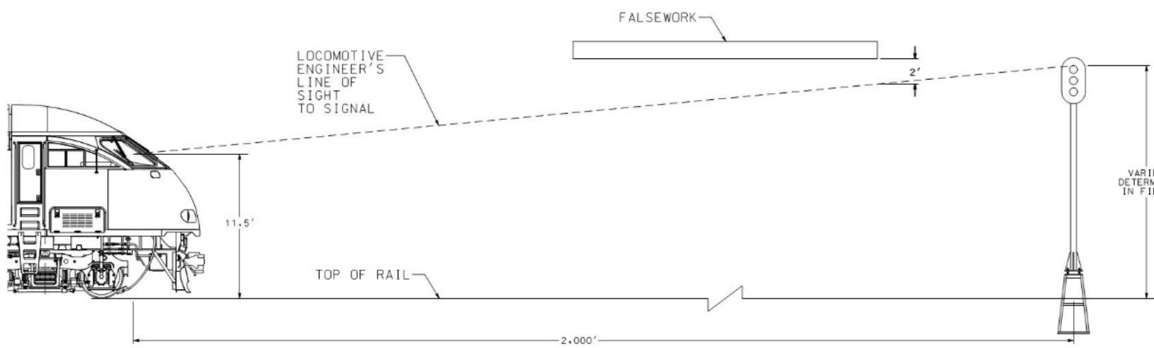

FIGURE 12-2. FALSEWORK SIGNAL CLEARANCE

<u>Maintenance</u>

The Project Sponsor is responsible to maintain, repair, and renew the entire Overhead Structure, including piers and abutments, retaining walls, lighting, drainage system, roadway pavement, roadway facilities, curb and gutter, striping, signage, and appurtenances. The Project Sponsor is responsible for removal of graffiti from the Superstructure, piers, abutments, and retaining walls on a regular basis or as requested by SCRRA.

12.4.3 Underpass

The Project Sponsor responsible for funding and designing the Underpass Structure, structure carrying SCRRA track and other facilities over the road or feature being crossed shall comply with SCRRA Design Criteria, including Chapter 11.0 (Structures), Standard Specifications, and other reference standards listed in these Criteria.

For other project elements that are not integral components of the Underpass Structure or other SCRRA facilities, and not specifically referenced in these Criteria, their design shall comply with the applicable codes approved by the Project Sponsor.

<u>Loading</u>

The primary design criteria to be used in the design of SCRRA Underpass Structures shall be the American Railway Engineering and Maintenance-of-Way Association (AREMA) – Manual of Railway Engineering (latest edition) and SCRRA Design Criteria Manual. Final determination of the appropriate use and application of the AREMA Manual, SCRRA Design Criteria Manual, or other applicable codes and standards shall be discussed with and accepted by SCRRA.

For multiple track structures, live load, as described by the AREMA Manual, shall be calculated based on the assumption that the track(s) can be located anywhere on the bridge and at a minimum spacing of 13 feet.

Live load distribution for concrete span elements shall be in accordance with Chapter 8, Part 2, Reinforced Concrete Design, and Article 2.2.3.c of AREMA. Live load distribution for steel span elements shall be in accordance with Chapter 15, Part 1, (Steel) Design and Article 1.3.4 of AREMA. This means that it shall not be assumed that the live load is necessarily equally distributed to the concrete or steel span elements supporting the track(s).

Underpass Structures shall be designed for all applicable loads and loading conditions specified in Chapters 8, 9, or 15 of the AREMA Manual and shall comply with the requirements of Chapter 11.0, Structures, of this Design Criteria Manual.

Materials

Materials used in the construction of Underpass Structures shall comply with AREMA, SCRRA Reference Standards, Standard Specifications, and Chapter 11.0 of this Design Criteria Manual.

Concrete Requirements

Minimum Compressive Strength – 4000 psi at 28 days (suggested for substructure).

Concrete shall be proportioned such that the water-cementitious material ratio (by weight) does not exceed the values in AREMA Table 8-1-9. Precast concrete shall contain a minimum of 610 pounds of cementitious material per cubic yard of concrete. Cast-in-place concrete shall contain a minimum of 565 pounds of cementitious material per cubic yard. If fly ash is used with cement it shall be limited to 15 percent of the cementitious material.

Cement shall be Type I, II, or III Portland Cement per ASTM C150.

All concrete shall have an air entrainment additive and contain 5 percent to 7 percent entrained air by volume.

Course Aggregate shall be size No. 67.

Fine Aggregate shall be fine sand.

Admixtures shall not be used without SCRRA acceptance.

Membrane curing compound shall conform to ASTM C309 Type 2.

Apply an approved epoxy adhesive before placing new concrete against hardened concrete surfaces.

For precast elements, the fabricator shall stencil the fabricator’s name, date of fabrication, the bridge number, lifting weight, and piece mark on each component.

The production facility shall be pre-certified. Production procedures for the manufacture of precast members shall be in accordance with AREMA and the current edition of the Precast Concrete Institute’s Manual MNL 116 for Quality Control.

Dimensional tolerances governing the manufacture of precast members shall conform to Division VI, Section 6.4.6 of the Precast Concrete Institute’s Manual MNL 116 for Quality Control.

Tolerance for location of lifting devices shall be plus or minus half an inch.

All concrete components shall be made available, at SCRRA's discretion, for inspection by the Engineer in Responsible Charge and SCRRA at the fabricator's plant prior to shipment.

Reinforcing Steel Requirements

Reinforcing steel shall be deformed, new billet bars per current ASTM A615 Specifications and meet Grade 60 requirements.

Reinforcing steel requiring field welding, or in substructure elements that could be subject to ductility from seismic event, or bending shall conform to ASTM A706 Specifications, Grade 60 requirements.

Fabrication of reinforcing steel shall be per Chapter 7 of the CRSI Manual of Standard Practice. Dimensions of bending details shall be out to out of bars.

Reinforcing steel is to be blocked to proper location and securely wired against displacement. Tack welding of reinforcing is prohibited. Minimum concrete cover not otherwise noted shall meet current AREMA criteria.

Prestressing Strand Requirements:

Prestressing strand shall be seven-wire, uncoated and low relaxation which is in accordance with the requirements specified in ASTM A416, ACI 318 and AREMA Chapter 8.

The strand shall have an ultimate tensile strength of 270 ksi.

Structural Steel Requirements

All major elements subjected to track live loads shall conform to the following minimum specifications, except as otherwise noted:

Painted structures: ASTM A709 Grade 50 T1

Unpainted structures: ASTM A709 Grade 50W T1

All bolted connections shall be made with high strength bolts using turn of the nut tightening methods

Track Geometry

In the design of Underpass Structures, the top of rail elevation and alignment are generally preferred to remain at the existing location. An existing top of rail survey covering a distance that includes an additional 1,000 feet at 100 foot stations from each end of the proposed Underpass shall be provided to the SCRRA for review and direction for establishing final track grade. All existing Overheads and Highway-Rail Grade Crossings within ½ mile of the proposed Underpass structure shall be shown on the survey, with Overhead's low chord and Highway-Rail Grade Crossing top of roadway elevations clearly noted.

Where it is proposed for other reasons that the track grade or alignment be changed due to the circumstances of design, SCRRA shall be consulted and the following considerations be given:

- The change in track grade for both temporary and permanent alignment shall minimize the impact on train operations, adjacent station platforms, parking lots, and SCRRA maintenance access.
- The change in track grade shall minimize any undulating effect on the track profile relative to existing Underpass Structures, future Underpass Structures, or nearby Grade Crossings.
- The effects of a track grade change that will require any adjustments or relocations to the fiber optic line along the corridor shall be identified and solutions investigated.

Structure Selection Criteria

Refer to Drawing numbers GSG-02 to GSG-06, Appendix C-5, for different types of bridge structures acceptable to SCRRA. Refer to SCRRA Engineering Standards 6001 and 6002 for details of precast/prestressed concrete beam bridges. Cast-in-place bridge Superstructure for Underpasses is not approved for construction on the SCRRA Operating System. Materials used in the design of SCRRA facilities shall conform to SCRRA standard specifications and the AREMA Manual unless otherwise specified in this section.

- Bridge Structures shall be of simple span construction. Monolithic, continuous span bridge structures are not permitted.
- Superstructure shall have a ballasted deck; open deck type Superstructures are not permitted.
- Structures are to be designed to be redundant and to remain serviceable after damage by accidents and earthquakes.
- All concrete bridge structures shall be protected by collision impact devices or crash (fascia) beams with an embedded steel angle over the traveled lanes of traffic.
- Structures adjacent to an existing or new separate structure shall be designed to protect against collision impact.
- Retaining walls are similarly based on simple designs.
- Structures shall be designed for a service life of at least 100 years.

The Underpass Engineer in Responsible Charge shall address construction sequencing during the early phases of the design and structure selection process. The Engineer in Responsible Charge shall incorporate sequencing of construction in their design that will minimize SCRRA signal changes for the existing track(s) and Shoofly. The preferred sequence is to close the highway, or relocate traffic to another location rather than providing a temporary highway crossing at the site.

The SCRRA preferred construction method for Underpass Structures incorporates “top-down” construction. This method minimizes the amount of excavation and shoring, and allows for the majority of excavation for the highway after the structure is constructed and the track back in service.

The track on an Underpass Structure may require the addition of inner guard rail ties and inner guard rails to extend across the bridge and to include 50 feet from each end of the bridge. If existing rail and ties are used for this work, all welds shall be tested ultrasonically. Refer to SCRRA Engineering Standards for inner guard rail details and to determine if the proposed bridge will require inner guard ties and inner guard rails.

Table 12-4 is a list in order of preference of bridge structure types acceptable to SCRRA:

TABLE 12-4. UNDERPASS BRIDGE TYPES

Bridge Structure Type	Min. No. of Beams/Girders per Track	Range of Span Lengths (feet)
Standard Precast (pre-stressed) Concrete Double Cell Box Beam	2	20 - 35
Standard Precast (pre-stressed) Concrete Slab Beam	2	9 – 22
Steel Beam	5	30 – 69
Non-standard precast (pre-stressed) Double Cell Box Beam, 42 inches deep	2	35 – 50
Non-standard precast (prestressed) Single Cell Box Girder, up to 80 inches deep with transversely post-tensioned tie rods	4	50 – 80
Steel Deck Plate Girder	4	up to 180
Steel Through Plate Girder	2	up to 180

SCRRA acceptance shall be obtained prior to final selection of the type of Superstructure for the Underpass.

Future Expansion

The Underpass Structure(s) shall account for future track expansion of at least one additional track. For example, if there are currently two existing tracks at the project location, the bridge and other facilities shall be provided for three (3) tracks. When allowing for future track, consideration shall be given to limitations due to track alignment and location on the existing Right-of-Way, Right-of-Way availability, adjacent Overhead Structures, and drainage provisions.

Future expansion can be accommodated by providing a single bridge wide enough for all tracks or multiple bridges with one or more tracks per bridge as long as provision is provided for one additional track and additional facilities.

The Designer shall take into consideration the manner in which the bridge could be widened when adding future additional track(s). The substructure shall accommodate future superstructure widening without requiring significant modifications to the seats, backwalls, and wing walls. The superstructure shall accommodate future expansion taking into account minimizing modifications to the superstructure and disruption of SCRRA operations. The locations of the abutments for underpass structure shall be designed to accommodate future tracks without substantial redesign and without track realignment.

Coordinate with the SCRRA to determine which side of existing track to provide provision for expansion and for required track spacing. SCRRA may require the Project Sponsor to prepare a short report showing the feasibility of a future expansion on both sides of the Grade Separation.

Skew of Bridge

The preferred angle of roadway crossing and bridge structure relative to the centerline of track is 90°. Prior acceptance from SCRRA is required in cases where a 90° crossing cannot be obtained. In cases where a 90° crossing cannot be obtained, the maximum skew of bridge structure from 90° degrees shall not exceed the following for various types of structures:

Type of Structure	Skew in Degrees
Steel span	30° Max.
Pre-stressed concrete beams	15° Max.

Roadway, bridge piers, and abutments shall be aligned as required to comply with the above maximum skew limitations.

Where conditions preclude any other solution, the skew proposal shall require special consideration and proof of adequacy.

Square-end abutment shall be provided at the end of the skewed bridge. If this is not possible and if SCRRA prior approval is obtained, at the end of skewed bridge, approach slabs, skewed end supported on the abutment and square end extending under the track, shall be provided for each track. The length of approach slab shall be of sufficient length to square off the track(s) approach to a minimum 12-foot width symmetrical to centerline of track.

Access to Underpass Structure

An access roadway with access from adjacent public roads to each end of the bridge, or an access roadway with bridge maintenance structure on one side of the track(s) with access to adjacent public roads, shall be provided for SCRRA off-track maintenance equipment.

Access roadway with turnaround pads shall be designed and constructed in conjunction with the Grade Separation project when a bridge maintenance structure is not provided. Turnaround pad shall start no further than 30 feet from the end of the bridge structure and with embankment shoulder 60 feet minimum from the centerline of the track. Roadway grade should not exceed 10 percent and should terminate at the sub-ballast elevation. Roadway shall have sufficient width to provide for one 12 feet wide road, drainage ditch, and shoulder. Roadway and turnaround pad shall be constructed on compacted material and have a 12 inch thick minimum base and 6-inch thick hot mixed asphalt (HMA) pavement. Turnaround pad and roadway shall be sloped to drain away from the track sub-grade and dispose water to drainage system. All down slopes of turnaround pad and roadway shall be protected with asphalt concrete curbs to prevent embankment erosion.

The bridge maintenance structure may be part of the track supporting structure or a completely separate structure. If bridge maintenance structure is part of the main track structure, the structure shall be designed for railroad E-80 loading to accommodate any future track needs and modifications. If the bridge maintenance structure is a totally separate structure, it shall be designed for HL-93 live load. The separate bridge maintenance structure width shall accommodate one (1) 12-foot paved lane with curbs and railing. The deck of bridge structure shall be Portland cement concrete deck pavement or steel plate deck with six inch thick HMA pavement. Bridge deck shall include curbs, railing, and drainage and joint seals as required. HMA pavement shall extend 12 feet past the end of the structure and be placed over a 12 inch thick minimum base. The access roadway with a bridge maintenance structure shall meet the same criteria as an access roadway with turnarounds.

<u>Clearances</u>

The Underpass clearances shall comply with the applicable requirements shown on Drawing GSG-08 - Underpass Structure Clearances, found in Appendix C-5.

Vertical

A minimum vertical clearance of 16 foot 6 inches shall be provided for all Underpass Structures, measured from the lowest point of the Superstructure to the highest point of the roadway pavement. A minimum vertical clearance less than 16 foot 6 inches may be provided if prior approvals were obtained on Special Design Consideration form from SCRRA and if sacrificial beams not carrying any track loads are provided over the traveled roadway. The vertical clearance must not be violated due to the deflection of the superstructure. Higher vertical clearances may be required by CALTRANS standards based on the roadway classification of the proposed road crossing under SCRRA.

Exceptions for minimum vertical clearance shall only be granted if it is uneconomical to provide the stated minimum vertical clearance over the roadway or geometry won’t allow minimum vertical clearance to be achieved. A thorough and complete analysis must be provided with the exception request that documents why the minimum vertical clearance cannot be provided. The exception request along with any supporting documentation shall be submitted on the SCRRA Request for Special Design Consideration form. Special design consideration and waiver requests shall be submitted at the Concept and Design Criteria (5 percent Design) or Preliminary Design (30 percent Design) review levels for consideration by SCRRA. Concept and Design Criteria (5 percent Design) exception and waiver requests are preferred. Design should not be advanced to the Interim Design (60 percent Design) level prior to receiving a decision on an exception or waiver request.

The Project Sponsor shall assume the repair costs and costs of operational impacts to SCRRA trains for damage to the bridge by highway traffic. In the event of damage to the bridge or the girders by highway traffic, the extent and method of repair shall be agreed upon by the Project Sponsor and SCRRA. If the Project Sponsor fails, refuses or neglects to perform the repair to the structure, SCRRA shall perform any work necessary to place the highway and appurtenances in such condition as shall not endanger or interfere with SCRRA facilities or operations, or jeopardize SCRRA employees. The Project Sponsor shall reimburse SCRRA for all the expenses including expenses incurred for delaying SCRRA trains and passengers.

If resurfacing or any other activity is to be performed below the Underpass structure, the Project Sponsor of the roadway shall submit a written request five (5) working days in advance of the activity for acceptance from SCRRA. This request must provide the existing measured and posted clearances of the structure and the proposed configuration after work is completed. The Project Sponsor shall be responsible for posting and maintaining signed structure clearances and any advance street notifications in accordance with CALTRANS and the AASHTO MUTCD, as required.

<u>Superstructure</u>

The minimum depth of ballast for the design of the structure under the ties at the lowest rail shall be eight (8) inches. In addition, a four (4) inch layer of Hot Mixed Asphalt (HMA) underlayment shall be provided for all structure types and eight (8) inch on the approaches for 50 feet past the bridge abutments. A steel cover plate and membrane waterproofing shall be provided at the underpass deck joints and membrane waterproofing applied over the entire bridge deck. All structures shall be designed for an additional seven (7) inches of ballast to accommodate a future track raise. Direct fixation of rail to Superstructure is not acceptable.

Minimum longitudinal structure grade of 0.2 percent shall be provided for drainage purposes. Drainage towards one end of the structure may be provided. When the structure is excessively long, adequate deck grades to drain the structure to both ends of bridge, or to pier locations, shall be provided. If the top of rail grade remains constant over the length of structure, the depth of ballast may be increased from the minimum depth but should be taken into account in the design.

Parallel structures shall have a minimum separation of five (5) feet to provide room for maintenance work and inspection. Raised walkways may be closer than five (5) feet if there is adequate room under the walkway to inspect the superstructure elements.

Bird screens may be provided below the Superstructure; however, the screens shall be designed to allow periodic inspections and maintenance by SCRRA. If attached to the Superstructure, the attachments need to provide stability when exposed to frequent vibratory loads and span deflection under live load.

Steel and Precast/Prestressed Concrete Beams and Girders

All steel and precast members shall be constructed from approved shop drawings and only after acceptance of the shop drawings is received from SCRRA. No materials should be ordered until SCRRA acceptance of the shop drawings is received. Structural members shall be constructed in accordance with the current AREMA Manual and methods accepted by SCRRA and as shown on the SCRRA accepted shop drawings. Structural members, drawings, and submittals that do not meet the project specifications shall be rejected. The Contractor at no additional expense to SCRRA shall replace rejected structural members. Members that have been delivered and are then rejected must be removed from the Right-of-Way with no additional cost to SCRRA.

<u>Deck Width</u>

For a single-track bridge structure, the width of the deck shall be as shown on the SCRRA standard drawings GSG-02 to GSG-06, ES 6001, and ES 6002, and shall not be less than 13 feet inside face to inside face of curb at top of the hot mix asphalt overlay.

Curb Height

The top of ballast curb shall be 24 inches above the bridge deck to allow for future track raises.

Walkway

The clear distance from centerline of track to inside face of the ballast retainer for bridges with walkway shall be 6 foot 6 inch minimum. To prevent cracking under live loads, provide ¼ inch wide joints at 10 feet maximum spacing on concrete curbs, walkways, and ballast retainers.

Walkways and handrails shall be provided on both sides of the deck. Walkways shall not be less than 2 foot wide with the top of walkway 24 inches above the bridge deck. That portion of the bridge walkway that spans over the highway and/or pedestrian walkway shall be constructed of solid material and a curb or toe board shall be provided.

When walkway structures are used, provide a detail showing the walkway transition from bridge to roadbed at bridge ends. Where there is a vertical distance from the roadbed walking surface to the bridge walkway, adjust the roadbed walkway profile to eliminate the vertical separation or provide other means to provide a safe transition.

Handrail

Handrails or chain link railing (fencing) shall be provided on both sides of the structure and shall meet FRA, AREMA, and OSHA requirements. The design of handrail or the chain link railing shall be project specific design and will provide architecturally pleasant appearance since it will be visible from the roadway. The design will be approved by SCRRA and by the local jurisdiction. Consideration shall be made to prevent ballast from falling onto traffic below via toe-board and/or chain link railing.

Deck Drainage

The HMA overlay on top of the deck for steel beam/girders and concrete box or slab beams shall be sloped transversely not less than 1 percent to the longitudinal drainage collection system.

A longitudinal drainage collection system shall be provided to dispose of drainage without permitting it to enter the ballast section and backfill beyond the limits of the bridge structure. Longitudinal drains shall be connected to the storm drain system or properly discharged at the toe of embankment slopes or at the bottom of piers into new or existing drainage ditches.

If an approach grade descends toward the bridge, drainage from the approach shall be intercepted by appropriate means so that it shall not drain onto the bridge.

Hot Mixed Asphalt (HMA) Overlay

HMA overlay shall comply with Caltrans Standard Specification, Section 39 “Hot Mixed Asphalt”. The HMA shall be four inches in thickness at the crown on top of the bridge deck. A 12 inch layer of HMA, 15 feet in width and symmetrical to the track, shall be placed for the bridge approach on top of the embankment and extend 50 feet from each end of the bridge. When there is more than one track the HMA layer shall extend between tracks and seven feet six inches outward on field side of each track. HMA layer shall be crowned at centerline of single track or at the centerline between two tracks and slope away from tracks at a 1percent slope toward the field side of each track.

Fire Protection

SCRRA structures and facilities shall be designed to provide a minimum fire rating as specified in the applicable local code, in accordance with the “UL List”.

Substructures

The Substructure elements shall be designed in accordance with Chapter 8 of the current AREMA Manual and SCRRA Design Criteria Manual.

Gamma-gamma logging (GGL) testing shall be required by SCRRA to evaluate the integrity of drilled shafts/caissons if used for foundation support. The Plans and Specifications shall include provisions for this testing.

Drilled shafts within the influence of track live load surcharge shall be designed with temporary casing for protection against cave-in, subsidence, and/or displacement of surrounding ground. Casing shall be designed for live load due to the track surcharge in addition to all other loads. Design of casing as shoring shall be in accordance with SCRRA’s Excavation Support Criteria, Chapter 15.0. Drilled shafts and piling shall be designed to allow the drilling or pile driving operation to proceed without stopping trains.

Soil and Geotechnical Data

Soil properties shall be established by subsurface investigations and laboratory testing. A Geologic Hazard Assessment shall be provided.

Soils and geologic data shall be prepared in accordance with the appropriate AREMA practices. These data should consist of boring location plans, boring logs, and test results and geologic sections and profiles.

Earth Retaining Structures

Earth retaining structures shall be designed in accordance with Chapter 8, Part 5 of AREMA Manual. Refer to Section 11.12, Permanent Retaining Walls of SCRRA’s Design Criteria Manual for more information on design and construction of retaining walls.

Abutments

The abutments shall be designed in accordance with the recommendations of Chapter 8, Part 5 of the AREMA Manual and SCRRA Design Criteria Manual (non spill-through type abutments shall be at least 0.2H in thickness at the base). The abutments shall be wide enough to satisfy SCRRA standard roadbed shown on Engineering Standards ES 2001 and ES 2002.

For multiple track bridges, the abutments shall be sufficient to provide standard shoulders, plus 20 feet for each existing or future track. Wing walls shall be designed to support 2:1 embankment slopes. Handrails shall be returned on the backwall and/or wing walls.

Abutment seats shall be sloped to drain away from bearing locations. When weathering steel is used for the Superstructure, details on top of abutment seat shall indicate method of collecting and disposing of water without staining the vertical concrete surfaces.

At certain locations, where the face of an abutment or retaining wall stem is exposed to public view, it may be desirable to treat the face architecturally. Such treatment may include the use of textured form liner, sandblasting, or bush-hammering. Such architectural treatment will not reduce the minimum clearances for reinforcing steel shown in Chapter 8 of the AREMA Manual nor shall it be allowed to reduce the effective wall section.

Sloping embankments in front of abutments shall be landscaped and/or paved as per SCRRA input and acceptance. Landscaping shall be as per SCRRA Landscaping Criteria and/or SCRRA Specifications Section 32 90 00 - Landscaping.

Piers

Single column piers will not be accepted for Underpass Structures. For single-track structures, solid wall piers or two columns shall be provided. For multiple-track structures, solid wall piers or a minimum of two columns shall be provided per track, with each intermediate column allowed to share the load between tracks (i.e. a two-track bridge will require a minimum of three columns).

Bridge piers adjacent to roadways shall be protected from vehicular traffic by use of concrete barrier. The type, design, and detailing of the concrete barrier that is used shall comply with AASHTO and Caltrans standards.

Bearings

Refer to the SCRRA Design Criteria Manual for guidance on selection and design of acceptable end bearing provisions for steel and concrete spans for Underpass Structures.

Provide a minimum of six (6) inches from edge of masonry plate or bearing to edge of concrete.

Painting

All steel bridge Underpass Structures shall be fabricated with weathering steel for exposed members unless located within one (1) mile from the ocean in which case the structure shall be painted. Painting shall conform to the requirements of current AASHTO specifications and recommendations of Steel Structures painting Council Manual (SSPC). Paint shall be applied in accordance with manufacturer's recommendations and in compliance with SSPC recommendations. Paint shall be submitted by the painting agency for review and acceptance by SCRRA prior to application of any of the coatings.

All accessible concrete, masonry, and porous surfaces from finish grade or floor to 10 feet above finish grade or floor shall be painted with clear graffiti-resistant coating. Refer to SCRRA specifications 34 80 61 – Painting and Protective Coating for Bridges for material and construction requirements.

Signal and Communications Conduits

Provisions shall be made for all Underpass Structures to carry SCRRA signal and communications conduits and cables for either active and future expansions or additions to communications systems, if required. Attachment points of SCRRA signal and communications conduits to cut-and-cover structures shall be positively located to avoid all reinforcement. This may be accomplished by casting inserts directly into the concrete, or by casting block-outs into which attachments can be secured.

No public or private utility attachments are allowed on Underpass Structures. Lighting conduit and lights are allowed to be attached to Substructure units, but shall not be attached to Superstructure components. Existing or future public and private fiber optic lines should be placed underground and away from the structure. Relocation of existing utilities interfering with construction of the project shall be the responsibility of the Project Sponsor.

<u>Drainage</u>

Drainage plans and hydrology report shall be prepared per the SCRRA Design Criteria Manual, Chapter 8, and shall be submitted for SCRRA review and acceptance.

<u>Maintenance</u>

The C&M Agreement assigns SCRRA responsibility for the inspection and maintenance of the Superstructure of the Underpass Structure above the bridge seats, including bearing assemblies, spans, roadbed, tracks, railroad drainage, and all other related SCRRA facilities.

The C&M Agreement assigns the Project Sponsor responsibility to maintain the structure and appurtenances below the bridge seats, including: piers and abutments; retaining walls; roadway illumination and electrical appurtenances; drainage system; roadway pavement; roadway facilities; curb and gutter; striping; signage; and aesthetic or cosmetic design elements or painting added to the Superstructure soffits or facades and appurtenances. The Project Sponsor is responsible for removal of graffiti from the entire project, including retaining walls, Substructure and Superstructure (above and below the bridge seats) of the Grade Separation structure.

The Project Sponsor shall be responsible for maintaining facades and fascia girders including removing fascia girders or facades prior to SCRRA scheduled maintenance or repair to the structure. SCRRA can remove the fascia girders or facades during emergencies and then be reimbursed by the Agency.

The Project Sponsor shall be responsible for all roadway work and closures that occur during structure inspection, maintenance, or repair. The Project Sponsor shall also be responsible to obtain written acceptance in advance of performing any work that could affect the structural integrity of the structure or interfere with SCRRA operations.

12.4.4 Pedestrian Grade Separations

Pedestrian grade separations shall comply with all applicable Federal, State, and Local laws, and shall provide an accessible facility under the Americans with Disabilities Act of 1990 (ADA) and the Rehabilitation Act of 1973 (Section 504). The FHWA is responsible for ensuring access for persons with disabilities and it is recommended the designer refers to the best practices design guidelines publications on the FHWA website.

New pedestrian crossings shall be grade separated as a minimum standard.

The design of Pedestrian grade separations shall consider and balance initial project capital costs and life-cycle costs including maintenance. Underpass structure usually requires higher initial capital cost while overhead structure requires higher life-cycle costs. Most of the overhead structures at the stations are maintained by the local agency where the station is located and they are responsible for the maintenance cost. Maintenance of the elevators for overhead structures is the most reported problem at the station. Based on this, selection of an overhead for pedestrian grade separation is the SCRRA preferred alternative.

Pedestrian Overhead

The Pedestrian Overhead Structure, as a minimum, shall meet the specifications and design standards of AASHTO and Caltrans. The structure shall also meet all general requirements for Overhead Structures outlined in Section 12.4.2 of these Criteria.

The Pedestrian Overhead Structure shall be designed to span the entire width of SCRRA Right-of-Way and if practical at 90 degrees to the track(s).

The Pedestrian Overhead Structure shall be of sufficient length to allow for future track(s) and access road(s) as directed by SCRRA. Refer to Section 12.4.3 of these Criteria for future expansion requirements.

Protection of SCRRA Operations

The Pedestrian Overhead Structure shall provide protection for the entire width of the SCRRA Right-of-Way to prevent the throwing of objects from the structure onto the Right-of-Way. The structure shall be totally enclosed or provided with a fence on both sides that extends a minimum of 8 feet above the deck as depicted on Drawing GSG-07, Overhead Structure Clearances, in Appendix C-5.

The Pedestrian Overhead Structure and approaches shall be adequately lighted, however; lighting must be designed and installed in a manner that will not interfere with the train crew’s ability to clearly observe track signals.

The Pedestrian Overhead Structure shall not interfere with train crew’s unobstructed line of sight to the wayside or at-grade crossing signal systems.

Minimum Width

The minimum traveled width for Pedestrian Overhead Structures shall be 10 feet.

Clearances

The Pedestrian Overhead Structure final minimum clearances shall comply with the applicable requirements shown on Drawing GSG-07, Overhead Structure Clearances, refer to Appendix C-5. The vertical clearance from the top of the high rail to the lowest point of the structure shall be 24 feet 6 inches. Standard and minimum clearances shall be as per ES 2101 and ES 2102.

A temporary minimum horizontal clearance of 12 feet from the centerline of track(s) (including temporary falsework) shall be provided during erection of the Pedestrian Overhead Structure.

A temporary minimum vertical clearance of 22 feet 6 inches above top of the rail shall be provided during erection of the Pedestrian Overhead Structure.

Access

The Pedestrian Overhead Structure shall be designed and constructed with stairways, approach ramps, and elevators as necessary to comply with sponsoring Project Sponsor codes and requirements and the ADA.

SCRRA Right-of-Way shall be protected against unauthorized access by pedestrians by providing railings or fences. The height of the railings or fences shall be as shown in ES 5103, ES 5104, and ES 5105 depending on the material and constructed to discourage climbing over the railing or fence to gain access to the SCRRA Right-of-Way.

Construction

The Pedestrian Overhead Structure design shall include consideration of construction and erection methods in order to minimize disruption to SCRRA operations. Construction track windows where train traffic can be stopped to allow uninterrupted construction are generally limited to 8 to 12 hours during the week with maximum weekend windows of 48 hours.

Checklists

A design and construction criteria compliance checklist shall be provided with each Pedestrian Overhead Structure review submittal for design and construction, see Appendix E-2 and E-3 for the standard checklist.

Maintenance

The Pedestrian Overhead Structure shall be maintained by and at the expense of the sponsoring Project Sponsor.

<u>Pedestrian Underpass</u>

The Design of precast and cast-in-place concrete box sections used for Pedestrian Underpass Structures shall comply with the current edition of the AREMA Manual, Chapter 8, Part 16 – Design and Construction of Reinforced Concrete Box Culverts, and the SCRRA Design Criteria Manual. When other structure types are proposed the design shall comply with appropriate Chapters and Parts of AREMA and SCRRA Design Criteria Manual. The structure shall be designed to cross the Right-of-Way at 90 degrees to the track(s) if practical.

Concrete box structures are preferred for Pedestrian Underpass Structures. Where concrete box structures are used, precast box sections shall be utilized to minimize construction track windows. The length of precast box sections shall be at least of sufficient overall length that any cast-in-place section(s) can be installed after the track(s) is put back in service and shoring installed per Excavation Support Criteria, Chapter 15.0.

Precast box sections shall be positively connected to provide closure of the joints, engage the gasket seals, and prevent possibility of future separation of the box sections. The connections shall be provided on the top (two minimum), and on each side (one minimum) of the box sections. The connections may be bolted, welded, or a combination of both. Any open holes left after erection shall be grouted closed.

The Pedestrian Underpass Structure shall be of sufficient length to allow for future track(s) as directed by SCRRA.

Width and Height

The minimum inside clear dimensions of the Pedestrian Underpass Structure shall not be less than 9 feet wide by 9 feet high prior to installing the floor. The maximum inside clear dimensions of the structure shall not be more than 16 feet wide by 11.5 feet high. The width and height of the structure shall be determined based on individual analysis to provide adequate visibility through the structure.

The Pedestrian Underpass Structure shall be designed to minimize the “tunnel” perception. The structure architecture should consider an arc shaped inside roof line that is six to twelve inches lower at the walls.

Hot Mix Asphalt (HMA) Overlay

HMA shall be applied directly over the Pedestrian Underpass Structure’s waterproofing system. The HMA width shall provide for existing and future track(s). The HMA shall be continuous between existing and proposed track(s) and extend out a minimum of 7 feet 6 inches on the field side of track(s). The HMA shall extend 30 feet along the approaches measured from the outside faces of the structure’s walls.

The HMA shall have a minimum layer depth of 8 inches over the crown at the centerline of the Pedestrian Underpass Structure and slope to 6 inches at the ends of the 30 foot approaches. The HMA layer shall slope away from the track(s) to the field side at 1 percent slope. Refer to Appendix C-5, Drawing GSG-09.

Waterproofing

The Pedestrian Underpass Structure shall be waterproofed such that it remains watertight.

A waterproofing system shall be provided to protect the Pedestrian Underpass Structure in addition to the HMA overlay. The waterproofing system used shall be of a quality that will prevent any leakage into the structure over its useful lifespan. A warranty shall be provided to SCRRA by the Contractor that will cover repairs for material and labor for 20 years after construction is complete if the structure develops leaks. The waterproofing system shall be protected from damage during installation of the HMA overlay.

Precast box section joints shall be of watertight construction incorporating a rubberized gasket installed between the tongue and groove sections of the sections.

Cast-in-place box sections shall incorporate water stops at all construction joints.

Other type structures used for Pedestrian Underpass Structures shall be suitably designed to provide watertight construction.

The waterproofing system details for the structural type of Pedestrian Underpass Structure to be used shall be submitted to SCRRA for acceptance prior to fabrication and construction.

Drainage

The Pedestrian Underpass Structure shall include an inside drainage collection system to allow for water removal due to maintenance cleaning and any storm runoff from adjacent approach ramps and stairways. It is preferred that a drainage collection system be installed on each side of the floor along the full length of the structure and then routed to an existing storm drainage system. A sump with pump and lift station should only be considered if connecting to an existing storm drain by gravity flow is not practical. The inside structure's floor shall be sloped as required to facilitate draining to the drainage collection system.

Pedestrian Underpass Structures shall also have a sub-drainage system installed along the external walls below floor level in conjunction with pervious backfill material and/or geo-composite drainage board to collect water from groundwater fluctuations and surface infiltration. When the structure is also located in an area with a high ground water table a permanent dewatering system should be considered in addition to the sub-drainage system.

The drainage system details shall be submitted to SCRRA for acceptance prior to construction.

Access

The Pedestrian Underpass Structure shall provide access that includes stairways and approach ramps that provide adequate site distances to the pedestrian. The structure shall provide access that is ADA compliant.

SCRRA Right–of-Way shall be adequately protected against unauthorized access by providing railings or fences. Railings or fences shall be a minimum 6 feet in height and of a construction type that will discourage climbing over the railing or fence to gain access to the SCRRA Right-of-Way. Right-of-Way fencing shall be provided on both sides of the right-of-way and shall extend a minimum of 250-ft. from the Pedestrian Underpass Structure perpendicular to the structure.

Lighting

The Pedestrian Underpass Structure, stairways, and approach ramps shall be lighted for security of the pedestrian. Lighting in underpasses requires addressing pedestrians' personal safety. Lighting on the approaches and within the underpass should appear bright while avoiding glare and shadows. This can be accomplished by carefully selecting surface textures and colors.

When the ratio of the Pedestrian Underpass Structure length to height exceeds 10:1, lighting should operate continuously.

During the day, the Pedestrian Underpass lighting should be bright enough to allow pedestrians to see into the underpass. At night, pedestrians in the underpass should be able to see the areas surrounding the exits. This can be accomplished by reducing the lighting intensity at each entrance to the underpass.

Avoid using recessed lamps that could create pools of light. Since Pedestrian Underpass lamps are generally located at a relatively low level, they should be made of polycarbonate or of some other type that is resistant to vandalism.

An emergency lighting system shall be installed to provide illumination if the main power supply fails.

Construction

The Pedestrian Underpass Structure design shall include consideration of construction and erection methods previously successfully used on SCRRA projects of similar type in order to minimize disruption to SCRRA operations. Construction track windows where train traffic can be stopped to allow uninterrupted construction are generally limited to 8 to 12 hours during the week with maximum weekend windows of 48 hours. Include one and one half hour to remove each track and the same timeframe to replace each track in the allowable track window timeframes.

Checklist

A design and construction criteria compliance checklist shall be provided with each Pedestrian Underpass Structure review submittal for design and construction, see Appendix E-2 and E-3 for the standard checklist.

Maintenance

The Pedestrian Underpass Structure shall be designed considering ease of maintenance. Lighting fixtures, signage, aesthetic treatments, and other materials proposed for use in the structure shall be included in the design considerations to reduce maintenance frequency and requirements.

For example, lighting fixtures should be recessed with unbreakable lenses or provided with lens protection. Signage should be adequately fastened to supports and out of reach to the extent possible. Aesthetic treatments should be inlaid or anchored and protected by other means from vandalism damage. Concrete should have graffiti protection if warranted, and handrails and exposed metals should be protected from corrosion (galvanized steel is preferred).

The Pedestrian Underpass Structure shall be maintained by and at the expense of the sponsoring Project Sponsor.

Shoofly Track

The most effective method of maintaining traffic is to temporarily reroute railroad traffic around the construction site using Shoofly Tracks. The Shoofly shall be designed to comply with current rail operations and existing conditions. The Shoofly design shall be submitted for review in the early stages of project design. The Shoofly for construction of the permanent structure shall be designed for construction staging to minimize the traffic interference with the Operating System. SCRRA requires that the track remain fully operational at all times, except for “track outage window”, during which a track is shut down to train traffic for certain periods of time. It shall be the Project Sponsor’s or the Contractor’s responsibility to secure permission for any such track outage window from SCRRA. The Project Sponsor or the Contractor shall make a request for such track outage window to SCRRA at least sixty (60) working days in advance. The Project Sponsor’s or the Contractor’s request shall be subject to SCRRA approval for each outage. The Project Sponsor or the Contractor shall not regard track outage window as routine events.

If the Shoofly track centerline will be located within 15 feet of the face of a shored excavation, then the Shoofly track must be constructed with a hot mix asphalt (HMA) sub-ballast, 8 inches thick, 12 feet wide (centered about the track centerline), and extending 20 feet in both directions past the shored excavation.

The Shoofly Track design shall conform to all applicable Federal, State, Local, and SCRRA Design Criteria Manual standards and regulations. The Shoofly shall be designed for maximum authorized speed for passenger and freight trains shown in SCRRA Timetable and Track Charts. SCRRA approval shall be obtained if the Shoofly is to be designed for lower speeds to meet existing site conditions. The track curve speed, super-elevation and spiral length shall meet the requirements shown in SCRRA Engineering Standards ES 2202 and ES 2203.

If existing track is removed temporarily during Shoofly construction, the existing rail shall be put up on blocks and not on the ground, ties shall be stacked with space dunnage boards so that the ties are not resting on the shoulders of the lower ties, and clips are put in containers protected from weather.

The Shoofly Track crossings shall meet the requirements of Chapter 8.

When Shoofly construction is performed by the Agency Contractor, SCRRA shall perform a field review and accept the track(s) prior to cut-over. Contractor shall coordinate cut-over with SCRRA forces. Signal, communications, and PTC changes and required as a result of the shoofly track will be included as a part of the design and construction.

12.4.5 Construction

The construction shall meet requirements stated in SCRRA's Standard Specifications, SCRRA Reference Standards and Criteria, Form 37: Rules and Requirements for Construction on Railway Property, and shall also comply with the AREMA Manual unless the SCRRA requirements are more restrictive.

During construction of Underpass Structures, the Project Sponsor shall provide an independent qualified Resident Engineer to be onsite during all construction activities. The Resident Engineer will be the coordinator of project correspondence and construction questions between the Agency and SCRRA.

SCRRA or designated Engineering Consultant shall have the option to conduct site observations of the work anytime during construction of the project. Site observations will be required for those activities outlined in the Agreements for SCRRA to provide acceptance or approvals of the work performed.

All work on, over, or adjacent to the tracks must be coordinated with SCRRA, and the work is subject to SCRRA operating rules for work on all tracks. Project Specific Work Windows shall be obtained from SCRRA. The Project Specific Work Window hours and days will be included in the specifications by the Project Sponsor. If work windows are not included in the project specifications, they will be provided based on SCRRA safety requirements and SCRRA operating rules.

Any damage to rails, ties, structures, embankment, third party property, signal and communications equipment, or any other facilities shall be repaired, at Project Sponsor or Contractor expense, to a condition equal or better to the condition prior to entry and as accepted by SCRRA. The Project Sponsor or the Contractor agrees to reimburse SCRRA and/or any operating railroads for any and all cost and expense incurred as a result of Contractor's work which may result in: (i) unscheduled delay to the trains or interference in any manner with the operation of trains; (ii) unscheduled disruption to normal train operation; (iii) unreasonable inconvenience to the public or private user of the system; (iv) loss of revenue; and (v) alternative method of transportation for passengers.

The Site Specific Work Plan (SSWP) submittal and electronic ".PDF" drawings showing details of construction affecting tracks and property, specifications, and plans and procedures for excavation, demolition, falsework, sheeting and shoring, drainage, and any other proposed work that may infringe on SCRRA Right-of Way or affect operations shall be submitted to SCRRA for review and acceptance prior to procurement, manufacture, fabrication, and construction.

During operations adjacent to live track, all work within 25 feet of the live track or within 50 feet of any main track(s) switch shall be stopped when trains are approaching, and equipment and employees moved to a safe distance from the tracks.

The Project Sponsor and its Contractors shall comply with the rules and regulations contained in the current editions of the following SCRRA documents during the construction of the project:

- Temporary Right-of-Entry Agreement (SCRRA Form No. 6)
- Rules and Requirements for Construction on Railroad Property (SCRRA Form No. 37)
- General Safety Regulations for Third Party Construction and Utility Workers on SCRRA Property
- Applicable SCRRA Engineering Standards.

The Project Sponsor shall notify SCRRA thirty (30) working days prior to beginning work on the Right-of-Way and secure any protection SCRRA deems necessary.

Excavation and Backfill

The excavation and backfill shall meet all the requirements shown in Chapter 15.

Erosion Control

The general plans for the Grade Separation shall indicate the proposed methods of erosion control and must specifically address means to prevent silt accumulation in the ditches and culverts and to prevent fouling the track ballast, sub-ballast, and existing drainage system. Existing track ditches shall be maintained at all times throughout the construction period. All erosion control shall meet current California and County requirements for SWPPP and shall have Agency approval prior to construction. After the construction has been completed, all erosion control devices shall be removed, all deposits of silt removed, and the ditches restored. Acceptance of the erosion control plan does not relieve the submitting agency, consultant, and/or Contractor of the ultimate responsibility and liability for a satisfactory erosion control plan.

Temporary Traffic Control

The construction of a new Grade Separation, or the modification of an existing Grade Separation, may require temporary traffic control. Chapter 36, Temporary Traffic Control, shall be referenced for further information on definitions, referenced standards, traffic control plans, submittals, traffic control elements, and responsibility/authority for temporary traffic control at Highway-Rail Grade Crossings. Chapter 36 provides acceptable alternatives and procedures to prescribe the appropriate temporary traffic control measures at Highway-Rail Grade Crossings.

Utility Adjustments

The existing utilities shall be located prior to commencing any excavations in conformance with criteria set forth in Chapter 10.

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13.0 LOAD RATING

In accordance with SCRRA requirements, a detailed load rating that is representative of a structure's current condition shall be completed for each structure that carries railroad traffic. SCRRA's load rating methodology, assumptions, analysis methods, and reporting requirements, provided below, shall be followed unless otherwise directed by the SCRRA Director of Structures.

13.1 RATING METHODOLOGY

SCRRA's load rating guidelines, presented herein, supplement the general bridge load rating requirements outlined in the AREMA Manual for Railway Engineering. The following sections of the AREMA manual provide direction on how to rate a railroad structure based on the material it is composed of:

- Chapter 7, Section 3, Rating Existing Wood Bridges and Trestles
- Chapter 8, Section 19, Rating of Existing Concrete Bridges
- Chapter 15, Section 7.3, Rating [of Existing Steel Bridges]

SCRRA's load rating guidelines serve to provide clarification of AREMA load rating requirements and give direction where the AREMA Manual for Railway Engineering is silent. These guidelines shall supersede AREMA requirements where conflicts exist.

Typically, ratings are performed on superstructure elements. Substructures, due to unknown foundation support or design information, are typically inspected and not rated, as substructure defects are either repairable or steps can be taken to protect movement of trains. Refer to further details in this chapter.

13.2 PRE-RATING BRIDGE INSPECTION

Prior to load rating any structure, as-built plans shall be located and a pre-rating bridge inspection or condition inspection shall be completed by SCRRA or the rating engineer to verify the following information, and any other conditions, that could affect the load rating of the bridge in accordance with SCRRA's current Bridge and Tunnel Safety Management Policy:

- Actual sections and details conform to the as-built drawings. The inspection should verify that repairs, strengthening, additional section loss or other modifications have not occurred; if they have, dimensions should be recorded to determine accurate section properties and dead loads.
- An estimate of any additional dead load that has been added to the structure.
- Position of the track relative to the centerline of the structure.
- Superelevation of the track across the bridge.
- Degree of curvature of the track across the bridge.
- Horizontal and vertical alignment of the track over the bridge.

- Operating speed of the track, in order to accurately determine the impact factor applied to the bridge.
- Uneven settlement of piers.
- Span bearing types and simple vs. continuous span supports.
- Structural condition of all members of the bridge, noting any deficiencies, defects, or deterioration that may exist that affect the load rating of the member or cause the rating of other members to be required. At a minimum, the following structural conditions should be noted:
    - Timber member rot or decay
    - Concrete condition (spalls, cracking, lost concrete, rust-colored efflorescence)
    - Reduction in steel reinforcement area
    - Steel member corrosion or section loss
    - Loose rivets, bolts, or connections in any type of member
    - Crooked or damaged members
    - Cracked welds or live load carrying steel members

The intent of the inspection is to verify that the load rating engineer has accurate information of the condition of the structure and that all factors are appropriately considered during the load rating process. The load rating engineer needs to exercise engineering judgment to determine what defects, if any, found during the inspection are necessary to include in the rating.

The current SCRRA Bridge, Tunnel and Culvert Safety Management Policy and the AREMA Bridge Inspection Handbook, latest edition, provides further direction on how to conduct a thorough bridge inspection of a railroad structure. Each inspection should be coordinated with the SCRRA Director of Structures and shall conform to all SCRRA safety and procedural requirements.

13.3 RATING LEVELS

Depending on the material type of the member, the component being rated may have up to three different ratings determined – Normal, Fatigue (if considered) and Maximum – which are described below:

- The Normal Rating of a structure (or component) is the load level that the structure can support on a repetitive basis for its expected service life. The Normal Rating of a structure (or component) is based on the full loading (Dead, Live, Impact, etc.) characteristics of the structure compared to design-level allowable member stresses or capacities.
- The Fatigue Rating of a structure (or component) can be calculated to aid in the evaluation of the structure for probability of fatigue crack growth and used to provide an estimation of remaining fatigue service life. It applies only to steel spans or mild reinforcing in concrete that is in tension and considers the type of fabrication and assembly, as well as the cyclic characteristics of the Live Load. If necessary, the structure’s Load History and projected future Live Loading can be used to predict the remaining fatigue life of the structure.

- The Maximum Rating of a structure (or component) is the maximum load level that the structure can support at infrequent intervals. It is based on the full loading (Dead, Live, Impact, etc.) characteristics of the structure compared to maximum overload-level member stresses or capacities.

The AREMA Manual for Railway Engineering includes the Fatigue Rating as part of the Normal Rating process, the results of which can sometimes mask the Strength capacity of a member. The Strength Rating of the bridge is a measure of its structural load capacity and indicates if the bridge is structurally deficient, whereas the Fatigue Rating is based on a reduced allowable live load stress range that varies based on the type of member and fabrication details. The risk associated with fatigue-sensitive bridge details can be mitigated through enhanced inspection intervals and techniques and are less severe on inherently redundant structures. For this reason, the Fatigue Rating of a bridge or component shall be listed separately from the Strength Rating and both shall be included under the Normal Rating heading. The Normal Rating of a structure is based on the strength rating

The fatigue rating results and requirements may be waived if so decided by the Bridge Engineer. The decision should be made and documented in the bridge record on the basis of the individual railroad's current and historic traffic loading patterns, bridge management criteria, fatigue details, existing structure condition and defects, inspection procedures, and failure history.

A detailed calculation of a structure's remaining life based on its load history and predicted Live Load shall only be done at the direction of the SCRRA Director of Structures.

13.3.1 Timber Bridges

Timber bridges or components are only rated for Normal (Strength) and Maximum levels per the AREMA Manual for Railway Engineering, Chapter 7, Section 3.1.14. The Normal (Strength) rating is to be completed using allowable stresses for "Regularly Assigned Equipment or Locomotives," and the Maximum rating is to be completed using allowable stresses for "Equipment or Locomotives Not Regularly Assigned."

Timber bridges shall be rated using service level methods (i.e., working stress design, allowable stress design).

13.3.2 Concrete Bridges

All concrete bridges or components are to be rated for Normal and Maximum levels per the AREMA Manual for Railway Engineering, Chapter 8, Sections 19.2.2 and 19.2.3. The Fatigue, if considered, Rating of mild steel reinforcement in concrete in tension shall be determined per Chapter 8, Section 2.26.2b.

Concrete bridges or components may be rated using service or strength level methods for either Normal or Maximum rating levels. The service level rating method must be used to determine the Fatigue rating of steel reinforcement in tension.

The AREMA Manual for Railway Engineering, Chapter 8, Sections 2.25 through 2.29, describe how to determine a concrete member's capacity using service level rating methods; Sections 2.30 through 2.39 describe how to determine a concrete member's capacity using strength design methods. If the original design method is known, the load rating should reflect that method.

13.3.3 Steel Bridges

All steel bridges or components are to be rated for Normal, Fatigue (when considered) and Maximum levels per the AREMA Manual for Railway Engineering, Chapter 15, Sections 7.3.1.1 and 7.3.1.2.

Most steel members of a bridge will require a Fatigue rating to be performed, unless the member does not experience tension due to live load effects or the bridge/component carries less than 5 million gross tons per year of mixed traffic (AREMA Manual for Railway Engineering, Chapter 15, Section 7.3.4.2b).

Steel bridges or components shall be rated using service level methods for Normal, Fatigue (if considered) and Maximum Rating levels.

13.4 LOADS TO CONSIDER FOR RATING

Generally, the loads to be considered when determining a structure's rating are the same types that are considered during design. However, the loads applied to the structure are to represent the current conditions on the structure, and the live load effects shall be proportioned to equivalent levels that maximize a component's loading.

13.4.1 Dead Load

The dead load applied to a structure shall be based on the conditions observed during the inspection. Actual depth of ballast measured in the field shall be used. Appropriate weight shall be included for items that have been added to the structure since it was originally built (utilities, walkways, span protection devices, etc.).

Assumed material unit weights shall be as directed by the AREMA Manual for Railway Engineering, Chapter 7, Section 2.5.2; Chapter 8, Section 2.2.3b; or Chapter 15, Section 1.3.2.

Actual weights of steel members shall be calculated in accordance with the as-built plans or the field inspection. Estimates of member weight that increase the primary member's weight by a percentage to account for bracing, bolts, etc., will be allowed, but shall be refined if any member does not meet the required rating levels determined in Section 13.10, Equipment Demands on Structures.

13.4.2 Live Load

The results of a rating analysis shall indicate the maximum Cooper's Equivalent load that the structure can handle for the Normal and Maximum rating levels. As a result, the live load that shall be applied to the structure to determine the rating shall be the Cooper E80 live load as detailed in the AREMA Manual for Railway Engineering, Chapter 8, Section 2.2.3c, or Chapter 15, Section 1.3.3, or an equivalent that uses the same axle spacing but has a proportional reduction or increase in the axle and uniform load (that is, the heaviest axle in an E-1 load shall be 1 kip). The Cooper E80 live load is shown in Section 13.10 for reference.

13.4.3 Impact

For timber structures, increases in the live load effect due to impact have not been well established, but are expected to be less than the increase in allowable stresses that result from load duration multipliers that are used to determine allowable stress levels. As a result, impact does not need to be applied to timber structures or components.

For concrete or steel bridges, the impact factor applied to the live load on the bridge or member shall be as follows:

- Concrete – per the AREMA Manual for Railway Engineering, Chapter 8, Section 2.2.3d, reduced for operating speed per Chapter 8, Section 19.3.4b
- Steel members – per AREMA Manual Chapter 15, Section 1.3.5, reduced for operating speed per Chapter 15, Section 7.3.3.3

Considerations shall be made for length of bridge, ballast deck spans, rocking effect of cars, and type of locomotive, as appropriate.

The impact load for the Fatigue Rating for steel members shall be reduced per the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.13.

13.4.4 Centrifugal Force

If the track across the bridge is not tangent and has either a spiral or a circular curve, the live load effects shall be amplified for centrifugal force effects. Centrifugal force effects shall be calculated using the standard AREMA equation from either Chapter 7, Section 2.3.4; Chapter 8, Section 2.2.3.e; or Chapter 15, Section 1.3.6, except the center of gravity of the live load application shall be assumed to be 8 feet above the top of rail in all cases.

The maximum degree of curvature of the track across the bridge (measured in the field during the inspection) and the timetable operating speed shall be used in the centrifugal force equation. Track position relative to the centerline of the structure shall also be used to amplify/reduce live load force effects as appropriate.

13.4.5 Longitudinal Force

Longitudinal force effects due to train braking and traction forces manifest themselves in the superstructure by increasing or decreasing train car truck vertical reactions due to the center of force (drawbar elevation or center of gravity) acting above the top of rail elevation. As a result, axial forces, shear forces, and bending moments in the superstructure may increase.

Longitudinal force shall be determined per the AREMA Manual for Railway Engineering, Chapter 8, Section 2.2.3.j, or Chapter 15, Section 1.3.12; Chapter 7, Section 2.5.5.4.a, need not apply for timber structures, and instead, the provisions of the concrete or steel sections shall be used. For the purposes of determining force coupling effects, an idealized consist of cars with trucks 30 feet apart on the same car and 10 feet apart on adjacent cars shall be assumed to determine the force effects on the superstructure. Further explanation of how the longitudinal force shall be applied is provided in Appendix H of this DCM.

13.4.6 Earth Pressure

For arch structures filled with soil, the earth pressures that shall be applied to the masonry or concrete arches and their spandrel walls shall be calculated and applied in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Part 5.

If as-built information regarding the soil used to fill the arch is not available, the soil shall be assumed to be a dense sand with a friction angle of 45 degrees.

13.4.7 Other Loads

Other lateral loads will not be required to be considered unless the bridge appears inadequate for buoyancy, wind effects, stream flow, ice pressure, or other forces.

13.5 BRIDGE MATERIAL ALLOWABLE CAPACITIES

Allowable member capacities, either working stress or ultimate strength, shall be based on the material used during construction and will vary significantly depending on the year the structure was built. Preferably, as-built plans will exist for the structure that will specify the material grade, type, or species used during construction.

13.5.1 As Built Plans and Historical Data

If as-built plans are not available, the load rating engineer shall use the age of the structure along with historical data of typical material strengths that were predominant in the era of the bridge to determine the material properties of the structure.

Material testing of the actual bridge materials shall not be done without approval from the SCRRA Director of Structures.

13.5.2 Timber

The species of the timber of an existing bridge shall be determined from as-built plans or from the standard plans used by the railroad that originally constructed the bridge. If as-built or standard plans are not available, the species of the wood shall be assumed based on what was predominantly used in the area at the time.

Allowable stresses to be used to determine the Normal Rating of the structure or component shall be per the AREMA Manual for Railway Engineering, Chapter 7, Section 3.1.14.

13.5.3 Concrete

The compressive strength of the concrete, yield strength of the mild reinforcement, or ultimate strength of the prestressing strands shall be assumed to match the design requirements listed on the as-built plans, unless field observations or construction documentation suggests that reduced values should be used. If as-built plans are unavailable and the material strengths are unknown, the load rating engineer shall use the age of the structure along with historical data of typical material strengths that were predominant in the area of the bridge to determine the material properties of the structure. If information specific to the area cannot be found, the AREMA Manual for Railway Engineering, Chapter 8, Sections 19.4.1.1 and 19.4.2.2.2, provide suggested values to use for concrete and reinforcement capacity.

Service Level Methods

For Normal and Maximum Rating levels, conventionally reinforced concrete's permissible stress shall be per the AREMA Manual for Railway Engineering, Chapter 8, Section 19.4.1.2a, and modified as appropriate using strength modification factors in the load rating equations in Chapter 8, Section 19.5.3.1.

For the Normal Rating level, mild reinforcement steel's permissible stress shall be 1.2 times the allowable levels provided in the AREMA Manual for Railway Engineering, Chapter 8, Section 2.26.2a. For the Fatigue Rating level, the permissible live load stress in mild reinforcement shall be limited to 1.2 times the allowable level per Chapter 8, Section 2.26.2b, and should only be checked using Equation 19-1. For the Maximum Rating level, mild reinforcement steel's permissible stress shall be per Chapter 8, Section 19.4.2.1, divided by 1.2.

For Normal and Maximum rating levels, prestressed concrete's permissible stress shall be per the AREMA Manual for Railway Engineering, Chapter 8, Section 17.16.2.2, and modified per Chapter 5, Section 19.4.1.2a.

Load Factor Methods

The nominal strength capacity of a concrete member is calculated in the same manner for Normal and Maximum Rating levels and is described in the AREMA Manual for Railway Engineering, Chapter 8, Sections 2.30 through 2.39. The differences between a Normal and Maximum Rating result from the different load factors used in equations 19-7, 19-8, 19-10, and 19-11.

13.5.4 Steel

The yield and/or ultimate strength of the steel used in a steel bridge or component shall be determined from as-built plans or from the standard plans used by the railroad that originally constructed the bridge. If as-built plans are unavailable and the material strength is unknown, the load rating engineer shall use the age of the structure along with historical data of typical material strengths that were predominant in the area of the bridge to determine the material properties of the structure. The AREMA Manual for Railway Engineering, Chapter 15. Section 7.3.4.3a, provides suggested values to use for various types of steel.

Allowable stresses to be used for the Normal Rating shall be per Chapter 15, Table 15-1-11.

Allowable stresses to be used for the Fatigue Rating, when considered, shall be per Chapter 15, Section 7.3.4.2.

Allowable stresses to be used for the Maximum Rating shall be per Chapter 15, Table 15-7-1, as described in Chapter 15, Section 7.3.4.3.b.

13.6 BRIDGE MEMBER SECTION PROPERTIES

Section properties of bridge components for both dead load calculations and geometric properties shall be based on the as-built plans supplemented with field observations. Calculated geometric properties shall accurately account for loss of section due to corrosion, decay, spalling, damage, or wear.

For steel members, gross or net section properties shall be calculated as appropriate and shall account for the actual, in-situ condition or bolt/rivet pattern. Gross properties for dead load calculations may be overestimated by factoring up the primary member's gross area by a percentage to account for bracing, bolts, etc., but shall be refined if any member does not meet the required rating levels determined in Section 13.9, Equipment Demands on Structures.

13.7 REQUIRED RATING CHECKS AND ANALYSIS METHODS PER BRIDGE COMPONENT

13.7.1 FRA Bridge Rating

Any rail supporting structure with a span length over 10 feet constitutes a bridge per the FRA definition and shall be rated unless otherwise directed by the SCRRA Director of Structures. This definition is extended for SCRRA purposes to require any component on a rail structure that is directly supporting track load to be rated, unless otherwise excluded in the following sections.

13.7.2 Analysis Methods

Axial forces, shear forces, and bending moments shall be determined from an analysis that is consistent with the member support and connection conditions. Simple span support assumptions shall be used where the assumption matches the existing condition of the member, or where it would be conservative to assume a simple span condition. The following sections have suggestions for analysis methods; alternative rational analysis methods that provide the appropriate level of accuracy and detail may be used at the engineer's discretion.

Span deflections need not be checked unless the span is over a roadway.

Diaphragms, horizontal cross-bracing, lateral cross-bracing, and other secondary members themselves need not be checked unless the inspection reveals that such members are being overstressed. In all cases, the condition of secondary members used to laterally brace primary components shall be accounted for in the rating of primary members.

Components subject to combined loading effects (axial and bending effects) shall use the appropriate interaction equation that combines such effects.

13.7.3 Open-Deck Timber Ties

Timber ties that rest directly on the top flanges of the steel beams that comprise the superstructure are structural members and need to be evaluated and rated if their sizes do not meet current SCRRA design criteria, as shown in Table 13-1, or if their current condition justifies an analysis. Open-deck ties shall be rated for bending moment, shear, and bearing (between the bottom of the tie and the supporting top flange). Timber ties supported by chorded timber stringers do not need to be rated if the stringer chords are located directly beneath each rail.

TABLE 13-1. OPEN DECK TIMBER TIES REQUIREMENTS

Beam Spacing (#/track)	Minimum Tie Depth
5'-0"* (4/track)	7 1/8"
3'-9" (3/track)	8 1/8"
4'-0" (3/track)	9 1/2"
5'-0" (3/track)	11"
6'-0" (2/track)	6 1/8"
6'-6" (2/track)	7 1/2"
7'-0" (2/track)	9 1/4"
7'-6" (2/track)	10 1/2"
8'-0" (2/track)	12"
8'-6" (2/track)	15 1/2"
9'-0" (2/track)	16 1/2"
10'-0" (2/track)	18 3/8"

Notes:
* 2 beams/chord with 5’-0” between chord centerlines.
Ties shall extend a minimum of 1'-0" from CL of exterior beam or shall be 10'-0" minimum.
All ties shall be hardwood ties of Oak-Hickory group (Red Oak, White Oak, and Hickories)

Open-deck ties shall be analyzed as continuous beams, as appropriate, and modeled with one of the following possible support conditions provided by the supporting beams:

1. Point supports at each beam centerline
2. Point supports at each edge of the top flange (two supports per beam)
3. Uniform bearing pressure across the whole top flange

Longitudinal distribution of an axle load shall be per the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.1.

13.7.4 Timber Deck Planks

Timber deck planks that serve as the ballast pan of ballast deck bridges that rest on the top flanges of the beams that comprise the superstructure are structural members and need to be evaluated and rated if their sizes do not meet current BNSF or UP criteria (whichever is more stringent) or if their current condition justifies an analysis. Timber deck planks shall be rated for bending moment, shear, and bearing (between the bottom of the plank and the supporting top flange).

Timber deck planks shall be analyzed as continuous beams, as appropriate, and modeled with one of the possible support conditions listed in Section 13.7.3, Open-Deck Timber Ties. Distribution of an axle load shall be per the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.2.2.

13.7.5 Timber Stringers

Timber stringers shall be rated for bending moment, horizontal shear, and compression perpendicular to grain.

Analysis of the stringers shall account for the continuity that may exist across bent caps due to the arrangement and layout of stringers within each chord that is typical of timber trestle construction, as discussed in the AREMA Manual for Railway Engineering, Chapter 7, Section 3.1.5c.

13.7.6 Timber Pile Caps and Piles

Per the SCRRA Director of Structures, primary timber trestle substructure components shall be rated.

A standard bent with driven timber piling and a timber pile cap shall be modeled as a continuous beam (pile cap) on elastic springs (piles). The springs shall be calculated based on the piles' axial stiffness with an assumed depth to fixity of 10 feet, or as appropriate to the bridge site conditions.

Pile caps shall be rated for bending moment, horizontal shear, and compression perpendicular to grain. Piles shall be rated for axial capacity only. If design information does not exist, the allowable axial capacity shall be assumed to be 20 tons.

13.7.7 Masonry Arches

Masonry arch structures with a span length from spring line to spring line that is greater than 10 feet shall be rated. Masonry arch structures may be rated using any reasonable method that accounts for the passive resistance of the contained soil, the load path of the train effects onto the arch and spandrels, and the lack of tensile capacity of a masonry structure (unless it is somehow reinforced).

The arch component shall be rated based on its compressive capacity. A spandrel wall shall be rated for overturning and sliding; bearing pressure need not be checked.

Several different methods of analysis have been developed by engineers in the railroad industry in recent years. Further direction is provided in the 2001 and 2009 AREMA Conference Proceedings.

13.7.8 Reinforced Concrete Box Culverts

Reinforced concrete box culverts with a span(s) over 10 feet shall be rated for positive/negative bending moment and shear on all slabs adjacent to soil and for axial compression on interior walls supporting the top slab.

Analysis of a reinforced concrete box culvert may be done in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Section 16.4.2e. Alternatively, the box culvert may be modeled using assumed non-linear soil spring restraints at 1-foot intervals around the perimeter of the box with the appropriate loads applied perpendicular to each face of the box; in this analysis, the model shall not be rigidly supported at any node.

13.7.9 Concrete Decks

Concrete decks (composite/non-composite, conventional/prestressed) shall be rated for positive/negative bending moment and shear in the transverse direction. In the transverse direction, the deck shall be modeled as a continuous beam with point supports at each beam centerline. Reinforcing steel fatigue checks need not be made for concrete decks in multi-beam applications.

In the longitudinal direction, rating of a composite concrete deck shall be included during the longitudinal beam rating of the structure and shall include a horizontal shear rating at the interface between the bottom of the deck and the top of the beam.

13.7.10 Conventionally Reinforced Concrete Beams

Reinforced concrete beams with mild reinforcing shall be rated for positive bending moment and shear; beams shall be rated for negative bending moment if appropriate. At a minimum, ratings shall be completed at the section with maximum positive bending moment and at a distance “d” from the face of the support for shear; additional sections shall be rated if longitudinal reinforcing is not continuous or where transverse shear reinforcing changes spacing or size.

Composite action between a concrete deck and the beams may be used if an adequate shear transfer mechanism exists between the deck and the beams.

13.7.11 Prestressed/Post-Tensioned Concrete Beams

Concrete beams with high-strength prestressing or post-tensioned strands shall be rated at service level and at strength level. Service level rating checks shall consist of a concrete compression stress rating, a concrete tension stress rating, and a prestressing/post-tensioning strand stress rating. Strength level checks shall consist of shear and positive moment ratings. At a minimum, ratings shall be completed at the section with maximum positive bending moment and at a distance “d” from the face of the support for shear; additional sections shall be rated if prestressing strands are harped or where transverse shear reinforcing changes spacing or size.

Composite action between a concrete deck and the beams may be used if an adequate shear transfer mechanism exists between the deck and the beams.

13.7.12 Steel Ballast Pan

Steel plates that serve as the ballast pan of ballast deck bridges that rest on the top flanges of the beams that comprise the superstructure are structural members and need to be evaluated and rated. Steel ballast pans shall be rated for bending moment.

Steel ballast pans shall be analyzed as continuous beams, as appropriate, and modeled with one of the possible support conditions listed in Section 11.7.1, Open-Deck Timber Ties, above. Distribution of an axle load shall be per the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.2.2.

13.7.13 Steel Rolled Beam Spans

Steel rolled beam spans shall be rated for bending moment and shear at the locations of maximum demand. If the beams are spliced, the splices shall be rated for the checks listed in Section 11.7.17, Splices in Steel Members, below.

Loads shall be appropriately distributed to each beam line according to the deck conditions, the bracing and diaphragm spacing, and the location of each beam relative to the group and centerline track. Further guidance on open-deck and ballast-deck spans and direct fixation is provided in the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.

13.7.14 Steel Deck Plate Girders

Steel riveted/bolted/welded deck plate girder spans shall be rated for bending moment and shear at the locations of maximum demand and at all locations where the beam changes section properties. If the girders are spliced, the splices shall be rated for the checks listed in Section 13.7.19, Splices in Steel Members.

Loads shall be appropriately distributed to each girder line according to the deck conditions, the bracing and diaphragm spacing, and the location of each girder relative to the group and centerline track. Further guidance is provided in the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.

13.7.15 Steel Through-Plate Girders

Steel TPG spans are built in a variety of ways, but generally are comprised of a flooring system that supports the track which transfers load to the TPGs on the outside of the track(s). The following sections detail the required rating checks that are to be made for TPG spans, as appropriate.

<u>Stringers</u>

Stringers that span between floorbeams may be made up of either rolled beams or built-up members. In accordance with the AREMA Manual for Railway Engineering, Chapter 15, Section 1.2.7, stringers shall be assumed to be a simple span from centerline to centerline of the floorbeams.

Stringers shall be rated in accordance with Section 13.7.13, Steel Rolled Beam Spans, or Section 13.7.14, Steel Deck Plate Girders, depending on if they are rolled shapes or built-up members, respectively.

<u>Floorbeams</u>

Floorbeams that span between TPGs may be made up of either rolled beams or built-up members. In accordance with the AREMA Manual for Railway Engineering, Chapter 15, Section 1.2.7, floorbeams shall be assumed to be a simple span from centerline to centerline of TPGs.

Floorbeams shall be rated in accordance with Section 13.7.13, Steel Rolled Beam Spans, or Section 13.7.14, Steel Deck Plate Girders, depending on if they are rolled shapes or built-up members, respectively.

TPGs

TPGs are usually steel riveted, bolted, or welded built-up members that are designed as a simple span member between bent or pier supports. Track loads shall be appropriately distributed to each TPG line considering track superelevation and position.

TPGs shall be rated in accordance with Section 13.7.14, Steel Deck Plate Girders, including the splice requirements discussed in Section 13.7.19, Splices in Steel Members.

13.7.16 Steel Trusses

Steel truss spans usually consist of a flooring system that supports the track which transfers the load to each truss line, either below or adjacent to the track. The following sections detail the required rating checks that are to be made for truss spans, as appropriate.

Stringers

Stringers that span between floorbeams may be made up of either rolled beams or built-up members. In accordance with the AREMA Manual for Railway Engineering, Chapter 15, Section 1.2.7, stringers shall be assumed to be a simple span from centerline to centerline of floorbeams.

Stringers shall be rated in accordance with Section 13.7.13, Steel Rolled Beam Spans, or Section 13.7.14, Steel Deck Plate Girders, depending on if they are rolled shapes or built-up members, respectively.

Floorbeams

Floorbeams that span between truss lines may be made up of either rolled beams or built-up members. In accordance with the AREMA Manual for Railway Engineering, Chapter 15, Section 1.2.7, floorbeams shall be assumed to be a simple span from centerline to centerline of trusses.

Floorbeams shall be rated in accordance with Section 13.7.13, Steel Rolled Beam Spans, or Section 13.7.14, Steel Deck Plate Girders, depending on if they are rolled shapes or built-up members, respectively.

Trusses

Each individual member in a truss line shall be rated for axial tension or compression (or both), as applicable, using the maximum forces that develop in the truss configuration based on the track configuration and location. The following ratings shall be made per truss member type:

- Tension Members – Rate for yield on the gross section (with special consideration for eyebars) and fracture on the net section.
- Compression Members – Rate for gross axial compression.
- Dual Members – Rate for all tension member and compression member limit states.

Pins

Pins used to connect individual truss members together (except at bearings) shall be rated for flexure and shear. The actual position of the members attached to the pin shall be determined during the inspection to ensure that forces are accurately applied to the pin during the rating.

13.7.17 Bearings

Bearings shall generally not be required to be rated unless the SCRRA Director of Structures or the inspection results indicate a need for a bearing to be analyzed. If necessary, pins shall be rated as described above, and all other bearings shall be rated for compression (or bearing) on the materials (typically concrete, steel, or elastomer) that are in contact. Load transfer may generally be assumed to follow a 1:1 slope from the top contact plane through a material to the bottom contact plane, unless limited by the dimensions of the layer.

13.7.18 Connections

The capacity of connections between primary members (stringer to floorbeam, floorbeam to TPG, etc.) shall be rated for a minimum of bolt/rivet shear and bearing or weld/base metal shear capacity.

Connections between secondary and primary members need not be rated unless otherwise directed by the SCRRA Director of Structures; however, the bracing capacity of secondary members shall be accurately accommodated during the rating of the primary member.

13.7.19 Splices in Steel Members

A primary superstructure member that is spliced shall have additional rating analyses performed on the splice itself. Typically, steel beams, DPGs, or TPGs are only spliced as a result of shipping or weight limitations that may have existed during fabrication; truss members are generally spliced at changes in section or to facilitate field erection. If other types of members are spliced, special consideration shall be required and shall be coordinated with the SCRRA Director of Structures.

The following checks need to be made for steel I-shaped members and steel truss chords that are spliced:

- Top Flange/Compression Chord Splice – Verify that the splice plate area is greater than the flange being spliced, rate axial stress in the splice plate, and rate the connection material (weld, bolt, rivet) stress for shear flow and load transfer effects.
- Web (Shear) Splice – Verify that the splice plate area and net moment of inertia are greater than the web being spliced, rate the flexural capacity of the splice plates, and rate the rivet or bolt capacity. Rating calculations shall include bending and eccentric load effects on the plates and bolts/rivets.
- Bottom Flange/Tension Chord Splice – Verify that the splice plate area is greater than the flange being spliced, rate axial stress in splice plate for yield on the gross and fracture on the net, and rate the connection material (weld, bolt, rivet) stress for shear flow and load transfer effects.

13.8 RATING OF RAILROAD BRIDGES WITHOUT DESIGN DOCUMENTATION

When little or no documentation is available regarding material properties and design details of a bridge, the difficulty encountered in determining a load rating increases significantly. As a result, refer to the technical paper entitled "CTO34 – Rating of Railroad Bridges without Design Documentation" developed for SCRRA dated March 29, 2013, offering possible solutions to the challenge of rating railroad bridges without design documentation. A brief discussion is provided for bridges with steel components for reference. Available methods and testing technology for bridges with concrete components are also presented in greater detail due to the inability to visually determine the properties necessary for rating these structures.

13.9 SUBSTRUCTURE RATING

A rating (Normal, Maximum) for a substructure component is generally not required unless the field inspection indicates signs of settlement, cracking, deflection, scour, etc., that suggest the capacity of the substructure member is deficient.

If a substructure rating is determined to be necessary, adequate as-built information is required of the foundation type, materials, extents, etc., for an accurate rating to be completed. If adequate information does not exist to rate the substructure component, a permanent repair (or temporary repair until a permanent one can be completed) may be required in lieu of a load rating calculation.

Substructure rating shall be authorized by the SCRRA Director of Structures.

13.10 EQUIPMENT DEMANDS ON STRUCTURES

Once the controlling Normal and Maximum Load Rating levels of all required elements have been determined, the demand required by typical train consists on SCRRA tracks shall be calculated and contrasted to a member's capacity in order to determine which structures or components do not have the requisite strength necessary to carry the load.

The Normal Rating comparison shall be used to determine structural repair or replacement recommendations and the immediacy with which they should be completed. The Fatigue Rating comparison, where necessary, shall be used to estimate the structure's or component's remaining life. The Maximum Rating shall be kept on file and used where infrequent heavy load clearance authorization is required.

Figure 13-1 through Figure 13-7 have units of kips and feet. In all cases except the Cooper E80 consist, the number of trailing passenger or freight cars shall be extended to maximize the load on a long span, if necessary. The SCRRA Director of Structures shall indicate if any of the consists shown in Figure 13-2 through Figure 13-7 do not apply to the structure.

13.10.1 Cooper E80 Consist

For reference, the Cooper E80 consist is shown in Figure 13-1 and shall be used as the basis for the load rating capacity calculations and the typical train consist demand requirements of a bridge component. All capacities and consist demands shall be listed as a Cooper's Equivalent.

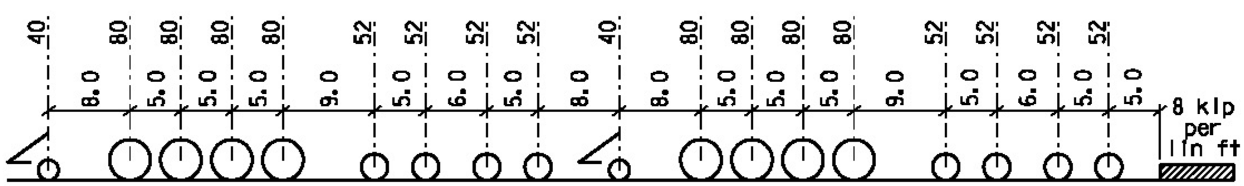


FIGURE 13-1. COOPER E-80 CONSIST

13.10.2 286-kip Gross Weight Car Unit Train Consist

A typical 286-kip gross weight car unit train consist is shown in Figure 13-2. It assumes two SD70AC locomotives are pulling a consist of 286-kip coal cars.

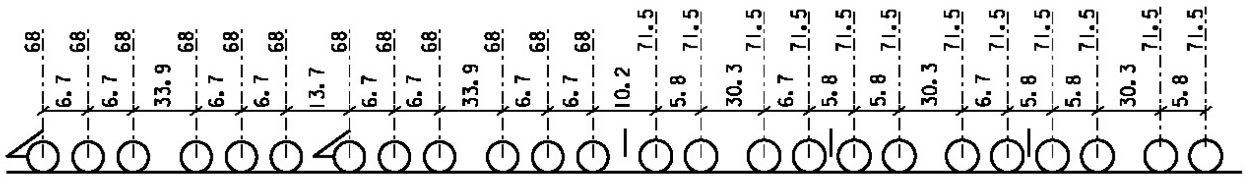


FIGURE 13-2. 286-KIP GROSS WEIGHT UNIT TRAIN CONSIST

13.10.3 315-kip Gross Weight Car Unit Train Consist

A typical 315-kip gross weight car unit train consist is shown in Figure 13-3. It assumes two SD70AC locomotives are pulling a consist of 315-kip coal cars.

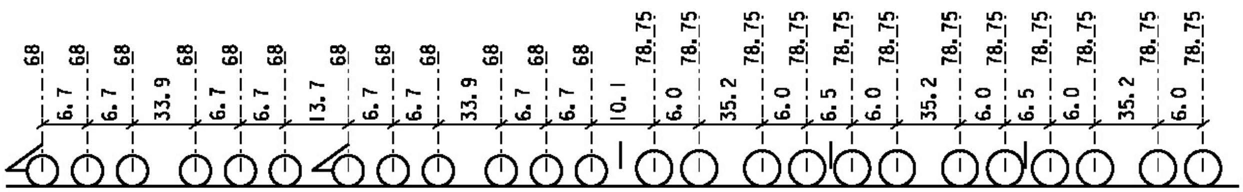


FIGURE 13-3. 315-KIP GROSS WEIGHT UNIT TRAIN CONSIST

13.10.4 125-ton Intermodal Double Stack Unit Train Consist

A typical intermodal unit train consist is shown in Figure 13-4. It assumes two SD70AC locomotives are pulling a consist of 125-ton five-unit articulated intermodal well cars.

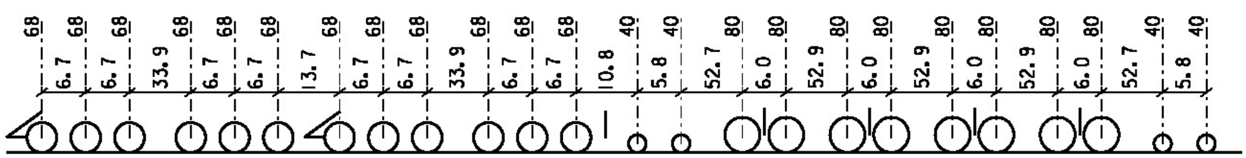


FIGURE 13-4. 125-TON INTERMODAL DOUBLE STACK UNIT TRAIN CONSIST

13.10.5 Amtrak Passenger Train Consist

A typical Amtrak passenger train is shown in Figure 13-5. It assumes a single GE Genesis Series 1 locomotive pulling several Superliner coach cars.

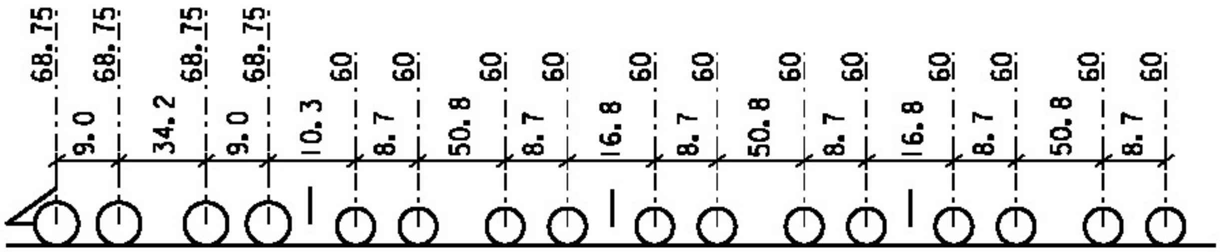


FIGURE 13-5. AMTRAK PASSENGER TRAIN CONSIST

13.10.6 SCRRA Passenger Train Consist A

A typical SCRRA passenger train is shown in Figure 13-6. It assumes a single F40PHM locomotive pulling several Bombardier coach cars.

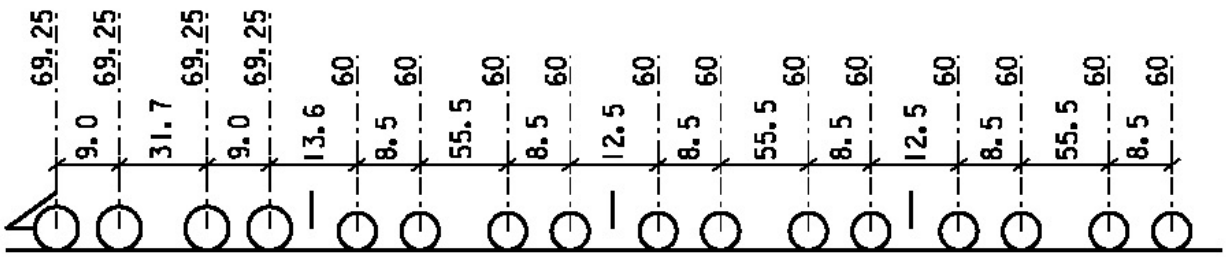


FIGURE 13-6. SCRRA PASSENGER TRAIN CONSIST A

13.10.7 SCRRA Passenger Train Consist B

Another typical SCRRA passenger train is shown in Figure 13-7. It assumes a single F125 locomotive pulling several Bombardier coach cars.

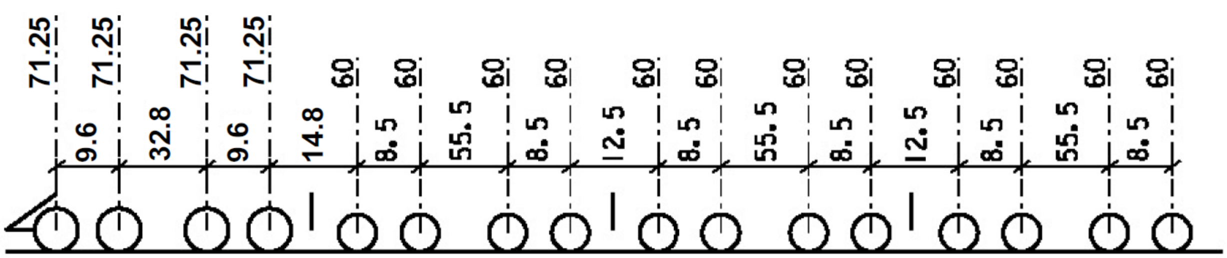


FIGURE 13-7. SCRRA PASSENGER TRAIN CONSIST B

13.11 RATING RESULTS FORMAT

The Normal and Maximum Ratings for each member and for each required check shall be listed in tabular format and compared to the typical consist demands that occur over that bridge. A sample table for a steel rolled beam stringer that is not spliced with bolted connections is provided in Table 13-2.

The load rating report shall indicate any members whose ratings are below the actual train demands on the structure and shall suggest and recommend ways for SCRRA to safely carry train traffic. Load rating results that show that a member is significantly overstressed shall immediately be brought to the attention of the SCRRA Director of Structures.

TABLE 13-2. RATING RESULTS SAMPLE TABLE

Rating Check		**Normal**	**Fatigue**	**Maximum**	**286-kip Unit Train**	**Amtrak Passenger Train**	**SCRRA Passenger Train A**
Stringer Rating As-Built / Existing Conditions	Flexure	E-72.1	E-140.0	E-114.6	E-70.2	E-60.1	E-58.8
	Shear	E-90.5	N/A	E-150.2	E-65.5	E-58.1	E-56.8
	Bolt Shear	E-95.4	N/A	E-160.2	E-65.5	E-58.1	E-56.8
	Bolt Bearing	E-105.7	N/A	E-175.6	E-65.5	E-58.1	E-56.8

Only the 286-kip unit train, Amtrak passenger train, and SCRRA passenger train A demands are shown in Table 13-2, as the example assumes that 315-kip unit trains, SCRRA passenger train B and intermodal unit trains do not run across this bridge.

14.0 SEISMIC DESIGN

14.1 SCOPE

The preferred and in some cases minimum seismic design provisions included in this chapter shall apply to structures proposed for support of SCRRA railroad tracks, including bridges, earth-retaining structures, and earthen embankments that directly support railroad live loads or may be influenced by railroad live load surcharge. The concurrence of railroad live load and the design seismic event need not be considered, as is consistent with AREMA guidelines. Separate provisions are presented for seismic design of bridges, retaining walls, and soil slopes. Design of culverts need not consider seismically induced deformations or forces unless determined necessary by the design engineer. Bridges and earth-retaining structures that do not support railroad tracks shall be designed in accordance with current Caltrans requirements. For building facilities and other structures, seismic design shall conform to the applicable building codes.

14.2 STANDARDS AND CODES

In general, the seismic design considerations included in this chapter have been developed to be consistent with AREMA guidelines and current railroad industry design practices. In some cases, practices or recommendations for seismic design of structures in other codes and standards commonly applied in southern California and other seismically active areas have been included to provide specific guidance on applying and satisfying the provisions of AREMA.

The AREMA Manual for Railway Engineering, Chapter 9, Seismic Design for Railway Structures, is the primary design reference. All provisions of the AREMA Manual for Railway Engineering, Chapter 9 shall apply unless specifically excluded by the provisions of this chapter.

In addition to the AREMA Manual for Railway Engineering, the following documents were consulted in the development of this chapter:

- AASHTO “Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition” (2011)
- AASHTO “LRFD Road Tunnel Design and Construction Guide Specifications, 1st Edition” (2017)
- Caltrans “Seismic Design Criteria,” Current Version
- M.J.N. Priestly, F. Seible, and G.M. Calvi, *Seismic Design and Retrofit of Bridges* (1996)
- Zolan Prucz and Abbas Pourbohloul, “Bridge Configurations and Details that Improve Seismic Performance” (1999)
- Howard C. Swanson, “Structural Importance Classification of Railroad Structures for Seismic Design” (June 1, 1999)
- METRO “Rail Design Criteria, section 1.3.2 and 2.3.3 in Appendix, Chapter 3 Part B

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

14.3 SEISMIC HAZARDS

Several potential hazards associated with seismic activity, including ground surface rupture, strong ground motion, liquefaction, lateral spreading of unconfined layers, and seismically induced settlement, must be considered during the design process and are discussed below.

14.3.1 Ground Surface Rupture

Each site shall be evaluated for hazard of ground surface rupture based on mapped active faults and geologic reconnaissance, which may include site visits, reference reports, geologic maps, and stereoscopic aerial photographs. Evidence of known active fault splays (faults that have exhibited evidence of ground displacement within the last 11,000 years) should be considered. The potential for ground rupture due to faulting at the site shall be determined, and if necessary, specific design considerations to prevent collapse in such an event shall be included. Lurching or cracking of the ground surface as a result of nearby events should also be taken into consideration during design.

14.3.2 Ground Motion

To evaluate anticipated ground accelerations at each site, a site-specific probabilistic seismic hazard analysis for each site shall be performed. A probabilistic analysis incorporates uncertainties in time, recurrence intervals, size, and location (along faults) of hypothetical earthquakes. This method thus accounts for the likelihood, rather than certainty, of occurrence and provides levels of ground acceleration that might be more reasonably hypothesized for a finite exposure period.

In addition to the AREMA three-level ground motion hazards, the Caltrans Maximum Credible Earthquake (MCE) shall be provided. The estimated PGA values for each ground motion level, as well as the site-specific acceleration response spectra (ARS) curves for each ground motion level, shall be provided in graphic and tabular format for the site.

14.3.3 Liquefaction, Lateral Spreading, and Seismically Induced Settlement

Liquefaction is the phenomenon in which loosely deposited granular soils with a clay content (particles less than 0.005 mm) of less than 15 percent, a liquid limit less than 35 percent, and a natural moisture content greater than 90 percent of the liquid limit, and that are located below the water table, undergo rapid loss of shear strength when subjected to strong earthquake-induced ground shaking. Ground shaking of sufficient duration results in the loss of grain-to-grain contact due to a rapid rise in pore water pressure, causing the soil to behave as a fluid for a short period of time. Liquefaction is known generally to occur in saturated or near-saturated cohesionless soils at depths shallower than 50 feet below the existing ground surface. Factors known to influence liquefaction potential include composition and thickness of soil layers, grain size, relative density, groundwater level, degree of saturation, and both intensity and duration of ground shaking. Liquefaction of subsurface layers can cause lateral spreading of unconfined layers above, lurching, cracking, and significant settlement.

The potential for liquefaction, lateral spreading, and seismically induced settlement should be evaluated at each site through site-specific subsurface and laboratory analyses during the design phase of the project. Structural analysis and design for structures shall include reduced lateral stiffness and/or stability of the foundations due to liquefiable soils. Liquefaction may occur at any level of seismic event, and recommendations shall be provided specifically for each design level under consideration.

14.4 GENERAL REQUIREMENTS

14.4.1 Design Approach

SCRRA structures shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 9, as modified or augmented in this chapter based on pertinent sections of the following standards or codes:

- Caltrans “Seismic Design Criteria” (SDC), Current Version “Capacities of Structural Components,” Section 7 “Design,” and Section 8 “Seismic Detailing.”
- AASHTO “Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition”, Section 7 “Structural Steel Components”
- AASHTO “LRFD Road Tunnel Design and Construction Guide Specs 1st Edition” (2017)

The seismic design guidelines included in the AREMA Manual for Railway Engineering, Chapter 9, are based on a three-level ground motion and performance criteria approach that is consistent with the railroad post-seismic-event response procedures.

Caltrans SDC and AASHTO provisions are applied with AREMA Level 2 and Level 3 events to provide design methodology and ductility requirements on which AREMA is silent. In general, railroad-bridge-specific research and testing regarding seismic detailing and performance is limited. Therefore, recommendations for highway bridge design have been substituted through the use of Caltrans SDC and AASHTO. In some cases, meeting those provisions for AREMA events can result in more conservative designs than would be otherwise necessary.

Design process for all seismic measures/retrofits shall include a climate vulnerability review to identify opportunities to simultaneously address climate hazard vulnerability based on projected future conditions within the anticipated lifetime of the asset. If undertaking climate adaption measures/retrofits, combine with seismic retrofits where needed to ensure assets are resilient to earthquakes and climate vulnerability to minimize service disruptions.

14.4.2 Structure Importance Classification

Structure importance classification (SIC) is used to determine the appropriate return period for each of the three ground motion levels per AREMA Manual for Railway Engineering, Chapter 9. The SIC is determined by three measures, which are weighted according to the limit state to determine the overall SIC:

- Immediate Safety – Factor based on occupancy, hazardous material, and community lifelines.
- Immediate Value – Factor based on railroad utilization and the detour availability.
- Replacement Value – Factor based on span length, bridge length, and bridge height.

14.4.3 Risk Factors

The factors provided in Table 14-1 may be assumed in calculating a set of Preliminary Bridge SICs for each of the three limit states.

TABLE 14-1. BRIDGE SIC RISK FACTORS

Risk Factor	AREMA Manual for Railway Engineering, Chapter 9, Reference	Value*
Immediate Safety	1.3.2.2.1	
Occupancy Factor	1.3.2.2.1(a)	4
Hazardous Material Factor	1.3.2.2.1(b)	1
Community Lifelines Factor	1.3.2.2.1(c)	1
Combined Immediate Safety Factor	1.3.2.2.1	4
Immediate Value	1.3.2.2.2	—
Railroad Utilization Factor	1.3.2.2.2(a)	2 to 4
Detour Availability Factor	1.3.2.2.2(b)	1
Combined Immediate Value Factor	1.3.2.2.2(b)	2 to 4
Replacement Value	1.3.2.2.3	—
Span Length Factor	1.3.2.2.3(a)	per AREMA
Bridge Length Factor	1.3.2.2.3(b)	per AREMA
Bridge Height Factor	1.3.2.2.3(c)	per AREMA
Combined Replacement Value Factor	1.3.2.2.3	per AREMA

* Values specific to each site are to be determined during final design in coordination with SCRRA. Some values may be the same for all sites on a given route. The difference in values between preliminary and final design should not affect structure type selection.

14.4.4 Combining Factors to Determine Return Periods

Combined risk factors are weighted as described in the AREMA Manual for Railway Engineering to determine the SIC for each ground motion level. A range of average return period (Table 14-2) is associated with each ground motion level. The specific average return period is calculated by using the SIC with a linear relationship between shortest and longest return period for that ground motion level. A SIC of 0 is associated with the shortest return period, and a SIC of 4 is associated with the longest return period.

14.5 BRIDGE SEISMIC PERFORMANCE CRITERIA

The seismic performance criteria shall be based on the design stress levels and expected behavior of the members in the structure:

- All of the members respond elastically to the occasional seismic event (Level 1, Serviceability Limit State).

- Critical non-redundant members respond elastically, with the balance of the structure deforming inelastically to the rare seismic event (Level 2, Ultimate Limit State).
- Critical members that are designed and detailed for ductile behavior under seismically induced movements respond inelastically with full plastic deformation during the very rare seismic event (Level 3, Survivability Limit State).

These seismic performance criteria define limit states of serviceability, ultimate, and survivability, as shown in Table 14-2.

TABLE 14-2. BRIDGE SEISMIC PERFORMANCE CRITERIA

Ground Motion Level	Performance Criteria Limit State	Frequency	Average Return Period	Critical Member Behavior
1	**Serviceability**	Occasional	50-100 years	Elastic stress range
2	**Ultimate**	Rare	200-500 years	Ultimate strength and structure stability
3	**Survivability**	Very Rare	1,000-2,400 years	Emphasis on detailing for inelastic ductility

The characteristics of each ground motion level are as follows:

- Level 1 Ground Motion
  - Structure members shall remain in the elastic stress range.
  - Trains may continue at normal or restricted speed over bridges subjected to this ground motion level, as stated in the SCRRA Engineering Instructions. Structure inspections may or may not be performed based on SCRRA Engineering Instructions.
  - No structure damage is expected.
- Level 2 Ground Motion
  - Strength and stability of critical structure members shall not be exceeded.
  - Trains must stop until inspections of bridges subjected to this ground motion level are completed, as stated in the SCRRA Engineering Instructions.
  - Structure damage should be easily detected and accessible for repair.
  - Foundation elements below ground shall be designed to remain elastic.
- Level 3 Ground Motion
  - Critical structure members exhibit ductile behavior under inelastic deformations with no structural collapse.
  - Trains must stop until inspections of bridges subjected to this ground motion level are completed, as stated in the SCRRA Engineering Instructions.
  - Extensive structure damage is expected and may not be repairable.

- Survivability limit state analysis and design should be performed in accordance with Caltrans SDC, with the AREMA Level 3 response spectrum and the applicable return period of the earthquake event. The design approach references the Caltrans SDC because AREMA does not specify a defined approach for designing to meet the survivability limit state.

14.6 BRIDGE DAMAGE CONTROL CRITERIA

A three-level ground motion and performance criteria approach is employed to enable train safety and structure serviceability after an occasional earthquake, to minimize the cost of damage and loss of structure use after a rare earthquake, and to prevent structure collapse after a very rare earthquake, as shown in Table 14-3.

TABLE 14-3. BRIDGE DAMAGE CONTROL CRITERIA

Limit State	Description
Serviceability	No Damage
Ultimate	No Underground Damage
Survivability	No Collapse

14.7 BRIDGE RESPONSE LIMITS CRITERIA

Governing limits on the response of structures to seismic effects and the performance of structural members and connections differ based on structure configuration, material type, ground motion level, damage control, and expected ductility. The response limits provided in Table 14-4 shall be satisfied for each structure material:

TABLE 14-4. BRIDGE RESPONSE LIMITS CRITERIA

Limit State	Material	Stress Limits/Behavior
Serviceability	Steel	AREMA Manual for Railway Engineering, Chapter 15, allowable stresses may be increased by 50%
	Concrete	AREMA Manual for Railway Engineering, Chapter 8, load factor design with load factors of 1.0
Ultimate	Steel	F_{ye}=1.1Fy and AASHTO “Guide Specifications for LRFD Seismic Bridge Design,” as applicable
	Concrete	Caltrans SDC
Survivability	Steel	F_{ye}=1.1Fy and AASHTO “Guide Specifications for LRFD Seismic Bridge Design,” supplemented with project specific design criteria for substructures composed of braced frames or W or H section steel members.
	Concrete	Caltrans SDC

14.8 BRIDGE TYPE SELECTION CRITERIA

14.8.1 Structure Configuration

When determining the structure configuration and layout, the designer shall consider factors including simplicity, regularity, integrity, redundancy, ductility, and ease of inspection and repair after a seismic event.

14.8.2 Superstructure

Simply supported spans of standard configuration are accepted by SCRRA because they have performed well during past earthquakes and can be repaired or replaced more readily than continuous spans.

14.8.3 Substructure

Wide seat widths at the abutments and piers allow for large displacements without unseating the bridge spans. Seat widths shall be provided in accordance with the AREMA Manual for Railway Engineering, Chapter 9, Section 1.4.7.4.1.

14.8.4 Foundations

When selecting the foundation type, the designer should consider the seismic hazard and the soil conditions at the site. To the extent possible, bridge foundations in regions of high seismicity should be founded on stiff and stable soil layers, preferably rock. Deep foundations are required in order to reach below liquefiable soil layers. Piles should have sufficient buckling capacity to resist vertical loads in case of liquefaction of surrounding soil layers.

Deep shaft foundations shall be upsized to meet the weak column provisions of Section 14.11.3 and remain elastic under seismic loading. This is commonly defined as a Type II shaft, where the below-ground shaft is larger in diameter than the above-ground column.

A substitution request for a Type I shaft may be considered, where a constant diameter shaft and column are constructed, if the magnitude of scour at a river crossing results in an unreasonable design with Type II shafts. However, if a Type I shaft is approved by SCRRA, steel casing and/or added reinforcing steel shall be used to strengthen the below-ground shaft to meet the weak column provisions.

14.9 BRIDGE CONFIGURATION AND LAYOUT CRITERIA

14.9.1 Simplicity

Simplicity is an important characteristic for good seismic behavior. Bridges with a direct and clear seismic load path, a predictable response, and simple connection details are preferred over complex structures. Bridges that are simple will be easier to inspect and repair. In simple structures, the most important members in the seismic load transfer system can be readily identified, designed, and detailed for adequate behavior. Bridges with sufficient seat widths and simply supported spans have performed well in the past and should continue to be used whenever possible.

14.9.2 Symmetry and Regularity

Symmetry and regularity characteristics tend to minimize torsional effects, which are likely to result in large and unexpected seismic demands. Rotational response of structures has been a main cause of damage during past earthquakes. Therefore, to the extent possible, the following symmetry and regularity criteria should be considered:

- The bridge structure should have a uniform distribution of mass, strength, and stiffness in both the longitudinal and the transverse directions.
- Abrupt or unusual changes in weight, strength, stiffness, and geometry along a span, and large changes in these parameters from span to span, should be avoided.
- The horizontal strength and stiffness of substructure elements should not vary much along the bridge, and the placement of the fixed and expansion bearings should be such that a balanced seismic load distribution to all piers can be achieved.
- Columns in multi-column bents should be of equal height, and there should not be any abrupt changes in geometry along the height of piers.
- Severe skews should be avoided even at the expense of providing longer spans or making changes in alignment.

14.9.3 Integrity

Different parts of a bridge may respond differently during an earthquake and may result in large relative displacements. Displacement compatibility may be achieved by either designing connections to resist deformations or by allowing displacements or deformations to occur in a controlled manner.

The design of expansion joints and bearings is critical to the seismic performance of the structure. Large earthquake-induced seismic forces and displacements can result at these locations and at other discontinuities within the superstructure, and they must be accounted for during design. Increased integrity is achieved by keeping the number of connections that are vulnerable to seismic loading to a minimum.

Measures for preventing excessive relative displacements of superstructure components include placing foundations on firm and stable ground and driving piles to stable soil as well as providing shear keys and other restraining devices at the seats. Track structures continuous through the bridge can increase integrity, especially in the longitudinal direction. Catcher and back-up systems may be added to prevent collapse during a severe earthquake, even if significant damage has occurred.

14.9.4 Ductility

During large earthquakes, stresses and strains in bridge members and connections exceed the elastic range, and structures could experience large inelastic deformations. Ductility is the ability of a member, component, or structure to sustain large deflections beyond the elastic range without failure or collapse. It is usually defined in terms of the ratio between maximum deformation without failure and yield deformation.

The ductility of a structure depends on the individual member ductility and its loading condition, the ductility of the connection details, and the structure configuration. For example, nonductile and poorly braced members loaded in compression may experience sudden failure even prior to reaching yield stresses.

14.10 BRIDGE DUCTILITY REQUIREMENTS

14.10.1 General

Ductility is the main criteria for satisfying the ultimate and the survivability limit state requirements. It is generally quantified as a ratio of ultimate deformation to yield deformation, and it could refer to member, component, or structure ductility.

14.10.2 Reinforced Concrete Structures

Ductility requirements for reinforced concrete members aim to prevent brittle shear failure and to provide adequate reinforcement for ductile bending mechanisms at plastic hinge locations.

For columns, the seismic design and detailing requirements cover the following areas:

- Amount and spacing of vertical reinforcement
- Column flexural resistance for large axial loads
- Column shear and transverse reinforcement in plastic hinge regions
- Transverse reinforcement for confinement at plastic hinge regions
- Spacing of transverse reinforcement for confinement
- Splicing and anchorage of reinforcing bars in plastic hinge regions
- Extension of column reinforcement into bent caps and footings
- Concrete column joints

Seismic detailing requirements for foundations include:

- Increase in footing thickness
- Requirement of minimum pile penetration into the footing and/or special connections for foundations in tension
- Top footing reinforcement and vertical stirrups connecting the top and bottom mats
- Confining ties for longitudinal column reinforcement

14.10.3 Steel Structures

The ductility requirements for steel structures intend to prevent buckling and fracture and provide adequate connections and details. Criteria below are listed for a general starting point in design, but a detailed project-specific criteria needs to be developed and submitted to SCRRA for review and approval.

Seismic detailing requirements for steel structures include:

- Limit the width to thickness (b/t) ratios for plates in compression.
- Limit the slenderness ratio for main compression and bracing members.
- Avoid details that are prone to stress concentrations such as reentrant corners and abrupt changes in thickness.
- In general, avoid using any details susceptible to fracture, especially in areas expected to respond in the plastic range.
- Avoid field welds and other fatigue-prone details.
- Design steel members such that yielding of the gross section occurs before local buckling or fracture.
- Avoid tri-axial tension stress conditions that may occur at locations such as near the intersection of welds in thick elements. They can inhibit the ability of steel to exhibit ductility.
- Use stiffeners that are more rigid than the minimum needed to prevent buckling.

Other recommendations include:

- Limit the axial compression load in columns to a percentage of their yield capacity.
- Provide means for alternate load path in case of damage.
- Ensure that damage occurs in secondary, non-gravity-carrying elements, such as bracing members.
- Consider using the end diaphragms or cross frames as locations for ductile behavior.

14.10.4 Pile Bents

The ductility of bents with batter piles may be limited by the low capacity of the pile to cap connections. When subjected to the high loads that are attracted by the batter piles, these connections are likely to fail in a brittle fashion. Pile bents with vertical piles only can offer a higher ductility capacity than that of bents with batter piles. Pile bents with vertical piles may be designed to perform as ductile moment-resisting frames with significant ductility capacity. Therefore, in regions of high seismicity, the use of bents with vertical piles only should be considered. They may require a larger number of piles or piles with a larger cross section.

In addition, the pile-to-cap connections would need to be designed and detailed for the expected inelastic moments.

14.10.5 Connections

Connections can have a significant effect on seismic resistance. They attract some of the largest seismic demands, and they often are the weakest links in the seismic load-resisting system. Bolted connections are preferable over welded connections. Bolted connections are more ductile and reliable and also provide for more damping. Field welds should be avoided, especially in regions of expected inelastic deformations. Intermittent welds and partial penetration groove welds (transverse to direction of primary stress) are prohibited, as well as those listed in AREMA Chapter 15, Section 1.10.2. Gusset plates should be designed to carry the compressive design strength of the members without local buckling. In order to prevent premature buckling of gusset plate edges, the ratios of the length of free edge of gusset plate to thickness should be limited based on b/t ratio criteria for plates with an unsupported edge.

14.11 BRIDGE DETAILING PROVISIONS FOR LEVEL 2 AND 3 EVENTS

14.11.1 Continuity Provisions

Superstructure

The superstructure shall be designed to carry the lateral loads to the bearings or shear transfer connectors.

The lateral loads from the span may be carried to the end supports by the following load paths:

- Lateral bracing system
- Lateral bending of the girders, including torsional effects as applicable
- Diaphragm action of concrete decks or steel ballast pans provided that the deck is adequately connected to the girders

End cross frames or diaphragms shall be designed to carry the lateral loads to the bearings or shear transfer connectors.

Bearings

The bearings shall be designed to transfer the lateral loads to the substructure.

Bearing may be supplemented by shear connectors to help transfer the lateral loads without failure of the bearing devices.

Elastomeric bearing pads may exceed the allowable shear deformation by 50 percent for Level 1 and may exceed the ultimate shear deformation capacity of the pad for Levels 2 and 3.

14.11.2 Ductility Provisions

General

Seismic ductility and detailing provisions shall conform to the AREMA Manual for Railway Engineering, Chapter 9, Section 1.4.7, and Caltrans SDC Section 8 “Seismic Detailing.”

Longitudinal Reinforcing Confinement

Longitudinal reinforcing in concrete columns, pier walls, and piles shall be adequately confined to allow the member to respond in the inelastic range.

Splices in Reinforcing

Lap splices are not allowed in a main load-carrying member within a distance “d” (effective depth) of any area designed to respond in the inelastic range, including a plastic hinge zone.

14.11.3 Provision to Limit Damage

Weak Column Provisions

Reinforced concrete columns that are designed to respond in the inelastic range shall be detailed to prevent damage to the adjacent superstructure, bent cap, and foundations:

- The bent cap and foundation shall be designed for the lesser of 1.3 times the nominal expected column strength or the Level 3 ground motion load.
- The plastic hinge zone should be designed to occur in a location that can be inspected. A plastic hinge shall not be allowed to form underground.

Concrete Joints

Concrete joints shall be configured and reinforced to reduce the possibility of damage to the superstructure, bent cap, and foundation:

- Provide adequate longitudinal column reinforcement embedment and confinement.
- Provide joint shear reinforcement.

Steel Joints

Joints in main lateral load-carrying steel members shall be designed to be stronger than the adjoining members. This requirement may be met by designing the connections for the lesser of 1.3 times the connecting member expected yield strength or the Level 3 ground motion load.

14.11.4 Redundancy Provisions

Bearing Seats

Bearing seats should be proportioned to accommodate the maximum relative movements caused by seismic actions.

Shear Connectors

Shear connectors may be provided to resist the maximum seismic loads. The shear connectors should be positioned so that they engage prior to failure of the bearing device.

14.12 RETAINING WALLS AND EARTH-RETAINING STRUCTURES

Seismic design of retaining walls and earth-retaining structures need consider only the AREMA Level 2 event. One-half of the AREMA Level 2 PGA shall be applied to the soil mass. Inertia effects on the wall itself generally may be neglected. Only horizontal acceleration due to ground motion need be considered unless determined otherwise by the geotechnical engineer. Increased active earth pressure and decreased passive earth pressure due to ground motion shall be applied to the structure as recommended by the geotechnical engineer. The “Mononobe-Okabe” method or other recognized methods may be used to determine the earthquake active and passive earth pressures. The selected method for determining earth pressures shall be appropriate for the proposed retaining structure type.

In general, earth-retaining structures should be designed to fail by sliding rather than by overturning, if sliding is an applicable failure mechanism, thereby taking advantage of passive earth pressures developed by the sliding and also thereby reducing the seismically-induced active earth pressure. Earth-retaining structures that slide during an earthquake will dissipate a large amount of energy and reduce damage to the track structure supported on the embankment behind the structure. By limiting damage, the risk of losing track line and surface in amounts exceeding what may be readily corrected may be greatly reduced.

If a retaining wall is subject to soil liquefaction under a Level 2 event, the performance level of the wall, including allowable wall settlement, shall be addressed in the project-specific design criteria.

If a soldier pile retaining wall is subject to soil liquefaction under a Level 2 event, wall stability shall be maintained, achieved by including redundant piles, adding tiebacks or other acceptable methods. The wall behavior and stability during a Level 2 event shall be addressed in the project-specific design criteria.

Retaining walls and earth-retaining structures shall be designed such that the following criteria are satisfied for the specified seismic event, as applicable:

- Factor of Safety (FS) > 1.1 against sliding stability failure (ratio of horizontal resisting forces to driving forces).
- FS > 1.5 against overturning stability failure (ratio of moment due to weight of resisting elements to the moment due to driving forces with moments taken about the front toe of the footing).
- FS > 2.0 against bearing capacity failure -OR- increase in allowable bearing pressure of one-third above the static allowable bearing pressure.
- Resultant of vertical force on the structure shall remain within the middle half of the footing.
- The requirements for global stability against deep-seated failure given in Section 14.13 shall apply to earthen embankments with retaining walls.

The minimum factors of safety specified above apply to common retaining wall and earth-retaining structure types with soil and subsurface conditions that have been investigated at the site and generally conform to normal conditions in the local area. For special conditions involving unknown or poorly understood subsurface conditions or uncommon types of earth-retaining structures, more conservative factors of safety should be considered.

In addition, structural components shall be designed to provide ultimate strength in excess of the expected demands of the AREMA Level 2 event and, if possible, to remain within the elastic stress range. Ductile detailing shall be provided for critical structure members and connections.

14.13 EARTHEN EMBANKMENTS AND SOIL SLOPES

The geotechnical engineer shall determine the stability of earthen embankments and soil slopes for the AREMA Level 2 event. Horizontal acceleration equal to one-half of the AREMA Level 2 PGA shall be applied to the soil mass. Vertical acceleration need not be considered unless determined otherwise by the geotechnical engineer. Limit equilibrium slope stability analyses shall be used to determine the critical slip surface and minimum FS. For irregular or non-circular slip surfaces, a limit equilibrium method satisfying both force and moment equilibrium is required, with Spencer's method preferred. For circular slip surfaces, Modified Bishop's or Spencer's method may be used. The infinite slope method may be used for shallow slip surfaces in cohesionless soils with slope lengths of 30 feet or more. Soil shear strength used in slope stability analyses shall be determined for both short-term (undrained) and long-term (drained) conditions, as applicable. The FS as a ratio of available shear strength to mobilized shear strength shall be greater than 1.1 for the specified seismic event.

If the earthen embankment is subject to soil liquefaction under a Level 2 event, the performance level of the earthen embankment shall be addressed in the project-specific design criteria.

The minimum factor of safety specified above applies to soil and subsurface conditions that have been investigated at the site and generally conform to normal conditions in the local area. For special conditions involving unknown or poorly understood subsurface conditions, more conservative factors of safety should be considered.

14.14 BURIED STRUCTURES

The provisions below are the minimum seismic design requirements for conventional buried structures including tunnels and box culverts. Additional provisions may be specified on a case-by-case basis to achieve higher seismic performance criteria for essential or critical buried structures. Where such additional requirements are specified, they shall be site- or project-specific and are tailored to a particular structure type.

Buried structures with spans greater than or equal to 14' shall be designed for seismic effects. Seismic design of buried structures shall be in accordance with the AASHTO LRFD Road Tunnel Design and Construction Guide Specs 1st Edition (2017) with current interims. The seismic effects of transient racking deformations on culverts and buried structures shall be considered in addition to the normal load effects from dead loads, earth, water, and live load surcharges.

The seismic effects of potential unstable ground conditions (i.e. liquefaction, liquefaction induced settlement, landslides, and fault displacements) around the buried structures shall be considered, except liquefaction need not be considered if the liquefaction, landslides, or fault displacements do not cause life safety hazards.

15.0 EXCAVATION SUPPORT CRITERIA

15.1 SCOPE

These Excavation Support Criteria provide the minimum requirements for excavations and temporary excavation support adjacent to the Southern California Regional Rail Authority (SCRRA) railroad tracks. The design of permanent retaining walls and other systems of permanent earth retention adjacent to SCRRA tracks is addressed in other sections of the SCRRA Design Criteria Manual and other applicable guidelines.

SCRRA has developed the criteria and requirements specified herein for the protection of their rail facilities and operating system when construction and excavation activities requiring temporary excavation support occur adjacent to active railroad tracks. Given the risks associated with construction and excavation adjacent to an active commuter/passenger and freight railroad line, the design requirements and construction limitations specified herein are conservative and may be more restrictive than those commonly required by other agencies, for example, excavations adjacent to a highway. Specialized requirements and recommended design practices for excavation and temporary excavation support contained in these Criteria are intended to improve safety of excavation adjacent to active railroad tracks for railroad operations, the traveling public and Contractor personnel, and reduce delays and impacts to railroad operations.

15.2 REFERENCES

The design shall meet all applicable parts of the State of California general laws, California Public Utilities Commission (CPUC) requirements, FRA and SCRRA safety requirements, the requirements listed in this section and the specific project requirements. Where any conflict in criteria exists, the stricter criteria shall govern.

See the standards and codes listed in Appendix A.

15.2.1 SCRRA Standards

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

15.2.2 SCRRA Design Procedures Manual

The overall design process will follow the steps defined in the SCRRA Design Procedures Manual (DPM), which defines the required submittals, deliverables, and reviews. The manual also defines the development of specifications and estimates. As previously noted, the design shall incorporate existing SCRRA standards, plans, and specifications.

15.3 DEFINITIONS

Criteria: For the purpose of this chapter, Criteria shall be considered this document (SCRRA Excavation Support Criteria) in part or in its entirety. Other documents may be referred to as criteria and shall not mean this document.

Deadman: A buried or partially buried structure that is utilized as an anchorage for tension rods that restrain a shoring wall. Deadman anchorage may be provided by soldier piles, sheet piling, or concrete blocks or walls.

Deep Soil Mix Wall: An augered, cement grout soil improvement technique, incorporating soldier pile reinforcement, whereby in-situ soils are mixed in place with cement grout to form a row of overlapped soil-cement columns. These overlapped soil-cement columns are used for both groundwater cutoff and, with soldier piles, as a reinforced-soil diaphragm-type shoring wall.

Diaphragm Wall: A continuous shoring wall comprised of concrete or a mixture of cement and soil (usually with embedded vertical steel members) that is drilled or excavated in place prior to excavation in order to support lateral loads from retained soil and water. Examples of diaphragm walls include deep soil mix walls, secant walls, tangent walls, and slurry walls.

Exclusive Track Window: An approved Work Window in which no train movements (except Contractor, SCRRA work trains or equipment under control of the Employee-in-Charge/Flagman, per the SSWP) will operate on Segment of Track with Definite Boundaries (Working Limits). The Contractor may dismantle, remove, reconstruct, or otherwise obstruct tracks within the limits of such a window. Tracks removed, reconstructed, or otherwise obstructed within the limits of such a window must be returned to at least the same condition as they were before the work started, or as required by the project, at the end of the time limits granted. This Work shall be completed such that it is safe to operate trains in accordance with SCRRA and FRA track safety requirements as determined by a qualified Track Inspector**.**

Grouting: Injection of fluid materials into the ground to improve the strength of ground, decrease permeability and prevent water inflows, and/or compensate for ground settlements and movements. Types of grouting include permeation grouting (cement, micro-cement, chemical, etc.), jet grouting, and compaction grouting.

Lagging: Timber boards, planking or sheathing, reinforced concrete planks, or steel plate secured between adjacent soldier piles.

Packing: Steel, wood, concrete or non-shrink grout used to fill gaps and transfer load between the shoring wall and bracing elements.

Preloading: Placement of initial loads in bracing members by jacking and shimming or wedging to assure adequate bearing of connected shoring elements and to reduce ground movements.

Railroad Zone of Influence: The zone within which shored excavation is required and the shoring system is required to be designed for railroad live load surcharge. See Figure 15-1.

Secant Wall: A continuous shoring wall formed by a series of overlapped, concrete-filled drilled piers (otherwise commonly referred to as drilled shafts or cast-in-drilled-hole [CIDH] piles). A minimum of every other pier is reinforced to span vertically.

Sheet Piling: Vertical steel shapes that are driven/vibrated into the ground and interlocked with each other to form a continuous wall in order to support lateral loads from retained soil and water.

Slurry Wall: Continuous, reinforced concrete wall constructed by filling a series of discrete trenches with tremie concrete. Tremie concrete displaces bentonite or polymer slurry that is in the trench. The slurry is used to prevent collapse of the trench during excavation for slurry wall placement or CIDH excavation. The resulting concrete barrier wall retains soil and groundwater on the exterior side of the slurry wall and permits the excavation and removal of soil on the interior side of the wall. Walls may be reinforced or non-reinforced.

Soil Nailing: A system in which soil nails are typically grouted, un-tensioned rebars that are installed in drilled holes in order to form a reinforced soil mass. Reinforced shotcrete is applied to the face of the excavation. Shotcreting and nail installation proceed in a top down manner as excavation proceeds.

Soldier Piles: Vertical steel shapes (typically wide flange “W” or “H” pile) installed to support lateral loads from retained soil (and water, if part of a sealed shoring system).

Strut: A brace (compression member) that resists thrust in the direction of its own length.

Tangent Wall: A shoring wall formed by a series of concrete-filled drilled piers (otherwise commonly referred to as drilled shafts or cast-in-drilled-hole [CIDH] piles) that are installed tangent to each other and do not overlap. A minimum of every other pier is reinforced to span vertically.

Tieback (Soil Anchor): A tension element utilized to restrain a shoring wall. A tieback consists of a steel tendon (bar or strands) installed in a drilled hole. The tendon is bonded to the soil over its anchorage length with cement grout or epoxy grout. The tendon is tensioned to provide positive restraint to the shoring wall and to reduce wall deflections.

Tremie Concrete: Tremie concrete refers to placement by gravity feed from a hopper through a vertical pipe extending from above the surface to the underwater floor. The concrete displaces the water or slurry as the concrete is deposited.

Trench Shield or Trench Box: Pre-fabricated structure that is commonly installed to support lateral earth loads for utility installation, and whose walls commonly have no embedment into the soils below excavation subgrade. Trench shields are typically installed within pre-excavated slots and/or pushed into the ground as the excavation proceeds.

Wale: Horizontal beam used to brace vertical excavation shoring elements.

15.4 BASIC EXCAVATION REQUIREMENTS

Any proposed excavation that may occur in SCRRA Right-of-Way, adjacent to SCRRA Right-of-Way, or that may affect operations on SCRRA tracks must adhere to the design, submittal and review requirements presented in these Criteria and shall not proceed without acceptance by SCRRA.

15.4.1 Railroad Zone of Influence

The Railroad Zone of Influence is defined in Section 15.3 Definitions and shown in Figure 15-1. The area below the Influence Line is divided into four zones. Requirements and limitations for excavation and temporary excavation support systems within each zone are described in detail below. Excavation requirements apply on or off SCRRA Right-of-Way. Excavation beyond the Railroad Zone of Influence shall satisfy OSHA and other applicable requirements.

ZONE 1:

A. Excavation is prohibited.

B. Alternates to shored excavations shall be utilized. Potential alternates include temporary relocation of the tracks away from the area of excavation or completion of excavation and backfilling work during an Exclusive Track Window that has been planned and approved in advance by SCRRA. Requirements for requesting an Exclusive Track Window are provided in Section 15.4.2. Minimum requirements for excavation and backfill work within Zone 1 are provided in Section 15.4.2. Prior to beginning any shoring SCRRA will typically require that the track be removed and hot mix asphalt concrete (HMAC) sub-ballast layer be placed, 8 inches thick, 12 feet wide (centered on the track centerline) and extending 20 feet in each direction past the length of the shored excavation. SCRRA shoofly requirements are provided in the SCRRA Design Criteria Manual.

ZONE 2:

A. **No excavation or temporary shoring installation will be allowed without the special written permission of SCRRA.** Additional requirements for excavation and shoring within Zone 2 are provided in Section 15.4.2.

B. Alternates to shored excavations shall be utilized when practical.

C. If SCRRA grants a variance to allow excavation, vertical excavation with continuous shoring walls is required. Shoring installation shall be complete prior to any excavation. Design of the shoring system shall include lateral surcharge due to railroad live load and account for loading from multiple tracks if present.

D. Prior to beginning any shoring SCRRA will typically require that the track be removed and hot mix asphalt concrete (HMAC) sub-ballast layer be placed, 8 inches thick, 12 feet wide (centered on the track centerline) and extending 20 feet in each direction past the length of the shored excavation.

E. Examples of continuous shoring wall types include interlocked sheet piling or diaphragm walls. Diaphragm wall types include deep soil mix walls, secant pile walls, tangent pile walls, and slurry walls. Soldier piles and lagging are not allowed if excavation is necessary to install lagging.

ZONE 3:

A. **Excavation requires temporary shoring.** Excavations shall be vertical. Continuous shoring walls installed prior to any excavation are preferred. Maximum excavation lifts shall be limited to five feet for each stage of excavation for soldier pile and lagging walls or any other type of shoring that requires excavation of an open soil face prior to installing continuous support elements.

B. If the shored excavation is 15 feet or less from the centerline of the track, prior to beginning any shoring SCRRA may require that the track be removed and hot mix asphalt concrete (HMAC) sub-ballast layer be placed, 8 inches thick, 12 feet wide (centered on the track centerline) and extending 20 feet in each direction past the length of the shored excavation.

C. Design of the shoring system shall include lateral surcharge due to railroad live load and account for the loading from multiple tracks if present.

ZONE 4:

A. Excavation requires temporary shoring.

B. Lateral surcharge due to railroad live load need not be considered in the shoring design.

C. The excavation shall be provided with a shoring system that actively supports the sides of the excavation and prevents the excavation faces from unraveling or moving. Sloped excavations are not permitted.

D. Hydraulic and mechanical trench shores with sheeting, trench shields, and timber shoring may be utilized. However, installation of the shoring system must be completed before movement of trains is allowed on the adjacent track. Work Windows, within which the shoring system installation must be completed, shall be coordinated with SCRRA.

EXCAVATIONS BEYOND INFLUENCE LINE:

A. Lateral surcharge due to railroad live load need not be considered in the shoring design.

B. Shored vertical excavations are preferred. Sloped excavations are discouraged. SCRRA may require slope stability analysis for sloped excavations.

C. Excavation and temporary shoring shall comply with Cal/OSHA and other applicable requirements.

Excavations shall also comply with the following:

A. Finished excavation surfaces shall be in uniform planes, with no abrupt breaks.

B. Positive drainage shall be maintained away from the tracks and track subgrade at all times.

C. Backfilling materials, procedures, placement and performance criteria shall meet the requirements of SCRRA Standard Specifications for Earthwork Section 31 20 00 and other applicable specifications including: Hot Mix Asphalt (32 12 00 and 34 80 33), Sub-Ballast and Aggregate Base (SS 34 11 27).

Jacking and receiving pits for installation of culverts or utility casings shall be a minimum of 25 feet from centerline of the nearest active track. Construction activities on SCRRA Right-of-Way and excavations for jacking and/or boring operations shall comply with all other provisions of these Criteria as applicable.

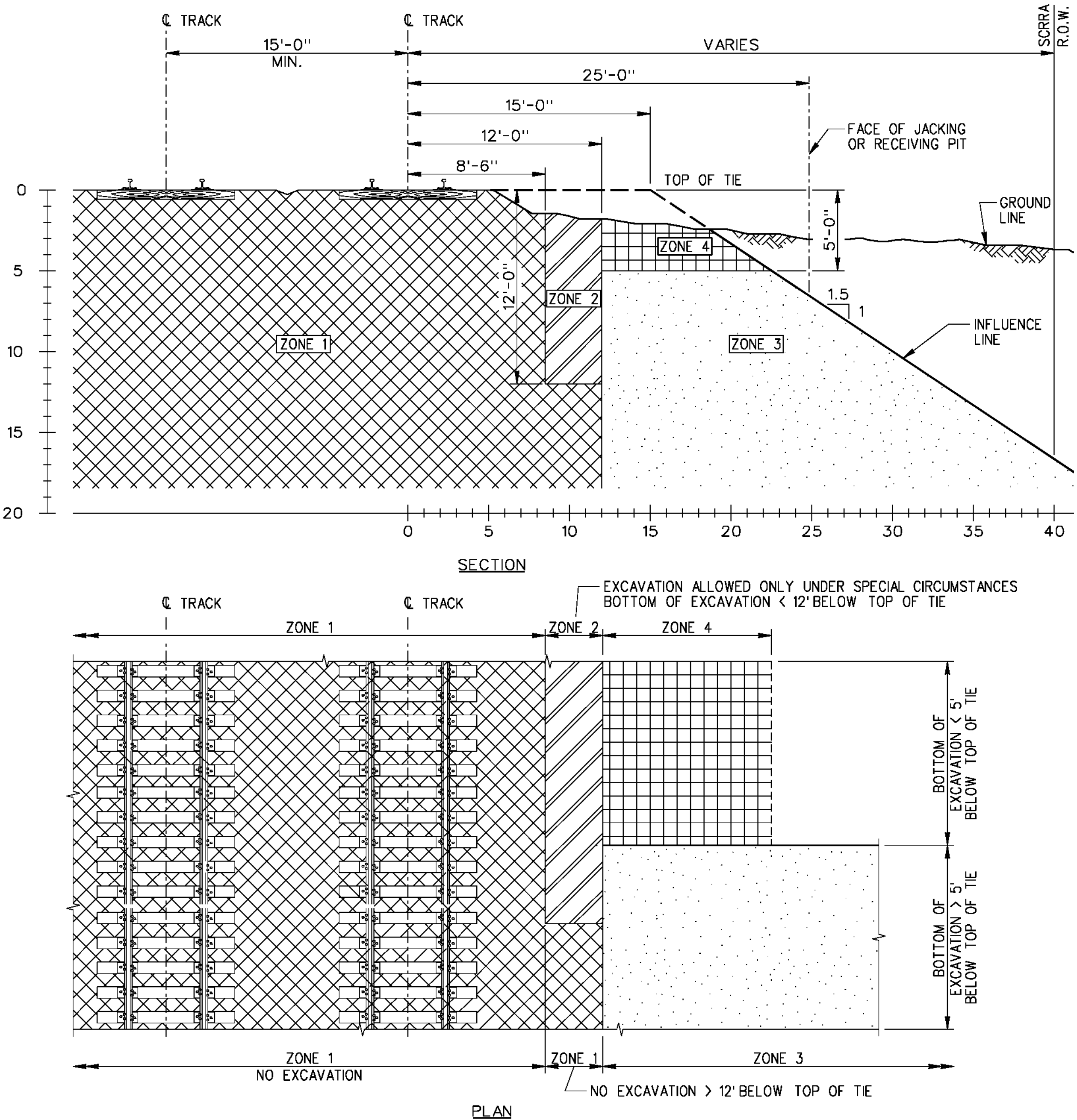


FIGURE 15-1. RAILROAD ZONE OF INFLUENCE

15.4.2 Variances

SCRRA prohibits excavation in Zone 1 and does not allow excavation in Zone 2 without special written permission. Variances for allowing excavation within these prohibited areas may be granted on a case-by-case basis by SCRRA at its sole discretion. Planning, design and bidding shall not be based on the assumption that a variance will be granted to allow shored excavation or that an Exclusive Track Window will be approved.

The following minimum requirements shall be met for excavation and backfilling in Zone 1 under an Exclusive Track Window.

A. Excavation and backfilling must be completed during a single, uninterrupted period of time during which no train movements will occur on the track(s).

B. Typically, these activities will be restricted to nights and weekends and limited to 4-6 hours or less. Exclusive Track Window requests with durations of more than 12 hours will not be considered.

C. Backfilling materials, procedures, placement and performance criteria shall meet the requirements of SCRRA Standard Specifications for Earthwork Section 31 20 00.

D. The SCRRA will typically require that a hot mix asphalt concrete (HMAC) sub-ballast layer, 8 inches thick, 12 feet wide centered on the track center line, and extending 20 feet in both directions past the length of the shored excavation be installed. The nominal thickness of the ballast above the HMAC layer and below the bottom of the tie shall be 6 inches.

E. SCRRA shall be compensated for the full cost of removing and replacing track and ballast and any other work deemed necessary by SCRRA to provide safe and fully operational track. The Contractor will be required to install the HMAC sub-ballast layer.

F. SCRRA shall be compensated for the full cost of having a qualified inspector on site throughout the duration of the work.

The following additional minimum requirements for shored excavations in Zone 2 above and beyond the other requirements of these Criteria shall be met for Special Design Consideration requested in accordance with Section 3.2.2:

A. Excavation shall have a length parallel to the track no greater than 100 feet.

B. Vertical excavations with continuous shoring walls are required.

C. A hot mix asphalt concrete (HMAC) sub-ballast with dimensions described above will typically be required.

D. Shoring installation shall be complete prior to any excavation.

E. Depth of excavation shall be limited to 12 feet below top of tie.

F. Time that excavation remains open shall be limited to 30 days.

G. Supplemental monitoring of the track will be required.

15.4.3 Exceptions for Minor Construction

SCRRA may permit unshored excavation within the Railroad Zone of Influence provided that the excavation has a limited plan area and is no greater than 5 feet in depth. Further, excavation and backfilling, including meeting all placement and compaction requirements must be completed during a single, uninterrupted period of time during which no train movements will occur on the adjacent track. Planning and bidding shall not be based on the assumption that an exception to the Railroad Zone of Influence shoring requirements will be granted.

Unshored excavation adjacent to a track will only be allowed in soil conditions that will permit the work to be performed without disturbing the adjacent track and/or the materials supporting the track.

Localized shallow trenching for utility installation and excavations for the installation of precast concrete foundations (such as signal foundations) are examples of cases where exceptions may be granted. Exceptions will be granted on a case-by-case basis by SCRRA at its sole discretion. Factors SCRRA will consider when assessing whether or not to grant an exception include: the length of time required to complete the excavation and backfilling, the available time between train movements on the adjacent track, and local soil conditions.

15.4.4 Right-of-Entry Agreements

In order to perform work on Right-of-Way that is operated and maintained by SCRRA, Right-of-Entry Agreements are required. For temporary or short-term uses of Right-of-Way, such as surveying activities and shallow geotechnical investigations, the Public Agency or Contractor is required to submit SCRRA Form 5 – Indemnification and Assumption of Liability Agreement.

For projects involving construction on SCRRA Right-of-Way, the Public Agency or Contractor is required to enter into SCRRA Form 6 – Temporary Right-of-Entry Agreement. This agreement defines the nature of the work, the flagging requirements, and the appropriate safety measures that must be in place during the work. This includes all work within the Right-of-Way, from initial design through the completion of construction.

Additionally, the movement of oversize vehicles over SCRRA maintained and operated crossings requires a fully executed SCRRA Form 4 – Agreement for Moving Oversized Loads Over Highway-rail Grade Crossings. These agreements are available on the SCRRA web site: www.metrolinktrains.com.

15.4.5 Right-of-Way

Railroad Right-of-Way, in many cases, is maintained by SCRRA and owned in fee by the Member Agencies. Public Agency or Third-Party projects that affect the Right-of-Way must be coordinated with SCRRA Rail Corridor Crossings and Encroachment (C&E) Division. The procedures for applying for Right-of-Way encroachment, and the appropriate forms are found in Form 36 – Right-of-Way Encroachment Approval Procedures, available on the SCRRA web site: www.metrolinktrains.com.

Excavation work will often have an effect on the existing Right-of-Way. The Public Agency shall determine the status of the Right-of-Way within the limits of the project at the earliest stages of the project in order to properly identify the encumbrances and issues related to any proposed excavation. The application of these SCRRA Criteria to proposed excavations may result in the need for additional Right-of-Way. In cases where additional Right-of-Way is required, the Engineer in Responsible Charge shall develop the appropriate mapping and Right-of-Way definition in accordance with SCRRA standards for the proper definition of the Right-of-Way. The Public Agency shall take the lead for land acquisition. The Engineer in Responsible Charge shall properly define the necessary Right-of-Way, provide legal descriptions, and work with SCRRA's

Right-of-Way administrator, and the Member Agency's real estate department, as needed, to advance the process of property acquisition, easement or preparing a license agreement.

In some cases, SCRRA also shares Right-of-Way with BNSF Railway Company (BNSF) and Union Pacific Railroad (UPRR). In order to perform work on their Right-of-Way, approval shall also be obtained from BNSF and/or UPRR depending on the Right-of-Way ownership.

15.4.6 Utilities

Existing utilities shall be located prior to commencing any excavation. Acceptance of the project by SCRRA does not constitute a representation as to the accuracy or completeness of location or the existence or non-existence of any utilities or structures within the limits of the project. The appropriate regional notification center [Underground Service Alert of California (DIGALERT) at (800) 227-2600 or 811], railway companies and utility companies shall be notified prior to performing any excavation close to any underground pipeline, conduit, duct, wire, cable or other structure. Refer to the SCRRA web site: www.metrolinktrains.com to ensure proper contacts and phone numbers.

SCRRA is not a member of DIGALERT; it is, therefore, necessary to call the SCRRA signal department phone number to mark, at Public Agency or Contractor expense, signal and communication cables and conduits. In case of signal emergencies, the Contractor shall call the SCRRA 24-hour signal emergency number. If utilities cannot be located, potholing shall be performed to locate the utilities. SCRRA and appropriate utility owners shall be notified immediately when utility lines that were not known or indicated on the drawings are encountered. No service shall be disrupted until the utility owner and SCRRA have determined the required action on such lines.

15.4.7 Safety Regulations

Specific safety regulations of SCRRA are provided in the Right-of-Entry Agreement and General Safety Regulations for Third Party Construction and Maintenance Activity on SCRRA Member Agency Property. In addition to safety regulations specific to SCRRA, all construction shall conform to the applicable safety provisions of the latest U.S. Department of Transportation, Federal Railroad Administration (FRA) – Code of Federal Regulations (CFR), Title 49, Part 214, Railroad Workplace Safety, and Cal/OSHA Standards – California Code of Regulations, Title 8, Chapter 4, Division of Industrial Safety, Subchapter 4, Construction Safety Orders. Construction shall also conform to the applicable California Public Utilities Commission (CPUC) General Orders, as well as any other applicable government agency safety regulations.

15.4.8 Construction

Construction of excavations or temporary shoring systems within the Basic Safety Envelope (i.e., within 25 feet of the centerline of the nearest active track), or with the potential of entering the Basic Safety Envelope requires a Site Specific Work Plan (SSWP). Once the applicable right-of-entry requirements, safety training requirements, and an accepted SSWP are in-place, the Contractor may proceed with construction according to the design plans, specifications and accepted SSWP. The Contractor or Public Agency shall notify SCRRA 30 working days prior to beginning work on the Right-of-Way.

Any damage to rails, ties, structures, embankments, Third Party property, signal and communications equipment, or any other facilities during construction shall be repaired, at the expense of the Public Agency or Contractor, to a condition equal to or better than the condition prior to entry and to a level accepted by SCRRA. The Public Agency or Contractor agrees to reimburse SCRRA and any affected operating railroads for any and all costs and expenses incurred as a result of their work, which may result in the following:

A. Unscheduled delay to trains or interference in any manner with the operation of trains.

B. Unscheduled disruption to normal railroad operations.

C. Unreasonable inconvenience to the public or private users of the system.

D. Loss of revenue.

E. Alternative method of transportation for passengers.

The Public Agency and Contractor shall comply with the rules and regulations contained in the current editions of the SCRRA documents listed below during construction. The following documents are available on the SCRRA web site: www.metrolinktrains.com:

A. Temporary Right-of-Entry Agreement (Form 6)

B. Rules and Requirements for Construction on Railroad Property (Form 37)

C. General Safety Regulations for Third Party Construction and Maintenance Activity on SCRRA Member Agency Property

D. Applicable SCRRA Engineering Standards

15.4.9 Contractor Operating Restrictions

When operating near active tracks, whether on or off SCRRA Right-of-Way, the Contractor's operations will be constrained as necessary to protect the Operating System. In general terms, if the Contractor's operation has the potential to interfere with the safe passage of rail traffic or has the potential to foul the track, restrictions will be imposed on the Contractor's operations.

When working within the Basic Safety Envelope the Contractor is considered to have the potential to foul the track, regardless of the operation or equipment being used.

The Contractor will still be considered as having the potential to foul the track when working outside the Basic Safety Envelope, depending upon the operation. For example, if the Contractor operates a crane or backhoe with a boom sufficient in length to foul a track if the boom were in the horizontal position, or if the Contractor is handling long beams or piles that could fall across a track, such an operation would be restricted.

SCRRA shall have sole discretion to determine if the Contractor's operation has the potential to foul a track.

Unless otherwise approved by SCRRA, the Contractor will not be permitted to perform operations that have the potential to foul mainline tracks during weekday commute hours, and must work around the weeknight and weekend train traffic. Other tracks may be fouled as allowed by SCRRA in accordance with train operating schedules and the work to be performed.

SCRRA may operate work trains along the corridor for the Contractor on various construction projects. The work trains transport a variety of equipment and materials for these projects. The time and number of work train traffic will vary.

The Contractor's activities that have the potential to foul the tracks (mainline or otherwise) will be suspended during all train movements within the construction limits.

The Contractor will generally be directed by SCRRA flagperson as to the need to suspend operations. The number of flagmen required will be determined by SCRRA per its review of the Contractor's SSWP.

All shoring work within the Basic Safety Envelope shall be performed in accordance with an accepted SSWP.

15.4.10 Protective Dividers

A protective divider shall be provided between the construction operations and the Operating System if approved by SCRRA. The divider shall be placed and secured a minimum of 10 feet clear from the centerline of the nearest active track.

Caltrans temporary railing Type K (K-rail) is an acceptable divider. SCRRA prefers that protective dividers have fence installed to 10 feet above ground line.

15.4.11 Handrails and Walkways

Adequate physical protection barrier shall be provided for all excavations in accordance with Cal/OSHA requirements.

In the event that there is insufficient space to place a protective divider, a handrail shall be provided along the side of the excavation adjacent to the track. The preferred minimum clearance from the centerline of the nearest track is 10 feet.

In the event that there would be insufficient clearance to handrail placed along the side of the adjacent track, walkway and handrail shall be provided. Walkway shall consist of a slip resistant surface supported by and securely fastened to supports with fasteners that do not extend above the walkway surface. Walkway supports may be connected to and supported by shoring walls. The walkway surface shall be even with the top of shoring.

Handrails and walkways shall be designed in conformance with the requirements of Section 8.5 "Walkways and Handrails on Bridges" in Chapter 15 of the AREMA Manual for Railway Engineering.

15.4.12 Clearances

All elements of the shoring system shall be placed such that they satisfy the clearance requirements specified in CPUC General Order 26-D.

The preferred clearance from centerline of track to fixed objects such as posts, poles, signs, and elements of shoring systems that extend above the top of rail is 10 feet.

15.4.13 Shoring Removal

At the conclusion of construction, staged backfill and removal will often be necessary to safely remove bracing and connection elements of the shoring system. Removal of these elements shall be included as part of the shoring construction sequence and the Contractor shall comply with removal requirements as stated on the drawings. Contractor removals shall not proceed if safety of operations is jeopardized or if SCRRA determines that safety could be jeopardized.

Vertical shoring elements (sheet piles, soldier piles, and diaphragm walls) shall be left in place unless otherwise approved by SCRRA. Vertical shoring elements shall be cut off or demolished to five feet below railroad subgrade if within 15 feet horizontally from centerline of track or otherwise to five feet below finished ground surface. All other elements of the shoring system shall be completely removed if it is safe to do so and if the risks of track settlement or movement are low. If other elements of the shoring system cannot be completely removed, then at a minimum, they shall be removed to five feet below railroad subgrade if within 15 feet horizontally from centerline of track or otherwise to five feet below finished ground surface.

If the Contractor desires complete removal of vertical shoring elements for salvage or reuse, the Contractor shall submit the proposed removal procedure along with a completed SCRRA's Request for Special Design Consideration Form to SCRRA. This form is available on SCRRA's website at www.metrolinktrains.com. The proposed removal procedure shall include provisions that will prevent movement or settlement of the track(s) and fill all voids that might remain after shoring removal. Complete removal of vertical shoring elements may be allowed by SCRRA at their sole discretion.

15.5 TEMPORARY SHORING SYSTEMS

Design of temporary shoring systems for temporary excavation support shall be prepared by a licensed California professional engineer who shall be solely responsible for verifying the accuracy, suitability, and applicability of the information contained in these Criteria for any specific project. Excavation safety shall be the responsibility of the Contractor performing the excavation and the Engineer in Responsible Charge who designed the shoring for the excavation. Review and acceptance of submittals by SCRRA shall not relieve the Contractor and Engineer in Responsible Charge of responsibility for the design and construction of the temporary shoring or excavation support system, including responsibility for errors and omissions in submittals, and construction deviations from accepted design plans.

15.5.1 Owner-Designed Temporary Shoring

For construction projects that will require temporary shored excavation within the Railroad Zone of Influence, SCRRA requires that Contract Documents (plans, specifications and estimates) include detailed design drawings and specifications for the temporary shoring system. In addition to clarifying the required construction sequence, defining the impacts to the Operating System and having a temporary shoring system accepted by SCRRA prior to the onset of construction, uncertainty regarding the time and expense required for the Contractor to prepare a temporary shoring submittal that satisfies SCRRA requirements may be effectively eliminated. Specifications shall incorporate provisions of SCRRA Standard Specifications for Earthwork and Excavation

Support Systems Sections 31 20 00 and 31 50 00. These specifications allow for Contractor-designed alternates to be submitted to SCRRA for review and acceptance prior to construction.

15.5.2 Preferred Shoring Types and Elements

The following types of shoring are preferred by SCRRA for use within the Railroad Zone of Influence:

A. Continuous Shoring Walls versus Soldier Piles and Lagging: Because they are completed in place prior to any excavation, continuous shoring walls (such as sheet piling and diaphragm walls) are preferred over soldier piles and lagging. When soldier pile and lagging systems are utilized, lagging members are installed as excavation proceeds. During the excavation process, vertical cuts (of limited extent) are required to stand unsupported until the lagging has been installed. During the time the ground is unsupported, raveling or ground loss can result in ground settlements that negatively impact track profile and alignment. Additionally, if the lagging is not installed tight to the excavated ground, the ground will tend to move to fill the gaps, which can result in settlement behind the shoring wall that negatively impacts track profile and alignment. Consequently, the chance of ground loss that could undermine or settle the tracks is significantly reduced when continuous shoring walls are used.

B. Deep Soil Mix Walls versus Sheet Piling: It has been SCRRA's experience that the soil mixing (drill) rig and other equipment utilized during a soil mixing operation typically pose a lesser risk to SCRRA than the pile driving equipment utilized to install sheet piling. Additionally, pre-drilling and vibration associated with sheet pile installation and extraction can cause track settlement. Consequently, the Contractor's operations may be somewhat less restricted if deep soil mix walls are used in lieu of sheet piling.

C. Preloaded Bracing: Preloading of bracing elements can reduce shoring deflection and ground settlement during excavation and assure good bearing and a tight fit between shoring elements. Where feasible, struts shall be preloaded to about 50 percent of their design load to achieve adequate bearing between connected shoring elements and to reduce the track settlement that can occur during excavation.

15.5.3 Prohibited Shoring Types and Elements

The following types of shoring are prohibited from use within the Railroad Zone of Influence:

A. Soil Nailing: Soil nailing shall not be utilized to shore excavations within the Railroad Zone of Influence. In addition, soil nails shall not extend into the Railroad Zone of Influence from walls supporting excavations outside of the Railroad Zone of Influence.

B. Helical Screw Anchors: Helical Screw Anchors shall not be utilized to shore excavations within the Railroad Zone of Influence. In addition, helical screw anchors shall not extend into the Railroad Zone of Influence from walls supporting excavations outside of the Railroad Zone of Influence.

15.6 LOADING ON TEMPORARY SHORING SYSTEMS

15.6.1 General

Lateral loading from the following sources shall be considered in the design of the temporary shoring system:

A. Retained Soil

B. Retained Groundwater (hydrostatic pressure)

C. Surcharge from all applicable sources, including, but not limited to, railroad live load, equipment and vehicles, material stockpiles, structures and improvements, etc.

Additionally, under certain conditions, earthquake (seismic) loading shall be considered. See Section 15.6.5.

Other sources of load, including centrifugal force from a train, impact loads, thermal loads, and wind loads are typically not required to be considered in the design of shoring. Such loads need only be considered in cases where they are significant. For example, centrifugal forces may need to be considered in the design of a shoring system constructed at a curve over which trains travel at high speeds.

15.6.2 Soil Loads

The following examples are located in Appendix G of in this DCM:

- Example G-09-1 Develop an Active Soil Pressure Diagram
- Example G-09-2 Develop an Apparent Pressure Diagram
- Example G-09-3 Determine Passive Resistance (Cohesionless Soil)
- Example G-09-4 Determine Passive Resistance (Cohesive Soil)

Soil Types and the Determination of Soil Properties

Soil types and applicable properties shall be ascertained by taking borings and performing appropriate field and laboratory tests. Sufficient geotechnical exploration shall be performed to establish an understanding of the soil profile for the subject site. In addition to establishing the soil profile, key soil parameters for the design of shoring to be ascertained during exploration include the unit weights and strengths for the soils [i.e., the cohesion (c) and angle of internal friction (Φ)].

The design soil properties shall be established by a Registered Geotechnical Engineer, or, alternatively, by a Registered Civil Engineer specializing in geotechnical engineering.

Loading from Retained Soil on Flexible Systems

The loading defined in this section applies to shoring systems that have some degree of flexibility. Shoring types that may be considered flexible include cantilever shoring walls and, in most cases, shoring walls supported by a single level of bracing. The active soil pressure distribution for a flexible shoring system shall be assumed to take the form of an equivalent fluid pressure (EFP); i.e., a triangularly shaped pressure distribution.

EFP values used for shoring design shall be ascertained by a Registered Geotechnical Engineer, or, alternatively, by a Registered Civil Engineer specializing in geotechnical engineering. In no case shall the design active EFP for soil above the groundwater table be less than 30 psf/ft for level retained earth when this approach is used (i.e., the active pressure at any depth shall not be less than 30(Y) psf where Y is a depth below the ground surface in feet). This minimum EFP value must be increased appropriately when the shoring system is retaining a sloped cut.

Alternatively, the retained soils may be classified as either Type 2, 3, 4, or 5 in accordance with the soil descriptions in Table 8-5-1 in Chapter 8 of the AREMA Manual for Railway Engineering. Representative soil properties for each classification are given in Table 8-5-2 in Chapter 8 of the AREMA Manual for Railway Engineering. The soil properties for the Type 1 classification given in AREMA Table 8-5-2 shall not be used. In no case shall the design EFP for soil above the groundwater table be less than 37 psf/ft for level retained earth when this approach is used (i.e., the active pressure at any depth shall not be less than 37(Y) psf where Y is a depth below the ground surface in feet). This EFP corresponds to Type 2 soil classification. This minimum value must be increased appropriately for the case of shoring that is retaining a sloped cut.

<u>Loading from Retained Soil on Restrained Systems</u>

Shoring walls with multiple levels of bracing tend to restrict movements of the soil behind the wall. This restraint alters the soil pressure distribution from that anticipated based on the theory of active loading. “Apparent pressure” diagrams for braced (restrained) shoring systems have been developed by numerous authors. Generalized apparent pressure diagrams suitable for use in both cohesionless and cohesive soils, as well as interlayered soil profiles, can be constructed from active pressure diagrams as shown in Figure 15-2.

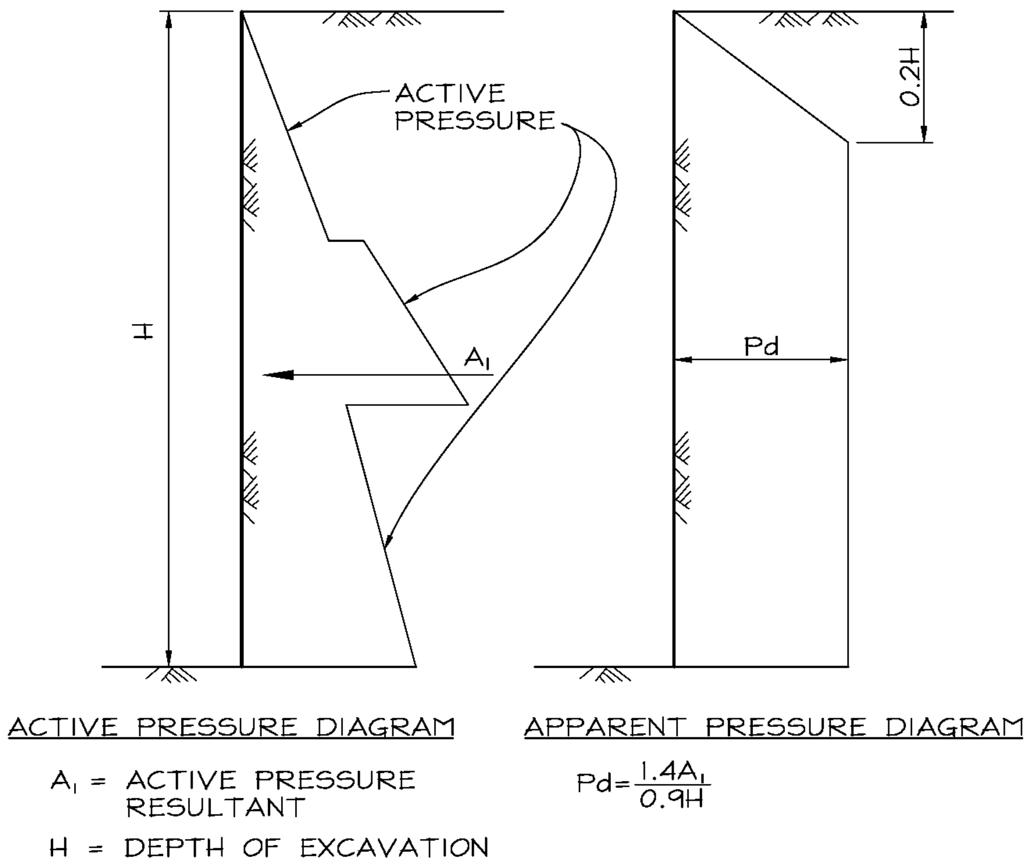


FIGURE 15-2. CONSTRUCTION OF AN APPARENT PRESSURE DIAGRAM

Alternatively, a number of diagrams, applicable to either cohesionless or cohesive soils, are presented in Chapter 5 of the Caltrans Trenching and Shoring Manual. These diagrams may be utilized, provided that the resulting loading magnitudes are not significantly less conservative than those determined by the by procedure outlined in Figure 15-2.

When apparent pressure loading is utilized for design, active soil loading developed in accordance with Section 15.6.2 shall be assumed to act below excavation grade.

Passive Resistance

Cohesionless Soil

The passive resistance in cohesionless (c = 0) soils shall be determined based upon log-spiral theory (refer to Figure 8 in the Caltrans Trenching and Shoring Manual). Determination of the coefficient of passive pressure (K_p) is a function of Φ and the angle of wall friction (δ).

Previous railroad design criteria have required that δ be assumed to be 0° due to dynamic train loading. However, this assumption can produce overly conservative results. In lieu of requiring δ = 0°, at the shoring designer's option, δ_{design} may be assumed to be a maximum of $\delta_{typ}/2$, where δ_{typ} is the wall friction value that would be utilized in the design of typical shoring away from railroad tracks. In no case shall δ exceed Φ/4.

Cohesive Soil

In cohesive ($\Phi = 0°$) soil, $K_p = 1.0$, and the passive resistance is $\gamma_e z+2c$, where γ_e is the effective unit weight of the soil (i.e., the moist unit weight above the water level and the buoyant unit weight below the water level) and z is a depth below excavation grade.

Negative active pressures shall not be utilized to increase the available passive resistance under any circumstances. (Negative active pressures can be computed when 2c exceeds $\gamma_e H$, where H is the depth of excavation.)

c, Φ Soil

Passive pressure diagrams can be developed for c, Φ soils using more complex theoretical expressions. However, it is common to consider a soil stratum as either a purely cohesionless or cohesive soil depending on the soil's predominant physical properties and expected behavior.

Effect of Unbalanced Water Head

In cases where the shoring system will retain an unbalanced water head, available passive resistance may need to be reduced to account for upward seepage pressures.

15.6.3 Groundwater Load

Groundwater loading acting on the shoring system shall be based upon the maximum groundwater level that can be reasonably anticipated during the life of the shored excavation.

The design groundwater table shall be established based upon available historical groundwater monitoring (well) data and/or boring data for the subject area. For projects where historical records are not available, the groundwater table utilized for design should be assessed conservatively.

15.6.4 Surcharge Loads

Lateral pressure acting on the temporary shoring system resulting from the following sources of surcharge loading shall be considered in the design of the shoring as appropriate:

A. Railroad live load (see Section 15.7)
B. Track, ties and ballast (where not included in soil loads)
C. Equipment and vehicles
D. Material stockpiles
E. Existing structures
F. Any other source of surcharge load

Lateral pressure resulting from vertical surcharge loads should be computed in accordance with the equations presented in Section 20.3.2 in Chapter 8 of the AREMA Manual for Railway Engineering.

15.6.5 Earthquake (Seismic) Load

In atypical situations, such as where a shored excavation of substantial length parallels the Operating System or where a shored excavation will remain open for more than 3 months, SCRRA may require that lateral loading due to earthquake (seismic) shaking be considered. Subway construction parallel to the tracks is an example of a situation where the application of earthquake loading may be appropriate because an extensive length of open excavation may be present at one time.

This issue will be addressed on a project-specific basis by SCRRA.

15.6.6 Combination of Loads and Loading Cases

All elements of the temporary shoring system shall be designed for a combination of lateral soil, groundwater, and surcharge loads acting in conjunction with vertical dead and live loads.

Loading conditions during all stages of excavation, support removal, and support relocation shall be analyzed. No reduction in loading from that present during the full depth excavation stage shall be assumed for the stages of support removal or relocation.

In situations where loading conditions on opposite sides of an internally braced excavation are not equal, the shoring design shall account for this unbalanced loading condition. The shoring system shall be designed for, and be compatible with, the more heavily loaded side of the excavation.

15.7 RAILROAD LIVE LOAD SURCHARGE

15.7.1 General

All temporary shoring systems supporting excavations within Zones 1, 2 and 3 of the Railroad Zone of Influence (see Section 15.4.1) shall be designed for lateral pressure due to railroad live load surcharge. Railroad live load surcharge shall be based on Cooper's E-80 live load and the presence of multiple tracks shall be included. Lateral pressure resulting from railroad live load surcharge shall be computed using the Boussinesq equation (see Figure 15-3). No reduction in lateral surcharge pressure shall be allowed for "flexible" or "semi-rigid" wall behavior, typically 50 percent and 75 percent in non-railroad applications, respectively (i.e. 100 percent Boussinesq live load surcharge for "rigid" wall behavior is required for design of all shoring wall types).

Lateral surcharge pressure values for various depths below bottom of tie and distances to centerline of track computed using the Boussinesq equation are provided in Table 15-1.

The values in Table 15-1 were developed for the standard wood tie length (TL) of 8 feet 6-inches. The values developed for the standard concrete tie length (8.25 feet) are not meaningfully different from those presented in Table 15-1. Note that the tabulated values apply only for situations where the top of shoring is at or above the elevation of the bottom of railroad ties.

The following examples are located in Appendix G of this DCM:

- Example G-09-5 Railroad Live Load Surcharge from Two Tracks
- Example G-09-6 Railroad Live Load Surcharge from Three Tracks

- Example G-09-7 “Simplified” Railroad Live Load Surcharge

15.7.2 Surcharge from Multiple Tracks

Surcharge loading from multiple tracks shall be considered as follows:

A. Two tracks – Full surcharge from both tracks.

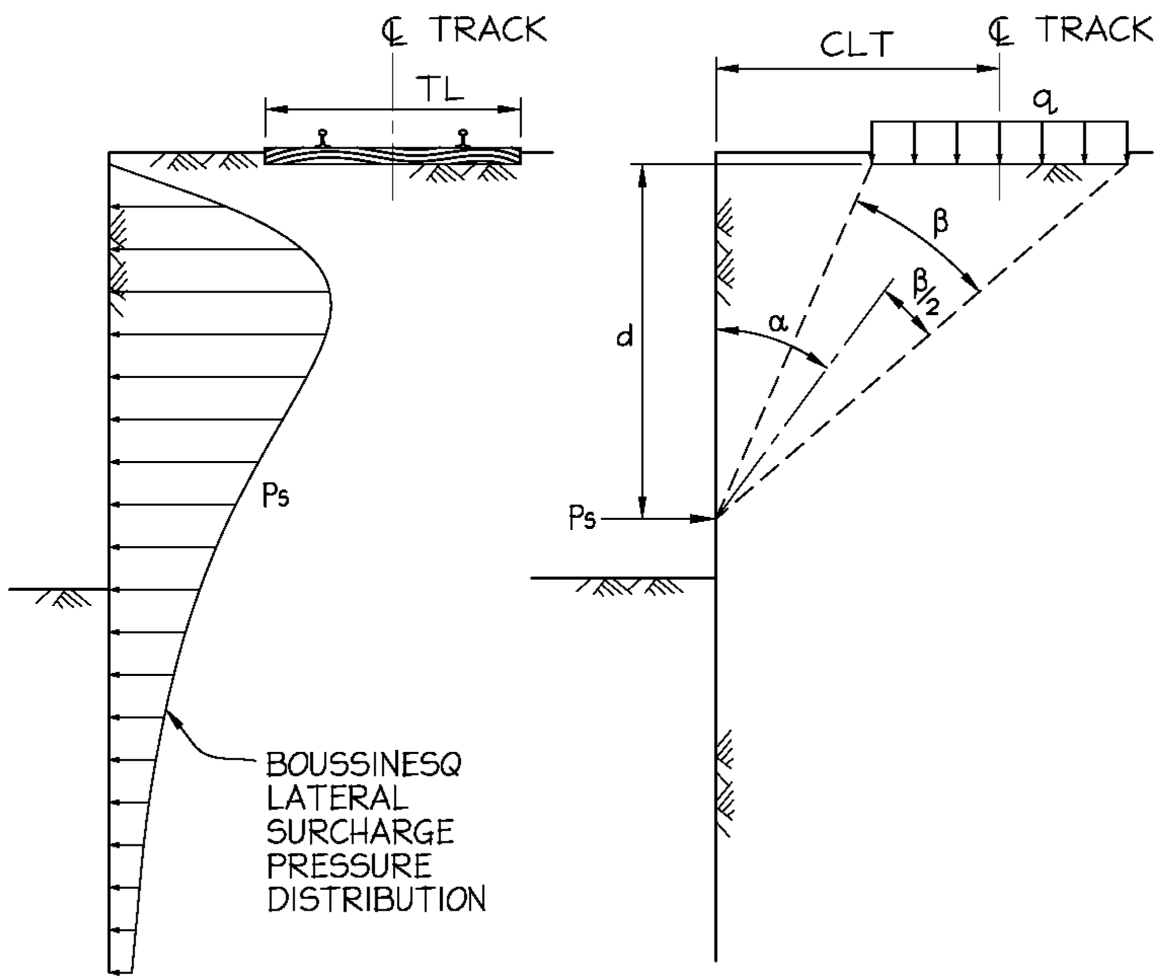
B. Three tracks – Full surcharge from two closest tracks combined with 50 percent surcharge from third track.

C. Four or more tracks – Full surcharge from two closest tracks combined with 50 percent surcharge from third track and 25 percent surcharge from fourth track.

Only surcharge from those tracks for which the shored excavation is within the Railroad Zone of Influence need be considered.

15.7.3 Simplified Surcharge Pressure Distribution

In lieu of using the detailed Boussinesq pressure distribution, railroad live load surcharge pressures may be assumed to have a rectangular distribution with a magnitude equal to 80 percent of the maximum Boussinesq pressure.



- d = DEPTH BELOW BOTTOM OF TIE
- CLT = DISTANCE FROM ℄ TRACK TO FACE OF SHORING WALL
- TL = TIE LENGTH
- Ps = LATERAL SURCHARGE PRESSURE
- q = VERTICAL SURCHARGE PRESSURE

$$\boxed{P_s = \frac{2q}{\pi}(\beta - \sin\beta\cos 2\alpha)}$$

$q(E\text{-}80) = 80{,}000/(5TL)$

TL = 9' STANDARD WOOD TIE
$\Rightarrow q = 1778$psf

TL = 8'-3" STANDARD CONCRETE TIE
$\Rightarrow q = 1939$psf

FIGURE 15-3. E-80 RAILROAD LIVE LOAD SURCHARGE USING THE BOUSSINESQ EQUATION

15.7.4 Application of Surcharge Pressures

Railroad live load surcharge pressures shall be assumed to act over the full height of the temporary shoring wall. Where the top of the shoring wall is at or above the bottom of railroad tie elevation, the vertical surcharge pressure (q) used in the Boussinesq distribution shall be the pressure under the ties and shall be applied starting at the bottom of tie elevation. Where the top of the shoring wall is below the bottom of railroad tie elevation, the vertical surcharge pressure used in the Boussinesq distribution shall be an equivalent pressure at the top of the shoring wall. The equivalent vertical surcharge pressure shall be distributed over a length equal to the tie length plus the vertical distance from bottom of tie to top of wall (1H:2V distribution outward from each end of the tie). The magnitude of the equivalent vertical surcharge (q) will be equal to the pressure under the tie multiplied by the ratio of the tie length to the equivalent distributed length.

15.7.5 Surcharge for Perpendicular Shoring Walls

When temporary shoring walls are to be installed perpendicular to the centerline of track or used as temporary bridge abutments, the design railroad live load surcharge acting on such walls shall be computed in accordance with Chapter 8, Section 5.3.1 of the AREMA Manual for Railway Engineering.

15.7.6 Combination with Surcharge from Other Sources

Surcharge from other sources (e.g., heavy equipment, existing structures, etc.) shall be considered in the design of temporary shoring systems for excavation support as appropriate. Surcharges from other sources shall be added to the railroad live load surcharge if the surcharge loads can act concurrently. An example of combined surcharges may be Contractor cranes, trucks, or material stockpiles above an excavation concurrent with a passing train.

TABLE 15-1. RAILROAD (E-80) LIVE LOAD LATERAL SURCHAGE

d	distance from centerline of track to face of shoring (feet)																
(feet)	**5**	**6**	**7**	**8**	**8.5**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	1469	974	625	434	370	320	247	197	161	135	114	98	86	75	67	59	53
2	1304	1172	930	719	635	563	450	367	305	257	220	191	166	147	130	117	105
3	1103	1092	983	838	767	701	585	492	418	359	310	271	239	212	189	170	153
4	921	955	924	846	799	750	655	570	496	434	381	337	299	267	240	217	197
5	762	817	828	797	771	741	674	605	541	482	431	386	347	313	283	257	234
6	629	692	724	725	715	699	658	609	558	508	461	419	381	347	317	290	266
7	518	583	627	646	646	642	622	591	553	514	475	438	403	371	341	315	291
8	428	491	539	568	576	580	575	559	535	506	476	444	414	385	358	333	309
9	354	413	462	497	509	518	525	520	507	488	466	441	416	391	367	344	322
10	295	349	396	434	448	460	474	479	474	464	449	431	411	390	370	349	329
11	246	295	340	378	394	407	426	437	439	436	427	415	400	384	367	349	332
12	207	251	293	330	345	359	382	396	404	406	403	396	386	373	360	346	331
13	175	215	253	288	303	317	341	359	370	376	377	374	368	360	350	338	326
14	149	184	219	252	267	281	305	324	338	347	351	352	349	344	337	329	319
15	127	159	190	221	235	248	272	292	307	319	326	329	330	328	323	317	310
16	110	138	166	194	207	220	243	263	280	292	301	307	310	310	308	305	300
17	95	120	146	171	184	196	218	237	254	268	278	285	290	293	293	291	288
18	82	105	128	151	163	174	195	214	231	245	256	265	271	275	277	277	276
19	72	92	113	134	145	155	175	194	210	224	236	246	253	258	261	263	263
20	63	81	100	120	129	139	158	175	191	205	217	228	236	242	246	249	250
21	56	72	89	107	116	125	142	159	174	188	200	211	219	226	232	235	238
22	49	64	79	96	104	112	129	144	159	172	184	195	204	211	217	222	225
23	44	57	71	86	94	101	116	131	145	158	170	181	190	198	204	209	213
24	39	51	64	77	84	92	106	119	133	145	157	167	176	185	191	197	202
25	35	46	58	70	76	83	96	109	122	134	145	155	164	172	179	185	190
26	32	41	52	63	69	75	88	100	112	123	134	144	153	161	168	174	180
27	29	37	47	58	63	69	80	91	102	113	124	133	142	150	158	164	170
28	26	34	43	52	58	63	73	84	94	105	114	124	132	141	148	154	160
29	23	31	39	48	53	57	67	77	87	97	106	115	123	131	139	145	151
30	21	28	36	44	48	53	62	71	80	89	98	107	115	123	130	137	142
31	19	26	33	40	44	48	57	65	74	83	91	100	108	115	122	128	134
32	18	23	30	37	41	44	52	60	69	77	85	93	101	108	115	121	127
33	16	22	27	34	37	41	48	56	64	71	79	87	94	101	108	114	120
34	15	20	25	31	35	38	45	52	59	66	74	81	88	95	101	107	113
35	14	18	23	29	32	35	41	48	55	62	69	76	82	89	95	101	107
36	13	17	22	27	30	33	39	45	51	58	64	71	77	84	90	95	101
37	12	16	20	25	28	30	36	42	48	54	60	66	73	79	84	90	95
38	11	15	19	23	26	28	33	39	45	50	56	62	68	74	80	85	90
39	10	13	17	22	24	26	31	36	42	47	53	58	64	70	75	80	85
40	9	13	16	20	22	24	29	34	39	44	50	55	60	66	71	76	81
41	9	12	15	19	21	23	27	32	37	42	47	52	57	62	67	72	77
42	8	11	14	18	19	21	25	30	34	39	44	49	54	58	63	68	73
43	8	10	13	16	18	20	24	28	32	37	41	46	51	55	60	64	69
44	7	10	12	15	17	19	22	26	30	35	39	43	48	52	57	61	65
45	7	9	12	14	16	18	21	25	29	33	37	41	45	49	54	58	62
46	6	8	11	14	15	17	20	23	27	31	35	39	43	47	51	55	59
47	6	8	10	13	14	16	19	22	25	29	33	37	40	44	48	52	56
48	6	7	10	12	13	15	18	21	24	27	31	35	38	42	46	50	53
49	5	7	9	11	13	14	17	20	23	26	29	33	36	40	44	47	51
50	5	7	9	11	12	13	16	19	21	25	28	31	34	38	41	45	48

Based on the Boussinesq equation (see Figure 15-3)
d = depth below bottom of tie
surcharge values in psf

Table 15-1 Continued

d	distance from centerline of track to face of shoring (feet)																
(feet)	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1	48	44	40	37	34	31	29	27	25	23	22	20	19	18	17	16	15
2	95	86	79	72	66	61	57	53	49	46	43	40	38	36	34	32	30
3	139	127	116	106	98	91	84	78	73	68	64	60	56	53	50	47	45
4	179	164	150	138	128	118	110	102	95	89	84	79	74	70	66	62	59
5	214	197	181	167	155	144	134	125	117	109	103	96	91	86	81	77	73
6	244	225	208	193	179	167	156	146	136	128	120	113	107	101	96	91	86
7	269	249	231	215	201	187	175	164	154	145	137	129	122	115	109	104	98
8	288	268	250	234	219	205	192	181	170	160	151	143	135	128	122	116	110
9	302	283	265	249	234	220	207	195	184	174	165	156	148	140	133	127	121
10	311	293	276	260	246	232	219	207	196	186	176	167	159	151	144	137	131
11	315	299	283	269	254	241	229	217	206	196	186	177	168	161	153	146	140
12	316	302	287	274	261	248	236	225	214	204	194	185	177	169	161	154	147
13	314	301	289	276	264	252	241	230	220	210	201	192	184	176	168	161	154
14	309	298	287	276	265	255	244	234	224	215	206	198	189	182	174	167	161
15	302	293	284	274	265	255	246	236	227	218	210	202	194	186	179	172	166
16	293	286	279	271	262	254	245	237	228	220	212	205	197	190	183	176	170
17	284	278	272	265	258	251	244	236	228	221	214	206	199	192	186	179	173
18	273	269	265	259	253	247	241	234	227	220	214	207	201	194	188	182	176
19	262	259	256	252	247	242	237	231	225	219	213	207	201	195	189	183	178
20	250	249	247	244	241	237	232	227	222	217	211	206	200	195	189	184	179
21	239	239	238	236	233	230	227	223	218	214	209	204	199	194	189	184	179
22	227	228	228	227	226	223	221	217	214	210	206	201	197	193	188	183	179
23	216	218	219	219	218	216	214	212	209	206	202	198	195	191	186	182	178
24	205	207	209	210	210	209	208	206	204	201	198	195	192	188	184	181	177
25	194	197	200	201	202	201	201	200	198	196	194	191	188	185	182	179	175
26	184	188	190	192	193	194	194	193	192	191	189	187	184	182	179	176	173
27	174	178	181	184	185	186	187	187	186	185	184	182	180	178	176	173	171
28	165	169	173	175	177	179	180	180	180	180	179	178	176	174	173	170	168
29	156	161	164	167	170	172	173	174	174	174	174	173	172	170	169	167	165
30	148	152	156	160	162	165	166	167	168	168	168	168	167	166	165	164	162
31	140	144	149	152	155	158	160	161	162	163	163	163	163	162	161	160	159
32	132	137	141	145	148	151	153	155	156	157	158	158	158	158	157	156	155
33	125	130	134	138	141	144	147	149	150	152	153	153	153	153	153	152	152
34	118	123	127	131	135	138	141	143	145	146	147	148	149	149	149	149	148
35	112	117	121	125	129	132	135	137	139	141	142	143	144	145	145	145	144
36	106	111	115	119	123	126	129	132	134	136	137	139	139	140	141	141	141
37	100	105	109	114	117	121	124	126	129	131	132	134	135	136	136	137	137
38	95	100	104	108	112	115	118	121	124	126	128	129	131	132	132	133	133
39	90	95	99	103	107	110	113	116	119	121	123	125	126	127	128	129	130
40	85	90	94	98	102	105	109	111	114	116	119	120	122	123	124	125	126
41	81	85	90	94	97	101	104	107	110	112	114	116	118	119	120	121	122
42	77	81	85	89	93	96	100	102	105	108	110	112	114	115	117	118	119
43	73	77	81	85	89	92	95	98	101	104	106	108	110	111	113	114	115
44	69	74	77	81	85	88	91	94	97	100	102	104	106	108	109	111	112
45	66	70	74	77	81	84	87	90	93	96	98	100	102	104	106	107	108
46	63	67	70	74	77	81	84	87	90	92	94	97	99	101	102	104	105
47	60	64	67	71	74	77	80	83	86	89	91	93	95	97	99	100	102
48	57	61	64	67	71	74	77	80	83	85	88	90	92	94	96	97	99
49	54	58	61	65	68	71	74	77	79	82	84	87	89	91	92	94	96
50	52	55	58	62	65	68	71	74	76	79	81	84	86	88	89	91	93

Based on the Boussinesq equation (see Figure 15-3)
d = depth below bottom of tie
surcharge values in psf

Table 15-1 Continued

d	distance from centerline of track to face of shoring (feet)												
(feet)	38	39	40	41	42	43	44	45	46	47	48	49	50
1	14	14	13	12	12	11	11	10	10	9	9	9	8
2	28	27	26	24	23	22	21	20	19	19	18	17	16
3	42	40	38	36	35	33	32	30	29	28	27	25	24
4	56	53	51	48	46	44	42	40	38	37	35	34	32
5	69	66	62	60	57	54	52	50	47	45	44	42	40
6	82	78	74	70	67	64	61	59	56	54	52	50	48
7	93	89	85	81	77	74	71	68	65	62	60	57	55
8	105	100	95	91	87	83	80	76	73	70	67	65	62
9	115	110	105	100	96	92	88	84	81	78	75	72	69
10	125	119	114	109	104	100	96	92	88	85	82	79	76
11	133	128	122	117	112	108	103	99	95	92	88	85	82
12	141	135	130	124	119	115	110	106	102	98	95	91	88
13	148	142	136	131	126	121	117	112	108	104	100	97	93
14	154	148	142	137	132	127	122	118	114	110	106	102	99
15	159	153	148	142	137	132	127	123	119	115	111	107	103
16	164	158	152	147	142	137	132	128	123	119	115	111	108
17	167	162	156	151	146	141	136	132	127	123	119	115	112
18	170	165	159	154	149	144	140	135	131	127	123	119	115
19	172	167	162	157	152	147	143	138	134	130	126	122	119
20	173	168	163	159	154	149	145	141	137	133	129	125	122
21	174	169	165	160	156	151	147	143	139	135	131	128	124
22	174	170	165	161	157	153	149	145	141	137	133	130	126
23	174	170	166	161	157	153	150	146	142	138	135	131	128
24	173	169	165	161	158	154	150	147	143	140	136	133	129
25	172	168	165	161	158	154	150	147	144	140	137	134	131
26	170	167	164	160	157	154	150	147	144	141	138	135	131
27	168	165	162	159	156	153	150	147	144	141	138	135	132
28	166	163	160	158	155	152	149	146	144	141	138	135	132
29	163	161	158	156	153	151	148	146	143	140	138	135	132
30	160	158	156	154	152	149	147	145	142	140	137	135	132
31	157	155	154	152	150	148	146	143	141	139	136	134	132
32	154	153	151	149	148	146	144	142	140	138	136	133	131
33	151	150	148	147	145	144	142	140	138	136	134	132	130
34	147	146	145	144	143	142	140	138	137	135	133	131	129
35	144	143	142	141	140	139	138	136	135	133	132	130	128
36	140	140	139	139	138	137	136	134	133	132	130	129	127
37	137	137	136	136	135	134	133	132	131	130	129	127	126
38	133	133	133	133	132	132	131	130	129	128	127	126	124
39	130	130	130	130	129	129	128	128	127	126	125	124	123
40	126	127	127	127	127	126	126	125	125	124	123	122	121
41	123	123	124	124	124	124	123	123	122	122	121	120	119
42	119	120	120	121	121	121	121	120	120	119	119	118	117
43	116	117	117	118	118	118	118	118	118	117	117	116	116
44	113	114	114	115	115	115	115	115	115	115	115	114	114
45	109	110	111	112	112	113	113	113	113	113	112	112	112
46	106	107	108	109	109	110	110	110	110	110	110	110	110
47	103	104	105	106	107	107	107	108	108	108	108	108	108
48	100	101	102	103	104	104	105	105	106	106	106	106	106
49	97	98	99	100	101	102	102	103	103	103	104	104	104
50	94	95	97	98	98	99	100	100	101	101	101	102	102

Based on the Boussinesq equation (see Figure 15-3)
d = depth below bottom of tie
surcharge values in psf

15.8 SHORING ANALYSIS METHODOLOGIES

Classic shoring analysis methodologies have been summarized here and should be considered minimum analysis requirements for temporary shoring design. Computer programs and more advanced soil-structure interaction analyses may be utilized for design, but shall be accompanied by verified hand calculations showing significant agreement with the classic methodologies presented herein. The Engineer in Responsible Charge shall be solely responsible for input and results of computer programs utilized for shoring analysis and design.

Typical temporary shoring applications may not require stability analysis beyond determining the minimum embedment. The factor of safety against sliding, overturning, and global slope stability shall be calculated as applicable to the particular temporary shoring system. The minimum factor of safety for stability, including sliding, overturning, and global slope stability, shall be 1.5. See Section 15.10.3 for global stability analysis requirements.

The following examples are located in Appendix G of this DCM:

- Example G-09-8 Cantilever Soldier Pile and Lagging Shoring Wall
- Example G-09-9 Sheet Pile Shoring Wall, One Level of Bracing (Free Earth Support Method)
- Example G-09-10 Sheet Pile Shoring Wall, One Level of Bracing (Fixed Earth Support Method)
- Example G-09-11 Analysis of a Diaphragm Shoring Wall with Three Levels of Bracing

15.8.1 Continuous Shoring Walls

Continuous shoring walls, such as steel sheet piling and diaphragm walls, are typically analyzed on a longitudinal per-foot-of-wall (unit) basis for the lateral pressures computed in accordance with Sections 15.5 and 15.6 of these Criteria. The wall is designed for the unit bending moments and shears resulting from the lateral pressures acting on the wall. When the shoring wall is designed to support vertical loads, these loads must be considered in the design as well.

In the case of sheet piling, the structural strength of the wall is provided by sheets themselves. Wide flange sections installed in deep soil mix, secant, tangent, or slurry walls are the primary structural elements for these systems. Rebar reinforced slurry walls are designed as a continuous vertically reinforced concrete wall.

15.8.2 Soldier Pile Shoring Walls

Soldier pile and lagging walls are analyzed in a somewhat different manner than continuous shoring walls. Soldier pile and lagging walls are not continuous below excavation grade, and the loading acting on the active and passive sides of the wall for the embedded portion of the wall must be constructed to reflect the discontinuous nature of the wall. The “effective width” of the embedded portion of the soldier pile (for both active and passive loading) shall be computed using the “Arching Capability” values given in Table 10-1 of the Caltrans Trenching and Shoring Manual. As for continuous walls, lateral pressures utilized to construct the loading diagrams shall be computed in accordance with Sections 15.5 and 15.6 of these Criteria.

Soldier piles are designed as vertical beams to resist the bending moments and shears resulting from the lateral loads acting on the piles. Vertical loading (if any) shall be considered in the soldier pile design.

15.8.3 Analysis of Cantilever Walls

Cantilever shoring walls shall be designed using the “Conventional Methods” of analysis illustrated in Figures 8-1 (cohesionless soil) and 8-2 (cohesive soil) of the Caltrans Trenching and Shoring Manual.

Alternatively, cantilever walls may be designed using the “Simplified” method illustrated in Figure 8-3 of the Caltrans Trenching and Shoring Manual. If this method is used, the computed embedment depth (referred to as D0 in the above referenced figures) shall be increased by 20 percent to determine the minimum theoretical embedment depth.

“Design Curves” (e.g., Figure 8-4 in the Caltrans Trenching and Shoring Manual shall not be used for the design of cantilever shoring walls within the Railroad Zone of Influence.

A factor of safety for the cantilever wall embedment shall be provided. When the theoretical embedment depth is computed based on the “unreduced” passive resistance (factor of safety equal to 1.0), this theoretical embedment depth shall be increased by a minimum of 40 percent to determine the design embedment depth (i.e. minimum factor of safety on theoretical embedment depth of 1.4). This 40 percent increase is provided in addition to the 20 percent increase required if the “Simplified” method of analysis has been utilized.

Embedment depths computed based on passive resistance that has been divided by a factor of safety of 2.0 will also be acceptable, provided that the resulting embedment depth is not significantly less than that computed using the nominal 40 percent increase in embedment depth discussed above.

Analysis utilizing “unreduced” passive resistance should be applied with caution when the shoring wall is embedded in stiff to hard clays, because the computed embedment may be unrealistically short. See Section 15.8.8 for minimum embedment depths.

15.8.4 Analysis of Walls with a Single Level of Bracing

Walls supported by a single level of bracing (or a single tier of tiebacks) may be analyzed using the Free Earth Support or Fixed Earth Support Method at the shoring designer’s option. Each of these methods is outlined below.

<u>Free Earth Support Method</u>

This method is based on the assumption that the shoring wall is embedded far enough to assure stability, but that the available passive resistance is incapable of restraining the shoring wall sufficiently to induce negative moment in the wall (i.e., there is no reversal of moment below excavation subgrade). The theoretical embedment required for stability is determined by statics. The theoretical depth of embedment required is determined by summing moments due to all pressures acting on the shoring wall about the bracing level. The embedment depth is adjusted until the sum of the moments about the bracing level is zero. Moments and shears in the shoring wall and the bracing reaction may be computed after the embedment depth is determined.

Fixed Earth Support Method

This method is based on the assumption that the shoring wall is embedded sufficiently to provide effective "fixity" at the bottom of the shoring wall (i.e., the deflected shape of the shoring wall is such that the wall reverses curvature over its embedded length and becomes vertical at its bottom). Unlike the Free Earth Support Method, moment reversal takes place over the embedded portion of the shoring wall. In comparison to the Free Earth Support Method, the embedment computed using the Fixed Earth Support Method would be longer; however, pile moment demand, pile deflection, and the bracing reaction will typically be reduced.

Hand calculating the required embedment depth for the Fixed Earth Support Method is not a trivial matter. However, through the use of commonly available structural analysis software, determining the depth of embedment required to produce the appropriate deflected shape of the shoring wall (i.e., effective fixity) is just a matter of iterating the depth of embedment. As for the Free Earth Support Method, moments and shears in the pile, and the bracing reaction may be computed after the theoretical embedment depth is determined.

Factor of Safety for Shoring Wall Embedment Depth

A factor of safety for the shoring wall embedment depth must be provided when either the Free Earth Support Method or Fixed Earth Support Method is used. When the theoretical embedment depth is computed based on the "unreduced" passive resistance (factor of safety equal to 1.0), this theoretical embedment depth shall be increased by a minimum of 40 percent to determine the design embedment depth (i.e. minimum factor of safety on theoretical embedment depth of 1.4). (This method should be used with caution when stiff to hard clays provide passive resistance, because the computed embedment depth may be unrealistically short.)

Embedment depths computed based on passive resistance that has been divided by a factor of safety of 2.0 will also be acceptable, provided that the resulting embedment depth is not significantly less than that computed using the nominal 40 percent increase in embedment depth discussed above.

See Section 15.8.8 for minimum embedment depths.

In Example G-09-12, located in Appendix G of this DCM, illustrates the Free Earth Support Method and Example G-09-13 illustrates the Fixed Earth Support Method for the same excavation geometry in the same soil conditions for comparison purposes.

15.8.5 Analysis of Walls with Multiple Levels of Bracing

Embedment Depth

The required depth of penetration for a shoring wall supported by two or more levels of bracing shall be determined by one of the following methods (see Section 15.8.8 for minimum embedment depths.):

A. The theoretical embedment may be calculated by balancing moments due to all soil, hydrostatic, lateral surcharge, and “unreduced” passive pressures (factor of safety equal to 1.0) acting below the lowest bracing level about the lowest bracing level. The moment capacity of the shoring wall shall be conservatively neglected in this analysis. The depth of penetration is adjusted until the sum of the moments equals zero. The computed theoretical embedment depth shall be increased by a minimum of 40 percent to determine the design embedment depth. (This method should be used with caution when stiff to hard clays provide passive resistance, because the computed embedment depth may be unrealistically short.)

B. The embedment depth may be computed by summing moments as noted above, using passive resistance values that have been reduced by dividing them by a factor of safety of 2.0. No increase in embedment is required when this method is used. This method will be acceptable provided that the resulting embedment depth is not significantly less than that computed using the nominal 40 percent increase in embedment depth discussed above.

Analysis of Shoring Wall

Moments and shears in the shoring wall shall be computed using beam analysis, assuming that the shoring wall is hinged at all bracing levels except the uppermost. Moments may be reduced to 80 percent of their computed values for design to account for wall continuity over the bracing locations.

Analysis of the portion of the shoring wall below the lowest bracing level shall be based on statics, including a consideration of all loads acting on the embedded portion of the shoring wall. A fictitious support at or below subgrade shall not be assumed for analysis purposes.

No redistribution of loads or reduction in the demand on the shoring wall due to soil arching shall be assumed.

Determination of Bracing Loads

Bracing loads shall be determined by beam analysis assuming that the shoring wall is hinged at all the bracing levels except the uppermost.

The load on the lowest bracing level shall be determined by statics, including a consideration of all loads acting on the embedded portion of the shoring wall. A fictitious support at or below subgrade shall not be assumed for analysis purposes.

15.8.6 Analysis of Bracing Systems

Unit (per foot) reactions at each bracing level are determined during the analysis of the shoring wall. For shoring walls with soldier piles (e.g., soldier pile and lagging walls, deep soil mix walls, and secant walls) point loads from each pile are computed by multiplying the pile spacing by the unit bracing reactions. Bracing loads for sheet piling may be assumed as a horizontal uniform load equal to the unit reactions.

Internal (cross-lot) bracing systems consisting of wales and struts shall be designed to resist the computed bracing loads. Moments, shears and axial loads in the bracing members shall be computed using standard methods of structural analysis.

Tieback or deadman systems that are used to restrain the shoring walls shall be designed to resist the computed bracing loads.

No redistribution of loads or reduction in the demand on bracing elements due to soil arching shall be assumed.

15.8.7 Lagging Analysis

Lagging may be designed for a load equal to 60 percent of the shoring design load (soil and surcharge pressures) to account for soil arching. The lagging members shall be designed as horizontal beams spanning between soldier piles.

In cases where soil arching cannot develop, reduced lagging loads shall not be considered.

Tabulated lagging thicknesses (such as those presented in Table 10-2 of the Caltrans Trenching and Shoring Manual) shall not be utilized.

15.8.8 General Shoring Requirements

<u>Minimum Embedment Depth</u>

Computed embedment depths shall be compared with the following minimum values. In cases where the computed embedment depth is less than that specified below, the minimum embedment depth specified below shall be utilized:

A. Cantilever walls: Embedment depth shall not be less than the height of the retained cut.

B. Braced walls less than 20 feet high: Embedment depth shall not be less than 6 feet.

C. Braced walls 20 feet high or more: Embedment depth shall not be less than 8 feet.

<u>Secondary Bracing</u>

Primary elements of the shoring system shall be provided with secondary bracing as required for stability. The secondary bracing elements shall be designed for an axial load equal to 3 percent of the axial load in the braced member.

Connections

Connections between the various elements of the shoring system shall be designed for tension and shear loads equal to at least 10 percent of the design compression load transferred through the connection. If the actual shear or tension at a connection is larger than this 10 percent value, then the actual shear or tension load shall be utilized for design.

Stiffeners

Stiffeners shall be provided at shoring member connections when required by the provisions of Chapter K of the AISC, ASD.

15.8.9 Shoring Deflection and Settlement

All shoring designs within the Railroad Zone of Influence shall include an estimate of shoring deflection and retained earth settlement. Maximum permissible deflection shall enable the horizontal and vertical movement of the track to be limited to the requirements of Section 15.11.2. The amount of settlement that occurs will depend upon the soil type, the size of the excavation, the construction methods and quality of workmanship, and the design of the shoring system (including the stiffness of the shoring wall and bracing systems).

Elastic analyses of the shoring system should be performed for the various stages of support installation and removal in order to estimate lateral shoring deflection, which should then be used to make settlement estimates.

15.9 MATERIAL PROPERTIES AND ALLOWABLE STRESSES

The following examples are provided in Appendix G of this DCM:

- Example G-09-14 Wide Flange Wale Design
- Example G-09-15 Pipe Strut Design
- Example G-09-16 Shoring Wall Design
- Example G-09-17 Wood Lagging Design

15.9.1 Steel

Steel may be second-hand material, provided that is free from any strength impairing defects.

Structural Steel

Allowable stresses for steel shall conform to the AISC, Steel Construction Manual - Allowable Stress Design (ASD), thirteenth edition, 2005, with the following additional constraints for struts:

A. Slenderness ratio (L/r) shall not exceed 120.
B. Axial stress shall not exceed 12 ksi.

No overstress shall be permitted.

Structural steel for which mill certificates are not available (unidentified steel) shall be designed for allowable stresses no greater than those allowed for ASTM A36 steel.

Bolted and welded connections shall be designed in accordance with the provisions of the AISC, ASD.

Steel Sheet Piling

The maximum allowable flexural stress in sheet piling shall not exceed 65 percent of the yield strength of the steel.

Prestress Strand or Rod

If prestress strands or rod are used as tieback tendons or as tie rods to a deadman, the allowable working stress shall not exceed 40 percent of the guaranteed ultimate tensile strength (GUTS).

If the strands or rod are used for purposes other than those specified above, the allowable working stress shall not exceed 60 percent of GUTS.

The shoring designer shall evaluate the potential effects of corrosion on strands and rods. Corrosion protection suitable for the installation environment and anticipated service life shall be provided.

Wire Rope Cable

The allowable working load for wire rope shall be no greater than 25 percent of the rated breaking strength.

If wire rope connectors with an efficiency less than 100 percent are used, the allowable working load shall be taken as no greater than 25 percent of the rated breaking strength multiplied by the efficiency of the connectors.

Wire rope used as a structural element for more than 30 days shall be galvanized.

15.9.2 Concrete

Reinforced and plain (unreinforced) concrete shall be designed using the Strength Design Method in accordance with ACI 318. No stress increases or load factor reductions shall be allowed.

15.9.3 Wood

All wood shoring elements shall be Douglas Fir, No. 2 or better.

All wood that will remain in place permanently shall be pressure treated for ground contact use.

Allowable stresses shall be as follows:

Compression perpendicular to the grain = 450 psi

Compression parallel to the grain = $480{,}000/(L/d)^2 \le 1600$ psi, where

L = unbraced length of member

d = lesser cross-sectional dimension of member

(L and d to have consistent units)

Flexural stress = 1700 psi

(reduced to 1,500 psi for members with a nominal depth of 8 inches or less)

Horizontal shear = 140 psi

15.9.4 Other Materials

Allowable stresses for materials other than steel, concrete, and wood will be reviewed by SCRRA on a case-by-case basis. Typically, industry-accepted allowable stresses or load factors (with no overstress allowances) will be acceptable.

15.10 SPECIAL CONDITIONS

15.10.1 Sealed Shoring

Under certain conditions, excavation below the groundwater table will require that a sealed shoring system be utilized. Examples of situations where sealed shoring is needed include, but are not limited to:

A. Excavations in permeable soils where dewatering is infeasible or where the quantity of water to be handled and disposed of would be excessive.

B. Locations where the groundwater is contaminated.

C. Locations where dewatering would result in unacceptable settlement of the surrounding area.

Relatively watertight shoring is most commonly provided using interlocked sheet piling or diaphragm walls.

Where possible, groundwater flow around the bottom of the shoring wall should be prevented by extending the wall into an underlying low permeability soil layer (such as a clay layer). If a low permeability cut off layer is not present, or if it is at such a great depth that penetrating it is not feasible or cost effective, a tremie concrete or grouted seal slab should be considered for the base of the excavation.

In cases where a positive bottom seal is not provided, the potential for piping must be evaluated. See Section 15.10.3.

15.10.2 Dewatering

Dewatering can be an effective means of reducing shoring loading and improving shoring stability and constructability. In some cases, it may also be required to allow construction of proposed project elements.

In cases where dewatering is not precluded by other factors (see DPM), SCRRA will consider allowing dewatering, provided that it won't cause problematic track settlement. The potential for problematic track settlement to occur will be a function of the site soil profile and the depth to which the site needs to be dewatered. Track settlement in excess of that specified in Section 15.11.2 may be acceptable if it can be shown that differential track settlements resulting from dewatering will be minimal (i.e., settlements will occur over a broad area). Engineering calculations demonstrating that excessive differential settlement will not occur will be required.

In cases where the performance of the temporary shoring system depends upon the functionality of the dewatering system, the dewatering system shall be fail-safe. Elements such as an uninterrupted power supply, back-up pumps, and failure alarm signals will be required to guarantee that the dewatering system will never shut down for a period of time that could compromise the stability of the shored excavation.

Dewatering system design shall be performed by a Civil Engineer registered in the State of California with previous experience in the design of the specific type of dewatering system being proposed. Removed water shall not be drained along the tracks, but shall be drained off the Right-of-Way in accordance with environmental restrictions.

15.10.3 Bottom Stability

<u>Piping</u>

For excavations in pervious materials, the possibility of piping must be evaluated. Piping occurs when an unbalanced hydrostatic head causes large upward seepage pressures in the soil at and below the bottom of the excavation. The upward seepage pressure reduces the effective weight of the soil below the bottom of the excavation. As a result, the ability of the soil to laterally support the embedded portion of the shoring wall (i.e., passive resistance) is reduced. In the extreme, a quick condition can develop at the bottom of the excavation and large quantities of soil can be transported rapidly from outside to inside the excavation, thereby causing large ground settlements, and possibly even shoring system collapse.

Piping can be controlled by dewatering outside the shoring walls (where allowed) or by making the shoring walls deeper in order to reduce the upward hydraulic gradient. Alternatively, a tremie or grouted slab can be used as a bottom seal.

The potential for piping may be evaluated using published procedures (see the Caltrans Trenching and Shoring Manual). The minimum acceptable factor of safety against piping shall be 1.5. Additionally, a reduction in the available passive resistance due to upward seepage pressures shall be taken as appropriate.

Bottom Heave

In cases where excavations are made in soft (and sometimes medium) clays the potential for bottom heave must be evaluated. Bottom heave occurs when the depth of excavation is sufficient to cause upward movement of material in the bottom of the excavation and corresponding downward displacement of material surrounding the excavation. Heave can result in excessive settlement of the ground retained by the shoring system, and distress or failure of the shoring.

The possibility for heave should be evaluated further in cases when the Stability Number (No) exceeds 4, where:

No = $(\gamma H+q)/c$, and

γ = unit weight of soil

H = depth of excavation

q = vertical surcharge pressure

c = cohesive strength of soil

When No exceeds 4, the factor of safety against bottom heave should be computed using procedures outlined in the Caltrans Trenching and Shoring Manual. The minimum acceptable factor of safety against bottom heave shall be 1.5.

Global Stability

Typical shoring applications may not require global slope stability analyses. The Engineer in Responsible Charge shall determine if global stability calculations are warranted. However, SCRRA reserves the right to require global stability calculations at their sole discretion.

If applicable and/or required by SCRRA, temporary shoring systems and sloped excavations shall be demonstrated to be safe using limit equilibrium analyses with appropriate potential failure surfaces. Slope stability analyses shall consider the presence of Cooper’s E-80 live loading on active tracks.

The minimum factor of safety against failure of the whole, or any portion of, shored or sloped cuts shall be 1.5.

15.10.4 Tiebacks

Tiebacks will be allowed only where necessary and where Right-of-Way limits are sufficient. If tiebacks are permitted they must be installed using a method in which the drilled holes for the tiebacks will be stable and open at all times. In some soil types, this will necessitate fully cased holes beneath active tracks. Tiebacks shall be located a minimum of 5 feet below top of rail.

Tiebacks shall be designed in accordance with the procedures and criteria outlined in the Post-Tensioning Institute (PTI), Recommendations for Prestressed Rock and Soil Anchors, with the exception that the allowable stresses for the tieback tendons shall be limited to those values specified in Section 15.11 of these Criteria. A minimum factor of safety of 2.0 shall be used.

All tiebacks shall be load tested. Procedures and acceptance criteria for performance and proof testing shall conform to those given in the Post-Tensioning Institute (PTI), Recommendations for Prestressed Rock and Soil Anchors. The first 3 tiebacks installed and a minimum of 10 percent of the remaining tiebacks shall be performance tested. All remaining anchors shall be proof tested.

When tiebacks are bonded in fine-grained soils, creep testing shall be done in lieu of performance testing. Creep testing procedures and acceptance criteria shall conform to those given for temporary anchors in the Post-Tensioning Institute (PTI), Recommendations for Prestressed Rock and Soil Anchors.

In addition to the PTI Recommendations for Prestressed Rock and Soil Anchors, the designer may also reference FHWA Geotechnical Engineering Circular No. 4, Ground Anchors and Anchored Systems, FHWA-IF-99-015.

Tiebacks shall be locked-off at a minimum of 75 percent and a maximum of 100 percent of their design load.

15.10.5 Deadmen

Under the appropriate conditions SCRRA may allow temporary shoring walls to be supported using deadmen located on the opposite side of the tracks from the shored excavation. The proposed location(s) for deadman anchorage will require review and acceptance by SCRRA and any Third-Party property owners as appropriate. Tie rods to deadmen shall be a minimum of 5 feet below top of rail.

Deadman anchorage may be provided by soldier piles, sheet piling, or concrete blocks or walls. Deadman anchors shall be designed in accordance with the procedures outlined in the Caltrans Trenching and Shoring Manual.

Deadman anchors shall be designed to provide a minimum factor of safety of 2.0 against failure.

In order to minimize the deflection of the shoring, deadman anchors shall be prestressed to remove the slack in the system and to mobilize the passive resistance. A portion of the final design load shall be locked off.

Tie rods that pass under the tracks must be electrically isolated from the track. Details of proposed system of electrical isolation shall be submitted for review.

15.11 TRACK MONITORING

15.11.1 Purpose

SCRRA requires monitoring of the excavation, temporary shoring system and adjacent track(s) throughout the duration of shoring installation, excavation, construction, removal and backfill. The monitoring procedures specified below are intended to confirm that shoring systems are performing in a satisfactory manner and to identify locations of excessive ground movement so that they can be controlled and corrected in a timely manner.

15.11.2 Limitation on Track Movement

SCRRA requires that track settlement or track heave associated with all aspects of shoring and excavation shall not exceed ½ inch vertical change. Track movement shall not exceed ½ inch horizontal change due to temporary shoring and excavation. Track resurfacing or other remedial measures may be required if these limits are exceeded.

15.11.3 Minimum Monitoring Requirements

The excavation and temporary shoring system shall be visually inspected at least daily by qualified Contractor personnel to check for obvious movements or changes that were unplanned or that may be detrimental to railroad operations or safety. Visual monitoring should be performed more often during the performance of critical activities, such as excavation or foundation installation immediately adjacent to shoring or after moderate to severe rain events.

SCRRA requires that tracks adjacent to excavations within the Railroad Zone of Influence be monitored for movement and settlement. At a minimum, track monitoring shall consist of the following:

A. Survey points shall be established along all tracks for which the excavation is within the Railroad Zone of Influence. The maximum spacing and minimum extent of these points shall be as shown on Figure 15-4. A minimum of three (3) control points shall be established in areas that will not be subject to possible disturbance due to construction activities or railroad operations.

B. The surveying method utilized for track monitoring shall be accurate to ±1/8 inch and shall comply with the railroad surveying requirements in this Design Criteria Manual.

C. The horizontal coordinates and elevation of both rails shall be measured at each survey point location in accordance with the following schedule:

   1. A baseline reading of coordinates and elevations shall be taken prior to installation of any elements of the shoring system. In cases where track maintenance activities are performed to correct movements, a new baseline shall be established and its relationship to the previous baseline documented.

   2. Readings shall be taken twice weekly from the time at which shoring installation commences until shoring removal is completed. Supplemental readings may be required if excessive or unanticipated settlements are recorded.

   3. Readings shall be taken daily when shoring elements are driven on or adjacent to SCRRA right-of-way.

   4. Readings shall continue on a once weekly basis for a minimum of four weeks after shoring removal has been completed.

The monitoring requirements outlined above may be relaxed or waived on a project-specific basis at the sole discretion of SCRRA.

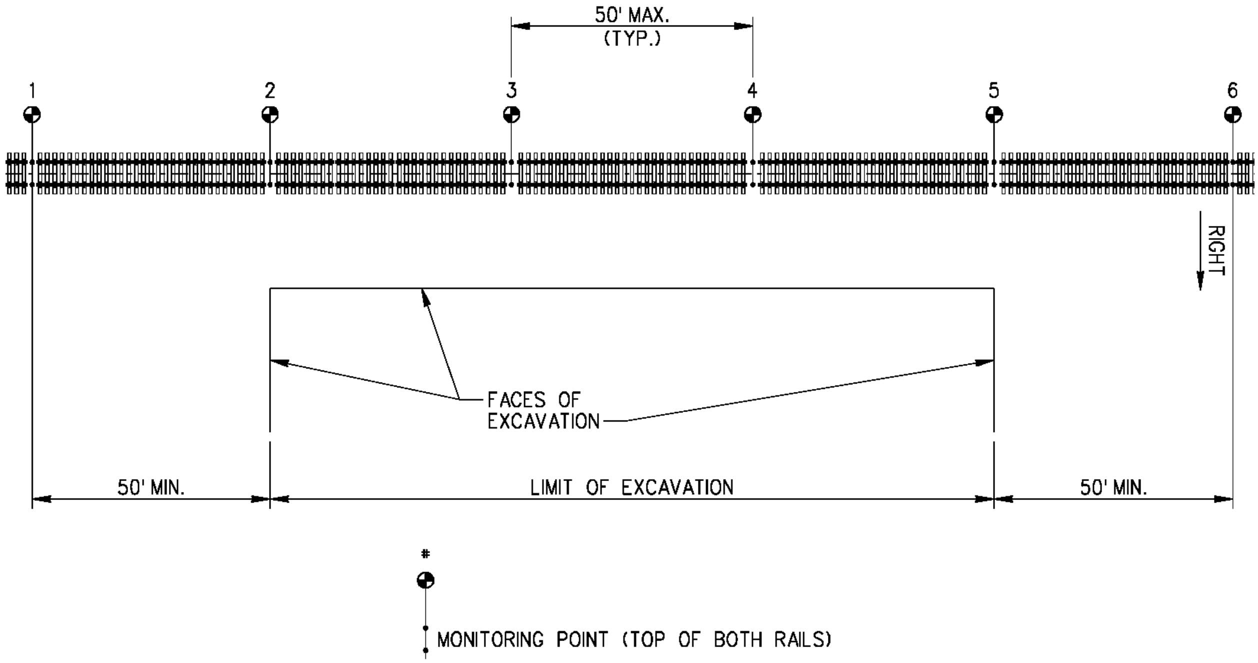


FIGURE 15-4. MINIMUM MONITORING REQUIREMENTS

15.11.4 Supplemental Monitoring

Supplemental monitoring may be required by SCRRA. Typically, supplemental monitoring will be required when any vertical change of ¼ inch or greater is measured by survey readings of static track elevation. Supplemental monitoring consists of the following:

A. More frequent survey measurements of static top of rail elevations and coordinates.

B. Measurement of rail movements and cross-slope under load.

Figure 15-5 depicts a method of measuring rail movements under load. Loaded rail movement measurements may be performed as follows:

A. At each survey point, place a 20d nail vertically into the ballast crib between ties with the head end directly under the base of each rail, taking care to place the nail head in direct contact with the rail.

B. Allow a typical commuter or freight train to pass through the location at normal speed.

C. Return to each survey point and measure and record the distance from the base of each rail down to the top of the nail head using a tape or gauge to the nearest 1/8 inch.

Survey readings and reduced survey data shall be provided to SCRRA immediately following each survey. Survey data and comparison to previous and baseline data should be provided on a form similar to that shown in Figure 15-6. SCRRA shall be specifically notified of any change in elevation of ¼ inch or greater. It is likely that SCRRA will require supplemental monitoring in the case of vertical movements in excess of ¼ inch.

Provide SCRRA with survey readings, reduced survey data, loaded measurements, and reduced loaded measurement data immediately following the survey. Loaded measurement data and comparison to previous and baseline data should be provided on a form similar to that shown in Figure 15-7.

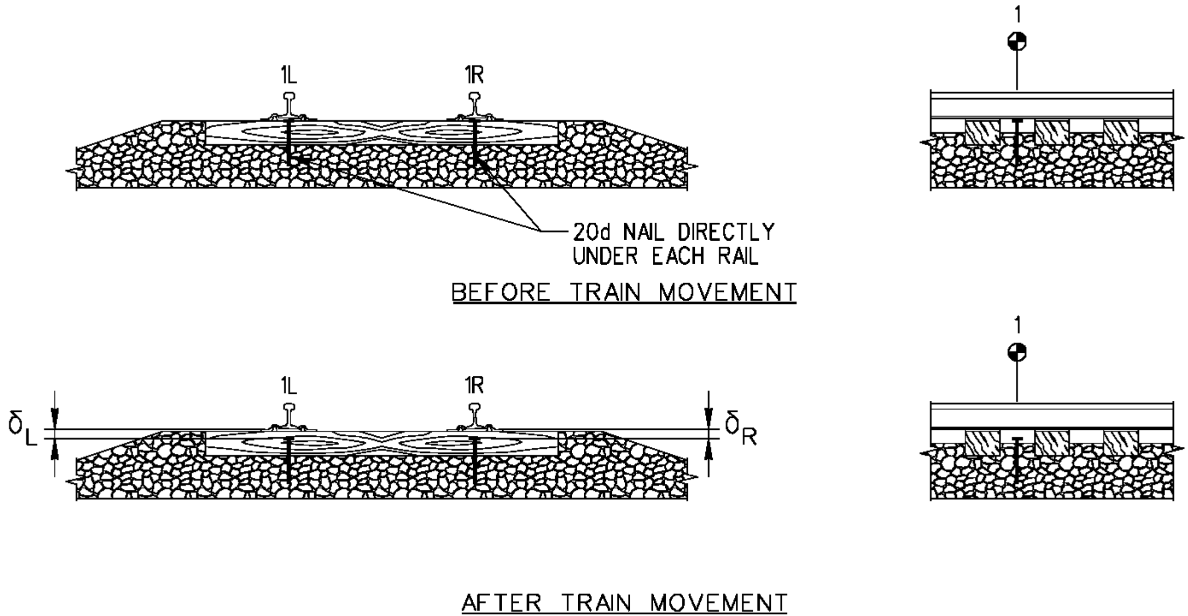


FIGURE 15-5. METHOD OF LOADED MEASUREMENT

Point No.	Station	Surveyed Static T/Rail Elevations			Static T/Rail Change from Previous			Static T/Rail Change from Baseline		
		E_L	E_R	E_{avg}	ΔE_L	ΔE_R	ΔE_{avg}	ΔE_{Li}	ΔE_{Ri}	ΔE_{avgi}
1	100+00									
2	100+50									
3	101+00									
.	.									
.	.									
.	.									
n										

FIGURE 15-6. REPORTING STATIC TOP OF RAIL SURVEY RESULTS

Point No.	Station	Measured Loaded Movements				Loaded Change from Previous				Loaded Change from Baseline			
		Total			Cross-Slope	Total			Cross-Slope	Total			Cross-Slope
		δ_L	δ_R	δ_{avg}	$\delta_{CS} = \lvert\delta_L - \delta_R\rvert$	$\Delta\delta_L$	$\Delta\delta_R$	$\Delta\delta_{avg}$	$\Delta\delta_{CS} = \lvert\Delta\delta_L - \Delta\delta_R\rvert$	$\Delta\delta_{Li}$	$\Delta\delta_{Ri}$	$\Delta\delta_{avgi}$	$\Delta\delta_{CSi} = \lvert\Delta\delta_{Li} - \Delta\delta_{Ri}\rvert$
1	100+00												
2	100+50												
3	101+00												
.	.												
.	.												
.	.												
n													

FIGURE 15-7. REPORTING LOADED MEASUREMENT RESULTS

15.11.5 Special Monitoring

SCRRA reserves the right to require that special monitoring be done for large, atypical, or long-lived shoring projects. Special monitoring may include the use of inclinometers, piezometers, tiltmeters, or other types of monitoring instrumentation. SCRRA will address this issue on a project-specific basis.

15.11.6 Access and Flagging

Access and flagging for establishing and reading survey points and monitoring instrumentation shall be coordinated with SCRRA.

15.12 SHORING SUBMITTAL REQUIREMENTS

15.12.1 General

All drawings and calculations for temporary shoring shall be prepared, sealed and signed by a Professional Engineer (civil or structural) currently licensed in the State of California who has previous experience in the design of temporary shoring systems of the type being submitted (preferably 10 years). Preferably, temporary shoring systems will be designed by a team composed of a railroad civil engineer who is experienced, knowledgeable and competent in design, construction, operations and maintenance parameters for commuter/passenger and freight railroad systems, and a licensed civil or structural engineer who is experienced, knowledgeable and competent in the design and construction of shored excavations adjacent to railroad tracks.

The designer will be responsible for the accuracy of all controlling dimensions as well as the selection of soil design values that accurately reflect the actual field conditions. No shoring installation or excavation within the Railroad Zone of Influence will be allowed until the drawings and calculations are reviewed and accepted by SCRRA.

All submittals, design calculations, specifications and drawings shall be prepared in accordance with a QA/QC process. The QA/QC process may follow the established program of SCRRA, Public Agency, Engineer in Responsible Charge firm, or Contractor. At a minimum, the QA/QC process must consist of an independent check of design calculations and an independent QC review of the drawings and specifications prior to submittal to SCRRA by qualified individuals. Documentation of the QA/QC process, including names and contact information of independent reviewers, shall be made available to SCRRA at their request.

A minimum of 30 calendar days should be allowed for SCRRA's review, provided that all required submittal materials are included and properly identified.

15.12.2 Drawings

The shoring drawings must be complete and shall accurately describe the nature of the work. Drawings shall be to-scale.

At a minimum the shoring drawings shall include the following:

A. Plan view that includes the following information and meets the following criteria:
    1. Railroad stationing and milepost (SCRRA will assist in providing this information)
    2. North arrow
    3. All pertinent topographic information

4. All Operating System elements and facilities
5. All overhead and underground utilities
6. All of the proposed excavations and distances from centerline of the track(s) to the face of the excavation and temporary shoring at relevant locations
7. Proposed types and locations of equipment used to install the temporary shoring
8. The drawing shall be in U.S. units with a scale no less than 1”=10’. Acceptable scales include 1”=10’, 1/8”=1’-0”, and 1/4”=1’-0”.

B. Section view normal to the track(s) showing the temporary shoring system relative to the centerline of the track(s). The section shall show elevations of the track(s), the existing ground surface, excavation lines at each stage as applicable, and bracing elements. Protective dividers, fences, handrail and walkway shall be shown as applicable. Minimum horizontal clearances from centerline of track to nearest obstruction at top of rail elevation and above shall be provided. The section shall also show shoring wall embedment depth and approximate groundwater depth.

C. Arrangement and sizes of shoring elements and details of all connections.

D. Specifications for materials and requirements for shoring fabrication and installation.

E. Construction sequence(s) detailing all steps in the shoring installation, excavation, and shoring removal. Include and highlight those items requiring Work Windows.

F. Track monitoring requirements (types, locations, reading schedule, etc.). See Section 15.11 for requirements.

15.12.3 Design Calculations

Design calculations shall be provided for all elements of the shoring system.

The calculations shall consider each stage of excavation and support removal.

The calculations shall include estimates of shoring deflection, demonstrating that the proposed system will not cause excessive settlement of the tracks. See Section 15.11.2 for settlement limitations.

A summary of the soil parameters used in the design shall be included in the calculations, and the source reference for these parameters shall be identified and provided. Include a copy of the geotechnical report if available.

Input and output from computer programs used for analysis and design of temporary shoring shall be accompanied by hand calculations verifying the input and results. In cases where the analysis methods used by the program are not shown in the output, appropriate documentation of the program’s calculations shall be provided.

15.12.4 Design Checklist

The shoring designer shall complete, seal and sign a copy of the Submittal Checklist included in Appendix E-9. The completed checklist shall accompany the shoring submittal.

15.12.5 Other Information

In the event that all or part of the proposed shoring system consists of commercially available, prefabricated elements (e.g., a trench shield), the shoring submittal shall include complete design data for these elements, including data to show that the system is compatible with the geotechnical characteristics at the site and provides capacity to handle all anticipated loads.

15.12.6 Site Specific Work Plan (SSWP)

The construction of all shoring and excavation work within the Basic Safety Envelope will require the Contractor to submit a Site Specific Work Plan (SSWP).

A. All work with the potential to impede the normal functioning of any part of the Operating System shall include a detailed SSWP's showing schedule of events, indicating the expected hourly progress of each activity that has duration of one hour or longer. The schedule shall include a time at which each activity planned under the SSWP and the requested Work Window will be completed, and the total duration of all the construction activities shall be less than the approved Work Window. Failure of the Contractor to complete the scheduled activities by the planned time or to put in place an approved contingency plan may adversely affect the operations of scheduled trains.

B. The SSWP shall include at minimum the information specified below.

   1. The SSWP shall include scope, brief schedule, location, equipment, material and staging, schedule, haul routes, safety plan, contingency plan, worksite representative, emergency response plan, excavation plan, boring and jacking plan, drilling and pile driving plan, falsework plan, and temporary traffic control plan.
   2. All activities necessary to perform construction activities within the Operating Envelope, including use of stations, tracks, signals, proposed storage areas and any other railroad facility.
   3. A description of any proposed changes in the Operating System between start and finish of the work, including any requested Work Windows.
   4. A schedule of the work, showing each activity and where and how it affects normal operation of the Operating System. This schedule shall integrate and allow for the necessary work of the Signal and Communication forces. Each activity in the plan shall include all labor, materials, and equipment required to complete the activity within SCRRA allotted time period. The Contractor shall identify on the schedule all SCRRA furnished labor, equipment and materials.
   5. The Contractor shall have SCRRA approved contingency plans for putting the Operating System back in operation in case of an emergency, or in case the Contractor fails to perform and complete the work on time. The contingency plans shall address the various stages of activities necessary to restore the System.
   6. List all of the approved proposed work plans to be performed under the SSWP, and provide the name(s) and number(s) of the Contractor's supervisor(s) in charge of the SSWP tasks.
   7. Plans showing all the existing underground and overhead utilities, including SCRRA's signal and communications cables when the excavation, boring and jacking, and drilling & pile driving work is within twenty feet of railroad tracks. The plans will show the actual locations of utilities based on potholing operation.

C. The SSWPs must be of sufficient detail, clarity, and organization to permit easy review and approval by SCRRA before the proposed work is performed. The SSWP shall be submitted and approved prior to starting work. The Contractor shall anticipate obtaining approvals from SCRRA as follows:

   1. At least 14 calendar days prior to start of the work within the Operating Envelope for work other than signal or third-party activity.
   2. At least 30 calendar days prior to the start of work for work involving signal or third-party installation.

D. SCRRA may request explanations and changes to the SSWP to conform the SSWP to the requirements of the Contract Documents. If the SSWP is not acceptable, the Contractor shall revise the SSWP to make it acceptable. The Contractor is responsible for submitting a revised SSWP that can be reviewed and approved by SCRRA at least seven days in advance of any work that affects the Operating System.

E. The Contractor will be informed if the SSWP is acceptable not less than seven calendar days prior to the scheduled start of work within the Operating Envelope. Once the plan is accepted, the Contractor shall assemble the resources necessary to perform the work represented by the SSWP, so that necessary resources are available one calendar day before the work is to be accomplished, thereby demonstrating to SCRRA the readiness of the Contractor to perform the work. At this time, SCRRA will make a final decision as to whether or not the Work is to proceed as planned or be canceled.

15.12.7 Construction Verification

The temporary shoring Engineer in Responsible Charge (or his/her authorized designee) shall inspect the as-built shoring system to verify that the system is constructed in accordance with the shoring plans that have been reviewed and accepted by SCRRA. The Engineer in Responsible Charge shall prepare a letter that shall be submitted to SCRRA confirming that the shoring system has been inspected and verified. Any field changes shall be listed in the letter and the effect of those changes shall be evaluated by the Engineer in Responsible Charge. Any deficiencies noted by the Engineer in Responsible Charge shall be corrected by the Contractor. Deficiencies and corrections shall be noted in the letter with verification of adequate correction by the Engineer in Responsible Charge.

The number of site visits and the stage or stages of construction at which they shall be performed will be specified by SCRRA as a condition of acceptance of the temporary shoring design. The intent will be to have the temporary shoring installation verified by the Engineer in Responsible Charge at critical construction stages.

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16.0 PROTOTYPICAL LAYOVER AND MAINTENANCE FACILITY

16.1 SCOPE

The following functional areas represent a detailed description of specific design issues for each space in a typical Layover and Servicing Facility. Each of the functional areas contains information regarding the function of the space, critical clearances and/or dimensions, major equipment, furnishings, and typical design features related to the facility, if applicable. The size of the prototypical layover or maintenance facility will be determined based on accommodation of programmatic requirements listed below.

The Layover and Maintenance Facility will be storing, servicing, maintaining, and operating Diesel-electric Locomotives and Passenger Coach and Cab Vehicles.

The project site must be assessed for climate vulnerability (see Section 3.3) to ensure any work is designed to be resilient to future climate conditions.

For all facility types, if the site has been identified as vulnerable to flooding, the site shall be graded, and/or the facility elevated to remove it from flood exposure. As applicable, further modelling work shall be carried out to identify overland flow paths.

16.2 STANDARDS AND CODES

See Appendix D and Chapters 17 and 18 for discipline specific information.

16.3 SCRRA PROTOTYPICAL FACILITY WORKSPACE REQUIREMENTS

SCRRA Oversight department is responsible for facility maintenance and supervision. Office spaces shall be furnished according to DCM Appendix D space needs programmatic requirements and owner furniture standards, but not limited to sit/stand workstations, file cabinets, tables, and chairs in order to provide optimal work conditions for administrative staff.

16.3.1 Director

Provide a private office for completing work tasks and holding small meetings. Locate adjacent to Manager and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.3.2 Manager

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Director and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.3.3 Assistant Manager

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Manager and Administrative Assistant, with access to Copy/Workroom/Supplies.

Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.3.4 Supervisor

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Assistant Manager and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.3.5 Administrative Assistant

Provide an open office workstation for completing work tasks. Locate adjacent to Director, Manager, Assistant Manager, and Supervisor, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.3.6 Kitchenette

Provide a dedicated alcove or room used for staff to eat, prepare, and store food. Locate centrally within SCRRA Oversight area with access to all office and support areas for SCRRA Oversight. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting and address applicable Health Department requirements. Major equipment/furnishings include (but are not limited to) the following:

- Counter space
- Upper and lower cabinets
- Sink with water filter
- Microwave
- Refrigerator
- Coffee maker
- Vending (optional)
- Trash/recycling/compost bins

16.3.7 Copy/Workroom/Supplies

Provide a dedicated alcove or room for copier/printer/scanner/fax machine, storage for office supplies, and work surface. Location shall have access to SCRRA Oversight Office Area. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting. Major equipment/furnishings include (but are not limited to) the following:

- Copier/printer/scanner/fax machine
- Work surface with cabinets below and above
- Office supply storage
- Filing cabinets

16.3.8 Conference Room

Provide a room for personnel to meet. Location shall be accessible by all departments in the building. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting. Owner furniture standards include (but are not limited to) the following:

- Table (with USB and electrical outlet ports. Evaluate based on current technology)
- Chairs
- White board and/or television
- Computer with ability to connect to a projector or the television. Evaluate based on current technology.

16.3.9 Secure File Storage

Provide a secure room for storing files, records, and other documents. Location shall be accessible from SCRRA Oversight Office Area. Provide 9'-0" vertical clearance (minimum). Humidity levels need to be consistent. Major equipment/furnishings include (but are not limited to) the following:

- File Cabinets
- Flat File Cabinets

16.3.10 Custodial Room

Provide an enclosed area for janitorial supplies and mop sink. Locate adjacent to Restrooms. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Mop Sink
- Metal Shelving
- Mobile Cart
- Mop Holder

16.3.11 Men's Restroom

The above support space to be provided and addressed per applicable codes for each facilities (Oversight, Train Operations, Equipment Maintenance, Material Handling and Service Areas.)

16.3.12 Women's Restroom

The above support space to be provided and addressed per applicable codes for each facilities (Oversight, Train Operations, Equipment Maintenance, Material Handling and Service Areas.

16.3.13 Unisex Restroom

The above support space to be provided and addressed per applicable codes for each facilities (Oversight, Train Operations, Equipment Maintenance, Material Handling and Service Areas.

16.4 FACILITIES FOR TRAIN OPERATIONS CONTRACT STAFF

Train Operations department is responsible for dispatch of fleet vehicles. Additionally, this department provides vehicle operational training/instruction for personnel. Office spaces shall be furnished according to owner furniture standards (but not limited to) sit/stand workstations, file cabinets, tables, and chairs in order to provide optimal work conditions for operations staff.

16.4.1 Manager

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Assistant Manager and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.4.2 Assistant Manager

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Manager and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.4.3 Supervisor

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Assistant Manager and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.4.4 Administrative Assistant

Provide an open office workstation for completing work tasks. Locate adjacent to Director, Manager, Assistant Manager, and Supervisor, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.4.5 Conductor and Train Engineer

Provide an open office workstation for completing work tasks. Locate adjacent to Supervisor, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.4.6 Conductor and Train Engineer Lockers

Provide an alcove for the Conductors and Train Engineers to store personal gear and clothing in half-height lockers. Provide co-ed locker area with private changing areas in respective restrooms. Locate adjacent to Men’s and Women’s Restrooms and connect to Driver’s Room. Provide 9’-0” vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Heavy duty, two-tier, 3-foot, well-ventilated, slant-top, half-height lockers; one each per Conductor and Train Engineer assigned to the facility

16.4.7 Drivers' Room

Provide an area for Conductors and Train Engineers to gather, take breaks, and relax between shifts. Locate adjacent to Dispatch, TV Room, Quiet Room, Restrooms, Conductor and Train Engineer Lockers, and Mailboxes and connect to Train Engineer Break Room. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting. Major equipment/furnishings include (but are not limited to) the following:

- Computer workstations
- Tables and chairs. No tables with chairs attached
- Message and information television and/or bulletin boards
- End tables
- Comfortable chairs
- Recreation equipment
- Mailboxes

16.4.8 TV Room

Provide an enclosed room for Conductors and Train Engineers to watch television between, before, and after shifts. Locate adjacent to Drivers' Room. Provide 9'-0" vertical clearance (minimum). Typical design features shall include darker painted walls and no exterior windows. Major equipment/furnishings include (but are not limited to) the following:

- Television
- Chairs
- End tables

16.4.9 Quiet Room A and B

Provide an enclosed room for Conductors and Train Engineers to relax between, before, and after shifts. Locate adjacent to Drivers' Room. Provide 9'-0" vertical clearance (minimum). Typical design features shall include darker painted walls and no exterior windows. Major equipment/furnishings include (but are not limited to) the following:

- Chairs
- Side tables
- Bookcase

16.4.10 Uniform Locker

Provide an alcove area for vendors to drop off clean and pick up dirty uniforms with co-ed locker/changing area in respective restrooms. Locate adjacent to an exterior door for vendor pick up/drop off with accessibility from Men's and Women's Restroom and Locker Areas. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Vender provided well-ventilated uniform lockers, bin for dirty uniforms

16.4.11 Dispatch

Provide open office workstation to complete work tasks located in secured part of the facility with limited access. Locate adjacent to Drivers' Room, Restrooms, and Data/Comm. Room. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting. Owner furniture standards include (but are not limited to) the following:

- Sit/stand Workstation
- File Cabinets
- Task chair

16.4.12 Radio Storage

Provide secure area to store radio equipment. Locate adjacent to Dispatch. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Shelving
- Racking

16.4.13 Dispatch Storage

Provide secure area to store materials. Locate adjacent to Dispatch. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Shelving
- Racking

16.4.14 Lobby

Provide central entry area with open space to accommodate visitors (internal or external). Location shall be accessible from Train Engineer Areas. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting. Major equipment/furnishings include (but are not limited to) the following:

- Chairs
- Side tables

16.4.15 Copy/Workroom/Supplies

Provide dedicated alcove or room for copier/printer/scanner/fax machine, storage for office supplies, and work surface. Location shall have access to Train Engineer Office Area. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Copier/printer/scanner/fax machine
- Work surface with cabinets below and above
- Filing cabinets

16.4.16 Conference Room

Provide room for up to a ten-person meeting. Location shall be accessible from all departments in the building. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting. Owner furniture standards include (but are not limited to) the following:

- Table
- Chairs
- White board and/or television

16.4.17 Large Conference Room

Provide room for up to a 20-person meeting. Location shall be accessible from all departments in the building. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting. Owner furniture standards include (but are not limited to) the following:

- Table (with USB and electrical outlet ports. Evaluate based on current technology)
- Chairs
- White board and/or television
- Computer with ability to connect to a projector or the television. Evaluate based on current technology.

16.4.18 Break Room

Provide enclosed room used as a break area for staff. Shall be centrally located, adjacent to the Drivers' Room, with access to all office areas, support areas, and restrooms. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting. Major equipment/furnishings include (but are not limited to) the following:

- Counter space
- Upper and lower cabinets
- Sink
- Microwaves
- Refrigerators

- Coffee makers
- Ice maker
- Water filter
- Vending machines
- Water coolers
- Tables, Hard-surface chairs (with USB and electrical outlet ports. Evaluate based on current technology)
- Trash/recycling/compost bins

16.4.19 Training Room A and B

Provide large room for staff to participate in training activities. Training Rooms shall have a dividable wall between each of them. These spaces will also be available as a Conference Room, but training will be the primary function. Locate adjacent to Train Engineer Office Area with accessibility to all departments in the building. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting. Major equipment/furnishings include (but are not limited to) the following:

- Tables (with USB and electrical outlet ports. Evaluate based on current technology)
- Chairs
- Whiteboard and/or Television
- Overhead projector

16.4.20 Chair/Table Storage

Provide enclosed space to store chair and tables used for training, and activities. Location shall be accessible from inside Train Engineer Training Rooms A and B. Provide 9'-0" vertical clearance (minimum).

16.4.21 Training Supply/Storage Room

Provide secure area to store supplies and materials. Location shall be accessible from inside Train Engineer Training Rooms A and B. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Cabinets
- Shelving

16.4.22 Wellness Room

Provide dedicated room for privacy to take care or personal matters and storage of first aid supplies. Location shall be accessible from all departments in the facility. Provide 9’-0” vertical clearance (minimum). Typical design features include a lockable door with occupied sign and no windows. Major equipment/furnishings include (but are not limited to) the following:

- Sink
- Countertop and cabinets
- Small personal lockers
- Side table
- Refrigerator
- Chairs

16.4.23 Drug Test Room

Provide dedicated room for privately collecting screening samples from staff. Location shall be accessible from all departments in the facility. Provide 9’-0” vertical clearance (minimum). Typical design features include connecting to a single toilet and no windows. Major equipment/furnishings include (but are not limited to) the following:

- Sink
- Countertop and cabinets
- Refrigerator
- Chairs

16.4.24 Custodial Room

Provide enclosed area for janitorial supplies and mop sink. Locate adjacent to Restrooms. Provide 9’-0” vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Mop Sink
- Metal Shelving
- Mobile Cart
- Mop Holder

16.4.25 Fitness Room

Provide enclosed area for employees to exercise. Location shall be accessible from the Drivers' Room, Lockers, and Restrooms and Showers and all departments in the facility. Provide 9'-0" vertical clearance (minimum). Typical design features include natural daylighting, acoustically separated from surrounding spaces, and athletic rubber floor tiles with base (recommended). Major equipment/furnishings include (but are not limited to) the following:

- Miscellaneous fitness equipment determined by the owner
- Televisions
- Bulletin boards

16.4.26 Secure File Storage

Provide secure room for storing files, records, and other documents. Location shall be accessible from Train Engineer Office Area. Provide 9'-0" vertical clearance (minimum). Keep consistent humidity levels. Major equipment/furnishings include (but are not limited to) the following:

- File Cabinets
- Flat File Cabinets

16.4.27 Lost and Found

Provide secure area to temporarily store miscellaneous items found throughout the rail lines and on trains. Location shall be adjacent to Lobby and accessible from exterior door. Provide 9'-0" vertical clearance (minimum). Keep consistent humidity levels. Major equipment/furnishings include (but are not limited to) the following:

- Shelving
- Racking

16.4.28 Men's Restroom

The above support space to be provided and addressed per applicable codes.

16.4.29 Women's Restroom

The above support space to be provided and addressed per applicable codes.

16.4.30 Unisex Restroom

The above support space to be provided and addressed per applicable codes for each facilities (Oversight, Train Operations, Equipment Maintenance, Material Handling and Service Areas.

16.5 FACILITIES FOR EQUIPMENT MAINTENANCE CONTRACT STAFF

Equipment Maintenance department is responsible for light and heavy-duty maintenance and repairs to train and locomotive components. Office spaces shall be furnished according to owner furniture standards (but not limited to) sit/stand workstations, file cabinets, tables, and chairs in order to provide optimal working conditions for equipment maintenance staff.

16.5.1 Director

Provide private office for completing work tasks and holding small meetings. Locate adjacent to Manager and Administrative Assistant with access to Copy/Workroom/Supplies. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting.

16.5.2 Manager

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Director and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting.

16.5.3 Assistant Manager

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Manager and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting.

16.5.4 Supervisor

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Shop Areas and Positions with views of the equipment maintenance floor, with access to Copy/Workroom/Supplies. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting.

16.5.5 Administrative Assistant

Provide an open office workstation for completing work tasks. Locate adjacent to Director, Manager, Assistant Manager, and Supervisor, with access to Copy/Workroom/Supplies. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting.

16.5.6 Copy/Workroom/Supplies

Provide a dedicated alcove or room for copier/printer/scanner/fax machine, storage for office supplies, and work surface. Location shall have access to Equipment Maintenance Office Areas. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Copier/printer/scanner/fax machine
- Work surface with cabinets below and above
- Filing cabinets

16.5.7 Manuals Library

Provide enclosed area for storage and reference of vehicle maintenance reference manuals and materials used by Car Mechanics and Locomotive Mechanics. Locate adjacent to Shop and Positions with views of the equipment maintenance floor and accessible from Supervisor Office and Equipment Maintenance Office Area. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting. Owner furniture standards include (but are not limited to) the following:

- Workstations
- Bookshelves
- Chairs

16.5.8 Break Room w/ Kitchenette

Provide enclosed room used as a break area for staff. Location shall be centrally located with access to all office areas, shop areas, repair positions, and restrooms. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting. Major equipment/furnishings include (but are not limited to) the following:

- Counter space
- Upper and lower cabinets
- Sink
- Microwaves
- Refrigerators
- Coffee maker
- Ice maker
- Water filter
- Vending machines
- Water cooler
- Tables and hard-surface chairs
- Trash/recycling/compost bins

16.5.9 Training Room – Equipment Maintenance

Provide large room for staff to participate in training activities. This space will also be available as a Conference Room, but training will be the primary function. Locate adjacent Equipment Maintenance Office Area with accessibility to all departments in the building. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting. Owner furniture standards include (but are not limited to) the following:

- Tables (with USB and electrical outlet ports. Evaluate based on current technology)
- Chairs
- Whiteboard and/or Television
- Overhead projector

16.5.10 Training Supply/Storage Room

Provide secure area to store supplies and materials. Location shall be accessible from inside Training Room - Equipment Maintenance. Provide 9’-0” vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Cabinets
- Shelving

16.5.11 Chair/Table Storage

Provide enclosed space to store chair and tables used for training, and activities. Location shall be accessible from inside Training Room - Equipment Maintenance. Provide 9’-0” vertical clearance (minimum).

16.5.12 Conference Room – Equipment Maintenance

Provide room for up to a 10-person meeting. Location shall be accessible from all departments in the building. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting. Owner furniture standards include (but are not limited to) the following:

- Table
- Easy to clean vinyl cover chairs. No cloth
- White board and/or television.

16.5.13 Uniform Locker

Provide an alcove area for vendors to drop off clean and pick up dirty uniforms with co-ed locker/changing area in respective restrooms. Locate adjacent to an exterior door for vendor pick up/drop off with accessibility from Men’s and Women’s Restroom and Locker Areas. Provide 9’-0” vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Vender provided well-ventilated uniform lockers, bin for dirty uniforms

16.5.14 Custodial Room

Provide enclosed area for janitorial supplies and mop sink. Locate adjacent to Restrooms. Provide 9’-0” vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Mop Sink
- Metal Shelving
- Mobile Cart
- Mop Holder

16.5.15 Secure File Storage

Provide secure room for storing files, records, and other documents. Location shall be accessible from Equipment Maintenance Office Area. Provide 9'-0" vertical clearance (minimum). Keep consistent humidity levels. Major equipment/furnishings include (but are not limited to) the following:

- File Cabinets
- Flat File Cabinets

16.5.16 Equipment Maintenance Lockers

Provide a locker area for each male and female Equipment Maintenance employees. Locate within Equipment Maintenance Men's and Women's Restrooms with accessibility by Shop Areas and Positions. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- 6-foot high gear, well-ventilated lockers with built-in bench
- Lockers must be ADA compliant and have mirrors
- Lockers must have slanted tops
- Lockers must be a minimum of 18" x 18" with 72" of clearance

16.5.17 Men's Restroom

The above support space to be provided and addressed per applicable codes.

16.5.18 Women's Restroom

The above support space to be provided and addressed per applicable codes.

16.5.19 Unisex Restroom

The above support space to be provided and addressed per applicable codes for each facilities (Oversight, Train Operations, Equipment Maintenance, Material Handling and Service Areas.

16.5.20 Car (Heavy) Position

Provide position to perform heavy duty repair maintenance of passenger cars, such as replacing trucks, HVAC units, and under vehicle components of passenger cars with a gauge pit and roof top component repair and replacement with an Upper Level Work Platform (ULWP) as well as windows and components on the side of the cars with a midlevel platform. Locate adjacent to A/C Shop/Storage and Truck Shop/Storage with access to Common Work Area, Material Handling Storage, Portable Equipment Storage, and Equipment Maintenance Office Area with accessibility from Supervisor Office with view. Critical clearances and dimensions are as follows:

- 24'-0" vertical clearance to structure and fixtures (minimum)
- 25'-0" wide x 85'-0" long
- Gauge Pit: 85'-0" long (length of vehicle) x between track x 5'-6" deep (minimum)

- Midlevel Platform: 85’-0” long (length of vehicle) x 10’-0” wide on both sides of vehicle (minimum). Final height placement per car specifications
- ULWP: 85’-0” long (length of vehicle) x 10’-0” wide on both sides of vehicle (minimum). Final height placement per car specifications
- All level dimensions to be designed per latest car information during final design

Major equipment/furnishings include (but are not limited to) the following:

- Portable Car Jacks
- Shore Power
- Overhead Bridge Crane
- Overhead fall protection lines
- Turntables
- Truck Hoists
- Platforms for upper level and midlevel access
- New and Used Fluid systems as required
- Compressed air:
    - 2” compressed air piping loop (minimum)
    - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4’-0” AFF
    - Provide disconnect for 3/8” and 1/2 “ impact tools at locations to be determined during final design
    - Provide in Pit and ULWP
    - As required by equipment. NOX monitor/alarm

Typical design features include:

- Natural Daylighting
- Forklift access, requiring a thickened slab
- Gauge pit open full length of car
- One car position
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

- Overhead doors to be sectional, galvanized steel, insulated, 16’-0” wide by 20’-0” tall with view panels, automatic operator, interior and exterior push button controls
- Personnel door with view panel to meet applicable code exit requirements

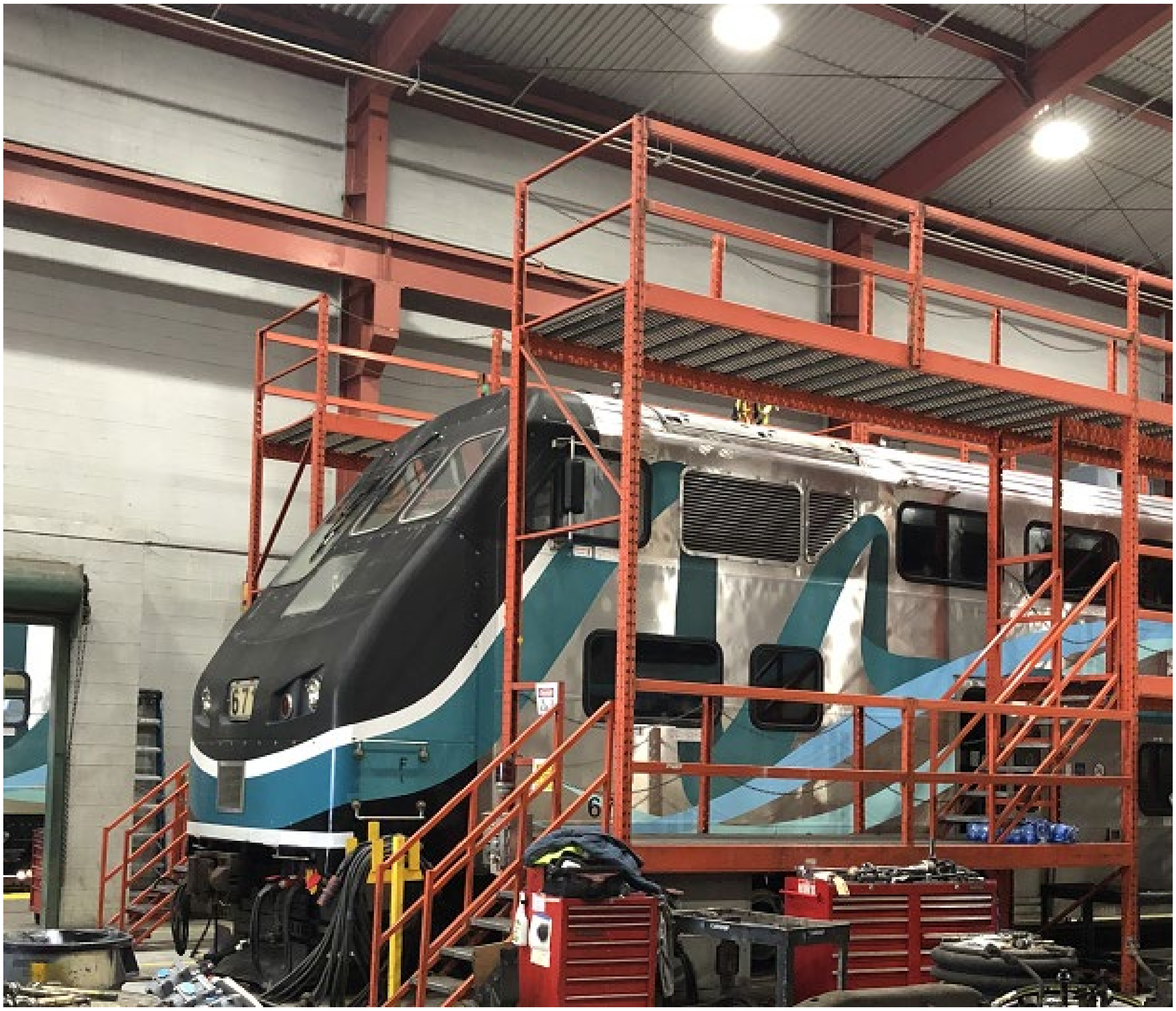

FIGURE 16-1. ULWA PLATFORM ALLOWS ACCESS TO REMOVE WINDOWS AND PERFORM ROOF WORK SUCH AS AC UNIT MAINTENANCE

16.5.21 Locomotive Position/Drop Table

Provide position to perform heavy duty repair maintenance of locomotive cars, such as replacing components, rebuilding components, and under vehicle components of locomotive cars with a gauge pit, Lower Level Work Area (LLWA) to replace components on the lower portion of the cars, midlevel platform to repair and replace major interior locomotive components, and Upper Level Work Platform (ULWP) to replace locomotive roof components.

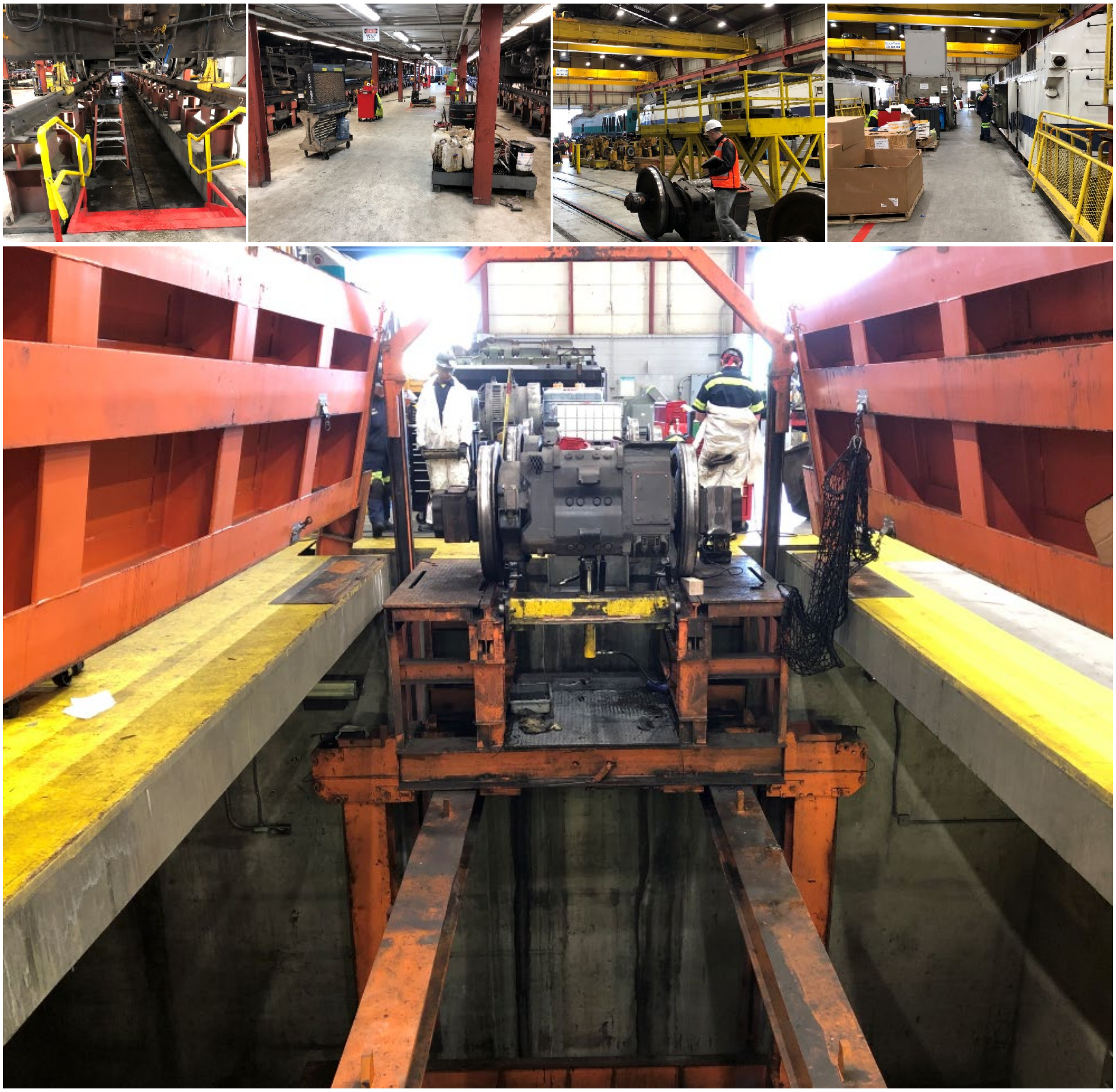

FIGURE 16-2. FIXED FOUR LEVEL WORK AREA ALLOWS COMPLETE LOCOMOTIVE SERVICE IN A SINGLE POSITION

A drop table is the preferred means of removing and transferring truck set to side of train for maintenance/replacement. Locate adjacent and open to Traction/Machine/Rebuild Shop with access to Common Work Area, Material Handling Storage, Portable Equipment Storage, and Equipment Maintenance Office Area and accessibility from Supervisor Office with view. Critical clearances and dimensions are as follows:

- 24’-0” vertical clearance to structure and fixtures (minimum)
- 28’-0” wide x 70’-0” long
- Gauge Pit: 70’-0” long (length of vehicle) x between track x 5’-6” deep (minimum)

- LLWA: 70'-0" long (length of vehicle) x 10'-0" wide on both sides of vehicle x 6'-0" deep (minimum). Final depth per car specifications
- Midlevel Platform: 70'-0" long (length of vehicle) x 10'-0" wide on both sides of vehicle (minimum). Final height placement per car specifications
- ULWP: 70'-0" long (length of vehicle) x 10'-0" wide on both sides of vehicle (minimum). Final height placement per car specifications
- All level dimensions to be designed per latest car information during final design

Major equipment/furnishings include (but are not limited to) the following:

- Shore Power
- 20 ton and 30-ton overhead Bridge Cranes (minimum) to also cover Traction/Machine/ Rebuild Shop
- Drop tables
- New and Used Fluid systems as required: Two new oil, 1 antifreeze, 1 used oil and 1 used antifreeze; piped with pumps between user area(s) and appropriate bulk storage tanks
- Compressed air:
  - 2" compressed air piping loop (minimum)
  - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4'-0" AFF
  - Provide disconnect for 3/8" and 1/2 " impact tools at locations to be determined during final design
  - Provide on all four levels
  - As required by equipment
  - Provide an integrated air monitoring with automotive exhaust and fresh air supply system

Typical design features include the following:

- Natural Daylighting
- Forklift access, requiring a thickened slab
- Gauge pit open full length of car
- One car position
- Stationary safety railings as required per final design
- Rolling safety railing at on ULWP and midlevel platform pertinent locations to access major points for locomotive car (locations to be determined in final design)
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer

- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Overhead doors to be sectional, galvanized steel, insulated, 16’-0” wide by 20’-0” tall with view panels, automatic operator, interior and exterior push button controls
- Personnel door with view panel to meet applicable code exit requirements

16.5.22 Progressive Track

Provide track to perform preventive maintenance such as inspections and minor brake work with a gauge pit and Lower Level Work Area (LLWA) as well as inspections and minor replacement or windows and components on the side of the car with a midlevel platform.

Location should be accessible from Supervisor Office with view with access to Common Work Area, Material Handling Storage, Portable Equipment Storage, and Equipment Maintenance Office Area. The critical clearances and dimensions are as follows:

- 24’-0” vertical clearance to structure and fixtures (minimum)
- 22’-0” wide x 665’-0” long (length to accommodate an 8-train car set, one locomotive and seven passenger cars)
- Gauge Pit: 665’-0” long (length of vehicle) x between track x 5’-6” deep (minimum)
- LLWA: 665’-0” long (length of vehicle) x 5’-0” wide on both sides of vehicle x 6’-0” deep (minimum). Final depth per car specifications
- Midlevel Platform: 70’-0” long (length of vehicle) x 5’-0” wide on both sides of vehicle (minimum). Final height placement per car specifications
- All level dimensions to be designed per latest car information during final design

Major equipment/furnishings include (but are not limited to) the following:

- New and Used Fluid systems as required
- Compressed air:
  - 2” compressed air piping loop (minimum)
  - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4’-0” AFF
  - Provide disconnect for 3/8” and 1/2 “ impact tools at locations to be determined during final design
  - Provide in gauge pit and LLWA
  - As required by equipment

Typical design features include the following:

- Natural Daylighting
- Forklift access, requiring a thickened slab

- Gauge pit open full length of track (665’-0”)
- Position length to accommodate an 8-train car set, one locomotive and seven passenger cars
- Midlevel platform at each end of track length of locomotive
- Stationary safety railings as required per final design
- Rolling safety railing on LLWA and midlevel platform pertinent locations to access points for inspection (locations to be determined in final design)
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Overhead doors to be sectional, galvanized steel, insulated, 16’-0” wide by 20’-0” tall with view panels, automatic operator, interior and exterior push button controls
- Personnel door with view panel to meet applicable code exit requirements

16.5.23 Wheel Truing Lathe Position

Provide a dedicated position for truing wheels on vehicles without removing truck assembly as well as capability to true a truck as a stand-alone item. The machine shall be positioned so that wheels on any axel can be trued while keeping the vehicle inside the building and not blocking track circulation. Locate in separate building or on end of large Equipment Maintenance Building. The critical clearances and dimensions are as follows:

- 24’-0” vertical clearance to structure and fixtures (minimum)
- 30’-0” wide x 200’-0” long

Major equipment/furnishings include (but are not limited to) the following:

- Wheel Truing Lathe
- Compressed air:
  - 2” compressed air piping loop (minimum)
  - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4’-0” AFF
  - Provide disconnect for 3/8” and 1/2” impact tools at locations to be determined during final design
  - As required by equipment

Typical design features include the following:

- Natural Daylighting
- Forklift access, requiring a thickened slab

- Stairs down to pit level
- Pit level designed with space for maintenance tools and supplies
- Length of the bay is determined by ability to run all wheels of vehicle on wheel truing machine without blocking critical functions
- Wheel truing machine to be operational from both directions. Visual indicators must be able to be observed by the operator in the operating cab of the train car while positioning the vehicle over the wheel truing equipment from other direction
- Fume extraction system required to remove exhaust fumes from pit area and surrounding work spaces (supplied with wheel truing lathe).
- Acoustically mitigated from surrounding spaces
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Overhead doors to be sectional, galvanized steel, insulated, 16’-0” wide by 20’-0” tall with view panels, automatic operator, interior and exterior push button controls
- Personnel door with view panel to meet applicable code exit requirements
- Provide provisions for industrial waste (metal chips) disposal
- A step up ledge 10 inches above the pit floor shall be provided to assist in the inspection and repair of hard to reach hardware.
- The depressed floor areas shall be supplied with necessary maintenance utilities (i.e. lights, compressed air, electrical outlets, water) through the mounting of these utilities on the posted rail; welding outlets and traction and auxiliary power systems shall also be provided at strategic locations on the posted rail sections.

16.5.24 Common Work Area

Provide designated area for common fixed shop equipment which supports all repair positions and associated shop areas. Locate on first floor adjacent to Car (Heavy) Position, Locomotive Position, Progressive Track, Material Handling Storage, and Portable Equipment Storage with access from Maintenance Office Areas. Provide 12’-0” vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Workbench with vise
- Hydraulic Press
- Drill Press
- Band Saw

- Buffer/Grinder
- Blast Cabinet with Dust Collection
- Parts Washer
- Parts Cleaning Tank
- Shelving
- Cabinets
- Flammable Materials Cabinets
- Compressed air:
  - 2” compressed air piping loop (minimum)
  - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4’-0” AFF
  - Provide disconnect for 3/8” and 1/2 “ impact tools at locations to be determined during final design
  - As required by equipment

Typical design features include the following:

- Natural Daylighting
- Forklift access, requiring a thickened slab
- Road access for service, maintenance, and deliveries
- Half-height 56-inch walls on three sides for utilities and to prevent blocking vision of shop from office areas and repair positions
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

16.5.25 Brake Shop

Provide enclosed room to perform inspections and maintenance of brake and coupler components. Locate with accessibility from Progressive Track, Common Work Area, Material Handling Storage, and Portable Equipment Storage. Provide 12’-0” vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Workbench with vise
- Racking
- Shelving

- Lift Table
- Compressed air:
    - 2” compressed air piping loop (minimum)
    - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4’-0” AFF
    - Provide disconnect for 3/8” and 1/2 “ impact tools at locations to be determined during final design
    - As required by equipment

Typical design features include the following:

- Natural Daylighting desired
- Forklift access, requiring a thickened slab
- Physically separated with full height walls from other areas to prevent migration of noise, dirt, and fumes
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Overhead doors to be sectional, galvanized steel, insulated, 10’-0” wide by 10’-0” tall with view panels, automatic operator, push button controls
- Personnel door with view panel to meet applicable code exit requirements

16.5.26 Electronics Repair Shop

Provide enclosed area for repairing and modifying car electronic and computer control systems. Install and maintain radio equipment, electrical signage, and other electrical equipment. Locate with accessibility from Car (Heavy) Position, Locomotive Position, Progressive Track, Material Handling Storage, and Common Work Area. Provide 12’-0” vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Electrostatic Workbench with electrostatic vise
- Cabinets
- Shelving
- Test Bench
- Compressed air:
    - 2” compressed air piping loop (minimum)

- Compressed air drops with shut-off valve, union, separator, regulator with gauge, filter, and quick disconnects, 4’-0” AFF
- Provide disconnect for 3/8” and 1/2 “ impact tools at locations to be determined during final design
- As required by equipment

Typical design features include the following:

- Natural Daylighting desired
- Physically separated with full height walls from other areas to provide dust proof environment
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Personnel double (6’-0”) door with view panel to meet applicable code exit requirements
- Shall be separately enclosed and temperature controlled.

16.5.27 Traction/Machine/Rebuild Shop

Provide open designated shop area for maintaining and rebuilding components of locomotive cars. Locate adjacent and open to Locomotive Position. Provide 24’-0” vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Open Face Paint Booth
- 20 ton and 30 ton overhead Bridge Cranes (minimum) to also cover Locomotive Position
- 7.5-ton Jib Crane (minimum)
- Workbench with vise
- Truck Stands
- Truck Hoists
- Parts Washer
- Shelving
- Cabinets
- Flammable Materials Cabinets
- Compressed air:
    - 2” compressed air piping loop (minimum)

- Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4’-0” AFF
- Provide disconnect for 3/8” and 1/2 “ impact tools at locations to be determined during final design
- As required by equipment

Typical design features include the following:

- Natural Daylighting desired
- Forklift access, requiring a thickened slab
- Track extended into shop from Locomotive Position for easy movement of components
- Track to store
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

16.5.28 Fabrication/Welding Shop

Provide designated shop area for maintaining and welding components used on vehicles (including storage of welding materials). Locate adjacent and open to Traction/Machine/Rebuild Shop and Locomotive Position. Provide 24’-0” vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Welding Screens
- Overhead Bridge Crane
- Arm Racks
- Cabinets
- Welders
- Extraction fume arm
- Welding Table
- Workbenches with vise

Typical design features include the following:

- Natural Daylighting desired
- Forklift access, requiring a thickened slab
- Physically separated with 3-4 full height walls from other areas to prevent migration of noise, dirt, sparks, and fumes.

- Embedded rail extended into shop from Locomotive Position for easy movement of components
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Opening in Wall for crane access to move components (if fully enclosed)
- Personnel door with view panel to meet applicable code exit requirements (if fully enclosed)

16.5.29 A/C Shop/Storage

Provide designated shop for repair and storage of air conditioning units. Locate adjacent to Car (Heavy) Position. Provide 24'-0" vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Overhead Bridge Crane
- Cabinets
- Racks
- Carts
- Workbench and vise
- A/C Storage Rack
- Compressed air:
  - 2" compressed air piping loop (minimum)
  - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4'-0" AFF
  - Provide disconnect for 3/8" and 1/2 " impact tools at locations to be determined during final design
  - As required by equipment

Typical design features include the following:

- Natural Daylighting desired
- Forklift access, requiring a thickened slab
- On mezzanine with direct access to roof level of cars
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry

- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

16.5.30 Truck Shop/Storage

Provide dedicated area for repair, component replacement, and storing train car trucks. Locate adjacent to Car (Heavy) Positions and Truck Wash. Provide 24'-0" vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Workbench and vise
- Overhead Bridge crane
- Truck Repair Hoist
- Cabinets
- Shelving
- Racking
- Parts cleaning tank
- New and Used Fluid systems as required
- Compressed air:
    - 2" compressed air piping loop (minimum)
    - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4'-0" AFF
    - Provide disconnect for 3/8" and 1/2 " impact tools at locations to be determined during final design
    - As required by equipment

Typical design features include the following:

- Natural Daylighting desired
- Forklift access, requiring a thickened slab
- Embedded rail from Truck Shop to Car (Heavy) Position, and Truck Wash.
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

16.5.31 Truck Wash and Wash Equipment Alcove

Provide alcove area for washing train car trucks with a high-pressure washer. A Wash Equipment Room adjacent to the Truck Wash for storage of high-pressure washer and soap drums. Locate adjacent to Truck Shop/Storage. From the Truck Shop, trucks must be allowed to conveniently move to and from CCO (C-frame lift area), Heavy Repair, and wheelset storage areas. In addition, trucks must be allowed to be pushed directly to the Truck Wash for steam cleaning from this area. The steam cleaning should be placed on an exterior wall to allow for convenient venting Provide 24'-0" vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Separation Curtain from Truck Wash, Wash Equipment Room, and surrounding areas
- Wand, reel, scabbard, and controls in Truck Wash
- High Pressure Washer with soap drum in Wash Equipment Alcove

Typical design features include the following:

- Natural Daylighting desired
- Forklift access, requiring a thickened slab
- Large containment sump with grated area
- Provide heavy duty plastic curtain to close off opening
- 10'-0" high (minimum) capped walls to adjacent shops, full height walls for exterior or major separations
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry with polyuria coating treatment for wet and moisture protection
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

16.5.32 Battery Room

Provide enclosed and secure room for storage of batteries and components. Locate adjacent to Material Handling Storage with accessibility from all shops and positions. Provide 12'-0" vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Shelving
- Battery Bench
- Racking
- Cabinets

Typical design features include the following:

- Acoustically and physically separated from other areas to prevent migration of noise, dirt, and fumes.
- Acid neutralizing floor drain and piping to acid dilution tank

- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Personnel door with view panel to meet applicable code exit requirements

16.5.33 Secure Tool Crib

Provide secure area for storing specialized tools and equipment. Locate shall be accessible from shops and positions. Provide 12'-0" vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Shelving
- Cabinets
- Peg Board

Typical design features include the following:

- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Personnel door with view panel to meet applicable code exit requirements

16.5.34 Quick Pick Area

Provide dedicated area for the storage small parts such as nuts and bolts. Location shall be accessible from shops and positions. Provide 12'-0" vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Bolt Bins
- Parts Vending Machines

Typical design features include the following:

- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

16.5.35 Toolbox Storage

Provide dedicated area for the storage of toolboxes and carts. Location shall be accessible from shops and positions. Provide 12'-0" vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Toolboxes
- Carts
- Anchors to be installed for security of toolboxes

Typical design features include the following:

- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

16.5.36 Portable Equipment Storage

Provide a dedicated area for storage of portable shop equipment. Location shall be accessible from shops and positions. Provide 12'-0" vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Portable equipment including but not limited to: Service jacks, bottle jacks, jack stands, ladders, diagnostic equipment, used fluid drain pans, battery chargers, work platforms, welders, welding screens, etc.

Typical design features include the following:

- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

16.5.37 Lube/Compressor Room

Provide enclosed room for storage and central distribution of lubricants. Space shall include a compressor(s) and refrigerated air dryer(s). Location shall have access to exterior for deliveries. Provide 12'-0" vertical clearance to structure and fixtures (minimum).

Major equipment/furnishings include (but are not limited to) the following:

- Double Wall Fluid Tanks
- Air Compressor
- Dryer
- Receiver tank

- Pumps
- Tank mount all piston lubricant pump(s)
- Wall mount all diaphragm pump(s)
- Plumb tanks to corresponding lube reel banks located in repair positions
- Emergency Shower and Eyewash
- Compressed air:
    - 2” compressed air piping loop (minimum) started in Lube/Compressor Room
    - Compressed air line with 3/8” and 1/2” shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4’-0” AFF
    - Connect to lubricant pumps
    - As required by equipment

Typical design features include the following:

- Exterior access for deliveries
- Acoustically and physically separated from other areas to prevent migration of noise, dirt, and fumes.
- Acoustics based on equipment and location of adjacent spaces
- Containment of fluids per local code
- Floor sink between air compressor and dryer
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

  Personnel double (6’-0”) door with exit device, view panel to meet applicable code exit requirements.

16.6 FACILITIES FOR MATERIALS HANDLING CONTRACT STAFF

Material handling department is responsible for parts storage, dispensing, dispensing and receiving. Office spaces shall be furnished according to owner furniture standards (but not limited to) sit/stand workstations, file cabinets, tables, and chairs in order to provide optimal work conditions for materials handling staff.

16.6.1 Manager

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Supervisor with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.6.2 Supervisor

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Manager and Storage Area with views of the Storage Areas, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.6.3 Analyst

Provide shared office for completing work tasks. Locate adjacent to Manager with access to all Material Handling Office Area. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.6.4 Clerk

Provide shared office for completing work tasks. Locate within Parts Storage Areas, adjacent to Manager with access to all Material Handling Office Areas. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.6.5 Copy/Workroom/Supplies

Provide dedicated alcove or room for copier/printer/scanner/fax machine, storage for office supplies, and work surface. Locate with access to Material Handling Office Area. Provide 9’-0” vertical clearance (minimum).

16.6.6 Parts Storage/Bulk Parts Storage/High-Density Storage/Staging Area/Shipping and Receiving Area

Provide dedicated secure area for receiving, storage of materials, and specialized tools. Locate adjacent to Material Handling Office Area with access to exterior for deliveries and accessibility from shops and repair positions. The critical clearances and dimensions are as follows:

- Vertical clearance below mezzanine: 12’-0” (minimal) (if desired)
- Vertical clearance above mezzanine: 15’-0” (minimal) (if desired)
- 20’-0” vertical clearance to structure and fixtures (minimum) for high bay pallet storage
- Vertical Lift Modules (VLM) and Stack System clearances can be any desired height

Major equipment/furnishings include (but are not limited to) the following:

- Racking
- Shelving
- Cabinets
- VLM
- Stack System
- Flammable Material Cabinets
- Hose Racks

- Under-bench draw cabinets
- Receiving Table

Typical design features include the following:

- Natural Daylighting desired
- Forklift access, requiring a thickened slab
- Secured entry
- Provide Parts Counter with stainless steel top and fire rated rolling overhead door
- Exterior access for deliveries
- Provide staging area for shipping/receiving with an overhead door to the exterior of the building
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Exterior overhead doors to be sectional, galvanized steel, insulated, 10'-0" wide by 10'-0" tall with view panels, automatic operator, interior and exterior push button controls, with lockout on exterior
- Interior overhead doors to be sectional, galvanized steel, insulated, 10'-0" wide by 10'-0" tall with view panels, automatic operator, push button controls, lockable
- Personnel door with view panel to meet applicable code exit requirements
- The Shipping/Receiving area within the Storeroom shall be adjacent to loading docks.

16.7 FACILITIES FOR VEHICLE SERVICE AREAS CONTRACT STAFF

Vehicle Service Areas Department is responsible for fleet vehicle wash, inspection, and service. Office spaces shall be furnished according to owner furniture standards (but not limited to) sit/stand workstations, file cabinets, tables, and chairs in order to provide optimal work conditions for vehicle service staff. For lighting requirements reference Chapter 18, table 18-1. REQUIRED ILLUMINATION LEVELS.

16.7.1 Service Worker Supervisor

Provide private office for completing work tasks and holding one on one meetings. Locate adjacent to S&I Positions with access to Copy/Workroom/Supplies. Provide 9'-0" vertical clearance (minimum). Typical design features shall include natural daylighting.

16.7.2 Service Staff Lockers

Provide locker area for each male and female Service Worker and Hostler employees. Could be collocated with Equipment Maintenance Staff Lockers. Locate within Equipment Maintenance

Men's and Women's Restrooms. Location shall be accessible by Shop Areas and Positions. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- 6-foot high gear, well-ventilated lockers with built-in bench
- Lockers must be ADA compliant and have mirrors
- Lockers must have slanted tops
- Lockers must be a minimum of 18" x 18" with 72" of clearance

16.7.3 Custodial Room

Provide enclosed area for janitorial supplies and mop sink. Locate adjacent to Restrooms. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Mop Sink
- Metal Shelving
- Mobile Cart
- Mop Holder

16.7.4 Storage Room and Vacuum Equipment Storage

Provide secure room for storage of vehicle cleaning equipment and supplies. Location shall be accessible from Service and Inspection (S&I) Positions. Provide 9'-0" vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Shelving
- Racking
- Cleaning Carts
- Backpack vacuums
- Canister vacuums

16.7.5 Sand Storage Silo

Provide room and space for storage and distribution of sand to train cars at the Service and Inspection (S&I) Positions. Sand Silo and sanding system shall be located outside the building and piped to each S&I Position. Location shall be accessible from Service and Inspection (S&I) Positions. Provide 20'-0" vertical clearance to structure and fixtures (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Open space for sand pallets
- Sanding system
- Sand Silo(s) (outside)

Typical design features include the following:

- Exterior access for deliveries
- Forklift access, requiring a thickened slab
- Sand Silo(s) require a 6” housekeeping pad (minimum)
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Overhead door to be sectional, galvanized steel, insulated, 12’-0” wide by 12’-0” tall with view panels, automatic operator, interior and exterior push button controls, with lockout on exterior
- Personnel door with exit device, view panel to meet applicable code exit requirements, and no thresholds

16.7.6 Lube/Compressor Room

Provide enclosed room for storage and central distribution of lubricants. Space shall include a compressor(s) and refrigerated air dryer(s). Location shall have access to exterior for deliveries. Provide 20’-0” vertical clearance to structure and fixtures (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Double Wall Fluid Tanks
- Air Compressor
- Dryer
- Receiver tank
- Pumps
- Tank mount all piston lubricant pump(s)
- Wall mount all diaphragm pump(s)
- Plumb tanks to corresponding lube reel banks located in repair positions
- Emergency Shower and Eyewash
- Compressed air:
    - 2” compressed air piping loop (minimum) started in Lube/Compressor Room
    - Compressed air line with 3/8” and 1/2” shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4’-0” AFF
    - Connect to lubricant pumps
    - As required by equipment

Typical design features include the following:

- Exterior access for deliveries
- Acoustically and physically separated from other areas to prevent migration of noise, dirt, and fumes.
- Acoustics based on equipment and location of adjacent spaces
- Containment of fluids per local code
- Floor sink between air compressor and dryer
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes
- Personnel double (6'-0") door with exit device, view panel to meet applicable code exit requirements, and no thresholds

16.7.7 Service and Inspection (S&I) Position

Provide designated position used for sanding, interior cleaning, and dumping of train cars. Location shall be accessible from Sanding Silo Storage and Lube/Compressor Room. The critical clearances and dimensions are as follows:

- Exterior Position
- 25'-0" wide by 665'-0" long (each track) (length to accommodate an 8-train car set, one locomotive and seven passenger cars)
- Gauge Pit: 70'-0" long (length of one car) x between track x 5'-6" deep (minimum)
- Midlevel Platform: 70'-0" long (length of one car) x 5'-0" wide on both sides of vehicle (minimum). Final height placement per car specifications
- All level dimensions to be designed per latest car information during final design

Major equipment/furnishings include (but are not limited to) the following:

- Shower and Eyewash
- New and Used Fluid systems as required
- Compressed air:
    - 2" compressed air piping loop (minimum)
    - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4'-0" AFF
    - Provide disconnect for 3/8" and 1/2 " impact tools at locations to be determined during final design
    - Provide in gauge pit

- As required by equipment

Typical design features include the following:

- Exterior Position
- Gauge pit open one car length of track
- Position length to accommodate an 8-train car set, one locomotive and seven passenger cars
- Midlevel platform at each end of position length of locomotive
- Stationary safety railings as required per final design
- Rolling safety railing on midlevel platform pertinent locations to access points for inspection (locations to be determined in final design)
- Bumping posts if at end of tracks
- To minimize offsite lighting pollution and avoid complaints from nearby neighbors, a system of low clearance lighting shall be provided. The lighting levels should be designed for safe egress and inspection activities. The yard's public address system shall also be supported by the lighting system.

16.7.8 Vehicle Wash Position (Wash Equipment Room)

Provide designated bay for automatic washing of sides, top, front, back, and undercarriage of train cars. Locate adjacent to vehicle wash equipment room. The critical clearances and dimensions are as follows:

- 30'-0" wide x 160'-0" long
- Length may depend on speed that vehicle can reliably be operated through the wash

Major equipment/furnishings include (but are not limited to) the following:

- Vehicle Wash
  - Able to wash an 8-train car set
  - Brushes shall be spaced to adequately wash
  - Provide undercarriage spray
  - Provide reclaim system
  - Wash must work with existing and future vehicles
  - Program wash with vehicle car mode
  - Wash shall perform "forehead" cleaning operation
  - During a reverse move, the wash equipment sensors shall not be activated
  - Provide adequate drainage features which return rinse cycle water draining from the roof back to the wash filtered drainage system as the train is leaving the area

Typical design features include the following:

- Includes room for wash equipment controls, pumps, and reclaim equipment
- Forklift access, requiring a thickened slab
- Exterior Position
- Position to accommodate an 8-train car set
- Wash Position: Integrated trench drain and sump pit with removable covers
- Wash Equipment Room: Sump pits with removable covers
- Screen walls on long sides of the position for over spray mitigation

16.7.9 Unisex Restroom

The above support space to be provided and addressed per applicable codes.

16.8 FACILITY MAINTENANCE

Facility maintenance department is responsible for maintaining buildings and grounds on facility site. Office spaces shall be furnished according to owner furniture standards (but not limited to) sit/stand workstations, file cabinets, tables, and chairs in order to provide optimal work conditions for facility maintenance staff.

16.8.1 Director

Provide a private office for completing work tasks and holding small meetings. Locate adjacent to Manager and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.8.2 Manager

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Director and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum).

16.8.3 Assistant Manager

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Manager and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.8.4 Supervisor

Provide a private office for completing work tasks and holding one-on-one meetings. Locate adjacent to Assistant Manager and Administrative Assistant, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.8.5 Assistant Coordinator

Provide an open office workstation for completing work tasks. Locate adjacent to Assistant Supervisor, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.8.6 Environmental Compliance

Provide an open office workstation for completing work tasks. Locate adjacent to Assistant Supervisor, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.8.7 Administrative Assistant

Provide an open office workstation for completing work tasks. Locate adjacent to Director, Manager, and Assistant Manager, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.8.8 Mechanic/Technician

Provide an open office workstation for completing work tasks. Locate adjacent to Assistant Supervisor, with access to Copy/Workroom/Supplies. Provide 9’-0” vertical clearance (minimum). Typical design features shall include natural daylighting.

16.8.9 Copy/Workroom/Supplies

Provide dedicated alcove or room for copier/printer/scanner/fax machine, storage for office supplies, and work surface. Location shall have access to Facility Maintenance Office Areas. Provide 9’-0” vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Copier/printer/scanner/fax machine
- Work surface with cabinets below and above
- Filing cabinets

16.8.10 Facility Maintenance Staff Lockers

Provide a locker area for each male and female Facility Maintenance Mechanic/Technician. Could be collocated with Equipment Maintenance Staff Lockers. Locate within Equipment Maintenance Men’s and Women’s Restrooms with accessibility by Shop Areas and Positions. Provide 9’-0” vertical clearance (minimum). Major equipment/furnishings include (but are not limited to) the following:

- 6-foot high gear, well-ventilated lockers with built-in bench
- Lockers must be ADA compliant and have mirrors
- Lockers must have slanted tops
- Lockers must be a minimum of 18” x 18” with 72” of clearance

16.8.11 Facility Maintenance Shop/Storage

Provide enclosed, secure shop and material storage for maintenance of buildings and grounds on site. Location shall be accessible to all Restrooms, Lockers, and Break/Crew Areas. Provide 14’-0” vertical clearance to structure and fixtures (minimum). Major equipment/furnishings include (but are not limited to) the following:

- Workbench with vise
- Hydraulic Press
- Drill Press
- Band Saw
- Buffer/Grinder
- Blast Cabinet with Dust Collection
- Parts Washer
- Parts Cleaning Tank
- Shelving
- Cabinets
- Racking
- Flammable Materials Cabinets
- Floor Scrubber
- Compressed air:
  - 2” compressed air piping loop (minimum)
  - Compressed air drops with shut-off valve, union, separator, regulator with gauge, lubricator, filter, and quick disconnects, 4’-0” AFF
  - Provide disconnect for 3/8” and 1/2 “ impact tools at locations to be determined during final design
  - As required by equipment

Typical design features include the following:

- Natural Daylighting desired
- Forklift access, requiring a thickened slab
- Floor: soil, grease, water, slip resistant concrete with integral non-metallic light reflective hardener, and chemical bonded concrete sealer
- Walls: soil and grease resistant, light colored finished concrete or masonry
- Ceiling: painted exposed structure, ductwork, conduit and utilities with light color finishes

Reference the Space Needs Program for the required square footages for the following spaces:

- Covered Areas
  - Loading Dock
  - Material Handling Storage
- Exterior Areas
  - Material Handling Storage
  - Guard Shack
  - Fuel Delivery and Yard
  - DEF Tank
  - Trash/Recycling
  - Cardboard Recycling
  - Bike Storage Rack
- Covered Vehicle Parking
  - Small Vehicle Space (10x10)
- Uncovered Vehicle Parking
  - Medium Vehicle Space (10x20)
  - Large Vehicle Space (12x30)
  - Medium Vehicle Space (12x40)

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17.0 FACILITIES MECHANICAL SYSTEMS

17.1 SCOPE

This chapter contains preferred and in some cases minimum mechanical criteria developed for the SCRRA system, excluding vehicles, yard and shop equipment. These criteria govern the functional requirements, fire protection, water and sewerage systems, drainage facilities (except at-grade sections), operation, and control of the heating systems, ventilation systems, and air conditioning systems. These criteria are intended to promote uniformity of design and standardization of equipment and its location throughout the SCRRA system.

Mechanical system requirements shall be defined for each specific project and shall be based on the appropriate local codes and standards. Mechanical equipment and systems shall be designed so that the maximum noise levels generated and transmitted by the systems do not exceed allowable local limits for interior or outdoor noise levels.

The project site must be assessed for climate vulnerability (see Section 3.3) to ensure any work is designed to be resilient to future climate conditions. If the site is vulnerable to flooding, wildfire (directly or indirectly), increased temperatures or other environmental hazard, mechanical equipment must be hardened (e.g. elevated or enclosed) to mitigate potential impact.

17.2 STANDARDS AND CODES

Unless specifically noted otherwise in these criteria, the latest edition of the code, regulation, and standard that is applicable at the time the design is initiated shall be used. If a new edition or amendment to a code, regulation, or standard is issued before the design is completed, the design shall conform to the new requirement(s) to the extent practical or required by the agency enforcing the code, regulation, or standard changed, and as agreed to by SCRRA.

See the standards and codes listed in Appendix A.

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

17.3 FIRE PROTECTION

17.3.1 Fire Protection Systems

The fire protection systems shown in Table 17-1 may be employed. The specific system used shall be determined based on facility type, local code requirements, fire department requirements, and any applicable insurance requirements.

TABLE 17-1. FIRE PROTECTION SYSTEMS

Fire Protection Systems	
Sprinkler systems, wet and dry	Portable fire extinguishers
Sprinkler systems, clean agent	Smoke and heat alarm systems

Standpipe systems, wet and dry	

17.3.2 Sprinkler Systems

Fire water-service connections shall be determined by hydraulic calculations, with less than a 4-inch service and shall be metered with a bypass meter as approved by the water utility company.

Sprinkler systems shall include a main fire water supply, backflow preventer, fire department inlet connections, piping from inlet connections and water supply mains to the sprinkler heads, sprinkler heads (with spares), drain lines, provisions for remote alarm devices, pipe fittings, valves, hangers, inserts, sleeves, and appurtenances. Sprinkler systems shall conform to the requirements of NFPA 13. There are some locations at higher elevations where freezing conditions should be considered.

Review piping installation requirements at unheated spaces for possible freezing of fire water lines during winter months. In these cases, it is recommended that a dry pipe system be installed. Drains provided at low points in water lines installed in spaces under platforms shall be extended to accessible areas. Each drain shall have a valved connection

Train signaling and communication rooms shall be protected by a clean agent automatic fire- extinguishing system per NFPA 2001, and approved by the Authority Having Jurisdiction (AHJ). (Note: The use of the non-aqueous alternative fire protection system shall be determined to not have a detrimental effect on equipment). Fire protection design shall permit activation automatically and manually from outside the room. Automatic activation shall be through a cross-zoned detection system.

Automatic sprinkler systems shall be provided in all areas of maintenance buildings. The sprinkler systems shall be for light, ordinary, or extra hazard classification as appropriate, and shall be hydraulically designed in accordance with all applicable codes. Sprinkler systems in areas that are unheated or subject to freezing shall be dry type systems.

Electronics equipment rooms such as radio, repair, telephones, information technology, and computers shall have double interlocked pre-action sprinkler systems.

Vehicle wash areas will be provided with fire sprinkler coverage and will be designed per Ordinary Hazard, Group 2 requirements, as defined by NFPA.

Paint spray booths will be sprinklered and designed per Extra Hazard, Group 1 requirements, as defined by NFPA. An analysis will be performed for any paint spray booth to determine quantities and types of flammable and combustible liquids. Storage and handling of flammable and combustible liquids will be in accordance with the requirements of NFPA.

Battery rooms will be sprinklered. The hazard classification of battery rooms will be Extra Hazard, Group 2, as defined by NFPA 13.

Mechanical rooms, small electrical closets, janitor’s closets and similar spaces will be designed per Ordinary Hazard, Group 1 requirements, as defined by NFPA.

Maintenance pits/lower level work areas will be provided with fire sprinkler coverage. Maintenance pits/lower level work areas will be designed per Ordinary Hazard, Group 2 requirements, as defined by NFPA.

Shop areas will be provided with fire sprinkler coverage. Shop areas will be designed per Ordinary Hazard, Group 2 requirements, as defined by NFPA.

Administration areas will be provided with fire sprinkler coverage. Offices, corridors, restrooms and similar spaces will be designed per Light Hazard occupancy requirements as defined by NFPA.

Sprinkler shall be concealed head type in finished spaces, centered in ceiling tiles and brass pendent, upright or sidewall in unfinished spaces.

17.3.3 Horizontal Standpipe Systems

Horizontal standpipe systems shall include fire department inlet connections, piping from inlet connections to supply main, hose valves, fire hose cabinets, drain lines, pipe fittings, control valves, hangers, inserts, sleeves, and appurtenances. Standpipe systems shall conform to the requirements of NFPA 14.

17.3.4 Portable Fire Extinguishers

Portable fire extinguishers shall be installed in accordance with NFPA 10, CFC and as modified by these design criteria in repair bays, offices, data, and electrical rooms.

17.3.5 Smoke and Heat Detection Systems

Smoke and heat detection systems shall be provided as required by NFPA. Refer to Electrical chapter.

17.3.6 Fire Hydrants

Local fire marshal and fire departments may have more stringent requirements. They may require testing of the water supply, multiple sources (for larger facilities), on-site pumps, or even on-site storage.

Provide the required water pressure and backflow control.

Fire Hydrant Location

In shop and maintenance facilities, fire hydrants of a type approved by the local authority with jurisdiction shall be provided at each of the following locations (if one is not already present):

- Within 100 feet of each fire department connection to a standpipe system;
- Within 400 feet of the fire department connection to each sprinkler system.

Provide layover and servicing areas with fire hydrants spaced per the local AHJ. Fire hydrants and water supply mains shall be per NFPA 1 and 24, CFC and the local AHJ.

Water Supply

The adequacy of the water supply shall be supplied from records of the agency owning the water supply system.

Street mains (i.e., the mains of the local government supplying water service for fire protection) shall be sized to carry the design flow, but in no case shall have a diameter less than 6 inches.

The capacity of the connected water supply (of the local government) must be adequate for the supply of only the sprinkler portion of the fire protection systems. It may be assumed that standpipe systems will be charged by local fire departments after their arrival on the scene, even though the standpipe systems are connected to the supply main.

Where both sprinkler and standpipe systems are served, the building fire main shall not be less than 6 inches in diameter; where only standpipe systems are served, the building fire main shall not be less than 4 inches in diameter. No pressure-regulating valves shall be used in fire water-supply mains, except by special permission of the local authority with jurisdiction.

Where connections are made to a public water system, it may be necessary to guard against possible contamination of the public water supply. The requirements of the local authority shall be determined and met. As a minimum, a reduced-pressure backflow with a detector check shall be provided on the fire protection water mains on the discharge (or load side) of the main shutoff valve or immediately inside the building wall.

17.3.7 Fire Pump

When the existing water supply pressure is found to be inadequate, automatically controlled fire pump shall be provided per NFPA 13, 14 and 20. A jockey pump shall be provided per NFPA 20. Installation of fire pumps, jockey pumps, and associated equipment shall be per NFPA 20. If required, fire pumps shall be electrically driven and connected to a continuous power source and an emergency power generation source, and include automatic-transfer switches.

Hose outlets to discharge the fire protection system water to the exterior of the building or structure. The location of test header must be coordinated with area operations to avoid disruptions of operations. Coordinate with civil for drainage options.

17.3.8 Fire Department Connections

Provide fire protection systems with Siamese connections through which the fire department can pump water into the sprinkler, standpipe, or other system furnishing water for fire extinguishing.

There shall be no shut-off valve in the fire department connection.

An approved silent check valve shall be installed in each fire department connection, located as close as practicable to the point where it joins the system.

The pipe between the check valve and the outside hose coupling shall be equipped with an approved automatic drip, arranged to discharge to the exterior, away from entry ways.

Hose connections shall be approved by the local fire department and shall be of a listed type in accordance with NFPA.

Hose coupling threads shall conform to those used by the local fire department. (American) National Standard fire-hose coupling screw threads shall be used wherever they fit the local fire department hoses.

Hose connections shall be at the access road side of buildings and be located and arranged so that hose lines can be readily and conveniently attached to the inlets without interference with any nearby objects, including buildings, fences, posts, or other fire department connections.

Fire department connections shall be designated by a sign with raised letters, at least one inch in size, cast on a plate or fitting reading: “Autospkr,” “Open Spkr,” or “Standpipe,” whichever is appropriate. The sign shall also indicate the buildings or structures, or parts thereof, served by the connection.

17.4 PLUMBING

These criteria describe the functional and design requirements for the facilities plumbing and drainage systems. They are intended to promote uniformity of design and to standardize the type of plumbing and drainage equipment and its location throughout the system.

These criteria cover the facilities plumbing and drainage systems for yards and maintenance shops, train control center(s) and miscellaneous wayside ancillary spaces. In addition, they prescribe the requirements for sewage systems for human waste and other waste fluids to the public sewers.

All plumbing and drainage systems shall be designed for the following functional requirements:

Water Distribution – Convey water from public utility distribution and / or storage points to stations, buildings and other consumption and service points.

Waste Return – Collect and convey storm drainage to the public storm sewer system and sanitary sewage to the public sanitary sewer system from yards and buildings.

17.4.1 Pipes and Fittings

- Waste and soil pipe shall be service-weight cast iron pipe with bell and spigot fittings. Soil pipe from fixtures shall have a slope of 2 percent.
- Vent pipes within structures shall be galvanized steel threaded pipe or service-weight cast iron pipe with bell and spigot fittings.
- Hot and cold water piping embedded in structures shall be hard-drawn copper tubing Type K; all other hot and cold water piping shall be hard drawn-copper tubing Type L with wrought brass or copper fittings.
- Force mains shall be of standard-weight steel pipe with joints of a type approved by the local authority with jurisdiction.
- Water service entrances shall be ductile iron mechanical joint pipe.
- Hose bibs shall be provided with vacuum breakers.
- Dielectric couplings shall be provided for the connection of pipes of dissimilar metals and in all metallic piping entering a facility.
- Corrosion control measures shall be provided for buried pipes.
- Isolation and drain valves shall be located so they are easily accessible

17.4.2 Water Service

The domestic water-service connection shall be sized for system demand flow and pressure requirements, and be metered. Each service shall have a main shut-off valve immediately inside the structure wall. Piping material and backflow preventers shall be provided to conform to local code and water provider requirements. The minimum unit values may be reduced by local water conservation requirements, such as low flush toilets, and shall be according to the applicable local code.

The Engineer shall estimate separately the service requirements of outlets that are likely to impose continuous demand, such as hose connections, and add to the fixture service requirements to determine the required total-service connection capacity. The domestic water service connection to each facility shall be sized for the total peak demand. Each service shall have a main shutoff valve and backflow preventer immediately inside the structure wall of station or building. Remote meter reading facilities shall be provided for all facilities.

Maintenance shops, train control center and other buildings having plumbing fixtures shall be served with water mains sized for the total plumbing fixture demand. Minimum fixture service requirements in accordance with the CPC and local amendments.

The service requirements of such outlets which are likely to impose additional demand, shall be estimated separately and added to the above fixture service requirements to determine the required total service connection capacity.

Water service connection at each facility for fire protection systems shall be separate from that for domestic water systems. Refer to the fire protection systems section of this chapter for further information.

The domestic water service shall be provided with a pressure-reducing valve when water pressure inside the structure is higher than 75 pounds per square inch (psi). The pressure-reducing valve shall be generally located on the discharge side of the main shutoff valve immediately inside the building wall. Sizing of the domestic water distribution lines shall be based on maintaining uniform pressure at all plumbing fixtures located at the same level, to minimize shock and water hammer, and to maintain a minimum of 15 psi pressure at each flush valve.

All pipe lines shall be run in a systematic manner, parallel and at right angles with walls, and properly pitched for drainage. Water hammer arresters shall be provided for long pipe runs, and branches with flush valves. In addition to the main shutoff valve, isolation valves shall be provided in branch lines and for each floor level to facilitate maintenance in individual areas without losing service for the entire facility. Pressure-reducing backflow preventers or air gaps shall be provided where automatic makeup for heating, ventilating, and air conditioning (HVAC) equipment, including evaporative cooling, is connected to the potable water system.

Provide domestic water and reclaimed water connections to the train wash unit. The domestic water connection shall be provided with a reduced pressure backflow preventer and digital metering. This meter shall allow for the local and remote readings through the building automation system (BAS). Pipe connections shall be sized per wash manufacturer's recommendations. Provide makeup water and remote capable readout, sub-meter ~~where~~ readout ~~is~~ at the train wash facility control panel and BAS. Provide trench drains to collect wash water for return to the reclaim unit. All sanitary waste associated with the wash system shall first pass through filtration and dilution built into the wash loop prior to being routed through an oil/water separator and entering the city sewer to comply with local discharge standards and ordinances.

Provide plumbing connections to the reclaim system pumps, detergent tanks, and overflow drain connections for equipment operation. Duplex air compressor, compressed air dryer and water heater shall be mounted on housekeeping pads.

17.4.3 Recycled Water Service

Interior recycled water piping shall be at least Schedule 40 purple PVC or equivalent with local utility sign off, prior to installation.

The potable water line may be used to feed the recycled water lines(s) until such time that recycled water becomes available. When recycled water becomes available, the cross-connection will be broken by the local utility, and the potable and recycled water lines will be totally separated. Before recycled water is delivered to the property, cross-connection and backflow testing will take place to assure separation.

Connect water closet and urinal flushing, boiler water make-up and wash water system to metered recycled water system. Provide additional pulse meters for the boiler make-up water and wash water systems make-up water. Any irrigation systems shall have a dedicated recycled water tap with a separate meter. All meters shall connect to BAS.

17.4.4 Hot Water Service

Hot water systems for facilities having lavatories, showers, and service sinks shall include water heaters, circulating hot water pumps where required, hot water distribution piping, and pipe accessories. All hot water pipes serving more than a single fixture shall be sized for the simultaneous fixture demand with a minimum pipe size of ¾ inch. All pipes shall be arranged in a systematic manner, and provisions made for thermal expansion and drainage. All hot water pipes shall be insulated. Isolation valves shall be provided for all branches serving gang restrooms to facilitate maintenance.

Domestic water heaters of 30 gallons or less capacity shall be electric. Above 30 gallons, all water heaters shall be a natural gas fired type, unless natural gas is not conveniently available, in which case the water heaters may be electric regardless of capacity. Where practical, provide gas-fired, tankless water heaters for larger domestic hot water demand. Water heaters shall be properly sized for the plumbing fixture demand and shall be Underwriters Laboratories, Inc. (UL) listed and show the American Society of Mechanical Engineers (ASME) stamp of approval. The requirements for water softeners and their type shall be determined by the source water quality. Water heaters shall be seismically secured in place.

Water heater capacities shall be based on 100 degrees Fahrenheit recovery and sized to meet the demands of the fixtures to be served by each heater. Combination pressure-temperature relief valves shall be provided in accordance with code requirements and piped to the indirect waste system. For domestic hot water lines over 10 feet in length, provide a recirculation pump as required by Title 24. The recirculation pump shall operate during occupied hours.

All gas fired water heaters shall be of storage type, sized for the demand of plumbing fixtures to be served by each heater. Heaters shall be provided with electronic ignition. Heaters shall be glass-lined and equipped with temperature and safety controls, and thermal insulation. Where natural gas is not conveniently available, electric water heater as described in the following paragraph shall be provided.

Electric water heaters with a capacity of 10 gallons or less shall be the instantaneous type. All electric water heaters with a capacity above 10 gallons shall be the storage type, capacity and sized for plumbing fixture demand served by the heater. Storage type heaters shall be glass-lined and equipped with fast acting dual element immersion heating, temperature and safety controls, and thermal insulation. Units with heating elements of 2,900 watts or less shall be suitable for a 120 volt / 1-phase power supply. Units with heating elements of 5,500 watts or less shall be suitable for a 208 volt / 1-phase power supply. Units with heating elements above 5,500 watts shall be suitable for a 480 volt / 3-phase power supply.

17.4.5 Insulation and Freeze Protection

Hot water piping and portions of drainage and cold water piping subject to sweating shall be insulated.

Ensure that freezing pipes and ice build-up is prevented from blocking domestic water and drainage pipes by using prevention methods such as not installing piping in exterior walls or unheated spaces, heat tracing, ice guards, as per current California Building and Plumbing Codes.

17.4.6 Plumbing Fixtures

Location and type of plumbing fixtures shall be fully coordinated with the architectural requirements and in accordance with the CPC and Title 24, Part 5.

- Water closets and urinals shall be vitreous China, white, wall-hung with flushometer. Water closets shall utilize bariatric carriers and flush valves shall be low water consumption (1.28 gal. per flushing cycle), chrome plated, top spud, hard-wired or hydro-powered, sensor actuation, automatic flushing system, and be WaterSense labeled.
- Flushometer for urinals shall be of low water consumption (0.125 gal. per flushing cycle), chrome plated, top spud, hard-wired or hydro-powered, sensor actuation, automatic flushing system, and be WaterSense labeled.
- Utility sinks shall be provided in each janitor's closet. Faucet shall have integral vacuum breaker, hose threads and bucket hook. Provide stainless steel wall guard, flat vandal-proof drain, hose and hose bracket;
- Lavatories shall be wall or under-counter hung. All wall hung fixtures shall be supported by standard chair supports. Faucets shall be counter or fixture mounted, low water consumption (maximum 1.5 gal. per minute), chrome plated, hydro-powered, with sensor actuation, and be WaterSense labeled. Provide piping insulation kit as required to meet accessibility requirements.

- Utility/Service sinks shall be of stainless steel equipped with the stainless steel rim guard.
- Water coolers shall be wall mounted, and shall have a bubbler of vandal-proof design and a bottle filler.
- The service sink in the battery room shall be acid-resistant and equipped with a wall hanger, rim guard, and standard trap.
- Showers shall have private compartments complete with partitions, receptors, curtain rails and curtains. Shower heads shall have a maximum flow rate of 2.0 gallons per minute and be WaterSense labeled.
- The wash fountain shall be of stainless steel, circular or semi-circular and foot operated with supplies from below and shall have a vent-off drain, soap dispenser, with chrome finish hardware.

In facilities having more than one toilet (for each sex), plumbing fixtures in one toilet for each sex shall be installed to accommodate persons with disabilities in wheelchairs where required. In facilities having only one toilet, plumbing fixtures shall be installed to accommodate persons with disabilities in wheelchairs in accordance with ANSI codes and the applicable provisions of the California Building Code and city amendments.

Water hammer arrestors shall be installed for protection to individual or group of plumbing fixtures per Plumbing and Drainage Institute (PDI) standards. Provide access panels as needed for maintenance

17.4.7 Emergency Shower / Eyewash Facilities

Emergency shower / eyewash capability shall be provided within, or immediately adjacent to, areas with batteries, caustic chemicals and grinding operations in accordance with ANSI Z358.1. Where available, a tepid water service connection with a drain to a stationary type of eyewash system shall be provided. A flow switch shall be provided to signal local and remote alarms when eyewash is activated. Where the hazard is located in a facility without water service, the capability for eye protection shall be provided by a portable eyewash apparatus.

17.4.8 Hose Bibs and Floor Drains

Hose bibs in service facilities shall have copper fittings.

Hose bibs and floor drains in facilities with restrooms shall be provided in accordance with the instructions in Table 17-2. All hose bibs inside buildings shall be installed in walls in stainless steel boxes with flanges flush with the wall. All exterior hose bibs shall be installed in exterior walls in brass boxes with flanges flush with the wall. All exterior hose bibs and box hydrants in unheated areas shall be a non-freeze type.

TABLE 17-2. HOSE BIB AND FLOOR DRAIN LOCATIONS

Location	Requirements
Custodial Rooms	Hot- and cold-water single spout, a mop sink drain, and a floor drain.
Mechanical Rooms	A floor drain for wastewater produced by HVAC equipment, maintenance procedures and relief-valve actuation.
Trash Rooms	3/4 inch cold-water hose bib with an individual floor drain located immediately beneath the hose bib.
Toilet Rooms	Cold-water and hot-water service and a means of drainage.
Water Heaters	A floor drain for wastewater produced by maintenance procedures and relief-valve actuation.

17.4.9 Sanitary Facilities

Wherever feasible, all drains from shop sinks, lavatories, water closets, and other miscellaneous drains/sanitary waste shall be designed to flow by gravity to existing sewers. If a gravity flow cannot be accomplished, drain/sanitary waste lines shall be run to sewage ejector pits containing duplex sewage pumps. The discharge shall then be pumped to the nearest sewer line(s).

All sanitary waste associated with the wash system will first pass through filtration and dilution built into the wash loop prior to entering the city sewer to comply with local discharge standards and ordinances.

17.4.10 Toilet Dump Systems

SCRRA layover and service facilities shall have a manifold toilet dump system. To permit servicing the trains stored in the layover without moving the trains, spacing and location of the dump stations shall be consistent with the rail car location and size. Refer to ES 7101 for typical dump station layout. Figure 17-1 shows the location of the connection on the car. Layouts may need to accommodate trains that are both pushing and pulling. Multiple track arrangements offer opportunities to minimize the number of connections.

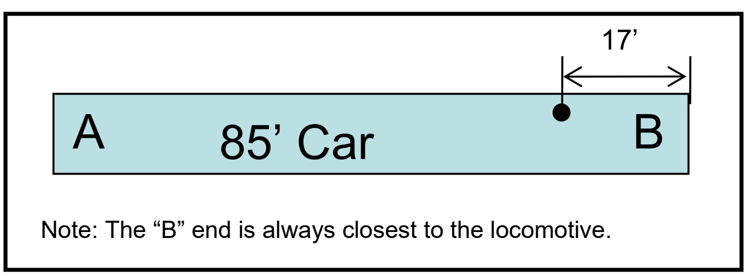

FIGURE 17-1. SANITARY DUMP LOCATION ON RAIL CAR

Provide a tight-fitting drain cover to prevent the escape of odors. The dump system is intended to be used to discharge waste from train cars by means of gravity dumping into a catch basin tied to a sanitary sewer line.

17.4.11 Sewage Pump Stations

Sewage pump stations, if required, shall be designed according to the local municipality's requirements. Due consideration shall be given to performance, noise, durability, standardization, and handling characteristics when selecting equipment for the sewage ejection systems. All equipment selected for the sewage ejection systems shall be manufacturer's standard products.

If the waste water drainage piping systems are unable to connect to the site sanitary sewer piping system elevation, a waste water lift station shall be provided. Provide duplex vertical dry pit sewage ejector pumps, each rated at 100 percent design load capacity at all locations where a gravity connection to a public sanitary sewer system cannot be achieved. Provide dry pits with hot-dipped galvanized steel access ladder and hot-dipped galvanized steel grating. Duplex pumps shall alternate starts and both have the capability to run simultaneously upon rising level. Pumps shall be controlled by float switches. For ease of maintenance pumps shall be provide with stainless steel rail retrieval system. Waste water lift station shall be connected to the emergency generator. Discharge effluent to a code compliant wet well that is sealed, vented, and accessed through a gas-tight manhole

17.4.12 Oil and Sand Interceptors

Oil and sand interceptors shall be provided as required by environmental standards for effluent to public waters. Interceptors shall conform to all local codes that govern the installation.

Floor drainage systems serving maintenance shops, train wash and vehicle storage areas shall be provided with oil separators and sand traps for extraction of oil, sand and other substances that are harmful or hazardous to the structure or to public drainage systems. Separators and traps shall have sufficient capacity to retain all sludge between cleaning.

17.4.13 Sanitary and Vent Systems

Sanitary and vent systems will collect and convey sanitary sewage to the public sanitary sewer system from stations and buildings.

All drains from plumbing fixtures, drains, or sanitary waste sources will be run by gravity to existing public sanitary sewers. If positive gravity drainage cannot be achieved, sanitary waste lines will be routed to sewage ejector pits equipped with duplex grinder ejector pumps, and clear waste lines will be routed to a sump equipped with non-clog duplex vertical centrifugal wet pit sump pumps. The discharge of either system will then be pumped to the nearest public sanitary sewer.

The soil, waste and vent system for facilities will include soil, waste and vent piping from all plumbing fixtures and floor drains. All soil and waste pipes will be sized for fixture demand, and as required by applicable plumbing codes and ordinances. Vent piping runs will be kept as short as possible and pitched toward soil and waste pipes. Each vent riser will be properly flashed at each roof penetration.

All drainage from HVAC systems will be removed through waste drains. All HVAC system drains will be indirectly connected to the building drainage system with an air gap.

Traps will be provided with all fixtures without integral traps. All traps will be of plain pattern having a seal of not less than 2-1/2 inches and not greater than four inches. All traps will be of the same material as the piping system to which they are connected. All exposed traps in toilet rooms will have chrome finish. Provide trap primer and HDPE trap seal for all floor drains and sinks. Trap primer assembly shall include a vacuum breaker.

17.4.14 Stormwater Systems

When stormwater is collected and used for use in a gray water system, the system shall consist of a storage tank(s), UV filtration system, booster pumps, overflow discharge and a distribution system completely separate from the potable water system. A bypass from the potable domestic water system shall be provided for times when there is inadequate gray water. The bypass shall be protected by a reduced-pressure principle backflow prevention assembly. Identify and label gray water system as non-potable for train wash makeup water use only.

Roof drainage systems shall be designed to handle the rainfall intensity for 100-year frequency.

Roof drains shall be of cast iron, copper, lead, or other approved corrosion-resistant material. Roof drains passing through the roof into the interior of a building shall be made watertight at the roof line by the use of a suitable flashing material.

Roof drains shall be equipped with strainers extending not less than 4 inches above the roof surface and designed to minimize clogging with leaves. Drains shall have a minimum inlet area 1-1/2 times the areas of the pipe to which they are connected.

Roof deck drain strainers for use on parking decks and similar occupied areas may be of an approved flat-surface type which is level with the deck and shall be designed to minimize clogging with leaves. Such drains shall have an inlet area not less than 2 times the area of the pipe to which they are connected. The strainers shall be suitable for the anticipated maximum traffic load.

17.4.15 Compressed Air

Provide a 2-inch, minimum, looped compressed air systems throughout the maintenance shop areas from two air compressors and two dryer units, with a receiver located in the compressor room. Provide a valved, 1-1/2 inch connection for a mobile air compressor. Each air compressor and dryer shall be capable of supplying at least 75-percent of the calculated air demand and be piped with a bypass to allow servicing of one compressor or dryer without impacting the operation of the remaining compressor and dryer. Compressor shall operate lead/lag and simultaneously on high air demand. Each air dryer shall be sized to meet the compressed air output of a single compressor. Provide desiccant type air dryers to maintain 21 degree F dew point air distribution. Provide particulate and coalescing filters on the discharge. All condensate drains shall be no-loss and pneumatic powered.

Compressors, dryers and air receivers shall be mounted on a housekeeping pad. Compressors shall be rotary screw type of the same manufacturer. Compressors 30 horsepower and larger shall have variable frequency drives. Dryers rated for 120 cubic feet per minute (CFM) or larger shall be capable of cycling. Air receiver gallon capacity to be sized for at least two times the demand CFM. All equipment shall be ASME rated.

The compressed air systems piping to be ASME B31.1 aluminum tubing with nickel plated brass compression marine-grade aluminum fittings or copper tubing shall be type k, hard drawn, class 1 and conform to ASTM B 88 All branches and drops shall be from the top of the compressed air loop to control condensate.

All compressed air drops shall include a drip leg with manual valve drain and cap, filter/regulator combination and lubricator. All convenience drops and hose connections shall also include a 3/8-inch and 1/2-inch quick connector. All compressed air drops shall be provided with isolation valves within reach of operator Service Bays.

Spring-powered general service compressed air hose reels are required at all general compressed air drops providing 90 psi to 145 psi. In addition, provide hose only connections for all pneumatic powered pump and tool locations.

<u>Train Wash</u>

Provide hose only connections.

All equipment that produces vibrations shall be isolated from the structure by vibration isolators. All piping attached to rotating equipment shall be isolated from such equipment by flexible connections. Inertia blocks shall be provided as required.

Fit water fixtures that enable spraying at high pressure with lower volume to reduce water consumption.

17.4.16 Natural Gas

Natural gas supply system design to serve all gas loads for space heating, tempering cold makeup air, water heaters for domestic and wash systems. A UL listed shut-off valve shall be provided at the connection to each piece of equipment. Provide regulators, drip legs and flexible connections to all equipment. All gas trains and components shall be UL listed.

Provide an approved earthquake natural gas shut-off valve to automatically shut off natural gas service downstream of the gas utility meter in accordance with the local gas utility requirements and regulations.

17.5 HVAC SYSTEMS

HVAC and building automation systems (BAS) shall monitor, control, and manage temperature, humidity, air velocity, air pressure, rate of air pressure change, dust, odors, smoke control, smoke movement and smoke direction during fire emergencies to protect and preserve life. BAS shall have the capability to be operated remotely.

HVAC systems shall be provided for offices, employee areas, shops and maintenance rooms, operations control center, computer, and miscellaneous electronics equipment rooms. Dedicated HVAC systems may be required for areas that require uninterruptable conditioning in case of a sustained primary power outage.

Heating and ventilation systems shall be provided for the ancillary rooms in miscellaneous wayside structures. HVAC systems for occupied areas shall maintain an acceptable environment for patrons, operating and maintenance personnel.

HVAC systems for equipment fans shall be designed to prolong the life of equipment through control of temperature and pressure.

Seismic-restraint systems shall comply with California Building Code requirements. Refer to structural for wind- and seismic-restraint loading requirements.

17.5.1 Design Parameters

The outside conditions prescribed herein are for determining the required capacities of HVAC systems. The system equipment shall be suitable for continuous operation (at degraded capacity) during extreme weather conditions. The ventilation, heating, cooling, and refrigeration equipment shall continue to operate if the outside temperature reaches 105°F or drops to 0°F.

Title 24 requires HVAC design use the 0.4% ASHRAE design conditions for the current year. These design conditions may be exceeded for a number of hours per year (due to outside temperatures exceeding the ASHRAE 0.4% design conditions.) While designing to the ASHRAE 0.4% conditions by definition indicates that design set points will be exceeded during peak periods, typical design often requires a minimal amount of over sizing so that control is always maintained.

Systems that utilize electric resistance heating as the primary heating source are prohibited.

17.5.2 Inside Conditions for Normal and Congested Operations

The number of air changes per hour (total air volume circulated) shall be based on the requirements of applicable codes, heating and cooling loads, or odor control (whichever is greater). Ventilation systems shall be designed to provide cross ventilation. The outside requirement shall be in accordance with ASHRAE 62.1 requirements for all spaces being heated, ventilated, or air conditioned.

Table 17-3 details indoor design conditions for yards and shops, the train control center, and ancillary rooms. Ancillary rooms with electronic equipment may impose more stringent heat removal requirements. Designer shall analyze each room individually, and shall provide an ECS that will provide a room climate suitable for efficient equipment operation.

TABLE 17-3. INDOOR DESIGN CONDITIONS

Indoor Design Conditions			
	Winter[1]	**Summer[2]**	
Space	**(F°DB)**	**(F°DB)**	**(% RH)[3]**
Battery room	55	78	50
Closed circuit television room	68	78	50
Computer room	68	78	50
Conference room	68	78	50
Crew room	68	78	50
Electrical equipment room	55	105	—

TABLE 17-3. INDOOR DESIGN CONDITIONS

Indoor Design Conditions			
	Winter[1]	Summer[2]	
Space	(F°DB)	(F°DB)	(% RH)[3]
Elevator machine room	55	78	—
General offices	68	78	50
Locker rooms	68	78	50
Lunch rooms	68	78	50
Main control room	68	78	50
Maintenance service bays	65	85	50
Mechanical equipment room	55	105	—
Reception area	68	78	50
Security control room	68	78	50
Shops	68	—	—
Showers	68	78	--
Staff room	68	78	50
Standby power generator room	55	105	—
Storage areas	55	—	—
Tape storage room	68	78	50
Telephone equipment room	55	78	—
Toilets	68	—	—
Training room	68	78	50
Trash rooms	55	—	—
Uninterruptible power supply (UPS) room	55	78	—
Yard control room	68	78	50

Notes:

[1] Winter temperatures are based on the following parameters:

a. Rooms requiring the temperature to be maintained well above freezing to avoid maintenance problems: 55°F.

b. Rooms requiring no heating: no value provided. These rooms may be ventilated by transfer air.

[2] Summer temperatures are based on the following parameters:

a. Rooms occupied by personnel dressed in office attire: 78°F

b. Rooms with solid state electronic equipment: 78°F (to avoid maintenance problems)

c. Rooms that may be cooled by ventilation only: 105°F (ambient + 10°F)

d. Rooms requiring no cooling: no value provided. These rooms may be ventilated by transfer air.

Where:
°F = Degrees Fahrenheit
°F DB = Degrees Fahrenheit Dry Bulb
%RH = Percentage Relative Humidity

[3] Humidifiers are not required except Computer Room required to maintain 50% RH per ASHRAE

17.5.3 Design Velocities for Air Distribution Systems

Design velocities shall be selected to provide the required system performance and to minimize pressure loss and energy consumption, air-borne noise generation, draft, and the intake of dust particles. The design velocities in air distribution systems are described below:

- Sheet metal supply and return air duct sizes shall be determined in accordance with the requirements prescribed for low velocity air distribution systems in the duct design chapter of the ASHRAE *Fundamentals*, Society of Sheet Metal Contractors National Association (SMACNA), or Air Conditioning Contractors of America (ACCA) duct design guidelines.
- Supply registers shall be selected for throw and noise criteria. (Noise criteria are stated in Section 17.5.4. Throw must be consistent with room architecture).
- Variable air volume (VAV) terminals shall be selected for required air flow, pressure, and noise criteria.
- Diffusers shall be selected for throw and noise criteria.
- Exhaust and return grilles shall have a capacity based on maximum velocity of 750 fpm over the gross area.
- Transfer grilles shall have a maximum velocity of 600 fpm over the gross area.
- Transfer louvers shall have a maximum velocity of 600 fpm over the gross area.
- Fan sound attenuators have a maximum air velocity of 2,000 fpm over the gross area.

17.5.4 Noise Criteria

A proper acoustical environment is as important to human comfort as any of the other environmental factors controlled by BAS. Improper design of BAS equipment can create an unacceptable acoustic environment. The primary objective of BAS acoustical design is to achieve acceptable sound levels for all activities and people involved; however, this does not necessarily mean the lowest possible sound levels. Because of the wide range of activities, appropriate indoor acoustical design levels will vary considerably from room to room and acceptable outdoor levels will depend on local ambient sound conditions. Proper sound levels at various listener locations shall be achieved by controlling the sound generation of the various sources and the sound transmission from the sources to the listeners.

Sound control for environmental control systems shall be designed in accordance with the procedure outlined in the noise and vibration chapter of the *Handbook of Systems and Applications* (ASHRAE), and shall comply with local municipal codes and ordinances.

17.5.5 HVAC Systems and Equipment

<u>Maintenance Shops</u>

Roof-curb, mezzanine- or platform- mounted commercial packaged makeup air units and heating and ventilating units shall be provided with insulated cabinet casing of galvanized steel construction, steel frame construction, centrifugal supply fan with motor and direct-drive assembly, motor starter and fusible disconnect switch in the National Electrical Manufacturers

Association (NEMA) 3R rated enclosure, direct-fired gas heating furnace with modulating gas burner controls with 30% minimum turndown, replaceable MERV 8 prefilters section, modulating outdoor air intake and return air dampers and mixing section, insulated and seismic-rated prefabricated stationary curb. Heating and ventilating systems serving the shop facilities shall be designed to maintain a positive pressure in the shops with respect to the outdoors during the heating season, by means of allowing the minimum outdoor air supply to exfiltrate through doorways and wall construction.

Cooling shall be provided through the use of evaporative cooling, integrated with the heating and ventilating units. Evaporative cooling may be direct or indirect, depending upon the local wet bulb design temperature. Provide water circulation pump, overflow drain and thermostatically controlled drain to prevent freezing.

Heating and ventilation unit shall be provided with air to air heat exchanger or heat pipe to reclaim the energy from exhaust air stream.

Equipment motors shall be of premium efficiency type to meet or exceed the minimum efficiency requirements for electric motors as specified under the International Energy Conservation Code.

High Volume/Low Velocity (HVLV) fans or High-Level-Circulators (HLC) serving high-bay shop areas. HLCs shall be factory fabricated, packaged, roof curb mounted units equipped with axial fan with reversible motor and drive assembly, mixing box with motorized dampers capable of being automatically indexed to operate in either the outdoor air supply, the recirculation (de-stratification), or the exhaust air mode of operation, a downward angular discharge nozzle designed to project air downward to the floor level at 45 degrees from the horizontal in either the supply mode or the recirculation (de-stratification) mode of operation. HVLVs shall be factory fabricated, structure mounted units with reversible motor and drive assembly, with a remote control panel for fan direction and speed control.

Exhaust fans serving the battery room and parts cleaning solvent degreasing tank fume hoods shall be of spark resistant, explosion proof design, and the sheet metal exhaust ductwork shall be of G90 galvanized steel construction.

Façade mounted outdoor air intake louvers with motorized isolation dampers for provision of additional outdoor air makeup during the summer season.

For exhaust air ductwork serving maintenance pits/lower level work areas in shop floors, under-floor supply air ductwork shall be constructed of schedule 40, fiberglass reinforced thermosetting resin epoxy (FRTRE) piping or high density polyethylene (HDPE) ductwork. FRTRE shall include #10-gauge, American Society for Testing and Materials (ASTM) A167, American Iron and Steel Institute (AISI) type 316 stainless steel welded sheet metal transitions to pit sidewall exhaust air grilles, and with flanged, neoprene-sheet-gasketed, silicone-sealed and bolted junctions to sheet metal ductwork connections, both above grade and underground, to provide airtight and watertight connections.

Gas-fired unit heaters shall be suspended locally within the shop, where supplemental heating is required, and shall be provided with local space thermostatic temperature control, integrated with the BAS.

Nitrogen oxide (NOx) and carbon monoxide (CO) gas monitoring and alarm control system shall be provided in maintenance shops, to automatically energize exhaust fans upon detection of a leakage of products of combustion, and signal to actuate a local audio/visual alarm and a remote central alarm at the “head end” of the BAS temperature control system.

A remote, central, programmable electrical/electronic ASHRAE Building Automation and Control Network (BACnet) protocol type DDC BAS (Direct Digital Control Building Automation System), automatic temperature controls system shall be fully integrated to automatically monitor and regulate the operations of the heating and ventilating systems as necessary to continuously maintain the heating and ventilation systems within specified tolerances, year-round, complete with local manual override controls, where appropriate.

Paint Booth

Air replacement units shall be designed to provide ambient or tempered air to replace the air the booth withdraws from the facility. Replacement air shall be drawn directly from outside. An air replacement unit shall be installed to supply tempered and filtered air to the booth, minimizing temperature variations and removing particulates that compromise finish quality. Heating shall be provided as recommended by the spray paint equipment supplier. To maintain negative pressure in paint spray booths, the ventilation system for the paint spray area shall be sized so that the supply air volume is 5 percent less than then air volume exhausted by the paint spray booth exhaust. The system shall be complete with heater, filters, motor and blower, controls, mounting hardware and auxiliary equipment.

The number of air changes per hour (the ventilation rate) shall be as recommended by the spray paint equipment supplier, but the number of changes shall not be less than the rate required by the applicable codes. The filtration of supply and exhaust air shall be provided as recommended by the spray paint equipment supplier and as required by the applicable codes.

Design and construct exhaust stack to ventilate the booth to the outside. The stack shall discharge vertically for adequate exhaust air flow and shall extend a minimum of 15 feet above the roofline or as required by local codes and according to the requirements of authorities having jurisdiction. Ensure that all separation and emission requirements of local codes and according to the requirements of authorities having jurisdiction separation are met.

Provide a complete set of single-stage filtration media made for paint spray booth, tested to at least 99.00% particulates removal efficiency and field to meet the performance and reliability requirements. The filter shall be approved by National Emission Standard, based on 40 CFR Part 63 Subpart H consistent with ASHRAE 52.1.

Exhaust fan motors and temperature control equipment shall be explosion-proof construction. Spray finishing operations shall be in accordance with the CFC.

Mechanical and Electrical Rooms

Ventilation systems will be provided to serve mechanical and electrical equipment rooms, with makeup air and exhaust air flow rates adequate to absorb the heat dissipated by the mechanical and electrical equipment while maintaining the space temperature below the maximum allowable setpoint limits, and while, during the heating mode, maintaining the space temperatures high enough above the dew-point temperature to prevent the condensation of water vapor (sweating) on the surfaces of electrical contacts. Heating will be provided by means of the provision of indoor, suspended, packaged, heating water type unit heaters. Outside air gravity intakes will include motorized dampers to provide makeup air to the room while the exhaust fan is operating. All the exhaust fans, 3 hp and larger, serving the mechanical room, electrical room and compressed air room are to be operated with variable frequency drive.

Gas fired boiler equipment in mechanical equipment rooms will be providing hot water to all the terminal boxes serving administration areas and heating hot water unit heater throughout the facilities. The boiler will be a condensing boiler with two booster pumps, one in use and one standby. A carbon monoxide (CO) gas monitoring and alarm control system shall be provided in each boiler room, to automatically shut-down the burners upon detection of a leakage of products of combustion, and signal to actuate a local audio/visual alarm and a remote central alarm at the “head end” of the BAS temperature control system. Prefabricated, double-wall, sheet metal type breechings will be provided for gas-fired boiler, terminating outdoors in a code compliant manner.

Exhaust fans serving the battery room and the gas meter room shall be of non-sparking fan wheel construction, and any equipment mounted within the battery room and the gas meter room shall be of explosion-proof design and construction. Supply and exhaust air ductwork installed within the boundaries of the gas meter room and the battery room, including the battery charging benches exhaust hoods, shall be of G90 galvanized steel construction. The battery room and the gas meter room makeup air systems shall operate with 100% outdoor air and shall each be dedicated and independent makeup air systems, designed for continuous operation, and shall be provided with emergency power. The battery room exhaust air ductwork main shall be provided with an air flow monitoring switch that, upon detection of a loss of exhaust air flow, shall operate to automatically shut down the battery charging system, and actuate an audio-visual alarm signal, both locally and remotely via the BAS.

<u>Office Systems</u>

All air handling equipment drive motors shall be of premium efficiency type to meet or exceed the minimum efficiency requirements for electric motors as specified under the California Title 24.

Equipment mounted outdoors that are equipped with factory provided, unit mounted motor starters, shall be provided with NEMA-4X rated starter enclosures, and indoor mounted motor starters shall be provided with NEMA-12 rated starter enclosures.

The remote, programmable electrical/electronic ASHRAE Building Automation and Control Network (BACnet) protocol type DDC BAS (Direct Digital Control Building Automation System), automatic temperature controls system shall be fully integrated to monitor and automatically regulate the operations of the HVAC systems as necessary to continuously maintain the heating, cooling and ventilation systems within specified tolerances, year-round, complete with local manual override controls, where appropriate.

Heating, ventilating and air conditioning units serving administrative office areas, break rooms, locker rooms, toilets, conference rooms, multipurpose rooms and corridors shall consist of the following:

- Factory fabricated, packaged, variable-air-volume (VAV) type roof mounted air handling units or dedicated outside air system (DOAS).

- Units shall be equipped with double-wall insulated exterior galvanized steel casing with steel frame construction, stationary seismic roof curb, supply fan, return/exhaust fan, fan motors and variable-frequency-drive (VFD) assemblies.
- Chilled water or direct expansion (DX) cooling coil, pre-heat section, freeze protection thermostat with hard-wired shut-down signal to unit motor starter.
- Discharge air temperature sensor, return air temperature sensor, mixed air temperature sensor, MERV 8 prefilter and MERV 13 final filter section. Higher performance air filters shall be considered in areas identified as exposed to poor air quality during wildfire season.
- Mixing box with fully-modulating outdoor air intake, return air and exhaust/relief air motorized dampers, with an outdoor-air-intake air flow measuring station, with 100% outdoor air economizer capability. Allow for demand control ventilation (based upon CO_2 levels) and outside air shut-off should outdoor air quality be poor and internal conditions allow.
- Air cooled chiller or refrigeration coils with compressors, condenser coils, condenser fans, refrigeration piping.
- Integral electronic temperature controls system with BACnet protocol compatible interface connection to remote central DDC BAS control system head-end computer.
- Variable frequency drive.

HVAC systems, except those serving restrooms and locker rooms, shall be designed to maintain a positive pressurization of the conditioned space relative to adjacent corridors, adjacent non-conditioned zones, entrances and the outdoors, to mitigate infiltration. HVAC units serving multiple zones shall be provided with variable air volume (VAV) temperature controls with variable frequency drives on supply and return/exhaust fans, with pressure-independent, pressure independent type VAV duct terminal units provided in their associated ductwork distribution systems, and with heating hot water type baseboard radiation heating, radiant flooring, or VAV box integral heating hot water reheat coils.

A duct mounted smoke detector shall be installed in the return ductwork of each HVAC unit of 2,000 CFM or greater capacity, which shall operate to shut-down the unit through the remote central fire alarm control panel, upon activation. HVAC units of 15,000 CFM capacity and greater, where applicable, shall be additionally provided with smoke dampers and smoke detectors installed in their ductwork systems, as required by code.

<u>A/C Equipment and Accessories</u>

- For indoor units each unit shall be completely pre-piped and pre-wired internally. Compressors shall be a heavy-duty, semi-hermetic type. The fans shall be belt-driven, centrifugal with forward-curved blades and double inlets. Fan motors shall have an adjustable mount and an adjustable sheave to vary the fan speed. The re-heating apparatus shall be electric. Air filters shall be provided for pre-filter and final-filter.

- For outdoor units, the condensers shall maintain adequate condensing temperature for an ambient air temperature range of 0°F to 105°F. Air-cooled condensers shall have direct-driven propeller fans.

To maintain step control for temperature conditions, a solid state control system shall be used. The indoor temperature and humidity sensing elements shall be located in the return air stream. Provide at least two states of cooling and up to three states of reheat as required to maintain close room temperature tolerances. The humidity controller shall consist of one stage of humidification and one stage of dehumidification. The outside air sensors shall be provided in the fresh air intake duct. System operating mode configurations shall range from full cooling with minimum outside air to maximum free cooling with 100 percent outside air.

Air conditioning equipment serving the OCC shall be wired to the standby power supply as prescribed in the Facilities Electrical Systems requirements chapter of these criteria.

<u>Ancillary Space HVAC Systems</u>

Communication Rooms

The air conditioning system, when required, shall be designed so that the minimum outside air requirement is satisfied. Provide ventilation in accordance with ASHRAE 62.1. Maintain positive pressure within the space. Supply air shall be filtered.

The cooling load shall be calculated based on a summation of the following heat gains:

- Internal equipment load
- Lighting load of 1W/ft^2 (or actual lighting load if available)
- Outside air load
- Solar and transmission gains (where applicable)

Air handing unit equipment shall be of the DX split-system type, with an air handling unit in the room adjacent to or within the communication and server room. Air handing units shall include filters, DX cooling coils, and centrifugal fan, and a condensate drain pan. Installation shall include automatic temperature controls and a remote, air-cooled condensing unit. Although not essential, a system with dual compressors (each with 50 percent capacity), is preferred. Condensing unit for aerial and at-grade communication and server rooms shall be located outdoors. A condensing unit may be part of the air handling unit, or it may be remote from it. Where chilled water is conveniently available, an air handling unit with chilled water coils shall be provided.

The operation and control of the HVAC system shall be controlled by a room thermostat. The ventilation system will be automatically shut down in the event of fire or smoke detection within the communication and server rooms. The system shall have provisions so that high temperature indicators can transmit a summary fault indication to the OCC.

Auxiliary Electrical Rooms

Ventilation system shall be provided at the air intake to the space and a positive pressure shall be maintained when the system is in operation.

The ventilation capacity shall be based on a summation of the following internal heat gains:

- Four percent of the installed transformer capacity
- Heat rejected by the electrical equipment
- Solar and transmission gains (where applicable)
- A lighting load of 1 W/ft^2 (use actual lighting load when available)

The system shall consist of one or more supply fans, distribution ductwork and devices, air filters, motorized damper, automatic temperature controls, and intake and exhaust louvers. Use of exhaust fans shall be minimized.

Each system shall be controlled by an adjustable thermostat within the ancillary room having the highest continuous heat load served by the supply fan being controlled. For example, the fans shall start when the space temperature rises to 86°F or above and stop when the temperature falls to 80°F or below. Local manual control via a time switch shall be provided for operation of the ventilation system during human occupancy of the room. The ventilation system shall be automatically shut down in the event of fire or smoke detection within the room. A positive pressure within the room shall be maintained when the system is in operation.

Miscellaneous Ancillary Rooms

Ventilation shall be provided for each ancillary room shown on the Contract Drawings. Air shall be discharged to outdoors. Ventilation air shall be provided as required and shall be taken from adjacent areas or outside as applicable. When taken from outdoors, air shall be filtered. Each ventilation system shall be shut down automatically in the event of the detection of fire or smoke within the area served.

For the operation and control of the toilet rooms, an exhaust fan shall be provided that operates only when associated lighting is energized, with a time-delay on the light “off” switch. The ventilation system shall operate continuously in the following rooms: trash, sewage ejector, sump-pump, and battery rooms. Ventilation system shall be actuated by the light switch with time-delay off in custodial and storage room. In the elevator machine rooms, and the electrical equipment rooms, the ventilation system shall be controlled by a room thermostat and by manual override. Ventilation system shall be automatically shut down in the event of fire or smoke detection within the room.

Covered Outdoor Work Areas

Outfit major facilities identified as vulnerable to extreme heat with industrial/commercial grade evaporative coolers (swamp coolers), or alternative with SCRRA approval which can reduce temperatures in covered outdoor areas such as locomotive shops. Implementation shall consider the impact on water use to ensure the increase in demand does not jeopardize the supply to other demands and this system must include a shut-off to allow elimination of water use during water shortage events.

17.5.6 Piping Systems

All piping systems shall be designed to meet the requirements of American National Standards Institute (ANSI) B31.9. All pipe fittings, flanges, valves and accessories shall comply with ANSI B16, in all applicable sections for dimensional requirements. All piping systems shall be designed and arranged for neat appearance, properly sloped for drainage and venting, and properly supported, guided, and anchored to provide complete flexibility and to maintain the integrity of all systems without any damage or leaks under all operating conditions. All valves and accessories shall preferably be arranged in a manner so as to be accessible for operation without the use of chains or additional operating platforms. Where this is not possible, and valves are above 6 feet, they shall be chain-operated. Sleeves and escutcheons shall be provided wherever pipes pass through walls. Provide fire-rated assemblies for pipe passing through fire-rated walls and floor / ceiling assemblies.

Pipe Unions or Flanges

To facilitate easy removal for servicing, unions or flanges shall be provided on both the inlets and the outlets of all apparatus, isolation valves, control valves and accessories. Wherever two pipes made of dissimilar metals are connected, a dielectric union shall be used to isolate the two pipes from each other. Dielectric unions and flanges may also be required for cathodic protection.

Valves

Isolation valves shall be provided on both sides of such apparatus as chillers, pumps, heating coils, control valves, multiple installations and piping branches. The installation of all valves shall be designed to give a neat appearance and provide easy grouping with all parts accessible for operation and maintenance. Valve stems shall be in the upright position wherever possible.

Piping Accessories

To ensure the trouble-free operation of all piping systems, all required piping accessories shall be provided. These accessories shall include strainers, vent cocks, dirt-and-drip legs with drain-and-flush connections, expansion tanks, liquid flow indicators, balancing cocks, relief valves, pressure and temperature gauges, etc. All piping accessories requiring maintenance or replacement of parts shall be installed in accessible places. All dials of gauges and indicators shall be of sufficient size and arranged to be easily seen and read.

Refrigerant Piping

Refrigerant Piping shall be air conditioning and refrigerant (ACR) copper. Use only brazed joints.

Pipe Expansion Joints

The use of pipe expansion joints shall be avoided wherever possible. Pipe systems shall be arranged to have sufficient offsets and expansion loops to accommodate thermal expansion and vibration. Pipe expansion joints may be used only where pipe expansion loops are impractical. All such expansion joints shall be stainless steel or monel metal. They shall be the double-compensating type, with an anchor in the middle. These shall be guided on both sides in strict accordance with the manufacturer's recommendation. All expansion joints shall be flanged to facilitate easy and quick replacement.

Flexible Pipe Connections

Flexible pipe connectors are used such as on resiliently mounted air handling units and pumps, these flexible pipe connectors shall be of stainless steel or monel construction with flanged ends for quick and easy dismantling from the pipe systems. They shall be of sufficient length to provide an overall stiffness less than the resilient mounts used for supporting the apparatus.

Pipe Supports, Hangers, Guides and Anchors

Pipe supports, hangers, guides and anchors shall be designed to assure proper alignment of all pipes for operating conditions. The forces caused by seismic events, the motion of the fluid, the weight of the fluid, piping, valves and insulation and thermal expansion / contraction shall be considered as appropriate. All hangers and supports shall be so arranged as to prevent the transmission of vibration from the piping to the structure. Anchors and guides shall be designed to allow pipes to expand and contract without a build-up of excessive stress. Pipe rollers shall be used with all hangers where pipe movement due to expansion or contraction exceeds 0.5 inch. Flexible pipe connectors and/or spring hangers of constant or variable load types as the case requires, shall be used when piping is connected to vibrating equipment and where supporting vertical pipes

Insulation

Mineral fiber insulation with a Kraft facing vapor barrier shall be used on indoor piping as appropriate. The adhesive used to adhere the jacket of facing to the insulation shall meet the fire and smoke hazard ratings as tested by procedures ASTM E84, NFPA 255, and UL 723. In addition, this adhesive shall not exceed a flame spread of 25, a fuel contribution of 50, and a smoke development of 50. Accessories such as adhesives, mastics, cements, tapes, and cloths for fittings shall have similar component ratings. Insulation for chilled water supply and return piping, and cooling tower condenser return (to water chiller) piping shall be two-piece, heavy density, sectional insulation jacketed with an embossed vapor barrier laminate. Insulation for refrigeration suction piping shall be a one half-inch thick (minimum) slip-on type pre-molded cellular glass or one-inch flexible elastomeric closed-cell or expanded rubber insulation.

Wrap refrigerant piping in flexible elastomeric insulation, thickness as required by ASHRAE 90.1. Insulate suction and gas piping separately. Provide PVC jacket in mechanical rooms and other areas subject to damage. Provide stainless steel jacket outdoors above grade.

17.5.7 Pumps

As conditions dictate, pumps shall be either single- or double-suction. Pumps shall be arranged so that they can be serviced without any removal of the piping system. This shall include any disconnection of piping from the pumps. Pumps shall have the following characteristics as listed in Table 17-4.

TABLE 17-4. PUMP CHARACTERISTICS	
Pump Characteristics	
Maximum pump speed (less than 1.5 hp)	3,300 RPM
Maximum pump speed (1.5 hp and larger)	1,800 RPM
Operating efficiency at design flow rate	Within 5 percent of maximum efficiency
Pump type	Non-overloading

17.5.8 Equipment Foundations

All floor-mounted equipment shall be placed on reinforced concrete housekeeping pads at least 4 inches high. Pads shall be tied to the floor by floor-reinforcing bar grid, dowels, or anchor bolts.

17.5.9 Equipment Access

Provide sufficient clearance for the installation and removal of each completely factory-built item of equipment. Provisions shall be made in the form of monorails, lifting hooks, and/or removable panels for the installation and removal of equipment. Structural openings shall be sized so that each completely factory-built item or equipment can be installed or removed without disassembly or special construction / demolition.

17.5.10 Vibration Isolation

All equipment that produces vibrations shall be isolated from the structure by spring or rubber-in-shear vibration isolators. All piping and ducts attached to rotating and oscillating equipment shall be isolated from such equipment by flexible connections. Inertia blocks shall be provided as required. Vibration control for environmental control systems shall be designed in accordance with the sound and vibration, control chapter of the *Handbook of Systems and Applications* (ASHRAE, latest edition).

17.5.11 Air Filtration

Supply air units shall be provided with replaceable media filter sections arranged in banks as appropriate. Air filter material shall be rated UL Class I and ASHRAE 52.2.

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18.0 FACILITIES ELECTRICAL SYSTEMS

18.1 SCOPE

This chapter lists the requirements for the design, installation, and operation of the electrical systems and equipment throughout SCRRA facilities. These criteria cover AC power electrical distribution systems and equipment, lighting; communications systems; power supply control equipment; emergency power systems; clocks and alarm systems; CCTV and station public address systems; fire alarm and protection systems. The electrical distribution systems shall be coordinated with and provide power to all heating, ventilation, and air conditioning equipment, other mechanical equipment, all industrial repair equipment, pumping equipment and all other devices requiring power.

The project site must be assessed for climate vulnerability (see Section 3.3) to ensure any work is designed to be resilient to future climate conditions. If the site is vulnerable to flooding, wildfire (directly or indirectly), increased ambient temperatures or other environmental hazard, electrical systems must be designed to mitigate potential impact.

18.2 STANDARDS AND CODES

The latest edition of the following standards, codes, and guidelines shall be used for design of the ac power and lighting system.

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

See the standards and codes listed in Appendix A.

18.3 ELECTRICAL SERVICE

The incoming power service shall be provided by local utility. The incoming power service infrastructure shall meet all of the technical requirements of the utility provider and shall be in accordance with the National Electrical Code for locations where local utility provider has no jurisdiction. A duct-bank for local power utility service shall be furnished as required by the local utility. The facilities shall be served at 480/277 volts, 3 phase, 3 wire or 4 wire as required. Power shall be distributed throughout the facility at the highest voltage possible, 480/277 volts. Step down transformers will be provided locally to feed all 208/120 volts 3 phase, 4 wire loads.

A minimum of 25% spare capacity shall be provided for all electrical and communication equipment at all levels including switchboards, transformers, panelboards, cable tray/conduit fills, circuit loadings, electrical equipment spacing requirements, floor architectural spacing, number of spare conduits for each system, panel, rack, cable tray etc.

The following utilization voltage levels shall be provided in the facility:

- Lighting: 120 or 277-volt, 1 phase
- Convenience outlets: 120 VAC
- Motors under ½ HP: 120 VAC or 208 Volt, 1 phase

- Motors larger than ½ HP: 480 VAC (1 phase or 3 phase as required)
- Maintenance equipment: 480 VAC (1 phase or 3 phase as required)
- Small mechanical equipment: 120 VAC (1 phase)
- Large mechanical equipment: 208 VAC or 480 VAC (1 phase or 3 phase)

18.4 ELECTRICAL DISTRIBUTION CENTER

18.4.1 Switchboards

Incoming electric service for each facility shall be terminated at the AC switchboard. The switchboard shall include secondary metering for owners use. Switchboards shall be circuit breaker type, copper bus, 100% rated neutral. Series rated breakers shall be prohibited.

Utility metering shall be located in an accessible area of the station to allow meter reading by the utility company meter reader without requiring special access or assistance from SCRRA. Where required, essential and non-essential buses shall be established for distribution to the loads.

18.4.2 Panelboards

Panelboards shall be copper bus with fully rated neutral. All 208/120 Volt, 3 phase, 4 wire and 480/277 Volt panelboards, with 3 wire or 4 wire as required, shall have a main breaker. The main circuit breaker may be omitted when the panelboard is located in the same room as the device feeding that panelboard. Series rated breakers are prohibited. All panelboards loads shall be balanced and provided with accurate typed panel directory. All panelboards shall be of the same manufacturer and keyed alike.

18.4.3 Wiring Methods

Wiring methods shall meet the following requirements:

- Wiring shall be THWN / THHN insulation. All conductors shall be copper with 600-volt insulation. All feeders shall be run continuous between power supply point and the load with no splices. Provide oversized neutrals for electronic circuits with high harmonics distortion.
- Branch circuit volt wiring shall be #12 AWG minimum. Size wiring to maintain a maximum of 2% voltage drop, also on a 120-volt, 20 amp single pole breaker:
- Use #12 AWG up to 30 m (100 feet).
- Use #10 AWG up to 45 m (150 feet) or larger as required.
- Minimum size of control wires shall be AWG No. 14.
- Use larger size conductors as required to maintain 5% voltage drop to the servicing panel.
- A ground wire shall be run in all conduits.
- All conduit subject to physical damage shall be Rigid Metallic Conduit.
- All conduits shall be ¾ inch minimum.

- Conduits concealed within walls/ceilings and above 8-foot AFF shall be EMT conduit.

18.4.4 Ground Fault Protection of Equipment

Ground Fault protection shall be provided on the load side of all main and secondary breakers. Ground fault sensing shall provide maximum coordination so that a ground fault shall trip at the first upstream breaker from the fault and not cause tripping of another breaker before a preset time delay.

18.4.5 Metering

Custom-owned metering shall be provided. Each main distribution panel and switchboard shall include digital metering. Digital metering shall contain/monitor Current, (each phase and neutral), voltage (l-l, l-n l-n each phase and three phase average), Active power (kW),Reactive power (kVAR), apparent power (kVA), power factor, active energy (kWh), Demand Current active, reactive, apparent (present and maximum), THD. Meter shall provide digital outputs for KY pulsing. Provide software to allow full monitoring of the digital electrical meters. Coordinate with HVAC controls contractor for electrical meter information send to the BAS system. Utility metering shall be provided as required by Utility Company in compliance with 18.4.1.

18.4.6 Ambient Temperature Ratings

The designer shall consider future ambient temperature conditions when specifying temperature ratings for electrical equipment in non-air-conditioned buildings or exterior enclosures. Specifying 50C or 65C rated equipment may be appropriate.

18.5 EMERGENCY POWER SYSTEM

18.5.1 Essential Loads

The designer shall determine essential loads based on facility type and service requirements. Certain types of loads shall be considered uninterruptable or essential. It is absolutely essential to minimize interruption of power to safety and system operations. Thus, power interruption should be limited to the normal transfer time of automatic transfer. Loads requiring uninterruptible power shall be defined in consultation with SCRRA signal, communications, and information systems staff. In addition, a generator receptacle with a manual transfer switch shall be provided to supply power to the emergency power systems. The generator receptacle shall be located on outside wall accessible for connection to a portable generator.

An increase in electrical outages may be experienced anywhere in the SCRRA system due to climate impacts (i.e., a spike in power consumption causing a brown out during an extreme heat day) or Power Safety Power Shutoffs (PSPS) that are planned outages (usually to avoid starting wildfires during dry/windy weather conditions). These outages can last up to a week therefore the length of time essential loads need to be supported shall be considered in the sizing of generator fuel tanks.

SCRRA facilities shall be provided with an emergency generator. The emergency power shall be distributed throughout the facility through three emergency power systems:

- Life Safety Systems – powering all life safety systems such as; the emergency and egress lighting, fire alarm system, security systems, and their systems dealing with human life safety.
- Critical Systems – powering all critical systems such as system rail control (signal) systems, data server/Radio/Communications equipment rooms and systems, HVAC systems serving such spaces, UPS systems, and other such loads.
- Emergency Power Systems – all other equipment requested to be on emergency power such as; HVAC systems, equipment loads, and other such loads

These essential loads shall be on dedicated circuits that can be independently controlled and energized during a power outage. Emergency power systems shall be hardened and protected from the effects of climate events. Installing block heaters on generators, adding CMU wall structures to protect against wildfires and high winds, and elevating systems out of flood-prone areas shall be considered.

18.5.2 Uninterruptable Power Supply (UPS) System

The UPS system shall have a battery of sufficient capacity to provide the full emergency load continuously for 30 minutes after a power supply failure, with a minimum final terminal voltage of 115 volts.

The battery charger shall be a silicon-rectifier type with the capacity to supply emergency loads and charge the battery from a completely discharged condition in approximately 12 hours. It shall have an adjustable charge rate for equalization and shall provide “no-charge” indication to the supervisory control system.

18.5.3 Supply Voltages

Power for facilities shall be supplied at a nominal 480/277 volts, 3-phase, 4-wire, 60-Hz.

18.6 EXPOSED CONDUIT WIRING METHODS

18.6.1 Allowable Applications

In general, exposed conduit for wiring within facility areas shall be in metallic conduit or ducts. Both rigid galvanized steel and intermediate metal conduit are acceptable for exposed conduit installation. Electrical Metallic Conduit shall be used concealed in walls/ceilings and above 8-foot AFF where not subject to physical damage. Cable trays may be used in areas where approved.

18.6.2 Conduit Size

All conduit shall be sized in compliance with NEC requirements. Minimum conduit size shall be ¾-inch minimum.

18.6.3 Installation Criteria

Expansion fittings shall be used where conduits cross structural expansion joints and as required by the thermal expansion and contraction in a length of conduit.

Metallic conduit shall be grounded and bonded to assure electrical continuity and the capacity to safely conduct any fault current likely to be imposed. Where bare ground wire is run in metallic conduit, the ground wire shall be bonded to the conduit at both ends to avoid inductive choke effects.

18.7 EMBEDDED CONDUIT WIRING METHODS

18.7.1 Allowable Applications

Embedded conduit for wiring within facility slabs and underground shall be rigid galvanized steel or rigid nonmetallic conduit. Both Schedule 40 and Schedule 80 PVC and fiberglass-reinforced epoxy (FRE) conduit are acceptable rigid nonmetallic compositions for embedded conduit installations.

18.7.2 Conduit Size

Embedded or buried conduit smaller than 1-inch electrical trade size shall not be used.

18.7.3 Installation Criteria

Minimum cover requirements shall meet or exceed the requirements of NEC for the conduit composition and voltage class of wiring installed. Areas subject to heavy vehicular traffic shall have a minimum cover of 24 inches with a 3-inch concrete encasement. Concrete duct banks under station platforms, roadways or railroad tracks shall be reinforced. Any conduit protecting MV feeders shall be red in color. All distribution conduits shall be provided with a warning tape see Chapter 10.9. See Chapter 19 and ES 5001 and 5002 for criteria regarding conduits crossing under tracks.

Where multiple conduits or ducts are run as a duct bank, plastic spacers shall be used to support the rows of conduit and to maintain a clear separation of 2 inches between conduits. The separation provides space for backfill or concrete aggregates, permits the mounting of end bells or bushings at terminations, and facilitates heat dissipation.

Vertical conduit turn-ups from embedded conduit may be installed with either rigid galvanized steel or PVC conduit. The PVC conduit for use in this installation shall be ultraviolet-resistant.

18.8 MANHOLES AND HANDHOLES

Manholes should be large enough to accommodate the depth and cross-sectional area of the duct banks entering and to provide a minimum horizontal workspace of 36 inches clear of cable supports and a minimum vertical dimension of 7 feet.

Handholes shall be a maximum of 42 inches in depth and shall be covered with a removable or hinged checkered plate.

18.9 LIGHTING

18.9.1 Interfaces, Management and Control

Provide and coordinate the system-wide lighting design of the Maintenance and Storage Facility (MSF), including the Interfaces, Management and Control connections to the Energy

Management Control System (EMCS) for operational management and control of the lighting systems

18.9.2 Lighting

All lighting shall be LED sources. Utilize 3500 kelvin color temperature LED sources for all interior luminaires. Utilize 4000 kelvin color temperature LED sources for all exterior luminaires. Add motion sensors to exterior lighting to have the lights at half power absent of motion. Lights to move to full power when motion detected and stay at full power 20 seconds minimum after motion detected. All LED luminaires shall be provided with 0-10 volt dimmable drivers and capable of interface with occupancy control, daylight harvesting, and other controls as required.

Recessed LED fixtures shall be flush hinged steel frame with direct/indirect distribution for all office, corridor, training, conference rooms, and other such areas in the office areas. Provide 125 acrylic K12 prismatic lens in T-bar ceiling areas for all bathroom/shower areas, and other non-office areas.

Support light fixtures independently of ceiling suspension systems. Support outlet and junction boxes independently of conduits running to them.

Plaster frames and rings shall be provided for fixtures which are to be recessed in a plaster or drywall type ceiling. Suitable trim rings shall be provided for fixtures recessed in ceilings, color to match ceiling finish.

Lighting in lunchroom/training rooms shall have dimmable drivers with gradual illuminance control. Shower fixtures to be approved for wet location. Provide separate switch control for each bank/row of luminaires. Fixtures in unfinished equipment rooms, storage areas to be industrial LED strip lights with slotted reflectors and wire guards.

Fixtures in maintenance areas shall be stem mount high-bay controlled by three-way switches on either side of the maintenance access points. Locate fixtures between bays and clear of open garage doors. Fixtures in wash bay shall be waterproof controlled by weatherproof three-way switches on either entrance.

Required maintained average light levels shall be in full compliance with IESNA recommended practice considering typical Dirt Depreciation for each area of occupancy factoring-in Light Loss Depreciation Factor provided by each luminaire manufacturer. Lighting levels shall be in compliance with Table 18-1. Required illumination levels below.

All emergency lighting to be in full compliance with local Building Code requirements as well as IESNA recommended practice. The most stringent requirement shall apply if/where conflict between two references exist.

TABLE 18-1. REQUIRED ILLUMINATION LEVELS

Areas	Illumination Level (Avg. FC)	Max/Min Ration
Interior		
Electrical/Mechanical/IT Data Closets Room	20 fc	6:1
Communication Room	45 fc	6:1
IT Room	30 fc	5:1
Training Classrooms Room	35 fc	6:1

TABLE 18-1. REQUIRED ILLUMINATION LEVELS

Areas	Illumination Level (Avg. FC)	Max/Min Ration
Maintenance Shop	50 fc	6:1
Shop area	75 fc	3:1
Wheel shop area	75 fc	3:1
Machine Shop	50 fc	3:1
Offices	35 fc	3:1
Stores	10 - 20 fc	3:1
Paint booth	75 fc	3:1
Parking		
Open Parking: Parking Lots	1	15:1
Vehicle Access/Parking Circulator	2	10:1
Yards		
Rail Yards Storage Areas	1 fc	15:1
Rail Yards Work Areas	10 – 15 fc	10:1
Stations		
See Chapter 7 Table 7.2 for Station Illumination Levels		

Notes:

1 If the Max/Min ratios recommended in the current IES handbook for Table 10.3 areas are more restrictive, then IES handbook ratios prevail. Otherwise, Table 10.3 applies.

2 FC values are measured at 30 inches above the finished floor

18.10 CALCULATIONS

18.10.1 Lighting

Lighting shall be designed by point-by-point method utilizing computer generated calculations. The software used shall be industry recognized and the calculations shall follow IEDNA procedures. Calculation results shall include maximum, minimum, and average illumination levels along with the appropriate uniformity ratios and lighting power densities per ASHRAE 90.1. Calculations shall also include luminaire locations, mounting heights, manufacturer catalog data sheet with product selections and options indicated, lamp data sheet, wattage, lumens, color rendering index, color temperature, room surface reflectance values, light loss factors, and photometric file used.

18.10.2 Short Circuit

Provide short-circuit calculations based on short-circuit capacity in mega-volt amperes (MVA), which Design-Builder shall obtain from the electrical service provider.

18.10.3 Voltage Drop

Provide feeder voltage-drop calculations for feeders 100 feet and longer. Provide motor circuit calculations based on 90 percent lagging power factor and voltage drop limited to 3 percent. Voltage drop for the fan shafts and below-grade Stations shall be limited to 2 percent from the secondary unit substation to service entrance switchboard/switchgear. Provide a maximum total voltage drop for feeders plus branch circuits of 5 percent.

18.10.4 Lightning Protection

Provide a lightning risk assessment to be performed per NFPA 780. Provide lightning protection per NFPA 780, Standard for the Installation of Lightning Protection Systems (previously the Lightning Protection Code). Provide lightning protection for buildings and structures that are more than 14 feet above grade.

18.10.5 Grounding

System and equipment grounding shall be in conformance with listed codes.

- Ground resistance to remote earth shall not exceed 5 ohms as measured by the fall-of-potential method.
- Grounding scheme for electrically conductive or metallic materials running along the alignment, such as handrails, walkways, or conduits, shall be developed to minimize the flow of stray currents and limit touch potentials to safe levels.
- Means shall be provided, such as ground rods, to bleed off high fault current and minimize safety hazard.

18.10.6 Convenience Receptacles

In public areas convenience receptacles shall be spaced not more than 100 feet apart and may be located flush in a wall or column and be connected to a separate circuit. This circuit shall be energized only for operation by authorized personnel. In non-public areas of stations, receptacles may be surface mounted and shall be spaced not more than 20 feet apart and shall be supplemented where needed for fixed equipment. In shop and utility spaces of maintenance facilities, receptacles shall be spaced not more than 50 feet apart, not including receptacles required for fixed equipment. In office spaces of maintenance facilities, receptacles shall be spaced not more than 20 feet apart, not including receptacles required for fixed equipment. Receptacles shall be mounted 15 inches above the floor in finished spaces and 48 inches above the floor in unfinished spaces. Provide receptacles at specific locations identified in Architectural drawings.

18.10.7 Electric Automobile Charging

- Electric Vehicle (EV) parking spaces that are designated to be electric vehicle stations shall be provided with electric vehicle supply equipment (EVSE) for the purpose of conductive charging of the EV.
- Coordinate with architect and owner for the specific locations of EV charging stations. EVSE shall be suitable for use by the general public typically at public parking areas, transit stations, parking garages and Maintenance and Storage Facility employee and visitor parking lots.

- EVSE installations shall comply with the 2020 Edition of the NEC – Article 625 – Electric Vehicle Charging System. Provide the appropriate EVSE to accommodate the following charging levels as defined by the Society of Automotive Engineers SAE J1772.
  - Level 1: 120VAC delivered to the EV; full charge time is typically 11 to 16 hours depending on the EV. Level 1 is anticipated for long-term or overnight parking.
  - Level 2: 208-240 VAC delivered to the EV; full charge time is typically 4 t0 7 hours depending on the EV. Level 2 is anticipated for shorter term parking likely during the work day for commuters.
- EVSE shall be of the same model and manufacturer providing the same functionality, user interface, communication protocol and supported by a single software package. Software shall allow for adding future EVSE and shall provide the owner with a comprehensive system to manage, track, and report on energy usage and revenue collection at individual EVSE.
- In addition to power to each EVSE, provide communications to each EVSE. If wireless communication is utilized on the EVSE, provide a ¾" inch empty communications conduit for future use.
- Provide traffic-rated concrete bollards around EVSE to prevent accidental damage from traffic.

18.10.8 Cell phone recharged station

Provision for cell phone recharged station shall be provided.

18.10.9 Solar Panel

Provisions for future solar power shall be provided to include but not limited to allocated rooftop and/or carport space, allocation of power conduits, and panel capacity for installation. Solar panels shall be considered with energy storage (minimum capacity for emergencies). Space and consideration for connections shall also be identified for installation of future energy storage systems.

18.10.10 Fare Vending, Collecting, Gates

Provisions for fare vending, collection and gates shall be provided. The equipment shall be fed from a panelboard located in the electrical room. Provide raceway for future equipment.

18.10.11 Illuminated Signs

The number and location of patron direction and information signs and whether internally or indirectly illuminated shall be as shown and described on architectural drawings. Exit signs for passenger stations shall be provided in accordance with the above reference.

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19.0 SOIL AND WATER AND ATMOSPHERIC CORROSION CONTROL SYSTEMS

19.1 GENERAL

Design of the corrosion control systems shall conform to a 50-year design life for buried structures and a 100-year design life for stations and consider the infrastructure design life. Corrosion control provisions shall be required for all facilities when corrosion failure of such facilities may affect safety or interrupt continuity of operations. Corrosion control systems shall be economical to install, operate, and maintain. The geotechnical engineer, with the assistance of a registered corrosion engineer or NACE Certified Corrosion Specialist or Cathodic Protection Specialist, shall provide recommendations regarding the corrosivity of the environment and potential control measures.

The basic design criteria shall meet the following objectives:

- The service life of SCRRA system facilities shall be maximized by avoiding premature failure caused by corrosion.
- Minimize aesthetic deterioration resulting from the failure of material coatings and the consequential onset of visible corrosion;
- Minimize detrimental effects of stray earth currents during normal transit operations to facilities owned by SCRRA and others. Annual operating and maintenance costs associated with material deterioration shall be minimized.
- Continuity of operations shall be enhanced by reducing or eliminating corrosion-related failures of systems and subsystems.

All design relating to implementation of the corrosion control requirements shall conform to or exceed the requirements of the latest versions of codes and standards identified in this DCM and shall be compatible with relevant safety requirements.

Protection of metal structures shall include, but may not necessarily be limited to, corrosion control techniques such as coating, electrical isolation, electrical continuity, and cathodic protection.

Corrosion control measures provided by others, for facilities owned by others, shall be taken into account in the design. Coordination with the owners of the facilities shall be required to avoid conflicts, such as interference with cathodic protection systems, trackwork, electrification, signaling, and communications designs.

The designer shall identify concrete structures that may be subject to attack and shall specify cement types in accordance with ASTM C150-07, Standard Specification for Portland Cement. For severe environments, supplemental concrete coating systems, increase of concrete cover, addition of corrosion inhibitors in concrete mix may be required, as well as potential cathodic protection of the reinforcing steel within the concrete.

Structures that may be affected by soil and water corrosion shall be identified. Typically these include, but are not necessarily limited to:

- Buried and on-grade reinforced concrete structures
- Metallic piping systems (water, fire water, sewage, storm water, fuels, etc.)
- Underground storage tanks
- Electrical conduits and control systems
- Rails and rail fasteners

Ductile iron pipe should have a surface preparation pursuant to the National Association of Pipe Fabricators (NAPF) 500-03-04 for pipe and NAPF 500-03-05 for fittings.

The corrosion control designs shall be coordinated with other project element designs, including mechanical, Utilities, electrical, civil, structures, trackwork, traction power, vehicles, environmental, geotechnical, architecture, grounding, signaling, communications, safety, and security in order to produce a fully comprehensive and integrated design.

The project site must be assessed for climate vulnerability (see Section 3.3), to ensure any work is designed to be resilient to future climate conditions.

19.2 MATERIALS AND STRUCTURES

19.2.1 Pressure Piping

All pressure piping and conduit shall be non-metallic, unless metallic materials are required to adhere to SCRRA standards and/or the utility owner's standards. Aluminum and aluminum alloys shall not be used.

All new buried cast iron, ductile iron, and steel pressure piping within SCRRA ROW shall be cathodically protected. In general, sacrificial galvanic anodes to minimize interaction with other underground utilities are the preferred corrosion protection system. Corrosion protection systems will adhere to the following minimum criteria:

- Comply with existing standards and specifications of the owner.
- Comply with federal, state, and local codes for regulated piping.
- Apply protective coating as described in Section 19.4, Coatings. All coatings shall be electrically tested to ensure they are holiday-free prior to backfilling. Holiday detector voltage shall depend on coating thickness in accordance with manufacturer recommendations and in accordance with NACE RP0274 and SP0188.
- Piping encased in concrete, including thrust blocks, shall be provided with a coating material extending minimum of 6 inches beyond the concrete to soil interface.
- Provide electrical isolation of pipe from interconnecting pipe, casings, rebar, and other structures and segregation into discrete electrically isolated sections per Section 19.3.1, Electrical Insulation of Piping.

- For pressure piping entering facilities below grade, pipe shall be electrically isolated immediately inside of the wall penetration. For pressure piping entering facilities above grade, pipe shall be electrically isolated immediately outside of the wall penetration. Pipe penetrations through walls and floors shall be electrically isolated from building structural elements, including rebar and building grounding system.
- Provide electrical continuity through the installation of copper wires across all mechanical pipe joints per Section 19.3.2, Electrical Continuity of Underground Piping, with the exception of insulating flanges.
- Provide permanent test/access facilities to allow for verification of electrical effectiveness of insulators and coating and electrical continuity. Additional test/access facilities installed at intermediate locations shall be at the discretion of SCRRA.

19.2.2 Copper Piping

Buried copper piping shall be electrically isolated from non-buried piping, such as that contained in a station structure, through use of an accessible insulating union installed where the piping enters through a wall or floor. Pipe penetrations through the walls and floors shall be electrically isolated from building structural elements. The insulator shall be located inside the structure and not buried.

- Electrically insulate underground copper pipe from dissimilar metals and from above ground copper pipe with insulating devices per NACE SP0286.
- Electrically insulate cold water piping from hot water piping systems.
- Place buried cold water copper tubing in an 8-mil polyethylene sleeve or encase in double 4-mil thick polyethylene sleeves and bed and backfill with clean sand at least two inches thick surrounding the tubing. Clean sand should have a minimum resistivity of no less than 3,000 ohm-cm, and a pH of 6.0–8.0.
- Buried hot water tubing may be subject to a higher corrosion rate. Protect hot copper tubing by one of the following measures:
  - Prevent soil contact. Soil contact may be prevented by placing the tubing above ground or encasing the tubing with PVC pipe with solvent-welded joints.
  - Apply cathodic protection per NACE SP0169.

19.2.3 Gravity Flow Piping (Non-Pressured)

Corrugated steel piping shall be internally and externally coated with a sacrificial metallic coating and a protective organic coating. Cast or ductile iron piping shall be designed and fabricated to include the following provisions:

- An internal mortar lining with an external bituminous coating on ductile iron pipe only (not required for cast iron soil pipe)
- A bonded protective coating or unbonded dielectric encasement on the external surfaces in contact with soils (AWWA C105)

- A bituminous mastic coating on the external surfaces of pipe 6 inches on each side of a concrete/soil interface
- The need for electrical continuity, electrical isolation, and cathodic protection on an individual basis.

Reinforced concrete non-pressure piping shall include the following provisions:

- Water/cement ratios meeting the minimum provisions of ASTM C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
- Maximum 150-ppm chloride concentration in the total concrete mix (mixing water, cement, admixture, and aggregates)

19.2.4 Casing Pipes

Buried metallic casing pipes shall be cathodically protected unless the casing pipe thickness is increased to allow for corrosion without compromising the structural integrity of the casing pipe. Casing isolators and spacers shall be installed on the carrier pipe to avoid electrical contact between the casing and the carrier pipe. Test facilities shall be provided at each end of the casings to allow testing of the status of electrical isolation between the casing and the carrier pipe. The test stations shall have as a minimum:

- Two test wires connected to the carrier pipe;
- Two test wires connected to the casing;
- A reference electrode located adjacent to the surface of the carrier pipe as close as possible to the end of the casing;
- A terminal (test) box located as close as possible to the pipeline and in an accessible location.

19.2.5 Electrical Conduits

Buried metallic conduits shall include the following provisions:

- Galvanized steel externally coated with PVC and internally coated with urethane are acceptable for direct burial, including couplings and fittings. The PVC coating is not required when conduits are installed in concrete.
- Electrical continuity through use of standard threaded joints or bond wires installed across non-threaded joints.
- Conduit within duct banks shall have a minimum of 3-inch concrete cover on soil sides. Internal coating only may be provided when conduits are installed in concrete.
- Internal and external coating shall be provided for conduits installed above grade, in corrosive atmosphere, and in wet atmosphere. Coating shall be of a type suitable for exposure to wet and corrosive atmosphere.
- Couplings and fittings shall be coated with the identical coating materials used for the conduit lengths.

19.2.6 Buried Concrete/Reinforced Concrete Structures

The design of cast-in-place concrete structures shall be based on the following provisions:

- The use of non-standard cement in high sulfate soils must be reviewed and approved by SCRRA. The American Concrete Institute (ACI) Publication SP-77, "Sulfate Resistance of Concrete," should be used as a guideline for determining the cement type to be used for specific soil conditions.
- The water/cement ratio and air entrainment admixture shall be in accordance with specifications presented in the structural criteria to establish a dense, low-permeability concrete. Additional information is provided in applicable sections of ACI 201.2R, "Guide to Durable Concrete."
- The maximum chloride concentration shall be 150 ppm in the total mix (mixing water, aggregate, cement, and admixtures). The concrete mix should be such that the water-soluble and acid-soluble chloride concentrations at the concrete/ reinforcing steel interface do not exceed 0.15 and 0.2 percent by weight of cement, respectively, over the life of the structure. Additional information is provided in applicable sections of ACI 222R, "Protection of Metals in Concrete against Corrosion."
- Concrete cover over reinforcing steel shall comply with ACI codes and provide a minimum of 2 inches of cover on the soil/rock side of reinforcement when pouring within a form and a minimum of 3 inches of cover when pouring directly against soil/rock.

The need for additional measures as a result of localized special conditions shall be determined on an individual basis. Additional measures may include application of protective coating to concrete, reinforcing steel, or both and the increase of concrete cover.

Precast standardized facilities, such as vaults and manholes, must be reviewed on an individual basis to determine alternative criteria when they cannot be practically modified to meet some or all of the provisions specified herein. Precast segmented concrete ring construction shall meet the requirements of this section or be reviewed on an individual basis to determine alternative criteria when they cannot be practically modified to meet some or all of the provisions specified.

19.2.7 Below Grade Shotcrete

Below grade shotcrete used for permanent support shall be in accordance with ACI 506.2 and applicable provisions specified in this section. In the case of conflicting specifications, the more rigid or conservative specification shall be applicable. No special corrosion control measures are required for shotcrete applications that are not considered as providing permanent support.

19.2.8 Support Pilings

The following is applicable only to support piling systems that are to provide permanent support. Pilings used for temporary support do not require corrosion control provisions. Designs based on the use of metallic supports exposed to the environment, such as H or soldier piles, shall include the use of a barrier coating. The need for special measures, such as cathodic protection, shall be determined on an individual basis based on type of structure, analysis of soil borings for corrosive characteristics, and the degree of anticipated structural deterioration caused by corrosion. The minimum requirements listed here shall be coordinated with the structural design discipline. The minimum corrosion control specification may not be appropriate in all conditions.

Reinforced concrete pilings, including fabrications with prestressed members, shall be designed to meet the following minimum criteria:

- The water/cement ratio and cement types shall be in accordance with Section 19.2.6.
- Chloride restrictions for concrete with prestressed members shall be in accordance with Section 19.2.6, with exception that the concrete mix should be such that the water-soluble and acid-soluble chloride concentrations at the concrete/prestressed steel interface do not exceed 0.06 and 0.08 percent by weight of cement, respectively, over the life of the structure. Additional information is provided in ACI 222R, “Corrosion of Metals in Concrete.”
- A minimum of 3 inches of concrete cover shall be placed over the outermost reinforcing steel, including prestressing wires, if present.

Metallic supports shall have a barrier coating from the surface to a minimum of 10 feet below expected low groundwater level. Sacrificial thicknesses shall be considered based on the corrosivity of soil. The need for special measures, such as electrical isolation measures, electrical continuity, monitoring devices, and cathodic protection, shall be determined on an individual basis, based on type of structure, analysis of soil borings for corrosive characteristics, and degree of anticipated structural deterioration caused by corrosion.

Concrete-filled steel cylinder columns, where the steel is an integral part of the load bearing characteristics of the support structure, shall be designed considering the need for special measures, such as increased cylinder wall thickness, external coating system, stray current mitigation, and/or cathodic protection.

The design shall be determined on an individual basis based on type of structure, analysis of soil borings for corrosive characteristics, and the degree of anticipated structural deterioration caused by corrosion.

19.2.9 Reinforced Earth Retaining Walls

Epoxy-coated steel reinforcing strips shall be used in lieu of galvanized strips if the select granular backfill material used for construction is subject to low-resistivity water infiltration.

19.2.10 Impermeable and Clay Soils

Where clay soils or impermeable surfaces limit ability for stormwater to infiltrate and transferring water away from the site is not feasible, consideration shall be given to injection wells. Injection wells are simple bores that extend through impermeable/clay soils to allow water to infiltrate into the ground water table below. EPA permits will be necessary to install injection wells. As applicable, injection wells shall be added at the bottom of swales, basins, or other retention structures to aid infiltration.

19.3 PROTECTION OF UNDERGROUND STRUCTURES

19.3.1 Electrical Insulation of Piping

Where required, electrical insulation of piping shall be achieved using insulating flanges, couplings, unions, non-metallic inserts, and/or concentric support spacers that meet the following minimum requirements:

- Minimum clearance of 12 inches shall be provided between new and existing metallic structures. SCRRA shall be notified if this clearance cannot be achieved due to site-specific constraints.
- A protective coating shall be applied to all metallic devices (including those installed in chambers) exposed to high humidity, partial immersion, and/or soils.
- Temperature and mechanical ratings shall be equivalent to the attached structure.
- There shall be sufficient electrical resistance after insertion into the operating piping system such that no more than 2 percent of a test current applied across the device flows through the insulator, including flow through conductive fluids, if present.
- Isolating devices for metallic pipelines buried in soils shall be provided with a protective coating.
- Non-metallic, concentric support spacers and watertight end seals shall be used where piping is routed through a metallic casing.
- Design shall specify the need for, and location of, isolating devices. Inaccessible isolating devices, such as buried or elevated isolators, shall be equipped with accessible permanent test facilities. Test facilities shall include, at a minimum, two insulated, tagged wire test leads connected to each side of the isolating device and terminated at a test station box

19.3.2 Electrical Continuity of Underground Piping

Electrical continuity shall be provided for all non-welded metallic pipe joints (with the exception of insulating devices), and shall meet the following criteria:

- Direct burial, insulated, stranded, copper wire shall be used with the minimum length necessary to span the joint being bonded.
- Wire size shall be a minimum of 6 AWG and shall be based on the electrical characteristics of the structure and the resulting electrical network to minimize attenuation and allow for cathodic protection. Wire resistance shall be such that the bond resistance is a maximum of 110 percent of the theoretical calculated pipe resistance for an 18-inch length of pipe. Bonding wires shall be installed using the thermite welding method. Exothermic welds and adjacent bared piping shall be coated with a cold-applied, fast- drying mastic consisting of bituminous resins and solvents, or an approved epoxy.
- A minimum of two wires per joint shall be used for redundancy.
- Surface preparation of the structure to be coated shall be required in accordance with the coating manufacturer's recommendations.

- Copper piping joints shall be soldered.

19.4 COATINGS

19.4.1 General

The corrosion control design shall specify surface preparation, application procedure, primer, number of coats, and minimum dry film thickness for each coating system. Shop-applied coatings shall be specified wherever possible, with the use of compatible coating systems for field touchup and repairs. Coatings shall be able to demonstrate satisfactory gloss retention, color retention, and resistance to chalking over their minimum life expectancies. Coatings shall have minimum life expectancies, defined as the time prior to major maintenance or reapplication, of 15 to 20 years. Coatings specified for buried metallic or concrete facilities shall satisfy the following criteria:

- Minimum 5-year performance record
- Ability to withstand reasonable abuse during handling and earth pressure after installation
- Minimum volume resistivity per ASTM D257
- Minimum thickness as recommended for the specific system, but not less than 15 mils
- Minimum adhesion and bonding strength requirements specified by the manufacturer

Potentially acceptable generic coating systems include, but are not limited to, the following:

- Extruded polyethylene/butyl-based system
- Coal-tar epoxies (two-component systems)
- Polyethylene-backed butyl mastic tapes (cold applied)
- Bituminous mastics (airless spray)

Non-bonding corrosion protection systems (polyethylene wrap) may be used in special instances after review and approval by SCRRA.

19.4.2 Barrier Coating Systems

One of the following barrier coating systems, in accordance with the Steel Structures Painting Council (SSPC) Surface Preparation Standards and Specifications, shall be used where corrosion protection is needed but appearance is not a primary concern:

- Near-white blast surface according to SSPC-SP 10. Follow with a three-coat epoxy system.
- Commercial blast surface according to SSPC-SP 6. Follow with a two-coat inorganic zinc, high build epoxy system.
- Near-white blast surface according to SSPC-SP 10. Follow with a three-coat inorganic zinc, high build epoxy system.

One of the following barrier coating systems, in accordance with SSPC Surface Preparation Standards and Specifications, shall be used where both corrosion protection and good appearance are needed:

- Near-white blast surface according to SSPC-SP 10. Follow with a three-coat inorganic zinc, high build epoxy, polyester urethane system.
- Near-white blast surface according to SSPC-SP 10. Follow with a three-coat vinyl system.
- Commercial blast surface according to SSPC-SP 6. Follow with a three-coat inorganic zinc, high build epoxy, polyester urethane system.
- Commercial blast surface according to SSPC-SP 6. Follow with a three-coat inorganic zinc, high build epoxy, acrylic urethane system.

All coatings shall be applied according to the manufacturer's specifications.

19.4.3 Metallic-Sacrificial Coatings

Acceptable coatings for carbon and alloy steels for use in tunnels, crawlspaces, vaults, or above grade are as follows:

- Zinc (hot-dip galvanized [2 ounces per square foot] or flame sprayed)
- Aluminum (hot-dip galvanized [2-mil thickness] or flame sprayed)
- Aluminum-zinc
- Electroplated zinc (sheltered areas only)
- Inorganic zinc (as a primer)

Cadmium shall not be allowed.

19.4.4 Sealants

Crevices shall be sealed with a polysulfide, polyurethane, or silicone sealant as appropriate for the application and exposure conditions.

19.5 CATHODIC PROTECTION

Cathodic protection installations shall be designed consistent with structure life objectives and NACE International standards. Design of cathodic protection shall be by a NACE International Certified Cathodic Protection Specialist, and include a Cathodic Protection Monitoring System (CPMS). In general, sacrificial galvanic anodes to minimize interaction with other underground utilities are the preferred corrosion protection system. The use of impressed current systems in lieu of sacrificial anodes will be allowed only after review and approval by SCRRA.

When galvanic cathodic protection is used for new facilities, the facilities shall be provided with a compatible coating system. All galvanic anodes shall be connected to the structure via test stations. Anodes shall not be directly connected to the structure.

Designs shall be based on NACE International standards, recommended practices, and theoretical calculations. At a minimum, the design process shall assess the following:

1. Soil environment
2. Presence of anaerobic bacteria;
3. Mutual structure protection or interference configuration
4. Limitation of protection potentials
5. Accessibility after construction is completed
6. Optimum location of anodes for ease of replacement and avoidance of interference with other structures.
7. Test monitoring stations and facilities
8. Anode service life and ground bed resistance
9. Minimum anode service life of 25 years

At a minimum, the test facilities shall contain the following:

- Two structure connections for each structure
- One reference electrode test wire connection
- Conduits and terminal (test) boxes

The number, type, and spacing of the test facilities shall be sufficient to determine the adequacy of cathodic protection, electrical continuity, and electrical isolation.

19.6 QUALITY CONTROL TESTING

19.6.1 Electrical Continuity

The electrical continuity of select utility structures and pipelines is required by the design criteria. The requirements for determining and testing the proper electrical characteristics of these structures shall be incorporated into the design of the structure. Guidelines for developing the quality control test procedures for electrical continuity are as follows:

- All structures that are to be made electrically continuous shall be tested for electrical continuity and compared to theoretically based criteria, and shall meet or exceed the accepted criteria.
- A specific set of test procedures and acceptance criteria for the electrical continuity testing shall be incorporated into the project specifications.
- Selection criteria for the entities to perform the quality control testing shall be incorporated into the project documents. The criteria shall include the qualifications of the agency, personnel requirements, and equipment requirements. A minimum of 5 years of experience performing this work is required.
- Specific reporting requirements for the electrical continuity testing shall be incorporated into the project documents.

19.6.2 Cathodic Protection

The application of cathodic protection on select underground utility structures and pipelines is required by the design criteria. The requirements for determining proper application of cathodic protection include the verification of electrical continuity and verification of cathodic protection compliance with industry standards (NACE International). Guidelines for developing the quality control test procedures for verification of cathodic protection levels are as follows:

- All structures that are required to have cathodic protection shall be tested in accordance with NACE International SP0169. A test plan shall be submitted by the testing agency to be approved by SCRRA.
- Specific reporting requirements for the cathodic protection testing shall be incorporated into the project documents.
- Selection criteria for the entities to perform the quality control testing shall be incorporated into the project documents. The criteria shall include the qualifications of the agency, personnel requirements, and equipment requirements. A minimum of 5 years of experience performing this work is required.

19.6.3 Coatings

The quality control measures required for the verification of proper application and handling vary greatly depending on the coating type. Guidelines for establishing general procedures for quality control testing are as follows:

- Coatings shall be tested in accordance with the manufacturer's recommendations and in accordance with NACE International recommended practices.
- A quality control test plan shall be required for the application and testing of all coated surfaces. The test plan shall address the allowable coating thickness measurements, adhesion requirements, hold points for test, test procedures to be used in the quality control process, and reporting and acceptance requirements for each specific type of coating system being used.
- All shop coated surfaces shall first be tested, witnessed, and accepted at the coating facility.
- Additional field quality control hold points shall be required.
- Selection criteria for the entities to perform the quality control testing shall be incorporated into the project documents. The criteria shall include the qualifications of the agency, personnel requirements, and equipment requirements. A minimum of 5 years of experience performing this work is required.

19.7 ATMOSPHERIC CORROSION CONTROL

Atmospheric corrosion control requirements shall be applied to mitigate corrosion caused by local climatological conditions, air pollutants and airborne chloride near the ocean. Structures and systems shall be protected by the use of materials selection, coatings, sealants, and design details that provide for proper drainage in order to maintain necessary function and appearance of transit system structures exposed to the environment. Corrosion surveys shall be conducted to determine and document the corrosive characteristics of the atmosphere and to be used as the basis of the atmospheric corrosion control system designs.

19.7.1 Evaluation of Atmospheric Exposures

Evaluation of atmosphere shall be conducted by research of the local air quality agency to identify pollutant and airborne aggressive ions types, and levels. The pollutants and levels identified shall be evaluated to determine approximate corrosion rates based on the atmospheric exposure to these materials.

Evaluation of past meteorological history of the region shall be conducted through research of local weather agencies. The data gathered shall be used to evaluate the impact on atmospherically exposed structures. Design of the atmospheric corrosion control systems shall be based on recommendations of the reports and shall be used to significantly decrease atmospheric corrosion rates.

19.7.2 Graffiti-Resistant Coatings

Surfaces which are susceptible to graffiti shall be protected with graffiti-resistant coating. This includes concrete and painted steel surfaces within stations, such as walls, columns, and equipment enclosures. Such areas shall be protected up to a height of 10 feet. The coating shall be a two-part epoxy-type coating, applied in three coats, a filler or prime coat, a color coat, and a clear finish coat in accordance with the latest-published manufacturer instructions.

19.7.3 Metals Exposed to Below-Grade Atmospheric Environments

The water seepage into below-grade structures shall be minimized and any water that might enter shall be drained in the most efficient manner. Below-grade metals and protective coatings shall be selected after the corrosiveness of the environment is identified.

19.7.4 Steels and Ferrous Alloys

Carbon steel, ductile, and cast iron exposed to the atmosphere, except for track and track fasteners, such as spring clips, spikes, and rail plates, shall be protected with a barrier or sacrificial coating applied to external surfaces. Barrier coatings may be appropriate for track fastening hardware inside tunnels. High strength, low alloy steels shall be protected similarly to carbon steels except where used as a weathering steel exposed to the outside environment. The design shall incorporate complete drainage of surfaces, the coating of metal-to-metal contacting surfaces, and the sealing of crevices. The potential staining of adjacent structures shall be considered.

Stainless steels series 200 and 300 are suitable for use in most exposed situations without further protection, with Type 316 being preferred for superior corrosion resistance. Series 400 stainless steel may also be used, if staining over time is not detrimental. A barrier coating shall be used on stainless steel exposed to marine environments. Hardware used to couple or connect shall be the same stainless series, or as approved by corrosion control engineering.

Corrosion resistance reinforcing steel with a minimum of 3-inch concrete cover, and corrosion resistance metals for any exposed metal in the area subjected to extreme environmental conditions shall be used.

Glass fiber concrete reinforcement bar in areas of saltwater spray or potential inundation from salt or brackish water shall be considered after prior written approval from SCRRA.

19.7.5 Aluminum Alloys

Aluminum alloys shall receive a sealed, hard anodized finish to provide the best weather-resistant surface. A barrier coating shall be used on aluminum exposed to airborne chloride or atmospheric corrosive pollutants. Aluminum shall not be in direct contact with concrete unless properly coated.

19.7.6 Copper Alloys

Copper and copper alloys can be used where equipment is exposed to weather without additional protection. A coating shall be utilized only where a natural patina is not desired. Bimetallic couplings shall be prohibited.

19.7.7 Zinc Alloys

Zinc alloys can be used without additional protection. A shop-applied barrier coating may be utilized to extend the design life of components or to enhance the component appearance. Bimetallic coupling shall be prohibited, unless the intent is for sacrificial protection by the zinc alloy.

19.7.8 Miscellaneous Electrical Equipment

Electrical equipment enclosures, such as, but not limited to, switch boxes, transformers, and connection cabinets shall be non-metallic where practical. Where metallic equipment is required, it shall include the following minimum provisions:

- Enclosures shall be placed in an air-conditioned environment, if possible. Otherwise,
- Metallic surfaces shall be coated with a barrier coating;
- Vapor phase inhibitors shall be used in sealed cabinets; and
- Compressor mounting hardware shall be a corrosion-resistant material, such as a stainless steel.

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20.0 COMMUNICATIONS SYSTEMS

20.1 SCOPE

This section describes the design criteria for SCRRA Communications Systems, which are a collection of various wayside communications subsystems. These subsystems utilize local area networks (LAN) and wide area networks (WAN) for remote control and monitoring at the Dispatch Operations Center (DOC). The Communications System shall be designed to provide interoperable subsystems that support the total operational and availability objectives of the SCRRA system. These subsystems shall be designed to be technically compatible when interconnected and form an integrated whole. This design criteria shall be applied by the design consultant when additions, modifications, and removals within existing subsystems are required. The design criteria shall be applied during the expansion of systems as SCRRA territory and operations evolve.

The following functional areas shall be considered part of the Communications System and its design:

- Train Control System (ATCS Radio)
- Voice Radio System
- Positive Train Control (PTC) Radio System
- Video Surveillance System
- Customer Information System (CIS)
- Ticket Vending System (TVD)
- Fiber Optic System
- Microwave Radio System
- Data Radio System
- Communications Shelter
- Communications Tower Structures
- Power and grounding
- Documentation and training

Systemwide functions

In addition, the design of the Communications System requires review and consideration of other chapters within this manual:

- Chapter 7.0, Stations
- Chapter 8.0, Grade Crossings
- Chapter 11.0, Structures

- Chapter 13.0, Load Rating
- Chapter 14.0, Seismic Design
- Chapter 15.0, Excavation Support Criteria
- Chapter 23.0, Environmental Guidelines

The project site must be assessed for climate vulnerability (see Section 3.3) to ensure any work is designed to be resilient to future climate conditions.

20.2 STANDARDS AND CODES

The latest editions of the following standards, codes, and guidelines shall be used, as applicable, for the design and implementation of the Communications System:

- American Railway Engineering and Maintenance of Way Association (AREMA)
- Association of American Railroads (AAR)
- Federal Railroad Administration (FRA)
- American National Standards Institute (ANSI)
- Telecommunications Industry Association (TIA)
- Federal Communications Commission (FCC)
- National Environmental Policy Act (NEPA)
- Antenna Structure Registration (ASR)
- National Historic Preservation Act (NHPA) Section 106
- Tower Construction Notification System (TCNS)
- Institute of Electrical and Electronics Engineers (IEEE)
- IEEE Standard 729 Software Design and Documentation
- IEEE Standard 730 Software Quality Assurance
- National Fire Protection Association (NFPA)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- All applicable Underwriters Laboratories, Inc. standards
- California Occupational Safety and Health Administration (CalOSHA)
- Electrical, fire, and safety codes of applicable local jurisdictions
- Americans with Disability Act (ADA)
- SCRRA Engineering Standard Drawings Series 9000, Communications

20.3 GENERAL COMMUNICATIONS SYSTEM DESIGN REQUIREMENTS

It is critical that the Communications System supporting SCRRA system operations is highly available. High availability aims to ensure an agreed level of operational performance for a higher than normal period. For the purpose of this design criteria, whether a system is available shall be determined from the users' point of view and their ability to utilize a subsystem. System users within SCRRA are diverse groups depending on the subsystem utilized. For example, the following scenarios identify various system users:

- Riders using ticket vending devices at passenger stations to purchase a ticket
- Riders reliant on timeliness of scheduled train service
- Train dispatcher clearing a signal on the Valley subdivision
- Locomotive engineer requesting authority to enter Form B limits from a Roadway Worker In Charge (RWIC)
- Security personnel reviewing video at a passenger station

The design consultant shall apply the following principles of systems design to achieve high availability:

- Redundancy shall be added to the system to minimize single points of failure. Redundancy prevents the failure of a single component leading to the failure of the entire system. Components that cannot be eliminated as a single point of failure shall be evaluated for acceptability in Mean Time Between Failures (MTBF). MTBF shall exceed the intended time between planned maintenance, upgrade events, or system lifetime.
- Design organization, consistent application of standards, and documentation shall support maintenance personnel's ability to ensure a timely response for correction and repair of system failures. Visibility of component failures shall be provided through automated monitoring and notification.
- Automatic transition (failover) to a redundant standby system shall be reliable when the active system fails.
- Systems shall be protected against extreme heat events causing outages through shading, adequate air conditioning (with solar or battery back-up) or other; systems will be protected from future flooding through elevation or appropriate casements.

Availability is expressed as a percentage of the uptime in a given year. The term downtime is used to refer to periods when a subsystem is unavailable. Periods of downtime can be scheduled or unscheduled. Scheduled downtime is a result of maintenance that is disruptive to the system operation and cannot be avoided within the active system. This downtime is the result of a pre-planned, management approved action. Examples of unscheduled downtime events include power outages, failed components, temperature related failure, physically severed network connections, and operating system failures. The design consultant's Communications Systems design shall minimize the impacts of unscheduled downtime.

20.3.1 Qualifications of Communications Designer

The Communications Designer responsible for SCRRA communications designs shall be a licensed Professional Engineer in the state of California, with a working knowledge of electrical engineering, electronics engineering, and telecommunications. The Communications Designer shall have a minimum of five (5) years of experience designing communications systems for passenger rail projects. The Communications Designer shall have a Bachelor of Science in Electrical Engineering or related area of study, covering the analysis of analog and digital communication systems, systems models, requirements development, performance analysis, and component selection techniques. It is preferred that the Communications Designer have familiarization with train control concepts and train operations to effectively translate operational requirements into Communication Systems design requirements.

20.4 RADIO AND MICROWAVE ANTENNA TOWERS

20.4.1 Regulatory Compliance Requirements

Any antenna tower that utilizes licensed spectrum is regulated by the Federal Communications Commission (FCC). These antenna towers are subject to the National Environmental Policy Act (NEPA) in which Agencies must consider and disclose the environmental effects of their actions. These actions (in this case, installation of a new antenna tower) become federalized through mechanisms of funding, licensing, or permitting subject to federal control. Antenna towers built within a Right of Way with minimal or no impacts to the environment may be eligible for Categorical Exclusion (CATEX).

The placement of each FCC regulated antenna tower shall be assessed by the design consultant for Extraordinary Circumstances. In accordance with 47 CFR Section 1.1307, preparation of an Environmental Assessment (EA) is required for the following Extraordinary Circumstance criteria:

- High intensity lighting in residential neighborhoods
- RF exposure in excess of FCC guidelines
- Location within a designated wilderness area
- Presence of sensitive species or their habitat
- Historic districts and properties
- Indian religious sites
- Location within a floodplain
- Significant change in surface features (wetland fill, water diversion, deforestation)
- Structure over 450 feet tall (migratory birds)

The EA will determine whether an Environmental Impact Statement (EIS) is required or release a Finding Of No Significant Impact (FONSI) and continue with the proposed action.

FCC regulated antenna towers are subject to Section 106 of the National Historic Preservation Act (NHPA) and the Nationwide Programmatic Agreement (NPA) for Review of Effects on Historic Properties for certain Undertakings Approved by the FCC. The Electronic Section-106 system enables parties constructing a new tower to file E-Form 620 with the FCC. The system then forwards the filing to stakeholders choosing to participate electronically, including the State Historic Preservation Officer (SHPO), federally recognized Indian tribes, and other consulting parties, allowing them to comment as the whether they have concerns about the proposed tower construction. The FCC has also developed a proprietary Tower Construction Notification System (TCNS) to facilitate identification of and contact with potentially affected tribes and State Historic Preservation Officers (SHPOs). This system is a tool meant to facilitate Section 106 consultation and is not a substitute for it. The TCNS system contains confidential maps that these stakeholders can utilize for evaluation. Tribes can also request a government to government consultation, if necessary, during the evaluation period.

FCC regulated antenna towers may be subject to the Antenna Structure Registration (ASR) program. In general, this includes structures that are taller than 200 feet above ground level or those that may interfere with the flight path (glide slope) of a nearby airport. Specific information for the tower (latitude, longitude, height above ground level, and site elevation) must be submitted for a TOWAIR determination for antenna registration.

Within the California Environmental Quality Act (CEQA), SCRRA received a Statutory Exemption for construction and operation of commuter rail facilities within an existing railroad Right of Way (ROW). Unless modified by the State, it is not anticipated that antenna towers constructed within the ROW are subject to CEQA. Any antenna towers constructed outside of the ROW shall be evaluated for CEQA.

All regulatory reviews shall be completed during the design phase and prior to any construction. SCRRA's Communications Licensing Coordinator (CLC) will facilitate the antenna regulatory approval effort. The CLC shall be notified of proposed antenna tower locations at the 30% design concept level. The design consultant shall provide all drawings, exhibits, and calculations required for the CLC to complete regulatory applications at the 90% design phase.

20.4.2 Structure Requirements

Antenna tower design drawings shall provide detail for the following:

- Structure type (Monopole, Self-Supporting, or Tilt down tower)
- Structure height above ground level (AGL)
- FAA lighting, if required
- FAA painting, if required
- Antenna model number
- Antenna center heights and azimuths
- Antenna mounting requirements
- Transmission Lines
- Grounding and Lightning Protection
- Waveguide Bridge
- Exposure Category or clutter

- Topographic Category
- Seismic rating
- Climbing and Working Facilities
- Tower Security and Fencing

The design consultant shall complete a structural analysis for new and existing antenna tower loads with ANSI/TIA-222-H or latest revision. This analysis shall be sealed by a qualified Professional Engineer in the State of California and requires information such as: antenna tower dimensions, local climate conditions, location and type of antennas, mounts, transmission lines, and other appurtenances. Wind loading governs many tower designs, and as additional antennas are placed on an existing tower, it shall be reevaluated for any necessary structural modification requirements. When designing a new antenna tower, consult with SCRRA to determine location specific additional tower load criteria for possible future expansion.

Antenna towers shall utilize an engineered foundation plan sealed by a qualified Professional Engineer in the State of California using the latest edition of the California Building Code (CBC). Microwave antenna tower designs shall include a soil survey geotechnical report for the proposed tower location. The antenna tower foundation design shall factor wind, ice, and seismic loads. The foundation design shall use a minimum wind speed of 100mph and ½ inch of solid radial ice. The tower manufacturer shall provide the axial, shear, and moment base reactions.

Tilt down antenna towers shall be oriented to tilt down parallel to the tracks. The design consultant shall confirm that the antenna tower will not conflict with overhead power lines when upright or wayside infrastructure when in the tilt down position. As the antenna load increases, appropriate counterweights shall be provided to counterbalance the antenna when in the tilt down position.

20.5 MICROWAVE RADIO NETWORKS

20.5.1 Scope

Point to point microwave radio is utilized by SCRRA for backhaul as a primary network in railroad Right of Way where no fiber exists or where fiber networks are segmented (having no direct path) from the Dispatch Operations Center (DOC). SCRRA's microwave system utilizes route diversity, in which secondary or alternate microwave paths serve as failover links to protect the system if the primary link is lost.

20.5.2 Link Design

Microwave link design is an iterative process inclusive of the following activities:

- Selection of equipment and locations governed by eligibility
- Frequency planning governed by interference analysis
- Link budget governed by propagation losses (free space and obstacle loss) and branching losses (waveguides, splitters, and attenuators)
- Fading predictions governed by rain attenuation, multipath propagation and diffraction-refraction losses

- Quality and availability calculations

Each SCRRA microwave link shall have 99.999% availability as demonstrated by the path loss and fade margin calculations. The minimum allowable fade margin shall be 20dB. Radio receiver sensitivity shall be evaluated at a maximum Bit Error Rate (BER) of $1x10^{-6}$. Each end of the microwave link shall use the same manufacturer's equipment. The microwave equipment shall be capable of hitless failover and have compatibility with SCRRA's network management system.

20.5.3 Path Surveys

The design consultant shall verify that the microwave link design has optical Line of Sight (LOS). LOS exists when there is a direct path between two separate points and no obstructions (buildings, trees, hills or mountains) between them. In addition, the first Fresnel Zone shall be clear of all obstructions. The path shall be driven to evaluate if additional clearance is required to protect against future growth of buildings and trees.

The design consultant shall conduct path surveys after the 10 percent concept design phase. These surveys shall be completed through means to confirm the LOS is not obstructed for the intended link. Survey reports shall be submitted including photos, description of path, and path profile with existing obstruction heights.

20.5.4 Frequency Planning

Existing frequencies used by the current SCRRA microwave network are in the Lower 6GHz (L6) and 11GHz bands. After selecting proposed frequencies and equipment, the design consultant shall conduct frequency planning with a certified FCC frequency coordinator to ensure that frequencies are available for licensing and do not interfere with existing users in the surrounding area. All information from the frequency planning shall be provided to SCRRA's CLC.

20.5.5 Coverage

The designer shall coordinate with the microwave radio manufacturer to provide link calculations that estimate availability. The link calculations will detail microwave radio equipment, output power, frequency, antenna, waveguide, location coordinates, and mounting height.

In remote areas where maintenance access is difficult, a standby generator shall be considered to support network availability. Microwave radio hardware shall contain a chassis with multiple card configurations and redundancy to provide module protection. At locations where no fiber is present at the microwave link site providing an alternate path, a telco circuit is required to be installed as the alternate path.

20.5.6 Licensing

Microwave radio spectrum is licensed by the Federal Communications Commission (FCC). The Universal Licensing System (ULS) is the consolidated database and application filing system for most wireless radio services. SCRRA's Communications Licensing Coordinator (CLC) will facilitate the regulatory approval effort. The designer shall provide all information to complete the FCC Form 601 (initial application).

Microwave site construction shall not commence without an approved FCC license. Per 47 CFR 1.946, licensees are required to construct their authorized system or meet specific coverage requirements within a given time period and notify the FCC that the requirement was met. If the licensee fails to construct a frequency, location, or coverage requirement, the frequency, location, or license terminates automatically as of the applicable construction/coverage deadline. Licensees may request a waiver of 47 CFR 1.946 to extend a construction or coverage period. The design consultant shall communicate with the CLC to update for changes that impact a microwave site during construction.

20.5.7 Design and Deployment

Microwave radio design shall include the following characteristics:

- Site Overview: The site overview shall include detailed property surveys, tower type, placement, grounding, GPS coordinates, and supporting telco circuit (when applicable). Antenna information shall detail type, height, azimuth, and standoff bracket. Antenna cable configurations shall be described to capture the necessary waveguide types, grounding, and connection points. At remote and/or strategic sites, generator standby power with an automatic transfer switch shall be considered.
- Shelter Layout: The communications shelter layout shall identify the equipment rack that houses the Microwave radio equipment. Waveguide port entrance into the shelter shall be identified and aligned with overhead ladder rack for waveguide support.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources, and breaker sizes. Dehydrator and alarm wiring shall be shown. Automatic transfer switch and generator power wiring shall be detailed. Wayside microwave radio equipment shall be supported by DC power with battery backup of 24 hours standby time. At remote sites, 72 hours of standby time shall be designed. Standby time shall be calculated to include 25 percent capacity for future equipment loads.
- Equipment Rack Layout: Microwave equipment rack detail shall be provided to show equipment spacing, cable management, power, shelving, and total rack unit (RU) space requirements.

Microwave radio deployment specifications shall require the following tests and verification:

- Grounding
- Antenna/waveguide return loss
- Hardware performance under power failure
- Pressurization
- Frequency accuracy
- Transmitter power
- Back office testing of alarm verification and network management system (NMS)
- Orderwire

- Bit Error Rate (BER)
- Failover to standby microwave links

20.6 OPTICAL WIDE AREA (FIBER) NETWORKS

20.6.1 Scope

The SCRRA preferred backhaul network type is an Optical Wide Area Network (WAN) utilizing fiber optic cable. The design consultant shall consider feasibility of fiber installation in project Right of Way or conduit for future fiber installation in locations that do not have fiber. If fiber or fiber accommodations are excluded from a project, a detailed justification of the tradeoffs considered shall be submitted to the SCRRA Director, PTC, C&S Systems, or Designate.

20.6.2 Logical Design

Fiber networks shall be designed in a ring topology with Ethernet IP/packet-based Rapid Spanning Tree Protocol (RSTP) 802.1w. Spanning tree protocol addresses a network loop topology by blocking ports, which absent RSTP would cause broadcast storms and degrade network performance. Automatic Protection Service (APS) shall be utilized to support sub 5 seconds failover time.

Network optics shall be selected for each link based on optical link calculations. All optical link calculations shall confirm a power budget with a minimum of 6dB margin to maintain high availability within the network. When 6dB margin is not available, a higher optical power source will be used in the link. Within the link calculation, optical losses incorporated shall include fiber attenuation over link distance, connector losses, and splice losses. The manufacturer specified worst-case transmitting power and receiver sensitivity shall be used in the calculation to account for variation in optics performance.

When connecting logical ring links to active network switch equipment, switch port connections shall be made consistently at each location from the railroad west link to Port 2 and the railroad east link to Port 1 in a clockwise fashion around the ring. All logical ring link connection information shall be detailed in an optical WAN drawing. The optical WAN drawing shall show all router, switch, microwave, and telco circuit elements that support and illustrate the WAN transport of information between a field location and the DOC in Pomona. Refer to ES9515 for additional information.

The Train Control Ethernet switch shall be Open System Interconnection (OSI) Layer 2 network capable, hardened, modular, fanless, and supported by both AC and DC power sources. The local area network (LAN) connections at each location shall be made using Small Form-factor Pluggable (SFP) port cards and Category 6 Ethernet port cards. Within the Layer 2 network, the LAN connections shall be made by assigning VLAN 50 to the Ethernet switch port. The WAN connection to the router shall be made by assigning VLAN 10 to the Ethernet switch port. The following LAN devices are eligible to be connected to the train control network switch:

- ATCS wayside or base radio
- Ethernet radio access point
- VHF base radio

- PTC wayside or base radio
- Wayside Message Server (WMS)
- Site power monitors for standby battery plant(s)
- Crossing event collectors
- PTC initialization access point
- Room monitor camera

Any devices other than listed those above shall be approved by the SCRRA Director, PTC, C&S Systems, or Designate prior to making a connection into the train control network. All devices intended to be connected to the train control network shall be submitted to the SCRRA PTC C&S Systems group to receive IP address assignments.

20.6.3 Physical Design

The design consultant shall use a 72-strand loose tube outdoor dielectric single-mode fiber cable for backhaul networks. This cable shall meet the TIA 492CAAB OS2 standard, contain water blocking material, and have a minimum pull strength of 600 lbs. This cable shall be installed along the SCRRA right of way (ROW) and include an embedded trace wire for cable locating purposes.

Fiber networks shall be designed and terminated in a consistent manner following the railroad west and railroad east orientation of a subdivision’s line plan or track charts. Fiber distribution termination panels shall be arranged using a mirror image about the center of the equipment to terminate fiber in the railroad west and railroad east directions. This arrangement, in order to accommodate a 72-strand fiber cable, requires a 4-rack unit (RU) panel capable of 144 fiber connections. Fiber distribution panels shall use SC duplex style connectors. Terminations in numerical order shall be made following the standard TIA-598-C color code for fiber strand assignments. Patch cables shall be of the same type of fiber as the backbone cable. Refer to ES9510 for additional information.

When creating the physical ring, the same number of fibers used to create the ring shall be allocated as spare fibers. These spare fibers shall be terminated in the same way as the active fibers, so patch cables can be relocated quickly without requiring additional fiber splices. At the extreme ends of the fiber cable and/or network ring, all fibers shall be terminated to allow for power meter or optical time-domain reflectometer (OTDR) test visibility.

The physical fiber termination drawing shall detail fiber type, fiber strand number, splices, underground splice enclosures, terminations, and active connections. The design consultant shall ensure that the physical fiber diagram connections are consistent with the optical WAN logical diagram. When modifying an existing ring, the design consultant shall consider the existing physical connections of the ring (fiber strand assignments) and provide a connection scheme that is consistent for ease of maintenance. For new or expansion fiber network rings, the connections shall follow the physical geography of the wayside locations using the same fiber pair (for example, fiber strands 1 and 2 with spare fiber strands 3 and 4) from railroad west to railroad east. A second fiber pair (for example, fiber strands 5 and 6 with spare fiber strands 7 and 8) will close the ring with a connecting link at each extreme geographic end. This standard approach can be balanced with consideration of design tradeoffs for location adjustment and optics selection. For example, although a fiber cable may terminate at a control point as the last geographic location, the design consultant may want to terminate all fibers at the closest non-vital communications shelter for communications personnel access and ease of testing rather than within the vital control point. Refer to ES9610 for more information.

20.6.4 Location Design and Deployment

Fiber network design shall include the following characteristics:

- Logical Network Diagram: The logical network diagram shall detail the arrangement of the fiber ring and identify the locations connected to each other. At the contract bid stage, sensitive information such as IP addressing shall not be identified. After bid award and during design support during construction, this information shall be coordinated with SCRRA and added to the as-built documentation for SCRRA use.
- Physical Fiber Diagram: The physical fiber shall be detailed to identify all cable types, locations, fiber distribution cards, fusion splices, underground fiber splice enclosures, and fiber segment assignments from railroad west to railroad east.
- Site Overview: The site overview shall detail fiber pull box information, cable types, cable slack and support, fiber splice enclosure, and innerduct requirements.
- Shelter Layout: The communications shelter layout shall identify the rack that houses the fiber network equipment.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources, and breaker sizes. The train control switch shall be supported by DC power with battery backup of 24 hours standby time.
- Equipment Rack Layout: Fiber equipment rack detail shall be provided to show equipment spacing, cable management, power, shelving, and total rack unit (RU) space requirements.

Fiber network deployment shall include the following tests and verification:

- OTDR and power meter measurements taken bidirectionally at 1310nm and 1550nm
- Ethernet switch port verification (all ports)
- Optical link data
- Ring failover

20.6.5 Outside Plant Infrastructure

Fiber cable slack is important to support future adds, drops and repairs when unintentional damage occurs within the fiber system. Fiber optic cable shall be installed with pull box spacing that does not exceed 1500 feet. Every pull box that contains fiber shall have a 150 feet cable service loop installed. When fiber splice enclosures are necessary, all fiber optic cables that are spliced shall have 75 feet cable service loops within the pull box. This shall enable removal of the underground fiber splice enclosure to facilitate future splicing within the Right of Way. Fiber optic cable shall be labeled in accordance with ES 9645.

When a location requires access to the 72-strand fiber optic cable, it shall be made via an underground splice enclosure of a 24-strand fiber lateral cable within innerduct for each buffer tube that requires access. Lateral conduit shall be 4-inch schedule 40 PVC, with a minimum of 3 innerducts installed for future use. Within the lateral fiber cable, the blue buffer tube shall be used for railroad west link connections and the orange buffer tube shall be used for railroad east link connections.

Fiber optic cable markers facilitate access and identification during the long-term maintenance of the cable. These markers provide important visual landmarks to determine fiber placement for emergency repairs and future improvements. All new fiber cable installed shall include the placement of fiber optic cable markers in accordance with ES9655.

20.7 VHF (VOICE) RADIO NETWORKS

20.7.1 Scope

The VHF band utilized by railroad operations for voice radio communications covers the frequency range of 160.215MHz – 161.565 MHz. SCRRA channel assignments utilize the narrowband with 12.5 kHz equipment bandwidth. SCRRA uses two types of carrier squelch simplex channels: a road channel and a yard channel. These channel types can be used by railroad dispatchers, locomotive engineers, conductors, maintainers, yard personnel, and wayside work groups (Employees in Charge (EICs)). Road channels are segmented by each train dispatcher's subdivision or territory and the dispatcher selects the preferred transmitting base station communication. Specific VHF radio channel assignments can be found in the latest version of the timetable.

The wireless VHF network is the primary voice network, covered by redundant base stations. VHF base radio locations are connected to fiber or microwave backhaul networks when possible. For remote base radio locations, a telco circuit shall be provided. The design consultant shall consider VHF coverage when the SCRRA system expands to determine if additional base stations are required.

20.7.2 Coverage

In order for a new Right of Way to be added to the VHF radio network, it shall receive full radio coverage, with an availability of at least 99 percent, from a minimum of two Base Station sites. At time of design this shall be simulated for radio frequency (RF) predicted area of coverage to the locomotive antenna and to the roadway worker / maintainer portable radio. For simulation purposes, the portable radio antenna gain shall be -11.3dB at a height of five (5) feet. Terrain data will have a minimum of 30m resolution. Within tunnels, the design consultant shall use a distributed antenna system comprised of radiating cable and low-profile antennas.

20.7.3 Licensing

The VHF band utilized by SCRRA railroad operations is regulated by the Federal Communications Commission (FCC). The Association of American Railroads (AAR) issues sub-licenses to the individual railroads that use voice radio. In applying for a license, certain information shall be provided by the designer to SCRRA's Communications Licensing Coordinator (CLC). The Height Above Average Terrain (HAAT) shall be calculated, as it helps in determining the range in broadcasts and can be subject to power restrictions. Using HAAT, Effective Radiated Power (ERP), and antenna gain, the designer shall determine the maximum power for the license application.

20.7.4 Design and Deployment

Voice radio design shall include the following characteristics:

- Site Overview: The site overview shall detail tower type, placement, grounding, GPS coordinates, and supporting telco circuit (when applicable). Antenna information shall detail type, height, azimuth (if antenna is directional), and standoff bracket. Antenna cable configurations shall be described to capture the necessary cable types, diameters, grounding, and connection points. Voice radio cables shall utilize ½ inch coaxial cable when cable length is less than 100 feet. Otherwise 7/8-inch coaxial cable shall be used.
- Shelter Layout: The communications shelter layout shall identify the rack that houses the VHF radio equipment.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources and breaker sizes. VHF radio shall be supported by DC power with battery backup of 24 hours standby time.
- Equipment Rack Layout: VHF equipment rack detail shall be provided to show equipment spacing, cable management, power, shelving, and total rack unit (RU) space requirements.

Voice radio deployment shall include the following tests and verification:

- Grounding
- Hardware performance under power failure
- Voltage Standing Wave Ratio (VSWR) test measuring impedance match of transmission line to antenna (reflected power)
- Back office testing of controls and indications
- RSSI Measurements via drive tests representing coverage to each base station

20.8 TRAIN CONTROL SYSTEM (ATCS RADIO)

20.8.1 Scope

Advanced Train Control System (ATCS) radio is a data radio network that operates in subdivisions where Centralized Traffic Control (CTC) is active. The primary user of the ATCS radio system is the train dispatcher via the Train Management Dispatch System (TMDS). ATCS radio is a secondary system to improve network availability for train movements, which are a mission critical function of SCRRA. Data transport is based on ATCS Spec 200, which supports train control system messages (control, indication, recheck, and switch status) between Control Points and Base Stations. The data radio system uses a pair of Multiple-Address-System frequencies in the 900MHz band for full duplex operation. Although the ATCS network is non-vital (not required for the safe movement of trains), ATCS reliability directly impacts on-time performance. Therefore, a primary (backhaul) network and secondary (RF) network shall simultaneously remain active.

The system redundancy of ATCS radio is arranged to become the primary operating network when fiber, ethernet radio, or microwave (backhaul) networks are impacted as scheduled downtime. This is an approach that can be utilized during construction phasing, upon review and approval of SCRRA. The ATCS radio network may also become the primary operating network for a Control Point when it becomes physically isolated due to theft, vandalism, or equipment failure (unscheduled downtime).

The design consultant shall evaluate ATCS coverage for new Control Point (CP) locations. In areas of SCRRA system expansion, the design consultant shall simulate coverage to determine if additional ATCS base stations are required.

20.8.2 Coverage

In order for a CP to be added to the ATCS data radio network, it shall receive full radio coverage, with an availability of at least 99 percent, from a minimum of two Base Station sites. At time of design, this shall be simulated for radio frequency (RF) predicted area of coverage, using 20dB fade margin to wayside CPs. Terrain data shall have a minimum resolution of 30 meters in the simulation. If a CP cannot be covered by two Base Station sites, a leased telephone circuit shall be used as an active standby system to the data radio link, requiring the use of an ATCS communications controller.

In areas of SCRRA system expansion, Base Station locations shall be selected by balancing CP coverage objectives with the impact of RF network collisions. ATCS radio utilizes a contention-based protocol which allows many users (Control Points) to use the same radio channel without pre-coordination. Although higher elevation (mountain top) Base Station sites can increase coverage and require fewer overall sites within the system, the increasing number of RF network collisions will decrease efficiency. This effect on the ATCS radio system has been referred to as experiencing “slow codes”. A higher number of lower elevation (wayside) Base Stations with overlapping coverage is preferred by SCRRA.

20.8.3 Licensing

ATCS radio utilizes licensed spectrum that is regulated by the Federal Communications Commission (FCC). The Association of American Railroads (AAR) holds a single geographic area license with six (6) 900MHz channel pairs, as a seventy (70) mile zone or “ribbon” on either side of rights of way of all operating rail lines in the United States. The AAR issues sub-licenses to the individual railroads that use ATCS.

Channel Number	Base to Mobile Frequency (MHz)	Mobile to Base Frequency (MHz)
1	935.8875	896.8875
2	935.9375	896.9375
3	935.9875	896.9875
4	936.8875	897.8875
5	936.9375	897.9375
6	936.9875	897.9875

Metrolink uses Channel Number 3. In applying for a license, certain information shall be provided by the designer to SCRRA's Communications Licensing Coordinator (CLC). The Height Above Average Terrain (HAAT) shall be calculated, as it helps in determining the range in broadcasts and can be subject to power restrictions. Using HAAT, Effective Radiated Power (ERP), and antenna gain, the designer shall determine the maximum power for the license application.

20.8.4 Design and Deployment

ATCS radio design shall include the following characteristics:

- Site Overview: The site overview shall detail tower type, placement, grounding, GPS coordinates, and supporting telco circuit (when applicable). Control Points shall utilize tilt down towers of 40 feet or 60 feet. Antenna information shall detail type, height, azimuth (if antenna is directional), and standoff bracket. Antenna cable configurations shall be described to capture the necessary cable types, diameters, grounding, and connection points. ATCS radio cables shall utilize ½ inch coaxial cable when cable length is less than 100 feet. Otherwise 7/8-inch coaxial cable shall be used. When a tilt down tower is used, a cable disconnect shall be installed within the tilt down access port. Tilt down tower when lowered shall not foul the track.
- Shelter Layout: The communications shelter layout shall identify the rack that houses the ATCS radio equipment.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources, and breaker sizes. ATCS radio shall be supported by DC power with battery backup of 24 hours standby time.
- Equipment Rack Layout: ATCS equipment rack detail shall be provided to show equipment spacing, cable management, power, shelving, and total rack unit (RU) space requirements.

ATCS radio deployment shall include the following tests and verification:

- Grounding
- Poll ID assignment
- Hardware performance under power failure
- Voltage Standing Wave Ratio (VSWR) test measuring impedance match of transmission line to antenna (reflected power)

- Back office testing of controls and indications
- RSSI Measurements representing coverage to each base stations and total number of base stations providing coverage
- Failover from fiber transport to RF transport

20.9 ETHERNET RADIO NETWORK

20.9.1 Scope

In areas of SCRRA operation where fiber is not available, wireless Ethernet radio access points can be placed at the edge of a fiber network or within a microwave network where a communications shelter is available. At isolated Control Points, Ethernet radio subscriber nodes can form point to point connections to the access points, providing the last mile connection for ATCS radio communications. In these scenarios, Ethernet radio is the primary network that serves the Control Point backhaul. The secondary network would be the ATCS RF network.

20.9.2 Coverage

The wireless Ethernet radio shall utilize direct sequence spread spectrum modulation operating in the Industrial Scientific and Medical (ISM) 900MHz band from 902MHz to 928MHz. The radio shall be capable of synchronized RF transmissions for co-located radios. The radio shall also be configurable for different transmit and receive frequency assignments.

At time of design this shall be simulated for radio frequency (RF) predicted area of coverage, using 20dB fade margin to wayside Control Points. Terrain data shall have a minimum resolution of 30 meters in the simulation.

20.9.3 Path Surveys

The design consultant shall verify that the Ethernet radio design has optical Line of Sight (LOS). LOS exists when there is a direct path between two separate points and no obstructions (buildings, trees, hills or mountains) between them. In addition, the first Fresnel Zone shall be clear of all obstructions. The path shall be evaluated whether additional clearance is required to protect against the future growth of buildings and trees.

The design consultant shall conduct path surveys after the 10 percent concept design phase. These surveys shall be completed through means to confirm the LOS is not obstructed for the intended link. Survey reports shall be submitted including photos, description of path, and path profile with existing obstruction heights.

20.9.4 Licensing

Ethernet radio uses unlicensed spectrum. The design shall follow the manufacturer’s guidelines for power. The design consultant shall complete an RF interference study to recommend optimal channel assignments.

20.9.5 Design and Deployment

Ethernet radio design shall include the following characteristics:

- Site Overview: The site overview shall detail tower type, placement, grounding, GPS coordinates, and supporting telco circuit (when applicable). Control Points shall utilize tilt down towers of 40 feet or 60 feet. Antenna information shall detail type, height, azimuth (if antenna is directional), and standoff bracket. To keep the Fresnel Zone clear, do not mount other antenna or protrusion closer than 5 feet vertically. Antenna cable configurations shall be described to capture the necessary cable types, diameters, grounding, and connection points. Ethernet radio cables shall be outdoor ultraviolet (UV) rated. When a tilt down tower is used, a cable disconnect shall be installed within the tilt down access port. Tilt down tower when lowered shall not foul the track.
- Shelter Layout: The communications shelter layout shall identify the rack or wall detail that houses the Ethernet radio equipment.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources and breaker sizes. Ethernet radio access points shall be supported by DC power with battery backup of 24 hours standby time. Ethernet radio subscribers shall have redundant system and PoE power supplies when 48V DC battery plants are not available.
- Equipment Rack Layout: Ethernet radio equipment rack detail shall be provided to show equipment spacing, cable management, power, shelving and total rack unit (RU) space requirements.

Ethernet radio deployment shall include the following tests and verification:

- Surge protection
- Hardware performance under power failure
- Voltage Standing Wave Ratio (VSWR) test measuring impedance match of transmission line to antenna (reflected power)
- Back office testing of controls and indications
- RSSI Measurements representing coverage to each base stations and total number of base stations providing coverage
- Failover from Ethernet radio transport to RF transport

20.10 GRADE CROSSING SYSTEM DATA COLLECTION NETWORK

20.10.1 Scope

Grade crossing locations contain an event recorder as an independent monitor of events for use in cases of incident and accident investigation. This information is locally recorded and can be retrieved locally. The grade crossing systems data collection network (Crossing Controller Network) is an overlay system that can transmit this event recorder information to surrounding communications shelters to be relayed to the Dispatch Operations Center via the backhaul network.

20.10.2 Coverage

At time of design this shall be simulated for radio frequency (RF) predicted area of coverage, using 20dB fade margin to wayside control points. Terrain data shall have a minimum resolution of 30 meters in the simulation.

20.10.3 Licensing

The VHF band utilized by railroad operations are regulated by the Federal Communications Commission (FCC). The AAR issues sub-licenses to the individual railroads that use voice radio. In applying for a license, certain information shall be provided by the designer to SCRRA's Communications Licensing Coordinator (CLC). The Height Above Average Terrain (HAAT) shall be calculated, as it helps in determining the range in broadcasts and can be subject to power restrictions. Using HAAT, Effective Radiated Power (ERP), and antenna gain, the designer shall determine the maximum power for the license application.

20.10.4 Design and Deployment

Crossing collector design shall include the following characteristics:

- Site Overview: The site overview shall detail tower type, placement, grounding, GPS coordinates, and supporting telco circuit (when applicable). Crossing locations shall utilize a pipe mast attached to the crossing enclosure. Antenna information shall detail type, height, and azimuth (if antenna is directional). Antenna cable configurations shall be described to capture the necessary cable types, diameters, grounding, and connection points.
- Shelter Layout: The communications shelter layout shall identify the rack or wall detail that houses the Crossing Collector equipment.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources and breaker sizes. Crossing collector equipment shall be supported by DC power with battery backup of 24 hours standby time.
- Equipment Rack Layout: Crossing collector equipment rack detail shall be provided to show equipment spacing, cable management, power, shelving and total rack unit (RU) space requirements.

Crossing collector radio deployment shall include the following tests and verification:

- Grounding
- Hardware performance under power failure
- Voltage Standing Wave Ratio (VSWR) test measuring impedance match of transmission line to antenna (reflected power)
- Back office testing of event recorder information for crossing location

20.11 LEASED MPLS AND ROUTER REQUIREMENTS

20.11.1 Scope

SCRRA prefers to utilize agency owned network infrastructure as much as possible in order to reduce its recurring operating costs. At select strategic network locations where approved by SCRRA, leased MPLS is added to increase the availability of the overall network. MPLS is typically a tertiary level of standby network for SCRRA.

A network router is installed at each communications shelter to provide an Open System Interconnection (OSI) Layer 3 element to segment (via subnet) the following networks:

- Train Control
- Customer Information Systems
- Ticket Vending Devices

20.11.2 Planning

The designer shall coordinate the MPLS circuit with the SCRRA Communications MPLS Coordinator. This is a long lead item that shall be defined and coordinated with the provider prior to release of issue for construction documents.

20.11.3 Design and Deployment

MPLS and router design shall include the following characteristics:

- Site Overview: The site overview shall detail where the lessor demarcation point is located. Design consultant shall construct dedicated conduit to the demarcation point and place a dedicated pull box near the communications shelter in order for the lessor to complete installation.
- Shelter Layout: The communications shelter layout shall identify the rack that houses the router equipment. MPLS leased equipment shall be placed on the communications shelter backboard.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources and breaker sizes. Router equipment shall be supported by DC power with battery backup of 24 hours standby time or via AC power connected to a DC inverter. The router is sensitive to power glitches and will reboot. The design shall take steps to minimize this.
- Equipment Rack Layout: Router equipment rack detail shall be provided to show equipment spacing, cable management, power, shelving and total rack unit (RU) space requirements.

Router and MPLS deployment shall include the following tests and verification:

- Router hardware performance under power failure
- Back office testing of all subnets and ability to see all devices on the network
- Failover testing to MPLS network

20.12 PRIMARY AND STANDBY POWER REQUIREMENTS

20.12.1 Scope

Power reliability is fundamental to SCRRA's ability to maintain a highly available network. Primary power and standby power are required within each communications shelter. Minimum standby power times are determined relative to the accessibility to each location. Standby power systems shall be sized based on operating load calculations for the communications location. For wayside locations that are easily accessible, standby power shall operate the location for a minimum of 24 hours in the event of primary power loss. For remote locations, standby power shall operate the location for a minimum of 72 hours in the event of primary power loss.

SCRRA communications shelters use a single phase 100A 240V/120V electrical meter service as primary power. SCRRA Standby power utilizes DC voltage battery plants of 48V, 24V and 12V. All standby power systems shall be monitored and have the ability to send alarm notifications to the Dispatch Operations Center (DOC). In strategic and/or remote network locations, such as mountain top base station locations, a standby generator may be required in addition to DC battery plants.

20.12.2 Planning and Permitting

When placing a communications shelter at a new location, the design consultant shall coordinate the electrical meter service with the SCRRA Communications Coordinator. This is a long lead activity that shall be defined and coordinated with the utility provider prior to release of issue for construction documents.

Standby generators whose internal combustion engines are greater than 50 brake horsepower (bhp) or gas turbines greater than 2,975,000 British thermal units (Btu) per hour are required to obtain a Permit to Construct (PC) from the South Coast Air Quality Management District (SCAQMD) prior to the installation of the engines at a site. SCAQMD considers an emergency backup generator as one that does not operate more than 200 hours a year and is only operated in the event of an emergency power failure or for routine testing and maintenance. A PC is required for new or relocated equipment as well as alteration of existing equipment. The SCAQMD has certified certain models/families of equipment meeting all applicable air quality requirements. A list of these certified dealers/distributors is available on their website.

Once a piece of equipment is installed, modified and/or operated SCAQMD processes the application for a Permit to Operate (PO).

20.12.3 DC Battery Plants

DC battery plants shall use Valve Regulated Lead Acid (VRLA) batteries configured in plants to provide 48V, 24V or 12V, depending on the equipment needs within the communications shelter. The VRLA battery shall contain an absorbent glass mat (AGM) containing the electrolyte to allow for plant arrangement in any orientation. Within the communications shelter, battery plants shall be placed along the walls of the shelter while providing sufficient walk space for maintenance personnel. The impact of battery plant weight and load distribution shall be considered when placing plants in existing shelters and during foundation design stage of new shelters.

20.12.4 Design and Deployment

Primary and standby power design shall include the following characteristics:

- Site Overview: The site overview shall detail where the power demarcation point is located. Designer shall construct dedicated conduit to the demarcation point and place a dedicated pull box near the communications shelter in order for the power provider to complete installation.
- Shelter Layout: The communications shelter layout shall identify the rack that houses the power systems equipment. Plans shall detail a panel schedule and load calculations. Battery plant placement shall account for walk and work space.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources, breaker sizes, power monitoring and alarms. Battery plant total ampere hours shall be indicated on the design plans. New battery plants shall be designed to support a 25 percent future load in addition to anticipated equipment loads.
- Equipment Rack Layout: Router equipment rack detail shall be provided to show equipment spacing, floor space and total rack unit (RU) space requirements.

Primary and standby power deployment shall include the following tests and verification:

- Power failure demonstration and battery cell standby capacity after 1 hour

20.13 COMMUNICATIONS SYSTEMS CONDUIT AND PULL BOX REQUIREMENTS

20.13.1 Scope

Communications system conduit and pull boxes support and protect the backhaul communications infrastructure in essential ways. Selection and placement of conduit and pull boxes can have significant impact on existing and future system requirements and ease of maintenance.

20.13.2 Planning

SCRRA does not allow direct burial installation of any communications cable. All cable shall be installed in PVC or HDPE conduit. All conduit shall be installed at a minimum depth of 36 inches. PVC conduit shall be schedule 40 when placed adjacent to track and schedule 80 when placed under track. All conduit shall remain clear of Zone 1 with exception to conduit crossing underneath the tracks when necessary.

SCRRA prefers separate 4’x4’x4’ pull boxes for communications cable isolated from signal cable when feasible. This decision shall be made in context of the project scope, funding and available room for pull box placement and installation. When conduit crosses tracks or roadways, a pull box shall be placed on either side. All pull boxes shall have H20 traffic rated lids to allow Right of Way (ROW) maintenance vehicles to drive over them without causing damage.

Analysis of the project scope may provide cost savings for the installation of duct bank conduit in one shared trench for multiple systems. These systems can include non-vital fiber, vital fiber, and grade crossing express cable.

In greenfield SCRRA expansion projects or more remote areas there may be a cost advantage to plowing in HDPE conduit in conjunction with other construction activities.

20.13.3 Design and Deployment

Conduit and pull box design shall include the following characteristics:

- Site Overview: Within location plans, the site overview shall detail all required pull boxes, and conduit. The designer shall make clear anticipated distances, conduit sizes, and quantity of conduit
- Conduit and pull box placement shall be coordinated on the civil plans with the civil designer

20.14 PASSENGER STATION COMMUNICATIONS INFRASTRUCTURE

20.14.1 Scope

Passenger stations require a communications infrastructure to properly support ticket vending, passenger communications, fiber optic systems, and security. Passenger stations are an area that require interdisciplinary coordination to achieve a well-designed layout for maintenance, future expansion and public use.

20.14.2 Station Communications Shelter

A 10’x20’ dual tenant station pre-fabricated communications shelter shall be included in all new stations. The tenant side (10’x7’) of the shelter is reserved for use of the city/county owner of the station and the SCRRA side of the shelter is 10’x13’. The dual tenant shelter shall have separate AC breaker panels so that utility power can be divided between city/county paid use and SCRRA paid use. The dual tenant shelter shall be divided by a chain link fence and shares overhead cable ladder between the areas. Each tenant side has a floor void for underground conduit entry, a waveguide entry and a backboard for Main Point of Entry (MPOE) circuits. There are two HVAC units that are powered and controlled by SCRRA. The design consultant shall include the following items in the communications shelter:

- Air conditioner thermostat
- High temperature alarm thermostat
- Low temperature alarm thermostat
- Emergency exit sign with light
- Magnetic door alarm switch
- Smoke detector
- Exterior light fixture with photocell
- Eyewash station
- First aid kit
- Fire extinguisher

- Telecommunications main ground busbar (TMGB)
- Plywood backboard(s) painted white
- 30A (L14-30P) exterior generator receptacle weatherproof cover
- Door security bars
- Waveguide windows
- Room monitor camera system

At a minimum, the shelter shall utilize a 200A meter service with two (2) 100A load centers (120V/240V). Final load calculations shall determine supplied service amperage. The design consultant shall include panel schedule information.

The shelter foundation shall be a full concrete pad with voids for the underground conduit entry. The full foundation pad shall be designed to support the weight of heavy standby battery plants.

Within the communications shelter, two (2) post 90-inch high equipment racks shall be used. Four (4) post racks and racks with vertical cable management shall not be used in order to maximize space for future growth. In addition, no electrical conduit and junction boxes shall be installed on the vertical channels of the racks. These items may facilitate a short-term purpose but they fail to use the available space efficiently, reducing walkways, working space and overall rack placement.

The station communications shelter requires a conduit connection for communications data transport to the following equipment on the station platform:

- Ticket vending devices
- LED message signs
- LED monitors
- Video surveillance cameras
- Emergency management panel (EMP)
- Public address speakers

The station communications shelter requires a conduit connection for power for the following equipment:

- LED message signs
- Video security cameras
- Public address speakers

The following equipment shall be powered from the station electrical panel rather than the communication shelter:

- Platform lighting and photosensors
- Platform irrigation when applicable
- Ticket vending devices

- LED monitors

20.14.3 Station Customer Information Systems (CIS)

Station CIS consists of LED message signs, speakers for public address, ticket vending devices (TVDs), LED monitors and an emergency management panel (EMP).

Typical LED message sign placement is in a back to back configuration on a light pole. The sign closest to the communications shelter shall determine the designation of sign 1. LED message signs are connected with multimode fiber to the first sign and serially via an RS422 daisy chain thereafter. All signs shall be placed to meet ADA requirements for passengers and at heights to reduce the chance of vandalism.

TVDs and LED monitors are collocated to provide ticket purchasing passengers with train schedule information. This equipment shall be installed facing north when possible and placed under a canopy to shield direct light and provide improved visibility.

Within the communications shelter, a CIS ethernet switch shall be designated to connect all equipment. This switch will connect to the backhaul router for communication with the Dispatch Operations Center (DOC) and CIS support personnel. A CIS controller computer shall be installed to provide message and audio information from the head end system located at the DOC.

Twelve (12) strand multimode fiber cables shall route to the TVDs, LED monitors, and first LED message sign on each platform. Each fiber cable shall terminate on a fiber distribution panel. A modular media converter chassis shall hold multiple point to point media converters to translate from fiber to Category 6 Ethernet cable.

An uninterruptible power supply (UPS) shall be installed to provide power to each platform's string of LED message signs and CIS equipment. Controllable AC power strips shall connect to the UPS and support the power cycle of individual receptacles for remote troubleshooting.

20.14.4 Design and Deployment

The communications shelter and CIS systems shall include the following characteristics:

- Site Overview: Within location plans, the site overview shall detail station platform layout and systems equipment placement. All platform light poles shall be labeled and assigned a number for system reference and maintenance. Symbols for LED signs, speakers, TVDs, EMP and LED monitor shall indicate placement for installation and bidding purposes.
- Station platform conduit and pull box placement shall be coordinated on the civil plans with the civil designer. Equipment placements and those that require city electrical power shall be coordinated with the station electrical designer.
- Shelter Layout: The communications shelter layout shall identify the rack that houses the CIS equipment. Plans shall detail a panel schedule and load calculations. Battery plant placement shall account for walking and working space.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources, breaker sizes, power monitoring and alarms.

- Equipment Rack Layout: CIS equipment rack detail shall be provided to show equipment spacing, floor space and total rack unit (RU) space requirements.
- Light pole and canopy placement shall be coordinated on the civil plans with the civil designer and special consideration shall be made for the loading of the CIS equipment on these structures.

CIS deployment shall include the following tests and verification:

- Demonstration of test messages to LED signs, LED monitors, EMP, TVDs and Public Address Speakers.

20.15 VIDEO SURVEILLANCE SYSTEMS (VSS)

20.15.1 Scope

Video surveillance systems are required to improve security at SCRRA passenger stations and other facilities. Although these systems are not mission critical infrastructure for operations, they have importance in preventing theft and vandalism that impact mission critical systems.

20.15.2 Planning

Video Surveillance Systems consist of the following equipment:

- Cameras
- VSS Ethernet switch capable of power over Ethernet (PoE)
- Uninterruptible power supply
- Network Video Recorder
- Category 6 patch panels
- Fiber patch panels

At passenger stations, cameras shall be placed at TVDs and distributed along the platform to provide remote security visibility. Mounting of equipment shall be on light poles and canopies, based on conduit access and optimum visibility. Power over Ethernet (PoE) extender equipment may be installed in small NEMA 4X boxes collocated on the light poles.

20.15.3 Design and Deployment

VSS design shall include the following characteristics:

- Site Overview: Within location plans, the site overview shall detail station platform layout and camera equipment placement. All light poles and canopies shall be labeled and assigned a number for reference. Symbols for VSS cameras shall indicate placement for installation, bidding and maintenance purposes.
- Shelter Layout: The communications shelter layout shall identify the rack that houses the VSS equipment.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources and breaker sizes.

- Equipment Rack Layout: VSS equipment rack detail shall be provided to show equipment spacing, floor space and total rack unit (RU) space requirements.
- Conduit and pull box placement shall be coordinated on the civil plans with the civil designer.
- Light pole and canopy placement shall be coordinated on the civil plans with the civil designer and special consideration shall be made for the loading of the VSS equipment on these structures.

VSS deployment shall include the following tests and verification:

- Demonstration of video at Security Operations Center (SOC).

20.16 TICKET VENDING DEVICE (TVD) SYSTEMS

20.16.1 Scope

Ticket vending devices provide revenue recovery for SCRRA. These systems shall be designed to have high availability as a part of SCRRA's fiscal responsibility.

20.16.2 Planning

TVD Systems consist of the following equipment:

- Ticket vending cabinet
- Media converter
- Fiber patch panel
- TVD switch

20.16.3 Design and Deployment

TVD systems design shall be limited to the following:

- Site Overview: Within location plans, the site overview shall detail station platform layout and TVD equipment placement.
- TVD conduit and pull box placement shall be coordinated on the civil plans with the civil designer.
- Shelter Layout: The communications shelter layout shall identify the rack that houses the TVD systems equipment.
- Circuit Schematic: The circuit schematic shall detail connections, cable types, power sources and breaker sizes.
- Equipment Rack Layout: TVD equipment rack detail shall be provided to show equipment spacing and total rack unit (RU) space requirements.

21.0 WAYSIDE SIGNALS

21.1 SCOPE

The consultant providing design services for SCRRA operated and maintained property shall specify equipment and applications that not only provide optimum safety but shall also maximize the operational efficiency and reliability of the shared commuter/freight rail system. The design shall incorporate methodologies, applications and equipment that have been proven to be reliable, durable and effective on SCRRA properties or similar commuter/freight rail environments and that are currently accepted by SCRRA. The introduction of new materials, which require an inventory of additional spare parts, additional training and/or instructions must be approved by the SCRRA Director, PTC, C&S Systems, or Designate, herein referred to as SCRRA.

Any proposed designs shall incorporate features that aid signal personnel in the inspection, testing, repair, and overall maintenance of the system. As much as is practical within the scope of a project, equipment to be installed shall be scalable for future expansion, and the signal enclosures shall be sized accordingly. Application logic software shall be fail-safe and conform to all applicable regulatory rules and regulations and be designed simple in form to be easily understood by personnel responsible for the maintenance and care of the system. Where these criteria refer to system logic and design criteria using vital relays, the same logic shall be applied to solid-state electronic interlocking application programs.

All designs shall adhere to the rules and regulations contained in 49 CFR 234, 235, and 236. Signal designs shall incorporate the rules and instructions as contained in the most current issue of the California Public Utilities Commission General Orders, General Code of Operating Rules (GCOR), Maintenance of Way Operating Rules (MOWOR), Metrolink General Orders, Timetable and Special Instructions and AREMA Communications & Signals Manual of Recommended Practices. Where the AREMA manual is used, “may” and “should” are to be interpreted as “shall” unless in conflict with these standards or otherwise directed by SCRRA. Note that the SCRRA General Orders, Timetable, and Special Instructions supersede GCOR and MOWOR where they conflict.

The project site must be assessed for climate vulnerability (see Section 3.3) to ensure any work is designed to be resilient to future climate conditions. If the site is vulnerable to flooding all signaling systems must be elevated out of likely flood exposure and/or provided with watertight sealing of ducts, conduits or other penetrations.

The designer is advised that wayside signaling systems, crossing warning systems, communication systems and positive train control (PTC) systems are present on the SCRRA tracks and right-of-way. Any modifications to the wayside signaling system must consider and mitigate impacts to these other systems. Please refer to the following Design Criteria Manual Sections for related information;

- Section 20.0, Communications Systems
- Section 22.0, Positive Train Control (PTC)

- Section 33.0, Grade Crossing Signals.

21.2 POSITIVE TRAIN CONTROL (PTC) CONFIGURATION MANAGEMENT

All wayside signal equipment, programs, devices and components are critical features necessary to the safe and efficient operation of SCRRA's Positive Train Control System. Any changes being proposed to wayside systems are subject to SCRRA's Change Configuration Management policy and procedures. Consultants providing signal design services are required to comply. Refer to SCRRA's Design Criteria Manual Section 22.4 for related requirements and direction.

21.3 NEW METHODOLOGIES, APPLICATIONS OR EQUIPMENT

Design service consultants recommending new methodologies, applications, or equipment not currently used on SCRRA properties will be required to obtain, before commencing with design efforts, approval from SCRRA. No design submittals containing new methodologies, applications, or equipment will be approved without prior consent. When proposing new equipment not currently utilized by SCRRA, the company providing design shall provide SCRRA with documentation detailing where the equipment is currently in use as well as general maintenance requirements for the equipment. Upon approval, the responsible design services consultant will be required to provide additional information to supplement SCRRA's instructions and standards. Requirements may include additions and/or revisions to, but are not limited to, the following documents:

- SCRRA Engineering Standards
- SCRRA Standard Specifications
- SCRRA Timetable
- SCRRA Instructions Governing Installation, Maintenance, Inspection, and Testing of Signal Apparatus and Signal Systems
- SCRRA Maintenance of Way Operating Rules

During construction or replacement of all critical lineside equipment and equipment cabinets, consider passive heat mitigation measures such as external shading using structures, use of vegetation, and painting cabinets with heat-reflective paint coating. Assess whether electronic design temperature thresholds for signaling electronics and signal cables are appropriate given projected climate change.

All new equipment shall be provided with an air conditioning unit. Consideration will be given to increased insulation thickness in equipment houses or cabinets to maintain temperature for longer periods.

Equipment houses and equipment cabinets shall be provided with external connection for temporary power to permit use of external generator. Monitoring of house temperature and external power shall be considered on a case-by-case basis after consultation with SCRRA.

21.4 QUALIFICATIONS OF SIGNAL DESIGN PERSONNEL

21.4.1 Qualifications of Signal Designer

Signal Designers who work on SCRRA signal circuits or programs are subject to the approval of SCRRA. The classification of Signal Designer is generic and refers to the responsible individual who produces or modifies signal circuits or programs. A company or third-party agency may classify this position as a Signal Engineer or other title.

In general, a Signal Designer shall have a minimum of five (5) years of experience designing signal systems for Class 1 freight or commuter rail systems which are governed by the FRA and adhere to the guidelines set forth in the AREMA C&S manual.

SCRRA may require that Signal Designers demonstrate their familiarity with applicable regulations, both state and federal, and their familiarity with traditional relay logic, ladder logic or Boolean logic equations. Principles of railroad signaling, including automatic block signals, centralized traffic control and interlocking system's functionality must be demonstrated to the satisfaction of SCRRA. An understanding of train operations and the interaction of the signal system is required, as well as the ability to analyze braking distances and the ability to calculate locking release times. In addition to this, the Signal Designer must have an ability to demonstrate their understanding of how the signal system interacts with grade crossing warning systems and PTC systems.

The Signal Designer may be interviewed by SCRRA or designate. The interview may require a demonstration of circuit and program analysis. The determination of qualification is at the sole discretion of SCRRA.

These requirements apply to both signal circuit and application program development, either developing new systems or modifying existing systems.

21.4.2 Qualifications of Signal Checker

The classification of Signal Checker is generic and refers to the responsible individual who performs Quality Control (QC) and safety analysis of signal designs or application programs. A company or third-party agency may classify this position as a Senior Signal Engineer or other title. In general, the Signal Checker is subject to the qualifications of a Signal Designer as described in Section 21.4.1. In addition to these qualifications, the Signal Checker must possess an additional five (5) years of experience checking signal designs and vital application programs.

The Signal Checker may be interviewed by SCRRA or designate. The interview may require a demonstration of circuit and program analysis and a demonstration of applicable checking and testing methods used in the performance of their duties. The determination of qualification is at the sole discretion of SCRRA.

21.4.3 Qualifications of Signal Test Engineer

The classification of Signal Test Engineer is generic and refers to the responsible individual who performs and directs testing and commissioning of new, or modifications to existing, signal systems. A company or third-party agency may classify this position as a Signal Test Engineer or other title. In general, the Signal Test Engineer is subject to the qualifications of the Signal Checker as described in Section 21.4.2. In addition to these qualifications, the Signal Test

Engineer must possess an additional five (5) years of experience performing and leading field-testing efforts for signal system testing and commissioning.

The Signal Test Engineer must be able to demonstrate an ability to develop, coordinate and execute field test plans. The Signal Test Engineer must possess a thorough understanding of SCRRA train operations, signal and crossing system functionality, positive train control functionality and demonstrate an ability to analyze and determine the level of testing needed to safely commission signal and crossing system modifications in a commuter rail environment.

The Signal Test Engineer may be interviewed by SCRRA or designate. The interview may require a demonstration of the candidate's ability to organize and perform in-service testing activities. The determination of qualification is at the sole discretion of SCRRA.

21.5 DESIGN CHECK REQUIREMENTS

Signal system design work shall only be completed by signal design firms authorized by SCRRA to provide such services.

To ensure the quality and integrity of SCRRA system design plans and programs, all new or modified systems shall receive a QA/QC check at each design submittal level. The check shall ensure that all designs meet the requirements of applicable regulations, recommendations and standards. All design applications shall meet or exceed the manufacturer's minimum requirements.

All authorized signal design firms shall have an established, written, procedure outlining the firm's QA/QC process. This process shall be submitted to SCRRA for review upon the request of SCRRA. Additionally, the firm performing signal design work shall store all QA/QC check plans for a minimum of three (3) years after final project submittal has been made. These project check plans shall be produced to SCRRA for review upon the request of SCRRA.

When an independent check is required, two complete plan sets, or an electronic PDF copy shall be distributed to the designated firm performing the independent check. An independent check is required when a new program is being planned or when changes to an existing program are extensive enough to warrant a complete system re-test.

21.6 SIGNAL PLAN DESIGN REQUIREMENTS

21.6.1 General

Signal computer aided drafting and design (CADD) files are living documents that must be properly maintained to ensure the integrity of the signal system. Duplicate CADD files increase the possibility of inaccurate drawings being distributed to construction or maintenance forces. Files shall not be duplicated without the authorization of the SCRRA. Drawings shall be produced utilizing Bentley MicroStation. CADD files shall be version 7 compatible in the two-dimensional format. Designers shall adhere to the format requirements indicated within this section.

Prior to beginning a design project, CADD files shall be requested from SCRRA. The design firm shall provide a general description of the project along with specific milepost limits. SCRRA shall provide current CADD files, SCRRA border files, SCRRA official cell libraries, and any pertinent typical files (example, pre-wired typical files) available. Files shall be provided to the designer electronically via email or through delivery on a compact disc or USB drive.

Upon completion of the design, the contractor shall return the CADD files to SCRRA. The designer shall also include an itemized list of the files returned. The list shall categorize files by new, modified, and deleted files. Upon completion of construction, CADD files returned to SCRRA shall be in SCRRA maintenance format, with SCRRA borders and job notes attached.

Any modifications made to SCRRA CADD files require that a job note be added to the drawing affected. No changes, regardless of size or content, shall be made without attaching a job note.

Border files shall be reference attached to the drawing files. New cells shall not be added to the SCRRA cell library without proper authorization from SCRRA. Any new cells developed with approval shall be returned to SCRRA so that they may be included within the SCRRA cell library for future distribution.

21.6.2 CADD File Coordination

There will be projects that overlap between signal design consultants where two or more firms are performing work within the same plan set. It is the sole responsibility of all design firms to coordinate their efforts between themselves and SCRRA to ensure that the final as-built plan set(s) are accurate and correctly reflect all changes and modifications performed.

Upon initial file request, it is the design consultant’s responsibility to verify with SCRRA whether the requested file is currently checked out to another firm. If the file is currently checked out, it is the requesting consultant’s responsibility to notify the other consultant of their intent to work within the same plan set. It is then the responsibility of the requesting firm, as a part of their work authorization, to present SCRRA with a coordination plan detailing how the two projects will coordinate final as-built conditions and proper plan field distribution. This plan must be approved by SCRRA before the requesting firm may begin any design work.

21.6.3 CADD Standard Deviations and Modifications

Drawings, borders, and cells shall not be scaled up or down. All design work shall be performed on grid. Signal design consultants shall adhere to these standard requirements. Deviations shall only be done with permission from SCRRA. Signal design consultant may be required to reimburse SCRRA for all costs associated with correcting plan discrepancies.

21.6.4 Filename Convention

The first two characters of the file name shall display the subdivision related to the drawing as follows in Table 21-1:

TABLE 21-1. CADD FILE SUBDIVISION NAMING

Extension	Subdivision
MO	Montalvo
OL	Olive
OR	Orange
PA	Pasadena
PV	Perris Valley

RD	Redlands
RI	River
RO	Rialto
SG	San Gabriel
SW	Short Way
VN	Ventura
VY	Valley

After the subdivision, six characters of the file name shall display either a specific milepost location or a specified area from one milepost to another. For example, 025_20 is milepost 25.20 and 043051 is milepost ranging from 43 through 51.

All CADD files shall be returned to SCRRA with the ".dgn" file extension. SCRRA uses a sub extension naming convention for further information on the file. The sub extension shall be preceded with a "_".

TABLE 21-2. CADD FILE SUB EXTENSION NAMING

Sub Extension	Description
AXX	Aspect Chart
BXX	Field Verification Drawing
CXX	Construction Drawing
LXX	Layout Drawing
MXX	Maintenance (As in service) Drawing
TXX	Temporary Drawing
CFC	Construction Front Cover
MFC	Maintenance Front Cover

File sub extension examples include the following:

- sg040_20_c09.dgn – File is for milepost 40.20 on the San Gabriel subdivision, sheet 9, containing construction work.
- ri000001_m02.dgn – File is for track and location plans within milepost 0 through 1 on the River subdivision, sheet 2, as in service.

Aspect charts contain an additional character within the file name associating direction as follows:

- vy068072e_a01.dgn – File is for an eastbound aspect chart within milepost 68 through 72 on the Valley subdivision, sheet 1.
- vy068072w_a01.dgn – File is for a westbound aspect chart within milepost 68 through 72 on the Valley subdivision, sheet 1.

21.6.5 Format Requirements

If typical CADD files are available, they shall be used as seed files for all signal CADD work. The following file format settings shall be adhered to:

- All new design files shall be single sheet, with lower left corner starting at XY=0,0 (GLOBAL ORIGIN)
- All design work shall be placed on the appropriate levels as follows:

TABLE 21-3. SIGNAL CADD FILE LEVEL USAGE

Level	Description
1	Circuits and general text notes
2	Black boxes and shapes (No fill)
3	Yellow/Grey Shapes (Filled solid)
4-7	Reserved for future
8	Wire size
9	Relay location number
10	Wire nomenclature
11	Relay qualifier
12-13	Reserved for future
14	Contact qualifier
15	Contact number
16	Crossing DOT number
17-25	Reserved for future
26	Title block
27-63	Reserved for future

- Drawing settings shall have SETTINGS SAVED as follows:
    - Levels 1-39 ON, Levels 40-63 OFF
    - Data Fields turned OFF (All views)
    - SNAP and GRID locks ON, LEVEL lock OFF
    - TX = 0.08 (Text size)
    - FT = 0 (Font)
    - Text Justification = Center Center (CC)
    - Line Spacing = 0.05
    - WT = 1 (Line Weight)
    - LV = 1 (Level)
    - AS = 1 (Active Scale)

- AA = 0 (Active Angle)
- CO = 0 (Color)
- View #1 = View of title block area
- View #5 = View of complete drawing (FIT ALL)

- The design file name shall be placed in the lower left-hand corner of the design file border and shall match the external file name.
- Crossing Street Width (Standard) = 10 grid spaces minimum
- Track = WT=7, LV=1
- Distance between Tracks = 6 grid spaces
- Circuits = WT=2, LV=1
- Black Boxes and Shapes = WT=3, LV=2
- Project Revision Information = JBNOTE cell
- All circuits shall be placed ON GRID
- Identifiers shall be placed directly above the item:
    - Street Names
    - DOT Number
    - CPUC Number
    - Engineering Stationing
    - Control Point Name
- Engineering Stationing shall be followed by an abbreviated descriptor as follows:
    - SIG = Signal
    - HB = Head Block (Powered or hand thrown)
    - DERAIL = Derail (Powered or hand thrown)
    - IJ = Insulated Joint
- The front cover sheet shall contain an index of the drawings included in the plan set. The index shall indicate the sheet number and corresponding sheet title block name. The cover sheet shall indicate the drawing set name.
- Do not DROP STATUS on cells.
- Track and Location sheets shall be drawn so that each sheet in the book could be placed side by side with all corresponding tracks, cables, and circuits lining up.

Wayside signal plans utilize a color scheme for depiction of design changes within existing or new plan sets. The use of non-colored depiction of design changes (black X's and O's) is not allowed.

Acceptable color codes are as follows:

- **Red = In** **Yellow = Out**
  - Default color scheme.
  - All new information shall be colored red.
  - All removal information shall be colored black with a yellow fill in background.
- **Green = In** **Brown = Out**
  - Color scheme to be used if “Red = In, Yellow = Out” already used.
  - All new information shall be colored green.
  - All removal information shall be colored brown.
- **Blue = In** **Gray = Out**
  - Color scheme to be used if “Red = In, Yellow = Out” and “Green = In, Brown = Out” already used.
  - All new information shall be colored blue.
  - All removal information shall be colored black with a gray fill in background.

21.6.6 Plan Set Composition

Plan set makeup shall follow a logical flow as shown in the following lists. Not all plan sets shall contain the following specific sheets or may have additional sheets based upon specific needs.

- Signal Circuit Plan – Contains multiple locations complete with signal equipment, stationing, location to location circuitry and cable
  - Cover Sheet (Index)
  - Signal Circuit Plan
- Control Point Location Plan – Contains specific location circuitry and details
  - Cover Sheet (Index)
  - Track and Location Plan
  - Aspect Sheet
  - Fiber Optic Circuit Plan
  - Communications Circuit Plan
  - Radio/Block Diagram & Code Assignments
  - Crossing Circuit Plan (If remote start crossing circuits within the location)
  - Program Options Plan (If remote start crossing circuits within the location)
  - PTC Radio Sheet
  - Track Circuit Details
  - I/O Connections
  - Lighting Circuits

- Switch Circuits
- Local Control Panel
- Local Control Panel Circuits
- Power, Battery & Alarm Circuits
- WAGO Detail
- Racks # Layout
- Comm. Equipment Rack # Layout
- Terminal Board Layout (Front)
- Terminal Board Layout (Back)
- Side A – House Layout
- Side C – House Layout
- Cable Sheet
- Conduit Plan
- Comm. Tower Details

- Intermediate Signal Location Plan – Contains specific location circuitry and details
  - Cover Sheet (Index)
  - Track and Location Plan
  - Aspect Sheet
  - Fiber Optic Circuit Plan
  - Crossing Circuit Plan (If remote start crossing circuits within the location)
  - Program Options Plan (If remote start crossing circuits within the location)
  - Electrocode Circuits
  - PTC Radio Sheet
  - Signal Lighting Circuits
  - Power & Battery Circuits
  - Racks # Layout
  - Side A – House Layout
  - Side C – House Layout
  - Cable Sheet
  - Conduit Plan
- Electric Switch Lock/Leaving Signal – Contains specific location circuitry and details
  - Cover Sheet (Index)

- Track and Location Plan
- Track and Battery Circuits (Electric Switch Lock)
- Track, Signal, and Battery Circuits (Leaving Signal)
- Case Layout
- Cable Layout
- Conduit Layout

- Aspect Charts
  - Signal aspect strings with applicable code rates
  - Charts to include braking information from SCRRA Braking Calculator
  - Charts to include relevant speed information for turnouts and tracks. This information shall be obtained from SCRRA's most current Timetable.
  - Charts shall be direction based, meaning east and west aspects over an area are shown on separate sheets.

21.6.7 Location Naming Guidelines

Crossing names shall be as listed within the Federal register. New station and control point names are subject to the approval of SCRRA's Chief Operating Officer. Existing station and control point names shall not be changed without the permission of SCRRA's Chief Operating Officer. All other system location names shall be generic in nature and refer to the location's milepost as a general locator.

21.7 SIGNAL SPACING AND SIGNAL PLACEMENT

21.7.1 Signal Spacing

It is the goal of the SCRRA to establish signal block lengths that utilize standard aspect sequences. Unconventional aspect sequences, such as consecutive approach aspects to a stop, should be considered as a last resort and adopted only with the permission of SCRRA.

Signal spacing shall consider all factors necessary to provide safe and efficient train operations. Signal blocks should be a nominal 6,000 to 8,000 feet in length except where traffic density requires shorter blocks for closer signal system headways. Under ideal circumstances, such spacing allows mixed traffic to operate with optimum headways and, combined with the use of an advanced approach aspect, provides safe braking distance for freight trains.

On projects where signal spacing or aspects strings are being affected, SCRRA may request that a signal system headway study be performed to quantify impacts to commuter operations.

21.7.2 Signal Placement

Where possible, block signals shall be placed to the right of the track governed, except back-to-back ground signals shall be placed where practical to minimize construction costs. Left-hand signals shall be placed where track centers do not accommodate right-hand placement. Bridge or cantilever signal structures shall be placed where more than two tracks must be signaled and where right-of-way (ROW) constraints will not permit placement of ground signals. Where visibility, spacing, and braking considerations allow, it is desirable to locate signals at grade crossings to minimize additional insulated joints and economize commercial power requirements.

Where practical, signals shall be placed in full view of station platforms so that the aspect displayed can be seen by the locomotive engineer when leaving the station. Doing so will eliminate the need for operating crews to comply with TIMETABLE RULE 9.9 - TRAIN DELAYED WITHIN A BLOCK as they depart the station.

Signals shall be placed and aligned to allow optimum viewing by the locomotive engineer. Where possible, signals shall be placed adjacent to tangent track. Where practical, the locomotive engineer shall be provided an unrestricted view of the signal for a minimum of 2,000 feet in advance of the signal. 2,000 feet provides over 15 seconds of preview for a 79-mph train. In lower speed territory where 2,000 feet preview is not practical, 15 seconds of preview at timetable speed will be acceptable, subject to the approval of SCRRA.

Where signals are located on curves and adjacent tracks are present, signal height should consider visibility obstructions from standing rail cars. The designer shall verify that upper and lower signal units are visible. The use of bridge or cantilever signals may be required under these circumstances.

The designer shall perform a thorough field review of proposed wayside signal locations to ensure that signals are placed in accordance with SCRRA standards and will not be obstructed by vegetation, buildings, highway overpasses, or other structures. Each location shall provide adequate space for each signal, signal enclosure, and other related apparatuses. The selected site shall provide ample walkways and access for railroad maintenance personnel.

21.7.3 Wayside Signal Devices

In general, absolute signals at control points will have two heads and automatic signals approaching control points will have two heads. Typically, all other automatic signal applications will have one head.

Signal heads shall be of color light type and comply with the with the requirements of SCRRA Engineering Standard ES 8525. Each lamp unit shall be equipped with an LED assembly as described in the AREMA C&S Manual, Part 7.1.5. Unused lamps are to be affixed with manufacturer provided blank cover plates.

Ground signals shall comply with the requirements of SCRRA Engineering Standards ES 8500, ES 8505 and ES 8506.

Cantilever and bridge structures shall be installed with a minimum clearance of 23 feet 6 inches above top of rail, unless a special design consideration is granted by SCRRA. This placement will accommodate future track elevation increases. Cantilever signal structures shall comply with the requirements of SCRRA Engineering Standard ES 8510. Bridge signal structures shall comply with the requirements of SCRRA Engineering Standard ES 8515.

Dwarf signals shall comply with the requirements of SCRRA Engineering Standard ES 8520. No portion of a dwarf signal shall be placed closer than 6 feet from centerline of any track. No portion of the dwarf signal shall be located higher than 34 inches above top of rail. (Note: Although the CPUC regulation allows placement of signal apparatus up to 36 inches above top of rail, the 2-

inch variation should accommodate settling of the track, thus ensuring compliance with the regulation).

The use of dwarf signals is restricted to areas where trains operate at slow speeds or where high-mast ground signals are not practical. Typically, dwarf signals are used only where trains enter CTC territory from non-signalized tracks. Dwarf signals are not allowed for use on main or siding tracks without the permission of SCRRA.

21.8 SAFE BRAKING AND AVERAGE GRADE CRITERIA

21.8.1 Safe Braking Criteria

The signal system will be designed for the greatest possible passenger train efficiency while accommodating freight train braking.

Both freight and passenger braking shall utilize ***SCRRA's Braking Distance Calculator*** which will be provided by SCRRA upon request. Tons Per Operative Brake (TPOB) and speeds for freight trains shall be those listed within SCRRA's Timetable Special Instructions, Rule 6.31.2 - OTHER MAXIMUM SPEEDS. Additionally, the signal design consultant shall ensure freight braking complies with any subdivision specific freight TPOB and speed restrictions. These restrictions are listed within the current SCRRA Timetable, current General Orders or Track Bulletins. It is the responsibility of the signal design consultant to verify current speeds and tonnage restrictions throughout the Timetable, Special Instructions, and current General Orders. Any discrepancies found must be immediately brought to the attention of SCRRA for resolution.

For both passenger and freight trains, it is the signal design consultant's responsibility to verify that all classes of trains operating through the area of consideration have acceptable braking distances to safely operate. If block distances being analyzed do not allow for safe braking of any class, it is the design consultant's responsibility to propose remedial actions to SCRRA that will ensure compliance.

SCRRA signal aspects and indications are listed within SCRRA's Timetable – Appendix C. It is the signal design consultant's responsibility to arrange aspect sequences so that all classes of trains can safely operate in accordance with the aspect's intended indication. Specifically, all classes of trains must be able to:

- Safely stop before passing a red aspect (stop indication).
- Safely reduce speed before arriving at a reverse turnout. Reductions must be analyzed using the reverse turnout's prescribed turnout speed, as listed in the current Timetable.
- Safely comply with signal indication's associated speeds.

Special considerations for aspect strings include, but are not limited to:

- It is SCRRA's policy to display an advance approach (Rule 9.1.7) aspect in approach to any approach (Rule 9.1.9) aspect, approach restricting (Rule 9.1.8) aspect or any approach diverging (Rule 9.1.6) aspect.
- All Restricting (Rule 9.1.13) and Restricted Proceed (Rule 9.1.14) aspects shall be analyzed and considered as stop indications in braking calculations.

- Approach Sixty (Rule 9.1.4) and Approach Fifty (Rule 9.1.5) aspects are not currently used on SCRRA property. Use of these aspects requires the approval of SCRRA.
- Advance Approach (Rule 9.1.7) aspects should not be used where the approach block is less than 2,500 feet, or where the distance from the advance approach to the stop signal provides stopping distance for less than timetable speed for all classes.
- Approach Diverging (Rule 9.1.6) aspects should only be used in advance of control points that have the same turnout speeds. Where turnout sizes vary within a control point, the Approach Restricting (Rule 9.1.8) aspect may be required approaching the lower speed turnout, and a Restricting (Rule 9.1.13) aspect be provided for the diverging move through the lower speed turnout.

Other methods or programs used for calculating braking distances may not be used without the permission of SCRRA.

The SCRRA Engineering Standards contain braking and deceleration tables for both passenger and freight. These are provided as examples only and should not be considered in lieu of results obtained using the SCRRA Braking Distance Calculator.

21.8.2 Average Grade Criteria

The average grade shall be calculated for all signal blocks and the 1,000-foot and 6,000-foot approach distance to the signal being analyzed. This information is then entered in the ***SCRRA Braking Distance Calculator*** where it is used to determine safe braking distances.

The grades and distances used to determine average block grades shall be the information shown within SCRRA's current ***Composite Map Plan and Profile*** charts. SCRRA has compiled these charts for each of its subdivisions where commuter trains operate. For subdivisions where there are no Composite Map Plan and Profile charts, the signal design consultant shall use SCRRA's applicable track charts. These books will be provided to the signal design consultant upon request.

The formula for determining average grade is:

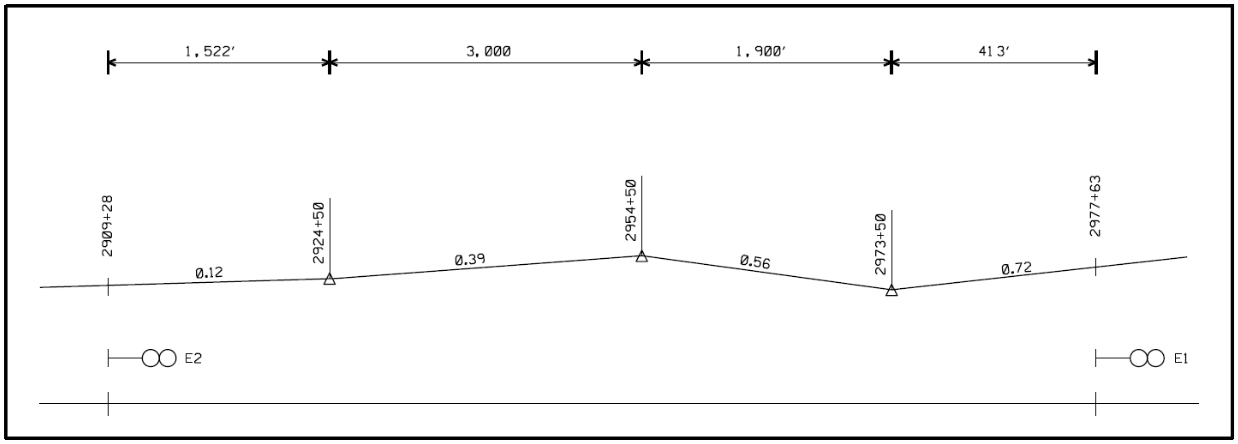
$$AG = \frac{(D1 \times G1) + (D2 \times G2) + (D3 \times G3) + (D4 \times G4)}{(D1 + D2 + D3 + D4)}$$

Where: AG = Average Grade

D = Distance

G = Grade

An example for determining the average grade within in a signal block is:



Example: SCRRA Valley Subdivision Composite Map Plan and Profile

$$AG = \frac{(1{,}522 \times 0.12) + (3{,}000 \times 0.39) + (1{,}900 \times -0.56) + (413 + 0.72)}{(1{,}522 + 3{,}000 + 1{,}900 + 413)}$$

$$AG = \frac{(182.64) + (1{,}170) + (-1{,}064) + (297.36)}{6{,}835} = \frac{586}{6{,}835} = 0.09\%\ \text{EASTBOUND}$$

21.9 SIGNAL SYSTEM EQUIPMENT

21.9.1 Signal Control Systems

Control points shall use solid-state interlocking systems configured for direct control of LED color light signal units and be integrated with an internal Positive Train Control (PTC) system interfacing capability. The solid-state interlocking system shall function in accordance with the requirements set forth in the SCRRA Standard Specific Section 34 42 38 INTERLOCKING CONTROLS.

Solid-state interlocking systems shall utilize customized application programs designed, developed, and tested for the specific requirements of the intended location. Executive programs shall be not be customized and may only be manufacturer developed and supplied programs.

Control point locations shall be equipped with custom local control panels (CLCP) for field maintenance operation. Local control panels shall have a keyed switch allowing for exclusive dispatcher, field, or fleeting control. CLCPs shall have a track diagram of the assigned location and be equipped with buttons or switches to allow for field request of signals and power operated switch machines. The CLCPs shall have LED lights to indicate dispatcher, field, or fleeting control, signal clear/stop, switch position (normal/reverse), track occupancy, switch locked, and light out indications. CLCPs can be either fixed or soft panel type configurations. The CLCPs shall not require any licensing or user fees to maintain or operate.

Automatic signals shall use solid-state systems configured for direct control of LED color light signal units and be integrated with an internal Positive Train Control (PTC) system interfacing capability. Solid-state systems shall function in accordance with the requirements set forth in the SCRRA Standard Specification Section 34 42 40 SOLID-STATE CODED TRACK CIRCUITS.

Application software shall be standard SCRRA universal programs. Customized programs are not allowed without the permission of SCRRA. Executive programs shall not be customized and may only be manufacturer developed and supplied programs.

Both the interlocking and automatic signal systems shall have the capability to emulate standard Electrocode© code rates and communicate through the rail with existing control equipment to transmit and receive vital block information.

The use of vital or non-vital relays to provide interface between coded track and non-coded track control systems is prohibited unless approved by SCRRA.

All signal control systems shall be equipped with data recorders that will record information useful in maintenance and repair of the system. Data recorders shall provide a minimum of 72 hours of recording without overwrite. Directly connecting external recording devices to signal lamp wires, track wires, switch motor control, or indication circuits is prohibited without the permission of SCRRA.

Elevate electrical components of signal/communications system along track that are sensitive to water damage by elevating concrete pads. In areas where contact with salt water (through wave action or spray), use of water-resistant enclosures is preferable.

Wayside communications control equipment – Refer to Section 20.0 Communications Systems for related information.

Positive Train Control (PTC) wayside control equipment – Refer to Section 22.0 Positive Train Control for related information.

21.9.2 Signal Equipment Houses

Signal equipment houses shall comply with the requirements set forth in the SCRRA Standard Specification Section 34 42 46 SIGNAL EQUIPMENT HOUSES.

21.9.3 Pre-Assembled Instrument Enclosures

SCRRA has an established Blanket Purchase Order (BPO) contract with an approved vendor for the purchase of pre-assembled instrument enclosures. The pre-assembled instrument enclosures comprise most variants of wayside signal system applications and include standard house assemblies for universal control points, end of siding control points, automatic signal locations, and leaving signal locations.

Signal design consultants incorporating these enclosures into their designs shall use the pre-assembled instrument enclosure CADD files as a base for their project specific designs. CADD files will be made available to the signal design consultant upon request.

The signal design consultant shall modify the pre-assembled instrument enclosures, using the standard SCRRA Signal Plan CADD Requirements, to configure the enclosure design for their project's specific needs. It is the signal design consultant's responsibility to ensure that all equipment, naming conventions, and wiring configurations meet SCRRA standards and adhere to their project's specific requirements.

The pre-assembled instrument enclosures can be ordered for a project with the use of a single SCRRA material ordering number. It is noted that pre-assembled instrument enclosures can only be used when the project materials are being purchased through SCRRA. For projects where materials are contractor provided, the signal design consultant shall use the pre-assembled instrument enclosures as a base for their design requirements, in conjunction with SCRRA's Standard Specification Section 34 42 46.

21.9.4 Power Operated Switch Machines

Switch machines shall be 110-volt direct current (VDC), 3-wire motor control with a 360:1 gear ratio. Power switch motor and indication assembles shall be mechanical. The use of electronic circuit controllers is prohibited without permission from SCRRA.

Switch machines shall be of the type that provide point locking while the switch machine is in hand operation.

Power switch machine layouts shall be in accordance with SCRRA Engineering Standards. Signal designer is reminded that layouts and configurations vary, depending on turnout size and whether the layout is wood or concrete tie type.

Standby power systems for switch machine motor control shall be provided by a separate 110 VDC supply source such as those manufactured by C-Can or National Railway Supply. All power systems for switch machine motor control shall be equipped with stand-by power capability in the event of a commercial power failure.

In double track corridors, switch machines shall be mounted to the field side of the tracks.

Power switch machines shall have separate external motor control relays assigned for each individual machine. Each switch machine shall have an assigned, separate, 20-amp breaker for motor control power interruption. The breakers shall be located near the custom local control panel.

Each switch machine will have individual normal, reverse, and hand throw lever indication circuit inputs assigned into the signal controller unit. The normal and reverse indication circuits shall be externally back-checked by the opposing motor control relay.

21.9.5 Power Systems for Wayside Signal Locations

Commercial power sources shall meet the requirements of SCRRA Standard Specification Section 34 42 62 SERVICE METERS.

All signal locations shall be supplied power from a commercial power source. Each location shall be evaluated, and the appropriate service connection provided. At a minimum, a 120/240 VAC, single phase, 100-amp service shall be provided. Where commercial power is not available, an express cable connection may be used to connect to the nearest available power source. In all cases, the power cable connection shall be sized in accordance with the National Electrical Code requirements for appropriate conductor size. The use of shared commercial power sources is prohibited unless approved by SCRRA.

Each signal enclosure shall be affixed with an external connection point allowing for a temporary generator connection. In areas critical to railroad operations, signal locations shall be equipped with a permanent standby power generator.

The use of 208 VAC commercial power sources is prohibited.

Each signal enclosure shall be equipped with standby battery and charging systems. These systems shall comply with SCRRA Standard Specification Section 34 42 52 RECTIFIERS, BATTERIES AND BATTERY CHARGING EQUIPMENT. Battery chargers shall be CALGreen compliant, programmable, be affixed with a visual display for current and voltage readings and have temperature sensing capabilities.

Batteries used for signal systems shall be low maintenance, lead-acid, single wet cell and conform to the requirements of AREMA C&S manual parts 9.1.1 and 9.1.30.

Battery capacity for signal systems shall provide a minimum of 48 hours of standby time under normal operating conditions. Normal operating condition is defined as the signal system operating with all signals lit for 24 hours, four power switch machine throws per hour, and all track circuits occupied for at least 12 hours. Battery capacity shall be determined using the **SCRRA Battery Sizing Calculator**, which will be provided upon request.

21.9.6 Hand Operated Switches

Hand operated switches used in signalized territory shall be equipped with a switch circuit controller for open switch point detection. The switch circuit controller shall be mounted and connected to the track in accordance to SCRRA Engineering Standard ES 8760. Independent battery relay track circuits are preferred for fouling track occupancy detection. All hand throw switches equipped with a switch circuit controller require a front rod per SCRRA Engineering Standard ES 8650.

The arrangement of the normal and reverse switch indications shall be in accordance to SCRRA Engineering Standard ES 8140. Normal and reverse switch indications shall be connected to the nearest wayside signal location for proper block detection.

The use of track circuit shunting type indication circuits is prohibited. The use of track circuit open and shunt type detection circuits, used in conjunction with insulated joints, is allowed for temporary construction phasing but shall not be installed for permanent use. When track circuit open and shunt type detection circuits are used, it is required that the track circuit polarities be opposing on each side of the insulated joints.

21.9.7 Leaving Signal Applications

Leaving signals or electric switch locks shall be installed at required hand operated switches in accordance with CFR 49 236.410. A thorough understanding between the signal design consultant and SCRRA is required to determine if a hand operated switch will need a leaving signal or electric switch lock. Leaving signals are preferred over electric switch locks. Use of electric switch locks should be used only when a leaving signal is not possible and then only with the permission of SCRRA.

Leaving signals shall not have number plates and typically will be dwarf signals unless a standard ground signal assembly is needed due to field conditions. A leaving signal can only be installed in conjunction with the use of a circuited derail. Leaving signals can be controlled locally with the use of a dedicated solid-state signal controller or connected remotely to the nearest wayside solid-state signal controller. A hard-wired cable connection is the preferred method of connection to a wayside signal location. However, the use of Phase Shift Overlay (PSO) circuits for this purpose is allowed if there are no interferences or conflicts with crossing warning systems or other audio frequency type circuits.

It is the responsibility of the signal designer to ensure that the solid-state signal controller controlling the leaving signal has application software capable of providing safe leaving signal functionality.

Leaving signals will display an approach (Rule 9.1.9) aspect when clear and require integration into SCRRA's PTC network. PTC map file variables will be controlled by a reverse indication true + appropriate WLR true + normal indication false = leaving signal clear indication. Light out detection monitoring is not required for leaving signals.

Leaving signals will only be clear if;

- No outer opposing controlled signals are cleared or in time, and;
- No track occupancy exists between outer opposing controlled signals, and;
- All other hand operated switches existing between the same outer opposing controlled signals are normal.

Track circuits will be installed on the approach to a leaving signal to provide approach lighting for the leaving signal. Typically, an AC/DC type (Ring-10) track circuit will be used for this purpose unless conflicts with crossing warning equipment exist. In these cases, a conventional DC track circuit shall be used.

21.9.8 Electric Lock Equipped Hand Throw Switches

Electric switch locks shall be mounted and connected to the track in accordance to SCRRA Engineering Standard ES 8765-01 and 8765-02.

Electric switch locks shall be affixed with a separate circuit detecting the removal of the padlock from the locking device. This circuit shall be used to drop the normal switch indication.

All switch locks will include provisions for approach locking, time release, and quick unlock release. A common timer can be used for more than one electric lock if both switches are in sight of each other and share the same track circuit. For switches that do not have line of sight, a separate timer shall be used. Additionally, for switches without a line of sight, false normal indications will prevent the adjoining switch lock from unlocking unless it has completed full time.

Quick unlock circuits typically shall be two-wire EPIC III circuits connected so that at no time will they react to a shunt placed within ten (10) feet in front of the switch points. Island circuits for crossings may not be used as quick unlock circuits.

21.9.9 Relays and Miscellaneous Equipment

All relays used for signal system control and functionality shall be those listed within SCRRA Engineering Standard ES 8110. All circuits being checked by relays should be double break, meaning both the positive and negative side of the circuit should be cut through the relay.

Miscellaneous signal components shall be those that are in accordance to SCRRA Standard Specification Section 34 42 60 SIGNAL SYSTEMS MISCELLANEOUS PRODUCTS.

21.9.10 Non-Coded Track Circuit Requirements

DC track circuits will be designed using biased neutral relays.

Battery eliminators (such as 1TC, 2TC and 3TC) will be used for conventional Battery/Relay type track circuits.

Maximum track circuit lengths vary with ballast resistance, drainage, condition of ties, condition of road crossings, platforms, insulated rods, plates and joints, track wire lengths, relay used, other circuits on the track or external interferences. DC type track circuits are not recommended for circuit lengths over 6,000 feet if possibility of external interference exists. Center fed battery track circuits should be limited to 12,000 feet in total length.

Center-fed track circuits shall have track relays with the same operating characteristics on either end. The maximum recommended offset of the battery from the center of a center-fed track circuit is 800 feet. Center-fed type track circuit will not be used for any type of crossing warning control.

DC track circuits will be used for all track circuits within the limits of a control point.

Independent track circuits are preferred for all turnout fouling sections (defined as section from polarity joints to the clearance joints). Separate track circuits will be used on turnout or crossover fouling sections where the turnout speed is 45MPH or greater.

Loss of shunt (minimum 5 seconds, 10 seconds typical) timers will be utilized for all track circuits within the limits of a control point.

When configuring for a holding signal, approach tracks must be configured with a 10 second loss of shunt timer.

When using Electro Code over line, track relays used to cut the Electro Code line circuit shall be configured with a loss of shunt timer.

Two section release, using the first two track circuits within the control point, will be used to release ASR. For end of siding configurations, the main track relay and the exiting track circuit (typically coded track) will be used.

If the track circuit on a non-signaled track is used for two-section release, the track circuit on the non-signaled siding must slot the governing signal.

PSO IV equipment can be used. All PSO equipment must be configured per manufacturer’s guidelines and must not interfere with any other systems.

Where marginal shunting conditions are anticipated, DC track circuits should be considered in lieu of coded track circuits. When DC track circuits are used for this purpose, vital fiber optic cable connections shall be installed to transmit vital block information between signal locations.

21.9.11 Coded Track Circuit Requirements

Electronic coded track circuits shall be used wherever practical to transmit and receive vital block signal data. Most SCRRA subdivisions utilize Electro Code 4® typical freight code rates. Any new systems shall be able to interface with the typical code rates used on SCRRA without the use of relay interface systems.

SCRRA requires the use of Alternating Code 5 for non-vital block occupancy indications. The following Code Rates and Aspects in Table 21-4 shall be typically used depending on site specific conditions;

TABLE 21-4. TYPICAL CODE RATES AND CORRESPONDING ASPECTS

Receiving Code Rate	Aspect	PTC Map File Code	Transmit Track Code Rate
7	Proceed (Green or Green over Red)	3	7
4	Advance Approach (Flashing Yellow or Flashing Yellow over Red)	7	7
3	Approach Fifty (Yellow over Green)	5	4
3	Approach Sixty (Yellow over Flashing Green)	4	4
8	Approach (Yellow or Yellow over Red)	9	4
2	Approach Diverging (Yellow over Yellow)	6	4
9	Approach Restricting (Yellow over Flashing Red)	8	4
7	Diverging Clear	10	2
4	Diverging Advanced Approach (Red over Flashing Yellow)	11	2
8	Diverging Approach (Red over Yellow)	12	2
NA	Restricting (Flashing Red)	13	8
NA	Stop Proceed (Red with number plate)	14	8
NA	Stop Inspect Proceed (Red with number and P plate)	28	8
NA	Stop (Red without number plate)	15	8
NA	Dark (with number and P plate)	29	8
NA	Dark	30	8
6	Accelerated Tumble Down	NA	6
5	Non-vital code providing block indication, or a hand throw switch in the block out of normal correspondence	NA	5
M	Non-vital code indicating power off or a lamp out condition in the block (Power off will indicate from the east end CP and lamp out will indicate from the west end CP	NA	M

21.9.12 Track Circuit Polarity Requirements

The following are typical locations where track circuit polarities must be staggered at insulated joint locations:

- At locations where coded track circuit is on both sides of the insulated joints.
- DC track circuit Relay/Battery and Relay/Relay locations.

The following are typical locations where it is acceptable to have the same polarities on either side of the insulated joints:

- DC track circuit Battery/Battery locations.
- DC track circuit/Electro Code track circuit if the DC track circuit is configured with a loss of shunt timer.
- DC track relays in the center of a crossover that has two track circuits.
- At insulated joints in the center of a crossover that are configured as shunt fouling.

21.10 APPLICATION LOGIC AND SYSTEM FUNCTIONALITY

21.10.1 Software Management Control Plan for Processor-Based Signal and Track Control Systems

The Software Management Control Plan (SMCP) applies to all existing processor-based signal and train control systems subject to 49 CFR Part 236, Subparts A-G, deployed on the railroad. It also applies to processor-based highway-rail grade crossing active warning systems which provide safety-critical data to or receive safety-critical data from a signal or train control system, processor-based or not. The SMCP defines standard practices for the management of the train control system safety-critical software used on SCRRA’s Metrolink rail system. The plan is applicable to all product lines that are governed by 49 CFR Part 234 section 275 and Part 236 section 18.

When modifying existing application software, it is the designer’s responsibility to obtain a current copy of the SMCP database, a field microprocessor data download detailing all installed current executive and application software checksums and CRCs, as well as the current existing application software, and to check that all items match. Any differences shall be reported to SCRRA for correction.

Upon completion of the project, a field data download detailing the final executive and application software checksums and CRCs as well as the final application software shall be submitted to SCRRA for an update to the SMCP database.

21.10.2 Application Logic Requirements

Application logic software shall conform to all regulatory requirements and AREMA guidelines. Applicable Route Locking, Indication Locking, Time Locking, or Approach Locking shall be used.

The company providing application logic programs must have a documented process of paper checking, computer simulation and rack testing of new or modified programs. All programs and supporting testing documentation shall be submitted to SCRRA before the programs are placed into service. Upon being placed into service, the executable application program files become the property of SCRRA.

All new application programs, or changes made to existing application programs, require a paper check, computer simulation and rack test, regardless if a reduced test procedure is going to be used.

When modifications are made to an existing application program, the company providing the application program shall recommend either a reduced test procedure or a complete retest of the location. Only reduced test procedures developed by the signal controller’s manufacturer may be used. All such recommendations shall summarize the changes and list the required field test procedures. These recommendations must be approved by SCRRA prior to implementation.

Route Locking shall be released utilizing the first two consecutive track circuits.

Two section ASR releasing shall be used. ASR releasing shall be accomplished using the first two track circuits within a control point. Crossover track circuits may be used to accomplish this for diverging routes if the crossover track circuit has an independent battery and relay and is input into the signal controller individually. Where a single track circuit exists within a control point, the exiting track circuit for the route will be used. Where the exiting track circuit is in non-signaled territory, the exiting track circuit (if used for ASR release) must slot the signal for the route.

New installations may use Approach Locking only when directed by SCRRA. At a minimum, approach locking shall be effective if any approaching control signal is clear, or any approach track is occupied, to a point at least 1,500 feet in advance of the first restrictive aspect (not green) approaching the control signal being analyzed.

SCRRA standard ASR times are six (6) minutes. Where any new work, or any significant modifications are being made, the signal designer shall recommend ASR times in accordance with AREMA C&S Manual part 2.4.20, using 30 seconds for the approach to the approach signal rather than the 1,500 feet at 30 MPH. ASR times shall be rounded up to the nearest 30 seconds. ASR times shall be set for sixty (60) seconds for signals governing movement from non-signaled territory. Separate signal timers may be used on each signal or in pairs, where Microprocessor systems are used and as determined by SCRRA.

Program nomenclature is to follow SCRRA naming conventions. Program Logic is to follow the typical SCRRA program logic. A sample SCRRA application logic program with corresponding location plan set shall be provided upon request. Any relay installations shall follow the same principles of application logic as microprocessor-based systems.

Application logic shall follow the following sequence of activities in order shown for the clearing of a signal:

- Request the switch(es) for the appropriate route.
- Request the signal.
- Check the Route – Switches in position, opposing signals at stop and not in time, vital codes received, detector tracks up, and any other applicable conditions.
- Tumble down to the adjoining Control Point upon request of a route into that block.
- Apply the route locking, locking all switches in the route.
- Upon verification of route locking (Switch Motor Control Relay outputs de-energized), clear the signal.
- Upon confirmation of signal aspect, transmit the applicable vital code, or information byte, to the approach signal.

When signal is not cleared and is at stop, an approach code, or information byte, shall be transmitted, allowing a train to proceed up to the stopped signal. Approach codes shall be transmitted behind a train while it is traversing through a control point.

An occupied detector track will not tumble out codes from the control point. However, application logic must be arranged so that a train flagging into a control point will cause vital codes to be turned off for the track that the train is flagging into.

Application logic shall be arranged so that a pumping switch correspondence will not result in a tumble down for adjacent track blocks. However, if the motor control lever check circuit (WJP) becomes de-energized while the detector track is occupied, a tumble-down will occur.

21.10.3 Sectional Releasing Requirements

Sectional releasing shall be utilized whenever possible. Once the train has cleared the fouling section of the switch, and the associated track circuit's loss of shunt time has expired, switch locking may be released. With the train still occupying the detector section, another viable route can be provided after switch locking is released and if there is adequate clearance to do so. An example of Sectional Releasing is shown below;

Figure 21-1. Shows the original route where the 4E signal is cleared over a diverging route. An eastbound train then proceeds past the 4E signal on the diverging route.

Figure 21-2. Once the diverging train move has cleared the 2T and 1T track circuits and occupies only the 1AT track circuit, the 1 crossover may then be requested normal and the 4E or 4W signals cleared for a straight route.

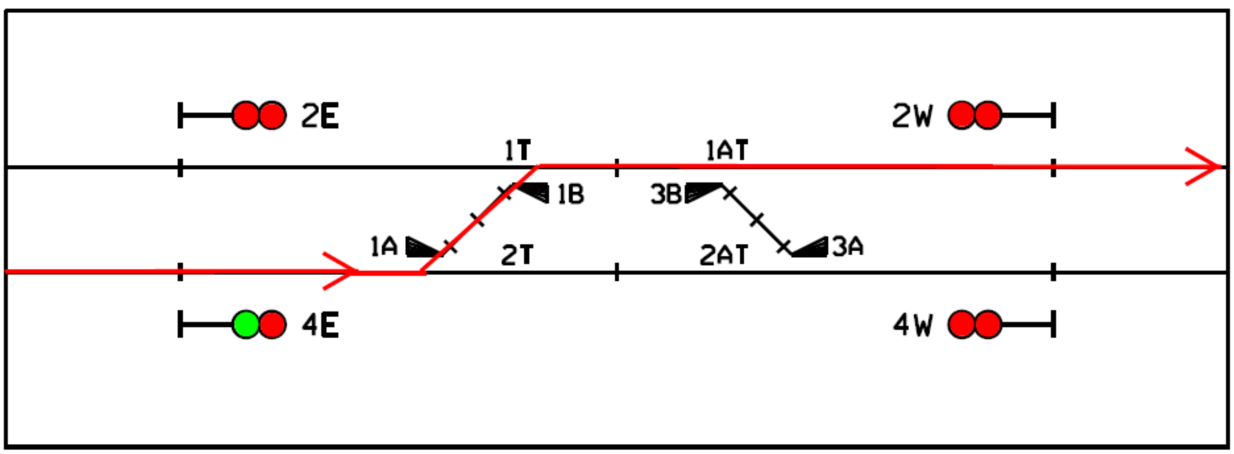


FIGURE 21-1. INTERLOCKING SECTIONAL RELEASE (SHOWING ORIGINAL ROUTE)

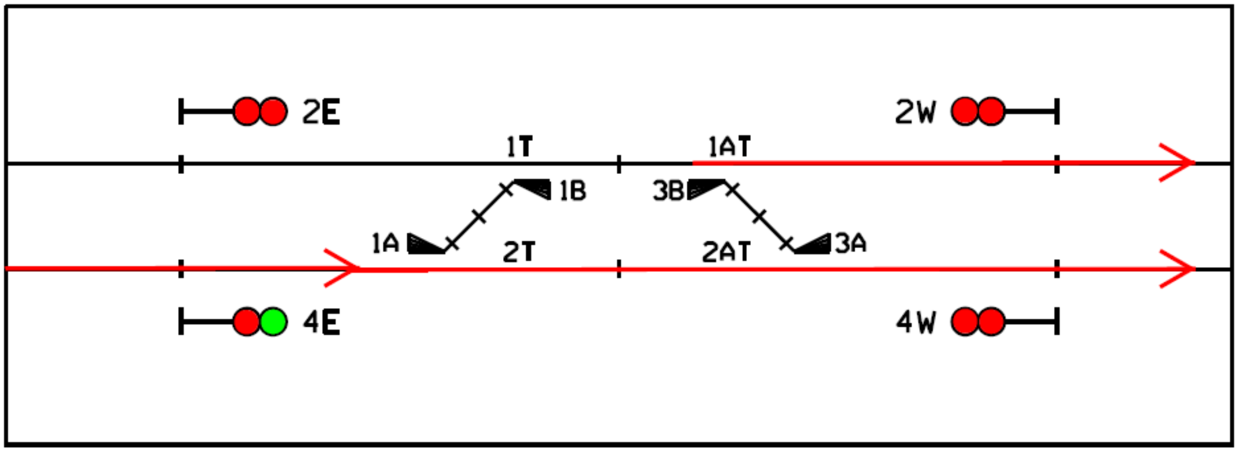


FIGURE 21-2. INTERLOCKING SECTIONAL RELEASE (SWITCH LOCK RELEASE, SIGNAL CLEARING)

Figure 21-3. Shows the original route.

Figure 21-4. Shows the eastbound train having travelled past the 2T track circuit and occupying only the 2AT track circuit. Under this scenario, switch locking can be released for the 1 crossover. However, due to the potential for an unintentional roll back, no signals can be cleared until the eastbound train exits off the 2AT track circuit.

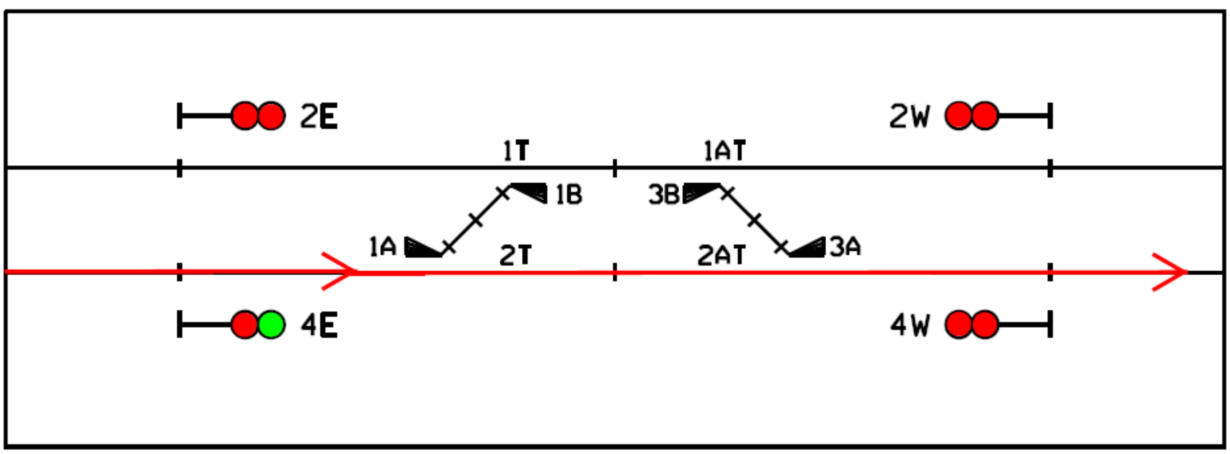


FIGURE 21-3. INTERLOCKING SECTIONAL RELEASE (SHOWING ORIGINAL ROUTE)

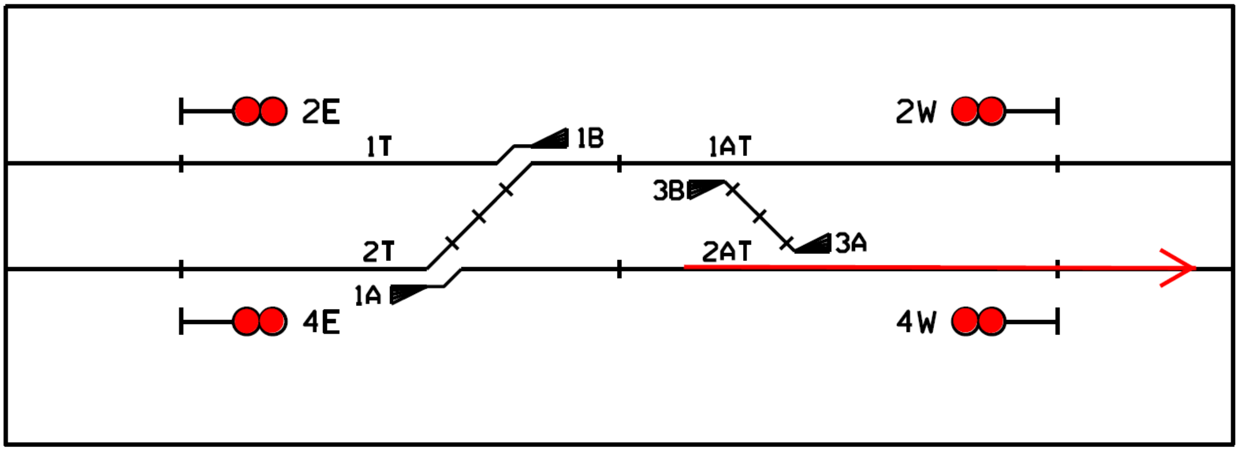


FIGURE 21-4. INTERLOCKING SECTIONAL RELEASE

(Showing Switch Lock Release, No Signal Clearing)

21.10.4 Independently Controlled Switches (ICS)

Independently Controlled Switch (ICS) machine logic will be used on crossovers which meet clearance requirements for ICS as described in this section.

ICS logic allows both switch machines on either end of a crossover track to work independently from each other. As an example, one switch can be out of correspondence, or reverse, while the other end of the crossover is showing in normal correspondence. This arrangement allows for MOW personnel to reduce their required track and time limits to only the track they are working on. Additionally, in the event of a switch failure, train moves can still proceed on signal indication on the adjacent track.

Occupying a main detector track while an ICS equipped crossover switch is out of correspondence, or reverse, will not affect adjacent track normal signal routes.

Occupying either crossover track circuit will place signals to stop on BOTH tracks.

Requisites for ICS include the following:

- ICS switches must have separate office controls and indications.
- ICS switches must have separate motor control relays and individual indication circuits reporting into the signal controller.
- ICS equipped crossovers must have independent, battery/relay crossover track circuits for each switch's fouling track. Bridled track relay configurations, or shunt fouling configurations, are not allowed.
- The custom local control panel (CLCP) must be configured for separate controls and indications. ICS equipped crossovers must be clearly identified on the CLCP.
- The dispatcher's screen, timetable, and the switch machine itself must clearly identify the crossover as being ICS equipped.

- In addition to these requirements, the following information provides a guide in determining if a crossover has the proper clearance to be equipped for ICS. Crossovers not meeting this criterion must not be configured for ICS.

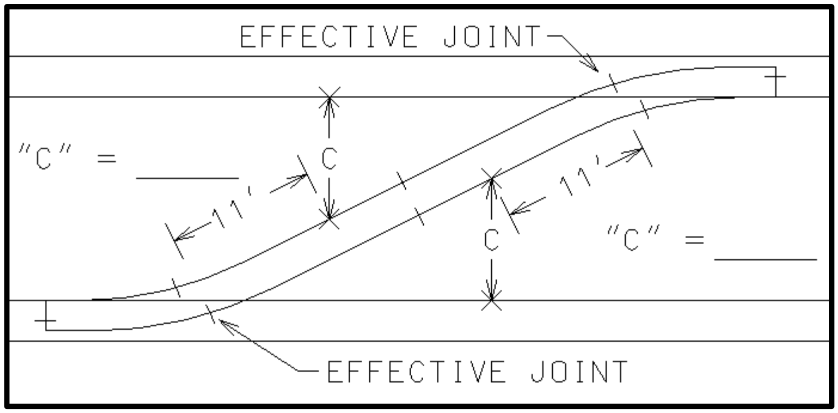


FIGURE 21-5. ICS MEASUREMENTS

ICS shall be determined in the following way on each side of the crossover:

- Measure 11 feet from the closest effective joint to the frog
- From that point, measure to the closest straight rail (Measurement C)
- If Measurement C meets or exceeds the required clearance from the following table's switch size, the crossover is ICS compliant.

TABLE 21-5. MINIMUM DISTANCE FOR MEASUREMENT C CLEARANCE

Turnout Size	Minimum Clearance	String Distance	Total Clearance Required – "C"
#8	6'-6"	0'-8"	7'-2"
#10	6'-6"	0'-6"	7'-0"
#14	6'-6"	0'-4-1/2"	6'-10-1/2"
#20	6'-6"	0'-1-1/2"	6'-7-1/2"
#24	6'-6"	0'-1"	6'-7"

21.10.5 Signal Lamp Out Logic

Lamp out application logic shall incorporate aspect downgrades that minimize train delay. Under normal conditions, the upper and lower units of two-unit signals shall be illuminated. The principle can be summarized as follows: A Top or Bottom Green will downgrade to a Flashing Yellow or Yellow as appropriate, all other Lamp outs will downgrade to a Restricting Aspect unless the Dark Aspect does not affect safety. The principle is that the lamp out condition will be acted upon more quickly when a restricting aspect is displayed. When elaborate lamp out downgrade schemes are used, signals may not be reported until there are multiple lamps out. Lamp out schemes shall be shown on the aspect charts or circuit plans within each individual location plan set. A lamp out indication shall be sent to the Dispatcher and shall be displayed on the Local Control Panel. The following typical downgrade logic shall be incorporated:

TABLE 21-6. ONE UNIT SIGNAL, ONE LAMP OUT

Lamp Out	Aspect	Transmitting Track Code
Green	Flashing Yellow	7
Flashing Yellow	Flashing Red	8
Yellow	Flashing Red	8
Flashing Red	Dark	8
Red	Dark	8

TABLE 21-7. TWO UNIT SIGNAL, TOP UNIT LAMP OUT

Lamp Out	Aspect	Transmitting Track Code
Green over Red	Flashing Yellow over Red	7
Yellow over Flashing Green (for a number plated signal)	Dark over Yellow	4
Yellow over Flashing Green (for an absolute signal)	Flashing Red over Red	8
Yellow over Green (for a number plated signal)	Dark over Yellow	4
Yellow over Green (for an absolute signal)	Flashing Red over Red	8
Yellow over Yellow (for a number plated signal)	Dark over Yellow	4
Yellow over Yellow (for an absolute signal)	Flashing Red over Red	8
Flashing Yellow over Red	Flashing Red over Red	8
Yellow over Red	Flashing Red over Red	8
Flashing Red over Red	Dark over Flashing Red	9
Red over Green	Dark over Flashing Red	8
Red over Flashing Yellow	Dark over Flashing Red	8
Red over Yellow	Dark over Flashing Red	8
Red over Flashing Red	Dark over Flashing Red	9
Red over Red	Dark over Red	8

TABLE 21-8. TWO UNIT SIGNAL, BOTTOM UNIT LAMP OUT

Lamp Out	Aspect	Transmitting Track Code
Green over Red	Green over Dark	7
Yellow over Flashing Green	Yellow over Yellow	4
Yellow over Green	Yellow over Yellow	4
Yellow over Yellow	Yellow over Yellow	4
Flashing Yellow over Red	Flashing Yellow over Dark	7
Yellow over Red	Yellow over Dark	4
Flashing Red over Red	Flashing Red over Dark	9
Red over Green	Red over Flashing Yellow	2
Red over Flashing Yellow	Red over Flashing Red	8
Red over Yellow	Red over Flashing Red	8
Red over Flashing Red	Flashing Red over Dark	9
Red over Red	Red over Dark	8

The applicable code transmitted from signals displaying the lamp out condition indicated above shall also downgrade if applicable.

21.10.6 Approach Lighting

Application logic shall be configured to provide “approach lighting” of signals. Control signals shall light on approach, when a “signal control” bit is received from control station, and when a test clip or switch is “closed” (i.e., lamp test). Where multiple track operations are present, all signals on adjacent tracks governing movements in the same direction as a track occupancy shall be illuminated where practical. Where a signal on one track is dark, the signal on the adjacent track(s) will not be put to Stop or Restricting unless there are concerns that the lit signal will be mistaken as governing movement on the track with the dark signal. One example is a bridge or cantilever signal with a curve in the approach and an overhead structure that inhibits preview. In those instances, the signal on the parallel track will be put to Stop or Restricting, and approaches downgraded accordingly. Special lighting circuits should be considered to illuminate a signal displaying a Stop aspect where an approach lighting circuit is effective less than 2,500 feet in approach of the signal. Although each design will utilize approach lighting, SCRRA Operations will be consulted regarding whether the feature will be applied. The designer shall evaluate each location to determine if special circuits should be applied to ensure aspects can be readily observed and acted upon by the locomotive engineer.

21.10.7 Interfacing with Foreign Railroads

SCRRA interfaces with foreign railroads on many of its subdivisions. When designing a signal system interface between railroads, the ideal configuration is end-to-end with discrete signals, each controlled by their respective railroad. This may not always be possible due to space, limited signal preview, or in cases of parallel tracks where trains crossover between the two railroads.

The design must account for the operational and philosophical differences between the two railroads. Failure modes must be identified and mitigated to the greatest extent that is safely possible. In general, this means the preferred interfacing method is either discrete circuits between the railroads or the introduction of a coded track circuit interface. Either of these configurations reduce the need and dependency on a serial connection.

Where there is a crossover between the two railroads, it is important that a fault on one railroad should not impact the ability of the adjoining railroad to operate on its parallel routes. The design should also account for the need to perform routine maintenance without requiring permission or coordination from the adjoining railroad.

Where the two railroads connect end-to-end, providing a restricting aspect up to the adjoining railroad's entering signal may be a desirable configuration. Where the two railroads are separated by a crossover, an ICS arrangement with a discrete cable connection may be desirable.

21.11 VITAL WAYSIDE OPTICAL NETWORK SYSTEM REQUIREMENTS

In areas of track where shunting is not reliable, the use of DC track circuits shall be considered. In areas where DMUs are proposed to be operated, DC track circuits shall also be used. As DC track circuits only provide track occupancy, aspect information shall be transferred between wayside signal locations utilizing vital wayside optical networking. Additionally, where nearside signaling is utilized, adjacent affected crossings shall utilize vital wayside optical networking.

Vital wayside optical networking shall utilize a single mode 24 fiber cable, containing two buffer tubes. If both signal and crossing vital wayside optical networking is utilized in a location, separate fiber cables shall be utilized, with no intermingling of signal and crossing fibers. A fiber to ethernet switch shall be utilized to provide fiber connection as well as microprocessor ethernet connection. At the termination locations, a vital loopback fiber cable shall be installed to provide loopback capability in the event of a single fiber cable break.

21.12 STATION NEARSIDE SIGNAL APPLICATION AND CONFIGURATION REQUIREMENTS

Where trains entering and stopping within the station cause an adjacent crossing or crossings to activate, deactivate, and finally activate again upon the train leaving the station towards the crossing, station nearside signaling should be considered. Nearside signaling inhibits the adjacent crossing when a train is to enter and stop at the station. Nearside signals are placed between the edge of the station and the closest adjacent crossing, providing a protecting signal.

Currently SCRRA is researching different options for nearside signaling. No design shall be performed without prior approval from SCRRA.

21.13 WAYSIDE HAZARD DETECTION SYSTEMS

21.13.1 Hazard Detector Placement

When determining placement for hot bearing, dragging or high-wide load detectors, consideration should be given as to where a train will be expected to set out and store a defective rail car. Signal designer will need to coordinate with track designer for the installation of a set-out spur track, or detector may need relocation to meet this need.

In the even project requirements dictate the need to remove an existing detector, the signal designer shall consult SCRRA as to whether the existing detector needs to be relocated.

All hazard detector locations are listed within the timetable. Any new or relocated detectors require coordination with SCRRA Operations so that the information can be properly bulletined.

21.13.2 Hot Bearing Detectors

Hot bearing detectors shall be placed not more than 20 miles apart, and not closer than 2,500' from any turnout or 200' from any road crossing. Consideration should be given if the proposed location will incur extraordinary train braking, and if so, the detector should be placed elsewhere. Hot bearing detectors shall comply with SCRRA Engineering Standard ES8800.

Hot bearing detectors shall broadcast messages over the applicable subdivision's operating road channel and shall not be connected to the signal system.

21.13.3 Dragging Equipment Detectors

Dragging Equipment Detectors shall be placed not more than 5 miles apart, and not closer than 2,500' from any turnout. Dragging equipment detectors shall comply with SCRRA Engineering Standard ES 8800.

Dragging equipment detectors shall broadcast messages over the applicable subdivision's operating road channel and shall not be connected to the signal system.

21.13.4 High-Wide Load Detectors

High-Wide load detectors shall be placed 5 miles prior to entry of a narrow bridge or tunnel. High-Wide load detectors shall meet the basic requirements of SCRRA Engineering Standards ES 8830 and ES 8831.

High-Wide load detectors shall broadcast messages over the applicable subdivision's operating road channel and shall not be connected to the signal system.

21.13.5 High Water Detectors

High water detectors shall be placed on bridges or culverts that have an increased likelihood of water rising over the bridge and washing out the track structure. High-water detection equipment shall meet the requirements of SCRRA Engineering Standard(s) ES 8820.

The high-water detector shall notify the signal system, placing signals governing movement over the detector to stop. High-water detector shall not allow clearing of signals until the detector has been inspected and reset.

Signals governing movement over high-water detectors shall be affixed with a "P" plate as per SCRRA Engineering Standard ES 8545.

21.13.6 Rock Fall and Slide Detectors

Rock fall and slide detectors shall be placed where there is an increased likelihood of rock or mud slides. Rock fall and slide detection equipment shall meet the requirements set forth in the AREMA C&S Manual Part 5.1.12. All proposed detection system design architectures shall be approved by SCRRA.

Rock fall and slide detectors shall notify the signal system, placing signals governing movement over the detector to stop. Rock fall and slide detectors shall not allow clearing of signals until the detector has been inspected and reset.

Signals governing movement over rock fall and slide detectors shall be affixed with a “P” plate as per SCRRA Engineering Standard ES 8545.

21.14 DESIGN STAGES

The design cycle is an iterative process that may involve numerous groups, such as Railroad Operations, Finance, Contracts, other railroad engineering disciplines, and other stakeholders. The design firm performing the signal design may provide the design services directly through SCRRA or through a third-party group, for example OCTA. Many signal projects involve multiple disciplines and therefore require close coordination with other design parties.

The various design stages include:

The 5 percent Submittal, or third-party equivalent, may be produced by the agency or the design firm with agency oversight. The purpose of the submittal is to establish a systems design concept for the project. The submittal generally consists of:

- A conceptual overview plan for the preferred alternative which consists of a single line drawing identifying existing and proposed track configurations as well as new additions or modifications to existing signal equipment and locations.
- A conceptual overview plan of each alternate configuration (if any).
- A rough Order of Magnitude budget estimate.
- A Project Design Report, when required, describing the scope of the project, existing conditions, operational benefits, construction phasing, and details on alternatives with a recommended preferred alternative.
- If working directly for SCRRA, a design delivery schedule detailing dates the firm shall provide each submittal.

The 30 percent Submittal, or third-party equivalent, builds upon the 5 percent Submittal. This document is suitable for review by all relevant stakeholders. Upon completion of the 30 percent submittal and acceptance of it, the track configuration should be considered final. The submittal generally consists of:

- Preliminary 500:1 scale layouts of the preferred alternative chosen at the conclusion of the 5 percent submittal review including the existing and proposed new track configuration as well as proposed new, modified, and removed signal equipment and locations.

- Preliminary aspect charts encompassing the entire project area as well as three existing locations railroad east and west of the project area limits complete with safe braking calculations.
- A preliminary Order of Magnitude budget estimate.
- If working directly for SCRRA, a preliminary material list containing long lead time items may be required in advance of design completion, particularly with a grade crossing project where an agreement is required with the public agency.
- If required, a technical specification outline listing all signal specifications.

The 60 percent Submittal, or third-party equivalent, builds on the 30 percent submittal. The submittal contents shall be developed to a point where the systems can be reviewed for operational completeness, though it is understood that due to ongoing discussions certain elements may not progress to an operational level. Detailed information such as terminal, rack, and equipment locations may not be advanced to a level for review, however if a separate material procurement is necessary, such detailed information may be required to be completed. The submittal generally consists of:

- Draft 500:1 scale layouts.
- Draft aspect charts complete with safe braking calculations.
- Draft track and location plans detailing a general overview of each signal location and circuits running between signal locations.
- Draft location specific circuit plans containing all required circuits for an operational review for completeness as well as detailed information such as terminal, rack, and equipment locations in progress.
- An updated Order of Magnitude budget estimate.
- If working directly for SCRRA, a draft material list containing a complete list of long lead time items.
- Draft battery calculations for each signal location.
- Draft ASR calculations for each signal location.
- Draft crossing approach calculations for each signal location.
- If required, draft technical specifications.
- If working directly for SCRRA, an SCRRA approved updated design delivery schedule.

The 90 percent Submittal, or third-party equivalent, builds on the 60 percent submittal and represents the systems in their final configuration. All submittal contents shall be considered final, allowing for a review of operational functionality and system completeness. Major issues with stakeholders are resolved and ongoing discussions will not impact the overall project. The submittal generally consists of:

- Final 500:1 scale layouts.

- Final aspect charts complete with safe braking calculations.
- Final track and location plans.
- Final location specific circuit plans.
- A final engineer’s estimate.
- If working directly for SCRRA, a final material list.
- Final battery calculations.
- Final ASR calculations for each signal location.
- Final crossing approach calculations.
- If required, final technical specifications.
- If working directly for SCRRA, an SCRRA approved updated design delivery schedule.

The 100 percent Submittal, or third-party equivalent, incorporates and finalizes comments received from the 90 percent submittal. Major issues with stakeholders are resolved and ongoing discussions will not impact the overall project. The submittal generally consists of:

- Final 500:1 scale layouts.
- Final aspect charts complete with safe braking calculations if modifications were made between the 90 percent and 100 percent submittals.
- Final track and location plans.
- Final location specific circuit plans.
- A final engineer’s estimate.
- If working directly for SCRRA, a final material list.
- Final battery calculations if modifications were made between the 90 percent and 100 percent submittals.
- Final ASR calculations if modifications were made between the 90 percent and 100 percent submittals.
- Final crossing approach calculations if modifications were made between the 90 percent and 100 percent submittals.
- If required, final technical specifications.
- If working directly for SCRRA, an SCRRA approved updated design delivery schedule.

The “Issued for Construction” or “Issued for Bid” package closes out the design phase of the project. The design is complete, and the construction package is ready for distribution. The submittal generally consists of:

- Final design for distribution incorporating any final changes.
- The package including all plans, technical specifications, and an engineer’s estimate.

Design services during construction (DSDC) provides services for agency or third-party work. These services generally consist of:

- Customized application software development for microprocessor-based systems.
- Intermediate signal application software shall utilize typical application software developed and retained by SCRRA, unless the location is completely custom and typical software cannot be used.
- New or modified PTC Wayside Interface Unit map files.
- If required, Request for Information (RFI) review and submittal review and response.
- Technical support during cutover for application software changes.
- Gathering and controlling project related as-built documentation from both the construction contractor and location-based plan changes held within field enclosures.
- If working for a third-party, the development and submittal of a conformed project as-built plan set.
- The development and submittal of SCRRA maintenance as-built plan sets on SCRRA signal borders with CAD files.
- Distribution of SCRRA maintenance as-built plans to the field, with removal of invalidated plans within the affected enclosure(s).

The design stages listed above are guidelines for the design cycle. SCRRA and/or third-party may require additional submittals or services. SCRRA and/or the third-party may choose to combine stages or introduce additional review cycles, however the spirit of review shall remain consistent. For example, if there are significant changes during the 30 percent operational review, SCRRA may require a 40 percent in progress submittal for review which reflects those changes. Also, due to the scope of a project, SCRRA may elect to skip the 30 percent and 60 percent submittals, going directly to a 90 percent design submittal.

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22.0 POSITIVE TRAIN CONTROL

22.1 SCOPE

The Rail Safety Improvement Act (RSIA) of 2008 mandated Positive Train Control (PTC) for SCRRA commuter rail following the requirements of 49 CFR Part 236, Subpart I. PTC uses communication-based/processor-based train control technology that provides a system capable of reliably and functionally preventing train-to-train collisions, overspeed derailments, incursions into established work zone limits, and the movement of a train through a main line switch in the wrong position. PTC technology automatically controls train speeds and movements should a train operator fail to take appropriate action for the conditions at hand. PTC systems must also provide for interoperability in a manner that allows for equipped locomotives traversing other railroad's PTC-equipped territories to communicate with and respond to that railroad's PTC system, including uninterrupted movements over property boundaries.

This design criteria shall be applied to all designs along the railroad Right-of-Way (ROW), herein referred to as wayside. The design consultant shall evaluate the implementation of PTC on new lines or identify impacts to PTC when making design changes on existing lines. These changes include not only new or modified infrastructure within the design, but the removal or elimination of existing infrastructure. Design changes that impact PTC shall be reported through the SCRRA change management process. The design consultant shall understand critical features and their importance to PTC.

22.2 PTC SYSTEM COMPONENTS

SCRRA has implemented an interoperable PTC System on all line segments where passenger operations are conducted. This system is known as the Interoperable Electronic Train Management System (I-ETMS) and has Type Approval from the Federal Railroad Administration (FRA). The system interfaces with signal systems, wayside devices, and SCRRA's Train Management Dispatch System (TMDS, or herein, Computer Aided Dispatch (CAD) system) via multiple communications links. I-ETMS provides the means to enforce compliance of movement authorities, speed restrictions, work zones and switch positioning while retaining existing field signal system and CAD system functions as the primary means of maintaining train separation and protection. The PTC system is designed and implemented to follow the standards and guidelines established by the Interoperable Train Control (ITC) Committee, which is composed of the four largest U.S. freight railroads - BNSF, CSX, NS, and UPRR. Within the operating area, SCRRA is a host railroad to BNSF, UPRR and Amtrak. SCRRA is a tenant railroad on BNSF, UPRR and NCTD.

I-ETMS is composed of four (4) unique segments:

- Office Segment: this segment contains a Back Office Server (BOS), which interfaces with other railroad BOS, the CAD system, and the Locomotive and Communications segments. The Office segment normalizes a railroad's operating data for exchange over an interoperable interface. The BOS contains databases for track geometry, wayside signaling configurations and permanent speed restrictions. This segment is non-vital. Modifications will be made to this segment without disruption to the in-service system.

- Wayside Segment: this segment monitors and reports switch position, signal indications, and status of other monitored wayside devices to the Locomotive and Office segments via the Communications Segment. The Wayside segment consists of microprocessor-based signal equipment to which a Wayside Interface Unit (WIU) has been added.
- Locomotive Segment: this segment is a set of independent onboard hardware, software, and devices that interface with the locomotive control equipment and includes a Train Management Computer (TMC), a Computer Display Unit (CDU), a locomotive identification (ID) module, a GPS receiver, and a brake cut-out switch. Each enabled locomotive provides current position, manages restrictions, calculates braking distance and enforces braking when the locomotive engineer fails to respond to directives. The Locomotive segment accepts movement authorities, temporary speed restrictions, other mandatory directives, train consist data, and other information from the Office segment.
- Communication Segment: this segment consists of an asynchronous messaging system and multiple wired and wireless networks through which messages are exchanged between the Locomotive, Wayside and Office Segments. The messaging system is known as Interoperable Train Control Messaging (ITCM). Through the Communications segment, the Locomotive segment can subscribe to receive WIU status messages from the Wayside Status Relay Service (WSRS). The WSRS runs as an application located in the back office that accepts status messages from WIU. Upon receipt of a status message, WSRS looks up subscriptions and forwards the message to the subscribing Locomotive segment.

22.3 PTC CHANGE CONFIGURATION MANAGEMENT AND AGENCY COORDINATION REQUIREMENTS

PTC has introduced additional levels of approval for design and construction projects that take place on SCRRA property. In order to identify and schedule all PTC related actions required to install new infrastructure or modify existing infrastructure on the railroad, formal PTC Change Configuration Management is necessary. Design consultants are responsible to identify design changes or new design elements that will impact PTC systems.

Design consultants shall ensure all design changes made to the track structure, signal appliances, bridges, grade crossings, operating rules, procedures or policy are reported to SCRRA in accordance with configuration and change control procedures. The failure to properly identify a project’s impact to PTC has a cumulative effect that can negatively impact the schedule and lead to increased project costs. Design consultants are a key partner to help prevent this. PTC Change Configuration Management training can be given by SCRRA at the request of the design consultant. This training is recommended to take place during the kickoff phase of the project.

Using the project applicable activities described under Section 22.5, PTC Systems Implementation, the Design Consultant shall allocate within the Project budget an estimate for PTC.

22.3.1 Definition of Critical Features and Track Database Elements

Within the PTC system, the track database, or SUBDIV file, contains critical features and their GIS location (latitude, longitude and elevation). Critical features are railroad features that affect the performance of trains and can undermine the effectiveness of the SCRRA PTC system if not accurately provided for in the Configuration Management System. Critical features within the SCRRA PTC System include:

- Track type
- Grades
- Track Alignment / Curves / Superelevation
- Type of Structure
- Type of Bridge
- Switch points
- Switch Type (Powered, Electrically Locked, Hand Operated, Leaving Signal, Non-clearing)
- Turnout (Size, Direction)
- Derail Type
- Clearance Points
- Grade crossings (Roadway alignment (angle), Roadway width, Crossing Panels, Warning devices, Approach Timing, Traffic Signal Interconnection)
- Wayside Signals (Type, Aspect, Direction, Location, Program)
- Control Point Limits
- High Water Detector
- High/Wide Load Detector
- Milepost Signs
- Speed Change Signs
- Freight Restrictions (Tons Per Operative Brake)
- Whistle Post / Quiet Zone
- Damage or Remove Track Marking
- Begin/End CTC sign

22.3.2 System Implementation Planning and Schedule Requirements

SCRRA's philosophy for PTC Change Management is to foster it at the lowest organizational levels possible with staff who work with the system on a day-to-day basis. At approximately the 65 percent design level, the SCRRA Project Manager (PM) will place the project into SCRRA's Jazz Change Tracking System via a Change Request (CR) to begin the notification process.

Based on the project scope, SCRRA will appoint a Technical Review Team (TRT) composed of SCRRA stakeholders anticipated to be impacted by the project. This group shall receive continuous updates with any and all proposed modifications throughout the duration of the project. The design consultant shall note that once the CR is in the Jazz system, it is manually monitored. Periodic communication with the SCRRA PM ensures the project's seamless progression through the PTC Change Management Process.

No later than the 100 percent design submittal, the proposed construction phasing shall be provided to the TRT by the SCRRA Project Manager. The TRT will identify the PTC SUBDIV changes at that time. Throughout procurement and construction, the design consultant shall consider the PTC impacts of value engineering proposals. These need to be communicated to the SCRRA Project Manager and the TRT. When applicable, project specifications shall include provisions of potential schedule impacts due to value engineering proposals which are dependent on the timeliness of submission to the TRT for review and approval.

All final data shall be provided to the TRT no later than 45 calendar days before a scheduled cutover of any construction phase. No changes shall be permissible beyond that time, without a review and approval of the TRT and an associated delay in schedule. Depending on the sequence of SUBDIV changes introduced by multiple construction projects, there may be times where no changes in schedule will be permissible.

The Change Control Board (CCB) membership consists of SCRRA director level staff. The CCB approves changes that are systemic or emergency in nature. In addition, the CCB will review and approve any projects that are escalated from the TRT.

22.3.3 Project Documentation Requirements

The design consultant shall evaluate design proposals at each submittal stage to determine if SCRRA reference documents subject to the Configuration Management change process are impacted. Designated design submittal stages shall include markups or exhibits that communicate the changes (additions, modifications or removals) to SCRRA stakeholders such as the PTC TRT, Operations and Executive staff for review. The design consultant shall communicate changes using the guidelines below on the following Controlled Documents:

- Timetable: Prepare markup of any changes in PDF format. Place markups in the subdivision section of the timetable where the change will apply. Include written justification for changes proposed.
    - Designated design submittals: 60 percent, 90 percent, 100 percent, Construction As-built
- Track Chart: Prepare track schematic exhibit that will communicate changes in turnout information, operating speeds, track geometry and composition, and profile information. Format shall match SCRRA's latest track charts. Base CADD files shall be provided to SCRRA.
    - Designated design submittals: 30 percent, 60 percent, 90 percent, 100 percent, Construction As-built

- Composite Maps: Prepare markup of any changes in PDF format. Markup each existing composite map sheet where the change will apply. Base CADD files shall be provided to SCRRA.
  - Designated design submittals: 100 percent, Construction As-built
- Google Earth KML files: SCRRA maintains Google Earth KML files that are created using the information from the data tables in the track charts. Markup changes to the data tables in the PDF.
  - Designated design submittals: 100 percent, Construction As-built

TABLE 22-1. PROJECT DOCUMENTATION SUBMITTAL REQUIREMENTS

Affected PTC Document	30 percent	60 percent	90 percent	100 percent	Construction As-built
Timetable		✓	✓	✓	✓
Track Chart	✓	✓	✓	✓	✓
Composite Maps				✓	✓
Google Earth KML				✓	✓

At either the 100 percent or Construction As-built level, SCRRA will modify these documents in-house, using the markups provided. Once the changes are complete, a copy will be distributed to the design consultant for final review and quality check of the documents.

Head-end videos are available on SCRRA's Google Earth KML files. Head-end videos will be updated at SCRRA's discretion. The design consultant shall consider the last revision date when reviewing head-end videos for wayside information.

22.4 PTC WAYSIDE SYSTEMS ENGINEERING REQUIREMENTS

PTC wayside systems contain active equipment that sends status messages to the locomotive or back office systems via the SCRRA communications system. PTC wayside systems utilize specially encrypted messages over the non-vital communications system in accordance with the FRA's I-ETMS Type Approval. Changes to these systems shall be documented to both SCRRA and interoperable stakeholders.

Design Criteria Section 20, Communications Systems, shall be reviewed by design consultants making changes to PTC wayside systems in conjunction with this Section. It is important to identify changes in systems that are subject to FCC requirements early in the design cycle to allow time for environmental/historic preservation notifications and licensing approvals.

PTC wayside signal locations such as control points or intermediate signals are composed of three components: the PTC wayside radio, the wayside messaging server (WMS) and the wayside interface unit (WIU). The locomotive's Computer Display Unit (CDU) is required to receive WIU status messages (WSMs) from a wayside device a minimum of 5.19 miles ahead of the train's current location. Changes to the existing wayside systems shall be evaluated in order to maintain performance requirements.

The PTC system's existing radio frequency (RF) design allows for the locomotive radio to have multiple attempts to receive a WSM before it assumes a more restrictive condition within the PTC operating zones. There are 3 zones of operational impact in advance of a locomotive:

- Zone 1: exposure to false enforcement when a brake application is invoked when actual conditions allow the train to operate safely
- Zone 2: exposure to false warning when the PTC CDU displays an enforcement warning when actual conditions permit safe operation without it
- Zone 3: exposure to false display when the PTC system displays a restriction when actual conditions allow safe movement without a restriction

PTC radio performance requirements are driven by the system's impact to locomotive operations. The transmission of these messages and the underlying communications systems shall be highly reliable.

22.4.1 Qualifications of the PTC Radio Frequency Designer

The designer responsible for SCRRA PTC radio designs shall be a licensed Professional Engineer in the State of California, with a working knowledge of electrical engineering, RF engineering and telecommunications. The PTC Radio Designer shall have a minimum of five (5) years of experience designing radio systems for passenger rail projects. The PTC Radio Designer shall have a Bachelor of Science in Electrical Engineering or related area of study, covering the analysis of analog and digital communication systems, systems models, radio propagation, cellular technology concepts and principles of frequency reuse. The PTC Radio Designer shall be certified by the PTC-220 LLC group, which allows for access, RF simulation and management of the PTC radio system within Infovista's Planet software. It is preferred that the PTC Radio Designer have familiarization with train control concepts and train operations to effectively translate operational requirements into PTC radio system design requirements.

22.4.2 Frequency Allocation and Slot Planning Coordination

PTC-220 LLC, owns spectrum for 14 nationwide 25kHz-wide Interoperable Train Control (ITC) frequency channels between 220 and 222 MHz, specifically reserved for PTC use. PTC radio deploys a frequency reuse plan and Time Domain Multiple Access (TDMA) timeslot assignments for base stations and wayside interface units. The Los Angeles basin is defined as a single Major Trading Area (MTA) which fits the interoperable requirements of the PTC system. Currently Transportation Technology Center, Inc. (TTCI) is the point of contact and coordinator of all changes between the stakeholder railroads within the Los Angeles MTA.

The design consultant's PTC radio designer shall propose site selection, antenna characteristics, antenna height and orientation, and calculate effective radiated power (ERP). Planet software shall be used to generate the predicted coverage and interference levels among sites and summarized in a proposal. This proposal shall be submitted to the SCRRA Communications License Coordinator for review. Once accepted by SCRRA and forwarded to TTCI, TTCI will incorporate the information into the slot plan assignments for base stations and WIUs.

22.4.3 PTC Wayside Radio

ITC compliant radios use 25 kHz wide channels in the 220MHz band. The PTC wayside radio is half-duplex (they cannot transmit and receive simultaneously). It has two receive channels, one for the common channel and one for the local base channel. The PTC wayside radio can transmit on only one channel at a time. The duty cycle limit shall be set to 10 percent.

The PTC wayside radio shall be provided by SCRRA for all direct or third-party related projects due to licensing agreements with the manufacturer. Project specifications shall clearly provide this information as well as a requirement for coordination between the Construction Contractor and SCRRA for installation, configuration and testing of the PTC wayside radio.

22.4.4 Wayside Messaging Server (WMS)

The Wayside Message Server (WMS) is an embedded computer and switch that receives WIU information and encapsulates it into ITCM format for message transport. The WMS sends this information over the radio to locomotives and to the Back Office Server (BOS) through the wayside PTC radio. If the WMS loses its connection to the wayside radio, it may be configured with a cellular interface as a backup to get the messaging to the BOS.

The WMS shall be provided by SCRRA for all direct or third-party related projects due to licensing agreements with the manufacturer. Project specifications shall clearly provide this information as well as a requirement for coordination between the Construction Contractor and SCRRA for installation, configuration and testing of the wayside messaging server.

22.4.5 Wayside Interface Unit (WIU)

At signal locations where vital microprocessors are utilized, the Wayside Interface Unit (WIU) shall be a component built into the microprocessor. Executive software versions to be utilized that have PTC features shall be reviewed and approved by SCRRA. When placed, a WIU shall be capable of transmitting to at least one base station.

22.4.6 WIU Mapping and Configuration

The WIU shall transmit information from the control point or intermediate signal to the Back Office Server for processing. Control point WIUs shall transmit switch position information and signal aspect information. Intermediate signal WIUs shall transmit signal aspect information. When mapping WIU assignments, switches shall be assigned first followed by signals. Switch and signal assignments shall be in alphanumeric order. Switches are assigned 2 bits, while signals are assigned 5 bits.

TABLE 22-2. PTC WIU MAPPING – TYPICAL WEST END OF SIDING

Type	Name	Offset
Switch	1	0
Signal	EA	2
Signal	EC	7
Signal	W	12

22.4.7 PTC Base Station Radio

ITC compliant radios use 25 kHz wide channels in the 220 MHz band. The PTC base radio is half-duplex (cannot transmit and receive simultaneously). It can receive up to eight channels simultaneously. Two channels are used for the common channel and the local channel of the base station. The remaining channels are set to the local channels that the surrounding WIUs will use for transmissions. The PTC base radio can transmit only on one channel at a time. The duty cycle limit shall be set to 50 percent.

New PTC base radio sites shall be coordinated with SCRRA's Communications Licensing Coordinator and TTCI to determine necessity, given the existing base station coverage and limited spectrum available within the Los Angeles MTA. If another railroad's base station provides coverage to the project's wayside, the system will rely on interoperability and a new base station will not be necessary. If a new base station is necessary, 95 percent of the 90-meter track buffer shall have a signal strength coverage of -94.37 dBm, and a minimum C/I of 11.5 dB. Each WSM shall be received by at least one base station site.

If necessary, the PTC base radio shall be provided by SCRRA for all direct or third-party related projects due to licensing agreements with the manufacturer. Project specifications shall clearly provide this information as well as a requirement for coordination between the Construction Contractor and SCRRA for installation, configuration and testing of the PTC base radio.

22.4.8 PTC Locomotive WiFi Initialization

Before a train can move onto mainline track, the train must be initialized. This generally occurs in yards, terminals, or layover facilities at the beginning of a trip and is necessary after the train is terminated. With the locomotive stationary, a wireless 802.11 a/b/g/n data network is utilized to verify the onboard SUBDIV and upload any necessary changes. Operating data such as train consist, work zones, temporary speed restrictions, advisories, critical alerts and other relevant information will also be communicated.

WiFi initialization design placement shall consider train movements within a facility to determine required coverage to the locomotive. Often multiple access points are installed to provide coverage to locomotives in various operating orientations. The coverage boundary shall be defined by a minimum signal to noise ratio (SNR) of 20dB.

Placement of the access point shall consider the proximity of an SCRRA backhaul connection and the use of Power over Ethernet, (PoE) 802.3at. Access points shall be placed at a height of 19 feet.

22.5 PTC SYSTEMS IMPLEMENTATION

Refer to SCRRA's PTC Engineering and Construction Change Management Process document for information regarding the measurement, verification and validation of critical features prior to placing a construction phase in service.

During and after construction the design consultant shall anticipate and support the SCRRA PM in the following activities (as determined applicable within the project's scope):

- Resurvey during substantial completion of project construction
- Changes to BOS

- Build of SUBDIV file incorporating critical feature changes
- SUBDIV testing and field validation
- Signal WIU verification and validation
- CAD testing and field validation
- Radio licensing changes
- Update of Controlled Documents
- Iterations required for construction phasing

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23.0 ENVIRONMENTAL GUIDELINES

23.1 SCOPE

General information and guidance regarding environmental compliance requirements for SCRRA projects is provided in this chapter. This information must be used in conjunction with specific design criteria established in the other chapters of this DCM. If the designer encounters situations where these guidelines are impractical to satisfy or where conflicts exist, the matter should be reviewed with SCRRA for resolution.

Construction, environmental, and permitting information presented in this chapter is taken from several sources, including permitting information available through the jurisdictional agencies referenced.

23.2 TYPES OF CONSTRUCTION ACTIVITIES AND ASSOCIATED PERMITTING PROCESSES

For SCRRA projects, non-administrative job functions generally fall under emergency construction, maintenance activities, and program work categories. Each of these work categories is identified by specific characteristics where special permit processes may apply.

23.2.1 Emergency Construction

Emergency construction is immediate work required to protect lives and property. These are projects that must be conducted immediately to protect or replace existing infrastructure (for example, culverts, rails, or bridges) or to repair damaged facilities (for example, bridge abutments or footings) to allow their continued safe use. Emergency construction is usually associated with specific events such as floods, landslides, and structural failures. These projects are generally performed within the footprints of existing facilities and do not result in major changes to existing facilities. Emergency construction may include minor upgrades or improvements, provided they do not result in a major change in the original footprint or operations of the facility prior to the emergency.

Emergency construction includes work to repair flood damage, remove debris from culverts and bridges, repair landslide damage, respond to derailments, or make repairs due to vandalism. Although these projects can generally be permitted under special regulatory provisions that allow for emergency response, environmental considerations must be identified during and evaluated after the emergency construction.

During emergency construction, more substantial retrofitting or improvement of an existing structure/facility may be identified. Construction that would substantially alter the original design, operation, or function of SCRRA infrastructure would be considered maintenance activities or program work, as discussed below.

23.2.2 Maintenance Activities

Maintenance activities include regular maintenance and repair of existing infrastructure or facilities that can be performed after completing the appropriate levels of environmental evaluation and permitting. Maintenance activities may include minor improvements of existing infrastructure or facilities (particularly work within existing footprints or ROW) and work following emergency construction to ensure that the damaged facility is repaired for the long term.

Maintenance activities undertaken during normal operations may or may not require specific permits. These activities should not begin until the appropriate levels of environmental evaluation have been completed to determine the potential for impacts on sensitive biological and cultural resources, to identify means to avoid or minimize adverse impacts, and to determine which agencies have jurisdiction over the activity or project location. When appropriate SCRRA may enter into long-term maintenance agreements to minimize duplicative permitting.

23.2.3 Program Work

Program work consists of new projects that have been planned in advance with environmental compliance and permitting built into the planning schedule before construction. It includes construction of new buildings, bridges, and railways that are not within existing ROW or that would result in substantial improvements/changes to existing facilities. Program work should not begin until the appropriate levels of environmental evaluation have been completed to determine the potential for public opposition, impacts on sensitive biological and cultural resources, to identify means to avoid or minimize adverse impacts, and to determine which agencies have jurisdiction over the activity or project location. Construction can begin only after an evaluation of potential environmental issues and after obtaining appropriate permits and jurisdictional approvals.

23.3 ENVIRONMENTAL COMPLIANCE PROCESSES

The environmental compliance process differs in emergency versus non-emergency situations. The first step in environmental compliance is to determine whether the proposed work has the potential to affect an environmentally sensitive resource (for example, cultural resources, wetlands, lakes, streams, drainages, coastal areas, and special status plants or animals). If environmentally sensitive resources **are not** present, then the work can proceed after local permits (for example, grading permits, building permits, and road encroachment permits) have been obtained. California Environmental Quality Act (CEQA) compliance may be required for projects outside existing ROW even if environmentally sensitive resources are not present (see Section 23.4.1 for further discussion of CEQA).

23.3.1 Emergency Construction Process

If the proposed work will be done immediately in order to protect lives and property and will be limited in extent, then the work may qualify as emergency construction. Under the CEQA, an emergency is defined as “a sudden, unexpected occurrence, involving a clear and imminent danger, demanding immediate action to prevent or mitigate loss of, or damage to, life, health, property, or essential public services. ‘Emergency’ includes such occurrences as fire, flood, earthquake, or other soil or geologic movements, as well as such occurrences as riot, accident, or sabotage” (California Public Resources Code, Section 21060.3). Other agencies such as the United States Army Corps of Engineers (USACE), California Department of Fish and Wildlife (CDFW), and California Coastal Zone Commission have definitions for an “emergency” that should be reviewed to determine application to the construction activity proposed.

Initial Agency Contact

The government agency(s) to be contacted depends on the environmental resource (for example, wetlands, streams, or coastal areas) affected by the emergency. If the emergency construction will affect a wetland, stream, lake, or marsh, then USACE and CDFW should be contacted immediately. Other agencies to be contacted may include the Regional Water Quality Control Board (RWQCB) and county and local municipal agencies with jurisdiction over drainage infrastructure and flood control facilities. When an agency is contacted, the following information should be provided:

1. The SCRRA contact person
2. The SCRRA contact phone number
3. What the emergency involved
4. Why it qualifies as an emergency
5. The type and extent of work to be done
6. Exact location of the emergency

Work Plan

After contacting the agencies, a SCRRA contact person should be identified and a work plan and site map prepared. These three items should be prepared and submitted to the agencies as soon as possible. If photographs of the emergency are available, they should be sent to the agencies.

Issuance of Emergency Permits

SCRRA shall notify the appropriate agencies prior to initiating emergency work activities. The notification will include the information identified in Section 23.3.1. The agencies may issue the Notice to Proceed within 24 to 48 hours of SCRRA's submittal of a work plan and site map. The agency notification and, if provided, agency Notice to Proceed must be kept on-site during emergency construction. Emergency repairs in sensitive areas typically require a construction monitor (biologist) to avoid or minimize encroachment into sensitive areas. Generally, SCRRA will be responsible for compensatory mitigation at reduced ratios. All emergency permits and agency conversations where directions were given or decisions were made should be documented, including email correspondence, and entered into the project file.

Supplemental Non-Emergency Work

If non-emergency work is necessary to ensure that the damaged facility is repaired for the long term, then the non-emergency permitting process should be followed, including acquisition of environmental clearances, CEQA/National Environmental Policy Act (NEPA) compliance, and other permits. If the emergency construction does not require additional work, then the project can be closed by documenting how SCRRA complied with the terms and conditions of the emergency construction environmental procedures. All emergency permits and agency conversations where directions were given or decisions were made should be documented, including email correspondence, and entered into the project file.

23.3.2 Non-Emergency Construction Process

If the proposed work is not immediately needed to protect lives and property, then it does not qualify as an emergency and should be conducted as maintenance or program work. This type of work includes repairs, maintenance, retrofit and upgrade of existing infrastructure, new projects, and supplemental work following emergency construction.

Environmental Review

SCRRA's environmental expert, whether an environmental consultant or SCRRA staff member, should review the proposed project and the environmental issues associated with implementing the work at approximately the 5 to 30 percent design phase depending on the project's complexity and geographic location. This initial review should identify which agencies should be contacted, what permits or approvals are potentially required, and the environmental constraints to the proposed work.

Potential Project Modifications

The environmental review may identify issues that require the Chief, Program Delivery to evaluate the significance of those issues relative to project schedule, budget, and operations. For example, if a new siding is planned for an area supporting habitat for an endangered species or wetlands, the Chief, Program Delivery may relocate the siding to avoid the habitat, thereby avoiding the often significant time and cost to prepare a biological assessment or habitat conservation plan and to purchase credits through an authorized mitigation bank or in-lieu fee program. That particular environmental constraint would then be avoided. This stage in the project is the most appropriate and effective time to identify environmental constraints and make project adjustments to avoid or minimize the issue, if possible. The availability of current resource mapping is critical to informing this decision.

Initial Agency Contact/Project Review

Once the appropriate agencies have been identified and project design has progressed to a level that adequately defines the project (5 to 30 percent design phase), then a contact person at the agency should be established and informed of the proposed project and its schedule. This pre-application meeting is generally completed through the submittal of project description information, site photographs, and sensitive species/habitat information. The agencies will review the project at this time and provide comments regarding jurisdiction, permit requirements, and CEQA compliance. Certain permits will not be issued prior to completion of CEQA compliance (see Section 23.4.1 for further discussion of CEQA).

Potential Additional Project Modifications, Mitigation, Monitoring, and Reporting

SCRRA may choose to modify the proposed project in response to agency comments to avoid or minimize environmental impacts. Any unavoidable environmental impacts will need to be mitigated. Mitigation measures generally involve onsite or offsite environmental compensation in the form of habitat creation, dedication, or restoration/enhancement or purchase of credits in an appropriate mitigation bank. Mitigation strategies that propose on-site mitigation within SCRRA ROW will generally be avoided. Where sensitive habitats are being affected or where construction occurs in proximity to a sensitive environmental resource, such as wetlands, least bells vireo, or

California gnatcatcher, a construction monitoring program will likely be required. The monitoring program and reporting requirements will need to be established in coordination with and approved by the applicable jurisdictional agency.

Performance of Work in Accordance with Permits and Approvals

The environmental requirements of the project should be communicated to the Chief, Program Delivery prior to commencement of any construction activities. These requirements should then be communicated to onsite workers through daily “tool box” or “tailgate” meetings or project-specific environmental training. The information conveyed to work crews should include the limitations and conditions of the environmental permits and approvals. These permits and approvals shall be added to the project’s special conditions and included in the contractor specifications to the extent feasible.

Documentation of Work Performed

During construction, the environmental monitor should keep a daily log and obtain photographs documenting that the work was performed in compliance with terms and conditions of all applicable permits. At this time, all close-out documentation should be prepared and submitted to the agencies for their written concurrence that the project was completed in accordance with permit terms and conditions.

23.4 ENVIRONMENTAL PERMITS

Environmental evaluations and permits commonly required for railroad work are discussed below. Table 23-1, located at the end of this chapter, lists typical SCRRA work and potential permits associated with that work.

SCRRA projects are subject to federal, state, and local environmental regulations and guidelines. State-funded projects or projects requiring a permit or approval from a State or local agency are subject to the CEQA. SCRRA projects that are federally funded are subject to NEPA and the implementing regulations of the federal agency (e.g. Federal Transit Administration (FTA) regulations). However, construction of facilities for railroad passenger service within existing railroad and highway ROW is generally exempt from the CEQA and NEPA evaluation process. All SCRRA projects should be reviewed during the planning phase to determine if specific environmental regulations, such as Federal Water Pollution Control Act (National Pollutant Discharge Elimination System (NPDES) [40 CFR 122]), Endangered Species Act (16 United States Code [USC] 1531-1543), and National Historic Preservation Act (36 CFR 800), may regulate the construction process.

23.4.1 California Environmental Quality Act

CEQA applies to projects undertaken, funded, or requiring issuance of a permit by a California public agency (California Public Resources Code, Section 21000; 14 California Code of Regulations [C.C.R.], Section 15000). However, on September 13, 1991, the SCRRA Commission filed a Notice of Exemption with the California State Office of Planning and Research and the County Clerk of the County of Los Angeles authorizing a Statutory Exemption (14 California Administrative Code Section 15260, et seq.) for the “…construction and operation of commuter rail facilities within existing railroad rights-of-way in Los Angeles, Ventura, San

Bernardino, Riverside, Orange, and San Diego Counties.” These activities are exempt from the regulations of CEQA under California Public Resources Code, Section 21080(b)(11) and 14 C.C.R., Chapter 13, Article 18, Section 15275. [**Note: Subject to Revision**]

A project that falls under a statutory exemption is not subject to CEQA even if it has the potential to significantly affect the environment. A copy of the SCRRA Notice of Exemption/Statutory Exemption is provided in Appendix J. [**Note: Subject to Revision**]

For projects conducted outside existing ROW or outside the counties specified in the Statutory Exemption, SCRRA may be subject to CEQA compliance and evaluation. For these projects, SCRRA should consult with a source knowledgeable of both the CEQA process and commuter rail construction and operations.

23.4.2 National Environmental Policy Act

Under NEPA (42 USC 4321; 40 CFR 1500.1), a process was established by which federal agencies must study the environmental effects of their actions “significantly affecting the quality of the human environment.” SCRRA projects that involve a federal agency, either through direct participation, funding, or authorization of a discretionary permit (for example, a Section 404 Clean Water Act permit), may be subject to NEPA evaluation.

The process for complying with NEPA and federal surface transportation statutes is defined in the joint Federal Highway Administration/Federal Transit Administration “Environmental Impact and Related Procedures” (23 CFR 771). The regulation sets forth the agencies' policy of combining all environmental analyses and reviews into a single process. It defines the roles and responsibilities of FTA and its grant applicants in preparing documents and in managing the environmental process within the various project development phases. The principle component of this regulation is discussed below.

Under “Classes of Action” (23 CFR 771.115), applicants intending to apply for federal transit funding should notify FTA at the time a project concept is identified. Once the applicant has furnished sufficient information and documentation, FTA will advise the applicant of the probable class of action and the related level of documentation required in the NEPA process. There are three classes of action:

1. Categorical Exclusion (23 CFR 771.115(b)) – Categorical Exclusions are granted for actions that do not individually or cumulatively involve significant social, economic, or environmental impacts. The projects listed in 23 CFR 771.117(c) and 771.118(c) require little or no construction and involve minimal or no effects off-site. The regulation gives a list of the types of projects that are categorically excluded. Once FTA has determined that a Categorical Exclusion applies, it may act on the application for financial assistance.
2. Environmental Assessment (23 CFR 771.115(c))
3. Environmental Impact Statement (23 CFR 771.115(a))

23.4.3 Federal Clean Water Act, Section 404

The Federal Water Pollution Control Act (Clean Water Act) Amendments of 1972 established the Section 404 Regulatory Program. Under this act, it is unlawful to discharge dredged or fill material into waters of the United States without first receiving authorization (usually a permit) from USACE. The term "waters of the United States" defines the extent of geographic jurisdiction of the Section 404 program. The term includes such waters as rivers, lakes, streams, tidal waters, and most wetlands. A discharge of dredged or fill material involves the physical placement of soil, sand, gravel, dredged material, or other such materials into the waters of the United States. Section 404 regulated activities that have received judicial attention include land clearing; stream channelization; the placing of pilings for bridges and piers; and discharges for converting waters to dry land, for raising bottom elevations, from road construction, and for loss or modification of aquatic habitat.

Avoidance and minimization of impacts on identified wetlands shall be considered carefully during the preliminary engineering and environmental review phase of any proposed SCRRA improvements. Delineation of wetlands and other waters of the United States in the project vicinity and a jurisdictional determination from USACE is recommended early to determine the level of involvement by USACE. Based on the results of the preliminary engineering environmental review phase, a conceptual wetland mitigation report and design may be required. Mitigation, in the form of enhancement of existing wetlands or construction of replacement wetlands to replace specific wetland functions and values lost due to project-related disturbances, will be determined during permit approval.

Section 404 permitting is required for SCRRA projects involving jurisdictional waters of the United States or wetlands. The three primary types of Section 404 permits addressing SCRRA actions are Nationwide Permits, Individual Permits, and Regional General Permits.

<u>Nationwide Permits</u>

Nationwide Permits (NWPs) are preauthorized permits for certain types of activities that are substantially similar in nature and cause only minimal individual and cumulative environmental impacts or would result in avoiding unnecessary duplication of regulatory control exercised by another federal, state, or local agency provided that it has been determined that the environmental consequences of the action are individually and cumulatively minimal. For NWPs, NEPA evaluation has already been completed as part of the preauthorization process. Therefore, no additional NEPA documentation is required. There are two types of NWPs, those that require a preconstruction notification (PCN) and those that do not require notification (non-notifying).

NWPs requiring a PCN are generally not useful for emergency situations although they can be useful for maintenance operations and program work because they take less time to process than Individual Permits, discussed below.

Non-notifying NWPs are most useful for emergency situations because they can be applied immediately. Before applying this permit, SCRRA must be sure that the terms and conditions of the non-notifying NWP are met.

For SCRRA projects, NWP 3, Maintenance, would apply in emergency situations. NWP 14, Linear Transportation Crossing, and NWP 33, Temporary Construction, Access, and Dewatering, generally apply to maintenance operations and program work. USACE reissues the NWPs every five years.

Individual Permits

The basic form of authorization is the Standard Individual Permit (IP). Activities that do not qualify for authorization under the NWP program, discussed above, may qualify for authorization under an IP. Authorization under an IP may be obtained only through application with USACE. These permits are issued for activities that have more than minimal adverse impacts on waters of the United States. The IP process can be lengthy and requires evaluation of alternatives to the proposed discharge, including conducting the project in an upland area. Each permit application involves a thorough NEPA evaluation and review of the potential environmental and socioeconomic effects of the proposed activity, public review, and potential benefits of the discharge. The length of time required to prepare and process an IP makes this permit impractical for emergency construction and many maintenance operations and program work that SCRRA conducts.

Regional General Permits

Like NWPs, Regional General Permits (RGPs) are preauthorized permits for certain types of activities that are substantially similar in nature and cause only minimal individual and cumulative environmental impacts. RGPs are authorized through notice and comment and may be conditioned with requirements for case-by-case reporting or notification. RGPs are available by contacting the local USACE district and requesting the applicable RGPs, if any are in effect. RGPs are typically reissued every five years.

23.4.4 Federal Rivers and Harbors Act, Section 10

The Rivers and Harbors Acts of 1890 (superseded) and 1899 (33 USC 401, et seq.) are administered through the USACE regulatory program. Various sections establish permit requirements to prevent unauthorized obstruction or alteration of any navigable water of the United States. Section 10 (33 USC 403) of the Rivers and Harbors Act covers construction, excavation, or deposition of materials in, over, or under such waters, or any work which would affect the course, location, condition, or capacity of those waters. Activities requiring Section 10 permits include structures (for example, piers, wharfs, breakwaters, bulkheads, jetties, weirs, and transmission lines) and work such as dredging or disposal of dredged material, or excavation, filling, or other modifications to the navigable waters of the United States.

The geographic jurisdiction of the Rivers and Harbors Act includes all navigable waters of the United States, which are defined as “those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce” (33 CFR 329). This jurisdiction extends seaward to include all ocean waters within a zone 3 nautical miles from the coastline (the “territorial seas”). Limited authorities extend across the outer continental shelf for artificial islands, installations, and other devices (see 43 USC 333 (e)).

USACE permits are required to authorize certain structures or work in, or affecting, navigable waters of the United States pursuant to Section 10 of the Rivers and Harbors Act. Certain activities may fall under an authorized NWP or RGP. If this is not the case, an individual Section 10 permit is required. SCRRA projects that require the modification or alterations of flood control projects and/or structures constructed by USACE are subject to a 408 Permission in accordance to 33 USC 408. When required, the issuance of the 408 Permission is required prior to the filing of a PCN under Section 404 of the Clean Water Act.

23.4.5 Navigable Waters

Federal law prohibits construction or repairs that alter clearances of any bridges, dams, dikes, or any other obstruction across navigable waters of the United States unless first authorized by the United States Coast Guard (USCG) (33 CFR 114-115). USCG approves the location and clearances of bridges through the issuance of bridge permits or permit amendments under the authority of Section 9 of the Rivers and Harbors Act of 1899, the General Bridge Act of 1946, and other statutes. This permit is required for new construction, reconstruction, or modification of a bridge or causeway over waters of the United States.

23.4.6 Federal Clean Water Act, Section 402 – National Pollutant Discharge Elimination System

Any SCRRA facility that is currently discharging, or proposing to discharge, waste into any surface water of the state must comply with waste discharge requirements. For discharges to surface waters, the requirements are to obtain a federal NPDES permit from the RWQCB in the project area.

SCRRA facilities that discharge waste into a municipal sanitary sewer system do not need to obtain an NPDES permit. The United States Environmental Protection Agency (USEPA), the State Water Resources Control Board (SWRCB), and the respective RWQCB or local wastewater management agency may require some industries to treat industrial hazardous wastes before such wastes are discharged to a municipal sanitary sewer system. These requirements are available from the local wastewater management agency.

<u>Storm Water</u>

Industrial – SCRRA facilities whose discharges are composed entirely of industrial storm water runoff may be eligible to be regulated under a General Industrial Storm Water Permit issued by the SWRCB rather than an individual NPDES permit issued by the RWQCB. The General Industrial Storm Water Permit regulates storm water runoff from eligible transportation facilities.

General Construction Activity – The SWRCB has adopted a General Construction Activity Storm Water Permit for storm water discharges associated with any construction activity including clearing, grading, excavation reconstruction, and dredge and fill activities that results in the disturbance of at least 1 acre of total land area. For SCRRA construction projects that disturb more than 1 acre of topsoil, SCRRA must complete the NPDES permit process, which includes submitting a Notice of Intent (NOI) to the SWRCB, preparing a Storm Water Pollution Prevention Plan (SWPPP) to be kept on-site during construction, and submitting a Notice of Termination (NOT) to the SWRCB when construction activities and requirements of the permit are complete.

23.4.7 Federal Clean Water Act, Section 401 – Regional Water Quality Control Board

Under the Clean Water Act, Section 401 water quality certification is required for any permit or license issued by a federal agency (USCG Section 10 permits and USACE Section 404 permits) for any activity that may result in a discharge into waters of the state to ensure that the proposed project will not violate state water quality standards. For example, if someone proposes to discharge dredged or fills material into navigable waters of the United States, including wetlands; they must obtain a Section 404 permit from USACE and a Section 401 water quality certification from U.S. EPA. In California, U.S. EPA has delegated this authority to the State Water Resources Control Board (SWRCB) and RWQCB. The USACE Section 404 permit is by far the most common federal permit issued in California that requires a Section 401 certification from the RWQCB. This water quality certification is part of the 1974 Clean Water Act, which allows each state to have input into projects that may affect its waters (rivers, streams, lakes, and wetlands). RWQCBs are responsible for issuing Section 401 certifications in California; unless the project extends across two RWQCBs in which case the SWRCB will issue the certification.

The California EPA SWRCB has issued guidance on Section 401 certification waivers that apply to all RWQCBs. The SWRCB lists the Section 404 NWPs that are exempt from Section 401 certification. An updated listing of NWPs with Section 401 certification waived in California is available from the appropriate RWQCB office.

23.4.8 California Department of Fish and Wildlife, Section 1600

Under Section 1600 of the Fish and Wildlife Code, CDFW regulates the alteration of streams, wetlands, and other waterbodies. Any person, government agency, or public utility proposing any activity that will substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake, or proposing to use any material from a streambed must notify CDFW of such activity before beginning the project.

Generally, the notification applies to any work undertaken within the normal high-water mark of a wash, stream, or lake that contains or once contained fish and wildlife or supports or once supported riparian vegetation.

CDFW provides regular permitting through the processing of a streambed alteration agreement. SCRRA would file a “Notification of Lake or Streambed alteration” form (FW 2023, REV. 01/01/18) and “Project Questionnaire” form (FW 2024) with the local CDFW office. For permitting of emergency construction, CDFW has established a process for emergency notification.

Section 1610 of the Fish and Wildlife Code exempts certain types of emergency work from the notification requirements. Notification is not required before beginning emergency work necessary to protect life and property and/or repair public service facilities necessary to maintain service as a result of a disaster.

All CDFW regions request that applicants notify the applicable regional office within 14 days of beginning emergency construction. Region 5 (South Coast Region) requests that applicants complete and submit its “Notification of Emergency Work” form.

23.4.9 Federal Endangered Species Act, Section 7

The Endangered Species Act (ESA) (16 USC 1531-1543) provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) administer the program and maintain a worldwide list of threatened and endangered species.

The law requires federal agencies, in consultation with USFWS and/or NMFS, to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species. The law also prohibits any action that causes a "taking" of any listed species of endangered fish or wildlife. Likewise, import, export, interstate, and foreign commerce of listed species are all generally prohibited.

Consultation with USFWS and/or NMFS is required for any activity that may affect a federally listed threatened or endangered species, or habitat that has been designated as critical habitat for a listed species. The need for consultation is typically determined during the environmental review and permitting phases of the project and the mitigation measures are identified in the environmental document(s) and permit(s). Depending on the project's potential to adversely affect a listed species, USFWS or NMFS may be required to issue a biological opinion before federal agency approvals or permits are issued.

In limited circumstances, if a plant or animal species is found in the project area that has been added to the list(s) since completion of the environmental review and permitting phases of a project, additional field survey and consultation will be required.

23.4.10 California Endangered Species Act

CDFW administers the California Endangered Species Act (CESA) under Fish and Wildlife Code Sections 2080 through 2085. A permit or approval from CDFW is required whenever an activity may affect state-listed threatened or endangered plant or animal species. The CESA allows for "take" incidental to otherwise lawful development projects. Fish and Wildlife Code Section 2081 (b) and (c) describes the incidental take permit process. The CESA emphasizes early consultation to avoid potential impacts on rare, endangered, and threatened species and to develop appropriate mitigation planning to offset project-caused losses of listed species. Complete requirements and procedures for CESA Incidental Take Permits are found in 14 C.C.R. 783.0-783.8.

The CESA has no provisions for emergency construction that may affect threatened or endangered species; therefore, it is necessary to begin immediate consultation with CDFW whenever an emergency activity may affect such species.

Multiple Species Conservation Plans (MSCPs) and Natural Community Conservation Plans (NCCPs) have been developed by various entities such as cities, counties, and utilities in a number of areas that include provisions for permitting pursuant to the ESA and CESA. Because MSCPs and NCCPs provide for protection and preservation of existing listed species as well as species that may be listed in the future, these MSCPs and NCCPs have the potential opportunity to streamline the permitting process while providing an adequate level of protection. Projects that meet the terms and conditions of these MSCPs and NCCPs and are in the MSCP and NCCP areas can use the MSCP or NCCP to authorize a project if the project proponent becomes a signatory to the MSCP or NCCP and agrees to its terms and conditions.

To be covered under a local MSCP or NCCP, SCRRA will have to apply for coverage through the applicable local jurisdictional (e.g. County or City) via a discretionary permit or similar approval, and, if required, comply with CEQA. Without this level of agency involvement, SCRRA may not be able to take advantage of the conditions of the local MSCP or NCCP.

23.4.11 National Historic Preservation Act, Section 106

The SCRRA system is rich in historic architectural, structural, and archaeological resources, including railroad station buildings and other facilities, railroad appurtenances, bridges, tunnels, engineering works, and recorded archaeological sites. It is essential that SCRRA projects be carried out in a manner that minimizes the potential for harm to such resources, consistent with applicable regulations and guidelines.

Significant architectural and archaeological resources are protected by Sections 106 and 110 of the National Historic Preservation Act (NHPA). The NHPA (16 USC 470) is the primary federal law governing the preservation of cultural and historic resources in the United States. It created the implementing procedures of the Advisory Council on Historic Preservation (ACHP) to evaluate all federal actions that will have an effect on properties listed on or eligible for listing on the National Register of Historic Places. Specifically, Section 106 of the NHPA (16 USC 470(f)) requires that a federal agency involved in a proposed project or activity is responsible for initiating and completing the review process. Section 110 of the NHPA sets out the broad historic preservation responsibilities of federal agencies and is intended to ensure that historic preservation is fully integrated into the ongoing programs of all federal agencies.

Federal actions subject to NHPA review include, but are not limited to, construction, rehabilitation, and repair projects, demolition, licenses, permits (for example, Clean Water Act Section 404 permits), loans, loan guarantees, grants, and federal property transfer. The agency sponsoring one of these activities is required to seek ACHP comments.

Section 106 applies to historic properties such as building sites, districts, structures, and objects. For example, SCRRA structures that are over 50 years old and significantly retain their original design and form and are relatively unique may qualify as a historic property. The Section 106 process requires agencies to identify such properties in advance of actions that may affect the integrity of the structure or site. FTA recently released its Section 106 Program Comment, which could potentially be applied to multiple railroad improvements owned and maintained by SCRRA. Leveraging the Program Comment requires early identification of rail-related historic properties located within the existing ROW and then determining which improvements and activities could be exempted from consideration of their effects.

A determination of eligibility and identification of potential effects is completed during the environmental review. The agency considers the possible effects of the action on the property and resolves any adverse effects through consultation with concerned parties such as the California State Historic Preservation Office (SHPO). Mitigation measures addressing any adverse effects would be specified in the environmental document(s) and recorded in a Memorandum of Agreement (MOA) between SCRRA, FTA, FRA, SHPO, and ACHP, as necessary.

23.4.12 Other Potential Permits and Approvals

In addition to the federal and state regulations discussed above, SCRRA projects will usually require working with local (county and municipal) agencies, particularly for work outside established rail corridors. Cities and counties prepare planning documents (General Plans) that provide guidance for development in a specific area and include relevant Land Use and Zoning regulations.

California Coastal Act

Under the California Coastal Act of 1976 (Division 20, Public Resources Code), construction proposed within the coastal zone (that is, 3 miles seaward and 1,000 yards inland of the high tide line) may be regulated by a Coastal Management Plan administered by the California Coastal Commission (CCC). Development occurring within the coastal zone will require a Coastal Development Permit. Many coastal communities have developed local coastal plans (LCPs). LCP permits may be required from the local agency; otherwise, if there is no LCP, a coastal permit will be required from CCC.

Under the federal Coastal Zone Management Act of 1972 (16 USC 1451-1464), federal or federally assisted projects must be, to the maximum extent possible, consistent with the approved state coastal zone management program (CZMP). A determination of consistency with the approved CZMP is required from the state before federal approval of the project may be granted. This consistency is ordinarily obtained during the preliminary engineering/ environmental review phase of a project.

California Public Utilities Commission

The California Public Utilities Commission (CPUC) ensures that railroad-highway grade crossings are designed, constructed, and properly maintained to ensure public safety. The CPUC Rail Crossings Engineering Section (RCES) engineers investigate and evaluate requests to construct new or modify existing rail crossings. They also investigate train-related incidents that occur at rail crossings and complaints regarding rail crossings safety or conditions. RCES engineers are assigned to territories by county and are responsible for rail crossing matters in those territories. SCRRA will need to file applications with CPUC for new rail crossings and will need to file “General Order 88-B authorization” requests for alterations of existing rail crossings.

County Flood Control Districts

County flood control districts have jurisdiction over many flood control structures that cross SCRRA rail corridors. SCRRA projects that cross but do not affect a flood control structure would receive a Letter of No Objection from the local district; projects that adversely impact a flood control structure may require a flood control district permit. In certain instances, the issuance of a local flood control permit may be predicated by the issuance of a 408 Permission from USACE. Early coordination with the flood control district is recommended to determine the level of involvement from USACE.

Local Zoning

All SCRRA projects and facilities will be planned and designed to comply insofar as practicable with applicable provisions of local zoning ordinances and regulations.

Environmental Justice

Pursuant to Executive Order 12898, Environmental Justice (Federal Register, Vol. 62, No. 72 pp. 18377-18381), procedures set forth in the DOT Final Environmental Justice Order of April 15, 1997, all SCRRA projects and facilities will be planned and designed insofar as feasible to avoid causing disproportionately high and adverse impacts on minority and low-income populations with respect to human health and the environment.

Section 4(f)

The DOT Act of 1966 included a special provision—Section 4(f)—which stipulated that FHWA and other DOT agencies cannot approve the use of land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless the following conditions apply:

- There is no feasible and prudent alternative to the use of land.
- The action includes all possible planning to minimize harm to the property resulting from use.

When a project uses land protected by Section 4(f), a Section 4(f) evaluation must be prepared (23 CFR 771 and 774; 49 CFR 662; FHWA Section 4(f) Policy Paper, March 2005).

23.5 PERMIT CONDITIONS

Agencies granting a permit to SCRRA, or its agent, may grant the application as filed, deny the application as filed, or most likely, grant it subject to terms, conditions, limitations, or modifications of the regulated activity. Such terms may include any reasonable measure that would mitigate the impacts of the regulated activity and that would:

1. Prevent or minimize pollution or other environmental damage
2. Maintain or enhance existing environmental quality
3. In the following order of priority, restore, enhance, and create productive wetland or watercourse resources.

To comply with permit conditions, SCRRA may be required to implement structural engineering controls (discussed below), conduct construction monitoring, or pay in-lieu mitigation fees. In-lieu mitigation fees are often required by agencies to restore, enhance, or create similar habitat through purchase of credits in off-site mitigation banks or restoration programs.

23.6 OTHER ENVIRONMENTAL CONSIDERATIONS

23.6.1 Contamination and Remediation

SCRRA projects may encounter contaminated soil and/or water that will require removal and/or remediation. As soon as information is available about any potential contamination issue, the project plan—scope, schedule, and budget—shall address the required activities for any necessary remediation. The preparation of a Phase I environmental site assessment in accordance with ASTM E1527-13 during preliminary engineering will assist in determining the potential presence of contaminants.

23.6.2 Standards, Codes, and Guidelines

The latest edition of the standards, codes, and guidelines listed in Appendix A shall be used during design of these projects.

There are also Executive Orders providing protection or directing special consideration to preservation of wetlands, floodplains, environmental justice, children's safety, and prevention of invasion by toxic plant species.

23.6.3 Topography, Soils, and Geology

General

Any subsurface testing program for SCRRA must include sufficient test borings to characterize the soils and potential fill materials, including composition and extent. Of primary importance is the identification of unsuitable material or waste in the soil (for example, hydrocarbons). If adverse environmental impacts could result from disturbance of subsurface materials during construction, the subsurface investigation must be adequately comprehensive and include a testing plan that defines the interval, depth, and extent of testing to facilitate the acquisition of data required to develop suitable mitigation measures.

During the investigation, if a test boring encounters an aquifer that could be contaminated by materials falling into the boring; the boring will be backfilled with grout slurry upon completion of boring operations, unless otherwise defined by local regulations.

Soil and Geology

SCRRA is located in a seismically active area. A moderate to major earthquake on any of the major faults in the area during the operational lifetime of the proposed project would subject the project to strong ground shaking. Such ground shaking could result in the failure of structures along the proposed corridor and could disrupt service along the corridor. Actual displacement or fault movement is less likely, but could occur.

The likelihood of a severe earthquake occurring during the construction period is low. However, the possibility does exist and should not be discounted. If the area is subject to a substantial seismic event and associated severe ground shaking during the construction period, the effects of the shaking can be minimized through appropriate construction techniques. All available construction techniques for the safety of workers, pedestrians, motorists, and nearby residents shall be implemented. These measures include shoring and falsework.

Construction over Inactive Landfills

During the preliminary engineering phase, a study will be undertaken to determine if any active or inactive disposal areas or mine dumps fall within the proposed construction areas. If SCRRA improvements are to be constructed on, or close to, an inactive landfill, then the density of the filled area and the presence of methane gas or other potentially harmful gas in the vicinity of the work must be determined. If an inactive landfill is discovered in proximity to new construction, alternative sites should be considered. If alternative sites are not feasible, mitigation measures to prevent such proximate areas from affecting the SCRRA improvements should be implemented.

23.6.4 Floodplains, Hydrology, and Water Quality

Siltation and Runoff

The addition of new SCRRA facilities and drainage improvements could increase the potential for water runoff. An increase in impervious area (e.g. paved surfaces) as a result of construction can lead to reduced infiltration, decreased storm water travel time, and an increase in peak storm water discharges and runoff. Higher storm water discharge rates can, in turn, increase erosion of the project area and the receiving stream, and can contribute to flooding in the area. This potential extends to both the construction and operation phases of the project.

In general, local and state regulations require that the maximum rate of storm water runoff after development be no greater than the rate of storm water runoff before development. This requirement may be met by constructing storm water detention facilities to control the rate of runoff, or by designing the project such that the relationship of impervious surfaces and travel time does not cause the maximum rate of storm water runoff to increase. Guidelines for storm water management can be found in United States Department of Agriculture, Soil Conservation Service, Technical Release 55, “Urban Hydrology for Small Watersheds,” dated June 1986.

Catch basins, curbing, culverts, gutters, and storm sewers shall be constructed as necessary for the permanent control of water runoff during the operation phase of the project. Specific drainage design criteria are provided in this DCM in Chapter 9.0, Drainage and Grading.

Storm water discharges associated with industrial wastes or activities, including construction sites larger than 1 acre require an NPDES permit from USEPA or the RWQCB under the federal Water Pollution Control Act (1972) as amended by the Clean Water Act.

Water quality certification or waiver may be required under Section 401 of the Clean Water Act from the RWQCB.

All projects shall be consistent with the State Non-Point Source Pollution Management Program and the SWPPP.

Water Contamination

Temporary construction impacts on water quality, such as increased turbidity in adjacent streams, can be controlled through implementation of proper erosion and sedimentation control practices. During fish spawning season, discharges to waterways from construction activities may be restricted. Conditions and time constraints affecting construction activities may be set forth in mitigation measures required by USFWS, NMFS (Section 7, Endangered Species Act), the Section 404 (Clean Water Act) permit or Section 1601 (California Fish and Wildlife Code) Agreement (also see Section 20.5, Wetlands). All SCRRA projects shall adhere to the terms and conditions specified in such mitigation commitments, permits, and agreements.

Floodplains

The placement of permanent facilities that increase impervious area and the introduction of fill material into floodplains may affect storage areas for flood waters and alter flooding characteristics along the corridor.

The placement of permanent SCRRA facilities that are within floodplains or that encourage future development within floodplains are subject to Executive Order 11988, as amended by Executive Order 12148 (DOT Order 5650.2, 23 CFR 650, Subpart A, and 23 CFR 771). These Executive Orders apply to construction of all federal or federally-aided facilities that encroach upon or affect the base floodplain, as defined by the Federal Emergency Management Agency (FEMA). An assessment of floodplain hazards with discussion of impacts in the context of preservation of natural and beneficial floodplain values is required during the preliminary engineering/environmental review phase of the project, and a specific finding must be reported in the final environmental document. Coordination may be with FEMA and state and local agencies, such as the RWQCB, CCC, local coastal zone management agencies, and flood control districts, as appropriate.

SCRRA facilities will be evaluated for protection from flooding hazards. All facilities to be located within floodplains will be designed in compliance with the appropriate agency regulations, and these agencies will be afforded an opportunity to review and comment on the design plans for such facilities.

All new bridges and their associated abutments will be designed to maintain or enhance stream flow capacity. During the preliminary engineering phase, hydrologic and hydraulic studies will be undertaken to ensure that design of the improvements will not adversely impact floodways and floodplains.

23.6.5 Vegetation and Landscaping

SCRRA improvements may require removal of some existing vegetation. In these locations, replacement planting will be provided where feasible and appropriate. The placement and types of vegetation and timing for planting, watering, and monitoring will be specified as part of preliminary engineering in a landscaping plan. The landscaping plan will include a master plant list of new vegetation that conforms to the surrounding environment and enhances visual appeal without hindering operation and maintenance of the SCRRA system. Such landscaping plans shall be consistent with the terms and conditions of any mitigation commitments adopted during environmental review, as set forth in any environmental permits obtained, and as required by the LCP or other applicable local planning documents.

23.6.6 Energy

As part of final design, energy conservation features and operating procedures will be evaluated for SCRRA systems. Such features and procedures will be evaluated and, if found practical and cost effective, made part of the normal operations of the SCRRA system.

23.6.7 Noise and Vibration

Standard noise and vibration criteria for commuter rail and rail transit applications were developed for use with new rail alignments in locations that did not previously have such facilities. Because SCRRA construction will usually be on existing, in-service rail alignment corridors, the project does not represent a new noise source, but will create improvements to an existing rail line. Consequently, the noise and vibration criteria are needed only for those locations, if any, where the project alignment deviates substantially from the existing alignment.

For the majority of SCRRA projects where existing in-service alignments are to be used, the standards for changes in noise and vibration levels before and after the project apply. No significant increase in noise levels is anticipated. The installation of new welded rail to replace the existing jointed rail and other programmed improvements are expected to reduce operational noise levels.

Construction Noise and Vibration

The control of noise and vibration during the construction of SCRRA projects is important because residential areas are located close to the railroad in many locations.

FTA and FRA specify a maximum 1-hour daytime Leq limit of 90 dBA for construction noise and an 80 dBA hourly Leq for nighttime construction noise for noise-sensitive areas. For all non-sensitive land uses, such as commercial and industrial uses, FTA and FRA procedures utilize a 100 dBA hourly Leq during day or nighttime construction noise. Vibration limits that are specified for operations will also apply to the construction activities.

In addition, local jurisdictions, such as counties and cities, may have specific noise and vibration criteria for construction activities. Typically, these criteria specify limits for construction noise and vibration levels that are close to sensitive areas. Specific noise control requirements in the construction specifications help reduce noise. While effort should be made to reduce night-time noise impacts, local noise ordinances may not prevent construction or maintenance activities.

Construction activities have the potential of creating significant levels of ground-borne vibration. In cases of extreme heavy construction, activities that have the potential of creating vibration of sufficient amplitudes to cause building damage should be identified and planned for in advance of the activity.

Noise Design Criteria

Noise design criteria are provided for maximum train pass-bys and average noise for a given period of the time. The maximum levels are not dependent on the number of operations or the existing background noise levels; however, average noise levels are directly related to the existing background noise levels. Design noise limits are normally higher for areas with existing high background noise levels compared to areas with low background noise levels.

FTA and FRA guidelines indicate that noise impacts are generally not significant if no noise-sensitive sites are located in the project area. The significance of increasing existing noise levels at noise-sensitive areas would be evaluated by following FTA and FRA procedures to compare the project noise and the existing background noise.

Specific guidelines for preparing noise and vibration impact assessments for rail transit project environmental documents are provided in the FTA publication “Transit Noise and Vibration Impact Assessment,” dated April 1995, and the FRA document “High-Speed Ground Transportation Noise and Vibration Impact Assessment,” dated December 1998. These documents set forth methods and procedures for determining the level of noise and vibration impact from transit projects and for determining what can be done to mitigate such impact.

23.6.8 Community Services

Emergency Vehicle Access

It is possible that SCRRA project construction or operations may temporarily obstruct certain at-grade crossings along the route, thereby increasing the response time of emergency vehicles. To the extent that signalization improvements, temporary detours, or other traffic management strategies can minimize this problem, such improvements shall be considered and implemented where feasible. In addition, the contractor shall be required to provide advance notification of the location, timing, and duration of such construction activities to local emergency service providers. Alternative access routes shall also be identified for concurrence and use by emergency vehicles.

Safety/Security

As with all public facilities, users of the SCRRA system could be subject to crimes against persons and property in vehicles, stations, parking areas, and other public areas created by the system. To minimize this potential, public areas associated with the SCRRA system shall be designed to promote maximum safety and security for patrons. Specific design measures for security shall be employed, including adequate lighting, good visibility, and good pedestrian and vehicle circulation.

Accessibility to Community Services

The placement of ROW fencing for safety may restrict access to some community service facilities, resulting in increased walking distances. To facilitate access to these facilities, existing legal track crossings may be closed or relocated where safety and traffic considerations warrant. In addition, the contractor shall be required to provide advance notification of such access restrictions and shall consult with local community service providers to identify and address their needs.

23.6.9 Visual Quality

Track and Track Support Systems

In general, SCRRA projects involve refurbishment or expansion of existing facilities and are not expected to result in visual incompatibilities. Nonetheless, as part of preliminary engineering design, materials and surface textures for replacement of any aerial structures or elevated track sections will be selected in accordance with generally accepted architectural principles to achieve an effective integration between the track structure and its surrounding environment. Architectural principles and local municipal regulations must also be considered during final design activities.

Area and track lighting fixtures and standards shall incorporate directional shielding where needed to avoid the intrusion of unwanted light and glare into adjacent sensitive land uses, such as residential areas.

Stations

SCRRA projects may involve replacement or refurbishment of existing facilities, such as station platforms, waiting areas, ticketing areas, access walkways, or other facilities, or the construction of new stations. As part of preliminary engineering and final design, all materials, surfaces, fixtures, furnishings, and other elements will be selected in accordance with generally accepted architectural principles to integrate SCRRA facilities with the surrounding environment.

23.6.10 Traffic and Transportation

Every effort shall be made to maintain existing local street capacities and cross vehicle traffic movements. If necessary, revised traffic signalization, the provision of adequate circulation to serve new facilities, and the reconstruction of certain intersections to maintain through and left-turn lanes may be required.

Increases in local traffic congestion could also occur in areas around SCRRA stations. To alleviate this, additional or revised traffic signals or other intersection improvements may be required, as deemed necessary by traffic studies and consultations with local jurisdictions. The project may cause increases in traffic and some traffic delays at grade crossings. Coordination of crossing protection with traffic signal operations, turn restrictions, and changes to roadway cross section or geometry will be evaluated in coordination with the local jurisdictions to reduce this delay.

It is anticipated that these needs, along with needs for expanded station parking areas, if any, will be identified with appropriate mitigation measures in the project environmental document(s). Construction activities for such projects shall be subject to the noise, air quality, water quality, and visual/aesthetic guidelines set forth in other sections of this DCM.

23.6.11 Air Quality

Pursuant to the Clean Air Act Transportation Conformity Rule (23 CFR 771.40), transportation projects in non-attainment and maintenance areas must conform with State Implementation Plans (SIPs) that provide for attainment of National Ambient Air Quality Standards (adopted in the federal Clean Air Act of 1970, as amended). The California Air Resources Board also establishes state air pollution standards that are generally more stringent than the national standards. Project conformity with the Clean Air Act is typically determined during the environmental review. All activities are subject to the regulations of USEPA, California Air Resources Board, and South Coast Air Quality Management District (SCAQMD).

Generally, SCRRA projects are expected to enhance regional air quality by minimizing vehicle miles of travel in the SCRRA service area. Changes to cross roadway geometry or signalization as described above, as well as system facilities for the movement of automobiles (Park-and-Ride, Kiss-and-Ride, etc.), shall be designed to minimize delays and vehicle idling, thereby minimizing contributions to local carbon monoxide, nitrogen oxide, and ozone levels. It is anticipated that if any violations of air quality standards are anticipated from SCRRA projects, the project modifications needed to address them will be identified as appropriate mitigation measures in the project environmental document(s). These project modifications and mitigation measures shall be incorporated into the final design of the project(s).

Construction activities for SCRRA projects may produce temporary air quality impacts that could contribute to violations of national and state standards. Carbon monoxide or ozone precursor emissions from construction equipment or particulate emissions from ground-disturbing activities are of particular concern. The contractor shall be required to be knowledgeable of and shall be required to implement the Best Management Practices, including SCAQMD’s Rule 403, and other mitigation measures identified in the project(s) environmental document(s) to reduce such emissions during construction activities.

TABLE 23-1. ENVIRONMENTAL PERMIT MATRIX

Permit or Approval	Responsible Agency	Applicable Work Activity
Federal		
NEPA	Federal lead agency	NEPA applies to SCRRA projects that involve a federal agency, either through direct participation, funding, or authorization of a discretionary permit (i.e., Section 404 Clean Water Act permit).
Section 404	United States Army Corps of Engineers	A Section 404 permit may be required where an activity affects a jurisdictional wetland or water of the United States. Nationwide Permits 3, 14, and 33 are the most commonly used permits for railroad activities.
Section 10 or 33 USC 408 permission	United States Army Corps of Engineers	Section 10 regulates all navigable waters of the United States, which are defined as "those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce."
Section 9	United States Coast Guard	Section 9 regulates construction, reconstruction, or modification of bridges or causeways across navigable waters of the United States.
Section 7 and 10a (Endangered Species Act)	United States Fish and Wildlife Service	The Endangered Species Act applies to SCRRA activities affecting federally listed threatened and endangered plants and animals and the habitats in which they are found. The Section 7 permit process occurs when a federal agency is involved, and the Section 10 permit process occurs when no other federal agency is involved.

TABLE 23-1. ENVIRONMENTAL PERMIT MATRIX

Permit or Approval	Responsible Agency	Applicable Work Activity
Section 4(f) Evaluation	United States Department of Transportation	Section 4(f) applies to projects affecting land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites.
Section 106	Federal lead agency	Section 106 applies to projects with federal agency involvement that may affect historic properties such as building sites, districts, structures, and objects. For example, SCRRA structures that are over 50 years old and significantly retain their original design and form, and are relatively unique may qualify as a historic property.
State		
CEQA	State or local lead agency	CEQA applies to projects undertaken, funded, or requiring an issuance of a permit by a California public agency. CEQA exemptions that may apply to SCRRA projects include 14 C.C.R. 15269, 15275, and 15303.
Section 402 - NPDES General Industrial Storm Water Permit	State Water Resources Control Board	The General Industrial Storm Water Permit regulates storm water runoff from eligible transportation facilities.
Section 402 - NPDES General Construction Activity Storm Water Permit	State Water Resources Control Board	The General Construction Activity Storm Water Permit regulates storm water discharges associated with any construction activity including clearing, grading, excavation reconstruction, and dredge and fill activities that result in the disturbance of at least 1 acre of total land area.
Section 401	Regional Water Quality Control Board	A Section 401 Water Quality Certification is required for any permit or license issued by a federal agency (USCG Section 10 permits and USACE Section 404 permits) for any activity that may result in a discharge into waters of the state.

TABLE 23-1. ENVIRONMENTAL PERMIT MATRIX

Permit or Approval	Responsible Agency	Applicable Work Activity
Section 1600	California Department of Fish and Wildlife	Section 1600 regulates the alteration of streams, wetlands, and other waterbodies. A Streambed Alteration Agreement may be required for SCRRA projects affecting waters of the state or waters of the United States.
CESA - Incidental Take Permit	California Department of Fish and Wildlife	A permit or approval from CDFW is required whenever an activity may affect state-listed threatened or endangered plant or animal species.
Coastal Development Permit or consistency determination	California Coastal Commission	Construction proposed within the coastal zone (i.e., 3 miles seaward and 1,000 yards inland) may be regulated by a Coastal Management Plan administered by the California Coastal Commission. Development occurring within the coastal zone will require a Coastal Development Permit.
Rail Crossings	California Public Utilities Commission	SCRRA will need to file applications with CPUC for new rail crossings or “GO 88-B authorization” requests for alterations of existing rail crossings.
Local		
Flood Control Permit	Flood Control District	A flood control permit may be required for SCRRA projects affecting county flood control structures.
Special Use Permits	Cities, Counties, Special Districts	For SCRRA projects occurring outside existing rights-of-way, additional city, county, or special district permitting may be required as determined by the local jurisdiction.
Building/Grading Permits	Municipal	For SCRRA projects occurring outside of existing rights-of-way, additional municipal permitting may be required.

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24.0 RIGHT-OF-WAY MAPPING AND SURVEYING

24.1 SCOPE

Design criteria for horizontal and vertical control of facilities within and along SCRRA Right-of-Way (ROW) are discussed below.

24.2 RIGHT-OF-WAY

As it pertains to a railroad, ROW refers to the real property and the improvements within the railroads legally described property boundaries. ROW acquisitions are generally referred to as full acquisitions or as some type of easement, these terms are used to describe the property being acquired. In most cases, railroads will own their land in fee, which gives them the right to sell off the entire interest or in the case of an easement, partial interests to other potential buyers

SCRRA ROW is made up of lengths of land of varying widths that typically increase in width at stations and yards to accommodate the increased real estate footprint that these facilities require. The uniformity of the ROW is sometimes interrupted by the acquisition of private or public parcels of land that adjoin the original ROW.

The width of railroad ROW is dependent on many variables, and the determination of the ROW width at particular locations along a rail corridor is based on the history and chain of title that shaped that corridor. The SCRRA corridor is ROW that originally belonged to the Southern Pacific Railroad (SP), Santa Fe Railroad (now BNSF Railway Company), and Union Pacific Railroad and consisted of both single-tracked and double-tracked corridors. Between 1990 and 1993, SCRAA member agencies acquired 200 route miles from Santa Fe Railroad, over 200 miles from SP, and 59 route miles from UP. Several line changes and curve revisions have occurred along the ROW throughout its history, some of which have been documented and others that have not. And routine maintenance over the years has worked to change the original geometry.

24.2.1 SCRRA Policy

The intent of SCRRA policy on ROW is consistent with safety, maintenance, and operating requirements. The policy intends to eliminate or reduce unnecessary property dispositions for proposed corridor improvements.

SCRRA's general policy on ROW is as follows:

- Preserve existing ROW.
- Renew all existing leases only with the approval of the Chief, Program Delivery.
- Execute any new leases only with the approval of the Chief, Program Delivery.
- Acquire additional ROW for current and potential uses in the future.

SCRRA may work on a partnership basis with local land use authorities in early corridor planning phases to identify properties adjacent to the SCRRA corridor and to explore all appropriate means for acquisition and preservation of those properties.

ROW engineers work in conjunction with the SCRRA member agency Real Estate Department and the SCRRA Engineering and Construction Department to determine existing ROW conditions and assess ROW needs. There is further discussion of this issue in sections below.

As of this writing, SCRRA has 7 routes and 61 stations in service, with 409 unduplicated route-miles traveling through 6 of the 7 southern most counties in California, all but Imperial County.

SCRRA currently references its system wide control network named "SCRRA Geodetic Survey Control Network." It is recommended all control be referenced to this network to maintain consistency throughout the corridor for all improvement projects.

24.2.2 Real Property Transfer

Land can be acquired by actual purchase, in which the purchaser can acquire land in fee simple, or an easement or right of use can be donated or dedicated. An easement may come in the form of an agreement with a local municipality, such as a Franchise Right. Land can also be acquired through eminent domain if a settlement cannot be attained and it can be shown that the acquisition is in the public's interest.

Real property is the interest that a person or entity has in lands, tenements, or hereditaments (inheritable), and also things that are permanent, fixed, and immovable and which cannot be carried out of their places, as land or tenements. This definition pertains to the land, but it also pertains to the rights arising out of or connected to the land.

The transfer of real property or conveyance of private lands between individuals, corporations, or other entities or to or from city or county entities is accomplished by a document known as a deed. There are many different types of deeds, such as grant deeds, quitclaim deeds, corporation deeds, warranty deeds, easement deeds and statutory deeds. These deeds are made public by the filing of such instruments at the County Recorder's Office. The types of instruments used to convey real property to the SCRRA corridor are grant deeds or quitclaim deeds. Located within a set of Valuation Maps are Schedule of Property tables that list property transfers, which occasionally provide the record data of the proper document to find at the County Recorder's Office. Under the Instrument column in these tables are abbreviations to the type of document; for example, B&S stands for Bargain and Sale, QC means quitclaim deed, and other remarks refer to how the land was disposed of or acquired.

<u>Fee Simple</u>

Fee simple or fee simple absolute is an estate where a right or rights to land exist without duration or limitations. This method of acquisition shall be proposed for the purchase of ROW for the construction of permanent surface facilities.

<u>Fee Simple Determinable</u>

Fee simple determinable is an estate where the creator or grantor retains a right or reversion such that should the subsequent owner violate the condition set out in the instrument that created it, the estate could be terminated and recovered.

Easement

An easement is the right of use over the real property of another. The right is often described as the right to use the land of another for a special purpose. Because the term ROW generally refers to an easement (though railroads adopted this phrase to describe their property), those portions of the railroad property that were acquired through an easement are quintessentially ROW.

An easement may be acquired as a permanent or temporary easement. Easements, in the form of Leases, Licenses or Permits shall be proposed for utilities, maintenance accesses, and railroad signal facilities. More permanent use of SCRRA's ROW will take the form of granting an Easement. Temporary construction easements (TCE) shall be proposed for access during construction periods usually for a limited time from the effective date of the order of possession.

SCRRA may grant rights to use its property in two ways, but in both cases retains ownership of the property. In addition to these Criteria, SCRRA Form No. 36, Right-of-Way Encroachment Approval Procedures, should be followed.

1. Granting of a Lease, License or Permit – used for less permanent rights of use including utility crossings, maintenance accesses or other similar encroachments as determined by the SCRRA Real Estate Department.
    a. No legal land description is required. The location of the encroachment needs to be tied to railroad milepost and a fixed object on the railroad such as a bridge end, culvert, or similar railroad feature. California Coordinate System coordinate of boundary corners may be determined by use of GPS, per California Public Resources Codes 8801-8819.
2. Granting of an Easement – used for more permanent rights of use such as crossing of roadways or pedestrian paths either at-grade or grade separated and for construction of such features.
    a. A legal land description is required. In addition to ties with the railroad milepost and a fixed object, a legal description based on field surveying per Section 24.2.4 is required.

SCRRA may also purchase or sell property. In this case a legal land description and plat is required. In addition to ties with the railroad milepost and a fixed object, a legal description based on field surveying per Section 24.2.4 is required.

Franchise Right

A franchise right is a non-transferable privilege to use the real property of another. The grantee of the franchise right does not hold any interest or ownership in the real property. When the real property is no longer in the use of the grantee, the original owner will presume sole right and ownership of the property. The grantee may extend the right to the property with a fee. A franchise right does not require a conveyance to be created. For example, a municipal agency may grant a franchise to a railroad that will give them sole authority to cross a street.

24.2.3 Right-of-Way Requirements

Because ROW plans approved by SCRRA are used as a basis for acquisition of property, all interests and uses required shall be shown on the ROW drawings together with the detailed property dispositions.

The proposed ROW takes shall be based on the project footprint and are influenced by the track alignment, site topography, drainage improvements, structural improvements, service/access roads, utilities, and other required related SCRRA facilities.

ROW is the composite total requirement of all interests and uses of real property needed to construct, maintain, protect, and operate the SCRRA system. Some ROW requirements are temporary, while other ROW requirements are permanent as dictated by operating and maintenance needs. The intent is to acquire and maintain the minimum ROW required consistent with the operating requirements of the SCRRA system.

The existing ROW shall be preserved and additional ROW acquired for potential uses in the future. All existing leases for renewal shall only be renewed after consultation with the Chief, Program Delivery. New leases shall not be executed without prior approval by the Chief, Program Delivery.

It is the responsibility of the ROW Engineer to coordinate ownership boundaries with new ROW requirements and to calculate areas of ownership, ROW requirements, excesses, and remainders as a basis for all ROW maps and descriptions. Because SCRRA's survey control network and its railroad design criteria are based on the California Coordinate System, ROW calculations shall be based on the California Coordinate System. Products, deliverables, and calculations having to do with ROW engineering shall be based on the California Coordinate System, the North American Datum of 1983 (NAD 83) horizontal datum and the North American Vertical Datum of 1988 (NAVD 88) vertical datum as the SCRRA specification. These datum specifications are described and discussed in detail in Section 24.3.1, Survey Control and Geodetic Surveying.

- Boundary Determination – Property boundaries shall be established on the same grid system as new ROW requirements (California Coordinate System) for:
    - Partial acquisition parcels.
    - Total acquisitions with a boundary line coincident with the ROW line.
    - Total acquisitions which include excess.
    - Ownership boundaries shall be located from field survey data and record information in accordance with established legal principles.
    - The underlying fee in an abutting public road will be mapped as part of an ownership as defined above only when it is specifically included in the record description of the property.
- Minor Design Changes

When minor design adjustments are required, a meeting should occur between the Chief, Program Delivery and the ROW Engineer.

Preliminary Right-of-Way Assessment

A Preliminary ROW Assessment is meant to be an elective in-house SCRRA tool or process for assessing property issues during the conceptual stage of proposed improvements. A Preliminary ROW Assessment process is not a boundary survey, nor is it designed to be used in replacement of, or in conflict with, state law and local law regarding boundary surveying. It is a process of examining available property record information in the area of a proposed improvement project. It is designed to produce an early assessment of the potential for property conflicts and the need for property acquisition in order to accommodate the needs of the proposed improvements. A Preliminary ROW Assessment, if requested by SCRRA, shall be performed at the preliminary engineering stage of all projects to identify ROW impacts. The preliminary ROW assessment shall include the following tasks:

1. Secure any title information and title reports as might be available in-house with SCRRA on the subject property.
2. Determine from available in-house recorded or unrecorded deed information, agreements, franchise rights, other rights, easements, or title that SCRRA has along that portion of the railroad corridor adjacent to or within the area of the proposed improvement project.
3. Secure all recorded or unrecorded deeds, rights, or agreements inherited by SCRRA as part of the purchase and sale agreement with SP.
4. Secure all recorded or unrecorded deeds, rights, or agreements inherited by SCRRA as part of the purchase and sale agreement with the State of California.
5. Trace record property transfers to UP as part of the merger with SP. This will require the assistance of a title company.
6. Research public records at the County of the subject property for recorded parcel maps, subdivision maps, records of survey, monumentation maps, and ROW mapping that may have been prepared in and around the subject property, which may influence the location of the subject property.
7. Gather all SP ROW and track mapping, valuation maps, and station maps available in SCRRA's in-house mapping records for original track alignment and parcel configuration information.
8. Research the SCRRA records for all ROW work previously performed in the area of the subject property.
9. Review available in-house SCRRA documentation on lease agreements.
10. Prepare a base map from all of the record information, topographic information and ROW mapping gathered and prepare an electronic file of this record ROW.
11. Prepare the base map and resulting ROW from available record deeds and record mapping and available topographic information.

Right-of-Way Boundary Resolution

ROW boundary resolution shall be performed at the final design stage for projects with definite ROW takes and permanent easements. The ROW boundary resolution shall include the following tasks:

1. Perform a field boundary evidence search and topographic survey of existing possession lines to determine the location of written title documents and recorded maps of adjacent subdivisions and properties in the field.
2. Research available documentation including recorded maps, assessor's information and maps, available title information, recorded deeds, SP valuation maps, and SCRRA conveyance maps to formulate a boundary evidence search plan and subsequent boundary resolution and ROW check.
3. Review Preliminary Record of Survey Map of the SCRRA ROW, if available.
4. Review Preliminary Record of Survey Maps, if available.
5. Resolve geometry of original single-track and/or subsequent double-track alignments to reconcile calls to "centerline of track" in recorded deed documents and title reports.
6. Prepare ROW base maps.
7. Prepare land information packages to assist the title company in searching SCRRA's ownership rights and any adjoining properties deemed necessary to assist in the resolution of SCRRA ROW lines. This procedure assists the title company greatly and minimizes the cost of Preliminary Title Report preparation.
8. Complete field verification of records.

24.2.4 Legal Descriptions

Prior to the preparation of legal descriptions and accompanying plat maps, all proposed parcels for ROW takes shall be coordinated closely with the project team and clearly identified in the ROW exhibit maps for the approval by the SCRRA Real Estate Department. The following documents shall be included in the maps:

- ROW base maps of resolved ROW
- ROW exhibits that clearly define areas of ROW takes
- ROW appraisal maps and record maps

A complete legal description shall consist of two parts, the legal description in writing and the plat map showing the area being described. A legal description submitted without both parts will be considered incomplete unless otherwise agreed upon by SCRRA.

Written Descriptions

There are many ways to describe land, but the type of legal description that is typically used for the SCRRA corridor is of the combination of metes and bounds type. This is a description that uses both written instructions for measurements and direction of travel along with a call for a map.

The other type of legal description used for the SCRRA corridor is a combination of bounds and strip descriptions.

Plat Maps

A plat map as defined by SCRRA is a map or drawing of the land being described in the legal description. The plat map is attached to, and made a part of, the legal description.

A plat map prepared for the SCRRA shall be drawn to scale and shall include, at a minimum, the following information:

- North arrow
- Basis of Bearing
- Legend
- Point of beginning
- Point of commencement, if applicable
- Thicker line indicating the land being described
- Adjoiner record deed or map information
- Relevant record deed or map data on the subject parcel of land
- Adjacent street names, ROW lines, and ROW widths
- Distances and bearings of all lines along the land being described
- Relevant bearings or distances to adjoiners
- Area of described land
- Stamp and signature of the licensed California land surveyor responsible for the map
- Title block
- Date
- Scale
- Title or name of the land being described
- Assigned SCRRA Real Estate Department Parcel Number
- Plat Map prepared on an 8.5 x 11 or 8.5 x 14 format sheet of paper

24.2.5 Right-of-Way Boundary Preservation

SCRRA may work on a partnership basis with local land use authorities in early corridor planning phases to identify under-utilized existing rail corridors or properties and to explore all appropriate means for acquisition and preservation of those corridors or properties. Preserving ROW for commuter rail use can be accomplished through various methods, including:

- Donations
- Dedications

- Transportation impact mitigations
- Advance ROW purchase

Fencing

Access to the SCRRA tracks should be controlled by fencing or other barriers, typically a welded wire mesh fence that is 6’-4” feet high as per ES 5105. Fencing shall be parallel to the track, forming an open-ended envelope and allowing unrestricted movement by SCRRA crews. Fence height shall be reduced to 4 feet within 150 feet of either side of road crossings.

Vehicle service, maintenance, and storage areas shall be secured by perimeter fencing. The size and type of fencing or barrier shall be as determined by site-specific requirements. All construction sites and work areas shall be secured by temporary fences or barricades.

Strategic Planning

The designer should be familiar with the overall strategic plan for the ROW, including potential SCRRA facilities such as additional tracks, stations, and grade separations. There are often additional planned uses such as light rail transit, high speed rail, or expanded freight operation. The current design should consider future plans.

24.2.6 Entering SCRRA Right-of-Way

Right-of-Entry Agreements are required to enter SCRRA operated and maintained ROW to perform investigation, including:

- Site walk
- Site Photography
- Marking out and clearing pothole or boring locations
- Utility Mark-out
- Measurements
- Biological investigations
- Surveying

For these limited activates and for temporary or short-term uses of ROW, such as surveying activities and shallow geotechnical investigations, the highway agency, or contractor, is required to submit “Indemnification and Assumption of Liability Agreement, SCRRA Form No. 5.” Form No. 5 upon approval is the Right-of-Entry for the actions described in the form. For investigation beyond those listed above, or with longer term usage of the ROW see the following paragraph and the use of Form No. 6

To perform work on ROW operated and maintained by SCRRA, Right-of-Entry Agreements are required. For projects involving construction on SCRRA ROW, the public agency or contractor is required to enter into “Temporary Right-of-Entry Agreement, SCRRA Form No. 6.” This agreement defines the nature of the work, the flagging requirements, including RWIC, and the appropriate safety measures that must be in place during the work. This includes all work within the ROW, from initial design through the completion of construction. These agreements are available on the SCRRA website: http//www.metrolinktrains.com.

Railroad ROW, in many cases, is maintained by SCRRA and owned in fee by the member agencies. In most cases, the local public agency takes the lead for land acquisition. The lead Engineer shall properly define the necessary ROW, provide legal descriptions, and work with SCRRA's ROW administrator and the member agency's real estate department, as needed, to forward the process of property acquisition, easement, or preparing a license agreement. In some cases, SCRRA also shares ROW ownership with BNSF Railway Company (BNSF) and Union Pacific (UP). In such cases, in order to perform work on their ROW, approval shall be obtained from BNSF and UP.

The procedures for applying for ROW encroachment and the appropriate forms are found in "Right-of-Way Encroachment Approval Procedures, SCRRA Form No. 36," available on the SCRRA website.

24.3 SURVEYING

Most SCRRA improvements involve rehabilitation and improvement of existing facilities. Supplemental surveys shall be provided for planning and engineering when detail topographic features are not available through aerial maps. Conventional (on the ground) surveying methods shall be used to gather data for supplemental surveys. The products resulting from supplemental surveys are generally topographic maps and digital terrain models (DTMs).

24.3.1 Survey Control and Geodetic Surveying

Survey control establishes a common, consistent network of physical points that are the basis for controlling the horizontal and vertical positions of rail transportation improvement projects and facilities. The survey control network ensures that adjacent projects have compatible control. Furthermore, a precise control network provides consistent and accurate horizontal and vertical control for all subsequent project surveys, including photogrammetric, mapping, planning, design, construction, and ROW.

The following policies, standards, and procedures are applicable to all survey control work for all SCRRA improvement projects. This includes surveys performed by SCRRA in-house survey staff, consultants, local agencies, private developers, and others.

Any new SCRRA Control Network shall employ the principals of geodesy. Surveys employing the principals of geodesy are of high precision and generally extend over large areas, such as the SCRRA corridor, which runs north to south from the City of Lancaster to the City of Oceanside and west to east from the City of Oxnard to the City of The Redlands for a total of 409 unduplicated route-miles. It is important to understand the elements that comprise geodetic surveys in order to understand SCRRA requirements for geodetic surveys along the SCRRA corridor.

Any new SCRRA Control Network also should be established to replace an aging corridor control network. Any control network along this corridor could be by nature linear and therefore presents problems associated with its geometric shape. Any survey network in a corridor shall be planned and performed with this important consideration in mind.

In addition to concerns with the geometry of the network, further planning shall be conducted to accommodate various levels of surveying expertise and instrumentation that may be employed along a corridor. This control network shall be designed to accommodate the 2-D Plane Surveyor and the Geodetic Surveyor as well as the myriad of different surveying instrumentation that a surveyor might employ. This network can accommodate theodolite, total stations, static global positioning system (GPS), radio-transmission-based real-time kinematic (RTK) GPS, long-range RTK GPS, laser scanner systems, and traditional and digital differential levels.

It is important to understand the following elements that comprise this geodetic survey in order to understand a control network. SCRRA currently references it's a system wide control network named "SCRRA Geodetic Survey2010 Control Network." It is recommended all control be referenced to this network to maintain consistency throughout the corridor for all improvement projects.

24.3.2 Horizontal Datums

The SCRRA Control Network is based upon NAD 83, and all geodetic surveying work performed for SCRRA shall adhere to this datum. This is partly because California State Code presently requires surveyors to use NAD 83 as the reference frame for geodetic surveys.

Relative positioning data collected by surveyors can be tied to the NAD 83 datum using a State HARN (High Accuracy Reference Network) or the national CORS (Continuously Operating Reference Stations) network, or calculated from either a HARN or CORS.

24.3.3 Epochs

California survey control points, because of crustal motion between the Pacific and North American Plates, are subject to "shifting" positions on a constant basis. Depending on the type of seismic activity, great horizontal and vertical deformation can occur in monument positions. The published positions of points must be continually updated to account for these shifts or deformations. Depending on the kind of survey being performed and the time frame within which it is performed, thought should be given to the epoch to use for the survey.

SCRRA shall specify which epoch was used as the basis for all geodetic survey performed on its ROW when required by a project or survey.

24.3.4 The Geoid

SCRRA specifies the use of the geoid (Geoid 12B) to be used in the processing and adjusting of geodetic survey data while performing geodetic surveys along its corridor.

This geoid is available to users to download on the NGS website.

24.3.5 Vertical Datums

Vertical project control surveys shall be based on a single, common vertical datum to ensure that various phases of a project are consistent. The vertical datum for SCRRA projects shall be NAVD 88, as established by NGS. All scopes of services developed for SCRRA shall be specified as on the NAVD 88 vertical datum. Control surveys performed for SCRRA will use NAVD 88 benchmarks, either new or adjusted, as the basis for their survey work

A full report of the vertical control used to vertically constrain a control network, such as a printout from a least squares adjustment report is to be included in the deliverables of any control project performed for SCRRA.

All vertical project control shall be accurate to within +/- 1/8 inch (0.01 foot) or within third-order accuracy specifications per the Caltrans Surveys Manual (CSM), Chapter 8, Differential Leveling Survey Specifications. The CSM contains valuable policies, standards, and procedures and are the basis for this section only. CSM Table 8-2, Third Order Differential Leveling Specifications, is reproduced in Table 24-1. If +/- 1/16 inch (0.005 foot) is required, Caltrans second-order leveling specifications should be used. These are more stringent measures and require substantially more effort to achieve the +/- 1/16-inch (0.005-foot) acceptable tolerances. CSM Table 8-1, Second Order Differential Leveling Specifications, is reproduced in Table 24-2.

Additional information on Caltrans' second- and third-order survey accuracy standards is provided in CSM Chapter 5, Accuracy Classifications and Standards. The CSM is available online at http://www.dot.ca.gov/landsurveys/surveys-manual.html.

TABLE 24-1. THIRD ORDER DIFFERENTIAL LEVELING SPECIFICATIONS

Operation/Specification	Compensator-Level Three-Wire Observation	Compensator-Level Single-Wire Observation	Electronic/Digital Bar Code Level
Difference in length between fore and back sights, not to exceed per setup	33 feet	33 feet	33 feet
Cumulative difference in length between fore and back sights, not to exceed per loop or section	33 feet	33 feet	33 feet
Maximum sight lengths	300 feet	300 feet	300 feet
Minimum ground clearance of sight line	1.6 feet	1.6 feet	1.6 feet
Maximum section misclosure	0.06 feet *x* (√D) *(See Note 2)*	0.06 feet *x* (√D) *(See Note 2)*	0.04 feet *x* (√D) *(See Note 2)*
Maximum loop misclosure	0.06 feet *x* (√E) *(See Note 3)*	0.06 feet *x* (√E) *(See Note 3)*	0.04 feet *x* (√E) *(See Note 3)*
Difference between top and bottom interval not to exceed:	.30 of rod unit	N/A	N/A
Collimation (Two-Peg) Test	Daily (not to exceed 0.007 feet) *(See Note 4)*	Daily	Daily

TABLE 24-1. THIRD ORDER DIFFERENTIAL LEVELING SPECIFICATIONS

Operation/Specification	Compensator-Level Three-Wire Observation	Compensator-Level Single-Wire Observation	Electronic/Digital Bar Code Level
Minimum number of readings. (Use repeat measure option for each observation)	N/A	N/A	3 *(See Note 5)*

Notes:
1 Leveling staff in backlit condition may decrease maximum sight distance.
2 *D* = Shortest one-way length of section in miles (section is defined as a series of setups between two permanent control points).
3 *E* = Length of loop in miles (loop is defined as a series of setups closing on the starting point).
4 Readjust level if 0.007 feet in 200 feet is exceeded.
5 If the standard error of the mean exceeds 0.0003 feet, continue repeat measurements until the standard error of the mean is less than 0.0003 feet.

TABLE 24-2. SECOND ORDER DIFFERENTIAL LEVELING SPECIFICATIONS

Operation/Specification	Compensator-Level Three-Wire Observation	Electronic/Digital Bar Code Level
Difference in length between fore and back sites, not to exceed per setup	16 feet	16 feet
Cumulative difference in length between fore and back sights, not to exceed per loop or section	33 feet	33 feet
Maximum sight lengths	230 feet	230 feet
Minimum ground clearance of sight line	1.6 feet	1.6 feet
Maximum section misclosure	0.04 feet x ($\sqrt{D}$) *(See Note 2)*	0.04 feet x ($\sqrt{D}$) *(See Note 2)*
Maximum loop misclosure	0.04 feet x ($\sqrt{E}$) *(See Note 3)*	0.04 feet x ($\sqrt{E}$) *(See Note 3)*
Difference between top and bottom interval not to exceed:	.20 of rod unit	N/A
Collimation (Two-Peg) Test	Daily (not to exceed 0.003 feet) *(See Note 4)*	Daily
Minimum number of readings. (Use repeat measure option for each observation)	N/A	3

Notes:
1 Leveling staff in backlit condition may decrease maximum sight distance.
2 *D* = Shortest one-way length of section in miles (section is defined as a series of setups between two permanent control points).
3 *E* = Length of loop in miles (loop is defined as a series of setups closing on the starting point).
4 Readjust level if 0.003 feet in 200 feet is exceeded.
5 If the standard error of the mean exceeds 0.0003 feet, continue repeat measurements until the standard error of the mean is less than 0.0003 feet.

Pertinent sections of the CSM were adopted below. This guideline will state and list third-order procedures only.

24.3.6 Precision and Accuracy

Precision is the degree of refinement in the performance of an operation (that is, in procedures and instrumentation) or in a statement of the results. The term ‘precise’ is also applied to the methods and equipment used in attaining the results of a high order of accuracy survey, such as using a 3-wire leveling method or using a one-second theodolite. The more precise the survey method is, the higher the probability that the survey results can be repeated. However, survey observations that have a high precision can also be inaccurate. For example, observing with a poorly adjusted instrument will make the survey inaccurate. The actual precision is governed by the accuracy of the source data and the number of significant figures that can be relied on rather than the number of decimal places.

The accuracy of a field survey depends directly upon the precision of the survey methods and equipment. Although by chance, some surveys with a high order of accuracy might be attained without a high order of precision; but such accuracies are not valid.

<u>Least Squares Adjustment</u>

Baselines generated during geodetic surveys shall be adjusted using a minimally constrained adjustment to check the measurement data and verify that the survey meets Federal Geodetic Control Subcommittee (FGCS) criteria and SCRRA specifications for Primary and Secondary Control Networks. A full report of this minimally constrained adjustment shall be included in the deliverables of any geodetic control project performed for SCRRA.

After field measurements are taken, an office analysis shall be performed and the data entered into a least squares adjustment software package, whether collected by levels, total stations, or GPS instruments. To be performed correctly, the adjustment is a two-part procedure. First, an unconstrained, free, or minimally constrained adjustment shall be done allowing the new observations to be analyzed, their quality determined, and errors detected. Second, a fully constrained adjustment shall be performed that fits the observations to the reference system, epoch, and unit measurements specified, thereby determining the values of the points observed. Supplied project control values shall be verified against published values, and level networks shall consist of properly formed closed loops that contain a minimum of two reference elevation checks.

24.3.7 Monumentation

Monuments shall be located along rail transportation corridors in secure locations. The monument site shall be selected with the highest safety considerations as a priority for the surveyor and given the highest priority.

Whenever possible, monument locations that can be easily described should be selected. Identifying stamping shall be noted. When several locations are equally satisfactory, the one that is near features that will aid in future monument recovery should be selected and the distance ties noted in the field book.

Benchmarks shall be of a stable and permanent nature. Monument types for benchmarks shall be chosen to suit the local conditions. Acceptable benchmarks are as follows:

- Concrete monument with metal disk
- Galvanized steel pipe with brass disk or plastic plug
- Steel rod or rebar with cap
- Metal disk epoxied in rock mass or bridge abutment
- Existing stable monuments

Control point monuments, in accordance with SCRRA Engineering Standards, shall be set at locations where the base will be very stable such as concrete bridge abutments, concrete wing walls, tops of concrete channel walls, concrete platforms, etc. and outside the rail corridor so as to avoid disturbance or obliteration due to construction projects taking place along the corridor.

Each control point and the corresponding monument will be established in an area where obstructions, electromagnetic fields, radio transmissions, and multipath environments are minimized and shall be occupied twice for two independent collection sessions. The second occupation of the new control point will have a minimum of 3 different satellites in the satellite constellation. This is achieved by observing 4 hours before or 4 hours after the time of day from the first occupation. Satellite geometry affects both the horizontal coordinates and the heights of points. The factors to be considered for the Control Network are Positional Dilution of Precision (PDOP), Geometric Dilution of Precision (GDOP); Vertical Dilution of Precision (VDOP); using a fixed height survey rod with locking pins and bipod/tripod; and standard methods of data transfer links.

24.3.8 Mileposts

Surveys and mapping will include the milepost location in addition to stationing. Project drawings and ROW mapping will be used to update track charts, which are accurate to 0.01 mile.

Stationing should be in the same direction as the mileposts. The mile posts and stationing for any project shall be based on the information used by SCRRA as shown in the Track Charts. Milepost sign markers are frequently moved or relocated, so they are not to be used as precise reference marks.

24.3.9 California State Plane Coordinates

Surveys performed for SCRRA shall be on the California Coordinate System, NAD83 (CCS83) in conformance with the California Public Resources Codes 8801 - 08819.

Conversions between geodetic (lat/long) coordinates and CCS83 coordinates are normally made using a computer program. The program can also calculate a convergence angle and combined grid factor for each position. Though grid factors will differ from point to point because of a change in elevation and latitude, as a general rule, a mean grid factor should be selected for each project. This policy will usually cause no appreciable loss in accuracy and will eliminate confusion caused by multiple grid factors. However for high-order control surveys, where the elevations of points vary significantly, or for projects extending large north/south distances, assigning more than one grid factor may be appropriate. The State Plane Coordinate System was developed to provide a common reference system for surveyors and mappers. This conformal mapping system had a maximum scale distortion of one part in 10,000. To maintain an accuracy of one part in 10,000, it was necessary to divide many states into zones. Each zone has its own central meridian or standard parallels to maintain the desired level of accuracy. Zone boundaries follow county boundaries.

The State of California is comprised of six zones, all utilizing the Lambert Conformal Conic Projection. The SCRRA corridor lies within two zones. Zone V covers six counties, which include Ventura, Los Angeles, San Bernardino, Kern, San Luis Obispo and Santa Barbara and Zone VI covers four counties, which include Orange, Riverside, Imperial and San Diego.

Survey work performed for SCRRA shall be based on either of these zones. Where the survey overlaps into two zones, the zone where the majority of the survey occurs is the zone that should be used. CCS83 coordinates for one zone can be easily converted to coordinates of a second zone by first converting to geodetic coordinates and then converting to CCS83 for the second zone.

24.3.10 Aerial Mapping and Photogrammetry

Mapping prepared for SCRRA shall be in conformance with National Map Accuracy Standards (NMAS). SCRRA may require a report of the checks that were made to verify that the mapping is in compliance with these standards, and this report may be requested at any time, including as part of deliverables.

Horizontal Accuracy

For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, as measured on the publication scale. As an example, a map with a published scale of 1”=100’ or (1:1,200), 90 percent of the measured checkpoints or mapped features should have a residual of no more than 100.0/30 feet or 3.33 feet.

For maps on publication scales of 1:20,000 or smaller, not more than 10 percent of the points tested shall be in error by more than 1/50 inch, as measured on the publication scale. As an example, a map such as the USGS quarter quads published with a scale of 1:24,000 or (1”=2,000’), 90 percent of the measured checkpoints or mapped features should have a residual of no more than 2,000.0/50 ft or 40.0 ft.

These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as benchmarks and property boundary monuments; intersections of roads, railroads, etc.; and the corners of large buildings or structures (or center points of small buildings).

In general, a point that is well defined is plottable on the scale of the map within 1/100 inch. Thus, while the intersection of two roads or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would not be practicable within 1/100 inch.

Similarly, features not identifiable on the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely on the map. This would include timber lines and soil boundaries.

Table 24-3 shows the standard for some common map scales. The conversion of paper maps into digital data usually creates additional error.

TABLE 24-3. AERIAL MAPPING ACCURACY

HORIZONTAL ACCURACY EXAMPLES		
Scale	**Engineering Scale**	**National Map Accuracy Standard**
1:480	1”=40’	+/- 1.33 feet
1:600	1”=50’	+/- 1.67 feet
1:1,200	1"=100'	+/- 3.33 feet
1:2,400	1"=200'	+/- 6.67 feet
1:4,800	1"=400'	+/- 13.33 feet
1:9,600	1"=800'	+/- 26.67 feet
1:12,000	1"=1000'	+/- 33.33 feet
1:24,000	1"=2000'	+/- 40.00 feet

Vertical Accuracy

Vertical accuracy as applied to contour maps on all publication scales shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown on it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be conducted by the producing consultant or by SCRRA. SCRRA shall also determine which of the maps are to be tested and the extent of the testing.

Published maps meeting these accuracy requirements shall note this fact in their legends, as follows: "This map complies with National Map Accuracy Standards."

Published maps whose errors exceed those as previously stated shall not make any mention of standard accuracy in their legends.

When a published map is a considerable enlargement of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."

Aerial Mapping and Photography

SCRRA does not have specific requirements in aerial mapping and photography except that any mapping shall adhere to NMAS, shown in detail above. However, SCRRA understands that these accuracies are map-sheet based. SCRRA understands that while it asks for adherence to NMAS, often the interpretations of these standards are misunderstood and that the Chief, Program Delivery should examine each potential consultant photogrammetrist's interpretation of NMAS so that the expectations of the final mapping product are met. In addition, accuracy standards vary in complexity and usability, and it is best that a discussion with the photogrammetrist take place regarding accuracy specification that would best suit the needs and budget of the project.

The concept of map standards and the statistics behind them can cause much confusion for contracting agencies. It should be understood that while some of these standards complement each other, mixing them within the same statement is counterproductive. Here is a typical example found within Requests For Proposals: "Data to be compiled to meet or exceed a horizontal accuracy of +/- 2 feet RMSE (root mean squares error) at a 95-percent confidence level (1"=200' map accuracy)." A statement written like this does not correctly describe the intended accuracy requirement. A vendor could interpret the 2-foot RMSE reference to mean that 67.6 percent of the data must meet the 2-foot accuracy figure, while the remaining 32.3 percent of the data can have errors as large as two to three times the RMSE, or 4 to 6 feet. If the statement was meant to indicate a 2-foot accuracy with a 95-percent confidence level, the agency will be asking the vendor to provide a dataset whereby 95-percent of the data is accurate to 2 feet, while ONLY 5 percent may have an error in the excess of 4 to 6 feet. The difference between the two stated requirements is too large to not be clarified and confirmed.

It is important to understand that the above reasoning and the given figures do not mean that the accuracy requirements at 95-percent confidence is better than the RMSE, it is just a different way to represent the rejection criteria and the threshold. If the agency were correct in expressing their requirement, their statement would be as follows: "Data to be compiled to meet or exceed a horizontal accuracy of +/- 2 feet RMSE or 3.46 feet at a 95-percent confidence level according to the National Standard for Spatial Data Accuracy (NSSDA) standard necessary for 1"=200' maps." In this case, the agency will be in a better position regarding the delivered products as 67.7 percent of the data will have maximum errors of 2 feet while 95-percent of the data will have maximum errors of 3.46 feet. The two terms in the new accuracy statement do not contradict each other; they just provide two different measures of confidence levels and error threshold.

The most commonly used data accuracy standards for county and municipal mapping applications are the American Society of Photogrammetry and Remote Sensing (ASPRS) Class I and II. In addition, an increasing number of counties and municipalities, such as the Peninsula Corridor Joint Powers Board (PCJPB), are requesting that their mapping projects be compliant with NMAS for large-scale mapping.

ASPRS developed new accuracy standards for large-scale maps (generally 1"=1000' and larger [for example, 1"=200', 1"=100', etc.]), which look at continuous datasets (not map-sheet based) from a statistical perspective (the root mean square error [RMSE]) and therefore are considered more stringent. In terms of RMSE (like the ASPRS standards), NMAS generally equates to ASPRS Class 1.5.

Mapping Scale and Application

Table 24-4 depicts various mapping scales and their applications.

TABLE 24-4. MAPPING SCALES

Map Scale	Contour Interval	Mapping Application
1"= 20'	1 foot	Grade Crossing, Bridge, and Station Sites for Final Design
1"= 40'	2 foot	Standard Maps for Engineering Design (PE and PS&E)
1"= 100'	5 foot	Standard Maps for Environmental Studies, Feasibility Studies, Planning, and Conceptual Engineering
1"= 200'	10 foot	Corridor Studies

Orthophotography

In digital orthophotography, pixel resolution correlates with map scale. Table 24-5 gives a general guidance of the pixel resolution as it correlates with various map scales. These correlations are typical, and the needs of the project may dictate a higher or lower level of output pixel resolution.

TABLE 24-5. PIXEL RESOLUTION SCALES

Target Map Scale		Orthophoto
1 in = x ft	**Ratio, ft/ft**	**Pixel Res. (ft)**
40	1:480	0.20
50	1:600	0.25
100	1:1,200	0.5
200	1:2,400	1.0
400	1:4,800	2.0

24.3.11 Supplemental Engineering Surveys

Supplemental engineering surveys shall be provided for planning and engineering design when detailed topographic features are not available through aerial maps. The products resulting from supplemental engineering surveys are generally topographic maps and DTMs. Conventional (on the ground) surveying methods shall be used to gather data for supplemental engineering surveys. The standards, procedures, and general information for performing conventional engineering surveys using the Total Station Survey System (TSSS), GPS, and differential leveling are provided below.

Planning

Planning begins with a meeting between the Project Surveyor and the Chief, Program Delivery to discuss the proposed survey request. From a planning perspective, an important part of this meeting is obtaining information about anticipated future related survey requests for the project. Consideration of future ROW surveys and construction surveys should be part of the planning process so that the most efficient survey work plan for the overall project can be formulated.

A work plan for supplemental engineering surveys shall be prepared by the Project Surveyor. This work plan shall contain the following:

- A survey request approved by the Chief, Program Delivery
- A list of the required deliverables
- A schedule for the requested project surveys, including critical milestones

Topographic Surveys

Topographic surveys are used to determine the configuration of the surface of the project site and the locations of all natural and manmade objects and features. The deliverables of topographic surveys, including topographic maps and DTMs, are the basis for planning studies and engineering designs.

A DTM is a representation of the surface of the project site using a triangulated irregular network (TIN). The TIN models the surface with a series of triangular planes. Each of the vertices of an individual triangle is a coordinated (x,y,z) topographic data point. The triangles are formed from the data points by a computer program, which creates a seamless, triangulated surface without gaps or overlaps between triangles. The standard program for generating the DTM shall be AutoCAD Land Development Desktop Civil Design.

The topographic surveys shall include the following items along the railroad corridor:

- Track centerline and profile, which shall include at least 200 feet beyond project limits
- Roadway surveys, which shall include at least 200 feet on each side of the proposed roadway ROW lines
- Items such as switch points, point of frogs, joints at project limits, joints at control points, signal facilities, and communication line locations

Most of SCRRA’s projects involve rehabilitation and major improvements of existing facilities. For these projects, elevations of existing topographic features including top of rail, top of pavement, and utilities are often required to develop accurate plans, specifications, and estimates. As a result, surveyors need to carefully select methods and procedures for conducting the survey work to obtain accurate data.

Utility Surveys

Utility surveys are used to locate existing utilities for the following purposes:

- Basis for planning and design
- Relocations of impacted utilities
- Acquisition for utility easements and/or ROW
- Information for coordination and negotiation with utility companies

Survey limits and types of utilities to be located should be shown on the survey request and/or its attachments. The field survey file should include all utility maps and drawings and descriptions of easements.

It is important to locate all significant utility facilities. The following are typical facilities and critical points to be located for various utilities; potholing shall be considered to verify locations of critical utilities:

- Oil and Gas Pipelines
    - Intersection point with centerlines and/or ROW lines
    - For lines parallel to ROW, location ties necessary to show relationship to the ROW lines
    - Vents
    - Angle points
    - Meter vaults, valve pits, etc.
- Water and Sewer Lines
    - Intersection point with centerlines and/or ROW lines
    - For lines parallel to ROW, location ties necessary to show relationship to the ROW lines
    - Manholes, valve boxes, meter pits, crosses, tees, bends, etc.
    - Elevation on waterlines, sewer inverts, and manhole rings
    - Fire hydrants
    - Curb stops
- Overhead Lines
    - Supporting structures on each side of roadway with elevation of neutral or lowest conductor at each centerline crossing point
    - On lines parallel to roadway, supporting structures that may require relocation, including overhead guys, stubs, and anchors

- Underground Lines
  - Cables/lines (denote direct burial or conduit, if known), etc.
  - Manholes, pull boxes, and transformer pads
  - Crossing at centerline or ROW lines
  - For lines parallel to ROW, location ties as necessary to show relationship to the ROW lines

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25.0 QUIET ZONE IMPLEMENTATION

25.1 SCOPE

The Federal Railroad Administration (FRA) published its Final Rule governing the use of locomotive horns at public Highway-Rail Grade Crossing under regulatory provisions contained in Title 49 of the Code of Federal Regulations (CFR) Part 222 effective June 24, 2005. The Final Rule was amended in August 17, 2006 with an effective date of September 18, 2006. By this law, train crews must sound the train's horn when approaching an at-grade crossing. Responding to the concerns of communities adjacent to railways, the Final Rule included a methodology for establishing, maintaining, and enforcing Quiet Zones where the train's horn would not need to be routinely sounded if highway-rail crossings meet certain safety conditions. The Final Rule facilitates the development of Quiet Zones, requiring the implementation of Supplemental Safety Measures (SSMs) or Alternative Safety Measures (ASMs), so as to maintain safety at highway-rail crossings where locomotive horns have been silenced.

SCRRA desires to cooperate with public authorities, such as municipalities or joint-powers agencies, that wish to pursue and establish Quiet Zones. SCRRA also places importance on the quality and timeliness of service to its customers and the communities it serves. As such, consistent with the Final Rule, SCRRA will seek to encourage communities requesting Quiet Zones to implement the safety enhancements needed while minimizing the impact on railroad operations. SCRRA will not apply for Quiet Zone(s). This is the responsibility of the public authority. SCRRA will require the public authority to cover maintenance costs of any additional safety features that are required at the crossing such as exit gate(s), etc. This will be fully defined in the Construction & Maintenance Agreement. The public authority will also be required to assume all liability at the crossing.

This chapter has been developed to communicate criteria for public authorities that wish to establish a Quiet Zone under the Final Rule impacting the SCRRA system.

25.2 DEFINITIONS

25.2.1 Alternative Safety Measures (ASM)

A safety system or procedure, other than an SSM, which is provided by the appropriate traffic control authority or law enforcement authority and which, after individual review and analysis by the Associate Administrator, is determined to be an effective substitute for the locomotive horn in the prevention of highway-rail casualties at specific Highway-Rail Grade Crossings. Alternative Safety Measures, as defined by the Final Rule, include modified SSMs and non-engineering SSMs.

25.2.2 Channelization Devices

A traffic separation system made up of raised longitudinal channelizers, with vertical panels or tubular delineators that are placed between opposing highway lanes. Channelization Devices are designed to alert and guide traffic around an obstacle or to direct traffic in a particular direction. "Tubular markers" and "vertical panels," as described in the CA MUTCD, are acceptable channelization devices.

25.2.3 Diagnostic Team

A joint design team that provides input on proposed modifications to existing crossings or proposed features of new public road crossings. Knowledgeable representatives of parties of interest in a Highway-Rail Grade Crossing, organized by the Public Authority responsible for that crossing, who, using crossing safety management principles, evaluate conditions at a grade crossing to make determinations or recommendations for the Public Authority concerning safety needs at that crossing in accordance with Part 8 of the CA MUTCD. The team includes representatives of the CPUC, all railroads that operate trains at the crossing and the Public Authority. Diagnostic Teams that are intended to address a proposed Quiet Zone must also include a representative of the FRA and must follow the form and content of the Diagnostic Team checklist as defined in the Final Rule. SCRRA representatives are typically from the Engineering and Signal Departments.

25.2.4 Locomotive Horn

An air horn, steam whistle, or similar audible warning device, as defined in 49 CFR 229.129, mounted on a locomotive or control cab car. The terms “locomotive horn”, “train whistle”, “locomotive whistle”, and “train horn” are used interchangeably in the railroad industry.

25.2.5 Nationwide Significant Risk Threshold (NSRT)

A number reflecting a measure of risk, calculated on a nationwide basis, which reflects the average level of risk to the motoring public at public Highway-Rail Grade Crossings equipped with flashing lights and gates and at which locomotive horns are sounded. The NSRT represents a statistical benchmark used during the Quiet Zone establishment process as a comparative measure to evaluate a Quiet Zone Risk Index. The NSRT is periodically revised by the FRA.

25.2.6 Public Highway-Rail Grade Crossing

A location where a public highway, road, or street, including associated sidewalks or pathways, crosses one or more railroad tracks at grade. If a Public Authority maintains the roadway on both sides of the crossing, the crossing is considered a public crossing per the Final Rule.

25.2.7 Quiet Zone

A segment of a rail line, within which is situated one or a number of consecutive public highway-rail crossings at which locomotive horns are not routinely sounded.

25.2.8 Quiet Zone Risk Index (QZRI)

A measure of risk to the motoring public which reflects the Crossing Corridor Risk Index for a Quiet Zone, after adjustment to account for increased risk due to lack of locomotive horn use at the crossings within the Quiet Zone (if horns are presently sounded at the crossings) and reduced risk due to implementation, if any, of SSMs and ASMs with the Quiet Zone.

25.2.9 Risk Index with Horns (RIWH)

A measure of risk to crossing users when locomotive horns are routinely sounded at every public Highway-Rail Grade Crossing within a Quiet Zone. The Risk Index With Horns is determined by adjusting the Crossing Corridor Risk Index to account for the decreased risk that would result if locomotive horns were routinely sounded at each public Highway-Rail Grade Crossing.

25.2.10 Supplementary Safety Measure (SSM)

A safety system or procedure established in accordance with the FRA, which is provided by the appropriate Public Authority responsible for safety at the Highway-Rail Grade Crossing that is determined by the Associate Administrator to be an effective substitute for the locomotive horn in the prevention of highway-rail casualties.

25.2.11 Wayside Horn

A stationary horn located at a highway rail grade crossing, designed to provide, upon the approach of a locomotive or train, audible warning to oncoming motorists of the approach of a train.

25.3 ROLES AND RESPONSIBILITIES

25.3.1 Public Authority

A Public Authority seeking to establish a Quiet Zone within its jurisdiction shall establish Quiet Zones that are consistent with the provisions of the FRA's Final Rule. If a proposed Quiet Zone includes public Highway-Rail Grade Crossings under the authority and control of more than one Public Authority (such as a county road and a State highway crossing the railroad tracks at different crossings), both public authorities must agree to establishment of the Quiet Zone, and must jointly, or by delegation provided to one of the authorities, take such actions as are required by FRA regulations.

The Public Authority shall submit all documentation to the SCRRA and others as required by §222. Public Authority shall establish a Quiet Zone either based on Public Authority designation [§222.39(a)] or Public Authority application [§222.39(b)].

Public Authorities are encouraged to contact and work with SCRRA and other affected parties from the beginning of the planning of the Quiet Zone to the end of construction for the railroad issues affecting SCRRA operated and maintained services.

25.3.2 SCRRA

SCRRA will facilitate the Quiet Zone application process by assisting the Public Authority and coordinating with the necessary parties throughout the application process.

SCRRA shall review Preliminary and Final Designs submitted by Public Authority at the expense of the Public Authority. SCRRA shall participate in Diagnostic Team evaluation meetings arranged by Public Authority as per §222.25(b), §222.27(b).

SCRRA shall prepare, submit and execute a Design Services Agreement (DSA) and/or C&M Agreement between SCRRA and Public Authority for alterations to the Highway-Rail Grade Crossings located in the proposed Quiet Zone. This agreement will include:

- detailed work description
- method of payment
- responsibility

  - design
  - construction
  - funding
  - maintenance
- cost estimates of railroad design
- construction
- maintenance costs
- inspection costs
- flagging costs
- form, duration, and amount of insurance
- liability at the public, private, and pedestrian crossings
- Agency cost for support to Public Authority during design and construction
- Agency cost for PTC updates

SCRRA shall submit invoices to the Public Authority for the incremental cost of maintenance of enhancement to the active Highway-Rail Grade Crossing warning system installed for the purpose of creating a Quiet Zone as identified in the executed C&M Agreement.

After filing Notice of Establishment by the Public Authority, pursuant to §222.43(e), SCRRA shall cease routine use of the locomotive horn at all public and private crossings identified by the Public Authority upon the date set by the Public Authority or within 21 days of notification, whichever is later.

25.3.3 FRA

FRA will approve the Quiet Zone if the Public Authority is in compliance with the Quiet Zone rules and requirements. If the Quiet Zone is established under Public Authority application, and not under Public Authority designation, FRA will approve the Quiet Zone if the Public Authority has satisfactorily demonstrated that the SSMs and ASMs proposed result in a Quiet Zone risk index meet FRA requirements. FRA may include such conditions as may be necessary to ensure that the proposed safety measures are effective.

The FRA must be included in the Diagnostic Team, helping identify safety concerns associated with each at-grade crossing within the proposed Quiet Zone. Additionally, the FRA will review any applications and all supporting documentation and is the agency which renders approval for any improvements.

25.3.4 CPUC

CPUC is required to receive and evaluate all notices of intent, establishment or continuation of Quiet Zones, and provide written comments. The evaluation requires research and verification of data submitted under the rule, as well as a field diagnostic review of the crossings.

Under the Final Rule, CPUC is required to participate in diagnostic reviews of crossings in the proposed Quiet Zone and makes recommendations for safety enhancements in lieu of the train's sounding of their horn. Some crossings will require improvements be implemented before the crossing will qualify for inclusion in a Quiet Zone. Some may qualify as currently configured, however, CPUC or the other parties involved in the Quiet Zone review (railroads, FRA, roadway authority) may recommend further improvements be implemented before establishing the Quiet Zone.

Where modifications to a crossing are proposed by a Public Authority, CPUC will process the application to the Commission for authority to alter the crossing. Authority to alter existing crossings must be obtained from the Commission, typically through the Commission's General Order (GO) 88-B process. Public Authority will submit GO 88-B application to CPUC for crossing modifications. CPUC information on General Orders, crossing rules and regulations, Quiet Zones, Form G reports of changes, crossing inventory, and contact information is available at www.cpuc.ca.gov/crossings/

25.3.5 Railroads

Crossings that include railroad users other than SCRRA, such as Amtrak, UP, and BNSF, must be invited to attend the Diagnostic Team evaluation meetings, helping to identify safety concerns associated with each Highway-Rail Grade Crossing within the proposed Quiet Zone. The railroad's representation will depend on their service on a particular segment of the territory.

25.4 QUIET ZONE PROCESS

25.4.1 General

Groups or individuals interested in Quiet Zones should first contact the Public Authority responsible for the roadway(s) where the Quiet Zone would be located. The Public Authority shall initiate coordination with SCRRA. Public Authorities are encouraged to contact SCRRA early in the process to maximize communications.

Public Authority will identify the public, private, and pedestrian Highway-Rail Grade Crossings within the proposed Quiet Zone. Public Authority will conduct a safety review of all crossings within the proposed Quiet Zone. Public Authority will complete U.S. Department of Transportation (U.S. DOT) Grade Crossing Inventory form to indicate current conditions and identify safety measures.

25.4.2 Submittals

Public Authority shall conduct new traffic and queuing studies as may be required to reflect current conditions as of the date of initiation of the project. If recommended by the Diagnostic Team, a separate pedestrian study may be required to evaluate the potential impacts of the proposed Quiet Zone on pedestrian safety. This study shall include each crossing that is located within the proposed Quiet Zone and any observed unsecured pedestrian access points within the proposed Quiet Zone. The purpose of these studies is to complete an accurate and current Grade Crossing Inventory form for each crossing, and to enable the Diagnostic Team to assess current and future conditions at each crossing. All such studies and reports shall be promptly provided to SCRRA and CPUC for review and comments.

Public Authority shall prepare Preliminary Design (30% Design) plans for the selected Highway-Rail Grade Crossings, pedestrian crossings, and unsecured pedestrian access points and submit them to SCRRA for review, comments, and approval. This Preliminary Design will form a basis for Diagnostic Team evaluation meetings. Public Authority shall submit the following information and forms to SCRRA with the Preliminary Design:

- An accurate, complete and current U.S. DOT National Highway-Rail Grade Crossing Inventory Form, OMB Form No. 2130-00170017. SCRRA will assist the Public Authority by providing updated railroad information required by the Form. Link: https://www.fra.dot.gov/eLib/details/L16197
- Detailed information as to which Supplementary Safety Measures (SSMs) as per Appendix A, Part §222 and Alternative Safety Measures (ASMs) as per Appendix B, Part §222 (ASMs are Modified SSMs, Non-Engineering ASMs and Engineering ASM's) are proposed to be implemented at each public or private Highway-Rail Grade Crossing within the proposed Quiet Zone.

Public Authority shall revise the Preliminary Design based on the input of the Diagnostic Team and resubmit Final Design (100% Design) plans and obtain a letter of approval from all affected jurisdictions.

25.4.3 Notice of Intent (NOI)

The Public Authority shall follow the processes established by the FRA regarding the issuance of Quiet Zone Notices. After conducting a Diagnostic Meeting, the Public Authority shall provide a Notice of Intent per §222.43: a written notice of its intent to create a Quiet Zone. Public Authority shall provide its Notice of Intent by certified mail, return receipt requested, to SCRRA, all railroads operating over the public Highway-Rail Grade Crossings within the proposed Quiet Zone, the State agency responsible for highway and road safety and the State agency responsible for grade crossing safety. SCRRA encourages the Public Authority to prepare the Notice of Intent after consultation with SCRRA and after conducting Diagnostic Team evaluation meetings.

The Notice of Intent shall be mailed at least 60 days before the mailing of the Notice of Quiet Zone Establishment, unless the Public Authority obtains written comments and/or ''no-comment'' statements from each railroad operating over public Highway-Rail Grade Crossings within the Quiet Zone, and the State agency. A party that receives a copy of the Public Authority's Notice of Intent may submit information or comments about the proposed Quiet Zone to the Public Authority during the 60-day period after the date on which the Notice of Intent was mailed.

25.4.4 Quiet Zone Qualifications

Safety is of paramount concern when establishing a Quiet Zone. A Quiet Zone may be established by either Public Authority designation [§222.39(a)] or Public Authority application [§222.39(b)] as summarized below.

Public Authority designation includes the following options for establishing a Quiet Zone:

- by implementing, at every public Highway-Rail Grade Crossing within the Quiet Zone, one or more Supplemental Safety Measures (SSMs) identified in FRA rules

- if the Quiet Zone Risk Index (QZRI) is at or below the Nationwide Significant Risk Threshold (NSRT) either in the existing condition or due to the implementation of SSMs at one or more of the crossings to reduce the QZRI
- or by reducing the QZRI to a level at or below the Risk Index with Horns (RIWH) by implementing SSMs at one or more of the crossings within the Quiet Zone

Public Authority application allows the Public Authority (i.e. the Project Sponsor) to apply to the FRA for approval of a Quiet Zone that does not meet the above standards, but in which it is proposed that one or more safety measures be implemented. Safety Measures typically include a combination of SSMs and Alternative Safety Measures (ASMs) at one or more of the crossings. If a Public Authority uses ASMs, they will need to submit an application to FRA for review and approval. Stakeholders have 60 days to comment after FRA application submittal.

Typical SSMs include permanent closure of crossing, upgrade to a four-quadrant gate system, the installation of medians or channelization devices, and conversion of a two-way street to a one-way street. Common ASMs include Modified Supplemental Safety Measures (MSSMs) such as three-quadrant gate systems and modified or shortened median or channelization devices.

Quiet Zones require a minimum length of ½ mile, with ¼ mile between each of the end crossings within the Quiet Zone and the next nearest crossing outside the Quiet Zone, and that all public Highway-Rail Grade Crossings are equipped with flashing lights and gates.

Pedestrian-only and private crossings may be included within a Quiet Zone if they are either between two public crossings within the Quiet Zone or less than ¼ mile of the end crossing within the Quiet Zone. The improvements or modifications required for pedestrian-only and private crossings will be determined by the diagnostic team, as outlined in the Final Rule.

25.4.5 Diagnostic Meeting

The Public Authority is responsible for preparing drawings and specifications for improvements at the Highway-Rail Grade Crossings. Public Authority is also required to conduct diagnostic meetings of all crossings included in the Quiet Zone. The Public Authority shall provide SCRRA, the FRA, all railroads operating over the public Highway-Rail Grade Crossings within the proposed Quiet Zone, affected SCRRA member agency or agencies, the State agency responsible for highway and road safety and the State agency responsible for grade crossing safety (CPUC) an opportunity to participate in the Diagnostic Team reviews of all crossings located in the proposed Quiet Zone. The Diagnostic Team should analyze and evaluate each crossing within the proposed Quiet Zone as per Appendix F, Part §222.

The crossings shall be equipped or treated in accordance with the recommendations of the Diagnostic Team. SCRRA expressly reserves the right to comment on and/or object to the FRA and/or the CPUC on any aspect, including the extent of the proposed Quiet Zone, the selection of improvements by the public authority or the design thereof, if in its judgment the proposed Quiet Zone, or any aspect thereof, will result in a reduction of safety within the zone.

25.4.6 CPUC Authorization

If an existing public rail crossing is being modified to create a Quiet Zone, the Public Authority shall file to obtain authorization from the CPUC by means of either a formal application or a GO 88-B submittal.

25.4.7 Construction of Safety Measures

Public Authority is responsible to construct, at its sole cost, the proposed and approved improvements at the crossings. Public Authority is responsible for the installation of advance warning signs conforming to the standards contained in the CA MUTCD that advises the motorist that train horns are not sounded at each highway approach to every public and private Highway-Rail Grade Crossing within a Quiet Zone, pursuant to §222.35(c). Public Authority shall install additional warning signs elsewhere within the proposed Quiet Zone, at locations other than Highway-Rail Grade Crossings as may be recommended by the Diagnostic Team, advising pedestrians or others that train horns are not sounded within the Quiet Zone.

The per-crossing costs of implementing the safety enhancements to offset the lack of trains sounding horns could run into $2.5 to $3.0 million (listed values are 2019 dollars) if exit gate SSMs or other railroad system or equipment modifications are required. The cost of the upgrades depends on the existing condition and geometry of the crossing, warning devices, traffic signal location adjacent to the crossing, street pavement conditions, preemption requirements, existing signal and communication cables, utility locations, vehicle traffic, location of parallel streets, and pedestrian improvements.

Public Authority shall wait to proceed with the non-railroad related improvements at the grade crossing until SCRRA and CPUC approve the construction of the project. Public Authority shall submit any and all SCRRA forms prior to start of the construction.

25.4.8 Notice of Establishment (NOE)

Once crossing improvements are completed and in service, the Public Authority shall provide a Notice of Quiet Zone Establishment (NOE). This notice must provide the date upon which the Quiet Zone will be established, but in no event shall the date be earlier than 21 days after the date of mailing. The NOE shall stipulate that the Quiet Zone will be in effect at 12:01 AM on the date when the Quiet Zone goes into effect.

25.4.9 Periodic Updates

Public Authority will conduct a periodic field review of crossings within a Quiet Zone on a schedule determined by C&M agreement. The field review will be attended by representatives of the Public Authority, SCRRA, SCRRA Member Agency, FRA, CPUC, and other affected parties, after completion of the construction and the establishment of the Quiet Zone. These reviews will be conducted onsite and will consider any changes, together with any future improvements or developments that may have or will affect the qualification of the Quiet Zone. Should additional railroad improvements be required in order to maintain the proposed Quiet Zone, the Public Authority shall reimburse SCRRA for any additional costs associated with said improvements.

For Quiet Zones implemented with an SSM at each public crossing, the Public Authority shall affirm, pursuant to §222.47(a), in writing to FRA and SCRRA that the SSMs implemented within the proposed Quiet Zones continue to conform to the requirements of Appendix A, Part §222 and provide an up-to-date, accurate and complete Grade Crossing Inventory Form for each public, private and pedestrian crossing within the proposed Quiet Zone, between 4½ and 5 years after the date of the Quiet Zone establishment notice, and between 4½ and 5 years after the last affirmation. Public Authority shall affirm, pursuant to §222.47(b), in writing to FRA and SCRRA that the proposed Quiet Zones which do not have SSMs at each crossing continue to conform to the requirements of Appendix A and B, Part §222 and provide an up-to-date, accurate and complete Grade Crossing Inventory Form for each public, private and pedestrian crossing within the proposed Quiet Zone, between 2½ and 3 years after the date of the proposed Quiet Zone establishment notice, and between 2½ and 3 years after the last affirmation.

Should the Public Authority neglect to conduct said periodic reviews, the FRA, at its discretion may rescind the Quiet Zone designation.

25.4.10 Maintenance

Public Authority shall pay SCRRA the cost of maintenance of any additions, improvements and/or modifications to any active Highway-Rail Grade Crossing warning system necessary for the implementation of the proposed Quiet Zone as per terms and conditions included in the C&M agreement. As an example, if a crossing within a proposed Quiet Zone requires an upgrade from entrance gates to both entrance and exit gates, SCRRA will continue to pay the cost of maintenance of the entrance gates, and the Public Authority will reimburse SCRRA for annual maintenance on the exit gates. The maintenance costs shall include inspections, testing, repairs, replacements, damage, third party utilities, and upgrades. The annual cost of maintenance of the active Highway-Rail Grade Crossing warning system shall be as determined by SCRRA, based on its annual survey of the maintenance cost of the system.

The Public Authority is solely responsible for maintaining the crossing(s) to a standard acceptable to SCRRA, CPUC, and the FRA. The FRA, at is sole discretion, may rescind Quiet Zone status if the Public Authority fails to maintain the crossings to the standards required for Quiet Zone establishment. Rescinding the Quiet Zone would result in all trains sounding their horns as if the Quiet Zone had never been established until such time the needed maintenance was completed to the FRA's and RR's satisfaction.

25.5 QUIET ZONE REQUIREMENTS

This section does not provide a comprehensive description of Quiet Zone regulations and requirements included in FRA's Code of Regulations. Additional information required for minimum requirements, who can establish Quiet Zone, how is a Quiet Zone established, what periodic updates are required, details on approved SSM and ASM, determination of risk level, wayside horns, Diagnostic Team considerations, notice of intent timing and requirements, notice of establishment timing and requirement, and other information are available of FRA's web site at https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title49/49cfr222_main_02.tpl.

25.5.1 Minimum Requirements

Public Authority shall meet the minimum Quiet Zone requirements mentioned in §222.35. Public Authority shall include all Highway-Rail Grade Crossings (public, private and pedestrian) in the proposed Quiet Zone. Minimum Quiet Zone requirements are as follows:

- A New Quiet Zone must have a minimum length of ½ mile along the railroad right-of-way.
- Each public Highway-Rail Grade Crossing within a New Quiet Zone must be equipped with active grade crossing warning devices. These devices are comprised of both flashing lights and gates which control traffic over the crossing and must be equipped with Constant Warning Time (CWT) circuitry if reasonably practical, and power-out indicators. Any necessary upgrades to or installation of active grade crossing warning devices must be completed before the New Quiet Zone implementation date.
- Each highway approach to every public and private Highway-Rail Grade Crossing within a New Quiet Zone shall be equipped with a California Manual on Uniform Traffic Control Devices (CA MUTCD) compliant advanced warning sign that advises motorists that train horns are not sounded at the crossing (W10-9 or W10-9P).
- Each public Highway-Rail Grade Crossing within a New Quiet Zone that is subjected to pedestrian traffic and is equipped with automatic bells shall retain those bells in working condition.
- Each pedestrian grade crossing within a New Quiet Zone shall be equipped with an CA MUTCD compliant advanced warning sign that advises pedestrians that train horns are not sounded at the crossing (W10-9 or W10-9P).

SCRRA ES4004 provides additional guidance on features recommended by SCRRA at pedestrian grade crossings.

25.5.2 Reimbursements

Public Authority shall pay for all the costs of environmental or permitting documentation, preliminary and final engineering, construction, maintenance and replacement services of any new equipment or facilities at all Highway-Rail Grade Crossings to meet Quiet Zone requirements.

Public Authority shall pay in advance an estimated amount of all costs related to review, coordination and flagging to SCRRA for in-house personnel and/or consultants retained by SCRRA. The original estimated costs would not be the upper limit of the costs but provide a guideline for budgeting purposes. Regardless, all costs incurred by SCRRA during design plan review process shall be fully recoverable from the Public Authority.

Public Authority shall reimburse SCRRA the actual costs and expenses incurred by SCRRA (less funds previously deposited), including any provisional overhead rates representing SCRRA’s costs for administration and management, and its contractors and consultants for all services and work performed in connection with the proposed Quiet Zones.

Public Authority also requires a Construction and Maintenance (C&M) agreement from SCRRA. C&M agreement includes requirements on reimbursement for construction and maintenance, indemnification and insurance requirements. The entire SCRRA process and requirements for grade crossings is included in Chapter 8. The purpose of Chapter 8 is to educate the Public Authority on the guidelines, practices, procedures, and policies that reflect current regulations, proven and accepted technological developments, and best available highway and rail industry design practices. The Public Authority can apply these standards and recommended design practices to SCRRA Highway-Rail Grade Crossings.

25.5.3 New Technologies

Public Authority shall reimburse SCRRA's cost of installation of technologically superior and more reliable equipment in the future to replace existing equipment that is obsolete. Such reimbursement shall be limited to the cost of such installations serving the equipment and facilities required to establish the Quiet Zone.

25.5.4 Indemnifications

The Public Authority shall Indemnify, defend and hold harmless SCRRA, LOSSAN, and SCRRA member agencies, which include:

- METRO
- VCTC
- OCTA
- SBCTA
- RCTC

The Public Authority shall also indemnify the Operating Railroads, including but not limited to:

- AMTRAK
- BNSF
- UP

Said indemnification shall extend to each entity's respective board members, member agencies, officers, agents, volunteers, contractors, and employees ("SCRRA Indemnitees"). The scope of indemnification shall include, but not be limited to, any and all liability, loss, expense (including reasonable attorneys' fees and other defense costs), demands, suits, liens, damages, costs, claims, including but not limited to, claims for bodily injury, death, personal injury, or property damage, that are incurred by or asserted against the SCRRA Indemnitees arising out of or connected with any negligent acts or omissions on the part of Public Authority, its council, officers, agents, contractors, or employees under or in connection with any work, authority or jurisdiction delegated to Public Authority related to establishment and operation of a Quiet Zones at Highway-Rail Grade Crossings.

25.5.5 Insurance

Public Authority shall obtain and maintain, at its sole cost and expense, in full force and effect during the construction of the improvements for the proposed Quiet Zone, general and railroad protective insurance as required by SCRRA in the amounts, coverage, and terms and conditions specified, and issued by insurance companies as described in the Temporary Right-of-Entry Agreement (SCRRA Form No. 6).

The Public Authority shall procure and maintain the insurance containing coverage for liability resulting from the implementation of the Quiet Zone and/or improvements required to implement the Quiet Zone, at its sole cost and expense, after the construction and implementation of the Quiet Zone.

25.5.6 SCRRA Contact

Public Authority shall submit all written communications related to proposed Quiet Zones to the following at:

Chief, Program Delivery
Southern California Regional Rail Authority
2558 Supply Street, Building A
Pomona, CA 91767

26.0 LANDSCAPING DESIGN CRITERIA

26.1 INTRODUCTION

26.1.1 Purpose

The following criteria provide minimum standards and general requirements for the design, construction, and maintenance of landscape materials in a manner compatible with the safe operation of railroad corridors and accommodation of anticipated rail capacity expansions.

Landscape materials within the railroad Right-of-Way can be an important aesthetic enhancement blending the railroad corridor with its environmental context. However, the installation of landscape materials in the Right-of-Ways must always be subordinate to the important primary role SCRRA has in providing a safe and maintainable rail transportation corridor. Landscape materials must not affect SCRRA's ability to provide commuter and freight rail transportation and meet its obligations to the freight railroads under the Purchase & Sale, and Shared Use agreements. These criteria balance opportunities for the aesthetic enhancement of the Right-of-Way with SCRRA's and Member Agencies' mandate to provide safe and efficient rail transportation to the public and the ability to meet interstate freight obligations.

SCRRA is the designated track owner of the Metrolink railroad system under the Code of Federal Regulations (CFR), Title 49 "Transportation", Subtitle B "Other Regulations Relating To Transportation", Chapter II "Federal Railroad Administration, Department of Transportation", part 213 "Track Safety Standards", Section 5 "Responsibility of Compliance" (49 CFR 213.5). As per part 213, SCRRA is required to provide minimum safety requirements for operation and maintenance of railroad tracks that are part of the general railroad system of transportation. The minimum requirements include roadbed, track geometry, track structure, track-related devices, and inspection. The requirements listed in the Landscape Design Criteria are subordinate to these minimum requirements.

Landscape plans and installations are required to consider the effect of the SCRRA IPM program for vegetation control (see Section 26.8, Vegetation Management Program).

The site must be assessed for climate vulnerability (see Section 3.3) to ensure it is designed to be resilient to future climate conditions.

26.1.2 Landscape Design Objectives

Develop a landscape design that:

1. Promotes safety and comfort to all SCRRA and Member Agency passengers. The principals of CPTED (Crime Prevention Through Environmental Design) shall be utilized and proposed landscaping shall be designed to avoid hiding places, blind corners, and obstructions for emergency response personnel or equipment.
2. Does not impede train operator, motorist, or pedestrian sight lines.
3. Does not encroach upon walkways, bike paths, or station platforms.

4. Does not conflict with existing or proposed utilities or signage.
5. Utilizes California friendly and/or native plants which are compatible with local climatic and soil conditions, conserves water, low maintenance, and produces minimal to no litter on walkways or station platforms.
6. Consistent in materials throughout the project and complements the character of surrounding community and existing landscape.
7. Enhances the station architecture, hardscape, lighting, signage, furnishings, etc.
8. Seeks to reduce urban heat island effect through planting of shade trees.
9. Seeks to use nature-based solutions such as bioswales or bioretention feature to reduce stormwater runoff in areas identified as vulnerable to flooding.

26.1.3 Scope

These criteria apply to the SCRRA and its Member Agencies operated and maintained Right-of-Ways that are owned wholly or in part by the county transportation Member Agencies. These criteria direct the development of plans proposing to place landscape materials within rights-of-way operated or maintained by SCRRA and its Member Agencies regardless of who is proposing or sponsoring the installation of landscape materials. (See *Definitions* in Appendix A). These criteria do not apply to Right-of-Ways fully owned by the BNSF Railway Company or the Union Pacific Railroad, where SCRRA has entered into joint use agreements to operate Metrolink commuter rail service.

26.1.4 Referenced Standards

Landscape plans and installations shall also comply with the Right-of-Way Preservation Guidelines adopted by SCRRA-specific Member Agency(s). Technical details of planting and irrigation design shall be prepared per the State of California MWELO (Model Water Efficient Landscape Ordinance) and other federal, state, and local requirements and in accordance with the accepted landscape installation and landscape management practices of the American Nursery and Landscape Association.

<u>Local Codes and Standards</u>

Unless otherwise stated, landscaping for new facilities or as part of alterations to existing facilities, shall be designed in conformance with local landscape ordinances as well as published standards of the agency having jurisdiction or with the SCRRA criteria contained herein, where such criteria exceed agency standards. If there is a conflict, the more stringent requirement shall govern.

The following documents are incorporated into these design criteria by reference and shall be adhered to, in the specification of plant materials:

- American Standard for Nursery Stock ANSI Z60.1, adopted by the American Association of Nurserymen, Inc.
- Bailey's Standard Cyclopedia of Horticulture.

- Standardized Plant Names, American Joint Committee on Horticulture Nomenclature (AJCHN)

Where the requirements stipulated in this document or any referenced sources are in conflict, the stricter requirements apply.

See additional standards and codes listed in Appendix A.

26.2 REAL ESTATE REQUIREMENTS

26.2.1 Existing Facilities

The proposed landscape project shall avoid any displacement of existing items for which leases and licenses on the Right-of-Ways have been granted, including billboards and bus stops. If displacement is unavoidable, the project's Sponsoring Party shall coordinate proper disposition, including paying associated costs in accordance with existing license or lease agreements.

26.2.2 Third Party Agreements

When the Sponsoring Party is not a Member Agency or SCRRA, it will be considered a Third Party. As a Third Party, the Sponsoring Party shall obtain a license or lease agreement for installing landscape materials from the Member Agency whose Right-of-Way is directly affected by the project. The license or lease agreement shall include requirements, terms and conditions related to indemnification, license fees and compensations, assumption of risk and waiver, insurance, tests and inspections, maintenance and repair, breach, abandonment, reimbursement, construction, relocation, payments, hazardous/toxic materials, compliance with laws, etc. The Third Party shall contact the affected Member Agency to request all information related to the real estate agreement. The Member Agency will be the sole authority on the fees and compensations due from the Third Party for the rights granted.

License or easement agreement shall also include requirements that provide for the removal and modification of the landscape materials to meet SCRRA's and Member Agency's mission to provide passenger rail transportation and their obligations to the freight railroads to provide rail freight service. At the request of SCRRA or Member Agency, the Third Party shall remove, relocate, or modify, at its own expense, the landscaping to accommodate additional track or tracks or other railroad related facilities in the Right-of-Way.

26.2.3 Permits

The Sponsoring Party of the proposed landscape project shall be responsible for obtaining and complying with any and all approvals, permits, licenses and other authorizations required by applicable laws, regulations, rules, and ordinances for its landscaping project within the Right-of-Way.

26.3 CONCEPTUAL DESIGN

The Sponsoring Party of the proposed landscape project shall prepare a concept report and submit it for SCRRA and the affected Member Agency for review and approval. The report shall include existing conditions (topography, utilities, railroad facilities, soil conditions), existing and future transportation, environmental setting, land ownership including rail Right-of-Ways, future needs, schematic design planting plan, identify and evaluate alternatives and concept level cost estimates. The schematic design planting plan shall be minimum 20 scale and show existing site conditions with proposed site and landscape design overlay. A proposed plant legend with initial sizes, spacing, water requirements and plant images shall also be included next to the plan or on a separate sheet. The proposed landscape design shall be color coded for clarity purposes. SCRRA and the Member Agency will review the report and inform the Sponsoring Party if the project is viable and acceptable for further consideration and if it conforms to the Member Agency's Preservation Guidelines.

26.4 COORDINATION

The Landscape Architect shall coordinate the proposed landscape design and production of construction drawings with all other design team members, SCRRA, and Member Agency to ensure that landscaping is aesthetically and functionally compatible with facility architecture, utilities, lighting, safety, path of travel, accessibility, and site furniture.

26.4.1 Submittal

After review and approval of the conceptual design by SCRRA and associated Member Agency, the Sponsoring Party shall prepare landscape contract drawings and submit two sets of each to SCRRA and the Member Agency for review and approval. Contract drawings include proposed planting plans, irrigation plans, water use calculations, details, and specifications. Any and all changes or modification during the design and construction that affect the rail Right-of-Way shall also be submitted to SCRRA and Member Agency for review and approval.

26.4.2 General Clearances

Ground covers, shrubs, and hedges are permitted only within 10 feet of the edges of the Right-of-Way. Trees planted adjacent to the Right-of-Way shall be placed such that the outer foliage shall not overhang into the Right-of-Way. No plantings are allowed closer than 25 feet from the nearest track.

Plants cannot be planted within 3 feet of or block visibility of an existing sign (regulatory, warning, guide, emergency, parking, railroad, and others) unless the jurisdiction or agency requiring the sign agrees to relocate the sign. The relocation of any sign noted above shall be approved by the owning jurisdiction or agency. The Sponsoring Party may be required to pay for the relocation cost, if necessary.

Landscaping near or adjacent to a station platform shall be limited to shrubbery with a maximum height of 36". The plants must be periodically maintained to be no higher than 36". If the plants are within a raised planter adjacent to the platform, the maximum height of the plant shall be 36" from the top of the plant to the bottom of the planter. Planters shall not be installed on platforms.

Large trees must be approved by SCRRA and the Member Agency for use within the Right-of-Way. If approved by SCRRA and Member Agency, large trees planted within the Right-of-Way shall be selected such that the outer foliage of any tree shall not be closer than 25 feet from the nearest rail when the trees reach mature size.

A zero-growth-herbicide treated buffer zone, 10 feet in width, shall be provided between the Right-of-Way and any landscaped areas.

See Section 26.4.3 for landscaping clearances at a grade crossing.

26.4.3 Grade Crossing Clearances

The vegetation, landforms and structures incorporated into the landscape plans proposed by a Sponsoring Party, may play a significant role in a crossing user's perception of grade crossings and the subsequent safety of the crossing. The crossing user must recognize the presence of the grade crossing, the type of traffic control devices and the location of a train approaching or occupying the crossing.

Ground cover, shrubs and hedges are not allowed on highway approaches within 150 feet of a highway-rail grade crossings. In order to assist the crossing user, trees and shrubs are prohibited in medians within 150 feet of the highway-rail grade crossing. Hardscape median is preferred within 150 feet of the crossing. Beyond 150 feet of the crossing, ground covers or shrubs not exceeding 36 inches in height may be permitted, with consistent periodic maintenance, on medians.

The criteria of this section shall also apply to stand-alone pedestrian grade crossings and station pedestrian grade crossings.

26.4.4 Utilities

The Sponsoring Party shall locate and show on their landscape plans the existing SCRRA signal and track facilities during the design phase at the expense of the Sponsoring Party. The project must be designed to avoid any relocation of the existing SCRRA facilities.

After the acceptance of landscape plans by SCRRA and Member Agency, the Sponsoring Party shall submit and obtain written approval of design drawings from telecommunications, fiber optic, gas, oil, or other companies that have prior use of the Right-of-Way under easement or license agreements. The design and installation of the landscape materials affecting the existing utilities shall be avoided. Any conflicts shall be coordinated with SCRRA, the Member Agency and the affected utility owner. Agreements allowing the relocation of utilities are required to be approved by SCRRA, the Member Agency and the affected utility owner. Approval may require modifications to the proposed landscape plans.

The existing utilities shall be located and staked and/or marked by the Contractor prior to commencing any excavation. Approval of the project by SCRRA, and the Member Agency does not constitute a representation as to the accuracy or completeness of location or the existence or non-existence of any utilities or structures within the limits of this project. The appropriate regional notification center [Underground Service Alert of California (DigAlert) at (800) 227-2600 or 811], railway companies, and utility companies shall be notified prior to performing any excavation close to any underground pipeline, conduit, wire, or other structure. The Sponsoring Party shall refer to SCRRA's website www.metrolinktrains.com to ensure proper contracts and phone numbers. SCRRA is not a member of DigAlert and the Sponsoring Party shall request locations of SCRRA utilities from SCRRA. It is therefore necessary to call SCRRA's signal department phone number (refer to SCRRA's website) to mark, at the Project Sponsor's or Contractor's expense, signal and communication cables and conduits; in case of signal emergencies or Highway-Rail Grade Crossing problems, the Contractor shall call SCRRA's 24-hour signal emergency number. If utilities cannot be located, potholing shall be done to locate the utilities. SCRRA and appropriate utility owners shall be notified immediately when utility lines not known or indicated on the drawings are encountered. No service shall be disrupted until the utility owner and SCRRA have determined and approved the required action on such lines.

26.4.5 Fencing

If there is no existing fence, the Sponsoring Party, at its sole cost and expense, shall install tubular steel fencing or welded wire mesh fencing as per SCRRA Engineering Standard ES 5104 or ES 5105 respectively. Exceptions may be granted by SCRRA, if the landscaping project design includes mitigation measures that include best practices to ensure safe rail operations, as per Section 26.10, Exceptions. The Sponsoring Party shall install gates having SCRRA locks to access the Right-of-Way for maintenance purposes at locations provided and approved by SCRRA. The Sponsoring Party shall install “No Trespassing” warning signs as per SCRRA Engineering Standard ES 5214.

A three-rail split-rail fence in combination with landscaping serving as a visual and physical barrier between the track and the landscaping may be used in rural or environmentally sensitive areas if approved by SCRRA and the Member Agency. Since newly planted landscaping may take a few years before becoming an effective barrier, suitable temporary measures may be required until the landscaping has reached mature size.

The height of the fence within 150 feet of any at-grade crossings shall be 4 feet. Beyond 150 feet of any at-grade crossing, the height of the fence along the Right-of-Way shall be at least 6 feet.

26.4.6 Drainage

The Sponsoring Party, at its sole cost and expense, shall provide and maintain suitable facilities for draining the proposed landscape project and shall not permit storm and/or irrigation water to flow or collect within the Right-of-Way. All proposed stormwater drainage facilities shall meet state and local code requirements and be sized to accommodate larger flows as anticipated by the CVA. Although the Sponsoring Party will not have the sole responsibility to correct any existing drainage deficiencies on the Right-of-Way, it will, allow the Member Agency the opportunity to correct any existing drainage conditions to meet SCCRA, state and/or local code requirements. At a minimum, the Sponsoring Party shall not worsen existing conditions.

Finished grading shall be sloped sufficiently to afford adequate drainage yet minimize drainage. When the railroad track is at a lower elevation than the surrounding ground and the street, a flat bottom swale (ditch) properly sized and flowing towards an existing or proposed stormwater facility, such as inlet, underground pipe, swale, creek, wash or channel shall be constructed to meet state and local code.

Mounding of earth within the Right-of-Way may be permitted only if it does not adversely affect access, railroad maintenance activities, visibility, and drainage within the Right-of-Way. The Sponsoring Party shall submit proposed grading plans showing the existing and proposed contour elevations to SCRRA and Member Agency for review and approval. The final grading elevations shall be approved solely by SCRRA and the Member Agency. If allowed, imported soil shall meet the Member Agency’s specifications for clean backfill material.

26.4.7 Access

SCRRA and Member Agency must be able to readily access, inspect, repair and maintain drainage systems, bridges, tie and track replacement, tunnel and trestle, signal and communications equipment and grade crossing equipment from existing roadways. Utility companies must be able to readily access their facilities for maintenance and operation purposes.

The landscape shall be subject and subordinate to the rights of all current and future tenants and licensees of the Member Agency, including the rights of reasonable access over the landscaped area.

26.5 MATERIAL

26.5.1 Plant Design Criteria

Proposed planting designs shall have the following characteristics:

- Shall promote safety and comfort to all SCRRA and Member Agency passengers. The principals of CPTED shall be utilized and proposed landscaping shall be designed to avoid hiding places, blind corners, and obstructions for emergency response personnel or equipment.
- Shall be California friendly and/or native plants which are compatible with local climatic conditions, non-poisonous; resistant to insects (bees, white flies or rodents) and diseases; free from sharp thorns, needles or pointed sword-like leaves; adaptable to variable soil conditions; adaptable to drought conditions; free from noxious odors; free from messy fruits or leaves; non-aggressive root system that can damage pavement and sidewalks and low maintenance.
- Shall be sufficiently durable and drought resistant to maintain themselves without regular, supplemental irrigation once they have been established.
- Shall be adaptable to the harsh conditions of a railroad environment because of compacted soils and residual chemicals.
- Shall not conflict with safety or maintenance access at maturity.
- Plants that are susceptible to limb breakage under adverse conditions are prohibited.
- Plants that produce large or popular fruits are prohibited within the Right-of-Way since they may entice animals and pedestrians onto the Right-of-Way.
- Integration with the existing acceptable plant materials in adjacent areas should be emphasized. Existing plant material shall be protected in place, as appropriate.
- Landscapes within designated fire risk zones shall meet local fire ordinance code including fuel modification exhibit approvals by the local fire authority. Plants selected for slope areas shall be varieties commonly used for erosion control. Slopes shall be stabilized to prevent physical failure, erosion, or maintenance issues.
- Plants may be used on sound and retaining walls, as appropriate, for graffiti management.
- Plants shall not be placed in a way to hinder a train operator’s view of the Right-of-Way facilities. Placement of trees, shrubs, and other vegetation or landscaping items shall

consider motorist, bicyclist, pedestrian, and maintenance safety. A crossing user and a train operator shall not have obstructed visibility of all traffic movements at intersections, crossovers, and turn lanes due to landscaping. Planting designs shall complement station architecture, site features, and surrounding community context.

- Within station areas, planting design is encouraged for separating vehicles and pedestrians. Planting designs are encouraged to enhance walkway patterns and pedestrian path of travel.
- Soil testing and soils report shall be prepared prior to installation to determine soil agricultural suitability and ensure proper plant selection. For the soils report shall provide recommendations for soil amendments to accommodate the health, growth and vigor of proposed plants.
- Due to the frequent use of arsenic along railroad Right-of-Way, it is strongly suggested testing be performed early in the design process to allow for proper soil remediation and/or replacement prior to a project being advertised for bidding purposes.

26.5.2 Plant Spacing

Spacing between trees and shrubs shall be governed by the ultimate spread of the species at maturity and by the environmental conditions present at each location. The placement of trees or shrubs shall not conflict with the location of existing or proposed tracks, sidewalks, trails, drainage facilities, underground or overhead utility lines, or any other usage required by the Member Agency.

CPTED principles, including providing surveillance by police and the public shall be utilized when selecting and locating plants within the Right-of-Ways. Spacing of plants shall not create potential security hazards such as places of shelter or concealment for humans or weapons. The safety of transit facility users and community is paramount.

26.5.3 Plant Material

The Sponsoring Party shall select ground covers, flowers, shrubs, hedges, ornamental trees or shade trees based on these criteria and other policies of the Member Agency. The Sponsoring Party shall submit a list of selected plants for SCRRA and Member Agency review and approval. It is recommended that the Sponsoring Party submit additional information (plant photos, water requirements, deciduous or evergreen, native or non-native) on the plants to SCRRA and the Member Agency that it believes may assist in the approval of the plant material. In addition to meeting regulatory requirements, plant material shall be hardy, tolerant of disturbance and stress, and appropriate to site conditions.

<u>Ground Covers</u>

Turf grass species commonly used as lawn are prohibited. The use of spreading ground cover to discourage weed growth and provide soil erosion control is acceptable.

Herbaceous Flowers

Flowering species are permitted provided the plan submitted by the Sponsoring Party commits to their continuous maintenance. Perennial flowers are preferred although annual flowers are allowed if the plan provided by the Sponsoring Party also commits to their yearly installation.

Shrubs

Shrubs are woody plants that can be deciduous or evergreen, although evergreen materials are preferred. Shrubs have a variety of applications and can also be used as ground cover, to discourage weed growth and stabilize soil.

Hedges

A hedge is a row of shrubs, preferably evergreen, planted in a continuous line, spaced to form a vegetative wall. Proposed hedges shall not interfere with visibility, pedestrian movement, or hiding places.

Ornamental Trees

Ornamental trees are smaller trees (or shrubs trained into tree form), which typically do not develop 4-inch diameter trunks as measured 4 feet above the ground within 10 years. Ornamental tree branching shall not interfere with visibility or pedestrian movement. Root barriers are required for all track within 50 feet of trees.

Shade Trees

Shade trees are large trees which within 10 years, have trunks 4 inches or greater in diameter as measured 4 feet above the ground. Shade trees must be approved by SCRRA and Member Agency individually for use on the Right-of-Way. Shade tree branching shall not interfere with visibility or pedestrian movement. Root barriers are required for all trees within 50 feet of the nearest track.

In parking areas, trees shall be planted between stalls and at end of row islands. Trees shall also be located, as appropriate, to provide additional shade within parking areas, waiting areas, and circulation paths.

At stations, trees shall be located, as appropriate, around the perimeter for screening.

Shade trees with the following criteria are prohibited for within the Right-of-Way: (a) trees which are granted protective status by the State or Federal Government, (b) trees that produce aggressive root systems that can radiate laterally through the soil and potentially under track ballast to ultimately damage the railroad track or structures and (c) fruit bearing trees.

26.5.4 Tree Protection and Support

Existing trees that are healthy and attractive shall be preserved whenever possible. All existing trees on site shall be indicated in the landscape plans and appropriate protection during construction shall be specified for those that remain.

Tree grates shall be provided where necessary to prevent compaction of the soil surface. Tree grates shall be sized according to tree growth requirements. Tree grates shall be designed to support the weight of one wheel of a service vehicle, and to allow unimpeded pedestrian movements.

Tree guards are to be considered at locations such as subway plazas and station platforms to prevent damage to trees from vehicles or pedestrians.

All trees shall be double staked. Any tree larger than 48” box shall be guyed.

Make sure trees have adequate space around the roots and select trees carefully. A small tree well in a sidewalk or parking lot island will not accommodate a large shade tree. The street, sidewalk, paved surface, wall, or curb will eventually crack and buckle.

26.5.5 Organic Mulch

All proposed planting areas and exposed soil surfaces of non-planted areas within the proposed landscape area shall be mulched with a minimum three-inch deep layer of weed-free, composted organic material. Inorganic material such as crushed rock or decorative cobble may also be used where appropriate, pending approval by SCRRA.

26.5.6 Irrigation

The Sponsoring Party shall determine the need for the permanent irrigation of the landscaping. If the Sponsoring Party chooses not to irrigate, a temporary system should be installed to water the landscaping materials for the first two years or as necessary. A permanent automatic irrigation system shall be installed at all station areas. The proposed irrigation system shall be designed to meet all state and local codes. Water use calculations based on state and local code are required to be submitted with the irrigation plans for review and approval.

All costs of the irrigation system shall be the responsibility of the Sponsoring Party including, but not limited to installation materials and labor, water supply and maintenance.

Where irrigation is used, the water spray and drainage shall be designed to maximize coverage and reduce overspray. All irrigation water shall be directed away from tracks, platforms, and walkways. The Irrigation system shall not impede access to adjacent properties in any way for tenants of the Member Agencies.

Irrigation systems shall be designed to avoid runoff, low head drainage, overspray, or other similar conditions. Water shall be prohibited from flowing onto railroad tracks, ballast, adjacent property, non-irrigated areas, walks, roadways, or structures. Proper irrigation equipment and schedules shall be used to closely match application rates to infiltration rates, thereby minimizing runoff. Anti-drain (check) valves shall be installed in strategic points to minimize or prevent low head drainage.

If installed, irrigation systems shall be high-efficiency and required to use automatic controllers and smart water management technology which meet or exceed state and local code. The irrigation system shall be designed so that no part of the water supply system is permanently above-ground in order to prevent vandalism or unauthorized use. Low-flow/drip irrigation systems are the preferred method of irrigation delivery but high-efficiency pop-up spray heads may be used, where more appropriate than drip. Platforms shall be provided with quick connect couplers in recessed boxes at the back of the platform. The couplers shall be at approximately 85 feet on center to allow full coverage with a 50-foot hose. Irrigation equipment components shall be located to minimize vandalism but ensure easy access by maintenance personnel.

Where readily available, reclaimed water shall be used for the irrigation system. If there is potential for future connection to reclaimed water, landscape irrigation system lines and equipment shall be “purple pipe”.

Soil, infiltration rate, local climate, and planting water requirements shall be considered when designing irrigation systems. Plant materials of similar water requirements shall be grouped together into hydro-zones.

Landscape irrigation shall be scheduled to operate between 9 p.m. and 3 a.m.

26.6 CONSTRUCTION

The Sponsoring Party or its contractors installing the approved landscape plans shall comply with the rules and regulations contained in the current editions of the following SCRRA documents during the construction of the landscaping project:

i. Temporary Right-of-Entry agreement (SCRRA Form No. 6)
ii. Rules and Requirements for Construction on SCRRA Right-of-Way (SCRRA Form No. 37)
iii. General Safety Regulations for Third Party Construction and Maintenance Activity on SCRRA Member Agency Property
iv. Applicable SCRRA Engineering Standards

SCRRA and Member Agencies do not allow any parties to cause or permit any hazardous materials to be brought upon, stored, used, generated, or treated on or about the Right-of-Way. The Sponsoring Party and its landscape contractor shall not bring in or use any imported soils unless it has been tested and the results reviewed and approved by Member Agency for acceptability.

26.7 MAINTENANCE

The Sponsoring Party shall maintain the landscape materials, including vegetation and other improvements that are part of the installed landscape, in good order and healthy and vigorous condition to the satisfaction of SCRRA and the Member Agency, at its own cost and expense.

The Sponsoring Party shall notify SCRRA five working days in advance of any maintenance activity that shall occur within the Right-of-Way. The Sponsoring Party shall be responsible to reimburse SCRRA or the Member Agency the actual cost and expense incurred by SCRRA for all services and work performed in connection with the installation and maintenance of the landscape including a computed surcharge representing SCRRA’s and the Member Agency’s costs for administration and management.

Pruning of the plant material shall be performed by a licensed professional arborist to preserve the health and structure of trees and shrubs, for the prevention of damage to adjacent property, and to provide safety for train, vehicular and pedestrian traffic. Tree pruning practices shall follow the current ANSI A-300 standards.

Maintenance shall include, but not be limited to, watering, fertilizing, pruning, weed prevention, control and prevention of insects and diseases, removal of debris and other practices necessary to maintain the planting in acceptable healthy and vigorous condition. Maintenance shall also include control or removal of weeds or vegetation within and on the crossing easement area to avoid creating a fire hazard, obstructing visibility, or otherwise adversely affecting safety. Vegetation shall not interfere with the function of railroad signs or signals along the Right-of-Way and at highway-rail crossings; prevent proper functioning of signal and communication lines; or prevent railroad employees from visually inspecting moving equipment from their normal duty stations. If the Sponsoring Party does not perform the control or removal work, SCRRA will serve notice upon the Sponsoring Party to provide proper maintenance. If the Sponsoring Party fails to do so, SCRRA will remove the offending material at the sole expense of the Sponsoring Party.

Weeds and grasses must be removed in a manner that their removal does not damage any plant materials or present a fire hazard.

Any dead or damaged plant materials installed or maintained by the Sponsoring Party shall be promptly removed by the Sponsoring Party with or without identification or notification by SCRRA or Member Agency. If the Sponsoring Party has received notification from SCRRA or a Member Agency of the need to remove dead or damaged plant material, the Sponsoring Party shall acknowledge in writing that it has removed and replaced the offending material in coordination with SCRRA and the Member Agency within two weeks of receiving the removal notice.

26.8 VEGETATION MANAGEMENT PROGRAM

26.8.1 Program Goals

SCRRA employs an Integrated Pest Management (IPM) program for vegetation control to comply with local fire agency standards, Federal Railroad Administration Rules and the California Public Utilities Commission Orders for vegetation control. All herbicides employed are California Department of Pesticide Regulation (DPR) registered herbicides for Right-of-Way use, applied in accordance with the Manufacturers Labels by a State of California Certified Applicator under the supervision of a Licensed Pest Control Advisor using a written Pest Control Recommendation approved by the Local County Agricultural Commissioner where required.

The goals of the program are to maintain the railroad properties in a way that meet all applicable regulations in the most environmentally sensitive manner using cost effective methods.

The program consists of the following elements:

A yearly one-time pre-emergent herbicide application scheduled during the months of December to February just prior to an expected rainfall event of at least ½ inch. This application is timed to prevent noxious weed seed germination in the spring.

A yearly one-time post-emergent herbicide spot treatment program applied on an as needed basis from July to September. This application is site specific and based on the intensity of noxious weed breakthrough.

26.8.2 Application

When applying herbicides within the Right-of-Way, SCRRA will prevent damage to landscaping located within the Right-of-Ways as much as possible. However, there is a possibility of wind causing drift of the spray mix materials, which could cause damage to plants adjacent to the Right-of-Way. The Sponsoring Party should take into consideration the effect of SCRRA IPM vegetation control program and the effect of wind and rain when designing a landscape project. The Sponsoring Party shall be responsible for the in-kind restoration of any damaged area at its own cost and expense.

A zero-growth-herbicide treated buffer zone, 10 feet in width, shall be provided between the Right-of-Way and any landscaped areas. Bark or wood chip mulching ground cover, pavement or decorative rock or gravel is required within the buffer zone.

26.9 FUNDING

SCRRA does not provide funding for landscaping projects on the Right-of-Way.

26.10 EXCEPTIONS

Topography, environment, Right-of-Way widths, obstructions, utilities etc., may make it difficult to follow the requirements of these criteria. In order to provide a balance between SCRRA and Member Agency mandates to provide safe and efficient transportation to the public and the ability to meet interstate freight obligations and aesthetic benefits offered by the landscape installations, SCRRA may grant deviations or variances from these criteria provided that the project as a whole is consistent with the overall intent of the criteria.

The Sponsoring Party shall prepare an engineering report showing in precise detail the deviations from these criteria and provide a rationale supporting the proposed deviations.

26.10.1 Deviations from Published Criteria

All criteria shall be adhered to throughout the design. Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

Deviations, which would be considered, are as follows:

- Vertical separation between the tracks and the landscaping, which could enhance safety and railroad operations, maintenance and construction services.
- Locations where a minor deviation granted for a short segment or segments of the landscaping would enable successful development of a lengthier segment of the landscaping in accordance with these criteria.
- Circumstances where short or minor deviations from the criteria would produce significant benefits for the landscaping.
- Other approved measures, which could enhance safety and railroad operations, reduce maintenance, reduce costs, and improve construction services.

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27.0 RAIL-WITH-TRAIL

27.1 SCOPE

The following criteria represent preferred and in some cases minimum standards for the design, construction and maintenance of Rail-with-Trail in a manner compatible with safe operation of railroad corridors and with the rail capacity expansions envisioned for most corridors.

When a Rail-with-Trail is considered for joint use in railroad Right-of-Way or adjacent/under/over it, it should be considered in the context of safety for all uses of the corridor. Rail-with-Trail may affect SCRRA's ability to provide commuter rail transportation. However, Rail-with-Trail can be a community asset and when designed properly it can benefit SCRRA and the communities where they are located.

The following criteria seek to balance SCRRA's and Member Agencies' mandate to provide safe and efficient transportation to the public and the ability to meet interstate freight obligations, while remaining consistent with FRA regulations.

These criteria apply to SCRRA and its Member Agencies operated and maintained Right-of-Ways that are owned wholly or in part by the county transportation Member Agencies. These criteria do not apply to Right-of-Ways fully owned by BNSF or UP, where SCRRA has entered into joint use agreements to operate Metrolink commuter rail service.

27.2 STANDARDS AND CODES

All criteria shall be adhered to throughout the design of the project. Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2). Where any conflict exists, the stricter criteria shall govern.

27.3 REAL ESTATE REQUIREMENTS

27.3.1 General

The Project Sponsor shall consider the existing Right-of-Way needs in accordance with Section 24.2.3, Right-of-Way Requirements, of the DCM. Project Sponsor shall obtain written concurrence from SCRRA and the Member Agency of the affected real property as part of the feasibility assessment of the proposed Rail-with-Trail Project.

27.3.2 Proposed Agreement

Project Sponsor shall obtain a license or easement agreement for the Rail-with-Trail from the Member Agency whose Right-of-Way is directly affected by the project. The license or easement agreement shall include requirements, terms and conditions related to indemnification, license fees and compensations, assumption of risk and waiver, insurance, tests and inspections, responsibility for maintenance and repair, breach, abandonment, reimbursement, construction, relocation, payments, hazardous/toxic materials, compliance with laws etc., and as specified in Chapter 24, Right-of-Way Mapping and Surveying, of the DCM. The Project Sponsor shall be responsible for all coordination with the affected Member Agency to obtain all information related to the real estate agreement and its implementation. The Member Agency will be the sole authority on the fees and compensations due from the Project Sponsor for the rights granted.

License or easement agreement may also include requirements that provide for the removal and modification of the Rail-with-Trail to meet SCRRA's and Member Agency's mission to provide passenger rail transportation and their obligations to the freight railroads to provide rail freight service. At the request of SCRRA or Member Agency, the Project Sponsor shall remove, relocate, or modify, at its own expense, the Rail-with-Trail to accommodate additional track or tracks or other railroad related facilities in the Right-of-Way.

27.4 PERMITS

Project Sponsor shall obtain and comply with any and all permits, licenses and other authorizations required by applicable laws, regulations, rules, and ordinances for Rail-with-Trail project within the Right-of-Way.

27.5 PLANNING

27.5.1 Feasibility Study

Project Sponsor shall undertake a comprehensive feasibility analysis of the project. The feasibility study should describe the setting, the relationship to local planning documents, need for the project, land ownership, railroad activity present or future, and other information necessary to determine the feasibility. As a part of the feasibility study, environmental concerns should be analyzed pursuant to local, State, and Federal environmental laws. The Project Sponsor should, early in the process; engage affected stakeholders such as freight railroads, utility companies, law enforcement officials, adjacent landowners, Rail-with-Trail user groups, transportation, public transit, and park and recreation departments. The feasibility study should include viable alternatives to any Rail-with-Trail that are proposed within an active railroad Right-of-Way.

27.5.2 Safety Plan

Project sponsor shall develop a public safety plan that includes engineering standards, maintenance practices, trespassing deterrents, and Crime Prevention through Environmental Design (CPTED) Principles:

- Appropriate damage-resistant construction materials
- Appropriately sized landscaping for natural surveillance
- Secure access areas
- Barrier systems
- Video monitoring

Coordinated and responsive patrol service designating and enforcing rules and regulations while employing crime prevention strategies such as:

- Territorial reinforcement,
- Education,
- Signage
- Incident management
- System map - detailing access points for fire and police use

Safety Plan shall be in conformance with the requirements of SCRRA and the Member Agency jurisdiction the project will impact.

27.6 DESIGN

27.6.1 Design Standards

Rail-with-Trail widths, clearances, sight distances, signs, markings, drainage grates, manhole covers etc. shall be selected as per Caltrans "Highway Design Manual", Chapter 1000, "Bikeway Planning and Design." CA MUTCD guidelines shall also be referred to in the selection of signs, markings and signals.

If the Rail-with-Trail project creates an adverse impact at a grade crossing, the Rail-with-Trail project shall include mitigation as part of the design and address all requirements of Chapter 8 Grade Crossings. The Rail-with-Trail design should acknowledge any future rail and highway improvements. Safety requirements, including but not limited to, turning radii for design vehicles, preemption timing, street profiles, pedestrian signals and channelization, and rail and traffic signals at grade crossings should be analyzed. The Project Sponsor shall work with SCRRA, affected Member Agencies and regulatory agency (CPUC) so as not to hamper or preclude such improvements and requirements.

Design the project in a manner that avoids any impacts to existing railroad or grade crossing infrastructure, including impacts to existing leases and license agreements on the railroad Right-of-Way. If the Member Agency agrees that the impact is unavoidable, the Project Sponsor shall coordinate proper disposition, including associated costs to be incurred by the Project Sponsor, with SCRRA and the affected Member Agency.

27.6.2 Clearances

Rail-with-Trail shall be designed along the outer edges of the railroad Right-of-Way adjacent to the property line, and to maximize the Setback between the centerline of the nearest track (existing or future) and the closest edge of the Rail-with-Trail to the extent feasible. The Setback clearance shall take into consideration the type, speed, and frequency of trains; separation technique, and existing and proposed topography; sight distances; future tracks/improvements; and SCRRA's maintenance requirements.

The recommended minimum setbacks are 45 feet of any main line track where the corridor design speeds exceed 90 mph; 40 feet where main line speed is between 90 mph and 79 mph; 35 feet where main line speed is between 78 mph and 60 mph; 30 feet where main line speed is between 59 mph and 40 mph; and 25 feet where mainline speed is below 40 mph.

It may not be possible to provide recommended minimum Setbacks at certain points. While a railroad Right-of-Way may be sufficiently wide, the tracks may be within a narrow cut or fill section or adjacent to bluffs making placement of Rail-with-Trail very difficult. Safety shall not be compromised at such points. Additional barriers, vertical separation or other methods shall be employed. In such cases, Project Sponsor shall review impacts to minimum setbacks and proposed mitigation measures with SCRRA and Member Agency during the initial project submission. Approval of proposed mitigation measures and setback, shall be at the sole discretion of SCRRA and the Member Agency.

27.6.3 Highway-Rail Grade Crossings

SCRRA policy on highway-rail grade crossings is defined in Chapter 8, of the DCM. In conformance with this policy, Rail-with-Trail shall be designed to utilize existing public grade crossings, and no new additional crossings shall be added, unless approved otherwise.

Rail-with-Trail designs shall meet the requirements specified in Chapter 8, Grade Crossings, of the DCM. In locations where Rail-with-Trail impacts an existing grade crossing, the Project Sponsor shall conform to the requirements detailed in that Chapter including specified design features and responsibility for all regulatory approvals and permits.

27.6.4 Trail Surface

If the Rail-with-Trail is the only access for SCRRA and emergency response vehicles to enter onto railroad Right-of-Way, the Rail-with-Trail surface and bridges shall be designed and constructed to accommodate heavy railroad trucks and equipment. When access for SCRRA and emergency response vehicles is available from an existing street, the Rail-with-Trail shall be designed and constructed with curb ramps and pavement surface to accommodate heavy railroad trucks and equipment at pre-selected access points only. Choice of Rail-with-Trail pavement material and its structural section shall be determined by the Project Sponsor based on sound engineering design and judgment.

27.6.5 Utilities

Utility design shall conform to the requirements of Chapter 10, Utilities, of the DCM. Project Sponsor shall locate the existing SCRRA signal and track facilities on their plans during the design phase and should be designed to avoid any relocation of the existing SCRRA facilities.

Project Sponsor shall obtain written approval of design drawings from telecommunications, fiber optic, gas, oil, signal lines, or other companies that have prior use of the railroad Right-of-Way under easement or license agreements. The Project Sponsor shall cover all costs associated with utility entities design review/participation, construction inspection, agreements, relocations if needed, etc.

27.6.6 Landscaping

Landscaping, shall conform to the requirements of Chapter 26, Landscaping Design, of the DCM, and criteria published by Member Agencies. Any existing landscaping and irrigation impacted by Rail-with-Trail project shall be restored in like condition within temporary impacted areas. The Project Sponsor shall be responsible for all costs associated with landscaping for construction and long-term maintenance.

27.6.7 Fencing

In the absence of existing fence, the Project Sponsor, at its sole cost and expense, shall install fencing as per ES 5103 through ES 5105, fencing choice to be coordinated with SCRRA. The fence shall be located at the shoulder edge of the Rail-with-Trail. Fencing shall be designed in such a way to prevent entrance onto the railroad and tamper resistant.

Project Sponsor shall install gates with SCRRA locks to access the Right-of-Way for maintenance purposes at locations provided by SCRRA. Project Sponsor should install “No Trespassing” warning signs as per SCRRA Engineering Standard ES 5214.

27.6.8 Lighting

Project Sponsor shall provide lighting for the Rail-with-Trail if required by the local, state, or federal guidelines, rules, and regulations. For Rail-with-Trail projects where night time use is permitted minimum lighting levels shall be in conformance with the Caltrans Highway Design Manual. Project Sponsor shall also consider areas of security concern when developing proposed lighting design.

27.6.9 Drainage and Grading

Drainage and Grading shall conform to the requirements of Chapter 9, Drainage and Grading, of the DCM. Project Sponsor shall provide and maintain suitable facilities for draining the Rail-with-Trail area and shall not permit storm and irrigation water to flow or collect upon the Right-of-Way. The Project Sponsor should not have the sole responsibility to correct any existing drainage deficiencies on the Right-of-Way, however, the Project Sponsor shall not make the conditions any worse than existing prior to the Rail-with Trail construction on the Right-of-Way.

The Rail-with-Trail and the area located between the Rail-with-Trail and the nearest railroad track should be graded to flow over the curb and onto the street, when the railroad track is at the higher elevation than the surrounding ground and the street. When the railroad track is at a lower elevation than the surrounding ground and the street, a flat bottom swale (ditch) properly sized and flowing towards existing or proposed stormwater facilities, such as inlet, underground pipe, swale, creek, wash, or channel shall be constructed.

Mounding of earth on the Right-of-Way may be permitted only if it shall not adversely affect access, railroad maintenance activities, visibility, and drainage on the railroad Right-of-Way.

27.6.10 Access

SCRRA and Member Agency must be able to readily access, inspect, repair and maintain drainage systems, bridges, tie and track replacement, tunnel and trestle, signal and communications equipment and grade crossing equipment from existing roadways. Utility companies must be able to readily access their facilities for maintenance and operation purposes.

The use of automobiles is prohibited on the Rail-with-Trail, except for authorized emergency and maintenance vehicles including SCRRA and Member Agency maintenance vehicles. Horses and other animals are not permitted on the Rail-with-Trail, except for guide or service dogs. Appropriate signage shall be placed at all entrances to the trail designating restricted use.

The Rail-with-Trail shall be subject to and subordinate to the rights of all current and future tenants and licensees of Member Agencies, including the rights of reasonable access over the Rail-with-Trail project.

28.0 TRANSIT ASSET MANAGEMENT

The overarching goal of Transit Asset Management (TAM) is to ensure that a transit agency's assets are maintained and operated in a consistent and measurable manner and kept in a State of Good Repair (SGR). The TAM Plan, a document required by the Federal Transit administration (FTA) per Moving Ahead for Progress in the Twenty-First Century (MAP-21) legislation for all agencies that receive federal funding, provides guidelines by which an agency can track progress toward a simple and robust data-driven asset management system. TAM involves activities related to maintaining thousands of physical assets such as rolling stock, maintenance facilities, and rail infrastructure, in an SGR together with providing for a safe and reliable public transit service. The goal of the TAM Plan is to prioritize reinvestments based on performance, condition, and risk assessment of assets.

The term "asset" refers to physical equipment and infrastructure including rolling stock, right-of-way, stations, facilities, systems, tools, etc. that make up SCRRA's commuter rail system.

The three main purposes of a TAM Plan are to elevate the importance of transit asset management to the entire SCRRA organization, demonstrate compliance with all FTA reporting requirements, to develop a "roadmap" for the implementation of the TAM Plan, and to support an orderly implementation of the SGR. Overall, the Plan is a strategy to help avoid or minimize, the reactive, costly, crisis-type repair and replacement of assets.

In 2016, SCRRA completed the initial TAM Plan which incorporates condition assessment ratings utilizing various asset management systems including of Transit Economic Requirements Model (TERM) Lite, GASB-4, Rail Asset Management System (RAMS), NetFacilites, and AssetWorks to track asset conditions and the Metrolink Rehabilitation Plan (MRP) to project and prioritize capital needs over a 25 year horizon. This information is also used to supplement the near-term needs. TERM Lite is an FTA decision support tool that helps transit agencies, such as SCRRA, with SGR reinvestment needs and for prioritizing those needs given funding constraints. The inventory along with pre-defined life-cycle activities are used by the model to predict future needs.

Ultimately the TAM Plan will have nine elements.

1. Inventory of Capital Assets
2. Condition Assessment
3. Decision Support Tools
4. Investment Prioritization
5. TAM and SGR Policy
6. Implementation Strategy
7. Annual Activities
8. Identification
9. Evaluation Plan

Each asset class will include a TERM rating of one of the following.

- Excellent
- Good
- Adequate
- Marginal
- Poor

28.1 DESIGN CONSULTANT RESPONSIBILITIES

It is critical that the Design Consultant understands the SCRRA process and requirements of the asset management system. Previously, the Design Consultant would design a project providing PS&E. But now with the FTA asset management requirement, and for good business practices, SCRRA now requires a more involved approach by the Design Consultant to integrate certain aspects of the design elements that will ultimately improve the state of good repair. Therefore, the Design Consultant shall perform the following tasks at various stages of project delivery.

28.1.1 Preliminary Design

1. Consult will work with the SCRRA Planning and Development Department (TAM Manager) prior to the start of any design tasks. This consultant shall evaluate lifecycle needs as compared to the existing lifecycles and will design appropriately to best optimize the design element.
    - Establish an Invitation for Bid bid list items to include the appropriate items using Table 28-1 as a guide.
2. Consult with the SCRRA Maintenance and Rehabilitation Department to discuss the project regarding:
    - Type and manufacture of material and systems desired.
    - Locations and type of potential maintenance issues that may be corrected or improved by the proposed project.
    - Depending on funding, additional rehabilitation of existing assets that should be included as part of the proposed project.

28.1.2 Final Design

- At a minimum, include the asset types shown in Table 28-1. The bid list shall include these items as described in Table 28-1 with additional bid items as needed. Table 28-1 includes those items identified in the TAM Plan that are tracked for inclusion of the asset management system.
- Provide accurate bid items quantities used for the bidding process.
- Provide accurate as-built information to the Construction Manager.

- Coordinate with the CM to identify the final as-built quantities relative to the bid list as well as any items added during construction that may have not been included on the initial bid list but are pertinent to Table 28-1. Transfer this information to the TAM Manager.

28.1.3 Exclusion

Since SCRRA does few vehicle procurements as compared to infrastructure improvements, this chapter focuses on the latter. However, if the procurement involves locomotives and rolling stock then the Design Consultant will work with TAM Manger to identify what bid items need to be included with the procurement bid.

TABLE 28-1. SCRRA ASSET MANAGEMENT INVENTORY AS-BUILT LIST

Asset Type	Unit	Quantity	Manufacturer
Track			
Tangent – Wood Ties	TF		Not applicable
Tangent – Concrete Ties	TF		Not applicable
Curved – Wood Ties	TF		Not applicable
Curved – Concrete Ties	TF		Not applicable
Track-Special Track Work			
Single Turnout	EA		
Single Crossover	EA		
Double Crossover	EA		
Slip Switch (Single or Double)	EA		
Lapped Turnout	EA		
Single Crossing	EA		
Bridges/Culverts			
Bridges	LF		Not applicable
Culverts	EA		Not applicable
Tunnels			
Tunnels	LF		
Signals and Trail Control			
Wayside detector	EA		
Intermediate signal	EA		
Intermediate signal – automatic transfer panel	EA		
Back-up battery system	EA		
Wayside detector – intrusion detection warning	EA		
Back-up generator/UPS system	EA		
Electrocode repeater	EA		

TABLE 28-1. SCRRA ASSET MANAGEMENT INVENTORY AS-BUILT LIST

Asset Type	Unit	Quantity	Manufacturer
Crossing remote start location, RTU	EA		
Radio antenna	EA		
Roadway crossing	EA		
Grade crossings	EA		
Control point interlocking	EA		
Control point switch machine hand thrown switch machine	EA		
Control point, motorized switch machine	EA		
Communications			
Fiber optics equipment	EA		
Ruggidized network equipment	EA		
Station communication shelters	EA		
NOX monitoring system	EA		
Intrusion detection system	EA		
Radio equipment	EA		
Base radio stations	EA		
Radio antenna	EA		
Communication hubs	EA		
Other Systems			
TVMs	EA		
Validators	EA		
Computer equipment	EA		
Stations			
Station platforms	SF		Not applicable
Station canopies	EA		Not applicable
Elevators and escalators	EA		
Pedestrian walkways	LF		Not applicable
Parking spaces	EA		Not applicable
Facilities			
Facility equipment	EA		Not applicable

29.0 TEMPORARY TRAFFIC CONTROL

29.1 SCOPE

Safe and effective traffic control zone near a highway-rail grade crossing is an integral and high-priority element of every project from planning through design and construction. The requirements set forth in this section establish the basis for safe traffic conditions at or in the vicinity of any SCRRA highway-rail grade crossings. Every effort must be made to provide safe conditions for motorists, bicyclists, pedestrians, trains, and other vehicles. Location and duration of temporary traffic control, protection or lack of protection by railroad crossing warning system in both directions, type of rail and highway traffic, and flagging can affect the selection of temporary traffic control, signs, signals, markings, lighting, barricades, hand signal devices, etc. These variable factors shall be carefully studied prior to designing and implementing temporary traffic control zones.

The primary function of temporary traffic control is to provide for the safe and efficient movement of the roadway users and to provide protection to individuals and equipment within the activity area that has interrupted the normal use of the highway. The following criteria will provide acceptable alternatives to prescribe the appropriate temporary traffic control measure at highway-rail grade crossings.

The criteria are not intended to be a substitute for engineering knowledge, experience, or judgment, nor are these criteria intended to establish a legal standard. It is expected that the railroad professionals and traffic engineers will review other applicable design standards for more detailed information. The material presented herein is not intended to serve as a statement of a standard or recommended practice in traffic engineering.

Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

29.2 DEFINITIONS

For definitions see Appendix A Terms and Definitions.

29.3 REFERENCED STANDARDS

Temporary traffic control will comply with the current editions of the referenced standards. See the standards and codes listed in Appendix A.

29.4 TRAFFIC CONTROL PLANS

Development and approval of temporary traffic control plans are the responsibility of the local Public Agency having jurisdiction over the roadway. Traffic control planning and design shall be coordinated with SCRRA for any traffic control setup that affects any highway-rail grade crossing, whether directly (traffic control through crossing) or indirectly (causing vehicles to queue over the crossing). If it is determined the traffic control operation has the potential to impact the highway-rail grade crossing, SCRRA must approve any and all temporary traffic control plans and devices to assure no degradation of the safe operation of grade crossings and to provide safe and efficient movements of all roadway users.

The traffic control plan shall at a minimum consider and include the following information:

- Narrative explaining traffic control scope, duration, work hours, working days
- Existing conditions and facilities such as roadway and lane dimensions, sidewalks, curbs, driveways, medians, parking conditions, existing striping and pavement markings, traffic signals, posted speed limits, and existing signs, as well as track location, right-of-way limits and property lines
- Location, dimensions, and limits of the work area in the public or railroad ROW
- Any necessary traffic control devices, such as signs, barricades, cones/delineators, surface mounted channelizers, flashing arrow signs (arrow boards), changeable message signs (CMS), temporary striping, crash cushions, and k-rail
- Appropriate traffic control design elements such as advanced warning area, transition area, activity area, termination area, road closures, lane closures, speed zoning, tapers, buffers and clearances, parking controls, signal controls, and the proposed improvements necessitating traffic control
- Appropriate detour plans for vehicles, pedestrians, and bicyclists as necessary
- Stage construction as necessary for completion of proposed work.
- Any necessary temporary lighting to assure all grade crossing users have adequate visibility throughout construction
- Locations of roadway flaggers
- Location of existing RR warning devices. The plan should specify that visibility to RR warning devices shall be maintained at all times. If the existing crossing has RR gates, gate coverage shall be maintained the duration of construction or a roadway flagger shall be required.

Every effort shall be made to have, in place, emergency traffic escape routes on the downstream side of the highway-rail grade crossing. As many lanes as possible should be provided for traffic movement in each direction. Traffic control plans shall minimize the inconvenience, delay, and accident potential to affect traffic. If traffic control has the potential to cause queuing over the highway-rail grade crossing (such as reduced number of lanes downstream of a crossing) a roadway flagger shall be placed at the crossing to stop vehicles from blocking the crossing. The roadway flagger must remain at the crossing until the traffic control devices have been removed.

29.5 SUBMITTALS

Traffic control plans shall be submitted to SCRRA for all activities located within or in the vicinity of any SCRRA highway-rail grade crossings. A written approval of the traffic control plan from SCRRA and the Public Agency having jurisdiction over the roadway is required prior to initiating any construction activity. It is also necessary to obtain SCRRA's written approval for any changes to the traffic control plan. Signature approval from the Public Agency must be provided to SCRRA, before SCRRA will approve and issue any Right-of-Entry Permits to perform work on or adjacent to railroad ROW.

It is recommended that the Public Agency schedule a meeting with the SCRRA and the Public Agency's design engineer prior to the first submittal of plans to discuss initial concepts of the traffic control plans.

ES 4301shall be consulted prior to preparing and finalizing traffic control plans. This standard shows a typical application and it shall be modified to meet the needs of changing conditions in the temporary traffic control zone. Additionally, special attention shall be paid to CA MUTCD Parts 6 and 8 during development and revision of traffic control plans.

29.6 TRAFFIC CONTROL ELEMENTS

The location and duration of temporary traffic control, protection or lack of protection by railroad crossing warning system in both directions, type of rail and highway traffic and flagging can affect the design and selection of temporary traffic control plan. These variable factors should be carefully studied prior to designing and implementing temporary traffic control zones. The following are requirements to integrate the various factors affecting the temporary traffic controls at or in the vicinity of highway-rail grade crossings. Refer to ES 4301 for additional information.

- Location of Temporary Traffic Control (Work is within Railroad right-of-way vs work is in the vicinity of Railroad right-of-way);
- Duration of work (short-term stationary vs intermediate term stationary vs long term stationary);
- Railroad signal location (Highway-rail crossing warning signals present in one direction vs both direction);
- If there is queuing of vehicles across the track.

29.7 WORK WITHIN OR IN THE VINCINITY OF RAILROAD RIGHT-OF-WAY

A Law Enforcement Officer(s)/Roadway Flagger(s) will be present at all times at the crossing when queuing of vehicles across the track(s) due to traffic control activities cannot be avoided.

The "DO NOT STOP ON TRACKS" (R8-8) shall be prominently displayed on all approaches to a highway-rail grade crossing within the limits of a Temporary Traffic Control Zone.

SCRRA Form No. 5 (Indemnification and Assumption of Liability agreement) will be executed and submitted when highway-rail grade crossings exist within or in the vicinity of a Temporary Traffic Control Zone, lane restrictions, flagging, or other operations and queuing of vehicles across the track(s) cannot be avoided. This form can be accessed through SCRRA's website www.metrolinktrains.com.

29.8 RESPONSIBILITY/AUTHORITY

29.8.1 Public Agency

Traffic control plans and devices are the responsibility of the Public Agency having jurisdiction of the highway.

Temporary traffic control planning and design shall be coordinated with SCRRA since Public Agencies and SCRRA are obligated to coordinate all installation, operation, maintenance, use and protection of grade crossings activities under the California Public Utilities Commission.

The Public Agency shall reimburse SCRRA for all cost and expenses related to plan reviews and RWIC services.

If the Public Agency itself does the construction within or in the vicinity of the highway-rail grade crossings, the Public Agency will be responsible for all the requirements mentioned in Section 29.8.2, Contractor.

29.8.2 Contractor

The Contractor shall obtain all necessary permits, provide timely notifications and coordinate the work with all affected Public Agencies. The Contractor shall submit and obtain written approval of the temporary traffic control plans from the Public Agency and SCRRA for all activities located within or in the vicinity of highway-rail grade crossing.

The Contractor will submit SCRRA Form No. 5 or Form No. 6 prior to any activities at or near highway-rail grade crossings as per requirements shown in Section 29.7. SCRRA shall be notified in writing at least five working days in advance of any work on the temporary traffic control at the highway-rail grade crossings.

The Contractor shall train all Roadway Flaggers in the fundamentals of flagging traffic before being assigned as Roadway Flaggers.

The temporary traffic control will be performed as per California State License Board rules and requirements.

Temporary Traffic Control Zones will be inspected regularly to check that applicable traffic control signs, signals, markings, lighting devices, barricades are effective, visible, clean, and in compliance with the approved traffic control plan. All temporary traffic control devices will be removed as soon as possible when they are no longer needed.

The Contractor shall cancel the temporary traffic control at the highway-rail grade crossing if requested by SCRRA for the conditions mentioned in Section 29.8.3 below.

29.8.3 SCRRA

SCRRA will review, comment, and approve the temporary traffic control plans and SCRRA Form No. 5 or Form No. 6 submitted by the Public Agency or the Contractor.

SCRRA will provide the services of an RWIC, at the Public Agency’s or Contractor’s cost.

SCRRA will ask the Public Agency or the Contractor to cancel the temporary traffic control under any one of the following conditions:

- The Public Agency or Contractor activity does not meet CA MUTCD Part 6 and Part 8 requirements
- In the opinion of SCRRA the work interferes with or endangers the movement of Road Users and train traffic

- Law Enforcement Officer(s)/Roadway Flagger(s) are not present at the highway-rail grade crossing
- The Flagger qualifications, clothing, hand-signaling devices, Flagger procedures and Flagger stations does not meet the CA MUTCD, WATCH, or Caltrans requirements

If any of the above unsafe conditions exist, the traffic control will be terminated immediately or as soon as practical and work may be resumed at a later date after approval has been granted by SCRRA.

29.8.4 Law Enforcement Officer/Roadway Flagger

Flagger qualifications, clothing, hand-signaling devices, Flagger procedures, and Flagger stations shall meet the requirements as stated in the CA MUTCD, WATCH, or Caltrans manuals.

A Flagger shall provide temporary traffic control, in conjunction with the required flagging operations traffic control devices, such as warning signs, cones/delineators, and barricades.

Flagger shall familiarize themselves with the traffic conditions, traffic controls, traffic signals, physical features, and visibility prior to performing temporary traffic control duties.

Flagger shall prevent vehicles from stopping within the highway-rail grade crossing, considered as being 15 feet on either side of the closest and farthest rail.

29.9 PEDESTRIAN AND BICYCLE TRAFFIC

Special consideration should be given to pedestrians and bicyclists safety when the work area encroaches upon a sidewalk, walkway, crosswalk, or bikeway within or in the vicinity of a grade crossing. Traffic control plans shall be designed to maintain pedestrian and bicycle access unless otherwise approved by the Public Agency. Traffic control plans for pedestrians and bicyclists shall at minimum consider:

- Maintaining existing pedestrian crossings and public transportation stops
- Maintaining sidewalks or providing alternate routes
- Providing a minimum of 5 feet of horizontal buffer space between walkways within the work site and the work areas or operating equipment
- Providing walkways that are not in direct conflict with vehicles operating within the work site or other traffic
- Providing barricades or temporary traffic barriers when necessary to divert pedestrians within a street
- Providing adequate visibility of the grade crossing, warning devices and approaching trains. Depending on the construction activity, visibility to any of these items can be blocked due to the construction activity on any given day. Regular care needs to be given to access pedestrian and bicycle users during construction at or near a grade crossing.
- Maintaining adequate lighting throughout construction

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30.0 SHARED USE

30.1 SCOPE

With recent emphasis on different modes of transportation to improve public transit in densely populated areas, it is a priority for SCRRA Member Agencies that own railroad Right-of-Way that make up most of the SCRRA system to allow other transportation uses within the same corridor as SCRRA. These additional uses at times can create limitations on SCRRA, such as, future expansion, conflicts with operations, and maintenance challenges as well as increased planning, design coordination, budgets, and constructability and operational complications.

The criteria provided in this chapter considers only the different types of shared uses along with specifics pertinent to the intended use. Specifics pertaining to detailed design features such as track, grade crossings, stations, bridges, drainage, communications and signals, and other major aspects of the design are spelled out in detail in other chapters. Safety is the top priority of any project including shared use projects. Deviation from the preferred design criteria will require the approval of the SCRRA Project Manager via written acknowledgement. Deviation from the minimum criteria will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

To ensure a successful project, the Project Sponsor along with their consulting team shall meet with SCRRA at the beginning of the planning phase to review the SCRRA approval process, operational goals, system rehabilitation and upgrades, compliance with standards and specifications, Design Procedure Manual and Design Criteria Manual requirements, funding sources, schedule, third-party and stakeholders, regulatory requirements, and coordination with SCRRA projects.

30.2 GENERAL REQUIREMENTS

30.2.1 Definition of Shared Use

As defined by 49 Code of Federal Regulations (CFR) Part 211- Rules of Practice, Subpart F – Interim Procedures for the Review of Emergency Orders, Appendix A – Statement of Agency Policy Concerning Waivers related to Shared Use of Track or Rights-of-Way by Light Rail and Conventional Operations.

1. *Shared Track* - Shared use of track refers to situations where light rail transit operators conduct their operations over or crossing the lines of the "*general railroad system of transportation*"* (FRA regulated) and includes light rail operations that are wholly separated in time (temporally separated) from conventional operations as well as light rail operations operating on the same trackage at the same time as conventional rail equipment (simultaneous joint use). Usage of the term conventional, in the context of this chapter, refers to SCRRA's track assets.
2. *Shared Right-of-Way*– Transit vehicles operate on separate tracks with their track centers less than 25 feet from adjacent freight track centerlines.

3. *Shared Corridor* - Transit and conventional rail operators share the corridor, but tracks are separated by at least 25 feet and no more than 200 feet. The FRA believes that intrusion by derailed freight or transit cars onto a parallel railroad track is unlikely beyond 200 feet.

**The Federal Railroad Administration (FRA) also defines “shared minor facilities” as:

1. Highway/rail grade crossing where transit lines and general railroad system share crossing protection.
2. Railroad
3. Level crossings (diamonds) between transit tracks and general railroad system tracks.
4. Shared movable bridges.

* *General Railroad System of Transportation* - FRA refers to the network of standard gage track over which goods may be transported throughout the Nation and passengers may travel between cities and within metropolitan and suburban areas. See 49 CFR Part 209, Railroad Safety Enforcement Procedures.

**USDOT, *Catalog of Common Use Rail Corridors,* FRA, April 2003

30.2.2 Standards

SCRRA Standards - See Chapter 3 Section 3.2.1 SCRRA standards for a listing of applicable standards and documents.

Miscellaneous Requirements

- All projects must follow SCRRA standards and while Project Sponsors are subject SCRRA’s final decisions, there are times when deviations from these standards are acceptable after review and approval by SCRRA. It shall also be the sole responsibility of the Project Sponsor to identify all project requirements of not only the project specifics but those of any regulatory entity such as the FRA and CPUC. This also applies the following requirements, including but not limited to: requirements by cities, other public agencies, public and private utilities, and private companies as well as those having superior or prior rights over railroads such as grade crossings where the road existed before the railroad.
- Property rights by encumbrance mechanism such as easements and licenses.
- Rights granted by project delivery agreements and property acquisition settlements. This includes Right-of-Way purchase agreements and temporary construction easements.
- RTC – Rail Traffic Controller modeling results
- Utility provider requirements
- Operating Railroad Requirements – BNSF, UP, and Amtrak

During all phases of a project, the Project Sponsor shall identify all requirements inclusive of third-parties and stakeholders, include these into a risk registry, and present both to SCRRA for resolution and approval.

30.2.3 Jurisdiction

The Rail Safety Improvement Act of 1988, Pub. L. 100-342, ("RSIA") amended the Federal Railroad Safety Act of 1970, 45 U.S.C. §§ 421, 431 et seq., to provide the Federal Railroad Administration (FRA) broader regulatory authority over the Nation's railroads. The term "Railroad" as used in the Act means all forms of non-highway ground transportation that run on rails or electro-magnetic guideways, including (1) commuter or other short-haul rail passenger service in a metropolitan or suburban area, as well as any commuter rail service that was operated by the Consolidated Rail Corporation as of January 1, 1979, and (2) high-speed ground transportation systems that connect metropolitan areas, without regard to whether they use new technologies not associated with traditional railroads. Such term does not include rapid transit operations within an urban area that are not connected to the general railroad system of transportation. For policy reasons, FRA does not exercise jurisdiction under all its regulations, 49 CFR Parts 200 – 299, to the full extent permitted by statute. See 49 CFR Part 209, Appendix A.

30.2.4 Project Sponsor

SCRRA operates Metrolink service on various lines that are owned by different entities, most of which are the five Member Agencies that comprise SCRRA; more specifically, the Los Angeles Metropolitan Transportation Authority (LACMTA or Metro), Orange County Transportation Authority (OCTA), Riverside County Transportation Commission (RCTC), San Bernardino County Transportation Authority (SBCTA), and the Venture County Transportation Commission (VCTC). A large portion of Metrolink service is operated on Right-of-Way owed by the BNSF Railway and Union Pacific Railroad with a lesser portion on North County Transit District's line from the Orange County line to the Oceanside Transit Center.

In most cases, a Project Sponsor would be a public agency either one of the five SCRRA Member Agencies or other ones such as the Metro Gold Line Foothill Extension Construction Authority. Generally, the Project Sponsor will fund and lead a project from concept through delivery, hiring consultants, and bidding and managing the construction. This would only apply to the Right-of-Way owned by the five SCRRA Member Agencies. Any work on BNSF or UP Right-of-Way would be up to each railroad.

While an ultimate Project Sponsor may do planning, without input from SCRRA, for their own use such as adding projects to the Regional Transportation Plan, it will not relieve them from executing an agreement with SCRRA should the project go beyond the planning phase. Below is a general discussion of these requirements.

30.2.5 Oversight and Post-Construction Costs

For any Shared Use or other projects, affecting the SCRRA ROW, infrastructure, and operations, it is SCRRA's policy to recover all project oversight costs from concept to construction, commissioning, testing, and maintenance. Depending on the project, these costs may incorporate the use of SCRRA staff, consultants, vendors, contractors, flag protection, and legal counsel.

As with oversight, depending on the project, the Project Sponsor shall pay all associate project costs that may include ongoing costs after construction. These may include but are not limited to:

- Known future costs of additional required improvements, operations, and maintenance not only for the railroad infrastructure but those improvements that may be an ongoing cost to SCRRA.
- Administration that would charge to project for specific project related tasks such as contract compliance, grants and funding reporting requirements, and accounts payable and receivable invoicing processing.
- Operations – dispatching, train crews, maintenance of equipment, and bus bridges.
- Maintenance of Way – Trackwork (49 CFR Part 213), structures, stations, drainage, and grade crossings.
- Maintenance of C&S - Communications and signals (49 CFR Part 234 and 49 CFR Part 236), Customer Information System, ticket vending machines, positive train control (PTC), warning devices.
- Roadway Worker Protection (49 CFR Part 214), e.g. – Flagging, Form Bs, absolute work windows, track and time.

Due to the sensitivity of the SCRRA communications and signal system, and the requisite experience needed to design, test, and commission the system, the Project Sponsor shall contract directly with one of the SCRRA on-call PTC Communications & Signal Systems Design and Engineering Services firms to perform all designs including PTC, testing, programming, and commissioning of the Project for any work that effects the SCRRA signal system.

30.2.6 Design for End User

The goal of any project is to provide a cost-effective deliverable project within budget and schedule and with the best configuration possible that meets the End User’s needs. The End User is the entity that will operate and maintain the system that was designed. This includes all planning tasks that may eventually be used to help deliver a project. The basic question that the Project Sponsor and all designers shall apply, “Can the Project Sponsor improve the Metrolink system resulting in SCRRA operating and maintaining the improvement cost effectively?”, or “Can the Project Sponsor design and construct a system using the SCRRA Right-of-Way so as not to adversely affect Metrolink operations.” If during planning or designing of a project, the Project Sponsor or their consultant realizes that the Project creates too high of a risk to SCRRA to effectively and efficiently operate and maintain the Metrolink system, all work on the Project shall stop until a thorough reevaluation has been completed. Should this reevaluation result in a risk that is unacceptable to SCRRA, then all work shall stop. To ensure that the goal is met with the End User, the Project team (Project Sponsor, SCRRA, and third-party/stakeholders) at the very beginning of the project shall engage in one or more discussions with the SCRRA operating and maintenance departments to ensure that the Project does not adversely affect the Metrolink system. The team should also include any regulators such as the FRA and CPUC when appropriately. These discussions are crucial to providing a successful project.

30.2.7 Planning

Planning and delivering a shared use project adjacent to an existing railroad can take considerable coordination and planning with public agencies and private companies but also with state and Federal regulators. Two key drivers of a project's viability are construction costs and impacts to future expansion of the existing railroad system. It is important that all factors contributing to the costs and impacts, to the best of the Project Sponsor's knowledge, on operations, risks, impacts, safety, maintenance, costs, liability, regulatory responsibilities, and future growth be identified during the planning or preliminary design stages of a proposed project so that SCRRA can easily review the proposed project. Therefore, at a minimum, the following items shall be presented to SCRRA for review, comment, and approval before moving to final design.

30.2.8 Concept Planning

This plan shall show the proposed use of the SCRRA ROW at a 5 percent design level as defined in the SCRRA Design Procedures Manual as well as all other features and operational impacts including a clear identification of the effects to the existing SCRRA railroad infrastructure. In particular, for projects other than those that would be delivered specifically for SCRRA, the plans shall show separation distances between SCRRA tracks and facilities to that of the proposed use such as, OCS, crash walls, Right-of-Way intrusion systems, maintenance access routes, grounding of existing SCRRA facilities to eliminate potential stray current effects, at-grade crossings verses grade separations, quiet zones, and construction phasing. The Project Sponsor shall review the SCRRA Design Procedures Manual in its entirety and apply these requirements to all phases of project development from concept through construction, testing, and commissioning.

<u>100-Year Look Ahead</u>

Railroads should always be aware of changes that could negatively affect consideration of future or potential projects in the same area. This applies to either projects that are specifically for the improvement of the SCRRA system or those that are occupying the SCRRA ROW. Therefore, in either case, the Project Sponsor shall examine and accommodate any upstream and downstream operational effects to the SCCRA system; meaning, system configuration five miles either side of the proposed changes. For example, additional mainline or siding tracks may be needed or be extended farther to incorporate an industrial spur or setout track; signal spacing and aspect changes may need to be revised based on braking distances for new signals and control point locations; or allowing ROW for an additional station track for express trains or run through. The intent of the 100-year Look Ahead is to accommodate future SCRRA growth and to capture nearby improvements so as not to cause an adverse condition for the operation and maintenance of the SCRRA system.

<u>Operational Modeling</u>

The Project Sponsor, using Rail Traffic Controller (RTC®) to build their model (Chapter 32), will demonstrate that the proposed project will not diminish SCRRA's existing service and that of future goals for expanded service. The modeling shall also show operational impacts to SCRRA service during each phase of construction, ridership effects, and considerations for multi-modal transit connections. SCRRA must grant approval of the concept design for both the proposed project and any changes to the SCRRA infrastructure prior to advancing to preliminary design.

Maintenance of Way Considerations

Project Sponsor shall conduct meetings with the SCRRA Maintenance of Way, Rehabilitation, and Communications and Signal Maintenance Departments. The proposed project shall be presented to these departments with a focus on what issues that may impact the maintenance of the SCRRA system. Items to discuss include, but are not limited to, materials, specifications, constructability, maintenance access routes, coordination with ongoing and existing maintenance, and rehab projects.

Operating Railroad Consideration

SCRRA is obligated to host commuter rail services to Amtrak and freight railroads under previous agreements made when the railroad property was purchased by the Member Agencies. After the presentation of the concept plan to SCRRA, SCRRA will conduct an operating railroad stakeholders' meeting with these entities to discuss existing agreements. In some cases, a project will have an impact on the Class I railroads (BNSF and UP) and Amtrak. It is crucial that all railroad stakeholders know exactly the intent of the project and how it may affect their agreements and respective railroad operations. Some of the impacts may include, but are not limited to, maintenance access to existing and proposed infrastructure, environmental requirements, disruption to rail traffic, costs, constructability, and schedule. SCRRA will obtain written approval of the Project Sponsor's project from the commuter and freight operators as required under the previous agreements. RTC modeling by SCRRA, at the Project Sponsor's sole cost, may also be necessary for the operating railroad to approve the project.

Preliminary Engineering and Environmental Clearance (PAED)

Project Approval/Environmental Document

30% design plans, as defined in the SCRRA Design Procedures Manual being a project approval/environmental document, of both the project and changes to the SCRRA system shall be submitted to SCRRA for review and approval based on the approved concept plans and shall include revised construction phasing plans support by Rail Traffic Controller (RTC) modeling. The plans shall include, but are not limited to, revised RTC modeling, all Right-of-Way acquisition and temporary construction easements, type selections for proposed retaining walls, intrusion barriers, bridges, track alignment, special trackwork, PTC System, signal locations including houses and enclosures, communication facilities, grade crossing configurations, drainage facilities, stations, utilities and relocations, and any other details as defined in the SCRRA Design Procedures Manual for 30% design. Closely collaborate and coordinate with SCRRA during the preparation of the environmental documents. SCRRA shall be included in all meetings, conference calls, meetings with regulators, and distribution of all documents.

Cost Estimates

Identify to the best possible level all 5% and 30% project costs for any and all impacts to the SCRRA ROW and the SCRRA infrastructure, including but not limited to:

- Oversight of operational analyses, design, constructability, construction, construction management, and construction phasing;
- Testing, inspections, commissioning, training, and cutovers;

- Track outages, absolute work windows, bus bridges, and related notification costs; and
- Long-term maintenance increases.

Funding

Projects exclusively for the SCRRA system improvements sponsored by one of the five SCRRA Member Agencies (MA), the MA shall be solely responsible for identifying funding sources including local, state, and Federal funds, grants and formula funds, programming of said funds, maintaining all reporting requirements, and of closing Project Closeout. However, for some projects, the MA may work jointly with SCRRA to acquire the project funding. In this case, the agency providing the majority of the funding, SCRRA or a MA, shall be the lead agency from PAED to delivery.

Should the Project Sponsor be a third-party with the goal of delivering a system using the SCRRA ROW, such as an LRT project, the Project Sponsor shall be solely responsible to acquire all funding and shall disclose said funding to SCRRA.

Regardless of the Project Sponsor, it is imperative that all funding sources along with the funding requirements be disclosed to SCRRA.

30.3 DESIGN CRITERIA

30.3.1 Shared Track

The use of Shared Track, high-speed rail (HSR) on SCRRA tracks, will be avoided if possible. If the Project Sponsor desires to use Shared Track operation, the Project Sponsor shall conduct a thorough safety study for Shared Track addressing speed, headways, mixed passenger and freight operation, track class, signal and train control, PTC, grade crossings and grade separations, Right-of-Way, maintenance of way equipment, and systems. After completing this study, the Project Sponsor shall obtain approval of using shared track from SCRRA and applicable operating railroads prior to proceeding past the planning phase.

30.3.2 Compliant Vehicles

Since the SCRRA system is part of the general railroad system of transportation, only compliant railroad vehicles will be allowed to operate on its tracks, see 49 CFR 238. Therefore, SCRRA will not allow LRVs to operate on its tracks including temporal separations. Furthermore, the crossing of SCRRA track with LRVs will also not be allowed except for spur access by freight operators.

The use of alternative vehicles such as diesel multiple units (DMUs) or zero emission multiple units (ZEMU)s on Shared Track will require SCRRA approval and the FRA prior to bidding the project for construction.

30.3.3 FRA Waiver for LRT Projects

Waiver Petitions Involving No Shared Use of Track and Limited Connections Between Light Rail and Conventional Operations - Even where there is no shared use of track, light rail operators may be subject to certain FRA rules based on limited, but significant connections to the general system. Of course, if the conventional railroad has responsibility for compliance with certain regulations that apply at that point (for example, where the conventional railroad maintains the track and signals and dispatches all trains), the light rail operator will still be responsible to comply with the related regulations.

For all projects that may require a waiver and approval by SCRRA, SCRRA will request the waiver for the Project Sponsor. SCRRA will also notify the CPUC of the waiver.

30.3.4 Grade Separations

The large number of SCRRA highway-rail grade crossings, combined with increasing number of trains, motorized vehicle, and pedestrian traffic, has driven the need for SCRRA to develop a grade separation policy. When considering changes and modifications to existing grade crossings, a new grade crossing, new SCRRA service, high-speed rail, or light rail service, the Project Sponsor of the new mode shall prepare, at its sole expense, shall prepare a report based on Chapter 12, Grade Separation Criteria and submit to SCRRA for approval. It is recommended that the Project Sponsor obtain SCRRA approval for any proposed grade crossing improvements or grade separation prior to advancing beyond the planning phase.

As part of the grade separation design, the Project Sponsor may need to perform an analysis of the Fresnel zone to determine if the PTC microwave system is negatively impacted. If so, the Project Sponsor shall discuss any PTC modifications with SCRRA prior to advancing a design.

30.3.5 Railroad (Diamond) Grade Crossings

Should a light rail operation need to cross SCRRA tracks at grade through a diamond, several Federal regulations will apply to the light rail operation. If movements at the crossing are governed by a signal system, Federal regulations (49 CFR Parts 233, 235, and 236) apply, as do the signal provisions of the hours of service statute, 49 U.S.C. 21104. To the extent radio communication is used to direct the movements, radio rules (49 CFR Part 220) apply. Likewise, track safety standards (49 CFR Part 213) covering any portion of the crossing that will affect the movement of the SCRRA equipment and trains as well as freight rail operators.

30.3.6 Parallel Highway-Rail Grade Crossings

Light rail operations over highway-rail grade crossings also used by commuter or freight trains will be subject to Federal and state regulations on grade crossing signal system safety (49 CFR Part 234) and the requirement to have auxiliary lights on locomotives (49 CFR 229.125). Even if SCRRA maintains the crossing, the light rail operation will still be responsible for reporting and taking appropriate actions in response to warning system malfunctions. Depending on the grade crossing configuration, if an LRT project uses one side of the crossing with SCRRA using the other side, then the Project Sponsor and SCRRA will negotiate a shared grade crossing maintenance agreement. This agreement basically requires the LRT operator to maintain the warning devices on their side of the crossing with SCRRA maintaining the warning devices on their side. For reference, similar agreements exist between San Diego Trolley and the North County Transit District and between San Diego Trolley and BNSF for the Right-of-Way in downtown San Diego.

30.3.7 OCS Stray Current

For any proposed mode that is electrified, the running rails are used as the return conductor for OCS**.** Low resistance between the traction return rails and the ground allows a significant part of the return current to leak into the ground, commonly known as stray current. This stray current creates or accelerates the electrolytic corrosion of the metal structures in proximity of the transit system causing metal pipes, cables, and earthing grids laid in or on to ground near the electrified tracks to have a much shorter life span. The original and new railroad infrastructure operated by SCRRA never considered stray current. Therefore, the Project Sponsor of an electric mode project proposed in the SCRRA Right-of-Way shall retrofit all SCRRA infrastructure including but not limited to stations, fencing, trackwork, grade crossings, bridges and other structures, signal and communication systems, warning devices, and all other infrastructure items subject to corrosion as needed to eliminate any and all stray current affects to the SCRRA system. Furthermore, no third-rail systems will be allowed within the SCRRA Right-of-Way.

The Project Sponsor shall identify all third-party infrastructure that may be influenced by stray current. This will be followed by a cathodic corrosion prevention plan with estimated costs to not only retrofit SCRRA systems and infrastructure but those of third-parties that have infrastructure within the SCRRA right-of-way.

30.3.8 Electrification

For Shared Track, the traction power supply system shall be designed so that the system is compatible with commuter and freight railroad operations. A study of the power supply system on the other modes of transportation shall be made and presented to SCRRA in conjunction with a plan to mitigating any adverse effect to the SCRRA system.

30.3.9 Maintenance Access

As expected, many parts of a railroad require direct vehicular access to maintain such infrastructure as switches, switch machines, signal houses and cases, signals, radio antennae, and culverts. However, in many locations along the SCRRA Right-of-Way vehicular access is limited or none-existent. This condition was generally a result of the previous Class I rail corridor owner. As a result, it is SCRRA’s policy that all projects shall provide vehicular access to all of the above referenced infrastructure, existing or proposed, by use of a 10’ wide graded road running adjacent to the tracks and originating from a public street.

30.3.10 Right-of-Way

The SCRRA operating railroad Right-of-Way is owned by the five SCRRA Member Agencies as discussed in Section 30.2.4 above. These rights-of-ways were secured from the three major Class I railroads, i.e. - Southern Pacific Railroad, Union Pacific Railroad, and the Atchison Topeka and Santa Fe Railway. Dating back as early as 1855, these railroads over the years had granted thousands of license agreements for various crossings and linear uses such as overhead and underground utilities, private and public roads, freeways and highways, drainage systems and flood control channels, fuel and communication lines, pedestrian bridges, and private uses by adjacent land owners. By Federal law, the Member Agencies have the same rights in all aspects as do the original owners including the ownership and management of these licenses.

Licenses

Working with each of SCRRA Member Agencies, the Project Sponsor shall be responsible for identifying all licenses, agreements, and in rare cases, easements on the railroad. This information shall be plotted on the project drawings and field verified where possible.

Usually the railroads have prior rights since they were there first in the 1800s. By reviewing the license agreements, the licensee may be required to move or modify their infrastructure at no cost to the railroad owner. However, there are some locations that others have the prior rights, mostly some roadways but also a few miscellaneous users for example, the City of Riverside water delivery channel in San Bernardino that dates back before the Santa Fe. In these cases, the Project Sponsor will need to comply with the user's requirements. Refer to Chapter 5 for additional Right-of-Way criteria.

Right-of-Way Acquisitions

Since SCRRA was created as a Joint Powers Authority and not by a legislative action, SCRRA cannot acquire ROW through eminent domain, commonly known as condemnation. Instead, any eminent domain action needed to acquire Right-of-Way will require the respective SCRRA Member Agency to take the lead. The Project Sponsor shall work with the respective SCRRA Member Agency to handle all Right-of-Way acquisitions, either by negotiation or eminent domain. While the SCRRA track charts show ROW, the Project Sponsor shall have a preliminary title report prepared of all of the proposed areas of the SCRRA system that require improvement. The Project Sponsor shall also survey the railroad Right-of-Way to the limits of the project, set Right-of-Way monuments at all ROW deflection points, beginning and end of ROW curves, centerline of roads, and prepare and record a Record of Survey with the respective county.

30.3.11 Track Separations

The minimum side distance from centerline of tracks between of SCRRA/Amtrak/freight verses any other mode shall be 30 feet inclusive of a SCRRA fencing with intrusion protection; a device or system that alerts SCRRA anytime that the something penetrates the fence line or the plane of the fence projected upward. Depending on the speed of both the new mode and SCRRA trains on adjoining tracks, SCRRA may require the track centers to be increased to include cash walls per AREMA recommendations.

30.3.12 Shared Stations

The Project Sponsor at the beginning of the concept phase should contact the respective SCRRA Member Agency regarding ownership and existing agreements for any station considered for shared use. The ownership is different in each of the five counties.

For example, in Riverside County, RCTC owns, maintains, and operates the Metrolink stations as compared to SBCTA who owns the station within the railroad ROW and has half ownership of the parking lot with the respective city. SCRRA does not own any of the stations.

For existing stations intended to be expanded to include Shared use, the following items shall be reviewed, including but not limited to; platforms with all associated appurtenances:

- Platform Shelters

- Platform signage
- Passenger information systems,
- Ticket vending
- Platform furnishings
- Level boarding
- Track and signal alignment
- Platform access
- At-grade pedestrian crossings
- Grade separated pedestrian access

All of which will require SCRRA approval during planning and final design as well as the FRA and CPUC.

Shared station size, access, parking, and passenger facilities will be designed to accommodate train and passenger volumes and frequency required to serve the future demands. The station designs will consider the need for waiting areas, concourses, ticketing, restrooms, safety and security, and other support services. Shared platforms may be allowed if the new mode is on the opposite side of an existing platform and if the platform is wide enough to allow for level boarding of the new mode. Shared platforms will be prohibited where Metrolink trains load and alight trains.

See Chapter 7 for detailed information about SCRRA stations.

30.3.13 Utilities

See Chapter 10 for detailed information about utilities.

30.3.14 Structures and Pier Protection

See Chapter 12 for Pier Protection requirements and the various structures related chapters for other requirements.

30.3.15 Railroad Intrusion Detection System

Most railroad systems are completely open to intrusion by errant vehicles, people, maintenance personnel, and objects coming into the railroad Right-of-Way. While statistics show most deaths occur in railroad Right-of-Way from trespassers, railroad workers can also be at risk. Adding a system such as an LRT adjacent to a railroad increases these risks. LRT systems are regulated by the CPUC as compared to railroads which are regulated by the FRA. Both have similar roadway workplace safety requirements, however Federal regulations hold railroads to a higher and different standard. If an intrusion barrier is not constructed between the two systems, LRT maintenance crews are more likely to encroach into the railroad Right-of-Way and be close enough to foul SCRRA tracks. For this reason, a railroad intrusion detection system or wall shall be required between the two types of systems. This requirement also applies to high-speed rail or any other different mode. The type of system or wall will depend on the speed of the rail vehicles, which direction they are traveling, and more notably, the spacing between system tracks.

However, unlikely as it is, separation distances of 200 feet and greater will not require an intrusion wall.

The type and height of railroad intrusion detection system or wall or device is subject to SCRRA approval. The intrusion system shall run continuously between the two modes. Furthermore, the detection system shall be independent and not a tied to the signal system. The system shall be designed and built by the Project Sponsor to SCRRA requirements. The ongoing maintenance costs shall be paid by the Project Sponsor.

30.3.16 Train Control Interaction

Where a light rail operation is governed by the same train control system as a commuter/freight railroad (e.g. - at a moveable bridge that they both traverse), the light rail operator will be subject to applicable Federal regulations, primarily the signal rules in 49 CFR Parts 233, 235, and 236, if it has maintenance or operating responsibility for the system.

30.3.17 Construction

As stated above, the Project Sponsor shall solely be responsible for all Project construction and oversight costs incurred by SCRRA staff, consultants, vendors, contractors, and legal counsel as well as all stakeholder costs such as the freight railroads, public agencies, and utility companies.

Refer to SCRRA specifications Section 01 14 00, Work Restrictions, for requirements, provisions, and rules and hours of operation regarding construction activities that affect SCRRA’s operating system.

31.0 SIGNAGE

31.1 SCOPE

The design of an SCRRA signage layout is site-specific and shall reflect the surrounding community. However, the functionality of SCRRA signage must be practical and consistent in order to effectively serve SCRRA train crews and passengers. The preferred criteria set forth in this chapter are intended to ensure that all signs are designed and placed to meet the minimum requirements for a SCRRA commuter train station, highway-rail crossing, pedestrian rail crossing, or railroad corridor. All signage and graphics shall fully conform to the most current version of the SCRRA Engineering Standards ES 3301 thru ES 3340. It is the DESIGN CONSULTANTS responsibility to be aware of changes to the Engineering Standard drawings.

31.1.1 Standards and Codes

This chapter provides preferred criteria for the selection of signs and materials necessary to communicate effectively with the public. Current standard signs shall be used as necessary to comply with all laws and regulations. Signage design shall meet all current and applicable parts of referenced and applicable standards. As well as meeting specific project requirements, where any conflict in criteria exists, the stricter criteria shall govern.

Deviation from the preferred design practices and standards will require the approval of the SCRRA Project Manager via either the project Design Submittal Report or a project specific Basis of Design Report. Deviation from the minimum standards will require approval by SCRRA through a Request for Special Design Consideration (see Section 3.2.2).

31.2 SIGN PLACEMENT

Signage on a railroad system is one of the crucial ways that the public learns to use the rail system safely. The designer shall take special care to layout signage plans in a manner that aids in that communication. Signs shall be placed such that visual conflicts with other signs and other warning devices are eliminated to the extent possible. Signs should be placed so that all signs at a location combine to produce a clear meaning such that a prudent user of the roadway has the information necessary to safely use the transportation systems.

Signs shall have a minimum clearance of 10 feet from centerline of track to edge of sign, see ES 2102.

31.3 SIGN SCHEDULE

A comprehensive signage schedule for the project under design shall be prepared that details all signs to be placed, their location, type, specific sign name, orientation, and legend. This sign schedule shall be included in the construction documents.

31.4 PROJECT SIGN DURING CONSTRUCTION

A construction specific project sign shall be placed to inform the public of the project title and regarding the project funding sources. See ES 5201.

31.5 RIGHT-OF-WAY SIGNAGE/RAIL CORRIDOR SIGNAGE

Signage along the rail corridor is placed to aid rail operations and to deter trespassers from entering the railroad Right-of-Way.

31.5.1 SCRRA ROW Station Signage

ROW signs are necessary for passenger information and train operations or are required by ADA. Additional signs shall be configured to control passenger and trespasser access to the tracks and the Rail ROW. See the ES 3000 series for examples of required and optional station signage.

At the station owner's cost, SCRRA will design, fabricate, and install various signs on the platform and in the ROW. SCRRA will be responsible for ongoing maintenance of ROW signage.

31.5.2 SCRRA Mile Posts

Mile post signs shall be placed along the project corridor in a manner that allows them to be read from both directions. In single track territory mile post signs shall be placed on the right hand side of the track as one faces increasing mile posts. In areas of multiple tracks, mile post signs shall be placed on the field side of the track farthest to the right. Horizontal signs are preferred. See the following SCRRA Engineering Standards from the ES 5000 series:

- ES 5211 for Mile Posts signs
- ES 5213 for Permanent Speed Restriction signs
- ES 5214 for No Trespassing and Tenth Mile Post signs

31.5.3 Quiet Zone Signage

Quiet Zone signage alerts the public to a crossing at which train horns are not routinely sounded as a train approaches.

31.5.4 Public Information Signs

The application of signage at highway-rail grade crossings that are in a Quiet Zones (QZ) is defined in Part 8 of the CA MUTCD and SCRRA ES 4002, ES 4005 and ES 4006. QZ signs are necessary for road-user information and safety. Design signage at each crossing shall comply with FRA 49 CFR 222 and MUTCD & CA MUTCD, in particular the following:

- FRA 49 CFR Section 222.25
  - At a minimum, each approach to every private highway-rail grade crossing within a new QZ, or partial QZ, shall be marked by a "Crossbuck" and a "STOP" sign, which are compliant with MUTCD standards unless otherwise prescribed by State law.
- FRA 49 CFR Sections 222.35(c)1
  - Each highway approach to every public and private highway-rail grade crossing within a QZ, or partial QZ, shall be equipped with an advance warning sign that advises the motorist that train horns are not sounded at the crossing. Such signs shall conform to the standards contained in the MUTCD.

- FRA 49 CFR Sections 222.35(f)
  - All pedestrian grade crossings within a QZ must be treated in accordance with Section 222.27 of this part.
- FRA 49 CFR Sections 222.27(d)1
  - Each approach to every pedestrian grade crossing within a QZ shall be equipped with a sign that advises the pedestrian that train horns are not sounded at the crossing. Such sign shall conform to the standards contained in the MUTCD.
- MUTCD Section 8B.01 Table 8B1 Grade Crossing Sign and Plaque Minimum Sizes
  - “No Train Horn” W10-9
  - “No Train Horn” W10-9P
- MUTCD Section 8B.17 LOOK Sign (R15-8)
  - At grade crossings, the LOOK (R15-8) sign may be mounted as a supplemental plaque on the Crossbuck support, or on a separate post in the immediate vicinity of the grade crossing on the railroad ROW. A LOOK sign should not be mounted as a supplemental plaque on a Crossbuck Assembly that has a YIELD or STOP sign mounted on the same support as the Crossbuck.

31.5.5 Train Crew Information

There are a variety of informational signs to provide information to train crews. These signs shall have a minimum clearance of 10 feet from centerline of track, see ES 2102. The following signs shall be placed:

- Whistle Point and Quiet Zone signs shall be placed per ES 5216
- Control Point Limit signs shall be placed per ES 5218
- Station Name signs shall be placed per ES 5222
- Mechanical Limit and No Ride Zone signs shall be placed per ES 5223

31.6 HIGHWAY RAIL GRADE CROSSING SIGNAGE

The application of signage at highway-rail grade crossings is defined in Part 8 of the CA MUTCD and SCRRA ES 4006. The requirements within this section of the CA MUTCD for the proper application of highway signs at the crossing and SCRRA ES 4006 shall be adhered to.

The highway agency is responsible for approving the use of highway signs, installation and maintenance. Design of highways signs at and around highway-rail grade crossings will require coordination between the highway agency, CPUC and SCRRA.

Additional warning signs (such as a “Low Ground Clearance” W10-5) are preferred to alert motorists of a low ground-clearance situation at multiple-track crossings involving concentric superelevated curves.

In addition to highway signs to be installed at the highway-rail grade crossing, there may be additional signs required to inform the public of warnings and regulations at a highway-rail grade crossing. Following is a partial list, other signs may be required:

- “No Dumping/No Trespassing” per ES 5214
- “Emergency Notification Sign (ENS) (I-13)” as per ES 8270-02 and as per CA MUTCD Section 8B.18
- Number of Tracks Supplemental Warning Panel W48 per CA MUTCD Section 8B.06
- “DO NOT STOP ON TRACKS” Sign (R8-8) per CA MUTCD Section 8B.09
- “STOP HERE ON RED” (R10-6) per CA MUTCD Section 8B.12
- “STOP HERE ON FLASHING” (R10-8) per CA MUTCD Section 8B.12
- Short Storage Space Signs (W10-11, W10-11a, W10-11b) per CA MUTCD Section 8B.24
- Skewed Crossing Sign (W10-12)
- TRAINS MAY EXCEED 80 MPH Sign (W10-8) per CA MUTCD Section 8B.20
- “LOOK” (R15-8) per CA MUTCD Section 8B.17 and ES 3319 & ES 4006
- “Warning! Do Not Cross Tracks When Gates Are Down” per ES 3317

Installation of such signs on SCRRA’s member-owned ROW shall be installed per the latest SCRRA Engineering Standards.

For temporary construction crossing signage refer to ES 4302.

31.7 PEDESTRIAN RAIL GRADE CROSSING SIGNAGE

The application of signage at pedestrian grade crossings is defined in Part 8 of the CA MUTCD and per the following SCRRA Engineering Standards:

- ES 4002
- ES 4006
- ES 4018
- ES 4021

The requirements within this section of the CA MUTCD for the proper application of pedestrian crossing signs at the crossing and SCRRA ES 4005 and ES 4006 shall be adhered to. All at-grade pedestrian crossings shall include horizontal warning signage on the pathway at each side of the crossing.

CA MUTCD Signs:

- “LOOK” (R15-8) per CA MUTCD Section 8B.17 and ES 3319 & ES 4006

31.8 WAYFINDING STATION SIGNAGE

31.8.1 Platform and Right-of-Way signs

Platform and ROW signs are necessary for passenger information and train operations or are required by Federal Standards for Accessible Design.

Signs shall be placed at sufficiently frequent intervals and at visible locations to provide clear directions and information to commuters without additional assistance.

Right-of-Way Signs

At the station owner's cost, SCRRA will design, fabricate, and install various signs on the platform and in the ROW. Alternatively, upon coordination and after approval from SCRRA, the station owner may design, fabricate and install most platform signage as reviewed and approved by SCRRA. These signs are necessary for passenger information and train operations or are required by Accessible Design.

Station signage will include train car position signs to indicate to train crews where to position trains at boarding locations, these signs must be allowed for in the design of other station features. See ES 3303.

Additional signs shall be configured to control passenger and trespasser access to the tracks and the ROW.

Platform Signage

At the station owner's cost, SCRRA will design, fabricate, and install various signs on the platform. Maintenance of all platform signage is the responsibility of the station owner.

Persons are subject to California Penal Code section 640 which regulates actions on or in facilities or vehicles owned or leased of a public transportation system. Signage limiting access to the transit station or vehicle shall be posted prior to the entrance to the platform or station 640.c(1)

https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=PEN&sectionNum=640

Wayfinding Signage

Accessibility requirements for Signage shall meet the provision of CBC 11B-216.1 Signs and CBC Chapter 11B Division 7: Communication Elements and Features.

Wayfinding is defined as "directional signage" for the purpose of accessibility requirements.

Refer to CBC 11B-703.5 for Accessibility requirements for directional signage. Accessibility requirements for directional signage include:

- Non-glare finish.
- Contrast: characters shall contrast with their background with either light characters on a dark background or dark characters on a light background.
- Case: Characters shall be uppercase or lowercase or a combination of both.
- Characters shall not be italic, oblique, script, highly decorative or other unusual forms.

- Characters shall be selected from fonts where the width of the uppercase letter “O” is 60 percent minimum and 110 percent maximum of the height of the uppercase letter “I”.
- Minimum character height shall conform to CBC Table 11B-703.5.5.
- Visual characters shall be 40 inches minimum above the finish floor or ground.
- Stroke thickness, character spacing, line spacing, and format shall comply with CBC 11B-703.5.

Braille

Refer to CBC 11B-703.3 for Accessibility requirements for braille signage. Braille signage is required for:

- Restrooms
- Permanent rooms
- Elevators
- Exit Routes
- As determined by CBC 11B-216.
- Doors leading into hazardous areas that might prove dangerous to a blind person shall be made quickly identifiable by tactile/Braille signage, mounted on the wall at the latch side of the door.

Where braille is determined to be included for accessibility, braille construction shall comply with CBC 11B-703.3. Additional braille that is not required but included shall also comply with CBC 11B-7.3.3.

Dual-Language Signage

A maximum of two languages on a single sign or sign assembly shall be allowed. Dual-language signage shall be limited to wayfinding signage from the platform area to the exit or entry of the station. The allowance and the determination of the second language shall be approved by SCRRA prior to fabrication of the signage.

See ES 3301 through ES 3340 for examples of required and optional station signage.

31.8.2 Customer Information Signs

Refer to Chapter 20, Communications Systems, for electronic or low-voltage powered customer information signs.

31.8.3 Fire Department signs

Fire department connections shall be designated by a sign with raised letters, at least one inch in size, cast on a plate or fitting reading: “Autospkr,” “Open Spkr,” or “Standpipe,” whichever is appropriate. The sign shall also indicate the buildings or structures, or parts thereof, served by the connection. The Authority’s logo shall be provided at each fire department connection for identification.

31.8.4 Multiple Track Signage

At highway-rail crossings that have multiple tracks signage shall at minimum follow the requirements of ES 5216, ES 4006, ES 4302, and ES 4311.

31.8.5 In-Station Pedestrian Crossing Signage

Pedestrian only crossings shall have signage laid out per ES 4018 and ES 4021.

31.8.6 Parking Lot Signage

All station parking lot entrances must include an entrance sign containing the SCRRA logo. The main entrance must also have a monument sign. The logo must be configured to comply with the SCRRA graphics standards. At the station owner's cost, SCRRA can design, fabricate, and install a porcelain enamel SCRRA monument sign. The station owner is responsible for all parking, informational, and traffic control signs in the station parking lot. SCRRA can assist in the design, fabrication, and installation of parking lot signs at the station owner's expense.

Other vehicular directional signs should be provided to direct motorists to the accessible parking and short term drop off (Kiss-n-Ride) areas as needed.

Parking Lot signage shall at a minimum include:

- ADA Parking Space signage
- ADA Van Accessible signage
- Short term Drop-off area signage
- Circulation/ Exit signage
- ADA Towing signage
- Wayfinding signage
- Electric Vehicle Charging Station (EVCS) signage

Placement of Accessible signage requirements shall comply with CBC Chapter 11B Division 5: General Site and Building Elements. Identification shall comply with CBC Chapter 11B-502.6.

Station signage placement will occasionally overlap with the placement of railroad operating signs. Refer to Section 31.2, Sign Placement, as all signs must be accommodated in locations with visibility for all users without blocking view of other signs or warning devices.

The station owner is responsible to maintain parking lot signage.

31.9 WAYFINDING SIGNAGE (OFF-SITE SIGNS)

Trailblazer signs are used to direct patrons from freeway off-ramps and major arterial highways to the stations. Station owners should coordinate with Caltrans for the installation of Caltrans trailblazers when appropriate. White-on-green Caltrans guide signs (G95G – train station next exit) are used to indicate the freeway exit for a station. White-on-green Caltrans guide signs (G97 – train station with supplemental SCRRA plate) are at the bottom of freeway off-ramps and on major arterial highways to direct motorists to the station. Trailblazer signs on local roads shall be per ES 3306. SCRRA can provide full-color SCRRA trailblazers to cities for installation by city forces on local streets, at the local agency's expense. Such signs will be maintained by city forces. If signs are posted in areas of poor lighting project owner may choose to light signs.

31.10 MONUMENT SIGNAGE

Monument signage shall include signage that at a minimum identifies the station. Monument signage shall be coordinated with the station identity and station architecture for signage assembly material selection. Monument signage shall be included near the entry of the station or integrated within the platform for stations that are not a part of a larger station. The minimum height of the letters shall be 5 inches in height but heights that exceed 5 inches shall be the responsibility of the designer to determine the recommended height based on the site conditions. Logos and additional graphics included in the monument signage shall be approved by SCRRA, See ES 3305. If Monument Sign is placed in an area of poor lighting, project owner may choose to light sign.

32.0 RAIL OPERATIONS MODELING

32.1 SCOPE

Rail operations modeling is used to test potential infrastructure improvement projects and service planning scenarios. Modeling will provide an estimate of train performance to help determine if the intended outcome of an improvement or operating plan might be achieved. The process uses a virtual simulation of operating conditions to validate enhancements designed to increase capacity, improve operational reliability, increase train speeds, or aid in determining environmental and social impacts. Validation the potential effects of an improvement through modeling is often a requirement for grant and loan applications.

32.2 DEFINITION

The rail operations modeling process compares current network train performance metrics against future metrics with new services and/or infrastructure improvements to estimate potential effects of the proposed improvement or service change.

The following is an example of how the process works:

A model of existing rail network infrastructure and operations is created, attempting to replicate, as accurately as possible, current network train performance metrics. This serves as the “base” model. Future models, or “test cases”, are then developed from the base model. All incorporate the hypothetical service scenario the improvement is designed to support, as well as estimated freight and passenger growth for rail operators using the same corridor for the improvement implementation year. One future model will incorporate the infrastructure or service plan improvements and one will not. Performance metrics from all three models will be compared to test and help determine whether a proposed improvement might achieve its intended purpose and need.

Modeling can be performed for small (micro) scenarios that focus on improvements of a single area or large (macro) scenarios that encompass single or multiple projects along a section of a corridor or the entire corridor. In cases where more than one corridor is impacted (e.g. Los Angeles Union Station) the model must be run for the entire network.

32.2.1 Micro Scenario Example

Rail operations modeling can test different types of passenger locomotives and consists, tracking potential variations in network performance. For example, the model can compare train grade crossing occupancy times with different consist/locomotive combinations and different maximum track speeds. This data, in conjunction with vehicle crossing data, can be used to estimate vehicle wait times at crossings as part of an environmental cost benefit analysis on crossing enhancements and closures.

32.2.2 Macro Scenario Example

Rail operations modeling can test entire corridors and whole network impacts from changes such as speed increases, double track and siding enhancements, and service changes. Additional conditions that may require the need to simulate rail operations are outlined below in Section 32.4, Potential Causes for Modeling.

32.3 SIMULATION SOFTWARE GUIDELINES

SCRRA will consider the use of various software applications for rail operations modeling if they serve the intended modeling purpose. Software systems currently used by SCRRA include the Viriato Planning Tool, developed by SMA and Partners, Ltd., and Rail Traffic Controller (RTC), developed by Berkeley Simulation Software, LLC.

In addition to the ability to accurately replicate SCRRA infrastructure and train operations, the simulation software should incorporate advanced randomization capabilities in order to realistically portray typical daily passenger and freight operations.

For modeling used to secure additional operating slots, or secure funding from other railroads, agreement must be reached on the software to be used. It is vital that the impacted railroads (BNSF, UP, Amtrak, NCTD) be consulted to ensure that the intended software is approved before being used on the project.

For modeling used to secure federal funding, it is suggested that the FRA be consulted to ensure that the intended software is approved before being used for the project.

32.4 POTENTIAL CAUSES FOR MODELING

Modeling will not be required for every project, such as those projects for emergency trackwork or other routine maintenance. The reason is while these programs do affect overall network management, the planning timeframe is condensed. The following chapters in the Design Criteria Manual suggest the potential need to perform rail operations modeling:

- Chapter 5.0 – TRACK GEOMETRY
    - Changes to track geometry that would yield permanent speed increases or decreases
- Chapter 6.0 – TRACKWORK
    - New or extended main tracks or sidings that would have an impact on line capacity, operational flexibility and/or speed
    - Upgrades in FRA track classifications that would allow for higher train speeds
    - Construction work that could reduce operational capacity or cause extensive speed restrictions over the course of a construction season. Modeling can be used to develop modified train schedules to maintain intended service levels through extended construction periods.

- Chapter 7.0 – STATIONS
  - Addition of train stations, platforms, and reconfigurations in platform lengths: any characteristic that would either change the stopping point of the train, the length of time the train is stopped at the station, and/or the operating rules for train movements through the station limits.
- Chapter 8.0 – GRADE CROSSINGS
  - Improvements to crossings, such as adjustments to crossings to increase train speeds on a corridor (i.e. from 79 to 90 MPH), that could result in changes to crossing arm down time on roadways.
- Chapter 11.0 – STRUCTURES
  - Modernization of bridge structures allowing permanent higher maximum authorized speeds.
- Chapter 21.0 – WAYSIDE SIGNALS
  - Changes in the positioning of signals, installation of new signals or changed positions at control points / interlockings, speed signal changes or sectionalized route releasing design modification that improve or diminish throughput capacity at interlockings, and/or conditions that create or remove delayed in block applicability.
- *Chapter 30.0 – ELECTRIFICATION (FUTURE CHAPTER)*
  - Changes in acceleration as a result of utilization of electrified rolling stock and motive power, as well as phasing of implementation of same. Modeling can inform capacity for available electric traction equipped routes during phased installations, as well as on station capacity at large terminals where portions may not be electrified either short term or long term.

Not every project under these categories will require modeling. SCRRA will determine the need for modeling for each individual project.

32.5 MODEL DEVELOPMENT

Existing rail operations models, as available, will be provided by SCRRA, Amtrak, NCTD or a freight carrier to aid in the development of the required model simulation. The models may require significant updates in order to properly perform the testing required. Some data sources may or may not exist electronically or be transferrable between formats. If a model is not available, the contractor will be responsible for its creation and development.

Base data requirements for rail operations models are:

- Infrastructure data, e.g., grade, curvature, track, signals, bridges, elevations, maximum track speeds and other features
- Current and anticipated future passenger train operating data for all carriers in project area, including non-revenue movements
- Proposed alternative equipment types, such as HSR, DMU, EMU trainsets

- Current and anticipated future freight train operating data
- Future potential train movements that may require shared rail traffic, such as SCRRA services (using different equipment types, such as DMUs), high speed rail, state supported trains, and freight
- Development and use of randomization protocols by train type, based upon the type and duration of delays currently experienced

32.6 MODEL VALIDATION

Once all of the core data is built into the model, the model will be analyzed to ensure it replicates current operations on the project corridor (or network, if required) with a high degree of accuracy. All trains operating in the model must operate within current operating parameters, including scheduled passenger trains and unscheduled freight trains. The model's performance is reviewed and validated with key SCRRA and foreign railroad stakeholders in the planning, engineering, and operations departments, as required. The model will need to be updated and/or modified until it replicates current operations to the satisfaction of SCRRA staff. Once the model is validated, this process should be documented in the technical memorandum and include information on where capacity or other network limitations emerged in the data. From this information, recommendations on improvements that will aid in future model optimization should be presented.

32.7 MODELING PROCESS

The model is run iteratively to test and generate train performance data based on current operations and infrastructure, including determining which trains are subject to the greatest amount of congestion. The duration of a micro model can be as short as necessary to validate an improvement or new service plan. (I.e. Testing a new commuter service schedule.) The duration of a macro model should be at least 24 hours. In simulations involving long distance trains (those originating or terminating outside of the study area) the duration should extend over several days. These data sets form the baseline for comparison against train performance from future model scenarios.

Model randomization is a critical component for making the model operate like an actual railroad does on a typical day, where operations don't always follow an exact schedule. Randomized events in a model can include, but are not limited to:

- Variable arrival of freight or passenger trains into model territory
- Late departure of passenger trains from origin terminal
- Extended station dwell times
- Planned and unplanned maintenance outages
- Mechanical delays

The exact events to be randomized will be determined in consultation with SCRRA.

Each scenario – including current operational model testing – should provide the following raw data:

- Train performance calculations
- Network congestion points
- Idealized run times (or pure run times)
- Time/ distance – stringline – diagrams
- Overall and specific train operating metrics
- Grade crossing occupancy times
- Fuel consumption
- Emissions produced

Once the base model has been established and tested to replicate current operating schedules with a high level of precision, test cases should be identified for future optimization of the network in context of proposed infrastructure enhancements. These include new schedule options, planned, programed, or budgeted capacity improvements, and/or improvements to be tested and compared with based on available funding.

If, during the development and validation of the model, alternative improvements are identified which meet or exceed the objectives of the planned improvements with potentially lower costs, reduced construction obstacles and/or improved operational capacity or reliability, these alternatives will be presented to SCRRA staff in the technical memorandum.

If a model is used over an extended period of time (6 months or longer), it should be checked regularly to ensure it incorporates the latest infrastructure improvements, operational changes and train schedules for the segment(s) modeled.

32.8 DATA ANALYSIS

Raw data generated from the models shall be presented for key stakeholder review and discussion.

Different operations simulation software suites offer varying methods to display operating metrics, but all should be able to track and display train delays by type of train and location. Typical comparative metrics are:

- Overall run time of specific train types (Train Performance Calculator charts, or facsimile thereof)
- Delay minutes per 100 train miles, by train type
- Average true delay, by train type
- Delays by train type by location
- Stringline charts

SCRRA planning, engineering, and operations teams should all review the data to ensure the raw data and the analysis of the data is in line with project assumptions, or if further test cases are required to validate other project options.

32.9 TECHNICAL MEMORANDUM

All of the above processes, as well as all finalized data and analysis of the data, should be compiled into a technical memorandum that summarizes:

1. Data assumptions
2. Methodology and processes
3. Test cases
4. Findings

33.0 GRADE CROSSING SIGNALS

33.1 SCOPE

The consultant providing design services for SCRRA operated and maintained property shall specify equipment and applications that not only provide optimum safety but shall also maximize the operational efficiency and reliability of the shared commuter/freight rail system. The design shall incorporate methodologies, applications and equipment that have been proven to be reliable, durable and effective on SCRRA properties or similar commuter/freight rail environments and that are currently accepted by SCRRA. The introduction of new materials, which requires an inventory of additional spare parts, additional training and/or instructions must be approved by the SCRRA Director, PTC, C&S Systems, or Designate, herein referred to as SCRRA.

Any proposed designs shall incorporate features that aid signal personnel in the inspection, testing, repair, and overall maintenance of the system. To the extent practical within the scope of a project, equipment to be installed shall be scalable for future expansion, and the crossing system enclosures shall be sized accordingly. Designs and configurations shall be fail-safe and conform to all applicable regulatory rules and regulations and be designed simple in form to be easily understood by personnel responsible for the maintenance and care of the system. Where these criteria refer to system logic and design criteria using vital relays, the same logic shall be applied to solid-state electronic interlocking application programs.

All designs shall adhere to the rules and regulations contained in 49 CFR 234, 235 and 236. The grade crossing signal designs shall incorporate the rules and instructions as contained in the most current issue of the California Public Utilities Commission General Orders, Maintenance of Way Operating Rules (MOWOR), Metrolink General Orders, Timetable, and Special Instructions; and AREMA Communications & Signals Manual of Recommended Practices. Where the AREMA manual is used, “may” and “should” are to be interpreted as “shall” unless in conflict with these standards or otherwise directed by SCRRA. Note that the SCRRA General Orders, Timetable, and Special Instructions supersede the MOWOR where they conflict with the MOWOR.

Construction and installation details will be found in the SCRRA Engineering Standards. Any new installations or modifications to existing locations must be coordinated and integrated with civil and track design and any local agency requirements. Refer to the SCRRA Highway-Rail Grade Crossings Recommended Design Practices and Standards Manual, which explains and integrates the Civil, C&S, Traffic Engineering, and other disciplines in treatment of Grade Crossings.

The designer is advised that wayside signaling systems, crossing warning systems, communication systems and positive train control (PTC) systems are present on the SCRRA tracks and right-of-way. Any modifications to grade crossing signals must consider and mitigate impacts to these other systems. Please refer to the following Design Criteria Manual Sections for related information;

- Section 20.0, Communications Systems
- Section 21.0, Wayside Signals
- Section 22.0, Positive Train Control (PTC)

33.2 POSITIVE TRAIN CONTROL (PTC) CONFIGURATION MANAGEMENT

All grade crossing warning control equipment, warning devices, programs, and components are critical features necessary to the safe and efficient operation of SCRRA's Positive Train Control System. Any changes being proposed to grade crossing signals are subject to SCRRA's Change Configuration Management policy and procedures. Consultants providing design services are required to comply. Refer to SCRRA's Design Criteria Manual Section 22.4 for related requirements and direction.

33.3 NEW METHODOLOGIES, APPLICATIONS OR EQUIPMENT

Design service consultants recommending new methodologies, applications, or equipment not currently used on SCRRA properties will be required to obtain, before commencing with design efforts, approval from SCRRA. No design submittals containing new methodologies, applications, or equipment will be approved without prior consent. When proposing new equipment, not currently utilized by SCRRA, the company providing design shall provide SCRRA with documentation detailing where the equipment is currently in use as well as general maintenance requirements for the equipment. Upon approval, responsible design services consultant will be required to provide additional information to supplement SCRRA's instructions and standards. Requirements may include additions and/or revisions to, but are not limited to, the following documents:

- SCRRA Engineering Standards
- SCRRA Standard Specifications
- SCRRA Timetable
- Metrolink Signal Maintenance Manual
- SCRRA Maintenance of Way Operating Rules

33.4 QUALIFICATIONS OF GRADE CROSSING SIGNALS DESIGN PERSONNEL

33.4.1 Qualifications of Signal Designer

Signal designers who work on SCRRA crossing warning circuits or programs are subject to the approval of SCRRA. The classification of Signal Designer is generic and refers to the responsible individual who produces or modifies crossing warning system circuits or programs. A company or third-party agency may classify this position as a Signal Engineer or other title.

In general, a Signal Designer shall have a minimum of five (5) years of experience designing grade crossing warning systems for Class 1 freight or commuter rail systems which are governed by the FRA and adhere to the guidelines set forth in the AREMA C&S manual.

SCRRA may require that Signal Designers demonstrate their familiarity with applicable regulations, both state and federal, and their familiarity with traditional relay logic, ladder logic or Boolean logic equations. Principles of railroad grade crossing warning systems, including warning devices, warning device control systems, constant warning device operation and railroad pre-emption interconnection system functionality must be demonstrated to the satisfaction of SCRRA. An understanding of train operations and the interaction of warning systems in a mixed freight/commuter rail environment is required, as well as the ability to analyze and develop warning times and identify and mitigate frequency conflicts between crossings. In addition to this, the Signal Designer must have an ability to demonstrate their understanding of how grade crossing warning systems interact with wayside signal and PTC systems.

The Signal Designer may be interviewed by SCRRA or designate. The interview may require a demonstration of circuit and grade crossing warning system engineering analysis. The determination of qualification is at the sole discretion of SCRRA.

These requirements apply to both signal circuit and application program development, either developing new systems or modifying existing systems.

33.4.2 Qualifications of Signal Checker

The classification of Signal Checker is generic and refers to the responsible individual who performs Quality Control (QC) and safety analysis of grade crossing warning system designs or application programs. A company or third-party agency may classify this position as a Senior Signal Engineer or other title. In general, the Signal Checker is subject to the qualifications of a Signal Designer as described in Section 33.4.1. In addition to these qualifications, the Signal Checker must possess an additional 5 years of experience checking grade crossing warning system designs and application programs.

The Signal Checker may be interviewed by SCRRA or designate. The interview may require a demonstration of circuit and program analysis and a demonstration of applicable checking and testing methods used in the performance of their duties. The determination of qualification is at the sole discretion of SCRRA.

33.5 DESIGN CHECK REQUIREMENTS

Grade crossing warning system design work shall only be completed by signal design firms authorized by SCRRA to provide such services.

To ensure the quality and integrity of SCRRA system design plans and programs, all new or modified systems shall receive a QA/QC check at each design submittal level. The check shall ensure that all designs meet the requirements of applicable regulations, recommendations and standards. All design applications shall meet or exceed the manufacturer’s minimum requirements.

All authorized signal design firms shall have an established, written, procedure outlining the firm’s QA/QC process. This process shall be submitted to SCRRA for review upon the request of SCRRA. Additionally, the firm performing signal design work shall store all QA/QC check plans for a minimum of three (3) years after final project submittal has been made. These project check plans shall be produced to SCRRA for review upon the request of SCRRA.

When an independent check is required, two complete plan sets, or an electronic PDF copy shall be distributed to the designated firm performing the independent check. An independent check is required at the discretion of SCRRA.

33.6 GENERAL DESIGN REQUIREMENTS

33.6.1 General

Refer to Section 21.6.1 for grade crossing warning system General Design requirements.

33.6.2 CADD File Coordination

Refer to Section 21.6.2 for grade crossing warning system CADD File Coordination requirements.

33.6.3 CADD Standard Deviations and Modifications

Refer to Section 21.6.3 for grade crossing warning system CADD Standard Deviations and Modification requirements.

33.6.4 Filename Convention

Refer to Section 21.6.4 for grade crossing warning system Filename Convention requirements.

33.6.5 Format Requirements

Refer to Section 21.6.5 for grade crossing warning system Format Requirements.

33.6.6 Plan Set Composition

Plan set makeup shall follow a logical flow as shown in the following lists. Not all plan sets shall contain the following specific sheets or may have additional sheets based upon specific locational needs.

- Grade Crossing Signal Location Plan – Contains specific location circuitry and details
  - Cover Sheet (Index)
  - Crossing Circuit Plan
  - Program Options Plan
  - Crossing Controller Circuit Plan
  - Gate Circuit Plan
  - Vehicle Detection Circuit Plan (If exit gates are utilized)
  - Data Recorder Circuit Plan
  - Power & Battery Circuits
  - Racks # Layout
  - Terminal Board Layout
  - Side A – House Layout
  - Side C – House Layout
  - Cable Sheet
  - Conduit Plan

33.7 WARNING TIME DEVELOPMENT

33.7.1 Warning Time

Warning time is summarized as the time elapsed between the activation of the warning device(s) lights and bells and when the train reaches the edge of the street. SCRRA's minimum warning time is to be a base time of thirty (30) seconds. This is derived from the FRA's required twenty (20) seconds minimum warning time plus ten (10) seconds buffer time. The buffer time is intended to account for variations in train handling. Reducing the ten (10) second standard buffer time is prohibited without permission from SCRRA.

The most current AREMA guidelines are to be followed in determining warning times. The only exception to the requirement for a 20 seconds minimum warning time occurs when a train stops and subsequently restarts in the approach to a grade crossing. Under these scenarios, operating rules govern the actions of the engineer and provide for the safe passage of the train move.

When calculating the warning time, the designer shall consider additional time for wide, or angled, track crossing applications, intended gate delay due to slow moving vehicles and traffic signal interconnections.

During the design process, consideration should be given to pedestrian usage of the crossing. Additional warning time may need to be assigned, depending on specific site conditions.

<u>FRA Minimum Required Warning Time</u>

The FRA requires a minimum of twenty (20) seconds of warning time for a train approaching a grade crossing. This minimum warning time is comprised of;

- Lamps and bells activated a minimum of three (3) seconds before gate descent begins.
- Gate descent time consisting of a minimum twelve (12) seconds.
- Gates are fully horizontal a minimum of five (5) seconds before the train begins to enter the crossing.

<u>Wide, or Angled, Track Crossing Applications</u>

A "wide track" is a crossing that is greater than 35 feet. Additional wide track time is determined by measuring the distance parallel to the centerline of the roadway between the governing warning device and 6 feet beyond the furthermost rail on which trains operate or between the governing entrance gate and the corresponding exit gate, whichever is greater. When this distance is greater than 35 feet, one second shall be added for each additional 10 feet, or fraction thereof. For example, if a measurement of 57 feet is made, 3 seconds of additional warning time is necessary.

<u>Intended Gate Descent Delays</u>

In specific cases, gate descent times may need to be extended beyond the minimum 12 second time typically used. This may be done in areas where heavy commercial truck traffic is present, resulting in an increase in broken gate occurrences. Any designed gate descent time exceeding 12 seconds must be added to the overall crossing warning time. The designer is advised that increasing gate descent times requires the approval of SCRRA.

<u>Advanced Pre-Emption Time (APT)</u>

Advanced Pre-Emption Time (APT) is additional time, provided by the railroad to the City's vehicular traffic control system before the activation of the crossing's warning devices occur. This time is determined by the City, or by the design team's designated Traffic Engineer.

Advanced Pedestrian Pre-Emption Time (APPT)

Advanced Pedestrian Pre-Emption Time (APPT) is additional time, for the purposes of controlling pedestrian movements at the crossing, provided by the railroad to the City's vehicular traffic control system before the activation of the crossing's warning devices occur. This time is determined by the City, or by the design team's designated Traffic Engineer.

33.7.2 Total Approach Time

Total Approach Time (TAT) is the sum of the following;

- SCRRA minimum thirty (30) seconds of warning time.
- Wide, or angled, track crossing time.
- Additional gate descent time.
- Advanced pre-emption time (APT).
- Advanced pedestrian pre-emption time (APPT).
- Equipment response time (ERT), per manufacturer's guidelines (5 seconds typical).

In accordance with AREMA guidelines, it is the goal of SCRRA to limit TAT to no more than fifty-five (55) seconds. Any proposed TAT exceeding fifty-five (55) seconds requires the approval of SCRRA.

33.7.3 Approach Distance

Once the total approach time (TAT) is calculated, the designer shall determine the required approach circuit distance. Termination shunts shall be placed in accordance with the manufacturer's recommendations. The minimum placement shall be the required distance to provide the calculated TAT. The actual location of the termination shunt(s) shall be measured from the point where the crossing island circuit is terminated on each side of the crossing. All warning time distance calculations shall account for the maximum authorized speed (MAS) of the subdivision (79mph or 90mph, depending on subdivision).

In some cases, approach distance may be factored for train speeds less than a subdivision's MAS. In these cases, the approach distance shall never be less than designated timetable speeds approaching the crossing. Any designed approach distances less than the designated subdivision's MAS require the approval of SCRRA.

A careful and detailed review of train operations shall be completed prior to finalizing the application to be used. Where trains accelerate from a station, or slow to stop at a station, additional systems may need to be incorporated.

Special consideration should be given when designing crossing approaches adjacent to a passenger station. When practical, island circuit location should be designed to avoid island circuit occupancy after a train has progressed through a crossing. This will avoid keeping the crossing activated after the train has passed the crossing but is still occupying the station platform.

33.7.4 Island Circuits

Crossing warning system island circuits shall be designed to extend fifty (50) feet beyond the crossing's curbs. Island circuit frequencies shall be determined by the length of the island and be those frequencies offered by the CWD manufacturer. Consideration, per the manufacturer's guidelines, should be given to avoid conflicting with adjacent island frequencies.

Special consideration shall be given when an island circuit encompasses an at-grade pedestrian walkway. The designer shall configure the island circuit so that it encompasses the pedestrian walkway.

33.8 TRAFFIC SIGNAL PREEMPTION

33.8.1 Background

Where field conditions require, the railroad train detection system shall be interconnected with the traffic signal controller so that the traffic signal phasing can be pre-empted, and vehicular traffic cleared off the track prior to the train arriving at the crossing. The decision to install an interconnected traffic pre-emption system shall be decided through an engineering diagnostic evaluation and driven by current regulatory requirements. The process to determine the need, type and application of traffic signal pre-emption interconnection systems is described in SCRRA's Design Criteria Manual, Section 8.0 GRADE CROSSINGS.

Additional time for traffic signal preemption (APT), or advanced pedestrian pre-emption time (APPT) shall be included in the railroad warning time calculation. The APT and/or APPT time shall be obtained from the roadway agency having maintenance responsibility for the traffic signals or the design team's designated Traffic Engineer. The signal designer shall not perform the traffic signal preemption time calculations.

Constant Warning Device systems have approach distance limitations, and when applied to tracks where trains operate at 79 MPH or greater, may not be able to support the requested preemption time. Upon obtaining the roadway agency's time request, the designer shall calculate the total warning time required and determine if the time request is feasible with respect to railroad equipment limitations. If the roadway agency's preemption time request is not technically feasible, the designer will inform the roadway agency and provide the time setting that is feasible with respect to the technical limitations of the railroad equipment. The roadway agency is responsible for any modifications to the traffic signal system that may be required to support this reduced time calculation.

Prior to design of a traffic signal preemption circuit, both the traffic and railroad systems designer should review the latest guidelines regarding traffic signal preemption as prepared by the Institute of Traffic Engineers, AREMA, MUTCD, CAMUTCD, CPUC, and other knowledgeable parties. Circuits described below are based upon fail-safe, supervised, closed loop methodologies. A vital serial data circuit in accordance with IEEE Standard 1570-2002 may be used in lieu of the referenced circuits, with permission from SCRRA.

Design and testing of traffic signal preemption interconnection circuits must be coordinated with the railroad and the agency having jurisdiction upon installation and at least annually thereafter.

It is the policy of SCRRA that any additions, modifications or upgrades to existing traffic pre-emption interconnection systems utilizing legacy unsupervised interconnection circuits be upgraded to current standards that utilize supervised architectures.

A warning decal indicating “WARNING! HIGHWAY-RAIL GRADE CROSSING WARNING SYSTEM AND HIGHWAY TRAFFIC SIGNALS ARE INTERCONNECTED,” located in both the traffic signal cabinet and railroad instrument shelter, as well as indicated on the signal plans, shall be present at a location where the railroad provides traffic signal preemption.

33.8.2 Interconnection Circuits

SCRRA utilizes three types of preemption interconnections: simultaneous, advanced with pre-signal, and advanced with queue cutter signal. An isolated 12 VDC battery supply shall be supplied to the railroad for use with these circuits. Interconnection circuits between the grade crossing signal enclosure and the traffic controller are as follows:

TABLE 33-1. WIRE FUNCTIONALITY – SIMULTANEOUS PREEMPTION

Wire Number	Simultaneous Preemption
1	Crossing Start Relay Energized (Front Contact)
2	Crossing Start Relay Deenergized (Back Contact)
3	Crossing Start Relay Source (Heel)
4	Supervisory Circuit Energized (Front Contact)
5	Supervisory Circuit Deenergized (Back Contact)
6	Supervisory Relay Source (Heel)
7	Traffic Signal Health Indication

TABLE 33-2. WIRE FUNCTIONALITY – ADVANCED PREEMPTION (NON-QUEUE CUTTER)

Wire Number	Advanced Preemption
1	Preemption Relay Energized (Front Contact)
2	Preemption Relay Deenergized (Back Contact)
3	Preemption Relay Source (Heel)
4	Supervisory Relay Energized (Front Contact)
5	Supervisory Relay Deenergized (Back Contact)
6	Supervisory Relay Source (Heel)
7	Crossing Start Relay Energized (Front Contact)
8	Crossing Start Relay Deenergized (Back Contact)
9	Crossing Start Relay Source (Heel)
10	Gate Down / Island Circuit Energized (Front Contact)
11	Gate Down / Island Circuit Deenergized (Back Contact)
12	Gate Down/Island Circuit Source (Heel)
13	Traffic Signal Health Indication

TABLE 33-3. WIRE FUNCTIONALITY – ADVANCED PREEMPTION (QUEUE CUTTER SIGNAL)

Wire Number	Advanced Preemption
1	Preemption Relay Energized (Front Contact)
2	Preemption Relay Deenergized (Back Contact)
3	Preemption Relay Source (Heel)
4	Supervisory Circuit Energized (Front Contact)
5	Supervisory Circuit Deenergized (Back Contact)
6	Supervisory Relay Source (Heel)
7	Traffic Signal Health Indication

Focusing on the most complex interconnection circuit, the advanced preemption (non-queue cutter), the interconnection circuit is as follows:

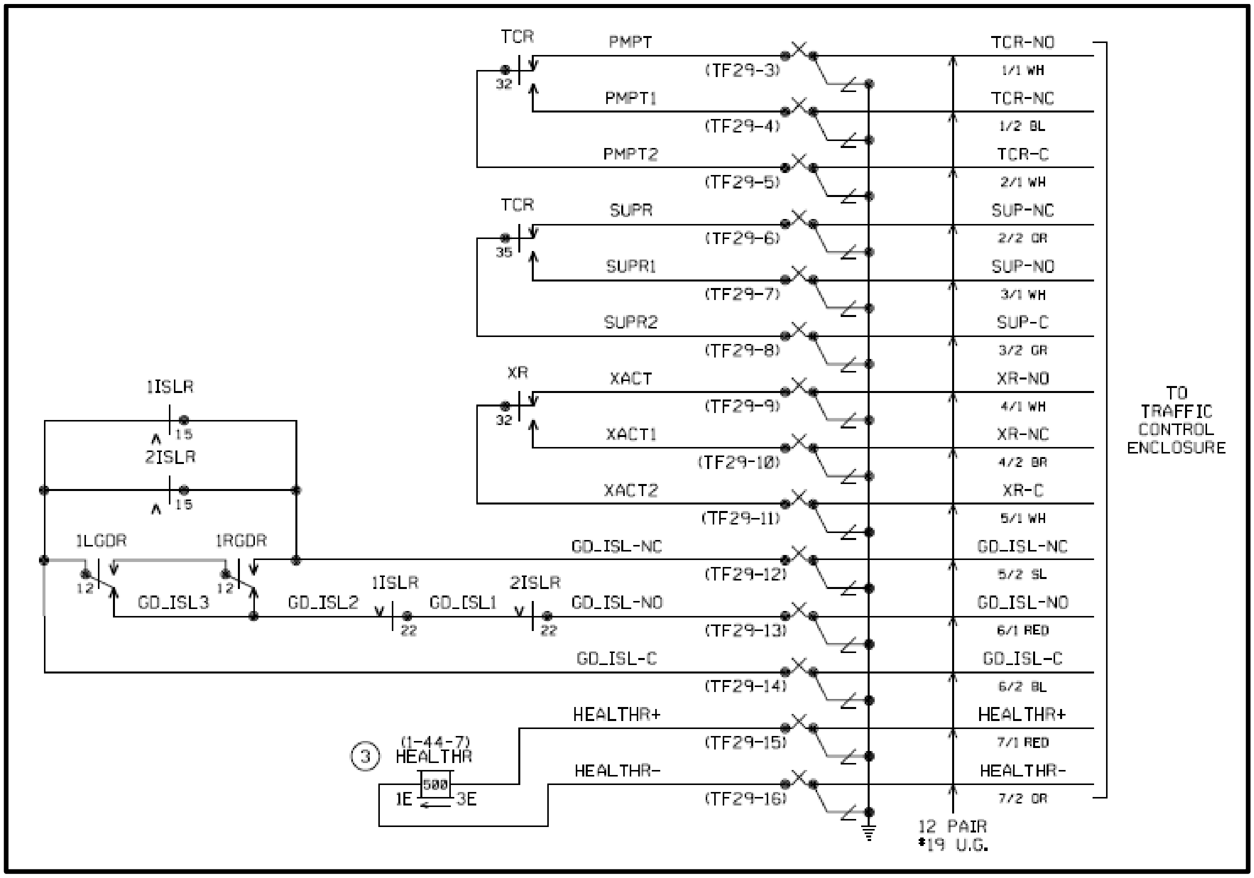

FIGURE 33-1. ADVANCED PREEMPTION (NON-QUEUE CUTTER)

Relays are as follows:

- TCR – Traffic Control Relay, providing the advanced preemption call on de-energization
- XR – Crossing Relay, providing the crossing activation call on de-energization
- ISLR – Island Relay, providing island occupancy on de-energization
- GDR – Gate Down Relay, providing gate down indication for all gates within the flow of traffic, entrance and exit
- HEALTHR – Traffic Controller Health Relay, receiving indication of Traffic Controller Health

When a train is detected and the call for preemption is generated, the TCR is de-energized. Both circuits shall provide the same information to the traffic controller, energized or de-energized. This indicates the integrity of the interconnection circuitry to the traffic signal controller. The traffic signal controller will then initialize track clearance green, allow vehicles to clear the crossing. As the train reaches a point where the crossing will activate, the XR is de-energized, letting the traffic controller know the state of the crossing. When the closest gate, entrance and/or exit, for the flow of traffic towards the pre-signal has descended and is fully horizontal, the GDR shall energize, allowing the traffic controller to cancel the track clearance green call and move to a limited service call. If the GDR does not energize due to a malfunction in a gate, track clearance green shall continue to be called until the ISLR is de-energized, notifying the traffic controller that the train is within the island, and allowing the cancelling of the track clearance green call.

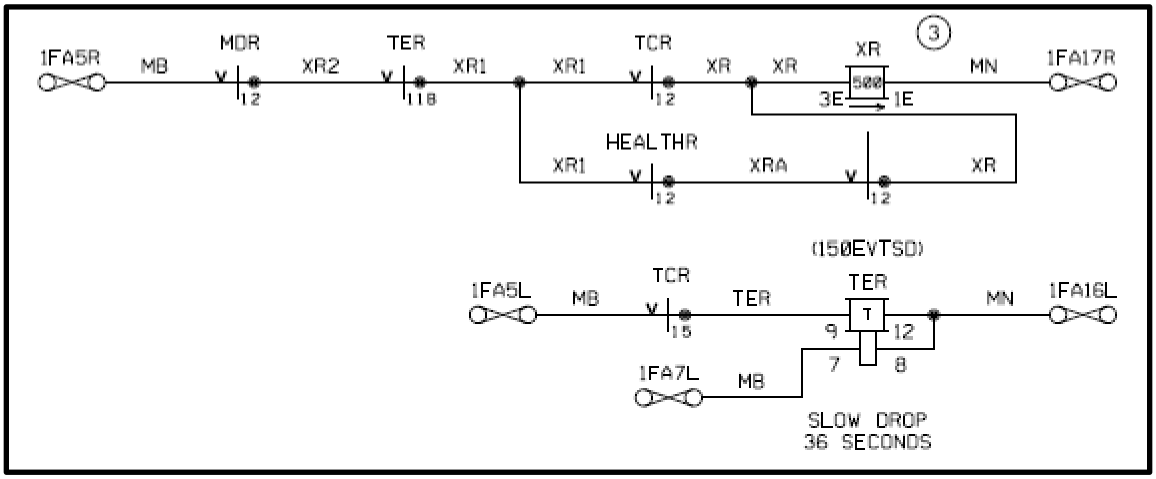

FIGURE 33-2. CROSSING ACTIVATION CIRCUIT

The health of the traffic signal controller is communicated to the railroad via the HEALTHR relay. If the traffic signal controller is not functioning or in All – Flash, the health relay will be de-energized. As shown in Figure 33-2, the de-energization of the HEALTHR relay will cause a preemption call to also call the crossing to activate, effectively making the crossing react as if a simultaneous preemption call was made. Under this condition, the railroad grade crossing warning system will cause the gates to be down longer for an approaching train since the traffic signals will not be able to clear out traffic as designed.

When utilizing an advanced preemption call, an associated Timer Enable Relay, or TER, shall be used. The TER can be a timer relay or can be an output from a microprocessor that is handling the timing internally. As Figure 33-2 shows, the TER is de-energized after 36 seconds, which is the amount of time determined for the advanced preemption call. The TER de-energization shall then cause the XR to be de-energized, activating the crossing. This ensures that even if a train slows in the approach, the advanced preemption time is still observed and is consistent. If a train speeds up while approaching the crossing and the train detection system calls for the crossing activation, the Motion Detect Relay, or MDR shall de-energize and activate the crossing, even if the TER is still counting down. Figure 33-2 circuits may be designed internally to a microprocessor if still meeting the functional requirements.

33.8.3 Supervisory Circuits

One potential problem with the two-wire interconnection is a short in the circuit. If the wires/cables between the traffic signal control cabinet and the railroad active warning system cabinet became shorted together, the preemption relay in the traffic control signal cabinet could be falsely energized even if the relay contact opened. The active warning devices would operate, but the traffic signal controller unit would not receive the preemption input.

To address these potential problems, a supervised double break, double wire circuit shall be installed as described above between the railroad and the traffic signal control system. In order to detect a shorted or open interconnection circuit, three additional wires are used to provide a supervised circuit. The energy source originates at the traffic signal controller, and two wires provide a return path verifying the railroad preemption control relay is energized and there is no call for preemption. The two additional wires verify circuit integrity when the railroad issues a call for preemption. The traffic controller system shall have the capability to detect an interconnection fault per the guidelines set forth in Section 8.4.1 INTERCONNECTION DESIGN.

33.8.4 Gate Down Circuits

A preempt trap is the condition where the clear track green interval ends before the flashing-light signals start to flash and gates start to descend and can occur with advance preemption. One of the solutions to avoid preempt trap is to use a “gate-down” circuit. The purpose of the “gate-down” circuit is to prevent the traffic signal from cancelling the track clearance green call until it is determined that the gates controlling access over the tracks are fully lowered. The “gate-down” circuit notifies the traffic signal controller unit when the gates controlling access over the tracks on the approach to the intersection have either fully lowered or the train has occupied the crossing.

33.8.5 Traffic Signal Health Check Circuits

A health check circuit provides an indication to the railroad active warning system cabinet when the traffic signals are in flashing mode or dark such as when the controller is in a failed state. This health check circuit requires additional wires/cables between the traffic control signal cabinet and the railroad active warning system cabinet. Consideration should be given to a fail-safe design for the health check circuit so that there shall be no case in which the circuit shall remain energized while the traffic signals are flashing or dark.

33.8.6 Second Train Logic

Where there is more than one track, a second train can approach at any time. If there is an advanced preemption interconnection between the traffic signals and the railroad, the appearance of a second train can hold the traffic signals in preemption and have the gates rise momentarily allowing vehicles to pull up on to the tracks. Where second train logic is employed, if a second train is detected on the outer approach, the gates will remain down until after the second train clears the island and no additional approaching trains are detected. Second train logic may be employed where no traffic signals are present if circumstances warrant.

Where second train logic is employed, Exit Gates or non-mountable medians shall be considered. Due to the increased amount of gate down time where second train logic is employed, there is the possibility motorists may interpret the gate remaining down after a train has passed as a malfunction of the warning system. Exit Gates discourage running around the Entrance Gates. This is especially critical where there is limited visibility on the approaches, or traffic density is such that the gates may be held down for 3 consecutive trains.

33.9 GRADE CROSSING WARNING SYSTEM EQUIPMENT

33.9.1 Train Detection Systems

Train detection systems used on SCRRA shall meet the requirements of AREMA C&S Manual Part 3.1.20. The preferred grade crossing train detection system incorporates the use of unidirectional or bidirectional redundant constant warning devices (i.e., units fully contained with an internal transfer function) without utilization of “wrap” circuits. The train detection system shall have an integrated island circuit capable of operating through a rail-grade crossing. This island circuit shall be used to detect an occupancy within the road section of the rail grade crossing. The island circuit shall be available for each track configured within the unit and be frequency isolated to allow multiple frequencies to operate simultaneously when used in multiple track configurations. The use of external equipment to provide island circuit protection requires approval of SCRRA.

The use of motion detectors or static audio frequency equipment in lieu of constant warning devices for the purpose of train detection is prohibited without the permission of SCRRA.

These train detection systems shall be combined with solid-state crossing controllers to ensure compliance with lamp voltage and standby lamp voltage regulations.

The train detection system shall be capable of providing multiple track detections within the same unit. When GCP 4000 or XP4 units are used in new design, it shall be the responsibility of the design firm to furnish the configuration file for field configuration of the location. After the location has been placed in service, the in-service configuration files shall be furnished to the SCRRA.

An application program options sheet shall be included in any design plan set where constant warning train detection systems are installed. The program options sheet shall be composed of the overall train approach layout with display of shunts and remote start locations if utilized and existing settings used at the crossing. Settings shall reflect menu information depicted on the train detection system.

Low impedance termination shunts shall be used on SCRRA property. By-pass couplers shall be used when possible to avoid remote DAX connections. However, by-pass couplers can only be used in strict accordance with manufacturer’s guidelines. By-pass couplers and the constant warning device they are configured with should be of the same manufacturer whenever possible.

33.9.2 Event Recording Systems

Event recorders shall be utilized to record data useful in the maintenance, troubleshooting, and repair of the entire grade crossing warning system. Event recording systems shall be independent of the primary constant warning device. Event recording systems shall have the capacity to record 72 hours of events at the crossing, without overwrite. Event recorders shall be capable of handling digital and analog inputs and have the capability to provide remote system monitoring. At a minimum, event recording equipment shall monitor the following warning system statuses without the use of external interfacing equipment;

- At least four analog, 12 VDC battery voltage monitoring inputs.
- At least four warning device lamp voltage inputs. Lamp voltage monitoring inputs shall have the capability of providing for over, or under, voltage alarm statuses.
- Monitor the status of all crossing start statuses, including XR, MDR and DAX relay positions.
- Monitor the status of all island circuits used at the crossing.
- Monitor the status of all traffic signal pre-emption controls, including TCR and Advanced Pedestrian Pre-Emption (APP) statuses.

- Monitor traffic signal pre-emption interconnection Health status input.
- Monitor vertical and horizontal gate positions for all warning gates at the crossing.
- Monitor commercial power status at the crossing.

In addition, event recording equipment shall be configured to control two (2) DTMF radio frequency controlled outputs, which in turn will provide for remote activation of the crossing's lights and gates.

All event recorder inputs, excepting battery and lamp monitoring inputs, shall not be directly connected to any relay controls or vital system outputs, such as an XR output on a CWD device. The preferred method for control monitoring is for the circuit to be checked through the contact of a relay.

Where it is necessary to deviate from these event recording requirements, approval must be obtained from SCRRA.

33.9.3 Power Supplies

Commercial power sources shall meet the requirements of SCRRA Standard Specification Section 34 42 62 SERVICE METERS.

All crossing locations shall be supplied power from a commercial power source. Each location shall be evaluated, and the appropriate service connection provided. At a minimum, a 120/240 VAC, single phase, 100-amp service shall be provided. Where commercial power is not available, an express cable connection may be used to connect to the nearest available power source. In all cases, the power cable connection shall be sized in accordance with the National Electrical Code requirements for appropriate conductor size. The use of shared commercial power sources is prohibited unless approved by SCRRA.

Each crossing enclosure shall be affixed with an external connection point allowing for a temporary generator connection.

The use of 208 VAC commercial power sources is prohibited.

Each crossing enclosure shall be equipped with standby battery and charging systems. These systems shall comply with SCRRA Standard Specification Section 34 42 52 RECTIFIERS, BATTERIES AND BATTERY CHARGING EQUIPMENT. Battery chargers shall be CALGreen compliant, programmable, be affixed with a visual display for current and voltage readings and have temperature sensing capabilities.

Batteries used for crossing systems shall be low maintenance, lead-acid, single wet cell and conform to the requirements of AREMA C&S manual parts 9.1.1 and 9.1.30. Six cells shall be utilized for all battery sets, with exception to crossing warning battery running gate mechanisms, where 7 cells shall be utilized.

Battery capacity for crossing systems shall provide a minimum of 48 hours of standby time under normal operating conditions. Normal operating conditions is defined as the crossing system operating with a normally scheduled amount of train traffic progressing through the crossing. Battery capacity shall be determined using the **SCRRA Battery Sizing Calculator**, which will be provided upon request.

An independent battery set and charging equipment shall be furnished for the train detection equipment, separate battery sets and charging equipment shall be furnished for the crossing warning devices, and a separate battery set and charging equipment shall be furnished for event recorders. Chargers shall be equipped with temperature compensation devices and dry contacts for use with power out indication.

Surge protection shall meet manufacturer requirements and shall be incorporated into all grade crossing design. Surge protection shall be installed on the AC supply source, battery supply, track leads, and for cable to crossing warning devices.

DC power input terminals on battery surge suppressors should be connected directly to battery terminals. This will permit the battery to filter out small power surges from the battery charger before they enter the surge suppressor.

Grounding of crossing enclosures shall be through the installation of ground rods. Ground rods shall be installed at each corner of houses and on each end of cases. Ground rods shall be 10 feet in length and connections to the rod shall be as direct as possible, with no short radius bends (less than 18”) in ground leads. Resistance to ground shall be no more than 15 Ohms.

Lead acid batteries shall be used for all batteries.

Wire and Cable

Grade crossing design shall include proper sizing of all electrical wiring to ensure proper operation of the equipment based upon the equipment loads and the operating parameters determined by the equipment manufacturers. Minimum conductor sizes to be used are as follows:

- Internal House / Case Wire
  - Battery chargers and feeds — #6 flex
  - Flasher lighting circuits — #10 flex
  - Track circuits — #10 flex
  - Loads in excess of 1 ampere — #10 flex
  - Loads less than 1 ampere — #16 flex
- Flashing Light Signals / Gates
  - Lamp wires — #10 flex
  - All other circuits — #10 flex
- Cable
  - Lamp circuits & gate battery feeds — #6 solid
  - All other circuits — #14 solid

33.9.4 Grade Crossing Warning System Houses

Grade crossing warning system houses shall comply with the requirements set forth in the SCRRA Standard Specification Section 34 42 46 SIGNAL EQUIPMENT HOUSES.

33.9.5 Pre-Assembled Instrument Enclosures

SCRRA has an established Blanket Purchase Order (BPO) contract with an approved vendor for the purchase of pre-assembled instrument enclosures. The pre-assembled instrument enclosures comprise most variants of grade crossing warning system applications and include standard house assemblies for multiple CWD variations, exit gate control systems, traffic pre-emption interconnection, remote crossing start configurations and auxiliary crossing control houses.

Signal design consultants incorporating these enclosures into their designs shall use the pre-assembled instrument enclosure CADD files as a base for their project specific designs. CADD files will be made available to the signal design consultant upon request.

The signal design consultant shall modify the pre-assembled instrument enclosures, using the standard SCRRA Signal Plan CADD Requirements, to configure the enclosure design for their project's specific needs. It is the signal design consultant's responsibility to ensure that all equipment, naming conventions, and wiring configurations meet SCRRA standards and adhere to their project's specific requirements.

The pre-assembled instrument enclosures can be ordered for a project with the use of a single SCRRA material ordering number. It is noted that pre-assembled instrument enclosures can only be used when the project materials are being purchased through SCRRA. For projects where materials are contractor provided, the signal design consultant shall use the pre-assembled instrument enclosures as a base for their design requirements, in conjunction with SCRRA's Standard Specification Section 34 42 46 SIGNAL EQUIPMENT HOUSES.

33.9.6 Crossing Warning Devices

Crossing warning devices shall be determined through the design process during a joint diagnostic review of the crossing. All warning devices shall comply with the requirements of SCRRA's Engineering Standards.

Grade crossing flasher lamp configuration shall comply with SCRRA ES 8400. Grade crossing flasher lamps shall be provided a minimum of 8.5 VDC. Cable shall be sized to limit voltage drop to 3 VDC. Flasher lamps shall be Light Emitting Diode (LED) type and shall be installed on all new crossing warning devices or when modifying an existing crossing warning device. For example, if designing to add an arm with an additional set of flashers to be installed on an existing crossing warning device with incandescent bulbs, all existing incandescent bulbs shall be replaced with LED units.

An electronic bell shall be installed in each quadrant containing a crossing warning device. Pedestrian gates shall be designed with front and back flashing pairs of lights.

An approved solid-state crossing controller should be installed to control crossing warning devices. The solid-state crossing controller shall be capable of flash synchronization with other existing crossing controllers.

33.10 EXIT GATE SYSTEMS

Exit gate systems consist of an entrance gate assembly, CPUC standard 9-E exit gate assembly, a vehicular detection system between the entrance gate and exit gate, and the necessary safety critical logic equipment to receive inputs from the Vehicle Intrusion Detection System and control the operation of the exit gate(s).

Exit gates are installed in order to:

- Provide warning at crossings.
- Increase deterrence of vehicles driving on the opposite direction of the flow of traffic and around lowered entrance gate arms.
- Create a “Sealed Corridor” for train travel.

The safety and operations through the vehicular crossings are the responsibility of both SCRRA and the Local Agency having jurisdiction of the roadway. Installation of exit gates must be approved by the CPUC. In general, the installation of exit gates will be recommended by a diagnostic team composed of the CPUC, SCRRA, local agency representatives, operating railroads sharing tracks, and the design group. The diagnostic team shall perform a site-specific review which considers crossing attributes, highway environment, and risk mitigation criteria.

33.10.1 Exit Gate Regulatory Requirements

The following are regulatory requirements for exit gates:

- Exit gates shall be designed to fail in the raised position. (CPUC General Order 75-D, CaMUTCD Section 8C)
- Entrance Gates shall begin their descent before Exit Gates and shall be horizontal before the Exit Gates are horizontal. (CPUC General order 75-D)
- A vehicle intrusion detection system shall be installed whenever exit gates are used. (CPUC General Order 75-D, CaMUTCD Section 8C)
- At locations where gate arms are offset enough distance for vehicles to drive between the entrance and exit gate arms, median islands shall be installed in accordance with the needs established by an engineering study. (CaMUTCD Section 8C)
- Exit gate arm activation and downward motion shall be based on detection or timing requirements established by an engineering study of the individual site. (CaMUTCD Section 8C)

33.10.2 Exit Gate Functional Requirements

Where Exit Gates are installed, the latest recommendations of the AREMA Communications and Signals Manual of Recommended Practices and the latest recommendations of the Institute of Transportation Engineers should be followed.

Entrance Gates are required to be fully horizontal 5 seconds prior to a train arriving at a crossing. This requirement does not apply to Exit Gates. (CFR 49, part 234, section 223).

Highway crossing warning systems on SCRRA which require Exit Gates shall use a solid-state control system for the timing of the Exit Gate that is integrated with the roadway vehicle detection system.

Currently SCRRA utilizes Inductive Loops for vehicle detection, however an SCRRA approved equal may be designed. The Inductive Loops for vehicle detection shall be able to detect motor vehicles with a wheel base equal to or greater than 96 inches, whether moving or stationary, within the roadway driving surface and within 20° of the roadway axis, between the Entrance Gates and the Exit Gates. The Vehicle Intrusion Detection System shall be a microprocessor-based system of a Safety Critical design with necessary self-checking. Vehicle detection loops shall be pre-formed and water repellent with an integral check loop such as that manufactured by Reno A & E.

Vehicle detection loops will be placed in accordance with SCRRA ES 8405. The vehicle detection loop system shall hold up the Exit Gate based upon the vehicle's direction of travel. Separate detection loops shall be provided for each direction of roadway travel such that detection of a roadway vehicle that is wholly within a single lane of travel for a given direction will not hold up both Exit Gates due to a vehicle in the crossing.

The Vehicle Intrusion Detection Devices shall be able to handle the following functions:

- Detect all motor vehicles, including all passenger motor vehicles, school buses, and trucks, but not including motorcycles or bicycles.
- Provide "occupied/not occupied" indications to railroad control circuits within two seconds of any state change.
- Verify, not less often than one time each time that the crossing gates are called down, that the Vehicle Intrusion Detection Devices are functioning and able to detect motor vehicle presence.
- Verify each time that the crossing gates are called down and the occupied indication is working.
- Not to generate false highway vehicle occupied indications, more often than minimum threshold values to be determined by the Engineering Study.
- Operate under battery back-up power or to default immediately to an occupied condition when external power is lost, based on the result of the Engineering Study.
- Meet the current applicable national and local standards.
- Provide individually isolated outputs for each loop that are energized to indicate "not occupied," in such a manner that a failed output circuit or wiring fault will result in a de-energized state and "occupied indication."
- Provide separate, individually isolated outputs for each loop that are energized to indicate "loop health," in such a manner that a failed output circuit or wiring fault will result in a de-energized state and a "loop health failure" indication.
- Not generate or induce levels of energy into the rails or other railway communication medium of such magnitude that will cause false occupancy or false vacancy of trains under any normal or abnormal mode of operation.
- Detection loops shall not be vulnerable to EMI that is generated within the environment of an electrified railway under normal or fault conditions.

- When highway vehicular occupancy is not detected, the Exit Gate must be controlled to begin its descent within one second after the minimum highway vehicle clearance time expires and the detection loops indicate that the crossing is unoccupied. Exit Gates shall remain lowered until the train has completed its movement through the grade crossing. Detection of occupancy will cause a descending Exit Gate to reverse direction and raise.
- The loop detection system shall not interpret a train movement through the crossing as vehicle occupancy, therefore train detection system reaction time shall be considered with maximum authorized speed for trains at the crossing to determine if train detection system track wires should be placed further than 50 feet from the edge of travelled way to take into account this reaction time.

Systems having Exit Gate systems should have remote health monitoring systems capable of automatically notifying maintenance personnel when anomalies have occurred within the system (CaMUTCD Section 8C).

Back lights directed toward the motorist shall not be installed on Exit Gates due to the possibility of confusing a motorist crossing the tracks (Preemption of Traffic Signals Near Railroad Crossings, A Recommended Practice of the Institute of Transportation Engineers 2006).

Where Pedestrian Gates are used, a separate gate mechanism shall be used in the quadrant containing the Exit Gate. Either the Exit Gate or the Pedestrian Gate shall have a bell.

Upon detection of an approaching train, the lights will begin to flash, and the bells will begin to ring. A minimum of three seconds after the activation of the lights and bells, the Entrance Gates will begin their descent. If no vehicles are present in the crossing, the Exit Gates will begin their descent after the Entrance Gates. After the train has passed the crossing, the Entrance and Exit Gates will begin their ascent. The time differential between Exit Gate Operation and Entrance Operation should be determined by the Engineering Study.

The need for Exit Gate Clearance time shall be evaluated based upon the criteria in the AREMA Communications and Signals Manual of Recommended Practices. When warning time is calculated at crossings with Exit Gates, the additional time necessary for “wide track” is calculated to the Exit Gate rather than to the point clear of the furthest rail.

33.11 DESIGN STAGES

The design cycle is an iterative process that may involve numerous groups, such as Railroad Operations, Finance, Contracts, other railroad engineering disciplines, and other stakeholders. See Section 21.14, DESIGN STAGES for requirements.

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Appendix A. Terms, Definitions, and References

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A.1 TERMS AND DEFINITIONS

absolute signal	A wayside signal without a number plate that conveys authority for the movement of trains.
accessible	Refers to designed, constructed and operated elements, facilities and programs that adhere to the most current federal ADA Standards for Accessible Design or the accessibility standards requirements of the applicable California Building Code or the applicable local ordinance and amendments for accessibility whichever is most stringent
advance preemption time	The period of time that is the difference between the required maximum highway traffic signal preemption time and the activation of the railroad warning devices.
advanced pedestrian Preemption	A pedestrian timing input into the traffic signal controller that if inputted, the controller will time a shortened “Walk” and “Don’t Walk Time.” After the Pedestrian interval has timed out, no further Pedestrian calls will be served until the input has returned to its normal state
aerial structure	A bridge or elevated structure with a track deck designed to accommodate direct fixation or ballasted track.
alignment	The horizontal and vertical location of the track, street, or highway as described by curves and tangents.
alternative safety measure (ASM)	A safety system or procedure, other than an SSM, which is provided by the appropriate traffic control authority or law enforcement authority and which, after individual review and analysis by the Associate Administrator, is determined to be an effective substitute for the locomotive horn in the prevention of highway-rail casualties at specific Highway-Rail Grade Crossings.
ampere	A unit of electric current.
Amtrak	The national rail passenger service.
annealing	A metal softening process, based on heating and slow cooling.
anticlimber	A horizontally ribbed steel fabrication mounted at floor level at each end of a rail car, which, during collision, will interlock with the other vehicle’s anticlimber and reduce the tendency of the vehicles to “telescope.”
approach slab	A reinforced concrete slab located at the interface of ballasted track with direct fixation track, embedded track, or an open deck bridge to provide a transition between ballasted track and the types of track with significantly higher track modulus.

aspect (signal aspect)	The appearance of a fixed signal conveying an indication as viewed from the direction of an approaching vehicle; or, the appearance of a cab signal conveying an indication as viewed by an observer in the cab.
at-grade crossing	The crossing of a railway track and a vehicular roadway at the same elevation; they are conventionally constructed of timber, asphalt, rubber, or concrete.
audio frequency overlay (AFO)	Track circuits that utilize audio frequencies that overlay another track circuit to detect another vehicle; they are mainly used for highway grade-crossing warning systems.
automatic block signal system	A series of consecutive blocks governed by block signals, cab signals, or both, which are activated by a train or by certain conditions that affect block use.
automatic train dispatching (ATD)	A function of the Operations Control Center computer system in which train dispatching from all terminal points, including the yard, is automatically driven by the current system timetable.
automatic train protection (ATP)	The subsystem of the train control system that maintains safe vehicle operation through a combination of vehicle detection, vehicle separation, and interlocking and speed-limit requests and enforcement.
automatic train stop (ATS)	The system that automatically applies the brakes on a train if the engineer fails to respond to a signal when the train passes over an inductor. Inductors are typically placed at signals or speed restrictions.
backwater	Water held, or restricted from flowing, by a dam or other obstruction within a stream or channel.
ballast	An integral part of the track structure, generally composed of crushed stone in which ties are embedded and is essential to good maintenance of track surface and alignment. FRA Track Safety Standards stipulate that: “Unless it is otherwise structurally supported, all track must be supported by material which will: (1) transmit and distribute the load of the track and railroad rolling equipment to the subgrade; (2) restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by railroad rolling equipment and thermal stress exerted by the rails; (3) provide adequate drainage for the track; (4) maintain proper track cross-level, surface, and alignment.”
baseline stray current survey	A survey conducted during pre-construction in which soil and groundwater corrosive characteristics are determined. These data serve as a basis for corrosion control designs.

basic safety envelope	The area within 25 feet horizontally of the centerline of the nearest active track. The pair of imaginary lines, which define the outside boundaries of the Basic Safety Envelope, extend vertically up and down infinitely. For the purpose of these Criteria, all construction activities within these boundaries will be considered to have the potential to foul the track and will be constrained as necessary by the SCRRA Roadway Worker -in-Charge/Flagman.
betterment	Betterment is defined as a replacement facility or any component thereof, or an enhancement to an existing facility, requested by an entity and agreed to by SCRRA (whether constructed by SCRRA or the entity), that increases the service capacity, capability, appearance, efficiency, or function, except that the following shall not be considered as Betterments: (a) An upgrade which the parties mutually agree will be of direct and principal benefit to the construction or operation of a project. (b) An upgrade resulting from compliance with the entity's applicable standards, provided, however, that any upgrade which exceeds such applicable entity standards shall be considered a "Betterment." (c) Measures to mitigate environmental impacts identified in the Project's final Environmental Impact Report or Statement and which are mutually agreed to be a project responsibility; provided, however, that any upgrade beyond minimally applicable requirements shall be considered a "Betterment." The term "Betterment" shall include any upgrade to a conflicting facility requested by the entity and agreed by SCRRA, in order to conform to revisions or additions to the entity's standards that SCRRA is not required to accept or which is not otherwise excluded from the definition of Betterment as set forth above. The term "Betterment" shall also include any new or upgraded facilities or portion thereof added to a replacement facility at the entity's request for the purpose of the improvement of facilities or services. A Betterment shall not be an entity's project. Betterments shall be entirely the financial obligation of the entity.
block	A length of track with defined limits set by the train control system design.
bond	An electrical or circuit connection made between rail ends.
braking requirement	A braking requirement reflects the maximum safe speed at any given point in the system based on the conditions of the systems.
cab signal	The automatic train protection speed limit as transmitted to the vehicle by the wayside equipment.
Caltrans	California Department of Transportation.

catenary	In electrified territory, an overhead contact system of one or more bare wires including contact wire, messenger wire, and the interconnecting hangers.
cathodic protection	A means of limiting the electrochemical process of corrosion whereby: (1) corrosion is diverted from the item to be protected (the cathode) to a sacrificial item (the sacrificial anode), which eventually corrodes and must be replaced, or (2) an outside electrical current is applied to the item to be protected to control differences in electrical potential between the item (the cathode) and the soil (the anode).
central business district (CBD)	The center or core within an embracing region in which the most intensive commercial activity is concentrated.
Centralized Traffic Control (CTC)	A term applied to a system of railroad operation by means of which the movement of vehicles over routes and through blocks on a designated section of track or tracks is directed by signals controlled from a designated point without requiring the use of train orders and without the superiority of trains.
channelization	The process of controlling automobile traffic by channeling vehicles into specific traffic lanes via barrier curbs and islands. Also, a method for improving the flow capacity of waterway
channelization devices	A traffic separation system made up of a raised longitudinal channelizer, with vertical panels or tubular delineators, that is placed between opposing highway lanes designed to alert or guide traffic around an obstacle or to direct traffic in a particular direction. “Tubular markers” and “vertical panels,” as described in the MUTCD, are acceptable channelization devices.
clearance envelope	Distance in all directions around a train that must be kept clear of obstructions.
closure rails	The rails between the parts of any special trackwork layout, such as the rails between the switch and the frog in a turnout; also, the rails connecting the frogs of a crossing or of the adjacent crossing, but not forming parts thereof.
coasting	The mode of operation of a train in which propulsion (positive traction) and braking (negative traction) are inactive.
compound curve	Track curve composed of more than one curve, each with a different curvature or radius.
compromise joint	A joint matching two rails of different sections or sizes. The four bars for the two joints make up a set of compromise bars for two compromise joints (left & right).
compromise weld	A welded joint matching two rails of different sections or sizes.

contact	A conducting part which co-acts with another conducting part to open or close an electric circuit.
contact wire	Portion of the overhead power distribution system which comes into contact with the sliding current-collector strips on the pantograph, thus transferring electrical power to the train, usually a solid grooved wire.
continuous cab system	A cab system that provides speed commands and other data to the vehicles throughout the system.
continuous welded rail (CWR)	A number of shorter length rails welded together into a single length of generally 400 feet or greater.
contract documents	Engineering design documents, such as design drawings and specifications, incorporated into a composite package for the purpose of soliciting construction bids.
contractor	A person or entity who agrees to furnish materials or perform services at a specified price, especially for construction. More Broadly: An individual, firm, partnership, corporation, or combination thereof, private, municipal or public, including joint ventures, who are referred to throughout this document by singular number and masculine gender. Contractor includes any sub-contractor, supplier, agent, or individual entering on or in the vicinity of the highway-rail grade crossings.
control operator	An employee assigned to operate CTC or interlocking control machine or authorized to grant track permits.
control point	A location of Absolute Signals controlled by a Control Operator.
control signal	A wayside train signal used to control the movement of trains at a control point; an Absolute Signal.
coupler	An appliance on a railroad car for coupling two vehicles.
creep	The tendency of materials to flow plastically due to increase in strain under sustained load.
crest curve	A convex vertical curve.
cross level	The difference in elevation between the tops of both rails measured along a line perpendicular to the track centerline.
cross-bond	An electrical connection from one track to another track to distribute traction power return currents.
crossing diamond	Special trackwork installed to allow two tracks to cross at grade.
crossover (double)	Two single crossovers which intersect each other between the two adjacent and generally parallel tracks forming a connection between them. Sometimes referred to as a “scissors” crossover or “diamond” crossover.

crossover (single)	Two turnouts, with track located between the frogs and arranged to form a continuous passage between two adjacent and generally parallel tracks.
crossover (universal interlocking)	Two single crossovers not intersecting each other but adjacent, allowing passage from one track to another in either direction.
crosstie	The portion of the track structure that supports the rails and maintains gage. Ties are constructed of wood, concrete or steel and are usually spaced 18-24 inches at right angles to the rails.
culvert	A drainage structure or pipe crossing under a track or roadway.
curb return	The portion of a curb at which vehicles make sharp turns.
cut-out (train control)	A circuit at the exiting point of an automatic train control system or cab signal territory by means of which a vehicle ATP system is actuated so as to be in the street running or yard control condition.
Data Capture and Reporting System	A function of central control that records all change-of-state information and system transactions for analysis and reporting purposes. The data capture and reporting system will produce an audit trail listing all controls and indications, as well as how and when they were initiated.
derail	Mechanical device used to derail or otherwise direct rail vehicles away from adjoining or connecting tracks.
design criteria	A document whose purpose is to describe the engineering design criteria to be used during preliminary and final design.
design load	Load which includes stresses due to effective prestress after losses, dead loads, maximum specified live loads, and impact loads.
detector locking	Electric locking, effective while a vehicle occupies a given section of a route, which prevents operation of switch-and-lock movements within that section.
diagnostic team	A joint design team that develops the configuration for a new or upgraded public road crossing. Knowledgeable representatives of parties of interest in a Highway-Rail Grade Crossing, organized by the Public Authority responsible for that crossing, who, using crossing safety management principles, evaluate conditions at a grade crossing to make determinations or recommendations for the Public Authority concerning safety needs at that crossing in accordance with Part 8 of the CA MUTCD. The team includes representatives of the CPUC, the using railroads, the roadway owner, and other involved agencies such as fire, school, etc. SCRRA representatives are typically from the Public Projects and Signal Departments.

direct fixation	Type of track construction in which the rails are fastened to a concrete slab using fasteners which provide lateral and longitudinal restraint, electrical and vibration isolation, and allow for adjustment of the rail position as the rail wears.
direct reverse curves	Sequential and opposite track curves with no intermediate section of straight track (S-shaped curve).
dispatcher	Person stationed in the Operations Control Center who monitors and controls train operations on the main line of the rail system.
division	A portion of the SCRRA system, which is itself made up of subdivisions.
draft gear	The component integrating the coupler to the vehicle underframe anchorage. The draft gear is designed to absorb the shocks incidental to multi-vehicle movements and coupling of vehicles and thereby cushion the force of impact to minimize stresses imposed on the vehicle structure.
dual control switch machine	A power-operated switch machine that can also be thrown by hand.
dwarf signal	A low wayside signal.
dynamic braking	A system of electric braking in which the traction motors, when used as controlled generators, retard the vehicle.
dynamic vehicle outline	The lateral limits of a train in motion considering factors such as vehicle roll, side sway, and fishtailing.
easement	The right legally afforded a person or entity to make limited use of another person's real property as the right-of-way.
effectiveness rate	A number between zero and one which represents the reduction of the likelihood of a collision at a public Highway-Rail Grade Crossing as a result of the installation of an SSM or ASM when compared to the same crossing equipped with conventional active warning systems of flashing lights and gates. Zero effectiveness means that the SSM or ASM provides no reduction in the probability of a collision, while an effectiveness rating of one means that the SSM or ASM is totally effective in eliminating collision risk. Measurements between zero and one reflect the percentage by which the SSM or ASM reduces the probability of a collision.
electric lock	A device to prevent the movement of a track switch unless the locking member is withdrawn by an electrical device such as an electromagnet, solenoid, or motor.
electromagnetic interference (EMI)	Electrical interference of communication signals caused by undesired electromagnetic energy within the atmosphere.

emergency load	An electrical load that is required to be energized from the emergency power source for a specific time interval after the loss of both normal and backup power.
end user	The entity that will operate and maintain the system that was designed.
engineer in responsible charge	The licensed professional engineer in responsible charge of shoring system design, whose seal and signature shall be affixed to the drawings, specifications, calculations, and other documents used in the design and construction of excavation support. For the purpose of these Criteria, the Engineer in Responsible Charge also includes other people designated by the licensed professional engineer in responsible charge and working at his/her direction.
equal construction	The process of constructing a new facility of the same type construction and capacity of existing facilities. Similar to replacement-in-kind.
essential load	An electrical load that is considered essential for safety and system operation so that interruption of power to these loads shall be held to a minimum time. This minimum time is the normal transfer time of automatic transfer equipment and the start time of standby generating equipment.
exclusive track window	An approved Work Window in which no train movements (except the Contractor or SCRRA work trains or equipment under control of the EIC, per the SSWP) will operate on any track within the window limits. The Contractor may dismantle, remove, reconstruct, or otherwise obstruct tracks within the limits of such a window. This Work may be protected by track out of service, track and time limits, or by Form B Track Bulletin
fail-safe	A device, system, or circuit that ensures that any malfunction affecting safety will cause the device, system, or controlled function of the circuit to revert to a state that is known to be safe.
feeder	An electrical conductor that connects a load or distribution point to its source of power.
field weld	A rail joint weld done in the field, typically using the thermite process.
fixed facilities	Facilities to be constructed as part of the project that are stationary (passenger stations, trackway, etc.) rather than mobile (rail vehicles).
flood storage capacity	The capacity of a drainage-way to store, or significantly delay, runoff from a storm event to prevent “flash” flooding.
floodplain	Area within and adjacent to a watercourse that would be expected to be inundated (flooded) during a storm event of a particular frequency (e.g., a 100-year storm).

freight or other track	All tracks that are constructed and/or maintained by SCRRA for use by freight railroads to serve their industrial clients, not generally used by SCRRA passenger equipment.
friction braking	Vehicle braking method that uses brake pads to exert friction forces on a rotating wheel to stop that wheel from rotating.
frog	A track structure or device used at the intersection of two running rails to provide support for wheel treads and passageways for their flanges, thus permitting wheels traversing either rail to cross the other.
frog number	The number used to designate the size of a frog, and being equal to ratio length to divergence.
galvanic corrosion	The electrochemical process of corrosion caused by a difference in electrical potential between dissimilar metals, dissimilar soils, or metals and soils.
girder rail	Any one of several types of rail sections most commonly used in electric or street railway construction. Girder groove rails are asymmetrical rails which provide a wheel flangeway adjacent to the gauge side of the railhead. Girder guardrails use a similar flangeway, but with a raised lip, to provide a guarding action similar to that provided by a separate restraining rail.
graceful degradation (recovery)	An equipment failure in which the system will function with little ill effect. When the failure is resolved, recovery has little effect on other parts of the system.
ground return bonding	Bonding to prevent ground return current.
ground return current	Current that returns to the source through the ground, such as in a damp road crossing.
guard rail	An assembly in a turnout placed opposite the frog point to prevent wheel flanges from contacting the frog point. Also used on crossing frogs.
guarded track	Track with an additional component located inside one or both running rails to bear against the back of the wheels to guide them in traversing small radius curves.
headblock	The tie arrangement under the point of the switch to hold the switch machine and the connecting rods. There are usually two headblock ties.

headway	The time-separation between two trains, both traveling in the same direction on the same track. It is measured from the time the head-end of the leading train passes a given reference point to the time the head-end of the immediately following train passes the same reference point.
heel of frog	The end of the frog in the turnout farthest from the point.
hertz	A unit of measurement that measures alternating electricity by the number of cycles in one second.
high frequency inverter/ballast unit	Self-contained power supplies for fluorescent lamp fixtures that use a high frequency switching rate to produce ac from dc input.
highway-rail grade crossing	A location where a highway, road, or street and the railroad ROW cross at the same level, within which are included the railroad tracks, highway, and traffc control devices for highway traffc traveling over the railroad tracks.
highway-rail grade crossing warning device	A device that provides a visual and/or audible warning and restricts access to the intersection of a highway grade crossing.
horizontal curve	A track curve connecting two horizontal tangents of different bearing.
impedance bond	A metallic device of low resistance and relatively high reactance, used to provide continuous path for the return propulsion current around insulated joints and to confine the audio frequency signaling energy to its own track circuit.
insulated joint	A joint between adjoining rails in which electrical insulation is provided.
interlocking	An arrangement of signals and signal appliances interconnected so that their movements must succeed each other in proper sequence and for which interlocking rules are in effect. It may be operated automatically or by sections.
interlocking limits	The boundaries of an area of track controlled by an interlocking, as defined by the extreme opposing home signals of that interlocking.
Intermediate-term Stationary	Work that occupies a location for more than one daylight period up to three (3) days, or nighttime work lasting more than one (1) hour.
intermittent block cab system	A cab system that provides speed commands to the vehicle at predetermined points.
inverter system	System dedicated to accepting primary dc power, changing it to ac voltages, single or multiple phases, as required.
jerk limit	Maximum rate of change of acceleration for a train. The normal units are feet per second cubed.

jointed rail	Running rail that is connected end to end by means of joint bars and bolts.
jumper cables	Electrical cables that provide electrical continuity in the overhead power distribution system at special trackwork and other locations where it is necessary to have mechanical separations between conductors.
junction box	Any enclosure in which electrical wires and cables are intersected or spliced.
kiss-and-ride	An access mode to a transit station that does not provide for long-term parking; the patron is brought to the station by private automobile, which departs after dropping off the patron.
last long tie	The last switch tie in a turnout farthest from the point of switch.
Law Enforcement Officer/Flagger	A person who provides temporary traffic control for the Road User.
leaky coaxial antenna	Slotted coaxial cable installed within the length of a tunnel that receives and distributes the rail operations and control radio signals; the cable allows operation of the radio channels while a train is in a tunnel.
level crossing (diamond)	Where LRT crosses general railroad tracks (SCRRA)
light unit	An assembly of one or more lenses, roundels or reflectors, arranged in a suitable frame or case with fixture and electrical lamp or lamps from which a light beam or beams can be projected and controlled.
local control panel	A panel provided in each train control room for monitoring and control of their movement in a designated area. The control panel displays the track diagram of the designated area and provides associated control devices and indicators.
local section	Section control equipment located at the site of the mechanical or electrical process that is being controlled.
lock rod	Part of a track switch or derail that locks the switch points or derail into normal or reverse position; consists of a rod, attached to the front rod or log, through which a locking plunger may extend when points or derail are in the normal or reverse position.
locomotive horn	A locomotive air horn, steam whistle, or similar audible warning device (see 49 CFR 229.129) mounted on a locomotive or control cab car. The terms “locomotive horn”, “train whistle”, “locomotive whistle”, and “train horn” are used interchangeably in the railroad industry.

long-term parking facilities	Parking facilities designed for vehicles parking for extended periods (i.e., greater than 15 minutes). Park-and-ride lots are designed as long-term parking facilities.
Long-term stationary	Work that occupies a location more than three (3) days.
loop detector	Vehicle detection coil imbedded in the roadway or trackway that detects vehicles requiring entry into the system. Part of the traffic control system.
low chord/soffit	The lowest horizontal surface of any span, including truss, beam, concrete, and/or deck plate girder.
main track	A track extending through yards and between stations that must not be occupied without authority or protection.
mainline	A section of track on which trains move at design operating speed, primarily for the purpose of transporting patrons during revenue service.
master clock	A single clock provided for the purpose of synchronizing all computer subsystems with the time received from a common master time source.
Master Utility Relocation Agreement	An agreement between SCRRA and local utility companies that spells out the procedure, responsibility, and financial liability for any required utility relocations, replacements, or other utility work.
member agency	The county transportation agency whose property is directly affected by the project. The SCRRA Member Agencies include: the Los Angeles Metropolitan Transportation Authority (METRO), the Orange County Transportation Authority (OCTA), the Riverside County Transportation Commission (RCTC), the San Bernardino County Transportation Authority (SBCTA), and the Ventura County Transportation Commission (VCTC).
messenger wire	A suspended wire attached to primary structural supports, from which is suspended a cable or conductor. In a catenary system, the conductive messenger wire supports the contact wire through hangers.
Metrolink Operations Center	The operations control center for SCRRA, located in Pomona.
nationwide significant risk threshold (NRST)	A number reflecting a measure of risk, calculated on a nationwide basis, which reflects the average level of risk to the motoring public at public Highway-Rail Grade Crossings equipped with flashing lights and gates and at which locomotive horns are sounded. The NSRT represents a statistical benchmark used during the quiet zone establishment process as a comparative measure to evaluate a Quiet Zone Risk Index. The NSRT is periodically revised by the FRA.

non-essential load	An electrical load of such a nature that interruption of power to it for a short period will not affect safety and system operation. Non-essential loads do not require a backup power source.
non-revenue track	See *secondary track*.
non-signaled territory	Sections of the track system in which no signals exist. The centralized traffic control system identifies all trains as they enter and exit non-signaled territory.
non-traversable curb	A highway curb designed to discourage a motor vehicle from running around lowered gate arms. Non-traversable curbs are used at locations where highway speeds do not exceed 40 miles per hour and are at least six inches high.
non-vital relays	Any relay that does not affect the safety of train operations.
ohm	An electrical unit that measures the resistance to the flow of current in a conductor.
omnibus backbone network	Electronic network that accommodates the data, voice, and closed circuit television transmission needs of the communications system and the voice and remote control connections to rail radio base stations.
operating railroad	Any passenger or freight-related railroad company operating on SCRRA tracks
operating rod	The rod through which motion is transmitted.
operating system	Includes, but is not limited to, the tracks on which trains and “on-track” equipment operate or may potentially operate, and in addition any facilities closely related to the operation of the railroad system including signal and communications masts, bridges, poles, cables and houses, tunnels, culverts, bridges, access roads, highway-rail grade crossings and station platforms.
overhead contact system (OCS)	An electrical power distribution system designed to conduct and transfer power from substations to the trains. The system comprises the bare wire overhead contact system, supporting structures and their foundations, supporting attachments to overhead bridge structures, parallel insulated traction power supply cable hardware and connections to the overhead contact system, and cable cross arm supports and hardware for locations where aerial support is selected for the signal control and communications cables. A collapsible and adjustable frame that is mounted on top of a vehicle and to which a sliding current-collector shoe is fitted at the upper end.
park-and-ride	A transit access mode in which a patron drives a private automobile to a station, parks in the areas provided for that purpose, and enters the transit system.

patron	A person who paid fare to use the transportation service provided by SCRRA.
pocket track	A track located between two primary tracks, which is used to store out-of-service, layover, or turning back trains.
point detector rod	A rod through which position is transmitted to the circuit controller to indicate position of the switch points.
point of vertical curvature (PVC)	Point of connection of a tangent track line to a vertical curve.
point of vertical tangency (PVT)	Point of connection of a vertical curve to a tangent track line.
primary track	Track constructed for vehicles in revenue service (carrying revenue passengers), including mainline, siding, and station tracks.
profile	The vertical alignment of the track, usually shown as the top of rail elevation.
profile grade (grade line)	The datum line which defines the vertical alignment of the track, applied at the top of the low rail.
project owner	The lead agency or a third-party project sharing the SCRRA ROW
project sponsor	The lead agency or third-party that is the lead entity for a proposed project
public agency	The federal government and any agencies, departments or subdivisions thereof; the State of California; and any county, city, city and county district, public authority, joint powers agency, municipal corporation, or any other political subdivision or public corporation therein, requesting and sponsoring the temporary traffic control. This includes SCRRA Member Agencies.
public highway-rail grade crossing	A location where a public highway, road, or street, including associated sidewalks or pathways, crosses one or more railroad tracks at grade. If a Public Authority maintains the roadway on both sides of the crossing, the crossing is considered a public crossing for purposes of this part.
quiet zone	A segment of a rail line, within which is situated one or a number of consecutive public highway-rail crossings at which locomotive horns are not routinely sounded.
quiet zone risk index (QZRI)	A measure of risk to the motoring public which reflects the Crossing Corridor Risk Index for a Quiet Zone, after adjustment to account for increased risk due to lack of locomotive horn use at the crossings within the Quiet Zone (if horns are presently sounded at the crossings) and reduced risk due to implementation, if any, of SSMs and ASMs with the Quiet Zone.

radio frequency interference (RFI)	Electrical interference of communication signals caused by undesired radio frequency energy within the atmosphere.
radio release	A reset command sent by radio communications to release the automatic trip stop (ATS) system.
rail anchor	A device attached to the rail that contacts the tie and prevents longitudinal rail movement.
rail clip	A resilient device used to secure running rails to crossties to provide vertical, lateral, and longitudinal restraint of the rail.
rail fastener	A device used to secure running rails to crossties to provide vertical and lateral restraint of the rail. This includes track spikes and resilient fasteners.
rail with trail	A marked or established shared use path used by bicyclists, pedestrians, wheelchair users, joggers and other non-motorized users that is located on or directly adjacent to an active railroad corridor.
railroad zone of influence	The zone within which shored excavation is required and the shoring system is required to be designed for railroad live load surcharge.
receiver	A device that converts electric energy input to the device to indicate electric energy is present.
receiver (track circuit)	Receiver so placed that upon detection of a voltage or frequency, a contact or voltage is supplied to controlling circuits to indicate its presence.
receiver (train control, cab control)	Receiver so placed that it is in a position to be influenced inductively or actuated by an automatic train stop, train control, or cab signal element.
redundancy	The existence in a system of more than one independent means of accomplishing a function.
regenerative braking	A system of electric braking in which the traction motors, when used as controlled generators, return a portion of the braking energy as electrical energy to the contact wire for use by other trains or other train subsystems.
relay	A device that is operated by a variation in the conditions of one electric circuit to affect the operation of other devices in the same or another electric circuit.
relay-based equipment	An electromagnetic device operated by a variation in the conditions of one electric circuit to affect the operation of other devices in the same or another electric current.
relay-based interlocking	(See *interlocking*.) Equipment used to control an interlock that consists primarily of relays.

replacement-in-kind	The process of replacing a facility with a facility of the same type, construction, and capacity. Similar to equal construction.
resilient fastening system	Rail Fastening assembly that incorporates, rolled, forged or fabricated steel tie plates with shoulder that accept an elastic (spring) rail fastening and are drilled, punched or machined to accept hold-down screw spikes; screw spikes; spring clips which applies a hold-down force (toe load) to the rail base; and insulating pads (when necessary), to control rail lift, lateral movement and longitudinal movement, dampening vibrations that originate at the rail/wheel interface, and incorporate electrical isolation measures either at the base of rail or between the plate and the cross tie.
resistance-to-earth criteria	The design desirable in-service electrical resistance per mile of mainline running rails, special trackwork, and ancillary system connections.
revenue track	See *mainline* and *primary track*.
reverse running	The operation of a vehicle against the normal direction of operation on a particular track.
rheostatic brake	Braking in which the power generated by the traction motors, when driven as generators, is dissipated through a resistor bank. Also called dynamic braking.
right-of-way (ROW)	Land or rights to land used or held for railroad operations or for public way. A strip of land, real estate or property of interest, under the ownership or operating jurisdiction of SCRRA or Member Agency on which railroad tracks, other structures and facilities are constructed.
risk index with horns (RIWH)	A measure of risk to the motoring public when locomotive horns are routinely sounded at every public Highway-Rail Grade Crossing within a Quiet Zone. The Risk Index With Horns is determined by adjusting the Crossing Corridor Risk Index to account for the decreased risk that would result if locomotive horns were routinely sounded at each public Highway-Rail Grade Crossing.
road user	A vehicle operator, bicyclist, or pedestrian within the highway, persons with disabilities, including workers in Temporary Traffic Control Zones.
roadway flagger	A person trained in the fundamentals of flagging automotive traffic.
running rail	That rail upon which the tread of rolling stock wheels bear.
sacrificial anodes	An item, such as a zinc plate, that limits the electrochemical process of corrosion by diverting corrosion from the item to be protected (the cathode) to itself (the anode), which eventually corrodes and must be replaced.

safe braking distance (SBD)	The distance allowed for the safe stopping of a train from a given speed, or for reducing velocity from one speed to another speed. The SBD will include the distance traveled at the initial speed during operator and equipment reaction time, stopping distance, or distance required to reduce to the new speed desired, and an appropriate safety-factor.
sag curve	A vertical curve that is concave.
sand box	Timber box structure filled with sand and located at the ends of stub-end tracks to stop rail cars and minimize damage to them.
SCRRA Roadway Worker in Charge (RWIC)	A Southern California Regional Rail Authority employee (SCRRA General Code of Operating Rules and territory qualified) providing warning to Public Agency or Contractor personnel of approaching trains or on-track equipment and who has the authority to halt work and to remove personnel from the railroad right-of-way to assure safe work.
secondary track	All track that is not primary track; or, track constructed for the purpose of switching, storing, or maintaining vehicles that do not carry revenue passengers.
self-service fare collection	A proof-of-payment fare collection system.
set back	The distance between the centerline of the nearest railroad track (existing or planned) and the closest edge of a trail.
shoofly	A temporary detour track to bypass an obstruction or construction site.
shop track	Track which consists of all yard and secondary track constructed within the limits of the maintenance buildings.
short duration	Work that occupies a location for up to one (1) hour.
short-term parking facilities	Parking facilities designed for vehicles parking for a limited time (i.e., less than 15 minutes). Kiss-and-ride lots are designed as short-term parking facilities.
short-term stationary	Work that occupies a location for more than one (1) hour, but less than 12 hours.
signals (automatic)	A signal at the beginning of a signal block that automatically changes its aspect to indicate whether the block is clear or occupied.
signals (controlled)	A signal that requires a request for its operation, i.e., a signal that is not automatic.
signals (wayside)	A signal of fixed location along the track right-of-way.

simulation	The representation of the functioning or process of one system by means of another, especially when examining a problem not subject to direct experimentation.
site specific work plan	A program, plan, and schedule prepared and submitted by the Contractor and accepted by SCRRA that accurately describes and illustrates the manner in which work within the Basic Safety Envelope will be accomplished, the potential impacts on elements of the Operating System and the manner and methods by which these elements will be protected from any potential impact, and/or the manner in which work will be accomplished within SCRRA allotted Work Windows.
slip	The act of train wheels sliding (rather than rolling) over the rails due to rapid deceleration of the train. Slip is detected and controlled by slip-spin protection.
special trackwork	A generic term referring to turnouts, single and double crossovers, track crossings, and other items that permit tracks to merge, diverge, or cross one another.
specific minimum yield stress (SMYS)	The minimum design pressure or stress at which a steel pipe will fail or yield.
speed	The maximum speed of operation for trains, often different for passenger and freight trains.
spin	The act of train wheels spinning (rather than rolling) over the rails due to rapid acceleration of the train. Spin is detected and controlled by slip-spin protection.
spiral curve	Curves that are used on mainline track alignments to transition from a tangent to a circular curve, and to develop the superelevation of the track.
sponsoring party	A private or public organization that proposes, plans, installs, and maintains landscapes within SCRRA or Member Agency rights-of-way, typically near stations. Although typically a third party (see *third party*), SCRRA or a Member Agency may also provide landscape improvements as a sponsoring party.
stand-alone validator	A device available at stations to imprint information on riders' tickets for self-service fare collection verification.
standard fastening system	Rail Fastening assembly that incorporates, conventional rolled steel tie plates with shoulder, punched with square holes to accept cut spikes; cut spikes; and rail anchors to control rail lift, lateral movement and longitudinal movement.
static vehicle outline	The lateral limits of a vehicle body, not in motion, and with all mechanical features in nominal factory condition.

station	A facility equipped with platforms to enable patrons to enter and leave trains.
stock rail	A running rail against which a switch point operates.
stray currents	Electrical currents, other than those generated for use by the rail system, which exist in the environment due to the electromagnetic and/or electrochemical interactions of the rail equipment, atmosphere, groundwater, and soils.
stub-up	Portion of underground electrical conduit that rises to or through the ground surface.
sub-ballast	A material superior in composition to the roadbed material which provides a semi-impervious layer between the track ballast and the roadbed for better drainage and distribution of load to the roadbed.
subdivision	Portion of the SCRRA system, such as the San Gabriel Subdivision.
subgrade	The native material underneath a constructed railroad track, which is commonly compacted and stabilized before construction of the railroad track.
substation	A facility containing electrical equipment which typically provides for the transformation of high transmission voltage electric power to one or more lower voltages for distribution of the electric power to consumers.
substructure	The part of an aerial structure or bridge below the bridge seats, tops of piers, haunches of rigid frames, or below the springlines of arches. Backwalls and parapets of abutments and wingwalls of bridges shall be considered part of the substructures.
superelevation (Ea)	Tilting or “banking” of the running surface of a roadway or trackway in areas of curved horizontal alignment, which permits vehicles to negotiate the curves at higher speeds than would be possible if the running surface were level. Superelevation is applied by raising the outside rail in a curve a specified number of inches, expressed as ‘Ea’ or ‘actual superelevation, the amount of super (inches) is determined by the speed and degree of curvature
superstructure	The part of an aerial structure or bridge above the bridge seats, tops of piers, haunches of rigid frames, or above the springlines of arches, including the floor, and not including the substructure.
supplementary safety measure (SSM)	A safety system or procedure established in accordance with FRA, which is provided by the appropriate traffic control authority or law enforcement authority responsible for safety at the Highway-Rail Grade Crossing that is determined by the Associate Administrator to be an effective substitute for the locomotive horn in the prevention of highway-rail casualties.

support equipment	Equipment used together to provide the basis of subsistence for a complete system.
switch control	An electrical circuit that directs the movement of a track switch.
switch machine	A device used to operate a track switch; a switch and lock is one type of switch machine.
switch point	The movable tapered rail of a split switch.
switch stand	A device next to the point of the switch that includes the switch lever mechanism.
switch tie	Special crossties of varying length used under a turnout.
switch, point of	The end of a switch point farthest from the frog.
switch, split	A track switch consisting of two movable switch points.
switch-and-lock	A device which performs the three functions of unlocking, operating, and locking a track switch or derail.
system-wide elements	Facilities that are continuous across the entire SCRRA system such as signal and communication systems.
tce	Temporary Construction Easement
tcns	Tower Construction Notification System
temporary traffic control zone	An area of a highway where Road User conditions are changed because of a work zone or an incident by the use of temporary traffic control devices, Flaggers, police, or other authorized personnel.
third party	A type of sponsoring party that is not SCRRA or a Member Agency, specifically an individual, firm, partnership or corporation, or combination thereof, private or public requesting and sponsoring a landscaping project. Third Party also includes the federal government and any agencies, departments or subdivisions thereof; the State of California; and any county, city, city and county district, public authority, joint powers agency, municipal corporation, or any other political subdivision or public corporation therein requesting and sponsoring a landscaping project.
tia	Telecommunications Industry Association
ticket-issuing device	A device to issue single ride documents showing that the passenger has paid the fare.
tie	A long timber or concrete member on which ballasted track is constructed; also referred to as a crosstie.
tie plate	A steel plate installed between the rail and the crosstie to distribute the load and restraint lateral movement.

time of concentration	The travel time required for overland flow plus the travel time required for channel flow of stormwater from the most remote point of the drainage area to the point under consideration.
timing device	A device that provides a contact or closure data indicating that a preset time has elapsed from a predetermined condition.
toe of frog	The end of the frog closest to the switch points.
total approach time	The Total Approach Time (TAT) is not necessary for calculation of the required preemption time, but it is very useful for the rail operator when determining where to place the detection equipment. The total approach time includes the total warning time, the advance preemption time, and the equipment response time. The total warning time includes the minimum warning time plus the buffer time. TAT = TWT + APT + ERT TWT = MWT + BT
track circuit	An arrangement of electrical circuits and/or electronic equipment, including a length of the running rails, which permits detection of vehicles.
track circuit (ac)	A track circuit that uses ac voltage to the rails to detect vehicles in a block.
track circuit (AF)	A track circuit that uses audio frequency to detect vehicles in a block.
track circuit (digital)	A processor track circuit that provides a means to transmit data to a train from the rails.
track circuit (double rail)	An AC track circuit that uses both rails for vehicle detection and uses impedance bonds for propulsion return.
track circuit (PF)	An A track circuit that uses the supplied ac for detection of vehicles. (PF power frequency).
track circuit (single rail PF) vehicle	A PF track circuit that uses one rail solely for detection.
track circuit boundaries	An area defined from the end point on the track circuit to the other end of the track circuit. (See *block*.)
track crossing	The point at which two running rails cross.
track detection	A device detecting the presence of a vehicle that is used by the signal system for controlling train operation.
track gauge	The distance between the inside faces of running rails of a track measured at a point ⅝ in. below the top of rail. Standard gauge is 56 ½ inches.

track, direct fixation	Track constructed of rail and rail fasteners attached by means of anchor bolts to a concrete trackbed.
track, embedded	Track constructed of rails and steel ties on a reinforced concrete slab and, except for the flangeways, embedded in asphalt or concrete to the top of rail to facilitate pedestrian or vehicle traffic over the tracks. For track located in streets, grade crossing, or vehicle maintenance facilities.
traction current return	The path followed by traction power electrical current from the train back to the substation.
traction power	Power used by the train for propulsion.
traffic control device	A sign, signal, marking, and other device used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility, or shared-use path by authority of a Public Agency having jurisdiction.
train	Locomotive and one or more vehicles coupled together (a consist) and acting as a single unit.
train stop	A device used by the signal system to command a train to stop.
train stop (inductive)	An automatic train stop which uses electric coils as a means to command a train to stop.
train to wayside (TTW) system	A system that routes trains to their scheduled destinations and provides central control with vehicle identification.
Transit Communications Interface Protocols	Standards developed by the Institute of Electrical and Electronics Engineers and subsequently maintained by the American Public Transit Association, defining communications protocols to be used in the transit industry.
transition length	The portion of a tangent track in which superelevation is developed immediately preceding a circular curve and removed immediately following a circular curve, when spiral curves are not used.
transmitter	A device that generates electrical energy to be used by a receiver.
transponder	A device located on the track side that transmits data and/or receives data.
ttci	Transportation Technology Center, Inc.
tunnel	An underground guideway constructed by methods such as soft ground tunneling, mixed face tunneling, or other means of boring into soil strata.
turnout	An arrangement of a switch and a frog with stock rails and closure rails that enables rail vehicles to be diverted from one track to another.

ultimate load	The load that causes failure of a structure with a single static application.
unbalanced superelevation	Occurs when trains operate at speeds higher than equilibrium or balanced speeds. The speed greater than equilibrium is expressed as an additional, imaginary, portion of the total superelevation. It is not actually built into the track.
uninterruptible power supply (UPS)	A battery power backup for the operation of critical signal and communications systems.
vending equipment interface	A specification for communication between elements of a fare vending system.
vertical curve	A parabolic curve connecting two vertical tangents in a track profile.
vital processor unit	A device in which a central processing unit provides a logical evaluation of predefined commands to determine an output. This device is designed to insure any failure conditions will provide no voltage, or zero data, to an output used for controlling circuits. (See *processor-based equipment*.)
vital relays	Relays that contain circuits that affect the safety of train operations.
volt	The unit of electromotive force, or that difference of potential that, when steadily applied against a resistance of one ohm, will produce a current of one ampere.
wayside	A term generally used to refer to the area alongside the path of a rail vehicle, but clear of its dynamic outline.
wayside horn	A stationary horn located at a highway rail grade crossing, designed to provide, upon the approach of a locomotive or train, audible warning to oncoming motorists of the approach of a train.
work window	A period of time with a specific beginning and ending time and duration for which the track, signals, bridges and other Operating System elements within the Basic Safety Envelope are temporarily removed from service or modified in some other manner and train and other operations suspended or modified to allow construction or maintenance to occur. Written authority from SCRRA and an accepted Site Specific Work Plan (SSWP) are required before a Contractor is granted a Work Window. The Contractor’s Work Window shall have specific geographic limits, which are defined in the accepted SSWP. Modifications or suspension of train and on-track equipment movements resulting from a Work Window involves written changes to SCRRA’s Rules of Train and On-Track Equipment Operations, which are known as Track Bulletins.
yard track	Secondary track constructed and operated for the purpose of storing, maintaining, or switching locomotive equipment or rail cars.

yardmaster	Person stationed at central control who coordinates all moves into or out of the yard.

A.2 Referenced Standards

The most current editions of the following standards, codes, specifications, and guidelines shall be consulted in the design of SCRRA projects: (*sub items are listed for clarity other sections and guidelines may apply)

- Air Conditioning Contractors of America (ACCA) Manual Q, Commercial Duct Design
- Air Conditioning and Refrigeration Institute (ARI) standards
- Air Movement and Control Association (AMCA) standards
- American Association of State Highway and Transportation Officials (AASHTO)
    - A Policy on Geometric Design of Highways and Streets*
    - “Guide for Development of Bicycle Facilities, 4th Edition”
    - “Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition” (2011)
        - Section 7 “Structural Steel Components”
    - Highway-Rail Crossing Elimination and Consolidation
    - Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 4th edition, 2006 Interim
- Americans with Disabilities Act (ADA)
    - Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)
- American Petroleum Institute
    - RP 1102, “Steel Pipelines Crossing Railroads and Highways”
- American Public Works Association
    - Standard Plans for Public Works Construction
    - “Work Area Traffic Control Handbook” (WATCH) published by Southern California Chapter of the American Public Works Association
- American National Standards Institute (ANSI)
    - A21 - Iron Pipe and Fittings
    - A117.1 - Standard for Accessible and Usable Buildings
    - B16 - Standards for Pipes and Fittings
    - B31.9 - Building Services Piping
    - B125 - Plumbing Supply Fittings
    - Z358.1 – Standard for Emergency Eyewash and Shower Equipment
- American Railway Engineering and Maintenance-of-Way Association (AREMA)

  - American Railway Engineering and Maintenance-of-Way Association Manual for Railway Engineering
  - American Railway Engineering and Maintenance-of-Way Association Recommended Practice
  - Manual for Railway Engineering, Volume 1, Chapter 1, Part 5, Pipelines
  - Chapter 9 Seismic Design for Railway Structures
  - The Communications & Signals Manual
  - The Document for Railway Engineering
  - The Portfolio of Track Work Plans (companion volume to the Railway Engineering Manual)
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
  - ASHRAE Handbook – *Fundamentals*
  - ASHRAE Handbook – *HVAC Applications*
  - ASHRAE Handbook - HVAC Systems and Equipment
  - ASHRAE Standard Commissioning Process for Buildings and Systems
  - ASHRAE Standard 52.2 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
  - ASHRAE Standard 62.1 Ventilation for Acceptable Indoor Air Quality
  - ASHRAE Standard 90.1 Energy Standard for Buildings
- American Society of Mechanical Engineers (ASME)
  - ASME A17.1, Safety Code for Elevators and Escalators
  - ASME/ANSI B16, Fittings and Valves package of standards
  - ASME B31 Pressure Piping package of standards
    - B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids

      B31.9 Building Services Piping
- American Society for Testing and Materials (ASTM)
  - ASTM B88 Standard Specification for Seamless Copper Water Tube
  - ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
- American Water Works Association (AWWA)
- Antenna Structure Registration (ASR)
- Association of American Railroads (AAR)
- California Building Code (CBC)

  - CBC 11B-216.1 Signs and CBC Chapter 11B Division 7: Communication Elements and Features
  - CBC 11B-703.3 Signs
  - CBC Accessibility requirements
  - CBC Chapter 11B Division 7: Communication Elements and Features.
  - CBC Chapter 11B-502.6 Parking Spaces
  - ADA requirements and California Building Code accessibility provisions
- California Coastal Act of 1976 (Public Resources Code, Division 20)
- California Department of Fish and Wildlife, Section 1600
- California Electrical Code
- California Endangered Species Act
- California Environmental Quality Act (CEQA)
  - California Public Resources Code Division 13, Sections 21000-21178) and CEQA Guidelines (California Public Resources Code Division 13, Sections 15000-15387)
- California Fire Code (CFC)
- California Fish and Wildlife Code
  - Sections 2081 and 1601
- "California Manual of Uniform Traffic Control Devices" (CA MUTCD) issued by the California Department of Transportation (Caltrans)
  - CA MUTCD Section 8B.17 and ES 3319 & ES 4006
- California Mechanical Code (CMC)
- California Phase II Low Impact Development (LID) Sizing Tool
- California Plumbing Code (CPC)
- California Public Resources Codes 8801 -08819
- California Public Utilities Commission (CPUC)
  - California Public Utilities Code (PU Codes)
  - Commission General Orders (CPUC GO) Effective versions, a partial list follows:
  - GO No. 26; Regulations Governing Clearances on Railroads and Street Railroads with reference to Side and Overhead Structures, Parallel Tracks, Crossings of Public Roads, Highways, and Streets.
  - GO No. 33; Construction, reconstruction, maintenance and operation of interlocking plants of railroads
  - GO No. 72; Standard types of pavement construction at railroad grade crossings

- GO No. 75; Regulations Governing Standards for Warning Devices for At-Grade Highway-Rail Crossings
- GO No. 88; Rules for Altering Public Highway-Rail Crossings
- GO No. 95; Rules for Overhead Electric Line Construction
- GO No. 112; Design, construction, testing, maintenance and operation of utility gas gathering, transmission and distribution piping systems
- GO No. 118; Construction, reconstruction and maintenance of walkways and control, of vegetation adjacent to railroad tracks.
- GO No. 128; Rules For Construction Of Underground Electric Supply And Communication Systems
- GO No. 135; The occupancy of public grade crossings by railroads
- GO No. 143; Design, construction and operation of light rail transit systems
- GO No. 175; Rules And Regulations Governing Roadway Worker Protection Provided By Rail Transit Agencies and Rail Fixed Guideway Systems

- California Stormwater Quality Association (CASQA)
  - Industrial & Commercial Best Management Practice (BMP) Online Handbook
  - Municipal BMP Online Handbook
  - New Development & Redevelopment BMP Online Handbook
- California Department of Transportation (Caltrans)
  - Caltrans Highway Design Manual (HDM)
    - "Highway Design Manual", Chapter 1000, " Bikeway Planning and Design"
  - Caltrans Standard Interconnection for Traffic Signal Preemption at Railroad Crossings
  - Chapters 800 to 890, Highway Drainage Design
  - "California Manual on Uniform Traffic Control Devices (CA MUTCD)"
  - Caltrans Standard Plans
  - "Seismic Design Criteria," Version 1.7 (April 2013)
  - "Seismic Design Criteria" (SDC), Version 1.7, Section 3 "Capacities of Structural Components," Section 7 "Design," and Section 8 "Seismic Detailing."
- California Title 24 Energy Regulations
- Clean Water Act of 1977 and 1987
  - Sections 401, 402, and 404 (33 USC 1251-1376)
- Coastal Zone Management Act of 1972 (16 USC 1451-1464)
- Crime Prevention through Environmental Design (CPTED)
- Current standards of utility owners

- Electronic Industries Association (EIA)
- Endangered Species Act of 1973
  - Section 7 (16 USC 1531-1543)
- Federal Clean Water Act, Section 404
  - Individual permits
  - Nationwide permits
  - Regional general permits
  - Section 401 – Regional Water Quality Control Board
  - Section 402 – National Pollutant Discharge Elimination System
- Federal Communications Commission (FCC)
- Federal and State National Pollutant Discharge Elimination System (NPDES) and Storm Water Pollution Prevention Plan (SWPPP) requirements
- Federal Emergency Management Administration (FEMA) National Flood Insurance Program (NFIP) guidelines for construction in FEMA-mapped regulatory floodplains
- Federal Highway Administration (FHWA)
  - Environmental Impact and Related Procedures (23 CFR 771)
  - Geotechnical Engineering Circular No. 4, Ground Anchors and Anchored Systems, FHWA-IF-99-015
  - Hydraulic Design Series (HDS)
  - Hydraulic Engineering Circulars (HEC)
  - Highway-Railroad Crossings: A Guide to Crossing Consolidation and Closure, FRA/FHWA Joint Publication
  - Railroad-Highway Grade Crossing Handbook, U.S. Department of Transportation
  - Section 4(f) of the Department of Transportation Act (49 USC 303 or 23 USC 138; 23 CFR 77I.135; 23 CFR 771 and 774; FHWA Section 4(f) Policy Paper, March 2005)
  - Section 7 of the Endangered Species Act of 1973 (16 USC 1531-1543)
  - Sections 9 and 10 of the Rivers and Harbors Act (33 USC 401 et seq.)
  - Section 106 of the National Historic Preservation Act of 1966, as amended (36 CFR 800)
  - Sections 401, 402, and 404 of the Clean Water Act of 1977 and 1987 (33 USC 1251-1376)
  - Sections 2081 and 1601 of the California Fish and Wildlife Code
- Federal Railroad Administration (FRA) (Title 23 and Title 49)
  - FRA 49 CFR Section 37 Transportation Services for Individuals with Disabilities

- FRA 49 CFR Section 38 Americans with Disabilities Act (ADA)
- FRA 49 CFR Section 192 Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
- FRA 49 CFR Section 195 Transportation of Hazardous Liquids by Pipeline
- FRA 49 CFR Section 213 Track Safety Standards Compliance Manual
  - Track Safety Standards, particularly 49 CFR 209, 213, 214, 220, 229, 233, 234, and 236
- FRA 49 CFR Section 214 Railroad Workplace Safety, and Cal/OSHA Standards – California Code of Regulations, Title 8, Chapter 4, Division of Industrial Safety, Subchapter 4, Construction Safety Orders
- FRA 49 CFR Section 214 Roadway Worker Protection
- FRA 49 CFR Section 222 Use of Locomotive Horns at Public Highway-Rail Grade Crossings
  - Section 222.25
  - Section 222.35(c)1
  - Section 222.35(f)
  - Section 222.27(d)1
- FRA 49 CFR Section 234 Grade Crossing Safety
- FRA 49 CFR Section 235 Instructions Governing Applications For Approval Of A Discontinuance Or Material Modification Of A Signal System Or Relief From The Requirements Of Part 236
- FRA 49 CFR Section 236 (Rules, Standards, and Instructions Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Appliances)
- FRA 49 CFR Section 270 System Safety Program
- "High-Speed Ground Transportation Noise and Vibration Impact Assessment," Final Draft, December 1998, Report No. 293630-I

- MUTCD Section 8B.01 Table 8B1 Grade Crossing Sign and Plaque Minimum Sizes
- MUTCD Section 8B.17 LOOK Sign (R15-8)
- Federal Rivers and Harbors Act, Section 10
- Federal Transit Administration (FTA)
  - "Transit, Noise and Vibration Impact Assessment," Publication DOT-T-95-16, April 2005
  - Transit Security Design Considerations
- Greenbook Standard Specifications and Standard Drawings for Public Works Construction, written and promulgated by Public Works Standards, Inc.

- Howard C. Swanson, “Structural Importance Classification of Railroad Structures for Seismic Design” (June 1, 1999)
- Illuminating Engineering Society (IES)
- Institute of Electrical and Electronics Engineers (IEEE)
  - IEEE Standard 729 Software Design and Documentation
  - IEEE Standard 730 Software Quality Assurance
- Institute of Transportation Engineers (ITE)
  - Preemption of Traffic Signals near Railroad Crossings
- Insulated Cable Engineers Association (ICEA)
- Low Impact Development Manual for Southern California: Technical Guidance for Site Planning Strategies
- M.J.N. Priestly, F. Seible, and G.M. Calvi, *Seismic Design and Retrofit of Bridges* (1996)
- National Association of City Transportation Officials
  - “Urban Bikeway Design Guide”
- National Electrical Code (NEC)
  - Emergency Egress Requirements
- National Electrical Manufacturers Association (NEMA)
- National Electric Safety Code (NESC)
- National Environmental Policy Act (40 CFR 1500-1508) (NEPA)
- National Fire Protection Association (NFPA)
  - Recommended Practices
  - NFPA 10 Standard for Portable Fire Extinguishers
  - NFPA 13 Standard for the Installation of Sprinkler Systems
  - NFPA 14 Standard for the Installation of Standpipe and Hose Systems
  - NFPA 20 Standard for the Installation of Stationary Pumps for Fire Protection
  - NFPA 24 Standard for the Installation of Private Fire Service Mains and Their Appurtenances
  - NFPA 25 Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
  - NFPA 33 Standard for Spray Applications Using Flammable or Combustible Materials
  - NFPA 72 National Fire Alarm and Signaling Code
  - NFPA 90A Installation of Air Conditioning and Ventilating Systems
  - NFPA 90B Installation of Warm Air Heating and Ventilating Systems

- NFPA 91 Exhaust Systems for Air Conveying of Vapors, Gases, Mists and Noncombustible Particulate Solids
- NFPA 92A Smoke Control System
- NFPA 92B Smoke Control Systems in Atria, Covered Mall and Large Areas
- NFPA 130 Fixed Guideway Transit and Passenger Rail Systems
- NFPA 204M Smoke and Heat Venting
- NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials
- NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems

* National Historic Preservation Act of 1966 (NHPA)
  - Section 106, as amended (36 CFR 800)
* Occupational Safety and Health Administration (OSHA)
* Post-Construction Water Balance Performance Standard
* Public Agency standards having jurisdiction over the local roadway
* Right-of-Way Preservation Guidelines adopted by the specific Member Agencies.
* Rivers and Harbors Act
  - General Bridge Act of 1946, Section 9
  - Sections 9 and 10 (33 USC 401 et seq.)
* SCRRA Maintenance of Way Operating Rules (MOWOR)
* SCRRA Maintenance of Way Safety Rules (MOWSR)
* SCRRA On-Track Safety Manual (OTSM)
* SCRRA Roadway Worker Protection Safety Manual
* SCRRA Track Maintenance Manual (TMM)
* Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA)
  - SMACNA HVAC Air Duct Leakage Test Manual
  - SMACNA HVAC Duct Construction Standards – Metal and Flexible;
  - SMACNA HVAC Systems Duct Design
  - SMACNA Rectangular Industrial Duct Construction Standards
* State of California Division of Occupational Safety and Health (Cal/OSHA)
* State of California MWELO (Model Water Efficient Landscape Ordinance)
* Telecommunications Industry Association (TIA)
* Tower Construction Notification System (TCNS)

- Transportation for Individuals with Disabilities at Intercity, Commuter, and High Speed Passenger Railroad Station Platforms
- Transportation Technology Center, Inc. (TTCI)
- WATCH-Work Area Traffic Control Handbook
- Underwriters Laboratories, Inc. (UL)
  - UL 555 Standard for Fire Dampers
  - UL 555S Standard for Smoke Dampers
  - UL 723 (ASTM E84), Test for Surface Burning Characteristics of Building Materials
- Uniform Building Code, including seismic requirements (UBC)
  - Including seismic requirements
- U.S. Access Board Proposed Guidelines for Accessible Rights-of-Way (PROWAG)
- U.S. Department of Commerce, Bureau of Public Roads, HDS Manuals
- U.S. Department of Transportation
  - Pipeline and Hazardous Materials Safety Administration, 49 CFR 195, Pipeline Safety: Hazardous Liquid Pipelines Transporting Ethanol, Ethanol Blends, and Other Biofuels (49 CFR 195)
  - “Rails-with-Trails: Lessons Learned”, prepared by U.S. Department of Transportation. (https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/RailsWithTrails.pdf)
  - Section 4(f) of the Department of Transportation Act (49 USC 303 or 23 USC 138; 23 CFR 77I.135; 23 CFR 771 and 774; FHWA Section 4(f) Policy Paper, March 2005)
- Zolan Prucz and Abbas Pourbohloul, “Bridge Configurations and Details that Improve Seismic Performance” (1999)

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Appendix B. Abbreviations and Acronyms

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A	ampere
A.T.	automatically tensioned
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ABS	automatic block signal
AC/ac	alternating current
ACHP	Advisory Council on Historic Preservation
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ADU	aspect display unit
AF	audio frequency
AFI	Air Filter Institute
AFO	audio frequency overlay
AGC	automatic-gain control
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AMCA	Air Moving Control Association, Inc
ANSI	American National Standards Institute
API	American Petroleum Institute
APTA	American Public Transit Association
APWA	American Public Works Association
AREMA	American Railway Engineering and Maintenance-of-Way Association
ARS	acceleration response spectra
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers
ASPRS	American Society of Photogrammetry and Remote Sensing
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials

ATCS	Advanced Train Control System
ATD	automatic train dispatching
ATP	automatic train protection
ATS	automatic train stop (sometimes automatic trip stop)
AVAS	Automatic Voice Announcement System
AWG	American Wire Gauge
AWS	American Welding Society
AWWA	American Water Works Association
BNSF	BNSF Railway Company
BOCA	Building Officials and Code Administrators
BPS	bits per second
BWA	balance weight anchor
C	Celsius
C&S	Communications and Signals
C.C.R.	California Code of Regulations
CA	California
CADD	Computer Aided Drafting and Design
Cal/OSHA	State of California Division of Occupational Safety and Health
Caltrans	California Department of Transportation
CBC	California Building Code
CC	center of curve
CCC	California Coastal Commission
CCD	charge-couple device
CCS	California Coordinate System
CCTV	closed circuit television
CDF	California Department of Forestry
CDFG	California Department of Fish and Game
CDRL	Contract Document Requirements List
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act

CFR	Code of Federal Regulations
CGS	California Geological Survey
CIDH	Cast-in-Drilled Hole
CIH	central instrument house
CIS	Customer Information System
CMF	Central Maintenance Facility
CORS	Continuously Operating Reference Stations
COTS	commercial off-the-shelf
CP	Control Point
CPM	Capital Program Management
CPTED	Crime Prevention through Environmental Design
CPUC	California Public Utilities Commission
CS	curve to spiral
CSB	client-server based
CSI	Construction Specifications Institute
CSM	Caltrans Surveys Manual
CSRS	California Spatial Reference System
CTC	centralized traffic control
CTS	Carrier Transmission System
CWH	contact wire height
CWR	continuous welded rail
CZMP	coastal zone management program
dB	decibels
dBA	decibel A-weighted sound level
DBE	Design Basis Earthquake
dc	direct current
DCM	Design Criteria Manual
DCRS	Data collection and Reporting system
DIDW	double inlet, double width
DOC	Dispatch and Operations Center

DoD	United States Department of Defense
DOT	Department of Transportation (U.S.)
DPG	Deck Plate Girder
DTM	digital terrain model
DVM	debit validator machine
E_a	actual (active) superelevation
EEPROM	Erasable electronically programmable read-only memory
EIA	Electronic Industries Association
EMF	Eastern Maintenance Facility
EMI	electromagnetic interference
EMP	emergency management panel
EPA	Environmental Protection Agency
EPROM	Electronically programmable read-only memory
ES	Engineering Standards (SCRRA standard drawings)
ESA	Endangered Species Act
E_t	total superelevation
E_u	unbalanced superelevation, or cant deficiency
F	Fahrenheit
F.T.	fixed termination
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FGCS	Federal Geodetic Control Subcommittee
FHWA	Federal Highway Administration
FMVSS	Federal Motor Vehicle Safety Standards
FONSI	Finding of No Significant Impact
FRA	Federal Railroad Administration
FRE	fiberglass-reinforced epoxy
FRP	fiberglass reinforced plastic
FS	Factor of Safety

ft	foot, feet
FTA	Federal Transit Administration
g	gram, or acceleration due to gravity
GCOR	General Code of Operating Rules
GDM	Graphic Design Management system
GEC	General Engineering Consultant
GO	General Order
GPS	global positioning system
GRS	Geodetic Reference System
HARN	High Accuracy Reference Network
HDM	Highway Design Manual (Caltrans)
HDPE	high-density polyethylene
HDS	Hydraulic Design Series
HEC	Hydraulic Engineering Circular
HEP	Head End Power
HEPA	high efficiency particulate air
HGCWS	Highway Grade Crossing Warning system
HID	high-intensity discharge (lighting)
HMA	hot-mix asphalt
HMAC	hot-mix asphalt concrete
HP	horsepower
HSR	High Speed Rail (California High Speed Rail Authority)
HST	High Speed Train (California High Speed Rail Authority)
HVAC	heating, ventilation, and cooling
HWTR MT	hardwood-treated main track
Hz	hertz; one hertz = one cycle per second
I/O	input/output
ICEA	Insulated Cable Engineers Association
ICS	Independently Controlled Switch
IEC	International Electrotechnical Commission

IEEE	Institute of Electrical and Electronics Engineers
IEOC	Inland Empire-Orange County
IES	Illuminating Engineering Society
IGLD	International Great Lakes Datum
IJ	insulated joint
in.	inch, inches
IP	Individual Permit
IPCEA	Insulated Power Cable Engineers Association
ISO	International Standards Organization
JPA	Joint Powers Authority
kg	kilogram
km	kilometer
kN	kilonewton
kV	kilovolt
kVA	kilovolt ampere
kW	kilowatt
L	liter
LACMTA	Los Angeles County Metropolitan Transportation Authority
LAHT	low-alloy high-tensile
LCD	liquid crystal display
LCP	local control panel or local coastal plan
LED	light-emitting diode
Leq	equivalent noise levels
LF	longitudinal force
LRFD	Load and Resistance Factor Design
LRT	Light Rail Transit
LRT	Light Rail Vehicle
L_s	length of spiral
LVC	length of vertical curve
m	meter

M	magnitude of earthquake
mA	milliampere
MAS	maximum authorized line speed
max.	maximum
MCE	Maximum Credible Earthquake
MED	maximum expected discharge
METRO	Los Angeles County Metropolitan Transportation Authority
MIL	Military Specification
min.	minimum
MIS	Management Information system
mm	millimeter
MOA	Memorandum of Agreement
MOC	Metrolink Operations Center
MOU	Memorandum of Understanding
MOE	maintenance of equipment
MOW	maintenance of way
MP	milepost
MPa	megapascal
MPA	midpoint anchor
mph	miles per hour
MSCP	Multiple Species Conservation Plan
MSE	Mechanically Stabilized Earth
MTBF	mean time between failures
MTTR	mean time to restore
MTTV	multi-trip ticket validator
MUTCD	Manual of Uniform Traffic Control Devices
MVA	megavolt ampere
NAD 83	North American Datum of 1983
NAPF	National Association of Pipe Fabricators
NAVD 88	North American Vertical Datum of 1988

NCCP	Natural Community Conservation Plan
NCTD	North County Transit District
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NGS	National Geodetic Survey
NGVD 29	National Geodetic Vertical Datum of 1929
NHL	National Historic Landmarks
NHPA	National Historic Preservation Act
NMAS	National Map Accuracy Standards
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NRPC	National Railroad Passenger Corporation (Amtrak)
NSRS	National Spatial Reference System
NWP	Nationwide Permit
o.c.	on center
OCC	Operations Control Center
OCS	overhead contact system or overhead catenary system
OCTA	Orange County Transportation Authority
OSHA	Occupational Safety and Health Administration
OTM	other track material
Pa	Pascal
PA	public address
PA/CMS	public address/changeable message sign
PBA	peak bedrock acceleration

PC	point of curvature
PCA	Portland Cement Association
PCB	printed circuit board
PCC	point of compound curvature
PCN	preconstruction notification
PF	power frequency
PGA	Peak Ground Acceleration
pH	the measure of acidity or alkalinity of a solution, measured on a scale from 0 to 14 with 0 = acid, 7 = neutral, and 14 = alkaline
PI	point of intersection
PIVC	point of intersection vertical curve
PLC	programmable logic controller
ppm	parts per million
PT	point of tangency
PTC	Positive Train Control
PTT	push-to-talk
PTZ	pan, tilt and zoom
PVC	polyvinyl chloride, or point of vertical curvature (trackwork)
PVT	point of vertical tangency
QA/QC	Quality Assurance/Quality Control
RBM	rail-bound manganese
RCES	Rail Crossings Engineering Section
RCTC	Riverside County Transportation Commission
RDBMS	relational database management system
RE	designation of AREMA standard rail end section
RF	radio frequency
RFI	radio frequency interference
RGP	Regional General Permit
RMS	root-mean-squared
RMSE	root mean square error

ROF	random oriented fiber
ROW	right-of-way
rpm	revolutions per minute
RTK	real-time kinematic
RTU	remote terminal unit
RWIC	Roadway Worker In Charge
RWP	Roadway Worker Protection
RWQCB	Regional Water Quality Control Board
RX	receive
SAE	Society of Automotive Engineers
SBCTA	San Bernardino County Transportation Authority
SC	spiral to curve
SBD	safe braking distance
SCADA	supervisory control and data acquisition
SCAG	Southern California Association of Governments
SCRRA	Southern California Regional Rail Authority
SDC	Seismic Design Criteria
SGSM	self-guarded solid manganese
SHPO	State Historic Preservation Office
SIC	structure importance classification
SIP	State Implementation Plan
SISW	single inlet, single width
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
SMYS	specific minimum yield stress
SONET	Synchronous Optical Network
SOPs	Standard Operating Procedures
SPI	spiral point of intersection
sq. mi.	square mile
SSFC	self-service fare collection
SSPC	Steel Structures Painting Council

SSWP	Site Specific Work Plan
ST	spiral to tangent
STB	Surface Transportation Board
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
T/R	top of rail
TCE	temporary construction easements
TCIP	Transit Communications Interface Protocols
TIA	Telecommunications Industry Association
TIM	ticket-issuing machines
TIN	triangulated irregular network
TPG	Through-Plate Girder
TPOB	Tons per Operative Brake
TS	tangent to spiral
TSSS	Total Station Survey System
TTW	Train To Wayside
TVD	ticket vending device
TWC	Train to Wayside Communication, also Track Warrant Control
TX	transmit
UBC	Uniform Building Code
UBE	Upper Bound Earthquake
UL	Underwriters' Laboratories, Inc.
UMTA	Urban Mass Transportation Administration (now known as Federal Transit Administration (FTA)
UPRR	Union Pacific Railroad
UPS	uninterruptible power supply
USACE	United States Army Corps of Engineers
USC	United States Code
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency

USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
V	velocity or vertical or Volt
VCS	Voice Communication system
VCTC	Ventura County Transportation Commission
VdB	vibration decibel
Vdc	volts direct current
VEI	vending equipment interface
VMS	Variable Message Sign
W	watt
w.g.	water gauge
WATCH	Work Area Traffic Control Handbook
WGS	World Geodetic System
WQCB	Water Quality Control Board
WSM	Wing Rail Spring Manganese or Welded Spring Manganese

Appendix C. Figures

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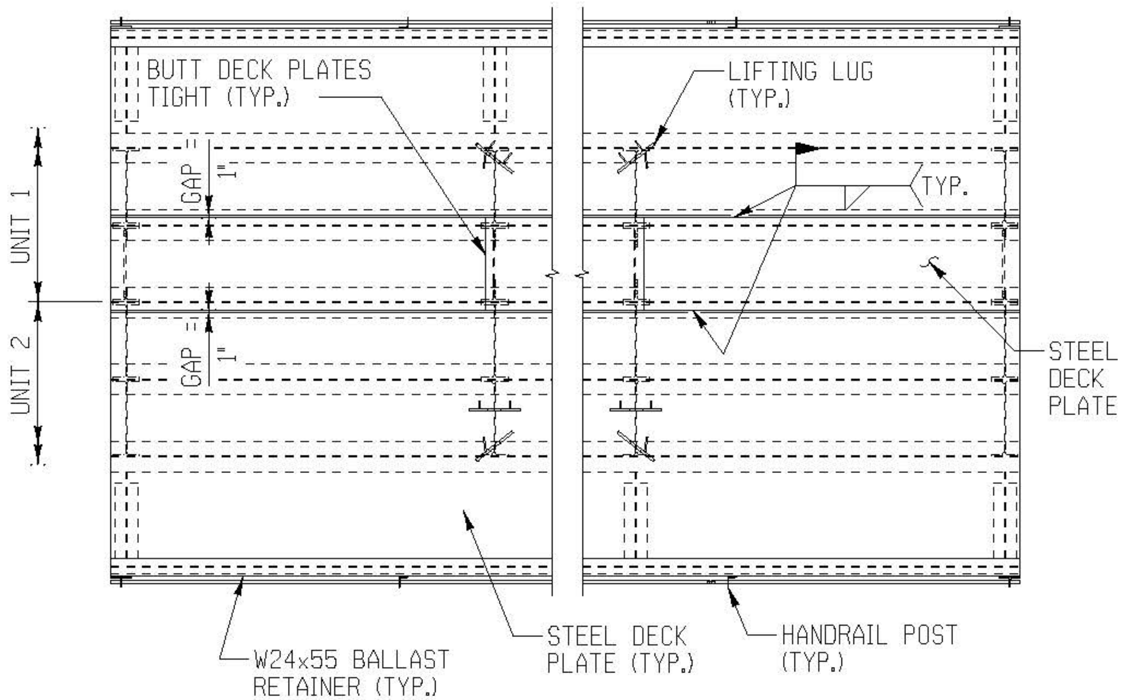
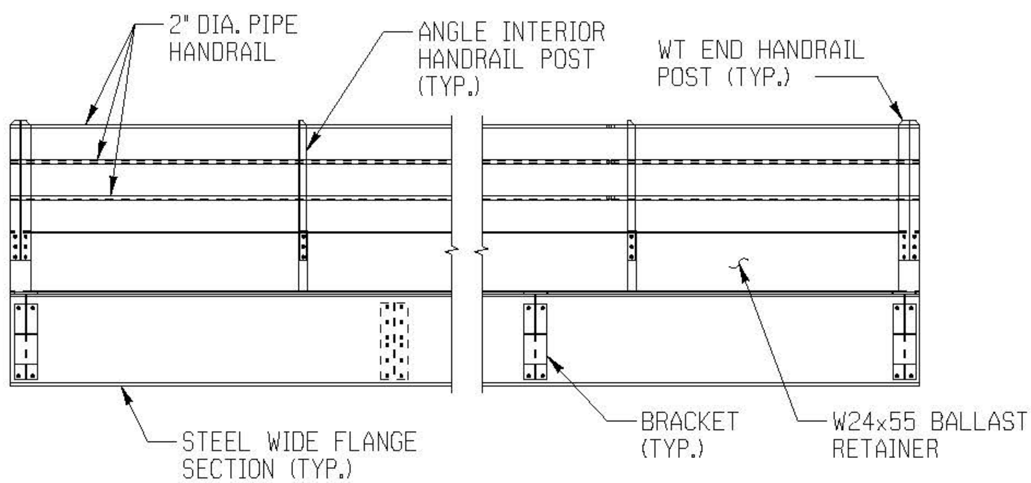
APPENDIX C-1
TYPICAL STEEL BEAM SPAN DETAILS

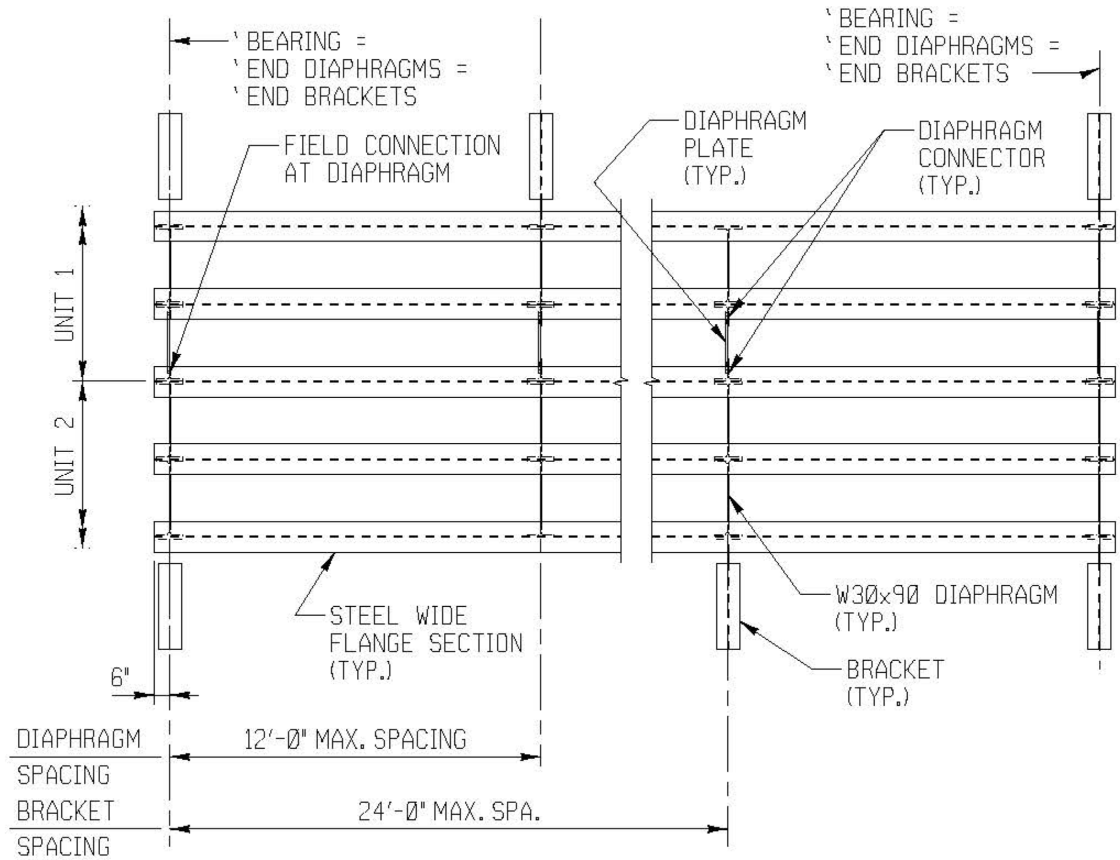


PLAN



ELEVATION

METROLINK	SCALE: NONE
	PLAN NO.
DRAWING TITLE: STEEL BEAM SPAN	SHEET NO. 1 OF 7



METROLINK	SCALE: NONE
	PLAN NO.
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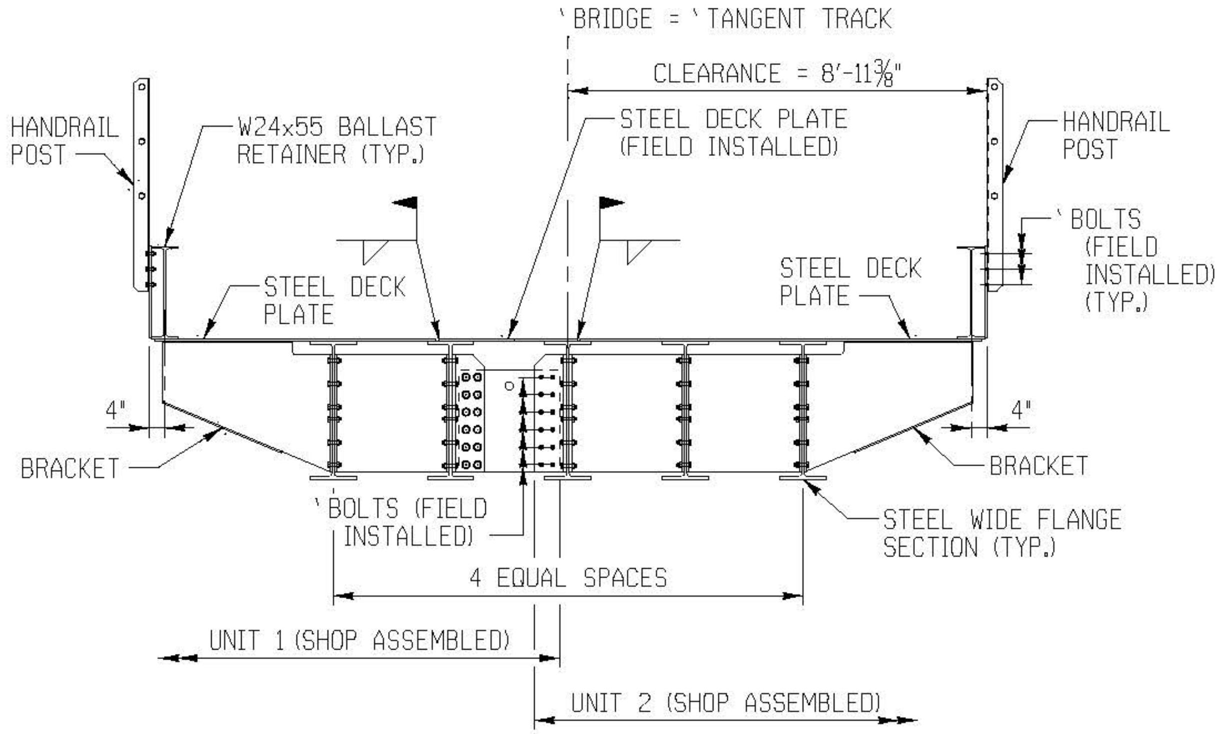

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	PLAN NO.
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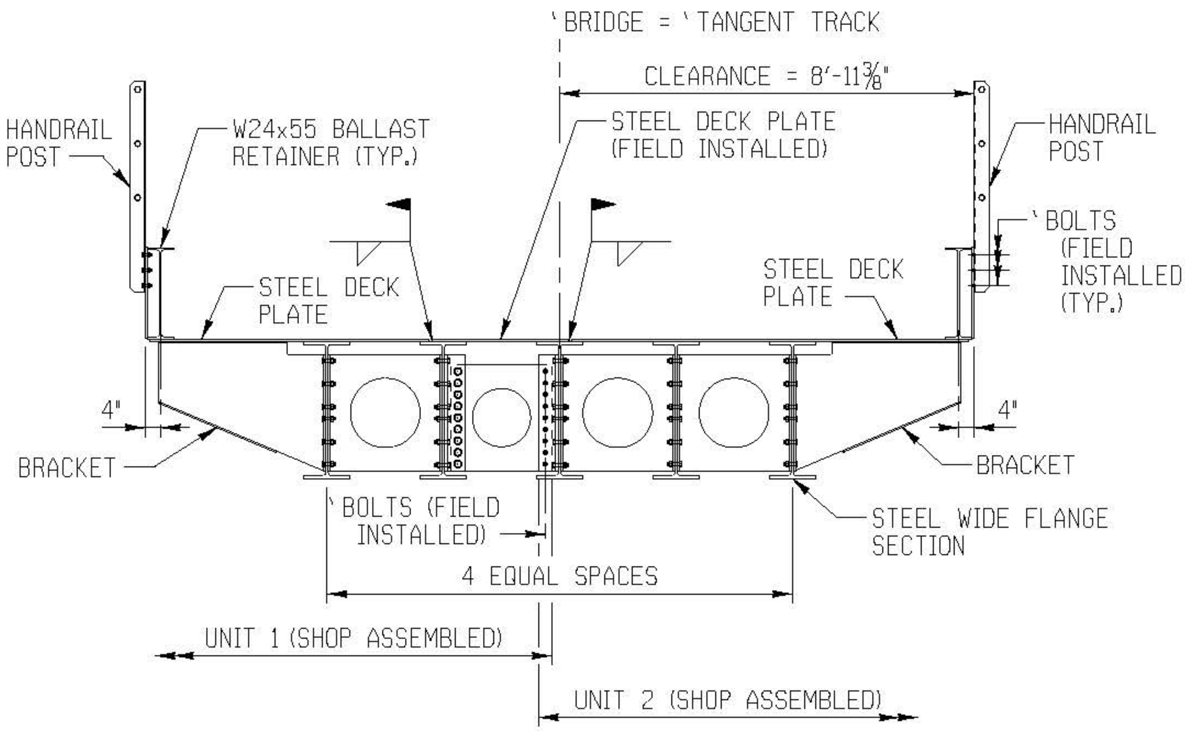
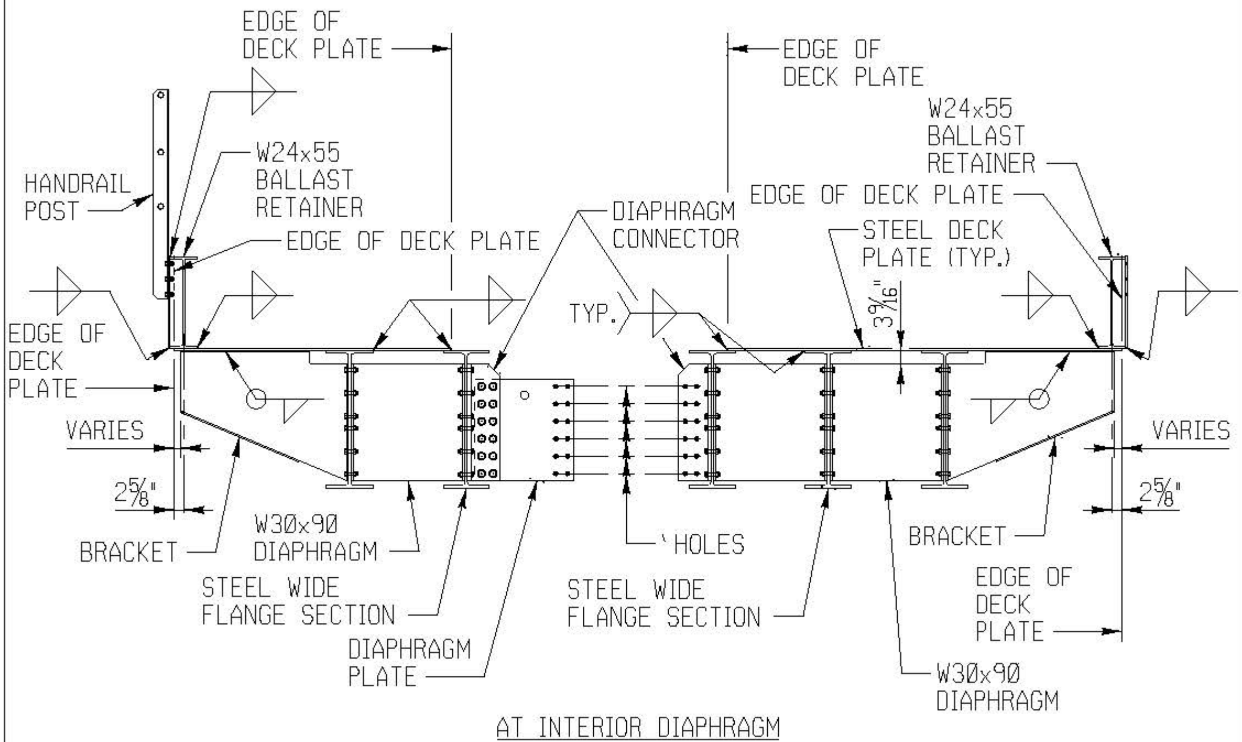
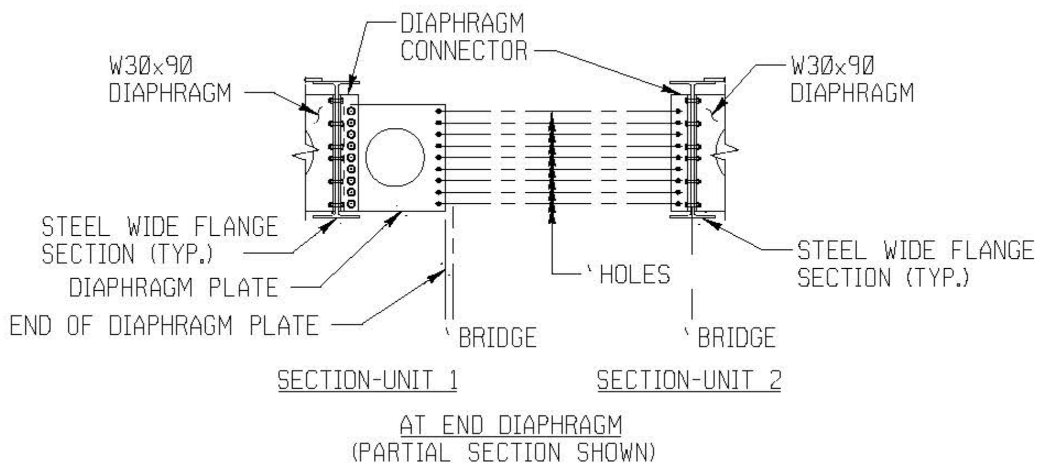
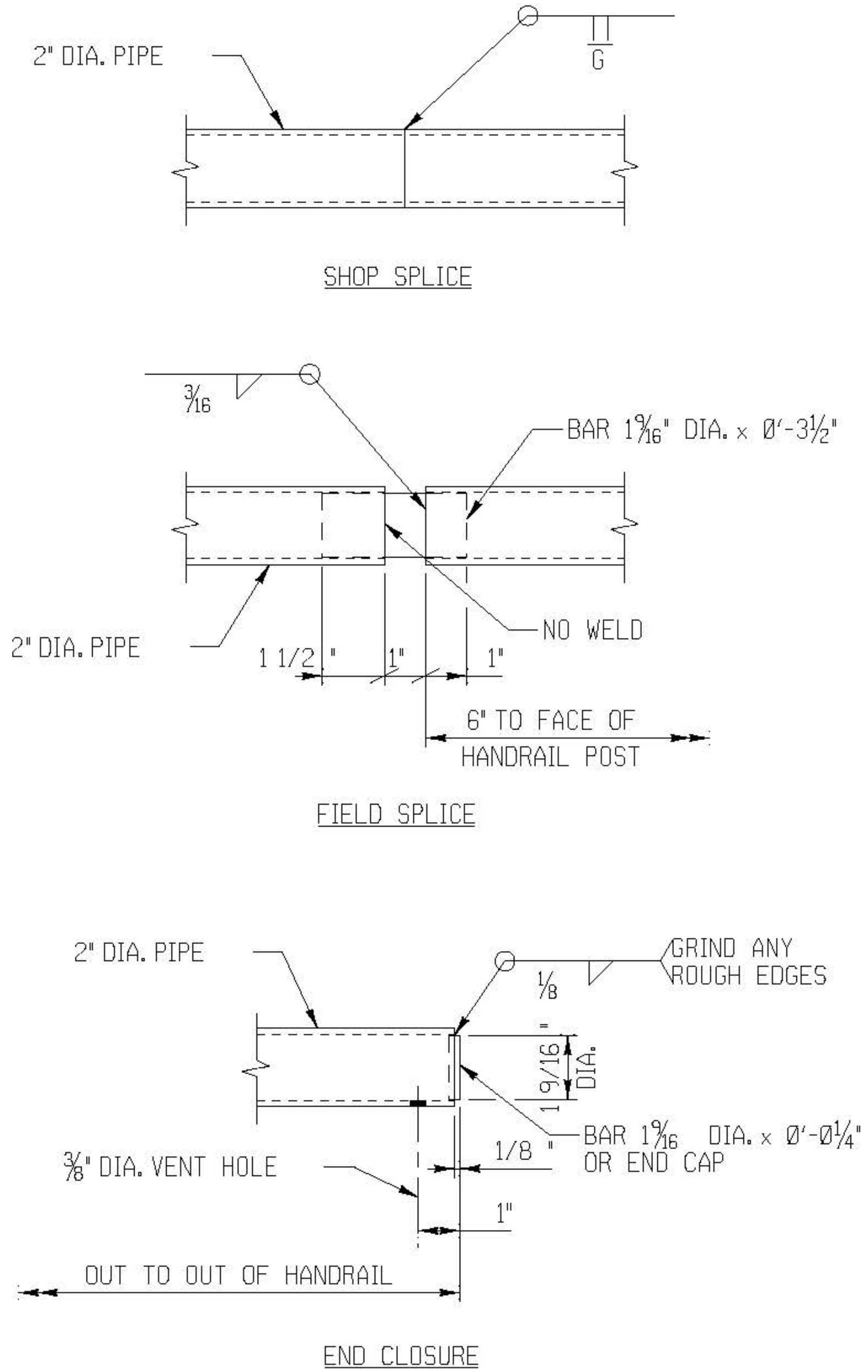


METROLINK	SCALE: NONE
	PLAN NO.
DRAWING TITLE: STEEL BEAM SPAN	SHEET NO. 4 OF 7



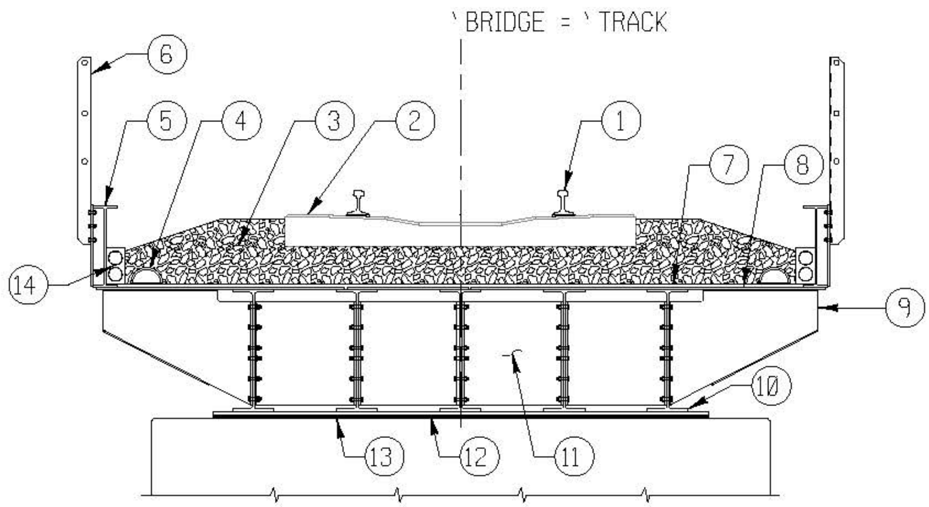


METROLINK	SCALE: NONE
	PLAN NO.
DRAWING TITLE: STEEL BEAM SPAN	SHEET NO. 5 OF 7



METROLINK

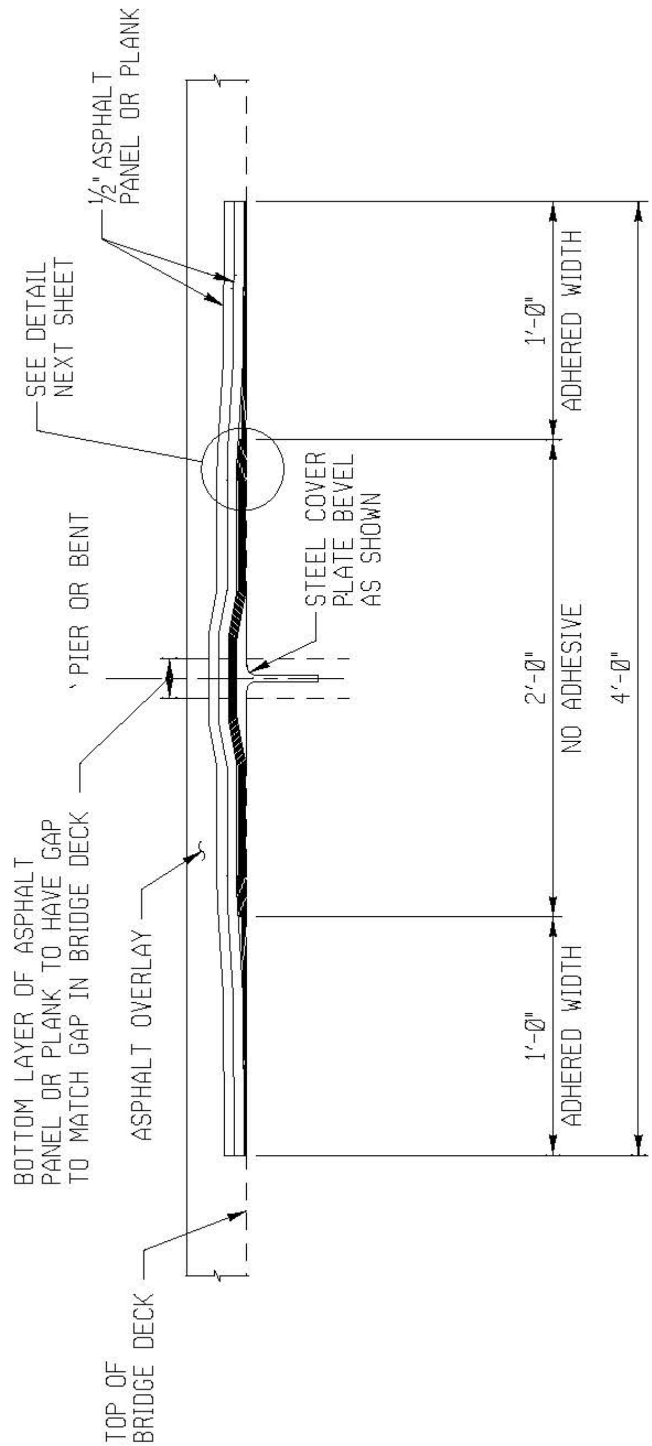
	SCALE: NONE
	PLAN NO.
DRAWING TITLE: STEEL BEAM SPAN	SHEET NO. 6 OF 7



(1) RAIL	(8) STEEL PLATE DECK
(2) CONCRETE TIE w/BOTTOM NEOPRENE PAD	(9) BRACKET
(3) BALLAST	(10) STEEL BEAM
(4) DRAIN	(11) DIAPHRAGM
(5) BALLAST RETAINER	(12) SOLE PLATE
(6) HANDRAIL	(13) BEARING PAD
(7) WATERPROOFING	(14) 2-4" I.D. GALVANIZED METAL CONDUIT EACH SIDE OF BRIDGE STRUCTURE

METROLINK	SCALE: NONE PLAN NO.
DRAWING TITLE: STEEL BEAM SPAN	SHEET NO. 7 OF 7

APPENDIX C-2
WATERPROOFING AT BRIDGE DECK JOINTS



METROLINK

SCALE: NONE

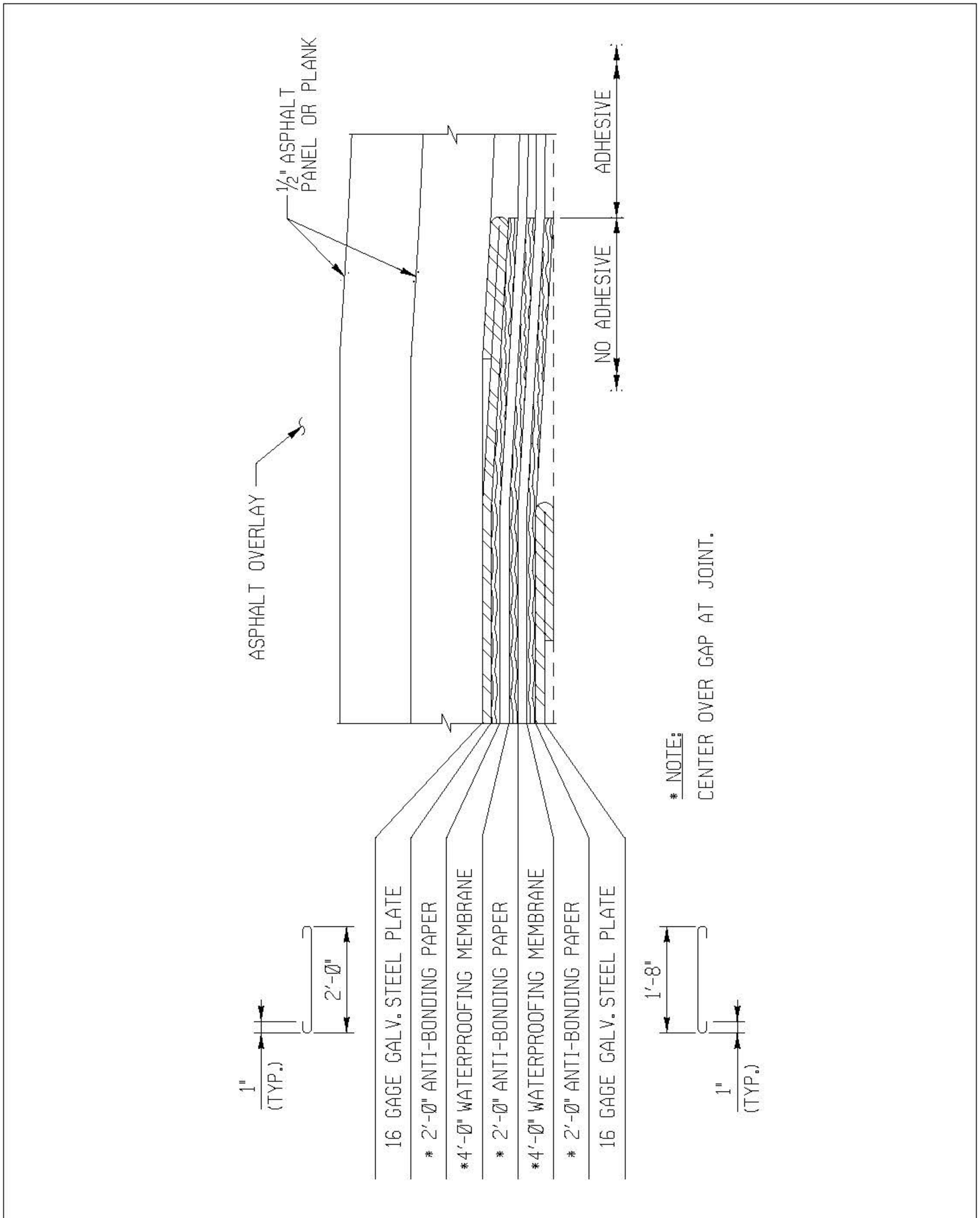
PLAN NO.

DRAWING TITLE:

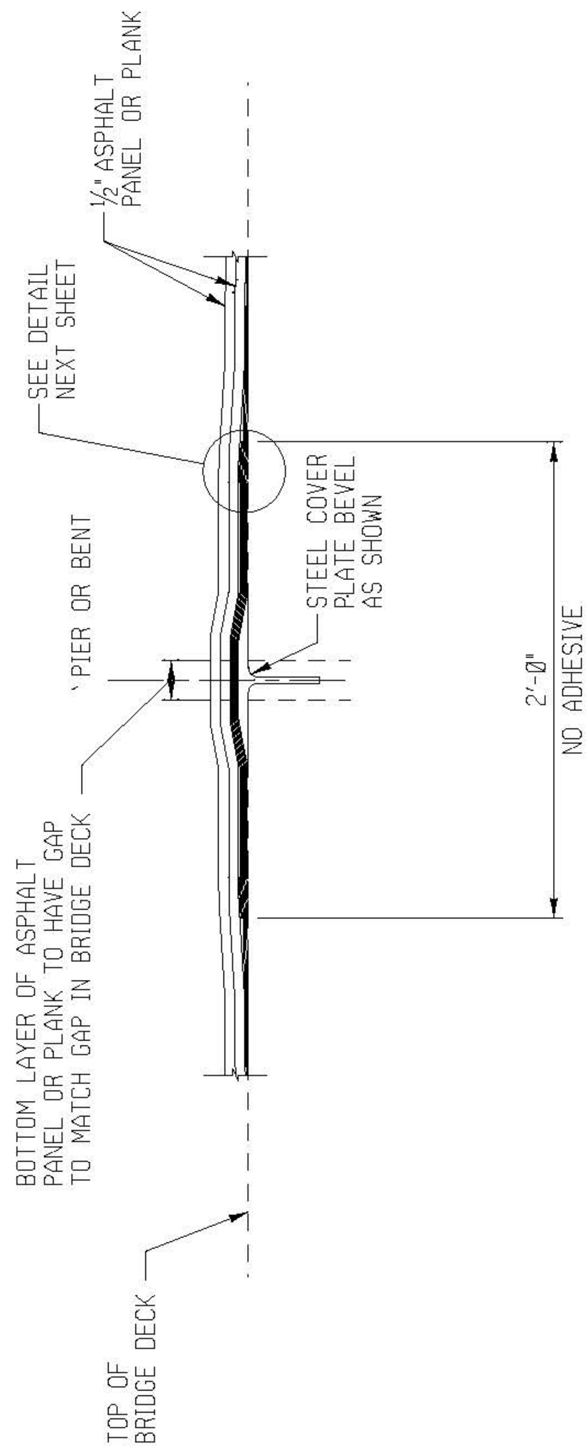
BRIDGE DECK JOINT DETAILS ON CONCRETE DECKS

SHEET NO.

1 OF 4



METROLINK	SCALE: NONE
	PLAN NO.
DRAWING TITLE: BRIDGE DECK JOINT DETAILS ON CONCRETE DECKS	SHEET NO. 2 OF 4



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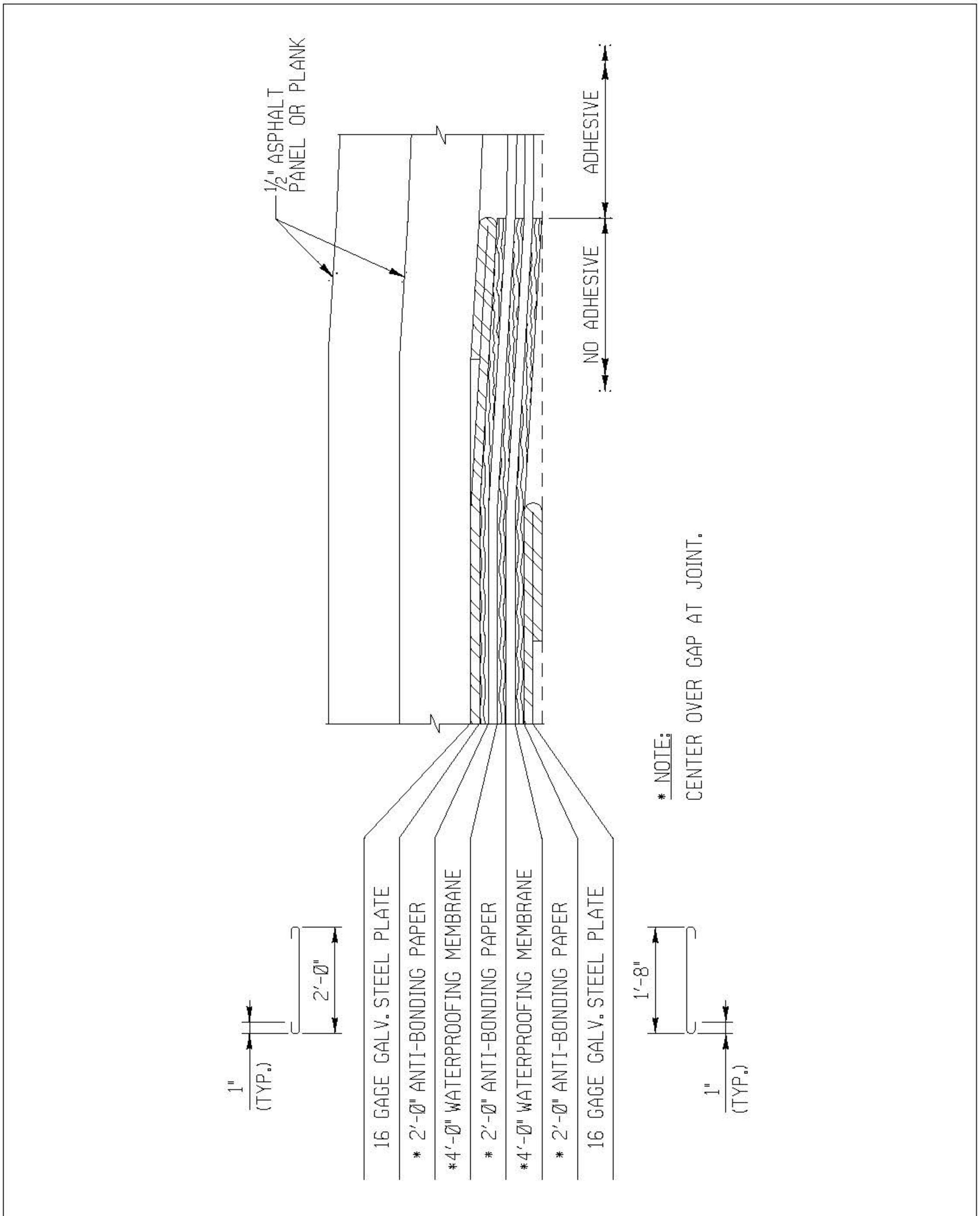
PLAN NO.

DRAWING TITLE:

BRIDGE DECK JOINT DETAILS ON CONCRETE DECKS

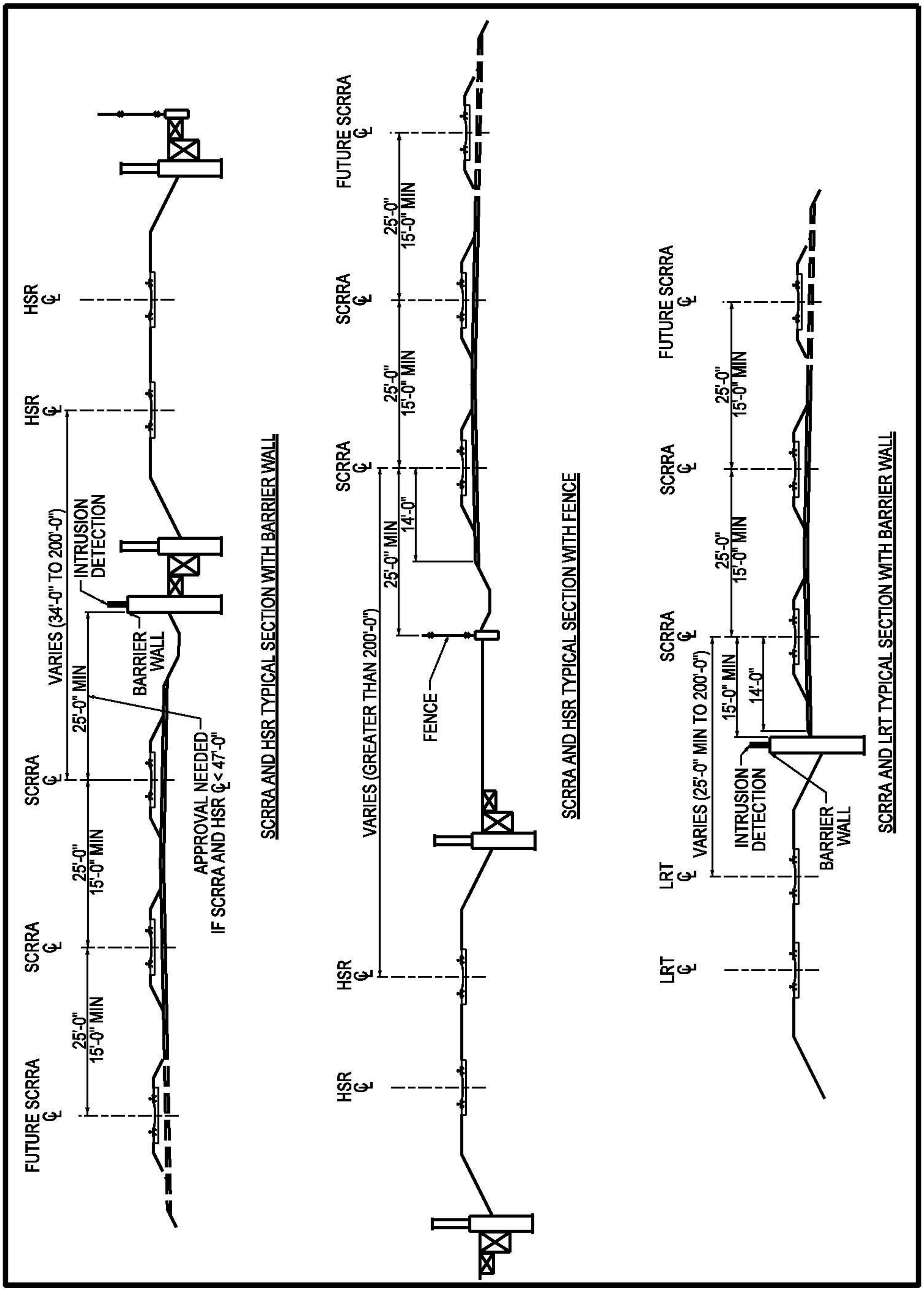
SHEET NO. 3 OF 4

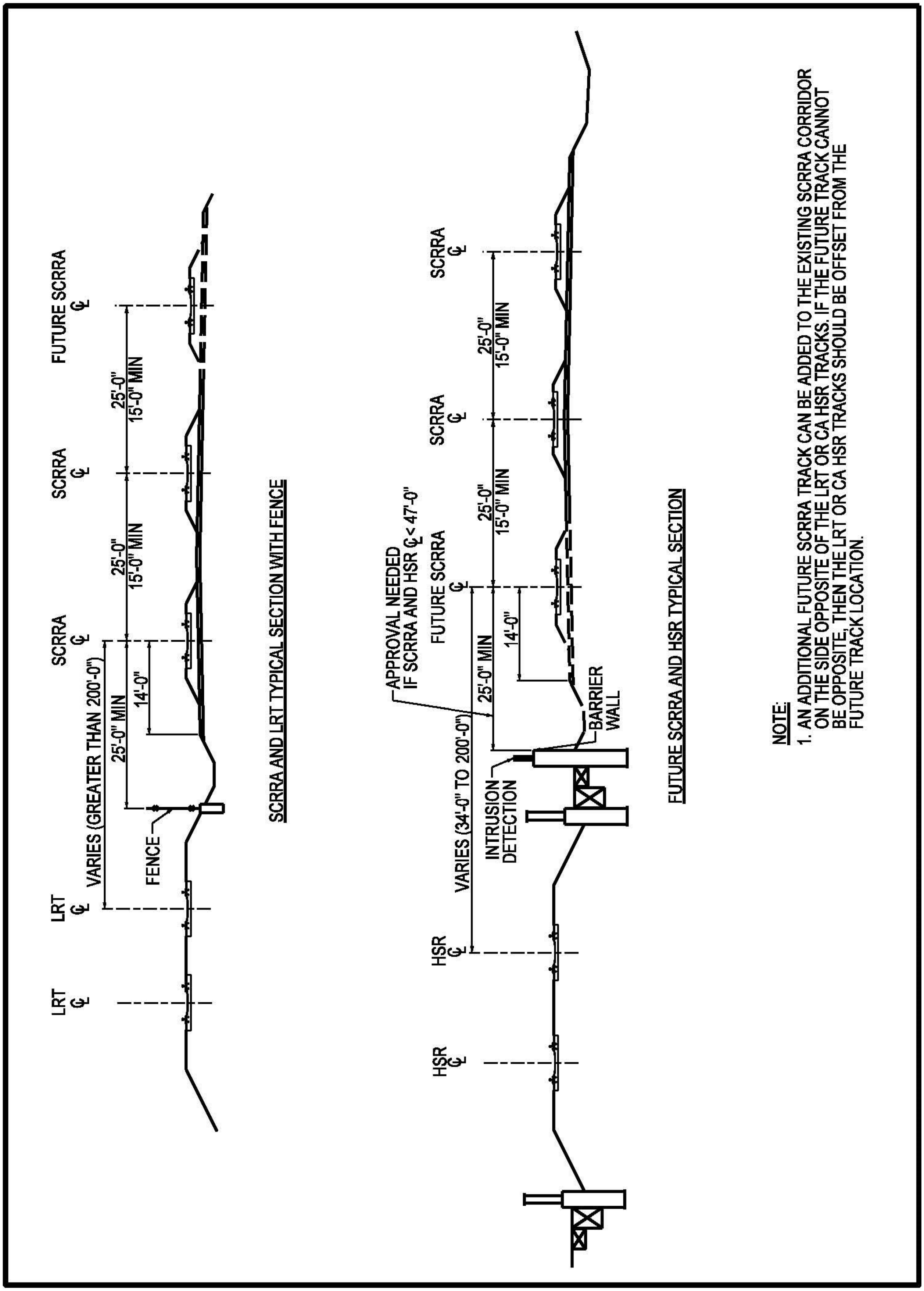


METROLINK

	SCALE: NONE
	PLAN NO.
DRAWING TITLE: BRIDGE DECK JOINT DETAILS ON CONCRETE DECKS	SHEET NO. 4 OF 4

APPENDIX C-3
SCRRA SHARED USE TYPICAL SECTIONS

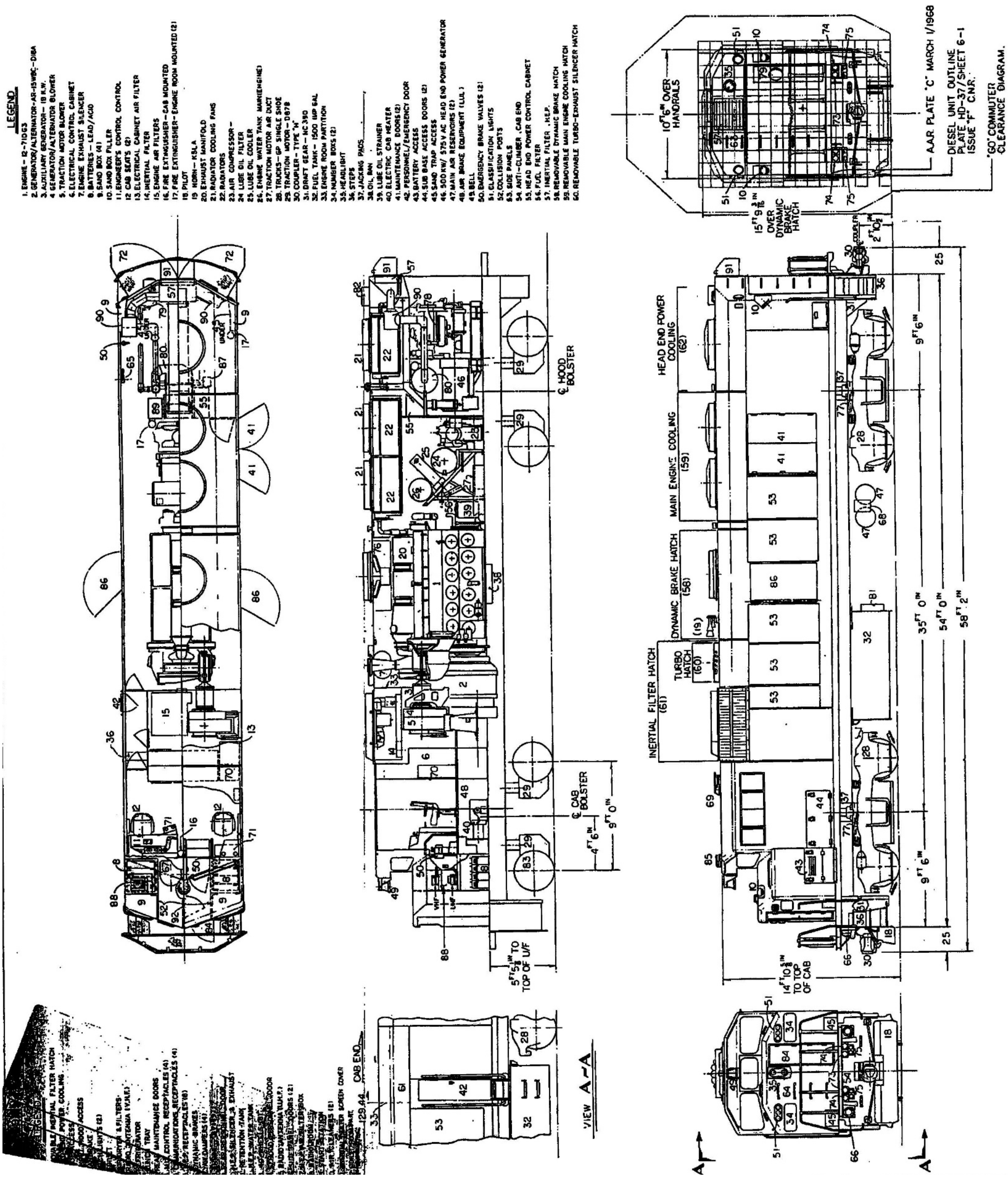

FUTURE SCRRA ℄
SCRRA ℄
SCRRA ℄
HSR ℄
HSR ℄
25'-0"
15'-0" MIN
25'-0" MIN
VARIES (34'-0" TO 200'-0")
INTRUSION DETECTION
BARRIER WALL
APPROVAL NEEDED IF SCRRA AND HSR ℄ < 47'-0"
SCRRA AND HSR TYPICAL SECTION WITH BARRIER WALL
HSR ℄
FUTURE SCRRA ℄
VARIES (GREATER THAN 200'-0")
25'-0" MIN
14'-0"
FENCE
SCRRA AND HSR TYPICAL SECTION WITH FENCE
LRT ℄
FUTURE SCRRA ℄
VARIES (25'-0" MIN TO 200'-0")
15'-0" MIN
SCRRA AND LRT TYPICAL SECTION WITH BARRIER WALL

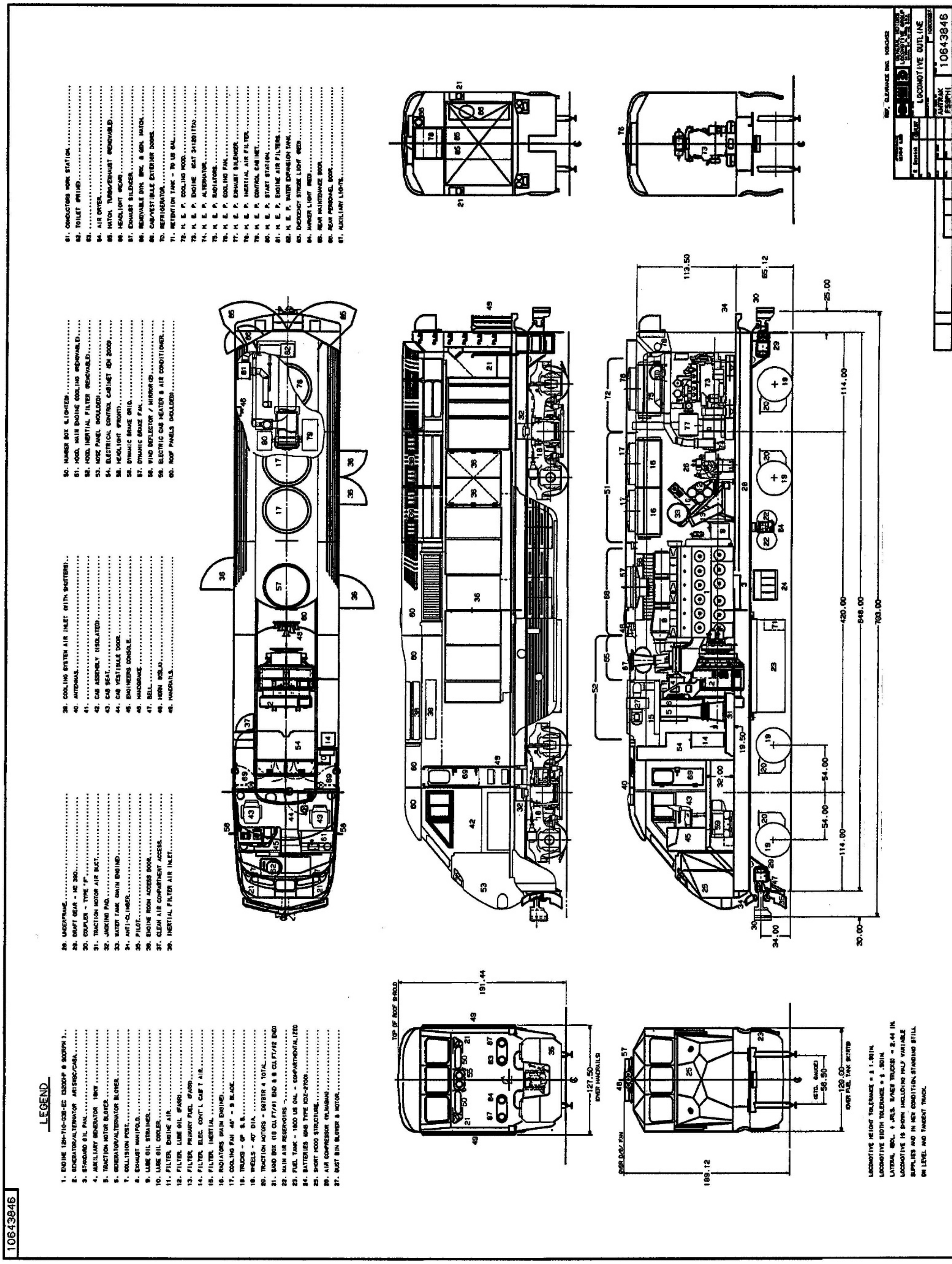

LRT ℄
LRT ℄
SCRRA ℄
SCRRA ℄
FUTURE SCRRA ℄
VARIES (GREATER THAN 200'-0")
FENCE
25'-0" MIN
14'-0"
25'-0"
15'-0" MIN
25'-0"
15'-0" MIN
SCRRA AND LRT TYPICAL SECTION WITH FENCE
HSR ℄
HSR ℄
FUTURE SCRRA ℄
SCRRA ℄
SCRRA ℄
VARIES (34'-0" TO 200'-0")
INTRUSION DETECTION
APPROVAL NEEDED IF SCRRA AND HSR ℄ < 47'-0"
25'-0" MIN
14'-0"
BARRIER WALL
25'-0"
15'-0" MIN
25'-0"
15'-0" MIN
FUTURE SCRRA AND HSR TYPICAL SECTION
NOTE:
1. AN ADDITIONAL FUTURE SCRRA TRACK CAN BE ADDED TO THE EXISTING SCRRA CORRIDOR ON THE SIDE OPPOSITE OF THE LRT OR CA HSR TRACKS. IF THE FUTURE TRACK CANNOT BE OPPOSITE, THEN THE LRT OR CA HSR TRACKS SHOULD BE OFFSET FROM THE FUTURE TRACK LOCATION.

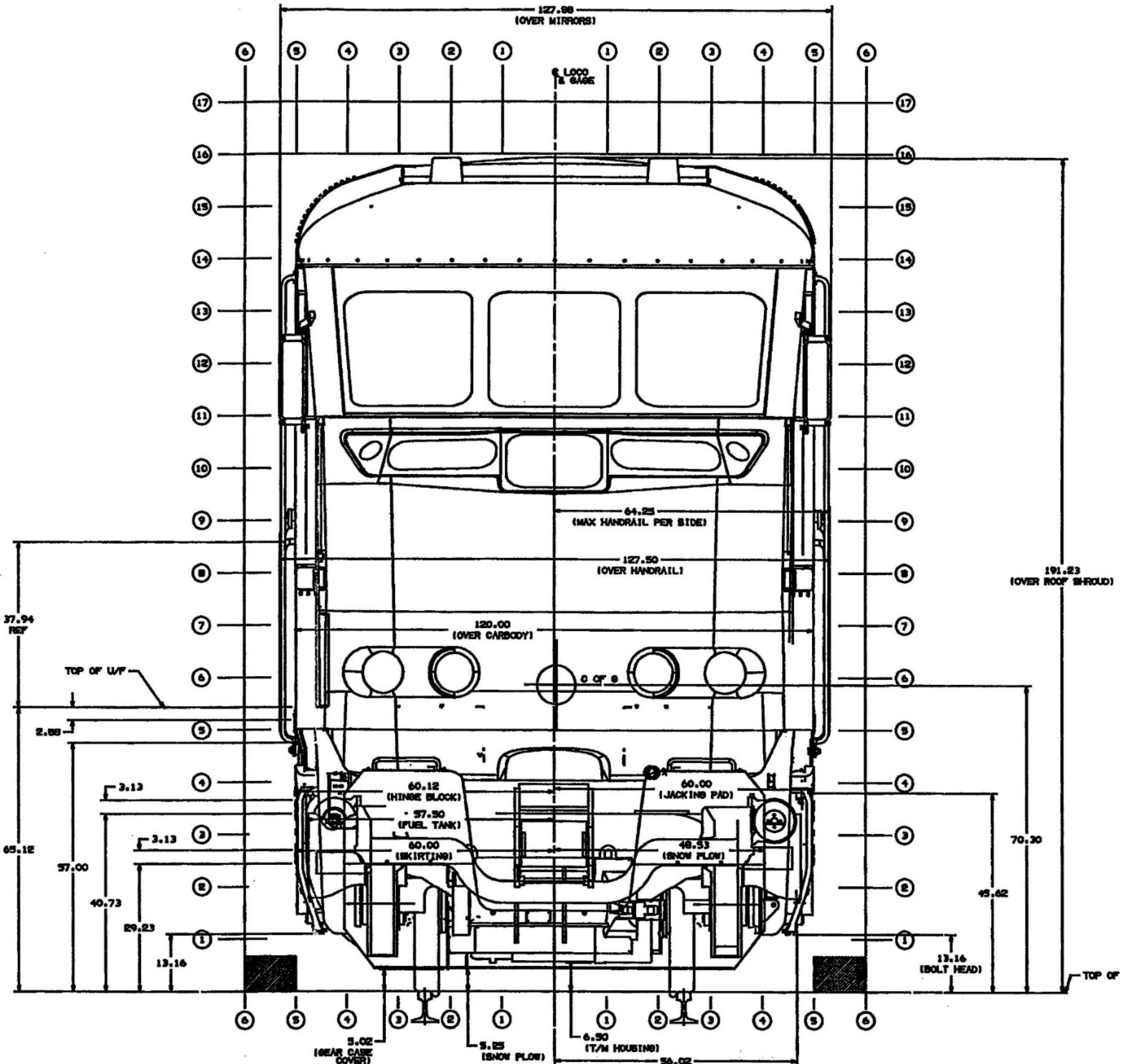
APPENDIX C-4
MANUFACTURER'S DRAWINGS OF LOCOMOTIVES AND CARS

The following manufacturer's drawings are included in this appendix:

- Model F59PH
- Model F59PHI
- Model MP36PH-3C
- Bombardier Cars
- Rotem Cars
- F-125 – Tier 4


LEGEND
1. ENGINE - 12-710G3
2. GENERATOR/ALTERNATOR-AR-15WBC-D18A
3. AUXILIARY GENERATOR - 18 K.W.
4. GENERATOR/ALTERNATOR BLOWER
5. TRACTION MOTOR BLOWER
6. ELECTRICAL CONTROL CABINET
7. ENGINE EXHAUST SILENCER
8. BATTERIES - LEAD/ACID
9. SAND BOX (4)
10. SAND BOX FILLER
11. ENGINEER'S CONTROL CONTROL
12. CAB SEATS (2)
13. ELECTRICAL CABINET AIR FILTER
14. INERTIAL FILTER
15. ENGINE AIR FILTERS
16. FIRE EXTINGUISHER - CAB MOUNTED
17. FIRE EXTINGUISHER - ENGINE ROOM MOUNTED (2)
18. PILOT
19. HORN - K5LA
20. EXHAUST MANIFOLD
21. RADIATOR COOLING FANS
22. RADIATORS
23. AIR COMPRESSOR
24. LUBE OIL FILTER
25. LUBE OIL COOLER
26. ENGINE WATER TANK
27. TRACTION MOTOR AIR DUCT
28. TRUCKS - GP SINGLE SHOE
29. TRACTION MOTOR - D87B
30. COUPLER - TYPE "H"
31. DRAFT GEAR - MC 390
32. FUEL TANK - 1500 IMP GAL
33. ENGINE ROOM PARTITION
34. NUMBER BOXS (2)
35. HEADLIGHT
36. STEPS
37. JACKING PADS
38. OIL PAN
39. LUBE OIL STRAINER
40. ELECTRIC CAB HEATER
41. MAINTENANCE DOORS (2)
42. PERSONNEL/EMERGENCY DOOR
43. BATTERY ACCESS
44. SUB BASE ACCESS DOORS (2)
45. SAND TRAP ACCESS
46. 500 KW/ 575 V AC HEAD END POWER GENERATOR
47. MAIN AIR RESERVOIRS (2)
48. AIR BRAKE EQUIPMENT (LUL)
49. BELL
50. EMERGENCY BRAKE VALVES (2)
51. CLASSIFICATION LIGHTS
52. COLLISION POSTS
53. SIDE PANELS
54. ANTI-CLIMBER, CAB END
55. HEAD END POWER CONTROL CABINET
56. FUEL FILTER
57. INERTIAL FILTER, H.E.P.
58. REMOVABLE DYNAMIC BRAKE HATCH
59. REMOVABLE MAIN ENGINE COOLING HATCH
60. REMOVABLE TURBO-EXHAUST SILENCER HATCH
HEAD END POWER COOLING (62)
MAIN ENGINE COOLING (59)
DYNAMIC BRAKE HATCH (58)
TURBO HATCH (60)
INERTIAL FILTER HATCH (61)
10FT 6IN OVER HANDRAILS
15FT 9 3/16 IN OVER DYNAMIC BRAKE HATCH
14FT 10 5/8 IN TO TOP OF CAB
5FT 5 1/8 IN TO TOP OF U/F
℄ HOOD BOLSTER
℄ CAB BOLSTER
9FT 6IN
35FT 0IN
54FT 0IN
58FT 2IN
A.A.R. PLATE "C" MARCH 1/1968
DIESEL UNIT OUTLINE PLATE HD-37/SHEET 6-1 ISSUE "F" C.N.R.
"60" COMMUTER CLEARANCE DIAGRAM.
CAB END
VIEW A–A

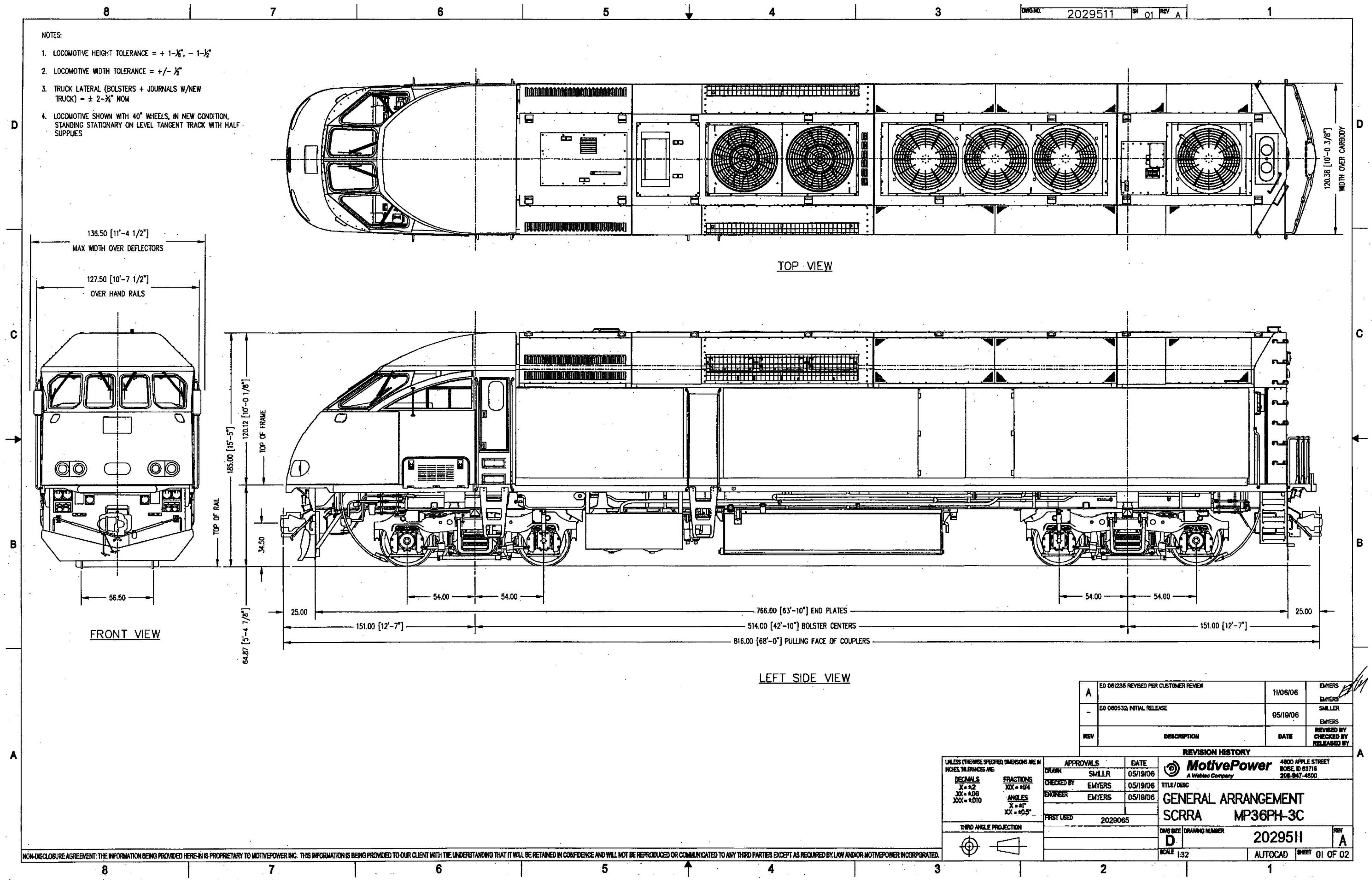

LEGEND
LOCOMOTIVE OUTLINE
10643846

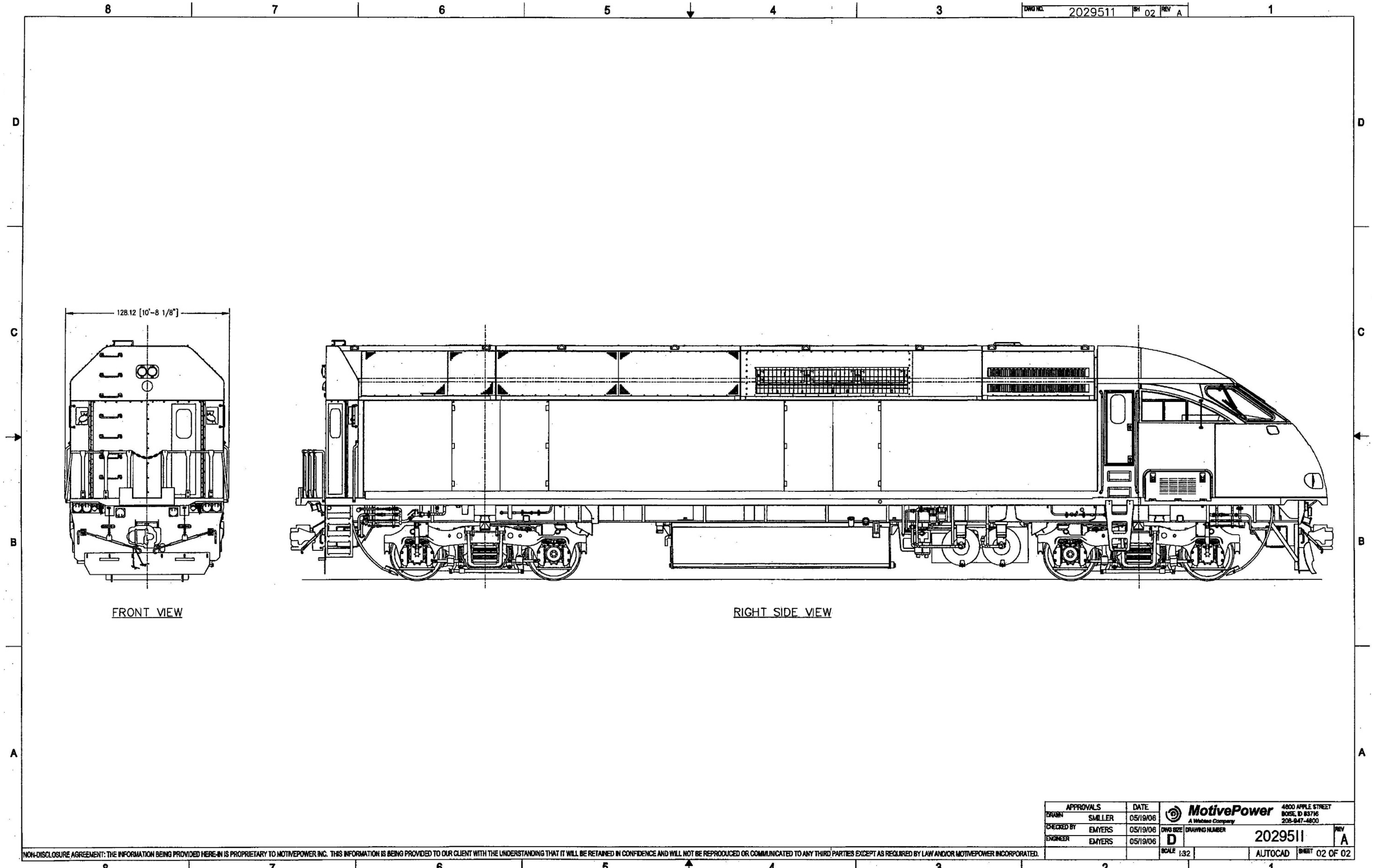


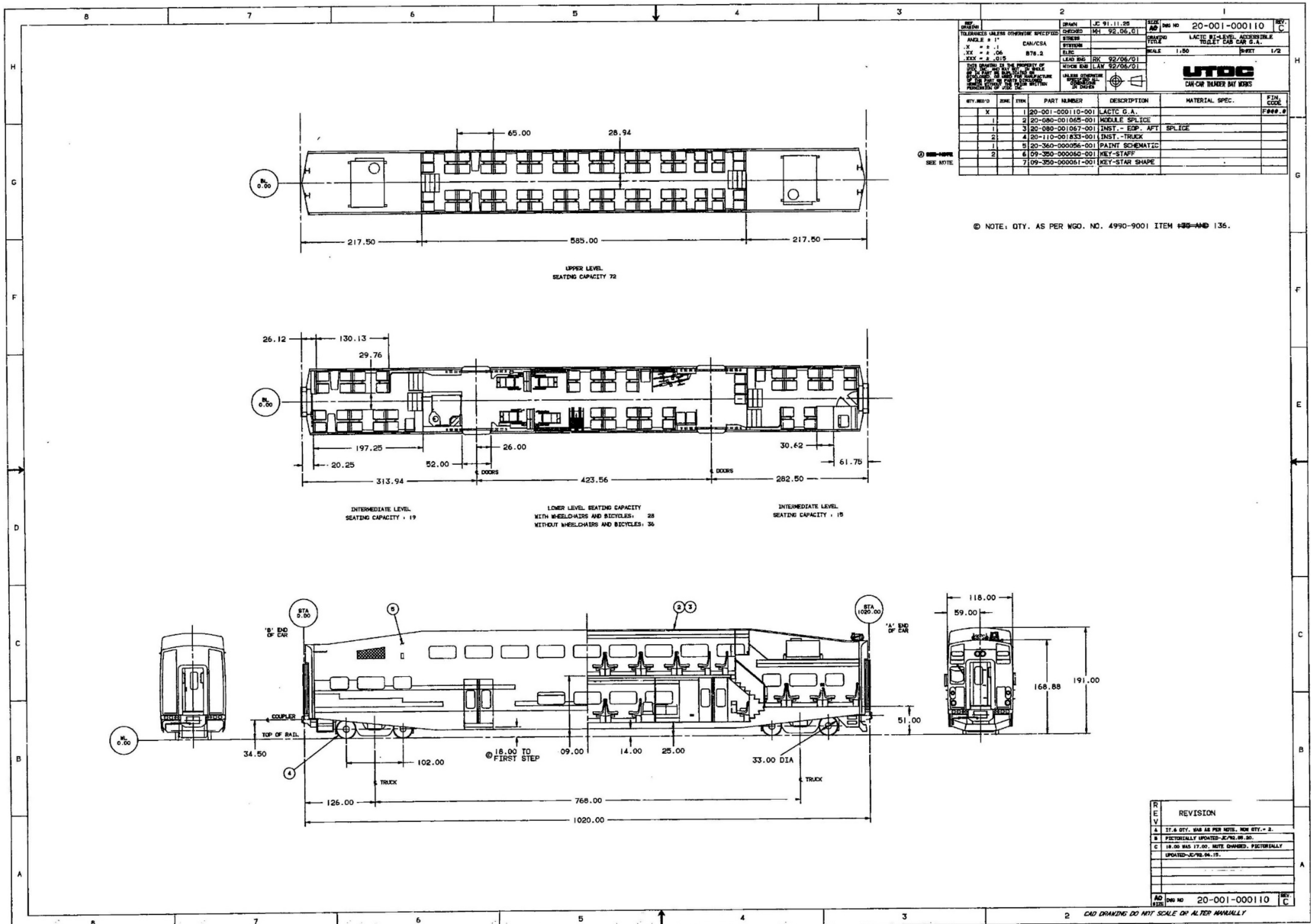
STATIC DIAGRAM

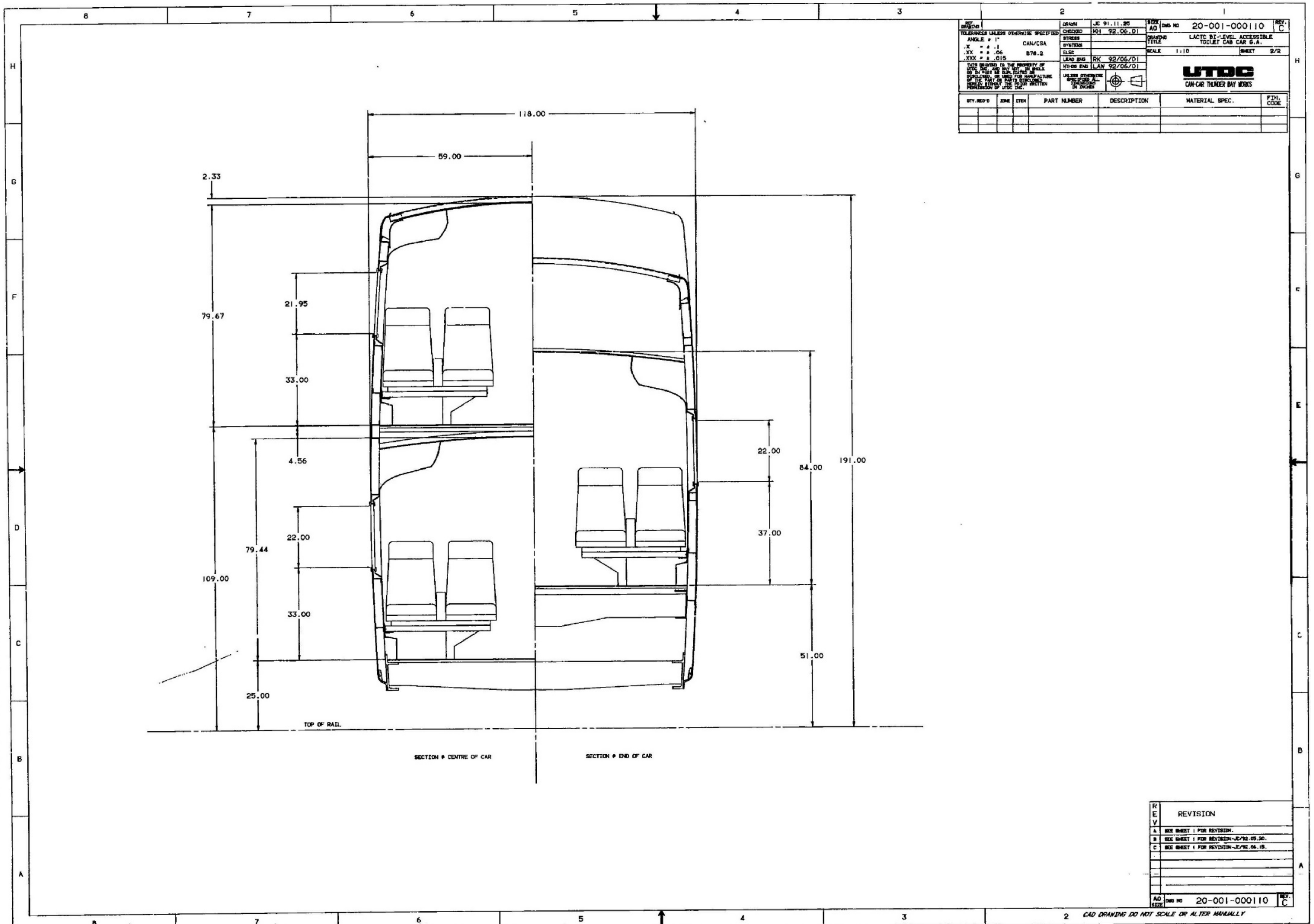
NOTES:
LOCOMOTIVE HEIGHT TOL. = ±1.50 IN.
LOCOMOTIVE WIDTH TOL. = ±0.5) IN.
LATERAL (BOL. + JNLS. WITH NEW TRUCKS) = ±2.44 IN.
LOCO IS SHOWN INCLUDING HALF VARIABLE SUPPLIES IN NEW CONDITION AND STANDING STILL ON TANGENT AND LEVEL TRACK.
VERTICAL DIMENSIONS WILL BE 1.50 IN. LESS WITH FULL WHEEL WEAR.

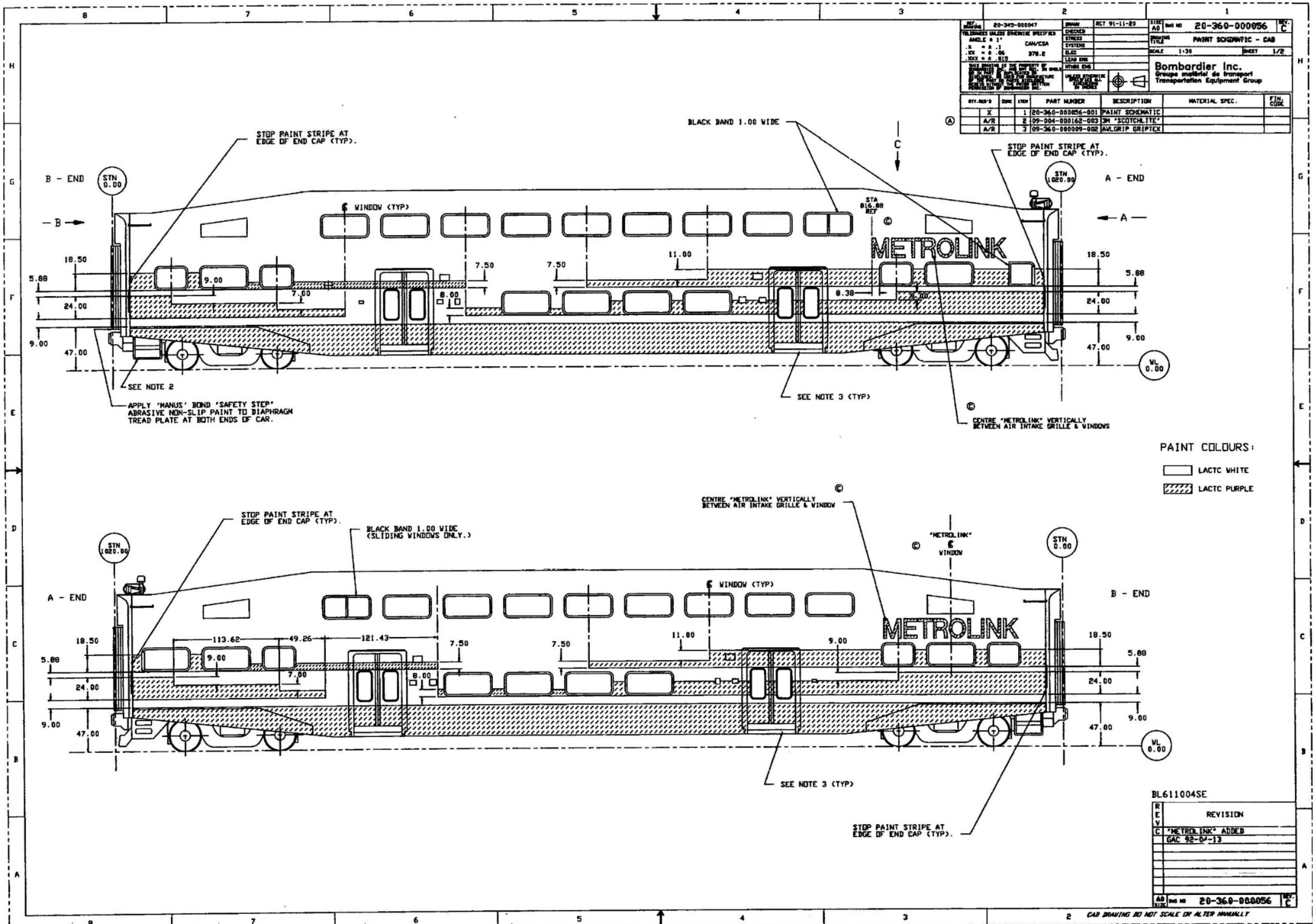
VERTICAL DIMENSIONS CAN VARY ±0.25 IN. DUE TO VARIABLE SUPPLIES.
VERTICAL DIMENSIONS WILL BE 3.50 IN. LESS WITH FULLY COMPRESSED PRIMARY SPRINGS (JOURNAL) AND WITH THE SECONDARY SPRINGS (ELLIPTICAL) TO THEIR STOPS.
LOCOMOTIVE ROOF SHROUD TO MATCH PROFILE AND FLUTING DIMENSIONS OF CALTRANS CALIFORNIA BI-LEVEL RAIL CAR.

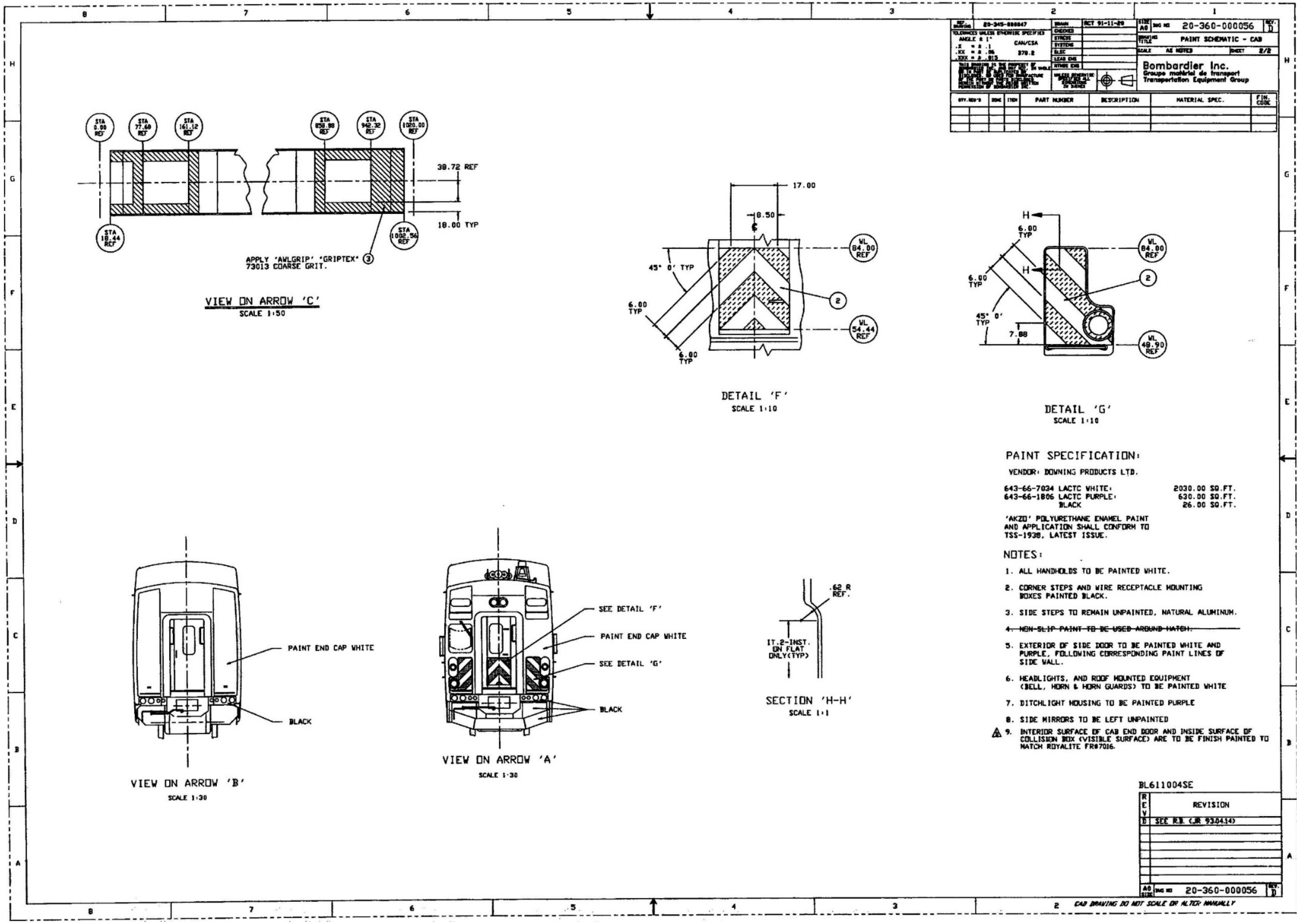

DWG NO. 2029511 SH 01 REV A
NOTES:
1. LOCOMOTIVE HEIGHT TOLERANCE = + 1-⅛", - 1-½"
2. LOCOMOTIVE WIDTH TOLERANCE = +/- ½"
3. TRUCK LATERAL (BOLSTERS + JOURNALS W/NEW TRUCK) = ± 2-¾" NOM
4. LOCOMOTIVE SHOWN WITH 40" WHEELS, IN NEW CONDITION, STANDING STATIONARY ON LEVEL TANGENT TRACK WITH HALF SUPPLIES
120.38 [10'-0 3/8"] WIDTH OVER CARBODY
TOP VIEW
136.50 [11'-4 1/2"] MAX WIDTH OVER DEFLECTORS
127.50 [10'-7 1/2"] OVER HAND RAILS
56.50
FRONT VIEW
185.00 [15'-5"]
120.12 [10'-0 1/8"]
TOP OF FRAME
TOP OF RAIL
34.50
64.87 [5'-4 7/8"]
54.00
54.00
54.00
54.00
25.00
766.00 [63'-10"] END PLATES
25.00
151.00 [12'-7"]
514.00 [42'-10"] BOLSTER CENTERS
151.00 [12'-7"]
816.00 [68'-0"] PULLING FACE OF COUPLERS
LEFT SIDE VIEW
A E0 061235 REVISED PER CUSTOMER REVIEW 11/06/06 EMYERS EMYERS
- E0 060532: INITIAL RELEASE 05/19/06 SMILLER EMYERS
REV DESCRIPTION DATE REVISED BY CHECKED BY RELEASED BY
REVISION HISTORY
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES, TOLERANCES ARE:
DECIMALS X = ±.2 XX = ±.06 XXX = ±.010
FRACTIONS XX = ±1/4
ANGLES X = ±1° XX = ±0.5°
THIRD ANGLE PROJECTION
APPROVALS DATE
DRAWN SMILLR 05/19/06
CHECKED BY EMYERS 05/19/06
ENGINEER EMYERS 05/19/06
FIRST USED 2029065
MotivePower A Wabtec Company
4600 APPLE STREET BOISE, ID 83716 208-947-4600
TITLE / DESC
GENERAL ARRANGEMENT
SCRRA MP36PH-3C
DWG SIZE D
DRAWING NUMBER 2029511
REV A
SCALE 1:32
AUTOCAD
SHEET 01 OF 02
NON-DISCLOSURE AGREEMENT: THE INFORMATION BEING PROVIDED HERE-IN IS PROPRIETARY TO MOTIVEPOWER INC. THIS INFORMATION IS BEING PROVIDED TO OUR CLIENT WITH THE UNDERSTANDING THAT IT WILL BE RETAINED IN CONFIDENCE AND WILL NOT BE REPRODUCED OR COMMUNICATED TO ANY THIRD PARTIES EXCEPT AS REQUIRED BY LAW AND/OR MOTIVEPOWER INCORPORATED.

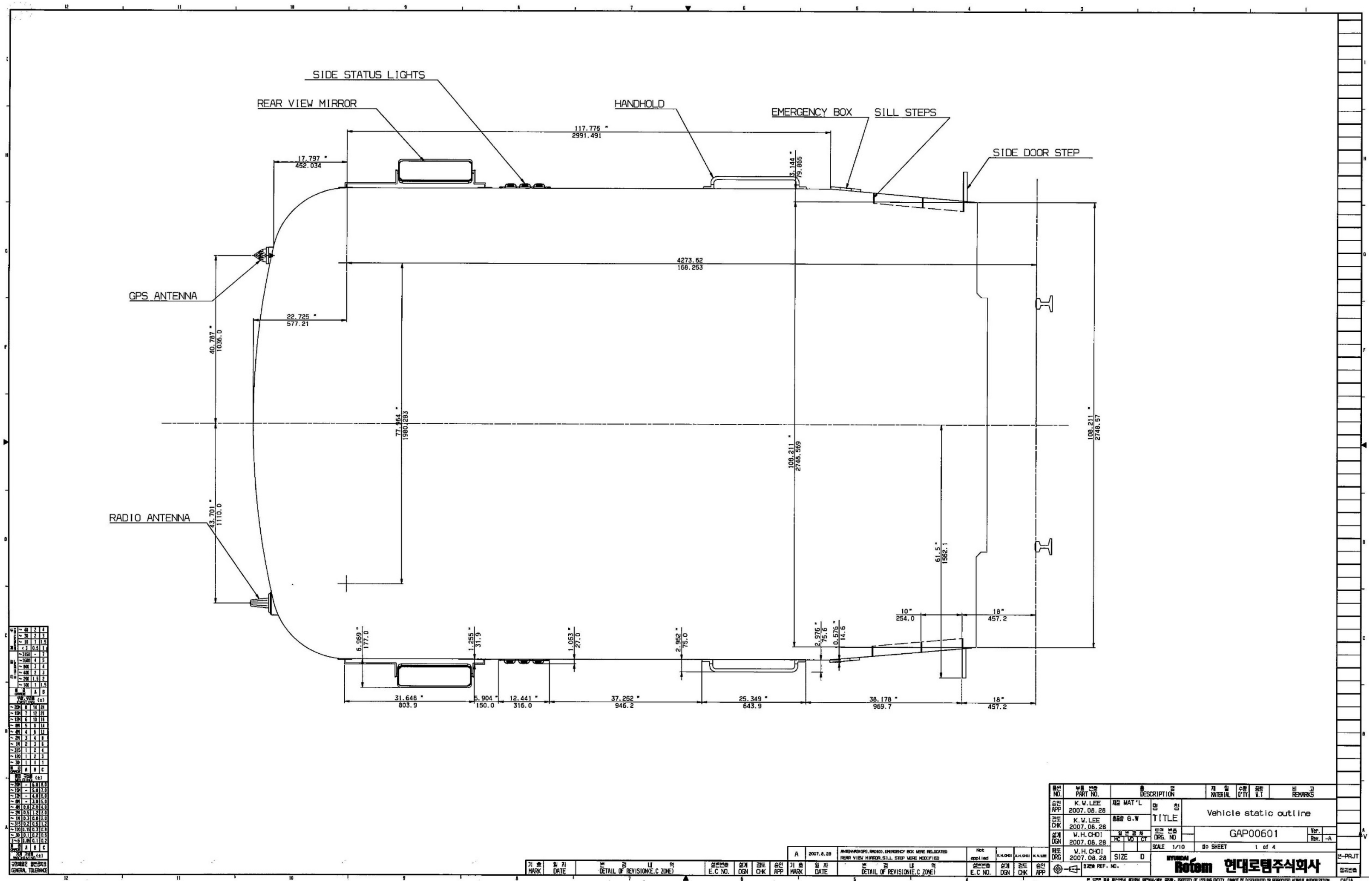

DWG NO. 2029511 SH 02 REV A
128.12 [10'-8 1/8"]
FRONT VIEW
RIGHT SIDE VIEW
APPROVALS
DATE
DRAWN SMILLER 05/19/06
CHECKED BY EMYERS 05/19/06
ENGINEER EMYERS 05/19/06
MotivePower
A Wabtec Company
4600 APPLE STREET
BOISE, ID 83716
208-947-4800
DWG SIZE D
DRAWING NUMBER 2029511
REV A
SCALE 1:32
AUTOCAD
SHEET 02 OF 02
NON-DISCLOSURE AGREEMENT: THE INFORMATION BEING PROVIDED HERE-IN IS PROPRIETARY TO MOTIVEPOWER INC. THIS INFORMATION IS BEING PROVIDED TO OUR CLIENT WITH THE UNDERSTANDING THAT IT WILL BE RETAINED IN CONFIDENCE AND WILL NOT BE REPRODUCED OR COMMUNICATED TO ANY THIRD PARTIES EXCEPT AS REQUIRED BY LAW AND/OR MOTIVEPOWER INCORPORATED.

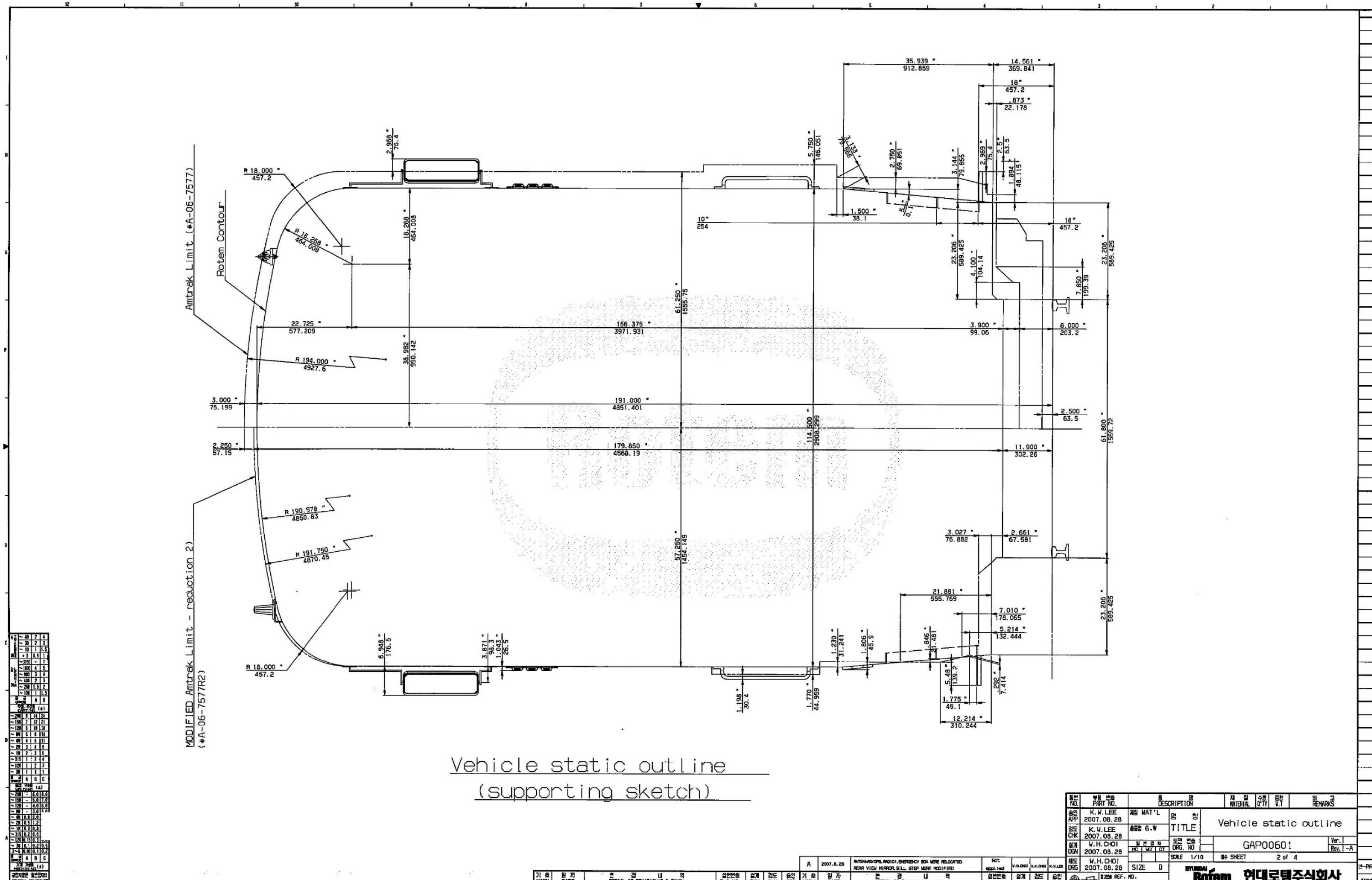

DRAWN JC 91.11.25
CHECKED MH 92.06.01
LEAD ENG RK 92/06/01
MTHOE ENG LAW 92/06/01
TOLERANCES UNLESS OTHERWISE SPECIFIED
ANGLE ± 1°
.X = ± .1
.XX = ± .06
.XXX = ± .015
CAN/CSA B78.2
SIZE A0 DWG NO 20-001-000110 REV. C
DRAWING TITLE LACTC BI-LEVEL ACCESSIBLE TOILET CAB CAR G.A.
SCALE 1:50 SHEET 1/2
UTDC
CAN-CAR THUNDER BAY WORKS
QTY. REQ'D ZONE ITEM PART NUMBER DESCRIPTION MATERIAL SPEC. FIN. CODE
X 1 20-001-000110-001 LACTC G.A.
1 2 20-080-001065-001 MODULE SPLICE
1 3 20-080-001067-001 INST.- EQP. AFT SPLICE
2 4 20-110-001833-001 INST.-TRUCK
1 5 20-360-000056-001 PAINT SCHEMATIC
2 6 09-350-000060-001 KEY-STAFF
7 09-350-000061-001 KEY-STAR SHAPE
SEE NOTE
© NOTE: QTY. AS PER WGO. NO. 4990-9001 ITEM ~~135 AND~~ 136.
65.00
28.94
217.50
585.00
217.50
UPPER LEVEL
SEATING CAPACITY 72
26.12
130.13
29.76
197.25
20.25
52.00
26.00
313.94
423.56
30.62
61.75
282.50
DOORS
INTERMEDIATE LEVEL
SEATING CAPACITY : 19
LOWER LEVEL SEATING CAPACITY
WITH WHEELCHAIRS AND BICYCLES: 28
WITHOUT WHEELCHAIRS AND BICYCLES: 36
INTERMEDIATE LEVEL
SEATING CAPACITY : 15
STA 0.00
'B' END OF CAR
STA 1020.00
'A' END OF CAR
118.00
59.00
168.88
191.00
51.00
COUPLER
TOP OF RAIL
34.50
102.00
18.00 TO FIRST STEP
09.00
14.00
25.00
33.00 DIA
TRUCK
126.00
768.00
1020.00
REVISION
A IT.6 QTY. WAS AS PER NOTE. NOW QTY.= 2.
B PICTORIALLY UPDATED-JC/92.08.20.
C 18.00 WAS 17.00. NOTE CHANGED. PICTORIALLY UPDATED-JC/92.04.15.
DWG NO 20-001-000110 REV. C
CAD DRAWING DO NOT SCALE OR ALTER MANUALLY

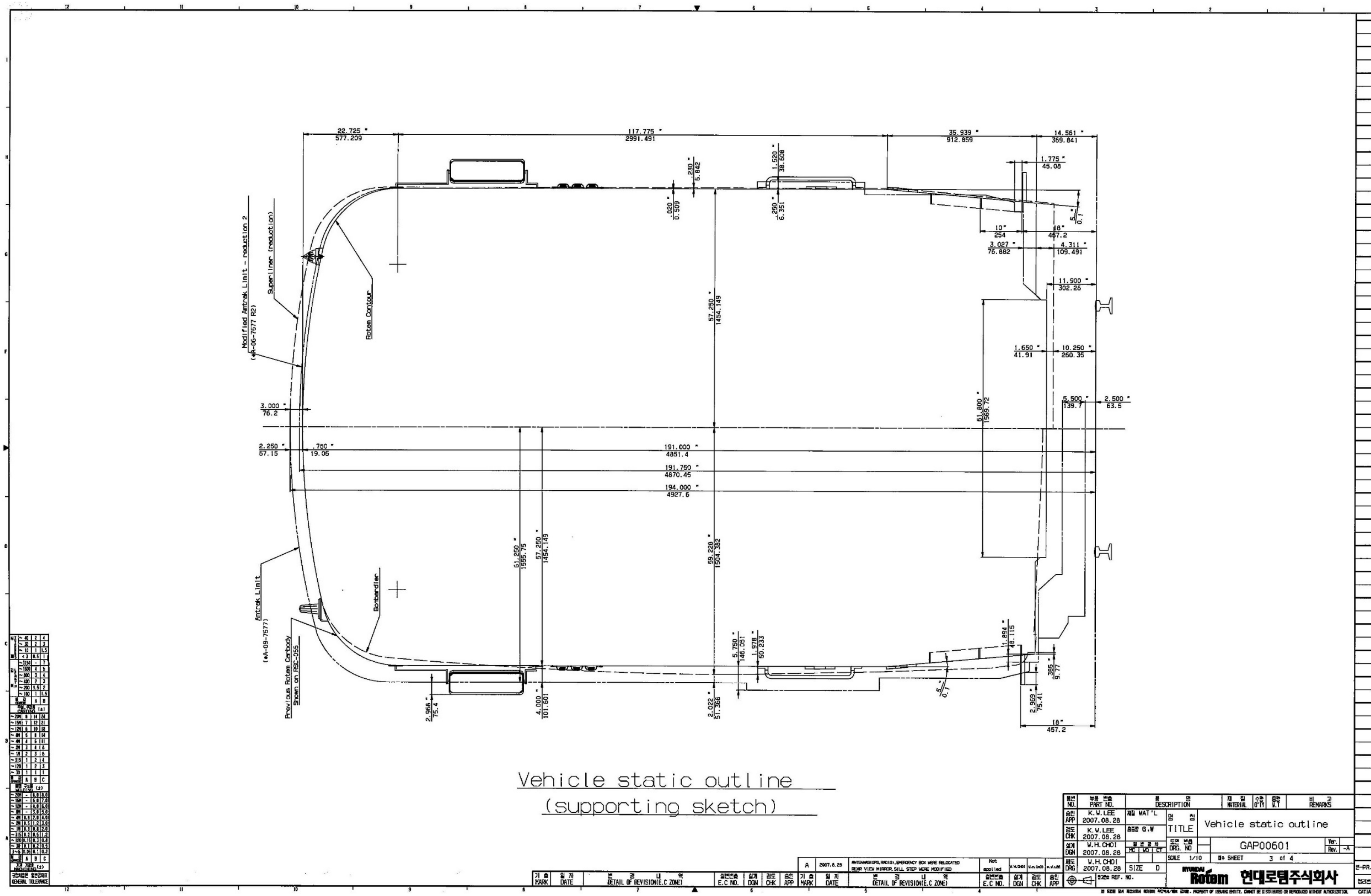

20-001-000110
LACTC BI-LEVEL ACCESSIBLE TOILET CAB CAR G.A.
1:10
2/2
UTDC
CAN-CAR THUNDER BAY WORKS
PART NUMBER
DESCRIPTION
MATERIAL SPEC.
118.00
59.00
2.33
79.67
21.95
33.00
4.56
79.44
22.00
33.00
109.00
25.00
22.00
37.00
84.00
191.00
51.00
TOP OF RAIL
SECTION @ CENTRE OF CAR
SECTION @ END OF CAR
REVISION
20-001-000110
CAD DRAWING DO NOT SCALE OR ALTER MANUALLY

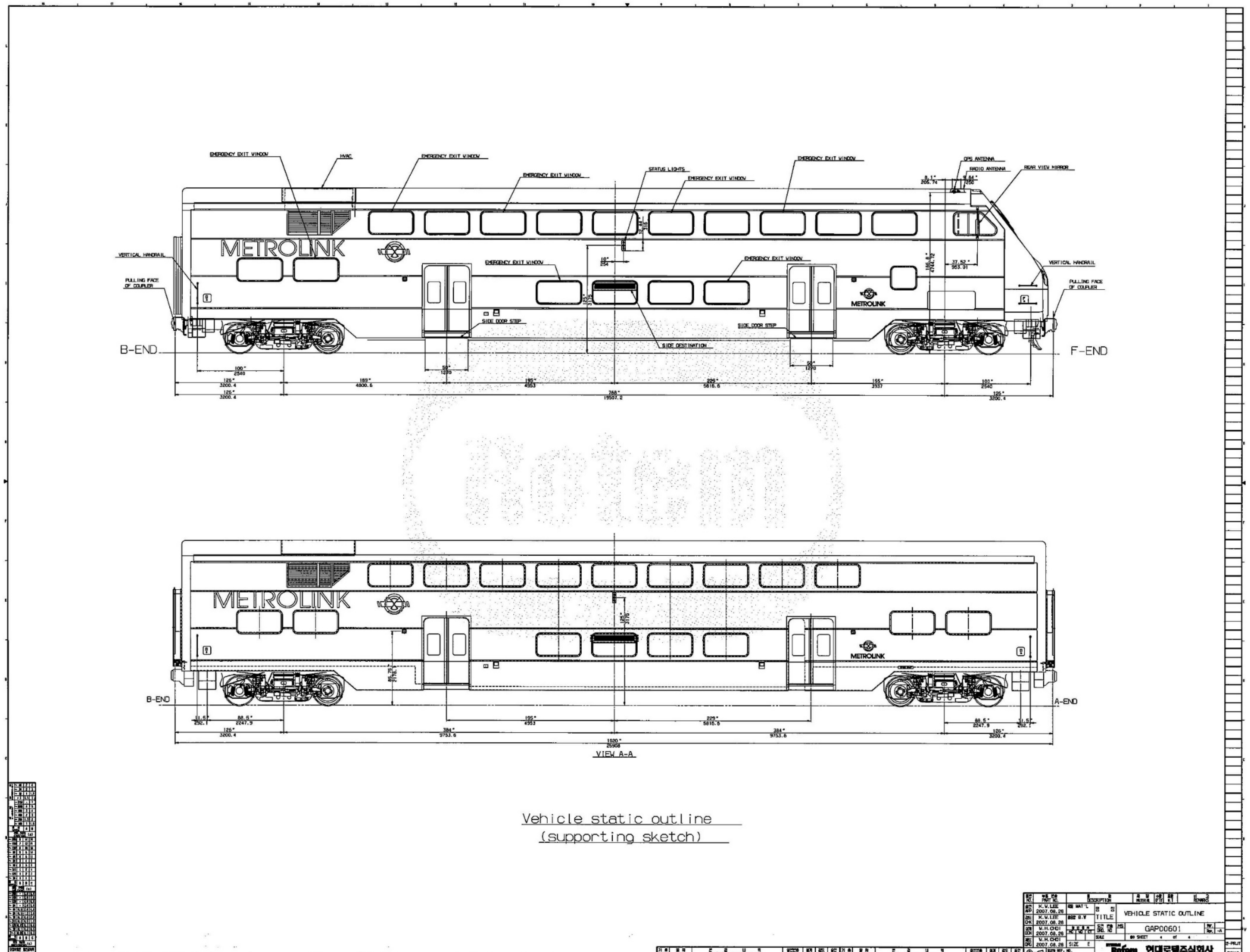

20-360-000056
PAINT SCHEMATIC - CAB
Bombardier Inc.
Groupe matériel de transport
Transportation Equipment Group
PART NUMBER
DESCRIPTION
MATERIAL SPEC.
20-360-000056-001 PAINT SCHEMATIC
09-004-000162-003 3M "SCOTCHLITE"
09-360-000009-002 AWLGRIP GRIPTEX
BLACK BAND 1.00 WIDE
STOP PAINT STRIPE AT EDGE OF END CAP (TYP).
B - END
A - END
METROLINK
SEE NOTE 2
APPLY 'MANUS' BOND 'SAFETY STEP' ABRASIVE NON-SLIP PAINT TO DIAPHRAGM TREAD PLATE AT BOTH ENDS OF CAR.
SEE NOTE 3 (TYP)
CENTRE 'METROLINK' VERTICALLY BETWEEN AIR INTAKE GRILLE & WINDOWS
PAINT COLOURS:
LACTC WHITE
LACTC PURPLE
BLACK BAND 1.00 WIDE (SLIDING WINDOWS ONLY.)
CENTRE 'METROLINK' VERTICALLY BETWEEN AIR INTAKE GRILLE & WINDOW
BL611004SE
REVISION
C "METROLINK" ADDED
CAD DRAWING DO NOT SCALE OR ALTER MANUALLY

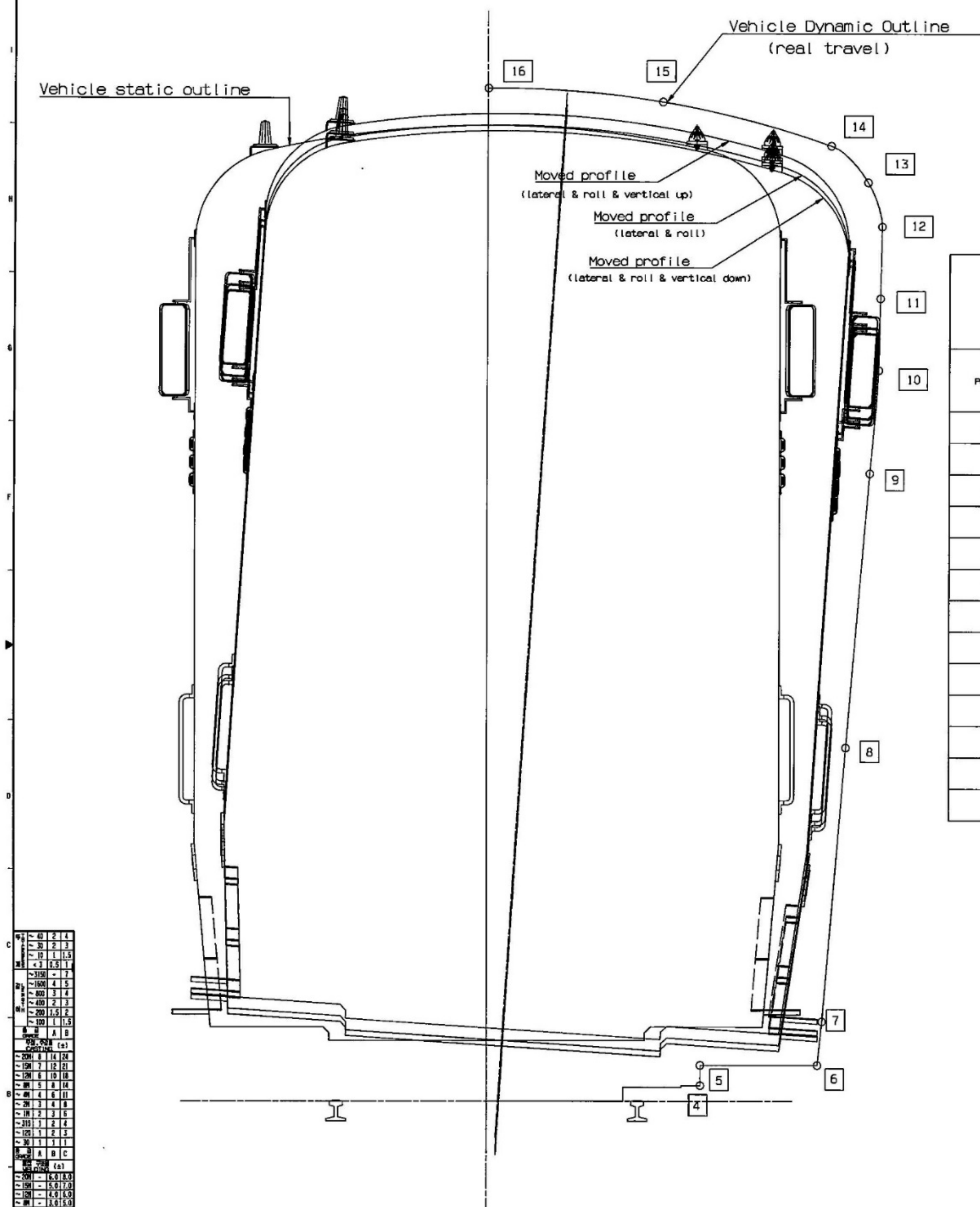

20-345-000047
TOLERANCES UNLESS OTHERWISE SPECIFIED
ANGLE ± 1°
.X = ± .1
.XX = ± .06
.XXX = ± .015
CAN/CSA
Z78.2
DRAWN
RCT 91-11-20
CHECKED
STRESS
SYSTEMS
ELEC
LEAD ENG
OTHER ENG
A0
DWG NO
20-360-000056
REV.
D
DRAWING TITLE
PAINT SCHEMATIC - CAB
SCALE
AS NOTED
SHEET
2/2
Bombardier Inc.
Groupe matériel de transport
Transportation Equipment Group
QTY. REQ'D
ZONE
ITEM
PART NUMBER
DESCRIPTION
MATERIAL SPEC.
FIN. CODE
STA 0.00 REF
STA 77.60 REF
STA 161.12 REF
STA 850.98 REF
STA 942.32 REF
STA 1020.00 REF
STA 18.44 REF
STA 1002.56 REF
38.72 REF
18.00 TYP
APPLY 'AWLGRIP' 'GRIPTEX' 73013 COARSE GRIT.
VIEW ON ARROW 'C'
SCALE 1:50
17.00
8.50
45° 0' TYP
6.00 TYP
WL 84.00 REF
WL 54.44 REF
DETAIL 'F'
SCALE 1:10
H
6.00 TYP
45° 0' TYP
7.88
WL 84.00 REF
WL 49.90 REF
DETAIL 'G'
SCALE 1:10
PAINT END CAP WHITE
BLACK
VIEW ON ARROW 'B'
SCALE 1:30
SEE DETAIL 'F'
PAINT END CAP WHITE
SEE DETAIL 'G'
BLACK
VIEW ON ARROW 'A'
SCALE 1:30
.62 R REF.
IT.2-INST. ON FLAT ONLY(TYP)
SECTION 'H-H'
SCALE 1:1
PAINT SPECIFICATION:
VENDOR: DOWNING PRODUCTS LTD.
643-66-7034 LACTC WHITE: 2030.00 SQ.FT.
643-66-1806 LACTC PURPLE: 630.00 SQ.FT.
BLACK 26.00 SQ.FT.
'AKZO' POLYURETHANE ENAMEL PAINT AND APPLICATION SHALL CONFORM TO TSS-1938, LATEST ISSUE.
NOTES:
1. ALL HANDHOLDS TO BE PAINTED WHITE.
2. CORNER STEPS AND WIRE RECEPTACLE MOUNTING BOXES PAINTED BLACK.
3. SIDE STEPS TO REMAIN UNPAINTED, NATURAL ALUMINUM.
~~4. NON-SLIP PAINT TO BE USED AROUND HATCH.~~
5. EXTERIOR OF SIDE DOOR TO BE PAINTED WHITE AND PURPLE, FOLLOWING CORRESPONDING PAINT LINES OF SIDE WALL.
6. HEADLIGHTS, AND ROOF MOUNTED EQUIPMENT (BELL, HORN & HORN GUARDS) TO BE PAINTED WHITE
7. DITCHLIGHT HOUSING TO BE PAINTED PURPLE
8. SIDE MIRRORS TO BE LEFT UNPAINTED
9. INTERIOR SURFACE OF CAB END DOOR AND INSIDE SURFACE OF COLLISION BOX (VISIBLE SURFACE) ARE TO BE FINISH PAINTED TO MATCH ROYALITE FR#7016.
BL611004SE
REVISION
D SEE R.B. (JR 930414)
A0 DWG NO 20-360-000056 REV. D
CAD DRAWING DO NOT SCALE OR ALTER MANUALLY


SIDE STATUS LIGHTS
REAR VIEW MIRROR
HANDHOLD
EMERGENCY BOX
SILL STEPS
SIDE DOOR STEP
GPS ANTENNA
RADIO ANTENNA
117.775 "
2991.491
17.797 "
452.034
4273.62
168.253
22.725 "
577.21
40.787 "
1036.0
77.964 "
1980.283
108.211 "
2748.569
108.211 "
2748.57
43.701 "
1110.0
61.5 "
1562.1
3.144 "
79.865
10 "
254.0
18 "
457.2
6.969 "
177.0
1.255 "
31.9
1.063 "
27.0
2.952 "
75.0
2.976 "
75.6
0.576 "
14.6
31.648 "
803.9
5.904 "
150.0
12.441 "
316.0
37.252 "
946.2
25.349 "
643.9
38.178 "
969.7
18 "
457.2
A
2007.8.28
Not applied
K.W.LEE
2007.08.28
K.W.LEE
2007.08.28
W.H.CHOI
2007.08.28
W.H.CHOI
2007.08.28
NO.
PART NO.
DESCRIPTION
MATERIAL
Q'TY
W.T
REMARKS
APP
CHK
DGN
DRG
MAT'L
G.W
MC
VD
CT
SIZE D
REF. NO.
TITLE
Vehicle static outline
DRG. NO
GAP00601
Ver.
Rev. -A
SCALE 1/10
SHEET 1 of 4
HYUNDAI Rotem 현대로템주식회사
MARK
DATE
DETAIL OF REVISION(E.C ZONE)
E.C NO.
DGN
CHK
APP
CATIA


Amtrak Limit (#A-06-7577)
Rotem Contour
MODIFIED Amtrak Limit - reduction 2)
(#A-06-7577R2)
R 18.000 " 457.2
R 18.268 " 464.008
R 194.000 " 4927.6
R 190.978 " 4850.83
R 191.750 " 4870.45
22.725 " 577.209
156.375 " 3971.931
191.000 " 4851.401
179.850 " 4568.19
3.000 " 76.199
2.250 " 57.15
35.939 " 912.859
14.561 " 369.841
18" 457.2
.873 " 22.176
61.250 " 1555.75
57.250 " 1454.149
114.500 " 2908.299
61.800 " 1569.72
23.206 " 589.425
3.900 " 99.06
8.000 " 203.2
2.500 " 63.5
11.900 " 302.26
3.027 " 76.882
2.651 " 67.581
21.861 " 555.769
7.010 " 178.055
5.214 " 132.444
1.775 " 45.1
12.214 " 310.244
Vehicle static outline
(supporting sketch)
Vehicle static outline
GAP00601
SCALE 1/10
2 of 4
SIZE D
K.W.LEE 2007.08.28
W.H.CHOI 2007.08.28
Rotem 현대로템주식회사


Vehicle static outline
(supporting sketch)
Modified Amtrak Limit - reduction 2
Superliner (reduction)
Rotem Contour
Amtrak Limit
Previous Rotem Carbody Shown on RSC-055
Bombardier
191.000 "
4851.4
191.750 "
4870.45
194.000 "
4927.6
Vehicle static outline
GAP00601
K.W.LEE
W.H.CHOI
2007.08.28
SCALE 1/10
3 of 4
Rotem
현대로템주식회사


EMERGENCY EXIT WINDOW
HVAC
STATUS LIGHTS
GPS ANTENNA
RADIO ANTENNA
REAR VIEW MIRROR
VERTICAL HANDRAIL
PULLING FACE OF COUPLER
SIDE DOOR STEP
SIDE DESTINATION
B-END
F-END
A-END
METROLINK
VIEW A-A
Vehicle static outline
(supporting sketch)
VEHICLE STATIC OUTLINE
GAP00601
Rotem 현대로템주식회사



Note

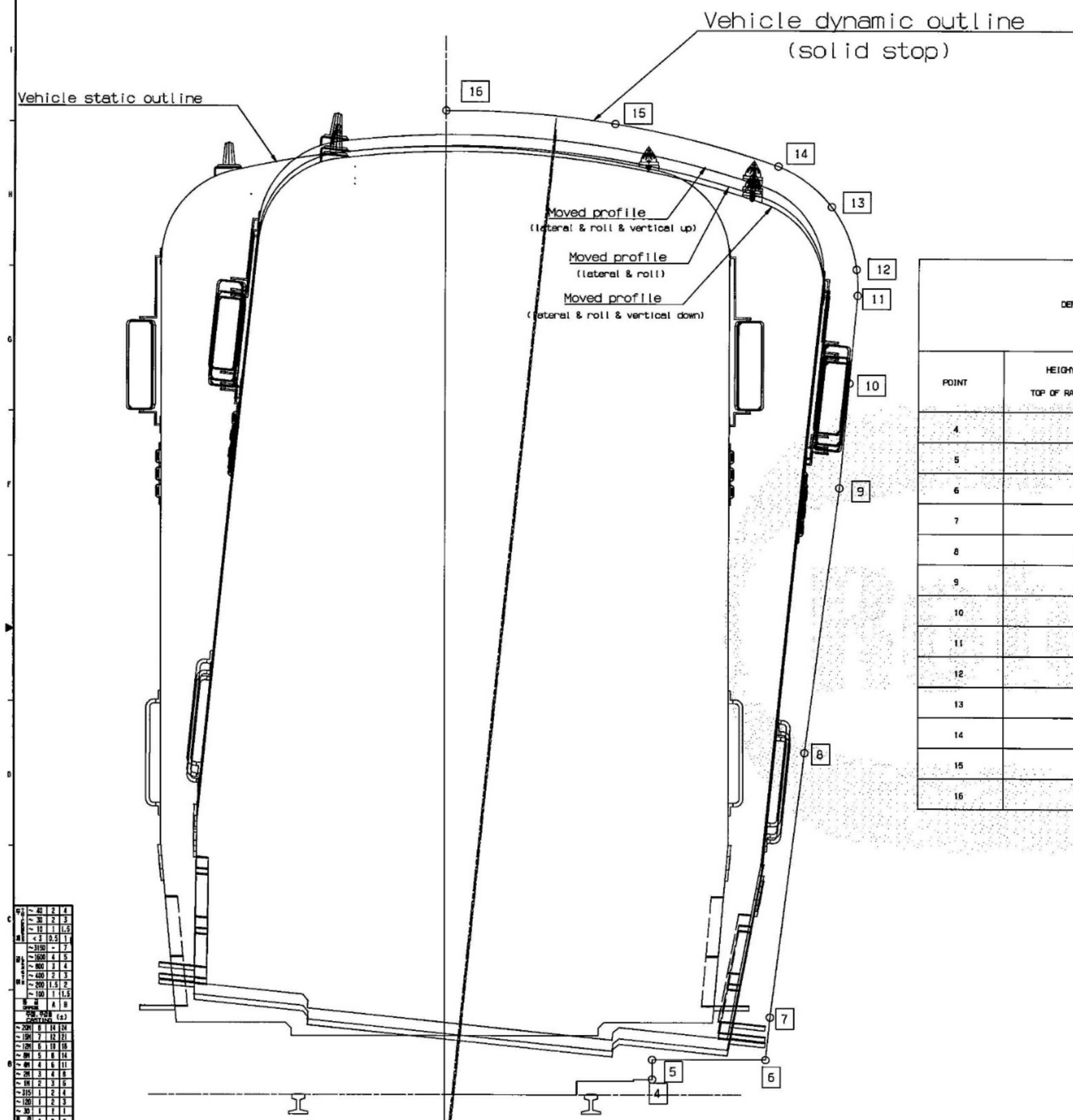
1. The considered carbody movements are shown as follows
2. The real suspension displacements are calculated for a stationary car on a track with 6 inches of unbalanced superelevation (AW3) relative to track

ROTEM CAR (REAL TRAVEL) DEFLECTED CAR DIMENSIONS (DYNAMIC OUTLINE) RELATIVE TO DATUM		
POINT	HEIGHY ABOVE TOP OF RAIL (INCH)	WIDTH FROM TRACK CENTER (INCH)
4	3.12	41.84
5	7.06	41.84
6	7.06	64.84
7	15.64	65.74
8	69.20	70.35
9	122.88	74.98
10	143.03	76.66
11	157.11	76.95
12	171.18	77.24
13	179.82	74.49
14	186.99	67.22
15	195.56	34.14
16	198.25	0

ITEM	ROTEM CAR (real travel)	UNIT
1.outline at the roof		
new 33 inch diameter wheels	33	inch
secondary air springs over-inflated to vertical stops	2.25	inch
2.outline at the side		
maximum wheel-rail clearance resulting from track widening and flange wear	1.37	inch
primary suspension lateral play	0.06	inch
primary suspension roll calculated for a stationary car on a track with 6 inches of unbalanced superelevation(AW3) relative to track	2.218	degree
lateral travel of the bolster	2.20	inch
bolster roll angle relative to bogie	0.663	degree
secondary roll relative to bolster	0.952	degree
3.outline at the truck		
maximum uncompensated wheel wear	0.50	inch
primary suspension deflection resulting from an AW3 load	0.62	inch

APP	K.W.LEE 2007.08.28	
CHK	K.W.LEE 2007.08.28	
DGN	W.H.CHOI 2007.08.28	
DRG	W.H.CHOI 2007.08.28	SIZE D
TITLE	Vehicle Dynamic outline	
DRG. NO	GAP00600	Rev. -A
SCALE 1/10	SHEET 1 of 2	

Rotem 현대로템주식회사



ROTEM CAR (SOLID STOP) DEFLECTED CAR DIMENSIONS (DYNAMIC OUTLINE) RELATIVE TO DATUM		
POINT	HEIGHY ABOVE TOP OF RAIL (INCH)	WIDTH FROM TRACK CENTER (INCH)
4	3.12	41.84
5	7.06	41.84
6	7.06	64.84
7	15.64	65.74
8	68.96	72.70
9	122.27	79.67
10	143.35	81.62
11	161.05	83.19
12	166.28	82.95
13	178.89	77.87
14	187.07	67.01
15	195.58	34.03
16	198.25	0

Note

1. The considered carbody movements are shown as follows

ITEM	ROTEM CAR (solid stop except the primary and bolster roll)	UNIT
1.outline at the roof		
new 33 inch diameter wheels	33	inch
secondary air springs over-inflated to vertical stops	2.25	inch
2.outline at the side		
maximum wheel-rail clearance resulting from track widening and flange wear	1.37	inch
primary suspension lateral play (maximum)	0.17	inch
primary suspension roll calculated for a stationary car on a track with 6 inches of unbalanced superelevation(AW3) relative to track	2.218	degree
lateral travel of the bolster to hard stops	2.78	inch
bolster roll angle relative to bogie	0.663	degree
secondary roll to the upstop on one side and the downstop on the other relative to bolster	3.091	degree
upstop	2.25	inch
down stop(AW3)	2.50	inch
3.outline at the truck		
maximum uncompensated wheel wear	0.50	inch
primary suspension deflection resulting from an AW3 load	0.62	inch

TITLE Vehicle Dynamic outline

DRG. NO GAP00600

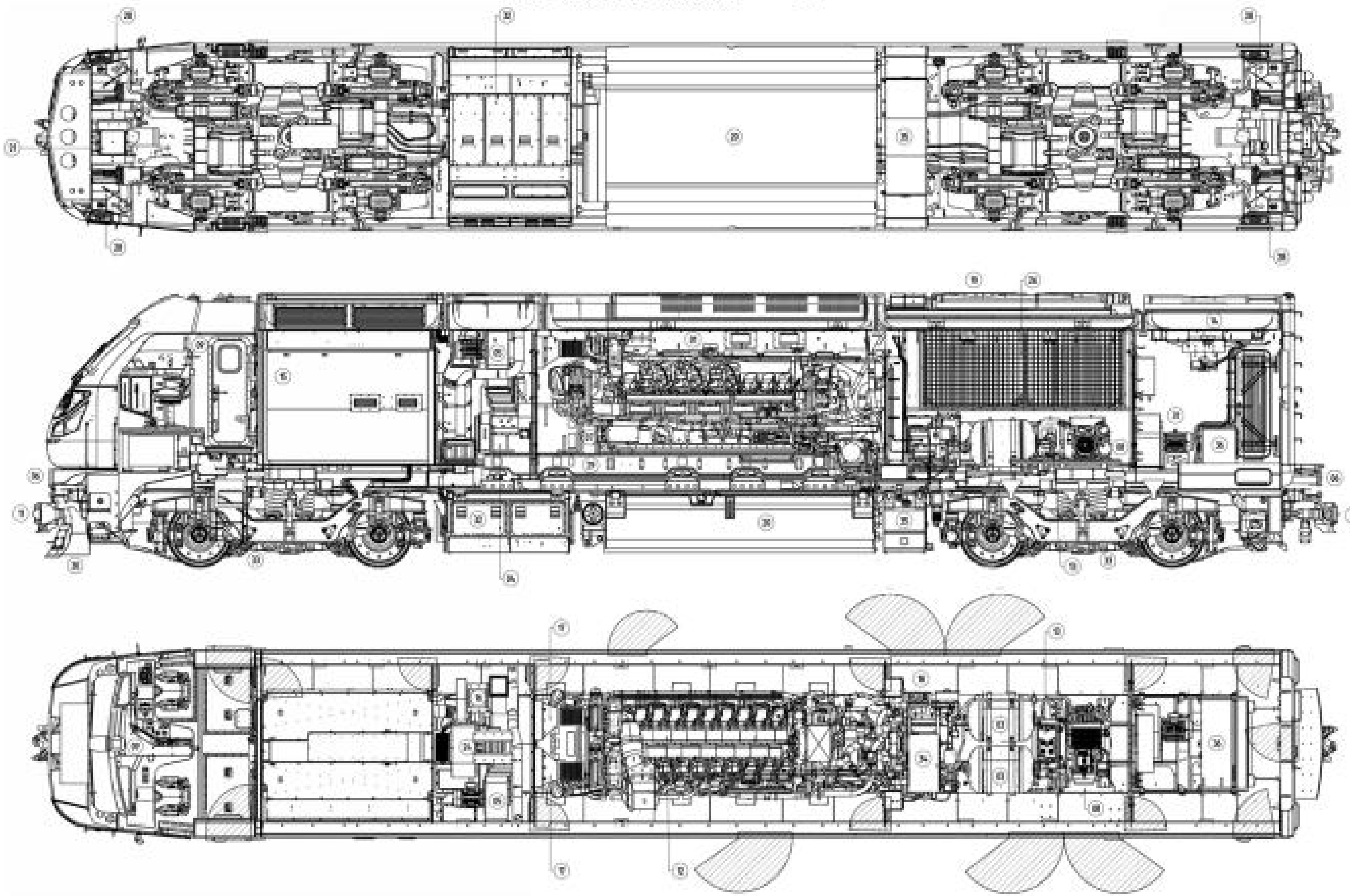
SCALE 1/10 SHEET 2 of 2

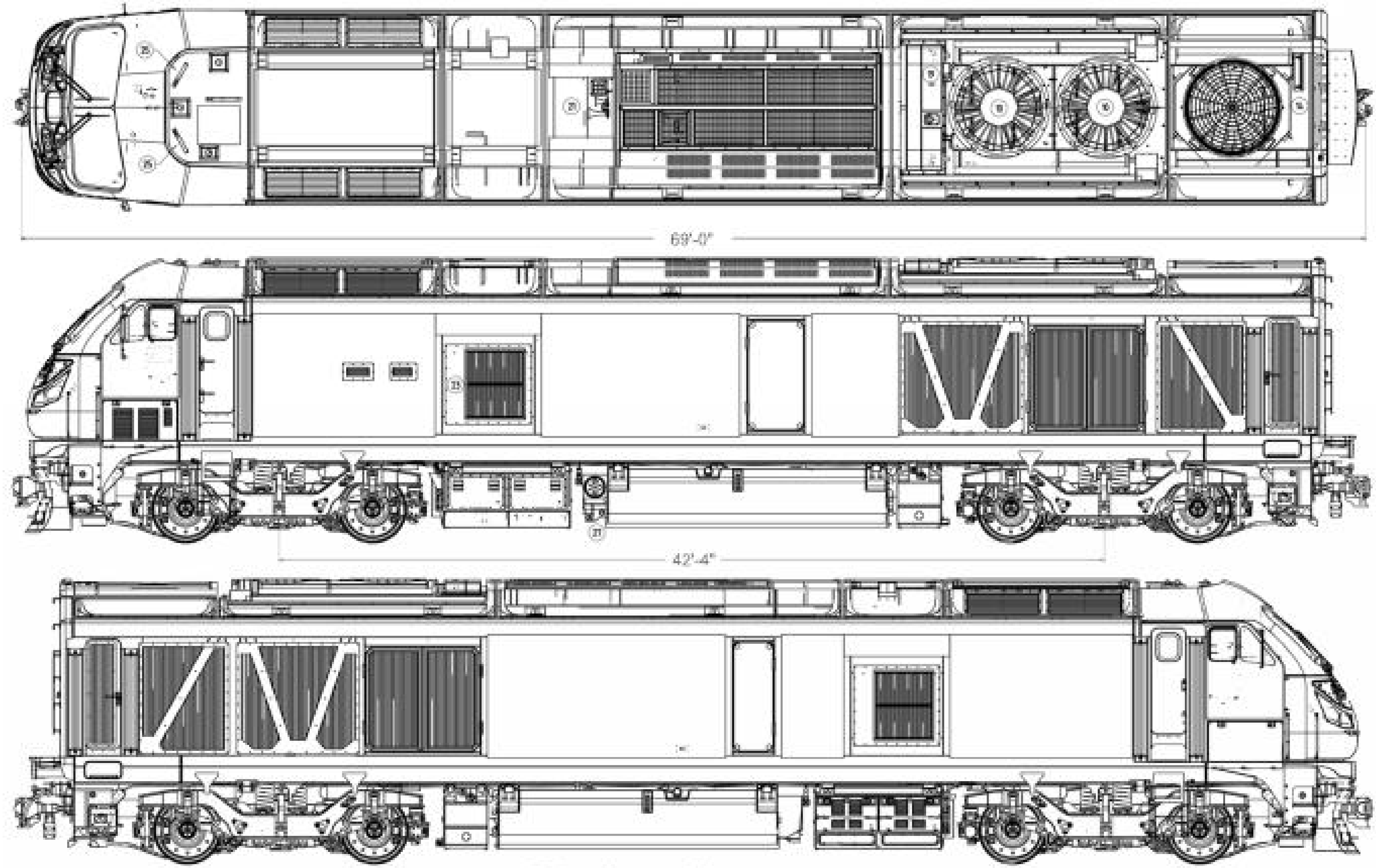
K.W.LEE 2007.08.28

W.H.CHOI 2007.08.28

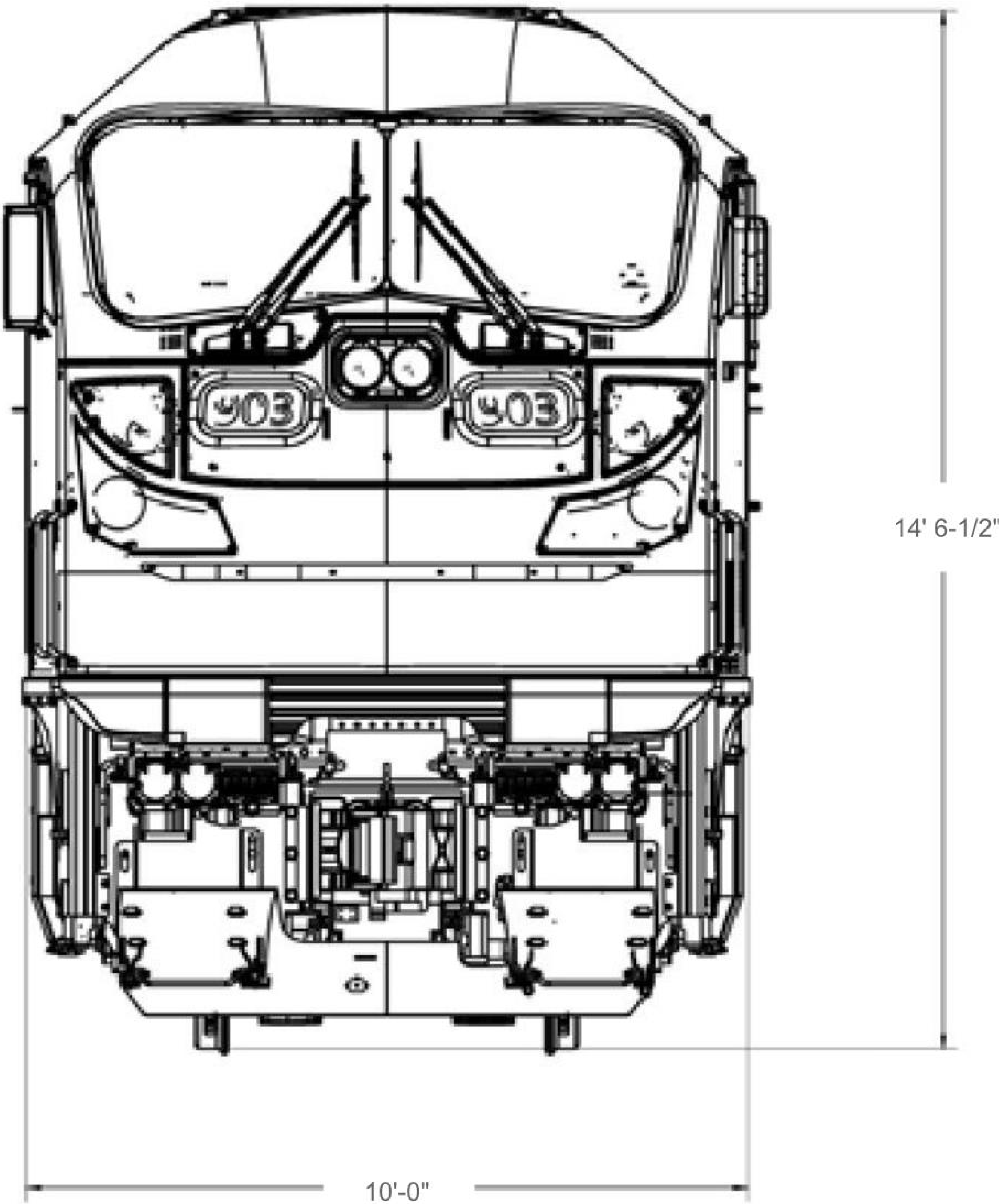
Rotem 현대로템주식회사

F125 General Arrangement
2016 Electro-Motive 1-9





F125 General Arrangement
2016 Electro-Motive 1-10



F125 General Arrangement
2016 Electro-motive 1-11

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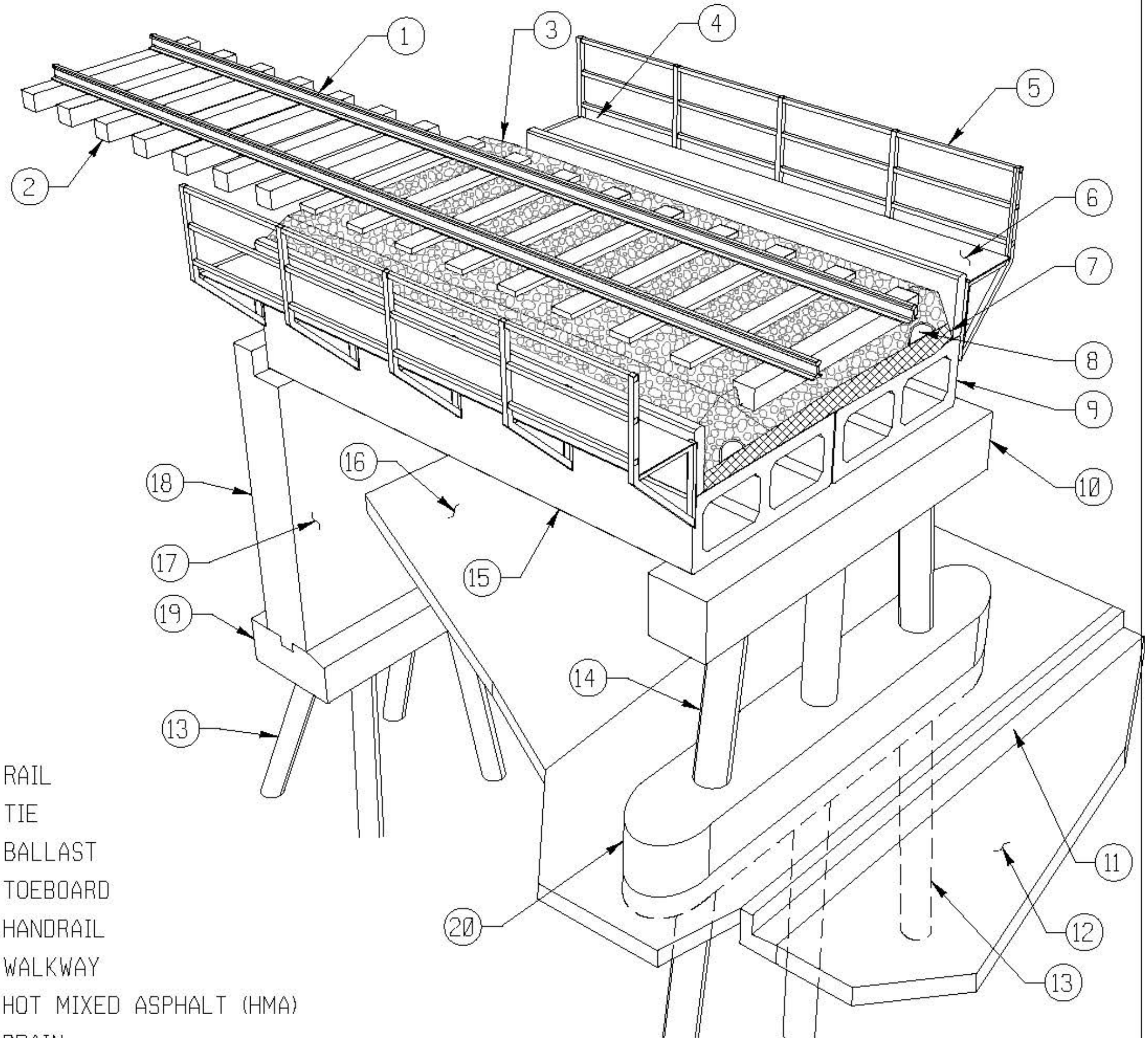
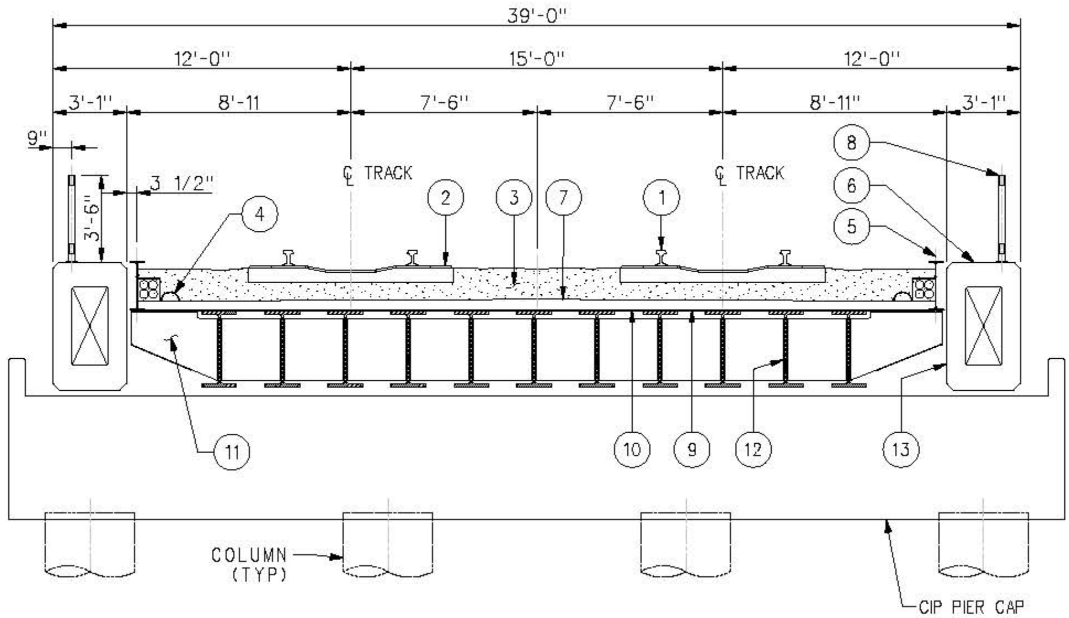
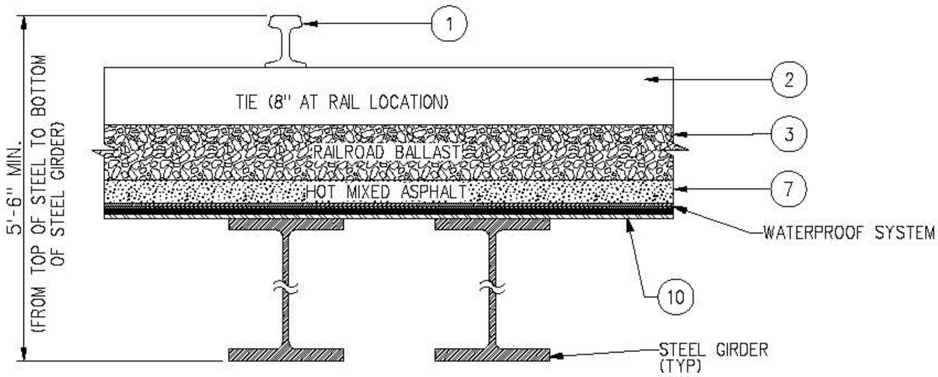
APPENDIX C-5
GRADE SEPARATION DETAILS



(1) RAIL
(2) TIE
(3) BALLAST
(4) TOEBOARD
(5) HANDRAIL
(6) WALKWAY
(7) HOT MIXED ASPHALT (HMA)
(8) DRAIN
(9) SUPERSTRUCTURE-PARTS OF A BRIDGE WHICH SPAN AN AREA AND CARRY TRAFFIC LOADS
(10) BENT-A LINE PERPENDICULAR TO THE LENGTH OF THE BRIDGE CONTAINING MULTIPLE COLUMNS
(11) CURB AND GUTTER-ROAD DRAINAGE
(12) ROADWAY-DRIVING SURFACE
(13) PILE-CONCRETE OR STEEL SUPPORTS DRILLED OR HAMMERED INTO THE GROUND TO SUPPORT THE WEIGHT OF BRIDGE AND TRAFFIC
(14) COLUMN-A VERTICAL SUPPORT FOR THE BRIDGE SUPERSTRUCTURE TYPICALLY CAST IN CONCRETE
(15) SOFFIT-BOTTOM OF SUPERSTRUCTURE
(16) SLOPE PROTECTION-SLOPED SURFACE AT THE ABUTMENT
(17) ABUTMENT-THE PERMANENT CONCRETE SEAT (SUBSTRUCTURE) AT THE ENDS OF THE BRIDGE WHICH SUPPORTS THE SUPERSTRUCTURE
(18) SUBSTRUCTURE-THE PARTS OF A BRIDGE WHICH COME INTO CONTACT WITH THE GROUND AND SUPPORT LOADS FROM ABOVE
(19) FOOTING-THE BASE OF A STRUCTURE WHICH TRANSFERS LOADS TO BEDROCK OR PILING
(20) CONCRETE COLLAR

METROLINK	SCALE: NONE
	PLAN NO.
DRAWING TITLE: BRIDGE GLOSSARY	SHEET NO. GSG - 01





1 RAIL	6 WALKWAY	11 BRACKET
2 TIE	7 HOT MIX ASPHALT (HMA)	12 STEEL BEAM
3 BALLAST	8 HANDRAIL	13 SACRIFICIAL BEAM
4 DRAIN	9 WATERPROOFING	
5 CURB	10 STEEL PLATE DECK	

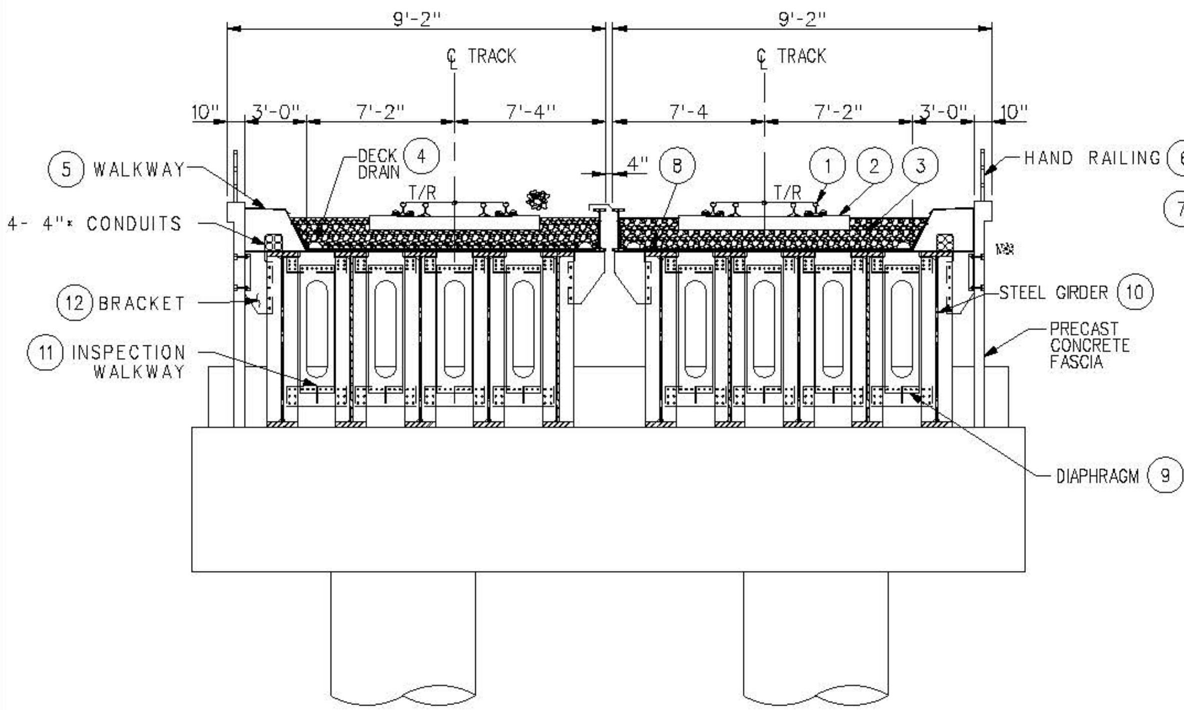
METROLINK

SCALE: NONE

PLAN NO.

DRAWING TITLE: STEEL BEAM BRIDGE WITH SACRIFICIAL BEAM

SHEET NO. GSG - 02



✳ 12" MIN. BALLAST CONCRETE TIE
9" MIN. BALLAST TIMBER TIE

1 RAIL	7 HOT MIX ASPHALT (HMA)
2 TIE	8 STEEL PLATE DECK
3 BALLAST	9 DIAPHRAGM
4 DRAIN	10 STEEL GIRDER
5 WALKWAY	11 INSPECTION WALKWAY
6 HANDRAIL	12 BRACKET

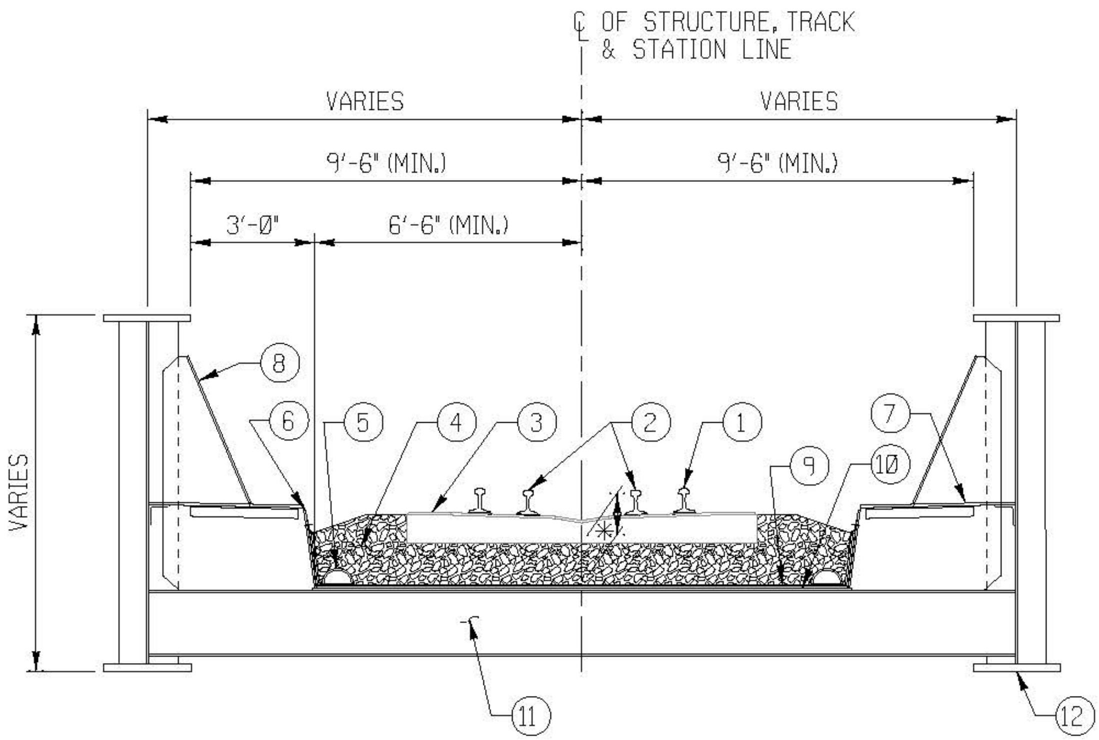
METROLINK

SCALE: 1/4" = 1'-0"

PLAN NO.

DRAWING TITLE: STEEL DECK PLATE GIRDER BRIDGE

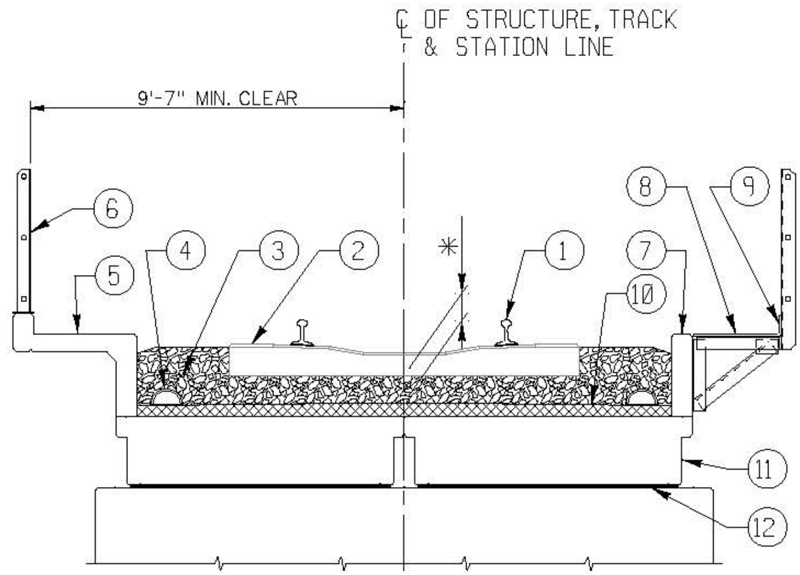
SHEET NO. GSG - 03



* 12" MIN. BALLAST CONCRETE TIE
9" MIN. BALLAST TIMBER TIE

(1) RAIL
(2) INNER GUARD RAIL
(3) TIE
(4) BALLAST
(5) DRAIN
(6) CURB PLATE
(7) WALKWAY
(8) KNEE BRACE
(9) WATERPROOFING
(1Ø) STEEL PLATE DECK
(11) TRANSVERSE FLOOR BEAM
(12) STEEL GIRDER

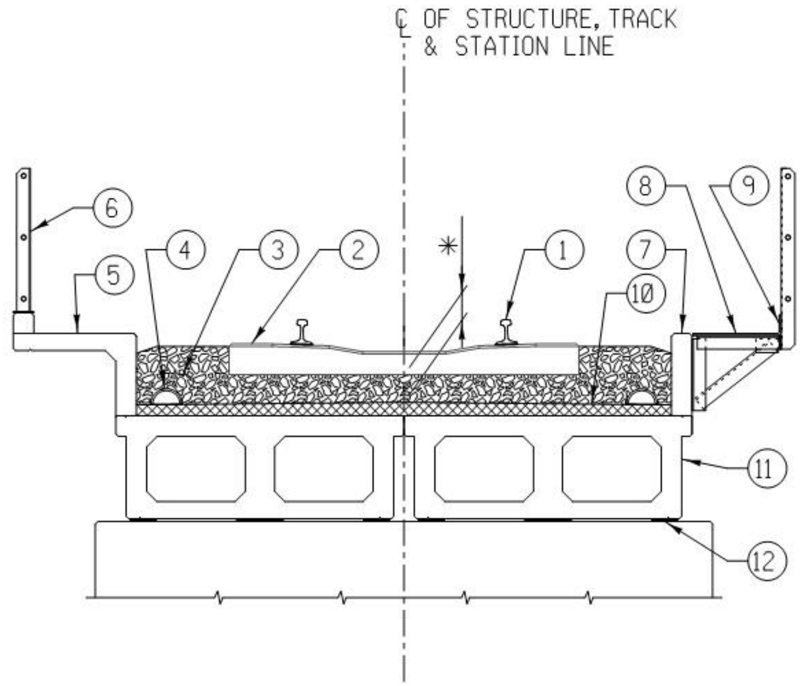
METROLINK	SCALE: 1/4" = 1'-0"
	PLAN NO.
DRAWING TITLE: STEEL THROUGH PLATE GIRDER BRIDGE	SHEET NO. GSG - Ø4



* 12" MIN. BALLAST CONCRETE TIE
9" MIN. BALLAST TIMBER TIE

1 RAIL
2 TIE
3 BALLAST
4 DRAIN
5 CONCRETE CURB AND WALKWAY
6 HANDRAIL
7 CONCRETE CURB
8 WALKWAY
9 TOEBOARD
10 HOT MIXED ASPHALT (HMA)
11 PRECAST CONCRETE SLAB BEAM
12 BEARING PAD

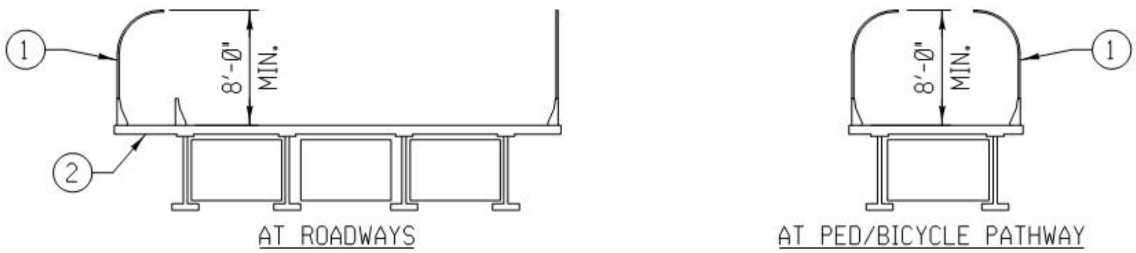
METROLINK	SCALE: 1/4" = 1'-0"
	PLAN NO.
DRAWING TITLE: PRECAST (PRESTRESSED) CONCRETE SLAB BEAM BRIDGE	SHEET NO. GSG - 05



* 12" MIN. BALLAST CONCRETE TIE
9" MIN. BALLAST TIMBER TIE

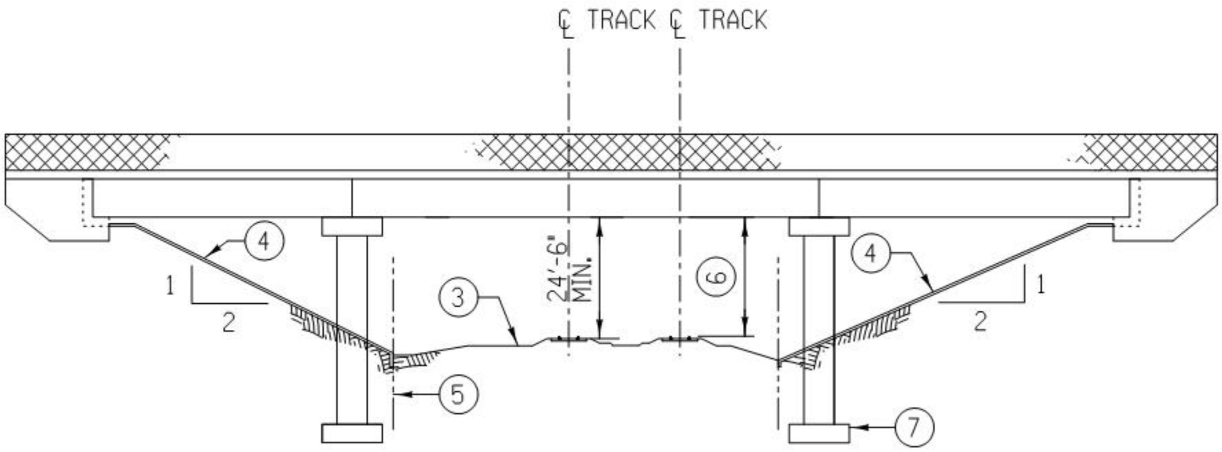
1. RAIL
2. TIE
3. BALLAST
4. DRAIN
5. CONCRETE CURB AND WALKWAY
6. HANDRAIL
7. CONCRETE CURB
8. WALKWAY
9. TOEBOARD
10. HOT MIX ASPHALT (HMA)
11. PRECAST CONCRETE DOUBLE BOX BEAM
12. BEARING PAD

METROLINK	SCALE: 1/4" = 1'-0"
	PLAN NO.
DRAWING TITLE: PRECAST (PRESTRESSED) CONCRETE DOUBLE BOX BEAM BRIDGE	SHEET NO. GSG - Ø6



CROSS SECTION THRU OVERHEAD

SCALE: NONE



1 FENCE
2 PEDESTRIAN/BICYCLE PATHWAY
3 SCRRA MAINTENANCE ROAD
4 SLOPE PROTECTION
5 SCRRA ROW LINE
6 CLEARANCE
7 FOOTING

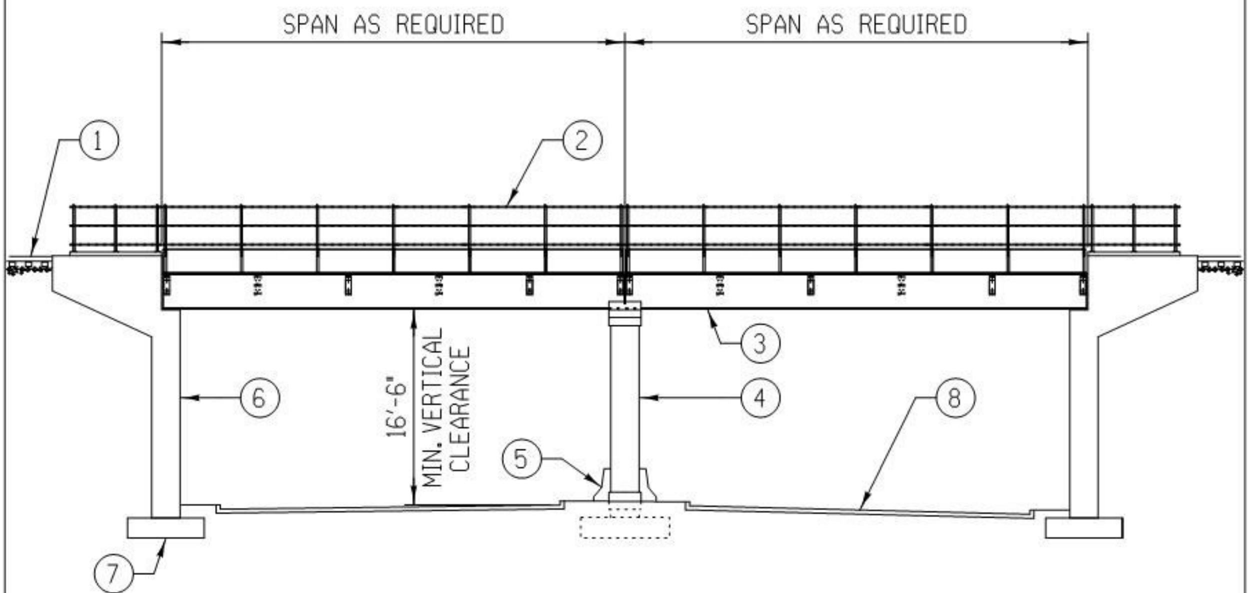
METROLINK

SCALE: NONE

PLAN NO.

DRAWING TITLE: OVERHEAD STRUCTURE CLEARANCES

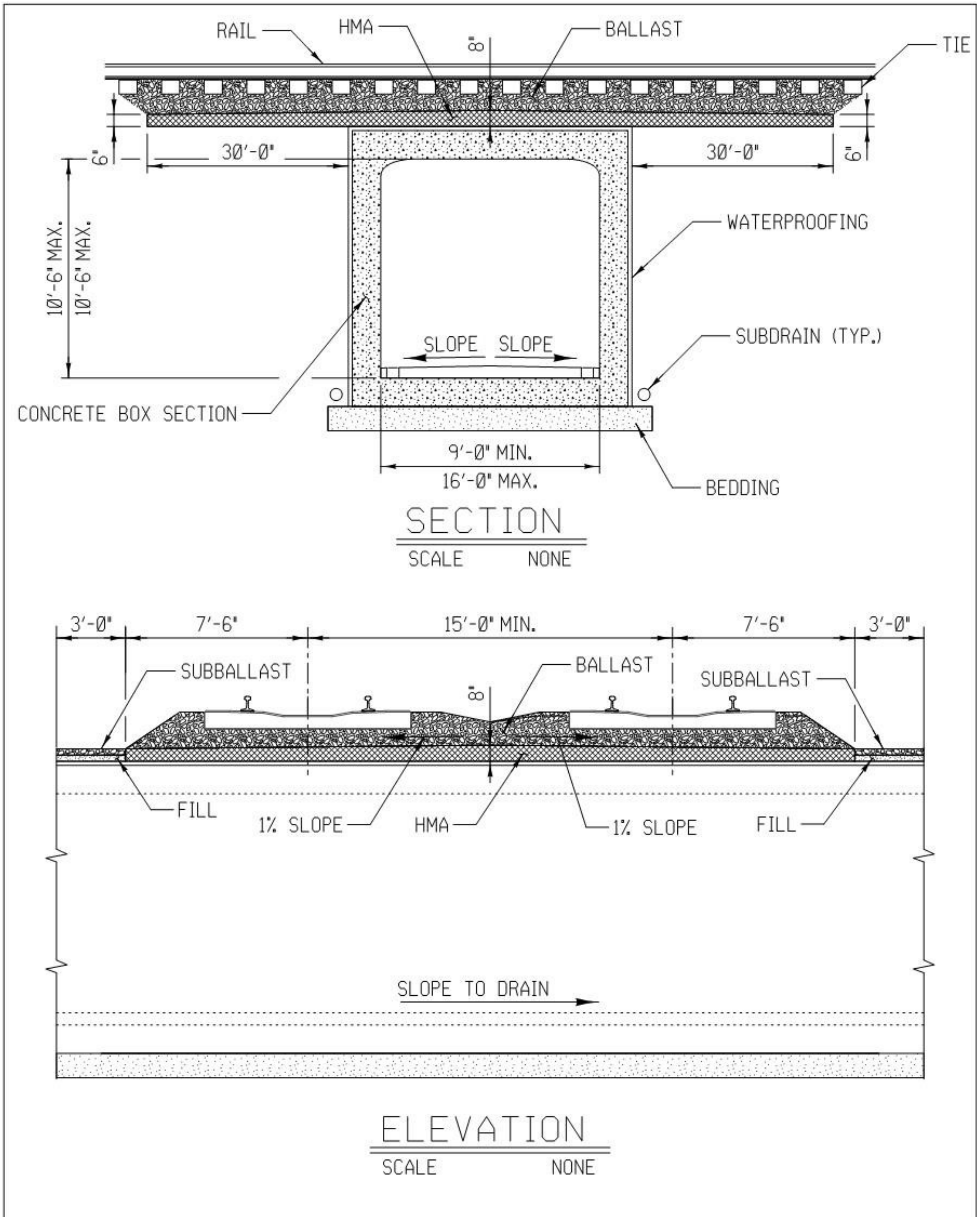
SHEET NO. GSG - Ø7



1 TOP OF RAIL
2 HANDRAIL
3 STEEL SUPERSTRUCTURE
4 BENT
5 BENT PROTECTION
6 ABUTMENT
7 FOOTING
8 ROADWAY

METROLINK

	SCALE: NONE
	PLAN NO.
DRAWING TITLE: UNDERPASS STRUCTURE CLEARANCES	SHEET NO. GSG - Ø8



METROLINK	SCALE: NONE
	PLAN NO.
DRAWING TITLE: PEDESTRIAN UNDERPASS	SHEET NO. GSG - 09

Appendix D. SCRRA Space Needs Program

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1.0 SECTION ONE – PROJECT OVERVIEW

1.1 INTRODUCTION

SCRRA Metrolink has identified a need for a Prototypical Layover and Maintenance Facility Space Needs Program and Design Criteria Narrative Chapter for current and future facilities. These prototypical documents can be used to update or modify existing facilities, as well as establish standards and guidelines for new Layover and Maintenance Facilities as Metrolink grows service.

One of the first steps in this process is the development of a conceptual program based on Metrolink's operational and functional criteria that will provide a methodology to support decisions for the selection of potential sites for this facility and pre-design for the selected site.

A Prototypical Layover and Maintenance Facility could include the following departments:

- SCRRA Prototypical Facility Work Space Requirements
- Facilities for Train Operations Contract Staff
- Facilities for Equipment Maintenance Contract Staff
- Facilities for Vehicle Materials Handling Contract Staff
- Facilities for Vehicle Service Areas Contract Staff
- Facility Maintenance
- Vehicle Parking/Storage
- Employee Parking

1.2 PURPOSE OF THIS DOCUMENT

The purpose of this document is to define the operational and maintenance criteria, future staffing needs, functional requirements, and space needs by way of program planning, which will serve as a general basis for site selection and design of a layover and maintenance facility.

1.3 REQUIREMENTS AND CRITERIA

The following are major program requirements and criteria that were taken into consideration when generating the Space Needs Program and Design Criteria Narrative.

1.3.1 General

- A Layover and Maintenance Facility needs to be in close proximity to the mainline track for ease of train movement.
- There will be no general public access or visitors at the facility.

1.3.2 Rail Vehicle

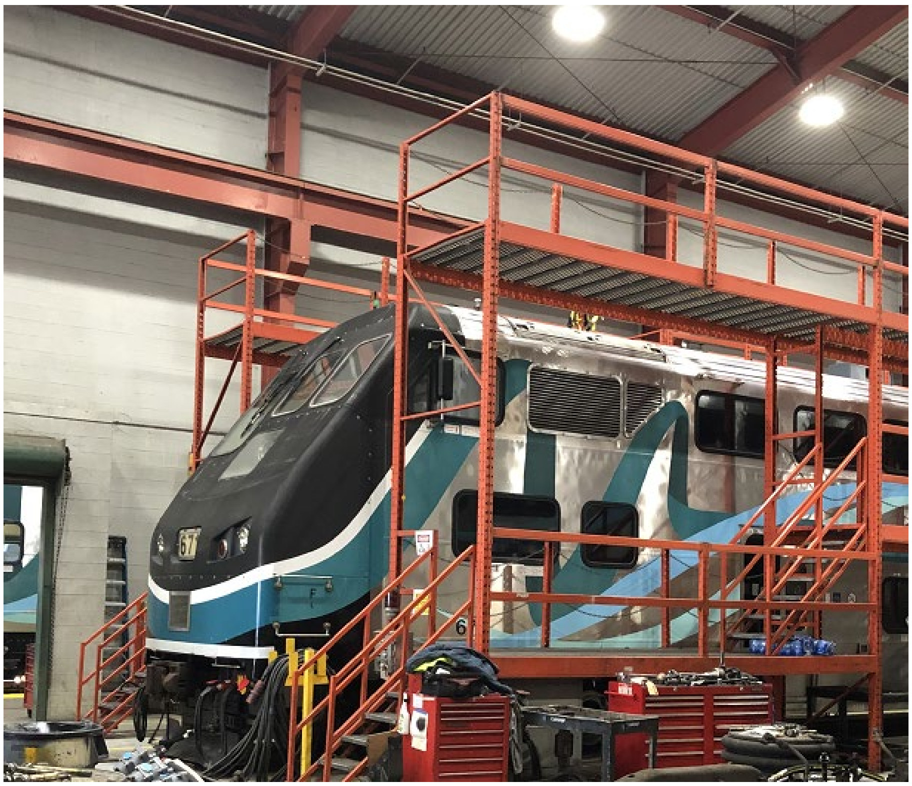
- The Prototypical Layover and Maintenance Facility will need to accommodate up to 220 rail cars, including 165 passenger vehicles and 55 locomotives.

1.3.3 Equipment Maintenance

Car (Heavy Position)

- Car positions with multiple level access are desired.

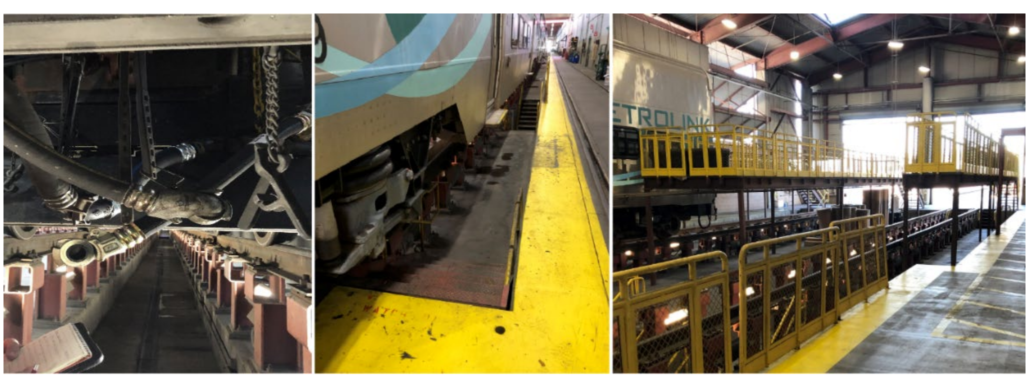
FIGURE 1-A. CAR POSITIONS WITH MULTIPLE LEVEL ACCESS



Progressive Track

- Pits to perform brake and minor maintenance on a train set are desired.

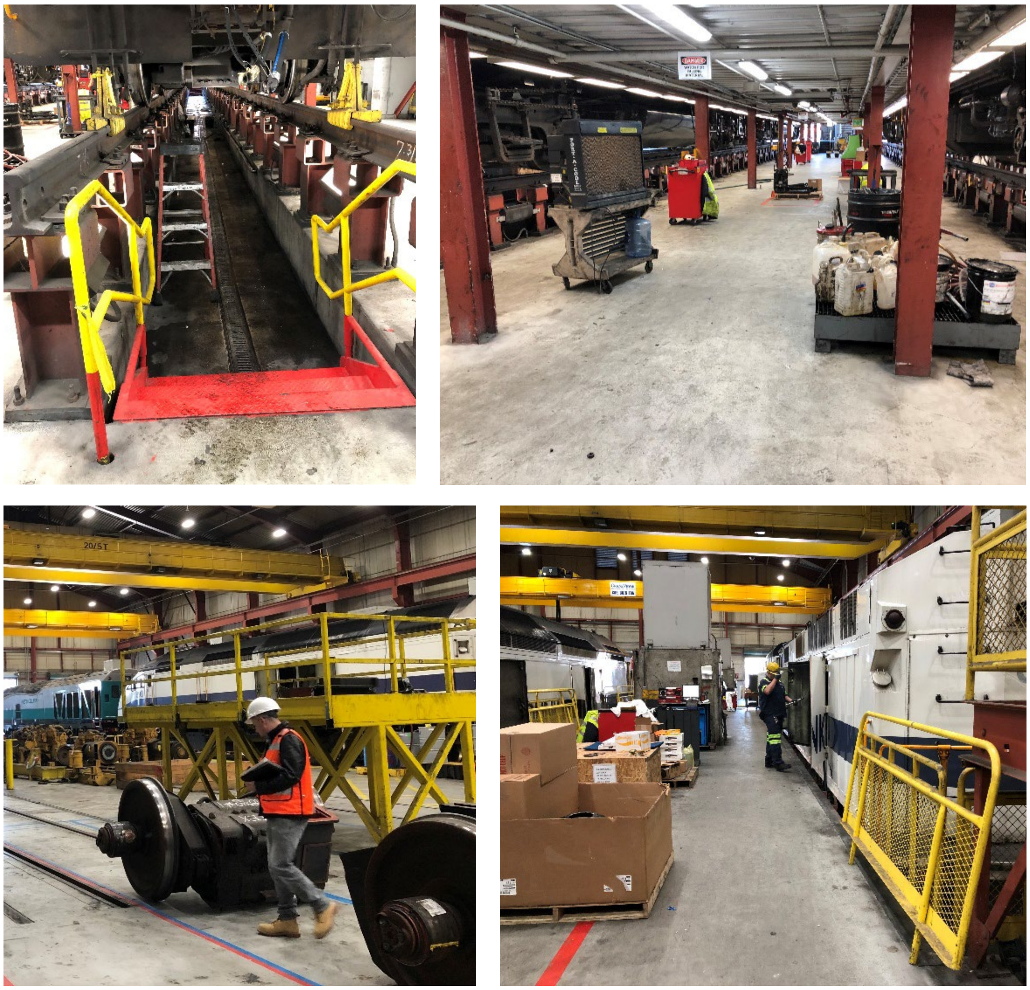
FIGURE 1-B. FULL-LENGTH PITS



Locomotive Position

- Fixed four-level work area allows for complete locomotive service in a single position.

FIGURE 1-C. FIXED FOUR LEVEL WORK AREA



- A drop table is the preferred means of removing and transferring truck sets to the side of the train for maintenance/replacement.

FIGURE 1-D. DROP TABLE

1.3.4 Facilities for Materials Handling Contract Staff

Vertical Lift Modules (VLM)

- Using VLM can save significant square footage and give larger storage capacity.

FIGURE 1-E. VERTICAL LIFT MODULES (VLM)

Stack Systems

- Using Stack Systems can save significant square footage and give larger storage capacity

Figure 1-F. Stack Systems

1.3.5 Facilities for Vehicle Service Areas Contract Staff

Service and Inspection Positions (S&I)

- Platforms at the end of each S&I Position are desired.

FIGURE 1-G. PLATFORMS AT END OF S&I POSITION

- Overhead piped sanding from sand silo to each S&I Position is desired.

FIGURE 1-H. OVERHEAD PIPED SANDING FROM SAND SILO

2.0 SECTION TWO – SPACE NEEDS PROGRAM

2.1 INTRODUCTION

The Space Needs Program illustrates the space requirements for efficient operations. The program is summarized at the end of this section which includes projected square foot needs for building areas and exterior areas. These projected space needs are subtotaled to include site access, landscaping, and setbacks for total site acreage requirements.

2.2 STAFF SUMMARY

Facility staffing levels are crucial to planning efforts when determining the number of parking spaces, size, of support facilities, and developing occupancy levels. The table below is the summary of the facility staffing levels for each department for a Prototypical Layover and Maintenance Facility.

TABLE 2-A. STAFF SUMMARY

Staff/Position	Prototypical
SCRRA PROTOTYPICAL FACILITY WORK SPACE REQUIREMENTS	5
FACILITIES FOR TRAIN OPERATIONS CONTRACT STAFF	956
FACILITIES FOR EQUIPMENT MAINTENANCE CONTRACT STAFF OFFICE AREAS	63
FACILITIES FOR EQUIPMENT MAINTENANCE CONTRACT STAFF SHOP & POSITIONS AREAS	0
FACILITIES FOR MATERIALS HANDLING CONTRACT STAFF	11
FACILITIES FOR VEHICLE SERVICE AREAS CONTRACT STAFF	9
FACILITY MAINTENANCE	20
Total	**1064**

2.3 VEHICLE SUMMARY

The following tables illustrate the parking needs for each department.

TABLE 2-B. RAIL FLEET VEHICLE SUMMARY

Vehicle Type	Prototypical
Passenger Coach and Cab Vehicle (12' x 85')	165
Diesel-electric Locomotive (12' x 70')	55
Total	**220**

TABLE 2-C. NON-REVENUE VEHICLE SUMMARY

Vehicle Type	Prototypical
Small Vehicle Space (10' x 10')	10
Medium Vehicle Space (10' x 20')	10
Large Vehicle Space (12' x 30')	20
Extra Large Vehicle Space (12' x 40')	10
Total	**50**

TABLE 2-D. EMPLOYEE/VISITOR VEHICLE SUMMARY

Vehicle Type	Prototypical
SCRRA PROTOTYPICAL FACILITY WORK SPACE REQUIREMENTS (9' x 18')	5
FACILITIES FOR TRAIN OPERATIONS CONTRACT STAFF (9' x 18')	650
FACILITIES FOR EQUIPMENT MAINTENANCE CONTRACT STAFF (9' x 18')	63
FACILITIES FOR MATERIALS HANDLING CONTRACT STAFF (9' x 18')	11
FACILITIES FOR VEHICLE SERVICE AREAS CONTRACT STAFF (9' x 18')	9
FACILITY MAINTENANCE (9' x 18')	20
Total	**758**

2.4 SPACE STANDARDS AND PLANNING RATIOS

Space standards and ratios are compiled generally for Offices, Support Areas, Shops, Positions, and Vehicle Parking Areas. Planning requirements in Shops and Storage Areas are derived from functional requirements and equipment space needs. The space standards listed below were utilized to develop the base program and overall area requirements.

The following table illustrates the ratios followed throughout the Space Needs Program.

TABLE 2-E. OFFICE SPACE STANDARDS AND PLANNING RATIOS

STAFFING SPACE STANDARDS AND PLANNING RATIOS	
Staff	**Space Standards**
Director	150 SF
Assistant Director	150 SF
Manager	120 SF
Assistant Manager	120 SF
Supervisor	120 SF
Assistant Supervisor	120 SF
Service Worker Supervisor	120 SF
Service Worker	64 SF
Coordinator	64 SF
Environmental Compliance	64 SF
Administrative Assistant	64 SF
Dispatcher	64 SF per Workstation
Conductor	36 SF
Train Engineer	36 SF
Mechanic/Technician	36 SF

TABLE 2-F. PARKING SPACE STANDARDS AND PLANNING RATIOS

PARKING SPACE STANDARDS AND PLANNING RATIOS	
Vehicle	**Space Standards**
Small Vehicle Space	10' x 10'
Employee Parking	9' x 18'
Visitor Parking	9' x 18'
Cleain Air/Electric Vehicle Parking	9' x 18'
Medium Vehicle Space	10' x 20'
Accessible Parking	13' x 18'
Large Vehicle Space	12' x 30'
Extra Large Vehicle	12' x 40'

2.5 CIRCULATION FACTORS

The space requirements shown for each function are net useable area. There are three Circulation factors utilized in the Space Needs Program. These factors are Interior or Building Circulation, Parking Circulation, and Site Circulation Factors.

Currently the Space Needs Program illustrates a one level facility. When site constraints begin to play a factor in the Master Plan designs, going vertical and increasing density will need to be evaluated.

2.5.1 Interior or Building Circulation

This factor is applied to the program as a percentage of the total building square footage. It accounts for miscellaneous building space such as hallways, stairwells, custodial closets, mechanical, plumbing, and electrical rooms, wall thickness, structure (CIrc/Mech/Elec/Strct - Net:Gross), and access requirements. The following is a list of the factors (in general) that shall be considered and applied to the design:

TABLE 2-G. BUILDING CIRCULATION

Area	Circulation Factor
BUILDING AREAS	
SCRRA PROTOTYPICAL FACILITY WORK SPACE REQUIREMENTS	40%
FACILITIES FOR TRAIN OPERATIONS CONTRACT STAFF	20%
FACILITIES FOR EQUIPMENT MAINTENANCE CONTRACT STAFF OFFICE AREAS	20%
FACILITIES FOR EQUIPMENT MAINTENANCE CONTRACT STAFF SHOP & POSITIONS AREAS	50%
FACILITIES FOR MATERIALS HANDLING CONTRACT STAFF	20%
FACILITIES FOR VEHICLE SERVICE AREAS CONTRACT STAFF	20%
FACILITY MAINTENANCE	20%
ENCLOSED VEHICLE PARKING	100%
IN-LINE (STACKED)	*80%*
DOUBLE-DEEP DRIVE-THROUGH	*125%*
ANGLED DOUBLE-DEEP DRIVE-THROUGH	*95%*
EXTERIOR AREAS	
COVERED AREAS	100%
EXTERIOR AREAS	50%
EXTERIOR PARKING AREAS	
COVERED VEHICLE PARKING	100%
IN-LINE (STACKED)	*55%*
DOUBLE-DEEP DRIVE-THROUGH	*105%*
ANGLED DOUBLE-DEEP DRIVE-THROUGH	*70%*
UNCOVERED VEHICLE PARKING	100%
IN-LINE (STACKED)	*50%*
DOUBLE-DEEP DRIVE-THROUGH	*100%*
ANGLED DOUBLE-DEEP DRIVE-THROUGH	*65%*
EMPLOYEE/VISITOR PARKING	100%
SITE CIRCULATION	100%

In addition to the above circulation factors, individual factors are included in the Space Needs Program for each department for Electrical Room, Data/Comm. Room, Mechanical Room, and Fire/Sprinkler Room.

2.5.2 Parking Circulation

This factor is included to account for the drive aisles, walkways, islands, and other areas created by site and access inefficiencies. This factor can vary from 50 to 100 percent of the actual space occupied by a vehicle. The following factors shall be applied to the design:

- Vehicle Parking Areas: 100%

2.5.3 Site Circulation

This factor is applied to the design as a percentage of the total facility square footage. It accounts for areas around buildings, site drive aisles, building access, and site access. For new construction, a 100 percent factor is normally applied on top of interior or building and parking circulation to account for all site inefficiencies. This site circulation can also account for wetlands, stream mitigation, and landscape setbacks, and stormwater facilities. As such, the better the site conditions, access, easement, the more efficient the site layout can become, reducing this factor to as low as 50 percent.

2.6 SPACE NEEDS PROGRAM AND SUMMARY

A summary of the Space Needs Program for a Prototypical Layover and Maintenance Facility is provided in Table 2-H. This summary table includes projected square footage needs for building areas, covered areas, exterior areas, and parking areas. These projected space needs are subtotaled into net square footage requirements and converted to the total site acreage requirements for a Prototypical Layover and Maintenance Facility and any potential residual land area. Site circulation, landscaping requirements, and total acres required are also shown.

The detailed Space Needs Program begins with the identification of each space by name and a space standard with a minimum area (if applicable). The next column identifies prototypical facility requirements. The final column is for any additional information needed to explain what the space requirements are or identify special functions.

The Space Needs Program can be used to develop site master plans and conceptual building plans for a Prototypical Layover and Maintenance Facility. If a potential site is less acreage than the programmed requirements, options such as, vertical stacking of program elements, deeper evaluation of the city and/or county setback, mitigation, landscape requirements, and storm water containment options can be explored.

Table 2-H. Space Needs Program and Compiled Summary

Summary - Space Needs Program 5/4/2020	Prototypical		
	Qty.		Area
	Staff	Space	(SF)
RAIL VEHICLE FLEET	0	220	214,500
BUILDING AREAS			
SCRRA PROTOTYPICAL FACILITY WORK SPACE REQUIREMENTS	5	0	2,554
FACILITIES FOR TRAIN OPERATIONS CONTRACT STAFF	956	0	32,732
FACILITIES FOR EQUIPMENT MAINTENANCE CONTRACT STAFF OFFICE AREAS	63	0	8,244
FACILITIES FOR EQUIPMENT MAINTENANCE CONTRACT STAFF SHOP & POSITIONS AREAS	0	0	142,495
FACILITIES FOR VEHICLE MATERIALS HANDLING CONTRACT STAFF	11	0	45,746
FACILITIES FOR VEHICLE SERVICE AREAS CONTRACT STAFF	9	0	92,242
FACILITY MAINTENANCE	20	0	7,818
ENCLOSED VEHICLE PARKING	0	0	80
EXTERIOR AREAS			
COVERED AREAS	0	0	9,800
EXTERIOR AREAS	0	0	15,740
EXTERIOR PARKING AREAS			
COVERED VEHICLE PARKING	0	10	2,000
UNCOVERED VEHICLE PARKING	0	40	28,000
EMPLOYEE/VISITOR PARKING	0	778	253,539
SUBTOTAL ALL AREAS	1,064		855,490
TOTAL SITE CIRCULATION	100%		855,490
GRAND TOTAL ALL AREAS	1,064		1,710,980
		Acres:	39.28

Appendix E. SCRRA Standard Forms and Checklists

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The following standard forms and checklists are included in this appendix:

E-1. SCRRA REQUEST FOR SPECIAL DESIGN CONSIDERATION FORM

E-2. SCRRA DESIGN CRITERIA COMPLIANCE CHECKLIST

E-3. SCRRA CONSTRUCTION CRITERIA COMPLIANCE CHECKLIST

E-4. SCRRA DESIGN, CONSTRUCTION, AND AS-BUILT SUBMITTAL CHECKLIST

E-5. SCRRA FALSEWORK CRITERIA COMPLIANCE CHECKLIST

E-6. SCRRA REPLACEMENT STRUCTURE RECOMMENDATION FORM

E-7. SCRRA HIGHWAY-RAIL GRADE CROSSING TRAFFIC SIGNAL PREEMPTION REQUEST FORM

E-8. LADOT RAILROAD PREEMPTION FORM EXAMPLE

E-9. SCRRA SHORING SUBMITTAL DESIGN AND REVIEW CHECKLIST

APPENDIX E-1

SCRRA REQUEST FOR SPECIAL DESIGN CONSIDERATION FORM

The following SCRRA Request for Special Design Consideration form (DPM-13) is an example of the form that shall be used to submit requests for variances to SCRRA criteria, as discussed in Section 3.2.2. This form is subject to frequent updates, therefore the designer shall request the latest version of the form from SCRRA to be used when a variances is needed for the project.

METROLINK

REQUEST FOR SPECIAL DESIGN CONSIDERATION FORM

Project Name: ______________________________ Location: __________________________

Project No.: ________________ Contract No.: ____________________

Date: ______________ Reference No.:____________________ Revision:___________

Subject:____

Part 1: To be Completed by Originator

ORIGINATOR	Requested by: ____________________ Title: ______________________ Company: ____	
IMPACTS	Does this Special Design Consideration impact Safety and Operations?	☐ Yes ☐ No
	Does this Special Design Consideration impact Positive Train Control?	☐ Yes ☐ No
	Does this Special Design Consideration conflict with any CPUC/CA MUTCD regulations and requirements?	☐ Yes ☐ No
	Does this Special Design Consideration impact economic, social or environmental issues?	☐ Yes ☐ No
SPECIAL DESIGN CONSIDERATION INFORMATION	Does this Special Design Consideration affect the following? Engineering Standards ☐ Yes ☐ No Specifications ☐ Yes ☐ No Design Criteria ☐ Yes ☐ No Manual Section ☐ Yes ☐ No	
	Description of Special Design Consideration: *(include location, extent of impact, affect on other operations)*	
	Rational for Special Design Consideration: *Reason the appropriate design criteria*	

Project Name:______________________________ Subject:_________________________

	cannot be met (include explanation as to impracticality of compliance with SCRRA standards/criteria/instructions and demonstrate all attempts to comply)
	Mitigation Measures: *Any mitigation that will be provided to further support or justify the request (describe how purpose/intent of SCRRA standards/criteria/instructions will attempt to be met by alternative means)*
REASON FOR REQUEST	**Request for Special Design Consideration must address the following:** • *Established Design Criteria versus proposed and existing criteria* • *Justification for the proposed Criteria* • *Any background information which documents, support or justify the request* • *Safety implication of the request* • *The comparative cost of the full standard versus the lower design being proposed. Show what it would cost to meet the standard for which the Special Consideration is requested* • *Long term effect of the reduced design as compared to the full standard* *(attach additional pages if needed)*

May 2020 Page 2 SCRRA Form DPM-13

Project Name:_______________________________ Subject:__________________________

ATTACHMENTS	*The completed Request for Special Design Consideration Form and all supporting documentation (drawings, reports, and calculations) shall be submitted with all requests for Special Design Considerations. This form (at the end of the last page) and all documentation attached with the request must be stamped and sealed by a Registered California Professional Engineer.* **List all attachments:**

This Request for Special Design Consideration has been prepared under the direction of the following registered professional engineer. The registered professional engineer attests to the technical information contained herein and the engineering data upon which recommendation, conclusion, and decisions are based.

____

Registered Professional Engineer *Date*

Project Name:______________________________ Subject:_________________________

Part 2: SCRRA Response

SCRRA RESPONSE	☐ Approved	*Additional SCRRA requirements upon which approval is granted:*
	☐ Resubmit	*Additional justification, explanation or information required:*
	☐ Rejected	*Reason:*

Part 3: SCRRA Approval Signatures

SCRRA APPROVALS	**Name**	**Date**
	Project Manager	
	Principal Engineer, Design and Engineering	
	Assistant Director, Design	
	Assistant Director, Project Management	
	Assistant Director, Stations and Structures	
	Assistant Director, PTC Technical Services	
	Assistant Director, Track and Structures	
	Chief, Program Delivery	
	Other:	

APPENDIX E-2

SCRRA DESIGN CRITERIA COMPLIANCE CHECKLIST

SCRRA DESIGN CRITERIA COMPLIANCE CHECKLIST

Project Name/Location:____

Submittal Date:____

Design Firm:____

	ITEM	YES	NO	N/A	IF NO, EXPLAIN
1.	DSA has been executed with SCRRA?				
2.	If this is first submittal has meeting been scheduled with SCRRA? A. If not, was previous submittal accepted by SCRRA?				
3.	Plans are signed and sealed by a Professional Engineer licensed in the State of California?				
4.	Affidavit included confirming plans have been checked and received a quality control review?				
5.	Previous review comments addressed and included with submittal?				
6.	SCRRA Director of Engineering and Construction contacted regarding future track and maintenance access requirements? A. If yes, have SCRRA requirements been incorporated into the plans?				
7.	Final horizontal and vertical clearances are compliant with the Criteria? A. If not, has an exception or waiver been formally approved?				
8.	Temporary minimum horizontal and vertical clearances are compliant with the Criteria? A. If not, has an exception or waiver been formally approved?				
9.	Are shoofly plans compliant with SCRRA requirements?				
10.	Proposed construction phasing including construction track windows has been discussed or accepted by SCRRA? A. If yes, has the proposed phasing including accepted track windows have been incorporated into the review or final contract plan set?				

	ITEM	YES	NO	N/A	IF NO, EXPLAIN
11.	Construction demolition plan provided, including sequence and description of procedures and equipment?				
12.	Structure compliant with applicable SCRRA standard grade separation drawing? A. If not, has an exception or waiver been formally approved?				
13.	Project documents include SCRRA Coordination requirements?				
14.	All dimensions and calculations of interest to SCRRA provided in English units?				
15.	Utilities have been located and shown on the plans?				
16.	Are there any SCRRA utilities or signals that need to be accounted for in the design of the structure or falsework? A. If yes, have they been accounted for in the design and coordinated with and approved by SCRRA?				
17.	All foundation elements are compliant with SCRRA Excavation Support Criteria? A. If not, has an exception or waiver been formally approved?				
18.	Does drainage impact SCRRA Right-of-Way? A. If yes, is drainage plan and hydrology report included with submittal?				
19.	Plans indicate proposed methods of erosion control?				
20.	Will temporary highway traffic control be required? A. If yes, is SCRRA's Temporary Traffic Control Criteria referenced?				
21.	Project assessed for vulnerability to climate hazards (sea level rise, riverine flooding, extreme heat, wildfires, drought, landslides/mudslides, earthquakes, and electrical outages) in accordance with DCM Section 3.3? Provide a brief summary of expected impacts and strategies implemented to reduce the vulnerability.				

APPENDIX E-3

SCRRA CONSTRUCTION CRITERIA COMPLIANCE CHECKLIST

SCRRA CONSTRUCTION CRITERIA COMPLIANCE CHECKLIST

Project Name/Location:____
Submittal Date: ____
Design Firm: ____

ITEM	YES	NO	N/A	IF NO, EXPLAIN
1. Submittal signed and sealed by a Professional Engineer licensed in the State of California?				
2. Submittal has been approved by Engineer-of-Record?				
3. Affidavit included confirming submittal has been checked and received a quality control review?				
4. Submittal meets SCRRA requirements shown on relative SCRRA Standard Specification Sections				
5. All dimensions and calculations of interest to SCRRA provided in English units?				

APPENDIX E-4

SCRRA DESIGN, CONSTRUCTION, AND AS-BUILT SUBMITTAL CHECKLIST

DESIGN, CONSTRUCTION, AND AS-BUILT SUBMITTAL CHECKLIST

Project Name/Location:____________________
Submittal Date: ____________________
Design Firm: ____________________

ITEM	YES	NO	N/A	IF NO, EXPLAIN
Concept and Design Criteria (5% Design)				
Submittal checklists, design submittal report, and a list of reports and analyses that should be prepared as a part of conceptual design.				
Conceptual roadway alignments and layouts complete with existing track locations and alignments, and critical Overhead and horizontal clearance dimensions.				
Plan, Elevation, and Typical Section of proposed Grade Separation.				
Identification of ownership for all project Right-of-Way needed for the Grade Separation.				
An initial assembly of utility information affecting the project location using the SCRRA Utilities Matrix. SCRRA is not a member of the Underground Service Alert (USA), and the Agency shall request location of SCRRA utilities from SCRRA.				
Photo log with pictures of the proposed project location. Site pictures shall be in all controlling directions including, but not limited to North, East, South, and West. The plan view should show a reference location and direction for each picture.				
Design criteria, which addresses bridge design, vertical and horizontal clearances, roadway design and track design as applicable (For Underpass only)				
Preliminary Design (30% Design				
Submittal checklists and applicant responses to SCRRA review comments on the concept submittal. The submittal shall reflect concept review comments				
Identification of all stakeholders and incorporation of their input into the Grade Separation plans				
Updated Preliminary Design Plans showing a Plan View, Elevation View, Typical Section, and Top-of-Rail Profile Grade Diagram for existing track(s) 1000 feet each way from the proposed Overhead Structure centerline. Plans to include general notes and indicate structure design criteria and construction methods. Include existing Grade Crossing locations with roadway elevations, and other Grade				

Separations, with existing vertical clearance dimension over existing track(s), within one (1) mile of the proposed Overhead structure				
Preliminary Project Specifications, including SCRRA coordination requirements				
Preliminary Geotechnical Report (For Underpass only)				
Preliminary Drainage Report				
Preliminary Shoofly Design, if required. The general plan shall show the location of the Shoofly, if a Shoofly is required, and indicate the footprint of the proposed Overhead Structure in relation to the centerline of Shoofly and existing track(s)				
Preliminary Construction Phasing Plans. Construction Phasing Plans must show all required phasing, track windows, and construction procedures				
Identify any potential conflicts with existing signal system				
Preliminary Shoring and Falsework Designs				
Design criteria (updated) (For Underpass only)				
Interim Design (60% Design)				
Submittal checklists and applicant responses to SCRRA review comments on the Preliminary Design (30% Design) submittal. The Interim Design (60% Design) submittal shall reflect the Preliminary Design (30% Design) submittal review comments				
Design Plans and calculations, including: Superstructure and Substructure details; bearing details; deck and waterproofing details; miscellaneous bridge details; and a complete set of structural calculations (For Underpass only)				
Revisions to Geotechnical Report/recommendations (For Underpass only)				
Updated Design Plans				
Revisions to Project Specifications and/or Special Provisions, including SCRRA coordination requirements				
Revisions to Drainage Report				
Revisions to Shoofly Design, if a shoofly is required				
Revisions to Construction Phasing Plans including track windows				
Revisions to Shoring and Falsework Design				
Design criteria (updated) (For Underpass only)				

Pre-Final Design (90% Design)				
Submittal checklists and applicant responses to SCRRA review comments on the Interim Design (60% Design) submittal. The Pre-Final Design (90% Design) submittal shall reflect the Interim Design (60% Design) submittal review comments				
Updated Design Plans and calculations				
Revisions to Project Specifications and/or Special Provisions, including SCRRA coordination requirements				
Revisions to Drainage Report				
Revisions to Shoofly Design, if a shoofly is required				
Revisions to Construction Phasing Plans including track windows				
Revisions to Shoring and Falsework Designs				
Design criteria (updated) (For Underpass only)				
Final Design (100% Design)				
Submittal checklists and applicant responses to SCRRA review comments on the Pre-Final Design (90% Design) submittal. The Final Design (100% Design) submittal shall reflect the Pre-Final Design (90% Design) submittal review comments				
Final Design Plans with agreed upon track windows annotated on the contract drawings				
Final Geotechnical Report/Recommendations (For Underpass only)				
Final Project Specifications and/or Special Provisions, including SCRRA coordination requirements				
Final Drainage Report				
Final Shoofly Design, if a Shoofly is required				
Final Construction Phasing Plans including agreed upon track windows				
Final Shoring and Falsework Designs				
Design criteria (updated) (For Underpass only)				
Construction				
Shoring				
Falsework Erection and Removal				
Demolition				
Erection				

Erosion Control				
Construction Phasing Plan				
Site Specific Work Plan (SSWP)				
Bearing Shop Drawings and Material Certifications (For Underpass only)				
Concrete Mix Design (For Underpass only)				
Structural Steel, Rebar and Strand Certifications (For Underpass only)				
28-day Cylinder Test of Concrete Strength (For Underpass only)				
Waterproofing Material Certification (For Underpass only)				
Test Reports for Fracture Critical Members (For Underpass only)				
Foundation Construction Reports (e.g.: Pile Driving Records, Caisson Drilling, and/or Crosshole Sonic Log Testing for Drilled Shafts) (For Underpass only)				
As-Built				
As-Built Plans and Construction Documents				
Shop Drawings				
Pile Driving Records				

APPENDIX E-5

SCRRA FALSEWORK CRITERIA COMPLIANCE CHECKLIST

SCRRA FALSEWORK CRITERIA COMPLIANCE CHECKLIST

Project Name/Location: ______________________________
Submittal Date: ______________________________
Design Firm: ______________________________

ITEM	YES	NO	N/A	IF NO, EXPLAIN
1. Are the falsework details and the method and procedure for installation and removal clearly shown and described on the plans?				
2. Are the designed horizontal and vertical clearance dimensions provided on the plans?				
3. If the SCRRA train signals are within ½ mile of the falsework have provisions been made to verify that there is clear sight distance for train operations?				
4. Are collision posts to protect falsework provided on the plans when falsework is located within 25 feet to the centerline of any adjacent track(s)?				

APPENDIX E-6

SCRRA REPLACEMENT STRUCTURE RECOMMENDATION FORM

The following SCRRA Replacement Structure Recommendation Form will be used to present relevant data regarding the hydrology, existing structure hydraulics, and proposed structure hydraulics, as discussed in Chapter 9, Drainage and Grading, of this DCM.

REPLACEMENT STRUCTURE RECOMMENDATION FORM

☐ Br. ☐ Culv. ☐ Siph.	MP:		Subdivision:		
State:			County:		
Latitude:	° ‘ N		Longitude:	° ‘ W	
Hydraulic Engineer:			Office:		
East Near Station:			Terminal Station:		
West Near Station:			Terminal Station:		
Date Assigned:		Date Presented:		Date Approved:	

SITE RECONNAISSANCE

Description of Existing Structure:

Date of Site Visit: Number of Tracks:

T/Rail Survey Req’d: ☐ Yes ☐ No Roadway/Cattle Pass: ☐ Yes ☐ No

Track Profile: ☐Uniform ☐Sag ☐Crest

Track Alignment: ☐Tangent ☐Curve Left ☐Curve Right

Structure Purpose: ☐ Equalizer ☐ Conveyance ☐ Irrigation

Skew Angles from a Normal to Track: Culvert: Bridge Abutments: Piers:

Bridge Abutments: ☐ Vertical ☐ Spill Slope ☐ Eroded ☐ Riprapped

Culvert Outlet: ☐ Projecting ☐ End Treatment ☐ Scoured ☐ Riprapped

Piers/Piling: ☐ Timber ☐ Steel ☐ Concrete ☐ Scoured ☐ Riprapped

Visual Characterization of Channel Bed & Banks Soil Type:

Stream: ☐ Flowing ☐ Dry ☐ Headcut D/S? (Height: ______)

Jurisdictional Waterway: ☐ Yes ☐ No Reason: ☐ Borrow Pit ☐ No Stream Connection

Approximate Water Depth at Ordinary High Water:

Evidenced by: ☐ Vegetation ☐ Detritus ☐ Other:

Observed Wetlands Areas: ☐Yes ☐No Description:

Relevant Hydraulic Structures: Upstream:

Downstream:

Adjacent RR Str(s):

Upstream Low Damage: Elevation:

Description:

Field Team Preliminary Recommendation (If Any):

Other Comments:

Stream Name: Blue Line on Quad: ☐ Yes ☐ No

USGS Quadrangle:

Methodology Name: ☐ Peak Flow ☐ Hydrograph Method

Total Drainage Area: Total Flow Length:

Average Slope: Total Time of Concentration:

No. of Subareas: Infiltration Method & Value:

Land Use: Percent Urbanized:

Design Storm Duration: Design Storm Distribution:

Design Storm Intensity- 50-yr: in/hr 100-yr: in/hr

Design Discharges:

Q_{50}	cfs
Q_{100}	cfs

Special Factors Influencing Hydrologic Response:

Other Comments:

EXISTING HYDRAULICS

Classification of Track: ☐ Mainline ☐ Other ___________________

Governing Criteria: Low Chord: ☐ 25-yr WSEL ☐ 50-yr WSEL

Subgrade: ☐ 50-yr EGL ☐ 100-yr EGL

Hydraulic Methodology: Datum:

Existing Bridge Piling Type and Size:

Bridge Backwalls: ☐ Vertical ☐ Sloping

Low Chord or Soffit Elev. At Lowest Point (Describe Location):

Base of Rail Elevation (Describe Location):

Upstream Face Channel/Culvert Invert Elevation:

Downstream Face Channel/Culvert Invert Elevation:

Controlling Subgrade Elevation Value: ☐ Computed ☐ Surveyed ☐ Design

Hydraulic Control Location: ☐ Upstream ☐ Downstream ☐ Mixed

Description of Control:

Water Surface Elevations:

		50-Year		100-Year	
Description	**Section Number**	**Water Surface Elevation**	**Δ From Criteria***	**Water Surface Elevation**	**Δ From Criteria***
Downstream					
U/S Face of D/S Str. (if any)					
Downstream Face (Repl.)					
Downstream Face (Exist.)					
Upstream Face (Exist.)					
Upstream Face EGL (Exist.)					
Upstream Face (Repl.)					
Upstream Face EGL (Repl.)					
U/S Face of U/S Str. (if any)					
Upstream					

Does Existing Structure Meet SCRRA Criteria: 50 YR ☐ Yes ☐ No 100-YR ☐ Yes ☐ No

Maximum Average Velocity at Structure (fps): 50-YR: 100-YR:

Is Structure in a FEMA Floodplain: ☐ Yes ☐ No In Floodway: ☐ Yes ☐ No

Floodplain Designation Zone:

Other Comments:

* Delta is found by subtracting the reference elevation (low chord, soffit, or subgrade) from the water surface elevation (i.e. negative indicates criterion is met).

RECOMMENDATION

Proposed Replacement Structure:

Special Considerations Identified in Developing Replacement:

Classification of Track: ☐ Mainline ☐ Other ___________________

Governing Criteria: Low Chord: ☐ 25-yr WSEL ☐ 50-yr WSEL
Subgrade: ☐ 50-yr EGL ☐ 100-yr EGL

Limiting Criterion: ☐ Low Chord ☐ Subgrade ☐ FEMA ☐ High Tailwater ☐ Other:

Variance from Criteria: Approved By:

Assumed Ties: ☐ Timber ☐ Concrete

Base of Rail Raise: ☐ Yes ☐ No Amount:

Replacement Low Chord or Soffit Elevation at Lowest Point:

Base of Rail at Lowest Point:

Controlling Subgrade Elevation:

Upstream Face Channel/Culvert Invert Elevation:

Downstream Face Channel/Culvert Invert Elevation:

Change in Invert Elevation: ☐ Yes ☐ No Amount:

Culvert Length: Culvert Cover at U/S Face:

Water Surface Elevations:

Description	Section Number	50-Year			100-Year		
		W.S. Elev.	Δ From Criteria	Δ From Existing	W.S. Elev.	Δ From Criteria	Δ From Existing
Downstream							
U/S Face of D/S Str.							
D/S Face (Repl.)							
U/S Face (Repl.)							
U/S Face EGL (Repl.)							
U/S Face of U/S Str.							
Upstream							

Impact to Low Damage Elevation:

Operation During Extreme Event:

Maximum Average Velocity at Structure (fps): 50-YR: 100-YR:

Change (+ -) from Existing (fps): 50-YR: 100-YR:

Require Channel Re-alignment: ☐ Yes ☐ No

Inlet/Outlet End-Treatment Assumed for Culvert Design: ☐ Yes ☐ No ☐ N/A

For Culvert Replacement, Will Culverts Fit Beneath Low Chord: ☐ Yes ☐ No ☐ N/A

Standard Bridge Abutment Stability Berms Used: ☐ Yes ☐ No ☐ N/A

Other Comments:

APPENDIX E-7

SCRRA HIGHWAY-RAIL GRADE CROSSING

TRAFFIC SIGNAL PREEMPTION REQUEST FORM

SCRRA Highway-Rail Grade Crossing Traffic Signal Preemption Request Form

The purpose of this form is to document the preemption operation and timing parameters being requested by the Highway Agency responsible for the traffic signal and convey the information to SCRRA. SCRRA recognizes that the Highway Agency is the final authority regarding the design and operation of the preemption system that is to be designed in accordance with the CA MUTCD Chapter 8C, Section 8C.09.

Please provide the following information:

Date of Request: ______________________ Highway Agency: ______________________

Requested by (Name/Title): ______________________

Phone: ______________________ Email: ______________________

Grade Crossing Information:

Crossing Street Name: ______________________

City: ______________________ County: ______________________

RR Subdivision: ______________________ Mile Post: ______________________

DOT #: ______________________

RR Interconnection Information:

1) Requested Interconnection Configuration: Single Break Circuit Double Break Circuit

2) Is this request for Simultaneous Preemption Operation? Yes No If "Yes" what is the requested Additional Warning Time? ________Sec

3) Is this request for Advanced Preemption Operation and Circuitry? Yes No If "Yes" what is the requested Additional Preemption Time (APT)? ________Sec

4) Is this request for Advanced Pedestrian Preemption (APP) Operation and Circuitry?* Yes No If "Yes" what is the requested Additional Pedestrian Preemption Time (APPT)? ________Sec

**Note: Request for APP Operation will* require *approval from SCRRA through a Special Design Consideration. Pedestrian Detection is required when using APP Operation.*

5) Indicate below which additional circuits are being requested:

a. Supervised Circuit	Yes	No
b. Gate Down Circuit	Yes	No
c. Crossing Active Circuit (XR)	Yes	No
d. Traffic Signal Health Circuit	Yes	No

6) Indicate the interconnection wire size and number of conductors:________AWG and _______ conductors

Additional Info:

If you have additional or enhanced preemption operation/interconnect requirements, please submit a detailed description with this request form. A circuit drawing or additional information should be provided to assist SCRRA in accommodating your needs.

SCRRA will provide the railroad circuit design to Highway Agency for review prior to finalizing the railroad circuit design. Highway Agency agrees to provide traffic signal timing and wiring diagram for traffic controller unit to SCRRA.

Please sign and submit electronically along with support documentation to SCRRA.

______________________ ____________

Signature of Agency representative Date

____

Print or Type Name of Agency representative

January 2021

APPENDIX E-8

LADOT RAILROAD PREEMPTION FORM EXAMPLE

The following LADOT Railroad Preemption Form is an example of the form that shall be used to submit requests for railroad preemption timing, as discussed in Chapter 8 of this DCM. This form must be filled out electronically, therefore the designer shall request an electronic copy of the form from SCRRA to be used for the project.

LADOT Railroad Preemption Form Instructions

The LADOT Railroad Preemption Form is entirely contained on one worksheet within an Excel workbook. If Additional approaches to the crossing are analyzed, the worksheet can be copied within the workbook to provide the appropriate analysis of the crossing.

Section 1 consists of the entries specific to the highway and traffic signal system.

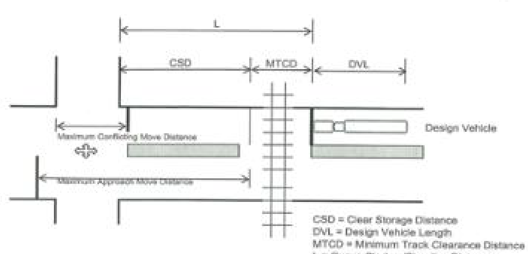
Part 1 contains entries for Maximum Approach Move Distance, Maximum Conflicting Move Distance, Minimum Track Clearance Distance (MTCD), Clear Storage Distance (CSD) and Grade. The Maximum Approach Move Distance is the distance (in feet) from the farthest intersection limit line towards the crossing. The Maximum Conflicting Move Distance is the longest distance (in feet) across the adjacent intersection that crosses the path of the track clearance phase. These are used to determine the time require for a design vehicle to clear the intersection prior to activation of the railroad warning devices or display of track clearance green. If these moves are on an uphill grade, enter the percent grade in the adjacent box labeled Grade. The MTCD is defined to be the distance (in feet) from the railroad warning device limit line or gate to a point 6 feet past the far rail. The CSD is the distance (in feet) from a point 6 feet past the far rail to the intersection limit line. The sum of the MTCD and CSD values determine the length (L). This is the total distance from the railroad warning device limit line or gate to the intersection limit line. If there is an uphill grade at the crossing, enter the percent grade in the adjacent box labeled Grade.

Part 2 contains information specific to the vehicle characteristics used in the calculation of the MTCD Queue Clearance Time. The default values provided on the form are standard for the types of vehicles shown. These should not be changed unless evaluation of specific vehicle lengths and heights is required. The information regarding the vehicle characteristics is used in the calculation of the vehicle times below the characteristic cells. These values are computed by the spreadsheet and cannot be changed by the user. The row beneath these calculated cells provides an “Include as Design Vehicle?” Yes/No selection for each vehicle type. If the roadway is restricted to certain classes of vehicles, the user may choose to not include a particular type of vehicle by selecting “No”. Typically, all vehicle types should be included in the calculations if they are permitted on the highway.

Part 3 contains the calculations for Green Track Clearance Time and MTCD Queue Clearance Time. These are displayed in the green and pink boxes immediately below the Part 2. These are the minimum amount of time necessary to display a track clearance green to clear the MTCD of a queue of vehicles.

Part 4 contains the entries specific to traffic signal timing.

a. The Minimum Walk time is the minimum amount of walk time that must be completed prior to entry into railroad preemption. This can be set to zero or more seconds based on the desired operation of the traffic signal during entry into preemption.
b. The Maximum Ped Clear is the longest pedestrian clearance time that must be completed prior to entry into preemption. This can be set to zero or more seconds based on the desired operation of the traffic signal during entry into preemption. This is typically the Flashing Don't Walk time setting in the controller.
c. The Minimum Green is the minimum amount of time a green signal must be displayed prior to entry into railroad preemption. This can be set to zero or more seconds based on the desired operation of the traffic signal during entry into preemption.



LADOT Railroad Preemption Form Instructions

d. The Maximum Yellow + All Red is the maximum amount of yellow and all red time that must be displayed prior to entry into preemption. This must be set to 3.0 seconds or more based on the traffic signal controller time settings.
e. The Maximum RWTT (Right of Way Transfer Time) is calculated as the maximum amount of time it takes the controller to transfer from its current phase to the railroad track clearance phase based on the timing parameters entered above.
f. Separation Time (ST) is additional time that can be provided between the time the traffic clears the track and the train arrival at the crossing. This is determined by the engineering judgment, and can be set to zero or more second. Values of 4 to 8 seconds are typically used.
g. The Maximum Preemption Time (MPT) is calculated to be the total of MTCD Queue Clearance Time, Maximum RWTT and Separation Time (ST). This is how much time in advance of a train arriving at the crossing that the traffic signal needs to be notified to provide sufficient track clearance green time.

Section 2 consists of the entries specific to the railroad warning system. These can be obtained from the railroad at existing crossings or determined with the railroad for new designs.

a. The Lights Flash time is the amount of time the railroad warning lights flash once activated before the gates begin to descend. This must be set to at least 3 seconds and can be as high a 9 seconds.
b. The Gate Descent time is the amount of time it takes the entrance gates to move from the vertical position to the horizontal position. This must be set to at least 8 seconds and can be as high as 20 seconds.
c. The Minimum Time (MT) is the minimum amount of time the crossing warning system is activated prior to train arrival at the crossing. This must be set to at least 20 seconds.
d. Clearance Time (CT) is additional warning time provided for wide crossings or other site-specific conditions. This can be set to zero or more seconds. Based on the MTCD entered at the top of the form, a minimum suggested value will be displayed to the right of this entry. The suggested value is based on the requirement that crossings more than 35 feet wide need an one second of Clearance Time for each additional 10 feet of width.
e. Minimum Warning Time (MWT) is computed from these entries, which is the minimum amount of time that the warning system is activated prior to train arrival at the crossing.
f. Buffer Time (BT) is discretionary time added by the railroad to account for train handling. This can be set to zero or more seconds.
g. Total Warning Time (TWT) is obtained by adding Buffer Time (BT) to Minimum Warning Time (MWT), which is the normal amount of warning time in advance of a through train arriving at the crossing
h. The entry “Include vehicle-gate interaction check?” is a Yes/No selection that the user can choose to adjust the Advance Preemption Time (APT) so the largest design vehicle will not be hit by the gates. This check is optional, but highly recommended to ensure that the design vehicle has sufficient time to move out of the path of the descending gates.
i. The “Distance from gate to vehicle” is required with a “Yes” selection on item h. This is the distance between the side of the design vehicle and the center of gate mast. This must be set to at least 4 feet and can be as much as 20 feet depending on lane width and gate setback.

The resultant Advance Preemption Time (APT) is shown in the purple box, and represents the time before warning system activation that the traffic signal needs to be notified of an approaching train to provide sufficient queue clearance time. If the vehicle gate interaction check is set to No, then the Advance Preemption Time (APT) is the difference between the Maximum Preemption Time (MPT) and the Minimum Warning Time (MWT). If the vehicle-gate interaction check is set to “Yes”, then the Advance Preemption Time (APT) is calculated so the largest design vehicle has enough time to start up and move before the descending gate hits the vehicle. This will usually result in a larger Advance Preemption Time (APT) than when the vehicle-gate interaction check is not performed. This may adjust the Green Track Clearance time and the Separation Time (ST) to account for the additional Advance Preemption Time (APT). A note is shown in red on the form if an adjustment is made.

The last two railroad parameters are use to determine the length of approach circuits necessary to provide the calculated Advance Preemption Time (APT).

LADOT Railroad Preemption Form Instructions

a. The Equipment Response Time (ERT) is the amount of time the railroad train detection equipment needs once a train has entered the track circuit before it can be acted upon. This can be set to zero or more seconds, and is typically between 2 and 5 seconds depending on the type of train detection equipment used.
b. Total Approach Time (TAT) is obtained by adding the Equipment Response Time (ERT) to the Total Warning Time (TWT)
c. Maximum Authorized Speed (MAS), is the highest speed trains are allowed to operate on the approach to the crossing. This must be set to at least 5 miles per hour and can be as high as 100 miles per hour.
d. The Total Approach Distance (TAD) is obtained by multiplying the Total Approach Time (TAT) by the Maximum Authorized Speed (MAS). This is the required length of the approach circuit.

Preemption Timeline

With the data entry completed, the Preemption Timeline will display the time relationships between the railroad Warning Device, Traffic Signal and the Design Vehicle. The timeline is read from right to left, with the leftmost time zero being train arrival at the crossing. The timeline is a graphical representation of the sequence of events leading up to the train arriving at the crossing, and can be used to determine if the preemption timings entered are adequate.

If a Phase Omit interval is shown on the Traffic Signal timeline, then the Maximum Approach Move Distance and/or the Maximum Conflicting Move Distance govern the advance preemption time at the intersection. This means that the traffic signal should not start the approach or conflicting moves during this time to prevent a design vehicle from being stopped at the crossing or blocking the track clearance phase. Appropriate settings in the traffic signal controller should be made to account for this situation at the start of the preemption.

Note that the Green Track Clearance time shown on the Preemption Timeline may be less than the value calculated on the form if it extends beyond the arrival of the train at the crossing. This can occur when a large Clear Storage Distance (CSD) exists, and the value shown on the form should be used for the track clearance green time. Also note that the MTCD Queue Clearance Time calculated on the form is shown in two parts on the preemption timeline: Queue Startup and Queue Clearance. This illustrates the portion of time that is needed before the last design vehicle within length begins to move as well as the time it takes the design vehicle to move through the MTCD. The sum of these two parts is equal to the MTCD Queue Clearance Time shown on the form.

Below the timeline is the “Preemption Timeline displays Minimum RWTT?” Yes/No selection box. Normally this is set to “No” and the preemption timeline displays the worst-case Maximum RWTT time that was used to determine the Advance Preemption Time (APT). Selecting “Yes” will cause the timeline to display the best-case Minimum RWTT time, and can be used to show the variability in preemption timing. Care should be taken when the Maximum RWTT time is large to ensure that track clearance green does not end prior to the warning system activation or vehicles may become trapped on the tracks. If the vehicle-gate interaction check is set to “Yes”, then track clearance green is automatically extended to the point when the gates are horizontal to specifically prevent vehicles from becoming trapped on the tracks. This requires either the programming of a longer track clearance green time, the use of a controller that is capable of dynamically adjusting the track clearance green time to account for RWTT variability, or an interconnection between the railroad system and the traffic signal that does not allow the track clearance green to end until the gates are down.

LADOT Railroad Preemption Form

Revised 1/25/2008

Street Name:	Crossing St	Crossing No:	

Section 1: Highway and Traffic Information

Part 1:

Maximum Approach Move Distance	90	ft	Grade	0.0	%
Maximum Conflicting Move Distance	145	ft	Grade	0.0	%
Minimum Track Clearance Dist, MTCD	35	ft	Grade	0.0	%
Clear Storage Distance, CSD	5	ft			
Queue Start-up/Stop line Distance, L	**40**	ft			

Part 2:

	Car	Truck	Bus	Semi	
Vehicle Length (ft)	15	30	40	65	
Vehicle Height (ft)	5	14	11	14	
Queue Space (ft/veh)	21	36	46	71	
Vehicles within L (veh)	1	1	0	0	
Start moving last vehicle in L (sec)	**3.9**	**3.9**	**2.7**	**4.0**	**4**
Move front of vehicle thru L (sec)	4.1	4.5	3.8	8.5	9
Move entire vehicle past gate (sec)	2.4	3.9	3.8	11.0	11
Move entire vehicle thru MTCD (sec)	**4.6**	**5.9**	**5.4**	**13.7**	**14**
Non-interaction gate descent time (sec)	10.1	2.9	4.0	2.9	3
Approach vehicle clearance time (sec)	8.9	9.6	8.6	17.0	17
Conflicting vehicle clearance time (sec)	11.2	12.7	11.4	24.1	24
Include as Design Vehicle?	**Yes**	**Yes**	**Yes**	**Yes**	Use

Part 3:

Green Track Clearance Time	**24**	sec	*Green Track Clearance extended to Gate Down*
MTCD Queue Clearance Time	**18**	sec	
Minimum Walk	0	sec	
Maximum Ped Clearance	12	sec	
Minimum Green	0	sec	
Maximum Yellow + All Red	6.0	sec	
Maximum RWTT	**18**	sec	
Separation Time, ST	5	sec	*See Preemption Timeline for actual Separation Time*
Maximum Preemption Time, MPT	**41**	sec	

Section 2: Railroad Information

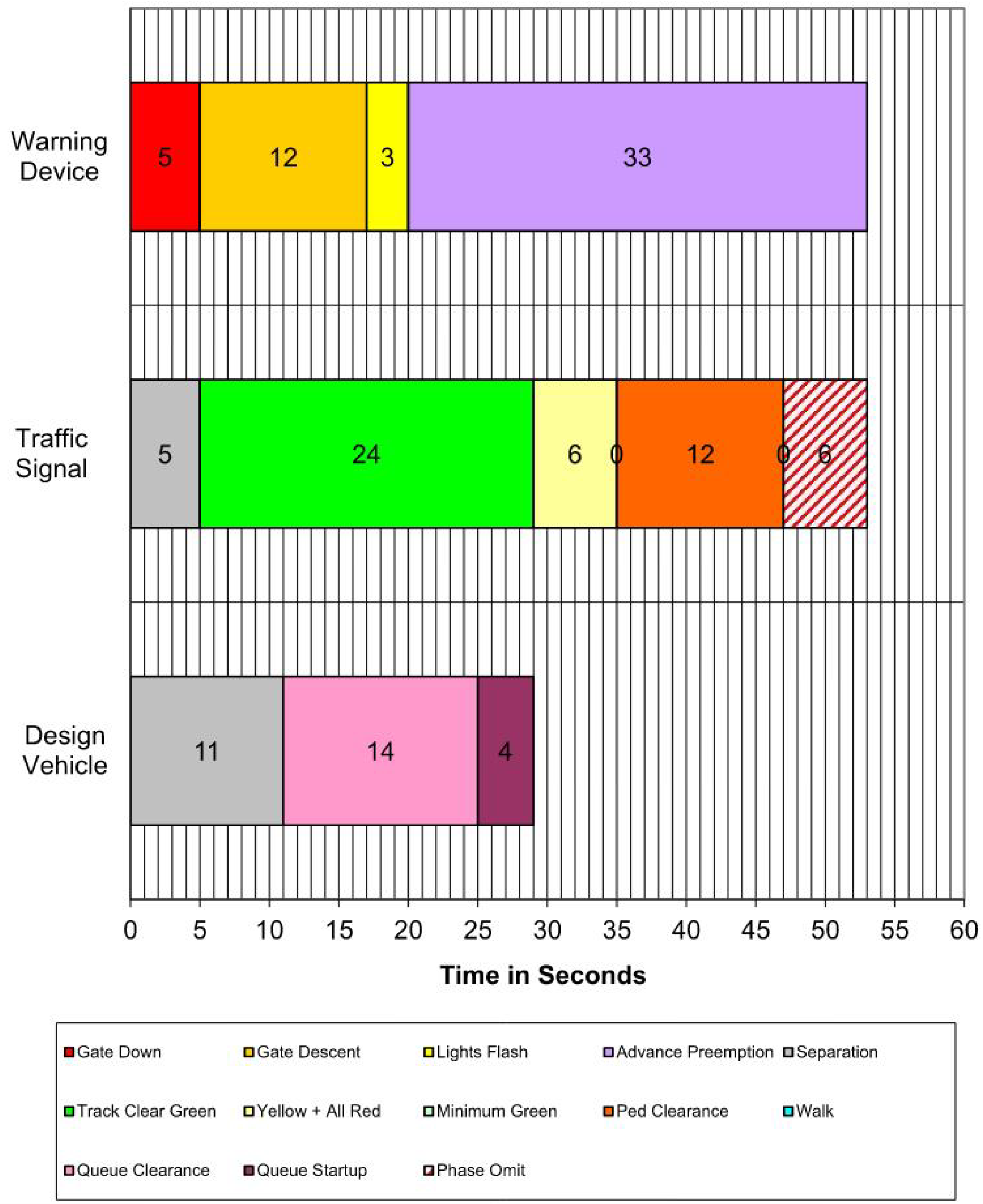
Lights Flash	3	sec	
Gate Descent	12	sec	
Minimum Time, MT	20	sec	
Clearance Time, CT	0	sec	0 sec minimum
Minimum Warning Time, MWT	**20**	sec	
Buffer Time, BT	10	sec	
Total Warning Time, TWT	**30**	sec	
Include vehicle-gate interaction check?	**Yes**		
Distance from gate to vehicle	4	ft	
Advance Preemption Time, APT	**33**	sec	
Equipment Response Time, ERT	5	sec	
Total Approach Time, TAT	**68**	sec	
Maximum Authorized Speed, MAS	79	mph	
Total Approach Distance, TAD	**7879**	ft	

Southern California Regional Rail Authority

LADOT Railroad Preemption Form Revised 1/25/2008

Street Name:	Crossing St	Crossing No:	

Preemption Timeline



Preemption Timeline Displays Minimum RWTT? **No**

APPENDIX E-9

SCRRA SHORING SUBMITTAL DESIGN AND REVIEW CHECKLIST

Design Checklist

The shoring designer shall complete, seal, sign, and submit the enclosed Shoring Submittal Design Checklist with the shoring design submittal.

Review Checklist

The enclosed Shoring Submittal Review Checklist shall be utilized by SCRRA staff or consultants to aid the review of shoring design submittals.

SCRRA SHORING SUBMITTAL DESIGN CHECKLIST

Project Name/Location:____

Submittal Date: ____

Shoring Design Firm: ____

Contractor: ____

Item	**Yes/No/NA**	**Explain if No or NA**
Drawings – Checked, Signed & Sealed?		
1. Drawings to-scale?		
2. Plan view is oriented correctly and shows relative position of shoring/excavation and tracks, railroad stationing and mileposts, and all pertinent Operating System facilities (surface and underground)?		
3. Section normal to track(s) shows elevations of track(s), ground surface, excavation subgrade, bracing elements and horizontal clearances?		
4. Dimensions defining the arrangement of all elements of shoring system provided?		
5. Sizes of all shoring elements provided?		
6. All connections detailed?		
7. Specifications for all materials provided?		
8. Specifications and requirements for fabrication and installation provided?		
9. Construction sequence(s) detailing all steps in the shoring installation, excavation, planned installation equipment location and shoring removal provided?		
10. Track monitoring requirements specified?		
11. Impacts to existing drainage addressed?		
Design Calculations – Checked, Signed & Sealed?		
General:		
1. Design calculations provided for all elements of the shoring system?		
2. Calculations for all stages of excavation and support removal?		
3. Shoring designer has verified the accuracy, suitability, and applicability of the information and criteria outlined in the Excavation Support Guidelines for the specific application being designed?		

<u>SCRRA SHORING SUBMITTAL DESIGN CHECKLIST</u> (CONTINUED)

<u>Item</u>	**Yes/No/NA**	**Explain if No or NA**
Loading:		
4. Soil loading (active and passive) developed in accordance with Section 15.6.2 of the DCM?		
5. Groundwater loading developed in accordance with Section 15.6.3 of the DCM?		
6. Surcharge loading (other than railroad surcharge) developed in accordance with Section 15.6.4 of the DCM?		
7. Seismic loading considered?		
8. Railroad live load surcharge developed in accordance with Section 5 of the Excavation Support Guidelines?		
9. All required loads considered in shoring analysis?		
Analysis:		
10. Shoring wall analyzed in accordance with Section 15.7 of the DCM?		
11. Bracing loads determined in accordance with Section 15.8 of the DCM?		
12. Embedment depth of wall determined in accordance with Section 15.8 of the DCM?		
13. Bracing system analyzed in accordance with Section 15.8.6 of the DCM?		
14. Lagging analyzed in accordance with Section 15.8.7 of the DCM?		
15. Secondary bracing, connections, and stiffeners analyzed and provided in accordance with Section 15.8.8 of the DCM?		
16. Shoring deflection and settlement estimated in accordance with Section 15.8.9 of the DCM?		
Material Properties and Allowable Stresses:		
17. Material properties and allowable stresses in accordance with Section 15.9 of the DCM?		

SCRRA SHORING SUBMITTAL DESIGN CHECKLIST (CONTINUED)

Item	Yes/No/NA	Explain if No or NA
Special Conditions:		
18. Is external dewatering proposed?		
a. If yes, has dewatering been accepted by SCRRA?		
b. If yes, has a settlement analysis (due to dewatering) been provided?		
19. Has the potential for piping been evaluated?		
20. Has potential for heave been evaluated?		
21. Has global stability of the shoring system been evaluated?		
22. Are tiebacks proposed?		
a. If yes, has SCRRA accepted their usage?		
b. If yes, are they designed and will they be tested in accordance with Section 15.10.4 of the DCM?		
23. Are deadmen proposed?		
a. If yes, has SCRRA accepted their usage?		
b. If yes, has third party approval been granted?		
c. If yes, are they designed in accordance with Section 15.10.5 of the DCM?		

____

Shoring Designer Signature

____

Print Name

____

Place Engineering Seal Above

SCRRA SHORING SUBMITTAL REVIEW CHECKLIST

Project Name/Location:____

Date:____

Name of Reviewer:____

Item	**Yes/No/NA**	**Explain if No or NA**
Drawings – Signed & Sealed?		
1. Drawings to-scale?		
2. Plan view is oriented correctly and shows relative position of shoring/excavation and tracks, railroad stationing and mileposts, and all pertinent Operating System facilities (surface and underground)?		
3. Section normal to track(s) shows elevations of track(s), ground surface, excavation subgrade, bracing elements and horizontal clearances?		
4. Dimensions defining the arrangement of all elements of shoring system provided?		
5. Sizes of all shoring elements provided?		
6. All connections detailed?		
7. Specifications for all materials provided?		
8. Specifications and requirements for fabrication and installation provided?		
9. Construction sequence(s) detailing all steps in the shoring installation, excavation, planned installation equipment location and shoring removal provided?		
10. Track monitoring requirements specified?		
11. Impacts to existing drainage addressed?		
Design Calculations – Signed & Sealed?		
General:		
1. Design calculations provided for all elements of the shoring system?		
2. Calculations for all stages of excavation and support removal?		
3. Shoring designer has verified the accuracy, suitability, and applicability of the information and criteria outlined in the Excavation Support Guidelines for the specific application being designed?		

SCRRA SHORING SUBMITTAL REVIEW CHECKLIST (CONTINUED)

Item	Yes/No/NA	Explain if No or NA
Loading:		
4. Soil loading (active and passive) developed in accordance with Section 15.6.2 of the DCM?		
5. Groundwater loading developed in accordance with Section 15.6.3 of the DCM?		
6. Surcharge loading (other than railroad surcharge) developed in accordance with Section 15.6.4 of the DCM?		
7. Seismic loading considered?		
8. Railroad live load surcharge developed in accordance with Section 15.7 of the DCM?		
9. All required loads considered in shoring analysis?		
Analysis:		
10. Shoring wall analyzed in accordance with Section 15.8 of the DCM?		
11. Bracing loads determined in accordance with Section 15.8 of the DCM?		
12. Embedment depth of wall determined in accordance with Section 15.8 of the DCM?		
13. Bracing system analyzed in accordance with Section 15.8.6 of the DCM?		
14. Lagging analyzed in accordance with Section 15.8.7 of the DCM?		
15. Secondary bracing, connections, and stiffeners analyzed and provided in accordance with Section 15.8.8 of the DCM?		
16. Shoring deflection and settlement estimated in accordance with Section 15.8.9 of the DCM?		
Material Properties and Allowable Stresses:		
17. Material properties and allowable stresses in accordance with Section 15.9 of the DCM?		
Special Conditions:		
18. Is external dewatering proposed?		
a. If yes, has dewatering been accepted by SCRRA?		
b. If yes, has a settlement analysis (due to dewatering) been provided?		

SCRRA SHORING SUBMITTAL REVIEW CHECKLIST (CONTINUED)

Item	Yes/No/NA	Explain if No or NA
19. Has the potential for piping been evaluated?		
20. Has potential for heave been evaluated?		
21. Has global stability of the shoring system been evaluated?		
22. Are tiebacks proposed?		
a. If yes, has SCRRA accepted their usage?		
b. If yes, are they designed and will they be tested in accordance with Section 15.10.4 of the DCM?		
23. Are deadmen proposed?		
a. If yes, has SCRRA accepted their usage?		
b. If yes, has third party approval been granted?		
c. If yes, are they designed in accordance with Section 15.10.5 of the DCM?		

Reviewer's Signature

Print Name

Finding:

- ☐ No Exceptions Taken
- ☐ Make Corrections Noted
- ☐ Amend and Resubmit

Appendix F. Bridge Longitudinal Force

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AREMA specifies a longitudinal force to be applied to the bridge that simulates tractive effort or braking forces from a train passing over the bridge. The following equations are provided in AREMA:

- Braking Force: $LF = 45 + 1.2 \cdot L$ applied 8 ft above t/rail
- Traction Force: $LF = 25\sqrt{L}$ applied 3 ft above t/rail

  where L = is the length of the portion of the bridge under consideration, ft

The shear force applied to each substructure is determined by assuming that the bridge acts as a unit and each substructure will attract a portion of the total force based on its relative stiffness within the bridge (i.e., the substructures are considered springs acting in parallel, and each will deflect the same distance due to the force each attracts). Stiffness of each substructure is a function of material elasticity, shape properties, soil properties, clear height, pile batter, and abutment soil resistance.[1]

An example bridge is shown below:

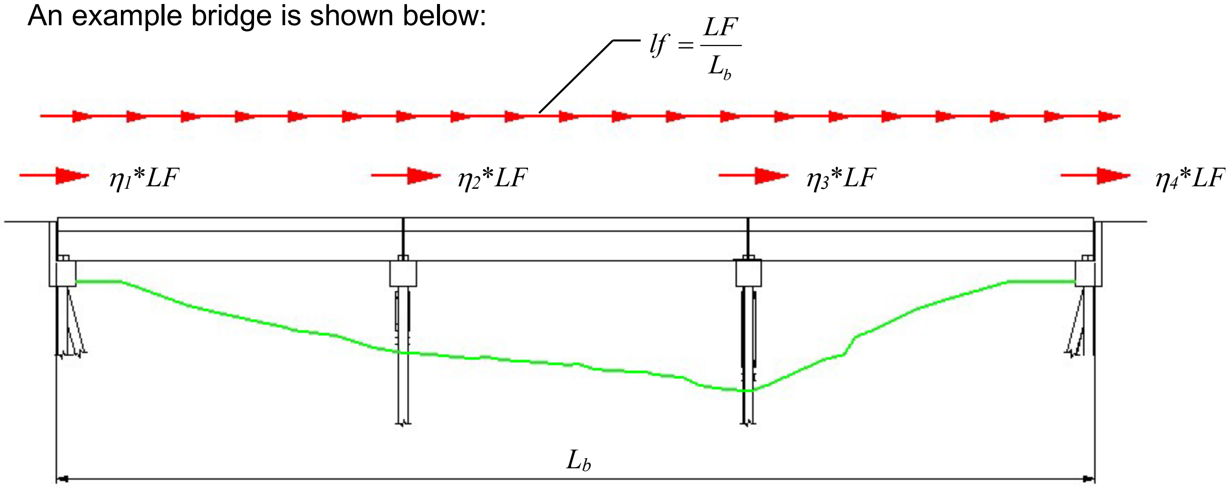

FIGURE 1

In the sketch above, the total longitudinal force is shown as a uniformly distributed lateral load. (The assumption on how the longitudinal force is distributed to the rail is not critical to determining the shear distribution, but is an essential step to calculating the moment effect on the substructures.) The shear force per substructure is then calculated by the following process:

1. Calculate the stiffness, k_i, of each substructure. Account for all variables as mentioned above.
2. Determine the total stiffness of the structure, assuming the substructures act in parallel.
3. Determine the portion of the total longitudinal shear force resisted by each substructure, η_i, as:

$$\eta_i = \frac{k_i}{\sum_{1}^{i} k_i}$$

[1] Expansion bearings utilizing rockers or sliding surfaces are assumed not to transfer any longitudinal load.

Bending moment due to the vertical reactions induced into the substructures by the longitudinal force is a result of the longitudinal load acting at a distance above the elevation of the superstructure bearings (8 ft or 3 ft above the top of rail + depth of the superstructure). The moment is passed into the caps by increasing or decreasing the vertical bearing reactions on the cap; because the CL of most bearings do not align with the CL of the cap, a force couple occurs at the bearing seat level (see Fig. 4) inducing a bending moment in the substructure. The following details the assumptions and derivation of the bending moment induced into the substructures by the longitudinal force.

1. The longitudinal load due to braking or traction is assumed to be applied to the bridge as a uniformly distributed shear force, acting 8 ft or 3 ft above the top of the rail. This shear force is passed from the train to the rail through friction between the wheels and the rail.
2. Due to the height of application (3 ft or 8 ft above the rail), a bending moment is assumed to be induced into the superstructure by a vertical force couple acting through train car wheel reactions. The free body diagram below shows the applied longitudinal force and the solved reactions on a car with the assumed dimensions.

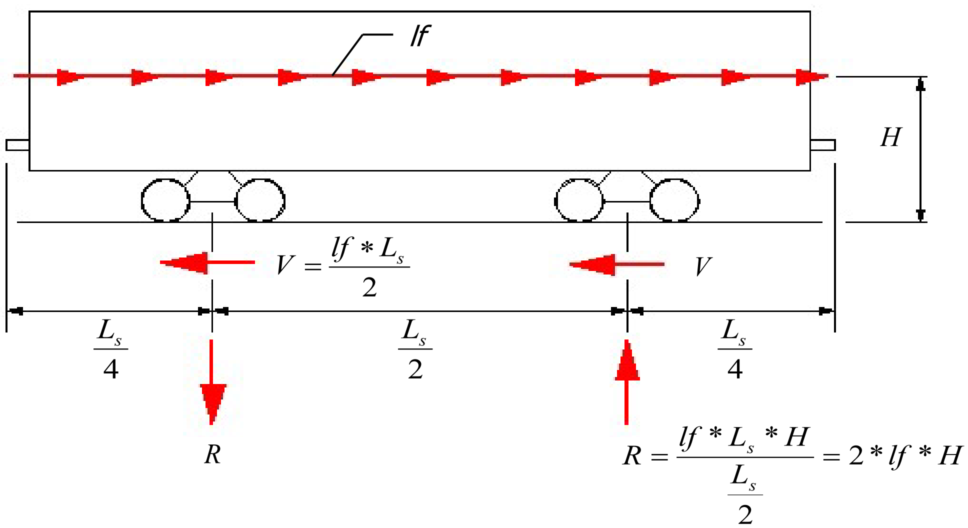

FIGURE 2

1. At this point, due to the variability of the train's positioning on the bridge, it is logical to separate the bending moment effects due to the longitudinal force into two parts: bending moment due to the longitudinal force acting at a distance, H, above the top of the rail, and the bending moment due to the longitudinal force acting at the top of the rail through the superstructure.

<u>Bending Moment Due to the Longitudinal Force Acting at the Top of the Rail Through the Superstructure:</u>

1. The free body diagram of the longitudinal shear force acting at the top of the rail is shown below. Equating forces and summing moments yields the bearing reactions, R, at each end of the span. The depth of the span, d_s, is the height between the top of the rail and the top of the cap/bottom of the bearing.

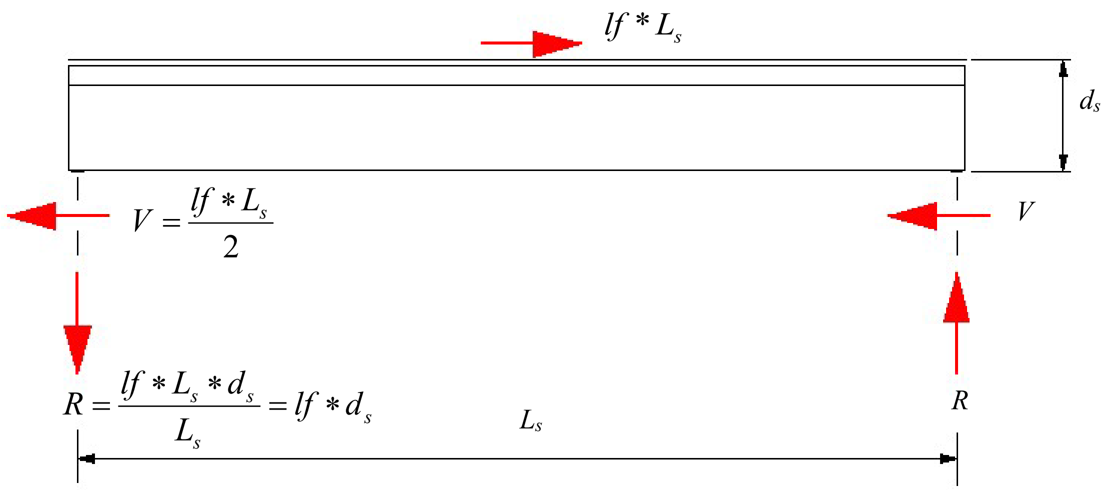

FIGURE 3

2. The next free body diagram depicts the pier cap below the right bearing of the span above. The adjacent span to the right of the span in the prior figure is assumed to be the same length as the span span (L_s), thus having the same fbd as seen above.

3. The bending moment due to the vertical reactions induced by the longitudinal force transferring from the top of the rail to the top of the cap is given by the following equation. Note that this moment acts in a direction that counteracts the direction of the shear force.

$$M = 2 * R * d_b = 2 * lf * d_s * d_b$$

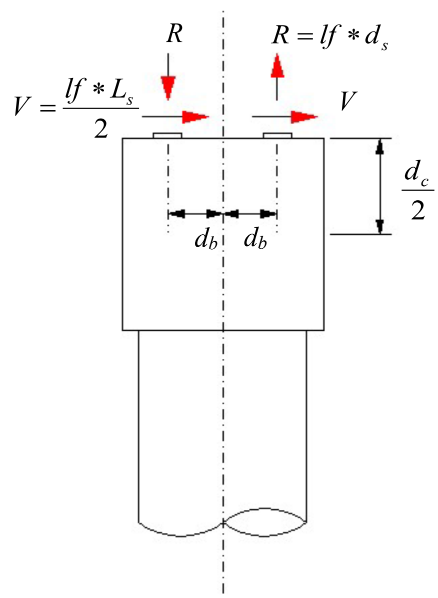

FIGURE 4

At this point, the longitudinal force has been applied a distance above the top of the rail (8 ft or 3 ft) and the shear force has been carried down to the substructure units. In addition, the bending moment caused by the longitudinal force moving from the top of the rail to the top of the cap has been estimated. What remains is to determine the bending effect on the cap from the application of the longitudinal force being applied at a distance above the top of the rail.

<u>Bending Moment Due to the Longitudinal Force Acting at a Distance Above the Top of the Rail:</u>

1. Starting with the free body diagram in Figure 2, a related free body diagram can be drawn for the span directly beneath it, as seen in Figure 5. The shear forces have been neglected, as they have already been accounted for in the prior moment derivation.

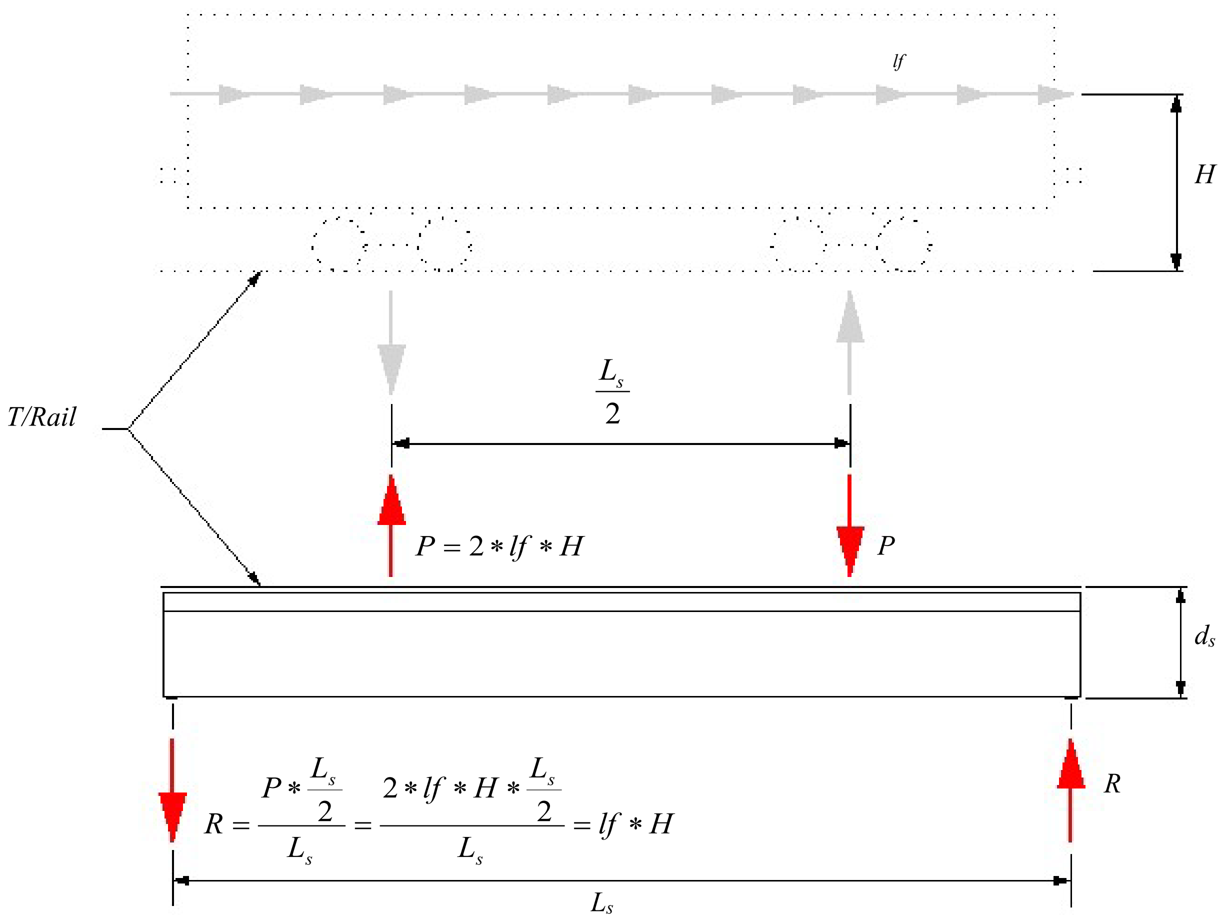

FIGURE 5

1. Focusing on the pier cap below the right bearing of the span in Figure 5, a free body diagram similar to Figure 4 can be drawn. In this case however, the bearing reactions, R, are as shown in Figure 5. This results in the following bending moment induced on the cap:

$$M = 2 * R * d_b = 2 * lf * H * d_b$$

1. The direction of this bending moment now depends on the placement of the train car. If the train cars are centered in the span, the bending moment will act to counteract the shear force (i.e., same direction as the bending moment induced by the shear force moving through the superstructure. However, if the train cars are centered over the pier, the bending moment direction will reverse and act to produce deflection in the same direction as the shear force.

Because of this moment direction reversal, it has been decided to conservatively assume all bending moments act to produce deflection in the same direction as the shear force. Therefore, the total load applied to the c.g. of the cap would be as follows:

$$V_i = \eta_i * LF$$
$$M_i = 2 * \frac{LF}{L_b} * (H + d_s) * d_b + V_i * \frac{d_c}{2}$$

where: η_i = percentage of the total longitudinal force attracted by substructure i,
LF = total longitudinal force applied to the bridge,
L_b = total length of the bridge,
H = height of longitudinal force above top of rail (3 ft or 8 ft),
d_s = distance between top of rail and top of cap,
d_b = distance between CL bearing and CL cap,
d_c = height of cap,
V_i = longitudinal force shear applied to the substructure, and
M_i = longitudinal force bending moment applied to the substructure.

Load Application From Train Through Superstructure to Substructure

As detailed above, the magnitude of the design shear and moment due to longitudinal force will be determined as shown. When following this procedure, some substructures will attract load that is applied several spans away, thus forcing the load to be transferred through the superstructure and either from superstructure span to superstructure span through compression of the joint filler (where used for precast spans) or from superstructure span through the bearings into the pile cap back through the bearings into the next span and so on until reaching the substructure element that resists the load. Force transfer can also be assumed to occur through the rails.

The design calculations should include a sketch of a longitudinal force diagram that documents the total force applied longitudinally to the bridge and the fraction of the total force resisted at each substructure element. The calculations should also describe how the force is transferred between the superstructure and each substructure element, and include a diagram or table indicating the fraction of the load carried at each substructure element by each bearing, connection, and by the rail.

Appendix G. Example Calculations

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Section 15.6 – Soil Loads

Section 15.7 – Railroad Live Load Surcharge

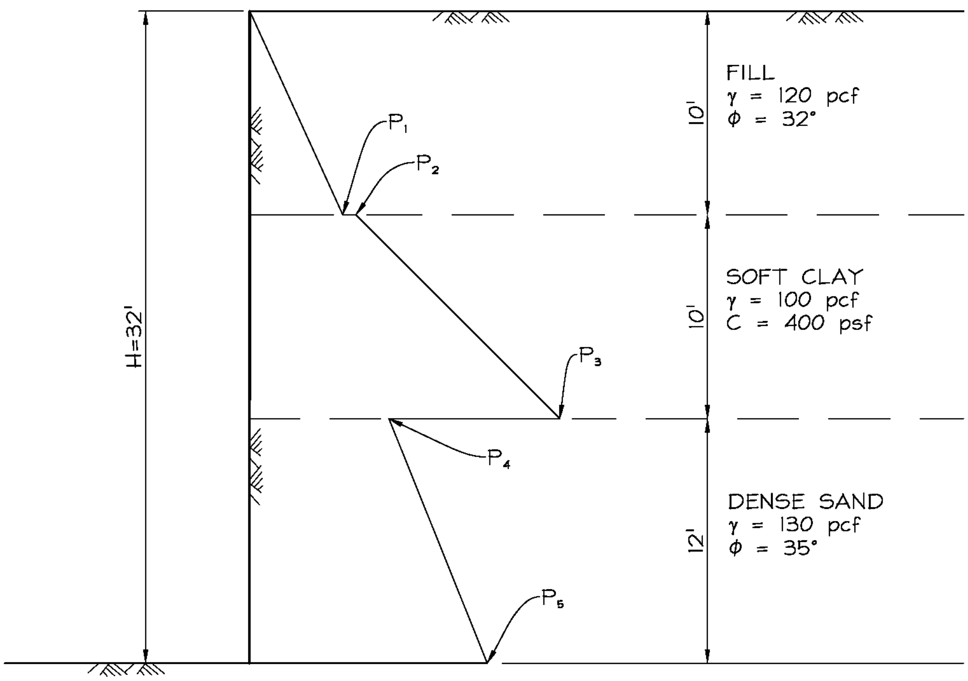
Section 15.8 – Shoring Analysis Methodologies

Section 15.9 – Material Properties and Allowable Stresses

EXAMPLE G-09-1 – DEVELOP AN ACTIVE SOIL PRESSURE DIAGRAM

PROBLEM:

DEVELOP ACTIVE SOIL PRESSURES FOR THE FOLLOWING SOIL PROFILE.



SOLUTION:

USING RANKINE THEORY -

$K_{A,FILL} = \tan^2(45°-{}^{Ø_{FILL}}/_2) = \tan^2(45°-32°/2) = \underline{\underline{0.31}}$

$K_{A,DENSE\ SAND} = \tan^2(45°-{}^{Ø_{DENSE\ SAND}}/_2) = \tan^2(45°-35°/2) = \underline{\underline{0.27}}$

COMPUTE ACTIVE PRESSURES -

$P_1 = K_{A,FILL}(\gamma_{FILL})(10') = 0.31(120)(10) = \underline{\underline{372\ psf}}$

$P_2 = \gamma_{FILL}(10') – 2c = 120(10) – 2(400) = \underline{\underline{400\ psf}}$

$P_3 = P_2 + \gamma_{SOFT\ CLAY}(10') = 400 + 100(10) = \underline{\underline{1400\ psf}}$

$P_4 = K_{A,DENSE\ SAND}[(\gamma_{FILL})(10')+(\gamma_{SOFT\ CLAY})(10')] = 0.27[(120)(10)+(100)(10)]$

$= \underline{\underline{594\ psf}}$

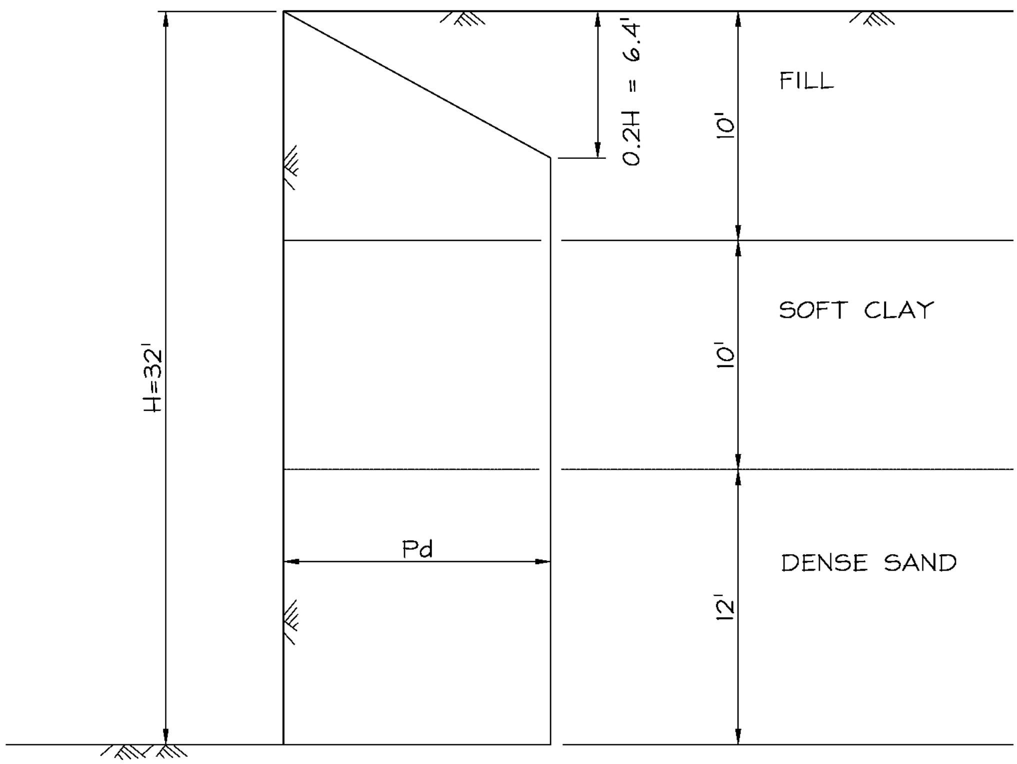
$P_5 = P_4 + K_{A,DENSE\ SAND}[(\gamma_{DENSE\ SAND})(12')] = 594 + 0.27(130)(12)$

$= \underline{\underline{1015\ psf}}$

EXAMPLE G-09-2 – DEVELOP AN APPARENT PRESSURE DIAGRAM

PROBLEM:

DEVELOP AN APPARENT PRESSURE DIAGRAM FOR THE SOIL PROFILE GIVEN IN EXAMPLE 4.1.



SOLUTION:

COMPUTE TOTAL ACTIVE PRESSURE RESULTANT (A_1) -

A_1 = (372)(10)/2+(400+1400)(10)/2+(594+1015)(12)/2

= 20,514 lbs/ft

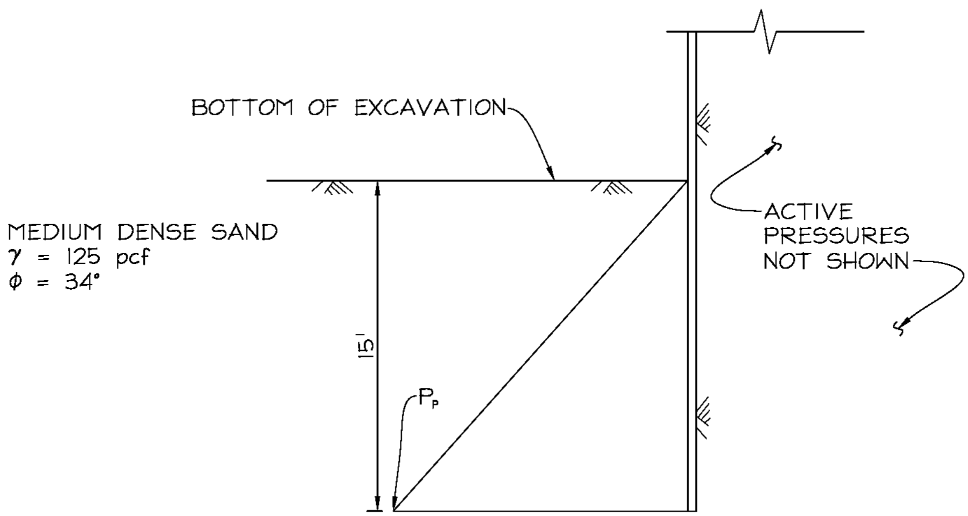
COMPUTE P_d -

$$P_d = \frac{1.4A_1}{0.9H} = \frac{1.4(20,514)}{0.9(32)} = \underline{\underline{997\text{ psf}}}$$

EXAMPLE G-09-3 – DETERMINE PASSIVE RESISTANCE (COHESIONLESS SOIL)

PROBLEM:

DETERMINE THE PASSIVE RESISTANCE ACTING ON THE BOTTOM OF A STEEL SHEET PILE WALL EMBEDDED IN MEDIUM DENSE CLEAN SAND WITH THE FOLLOWING PROPERTIES.



SOLUTION:

DETERMINE δ_{DESIGN} -

δ_{TYP} = 17° FOR STEEL SHEET PILES AGAINST CLEAN SAND

$\delta_{TYP}/2$ = 8.5° (≤0.25ø = 8.5°)

USE δ_{DESIGN} = 8.5°

USE LOG-SPIRAL THEORY TO COMPUTE K_P (REFER TO FIGURE 8, PAGE 4-10 OF THE CALTRANS *TRENCHING AND SHORING MANUAL*) -

$K_{P,\delta/\phi=-1.0}$ = 9.5 (FOR ø=34° & β/ø=0)

δ/ø = -8.5/34 = -0.25

REDUCTION FACTOR (R) ≈ 0.52

$K_P = RK_{P,\delta/\phi=-1.0} = 0.52(9.5) = \underline{\underline{4.9}}$

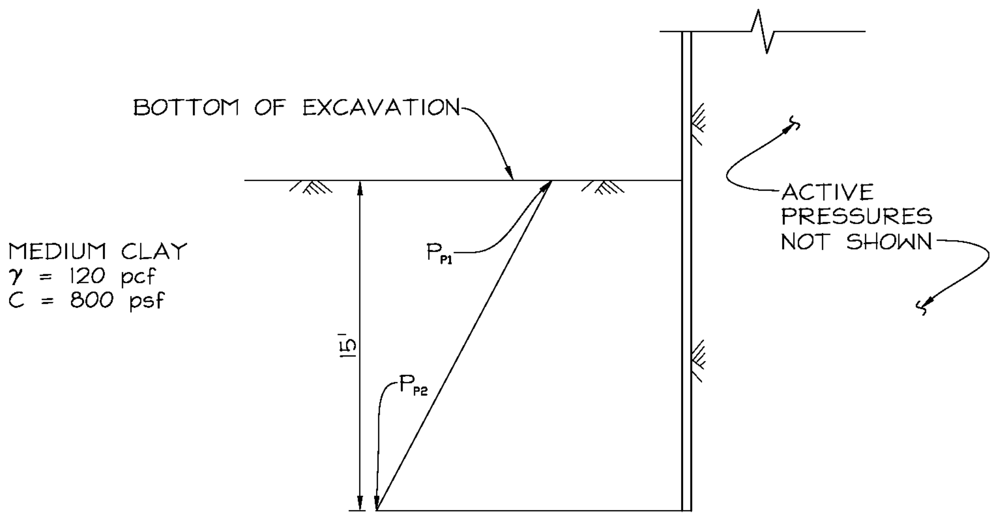
COMPUTE P_P –

$P_P = K_P(\gamma)(15') = 4.9(125)(15) = \underline{\underline{9188\text{ psf}}}$

EXAMPLE G-09-4 – DETERMINE PASSIVE RESISTANCE (COHESIVE SOIL)

PROBLEM:

DETERMINE THE PASSIVE RESISTANCE ACTING ON THE BOTTOM OF A SHORING WALL EMBEDDED IN MEDIUM CLAY WITH THE FOLLOWING PROPERTIES.



SOLUTION:

COMPUTE P_{P1} & P_{P2} -

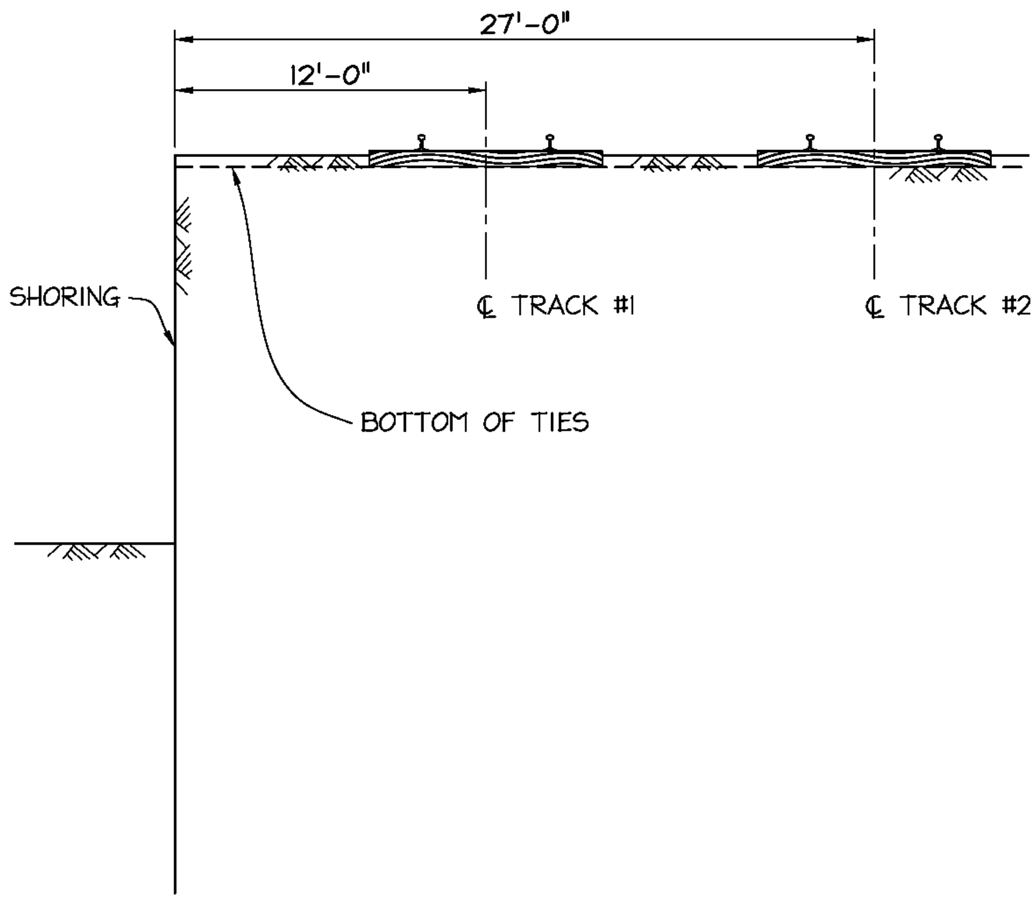
$P_{P1} = 2c = 2(800) = \underline{\underline{1600\text{ psf}}}$

$P_{P2} = P_{P1}+\gamma(15') = 1600+120(15) = \underline{\underline{3400\text{ psf}}}$

EXAMPLE G-09-5 – RAILROAD LIVE LOAD SURCHARGE FROM TWO TRACKS

PROBLEM:

COMPUTE THE LATERAL SURCHARGE PRESSURES ACTING ON THE SHORING WALL BASED ON THE FOLLOWING TRACK GEOMETRY.

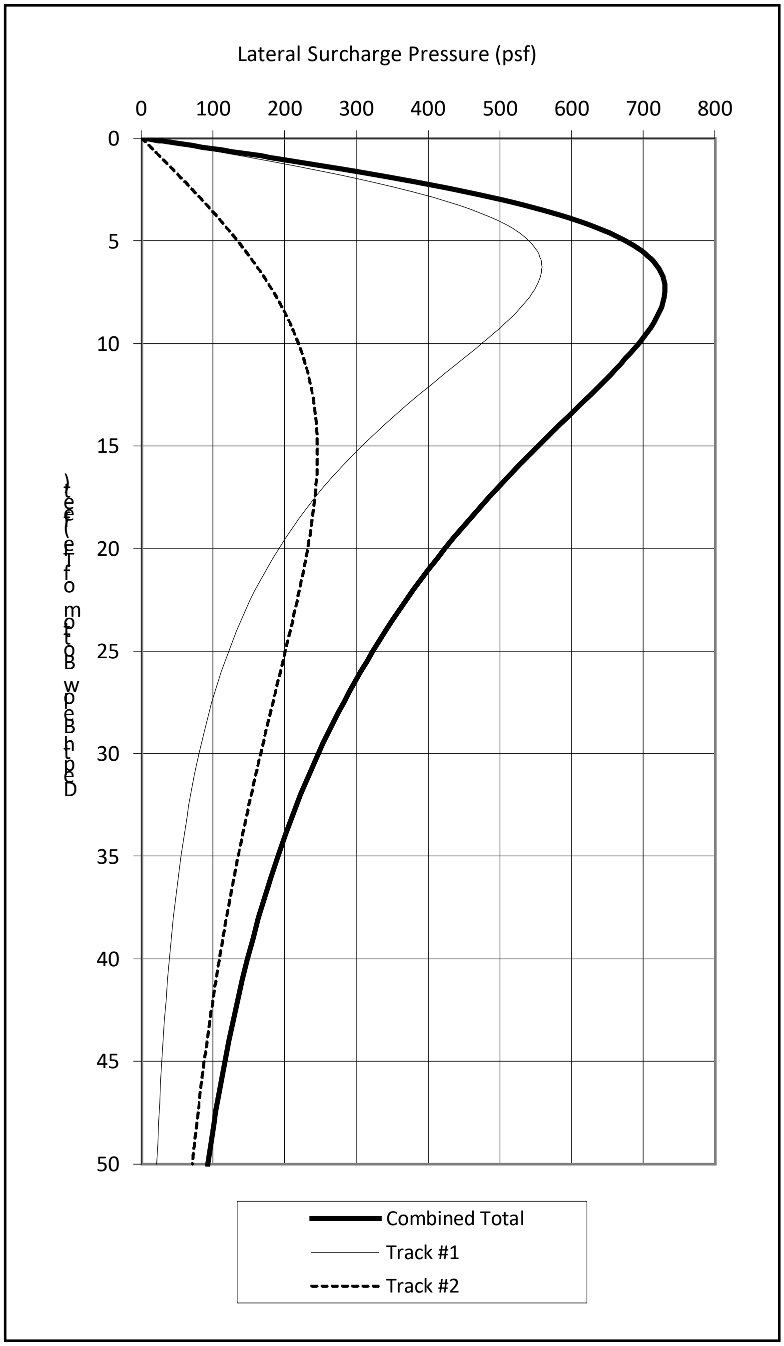


SOLUTION:

Centerline of Track #1 is 12 feet from face of shoring
Centerline of Track #2 is 27 feet from face of shoring

d (feet)	$P_{s,1}$ (psf)	$P_{s,2}$ (psf)	$P_{s,total}$ (psf)
1	161	29	**190**
2	305	57	**362**
3	418	84	**502**
4	496	110	**606**
5	541	134	**674**
6	558	156	**713**
7	553	175	**729**
8	535	192	**727**
9	507	207	**714**
10	474	219	**693**
11	439	229	**668**
12	404	236	**640**
13	370	241	**611**
14	338	244	**582**
15	307	246	**553**
16	280	245	**525**
17	254	244	**498**
18	231	241	**472**
19	210	237	**447**
20	191	232	**423**
21	174	227	**401**
22	159	221	**379**
23	145	214	**359**
24	133	208	**340**
25	122	201	**322**
26	112	194	**305**
27	102	187	**289**
28	94	180	**274**
29	87	173	**260**
30	80	166	**246**
31	74	160	**234**
32	69	153	**222**
33	64	147	**211**
34	59	141	**200**
35	55	135	**190**
36	51	129	**180**
37	48	124	**171**
38	45	118	**163**
39	42	113	**155**
40	39	109	**148**
41	37	104	**141**
42	34	100	**134**
43	32	95	**128**
44	30	91	**122**
45	29	87	**116**
46	27	84	**111**
47	25	80	**106**
48	24	77	**101**
49	23	74	**97**
50	21	71	**92**

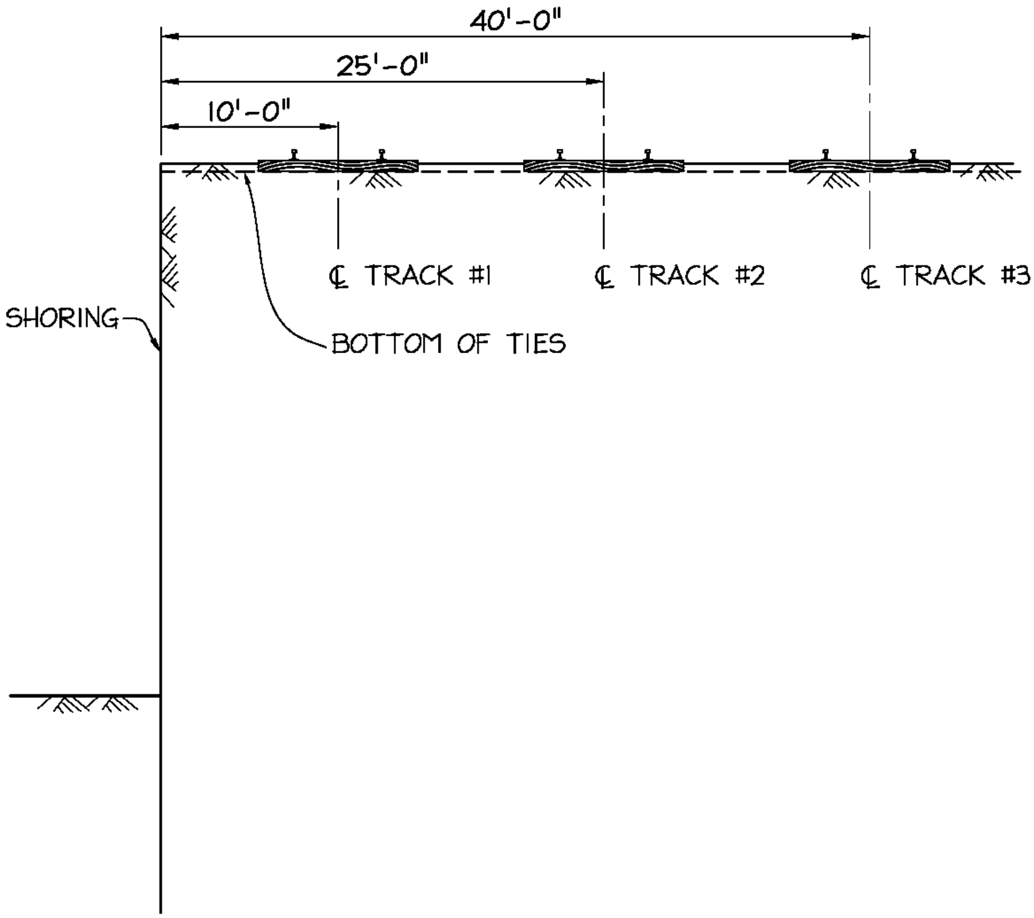
d = depth below bottom of tie
$P_{s,1}$ = lateral surcharge from Track #1
$P_{s,2}$ = lateral surcharge from Track #2
$P_{s,total}$ = combined lateral surcharge from Tracks #1 and #2 = $P_{s,1}+P_{s,2}$



EXAMPLE G-09-6 – RAILROAD LIVE LOAD SURCHARGE FROM THREE TRACKS

PROBLEM:

COMPUTE THE LATERAL SURCHARGE PRESSURES ACTING ON THE SHORING WALL BASED ON THE FOLLOWING TRACK GEOMETRY.

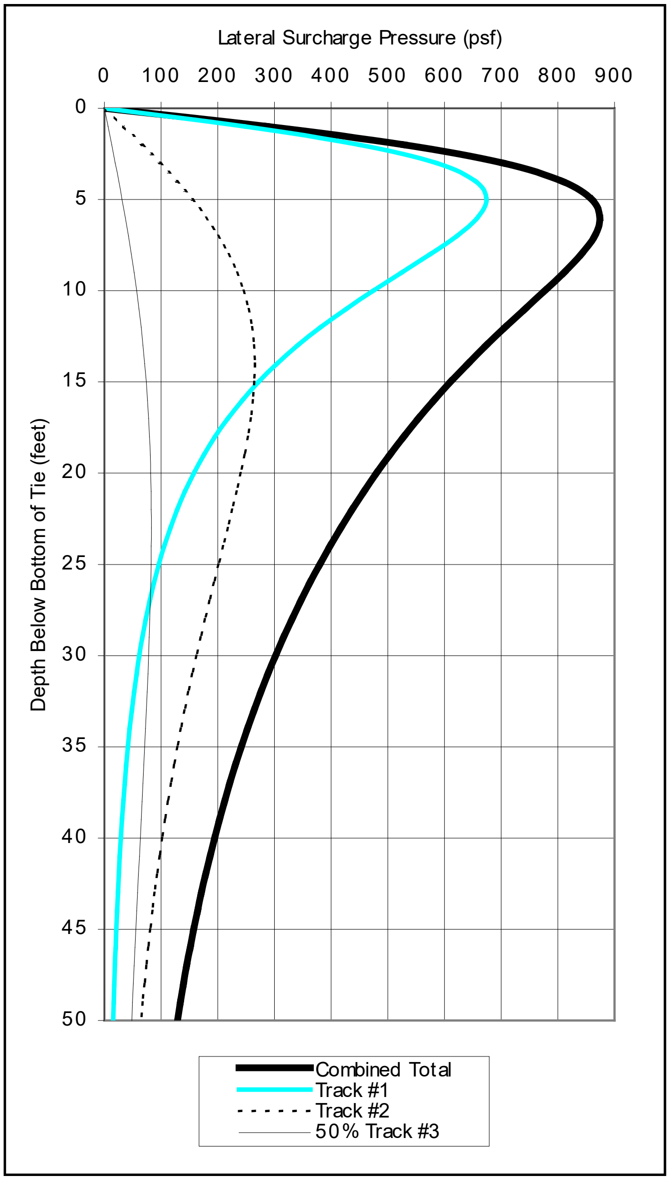


SOLUTION:

Centerline of Track #1 is 10 feet from face of shoring
Centerline of Track #2 is 25 feet from face of shoring
Centerline of Track #3 is 40 feet from face of shoring

d (feet)	$P_{s,1}$ (psf)	$P_{s,2}$ (psf)	$P_{s,3}$ (psf)	$0.5P_{s,3}$ (psf)	**$P_{s,total}$ (psf)**
1	247	34	13	6	**287**
2	450	66	26	13	**529**
3	585	98	38	19	**703**
4	655	128	51	25	**808**
5	674	155	62	31	**860**
6	658	179	74	37	**874**
7	622	201	85	42	**865**
8	575	219	95	48	**842**
9	525	234	105	52	**811**
10	474	246	114	57	**777**
11	426	254	122	61	**742**
12	382	261	130	65	**707**
13	341	264	136	68	**673**
14	305	265	142	71	**641**
15	272	265	148	74	**611**
16	243	262	152	76	**582**
17	218	258	156	78	**554**
18	195	253	159	80	**528**
19	175	247	162	81	**504**
20	158	241	163	82	**480**
21	142	233	165	82	**458**
22	129	226	165	83	**437**
23	116	218	166	83	**417**
24	106	210	165	83	**398**
25	96	202	165	82	**380**
26	88	193	164	82	**363**
27	80	185	162	81	**346**
28	73	177	160	80	**331**
29	67	170	158	79	**316**
30	62	162	156	78	**302**
31	57	155	154	77	**289**
32	52	148	151	76	**276**
33	48	141	148	74	**264**
34	45	135	145	73	**252**
35	41	129	142	71	**242**
36	39	123	139	70	**231**
37	36	117	136	68	**221**
38	33	112	133	67	**212**
39	31	107	130	65	**203**
40	29	102	127	63	**194**
41	27	97	124	62	**186**
42	25	93	120	60	**179**
43	24	89	117	59	**171**
44	22	85	114	57	**164**
45	21	81	111	56	**158**
46	20	77	108	54	**151**
47	19	74	105	53	**145**
48	18	71	102	51	**139**
49	17	68	99	50	**134**
50	16	65	97	48	**129**

d = depth below bottom of tie
$P_{s,1}$ = lateral surcharge from Track #1
$P_{s,2}$ = lateral surcharge from Track #2
$P_{s,3}$ = lateral surcharge from Track #3
$P_{s,total}$ = combined lateral surcharge from Tracks #1, #2 & #3 = $P_{s,1} + P_{s,2} + 0.5P_{s,3}$



EXAMPLE G-09-7 – "SIMPLIFIED" RAILROAD LIVE LOAD SURCHARGE

PROBLEM:

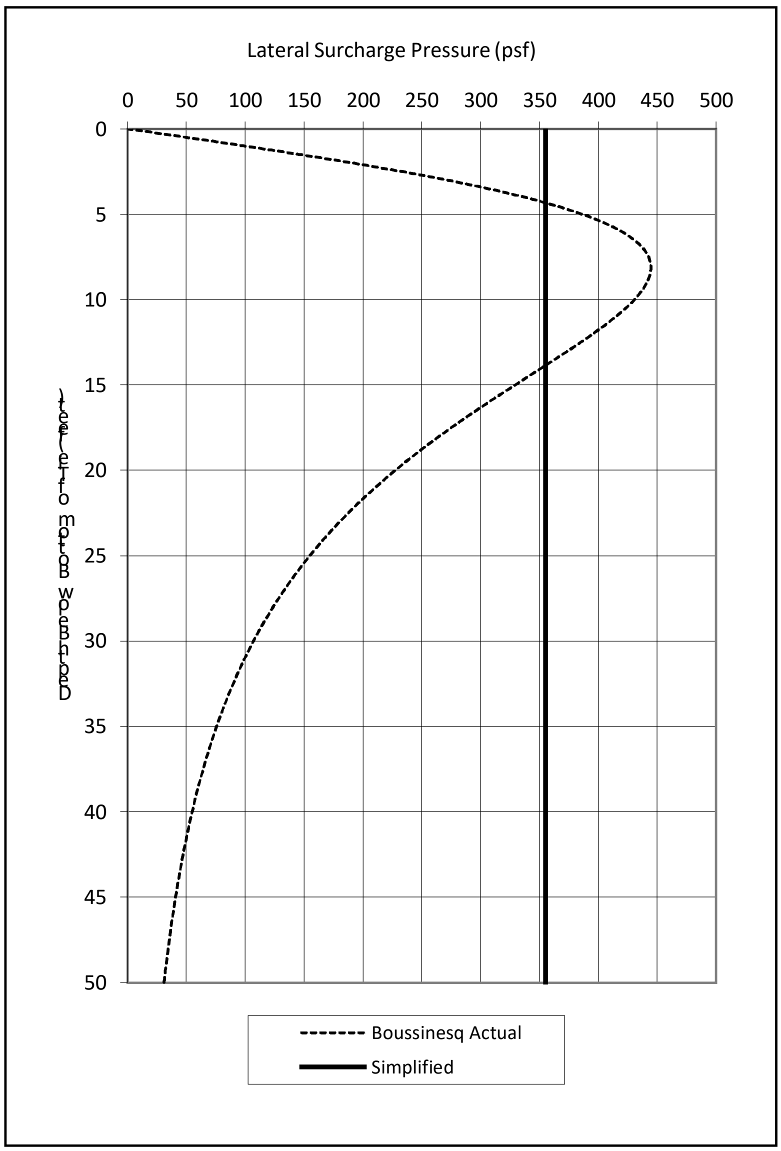
DEVELOP THE "SIMPLIFIED" LATERAL SURCHARGE PRESSURE DIAGRAM FOR A SINGLE TRACK WHOSE CENTERLINE IS LOCATED 15 FEET FROM THE FACE OF A SHORING WALL.

SOLUTION:

Centerline of track is 15 feet from face of shoring

d = depth below bottom of tie
P_s = Boussinesq lateral surcharge
$P_{s,simple} = 0.8P_{s,max} = 0.8(444) = 355$ psf

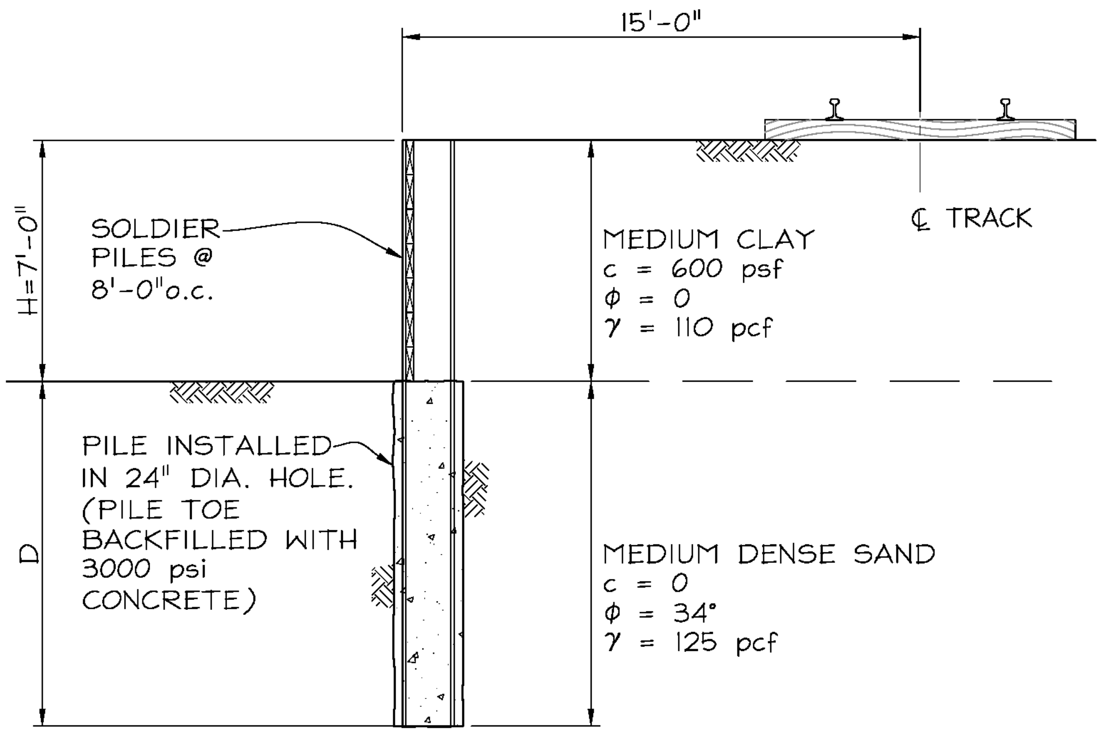
d (feet)	P_s (psf)	
1	98	
2	191	
3	271	
4	337	
5	386	
6	419	
7	438	
8	**444**	**$P_{s,max}$**
9	441	
10	431	
11	415	
12	396	
13	374	
14	352	
15	329	
16	307	
17	285	
18	265	
19	246	
20	228	
21	211	
22	195	
23	181	
24	167	
25	155	
26	144	
27	133	
28	124	
29	115	
30	107	
31	100	
32	93	
33	87	
34	81	
35	76	
36	71	
37	66	
38	62	
39	58	
40	55	
41	52	
42	49	
43	46	
44	43	
45	41	
46	39	
47	37	
48	35	
49	33	
50	31	



EXAMPLE G-09-8 – CANTILEVER SOLDIER PILE AND LAGGING SHORING WALL

PROBLEM:

DETERMINE THE REQUIRED DEPTH OF PENETRATION AND THE DESIGN SHEAR AND MOMENT FOR A CANTILEVER SOLDIER PILE AND LAGGING WALL FOR THE SOIL CONDITIONS AND PILE SPACING INDICATED BELOW.



SOLUTION:

COMPUTE ACTIVE SOIL PRESSURES –

MEDIUM CLAY:

NO THEORETICAL NET ACTIVE PRESSURE BECAUSE

$\gamma_{CLAY}H\text{-}2c = 110(7)\text{-}2(600) = \text{-}430 \text{ psf} < 0.$

THEREFORE, USE <u>30 psf/ft</u> EFP MINIMUM ACTIVE PRESSURE

MEDIUM DENSE SAND:

$K_A = \tan^2(45°\text{-}\phi/2) = \tan^2(45°\text{-}34°/2) = \underline{0.28}$

ACTIVE GRADIENT = $K_A\gamma_{SAND} = 0.28(125) = \underline{35 \text{ psf/ft}}$

COMPUTE PASSIVE SOIL PRESSURE USING LOG-SPIRAL THEORY –

REFER TO EXAMPLE 4.3: K_P = 4.9

PASSIVE GRADIENT = $K_P\gamma_{SAND}$ = 4.9(125) = 613 psf/ft

RAILROAD SURCHARGE –

USE "SIMPLIFIED" RAILROAD SURCHARGE (I.E., 80% OF MAXIMUM)

REFER TO EXAMPLE 5.3: P_S = 355 psf

EFFECTIVE WIDTH OF EMBEDDED PORTION OF SOLDIER PILE –

PER TABLE 10-1 IN THE CALTRANS *TRENCHING AND SHORING MANUAL*

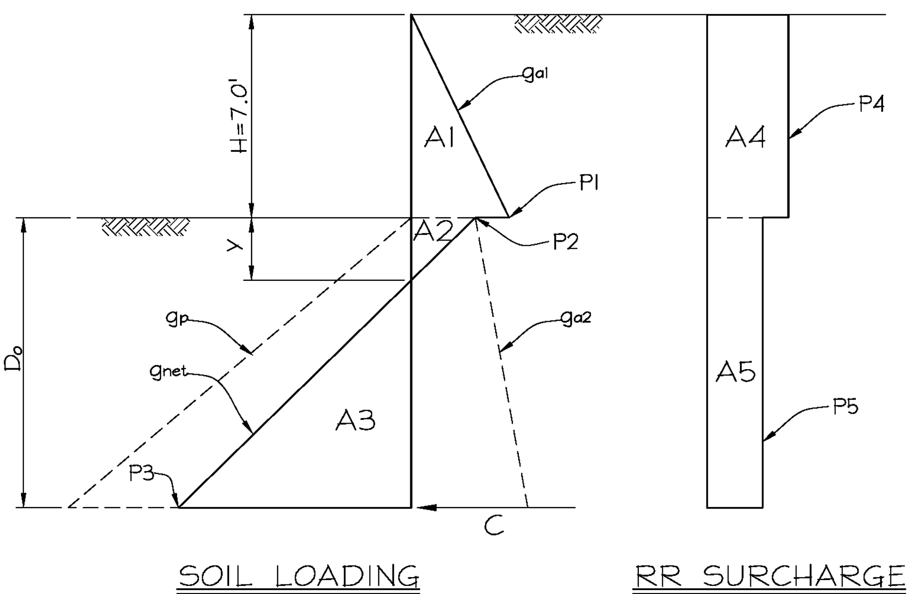
EFFECTIVE WIDTH (w_{EFF}) = (0.08ø)d,

WHERE d = DIAMETER OF CONCRETE FILLED DRILLED HOLE

w_{EFF} = 0.08(34)(2) = 5.4 feet

USE "SIMPLIFIED" METHOD OF CANTILEVER PILE ANALYSIS

SHORING LOADING DIAGRAM -



g_{a1} = 30(PILE SPACING) = 30(8) = 240 psf

g_{a2} = $35w_{EFF}$ = 35(5.4) = 189 psf

g_p = $613w_{EFF}$ = 613(5.4) = 3310 psf

g_{net} = g_p - g_{a2} = 3310-189 = 3121 psf

P_1 = 240H = 240(7) = 1680 lbs/ft

$P_2 = K_A \gamma_{clay} H w_{EFF} = 0.28(110)(7)(5.4) = \underline{\underline{1164 \text{ lbs/ft}}}$

$P_3 = g_{net} D_0 - P_2 = \underline{\underline{3121D_0\text{-}1164 \text{ lbs/ft}}}$

$P_4 = 355(\text{PILE SPACING}) = 355(8) = \underline{\underline{2840 \text{ lbs/ft}}}$

$P_5 = 355w_{EFF} = 355(5.4) = \underline{\underline{1917 \text{ lbs/ft}}}$

$Y = P_2/g_{net} = 1164/3121 = \underline{\underline{0.37 \text{ feet}}}$

$A1 = P_1(H/2) = 1680(7/2) = \underline{\underline{5880 \text{ lbs}}}$

$A2 = P_2(Y/2) = 1164(0.37/2) = \underline{\underline{215.3 \text{ lbs}}}$

$A3 = P_3(D_0\text{-}Y)/2 = (3121D_0\text{-}1164)(D_0\text{-}0.37)/2$

$= \underline{\underline{1560.5D_0^2\text{-}1159.4D_0+215.3 \text{ lbs}}}$

$A4 = P_4H = 2840(7) = \underline{\underline{19{,}880 \text{ lbs}}}$

$A5 = P_5D_0 = \underline{\underline{1917D_0 \text{ lbs}}}$

COMPUTE REQUIRED EMBEDMENT DEPTH -

SUM MOMENTS ABOUT BOTTOM OF WALL TO DETERMINE D_0 –

$A1(D_0+H/3) + A2(D_0\text{-}Y/3) - A3(D_0\text{-}Y)/3 + A4(D_0+H/2) + A5(D_0/2) = 0$

$5880(D_0+7/3) + 215.3(D_0\text{-}0.37/3) – (1560.5D_0^2\text{-}1159.4D_0+215.3)(D_0\text{-}0.37)/3 + 19{,}880(D_0+7/2) + 1917D_0(D_0/2) = 0$

$520.2D_0^3 – 1537.3D_0^2 – 25{,}761D_O – 83{,}300 = 0$

SOLVE FOR D_0:

$D_0 = \underline{\underline{9.74 \text{ feet}}}$

INCREASE EMBEDMENT DEPTH BY 20% TO ACCOUNT FOR “SIMPLIFIED” ANALYSIS AND THEN ADD AN ADDITIONAL 40% FOR SAFETY FACTOR.

$D = 1.4(1.2(9.74)) = \underline{\underline{16.4 \text{ feet}}}$ MINIMUM

PROVIDE $\underline{\underline{\text{17 feet}}}$ OF EMBEDMENT

DETERMINE DESIGN SHEAR FORCE –

MAXIMUM SHEAR FORCE IS AT BOTTOM OF PILE

$V_{MAX} = A3\text{-}A1\text{-}A2\text{-}A4\text{-}A5$

$= (1560.5D_0^2\text{-}1159.4D_0+215.3)\text{-}5880\text{-}215.3\text{-}19{,}880\text{-}1917D_0$

$= [1560.5(9.74)^2\text{-}1159.4(9.74)+215.3\text{-}5880\text{-}215.3\text{-}19{,}880\text{-}1917(9.74)]/1000$

$V_{MAX} = \underline{\underline{92 \text{ kips}}}$

DETERMINE DESIGN MOMENT -

FIND POINT OF ZERO SHEAR (depth of X below bottom of excavation)

$A1+A2+A4+P_5X-P_3(X-Y)/2 = 0$

$5880+215.3+19{,}880+1917X-(3121X-1164)(X-0.37)/2 = 0$

$1560.5X^2-3076.4X-25832 = 0$

SOLVE FOR X:

X = 5.17 feet

$M_{MAX} = A1(X+H/3)+A2(X-Y/3)+A4(Y+H/2)+P_5X^2/2-P_3(X-Y)^2/6$

$= [5880(5.17+7/3) + 215.3(5.17-0.37/3) + 19{,}880(5.17+7/2) + 1917(5.17)^2/2 - (3121(5.17)-1164)(5.17-0.37)^2/6]/1000$

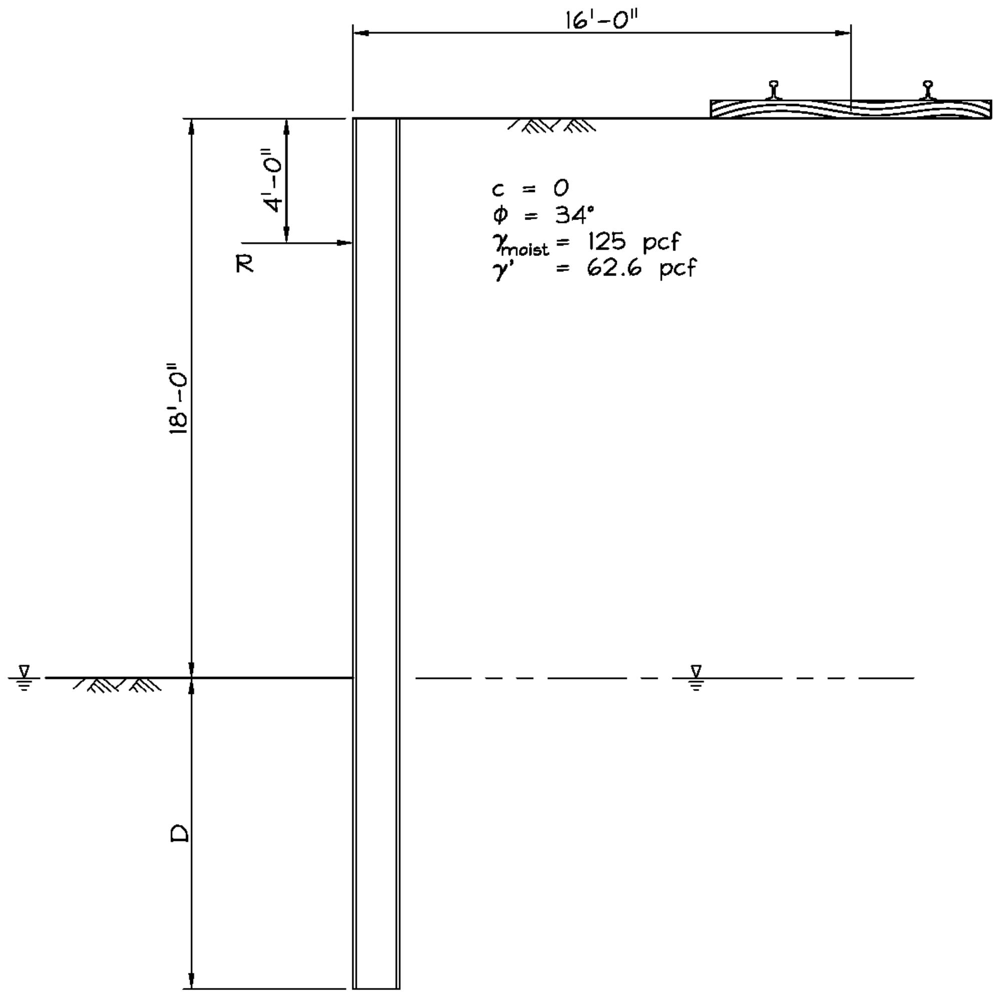
M_{MAX} = 186 kip-ft

EXAMPLE G-09-9 – SHEET PILE SHORING WALL WITH ONE LEVEL OF BRACING

(FREE EARTH SUPPORT METHOD)

PROBLEM:

DETERMINE THE REQUIRED DEPTH OF PENETRATION, THE DESIGN SHEAR AND MOMENT, AND THE BRACING REACTION FOR A SHEET PILE SHORING WALL WITH A SINGLE LEVEL OF BRACING IN THE SOIL CONDITIONS INDICATED. USE THE FREE EARTH SUPPORT METHOD OF ANALYSIS.



SOLUTION:

COMPUTE ACTIVE SOIL PRESSURES USING RANKINE THEORY –

$K_A = \tan^2(45°-ø/2) = \tan^2(45°-34°/2) = \underline{\underline{0.28}}$

ACTIVE GRADIENT ABOVE GWT = $K_A\gamma_{MOIST}$ = 0.28(125) = $\underline{\underline{35\ psf/ft}}$

ACTIVE GRADIENT BELOW GWT (INCLUDING WATER PRESSURE) = $K_A\gamma'+\gamma_W$

= 0.28(62.6)+62.4 = $\underline{\underline{80\ psf/ft}}$

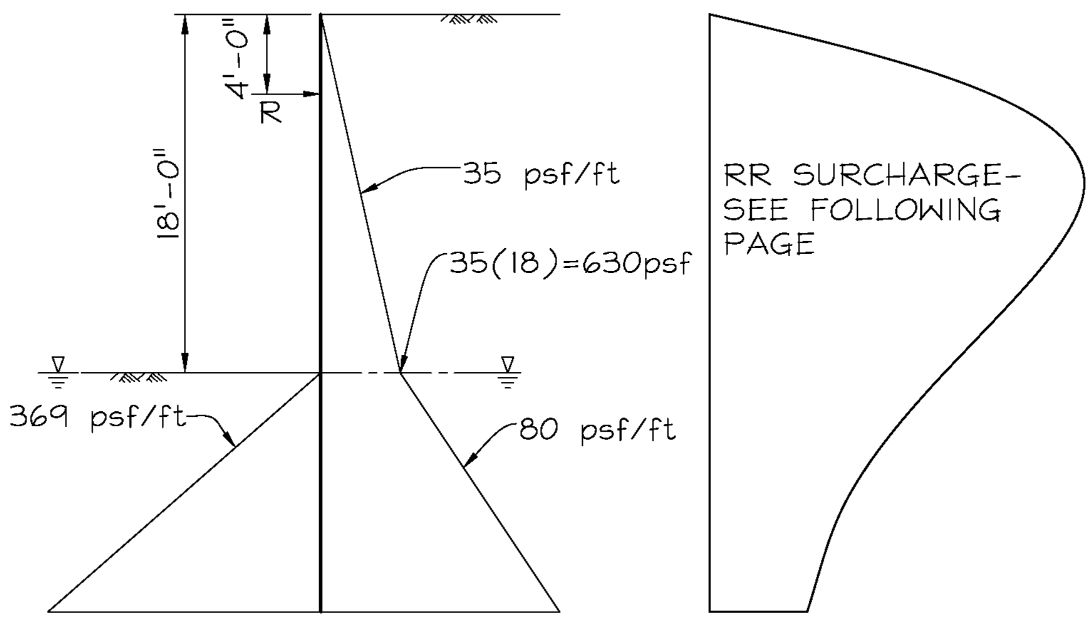
COMPUTE PASSIVE SOIL PRESSURE USING LOG-SPIRAL THEORY –

REFER TO EXAMPLE 4.3: K_P = 4.9

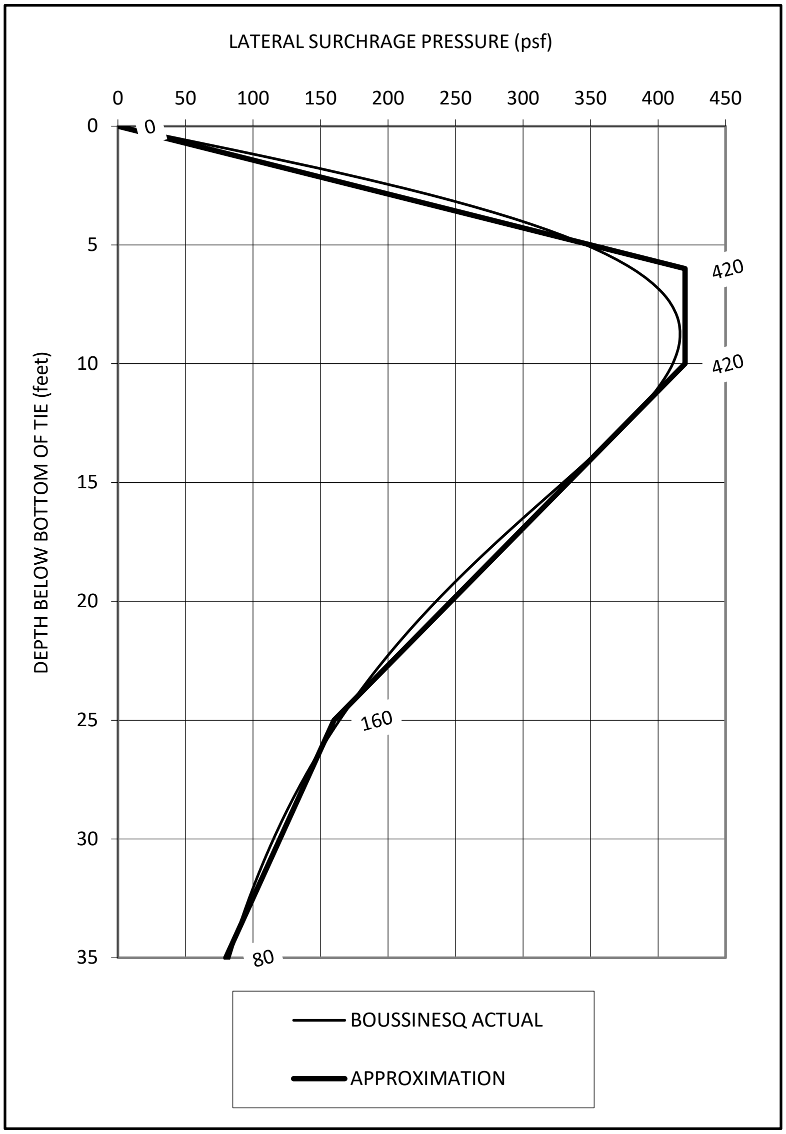
PASSIVE GRADIENT BELOW GWT (INCLUDING WATER PRESSURE) = $K_P\gamma'+\gamma_W$

= 4.9(62.6)+62.4 = $\underline{\underline{369\ psf/ft}}$

SHORING LOADING DIAGRAM -

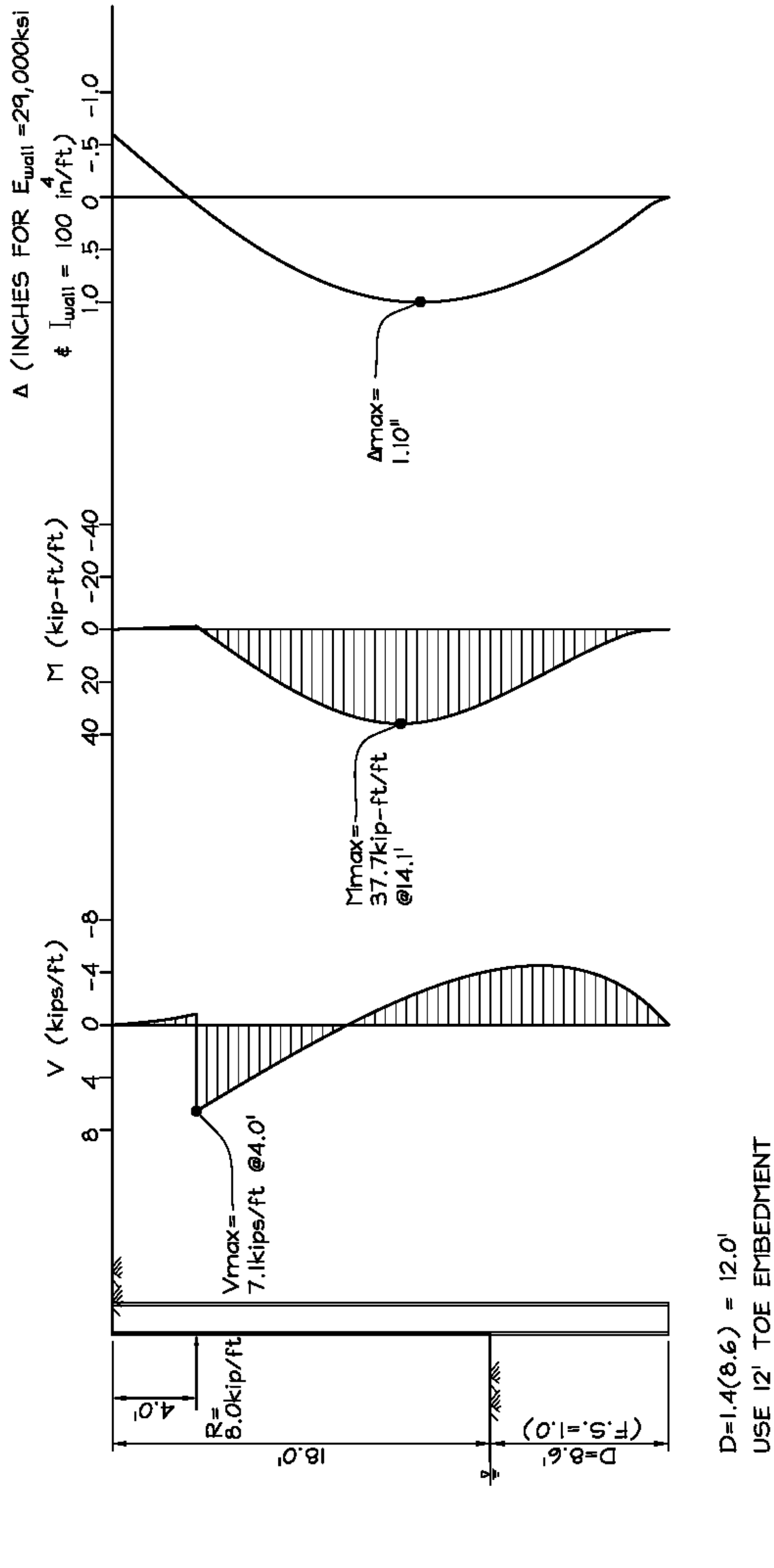


RAILROAD SURCHARGE PRESSURE DIAGRAM -



ANALYZE SHORING WALL USING BEAM ANALYSIS SOFTWARE TO DETERMINE DEPTH OF EMBEDMENT REQUIRED FOR STABILITY (I.E., SUM OF MOMENTS ABOUT BRACING LEVEL EQUAL TO ZERO).

THE COMPUTED BRACING REACTION, REQUIRED DEPTH OF EMBEDMENT, SHEAR AND MOMENT DIAGRAMS, AND ELASTIC WALL DEFLECTIONS ARE SHOWN ON THE FOLLOWING PAGE.


Δ (INCHES FOR E_{wall} =29,000ksi
& I_{wall} = 100 in^4/ft)
1.0 .5 0 -.5 -1.0
Δmax=
1.10"
M (kip-ft/ft)
40 20 0 -20 -40
Mmax=
37.7kip-ft/ft
@14.1'
V (kips/ft)
8 4 0 -4 -8
Vmax=
7.1kips/ft @4.0'
4.0'
R=
8.0kip/ft
18.0'
D=8.6'
(F.S.=1.0)
D=1.4(8.6) = 12.0'
USE 12' TOE EMBEDMENT

EXAMPLE G-09-10 – SHEET PILE SHORING WALL WITH ONE LEVEL OF BRACING (FIXED EARTH SUPPORT METHOD)

PROBLEM:

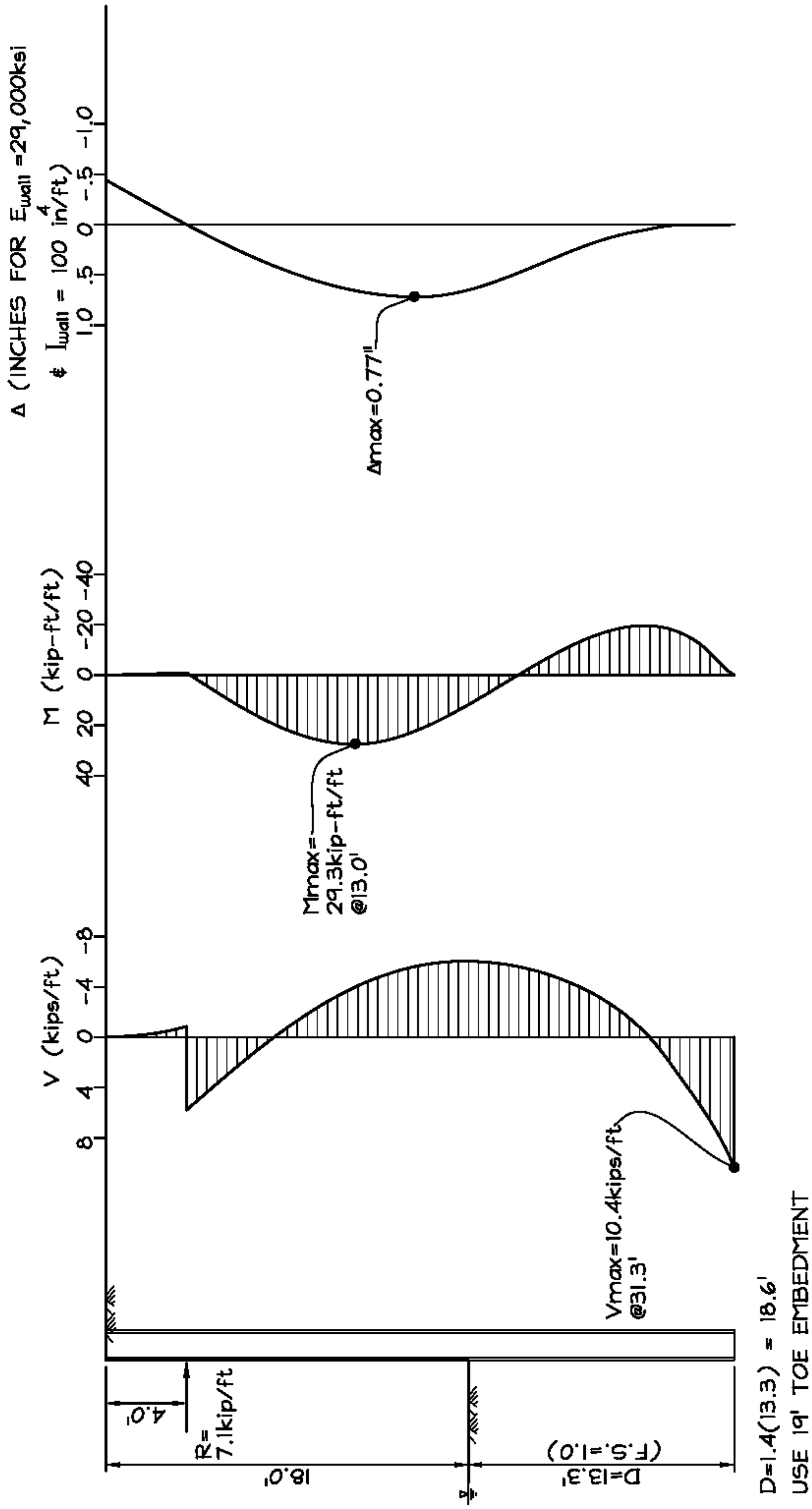
REANALYZE THE SHORING WALL DESCRIBED IN EXAMPLE 6.2 USING THE FIXED EARTH SUPPORT METHOD OF ANALYSIS TO DETERMINE THE REQUIRED DEPTH OF PENETRATION, THE DESIGN SHEAR AND MOMENT, AND THE BRACING REACTION.

SOLUTION:

SOIL AND SURCHARGE PRESSURES ARE THE SAME AS THOSE USED IN EXAMPLE 6.2.

ANALYZE SHORING WALL USING BEAM ANALYSIS SOFTWARE TO DETERMINE DEPTH OF EMBEDMENT REQUIRED TO PROVIDE EFFECTIVE FIXITY.

THE COMPUTED BRACING REACTION, REQUIRED DEPTH OF EMBEDMENT, SHEAR AND MOMENT DIAGRAMS, AND ELASTIC WALL DEFLECTIONS ARE SHOWN ON THE FOLLOWING PAGE.


Δ (INCHES FOR E_{wall} =29,000ksi
¢ I_{wall} = 100 in^4/ft)
1.0 .5 0 -.5 -1.0
Δmax=0.77"
M (kip-ft/ft)
40 20 0 -20 -40
Mmax=
29.3kip-ft/ft
@13.0'
V (kips/ft)
8 4 0 -4 -8
Vmax=10.4kips/ft
@31.3'
4.0'
R=
7.1kip/ft
18.0'
D=13.3'
(F.S.=1.0)
D=1.4(13.3) = 18.6'
USE 19' TOE EMBEDMENT

COMPARISON OF RESULTS FROM FREE EARTH AND FIXED EARTH SUPPORT METHODS –

ITEM	FREE EARTH (EXAMPLE 6.2)	FIXED EARTH (EXAMPLE 6.3)
DEPTH OF EMBEDMENT	12 feet	19 feet
BRACING REACTION	8.0 kips/ft	7.1 kips/ft
M_{MAX}	37.7 kip-ft/ft	29.3 kip-ft/ft
V_{MAX}	7.1 kips/ft	10.6 kips/ft
MAX. ELASTIC WALL DEFLECTION*	1.10 inches	0.77 inches

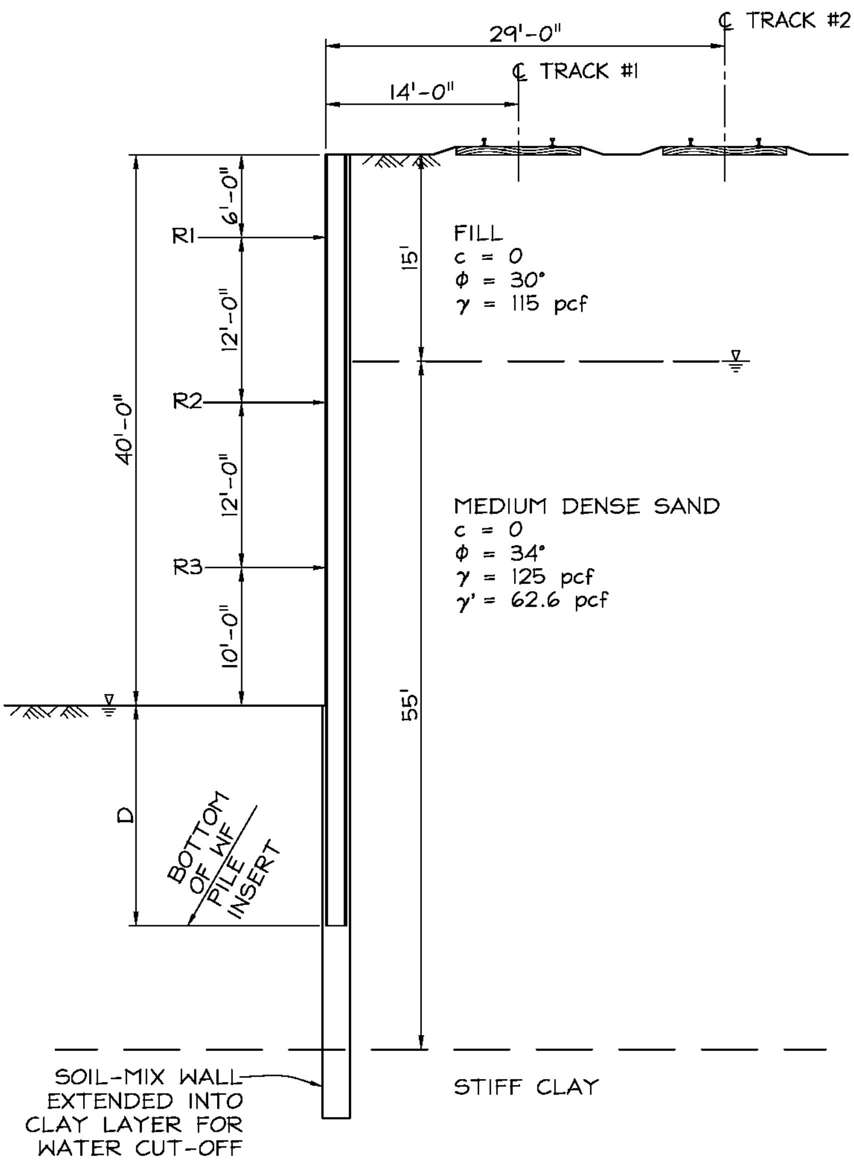
*FOR I_{WALL}=100 in^4/ft & E_{WALL}=29,000 ksi

EXAMPLE G-09-11 – ANALYSIS OF A DIAPHRAGM SHORING WALL WITH THREE LEVELS OF BRACING

PROBLEM:

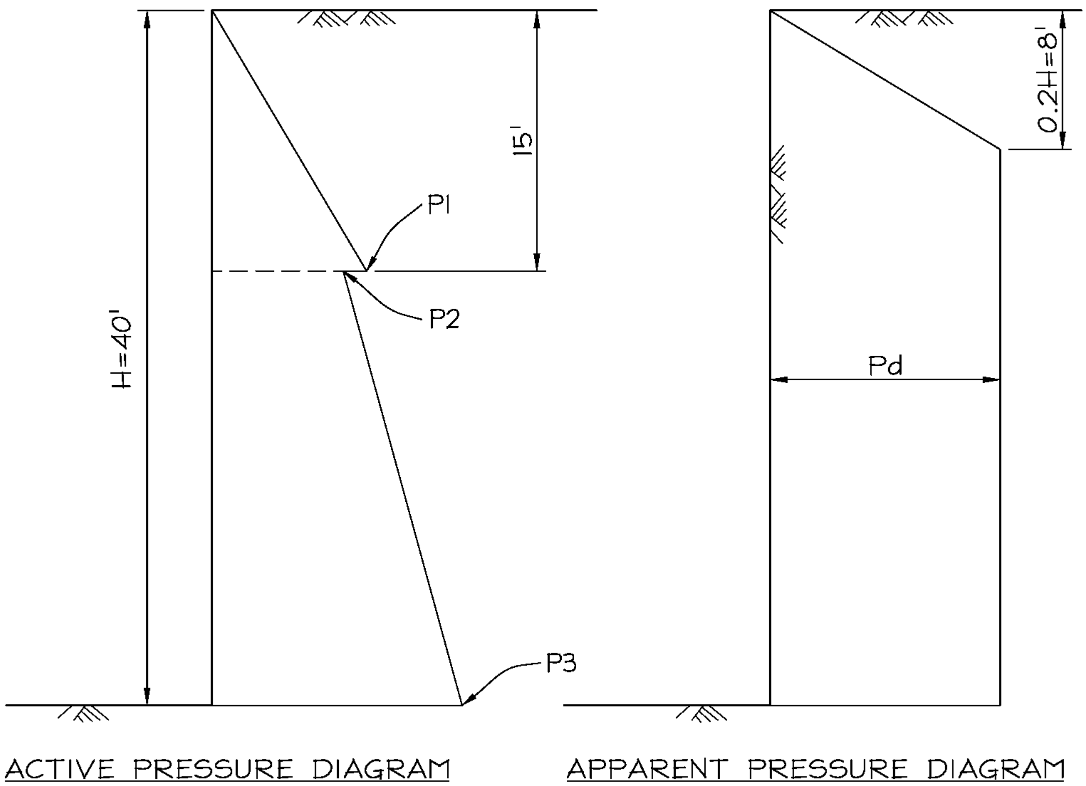
DETERMINE THE REQUIRED DEPTH OF PENETRATION, THE DESIGN SHEAR AND MOMENT, AND THE BRACING REACTIONS FOR A SOIL-MIX SHORING WALL SUPPORTED WITH THREE LEVELS OF BRACING IN THE SOIL CONDITIONS INDICATED. ASSUME THE WIDE FLANGE PILE INSERTS ARE SPACED AT 4 FEET ON-CENTER. ANALYZE FULL DEPTH CONDITION ONLY.

SOIL-MIX WALL (UNRENIFORCED) IS EXTENDED TO STIFF CLAY LAYER FOR GROUNDWATER CUT-OFF.



SOLUTION:

DEVELOP APPARENT SOIL PRESSURE DIAGRAM –



ACTIVE SOIL PRESSURES –

$K_{A,FILL} = \tan^2(45° - Ø_{FILL}/2) = \tan^2(45°-30°/2) = \underline{\underline{0.33}}$

$K_{A,DENSE\ SAND} = \tan^2(45° - Ø_{DENSE\ SAND}/2) = \tan^2(45°-34°/2) = \underline{\underline{0.28}}$

$P1 = K_{A,FILL}(\gamma_{FILL})(15') = 0.33(115)(15) = \underline{\underline{569\ psf}}$

$P2 = K_{A,DENSE\ SAND}(\gamma_{FILL})(15') = 0.28(115)(15) = \underline{\underline{483\ psf}}$

$P3 = P2 + K_{A,DENSE\ SAND}(\gamma')(25') = 483+0.28(62.6)(25) = \underline{\underline{921\ psf}}$

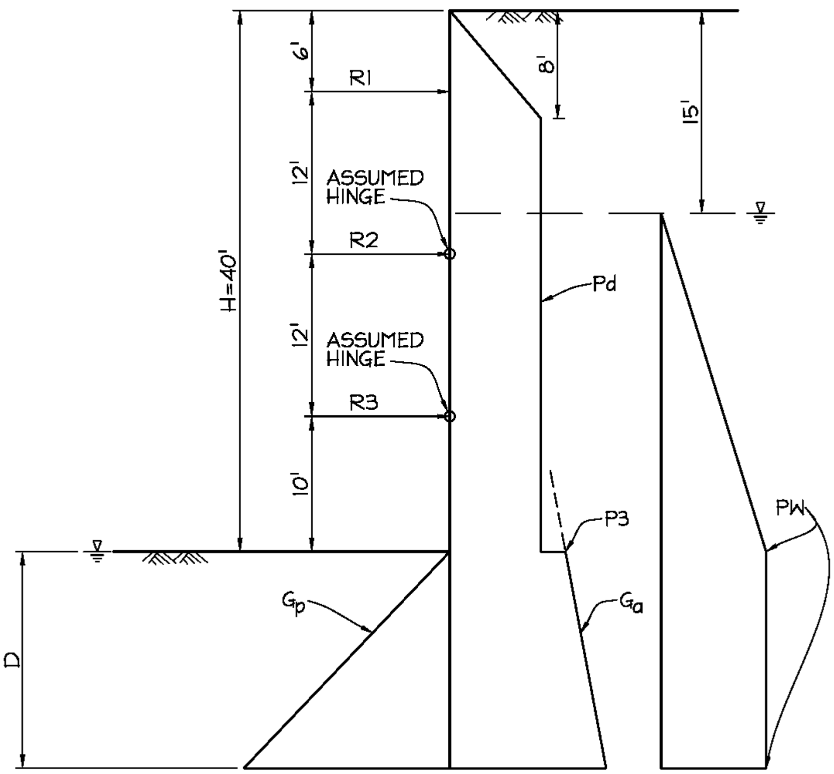
CALCULATE APPARENT PRESSURE –

ACTIVE SOIL PRESSURE RESULTANT $(A_1) = P1(15'/2) + [(P2+P3)/2](25')$

$= 569(15/2)+[(483+921)/2](25) = \underline{\underline{21{,}818\ lbs/ft}}$

$P_d = 1.4(A_1)/(0.9H) = 1.4(21{,}818)/[0.9(40)] = \underline{\underline{848\ psf}}$

SHORING LOADING DIAGRAM –



DESIGN SOIL & WATER PRESSURES*

* FOR RR SURCHARGE SEE NEXT PAGE

APPARENT SOIL PRESSURE

P_d = 848 psf (SEE PREVIOUS PAGE)

ACTIVE SOIL PRESSURES IN DENSE SAND BELOW EXCAVATION SUBGRADE

P3 = 921 psf (SEE PREVIOUS PAGE)

ACTIVE SOIL GRADIENT BELOW EXCAVATION SUBGRADE (G_a)

$= K_{A,DENSE\ SAND}(\gamma') = 0.28(62.6) = \underline{17.5\ psf/ft}$

PASSIVE SOIL PRESSURES IN DENSE SAND BELOW EXCAVATION SUBGRADE

K_P = 4.9 (REFER TO EXAMPLE 4.3)

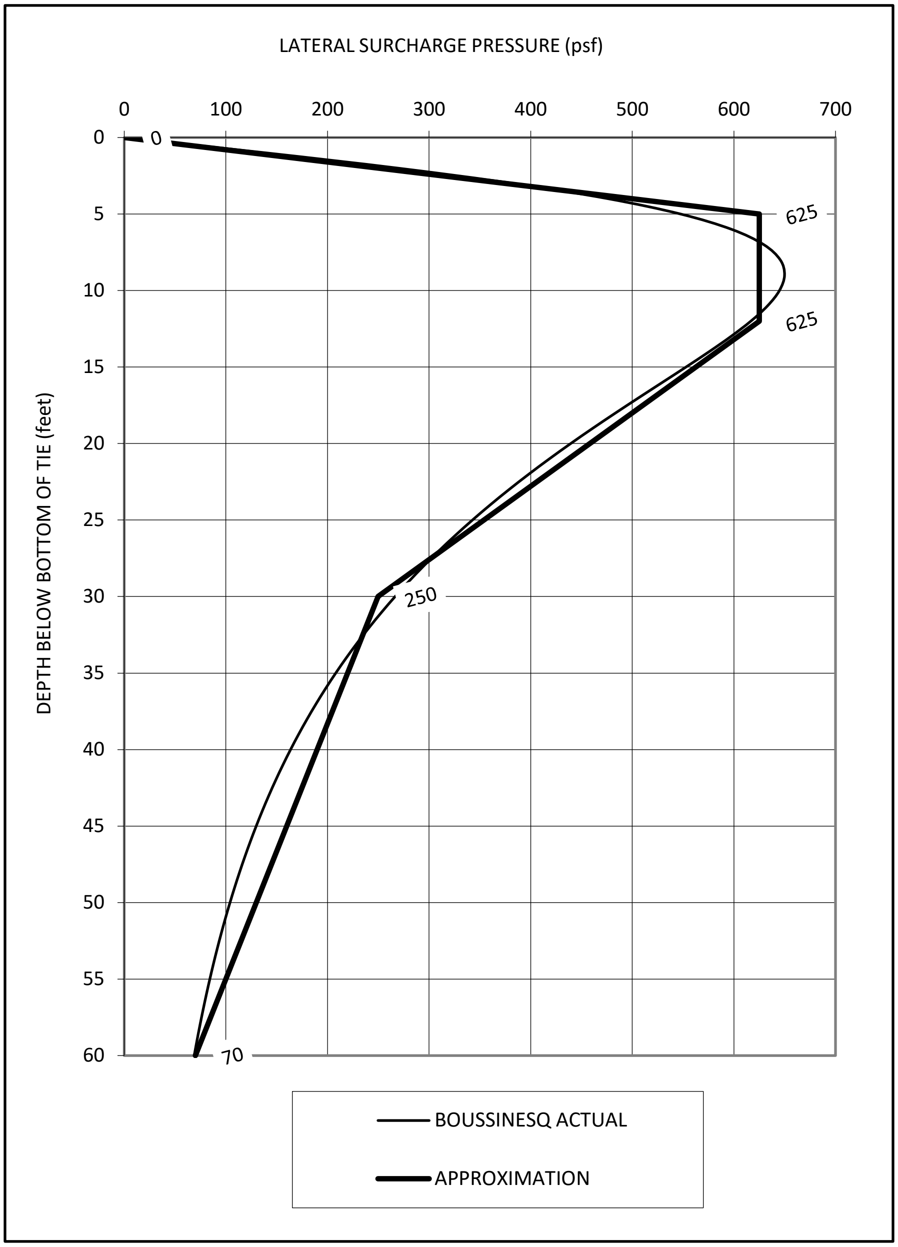
PASSIVE SOIL GRADIENT BELOW EXCAVATION SUBGRADE (G_p)

$= K_P(\gamma') = 4.9(62.6) = \underline{307\ psf/ft}$

NET HYDROSTATIC PRESSURE

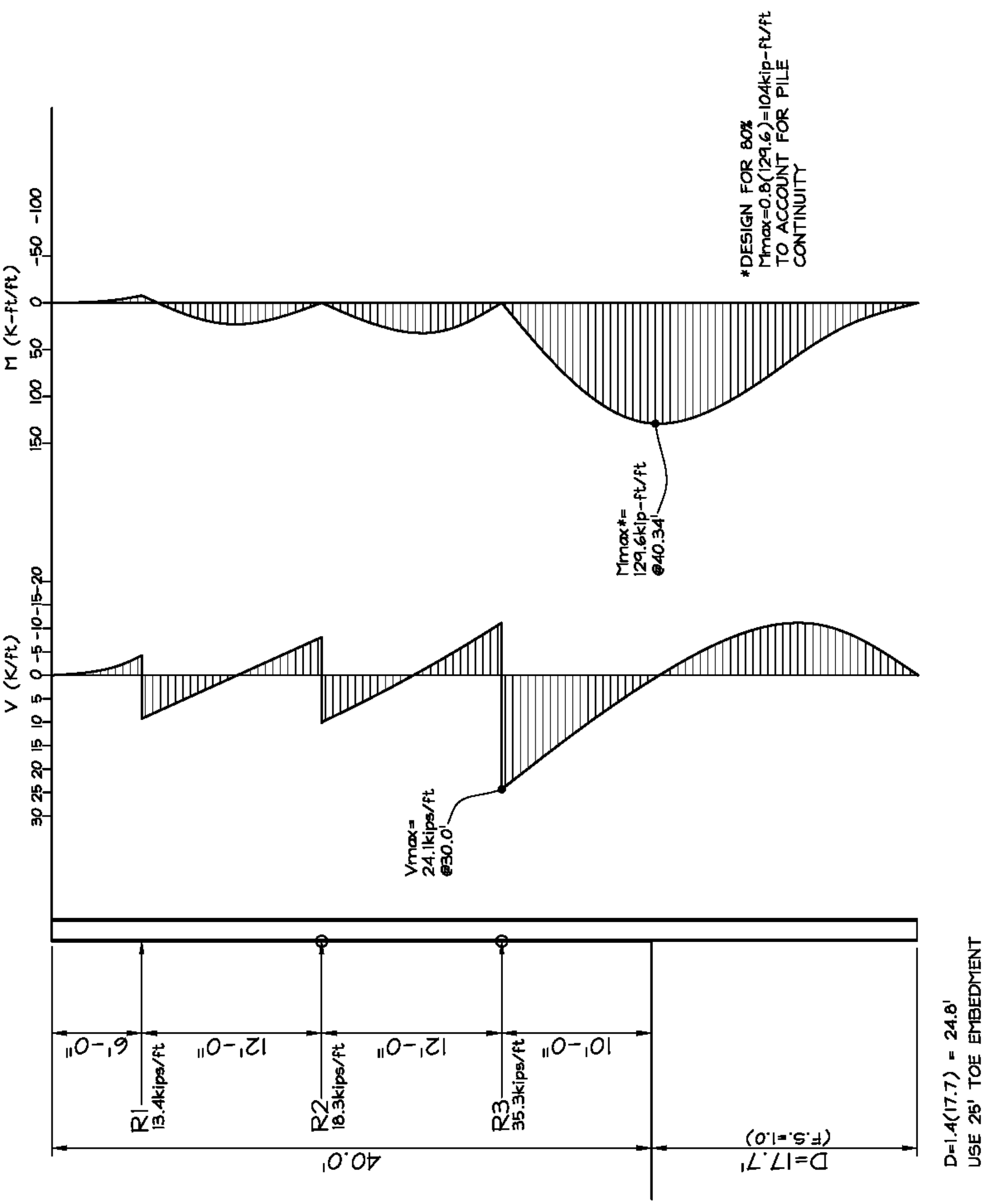
$PW = \gamma_W(25') = 62.4(25) = \underline{1560\ psf}$

RAILROAD SURCHARGE PRESSURE DIAGRAM –



ANALYZE SHORING WALL USING BEAM ANALYSIS SOFTWARE TO DETERMINE DEPTH OF EMBEDMENT REQUIRED FOR STABILITY (I.E., BALANCE MOMENTS DUE TO LOADS ACTING BELOW THE LOWEST BRACING LEVEL).

THE COMPUTED BRACING REACTIONS, REQUIRED DEPTH OF EMBEDMENT, AND SHEAR AND MOMENT DIAGRAMS ARE SHOWN ON THE FOLLOWING PAGE.



SUMMARY OF RESULTS

BRACING REACTIONS

R1 = 13.4 kips/ft

R2 = 18.3 kips/ft

R3 = 35.3 kips/ft

REQUIRED EMBEDMENT DEPTH = 25 feet

DESIGN (MAXIMUM) SHEAR

V_{MAX} = 24.1 kips/ft

V_{MAX} = 24.1(4) = 96.4 kips/pile

DESIGN (MAXIMUM) MOMENT

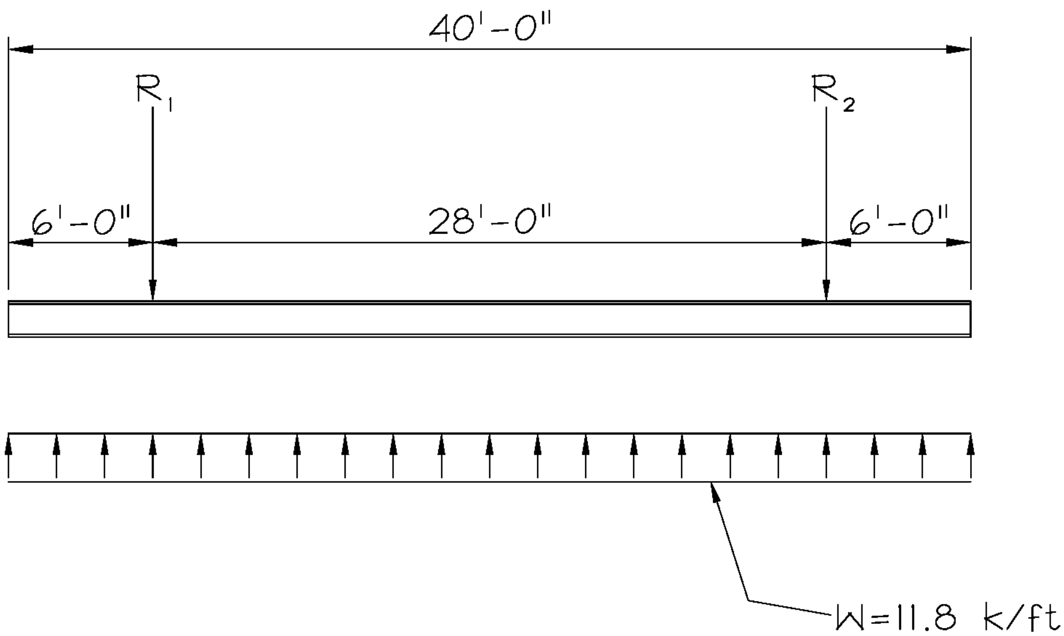
M_{MAX} = 104 kip-ft/ft

M_{MAX} = 104(4) = 416 kip-ft/pile

EXAMPLE G-09-14 – WIDE FLANGE WALE DESIGN

PROBLEM:

SIZE A WALE FOR THE FOLLOWING BRACING GEOMETRY AND LOADING.



SOLUTION:

ANALYZE WALER TO DETERMINE DESIGN MOMENT AND SHEAR -

$$M_{MAX} = \frac{11.8(28)^2}{8} - \frac{11.8(6)^2}{2} = \underline{\underline{944 \text{ kip-ft}}}$$

$$V_{MAX} = \frac{11.8(28)}{2} = \underline{\underline{165.2 \text{ kips}}}$$

$$\text{STRUT LOADS} = R1 = R2 = \frac{11.8(40)}{2} = \underline{\underline{236 \text{ kips}}}$$

ASSUMPTIONS -

USE GRADE 36 WIDE FLANGE BEAM FOR WALER

PROVIDE BRACING FOR WALER AT SPACING NO GREATER THAN $L_b \leq L_p$

$\rightarrow M_n = M_p = (F_Y)(Z)$ (EQ. F2-1) AND $M_{all} = M_n/\Omega_b$

$\rightarrow V_n = 0.6(F_Y)(A_w)(C_v)$ (EQ. G2-1), $C_v = 1.0$ (EQ. G2-2) AND $V_{all} = V_n/\Omega_v$

PROVIDE SUFFICIENT SUPPORT FOR WALER SO WEAK AXIS BENDING IS NEGLIGIBLE

COMPUTE REQUIRED SECTION PROPERTIES -

$Z_{REQD} = \Omega_b(M_{MAX})(12) / F_Y = 1.67(944)(12) / (36) = \underline{\underline{526 \text{ in}^3}}$

$A_{WEB,REQD} = \Omega_v(V_{MAX}) / \{0.6(F_Y)\} = 1.50(165.2) / \{0.6(36)\} = \underline{\underline{11.5 \text{ in}^2}}$

ACCEPTABLE SIZES*	Z (in^3)	A_{WEB} (in^2)
W24X192	559	20.6
W27X178	570	20.2
W30X173	607	19.9

OTHER ACCEPTABLE SIZES ARE AVAILABLE

*NOTE: NEED FOR STIFFENERS HAS NOT BEEN CONSIDERED IN THIS DESIGN EXAMPLE.

EXAMPLE G-09-15 – PIPE STRUT DESIGN

PROBLEM:

DESIGN A PIPE STRUT FOR THE STRUT LOAD (236 kips) COMPUTED IN EXAMPLE 7.1. ASSUME STRUT LENGTH (UNBRACED) IS 38 feet.

SOLUTION:

DETERMINE MINIMUM CROSS-SECTIONAL AREA REQUIRED BASED ON THE 12 ksi MAXIMUM AXIAL STRESS CRITERION –

$$A_{REQD} = \frac{\text{STRUT LOAD}}{12} = \frac{236}{12} = \underline{\underline{19.7\ in^2}}$$

TRY 18" DIA. X 3/8" WALL THICKNESS PIPE, ASTM A252, GRADE 2 (F_Y=35 ksi) -

PIPE PROPERTIES

$A = 19.4\ in^2$

$I = 754\ in^4$

$r = 6.24\ in$

$S = 83.8\ in^3$

$Z = 109\ in^3$

$D/t = 51.6 < 0.45(E) / (F_Y) = 372.9$

WEIGHT (W) = 71 lbs/ft

$$M_{SELF\ WEIGHT} = \frac{WL^2}{8} = \frac{71(38)^2}{8} = 12{,}816\ \text{LB-FT} = \underline{\underline{12.82\ \text{kip-ft}}}$$

DETERMINE FLEXURAL CAPACITY –

$M_n = M_p = (F_Y)(Z)$ (EQ. F8-1) AND $M_{all} = M_n/\Omega_b$

$M_{all} = (F_Y)(Z) / \{\Omega_b(12)\} = 35(109) / \{1.67(12)\} = \underline{\underline{190.4\ \text{kip-ft}}}$

DETERMINE AXIAL CAPACITY –

$P_n = (F_{cr})(A_g)$ (EQ. E3-1) AND $P_{all} = P_n/\Omega_c$

$kL/r = 1.0(38)(12) / 6.24 = 73.08 < 120$

$F_{cr} = 0.658^{(FY)/(Fe)}(F_Y)$ (EQ. E3-2) FOR $F_e > 0.44(F_Y)$

$F_e = \pi^2E / (kL/r)^2$ (EQ. E3-4)

$F_e = \pi^2(29{,}000) / (73.08)^2 = 53.6\ ksi > 0.44(35) = 15.4\ ksi$

$F_{cr} = 0.658^{(35)/(53.6)}(35) = 26.6\ ksi$

$P_{all} = (F_{cr})(A_g)/\Omega_c = 26.6(19.4) / 1.67 = \underline{\underline{309\ kips}}$

CHECK COMBINED AXIAL LOAD AND BENDING –

$(P_r)/(P_c) + (8/9)(M_r)/(M_c) \leq 1.0$ (EQ. H1-1a) FOR $(P_r)/(P_c) > 0.2$

$(P_r)/(P_c) = (236/309) = 0.76 > 0.2$

$(236/309) + (8/9)(12.82/190.4) = 0.76 + 0.06 = \underline{\underline{0.82 < 1.0}}$

<u>18” DIA. X 3/8” WALL THICKNESS (ASTM A252, GRADE 2) PIPE IS ACCEPTABLE</u>

EXAMPLE G-09-16 – SHORING WALL DESIGN

PROBLEM:

THE DESIGN BENDING MOMENT (M_{DESIGN}) FOR A SHORING WALL IS 84 kip-ft per lineal foot. SIZE THE FOLLOWING SHORING WALL MEMBERS FOR THIS DESIGN MOMENT*:

(A) STEEL SHEET PILES

(B) SOIL-MIX WALL PILES INSTALLED @ 4-0" ON-CENTER

*NOTE: OTHER FACTORS NOT CONSIDERED IN THIS EXAMPLE (e.g., SHORING WALL STIFFNESS REQUIRED TO LIMIT WALL DEFLECTION, AXIAL LOAD IN SHORING WALL PILES, ETC.) MAY AFFECT THE DESIGN OF THE SHORING WALL MEMBERS.

SOLUTION:

(A) STEEL SHEET PILES

ASSUME SHEET PILES CONFORM TO ASTM A328 (F_b=25 ksi)

$$S_{REQD} = \frac{12M_{DESIGN}}{F_b} = \frac{12(84)}{25} = \underline{\underline{40.3\ in^3/ft}}$$

ACCEPTABLE SHEET PILE SECTIONS	S (in^3/ft)
ARBED AZ26	48.4
HOESCH H2500	46.1
CASTEEL CZ148	40.9
OTHER ACCEPTABLE SHEET PILE TYPES ARE AVAILABLE	

(B) SOIL-MIX WALL PILES INSTALLED AT 4'-0" ON-CENTER

ASSUME PILE STEEL CONFORMS TO ASTM A572, GRADE 50 (F_b = 33 ksi)

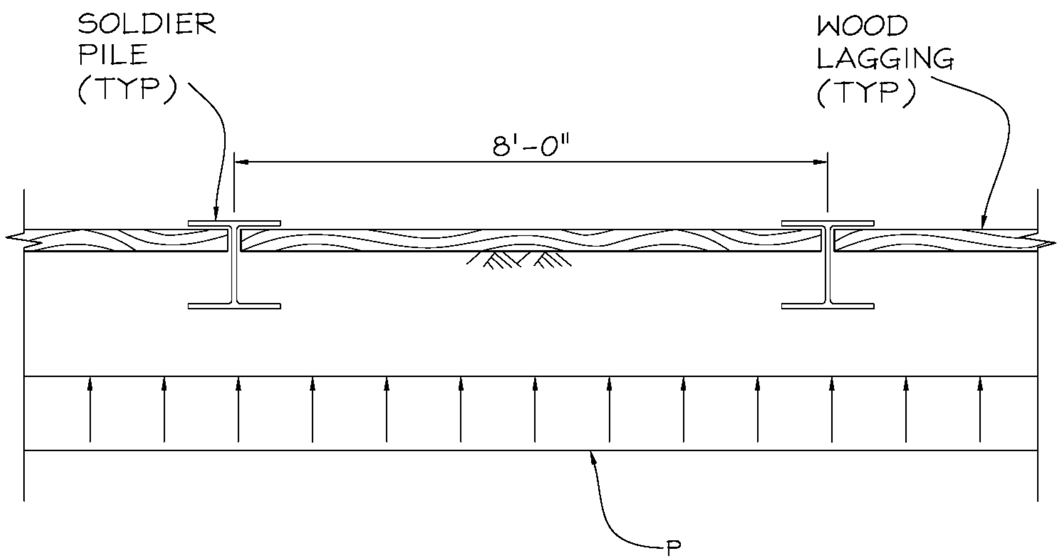
$$S_{REQD} = \frac{12(\text{PILE SPACING})(M_{DESIGN})}{F_b} = \frac{12(4)(84)}{33} = \underline{\underline{122.2\ in^3/pile}}$$

ACCEPTABLE PILE SIZES	S (in^3/pile)
W18X71	127
W21X62	127
W24X62	131
OTHER ACCEPTABLE PILE SIZES ARE AVAILABLE	

EXAMPLE G-09-17 – WOOD LAGGING DESIGN

PROBLEM:

DETERMINE THE WOOD LAGGING THICKNESS REQUIRED FOR THE SHORING GEOMETRY ILLUSTRATED BELOW. ASSUME P (SHORING DESIGN LOADING) IS 1200 psf.



SOLUTION:

COMPUTE LAGGING DESIGN LOADING ($P_{LAGGING}$) –

$$P_{LAGGING} = 0.6P = 0.6(1200) = \underline{\underline{720\text{ psf}}}$$

COMPUTE M_{MAX} AND V_{MAX} -

$$M_{MAX} = \frac{P_{LAGGING}(\text{PILE SPACING})^2}{8} = \frac{720(8)^2}{8} = \underline{\underline{5760\text{ lb-ft/ft}}}$$

$$V_{MAX}{*} < \frac{P_{LAGGING}(\text{PILE SPACING})}{2} = \frac{720(8)}{2} = \underline{\underline{2880\text{ lb/ft}}}$$

(*CONSERVATIVE, V_{MAX} CAN BE TAKEN H FROM SUPPORT)

TRY 6X, S4S (THICKNESS=5½”), DOUGLAS FIR NO.2 MATERIAL -

$$A = 5.5(12) = 66\text{ in}^2\text{/ft}$$

$$S = \frac{12(5.5)^2}{6} = 60.5\text{ in}^3\text{/ft}$$

CHECK BENDING AND SHEAR -

$$f_b = \frac{12M_{MAX}}{S} = \frac{12(5760)}{60.5} = \underline{\underline{1142\text{ psi} < 1500\text{ psi OK}}}$$

$$f_v = \frac{3V_{MAX}}{2A} = \frac{3(2880)}{2(66)} = \underline{\underline{65\text{ psi} < 140\text{ psi OK}}}$$

<u>6X, S4S, DOUGLAS FIR NO.2 MATERIAL IS ACCEPTABLE</u>

.

Appendix H. SCRRA Notice of Exemption Statutory Exemption

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Notice of Exemption

Appendix E

To: Office of Planning and Research
P.O. Box 3044, Room 113
Sacramento, CA 95812-3044

County Clerk
County of: Los Angeles
12400 Imperial Highway
Norwalk, CA 90650

From: (Public Agency): Southern California Regional Rail Authority (SCRRA)
1 Gateway Plaza, 12th Floor
Los Angeles, CA 90012
(Address)

Project Title: Southern California Regional Rail Authority Projects

Project Applicant: Southern California Regional Rail Authority (SCRRA)

Project Location - Specific:
See Figure 1, attached.

Project Location - City: See Figure 1, attached. Project Location - County: Counties of Los Angeles, Ventura, San Bernardino, Riverside, Orange and San Diego

Description of Nature, Purpose and Beneficiaries of Project:

See Attachment A, Project Description

Name of Public Agency Approving Project: Southern California Regional Rail Authority (SCRRA)

Name of Person or Agency Carrying Out Project: SCRRA

Exempt Status: **(check one):**

- ☐ Ministerial (Sec. 21080(b)(1); 15268);
- ☐ Declared Emergency (Sec. 21080(b)(3); 15269(a));
- ☐ Emergency Project (Sec. 21080(b)(4); 15269(b)(c));
- ☐ Categorical Exemption. State type and section number:
- ☒ Statutory Exemptions. State code number: CEQA Guidelines 15275(a). Specified mass transit project; Public Resources Code Reference: Section 21080(b)(10)

Reasons why project is exempt:
The project institutes commuter rail service on existing rail rights-of-way currently in use. According to sections 21080(b)(10) and 15275(a) of CEQA, the institution of commuter rail services on rail rights-of-way already in use are exempt from regulations of CEQA.

Lead Agency Contact Person: Don O. Del Rio Area Code/Telephone/Extension: 213-452-0331

If filed by applicant:

1. Attach certified document of exemption finding.
2. Has a Notice of Exemption been filed by the public agency approving the project? ☒ Yes ☐ No

Signature: [signature] Date: 5-22-14 Title: CEO

☒ Signed by Lead Agency ☐ Signed by Applicant

Authority cited: Sections 21083 and 21110, Public Resources Code.
Reference: Sections 21108, 21152, and 21152.1, Public Resources Code.

Date Received for filing at OPR:

THIS NOTICE WAS POSTED

ON June 26 2014

UNTIL July 28 2014

REGISTRAR – RECORDER/COUNTY CLERK

2014 173222
FILED
Jun 26 2014
Dean C. Logan, Registrar – Recorder/County Clerk
Electronically signed by MONIQUE DAVIS

Revised 2011

Southern California Regional Rail Authority

Attachment A
Amendment to Notice of Exemption
Southern California Regional Rail Project

Description of Nature, Purpose, and Beneficiaries of Project:

This is an amendment to the previously filed Notice of Exemption by Southern California Regional Rail Authority (SCRRA) adopted on September 13, 1991, approving construction, modification, and operations of commuter rail facilities under a California Statutory Exemption. Due to changes since approval of the existing Notice of Exemption and the build out of the Metrolink Commuter Rail System, this amendment is filed to update the original Notice to account for regulatory changes, references, and route maps that developed since the original agreement was approved in 1991.

The descriptions of the proposed projects remain the same as in the original NOE and include the construction, modification, and operation of commuter rail facilities within existing railroad rights-of-way owned by the Southern California Regional Rail Authority member agencies, Los Angeles County Metro Transit Authority, Ventura County Transportation Commission, San Bernardino County Associated Governments, Riverside County Transportation Commission, Orange County Transportation Authority, and North County Transit District.

A map of the Metrolink System commuter rail lines is included in Figure 1 and shows the following routes:

1) Ventura County Line from East Ventura to Los Angeles Union Station (LAUS);

2) Antelope Valley Line from Lancaster to LAUS;

3) San Bernardino Line from San Bernardino to LAUS;

4) Pasadena Subdivision from Pomona to Irwindale;

5) Orange County Line from Oceanside to LAUS on BNSF Railway Company's (BNSF) San Bernardino Subdivision and on SCRRA's Orange and River Subdivisions;

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Jun 26 2014
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Page 1 of 2

METROLINK.

Southern California Regional Rail Authority

6) Riverside Line from Downtown Riverside to LAUS on Union Pacific Railroads (UPRR)'s Los Angeles Subdivision;

7) Inland Empire - Orange County Line from San Bernardino to Oceanside along BNSF's San Bernardino Subdivision, and SCRRA's Olive and Orange Subdivisions;

8) Perris Valley Line from South Perris to Downtown Riverside (service begins in 2015);

9) Redlands Branch from Redlands to San Bernardino (future planned service);

10) 91 Line from Downtown Riverside to LAUS along BNSF's San Bernardino Subdivision and SCRRA's River Subdivision.

The projects also include Metrolink's Central Maintenance Facility north of downtown Los Angeles, the Eastern Maintenance Facility in Colton, and layover facilities in the Cities of Moorpark, East Ventura, Lancaster, Anaheim, San Bernardino, Oceanside and South Perris. The locations of these facilities are also shown on the System Map in Figure 1.

The goal of the project remains the same as stated in the original NOE to simultaneously improve regional mobility and air quality by reducing automobile trips. The beneficiaries include commuters who use the rail service, persons travelling on streets and highways who experience less traffic congestion and delay, and persons residing in the South Coast Air Basin who benefit from improved air quality.

Page 2 of 2

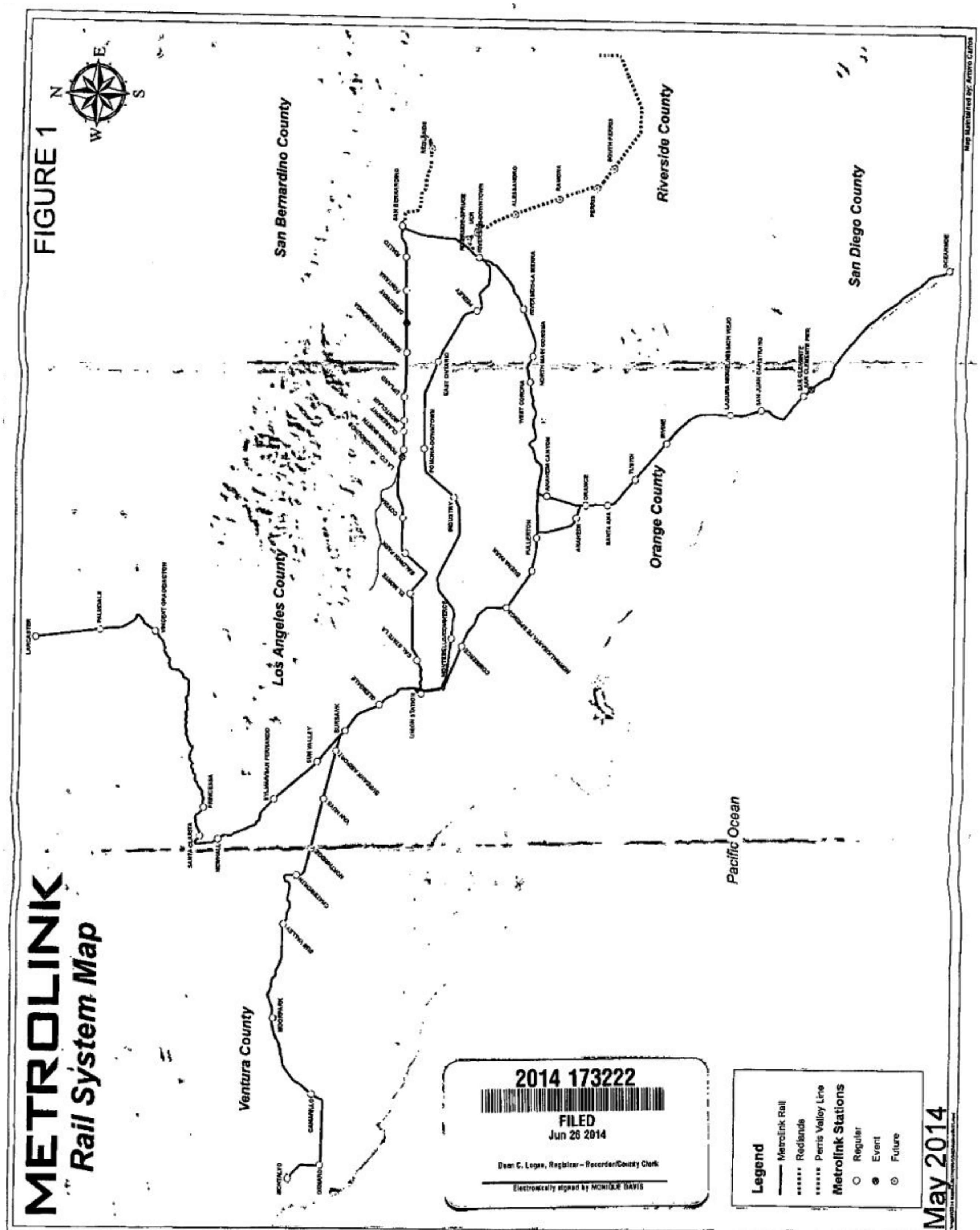
FIGURE 1
METROLINK
Rail System Map
San Bernardino County
Riverside County
San Diego County
Los Angeles County
Orange County
Ventura County
Pacific Ocean
2014 173222
FILED
Jun 26 2014
Legend
Metrolink Rail
Redlands
Perris Valley Line
Metrolink Stations
Regular
Event
Future
May 2014

EXHIBIT F
SHEET 1 of 4

SOUTHERN CALIFORNIA REGIONAL RAIL AUTHORITY

NOTICE OF EXEMPTION

ORIGINAL REC'D
SEP 18 1991
COUNTY CLERK
BY D. Coleman DEPUTY

To: County Clerk
County of Los Angeles
111 North Hill Street
Los Angeles, CA 90012

Subject: Filing of Notice of Exemption for Southern California Regional Rail Authority Commuter Rail (SCRRA) System

Contact Person: Richard Stanger

Project Location: Counties of Los Angeles/San Bernardino/Orange/Ventura/Riverside/San Diego

Attached is an action of the Southern California Regional Rail Authority adopted on September 13, 1991 approving the Project and authorizing this Notice of Exemption.

CERTIFICATION

The undersigned, duly qualified Executive Director of the SCRRA certifies that the attached memo to the SCRRA dated September 13, 1991 and this Notice of Exemption are true and correct copies of the action adopted at a legally convened meeting of the SCRRA Commission held on September 13, 1991.

APPROVED: Richard Stanger
RICHARD STANGER
Executive Director

Date 9/17/91

ATTEST: Lorraine Host
LORRAINE HOST
Secretary

Date 9/17/91

APPROVED AS TO FORM:

DE WITT W. CLINTON
County Counsel

Nina W. Phillips
NINA W. PHILLIPS
Senior Deputy County Counsel

2014 173222
FILED
Jun 26 2014
Dean C. Logan, Registrar – Recorder/County Clerk
Electronically signed by MONIQUE DAVIS

SHEET 2 of 4

NOTICE OF EXEMPTION

To: X Office of Planning and Research
1400 Tenth Street
Sacramento, CA 95814

From: Southern California Regional Rail Authority

X County Clerk
County of Los Angeles
111 N. Hill Street
Los Angeles, CA 90012

2014 173222
FILED
Jun 26 2014
Dean C. Logan, Registrar – Recorder/County Clerk
Electronically signed by MONIQUE DAVIS

Project Title: Southern California Regional Rail Project

Project Location - Specific: See Figure 1 attached.

Project Location - City: See Figure 1 attached.
Project Location - County: Counties of Los Angeles, Ventura, San Bernardino, Riverside, Orange, and San Diego.

Description of Nature, Purpose, and Beneficiaries of Project: The proposed project includes the construction and operation of commuter rail facilities within existing railroad rights-of-way in Los Angeles, Ventura, San Bernardino, Riverside, Orange and San Diego Counties. The proposed commuter rail lines are shown in Figure 1 and include: 1) Moorpark to Los Angeles Union Passenger Terminal (LAUPT) on the Southern Pacific Railroad Coast mainline; 2) Santa Clarita to LAUPT on the tracks of the Southern Pacific Railroad; 3) San Bernardino to LAUPT on the tracks of the Southern Pacific Railroad; 4) San Bernardino to LAUPT on the Santa Fe Pasadena subdivision and Southern Pacific Baldwin Park branch, Yuma Main line and State Street line; 5) Oceanside to LAUPT on the current route of Amtrak's San Diego service and the tracks of the Santa Fe Railway; 6) Riverside to LAUPT on the San Jacinto and San Bernardino Subdivisions of the Santa Fe Railway; 7) San Bernardino to Irvine on existing Santa Fe railroad rights-of-way; 8) Hemet to Riverside on the San Jacinto branch of the Santa Fe Railway; 9) Redlands to San Bernardino on an existing Santa Fe Railway branch line; and 10) Riverside to LAUPT on the Union Pacific Railroad right-of-way. The project also includes a central maintenance facility at the Southern Pacific Taylor Yard north of downtown Los Angeles, and layover facilities in the Cities of Moorpark, Santa Clarita and San Bernardino. The location of these facilities is also shown in Figure 1. The goal of the project is to simultaneously improve regional mobility and air quality by reducing automobile trips. The beneficiaries could include commuters who would use the rail service, persons travelling on streets and highways who would experience less traffic congestion and delay and persons residing in the South Coast Air Basin who would benefit from improved air quality.

Name of the Public Agency Approving Project: Southern California Regional Rail Authority (SCRRA)

Name of Person or Agency Carrying out the Project: SCRRA

Exempt Status (Check One):
___ Ministerial (14 Cal. Admin. Code S15268)
___ Declared Emergency (14 Cal. Admin. Code S15269[a])
___ Emergency Project (14 Cal. Admin. Code S15269[b])
X Statutory Exemption (14 Cal. Admin. Code SS15260 et. seq.)

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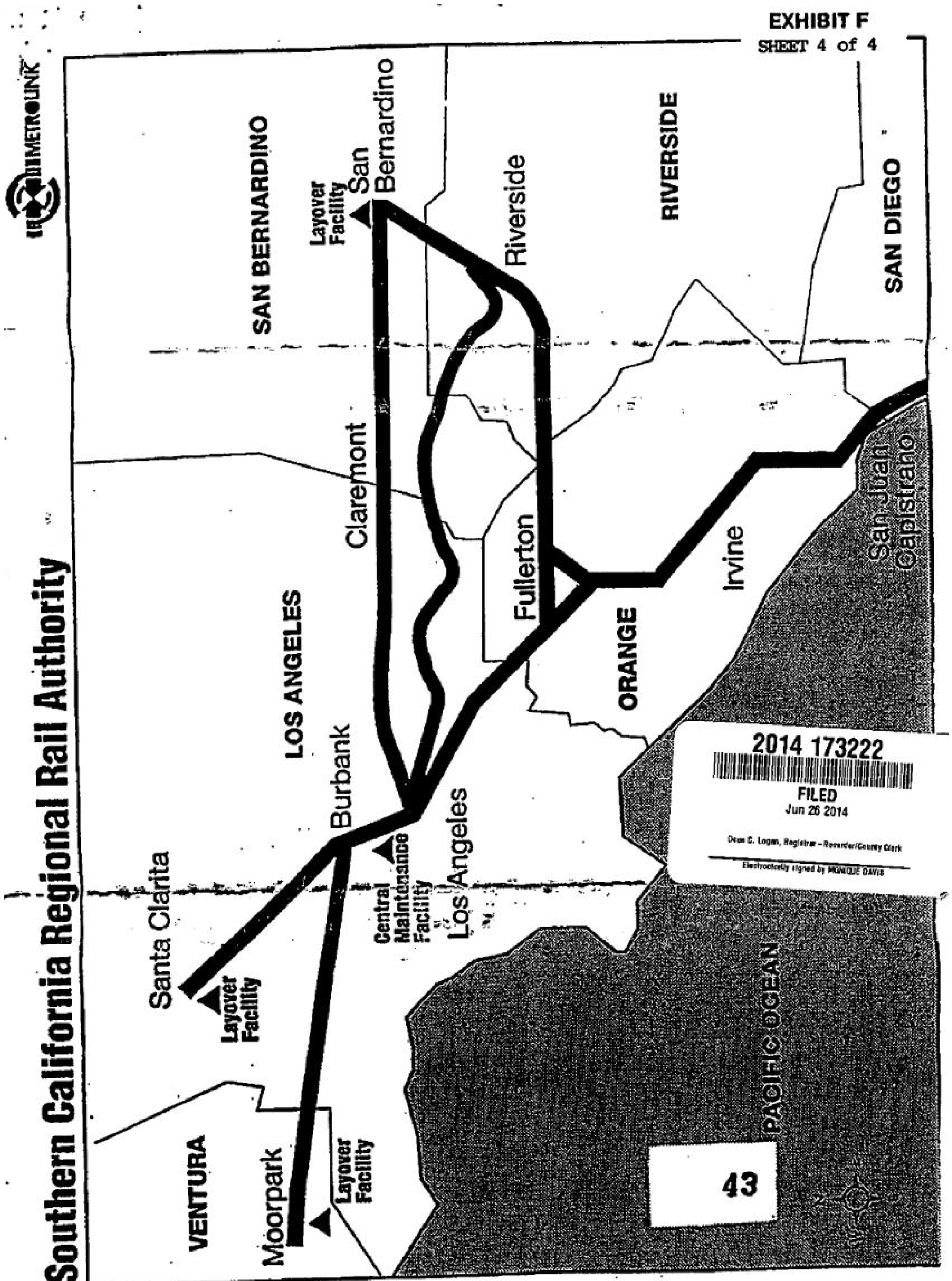


EXHIBIT F
SHEET 4 of 4
METROLINK
Southern California Regional Rail Authority
SAN BERNARDINO
Layover Facility
San Bernardino
Riverside
RIVERSIDE
SAN DIEGO
Claremont
LOS ANGELES
Fullerton
Irvine
ORANGE
San Juan Capistrano
Burbank
Central Maintenance Facility
Los Angeles
Santa Clarita
Layover Facility
VENTURA
Moorpark
Layover Facility
PACIFIC OCEAN
2014 173222
FILED
Jun 26 2014
Dean C. Logan, Registrar – Recorder/County Clerk
Electronically signed by MONIQUE DAVIS
43

FIGURE 1

This is a true and certified copy of the record if it bears the seal, imprinted in purple ink, of the Registrar-Recorder/County Clerk

AUG 27 2014

Dean C. Logan REGISTRAR-RECORDER/COUNTY CLERK
LOS ANGELES COUNTY, CALIFORNIA

REGISTRAR-RECORDER/COUNTY CLERK COUNTY OF LOS ANGELES

METROLINK.

Southern California Regional Rail Authc

REQUEST FOR CERTIFICED COPY
OF AMENDMENT TO EXISTING NOTICE OF EXEMPTION

To: County Clerk
County of Los Angeles
12400 Imperial Highway
Room #1201
Norwalk, CA 90650

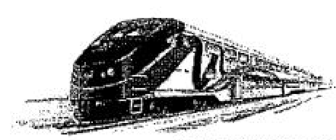
Subject: Request for Document # 2014173222 – Filing of Amendment to Existing Notice of Exemption for Southern California Regional Rail Authority (SCRRA) Commuter Rail System

Project Location: Counties of Los Angeles/San Bernardino/Orange/Ventura/Riverside/San Diego

Attached: Payment of $2

SEND COPY TO ADDRESSEE BELOW:

Patricia Watkins
Assistant Director, Public Projects
279 E. Arrow Highway, Suite 101
San Dimas, CA 91773



One Gateway Plaza, Floor 12 Los Angeles, CA 90012 T (213) 452.0200

metrolinktrains.com

700 S

Appendix I. SCRRA Highway-Rail Grade Crossing Board Resolutions

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Board Resolutions:

I. Resolution 91-3

II. Resolution 98-21

RESOLUTION 91-3

OF THE SOUTHERN CALIFORNIA REGIONAL RAIL AUTHORITY PROMOTING THE ELIMINATION OF RAIL-HIGHWAY GRADE-CROSSINGS AND THE UPGRADE OF EXISTING WARNING DEVICES IN THE REGION'S PASSENGER RAIL CORRIDORS.

WHEREAS, the overall purpose of the Southern California Regional Rail Authority is to advance the planning, design, construction, and then to administer the operation, of regional passenger rail lines serving the counties of San Bernardino, Los Angeles, Ventura, Orange, and Riverside; and

WHEREAS, consistent with this purpose, the Southern California Regional Rail Authority is undertaking a comprehensive capital program to reduce train running times, add track capacity, improve safety, and increase ridership; and

WHEREAS, as part of this program, the Southern California Regional Rail Authority is undertaking a public safety program including the upgrading and/or elimination of existing at-grade rail-highway crossings and the construction of grade-separated rail-highway crossings in the region's passenger rail corridors; and

WHEREAS the Southern California Regional Rail Authority and its member agencies, along with the United States Department of Transportation, the Federal Highway Administration, and the Urban Mass Transportation Administration, are intensifying efforts to promote safety through the elimination of rail-highway grade crossings and the upgrade of existing warning devices, in accordance with the Federal Aid Highway Program Manual, the Federal Aid Highway Act of 1973, 1976 Guidelines and Recommendations, the Surface Transportation Assistance Act of 1987, and the 1989 Report to Congress;

NOW, THEREFORE BE IT RESOLVED that the Southern California Regional Rail Authority does hereby adopt the following policy guidelines concerning rail-highway grade-crossings:

1. The Southern California Regional Rail Authority shall support and promote the elimination of rail-highway grade crossings to the extent feasible on all regional passenger rail lines.

2. Upon the request of a county transportation commission, the Southern California Regional Rail Authority Board will consider exceptions on a case by case basis.

3. The Southern California Regional Rail Authority shall promote to the extent feasible the improvement of remaining grade-crossings in the region's passenger rail corridors through the upgrade of active and passive warning devices and crossing surfaces.

Jacki Bacharach — October 11 1991

Chairman — Date

RESOLUTION 98-21
OF THE SOUTHERN CALIFORNIA REGIONAL RAIL AUTHORITY REGARDING RAIL-HIGHWAY GRADE CROSSINGS

WHEREAS, the overall purpose of the Southern California Regional Rail Authority (SCRRA) is to design, build and operate a premier regional passenger rail system, including commuter and other passenger services, in Southern California; and,

WHEREAS, consistent with this purpose, SCRRA has undertaken a comprehensive capital program to provide mobility for the region, leading to more livable communities; and,

WHEREAS, as part of this program, SCRRA has adopted a strategic plan which includes eliminating or improving existing at-grade rail-highway crossings, and supporting regional, county and local efforts to build grade-separated rail-highway crossings in the region's passenger rail corridors; and,

WHEREAS, SCRRA and its member agencies, along with the Federal Highway Administration, the Federal Railroad Administration, the California Public Utilities Commission, and the California Department of Transportation cooperate on efforts to increase safety through the minimization and elimination of risks at rail-highway grade crossings, in accordance with Federal and state programs and nationally-recognized transportation and traffic engineering standards and practices;

WHEREAS, SCRRA recognizes that California Public Utilities Commission ultimately determines whether a new rail-highway grade crossing will be built.

NOW, THEREFORE BE IT RESOLVED that SCRRA does hereby adopt the following policy guidelines concerning rail-highway grade crossings;

1. SCRRA shall support and promote the elimination of rail - highway grade crossings to the extent feasible on all regional passenger rail lines.

2. SCRRA shall oppose the creation of new rail - highway grade crossings to the extent feasible on all regional passenger rail lines.

3. SCRRA shall support additional funding for grade separations.

4. Any request for an exception shall be presented by a SCRRA member agency; and, upon request, the SCRRA Board will consider exceptions on a case-by-case basis.

5. The SCRRA shall promote to the extent feasible the improvement of remaining grade crossings in the region's passenger rail corridors through the upgrade of active and passive warning devices and crossing surfaces.

6. The SCRRA would support the creation of a new rail-highway grade crossing only if improvements to other grade crossings, including elimination of grade crossing(s), are made part of the creation of the new grade crossing which together clearly improve public convenience and safety.

Chairman — 9-11-98
Date