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SCRRA Design Criteria Manual

1.0 FORWARD

1.1 PURPOSE

This Southern California Regional Rail Authority (SCRRA) Design Criteria Manual (DCM) serves to define the procedures that govern the initiation, progress, and execution of design work for SCRRA. The General Engineering Consultant (GEC) 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 control manual and as such will be updated on a periodic and as-needed basis. The Manager, Civil Engineering will periodically issue revisions to this DCM. Any deviation from the standards and procedures presented herein must be approved in advance by the SCRRA.

Review and acceptance of submittals by SCRRA shall not relieve the GEC of responsibility for the design and construction of projects, including responsibility for errors and omissions in submittals, and construction deviations from accepted design plans.

The design criteria contained in this DCM are the property of SCRRA, and any use of these criteria for non-SCRRA work will be subject to SCRRA approval.

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 Engineering Manager 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 Manager, Civil Engineering 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 committee agrees with the suggested change, the DCM will be updated to reflect the change in the next revision. Corrections of any typographical errors contained herein that do not materially and significantly affect criteria will not require approval by the SCRRA committee. The current effective date of this DCM shall be March 2010.

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.
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. With a system comprising more than 512 route-miles, SCRRA is the nation’s second largest commuter rail system, second only to the Long Island Railroad.

SCRRA’s mission statement declares that SCRRA is a premier regional rail system, including commuter and other passenger services, linking communities to employment and activity centers. SCRRA provides reliable transportation and mobility for the region, leading toward more livable communities.

SCRRA is committed to and characterized by the following attributes:

- Technically superior and safe operations
- Customer focus and accessibility
- Dependable, high-quality service
- Cost-effective and high-value service
- Strategically located network of lines and stations
- Integration with other transit modes
- Environmental sensitivity
- Community involvement and partnerships with both the public and private sectors

2.2 COMMUTER OPERATIONS

2.2.1 The SCRRA System

The SCRRA system began operation in October 1992 with three lines: San Bernardino, Santa Clarita, 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. Most recently, SCRRA initiated service on the 91 Line (Riverside-Fullerton-Downtown Los Angeles) in May 2002.

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 Line (Riverside-Fullerton-Downtown Los Angeles)
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, below, shows the SCRRA system, including stations and connecting rail transit lines.

FIGURE 2-1

2.2.2 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, and Inland Empire-Orange County lines. Additional special event trains may be operated on some weekends.

SCRRA has no operations on the following holidays: New Year’s Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day. However, Amtrak, BNSF Railway Company (BNSF), and Union Pacific Railroad (UP) operate every day of the year on many SCRRA lines.

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 official website at www.metrolinktrains.com.
2.2.3 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, operation, 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 Central Maintenance Facility (CMF) located at 1555 San Fernando Road in Los Angeles, California. Vehicle inspection and light repair are also performed at various layover sites throughout the system. A new maintenance facility was completed in October 2009 in the City of Colton (1945 Bordwell Street, Colton, CA 92324) to service SCRRA locomotives and coaches.

Train operations are dispatched from the Metrolink Operations Center (MOC) located at 2558 Supply Street, Building A, in Pomona, California. The MOC is manned 24 hours per day, 365 days per year.

2.2.4 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 BNSF, UP, and North County Transit District (NCTD).

2.3 ORGANIZATION

SCRRA consists of five county transportation agencies, each of which is a voting member. These county transportation agencies, with their respective number of votes, are:

- Los Angeles County Metropolitan Transportation Authority (METRO), with four votes
- Orange County Transportation Authority (OCTA), with two votes
- Riverside County Transportation Commission (RCTC), with two votes
- San Bernardino Associated Governments (SANBAG), with two votes
- Ventura County Transportation Commission (VCTC), with one vote

Ex-officio members of SCRRA include the Southern California Association of Governments (SCAG), the San Diego Association of Governments, and the State of California Department of Transportation (Caltrans).

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. Figure 2-2, below, represents the organization of SCRRA operations.
2.4 FUNDING

SCRRA receives operating and capital funding from many sources. SCRRA fare box returns fund the largest portion of the system’s operating cost. 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.
2.5 ASSETS

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

<table>
<thead>
<tr>
<th>Real Property</th>
<th>Owner</th>
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<tbody>
<tr>
<td>Ventura County Line</td>
<td>In Los Angeles County: METRO &amp; UP</td>
</tr>
<tr>
<td></td>
<td>In Ventura County: VCTC &amp; UP</td>
</tr>
<tr>
<td>Antelope Valley Line</td>
<td>METRO</td>
</tr>
<tr>
<td>River Corridor (Dayton to Soto)</td>
<td>METRO</td>
</tr>
<tr>
<td>San Bernardino Line</td>
<td>In Los Angeles County: METRO</td>
</tr>
<tr>
<td></td>
<td>In San Bernardino County: SANBAG</td>
</tr>
<tr>
<td>Riverside Line</td>
<td>Riverside Terminal: RCTC</td>
</tr>
<tr>
<td></td>
<td>Remainder of Riverside Line: UP</td>
</tr>
<tr>
<td>Orange County Line</td>
<td>Los Angeles to Fullerton: BNSF</td>
</tr>
<tr>
<td></td>
<td>Fullerton to San Clemente: OCTA</td>
</tr>
<tr>
<td></td>
<td>In San Diego County: NCTD</td>
</tr>
<tr>
<td>IEOC Line</td>
<td>Riverside to Atwood: BNSF</td>
</tr>
<tr>
<td></td>
<td>Atwood to Orange: OCTA</td>
</tr>
<tr>
<td>91 Line</td>
<td>BNSF</td>
</tr>
<tr>
<td>Central Maintenance Facility</td>
<td>SCRRRA</td>
</tr>
<tr>
<td>Eastern Maintenance Facility</td>
<td>SCRRRA</td>
</tr>
<tr>
<td>Pomona MOC</td>
<td>SCRRRA</td>
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</tbody>
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Passenger Stations: Varies; however, station sites are typically owned by the local municipality.
3.0 DESIGN STANDARDS

3.1 SCOPE

The basic requirement for railroad geometric 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.

3.2 STANDARDS, CODES, AND GUIDELINES

The railroad design shall meet all applicable parts of the State of California general laws, CPUC requirements, FRA safety requirements, and the specific project requirements.

Where any conflict in criteria exists, the stricter criteria shall govern unless stated otherwise in this DCM or approved in writing by SCRRA.

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 completed, the design shall conform to the new requirements to the extent approved or required by the agency enforcing the standard, code, or guideline changed.

The design criteria assembled in this DCM are based on industry standards, governmental regulations, local practices, and railroad guidelines/standards. The most recent editions of the following publications and documents were used:

- SCRRA Engineering Standards (ES) and Standard Specifications
- FRA Track Safety Standards, particularly 49 Code of Federal Regulations (CFR) 213, 214, 234, and 236
- CPUC General Orders, as listed below
- American Railway Engineering and Maintenance-of-Way Association (AREMA) Recommended Practice
- Caltrans Highway Design Manual (HDM)
- 49 CFR 195, Transportation of Hazardous Liquids by Pipeline
- Government Code of the State of California
- State of California Division of Occupational Safety and Health (Cal/OSHA) safety orders

The specific CPUC GOS that shall govern are:

- CPUC GO No. 26 - Clearances
- CPUC GO No. 33 - Interlocking Plants
- CPUC GO No. 36 - Abolition of Services
3.3 SCRRA MANUALS

The following manuals are available from SCRRA and will be useful to the designer in specific circumstances:

- Project Manager Manual
- Project Management Manual
- Standard Operating Procedures (SOPs)
- Design Criteria Manual
- Design Procedures Manual
- Design Quality Assurance Plan
- CADD Standards
- CADD Users Guide
- SCRRRA Highway-Rail Grade Crossings Recommended Design Practices and Standards Manual
- Construction Management Manual
- Track Maintenance and Engineering Instructions
- Grade Separation Guidelines
- Excavation Support Guidelines
- Landscape Design Guidelines
- Rail-with-Trails Design Guidelines
- Quiet Zone Implementation Guidelines and Procedures
- SCRRRA Temporary Traffic Control Guidelines
4.0 CLEARANCES AND ROLLING STOCK

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, CODES, AND GUIDELINES

Minimum legal CPUC clearance standards are described in CPUC GO No. 26-D. No design variances can be granted that do not meet these legal minimums.

Required minimum SCRRA guidelines for clearance on mainline tracks, secondary tracks, and yard tracks are described in SCRRA ES2101 through ES2104. Any deviation from SCRRA guidelines shown in ES2101 requires approval from the Director of Engineering and Construction.

4.3 TRACKS

4.3.1 General

The SCRRA minimum standard clearance envelope is shown in ES2101. All permanent construction must comply with these clearance requirements. During construction, temporary clearances shown in ES2101 can be used for formwork or other temporary construction, which will be removed prior to final completion. Request for special design considerations must be requested and approved for any design that does not comply with the requirements stipulated in ES2101. The CPUC minimum legal clearances are shown in ES2102. No special design considerations will be considered if they do not meet the requirements to comply with CPUC GO No. 26-D. Clearance design must also comply with the requirements detailed in the SCRRA Grade Separation Guidelines, dated July 2009, for any proposed rail/highway or rail/rail grade-separated crossings. For curved track, the minimum horizontal clearance shall be the minimum horizontal clearances listed above increased by 1 inch per degree of curvature. Any variation not meeting the requirements of ES2101 must be approved by the Director of Engineering and Construction in accordance with the SCRRA Design Procedures Manual.

At all times, minimum approved clearances shall be maintained. If the facility is on another railroad, 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 Track Spacing

Track spacing, also discussed in Chapter 5.0, Track Geometry, is measured from centerline of track to centerline of adjacent track (centerline to centerline) and is preferably 25 feet,
although ROW limitations may cause closer track centers at many locations. For tangent mainline tracks, the minimum track spacing is 15 feet, and for curved mainline track, the minimum track spacing is 15 feet plus an additional 2 inches (1 inch for each track) per degree of curvature, as shown in ES2207. Bridges, tunnels, and stations will also impact the allowable minimum track spacing.

The preferred minimum spacing between a mainline track and an adjacent yard track is 25 feet, centerline to centerline. If movement of servicing equipment is not required between or adjacent to two yard tracks, the minimum track spacing is 15 feet. If movement of servicing equipment is required between or adjacent to two or more yard tracks, the 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 is required to ensure adequate clearance between and adjacent to tracks.

4.3.3 Shared Corridor

Clearances for high speed rail, light rail transit, or bicycle/pedestrian paths within the SCRRA corridor require compliance with and adherence to the guidelines in the Table 4-1 and the typical sections in Appendix C. Shared-corridor clearances shall allow for future SCRRA trackage.

All permanent and temporary vertical clearances for high speed rail facilities shall adhere to the latest version of the SCRRA Grade Separation Guidelines. Temporary horizontal clearances for high speed rail facilities shall adhere to the latest version of the SCRRA Excavation Support Guidelines.

Permanent horizontal clearance from center line of SCRRA track to the face of high speed rail corridor protection barriers must be a minimum of 25 feet. For short durations, and with prior approval by SCRRA, the minimum horizontal clearance may be decreased from this minimum.

High speed rail structures over SCRRA tracks shall adhere to the latest version of the SCRRA Grade Separation Guidelines, Chapter 7. Parallel high speed rail structures constructed adjacent to SCRRA structures shall have a minimum track centerline spacing of 34 feet between the high speed rail track and the nearest SCRRA track.

Drainage from the high speed rail corridor and facilities must be controlled so as to mitigate runoff on to SCRRA tracks, and shall adhere to Chapter 8.0, Drainage and Grading.
# TABLE 4-1

<table>
<thead>
<tr>
<th>Center to Center Spacing</th>
<th>High Speed Rail (HSR)</th>
<th>Light Rail Transit (LRT)</th>
<th>Bicycle/Pedestrian Paths</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to &lt;34 feet</td>
<td>Not permitted.</td>
<td>Barrier wall must separate tracks to prevent access to third rail or catenaries. Barrier wall to be placed a minimum of 15 feet from SCRRA track. LRT centerline must be a minimum of 25 feet from SCRRA centerline.</td>
<td>Not permitted.</td>
</tr>
<tr>
<td>≥34 feet to ≥ 47 feet</td>
<td>Not permitted.</td>
<td>Fence must separate track corridors. Fence to be a minimum of 25 feet from SCRRA track. An 8-foot chain link fence must separate SCRRA track from LRT track.</td>
<td>Trespass control fence must be placed a minimum of 25 feet from SCRRA track.</td>
</tr>
<tr>
<td>&gt;47 feet to &lt;120 feet</td>
<td>Barrier wall must separate corridor, face of wall to be placed a minimum of 25 feet from SCRRA track. No restriction on speed.</td>
<td>No restrictions. Normal ROW fencing required. Fence to be a minimum of 25 feet from SCRRA track.</td>
<td>Trespass control fence must be placed a minimum of 25 feet from SCRRA track.</td>
</tr>
<tr>
<td>≥120 feet</td>
<td>No restrictions. An 8-foot chain link fence must separate SCRRA track from HSR track. Face of fence to be a minimum of 25 feet from centerline of SCRRA track.</td>
<td>No restrictions. Normal ROW fencing required.</td>
<td>No restrictions. Normal ROW fencing required.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crossing SCRRA Tracks</th>
<th>High Speed Rail (HSR)</th>
<th>Light Rail Transit (LRT)</th>
<th>Bicycle/Pedestrian Paths</th>
</tr>
</thead>
<tbody>
<tr>
<td>At grade</td>
<td>Not permitted.</td>
<td>Not permitted if transit has catenaries, third rail, and/or three or more tracks.</td>
<td>Must be signalized to control pedestrian/bicycle traffic.</td>
</tr>
<tr>
<td>Grade separated</td>
<td>Permitted; must comply with SCRRA Grade Separation Guidelines.</td>
<td>Permitted; must comply with SCRRA Grade Separation Guidelines.</td>
<td>Permitted; must comply with SCRRA Grade Separation Guidelines.</td>
</tr>
</tbody>
</table>
4.4 ROLLING STOCK

4.4.1 Cars

SCRRA coach cars are bi-level commuter cars manufactured by Bombardier and Rotem. Coach cars are 85 feet long over coupler faces and 9 feet 10 inches wide over side sheets. Amtrak and privately-owned passenger cars will operate over all SCRRA lines.

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 three different locomotives; manufacturer’s drawings are included in Appendix D. The lengths of the locomotives are shown below, but other relevant dimensions are as shown in the manufacturer’s drawings:

<table>
<thead>
<tr>
<th>Model</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>F59PH</td>
<td>58 feet 2 inches over coupler faces</td>
</tr>
<tr>
<td>F59PHI</td>
<td>58 feet 7 inches over coupler faces</td>
</tr>
<tr>
<td>MP36PH-3C</td>
<td>68 feet 0 inches over coupler faces</td>
</tr>
</tbody>
</table>

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, CODES, AND GUIDELINES

Detailed alignment design information is available in SCRRA ES2201 through ES2209. The values and formulae for design parameters presented in this chapter are to be used throughout the SCRRA system. If in the process of design it becomes apparent that complying with the values presented in this chapter will result in unreasonable cost or significant physical impact on adjacent property and facilities, request for special design consideration to the criteria may be presented to SCRRA on a case-by-case basis to request a variance.

5.3 DESIGN SPEED

Unless otherwise specified, the maximum 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 currently 60 mph, but this may be increased to 80 mph.

Shoofly tracks are temporary detour tracks that should be designed to match the current train 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 to be considered include ROW, topography, and existing adjacent structures.

All new tracks shall be constructed to the following standards:

- Track shall be constructed to the alignment and grade prescribed.
  - Gage shall be 4 feet 8-1/2 inches.
  - Deviation from established gage and cross-level shall not exceed 1/8 inch, and profile grade and horizontal alignment variation shall not exceed 1/8 inch measured at the center of a 62-foot chord.
- Track must also comply with FRA Track Safety Standards (49 CFR 213) Class 5 Standards or higher, as required.

Tangent track shall be level, and superelevation with runoff spirals shall be provided on all curves in conformance with ES2202 through ES2204 unless otherwise directed by SCRRA.

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 approved by the Director of Engineering and Construction, considering the alignment, grade, braking distance, station proximity, and other factors.
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 **HORIZONTAL ALIGNMENT**

FRA Track Safety Standards, Part 213, Subpart C, and CPUC GO No. 26-D are the absolute limiting cases for the maintenance of track geometry; however, these are not necessarily the design limits that govern. SCRRA standards are the minimum and will govern track design. Any deviation from SCRRA standards requires approval from the Director of Engineering and Construction.

5.4.1 **Components**

The 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 \(\frac{1}{4}\) inch. Compound circular curves may be used; however, transition spirals between such curves shall be used and approval must be obtained from the Director of Engineering and Construction.

Circular curves shall be connected by a minimum tangent length unless the designer is retrofitting an old alignment with inadequate spirals and tangents where alternatives for correcting the condition do not exist and where the Director of Engineering and Construction has granted a special design consideration permitting the use of modified design tables ES2204-03 and ES2204-04.

5.4.2 **Curves and Superelevation**

Horizontal curvature shall be designed in accordance with ES2202 through ES2204. 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 the Director of Engineering and Construction 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 ES2204, 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 a request for special design consideration is approved by the Director of Engineering and Construction.

Curves should be designed to maximize speeds. The minimum curve radius is 573 feet \((D=10\text{ deg.})\), and the maximum actual superelevation is 5 inches. The minimum curve radius for non-mainline track is 479 feet \((D=12\text{ deg.})\), and the maximum actual superelevation is 5 inches. Certain combinations of superelevation and curvature are prohibited, as specified in ES2204. Minimum tangent lengths are discussed in ES2203.
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 the Director of Engineering and Construction.

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 track spacing, measured from centerline of track to centerline of adjacent track (centerline to centerline), is 25 feet as this allows unencumbered train operations on an adjacent track during maintenance operations. In SCRRA's urban environment, that spacing is seldom possible; however, the SCRRA minimum track spacing is 15 feet, centerline to centerline. Centerlines of mainline tracks shall be spaced as defined in ES2001, ES2002, and ES2207. Where possible, the designer should review the relevant strategic plans for the track segment such that the current design is consistent with future plans. The SCRRA minimum spacing between a mainline track and an adjacent yard track is 25 feet, centerline to centerline. Any required track spacing between mainline and adjacent yard tracks that is less than 25 feet requires an approved special design consideration by the Director of Engineering and Construction. 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.

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. Additional information is provided in Chapter 4.0, Clearances and Rolling Stock.

Piers, abutments, and columns as they affect track spacing must comply with the requirements in the SCRRA's current Grade Separation Guidelines and the AREMA Manual for Railway Engineering, Chapter 8. New piers, abutments, and columns shall not be permitted on the ROW without permission from the Director of Engineering and Construction.

5.4.4 Spirals

Spiral length is defined in ES2203, ES2204-01, and ES2204-02. 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 ES2204-03 and ES2204-04 to accommodate the required track speeds on these converted former freight branch lines. A request for special design consideration must be approved by the Director of Engineering and Construction before these shortened design spirals may be used.

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 Section 5.3, above, 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

Standards regarding tangent lengths between curves and between curves and other track components are shown in ES2203. 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 another solution is not practical or available and after an approved special design consideration has been granted by the Director of Engineering and Construction.

Where tangents connect circular curves in the same direction, it is usually more acceptable to deviate from the standard through substitution of shorter tangent lengths rather than through substitution of shorter spiral curves. It is less acceptable to make this substitution in the case of reversing curves than in the case of circular curves in the same direction.

5.5 VERTICAL ALIGNMENT

5.5.1 General

The profile grade shall represent the elevation of the top of the low rail (T/R) 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 the cross section template. Primary or single mainline tracks shall be constructed with a slight crown in the roadbed section at the centerline of the tracks.

When the T/R profile is given for one track only, the T/R elevations of the other tracks are to be calculated based on ES2001, ES2002, 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. All mainline and siding tracks shall be designed to the same vertical profile, although the T/R elevation may be different, and reflect the cross section.
5.5.2 Grades

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

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:

\[ L = 3V \]

Where

- \( L \) = minimum tangent length, feet
- \( V \) = design speed in the area, mph (which may be a future, higher speed)

Short grades up to 3.0 percent may be designed with the approval of the Director of Engineering and Construction. Grades shall be minimized in siding tracks where trains meet or pass and shall be uniform at station platforms unless approved by the Director of Engineering and Construction. 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.

5.5.3 Vertical Curves

Vertical curve design standards are shown in ES2201.

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

\[ L = \frac{D V^2 (K)}{A} \]

Where

- \( A \) = vertical acceleration in feet/second\(^2\)
- \( D \) = absolute value of the difference in rates of grades expressed as a decimal
- \( K \) = 2.15 conversion factor to give \( L \) in feet
- \( L \) = 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 vertical curve length 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 the Director of Engineering and Construction. 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. The Director of Engineering and Construction may require train performance simulations to verify that proposed T/R profiles will not produce unacceptable dynamic in-train forces.
5.6 TURNOUTS

5.6.1 Location

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 50 feet from the edge of the traveled roadway or sidewalk, if a sidewalk is present
- Facing point turnout spacing shall adhere to ES2209

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.

The minimum size of turnout to be designed for use in the mainline track will be a No. 10 Turnout.

5.6.2 Speeds

Maximum speeds through turnouts are defined in ES2208. The designer shall select turnouts based on operating speeds. The higher speed and tonnage operation should use the straight side of the turnout. Non-standard SCRRA turnouts shall be sized to minimize impact on both routes through required speed reduction.

5.7 YARDS

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

- Reverse curves, including turnouts, should have at least 50 feet of tangent, if possible.
- A special design consideration may be considered to allow reverse curves used in slow speed (that is, 10 mph or less), low-use turnouts to be reduced to a minimum required tangent of 20 feet. Additional protection measures may be necessary if a special design consideration is granted.
- Placement of switch-stands shall provide walkway clearance per CPUC GO No. 118 and shall be in compliance with ES2105.
- Placement of access/fire road crossings shall avoid turnouts.
6.0 TRACKWORK

6.1 SCOPE

Design of all elements of the system, such as grading, structures, utilities, and appurtenances, shall allow the construction of track within the required parameters. If situations arise during the design in which deviations from these criteria may be advantageous to SCRRA, these deviations shall be brought to the attention of the Director of Engineering and Construction, who will communicate the approved special design considerations to the designer.

6.2 STANDARDS, CODES, AND GUIDELINES

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

The latest edition of the following standards, codes, and guidelines shall govern in the design of all SCRRA trackwork in the following order:

1. SCRRRA Engineering Standards
2. SCRRRA Standard Specifications
3. SCRRRA Engineering Instructions
4. Specifications for SCRRA (owner-purchased) Material
5. AREMA Manual for Railway Engineering
6. AREMA Portfolio of Trackwork Plans

6.3 TRACKWORK

6.3.1 Track Classification

Primary Track

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

Secondary Track

Secondary track includes all other track that is constructed for the purpose of switching, storing, or maintaining vehicles not occupied by passengers in revenue service.

Freight and Other Track

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.

6.3.2 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).
Ballasted track without CWR is acceptable on low-use yard and secondary track as well as low- to moderate-use industrial track.

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/maintenance needs require consideration of this track construction type.

### 6.3.3 Track

#### Primary Track

SCRRA standards and specifications describe typical primary track construction as 136-pound, 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 as indicated for special trackwork to the furthest extent possible to eliminate in-track joints. Track sections and fastener details are shown in the appropriate SCRRRA Engineering Standards.

#### Secondary Track

SCRRA standards and specifications describe typical secondary track construction as 136-pound new or secondhand rail as directed by SCRRRA. 136-pound new rail is to be head-hardened rail.

On all lead and moderate- to high-use tracks, CWR shall be used. When connecting rail of differing sizes in lead tracks, transition rails shall be used, as presented in SCRRRA ES2372 and ES2373. 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 without permission of the Director of Engineering and Construction.

On low-use secondary tracks, jointed rail is acceptable. When jointed rail is used, poly-insulated bars and compromise bars are acceptable. Compromise bars shall also be considered acceptable for use on industrial spurs.

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 cut spikes and anchors shall be used. Track sections and fastener details are shown in the appropriate SCRRRA Engineering Standards.

#### Freight and Other Track

SCRRA standards and specifications describe typical freight or industrial track construction as the same as secondary track construction, except jointed rail, compromise bars, and poly-insulated bars are all acceptable. Secondary track standards shall be maintained for use in major lead tracks. Track sections and fastener details are shown in the appropriate SCRRRA Engineering Standards.

### 6.3.4 Turnouts

SCRRA will direct the use of premium concrete, standard concrete, or standard wood turnouts, as follows:

- Premium concrete turnouts consist of wing rail spring manganese (WSM) frogs using pseudo-tangential geometry constructed on concrete ties with hollow steel ties, including hot-mix asphalt concrete (HMAC) underlayment.
Standard concrete turnouts consist of WSM frogs using pseudo-tangential geometry constructed on all concrete ties, including HMAC underlayment.

- Standard wood turnouts consist of rail-bound manganese (RBM) or self-guarded solid manganese (SGSM) frogs using standard geometry constructed on timber (wood) ties.

Primary Track

The selection and location of turnouts are discussed in Chapter 5.0, Track Geometry. Turnouts shall be fully welded with elastic fasteners, timber ties, or concrete ties, as directed. Turnouts will be insulated and interlocked. Lateral geometry shall be used unless the Director of Engineering and Construction directs the use of equilateral geometry.

The designer shall plan the design to facilitate turnout fabrication on an adjacent temporary construction pad and installation during short preplanned outage windows.

Secondary Track

The selection and location of turnouts are discussed in Chapter 5.0, Track Geometry. 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. 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

The selection and location of turnouts are discussed in Chapter 5.0, Track Geometry. Turnouts shall be installed per the secondary track standard.

6.3.5 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 timber. 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 a crossing. SCRRA standards on grade crossings are presented in ES4001 through ES4023.

Traffic lanes and striping information is presented in the SCRRA Highway-Rail Grade Crossings Recommended Design Practices and Standards Manual.

6.3.6 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 ES2601 through ES2613.

All new industrial or spur track designs will 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 out-of-control rail vehicles from fouling 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 ES2601 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 out-of-control rail vehicles from fouling adjoining or adjacent secondary tracks. Derails shall be installed per the same standard as primary tracks (see ES2601).

Freight and Other Track

Derails shall be used to prevent out-of-control rail vehicles from fouling adjoining or adjacent lead tracks. On freight lead tracks, derails shall be installed per the same standard as primary and secondary track derails.

6.3.7 Bumping Posts

Primary Track

Primary track 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 end of the track. The face of the bumping post shall be located a minimum distance of 8 feet from the end of the track. An allowance of 3 feet shall be provided from the train stopping position to the face of the bumping post.

Secondary and Industrial Track

Secondary and industrial track bumping posts shall be installed at the end of each stub-ended operating track where the grade is descending toward the bumping post. A minimum distance of 8 feet shall be provided from the face of the bumping post to the end of the track. An allowance of 3 feet shall be provided from the train stopping position to the face of the bumping post. Wheel stops shall be permitted if the grade is ascending toward the wheel stop location or if the grade is flat.

6.3.8 Railroad (Diamond) Crossings

Rail/rail crossings shall be installed only where there is no other option available to allow trains to reach their respective destinations. Although economics may strongly dictate the requirement to install a railroad crossing, all other options shall be explored and presented to the Director of Engineering and Construction for guidance before designing railroad (diamond) crossings. The designer shall place the crossing in tangent tracks if possible. The designer shall not place the crossing where both tracks are in a horizontal curve.
Crossings shall be aligned as close to perpendicular as possible. Crossing at a shallow angle (typically under 30 degrees) requires moveable point frogs, which lead to increased complexity, cost, and maintenance. Crossings may require special signaling and/or other operating restrictions, particularly if primary tracks are involved. If train travel on the secondary track will be set to slow speeds (such as 10 mph), the designer shall consider the use of flange bearing crossing frogs. A hot-mix asphalt (HMA) underlayment shall be required for all new rail/rail crossings.

6.3.9 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 after thoughtful consideration for maintenance and the protection of a structure’s integrity.

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 the Director of Engineering and Construction.

SCRRA standards for inner guard rails associated with bridges are presented in ES2302 and ES2304.

6.4 TRACK MATERIALS

6.4.1 Rail

Primary track shall be 136-pound rail end (RE) section, head-hardened carbon steel rail meeting current SCRRA standard specifications and AREMA “Specifications for Steel Rail.” Secondary and industrial tracks that are used as lead tracks and high-use running tracks shall be 136-pound RE section, head-hardened CWR or as directed by SCRRA. Other secondary and industrial tracks, 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.

6.4.2 Ties

Concrete ties with elastic fasteners shall be used for new primary track construction. Concrete ties shall be 8 feet 3 inches long and spaced at 24 inches, center to center. 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 ties shall be new 9-foot-long and 7-inch-high by 9-inch-wide hardwood-treated main track (HWTR MT) grade 5 ties and spaced at 19.5 inches, center to center.

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 ES2351. Transition ties shall be new 10-foot timber ties.

Steel ties shall be used as directed by the Director of Engineering and Construction and in locations of substandard ballast depth or in locomotive service areas.

6.4.3 Other Track Material

Other track material (OTM) shall conform to current SCRRA and AREMA standards and specifications. Cut spikes may be used in timber tie construction where rail size remains the same. If cut spikes are used as primary fasteners, rail anchors shall also be used. If the rail size changes, tie plates shall be changed and elastic fasteners shall be used. Required fastener types are presented in ES2361 through ES2368.

The designer shall call for approved tie pads and insulators on concrete ties in the designs. SCRRA standards for approved tie pads and insulators are presented in ES2360-01 through ES2360-03.

6.4.4 Special Trackwork

Special trackwork shall conform to current SCRRA standards and specifications and AREMA recommended practices.

6.4.5 Ballast

Primary track ballast shall conform to SCRRA standard specifications and AREMA recommended practices. Secondary track ballast, where forces are likely to walk while inspecting or maintaining equipment, shall be yard ballast.

Standard ballast sections are presented in ES2001 and ES2002.

6.4.6 Sub-Ballast

Sub-ballast material shall conform to SCRRA standard specifications and AREMA recommended practices. 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 ES2001 and ES2002.

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.
6.4.7 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 SCRRA Engineering Instructions issued on February 12, 2009, particularly Section 3.1.12, Location and Preparation for Thermite Welds.

No joints or field welds are allowed in road crossings. Permanent joints shall be fully bolted. Temporary joints pending welding should not have bolts installed or holes drilled on the center two holes of six-hole bars. If holes are present in rail and bars, bolts shall be installed.

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. 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. Compromise bars and poly-insulated joint bars may be used on jointed rail track.

6.4.8 Insulated Joints

Permanent insulated joints shall be installed by insulated joint plugs fully welded in primary track. Poly-insulated bars may be used in closure rail of turnouts and on jointed secondary track. No compromise welds are allowed.
7.0 Stations

7.1 SCOPE

The design criteria for SCRRA stations are discussed below. The primary purpose of the stations design criteria is to educate the user on the improved guidelines, practices, procedures, and policies that reflect current regulations, proven and accepted technological developments, and best available rail industry design practices. The other purpose is to have the user apply these standards and recommend design practices to station design and construction. These station design criteria provide the minimum requirements for the design and planning of new or rehabilitated stations.

SCRRA intends to apply the recommended station design criteria when new stations or improvements are proposed. It is not intended that the requirements be applied retroactively to existing stations absent any proposed major physical or use changes or in the absence of an appropriate level of funding. Deviations from the criteria will require the approval of the Director of Engineering and Construction.

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 DCM are intended to ensure that a station is designed to meet the minimum requirements for a SCRRA commuter train station.

As of August 2009, SCRRA trains serve 55 stations located throughout Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura Counties, as shown in Table 7-1.

**TABLE 7-1**

<table>
<thead>
<tr>
<th>Station</th>
<th>Address</th>
<th>City</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaheim</td>
<td>2150 E. Katella St.</td>
<td>Anaheim</td>
</tr>
<tr>
<td>Anaheim Canyon</td>
<td>1039 N. Pacificenter Dr.</td>
<td>Anaheim</td>
</tr>
<tr>
<td>Baldwin Park</td>
<td>3825 Downing Ave.</td>
<td>Baldwin Park</td>
</tr>
<tr>
<td>Buena Park</td>
<td>8400 Lake Knoll Drive</td>
<td>Buena Park</td>
</tr>
<tr>
<td>Burbank</td>
<td>201 No. Front St. &amp; 5 W. Olive Ave.</td>
<td>Burbank</td>
</tr>
<tr>
<td>Burbank Airport</td>
<td>3750 Empire Ave.</td>
<td>Burbank</td>
</tr>
<tr>
<td>Cal State LA</td>
<td>5150 State University Dr.</td>
<td>Los Angeles</td>
</tr>
<tr>
<td>Camarillo</td>
<td>30 Lewis Road</td>
<td>Camarillo</td>
</tr>
<tr>
<td>Chatsworth</td>
<td>10046 Old Depot Plaza Road</td>
<td>Chatsworth</td>
</tr>
<tr>
<td>Claremont</td>
<td>200 W. 1st St.</td>
<td>Claremont</td>
</tr>
<tr>
<td>Station</td>
<td>Address</td>
<td>City</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Commerce</td>
<td>6433 26th St.</td>
<td>Commerce</td>
</tr>
<tr>
<td>Covina</td>
<td>600 N. Citrus Ave.</td>
<td>Covina</td>
</tr>
<tr>
<td>Downtown Pomona</td>
<td>101 W. 1st St.</td>
<td>Pomona</td>
</tr>
<tr>
<td>E. Ontario</td>
<td>3330 E. Francis St.</td>
<td>Ontario</td>
</tr>
<tr>
<td>El Monte</td>
<td>10925 Railroad St.</td>
<td>El Monte</td>
</tr>
<tr>
<td>Fontana</td>
<td>16777 Orange Way</td>
<td>Fontana</td>
</tr>
<tr>
<td>Fullerton</td>
<td>120 Santa Fe. Ave.</td>
<td>Fullerton</td>
</tr>
<tr>
<td>Glendale</td>
<td>400 W. Cerritos Ave.</td>
<td>Glendale</td>
</tr>
<tr>
<td>Industry</td>
<td>600 S. Brea Canyon Road</td>
<td>City of Industry</td>
</tr>
<tr>
<td>Irvine</td>
<td>15215 Barranca Parkway</td>
<td>Irvine</td>
</tr>
<tr>
<td>Laguna Niguel/Mission Viejo</td>
<td>28200 Forbes Road</td>
<td>Laguna Niguel</td>
</tr>
<tr>
<td>Lancaster</td>
<td>44812 N. Sierra Highway</td>
<td>Lancaster</td>
</tr>
<tr>
<td>Montalvo</td>
<td>6175 Ventura Blvd.</td>
<td>Ventura</td>
</tr>
<tr>
<td>Montclair</td>
<td>5091 Richton St.</td>
<td>Montclair</td>
</tr>
<tr>
<td>Montebello/Commerce</td>
<td>2000 Flotilla St.</td>
<td>Montebello</td>
</tr>
<tr>
<td>Moorpark</td>
<td>300 High St.</td>
<td>Moorpark</td>
</tr>
<tr>
<td>Newhall</td>
<td>24300 Railroad Ave.</td>
<td>Santa Clarita</td>
</tr>
<tr>
<td>North Main Corona</td>
<td>250 E. Blaine St.</td>
<td>Corona</td>
</tr>
<tr>
<td>Northridge</td>
<td>8775 Wilbur Ave.</td>
<td>Northridge</td>
</tr>
<tr>
<td>Norwalk/Santa Fe Springs</td>
<td>12700 Imperial Highway</td>
<td>Norwalk</td>
</tr>
<tr>
<td>Oceanside</td>
<td>235 S. Tremont St.</td>
<td>Oceanside</td>
</tr>
<tr>
<td>Orange</td>
<td>194 Atchison St.</td>
<td>Orange</td>
</tr>
<tr>
<td>Oxnard</td>
<td>201 E. Fourth St.</td>
<td>Oxnard</td>
</tr>
<tr>
<td>Palmdale</td>
<td>39000 Clock Tower Plaza Drive</td>
<td>Palmdale</td>
</tr>
<tr>
<td>Pedley</td>
<td>6001 Pedley Rd.</td>
<td>Riverside</td>
</tr>
<tr>
<td>Pomona</td>
<td>205 Santa Fe St.</td>
<td>Pomona</td>
</tr>
<tr>
<td>Princessa</td>
<td>19201 Via Princessa</td>
<td>Santa Clarita</td>
</tr>
<tr>
<td>Rancho Cucamonga</td>
<td>11208 Azusa Court</td>
<td>Rancho Cucamonga</td>
</tr>
<tr>
<td>Rialto</td>
<td>261 S. Palm Ave.</td>
<td>Rialto</td>
</tr>
<tr>
<td>Riverside-Downtown</td>
<td>4066 Vine St.</td>
<td>Riverside</td>
</tr>
<tr>
<td>Riverside-La Sierra</td>
<td>10901 Indiana Ave.</td>
<td>Riverside</td>
</tr>
<tr>
<td>San Bernardino</td>
<td>1204 W. 3rd St.</td>
<td>San Bernardino</td>
</tr>
<tr>
<td>San Clemente</td>
<td>1850 Avenida Estacion</td>
<td>San Clemente</td>
</tr>
<tr>
<td>San Juan Capistrano</td>
<td>26701 Verdugo St.</td>
<td>San Juan Capistrano</td>
</tr>
<tr>
<td>Santa Ana</td>
<td>1000 E. Santa Ana Blvd.</td>
<td>Santa Ana</td>
</tr>
</tbody>
</table>
7.2 STANDARDS, CODES, AND GUIDELINES

SCRRA commuter train service operates over trackage that is part of the general railroad system of transportation and, in most cases, SCRRA passenger trains share track with freight trains. Therefore, this DCM must be used in conjunction with current versions of SCRRA Engineering Standards, the AREMA Manual for Railway Engineering, and the AREMA Communications & Signals Manual of Recommended Practices.

In addition, the most current editions of the following standards, codes, specifications, and guidelines shall be consulted in the design of stations; should there be conflicts between codes, then the most restrictive code shall apply:

- Federal Transit Administration Americans with Disabilities Act (ADA) Standards for Transportation Facilities (effective 11/29/06)
- CPUC GOs
- California Public Utilities Code (PU Codes)
- Local Building Codes
- Local Planning and Zoning Codes and Standards
- SCRRA Documents:
  - SOPs
  - Design Criteria Manual
  - Design Procedures Manual
  - CADD Standards
  - CADD Users Guide
  - SCRRA Highway-Rail Grade Crossings Recommended Design Practices and Standards Manual
  - Track Maintenance and Engineering Instructions
  - Grade Separation Guidelines
  - Excavation Support Guidelines
  - Landscape Design Guidelines
  - Rails-with-Trails Design Guidelines
7.2.1  Station Standard Drawings

Detailed drawings related to the various stations elements are contained in SCRRA Engineering Standards. These standards are not intended to replace existing regulatory standards or substitute for engineering knowledge, experience, and judgment, but are requirements for safe construction, maintenance, and operation of stations. Because the actual design will typically be site specific, information shown on these standard drawings will be modified as necessary in close collaboration with SCRRA.

7.2.2  Codes and Approvals

For specific locations, approvals may be required from the United States Army Corps of Engineers (USACE), the California Coastal Commission, Caltrans, or other agencies or authorities.

Station construction and improvements design funded by the State of California may require review and approval by the State Architect.

Station construction and improvements design funded by the federal government may require historic preservation (Section 106) review.

California Public Utilities Commission

All facilities adjacent to track shall meet the requirements of CPUC GO 26-D for clearances. SCRRA has additional clearance requirements that are more stringent than CPUC. Refer to SCRRA ES3201 and ES3202 for minimum clearances (horizontal and vertical) for various elements at station platforms.

Americans with Disabilities Act

Access to the station shall conform to ADA requirements and California Building Code accessibility provisions.

Local

Station architecture, layout, parking, landscaping, and streetscape shall be designed to meet applicable county, city, district, or neighborhood guidelines and requirements. Any permits necessary to design and construct the station shall be obtained from the appropriate public agency.

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 Standards.

To design a new SCRRA station or modifications to an existing station, a station city/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 SCRRA station design.

### 7.3.2 SCRRA Station Equipment

For a typical station, SCRRA will provide the following services and equipment:

- Two ticket vending machines (TVMs) with installation
- Two multi-trip ticket validators (MTTVs) with installation
- Platform and right-of-way signage with design, fabrication, and installation
- Precast station communications shelter with installation
- SCRRA passenger information system with installation
- SCRRA passenger information phone with installation

These services and equipment items must be specially ordered for each station and must be funded by the station city/owner or SCRRA member agency.

SCRRA will be responsible for the ongoing operation and maintenance of these equipment items.

### 7.3.3 Agreements

Before any designs can be finalized and before any construction work can begin, an agreement must be executed by SCRRA and the public agency and any other outside parties participating in the funding that 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 construction and maintenance agreement, the public agency 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 public agency 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 representing SCRRA’s costs for administration and management.

To perform work on ROW that is operated and maintained by SCRRA, Right-of-Entry Agreements are required. 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.” 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, 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 the ROW with BNSF and UP. In such cases, in order to perform work on their ROW, approval shall be obtained from BNSF and UP. The procedures

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7.4 STATION SITES

To establish a sense of “place” of the station and to instill a sense of ownership by the community, station layout, station elements (canopies and fence), and architectural features should be discussed with public agency(s) and neighborhood community organizations. For new station construction, the design engineer should recognize emerging development that can compliment station development and increase ridership and should initiate and coordinate programs with the community that limit local traffic impacts and minimize disruption during and after the implementation phase. For existing station rehabilitation and renovation, the design engineer should generally match the existing architectural elements.

Areas with tangent track are preferred for a station site. Curved track should be avoided if at all possible. If a station is located on a curve, the platform should be on the inside of the curve. Platforms on the outside of a curve present concerns for the train engineer and conductor because the curve prevents them from seeing all of the cars and doors to ensure that all passengers have safely boarded or alighted prior to closing the doors. If a platform on an outside of 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 the curve shall require prior approval from the Director of Engineering and Construction. 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 18 feet between centerline of tracks. The expanded track centers 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 “Delayed in 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 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 agreement from a SCRRA member agency and/or a construction and maintenance agreement with the owner of the railroad ROW are typically required for a new station.

7.5 STATION PARKING

The minimum number of parking spaces at any new station is 500. 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. 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 lanes and vehicles backing out. Exit lanes are recommended to provide for controlled exiting and to minimize the back-up of vehicles into the parking stall lanes.

An area should be designated for short-term parking for pick-up and drop-off. The area must be compliant with ADA accessibility guidelines and should be located to prevent conflicts with buses or vehicles traveling down parking stall lanes.

A monument sign identifying SCRRA shall be provided at the station entrance to clearly identify the station parking area. Other vehicular directional signs should be provided to direct motorists to the accessible parking and Kiss-n-Ride areas as needed.

The station layout 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.

7.6 INTERMODAL ISSUES

SCRRA encourages the provision of intermodal connections at stations. These may take the form of regular transit bus service, bike paths, dedicated walkways, and pedestrian-friendly paths of travel.

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. If bus service is located on the street outside of the station, the path of travel from the bus stop to the station platform must comply with ADA requirements.

7.7 PLATFORMS

The station shall be designed with side platforms located opposite one another on the outside of the tracks. Center island platforms should be used only when the station site is not suited for side platforms.

In designing the station platforms, consideration should be given to future track additions and possible future platform extensions for longer train consists. New stations will be constructed with 680-foot-long platforms. 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.

The platform should be a minimum of 16 feet wide for a side platform and 30 feet wide for a center platform. Additional width should be provided at side platforms, if possible, for canopies and overcrossing or undercrossing structures. The center platform width allows the minimum required width for an overcrossing tower with its stairs, elevator, and crash walls. SCRRA prefers to keep the platform clear of any obstructions.

All side platforms should slope away from the track a minimum of 1 percent and no more than 2 percent in accordance with ADA guidelines. At center platforms, the slope shall be to a centerline swale with area drains for discharge to the municipal storm drain system. Drain the entire station site and contiguous railroad ROW. 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 10 feet beyond the limits of the platform or through the at-grade crossing.
and 10 feet beyond. Refer to Track Section of Engineering Standards for additional information.

In accordance with the amended Americans with Disability Act of 1990 (ADA) (42 U.S.C. 1201 et seq.), titled “Transportation for Individuals with Disabilities at Intercity, Commuter, and High Speed Passenger Railroad Station Platforms; Miscellaneous Amendments” (49 CFR Parts 37 and 38), the Department of Transportation require intercity, commuter, and high-speed passenger railroads to ensure, at new and altered station platforms, that passengers with disabilities can get on and off any accessible car of the train. Passenger railroads must provide level-entry boarding at new or altered stations in which no track passing through the station and adjacent to platforms is shared with existing freight rail operations. Passenger railroads are able to choose among a variety of means to meet a performance standard to ensure that passengers with disabilities can access each accessible train car that other passengers can board at the station. These means include providing car-borne lifts, station-based lifts, or mini-high platforms.

For new or altered stations serving 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 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 an intercity or high-speed rail system use the tracks serving the platform.

Platforms shall be at an elevation 8 inches above the top of the adjacent rail unless permission is obtained from SCRRRA and FTA/FRA in advance as per the requirements shown above. The platform edge shall be 5 feet 5 inches from the centerline of track. Platforms are to be constructed of concrete with a flush vertical wall on the track side. Designers will consult with SCRRRA 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.) In all cases, these two dimensions will control field construction and will supersede dimensions and/or elevations shown on the plans.

All station platform, structures, and equipment must be designed to meet the minimum clearance requirements of CPUC GO 26-D or the latest revision, which is available on their website at [www.cpuc.ca.gov](http://www.cpuc.ca.gov).
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, and a mini-high platform is required. The mini-high platform is 1 foot 1 inch above the general platform level for an 8 inches platforms and is set back 7 feet 11 inches from the centerline of track. The mini-high platform landing is centered 60 feet from the station end closest to Los Angeles Union Station. See ES3101-01 and ES3101-02 for details.

7.7.2 Surface

Platforms must be slip resistant; therefore, special finishes (for example, stamped concrete and ceramic tile) are not recommended.

7.7.3 Detectable Warning Strip

A detectable warning strip 2 feet wide is required at the rail side of the platform. The strip is required to be Federal Yellow in color for the entire platform, except near the mini-high platform where the color will be black and white as per ES3101, and must include the Federal Standard truncated domes. A 1-inch-wide black contrast stripe is required at the back of the detectable strip.

7.7.4 Striping

A painted 4½-inch-wide yellow stripe shall be installed on the platform located 3 feet 2 inches from the rail edge of the platform with text per ES3203.

7.7.5 Stairs/Ramps/Walkways

When platforms are placed above or below parking lot elevations, access to the platforms should be by stairs or ramps. The placement of these should be carefully planned to be convenient for passengers. Stairways should be a minimum of 48 inches wide using a maximum tread riser of 7 inches. Ramps with slopes of 5 percent or greater must have handrails per ADA guidelines. Walkways to and from platforms should be a minimum of 10 feet wide. There should be no walls, columns, stairwells, escalator faces, and other similar obstructions within 14 feet of the centerline of the nearest track to allow for passenger circulations sight distances.

7.7.6 Guardrails/Handrails

Stainless steel handrails are recommended to reduce station maintenance requirements. Guardrail shall be galvanized metal.

7.7.7 Other Design Considerations

At some stations, there will be service by both Amtrak and SCRRA. This introduces several design issues for the station platform. Amtrak may use a portable lift, which requires a secure storage space on the platform. Also, Amtrak may use baggage carts on the platform, so baggage cart circulation/turnaround and cart secured storage/recharging area must be considered. Amtrak may require a longer platform than SCRRA, usually a minimum of 1,000 feet long.
It is recommended that water connections be placed at the back of the platform or be near the platform for power washing.

### 7.8 PEDESTRIAN CROSSINGS

SCRRA must approve the final design of crossings at stations, regardless of ownership of the station. The preferred design is to have completely grade-separated pedestrian access to separate platforms from each operating track, with an inter-track fence between the tracks to prevent persons from crossing between platforms at grade. All new pedestrian crossings must be approved by CPUC through a formal application process. Refer to SCRRA’s Highway-Rail Grade Crossings Recommended Design Practices and Standards Manual for at-grade pedestrian crossings design and construction. Refer to SCRRA’s Grade Separation Guidelines Chapter 9.0 for detail information on pedestrian overheads and underpasses.

#### 7.8.1 Overheads

Where the track is at or below natural grade, then an overhead crossing may be used. The overcrossing span shall be a minimum of 24 feet clear above top of rail and shall be a minimum of 10 feet wide. The overcrossing can be served by stairs and either an elevator or a ramp system complying with ADA requirements. The overcrossing tower structure shall not be closer than 14 feet from the centerline of track. Refer to SCRRA Grade Separation Guidelines for overhead structure requirements. Fencing on overcrossings is required to prevent the dropping of large objects on passing trains. In order to comply with ADA guidelines, an overcrossing will require an elevator for each overcrossing tower. Due to reliability and maintenance cost issues related to elevators, SCRRA would not recommend using overcrossings. In addition, the relatively long travel distance of an overcrossing makes it undesirable to the public. Exterior maintenance of an overcrossing is difficult and costly. An alternate access should be designed for use in the event of elevator failure.

#### 7.8.2 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 of the pedestrian underpass structure shall not be less than 14 feet wide by 9 feet high. The maximum inside clear dimensions of the structure shall not be more than 16 feet wide by 10.5 feet high. The underpass should have as open an aspect as possible at each side. ADA-compliant access can be provided through the use of elevators or ramps. Ramps are preferred due to the reliability and maintenance cost issues of elevators. If elevators are used, an alternate access should be designed for use in the event of elevator failure.

Provisions for closed circuit television (CCTV) should be included in an undercrossing. 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. Provision should be made for an emergency lighting system in the event of a power outage.

#### 7.8.3 At-Grade Crossings

If the only practical design is to have an at-grade pedestrian crossing at a station, then the crossing(s) shall be constructed at the end(s) of the platform in accordance with ES3002 and ES3003. This prevents the blockage of the crossing(s) by a standing train. SCRRA approval is necessary to select at-grade pedestrian crossing.
7.9 PLATFORM AMENITIES

7.9.1 Canopies

It is suggested that canopies cover approximately 15 to 20 percent of the platform length. The canopies should be set back clear of a line 14 feet from the centerline of the track. It is suggested that the structural supports be set at the back of the platform clear of the 16-foot minimum side platform width. Canopy configuration and construction 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, sun, and rain. However, the principles of Crime Prevention through Environmental Design (CPTED) must be considered. That is, canopy structures should not create hiding areas, and the materials should be vandal resistant.

Misters and heaters may be considered in areas with extreme temperatures.

The canopies must have lighting and include conduits for SCRRA passenger information/communications and potential CCTV equipment.

The canopy closest to the mini-high platform must be accessible.

7.9.2 Platform Furniture

All platform furniture (benches and trash receptacles) should be located at the back of the platform.

Bench selection is at the discretion of the station designer. Benches should be a vandal-resistant design. They should be designed to discourage sleeping on the benches. Benches must be securely fastened to the platform.

Trash receptacles should be provided at regular intervals on the platform. Trash receptacles should be 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.

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 can be fabricated by SCRRA if they are not included in the station construction contract.

Kiosks and display cases are typically not internally illuminated, so they must be placed in a well-lit area in the vicinity of the TVM area.

7.10.2 Food and Beverage Vending Machines

The installation of vending machines is at the discretion of the station owner. It is recommended that a separate vending machine area be constructed off of the platform.
7.10.3 Public Telephones

If public telephones are offered at a station, they must comply with ADA guidelines.

7.10.4 Newspaper Racks

The installation of newspaper racks is at the discretion of the station owner. Newspaper racks must not be installed on the platform.

7.10.5 Bike Lockers and Racks

Bike lockers and racks should be provided in close proximity to, 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.

7.10.6 Passenger Information Phone

SCRRA provides, installs, and maintains a 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.

7.10.7 Restroom Facilities

Installation of station restrooms are at the discretion of the station owner. Restrooms are available on board trains for passengers.

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.

7.10.8 Ticket Vending Machines Area

A TVM area must be provided for each boarding platform. It is preferable to have the TVM area located off of the platform at the primary platform. The TVM area requires a 12-inch-thick concrete pad for installation of the TVMs and a canopy to provide weather protection for the TVMs and passengers.

It is preferable to have the face of the TVMs oriented to the north to minimize TVM screen glare throughout the day. Wheelchair turning space and adequate queuing area must be provided in front of each TVM.

The TVM area canopy must have lighting and provisions for passenger information and communications equipment and security camera systems.

The TVM area should not have benches or trash receptacles.

The typical TVM area will be configured to include provisions for two TVMs, one MTTV, and a debit card reader. Installation of information display cases near the TVM area is recommended.

See ES3405-01 and -02 for TVM pad details. The station owner is responsible for providing power to all TVMs, MTTVs, and debit card readers. SCRRA will install communications cables for all ticket vending equipment.
7.11 RECOMMENDED ILLUMINATION LEVELS

Recommended illumination levels are as shown in Table 7-2.

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Illumination Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platforms</td>
<td>5 foot candles</td>
</tr>
<tr>
<td>Canopies</td>
<td>10 foot candles</td>
</tr>
<tr>
<td>Overheads and Underpasses</td>
<td>10 foot candles</td>
</tr>
<tr>
<td>Stairways and Ramps</td>
<td>10 foot candles</td>
</tr>
<tr>
<td>Walkways</td>
<td>10 foot candles</td>
</tr>
<tr>
<td>TVM areas</td>
<td>10 foot candles</td>
</tr>
<tr>
<td>Parking lots</td>
<td>Per local requirements</td>
</tr>
</tbody>
</table>

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. 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. See ES5102 for details of inter-track fence.

Wherever the railroad ROW can be used as a shortcut to the station, ROW fencing must be installed to prevent trespassing onto the ROW. See SCRRA Engineering Standards for minimum ROW fencing requirements.

The station owner may consider perimeter fencing to better secure the parking area. Also, an entrance gate should be installed if the station owner would like to close the parking overnight.

7.13 SIGNAGE

Signs shall be placed at sufficiently frequent intervals and at visible locations to provide clear directions and information to commuters without additional assistance.

7.13.1 Parking Lot Signs

The station parking lot must include an entrance sign containing the SCRRRA logo. The logo must be configured to comply with the SCRRRA graphics standards. At the station owner’s cost, SCRRRA can design, fabricate, and install a porcelain enamel SCRRRA 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.

7.13.2 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. SCRRA can provide full-color SCRRA trailblazers to cities for installation by city forces on local streets.

7.13.3 Platform/Right-of-Way Signs

The platform and 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 ROW. See ES3301 through ES3331 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. These signs are necessary for passenger information and train operations or are required by ADA.

7.14 LANDSCAPE CONSIDERATIONS

All landscaping shall be kept a minimum of 12 feet clear from the centerline of track. Trees shall be located so that the anticipated canopy spread will not encroach closer than 12 feet to the centerline of the nearest track. Irrigated planters should not be installed on platforms.

In parking lots, the principles of CPTED should be applied, and landscaping should not create hiding areas.

Where irrigation is used, the water spray and drainage shall be designed to maximize coverage and reduce overspray, and shall be directed away from tracks, platforms, and walkways. 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.

Landscaping shall meet the requirements included in SCRRA Landscaping Design Guidelines, available on SCRRA’s website.

7.15 ARTWORK

Artwork should be installed off of the platform. Artwork should be under the ownership of the station owner.

7.16 STATION COMMUNICATIONS INFRASTRUCTURE

A complete and proper communications infrastructure is needed throughout a station to properly support ticket vending, passenger communications, railroad signaling, fiber optic systems, and security.
An essential element of the station communications infrastructure is the station communications shelter.

7.16.1 Station Communications Shelter

New station construction funding must include funds for a pre-fabricated climate-controlled station communications shelter. This shelter should be away from the platform along the railroad ROW, but may be placed in the station parking lot. The shelter location should not conflict with future station improvements (for example, platform extension). Also, the shelter must be accessible to maintenance crews and must not be in irrigated landscaped areas where the shelter will be constantly damp.

The station construction contractor is responsible for constructing the foundation for the shelter, and SCRRA will install and maintain the shelter.

The shelter will have two separate rooms. One room can be used by the station owner to house the station security camera equipment. The second room will house SCRRA communications equipment for the station and will be the minimum point of entry for telephone service to the station. Separate electric meter service is required for each room. See ES9400 through ES9440 for typical sizes and configurations.

7.16.2 Conduits

Station platforms and facilities shall contain power and communications conduits and pull boxes required to support all SCRRA equipment, including TVMs, MTTVs, Customer Information System (CIS), and Closed Circuit Television (CCTV). It is recommended that wherever possible, all conduit systems be located behind the platform. This is to prevent platform closure in the event that there is a failure in the conduit system requiring excavation within the platform area.

The ROW is used for fiber optic and signal lines, which are buried in conduit systems within the ROW. To prevent closure of the platform to allow excavation for these lines, it is SCRRA policy to provide at least three 4-inch-diameter conduits for the full length of the platform with 4-foot square pull boxes at maximum 200 foot centers and at each end of the platform. The conduits are to be provided with pull ropes tied off in each of the pull boxes. These conduits are to be in addition to any other conduit systems installed for the platform.

Concrete for ductbank encasements shall be Class 3000 and colored with a red mineral coloring pigment.

See SCRRA Engineering Standards for typical platform conduit and wiring systems.

7.16.3 Utilities

The station designer must work closely with electric utility and telephone company service planners to ensure that electricity and telephone service drops are in the vicinity of the station communications shelter.

The existing utilities shall be located prior to commencing any excavations. Approval 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, or other structure. Refer to SCRRA’s website to ensure proper contracts and phone numbers. SCRRA is not a member of DIGALERT; it is, therefore, necessary to call SCRRA’s signal department phone number (refer to SCRRA’s website) to mark, at the highway agency’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. SCRRRA 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 the required action on such lines.

7.16.4 Security Cameras

SCRRA station standards include sufficient conduit in the platform to support a security camera system. If desired by the station city/owner, member agency, and/or SCRRA, cameras at stations for passenger security shall be designed and installed.

7.16.5 Customer Information System

All new SCRRA stations will include a complete Customer Information System (CIS). The major components of CIS include light emitting diode (LED) message signs with strobe lights, liquid crystal display (LCD) monitor(s), and a PA amplifier with speakers. LED message signs with strobe lights and public address speakers are mounted high on platform light poles to broadcast service change information to waiting passengers. An LCD monitor is located in the vicinity of each TVM area to display both train schedule listings and service disruption bulletins.

Service information is transmitted over CIS from the Metrolink Operations Center (MOC) via SCRRA network equipment housed in the station communications shelter. Refer to the CIS standards for details on equipment placement in stations.

7.17 CONSTRUCTION

Similar to station design, a station city/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.

7.18 STATION MAINTENANCE

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

7.18.1 SCRRA Maintenance

SCRRA will be responsible for the ongoing operation and maintenance of the TVMs, MTTVs, CIS equipment, passenger information phones, platform and ROW signage, and station communications shelter.

7.18.2 Station City/Owner Maintenance

The station city/owner’s responsibilities include, but are not limited to, the following:
• Maintaining, repairing, sweeping, cleaning, and resurfacing all station parking areas, platform areas, and related access areas
• Maintaining, repairing, and cleaning all station lighting systems, irrigation systems, structures, parking lot signs, and other station improvements or fixtures
• Removing all trash, litter, and debris from the station
• Removing all graffiti from the station
• Keeping the station free of weeds
• Maintaining all planted/landscaped areas

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

8.1 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 following industry standards for design also protects SCRRA from liability for damage to other property from storm water flows caused by the construction of SCRRA improvements.

8.2 STANDARDS, CODES, AND GUIDELINES

The latest edition of the following standards, codes, and guidelines shall be used in the design of SCRRA drainage facilities:

- SCRRA ES1801, Standard Roadbed Section
- AREMA Manual for Railway Engineering
- Caltrans Highway Design Manual (HDM), Chapters 800 to 890, Highway Drainage Design
- U.S. Department of Transportation, Federal Highway Administration (FHWA) Hydraulic Engineering Circulars (HEC) and Hydraulic Design Series (HDS) reports
- American Public Works Association (APWA) Standard Plans for Public Works Construction
- 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
- State, regional, or local standards, ordinances, codes, and design criteria as applicable

8.3 GENERAL DRAINAGE DESIGN REQUIREMENTS

Criteria for design of SCRRA system drainage facilities are provided below. 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 engineer.
Apart from others’ design criteria, 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. New and replacement bridge and culvert openings shall be sized for two high-water design discharge events, designated “low chord/soffit” event and “subgrade” event.
   - For SCRRRA mainline and mainline siding trackage, the low chord/soffit event is the 50-year flood and the subgrade event is the 100-year flood.
   - For industrial leads, yards, and customer-owned or third-party trackage, these events are the 25-year and 50-year floods, respectively.
   - If a drainage structure crosses under both mainline and non-mainline tracks, the most restrictive criteria shall apply.
   - At locations 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.
   - 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 SCRRRA, FEMA, or other local water surface or freeboard criteria, whichever is more restrictive.
   - Drainage facilities for the SCRRRA 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 unless a variance is obtained from the Director of Engineering and Construction (see item 9, below).

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 2.52 feet below top of rail elevation for timber ties and 2.81 feet below top of rail elevation for concrete ties) unless a variance is obtained from the Director of Engineering and Construction (see item 9, below).

4. Both SCRRRA criteria and local regulatory flood passage criteria shall be evaluated. The SCRRRA criteria shall be adopted unless a variance of the SCRRRA standards is requested and approved or if FEMA or other applicable flood regulations are more restrictive.

5. If the existing bridge or culvert opening exceeds that required by the adopted criteria, a smaller section will be recommended based on SCRRRA and applicable local floodplain development criteria.

6. 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.

7. 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. Variances may be requested using Request for Special Design Consideration Form DPM-13, provided in Appendix E, if alternatives meeting SCRRA criteria cause extensive track raises or if the addition of relief structures is not feasible given the site geometry. In such cases, a variance matching existing conditions with no increase in 100-year water levels may be requested.

8. 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.

9. Variances to SCRRA criteria, but not to more restrictive criteria by others, can be granted upon written justification acceptable to the Director of Engineering and Construction. Requests for hydraulic or hydrologic criteria special design considerations must be submitted on Request for Special Design Consideration Form DPM-13, provided in Appendix E. Any variances to third-party criteria must be approved by that jurisdiction prior to submitting the special design consideration request to the Director of Engineering and Construction.

10. 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.

11. The engineer’s recommendation for structure replacement shall include one alternative that meets the above criteria along with any alternatives that would require a variance to one or more of the above criteria.

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 30-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.

8.4 HYDROLOGY

8.4.1 Design Discharge Rates

Design flow rates for the low chord/soffit and subgrade events described in Section 8.3, above, shall be determined by the engineer using local contemporaneously 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. Where practicable, the selected design flow rates should be compared and contrasted with rates derived from simple, alternative peak-flow methods.
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 contemporaneous and watershed-appropriate methods. Where published flow rates exist, the engineer should adopt the published values unless justification acceptable to the Director of Engineering and Construction is provided in support of alternative flow rates.

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 engineer should apply methods that incorporate only those future developments that can be reasonably predicted. Where less than ultimate development rates are suggested, the engineer shall provide his/her recommendation to SCRRA and receive approval from the Director of Engineering and Construction 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 engineer.

8.4.2 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 engineer 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.

8.4.3 Hydrologic Methods

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 design engineers should be researched and applied, with documentation provided justifying the engineer’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.

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 techniques as for non-tidal sites. If in the judgment of the engineer, further refinement is required, the engineer will so recommend and obtain approval from the Director of Engineering and Construction before proceeding.

If an assigned bridge or culvert appears to be one of multiple existing parallel structures crossing the same waterway in close proximity to one another, the engineer shall bring this to the attention of the Director of Engineering and Construction prior to making the site visit. When so directed, the engineer shall obtain field information on all affiliated structures and include them in the field data collection and office analysis.
8.5 HYDRAULICS

8.5.1 Standards, Codes, and Guidelines

The design of drainage waterways, culverts, and structures shall be based on sound hydraulic principles to achieve an optimum combination of efficiency and economy. The latest edition or version of the following standards, codes, guidelines, and/or equivalent approved software packages is to be used for the hydraulic design:

- AREMA Manual for Railway Engineering
- U.S. Department of Commerce, Bureau of Public Roads, HDS Manuals
- FHWA HECs
- FHWA HDS reports

8.5.2 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 engineer to complete the design and perform the required before-and-after comparison using the agency model.

8.5.3 Hydraulic Design of Storm Sewers, Ditches, and Off-Track Drainages

Surface drainage facilities, storm sewer inlets, and underground storm sewers in SCRRA stations, adjacent streets, rail yards, parking lots, ditches that do not cross the track, and bridges and culverts that do not carry rail traffic shall be designed for the 10-year peak flow rate or other applicable jurisdiction's criteria, whichever is more stringent.

Contemporaneous, industry-standard methods for hydrology and hydraulics in urban areas shall be applied. If a rainfall-runoff method is used, the design shall be for the peak runoff from the most critical 10-year storm. In the case of ditches, the engineer 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.

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 as in Section 8.5.2 but using the 10-year design event, or higher if required by other jurisdictions, as the low chord/soffit event.

Where a pipe or other closed conduit is part of a storm sewer system and crosses the track or track bed, it shall be designed as a storm sewer with the same design storm as the remainder of the system to which it is connected.
Ditches are open channels along the side of and generally parallel to the track for the purpose of carrying runoff from the track bed, pavement, shoulders, and adjacent areas. The most common types of ditches are triangular, trapezoidal, u-shaped, and rectangular and may be either concrete or grass lined.

The u-shaped or trapezoidal shapes 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.

Adverse backwater effects of others’ under-sized facilities downstream of new or replacement cross-track or off-track SCRRRA structures may occur if the facilities have lower flood passage capacities than SCRRRA standards. These limited-capacity facilities may result in unreasonable costs in order to meet the criteria discussed in Section 8.3. If the limiting structure is likely to wash out during a design event, or if it is likely to be replaced with an appropriately matched structure in the near term, the design can proceed, upon SCRRRA approval, as though the condition is improved. Regardless, the backwater shall be assessed, and one alternative meeting SCRRRA criteria shall be provided. The alternative may include a relief structure within SCRRRA 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. Any recommended alternative that deviates from the criteria discussed in Section 8.3 shall be submitted as part of a request for variance using Request for Special Design Consideration Form DPM-13, provided in Appendix E.

8.5.4 Parallel Track Construction

Many SCRRRA projects include parallel track construction, adding a second mainline or siding track alongside an existing mainline. The engineer should initially design the drainage structure for the new track to replicate (match) the hydraulics of the existing structure assuming it will remain unchanged, regardless of whether it meets the criteria discussed in Section 8.3. The agency or municipality responsible for ownership and/or maintenance of the drainage channel should also be consulted prior to selection of the final structure type.

On a case-by-case basis, the Director of Engineering and Construction may request analysis of the waterway opening and structure size that would be required for both structures to meet the criteria discussed in Section 8.3 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.
8.5.5 Non-SCRRA Facility Owners Wishing to Interconnect with SCRRA Drainage Facilities

Employees or consultants acting on behalf of owners of facilities being designed to interconnect with SCRRA drainage facilities shall design the facilities and provide design data and reports to the Director of Engineering and Construction affirming and certifying that the designs meet the same criteria required of designers of SCRRA drainage facilities as described herein.

Upon completion of construction of any approved designs, the owner of that facility shall provide to the Director of Engineering and Construction as-built drawings along with a certificate of compliance with SCRRA design criteria.

8.5.6 Consultant Typical Hydrology and Hydraulics Procedures

When design is by a consultant, the consultant will typically observe the following procedures:

1. Review descriptive documents provided by SCRRA. These will typically include SCRRA alignment maps, profile maps, inspection reports, and condensed profile pages. These documents, and any other information that may be supplied by SCRRA, are proprietary to SCRRA and are not to be used for any purpose other than the assigned study without the written consent of SCRRA.

2. Research the site. Locate the drainage structure on a United States Geological Survey (USGS) quadrangle map. Determine if the assigned bridge or culvert appears to be one of multiple structures that receive runoff from one drainage area. Contact federal, state, and local agencies to ascertain permit requirements, and schedule a meeting in the field, if required, to discuss hydraulic design and conceptual bridge and drainage crossing approach. Obtain state and local information and/or previous studies regarding historical or calculated flows at the site.

3. Using researched data, perform hydrologic calculations to establish preliminary low chord/soffit and subgrade event peak flow rates at the sites using peak flow formula procedures or runoff hydrograph analysis such as rational method, regression equations, Soil Conservation Service (now Natural Resources Conservation Service) TR-55, HEC-1, WMS, locally-derived peak flow or hydrograph methods, and HEC-HMS (using Soil Conservation Service Synthetic Unit Hydrographs, Clark’s or Snyder’s Unit Hydrograph methods, or other contemporaneously adopted methods).

4. Visit the site. Contact the appropriate SCRRA manager prior to the site visit to establish communications, schedule the trip, inquire about any recommendations or special conditions to be considered, obtain guidance regarding access, and (in cases of difficult access) secure transportation to the site. This contact shall be used to establish and coordinate compliance with SCRRA and FRA roadway worker safety requirements.

5. Conduct research and data collection, which shall include, but not be limited to, the following: (1) photograph the bridge opening, channel, abutments, and footings; (2) examine local scour problems and other site conditions, such as the presence of wetlands; (3) obtain information, if available, on flow and foundation conditions at other existing bridges in near proximity; (4) inspect the main channel and portions of the overbank area and obtain cross-section information required for hydraulic analysis; and unless specifically directed otherwise, (5) obtain top-of-
rail elevations (at bridge backwalls, even stations, and any other significant feature) and other survey information to develop profile and location plans. During the site visit, also inspect the bed and bank area and the existing abutments and footings to assess whether particularly difficult bed and embankment erosion problems might exist. If it is apparent that previous floods have caused damage to the existing structure, or if there appears to be a potential for damage, provide recommendations to SCRRA regarding measures that might be considered for protection. Note any obvious foundation concerns, particularly whether driving piles might be difficult. Note, flag, photograph, and record information describing the ordinary high water mark for the waterway.

6. When conducting bridge design and hydrology and hydraulics surveys for SCRRA structure replacements, take detailed measurements of any existing structure or component that SCRRA might be reusing (for example, an existing pier or backwall that will be supporting new spans). When taking photographs, take overall photos to complement any close-up shots, and photograph the existing structure from multiple viewpoints, especially if SCRRA might be reusing any existing bridge structure or component. In addition, photograph any signage within SCRRA ROW, ensuring that any telephone number or contact information is clearly visible. Contact SCRRA prior to the survey to establish specific needs for any measurements and photographs beyond those needed for hydrology and hydraulics analysis. Record all surveying to the one-hundredth foot elevations.

7. Place temporary benchmarks in a conspicuous location unlikely to be obstructed by vegetation or other debris and a sufficient distance away from the railroad structure to ensure that it will not be covered up by riprap or fill. Telephone poles, trees, or adjacent highway structures would be suitable locations.

8. Using acquired maps, reports, field data, and local criteria, interpret data and refine hydrologic calculations to establish final low chord/soffit and subgrade event peak flow rates at the site.

9. For the computed flow rates, evaluate the hydraulic adequacy of the existing structure using HEC-RAS, HY-8, WSPRO, HEC-2, or other techniques acceptable to SCRRA and governing agencies.

10. Propose a waterway opening to meet SCRRA hydraulic criteria using the same hydraulic analysis technique as for the existing structure. Evaluate the replacement structure in conjunction with the bridge designer preferably to maintain the existing track and embankment alignment and elevation. If more than one type of structure may be feasible, propose openings and provide hydraulic evaluations for each practical structure type.

11. In the event that a practical and reasonable replacement structure cannot be obtained with the stated criteria, contact the Director of Engineering and Construction for direction. Possible remedies include raising the track and subgrade elevations and/or relaxing SCRRA’s hydraulic criteria using the variance process.

12. If it appears likely that a significant reduction in bridge size can be made by further refining the hydrologic analysis, such as incorporating hydrograph routing, prepare a cost estimate for the additional analysis and then contact the Director of Engineering and Construction for direction.

13. Assemble relevant data regarding the hydrology, existing structure hydraulics, and proposed structure hydraulics on a SCRRA Replacement Structure Recommendation Form, provided in Appendix F. Meet with the SCRRA
engineering staff (preferably in person), and present the recommendation form, field survey drawing, and photographs. Discuss the analysis and recommendation, and obtain approval from SCRRA to proceed with permitting for the adopted replacement structure.

### 8.5.7 Riprap Scour Protection Guidelines

Where riprap is planned for scour protection, the following guidelines shall be adopted; recommended SCRRA riprap types are defined in SCRRA Standard Specifications, Section 348011, Stone Revetment (Riprap):

<table>
<thead>
<tr>
<th>Location</th>
<th>Exit Velocity</th>
<th>Recommended SCRRA Riprap Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream of Culverts:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(If downstream scour of the stream bed is a concern)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-8 fps</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>8-12 fps</td>
<td>II</td>
<td></td>
</tr>
<tr>
<td>Greater than 12 fps</td>
<td>III</td>
<td></td>
</tr>
<tr>
<td>Greater than 16 fps</td>
<td>IV</td>
<td></td>
</tr>
<tr>
<td>At Bridge Abutments:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-12 fps</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>12-14 fps</td>
<td>II</td>
<td></td>
</tr>
<tr>
<td>Greater than 14 fps</td>
<td>III</td>
<td></td>
</tr>
</tbody>
</table>

SCRRA riprap has the following properties:

<table>
<thead>
<tr>
<th>Type</th>
<th>Average Weight (lb/stone)</th>
<th>Approximate Size (in.)</th>
<th>General Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>50 to 200</td>
<td>9 to 14</td>
<td>Culverts less than 48”</td>
</tr>
<tr>
<td>II</td>
<td>200 to 1000</td>
<td>14 to 24</td>
<td>Culverts greater than 48”</td>
</tr>
<tr>
<td>III</td>
<td>1000 to 4000</td>
<td>24 to 38</td>
<td>Bridges, roadways, jetties</td>
</tr>
<tr>
<td>IV</td>
<td>&gt; 4000</td>
<td>&gt; 38</td>
<td>Special cases</td>
</tr>
</tbody>
</table>

The designer shall follow SCRRA’s variance request procedure if the above guidelines need modification for a specific crossing or situation.

For 100-year velocities over 14 feet per second in metal culverts, SCRRA recommends that the culvert invert be paved with concrete to prevent abrasion. Riprap thickness and placement should comply with local standards. If no standard exists, the thickness of riprap layers should be two to three times the median stone diameter. For bridges, riprap placed on the side slopes and spill slopes at the abutments should extend up to the 100-year flow depth or subgrade level, whichever is least. The lateral extent of riprap placed on the slope around the abutments should begin along the upstream side slope of the approach a distance from the backwall equal to twice the 100-year depth. The slope paving should wrap around the abutment spill slopes under the bridge and terminate at the backwall station on the downstream side. If possible, a blanket of riprap should also be buried (rather than placed on the bed) to a depth matching its thickness in the streambed around the abutment, extending to a width about twice the 100-year flow depth outward from the catch line.
8.5.8 Grouted Rock Scour Protection Guidelines

Where grouted rock riprap is planned for scour or erosion protection, the consultant’s design shall comply with the grouted rock specifications included in SCRRA Standard Specifications, Section 348011, Stone Revetment (Riprap).

8.5.9 Permitting

On behalf of SCRRA, and unless directed otherwise by SCRRA, the consultant shall make all contacts with floodplain development and environmental permitting agencies, obtain and submit all permit applications, and track progress of each permit. Unless directed otherwise, the 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 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 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 the existing structure, 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 consultant.
7. Where permitted, the 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 consultant shall transmit a final permit letter to SCRRA stating that all permit activity is completed and providing copies and summaries of all permits.

8.5.10 Consultant Hydrology and Hydraulics Reports

The consultant shall prepare a final site report summarizing the procedures followed, data collected, and calculations completed, and shall provide one copy to SCRRA. Separate reports per facility are preferred, but if more than one facility is described per report, the report must contain the sections outlined below for each structure. The report is for file purposes only; the replacement structure description in the report must not differ from the approved Recommendation Form. The report shall include the following sections as applicable:

I. Introduction
II. Site description
III. Hydrology
IV. Existing bridge hydraulics
V. Hydraulic design criteria
8.5.11 Drawings

The consultant shall prepare a field survey drawing showing the following:

- Location map, preferably a portion of a USGS 7.5 minute topographic map
- Bridge elevation showing locations and dimensions of abutments, footings, piers, pile bents, and cut off piles from previous structures
- Cross section at the bridge or culvert showing the flow line profile
- Typical embankment cross section adjacent to the bridge or culvert
- Plan view showing relative adjacent structures such as switches, signs, utilities, and benchmarks
- Top-of-rail profile for at least 1000 feet on either side of the bridge or culvert (longer if necessary to include vertical and horizontal curves)
- If a tie-in to a local geodetic system is available, the conversion noted on the drawing
- Location and elevation of temporary benchmark at project site (The temporary benchmark shall be at a secure location and discreetly identified.)

If the existing substructure is steel, concrete, or a composite of steel and concrete, the consultant shall prepare a supplemental field survey drawing showing the following:

- Elevations of all bridge seats referenced to the benchmark and base of rail of the hydrologic and hydraulic survey
- Lateral and longitudinal dimensions, including lateral offsets from centerline of track of all bridge seats
- Longitudinal dimensions to locating the backwalls and centerline of bridge seats
- If there are any riser blocks, grillages, or shims between the bridge seat and the structure, detailed drawings showing all dimensions.

If a readily available backsight on a point within the United States Coast and Geodetic Survey (USCGS) vertical datum cannot be made, a local vertical datum using the base of rail elevation at the low-milepost end of the existing bridge or at the centerline of the existing culvert should generally be set at elevation 100.00 with all other shots in the same local datum. If USCGS vertical datum cannot be made, measurements of cross sections for hydraulic analysis generally shall be referenced to local datum base of rail at the assumed elevation datum (usually 100.00) and not a local geodetic system. It is assumed that four to six channel cross sections and a detailed flowline profile will be surveyed at each site. Estimates and descriptions of ordinary high water elevation and zero damage elevation for upstream developed properties are to be obtained.
It is assumed that arbitrary horizontal control approximating available topographic maps can generally be adopted. If required by state or local criteria, horizontal and/or vertical control shall be established by the consultant.

Because construction of the new or replacement facility may require temporary removal of rails or on-track facilities, a temporary benchmark should be surveyed off-track, then visibly marked, and noted in the field survey data and drawings. This must not cause permanent damage to any adjoining facility, whether owned by SCRRA or not.

8.6 CULVERTS AND DROP INLETS

8.6.1 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. Accordingly, inlets, manholes, and storm sewer piping may be necessary to provide adequate drainage of the ROW.

8.6.2 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 8.1 through 8.5, above. Culvert lengths shall be per ES6003-01 and ES6003-02 for reinforced concrete box culverts and per the latest SCRRA Pipe Culvert Standards for smooth steel, corrugated steel, and steel structural plate pipes. Culvert inlet and outlet headwalls shall be per ES6003-03 and ES6003-04 for reinforced concrete box culverts and per the latest SCRRA Pipe Culvert Standards for smooth steel, corrugated steel, and structural steel plate pipes. Headwalls 4 feet in height or within 20 feet of the nearest track require handrails per ES2102 and CPUC GO No. 118.

Minimum Size

The minimum diameter of pipe for culverts under tracks shall be 30 inches, and the minimum diameter of pipe for culverts under roadways shall be 24 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.
concrete box culverts. Height of cover requirements for smooth steel, corrugated steel, and structural steel plate pipes must adhere to the latest SCRRA Pipe Culvert Standards. The designer may request a variance of the minimum slope requirement using Request for Special Design Consideration Form DPM-13, provided in Appendix E.

**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 348012, and the latest SCRRA Pipe Culvert Standards. Reinforced concrete box culvert material shall be in accordance with ES6003-01 and ES6003-02. 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 348012.

**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 after a variance is obtained from the Director of Engineering and Construction. 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. The designer may obtain a variance for unusual circumstances from the Director of Engineering and Construction by using Request for Special Design Consideration Form DPM-13, provided in Appendix E.

### 8.6.3 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 12. 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 sewer headwalls at inlets and outlets exceeding 4 feet in height or within 20 feet of the nearest track require handrails per ES2102 and CPUC GO No. 118.

### 8.7 STORM SEWERS AND MANHOLES

#### 8.7.1 General

Storm sewers 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 sewers as well as to provide locations for access and clean-outs. Manholes for non-SCRRA storm sewers shall not be located on SCRRA ROW unless agreed upon by the Director of Engineering and Construction and included as part of the Lease or Easement for such facility.

#### 8.7.2 Minimum Size

The minimum diameter of storm pipe for storm sewers not crossing under tracks, including connections to inlets, shall be 18 inches. The minimum diameter of pipe slope drains shall be 12 inches. Where possible, storm sewers that can connect with and use material meeting culvert sizes and requirements discussed in Section 8.6.2, above, shall be used. When not possible, storm sewers shall pass under the tracks as carrier pipes protected by casing pipes.

#### 8.7.3 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.

### 8.8 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 sewer 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.

8.9 UNDER DRAINS

8.9.1 Location

Slotted under drains 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 under drains 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

Under drains 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.

Under drains draining soils on SCRRA ROW shall outlet into culverts, storm sewer piping, or other drainage facilities.

8.9.2 Minimum Size

The minimum size of under drains 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 slotting shall be determined by the designer 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.

8.9.3 Filter Material

Under drain 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.
8.9.4 Under Drain Material

Under drains located under tracks or within 20 feet of a track shall be aluminized Type II coated corrugated metal culverts with perforations. Gage and corrugations shall be per the latest SCRRA Pipe Culvert Standards. Under drains 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 designer based on height of cover and location of roads or other permanent features.

8.10 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 13.0, Mechanical, of this DCM.

8.11 GRADING

8.11.1 General

SCRRA Standard Specifications, Section 312000, Earthwork shall apply. Ditches and other drainage features shall be graded to drain as shown in the plans. Water shall not be ponded on SCRRA ROW unless approved by the Director of Engineering and Construction.

8.11.2 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 sewers, including the use of drop inlets and manholes, as necessary to provide continuous drainage on SCRRA ROW.

8.12 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 329000, Soil Erosion, Sediment Control, Topsoil and Seeding.

8.13 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.
9.0 UTILITIES

9.1 SCOPE

These procedures and design criteria govern new utility construction exclusive of buildings, and the support, maintenance, 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.

Existing utility encroachments are typically covered by a real estate agreement between SCRRA 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 in advance in writing by the Director of Engineering and Construction.

Applicants for ROW utility encroachments shall follow SCRRA’s “Right-of-Way Encroachment Approval Procedures, 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), and other information as detailed in SCRRA Form No. 36.

9.2 STANDARDS, CODES, AND GUIDELINES

The latest editions of the following standards, codes, and guidelines shall be used in the design of SCRRA utility work:

- SCRRA ES5001, ES5002, and ES2104
- SCRRA “Right-of-Way Encroachment Approval Procedures, SCRRA Form No. 36”
- SCRRA “Rules and Requirements for Construction on Railway Property, SCRRA Form No. 37”
- SCRRA “General Safety Regulations for Third Party Construction and Utility Workers on SCRRA Property”
- SCRRA “Excavation Support Guidelines”
- FRA “Track Safety Standards Compliance Manual” (49 CFR 213) and FRA “Roadway Worker Protection” (49 CFR 214)
- 49 CFR 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
- American Society of Mechanical Engineers (ASME) B31.4, Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
- AREMA Manual for Railway Engineering, Volume 1, Chapter 1, Part 5, Pipelines
- American Water Works Association (AWWA)
- American Petroleum Institute (API) RP 1102, “Steel Pipelines Crossing Railroads and Highways”
9.3 GENERAL REQUIREMENTS

The objective of utility pre-construction activities is to obtain and properly incorporate pertinent utility information, including design and installation requirements, into the contract documents. Information to be acquired includes owner, type, size, easements, if applicable, and location within existing ROW of all existing and proposed utilities affected by construction within SCRRA ROW, including the disposition of utilities within any ROW 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 SCRRRA construction
- Utilities to be abandoned or removed

Utility service to adjoining properties shall not be interrupted except for brief temporary interruptions for new connections and only with notice to and agreement of 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. 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-owned ROW are permissible, but separate real estate agreements with SCRRA must be obtained for each utility.

9.4 UTILITY MARKERS

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.

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.

### 9.5 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 ES5001 and ES5002.

Casing pipes shall include seals and vents as noted in ES5001 and ES5002 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 design and installation across SCRRA ROW shall conform to the AREMA Manual for Railway Engineering, Chapter 1, Part 5, Pipelines, Section 5.2, and ES5002. A request for approval to install without casing must be submitted with the crossing application.

All reinforced concrete pipes shall be encased per requirements of ES5001. Where the track is constructed above utilities 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 from ROW to ROW line.

### 9.6 REQUIREMENTS FOR JACKING AND BORING, TUNNELING, AND HORIZONTAL DIRECTIONAL DRILLING

Jacking, tunneling, and drilling operations shall be as discussed in this section and in the SCRRA “Excavation Support Guidelines,” and as provided in ES5001 and ES5002. All pipe installed under this section shall use the dry bore process. In no case will water jetting or puddling be permitted to facilitate 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.

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. Jacking and boring or tunneling installation will not be permitted at locations with boulders, buried debris, or excessive groundwater.

Jacking and boring or tunneling of 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. Jacking and boring of pipes equal to or greater than 48 inches nominal diameter will require that rail elevations be monitored in compliance
with ES5001 and ES5002. Jacking and boring or tunneling of pipes greater than 72 inches nominal diameter shall not be allowed unless otherwise approved.

Horizontal directional drilling for all pipelines carrying flammable, hazardous, or highly volatile substances shall have minimum cover of 25 feet from base of rail to top of pipe. Horizontal directional drilling by 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. Horizontal directional drilling by a dry bore method for a pipeline with a nominal diameter of more than six inches or carrying liquids shall have a minimum cover of 12 feet from base of rail to top of pipeline. Some drilling may require pumping a viscous fluid to lubricate the cutter and pipe and temporarily support the bore hole and, under such conditions, is considered dry boring. The pipe shall be steel.

Jacking or boring, tunneling, and horizontal directional drilling operations shall not be permitted closer than 25 feet from the centerline of the nearest track.

9.7 **WIRELINE UTILITY CROSSINGS**

Wireline crossings beneath and over the track shall conform to ES2104 and as outlined in these design criteria. In the case of conflict between the utility license agreement, ES2104, and these design criteria, these design criteria shall govern for new or modifications to existing crossings unless otherwise approved by the Director of Engineering and Construction.

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.

9.7.1 **Underground Greater than 750 V**

Wireline encasement for underground lines carrying greater than 750 V shall be across the entire ROW in rigid metallic conduit a minimum of 4 feet below natural ground and a minimum of 5 feet 6 inches below base of rail. A 6-inch-wide warning tape shall be provided 2 feet below the ground line and 3 feet below base of rail outside of the ballast section.

The wireline shall be located 50 feet from the end of any bridge, culvert, or switching area.

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.

9.7.2 **Underground Less than 750 V**

Wireline encasement for underground lines carrying less than 750 V shall be as noted below in rigid metallic conduit a minimum of 3 feet below natural ground and a minimum of 5 feet 6 inches below base of rail.

The wireline shall be located 50 feet from the end of any bridge, culvert, or switching area.

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.

To accommodate future track construction, temporary or permanent track relocation, and/or construction and maintenance activity on SCRRA ROW, wireline encasement for lines
carrying less than 750 V shall extend 50 feet from the centerline of each main track, or to the ROW line, whichever is less.

9.7.3 Overhead Greater than 750 V

For overhead wirelines carrying greater than 750 V, a minimum vertical clearance shall be provided above top of rail per ES2104. A minimum 4-foot vertical clearance shall be provided above any signal or communication poles.

Support poles shall be located a minimum of 50 feet (200 feet for lines carrying 100KV or more) from the centerline of the closest track. Poles shall be located a minimum distance from signal or communication lines equal to the height of the support pole or guy at right angles to the pole lines.

The wireline crossing shall be located a minimum of 500 feet from bridge backwalls and a minimum of 300 feet from the closest face of culverts or switching area.

9.7.4 Overhead Less than 750 V

For overhead wirelines carrying less than 750 V, a minimum 25 foot vertical clearance shall be provided above top of rail. A minimum 4-foot vertical clearance shall be provided above any signal or communication poles.

Support poles shall be located a minimum of 50 feet from the centerline of the closest track. Poles shall be located a minimum distance from signal or communication lines equal to the height of the support pole or guy at right angles to the pole lines.

The wireline crossing shall be located a minimum of 500 feet from bridge backwalls and a minimum of 300 feet from the closest face of culverts or switching area.

9.8 FIBER OPTIC SYSTEMS

Fiber systems should be installed near the outer limits of SCRRA ROW. The system’s running line should be kept as straight as possible while maintaining a consistent distance from centerline of the nearest track. The system should be installed on the field side of all SCRRA structures, including bridges, signal facilities, buildings, and platforms.

If the fiber system has to be placed under an existing signal or communication structure, the system should be placed a minimum of 10 feet under natural ground. This extra depth may also be required in “signal sensitive areas,” such as interlocking or control points.

If the fiber system has to be located under existing signal or communication lines, a minimum 2-foot vertical separation is required.

Fiber optic cable shall not be installed within 5 feet horizontally of underground power or signal lines, unless suitably insulated.

The fiber system should be designed to be installed a minimum of 3 feet 6 inches below natural ground, except as noted herein. Warning tape shall be placed above the buried facility.

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 of the Director of Engineering and Construction 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 less than 18 inches requires permission of the Director of Engineering and Construction.

The fiber system should be designed to be buried a minimum of 5 feet below the bottom of all culverts on SCRRA ROW, or around the end of the culvert 5 feet below the bottom of the cleaned out ditch. In no case shall the fiber system be buried over the top of any culvert on SCRRA ROW.

The fiber system shall not be attached to SCRRA bridges or other structures.

Hand holes, splice boxes, and manholes located within 15 feet of centerline of nearest track should be designed to include Cooper E80 live load surcharge; if greater than 15 feet, installation should be designed to include current AASHTO live load surcharge in addition to all other loads.

The design location of the hand holes, splice holes, and manholes should not be within 100 feet of existing SCRRA signal or communication buildings or facilities.

Overhead crossings of the track by the fiber system shall comply with SCRRA ES2104.

Under crossings of the track by the fiber system shall comply with SCRRA ES5001 and ES5002.

The fiber system should 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. The fiber system should be located over the top and on the field side of the back-slope of a cut section whenever possible.

In the event that the fiber system has to be located in the drainage ditch, the system should be placed a minimum of 5 feet beyond the toe of the slope and a minimum of 60 inches from the bottom of the existing flow line. 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 cleaning maintenance.

The requirements of SCRRA “Excavation Support Guidelines” 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.

Where CPUC requirements meet or exceed the requirements of SCRRA, those requirements will apply. This would include, but not be limited to, safety, clearances, and walkways.
10.0 STRUCTURES

10.1 STANDARDS, CODES, AND GUIDELINES

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, 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 aforementioned AREMA and/or BNSF/UP guidelines shall apply.

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.

10.2 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.

10.3 GENERAL DESIGN GUIDELINES

10.3.1 Minimum Clearances

Minimum vertical clearance below underpass structures shall be in accordance with the current SCRRA Grade Separation Guidelines.

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 guidelines for curved tracks.
Parallel, separated structures shall have a minimum separation of 5 feet 0 inches 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.

### 10.3.2 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 double box beams and slab beams described in SCRRA ES6001 and ES6002, 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.

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 G, Sheet 7 of 8.

Longitudinal deck drains shall be used for all bridges. 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.

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 G.
10.3.3 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 ES6001 and ES6002 shall use the handrail approved for these standards.

Walkways other than the ballast deck shall be concrete or serrated steel bar grating. Handrails shall have a minimum of three horizontal rails. The horizontal rails can be made of steel cable or round tubular sections. Walkways and handrails shall be simple designs requiring minimum maintenance. Standard walkway and handrail configurations are shown in Appendix G as well as in ES6001 and ES6002. Grade separation structures shall follow theSCRRA Grade Separation Guidelines for walkway and handrail requirements.

10.3.4 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)
- Evaluation of site for potential accelerated corrosion issues
- Possible presence of hazardous materials
- Geologic hazards
- Site seismicity, including:
  - Fault rupture potential
  - Design peak bedrock acceleration (PBA)
  - Design magnitude of earthquake (M)
  - Soil profile type
  - 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) curve for each level of earthquake (AREMA level 1, 2, and 3, which are approximately equivalent to 100-year, 500-year, and 2500-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
- Recommendations for surface and subsurface drainage
10.4 LOADING

10.4.1 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: 120 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.

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.

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.

10.4.2 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.

10.4.3 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 H provides detailed methodology for distributing longitudinal force to the substructure element.

10.5 SEISMIC DESIGN CONSIDERATIONS

Seismic design for railroad bridges shall be in accordance with Chapter 12.0 of this DCM.

10.6 STRUCTURE TYPE SELECTION

10.6.1 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
- Number of tracks
- Track alignment
  - Vertical
  - Horizontal
- Geometry of feature being crossed
- Drainage
  - Hydraulic requirements (see Chapter 8.0, Drainage and Grading, of this DCM)
  - Deck
  - Discharge
- ROW
- Subsurface conditions
  - Geology
  - Seismicity
  - Soil reactivity
  - Water table
  - Hazardous materials
- Required clearances
- Physical constraints near the structure
  - At-grade crossings
  - Overhead structures
o Turnouts (switches)
o Stations
o Utilities

• Environmental Issues
  o Within 1 mile of the coast
  o Wetlands
  o Threatened and endangered species
  o Noise
  o Allowable working hours
  o Mitigation requirements
  o Aesthetics
  o Saltwater and brackish water

• Constructability
  o Shoring needs
  o Under rail traffic
  o Equipment access and material staging
  o Phased construction
  o Work windows
    • Quantity
    • Duration
  o Offline construction
    • Shoofly
    • Permanent track realignment

• Maintenance
  o Painting
  o Channel cleaning
  o Damage (vehicular hits, derailments, floods, seismic, etc.)
    • Track down time
    • Repair costs

• Project cost
  o Short term (construction)
  o Long term (maintenance)

• Project schedule
  o Fabrication times
  o Work windows
  o Environmental non-disturbance times for threatened and endangered species

The analysis shall do the following:

• Compare structure types and their impacts on the project cost and schedule.
• Compare structure types 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.

10.6.2 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 and seismicity.

When using ES6001 and ES6002, 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 salt water 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.

Spread footings shall not be used to support structures in a stream or river environment without protection from undermining.

### 10.6.3 Superstructure Types

The following are the allowed superstructure types in order of preference based on span length:

1. Standard double-box beams per ES6001 (20- to 35-foot span lengths)
2. Standard slab beams per ES6002 (10- to 20-foot spans)
3. Steel beam spans (30- to 69-foot spans) (see Appendix G for typical details)
   - SCARRA 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 SCARRA 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 SCARRA design criteria requirements.
   - All details required for the bridge construction shall be included in drawings.
   - SCARRA 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 SCARRA seismic design criteria.
   - The deck drainage will need to be modified to accommodate the waterproofing and longitudinal drainage system.
4. DPG spans with steel deck (up to 180-foot spans)
5. 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.

SCARRA Grade Separation Guidelines, Section 8.4, Structure Selection Criteria, provides further direction on structure type selection for underpass grade separation structures.
10.7 CONCRETE STRUCTURES

10.7.1 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.

10.7.2 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. SCRRA's Excavation Support Guidelines provide 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.

10.7.3 Concrete Superstructure Requirements

Concrete superstructures shall be in accordance with ES6001 and ES6002.

10.8 STEEL STRUCTURES

10.8.1 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
**10.8.2 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 shall have steel components painted or galvanized. 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.

Superstructure connection bolts shall be ASTM A325 minimum 7/8 inches in diameter, and the bolt type shall be consistent with the material being connected.

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.

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.

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.

**10.9 BRIDGE BEARINGS**

Bridge bearings shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Part 10.
Material requirements shall be in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Parts 10 and 11, 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 10.1.5, 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 10, 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 10.6.33, 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.

10.10 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 J, 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 I shall be used at all steel bridge deck joints.

10.11 CULVERTS

10.11.1 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.
10.11.2  Design and Detailing Requirements

Culverts shall be sized in accordance with Chapter 8.0, Drainage and Grading, of this DCM.

Pipe culverts shall be in accordance with ES6004.

Guidance on jacking and boring limitations for culvert installation is provided in Chapter 9.0, Utilities, of this DCM.

Precast concrete box culverts shall be in accordance with ES6003. 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 each end of the culvert. The headwalls shall have 45 degree flared wingwalls in accordance with ES6003 or 30 degree flared wingwalls in accordance with ES6004.

Energy dissipaters shall be in accordance with Chapter 8.0, Drainage and Grading, of this DCM and the Hydraulic Recommendation report developed for the culvert.

10.12  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 SCRRA’s Excavation Support Guidelines.

Retaining walls adjacent to tracks shall provide a minimum clearance of 10 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 SCRRA’s Excavation Support Guidelines.

Utilities shall not be attached to retaining walls.

Geotechnical subsurface requirements are discussed in Section 10.3.4, above.

Temporary shoring requirements are provided in the SCRRA Excavation Support Guidelines.

10.12.1  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
Concrete wall types are preferred due to their corrosion resistance and minimum maintenance requirements.

Mechanically Stabilized Earth (MSE) wall types are not preferred for use in supporting railroad loading. Special detailing, specifications, and construction requirements will be necessary to extend the design life of an MSE retaining wall.

10.12.2 Retaining Wall Details

Tie Backs

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.

10.12.3 Mechanically Stabilized Earth Retaining Walls

MSE walls shall be designed in accordance with AREMA and AASHTO guidelines.

The maximum wall height shall be 30 feet.

The design life shall be 100 years.

Minimum dead load surcharge shall be 240 PSF to account for future ballast depth of 30 inches.

Limiting differential settlements for wall facings are provided in Table 10-1.
**TABLE 10-1**

<table>
<thead>
<tr>
<th>Facing Type</th>
<th>Joint Width</th>
<th>Limiting Differential Settlement (in/ft of wall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precast concrete panel, 5 feet by 5 feet</td>
<td>0.75 inch</td>
<td>1/100</td>
</tr>
<tr>
<td>Precast concrete panel, 5 feet by 5 feet</td>
<td>0.50 inch</td>
<td>1/200</td>
</tr>
<tr>
<td>Precast concrete panel, 5 feet by 5 feet</td>
<td>0.25 inch</td>
<td>1/300</td>
</tr>
<tr>
<td>Full height concrete panel</td>
<td>0.50 inch</td>
<td>1/500</td>
</tr>
<tr>
<td>Segmental block</td>
<td></td>
<td>1/200</td>
</tr>
<tr>
<td>Wire mesh face</td>
<td></td>
<td>1/50</td>
</tr>
<tr>
<td>Geosynthetic wrap face</td>
<td></td>
<td>1/50</td>
</tr>
</tbody>
</table>

Differential settlements greater than the values shown in Table 10-1 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\textsubscript{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\textsubscript{ID}) and the chemical and biological degradation factor (RF\textsubscript{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 10-2.

**TABLE 10-2**

<table>
<thead>
<tr>
<th>U.S. Sieve Size</th>
<th>Percentage Passing for Steel Reinforcements</th>
<th>Percentage Passing for Geosynthetic Reinforcements</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inches</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>¾ inch</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>No. 40</td>
<td>0-60</td>
<td>0-60</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-3</td>
<td>0-3</td>
</tr>
</tbody>
</table>
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 sewer system.

10.13 MAXIMUM LOAD RATING

Maximum load ratings shall be performed for all new bridge structures. The ratings shall be calculated in accordance with Chapter 11.0 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.
11.0 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 Director of Engineering and Construction.

11.1 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 2.10, Rules for 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.

11.2 PRE-RATING BRIDGE INSPECTION

Prior to load rating any structure, as-built plans shall be located and a pre-rating bridge inspection shall be completed by SCRRA or the rating engineer to verify the following information:

- Actual sections and details conform to the as-built drawings. The inspection should verify that repairs, strengthening, 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.
- Uneven settlement of piers.
- 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

In addition to the above, the operating speed of the track shall be determined in order to accurately determine the impact factor that shall be applied to the bridge.

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 AREMA Bridge Inspection Handbook provides further direction on how to conduct a thorough bridge inspection of a railroad structure. Each inspection should be coordinated with the Director of Engineering and Construction and shall conform to all SCRRRA safety and procedural requirements.

11.3 RATING LEVELS

Depending on the material type of the member, the component being rated may have up to three different ratings determined—Normal (Strength, Fatigue) 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. A Normal Rating is the lowest of a Strength Rating and a Fatigue Rating, as follows:
  - The Strength 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) 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.
Rating heading. The Normal Rating of a structure is the lowest of the Strength or Fatigue Rating; conditions or details exist where either the Strength or the Fatigue Rating can control.

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 Director of Engineering and Construction.

11.3.1 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 2.10.14. 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).

11.3.2 Concrete Bridges

All concrete bridges or components are to be rated for Normal (Strength, Fatigue) and Maximum levels per the AREMA Manual for Railway Engineering, Chapter 8, Sections 19.2.2 and 19.2.3. The Normal (Fatigue) 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 (Strength) or Maximum rating levels. The service level rating method must be used to determine the Normal (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.

11.3.3 Steel Bridges

All steel bridges or components are to be rated for Normal (Strength, Fatigue) 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 Normal (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 (Strength, Fatigue) and Maximum Rating levels.

11.4 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.
11.4.1 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 11.9, Equipment Demands on Structures, below.

11.4.2 Live Load

The results of a rating analysis shall indicate the maximum Cooper’s Equivalent load that the structure can handle for the Normal (Strength, Fatigue), 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 11.9, below, for reference.

11.4.3 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 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 Normal (Fatigue) Rating for steel members shall be reduced per the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.13.

11.4.4 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 2.5.4;
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.

11.4.5 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.

11.4.6 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.

11.4.7 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.

11.5 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. 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 Director of Engineering and Construction.

11.5.1 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 (Strength) Rating of the structure or component shall be per the AREMA Manual for Railway Engineering, Chapter 7, Section 2.10.14.

11.5.2 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 (Strength) 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 Normal (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 (Strength) 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 (Strength) 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 (Strength) and Maximum Rating result from the different load factors used in equations 19-7, 19-8, 19-10, and 19-11.

11.5.3 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 (Strength) Rating shall be per Chapter 15, Table 15-1-11.

Allowable stresses to be used for the Normal (Fatigue) Rating 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.

11.6 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, 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 11.9, Equipment Demands on Structures, below. Net section properties shall be based on the actual net section; the net width maximum of 85 percent of the gross width allowed in the AREMA Manual for Railway Engineering, Chapter 15, Section 1.5.8b, shall not be used as an upper limit or estimate for net section properties of an element in bending.

11.7 REQUIRED RATING CHECKS AND ANALYSIS METHODS PER BRIDGE COMPONENT

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 Director of Engineering and Construction. 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.

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.

11.7.1 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 11-1, 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 11-1**

<table>
<thead>
<tr>
<th>Beam Spacing (#/track)</th>
<th>Minimum Tie Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>5'-0&quot;* (4/track)</td>
<td>7 1/8&quot;</td>
</tr>
<tr>
<td>3'-9&quot; (3/track)</td>
<td>8 1/8&quot;</td>
</tr>
<tr>
<td>4'-0&quot; (3/track)</td>
<td>9 1/2&quot;</td>
</tr>
<tr>
<td>5'-0&quot; (3/track)</td>
<td>11&quot;</td>
</tr>
<tr>
<td>6'-0&quot; (2/track)</td>
<td>6 1/8&quot;</td>
</tr>
<tr>
<td>6'-6&quot; (2/track)</td>
<td>7 1/2&quot;</td>
</tr>
<tr>
<td>7'-0&quot; (2/track)</td>
<td>9 1/4&quot;</td>
</tr>
<tr>
<td>7'-6&quot; (2/track)</td>
<td>10 1/2&quot;</td>
</tr>
<tr>
<td>8'-0&quot; (2/track)</td>
<td>12&quot;</td>
</tr>
<tr>
<td>8'-6&quot; (2/track)</td>
<td>15 1/2&quot;</td>
</tr>
<tr>
<td>9'-0&quot; (2/track)</td>
<td>16 1/2&quot;</td>
</tr>
<tr>
<td>10'-0&quot; (2/track)</td>
<td>18 3/8&quot;</td>
</tr>
</tbody>
</table>

* 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 Douglas Fir.

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.

11.7.2 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 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.

11.7.3 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 2.10.5c.

11.7.4 Timber Pile Caps and Piles

Per the Director of Engineering and Construction, 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.

11.7.5 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.

11.7.6 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.

### 11.7.7 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.

### 11.7.8 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.

### 11.7.9 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.

### 11.7.10 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.
11.7.11 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 both open-deck and ballast-deck spans is provided in the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.

11.7.12 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 11.7.17, Splices in Steel Members, below.

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.

11.7.13 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.

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 the floorbeams.

Stringers shall be rated in accordance with Section 11.7.11, Steel Rolled Beam Spans, or Section 11.7.12, Steel Deck Plate Girders, above, depending on if they are rolled shapes or built-up members, respectively.

Floorbeams

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. The shear and flexural rating of the floorbeams shall account for the bracing load in Chapter 15, Section 1.3.11.

Floorbeams shall be rated in accordance with Section 11.7.11, Steel Rolled Beam Spans, or Section 11.7.12, Steel Deck Plate Girders, above, 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 11.7.12, Steel Deck Plate Girders, above, including the splice requirements discussed in Section 11.7.17, Splices in Steel Members, below.

11.7.14 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 11.7.11, Steel Rolled Beam Spans, or Section 11.7.12, Steel Deck Plate Girders, above, 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 11.7.11, Steel Rolled Beam Spans, or Section 11.7.12, Steel Deck Plate Girders, above, 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.

11.7.15 **Bearings**

Bearings shall generally not be required to be rated unless the Director of Engineering and Construction 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.

11.7.16 **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 Director of Engineering and Construction; however, the bracing capacity of secondary members shall be accurately accommodated during the rating of the primary member.

11.7.17 **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 Director of Engineering and Construction.

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.

11.8 SUBSTRUCTURE RATING

A rating (Normal, Maximum) for a substructure component is generally not required unless the field inspection indicates signs of settlement, cracking, deflection, 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., in order 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 Director of Engineering and Construction.

11.9 EQUIPMENT DEMANDS ON STRUCTURES

Once the controlling Normal (Strength, Fatigue) and Maximum Load Rating levels of all required elements has been determined, the demand required by typical train consists on SCRRRA 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 (Strength) Rating comparison shall be used to determine structural repair or replacement recommendations and the immediacy with which they should be completed. The Normal (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.

Figures 11-1 through 11-6, below, 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 Director of Engineering and Construction shall indicate if any of the consists shown in Figures 11-2 through 11-6 do not apply to the structure.

11.9.1 Cooper E80 Consist

For reference, the Cooper E80 consist is shown in Figure 11-1 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.
11.9.2 286-kip Gross Weight Car Unit Train Consist

A typical 286-kip gross weight car unit train consist is shown in Figure 11-2. It assumes two SD70AC locomotives are pulling a consist of 286-kip coal cars.

11.9.3 315-kip Gross Weight Car Unit Train Consist

A typical 315-kip gross weight car unit train consist is shown in Figure 11-3. It assumes two SD70AC locomotives are pulling a consist of 315-kip coal cars.

11.9.4 125-ton Intermodal Double Stack Unit Train Consist

A typical intermodal unit train consist is shown in Figure 11-4. It assumes two SD70AC locomotives are pulling a consist of 125-ton five-unit articulated intermodal well cars.
11.9.5 Amtrak Passenger Train Consist

A typical Amtrak passenger train is shown in Figure 11-5. It assumes a single GE Genesis Series 1 locomotive pulling several Superliner coach cars.

![Figure 11-5](image)

11.9.6 SCRRA Passenger Train Consist

A typical SCRRA passenger train is shown in Figure 11-6. It assumes a single F40PHM locomotive pulling several Bombardier coach cars.

![Figure 11-6](image)

11.10 RATING RESULTS FORMAT

The Normal (Strength, Fatigue) 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. The controlling Normal Rating (lowest between Strength and Fatigue) for each check performed shall be shown in **bold** text. A sample table for a steel rolled beam stringer that is not spliced with bolted connections is provided in Table 11-2.
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 Director of Engineering and Construction.

### TABLE 11-2

<table>
<thead>
<tr>
<th>Stringer Rating As-Built / Existing Conditions</th>
<th>Normal</th>
<th>Maxium</th>
<th>286-kip Unit Train</th>
<th>Amtrak Passenger Train</th>
<th>SCRRA Passenger Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rateing Check</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexure</td>
<td>E-72.1</td>
<td>E-140.0</td>
<td>E-114.6</td>
<td>E-70.2</td>
<td>E-60.1</td>
</tr>
<tr>
<td>Shear</td>
<td>E-90.5</td>
<td>N/A</td>
<td>E-150.2</td>
<td>E-65.5</td>
<td>E-58.1</td>
</tr>
<tr>
<td>Bolt Shear</td>
<td>E-95.4</td>
<td>N/A</td>
<td>E-160.2</td>
<td>E-65.5</td>
<td>E-58.1</td>
</tr>
<tr>
<td>Bolt Bearing</td>
<td>E-105.7</td>
<td>N/A</td>
<td>E-175.6</td>
<td>E-65.5</td>
<td>E-58.1</td>
</tr>
</tbody>
</table>

Only the 286-kip unit train, Amtrak passenger train, and SCRRA passenger train demands are shown in Table 11-2, as the example assumes that 315-kip unit trains and intermodal unit trains do not run across this bridge.
12.0 SEISMIC DESIGN

12.1 SCOPE

The 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 (pipes and boxes less than 10 feet in span) 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.

12.2 STANDARDS, CODES, AND GUIDELINES

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” (May 2007)
- 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)

12.3 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.
12.3.1 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.

12.3.2 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.

12.3.3 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.
12.4 GENERAL REQUIREMENTS

12.4.1 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), Version 1.4, Section 3 “Capacities of Structural Components”, Section 7 “Design”, and Section 8 “Seismic Detailing”.
- AASHTO “Guide Specifications for LRFD Seismic Bridge Design”, Section 7 “Structural Steel Components”

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 (see Table 12-2, below).

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.

12.4.2 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.

12.4.3 Risk Factors

The factors provided in Table 12-1 may be assumed in calculating a set of Preliminary Bridge SICs for each of the three limit states.
**TABLE 12-1**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>AREMA Manual for Railway Engineering, Chapter 9, Reference</th>
<th>Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Safety</td>
<td>1.3.2.2.1</td>
<td></td>
</tr>
<tr>
<td>Occupancy Factor</td>
<td>1.3.2.2.1(a)</td>
<td>4</td>
</tr>
<tr>
<td>Hazardous Material Factor</td>
<td>1.3.2.2.1(b)</td>
<td>1</td>
</tr>
<tr>
<td>Community Lifelines Factor</td>
<td>1.3.2.2.1(c)</td>
<td>1</td>
</tr>
<tr>
<td>Combined Immediate Safety Factor</td>
<td>1.3.2.2.1</td>
<td></td>
</tr>
<tr>
<td>Immediate Value</td>
<td>1.3.2.2.2</td>
<td></td>
</tr>
<tr>
<td>Railroad Utilization Factor</td>
<td>1.3.2.2.2(a)</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Detour Availability Factor</td>
<td>1.3.2.2.2(b)</td>
<td>1</td>
</tr>
<tr>
<td>Combined Immediate Value Factor</td>
<td>1.3.2.2.2(b)</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Replacement Value</td>
<td>1.3.2.2.3</td>
<td></td>
</tr>
<tr>
<td>Span Length Factor</td>
<td>1.3.2.2.3(a)</td>
<td>per AREMA</td>
</tr>
<tr>
<td>Bridge Length Factor</td>
<td>1.3.2.2.3(b)</td>
<td>per AREMA</td>
</tr>
<tr>
<td>Bridge Height Factor</td>
<td>1.3.2.2.3(c)</td>
<td>per AREMA</td>
</tr>
<tr>
<td>Combined Replacement Value Factor</td>
<td>1.3.2.2.3</td>
<td></td>
</tr>
</tbody>
</table>

* 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.

12.4.4 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 (see Table 12-2) 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.

12.5 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.
- Critical non-redundant members respond elastically, with the balance of the structure deforming inelastically to the rare seismic event.
- 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.

These seismic performance criteria define limit states of serviceability, ultimate, and survivability, as shown in Table 12-2.
TABLE 12-2

<table>
<thead>
<tr>
<th>Ground Motion Level</th>
<th>Performance Criteria Limit State</th>
<th>Frequency</th>
<th>Average Return Period</th>
<th>Critical Member Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Serviceability</td>
<td>Occasional</td>
<td>50-100 years</td>
<td>Elastic stress range</td>
</tr>
<tr>
<td>2</td>
<td>Ultimate</td>
<td>Rare</td>
<td>200-500 years</td>
<td>Ultimate strength and structure stability</td>
</tr>
<tr>
<td>3</td>
<td>Survivability</td>
<td>Very Rare</td>
<td>1,000-2,400 years</td>
<td>Emphasis on detailing for inelastic ductility</td>
</tr>
</tbody>
</table>

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.

- **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 Version 1.4, 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.

### 12.6 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 12-3.

**TABLE 12-3**

<table>
<thead>
<tr>
<th>Limit State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serviceability</td>
<td>No Damage</td>
</tr>
<tr>
<td>Ultimate</td>
<td>No Underground Damage</td>
</tr>
<tr>
<td>Survivability</td>
<td>No Collapse</td>
</tr>
</tbody>
</table>

### 12.7 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 12-4 shall be satisfied for each structure material:

**TABLE 12-4**

<table>
<thead>
<tr>
<th>Limit State</th>
<th>Material</th>
<th>Stress Limits/Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serviceability</td>
<td>Steel</td>
<td>AREMA Manual for Railway Engineering, Chapter 15, allowable stresses may be increased by 50%</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>AREMA Manual for Railway Engineering, Chapter 8, load factor design with load factors of 1.0</td>
</tr>
<tr>
<td>Ultimate</td>
<td>Steel</td>
<td>$F_{ye} = 1.1F_y$ and AASHTO “Guide Specifications for LRFD Seismic Bridge Design,” as applicable</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>Caltrans SDC</td>
</tr>
<tr>
<td>Survivability</td>
<td>Steel</td>
<td>$F_{ye} = 1.1F_y$ and AASHTO “Guide Specifications for LRFD Seismic Bridge Design,” as applicable</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>Caltrans SDC</td>
</tr>
</tbody>
</table>

### 12.8 BRIDGE TYPE SELECTION CRITERIA

#### 12.8.1 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 (see Section 12.7).

#### 12.8.2 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.
12.8.3 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.

12.8.4 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 liquifiable soil layers. Piles should have sufficient buckling capacity to resist vertical loads in case of liquefaction of surrounding soil layers.

12.9 BRIDGE CONFIGURATION AND LAYOUT CRITERIA

12.9.1 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.

12.9.2 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.

12.9.3 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.

12.9.4 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.

12.10 BRIDGE DUCTILITY REQUIREMENTS

12.10.1 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.

12.10.2 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
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

12.10.3 Steel Structures

The ductility requirements for steel structures intend to prevent buckling and fracture and provide adequate connections and details.

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.

12.10.4 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.

12.10.5 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, intermittent welds, and partial penetration groove welds should be avoided, especially in regions of expected inelastic deformations. 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.

12.11 BRIDGE DETAILING PROVISIONS FOR LEVEL 2 AND 3 EVENTS

12.11.1 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.

12.11.2 Ductility Provisions

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.

12.11.3 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.

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.

12.11.4 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.

12.12 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.

In general, earth-retaining structures should be designed to fail by sliding rather than by overturning, 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.

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 12.13 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.

12.13 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.
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.
13.0 MECHANICAL

13.1 SCOPE

This chapter contains mechanical criteria developed for the SCRRA system, excluding vehicles and yard and shop equipment. These criteria govern the functional requirements, operation, and control of the heating systems, ventilation systems, air conditioning systems, water and sewerage systems, drainage facilities (except at-grade sections), and fire protection systems. These criteria are intended to promote uniformity of design and standardization of equipment and its location throughout the SCRRA system.

13.2 STANDARDS, CODES, AND GUIDELINES

The latest edition of the applicable standards, codes, and guidelines of the following organizations shall be used for all designs unless otherwise required by this section:

- SCRRA ES2901
- Uniform Building Code (UBC)
- California Building Code (CBC)
- Occupational Safety and Health Administration (OSHA)
- State of California Division of Occupational Safety and Health (Cal/OSHA)
- California Title 24 Energy Regulations
- American National Standards Institute (ANSI)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)
- American Society for Testing and Materials (ASTM)
- Sheet Metal and Air-Conditioning Contractors’ National Association (SMACNA)
- National Fire Protection Association (NFPA) “National Fire Codes”
- National Electrical Code (NEC)
- Safety code for mechanical refrigeration
- Codes of applicable local jurisdictions

Mechanical equipment and systems shall be designed so that the maximum noise levels generated and transmitted by the systems do not exceed allowable limits for interior or outdoor noise levels.

13.3 HEATING, VENTILATION, AND COOLING (HVAC)

HVAC requirements shall be defined for each specific project and shall be based on the appropriate local codes and standards. Evaporative coolers should be considered in locations where humidity is low. If possible, natural gas is preferred for heating.

13.4 PLUMBING

13.4.1 Pipe and Fittings

Pipes and fittings shall be as follows:
• 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.
• The minimum diameter of waste pipe installed underground shall be 4 inches. The minimum diameter of waste pipe installed in structural slabs shall be 3 inches.
• 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.

13.4.2 Water Service

The domestic water-service connection shall have a minimum diameter of 2 inches and shall be metered. Fire water-service connections shall have a minimum diameter of 4 inches and shall be metered with a bypass meter as approved by the water utility company. Each service shall have a main shut-off valve immediately inside the structure wall. Backflow preventors shall be provided to conform to local code 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.

13.4.3 Hot Water Service

Hot water shall be supplied to all toilet rooms and custodial rooms.

Water heater capacities shall be based on 100 degrees F 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.

A recirculation system shall be provided where the supply piping is more than 100 feet long.

13.4.4 Insulation

Hot water piping and portions of drainage and cold water piping subject to sweating shall be insulated.
13.4.5 Sewage Pump Stations

Sewage pump stations, if required, shall be designed according to the local municipality’s requirements.

13.4.6 Eyewash Facilities

Emergency eyewash capability shall be provided within, or immediately adjacent to, areas with batteries. The capability for eye lavage shall be provided by a portable eyewash apparatus. Where needed, a water service connection with a floor 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.

13.4.7 Hose Bibs and Floor Drains

Hose bibs in service facilities shall have copper fittings.

Hose bibs and floor drains in stations with restrooms shall be provided in accordance with the following instructions:

<table>
<thead>
<tr>
<th>Location</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Custodial Room</td>
<td>Hot- and cold-water single spout, a mop sink drain, and a floor drain.</td>
</tr>
<tr>
<td>Trash Rooms</td>
<td>¾ inch cold-water hose bib with an individual floor drain located immediately beneath the hose bib.</td>
</tr>
<tr>
<td>Toilet Rooms</td>
<td>Cold-water and hot-water service and a means of drainage.</td>
</tr>
<tr>
<td>Water Heaters</td>
<td>A floor drain for wastewater produced by maintenance procedures and relief-valve actuation.</td>
</tr>
</tbody>
</table>

13.4.8 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).

13.5 FIRE PROTECTION

13.5.1 Fire Protection Systems

The following fire protection systems 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.

- Sprinkler systems, wet and dry
- Standpipe systems, wet and dry
- Fire hose cabinets
- Portable fire extinguishers
- Smoke and heat alarm systems

13.5.2 Sprinkler Systems

Sprinkler systems shall include a main water supply, 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 Standard No. 13. There are some locations at higher elevations where freezing conditions should be considered.

13.5.3 Standpipe Systems

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 Standard No. 14.

13.5.4 Fire Hose Cabinets

Fire hose cabinets shall be provided as required by the applicable NFPA code.

13.5.5 Portable Fire Extinguishers

Portable fire extinguishers shall be installed in accordance with NFPA Standard No. 10 and as modified by these design criteria in offices and electrical rooms.

13.5.6 Smoke and Heat Detection Systems

Smoke and heat detection systems shall be provided as required by the applicable NFPA code.

13.5.7 Fire Hydrants

Local fire marshalls 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 500 feet of each fire department connection to a standpipe system;
- Within 500 feet of the fire department connection to each sprinkler system.

The 500-foot limits listed above are maximum; it is desirable that a fire hydrant be located within 200 feet of each of the points indicated above.

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.

**13.5.8 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, shall be provided.

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 a proper place.

Hose connections shall be approved by the local fire department and shall be of a listed type in accordance with NFPA codes.

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. The Authority’s logo shall be provided at each fire department connection for identification.

**13.6 SERVICE AND LAYOVER FACILITIES**

**13.6.1 General**

Layover facilities are designed to store trains overnight and to perform varying levels of servicing, primarily cleaning car interiors and emptying toilet tanks. To the extent possible, size and layout of the facilities should reflect the current and future train counts and consist sizes for that location.

Designers of service and layover facilities must consult with the Directors of Equipment and Operation at the start of every phase of design to assure that the project’s functional goals are being met. The Directors of Equipment and Operation must sign memo indicating
approval of the design before service and layover facility projects are issued for construction bid.

13.6.2 Track Lengths and Spacing

As indicated above, track lengths should reflect the required and planned train count and size, as well as any additional requirements, such as roadway crossings, turnouts, and blue flag protection.

Spacing between service tracks shall consider the planned maintenance activity and the available space. Service equipment, light poles, water connections, etc., will all impact the required track spacing.

13.6.3 Service Roadways

Service roadways allow vehicle access to the various service areas to service trains and on-site equipment. Such roadways should also serve as fire access roads. A service road shall be provided between alternate tracks.

13.6.4 Inspection Pit

Depending on the size of the facility and the anticipated service plan, an inspection pit may be required.

13.6.5 Jacking Pads

Portions of the service tracks may require jacking pads alongside.

13.6.6 Lighting

Site lighting shall reflect the planned use, including the presence of the large railroad coaches.

A minimum lighting level of 10 or 15 footcandles shall be provided.

13.6.7 Security

Fencing shall be provided around the entire site per ES2911. Provision for remote TV cameras and other security measures shall also be considered.

13.6.8 Electrical

Electrical service shall include Head End Power (HEP) connections per ES2901 and power adequate to perform the planned servicing activity. The site power requirements shall also reflect any planned expansion of the facility.

13.6.9 Employee Facilities

Planning for the site offices, welfare spaces, and parking should reflect current needs as well as any future expansion plans. Plan for space for:

- Service Personnel
- Train Crews
- Supervisors
13.6.10 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 consist location and size. The following graphic 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.

13.6.11 Compressed Air Systems

SCRRA layover and service facilities shall have a compressed air system with a centralized compressor (with a dryer) and compressed air connections available at the end of each car.

13.6.12 Track

Track for service and layover facilities will be constructed of new or second hand CWR of the size specified by the Director of Engineering and Construction, and wood or concrete ties. Turnouts shall be new 136-pound rail, insulated. Hand-operated switch stands shall be “ergometric” design with long, high operating handles to minimize operating effort by employees. Geometric layout must consider placement of switch stands vis-à-vis nearby tracks and roadways.

13.6.13 Derails

Blue flag protection for workers is provided by portable derails. Location of derails must be approved by the Director of Equipment. Locations for such derails shall not be in roadway crossings.

13.7 SYSTEM-WIDE ELEMENTS

Provisions shall be made for the system-wide elements.
14.0 SOIL AND WATER CORROSION CONTROL SYSTEMS

14.1 GENERAL

Design shall conform to a 50-year design life for buried structures and a 100-year design life for stations. 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 shall provide recommendations regarding the corrosivity of the soil 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.
- 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.

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 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

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.
14.2 MATERIALS AND STRUCTURES

14.2.1 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 14.4, Coatings.
- Provide electrical insulation of pipe from interconnecting pipe, casings, and other structures and segregation into discrete electrically isolated sections per Section 14.3.1, Electrical Insulation of Piping.
- Provide electrical continuity through the installation of copper wires across all mechanical pipe joints per Section 14.3.2, Electrical Continuity of Underground Piping.
- 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.

14.2.1 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.

14.2.2 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
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 250-ppm chloride concentration in the total concrete mix (mixing water, cement, admixture, and aggregates)

14.2.3 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.

14.2.4 Electrical Conduits

Buried metallic conduits shall include the following provisions:

- Galvanized steel with PVC or other coating 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.

14.2.5 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 SCRRRA. 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 250 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, “Corrosion of Metals in Concrete.”
- 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.
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.

14.2.6 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.

14.2.7 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.

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 14.2.6, above.
- Chloride restrictions for concrete with prestressed members shall be in accordance with Section 14.2.6, above, 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.

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.

14.2.8 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.
14.3 PROTECTION OF UNDERGROUND STRUCTURES

14.3.1 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.
- Buried or elevated insulators shall be equipped with accessible permanent test facilities.
- A protective coating shall be applied to all metallic devices 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.
- There shall be a minimum resistance of 10 megohms prior to installation.

14.3.2 Electrical Continuity of Underground Piping

Electrical continuity shall be provided for all non-welded metallic pipe joints 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 14 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.
- 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.

14.4 COATINGS

14.4.1 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 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 of 10,000,000,000 ohm-centimeters per ASTM D257
• Minimum thickness as recommended for the specific system, but not less than 15 mils

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.

14.4.2 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. Coatings shall have established performance records for the intended service and shall be compatible with the base metal to which they are applied. 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.

14.4.3 Metallic-Sacrificial Coatings

Acceptable coatings for carbon and alloy steels for use in tunnels, crawlspace, 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.

14.5 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. 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.

Designs shall be based on NACE International standards, recommended practices, and theoretical calculations. At a minimum, the design process shall assess the following:

- Soil environment
- Mutual structure protection or interference configuration
- Limitation of protection potentials
- Test monitoring stations and facilities
- Anode service life and ground bed resistance
- Minimum anode service life of 25 years

14.6 QUALITY CONTROL TESTING

14.6.1 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.
14.6.2 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 RP0169. 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.

14.6.3 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.
15.0 FACILITIES ELECTRICAL SYSTEMS

15.1 SCOPE

This chapter lists the requirements for the design, installation, and operation of all lighting and auxiliary electrical equipment throughout SCRRA. These criteria cover ac power electrical systems required to serve lighting; heating, ventilating, and air conditioning equipment; mechanical equipment; communications systems; power supply control equipment; emergency power systems; illuminated and variable message signs; clocks and alarm systems; CCTV and station public address systems; fire protection systems; and pumping equipment.

15.2 STANDARDS, CODES, AND GUIDELINES

The latest edition of the following standards, codes, and guidelines shall be used for design of the ac power and lighting system:

- National Electrical Code (NEC)
- California Electrical Code
- California Title 24 Energy Regulations
- National Electrical Safety Code (NESC)
- American National Standards Institute (ANSI)
- National Electrical Manufacturers Association (NEMA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Insulated Cable Engineers Association (ICEA)
- National Fire Protection Association (NFPA)
- Illuminating Engineering Society (IES)

15.3 ESSENTIAL LOADS

The designer shall determine essential loads based on facility type and service requirements. Certain types of loads shall be considered essential. For example, 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.

15.4 ELECTRICAL DISTRIBUTION CENTER

15.4.1 Power Source

Incoming electric service for each facility shall be terminated at the AC switchboard. The switchboard shall include the utility metering, where required by the power company, and the necessary circuit breakers and transfer switches for distribution to ac power loads within the facilities.

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.

15.4.2 Service Ducts

Ductwork for power company service drops shall be furnished in the structures as required by the power company.

15.5 EMERGENCY POWER SYSTEM

15.5.1 Requirements

Emergency power shall be provided for selected portions of the system’s train control (signal) and communications equipment located at the MOC facility and field locations, as required. The emergency power systems shall consist of an uninterruptible power supply (UPS), which includes a rectifier-charger, battery, inverter, and high-speed static transfer switch, with energy supplied from the battery during the emergency period.

15.5.2 Emergency Battery and Charger

The battery shall have sufficient capacity to provide the full emergency load continuously for 30 minutes after a power supply failure, with a minimum final terminal voltage of 105 volts. If required by local code, a separate, adequately ventilated battery room shall be provided.

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.

15.5.3 Inverter

The inverter shall be solid state, 120-volt dc input to 120-volt, 1-phase, 60-Hz, sine wave output, powered from the 120-volt battery during emergencies. Under normal operation, the emergency load will be supplied through the inverter.

15.5.4 Static Transfer Switch

An automatic high-speed static transfer switch shall transfer the load of the emergency panel from the inverter to the essential bus if there is a fault in the load or the inverter fails, with transfer in less than a quarter cycle.

The transfer switch shall provide an indication of transfer to the supervisory control system. When the trouble has cleared, and the essential-bus voltage remains stable, the transfer switch shall automatically retransfer the emergency panel load from the essential bus back to the inverter after 15 minutes.

15.5.5 Supply Voltages

Power for facilities shall be supplied at a nominal 480/277 volts, 3-phase, 4-wire, 60-Hz.
Motors

In general, equipment motors shall be squirrel-cage induction motors, NEMA Design B, unless the application requires other classifications. Enclosures shall be selected to suit the environmental conditions. Refer to Chapter 13.0, Mechanical, for specific requirements.

In general, circuit breaker combination starters in a motor control center construction shall be used for the 480-volt motors. However, individually mounted circuit breaker combination starters may be used where practicable. Starters shall be magnetic, full-voltage start, single-speed, and non-reversing, except where the equipment characteristics or power company limitations require other types. Each starter shall be equipped with a 120-volt control transformer and three thermal overload relays. In general, enclosures shall be NEMA Type 12, except where environmental conditions make other types more suitable. Refer to Chapter 13.0, Mechanical, for specific requirements.

Wiring shall not be permitted to exceed 5 percent of nominal voltage.

15.6 EXPOSED CONDUIT WIRING METHODS

15.6.1 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. Cable trays may be used in areas where approved.

15.6.2 Conduit Size

Exposed conduit smaller than ⅝-inch electrical trade size shall not be used.

15.6.3 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. See Chapter 14.0, Soil and Water Corrosion Control Systems, for additional requirements.

15.7 EMBEDDED CONDUIT WIRING METHODS

15.7.1 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.

15.7.2 Conduit Size

Embedded conduit smaller than 1-inch electrical trade size shall not be used.
15.7.3 Installation Criteria

Expansion fittings shall be used where embedded conduit passes through structural expansion joints. In general, expansion fittings are not required for embedded conduit installations where underground temperatures are relatively constant. However, due to the large change in length per degree change in temperature exhibited by nonmetallic conduit, such installation shall be backfilled or concrete-encased immediately.

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 roadways or railroad tracks shall be reinforced. See Chapter 14.0, Soil and Water Corrosion Control Systems, 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.

Duct banks shall be laid out in as straight a line as possible with a slope of 0.50 to 1 percent toward drain points. Where bends are required, large-radius field bends are preferable. The minimum conduit bending radius shall not be less than that permitted by NEC. Small-radius conduit bends should generally be constructed with factory-made fittings. The total number of bends in one run of conduit shall not exceed the equivalent of four quarter bends (360 degrees total).

Conduits shall be cleaned with a mandrel or rod after installation and before cable installation. If cable is not to be installed immediately, a pull-string shall be installed in the conduit.

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.

15.8 MANHOLES AND HANDHOLES

Manholes and handholes are located in underground duct banks to provide cable pull-points and junction points and to accommodate splices. 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.

Manhole openings provide both access and cable-installation space. Round access openings shall be a minimum of 26 inches in diameter. Rectangular access openings shall not have dimensions less than 22 inches by 26 inches. Grade adjustment rings can be installed around manhole openings to accommodate the depth of the duct banks.

Manholes shall be provided with sumps, and the floor shall be sloped toward the sump. Portable sump pumps can be used to pump out accumulated water.

Handholes shall be a maximum of 42 inches in depth and shall be covered with a removable or hinged checkered plate.
15.8.1 Direct-Buried Cable

Allowable Applications

Direct-buried cable may be used instead of aerial or conduit-encased wire or cable for signal and communications systems, electrolysis control cables, and stray-current return cables.

Installation Criteria

Direct buried cable installation shall conform to applicable requirements of NESC Section 35, Direct Buried Cable, and NEC Article 300-5, Underground Installations, except the minimum depth of cable shall be 30 inches and cables shall be embedded in sand before the trench is backfilled with excavated material. Plowing of direct buried cable is not permitted due to presence of other underground facilities within the ROW.
16.0 COMMUNICATIONS SYSTEMS

16.1 SCOPE

This section describes the criteria for the design of the Communications System, which is comprised of the MOC system and various communications subsystems described herein.

The communications and control system shall provide the necessary subsystems to support the total operational requirements of the SCRRA system. The following functional areas shall be considered part of the Communications System and its design, including certain requirements related to expanding the subsystems as SCRRA operations evolve:

- Voice subsystem
- Rail system monitoring and control
- CCTV
- Cable transmission system
- Structures
- Power and grounding
- Documentation and training
- System-wide functions

16.2 STANDARDS, CODES, AND GUIDELINES

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 National Standards Institute (ANSI)
- Electronic Industries Association (EIA)
- EIA Standard RS-152-C Transmitter Compliance
- EIA Standard RS-204-D Receiver Compliance
- EIA Standard RS-316-C Portable Transmitter
- EIA Standard RS-316-B Portable Receiver
- MIL-STD 810 C&D Rugged Environment Standards
- Federal Communications Commission (FCC)
- 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)
- All applicable Underwriters Laboratories, Inc. standards
- Electrical, fire, and safety codes of applicable local jurisdictions
- Americans with Disability Act (ADA)
- Telecommunications Industry Association (TIA)

16.3 TICKET VENDING SYSTEMS

Refer to Chapter 7.0, Stations, for information regarding ticket vending systems.
17.0 WAYSIDE SIGNALS

17.1 SCOPE

The designer shall specify equipment and applications that will not only provide optimum safety, but will also maximize the efficiency and reliability of the commuter and freight system. The design shall incorporate systems and equipment that have been proven to be reliable, durable, and effective on other rail networks and are in current use by SCRRRA. Introduction of new materials, which require an inventory of additional spare parts and additional training, must be approved by the SCRRRA Director, PTC, C&S System, or Designate. The design shall incorporate features that aid signal personnel in the inspection, testing, repair, and overall maintenance of the system. Application logic software shall be “safe” and conform to all applicable regulatory rules and regulations but “simple in form” so as to be easily understood by personnel responsible for the maintenance and care 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 houses shall be sized accordingly.

Where these criteria make reference 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 design criteria 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 and Instructions (MOWORI), 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 the SCRRRA Director, PTC, C&S Systems, or Designate. Note that the SCRRRA General Orders, Timetable, and Special Instructions supersede the MOWORI where they are in conflict with MOWORI.

Both the wayside signaling system and the crossing warning systems are present on the SCRRRA tracks. Any modifications to the wayside signaling must consider any impact on the grade crossing warning systems. Design criteria for grade crossing warning system are in Section 18.0, Highway-Rail Grade Crossing Signals.

17.2 STANDARDS, CODES, AND GUIDELINES

The latest editions of the following standards, codes, and guidelines shall be used, as applicable, for the design and implementation of the signal system:

- Federal Railroad Administration (FRA) standards, 49 CFR 234, 235, and 236
- American Railway Engineering and Maintenance-of-Way Association (AREMA)
- California Public Utilities Commission (CPUC)
- Maintenance of Way Operating Rules and Instructions (MOWORI)
- General Orders
- Timetable
- Special Instructions
- National Electrical Code (NEC)
- Institute of Electrical and Electronics Engineers (IEEE)
17.3 SAFE BRAKING CRITERIA

17.3.1 Signal Spacing

Signal spacing shall consider all factors necessary to provide a safe and efficient operation. The signal block length should be a nominal 8,000 feet in length except where traffic density requires shorter blocks for closer signal system headways. Under most circumstances, such spacing allows mixed traffic to operate with optimum headways and, combined with the use of “fourth aspect” (i.e., flashing yellow) signaling, provides “safe braking distance” for freight trains.

A signal system headway study may be required.

Braking criteria for freight trains should be calculated on a maximum of 100 TPOB (Tons per Operative Brake) at 50 mph. Passenger train braking should be based on Amtrak braking standards (CE-205 Standards). These standards should be used in calculating safe braking distance.

It is the responsibility of the design firm to verify current speeds and tonnage restrictions through the Timetable and Special Instructions and current General Orders. Any discrepancies must be brought to the attention of the Director, PTC, C&S Systems, or Designate and resolved.

The calculation of safe braking distance on all lines where multiple classes of trains operate shall be based on the more restrictive of the braking criteria.

The SCRRA Signal Standard Drawings contain braking and deceleration tables for both types of consist. The “average grade” shall be computed for each block for freight train braking, and Equivalent Level Track distances shall be computed for passenger trains to ensure that safe braking distance is provided. Where short blocks are unavoidable and safe braking distance cannot be achieved by using the flashing yellow aspect, the designer should repeat the “yellow” aspect to a point where the flashing yellow aspect is applicable. In some cases, it is preferable to repeat the flashing yellow aspect; in other cases, it may be advantageous to use the flashing red aspect approaching the red.

Computerized train performance programs are acceptable for calculating braking distances.

EXAMPLE:

RED--------YELLOW--------YELLOW--------FLASHING YELLOW-------GREEN

unsafe distance

SAFE DISTANCE
The signal system, while allowing for freight train braking, will also be designed for the greatest possible passenger train efficiency. In some cases, an Approach Fifty or an Approach Sixty may provide a more efficient operation than Advance Approach. Advance Approach 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. Care should be exercised when the approach block is short (2,500 feet or less).

In addition to providing safe stopping distance, the signals must provide safe reduction distance for turnouts. The Approach Diverging aspect should only be used where all turnouts at a Control Point are of the same size. Where turnout sizes vary within a Control Point, the Approach Restricting may be required approaching the lower speed turnout, and a Restricting provided for the diverging move through the turnout.

### 17.3.2 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 the 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 ROW constraints will not permit placement of ground signals. The use of dwarf signals is restricted to areas where trains operate at slow speeds or where high-mast ground signals are not practical. 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.

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. Where conditions require placement in advance of or on a curve, spread lenses shall be installed on the signal units to maximize the viewing area. 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 approval by the Director, PTC, C&S Systems, or Designate.

Each signal head consists of three lamp units. The signal heads shall be color-light, stacked type and equipped with removable lamp units for ease of maintenance. Signal housing shall be designed to allow easy removal of lamp units from the rear of the housing. 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 provided with Blank Cover Plates.

The designer shall make a thorough review of proposed signal locations to ensure that signals placed in accordance with SCRRA standards will not be obstructed by vegetation, buildings, highway overpasses, or other structures. Each location shall provide adequate space for each signal, signal house, and other apparatus and be of sufficient size to provide ample walkways. Where signals are located on curves and adjacent tracks are present, signal height should be sufficient to ensure that signals can be viewed above standing rail cars. The designer should ensure that upper and lower signal units are visible.

Ground signals shall be approximately 22 feet high measured from the base on the ground to the top of signal mast. This height will accommodate the placement of an upper and lower
unit. Masts of this length will also provide adequate space for the addition of a lower unit to a single-headed signal. Signals are top justified.

In general, Absolute Signals at Control Points will have two heads, Approach Signals to Control Points will have two heads, and intermediate signals that do not serve as Approach Signals to Absolute Signals will have one head.

Cantilever and bridge structures shall be installed with a clearance of 23 feet 6 inches above top of rail, unless a special design consideration is granted by the Director, PTC, C&S Systems, or Designate. This placement will accommodate future track elevation increases.

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.)

Signals shall be placed so that a train leaving a station can see the signal before reaching 40 mph so that no “delay in block” will occur. In some cases, it will be desirable to locate a signal at a grade crossing to eliminate additional insulated joints and economize on equipment.

17.4 SIGNAL SYSTEMS

Control points shall use solid-state interlocking systems configured for use with color-light signal units. Solid-state interlocking systems shall be the GETS Global Signaling Vital Logic Controller or equivalent systems. Intermediate color-light signals shall use electronic coded track circuit systems such as Electro Code 4 Plus, Electro Code 5, or equivalent systems that will emulate the Electro Code 4 Plus rates and communicate through the rail with existing equipment. The use of “vital or non-vital relays” shall be minimized where possible. All signal systems shall be equipped with data recorders that will record information useful in maintenance and repair of the system (minimum 72 hours of recording without overwrite).

Electronic coded track circuits shall be used wherever practical to transmit and receive vital block signal data. Electro Code 4 Plus code rates or equivalent shall be used. New application logic software must be approved by the Director, PTC, C&S Systems, or Designate. The following Code Rates and Aspects in Table 17-1 shall be used.
**TABLE 17-1**

<table>
<thead>
<tr>
<th>Code Rate</th>
<th>Aspect</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Clear (Green)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Advance Approach (Flashing Yellow)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Approach Fifty (Yellow over Green) or Approach Sixty (Yellow over Flashing Green)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Approach (Yellow)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Approach Diverging (Yellow over Yellow)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Approach Restricting (Yellow over Flashing Red)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Accelerated Tumble Down</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Non-vital code indicating track occupancy, or a hand throw switch in the block out of normal correspondence</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Non-vital code indicating power off in the block 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.)</td>
<td></td>
</tr>
</tbody>
</table>

“Light 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 Lampouts 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 lampout downgrade schemes are used, signals may not be reported until there are multiple lamps out. The following typical downgrade logic shall be incorporated: Lampout schemes should be shown on the aspect charts or circuit plans for each location. Refer to the following Table 17-2 through Table 17-4.

**TABLE 17-2**

<table>
<thead>
<tr>
<th>ONE UNIT SIGNAL, ONE LAMP OUT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GREEN lamp out</td>
<td>FLASHING YELLOW</td>
</tr>
<tr>
<td>FLASHING YELLOW lamp out</td>
<td>FLASHING RED</td>
</tr>
<tr>
<td>YELLOW lamp out</td>
<td>FLASHING RED</td>
</tr>
<tr>
<td>RED lamp out</td>
<td>DARK</td>
</tr>
</tbody>
</table>

DCM 136 November 2014
### TABLE 17-3

**TWO UNIT SIGNAL, TOP UNIT LAMP OUT**

<table>
<thead>
<tr>
<th>GREEN over RED</th>
<th>FLASHING YELLOW over RED</th>
</tr>
</thead>
<tbody>
<tr>
<td>YELLOW over FLASHING GREEN (for a Number Plated Signal)</td>
<td>DARK over YELLOW</td>
</tr>
<tr>
<td>YELLOW over FLASHING GREEN (for an Absolute Signal)</td>
<td>FLASHING RED over RED</td>
</tr>
<tr>
<td>YELLOW over GREEN (for a Number Plated Signal)</td>
<td>DARK over YELLOW</td>
</tr>
<tr>
<td>YELLOW over GREEN (for an Absolute Signal)</td>
<td>FLASHING RED over RED</td>
</tr>
<tr>
<td>YELLOW over YELLOW (for a Number Plated Signal)</td>
<td>DARK over YELLOW</td>
</tr>
<tr>
<td>YELLOW over YELLOW (for an Absolute Signal)</td>
<td>FLASHING RED over RED</td>
</tr>
<tr>
<td>FLASHING YELLOW over RED</td>
<td>FLASHING RED over RED</td>
</tr>
<tr>
<td>YELLOW over RED</td>
<td>FLASHING RED over RED</td>
</tr>
<tr>
<td>FLASHING RED over RED</td>
<td>DARK over FLASHING RED</td>
</tr>
<tr>
<td>RED over GREEN</td>
<td>DARK over FLASHING RED</td>
</tr>
<tr>
<td>RED over FLASHING YELLOW</td>
<td>DARK over FLASHING RED</td>
</tr>
<tr>
<td>RED over YELLOW</td>
<td>DARK over FLASHING RED</td>
</tr>
<tr>
<td>RED over FLASHING RED</td>
<td>DARK over FLASHING RED</td>
</tr>
<tr>
<td>RED over RED</td>
<td>DARK over RED</td>
</tr>
</tbody>
</table>

### TABLE 17-4

**TWO UNIT SIGNAL, BOTTOM UNIT LAMP OUT**

<table>
<thead>
<tr>
<th>GREEN over RED</th>
<th>GREEN over DARK</th>
</tr>
</thead>
<tbody>
<tr>
<td>YELLOW over FLASHING GREEN</td>
<td>YELLOW over YELLOW</td>
</tr>
<tr>
<td>YELLOW over GREEN</td>
<td>YELLOW over YELLOW</td>
</tr>
<tr>
<td>YELLOW over YELLOW</td>
<td>YELLOW over RED</td>
</tr>
<tr>
<td>FLASHING YELLOW over RED</td>
<td>FLASHING YELLOW over DARK</td>
</tr>
<tr>
<td>YELLOW over RED</td>
<td>YELLOW over DARK</td>
</tr>
<tr>
<td>FLASHING RED over RED</td>
<td>FLASHING RED over DARK</td>
</tr>
<tr>
<td>RED over GREEN</td>
<td>RED over FLASHING YELLOW</td>
</tr>
<tr>
<td>RED over FLASHING YELLOW</td>
<td>RED over FLASHING RED</td>
</tr>
<tr>
<td>RED over YELLOW</td>
<td>RED over FLASHING RED</td>
</tr>
<tr>
<td>RED over FLASHING RED</td>
<td>FLASHING RED over DARK</td>
</tr>
<tr>
<td>RED over RED</td>
<td>RED over DARK</td>
</tr>
</tbody>
</table>
The applicable code transmitted from signals displaying the lamp out condition indicated above shall also downgrade. 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 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. 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 provide for utilizing “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.

### 17.4.1 Application Logic

Application logic software shall conform to all regulatory requirements. Applicable Route Locking, Indication Locking, Time Locking, or Approach Locking shall be used. Route Locking shall be released utilizing the first two consecutive track circuits. Sectional releasing shall be used wherever possible. New installations may use Approach Locking when directed by the Director, PTC, C&S Systems, or Designate. Separate Timers may be used on each signal, in a pair, where Microprocessor systems are used and as determined by the Director, PTC, C&S Systems, or Designate. Program nomenclature is to follow SCRRA naming conventions. Program Logic is to follow the Typical SCRRA Program Logic. Any relay installations are to follow the same principles of application logic as microprocessor-based systems.

Companies providing Application Logic Programs must have a documented process of checking, computer simulating, and rack testing all programs. All programs and supporting documentation, upon being placed in service, are to be stored on a secure site as directed by SCRRA.

When modifications are made to an existing location, the company providing the application program shall recommend whether reduced test validation is sufficient. Such recommendations shall include documentation of the changes, necessary test procedures, and must be approved by the Director, PTC, C&S Systems, or Designate prior to implementation.

Application logic shall follow the following sequence of activities for clearing a signal:

1. Request the signal and switch.
2. Tumble down to the adjoining Control Point upon request of a route into that block.
3. Check the Route – Switches in position, opposing signals at stop and not in time, good codes received, detector tracks up, and any other applicable conditions.
4. Apply the Locking (Lock terms go false).
5. Upon verification of locking (Lock terms false, Switch Motor Control Relays de-energized), clear the signal.
6. Upon confirmation of signal aspects, upgrade the codes to the Approach Signal to display the proper signal aspect.

With no signals cleared, vital codes are transmitted in both directions on each track, only at the CP as in a two wire HD model.

Where Sectional Releasing is used, the switch will be allowed to change position as soon as the locking is released and applicable Loss of Shunt time has expired. If a new route can be created that is protected from fouling by switch position, then a signal can be cleared even though the first train is still in the CP.

![Diagram of Interlocking Release (Switch Locking Released)](image1)

**FIGURE 17-1: INTERLOCKING RELEASE (SWITCH LOCKING RELEASED)**

When the southbound train has crossed over and is occupying 1AT, as shown in Figure 17-1, the locking will be released as soon as 1T completes Loss of Shunt Time. At this moment, the crossover can be returned to the normal position, and a new route can be created as shown in Figure 17-2. Signals can be cleared on track 2, in either direction while the first train occupies the 1AT.

![Diagram of Interlocking Release (New Route Created)](image2)

**FIGURE 17-2: INTERLOCKING RELEASE (NEW ROUTE CREATED)**

In Figure 17-2, if the southbound train was occupying the 2AT, the locking on the switch would release, and the switch could be reversed as shown in Figure 17-1. However, a new route would not be allowed because the train in the 2AT could roll back and foul the 2T.

17.4.2 **Switch Machine**

110 Vdc Switch machines, with a 189:1 gear ratio, are to be used. Backup Battery shall be provided by a separate 110 Vdc supply as manufactured by C-Can or ERBC. Overload Timers in the Vital Program will be used. The M23E is the preferred switch machine. The M23E will be the M23A style because the points lock when the machine is in “hand” operation.
If In-Tie Switch Machines are installed, they should be of a type that locks the points when in hand operation.

Relays named NWR and RWR will be used for Switch Control. The last called for relay will be held in the energized position until such time as locking is applied. The switch contact will be back-checked in the microprocessor program.

In double track corridors where there is high traffic density, consideration will be given to mounting the switch machines on the outside (normally open point side) of the tracks. Independently Controlled Switch (ICS) machine logic will be used when directed by the Director, PTC, C&S Systems, or Designate. ICS logic allows a switch machine to be worked on for maintenance purposes while train moves take place under signal indication on the adjacent track. In other words, a movement on one track with the switch in the normal position will not check the position of the other end of the crossover. However, if the opposite end of the crossover is out of normal correspondence, the de-energization of the OS track on the adjacent track will place the signal to Stop. ICSs will indicate individually to the office and on the local control panel.

17.4.3 Requisites for CTC

The requisites for centralized traffic control (CTC) are as follows:

1. "Approach or Time Locking" shall be applied to all approaches. Time Locking is preferred but Approach Locking may be used where directed.
2. "Indication Locking" is required in connection with all electrically locked switches, movable-point frogs, or power derails at control points and interlockings.
3. "Route Locking" is required. Sectional route locking (Sectional Release) may be used to facilitate the movement of trains.
4. Detector Loss of Shunt time is to be 5 seconds in terminal areas and lower speed areas. It will be considered at Control Points in higher speed territories; however, the designer must carefully evaluate the time of OS occupancy of short fast trains in conjunction with the timing parameters of the Wayside signal system, communications system, control office processing and system loading, to ensure there is no degradation to train tracking in the Control Office. The 10 second Detector Loss of Shunt time should be used where train tracking is a concern or potential loss of shunt is possible due to rail conditions.

Time and Approach Locking

Time Locking is provided in connection with existing signals. Approach locking is to be provided in connection with signals on routes where greater facility is required than is possible with Time Locking.

Time Locking is used to assure that after a signal has been cleared, a conflicting or opposing signal cannot be cleared or the position of a switch or derail in the established route cannot be changed until expiration of a predetermined time interval after the signal has been placed at STOP, except when the locking is released by occupancy of two successive tracks in advance of the signal.

Approach Locking provides that the time locking will not be effective if the track is unoccupied from a point at least 1,500 feet in approach to the approach signal to the
controlled signal, or, in four aspect signal territory, from a point at least 1,500 feet in approach of the first normally restrictive signal approaching the control signal. In most cases, checking that the same direction controlled signal at the Control point in the rear is at Stop and not in time, and no intervening track circuits are occupied satisfies the requirement for Approach Locking.

SCRRRA Standard time is 6 minutes for existing signals with signaled approaches. At new installations, or where major program changes are taking place at existing locations, locking times shall be calculated by AREMA C&S Manual, Part 2.4.20, using 30 seconds for the approach to the approach signal rather than 1500 feet at 30 mph. If a locking time greater than 6 minutes is necessary, the time shall be as calculated and rounded up to the nearest 30 seconds. If the Director, PTC, C&S Systems, or Designate determines separate timers are advantageous in a signal pair, the locking times will be calculated by AREMA standards and likewise rounded up to the nearest 30 seconds. Locking times where the approach is non-signaled shall be set for 60 seconds unless otherwise directed by the Director, PTC, C&S Systems, or Designate.

EXAMPLES:

(ADEQUATE BRAKING DISTANCE) 1500’

RED ---------------------- YELLOW -------------- GREEN

(APPROACH LOCKING LIMITS)

(ADEQUATE BRAKING DISTANCE) 1500’

RED-----YELLOW------ FLASHING YELLOW------ GREEN

(APPROACH LOCKING LIMITS)

Time or approach locking should be released by a train occupying two consecutive track circuits beyond the control signal. On low speed routes, where a second track circuit is not available, one track circuit may be used to release time and/or approach locking; however, two track circuit releasing is preferred. It should also be released by a time element relay, or electronic timer, with automatic control.

Signal control circuits shall be arranged so that they cannot display proceed when the timing device is not normal.

Where the back contact of a detector section track relay, or track relay repeater, is used to release approach, or time locking, the control circuit for either the electric locking of the interlocked switches, or the control circuits for the interlocked signals, must be cut through the front contacts of the same relay whose back contact is used for releasing, or a repeater of that relay. Preferably, the control circuits for both the electric locking of the interlocked switches and the interlocked signals should be through front contacts of the same relay whose back contact is used for releasing, or a repeater of that relay.
Indication Locking

Indication locking shall be provided in connection with all interlocking signals. Approach signals of the light type, controlled by independent two wire circuits, need not be checked in the interlocking signal indication circuits. Indication locking does not apply to colorlight signals. The principle of Indication Locking applies to mechanical devices such as searchlight signals and power switch machines.

Route Locking

Route locking shall be provided in connection with all mechanical or power switches. It maintains the switch locking after the signal has been passed, and the train is in the route. It must be accomplished by a system of track circuits extending throughout the interlocking which control normal and reverse locks switches, derails, and movable point frogs.

Where there is more than one track circuit, a more complicated scheme of route locking will be necessary. In some cases, where there are a number of track sections in a route, it will be found convenient to use route locking relays to secure continuous switch protection throughout the route.

On interlocking plants where traffic is so heavy that maximum facility is needed, a system of sectional route locking may be installed to provide for the release of switches behind a train as soon as the rear end of a train has reached a point sufficiently beyond clearance to ensure safety from conflicting moves. Sectional route locking will be used in new design to facilitate train operations.

When parallel routes are proposed, there must be sufficient distance between the points of switch on the common track so that neither train will foul the route of the other. In general, this is 100 feet from Point of Switch to Point of Switch, and minimum 13-foot track centers through the parallel portion of the route. Design of signaling for a parallel route must be closely coordinated with the track design.

![Figure 17-3: Parallel Routes](image-url)
17.5 POWER SYSTEMS (FOR OTHER THAN VEHICULAR CROSSING LOCATIONS)

Power to each location shall be provided from a commercial power system. Each location shall be evaluated and the appropriate service connection provided. At a minimum, a 120/240 Vac 100-Amp service shall be provided at new locations. Where power is not readily available, an express cable shall be installed to the nearest power source. The size of the express cable conductor required shall be determined by utilizing National Electrical Code Standards. Each Control Point shall have an external plug connection for a generator to provide power to the house in the event of an extended outage. In high-use, operational critical Control Points a permanent standby generator should be provided.

Standby battery shall be provided at all locations. Battery chargers shall be of the programmable type equipped with temperature monitoring sensors. All storage cells shall be Lead Acid. Batteries shall be of sufficient capacity to provide 48 hours of standby time under “normal operating conditions”. “Normal operating conditions” is defined as “the signal system operating with all signals lit for 24 hours and four switch machine throws per hour, and all track circuits occupied for 12 hours. Battery capacity for highway crossings shall be as specified in Chapter 18.0, Highway-Rail Grade Crossing Signals. Reference the SCRRRA Communications and Signals Standard Drawings for battery sizes and type. For new designs, use the SCRRRA Battery Sizing Calculator to determine capacity.

17.6 SIGNAL BLOCKS

Electro Code Rates will be transmitted simultaneously in both directions throughout signal blocks. “Turn of Traffic” signaling shall be used. Tumbledown will take place after a signal has been requested into a block, and as a train moves through the signaled route. As soon as the lead train is within the OS track, a code 8 may be sent into the block so the Approach Signal displays Yellow up to the Red Absolute.

Code 6 is used to accelerate the tumbledown. Code 6 will be used when a signal is cleared into a block. When a train is flagging past a signal or a switch point pumps, the affected signals will go to Stop but vital codes will not be removed, and code 6 will not be transmitted into any routes other than the one into which the train is moving. This is to prevent unintentional tumbledown. Code 6 may also be used to release the directional stick at intermediate signals.

Figures 17-4 through 17-7 demonstrate the principles of the tumbledown under different scenarios.
In Figure 17-4, all signals are at stop and not in time code 8 is transmitted in all directions. If the OS track is dropped, or the switch is out of correspondence, Code 8 will continue to be transmitted.

![Figure 17-5: SIGNAL 4E CLEARED](image1)

In Figure 17-5, Signal 4E has been cleared over the normal switch and the 4EWLR term is false. Code 6 is transmitted in the direction of travel. The code transmitted in approach to signal 4E will be as called for by the aspect displayed.

![Figure 17-6: SIGNAL 4E CLEARED AND SWITCH IS OUT OF CORRESPONDENCE](image2)

In Figure 17-6, Signal 4E has been cleared over the normal switch and the 4EWLR term is false. Code 6 is transmitted in the direction of travel. The switch on the traveled track goes out of correspondence. If the crossover is conventional, the parallel track will tumble down. If it is an independently controlled switch, there will be no tumble down.

![Figure 17-7: TRAIN FLAGS PAST SIGNAL 4E](image3)
In Figure 17-7, Signal 4E has not been requested or cleared, the switch is normal and the 4EWLR term is true. No vital codes are transmitted in the direction of travel. Because the signal was not requested and did not clear, the accelerated tumbledown did not take place. When the OS became occupied by the directional train move, the Code 8 was removed.

When a train is to enter a signal block between Control Points over a hand operated switch, a come-out signal is preferred over an Electric Lock. In the case of a come-out signal or an Electric Lock, a short tumbledown timer shall run and code 6 shall be transmitted in both directions, then if vital codes are received in both directions, the Lock will release, and in the case of a come-out signal, after the hand operated switch is full reverse, the signal will clear.

17.7 AVERAGE GRADE

For freight train braking grade calculations, the 6,000 feet in approach of the beginning of the block must be considered when calculating the average grade for the entire block. If the average grade within the 6,000-foot approach length is negative (i.e., descending), then this 6,000 feet shall be added to the overall block length in calculating the average grade for the block.

1. Using the engineer’s scale measure the distance between all grade change points in the block. The sum of the distances is equal to the total block length.
2. Multiply each distance recorded by the grade indicated between each point. This is known as the “Distance Grade” (DG).
3. Sum the “distance grades” and divide by the total block distance. This is the Average Grade (AG) of the block.

\[
\text{DG} + \text{DG} + \text{DG} + \text{DG} + \ldots \text{TOTAL BLOCK LENGTH}
\]

For passenger train braking calculations, 1,000 feet in approach of the block must be considered in averaging. If the average grade within the 1,000-foot approach length is negative (i.e., descending), then this 1,000 feet shall be added to the overall block length in calculating the average grade for the block. Braking distance may be calculated either by using the average grade and using the charts, or converting the distance of the block to the equivalent distance of level track. Equivalent Distance may be calculated for ascending grades by the following:

\[
\frac{(\text{Actual Distance}) \times (6 + G)}{6}
\]

For descending grades it is:

\[
\frac{(\text{Actual Distance}) \times (4 - G)}{4}
\]
G is the average grade of the block being equated, plus the approach specified above. The Amtrak braking curve CE-205 with a 25 percent safety factor, and an additional 8 seconds free running will be used for the passenger trains with on-board equipment such as in the 90 mph ATS territory.

A commercially available train performance simulation program for calculating safe braking may be used. Any such program must be accepted for use on at least two Class One Railroads or Passenger Railroads subject to FRA regulation.

17.8 QUALIFICATIONS OF SIGNAL DESIGNER

Signal designers who work on SCRRA signal circuits or programs must be approved by the Director, PTC, C&S Systems, or Designate. The classification Signal Designer is generic and refers to the responsible individual who produces signal circuits or programs. A company or third-party agency may classify this position as a Signal Engineer or other title. In general, a circuit designer should have a minimum of 5 years of experience designing for a Class 1 or Commuter Railroad which operates under Sections 234, 235, and 236 of the FRA regulations.

The requirements for signal designers also apply to programmers of vital logic programs.

Designers may be called upon to demonstrate their familiarity with applicable regulations, both state and Federal, and their familiarity with traditional relay logic, ladder logic, and Boolean Equations. Principles of railroad signaling, including automatic block signals, centralized traffic control, and interlocking must be demonstrated to the satisfaction of the Manager of Signals and Communication. An understanding of train operations and the interaction with the signal system is required, as well as the ability to analyze braking distances, and calculates locking release times. In addition to this, knowledge of Highway Grade Crossing Warning systems must be demonstrated.

The designer may be interviewed, at the discretion of the Director, PTC, C&S Systems, or Designate. The interview may require a demonstration of circuit and program analysis.

17.9 QUALIFICATIONS OF SIGNAL CHECKER

Signal Checkers who work on SCRRA signal circuits or programs must be approved by the Director, PTC, C&S Systems, or Designate. The classification Signal Checker is generic and refers to the responsible individual who performs Quality Control (QC) and safety analysis on signal circuits or programs. A company or third-party agency may classify this position as a Senior Signal Engineer or other title. In general, a circuit checker should have a minimum of 5 years of experience designing for a Class 1 or Commuter Railroad that operates under Sections 234, 235, and 236 of the FRA regulations, and an additional 5 years of experience checking signal designs and vital signal programs.

Checkers may be called upon to demonstrate their familiarity with applicable regulations, both state and Federal, and their familiarity with traditional relay logic, ladder logic, and Boolean Equations. Principles of railroad signaling, including automatic block signals, centralized traffic control, and interlocking, must be demonstrated to the satisfaction of the Director, PTC, C&S Systems, or Designate. An understanding of train operations and the
interaction with the signal system is required, as well as the ability to analyze braking distances and calculate locking release times. In addition to this, knowledge of Highway Grade Crossing Warning systems must be demonstrated.

The signal checker may be interviewed, at the discretion of the Director, PTC, C&S Systems, or Designate. The interview may require a demonstration of circuit and program analysis.

17.10 FINAL CHECK INSTRUCTIONS

In an effort to ensure the quality and integrity of the SCRRA signal and highway grade crossing warning system design, all designs shall receive a “final check.” The final check shall ensure that all designs meet the minimum requirements of 49 CFR 234, 235, and 236. Designs shall also conform to SCRRA Communication/Signal Design Standards and applicable federal, state, and local regulations. All design applications shall adhere to the manufacturer’s minimum recommendations.

Signal designs shall be completed by a signal design firm authorized by SCRRA to provide such services. When an outside check is required, two complete plan sets, or an electronic PDF copy shall be distributed to an outside firm authorized by SCRRA to perform “final checks”. An outside check is required when a new program is used or the changes to an existing program are extensive enough to require a full retest of a location. For instance, converting from a low-voltage switch machine to a high-voltage switch machine would not require an outside check. Adding a crossover to an existing CP would.

Included with the plan sets shall be any pertinent information that may aid the final checker in performing this work. Pertinent information shall include field surveys, service contracts, CPUC application documents, project correspondence, calculations, etc. Pertinent information shall include circuit plans of adjoining locations sufficient to check all circuits and controls in the affected case to both point of origination and termination.

The “final checker” shall review the drawings for adherence to SCRRA standards, field survey requirements, service contracts agreements, CPUC application drawings, and circuit integrity. On one plan set, the final checker shall indicate any corrections that are needed. Once completed, the “marked up” plan set shall be returned to the originating design firm for correction. Upon completing the revisions, a corrected copy shall be sent to the final checker for approval. Once approved, the design firm shall place the final checker’s initials in the appropriate field in the “JBNOTE” cell and distribute the plans for construction.

In instances where construction must immediately begin and sufficient time is not available to complete the final check procedure prior to distribution, the plans shall be clearly marked PRELIMINARY and the checker’s field in the JBNOTE cell shall be left blank. At the time of this preliminary distribution, two plan sets shall be sent to a final checker. A final check shall be completed prior to placing the modifications in operation. Once the final check of the preliminary plan set is completed and corrections have been made, a final plan set shall be distributed. Prior to distribution, a new date shall be entered in the date field of the JBNOTE. The original date shall be displayed “yellowed out”. The transmittal letter shall reference the new plan date, and a statement will be incorporated instructing construction forces to destroy the preliminary plan set in lieu of the final plan set.

In an emergency situation, and only in such situations, modifications to the signal system may be made by field forces with concurrence of an authorized SCRRA agent. In such
instances, the modifications shall be clearly marked on a plan set and the modified plan set delivered to a final checker as soon as possible. All field modifications shall be thoroughly tested to ensure the integrity of the system.

17.11 FILE MANAGEMENT

Part 236 Section 1 and Part 234 Section 201 of CFR 49 requires that up-to-date and accurate signal plans are kept at each location. 49 CFR Part 236 Section 18 requires a Software Management Control Plan for Vital Signal Application programs.

Signal Drawings and Signal Programs are living documents that must be properly maintained to ensure the integrity of the signal system. Duplicate file copies increases the possibility of misleading or inaccurate drawings and programs being distributed to construction or maintenance forces. Files shall not be duplicated without the authority of the Director, PTC, C&S Systems, or Designate.

In order to maintain control of SCRRA Drawings and Programs and be compliant with Federal Regulations, the following checkout procedure will be followed by all design firms. A general description of the project(s) shall be submitted to the Director, PTC, C&S Systems, or Designate along with specific milepost limits. The designer should first request paper or PDF files of any locations within the project limits. Only files which the designer will need to modify for the project will be checked out to the design firm.

Upon completion of the design or program, the designer shall return the CADD files, application program files and an 11" x 17" hard copy of each drawing and 8-1/2" x 11" copy of the program to the Director, PTC, C&S Systems, or Designate or his representative. The designer shall include an itemized list of the files returned. The list shall categorize files by NEW FILES, MODIFIED FILES, and DELETED FILES. If the designer is required to furnish AS-BUILT files, the designer shall provide the Director, PTC, C&S Systems, or Designate or his representative with CADD files of drawings that are distributed for construction and then provide corrected CADD files upon completion of the project. Program files will be furnished after the location is placed in service.

17.12 SUPERVISORY CONTROL SYSTEM AND OFFICE TO FIELD COMMUNICATIONS

When a project requires the addition of a new control point(s), it is the responsibility of the designer to determine whether the additional control point(s) will require the addition of new codelines or additional regions to the Supervisory Control Office.

Empirical evidence suggests that no more than 12 control points should be on a radio codeline. The designer should make an analysis of the impact of increased radio traffic and office system capacity as a part of the 35 percent design submittal. This will allow SCRRA to make any necessary arrangements for capacity improvements.

It has been established that the radio code system is at or beyond capacity. It is the policy of SCRRA to migrate to a Fiber Optic Network for field to office communications. On existing radio codelines, where fiber optic lines are introduced, the radio system may be maintained as a back-up communications path. The basic principle is to provide a diverse communications path. A properly engineered sonnet ring will satisfy the requirement for diversity.
17.13 INTERFACING WITH FOREIGN RAILROADS

SCRRA interfaces with foreign railroads in many locations. When designing a signal system interface, the ideal configuration is end to end with discrete signals each controlled by the governing railroad. This may not be possible due to inadequate signal preview, or parallel tracks where trains cross over from one railroad to the other. The design must account for operational differences between the two railroads. Failure modes must be analyzed and mitigated to the extent possible. In general, it is preferable to have discrete circuits or Electrocode circuits for the interface and minimize the dependency on a serial connection. Where there is a crossover between railroads, it is important that a fault on one railroad does not adversely impact on the other railroad’s parallel routes. The design should also account for the need to perform routine tests and maintenance without requiring permission from or coordination with the foreign railroad. If the railroads connect end to end, the ability to provide a Restricting signal to the foreign railroad’s entering signal may accomplish this. Where the railroads are connected by a crossover, an ICS arrangement with discrete I/O may accomplish this.

17.14 SIGNAL AND TRAIN CONTROL SYSTEM MIGRATION

17.14.1 Migration of SCRRA Signal and Train Control System

The migration of the SCRRA Signal and Train Control System has evolved as follows:

1. Replacement of Relay Based Systems with Microprocessor based ones: All Control Points with the exception of CP Terminal, CP Mission, CP Dayton are microprocessor based.

2. Installation of a fiber-optic backbone communications system as a primary system and use of Advanced Train Control System (ATCS) Radio as a backup: ATCS Radio is the primary medium of train control communication. This system is at capacity, and installation of fiber optic cables will relieve pressure on the current system. Areas which will be dependent upon the ATCS radio are being re-engineered to make them more efficient and consistent in operation.

3. Replacement of dc track circuits and line circuits with Electronic Coded Track circuits took place during the buildout: OS (On Station) tracks remain dc.

4. Legacy ABS systems were converted to CTC in all but non-revenue lines.

5. Installation of a Positive Train Control System (PTC).

By defining the path of migration, the system in place today and future projects will lay the groundwork for PTC.

The migration path has been defined as moving the SCRRA signal and train control system from bi-directional CTC to a system of PTC. The base safety system of wayside signals is in place. The SCRRA signal system uses Electrode 5 Plus Code Rates. While this is a system manufactured by GETS, the code rate structure is an open architecture and can be emulated by competitive vendors. The microprocessors at Control Points in most cases are the GETS...
VHLCs. This equipment is able to communicate from controller to controller and from controller to radio and fiber network.

17.14.2 Migration from CTC to PTC

SCRRA is implementing an interoperable PTC System on all of its line segments where passenger operations are conducted (as set forth in the Rail Safety Improvement Act of 2008 (RSIA08) and 49 CFR 236 Subpart I). The purpose of a PTC System is to prevent train-to-train collisions, over speed accidents, incursion into work zones, and movements through a misaligned switch by requiring automatic control systems to override mistakes by human operators. This PTC system will be designed and implemented to follow the standard 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. In addition to and concurrently with the implementation of the PTC System, SCRRA is replacing its current computer-aided dispatch (CAD) system with a new system that includes both a primary and secondary redundant/backup system.

The Consultant services will also include field validation, PTC data Model creation, update shape files, and verify train simulation module graphics.

Reporting Procedures for Design and Construction

The process for the design and construction changes by General Engineering Consultant or Construction Management Consultant is shown within Positive Train Control (PTC) E & C change Management Process Manual. The process for reporting design and construction activities is also shown within Positive Train Control (PTC) E & C change Management Process Manual.

Other Procedures Required When Proposing Changes to PTC

The following procedures as established in the Positive Train Control (PTC) E & C change Management Process Manual shall also be accommodated for design changes proposed.

1. Reportable Changes
2. Timeline Requirements
3. Reporting Procedures for Design and Construction
4. Surveying
5. Track Charts and Aerial Composite Maps
6. PTC Mapping and Database
7. GPS Data Collection
8. Measuring Procedures
9. Guide to Data Collection
SCRRRA E&C Change Management Process

Currently, SCRRA field operation and maintenance personnel report any changes in the track and signal assets by completing necessary forms included in SCRRA’s Track Maintenance, Right-of-Way, and Structures, Engineering Instructions. In the past, it was not necessary to report all changes made in the field that were deemed not important. With the implementation of PTC system, it is now essential that field personnel provide accurate information of the changes in an expeditious manner to the appropriate offices. As part of the implementation of PTC system, most of the assets have been surveyed and given a reference point (latitude, longitude, elevation). Any new changes in the field must be reported with proper references to the appropriate responsible SCRRA offices.

As part of the change management process the designer will be required to submit a “CHECK B4 U CHANGE” form as shown in the SCRRA Signal Standards. Any changes forecasted will require Change Coordination Board Approval. Changes shall include and are not limited to new installations, relocations of existing, and removals to the Crossings, Turnouts, Signals, Signs, Track, and changes to the physical characteristics of the railroad.

17.14.3 Circuit & Program Modifications in Conjunction with Migration from CTC to PTC

Due to the on time performance penalties associated with an enforced signal stop, measures will be adopted to minimize and mitigate the occurrence of red signals.

1. Modify intermediate signal programs so that a handthrow switch out of correspondence will not tumble the block, but will place the protecting signals at Stop. This principle is explained in AREMA C&S Manual, Part 16.5.2, Recommended Vital Circuit and Software Design Guidelines for Limited Tumbledown Applications in Traffic Control Systems.

2. The field fleeting function will be established in the double track areas to mitigate a loss of codeline.

3. Automatic field clearing shall be considered in single track areas so if there is a loss of codeline, the signals will clear ahead of the train on a first come first serve basis.

4. ICS logic will be employed to the extent that a switch at the opposite end of a crossover will not put the signal on the adjacent main to Stop in the event it pumps under a train, or is out of correspondence with the OS unoccupied.

Software Management Control Plan

The 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.
This plan shall be used in conjunction with the following documents, as well as other documentation provided by the suppliers that is specific to a system or product. However, nothing in these documents can supersede applicable laws and regulations unless a specific exemption or waiver has been obtained.

1. 49 CFR Part 236, Subpart H – Standards for Development and Use of Processor-Based Signal and Train Control Systems; Final Rule, published March 7, 2005
   AREMA (American Railway Engineering and Maintenance of Way Association) C&S Manual, Section 17 – Quality Principles

2. SCRRRA Instructions Governing Installation, Maintenance, Inspection and Testing of Signal Apparatus and Signal Systems

3. Current SCRRRA Timetables

4. This SCRRRA Design Criteria Manual

17.15 DESIGN STAGES

The design cycle is an iterative process that may involve Railroad Operations, Finance, Contracts, and the other Railroad Engineering Disciplines:

1. The 5% Submittal may be produced by the agency or the Signal Engineering firm. It is a very basic document intending to capture the rationale for the project. It may consist of:
   - A conceptual overview. This is a single line drawing identifying track configuration, signals and switches.
   - Conceptual overview of any alternate configurations (if any).
   - Rough Order of Magnitude Budget estimate

2. The 35% Submittal builds on the 5% Submittal. This document is suitable for review by all of the stakeholders. Upon completion of the 35% submittal and acceptance of it, the track configuration should be locked in. This is the time when Operations may decide that they require an additional crossover or turnout. It generally consists of:
   - A preliminary scaled layout of the preferred alternative
   - Preliminary aspect charts
   - A Design Basis Report, when required describing the reason for the project and operational benefits. A discussion of alternatives
   - Order of Magnitude Estimate (Still Preliminary)
   - The preliminary materials list containing long lead time items may be required at this time, particularly with a grade crossing project where an agreement is required with the public agency.

3. The 65% Submittal is the evolving work in progress. It is essentially the final design although it may not be fully detailed. It consists of:
   - Final scaled layouts and aspect charts.
• Preliminary materials list (long lead time items accurately depicted). It may include the final design for prewired houses. If a procurement package is going out, it will go out at this time.

• Circuit plans that have house layouts and most equipment shown. The circuitry is still in progress. (Detailing not complete)

• Engineer’s Estimate (still preliminary but developed to the same level of detail that the design is

• The technical specifications

4. The 95% Submittal should be the last review opportunity in the design cycle. It consists of:
   • The final plans are transmitted to checking firm for review.
   • The final materials list.
   • The final Engineers Estimate.
   • The final technical specifications

5. The 100% Submittal is the “Issued for Construction” or “Issued for Bid” package. The design is complete, and the construction package is ready for distribution. It consists of:
   • Final design for distribution. (Incorporates any changes to the 95% document which may come out of the final check)
   • The IFB package including Plans, Specifications and Engineering Estimate if it is a Contract for third party work.
   • Software will be furnished for outside check after construction has begun, after the Issued for Construction plans, and after or during initial construction.

The design stages above are guidelines for the design cycle on SCRRA Signal projects. The Agency may choose to combine stages, or introduce additional review cycles. For instance if there are significant changes during the 35% review cycle, the Agency may require a 40% iteration which reflects those changes. On a rehabilitation project, the Agency may elect to go directly to 95% design.
18.0 HIGHWAY-RAIL GRADE CROSSING SIGNALS

18.1 GENERAL DESIGN REQUIREMENTS

18.1.1 Scope

The designer shall specify equipment and applications that will not only provide optimum safety, but also will maximize the efficiency and reliability of the commuter and freight train system. The design shall incorporate systems and equipment that have been proven to be reliable, durable, and effective on other rail networks and are in current use by SCRRRA. Introduction of new materials, which will require an inventory of spare parts and additional training, must be approved by the SCRRRA Director, PTC, C&S Systems, or Designate.

The design shall incorporate features that shall aid signal personnel in the inspection, testing, repair, and overall maintenance of the system. Any new test equipment or procedures required by new materials or methodologies must be identified and submitted to the Director, PTC, C&S Systems, or Designate, for consideration.

All designs shall adhere to the rules and regulations contained in 49 CFR 234, 235, and 236. Grade crossing design criteria shall incorporate the rules and instructions as contained in the most current issue of the SCRRRA General Code of Operating Rules, SCRRRA General Orders, SCRRRA Timetable, and SCRRRA Special Instructions. Construction and installation details will be found in the SCRRRA 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 SCRRRA 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.

Any modification to the grade crossing warning systems has the potential to necessitate changes to the system of wayside signaling. It should be noted that all changes to track structure, including installation of insulated joints and imposition of audio frequencies on the rails, need to be evaluated to determine the potential effect on the wayside signal system. Refer to Chapter 17.0, Wayside Signals, for wayside signal considerations and design criteria.

18.1.2 Train Detection System

The preferred grade crossing control incorporates the use of uni-directional or bi-directional redundant constant warning devices (i.e., units fully contained with an internal transfer function) without utilization of “wrap” circuits. These train detection systems shall be combined with solid-state crossing controllers to ensure compliance with “lamp voltage” and “standby lamp voltage” regulations. Event recorders shall be utilized to record data useful in the maintenance, troubleshooting, and repair of the entire system. Where it is necessary to deviate from preferred grade crossing control standards, approval must be obtained from the SCRRRA Director, PTC, C&S Systems, or Designate.

On multiple track where uni-directional applications are utilized, a single two-track unit should control warning for train movements on Main Track No. 1, a second unit should control warning for movements on Main Track No. 2, a third unit for Main Track No. 3, and so on. Deviation from this Standard requires approval of the SCRRRA Director, PTC, C&S Systems,
or Designate and documentation thereof.

An application program sheet should be included in the planset where HXP3 and GCP 3000’s and GCP 4000’ are installed.

Where GCP 4000’s are used, it shall be the responsibility of the design firm to furnish the Pac file on a USB Drive for field configuration of the location. After the location has been placed in service, the in-service files will be furnished to the SCRRA Software Configuration Manager. The settings will not appear on the plans, however a printout of the settings will be left in the shelter enclosed in a clear plastic envelope.

18.1.3 Selection of Warning Time

The warning time at a grade crossing must be sufficient for vehicles and pedestrians to clear the tracks. The minimum warning time, required by law for motor vehicles is 20 seconds. The design minimum for through train moves on SCRRA is 30 seconds, and is based upon 20 seconds minimum warning time plus 10 seconds buffer time. The actual warning time may differ from the design minimum due to variations in train speed in the approach to the crossing. The only exception to the requirement for a 20 second minimum warning time occurs when a train stops in the approach to a grade crossing.

Guidelines for vehicular warning time are spelled out in the AREMA Communications and Signals Manual of Recommended Practices as well as the requirements in Part 234 of CFR Title 49, however there are no comparable guidelines for pedestrians.

There are existing warning time guidelines for Light Rail Systems under MUTCD Part 10 as well as standards for pedestrian crossings for roadways under MUTCD Part 4. These standards derive timing based on a walking speed of 4 feet per second. American Disability Act Accessibility Guidelines (ADAAG), however, recommends a walking speed of 3 feet per second to allow for the elderly.

18.1.4 Background (Stations)

Where crossing warning times are long or inconsistent, motorists and pedestrians are more likely to engage in risky behavior. Therefore it is desirable to follow the SCRRA standard pedestrian station configuration and not increase warning times. MUTCD prescribes standard devices for vehicular and pedestrian warning and control for just these reasons. At a station, the risk is that the devices lose credibility and a person ignores the devices and steps out in front of an express traveling in the opposite direction. When warning times increase, impatience grows and the probability of risk taking increases.

The FHA Highway/Rail Grade Crossing Technical Group states, in its report issued in November of 2002 on Guidance on Traffic Control Devices at Highway Rail Grade Crossings, that after 40 to 50 seconds, motorists tend to become impatient and drive around gates. The same time can be attributed to pedestrians. Since the grade crossing is based on a 30 second warning time for MAS, a train approaching a station at speed and then decelerating for the station will have an increased warning time. Typically this time is in the 40 to 50 second range. Extending the warning time to accommodate longer walk distances has the potential of increasing the warning time for a decelerating train by over 50% and thus increases risk.
For this reason, the standard configuration should be used at SCRRA stations and deviations occur only for special circumstances.

### 18.1.5 Warning Time

All constant warning devices should be configured to provide 30 seconds of warning time, which currently includes a minimum 10 seconds of buffer time, for normal through trains operating at the maximum authorized district speed. Although federal regulations require a minimum of 20 seconds warning time, the 30 second application should allow for train acceleration in the approach. Additional warning time may be required for “wide track” applications; traffic signal interconnects, and increased time that may be desirable in lowering the gate to accommodate slow moving vehicles clearing the track area. The most current AREMA guidelines are to be followed in determining warning times.

A wide track is a crossing that is greater than 35 feet. Wide track is determined by measuring the distance parallel to the centerline of the roadway between the governing warning device and 6 feet beyond the furthestmost track on which trains operate. When this distance is greater than 35 feet, one second shall be added for each additional 10 feet, or fraction thereof.

The termination shunt shall be placed in accordance with the manufacturers recommendations. The minimum placement shall be the required distance to provide the 30 seconds warning time, plus the required reaction time of the device (i.e., normally 5 seconds). Additional time may be required to pre-empt an adjacent traffic signal and/or to accommodate clearing vehicles from the widely separate track sections.

Once the total time requirement is calculated the designer shall determine the required approach circuit distance. The actual location of the termination shunt shall be measured from the point where the signal island circuit is terminated on each side of the crossing.

### 18.1.6 Frequency Selection and Application

All systems shall be applied in accordance with the manufacturer’s recommendations. The preferred application is bi-directional but uni-directional applications shall be utilized to provide adequate frequency separation, where following train movements may occur, and where insulated joints must be maintained in the vicinity of crossings to support wayside signal systems.

Remote applications should be used where insulated joints exist within the approach limits to the crossing. Tuned joint couplers may be used only when applied in accordance with the manufacturer’s recommendations. Additional systems may be required to accommodate special applications and unique train operations. When a grade crossing adjoins a Control Point, the designer must carefully analyze moves towards the grade crossing and determine whether special circuits are required to mitigate a potential momentary loss of detection as the train diverges from the track on which detection is active.

The preferred constant warning device frequencies to be utilized are 86, 114, 156, 211, 285, 348, 430, 525, 645, 790, and 970 Hertz for the primary system. Utilization of the 348 HZ system shall be confined to areas where 60 HZ interference is not likely and electrified transit systems do not parallel the tracks. The frequency selected shall be dependent upon the required approach distance and ballast conditions. A 4 Ohm/1000 ft. distributed ballast
resistance value shall be utilized in comparing frequency to required “look” distance. “Six wire” applications shall be avoided where possible. High impedance termination shunts, such as the NBS-2 should be used.

Signal circuitry island frequencies shall be **10.0 KHZ, 11.5 KHZ, 13.2 KHZ, and 15.2 KHZ**. Harmon Electronics Random Signature Island (RSI) modules are acceptable for use on SCRRRA property. Careful evaluation of existing frequencies and equipment shall be made prior to selecting island frequencies.

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.

### 18.1.7 Power Supplies

An independent battery set and charging circuit shall be furnished for the train detection equipment and a separate battery set and charging circuit shall be utilized for the crossing warning devices. Chargers shall be equipped with temperature compensation devices.

Where the total load of the crossing warning devices exceeds 30 amperes, a separate shelter with a charger and bank of batteries may be required. Battery capacity shall be sufficient to provide 12 hours standby with the lights flashing and gate arms in the full horizontal position. Battery capacity for the constant warning device shall be sufficient to provide a minimum of 48 hours of normal operation. The manufacturers’ recommended surge protection apparatus shall be incorporated into all grade crossing design. Surge protection units shall be installed on the ac supply source, battery supply, and track leads.

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.

Each vehicular crossing shall have an external plug connection for a generator to provide power to the signal house in the event of an extended power outage.

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 Ohm.

### 18.1.8 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:

a. Internal House/Case Wire

1. Battery chargers and feeds  
   #6 flex
2. Flasher lighting circuits  
   #10 flex
3. Track circuits  
   #10 flex
4. Loads in excess of 1 ampere #10 flex
5. Loads less than 1 ampere #14 flex

b. Flashing Light Signals/Gates

1. Light wires #6 flex
2. All other circuits #10 flex

c. Cable

1. Flasher lighting circuits & gate feeds #6 solid
2. All other circuits #14 solid

Flasher Lamps

Grade crossing flasher lamps must be provided at a minimum of 8.5 Vdc Cable shall be sized to limit voltage drop to 3 Vdc.

LED’s

LED’s shall be installed on all new installations or significant upgrades to existing locations.

Electronic Bell

An electronic bell shall be installed in each quadrant containing gates.

Solid State Crossing Controller

Either relays or an approved solid-state crossing controller such as the SSCCIV or later model should be installed when modifying a crossing. The later model is preferred.

18.2 DESIGN CRITERIA FOR EXIT GATE SYSTEMS

18.2.1 Exit Gate Systems

Formerly called Four Quadrant Gate Systems, exit gate systems consist of the Exit gate assembly (CPUC Standard 9 – E), a vehicular intrusion detection system between the Entrance Gate and the Exit Gate, and the necessary safety critical logic equipment to control the operation of the Exit Gates and the vehicular intrusion detection system.

Exit Gates are installed in order to:

- Improve safety at crossings
- Increased deterrence of vehicles driving around lowered entrance gates
- Create an effectively “Sealed Corridor” for train travel

The safety and operations through the vehicular crossings are the responsibility of both SCRRRA 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. (CA MUTCD 8A.01) The diagnostic team shall perform a site specific review which considers crossing attributes, highway environment and risk
mitigation criteria.

18.2.2 Regulatory Requirements

The following are regulatory requirements for Exit Gates:

1. Exit Gates shall be designed to fail in the raised position. (CPUC General Order 75-D, CA MUTCD 8D.05)
2. Entrance Gates shall begin their descent before Exit Gates and shall be horizontal before the Exit Gates are Horizontal. (CPUC General order 75-D)
3. A vehicle intrusion detection system shall be installed whenever exit gates are used. (CPUC General Order 75-D, CA MUTCD 8D.05)
4. At locations where gate arms are offset a sufficient 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. (CA MUTCD 8D.05)
5. Exit gate arm activation and downward motion shall be based on detection or timing requirements established by an engineering study of the individual site. (CA MUTCD 8D.05)

18.2.3 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 SCARRA 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. The Exit Gate Management System as manufactured by Railroad Controls Limited or equal shall be used.

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 preformed and water repellent with an integral check loop such as that manufactured by Reno A & E. In general, the loops will be placed between the entrance gate and the nearest rail, between each set of tracks, and between the furthest rail and the exit gate. 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:

1. Detect all motor vehicles, including all passenger motor vehicles, school buses and trucks, but not including motorcycles, bicycles.
2. Provide “occupied/not occupied” indications to railroad control circuits within two seconds of any state change.
3. 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.
4. Verify each time that the crossing gates are called down and the occupied indication is working.
5. Not to generate false highway vehicle occupied indications, more often than minimum threshold values to be determined by the Engineering Study.
6. 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.
7. Meet the current applicable national and local standards.
8. 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”.
9. 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.
10. 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.
11. Detection loops shall not be vulnerable to EMI that is generated within the environment of an electrified railway under normal or fault conditions.
12. 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.
13. The loop detection system shall not interpret a train movement through the crossing as vehicle occupancy.

Systems having exit gate systems should have remote health monitoring systems capable of automatically notifying maintenance personnel when anomalies have occurred within the system (CA MUTCD 8D.05).

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 Exit Gates will begin their ascent. The Entrance gates will begin their ascent after the Exit Gates have begun 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 warning time is calculated to the Exit Gate rather than to the point clear of the furthest rail.

18.3 DESIGN CRITERIA FOR PEDESTRIAN CROSSINGS

Normal operation is for the bells to activate, lights to flash, and three seconds later, the gates to descend. The bells will continue to sound until the train has cleared the Island circuit and the gates complete their ascent. At that time, the bells will cease to ring. Bells are considered pedestrian warning devices, and a grade crossing shall have enough bells so that a bell can be heard by pedestrians in each approach. All new bells shall be electronic.

18.3.1 Warning Time

The ADAAG walking rate of 1.5 feet per second (FPS), the walking rate for a mobility impaired person, will be considered for calculating pedestrian warning times. Since one cannot rely on a locomotive engineer to see a slow moving person in the crossing and being able to brake in sufficient time, the mobility impaired individual is relying on the warning devices to provide sufficient warning time.

The standard warning time at SCRRA grade crossings is 30 seconds. There are special circumstances where the warning times are lengthened. The public is accustomed to this standard warning time, as well as to a slightly longer time caused by decelerating trains. In general, pedestrian walking times are calculated at a walking rate of 3.5 FPS. The distance is measured from the warning device approaching the crossing to the point of clearance on the far side of the pedestrian crossing.

Since the flashing lights (when used) for pedestrians are aimed across the tracks and the bells are primarily a pedestrian warning device, walking times will also be calculated for the mobility impaired person (at 1.5 FPS) from the clearance point on the start point to the clearance point across the tracks. So a warning time of 30 seconds allows a mobility impaired individual to safely traverse 45 feet.

In this manner, the needs of the able bodied and the mobility impaired will be considered without increasing warning times and compromising pedestrian patience.

The Roadway Worker Protection Act defines fouling a track thusly: *Fouling a track* means the placement of an individual or an item of equipment in such proximity to a track that the individual or equipment could be struck by a moving train or on-track equipment, or in any case is within four feet of the field side of the near running rail.
Four feet from the nearest running rail is approximately six and one half feet from track center. CPUC clearance is eight feet six inches from track center. The designer should use the 8’-6” distance from track center on both the entering and leaving side of the tracks to calculate the walking distance for the mobility impaired individual.

18.3.2 Center Fence

Track centers at stations with outboard platforms are widened to 18 feet to accommodate a center track fence which must be at 8 ft 6 inches clearance from each track center.

A fence will encompass the platform and will channel the passengers to crossings at the end of the platforms. ADA compliant ramps will be provided as a transition from platform height to rail crossing height.

18.3.3 Warning Devices

1. Gate and Flashing Lights: Pedestrian warning devices shall be standard AREMA compliant railroad gates and flashing lights that are commercially available. These devices are immediately recognizable to the public as train approach warning system. A separate gate mechanism for sidewalks should be provided in lieu of a supplemental or auxiliary gate arm installed as a part of the same mechanism to prevent a pedestrian from raising the vehicular gate at a highway-rail grade crossing.

2. Swing Gates: At a crossing with pedestrian gates, a person may have begun crossing the tracks when an approaching train activates the crossing. For this person not to be trapped by the gate arms, a swing gate is provided adjacent to the pedestrian gate arm. This gate only swings away from the crossing and is marked as an exit only.

18.3.4 Safety Buffer Zone

A pedestrian safety buffer zone is created on the platform between the clearpoint and the gate and swing gate. This will allow a person to recognize the gate and open it with room for a small group to stand in safety, or a wheel chair to maneuver. The perpendicular alignment of gate to rail allows a maximum safety buffer zone. This is the preferred arrangement, although where available space prohibits it a parallel alignment is used.

A safety buffer zone is provided for the slower moving individual to turn back and take refuge if he has passed the gate and sees and hears the activation. The presumption is the mobility impaired person will not attempt to beat the train.

18.3.5 Warning Assemblies

Pedestrian warning assemblies which require lights other than one on the gate arm will consist of lights arranged in a conventional horizontal arrangement. The CPUC standard #10 pedestrian flasher is obsolete and a single burnt out lamp will make the crossing out of compliance with FRA regulations (Part 234 of CFR49). It is imperative that lights aimed across the tracks be aligned so that a motorist will not perceive them as a device directing him to stop. If the pedestrian gate arm length does not exceed 10 feet, a counterweight assembly may not be required. Pedestrian gate assemblies should be located with allowance for maintainer accessibility to the mechanism.
At stations, lights will be aimed down the platform and across the tracks. The light aimed across the tracks is similar to the pedestrian walk light across a street at a standard pedestrian roadway crossing. If auxiliary lights are needed due to station entries perpendicular to the tracks or parallel to the tracks, they will be provided as needed.

**18.3.6 Gate Recovery**

After a train stops at the station, the gates should recover, and passengers should be able to safely cross from one platform to the other while the train dwells at the station. If a second train approaches on the opposite track, the gates will reactivate or remain down as required.

**18.4 TRAFFIC SIGNAL PREEMPTION**

**18.4.1 Background**

Traffic Signal preemption is a complex dynamic, little studied prior to Fox River Grove. Knowledge in the field continues to evolve. Prior to design of a traffic signal preemption circuit, the 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 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.

**18.4.2 Interconnection Circuits**

Older, widely used traffic signal controller units use interconnection circuits between the railroad active warning system cabinet and the traffic control signal cabinet for preemption. This interconnection circuit consists of two wires/cables buried in the ground between the above two points. The approach of a train to a highway-rail grade crossing opens the electrical circuit, which in turn activates the traffic signal controller preemptor. This establishes and maintains the preemption condition during the time the highway-rail grade crossing warning system is activated. If there is a break in either or both wires or cables of the interconnection circuit, (as example, an excavation contractors inadvertently breaking the wires or cables) the traffic signal controller unit would respond as if a train is approaching, clearing vehicles off the tracks, even though a train may not be approaching. The traffic signals remain in the preemption mode as long as the circuit remains open. If a train approaches during such a malfunction, the railroad active warning devices will activate, yet the traffic signal preemption cannot be reinitiated to clear vehicles off the tracks.

One potential problem with the two wire/cables interconnection is a short in the circuits. 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 between the railroad and the traffic signal control system.

**18.4.3 Supervisory Circuits**

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, 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 circuit logic is Exclusive OR. One circuit must be energized and the other de-energized. Both energized or both de-energized is indicative of a problem with the interconnect circuit and the traffic signal controller should assume a state known to be safe and to issue a notification that there is a circuit deficiency.

The following table identifies the number of wires and functions for the supervised interconnection circuit for Simultaneous and Advance Preemptions:

<table>
<thead>
<tr>
<th>Wires</th>
<th>Simultaneous Preemption</th>
<th>Advance Preemption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Source energy positive</td>
<td>Source energy positive</td>
</tr>
<tr>
<td>2</td>
<td>Source energy negative</td>
<td>Source energy negative</td>
</tr>
<tr>
<td>3</td>
<td>Preempt relay positive</td>
<td>Preempt relay positive</td>
</tr>
<tr>
<td>4</td>
<td>Preempt relay negative</td>
<td>Preempt relay negative</td>
</tr>
<tr>
<td>5</td>
<td>Supervision relay positive</td>
<td>Supervision relay positive</td>
</tr>
<tr>
<td>6</td>
<td>Supervision relay negative</td>
<td>Supervision relay negative</td>
</tr>
<tr>
<td>7</td>
<td>Gate down relay positive</td>
<td>Gate down relay positive</td>
</tr>
<tr>
<td>8</td>
<td>Gate down relay negative</td>
<td>Gate down relay negative</td>
</tr>
<tr>
<td>9</td>
<td>Traffic signal health positive</td>
<td>Traffic signal health positive</td>
</tr>
<tr>
<td>10</td>
<td>Traffic signal health negative</td>
<td>Traffic signal health negative</td>
</tr>
</tbody>
</table>

**18.4.4 Gate Down Circuits**

A preempt trap is a condition where the clear track green interval ends before the flashing-light signals start to flash and gates start to descend and it 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 leaving clear track green interval 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. The traffic signal controller unit shall change to the clear track green interval as usual, but shall dwell in the clear track green Interval until the “gate-down” confirmation is received, or until a user defined maximum time has expired.

**18.4.5 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 failure.
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.

**FIGURE 18-1: INTERCONNECTION CIRCUITS WITH SUPERVISION, GATE DOWN CIRCUITRY, AND HEALTH CIRCUIT**

### 18.4.6 Interconnection Circuits

In Figure 18-1, above, energy (BX, CX) is supplied to the railroad from the traffic signal controller. The TCPR is the relay which provides the call to pre-empt. This relay is normally energized and returns energy to the inputs of the traffic signal controller. When a train is detected and the call for preemption is generated, the TCPR is de-energized and the energy is returned to the traffic signal controller on the wires labeled SUP and NSUP. This is the supervisory circuit. The supervisory circuit must be de-energized and the preemption circuit energized, or vice versa. This indicates the integrity of the interconnection circuitry to the traffic signal controller. If both are energized, or both are de-energized, that is indicative of a fault in the interconnection. The wires labeled GD and NGD are energized when the gates approaching the signalized intersection are down after a call to preempt. Upon receipt of these inputs, the traffic signal controller can terminate Track Clearance Green (TCG) and transition to the phases allowed during preemption. These gates down contacts may be bypassed by contacts of the Island circuit so that TCG can terminate when the island is occupied in the event of a gate which does not fully lower.

The health of the traffic signal controller is communicated to the railroad via the Health Relay. If the traffic signal controller is not functioning or in All – Flash, the health relay will be de-energized and the railroad grade crossing warning system may 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 a serial connection is used, this information and more can be conveyed between the railroad control devices and the traffic signal control devices and operation of both systems enhanced.

**18.4.7 Not-to-Exceed Timing Circuits**

Railroads sometimes use the “Not-to-Exceed” timing circuits to control the maximum advance preemption time, which helps in eliminating a preempt trap.

**18.4.8 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 passes. 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-surmountable 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.
19.0 ENVIRONMENTAL GUIDELINES

19.1 SCOPE

General information and guidance regarding environmental compliance requirements for SCRRA projects is provided below. 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.

19.2 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.

19.2.1 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.

19.2.2 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 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 resources, to identify means to avoid or minimize adverse impacts, and to determine which agencies have jurisdiction over the activity or project location.

19.2.3 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 impacts on sensitive 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 approvals.

19.3 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 19.4.1, below, for further discussion of CEQA).

19.3.1 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 Game (CDFG), and 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 CDFG should be contacted immediately. Other agencies to be contacted may include the Regional Water Quality Control Board and county and local municipal agencies. When an agency is contacted, the following information should be provided:

1. The SCRRRA contact person
2. The SCRRRA contact phone number
3. What the emergency involved
4. Why it is 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 SCRRRA 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**

The agencies should issue emergency permits within 24 to 48 hours of SCRRRA’s submittal of a work plan and site map. The emergency permits 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, SCRRRA 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 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 SCRRRA 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 and entered into the project file.

**19.3.2 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, new projects, and supplemental work following emergency construction.

**Environmental Review**

SCRRRA’s environmental expert, whether an environmental consultant or SCRRRA staff
member, should review the proposed project and the environmental issues associated with implementing the work at approximately the 10 to 15 percent design phase. 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 Director of Engineering and Construction 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 Director of Engineering and Construction may relocate the siding to avoid the habitat, thereby avoiding the often significant time and dollars to prepare a biological assessment or habitat conservation plan and to buy into a mitigation bank. 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.

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 (10 to 15 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. Permits will not be issued prior to completion of CEQA compliance (see Section 19.4.1, below, 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. 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 Director of Engineering and Construction prior to commencement of any construction activities. These requirements should then be communicated to onsite workers through daily “tool box” meetings or project-specific environmental training. The information conveyed to work crews should include the limitations and conditions of the environmental permits and approvals.

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.

### 19.4 ENVIRONMENTAL PERMITS

Environmental evaluations and permits commonly required for railroad work are discussed below. Table 18-1, 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 are subject to the CEQA. SCRRA projects that are federally funded are subject to NEPA and 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.

#### 19.4.1 California Environmental Quality Act

The 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.

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.

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.

#### 19.4.2 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 771.117) – 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 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 771.119)

3. Environmental Impact Statement (23 CFR 123 et seq.)

19.4.3 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 may be required. 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.
Nationwide Permits

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.

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.

19.4.4 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
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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.

19.4.5 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.

19.4.6 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 Regional Water Quality Control Board (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.

Storm Water

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 to the SWRCB, preparing a Storm Water Pollution Prevention Plan (SWPPP) to be kept on-site during construction, and submitting a Notice of Termination.

19.4.7 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 the RWQCB. The USACE Section 404 permit is by far the most common federal permit issued in California that requires a Section 401 determination 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.

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.

19.4.8 California Department of Fish and Game, Section 1600

Under Section 1600 of the Fish and Game Code, CDFG 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 CDFG 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.

CDFG provides regular permitting through the processing of a streambed alteration agreement. SCRRA would file a “Notification of Lake or Streambed alteration” form (FG 2023) and “Project Questionnaire” form (FG 2024) with the local CDFG office. For permitting of emergency construction, CDFG has established a process for emergency notification. Section 1610 of the Fish and Game 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 CDFG 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.

19.4.9 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.

A permit or approval from 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. These evaluative steps are typically completed during the environmental review and permitting phases of the project and the mitigation measures are identified in the environmental document(s) and permit(s).

All such mitigation measures and permit conditions shall be incorporated into the final design.

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.

19.4.10 California Endangered Species Act

CDFG administers the California Endangered Species Act (CESA) under Fish and Game Code Sections 2080 through 2085. A permit or approval from CDFG 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 Game 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 CDFG 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 MSCP and NCCPs provide for protection and preservation of existing listed species as well as species that may be listed in the future, these MSCP and NCCP 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 would have to be subject to some discretionary permit and CEQA compliance from a local agency. Without this level of agency involvement, SCRRA may not be able to take advantage of the conditions of the local MSCP or NCCP.

19.4.11 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) and Section 4(f) of the Department of Transportation (DOT) Act of 1966. 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. Section 4(f) of the DOT Act also stipulates that the Federal Highway Administration (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 (1) there is no feasible and prudent alternative to the use of land, and (2) the action includes all possible planning to minimize harm to the property resulting from use.

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, SCRRRA 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.

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.

19.4.12 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

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 or “GO 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.

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).

19.5 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 mitigation banks or restoration programs.

19.6 OTHER ENVIRONMENTAL CONSIDERATIONS

19.6.1 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.

19.6.2 Standards, Codes, and Guidelines

The latest edition of the following standards, codes, and guidelines shall be used during design of these projects:

- National Environmental Policy Act (40 CFR 1500-1508)
- Federal Highway Administration, Environmental Impact and Related Procedures (23 CFR 771)
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.

19.6.3 Topography, Soils, and Geology

General

Any subsurface testing program for SCRRRA 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 to determine that no significant adverse impacts would result or must provide the data required to develop 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.

19.6.4 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 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 8.0, 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 Game 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 earth 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.

Proposed SCRRA improvements may increase the amount of paved area within the drainage areas where they are located. This could result in increased runoff and potentially higher stream discharge rates, which would require drainage improvements to control.

19.6.5 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.

19.6.6 Energy

As part of final design, energy conservation features and operating procedures will be evaluated for SCRRA system. Such features and procedures will be evaluated and, if found practical and cost effective, made part of the normal operations of the SCRRA system.

19.6.7 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 alignments, 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 the railroad is located close to residential areas 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 annoying levels of ground-borne vibration. In cases of extreme heavy construction, a few activities have the potential of creating vibration of sufficient amplitudes to cause building damage.

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.

19.6.8 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.

19.6.9 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.

**19.6.10 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.

**19.6.11 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.

Generally, SCRRA projects are expected to enhance regional air quality by reducing vehicle
miles of travel in the SCRRRA 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 SCRRRA 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 SCRRRA 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 and other mitigation measures identified in the project(s) environmental document(s) to reduce such emissions during construction activities.
<table>
<thead>
<tr>
<th>Permit or Approval</th>
<th>Responsible Agency</th>
<th>Applicable Work Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEPA</td>
<td>Federal lead agency</td>
<td>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).</td>
</tr>
<tr>
<td>Section 404</td>
<td>United States Army Corps of Engineers</td>
<td>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.</td>
</tr>
<tr>
<td>Section 10</td>
<td>United States Army Corps of Engineers</td>
<td>Section 10 regulates all navigable waters of the United States, which are defined as &quot;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.&quot;</td>
</tr>
<tr>
<td>Section 9</td>
<td>United States Coast Guard</td>
<td>Section 9 regulates construction, reconstruction, or modification of bridges or causeways across navigable waters of the United States.</td>
</tr>
<tr>
<td>Section 7 and 10a (Endangered Species Act)</td>
<td>United States Fish and Wildlife Service</td>
<td>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.</td>
</tr>
<tr>
<td>Section 4(f) Evaluation</td>
<td>United States Department of Transportation</td>
<td>Section 4(f) applies to projects affecting land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites.</td>
</tr>
<tr>
<td>Permit or Approval</td>
<td>Responsible Agency</td>
<td>Applicable Work Activity</td>
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<tr>
<td>Section 106</td>
<td>Federal lead agency</td>
<td>Section 106 applies to projects with federal agency involvement that may affect historic properties such as building sites, districts, structures, and objects. For example, SCRRRA 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.</td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEQA</td>
<td>State lead agency</td>
<td>CEQA applies to projects undertaken, funded, or requiring an issuance of a permit by a California public agency. CEQA exemptions that may apply to SCRRRA projects include 14 C.C.R. 15269, 15275, and 15303.</td>
</tr>
<tr>
<td>Section 402 - NPDES General</td>
<td>State Water Resources Control Board</td>
<td>The General Industrial Storm Water Permit regulates storm water runoff from eligible transportation facilities.</td>
</tr>
<tr>
<td>Industrial Storm Water Permit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 402 - NPDES General</td>
<td>State Water Resources Control Board</td>
<td>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.</td>
</tr>
<tr>
<td>Construction Activity Storm Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 401</td>
<td>Regional Water Quality Control Board</td>
<td>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.</td>
</tr>
<tr>
<td>Section 1600</td>
<td>California Department of Fish and Game</td>
<td>Section 1600 regulates the alteration of streams, wetlands, and other waterbodies. A Streambed Alteration Agreement may be required for SCRRRA projects affecting waters of the state or waters of the United States.</td>
</tr>
<tr>
<td>CESA - Incidental Take Permit</td>
<td>California Department of Fish and Game</td>
<td>A permit or approval from CDFG is required whenever an activity may affect state-listed threatened or endangered plant or animal species.</td>
</tr>
<tr>
<td>Permit or Approval</td>
<td>Responsible Agency</td>
<td>Applicable Work Activity</td>
</tr>
<tr>
<td>-------------------------</td>
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</tr>
<tr>
<td>Coastal Development</td>
<td>California Coastal Commission</td>
<td>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.</td>
</tr>
<tr>
<td>Rail Crossings</td>
<td>California Public Utilities Commission</td>
<td>SCRRA will need to file applications with CPUC for new rail crossings or “GO 88-B authorization” requests for alterations of existing rail crossings.</td>
</tr>
<tr>
<td>Local</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood Control Permit</td>
<td>Flood Control District</td>
<td>A flood control permit may be required for SCRRRA projects affecting county flood control structures.</td>
</tr>
<tr>
<td>Special Use Permits</td>
<td>Cities, Counties, Special Districts</td>
<td>For SCRRRA projects occurring outside existing rights-of-way, additional city, county, or special district permitting may be required as determined by the local jurisdiction.</td>
</tr>
<tr>
<td>Building/Grading Permits</td>
<td>Municipal</td>
<td>For SCRRRA projects occurring outside of existing rights-of-way, additional municipal permitting may be required.</td>
</tr>
</tbody>
</table>
20.0  RIGHT-OF-WAY MAPPING AND SURVEYING

20.1 SCOPE

Design criteria for horizontal and vertical control of facilities within and along SCRRRA ROW are discussed below.

20.2 RIGHT-OF-WAY

As it pertains to a railroad, whether a passenger or a freight system, ROW refers to the real estate or land on which the roadbed, track structure, and facilities are built. ROW generally refers to an easement, but railroads have adopted this term to describe their property; however, in most cases, railroads will own the land in fee.

SCRRA ROW is made up of lengths of land of varying widths that usually increase at stations and yards to accommodate the increased real estate 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 SCRRRA corridor is ROW that originally belonged to the Southern Pacific Railroad (SP), Santa Fe Railroad (now BNSF), and UP and consisted of both a single- and double-track system. 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 also worked to change the original geometry.

20.2.1 SCRRRA Policy

The intent of SCRRRA policy on ROW is consistent with safety, maintenance, and operating requirements. The policy eliminates or reduces 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 Director of Engineering and Construction.
- Execute any new leases only with the approval of the Director of Engineering and Construction.
- 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 SCRRRA corridor and to explore all appropriate means for acquisition and preservation of those properties.

ROW engineers work in conjunction with the SCRRRA Real Estate Department and the SCRRRA Engineering 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 54 stations in service, with approximately 512 miles of operating routes traveling through 6 of the 7 southern most counties in California, all but Imperial County.

20.2.2 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 acquired. An easement may come in the form of an agreement with a local municipality, such as a Franchise Right. Land can also be acquired when the railroad exercises its right of eminent domain if 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, 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.

Fee Simple

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.

Fee Simple Determinable

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 quite literally 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 SCRRRA’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.

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 20.2.4 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 20.2.4 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.

20.2.3 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 Director of Engineering and Construction. New leases shall not be executed without prior approval by the Director of Engineering and Construction.

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 20.3.1, Survey Control and Geodetic Surveying, below.

- 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 Director of Engineering and Construction 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.
20.2.4 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 SCRRRA corridor is of the quasi-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 SCRRRA corridor is a combination of bounds and strip descriptions. In legal descriptions for SCRRRA, the use of bounds-only descriptions is discouraged. The various types of descriptions are defined as follows:

- Metes descriptions are perimeter descriptions described by measurement and direction of travel only, and they have no bounds calls or calls to an adjoiner.
- Bounds descriptions are perimeter descriptions based on bounds calls only, and they have no measurement or direction of travel calls included.
- Metes and bounds descriptions are perimeter descriptions that are described by measurements, direction of travel, and calls to adjoiners.
- Strip descriptions are descriptions of property whose perimeter is described by widths from a given base line or centerline, say the centerline of a track, such as “30 feet on each side of the following described centerline.”
- Descriptions by reference are descriptions of property by reference to some map or plat, such as “Lot 1, Block 49 of the University Subdivision.”
- Descriptions by exception are descriptions of property that except out certain areas as a reservation from the conveyance, such as “Lot 1, Block 49 of the University Subdivision, except the northerly 50 feet.”

Plat Maps

A plat map as defined by SCRRRA 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 SCRRRA shall be drawn to scale and shall include, at a minimum, the following information:

- North arrow
- Legend
- Point of beginning
- Point of commencement, if applicable
- Thicker line indicating the land being described
SCRRA Design Criteria Manual

- 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

20.2.5 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 feet high. 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.

20.3 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).

20.3.1 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 approximately 512 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.

20.3.1.1 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. All future 2-D Plane Surveying performed on the SCRRA corridor should also be tied to this reference frame.

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. HARNs
and CORS are from different adjustments and should not be used together in the same survey.

Recently, the National Geodetic Survey (NGS) put all control under a new national control system known as the NAD 83 National Spatial Reference System (NSRS). The NGS will be combining all control points, both HARN and CORS points, under this one system. SCRRRA should use this system along with the California Spatial Reference System (CSRS), a cooperative CORS network that is a partner to the NGS to develop its framework for a new Control Network.

A horizontal datum is generally defined by three basic requirements:

- An ellipsoid
- An origin
- An orientation

The shape of the earth, although generally thought of as a sphere, is really a sphere with flattening at the poles. This flattening at the poles creates what is known as an oblate spheroid. Geodetic surveyors must take into account this true shape of the earth. Geodetic surveys establish control networks on a mathematical surface that most closely approximates the shape of the earth. This mathematical surface is known as the ellipsoid.

Although there are several mathematical surfaces or ellipsoids that have been developed over the years, the first reference spheroid used in North America was Clarke’s Spheroid of 1866. Much of Caltrans mapping is based on this spheroid.

A horizontal datum is dependent on the ellipsoid that is chosen to define its surface. For example, the North American Datum of 1927, or NAD 27, is based on Clarke’s Spheroid of 1866. The origin of this datum is the triangulation station at Meade’s Ranch in Kansas. The orientation was the geodetic azimuth from the station at Meade’s Ranch to the station at Waldo in the town of Waldo, Kansas.

With the launching of satellites, the NAD 27 horizontal datum was rendered unusable. All near-earth satellites orbit around the center of the earth’s mass, so an ellipsoid for satellite positioning had to have its origin at the center of mass. Unfortunately, the Clarke Spheroid of 1866 had its center roughly 300 meters away from the center of the earth’s mass.

In recent years, better mathematical models have been developed by NGS and the United States Department of Defense (DoD), and new reference spheroids have been developed that better approximate the actual shape of the earth. The latest ellipsoid developed by DoD is the WGS 84. The DoD uses this earth-centered, earth-referenced coordinate system or horizontal datum also called the WGS 84 that is based on this ellipsoid. The latest ellipsoid developed by NGS for civilian users is GRS 80, which has its origin position earth-centered and its orientation as that of the Bureau International de l’Heuer (BIH) terrestrial system of 1984 (BTS-84).

NGS developed NAD 83 to provide the survey community and other users with a reference system that was an earth-centered, earth-fixed system, orientated to the BTS-84 system and based on the GRS 80 ellipsoid.

20.3.1.2 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.

An epoch can be calculated for any given moment in time and is a “snapshot” in time of all the positions of the included monumentation. Currently, NGS has published the new 2007.0 epoch, and the CSRC has moved all of its data from the 2004.0 epoch to this new 2007.0 epoch. 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.

20.3.1.3 The Geoid

SCRRA specifies the use of the geoid (Geoid 03) to be used in the processing and adjusting of geodetic survey data while performing geodetic surveys along its corridor.

In geodetic surveying, the computations for the determination of the geodetic coordinates or positions of points is performed using models of the earth known as the ellipsoid and the geoid. The model that most closely represents the undulations of the surface of the earth is referred to as the geoid; but measurements made on the apparent or topographic surface of the earth are performed on an ellipsoid.

The ellipsoid is the mathematically defined surface with specific dimensions, but the geoid coincides with that surface to which the oceans could conform over the entire earth if free to adjust to the combined effect of the earth’s mass attraction and the centrifugal force of the earth’s rotation. The difference between these two models can be calculated for a specific location on the earth, and this difference is known as the Geoid Separation. These two models have many different definitions, and the right definitions must be used for the area of the survey in order to produce accurate final data.

The geoid is a surface along which the gravitational potential is everywhere equal and to which the direction of gravity is always perpendicular. This is significant because optical survey instruments containing leveling devices are commonly used to make geodetic measurements. When properly adjusted, the vertical axis of the instrument coincides with the direction of gravity and is therefore perpendicular to the geoid.

This geoid is available to users to download on the NGS website.

20.3.1.4 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. Various organizations use datums that best serve their needs, but these many different datums can cause confusion when trying to compare vertical data between projects performed by different agencies or private entities.

NAVD 88 is a vertical network defined by one station, Father Point/Rimouski, which is an International Great Lakes Datum (IGLD) water-level station located at the mouth of the St. Lawrence River in Quebec, Canada. This one station mean sea level elevation was held fixed in a minimally constrained least-squares adjustment performed by NGS. Because only one station was held fixed, the network was not distorted due to constraints of different mean sea level elevations, unlike the National Geodetic Vertical Datum of 1929 (NGVD 29).
Both datums, NGVD 29 and NAVD 88 are orthometric elevations. An orthometric elevation or height of a point on the earth’s surface is the distance from the reference surface (geoid) to the point, measured along the plumb line, normal to the geoid.

Local cities or agencies may still use different vertical datums that are of some variation of mean sea level or differ from that of the NGVD 29 or NAVD 88 vertical datums, but these differences have to be taken into consideration when trying to use as-built plans on work performed by others on adjacent projects or on projects that are dated.

Control surveys performed for SCRRA will use NAVD 88 benchmarks, either new or adjusted, as the basis for their survey work. NAVD 88 benchmarks with elevations that have been derived from a Vertcon shift of an NGVD 29 benchmark shall not be used in Primary and Secondary Vertical Control Networks as constraining elevation points, but may be used as a general vertical check. These Vertcon elevations are generally published only to the tenth of foot accuracy. SCRRA will not accept control point data using RTK- or GPS-derived elevation data unless derived from a static GPS survey.

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, dated September 2006. 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 20-1, below. 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 20-2, below.

TABLE 20-1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in length between fore and back sights, not to exceed per setup</td>
<td>33 feet</td>
<td>33 feet</td>
<td>33 feet</td>
</tr>
<tr>
<td>Cumulative difference in length between fore and back sights, not to exceed per loop or section</td>
<td>33 feet</td>
<td>33 feet</td>
<td>33 feet</td>
</tr>
<tr>
<td>Maximum sight lengths</td>
<td>300 feet</td>
<td>300 feet</td>
<td>300 feet</td>
</tr>
<tr>
<td>Minimum ground clearance of sight line</td>
<td>1.6 feet</td>
<td>1.6 feet</td>
<td>1.6 feet</td>
</tr>
<tr>
<td>Maximum section misclosure</td>
<td>0.06 feet (x(\sqrt{D})) (See Note 2)</td>
<td>0.06 feet (x(\sqrt{D})) (See Note 2)</td>
<td>0.04 feet (x(\sqrt{D})) (See Note 2)</td>
</tr>
<tr>
<td>Maximum loop misclosure</td>
<td>0.06 feet (x(\sqrt{E})) (See Note 3)</td>
<td>0.06 feet (x(\sqrt{E})) (See Note 3)</td>
<td>0.04 feet (x(\sqrt{E})) (See Note 3)</td>
</tr>
<tr>
<td>Difference between top and bottom interval not to exceed:</td>
<td>.30 of rod unit</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Collimation (Two-Peg) Test</td>
<td>Daily (not to exceed 0.007 feet) (See Note 4)</td>
<td>Daily</td>
<td>Daily</td>
</tr>
<tr>
<td>Minimum number of readings. (Use repeat measure option for each observation)</td>
<td>N/A</td>
<td>N/A</td>
<td>3 (See Note 5)</td>
</tr>
</tbody>
</table>

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 20-2

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in length between fore and back sites, not to exceed per setup</td>
<td>16 feet</td>
<td>16 feet</td>
</tr>
<tr>
<td>Cumulative difference in length between fore and back sights, not to exceed per loop or section</td>
<td>33 feet</td>
<td>33 feet</td>
</tr>
<tr>
<td>Maximum sight lengths</td>
<td>230 feet</td>
<td>230 feet</td>
</tr>
<tr>
<td>Minimum ground clearance of sight line</td>
<td>1.6 feet</td>
<td>1.6 feet</td>
</tr>
<tr>
<td>Maximum section misclosure</td>
<td>0.04 feet x (√D) (See Note 2)</td>
<td>0.04 feet x (√D) (See Note 2)</td>
</tr>
<tr>
<td>Maximum loop misclosure</td>
<td>0.04 feet x (√E) (See Note 3)</td>
<td>0.04 feet x (√E) (See Note 3)</td>
</tr>
<tr>
<td>Difference between top and bottom interval not to exceed:</td>
<td>.20 of rod unit</td>
<td>N/A</td>
</tr>
<tr>
<td>Collimation (Two-Peg) Test</td>
<td>Daily (not to exceed 0.003 feet) (See Note 4)</td>
<td>Daily</td>
</tr>
<tr>
<td>Minimum number of readings. (Use repeat measure option for each observation)</td>
<td>N/A</td>
<td>3</td>
</tr>
</tbody>
</table>

**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.

### 20.3.1.5 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 number of decimal places that a computation is carried out to and the results that can be stated indicate precision. However, calculations are not necessarily made more
precise by using more decimal places. 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.

20.3.1.5.1 Least Squares Adjustment

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.

If accuracies exceed expected tolerances, the level loop may be rejected or may need to be
redone, and the proper person shall be alerted so a course of action can be determined to
isolate the discrepancy.

20.3.1.6 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. Monuments shall be accessible to the public,
preferably in the railroad ROW or easement.

Whenever possible, monument locations that can be easily described should be selected.
Identifying stamping shall be noted in the field book. 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.

20.3.1.7 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.

If possible, stationing should be in the same direction as the mileposts. Milepost sign markers are frequently moved or relocated, so they are not to be used as precise reference marks.

20.3.2 California State Plane Coordinates

Surveys performed for SCRRA shall be on the California Coordinate System, NAD83 (CCS83) in conformance with the California Public Resources Code. Surveyors working on the SCRRA corridor shall be familiar with these codes because they define the CCS and provide for its use.

A plane survey coordinate system is on a flat surface; therefore, the geodetic positions of points must be projected from the curved surface of the spheroid to the flat surface to create flat plane coordinate positions. This is accomplished by using a “projection.” The CCS83 is based on the Lambert Conformal Conic Projection under the State Plane Coordinate System, defined below.

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 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. Depending on the orientation of the states, one of the following three conformal projections were used to create zones:

- Lambert Conformal Conic – for states that are longer east–west
- Transverse Mercator – for states that are longer north–south
- Oblique Mercator – for the panhandle of Alaska, because it lays at an angle

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.

There is no precise mathematical conversion for coordinates between CCS27 and CCS83. Conversion programs like NGS’s NADCON or U.S. Army Corps of Engineer’s CorpsCon are only approximate conversions not accurate enough for engineering and boundary surveys.

20.3.3 Aerial Mapping and Photogrammetry

Mapping prepared for SCRRA shall be in conformance with National Map Accuracy Standards (NMAS). NMAS was the first comprehensive standard developed in modern history for the United States. It was first announced by the U.S. Bureau of the Budget in 1941, and utilizes measurements made on the published map scale. 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 20-3 shows the standard for some common map scales. The conversion of paper maps into digital data usually creates additional error.

**TABLE 20-3**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Engineering Scale</th>
<th>National Map Accuracy Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:480</td>
<td>1&quot;=40'</td>
<td>+/- 1.33 feet</td>
</tr>
<tr>
<td>1:600</td>
<td>1&quot;=50'</td>
<td>+/- 1.67 feet</td>
</tr>
<tr>
<td>1:1,200</td>
<td>1&quot;=100'</td>
<td>+/- 3.33 feet</td>
</tr>
<tr>
<td>1:2,400</td>
<td>1&quot;=200'</td>
<td>+/- 6.67 feet</td>
</tr>
<tr>
<td>1:4,800</td>
<td>1&quot;=400'</td>
<td>+/- 13.33 feet</td>
</tr>
<tr>
<td>1:9,600</td>
<td>1&quot;=800'</td>
<td>+/- 26.67 feet</td>
</tr>
<tr>
<td>1:12,000</td>
<td>1&quot;=1000'</td>
<td>+/- 33.33 feet</td>
</tr>
<tr>
<td>1:24,000</td>
<td>1&quot;=2000'</td>
<td>+/- 40.00 feet</td>
</tr>
</tbody>
</table>

**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."
SCRRA Design Criteria Manual

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 Director of Engineering and Construction 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 huge.

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 20-4 depicts various mapping scales and their applications.

TABLE 20-4

<table>
<thead>
<tr>
<th>Map Scale</th>
<th>Contour Interval</th>
<th>Mapping Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1” = 20’</td>
<td>1 foot</td>
<td>Grade Crossing, Bridge, and Station Sites for Final Design</td>
</tr>
<tr>
<td>1” = 40’</td>
<td>2 foot</td>
<td>Standard Maps for Engineering Design (PE and PS&amp;E)</td>
</tr>
<tr>
<td>1” = 100’</td>
<td>5 foot</td>
<td>Standard Maps for Environmental Studies, Feasibility Studies, Planning, and Conceptual Engineering</td>
</tr>
<tr>
<td>1” = 200’</td>
<td>10 foot</td>
<td>Corridor Studies</td>
</tr>
</tbody>
</table>

Orthophotography

In digital orthophotography, pixel resolution correlates with map scale. Table 20-5 gives a general idea 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 20-5

<table>
<thead>
<tr>
<th>Target Map Scale</th>
<th>Orthophoto</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in = x ft</td>
<td>Ratio, ft/ft</td>
</tr>
<tr>
<td>40</td>
<td>1:480</td>
</tr>
<tr>
<td>50</td>
<td>1:600</td>
</tr>
<tr>
<td>100</td>
<td>1:1,200</td>
</tr>
<tr>
<td>200</td>
<td>1:2,400</td>
</tr>
<tr>
<td>400</td>
<td>1:4,800</td>
</tr>
</tbody>
</table>

20.3.4 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 Director of Engineering and Construction 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 prepared by the Director of Engineering and Construction
- 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 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

**END OF SECTION**