



Regional Transportation District

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May 19, 2016

The RTD Bus Transit Facility Design Guidelines and Criteria manual is being modified and renamed as **RTD Bus Infrastructure Design Guidelines and Criteria**.

The last approved set of general guidelines and specific criteria was written and approved in 2006. The purpose of the document is to provide guidance, and establish criteria to be used in the preparation and implementation of planning, design, and construction of new bus transit facilities, including improvements to existing facilities. These changes reflect the current bus fleet, safety requirements, accepted practices, and codes used by the industry. A new chapter on transit access has been added.

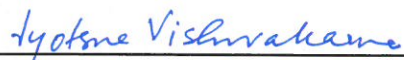
The updated RTD Bus Infrastructure Design Guidelines and Criteria's intent is to establish general criteria to be used in the planning and design process; however, deviations from these accepted criteria may be required in specific instances. Any such deviations must be approved by RTD in accordance with the established hierarchy of approvals ranging from minor deviations generated from RTD Engineering, to major deviations dictated by the Executive Safety & Security Committee.

Coordination with local agencies and jurisdictions is still necessary for determining requirement updates, fire protection, life safety, zoning, platting, land development, and security measures. Approvals by these local agencies and jurisdictions will be implemented as part of the planning and design of RTD facilities. Conflicting information or directives between the criteria set forth in this manual shall be first brought to RTD's attention, and will subsequently be addressed and resolved between RTD and the local agencies or jurisdictions.

This manual will be updated periodically either in part or in whole as deemed appropriate by RTD. Any updates or modifications will take precedence over previous versions or criteria at the time of approval of the updated material or sections thereof.

Submitted by:

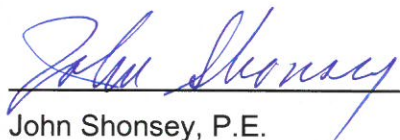
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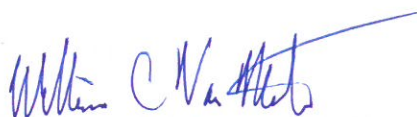
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RTD BUS INFRASTRUCTURE DESIGN GUIDELINES AND CRITERIA

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Prepared by the



Contact Engineering@RTD-Denver.com for questions related to this document

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SECTION 1 - INTRODUCTION

1.1.0 BUS TRANSIT FACILITIES

RTD bus transit facilities are intermodal transfer facilities. They provide collection and distribution points for travelers who transfer between auto and transit (bus or rail) modes, single occupant vehicles and high occupancy vehicle (vanpools or carpools) modes, transit modes (bus to bus, bus to rail and rail to bus) or by other means. Bus transit facilities require proper planning and forethought to serve this array of modal transfers, which if accomplished will optimize the facility activity and better integrate it with the surrounding community. Other modes supported by a properly designed bus transit facility may include: pedestrian, bicycle, paratransit, inner- and inter-city bus transit, airport service and rail (LRT and commuter).

Differing transit facility design views are held within engineering and planning professions. At one extreme, the primary goal is to maximize its efficiency as an extension of the highway or transit network. At the other extreme, the primary goal maximizes community integration characteristics and reduces regional transportation connectivity needs. RTD integrates both extremes and provides a coordinated design that equally serves the highway transit network and community integration. The level of coordinated design shall be appropriate to the surrounding existing and planned roads and land uses.

Experience and surveys show that facilities achieve success (measured by demand and operating expense) if form follows function. Design professionals shall consider the various access, circulation and service modes of the transit facility and shall include pedestrian and bicycle movements. These concerns and design requirements are at the top of the design priority list. Close attention to these issues will produce a superior facility with reduced maintenance requirements, lower operating costs and manageable security risks.

Many components are required for the design and development of a successful multimodal transit facility. These components fall into the following nine categories:

1. Providing for the design requirements of transit vehicles, automobiles and maintenance equipment
2. Functional zones (access, transfer, circulation, plazas, boarding, seating, lighting, utilities, drainage, information and fare collection) of a transit facility
3. Designing a community integrated facility
4. Providing for the design needs of pedestrians and bicyclists
5. Compliance with ADA requirements and guidelines
6. Design considerations for facility access management
7. Design considerations for convenient, efficient and cost effective maintenance
8. Design considerations for safety and security management
9. Aesthetic/Place making

Although a hierarchy can be applied to the nine categories, each is important to the success of the proposed facility. All bus transit facility designs shall address and integrate each of the above categories.

Access, circulation, storage and parking for transit, automobile, bicycle and pedestrian modes, and their requirements, services, amenities and conveniences shall provide smooth and seamless transfer capabilities, and promote efficient facility management.

The pedestrian mode is a component for all commuter trips. Design considerations, within a facility and surrounding land uses, shall provide for and promote pedestrian flow.

Bicycle access, circulation and parking and storage design shall be included with the facility and integrated with adjacent bike routes and pedestrian paths. Bicycles and automobiles must be accommodated for on-site circulation and parking.

As required, automobile parking lot (park-and-ride; PnR) sizes will vary pursuant to estimated demands. The PnR design shall be based on site characteristics such as parcel shape, topography and available access. They are classified as small, medium and large:

1. A small PnR may be located on a remnant few acres parcel along a freeway, adjacent to a freeway access ramp, or other site with no special access features, with a 200 space or less capacity, and a bus loading area along a parallel street.
2. A medium PnR may be located on an 8 acre parcel with a parking capacity of more than 200 and less than 1,000 spaces, and a bus loading area within the facility and a dedicated transit vehicle access driveway loop.
3. A large PnR lot may be located on a 15 acre site with a parking capacity of 1,000 or more spaces, with multiple transit vehicle loading areas and possibly different transit modes (e.g., I-25 & Broadway, Mineral or Wagon Road at I-25).

The following is an approximate parking space count to lot size ratio used by RTD for planning purposes:

1. 70 spaces per acre for a large PnR with several bus loops, multiple plaza areas, many pedestrian circulation routes and extensive amenities.
2. 75 spaces per acre for a medium PnR with a single bus loop, several plaza areas, pedestrian circulation routes and other amenities.
3. 80 spaces per acre for a small PnR with no internal bus loop (street stop only), single plaza area, limited pedestrian circulation routes and few amenities.

1.2.0 SCOPE

These Design Criteria relate to the following RTD design and construction elements:

1. Transit Access

2. Bus Transit Facility Design
3. Civil Design
4. Urban and Landscape Design Elements
5. Bicycle Facilities
6. Structural Design
7. Ancillary Structures at PNRs (Driver Relief Stations/ Elevators)
8. Signage
9. Lighting and Electrical
10. Communication, Fare Collection and Power
11. Construction Documents
12. Facility and System Safety and Security

1.3.0 PROCEDURES AND VARIANCES TO CRITERIA

It is RTD's goal to design the Bus Transit Facilities to be consistent with system reliability, passenger comfort, mode of operation, type of vehicle to be used and maintenance. Safety for passengers, workers and the public is of primary importance. Economic considerations in establishing the capital costs and the long term cost of maintenance are a major component of this process and should be considered throughout the design and should be done in accordance with the criteria established in this manual.

Design Engineers shall prepare drawings and technical specifications for each project in accordance with their design contract, as applicable, and the following RTD documents:

1. All RTD Approved Design Criteria Manuals
2. RTD CADD Standards
3. Contract Requirements
4. All other applicable requirements including codes, regulatory standards, environmental impact statements, and RTD Transit Service Policies & Standards.

Code analyses shall be prepared and submitted for RTD review. During the design phase of a project, there may be specific instances in which the design engineer needs to deviate from accepted RTD criteria in order to develop a solution to a particular design problem. Any deviation, discrepancy, or unusual solution must be approved by RTD in writing before it can be included in the design. Deviations from these established criteria shall be evaluated only if meeting the established requirements is determined by RTD to be impractical - not capable of being done within physical, social, or economic constraints.

In determining whether to grant a variance to these Design Criteria, RTD will consider all relevant factors, including whether:

1. A variance is reasonably necessary for, and would not be detrimental to, the convenience, safety, health and/or welfare of the public.
2. There is exceptional or undue hardship on the applicant, or a physical impracticality to meet the criteria.
3. A variance will not impair the bus operations, maintenance, or transit safety, nor otherwise conflict with the purposes of this Design Criteria.

The order of precedence for applicability of various requirements shall be:

1. Requirements mandated by Federal legislation
2. Requirements mandated by State legislation
3. Local Agency written standards within local agency ROW.
4. RTD Design Criteria
5. Applicable industry standards
6. Other State Agency requests
7. Local Agency requests

Specific attention shall be given to complying with the most recent version of the Americans with Disabilities Act (ADA).

It is the responsibility of the Design Engineer to identify, explain and justify any deviation or variance from the established criteria and to secure the necessary approvals from RTD. All variances to the criteria shall be submitted and approved by RTD in accordance with the procedure as defined in Chapter 7 of the RTD's Engineering Design Guidelines which establishes the RTD review and approval process for the requested variance.

Where manufactured products are specified, alternative products are acceptable if the proposed substitution is an approved equivalent and approved by RTD in writing.

1.4.0 DESIGN CODES AND MANUALS

The Design Engineer shall comply with all applicable engineering codes, standards, and all Federal, State and local jurisdictional requirements.

The most recent edition(s) of codes, manuals and requirements specified herein shall be used. Responsibility for all designs remains with the Engineer of Record (Design Engineer) in accordance with the terms and conditions of the design contract, and State of Colorado Laws and Regulations.

The Design Engineer shall identify all known or apparent code conflicts, shall notify RTD in writing and shall recommend a solution. The Design Engineer shall confirm those codes and manuals that have precedence.

Specific codes, standards and design guidelines include, but are not limited to, the following:

1. Americans with Disabilities Act (ADA)
2. Americans with Disabilities Act Standards for Accessible Design (ADASAD)
3. Americans with Disabilities Act Standards for Accessible Design for Transportation Vehicles
4. Americans with Disabilities Act Standards for Transportation Facilities
5. Colorado Department of Transportation (CDOT) - Standard Specifications for Road and Bridge Construction
6. CDOT - Standard Plans (M&S Standards)
7. CDOT – Roadway Design Guide
8. CDOT – Drainage Design Manual
9. CDOT – Bridge Design Manual
10. City and County of Denver - Rules for Street Standards
11. City and County of Denver - Standard Construction Specifications
12. FHWA - Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)
13. Metropolitan Government Pavement Engineers Council (MGPEC) - Pavement Design Standards and Construction Specifications
14. RTD – Facilities Standard and Directive Drawings for Bus and Light Rail Infrastructure Projects (RTD Standard Drawings)
15. Uniform Building Code (UBC)
16. International Building Code (IBC)
17. Uniform Fire Code (UFC)
18. American Association of State Highway and Transportation Officials (AASHTO)
19. American Institute of Steel Construction (AISC)
20. American Welding Society (AWS)
21. American Concrete Institute (ACI)
22. American Society for the Testing of Materials (ASTM)
23. National Bureau of Standards
24. National Electric Code (NEC)
25. National Electric Safety Code (NESC)
26. American National Standards Institute (ANSI)
27. National Fire Protection Association (NFPA) including NFPA 130 and 101
28. Local jurisdictional codes, requirements and ordinances, as applicable
29. Individual sections of these criteria may also define additional code requirements

1.5.0 CLIMATIC CONDITIONS FOR SYSTEMS DESIGN

The Denver metropolitan area, within which RTD operates, is situated east of the Rocky Mountains, near and within the eastern slopes of the Rocky Mountain foothills in central Colorado. The area has a semi-arid climate similar to the High Plains, but is modified by the Rocky Mountains located west of the area. Denver lies in a belt where there is a fairly rapid change in climate from the foothills to the plains. This change is largely caused by the increase in elevation towards the westerly foothills. Denver has an elevation of 5,280 feet.

The average annual temperature is about 50°F and it varies a few degrees with changes in elevation. The wide average range in daily temperature of 25° to 30°F in the Denver metropolitan area and a wide average range in annual temperature are typical for the High Plains. Variations in temperature are wide from day to day; extremely hot weather in summer and extremely cold weather in the winter normally do not last long and are followed by much more moderate temperatures.

Facilities materials and equipment shall be capable of maintaining operation within the following conditions:

TABLE 1A – TEMPERATURE AND PRECIPITATION

MONTH	TEMPERATURE					PERCIPITATION			
	AVERAGE DAILY MAXIMUM	AVERAGE DAILY MINIMUM	MEAN	2 YEARS IN 10 WILL HAVE AT LEAST 4 DAYS WITH		AVG. TOTAL	2 YEARS IN 10 WILL HAVE		AVG. NUMBER OF DAYS WITH SNOW COVER
				MAX TEMP EQUAL OR HIGHER THAN	MIN TEMP EQUAL OR HIGHER THAN		LESS THAN	MORE THAN	
	°F	°F	°F	°F	°F	IN.	IN.	IN.	DAYS
JANUARY	43.9	17	30.4	64.7	-4.6	0.5	0	0.8	11.4
FEBRUARY	46.5	20	33.3	66.8	-0.5	0.57	0.01	0.7	8
MARCH	52.9	26.2	39.6	73.2	8.1	1.21	0	1.6	5.7
APRIL	61.3	34.3	47.8	80.5	20	1.75	0.03	2.8	2.3
MAY	70.7	44	57.3	87.1	31.4	2.4	0.06	3.7	0.3
JUNE	81.9	52.9	67.4	95.4	42.3	1.63	0.03	2.6	0
JULY	88.2	59	73.6	97.8	51.3	2.08	0.15	3.2	0
AUGUST	86	57.4	71.7	94.3	49	1.67	0.06	2.1	0
SEPTEMBER	77.6	48.2	62.9	91.5	35.3	1.34	0.01	1.7	0.3
OCTOBER	66	36.6	51.3	83.3	22.6	0.99	0.05	1.5	1.4
NOVEMBER	52.7	25.5	39.1	73	7.5	0.79	0.01	0.9	6.1
DECEMBER	45	18.1	31.5	66.2	-3	0.57	0	0.6	9.6
YEAR	64.3	36.5	50.4	*101	** -5	15.59	9	18	45.1

Source: Colorado Climate Center
 66 years 1948-2014 calculated for
 CCC station 52220: Denver
 Stapleton

* Average annual highest temperature

** Average annual lowest temperature

Data for long periods indicate that the average annual precipitation ranges from 13.5 to 14.5 inches, with the highest precipitation occurring at the western edge of the metropolitan area. Particularly in summer and spring, precipitation may vary from year to year and in different areas in the same year. Precipitation in the winter is more in the western part of the Denver metropolitan area than it is in other parts. These differences are small but consistent from October to May. The annual snowfall is about 59 inches. The eastern part of the metropolitan area, however, usually receives more rainfall in summer than the west, but local rainfall varies widely from year to year.

The relative humidity averages 39% during the day and 62% at night, but these averages are slightly higher in winter than in summer. In an average year, the percentage of sunshine is about 69%.

Hailstorms cause some local damage almost every year. The hail usually falls in strips 1 mile wide and 6 miles long. These storms are more common in the eastern part of the Denver metropolitan area than the western part and they generally occur from about May 15 to September 1 but are most common in June and July.

Climate conditions vary throughout the RTD District. The local criteria shall be used in determining the conditions that should be used in the design of any of the RTD facilities. This is especially relevant for maximum wind speed; reference "Colorado Front Range Gust Map" as required in Section 7.13.0. Requirements for climatic conditions defined in other sections of these Design Criteria take precedence.

1.6.0 ACRONYMS AND ABBREVIATIONS

The following defined acronyms and abbreviations may appear in this document:

AASHTO	American Association of State Highways and Transportation Officials
ACI	American Concrete Institute
ACOE	Army Corps of Engineers
ADA	Americans with Disabilities Act
ADASAD	Americans with Disabilities Act Standards for Accessible Design
APTA	American Public Transit Association
ASTM	American Society for Testing and Materials
CCD	City and County of Denver
CCTV	Closed Circuit Television
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
CRT	Commuter Rail Transit
DBE	Disadvantaged Business Enterprise
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HVAC	Heating, Ventilating and Air Conditioning
IBC	International Building Code

IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society
ISO	International Organization for Standards
LED	Light Emitting Diode
LOS	Level of Service
LRT	Light Rail Transit
LRV	Light Rail Vehicle
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NETA	National Electrical Testing Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PUC	Public Utilities Commission
ROW	Right of Way
TOC	Transit Oriented Communities
TOD	Transit Oriented Development
TVM	Ticket Vending Machine
UBC	Uniform Building Code
UDFCD	Urban Drainage and Flood Control District
UFC	Uniform Fire Code
UL	Underwriters Laboratories, Inc.
USDCM	Urban Storm Drainage Criteria Manual
USDOT	United States Department of Transportation

1.7.0 TRANSIT FACILITY TYPES

The types of bus transit facilities are as follows:

1. Park and Ride (PnR)
2. Bus Rapid Transit (BRT) with/without expanded “Super Stop”
3. Transfer Station (pulse point) with no, or limited short-term parking (kiss-and-ride)
4. Street-side Bus Stop

The functions and services include modal transfers to other buses, rail and personal vehicles (autos, trucks, vans and bicycles). Vehicle, pedestrian and bicycle circulation shall be accommodated within the transit facility. Additionally, these movements may occur to and from adjacent areas of Transit Oriented Development (TOD), residence, employment, commerce, industry, learning, sport and entertainment centers.

The functional zones of transit facilities associated with specific bus operating activities are further discussed in the following sections.

A facility type and the size of its functional zones shall depend upon specific planning, community and environmental requirements. For example, an informal or opportunistic lot may provide only short-term parking and a transit loading area. In another case, the functional requirements of bus operations may require a specific number of bus loading bays, while identifying the need for independent bus arrivals and departures. In conjunction with RTD, the Design Engineer shall design site layouts that accommodate the number of transit vehicles and also determine the need for other transit facility types.

The Design Criteria shall be carefully applied so that the design fits local conditions, safely connects with roadway networks, meets local government codes and regulations and is easily maintained. RTD supports creativity and flexibility to encourage solutions that are constrained by local conditions and to use standard transit design elements that maximizes maintenance efficiencies. Many of the design parameters relate to the bus-oriented PnR facility. These concepts can also be directly applied to rail oriented PnR facilities.

Call-n-Ride services may be incorporated at any RTD bus transit facility in coordination with RTD service development division.

1.8.0 COMMUNITY INTEGRATION AND TRANSIT ORIENTED DEVELOPMENT (TOD)

Some concerns about bus transit facilities are that they do not discourage private automobile travel, have undesirable community and environmental impacts and are perceived to attract criminal activity. A successfully integrated design will mitigate these concerns, ease other apprehensions associated with bus transit facilities and provide the community with better transit facilities.

The community demands well built public works projects, and is very attentive to projects in areas where vacant land is scarce, environmental concerns are dominant, and local development or in-fill redevelopment activities are vigorous. In these areas, transit is becoming the solution to resolving traffic congestion, air pollution concerns and economic development. A community integrated facility will provide the maximum benefit to be realized from a fully intermodal/multimodal transit facility.

A community integrated facility benefits transit ridership and increases potential revenue streams for RTD and the community tax base. Better access improves community integration and promotes adjacent development. An integrated PnR can provide a focal point for future urban and transit oriented development (TOD).

A coordinated effort is required for a successfully integrated transit facility, and may involve several jurisdictions. Transit oriented zoning, platting and deed restrictions (easements) that promote transit facilities and TOD in the vicinity of the facility are beneficial for a successful community integration. There must also be a market for the facility and accompanying transit services in the community.

1.9.0 PEDESTRIAN AND PASSENGER FACILITY REQUIREMENTS

Pedestrian related factors shall be considered when designing a successful transit facility. At the site-specific level, the design shall include: the general site layout, pedestrian and vehicle circulation routes and the intermodal bus plaza area.

1. The following shall be considered when designing for pedestrians:
2. Separation of competing modes
3. Provision of pedestrian pathways
4. Provision of adequate pedestrian waiting areas (4 sf/ person min.)
5. Compliance with the ADA requirements and guidelines
6. Provide safe environments (adequate lighting and shelter)
7. Manage conflict points between pedestrian, bus and vehicle movements

1.10.0 DISABILITY RIGHTS LAWS

Specific attention should be given to the Americans with Disabilities Act (ADA), the ADA Standards for Accessible Design (ADASAD), the ADA Standards for Accessible Design for Transportation Vehicles and to any succeeding modifications that may be issued. Their applicability is noted in several sections of this Manual where apparent or appropriate significance apply. Adherence to ADA and ADA related guidelines is required for all areas of this Manual, regardless of explicit, implied or lack of reference herein.

1.10.1 ADA Accessible Parking

The number of ADA accessible parking spaces shall be coordinated with local jurisdictions to ensure that their requirements are met. If local codes are more stringent than Federal guidelines, the more stringent shall be followed. At least one van accessible space shall be placed at the site, and additional ones for every six ADA spaces are required. Table 1C summarizes the number of accessible car parking spaces required per facility by current ADA requirements.

TABLE 1C – ADA Parking

Total Parking in Lot	Required Minimum Number of Accessible Spaces
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1000	2% of total
1001 and over	20 plus 1 for each 100 over 1000

A facility design shall promote safe and convenient access for all patrons, and provide adequate ADA accessible parking stalls at the site. Design requirements for individual ADA accessible parking stall layouts can be found in the ADASAD. Grade changes and barriers between the ADA accessible parking stalls and the transit loading area should be eliminated. All facilities shall be clearly signed for restricted use according to ADA requirements and MUTCD standards.

1.11.0 BUS BOARDING AND ALIGHTING AREAS

Consideration for the disabled patron at transit loading facilities is required. Bus boarding and alighting areas shall have a firm, durable and stable surface (generally concrete). These areas shall be a minimum of 6 feet long and 8 feet wide (9 feet is preferable) at a minimum. Longer boarding and alighting areas shall be constructed as warranted by the number of boarding and alighting dictate. Bus boarding and alighting areas shall be connected to streets, sidewalks or pedestrian paths by an ADA accessible route.

Parallel to the roadway, the bus stop boarding and alighting area longitudinal slope shall be the same as the roadway. The maximum bus stop boarding and alighting area slope perpendicular (cross-slope) to the roadway shall be 2%, typically sloped toward the roadway.

All pedestrian facilities shall be designed to meet the requirements and guidelines of ADA and ADASAD. At a minimum, pedestrian areas shall be provided with ramps through curbs and other vertical barriers, textured pavement surfaces and a barrier-free “accessible” path between ADA accessible parking spaces and the transit terminal. Adequate space for full

deployment and loading of vehicle lifts shall be provided adjacent to each bus platform in accordance with ADASAD. Additional features such as Braille signage and audible signals shall be considered as aids to visually impaired patrons.

1.12.0 PROVIDING FOR THE TRANSIT VEHICLE

The required transit facility service will determine the design vehicle parameters. Transit service and access is as important as pedestrian access. Specific transit design elements for individual facilities will depend on the vehicles accessing and serving the site and the operational requirements. The design parameters may include Bus Rapid Transit (BRT) systems. The Design Engineer shall coordinate with RTD and determine the types and number of vehicles that must be designed for at the respective facility.

A precise definition of BRT is elusive. It generally includes services that are faster than traditional "local bus" service and may include a separated fixed guideway. The elements of a BRT system include the bus type, bus priority, fast boarding and alighting, fast fare collection and a uniquely identifiable system image. The PnR facilities that incorporate BRT should address vehicle characteristics, and the unique features that distinguish BRT from other transit buses. See Section 3 of this Manual for more information about BRT.

1.13.0 DESIGNING FOR THE TRANSIT VEHICLE

Designing adequate service roadways and features, both external and internal to the transit facility, are important to assure efficient transit access to the proposed facility and sufficient transit service. The design shall include the following important features:

1. Allowances for minimum horizontal and lateral bus clearances (dynamic envelope), including external bike racks and mirrors
2. Allowances for minimum turning radii, movements and curb returns
3. Accommodation of acceleration needs and grade issues
4. Provision of adequate clear sight distances
5. Construction of adequate pavement
6. Incorporation of appropriate roadway and driveway widths for transit operations
7. Allowances for underside road clearance at driveways, speed humps, dips, speed tables, raised pedestrian paths and railroad crossings

1.13.1 Bus Access and Parking Requirements

Bus access to the transit facility shall generally be separated from private vehicle access, but allowances shall be considered if this is not practical for the entire access route. For off-street transit terminals, the bus loading area shall be separated from general purpose traffic. Timed transfer scheduling, called "pulsing," occurs when several routes converge at a single transit facility at the same general time, dwell, and simultaneously leave the facility. These facilities are "pulse points" and the timed transfer or pulse point scheduling of independent routes generally require more bus bays.

Bus parking space requirements shall be based on the maximum number of transit vehicles requiring independent pull-in and pull-out bays at the same time. If all buses operate independently and access the transit facility simultaneously, curb space sufficient to park all vehicles must be provided. However, if a reduction in costs can be achieved with staggered bus arrivals and departures, individual bus bays can be shared. The design of “shared” bays must be coordinated with RTD. Extreme care is required to ensure the reliability of staggered bus-bays for each intersecting route through a single transit center, especially if transfers are expected between routes.

Bus bay configurations that may be used within a transit facility include:

1. Linear bays with successive transit vehicle lining up in single file
2. Sawtooth bus bays providing individual bays for specific routes (generally preferred configuration)
3. Angled or diagonal bays require back outs, and are typically used only when buses have extended dwell times (e.g., intercity bus terminal)
4. Drive-through bays are used in compact areas, and allow bus front destination signs to face arriving passengers (e.g. rail station exits)

The Design Engineer shall coordinate an appropriate bay configuration for the site with RTD during the conceptual design phase.

1.13.2 Other Operational Design Considerations

The following design considerations, which are generated by on site operations, shall be incorporated within a transit facility:

1. Provide layover space for scheduled down time
2. Provide necessary driver amenities

A layover is a scheduled time during which a transit vehicle dwells at a specific location for longer than needed to load passengers. Layovers can often be identified within a route schedule by location, as having a listed arrival and departure time. Driver amenities may include a driver relief station (DRS), vending machines and break areas.

Layover Space: As required, and determined in coordination with RTD, an adequate transit facility area shall be designed for layovers, preferably at a location separated from passenger loading bays. Buses using layover locations can re-enter the internal transit stream and pick up passengers after a layover is complete. This reduces passenger confusion and frustration with transit vehicles not leaving the transit stop promptly upon loading.

Dimensions for adequate layover space shall be determined by the number of buses to be stored at the site and the physical dimensions of the critical

design vehicle. The required layover space length is also determined by the scheduled layover overlaps, and by clear line of sight requirements. Typical layover spaces require:

1. 40 to 60 feet layover length per dwelling transit vehicle
2. 7:1 taper for pull in and 4:1 taper for pull out
3. 10 feet clearance between dwelling transit vehicle
4. 12 feet layover stall width

Drivers Relief Station (DRS): A DRS for transit operators shall be provided at RTD Transit Centers and Park-n-Rides where bus recoveries are scheduled. See Section 8 of this Manual for additional requirements.

1.14.0 PROVIDING FOR PRIVATE VEHICLES (AUTO, BIKE & MOTORCYCLE)

Pedestrian and transit movements within the facility must be emphasized to assure successful community integration and efficient facility operations. Private vehicles and transit elements are the primary modes for which intermodal transit facilities are designed. They are often the principal measure of effectiveness (MOE) for a facility (i.e., vehicle usage is often the main MOE that justifies the investment). In addition to providing pleasant and safe pedestrian environments and efficient transit operations, a successful transit facility must provide adequate and secure parking facilities for automobiles, motorcycles and bicycles.

As required by specific facility operational needs, private vehicle parking areas shall be provided to accommodate long-term (extended duration), all-day/part-time commuting, and short-term or “kiss-n-ride” activities.

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SECTION 2 – TRANSIT ACCESS

2.1.0 GENERAL

RTD provides transportation within eight Colorado Counties covering 2,348 square miles. The RTD network consists of bus routes, rail lines, and specialty services. RTD Service Planning aims to provide coverage across the district to the greatest extent possible, by coordinating different modes of travel. Having convenient connections for different modes is very important for service delivery.

The most important interface in the system is how passengers access the RTD system. Passengers access the RTD system via park-n-Rides, walk-ups, bicycles, and passenger drop off areas. Based on adjacent land uses, and population and employment densities, passenger access the RTD services differently. RTD is part of a regional solution to mitigate traffic congestion, and to improve air quality. As such, it is part of regional efforts to promote activities like bicycling, and Transit Oriented Communities (TOC). This section sets forth guidelines and standards for access to the RTD system.

2.2.0 GUIDELINES

Whether passengers drive up, walk, bike, or are dropped off, they ultimately have to walk to access a bus, train, or special vehicle. Hence the design of passenger access to services needs very careful consideration.

The RTD Transit Service Policies and Standards define Urban and Suburban Service classes based on population and employment density per acre, based on a quarter mile wide corridor along the route and stops. Various factors like existing and proposed land uses, proximity to trip generators, adjacent roadway and sidewalk network, and barriers must be considered in developing access plans for RTD infrastructure.

1. Pedestrian access and connectivity from nearby neighborhoods and developments should be encouraged by providing safe street crossings, sidewalks, bike lanes and direct access from adjacent parcels. This may require working with Local Agencies to formulate an overall plan, which will get implemented in an incremental fashion, as the area redevelops.
2. Pedestrian conflicts should be eliminated or at the very least minimized by separating pedestrian pathways from active bus lanes, vehicular, and trackway crossings. Signage shall be employed to direct pedestrians to their point of destination, and landmarks or points of reference should provide pedestrians with a continued sense of orientation and relationship within the space comprising the transit facility.
3. Facilities should be designed in consideration of the safety of bus passengers and the general public to minimize unsafe pedestrian conditions and conflicts, by providing clear pedestrian crossing zones, and limiting pedestrian crossings of bus lanes. Bus gates should be located in a manner that allows a visual

connection and direct bus to rail and/or bus to bus transfers across a pedestrian plaza without crossing bus or vehicular lanes or consolidate pedestrian crossings to single point crossings. Landscaping or fences should be used to direct pedestrian movements away from hazardous or unauthorized crossing points. Landscape elements, pavement color and texture, street furniture components, plazas, and kiosks should be designed to channelize, inform, make a point of refuge, and provide a sense of place and attractiveness of the facilities.

4. On-street bus transfer facilities should consider the safety of bus passengers and the general public. The design of the facilities should eliminate unsafe pedestrian conditions and conflicts. The design should provide a sufficient waiting area and a defined point of access to the bus. Clear pedestrian crossing zones with proper signing and limiting the number of pedestrian crossing points should be a priority.
5. Bicycle parking equipment should be located within a convenient walking distance of transit boarding platforms and in a well-lit and highly visible area to enhance overall security. On-street bike lanes should be considered for street connections to/from RTD transit facilities. Adequate signage should be provided directing cyclists to designated bicycle routes as well as markers showing distances to popular destinations (including transit nodes) and intersecting routes.
6. Bike lockers shall be placed away from passenger congregation or station areas, as directed by RTD Transit Police (see Section 13).
7. In the RTD system, the term Kiss-N-Ride Areas stands for areas designated for pick up and drop off for passengers. Kiss-n-Rides should be designed with on-street loading areas preferably when a grid-street pattern is present and/or where physical site constraints limit the potential for off-street loading and unloading. The Kiss-N-Ride should be designed to maximize vehicle turnover, facilitate traffic flow, and avoid conflicts between pedestrians and other access modes and vehicles. Parallel Kiss-N-Ride spaces are preferred, as they allow for faster pick up and drop off of passengers. One-way traffic flow is recommended and the site should allow for re-circulation.
8. Park-n-Rides should provide a convenient and safe place to leave a vehicle and transfer to different modes of transit. Parking spaces need to be convenient to bus and rail platforms. For locations with a need for large auto parking capacity, multiple Park-n-Ride sites should be considered if availability of Right-of-Way and connectivity between the lots is achievable.
9. The need for auto parking at a location is determined by RTD based on existing usage and projected ridership and service. Optimizing RTD auto parking at transit facilities should consider proximity to major urban centers that have substantial local feeder bus service and pedestrian and bicycle

connectivity. Parking in areas well served by feeder buses and with good pedestrian and bike connectivity may require less auto parking.

10. Transit Oriented Communities should be considered in the design of RTD facilities. Transit functions such as bus stops, bus pull-out lanes and Kiss-N-Ride shall be designed so that they are integrated into on-street configurations in TOC areas if the public facilities are contextually appropriate (e.g., grid pattern streets with traffic control measures such as signalized crossings and medians, adjacent transit supportive land use).
11. Off-site signage directing patrons to Park-n-Rides, and stations shall be installed within a half-mile radius. Attempt shall be made to install this signage using existing infrastructure.
12. RTD Stations and facilities have specialized equipment to operate transit service. Some examples are Traction Power Substations, Relay, and Communication houses. Maintenance access to facilities and equipment needed to operate, maintain and replace transit facilities shall be provided and maintained, and may need to be separated from general public use. Maintenance access shall be designed for vehicles expected to operate on them. These may include special equipment to monitor and maintain train tracks, or cranes to replace existing equipment.
13. Transit facilities may need to be evacuated in a hurry. Access design shall comply with relevant life, building, health, and safety codes. It is beneficial to involve local emergency responders in preliminary planning.

2.3.0 TRANSIT ACCESS STANDARDS

Transit access standards are requirements for the design of RTD transit facilities. Variances to standards will be considered on a case by case basis based on site constraints and other mitigating factors.

2.3.1 Pedestrian Access

- A. The following walk speeds shall be used at station facilities for transit access time and distance calculations:
 - Level walk speed: 200 feet per minute
 - Horizontal component of stair walk speed: 130 feet per minute
 - Appropriate adjustments for barriers, such as an elevator or street crossing, shall be added to the walk time
- B. At stations where elderly or disabled persons comprise an estimated 20% or more of transfers, a horizontal walk speed of 150 feet/minute and the elevator time shall be used instead of stair walk speed

2.3.2 Bus Transfer Access

RTD's current implementation for timed transfer allows for a maximum 2 to 5 minutes to make a transfer. The range of transfer times are determined by the RTD Transit Service Policies and Standards, published by Service Planning, and shall govern in case of any conflict with this document.

2.3.3 Bus Access at Rail Stations

- A. The most desirable transfer takes place within 100 feet of rail platform centroid to bus gate.
- B. Gate locations for bus routes making up a minimum of 75 percent of the weekday bus trips shall be located within the 400-foot maximum walk path distance or within less than a 2-minute walk of the rail platform.
- C. Gates for locations for all bus routes shall be located within the 1,000-foot maximum walk distance or within less than a 5-minute walk of the rail platform.
- D. A direct line of sight between bus gate locations and the rail platform is required except when prevented by physical site constraints. If a direct line of sight is not possible due to physical site constraints, then clear wayfinding signage must be provided.

2.3.4 Bike Access

- A. All transit facilities, regardless of whether they have auto parking, shall also have bicycle parking. Bike parking shall be provided in the form of bike racks, bike lockers, bike corrals, bike stations, or a combination thereof.
- B. The surrounding environment should be evaluated when deciding the quantity and type of bicycle parking to be provided. Higher connectivity between the roadway and bicycle facility, and adjacent land uses (high density residential, employment center, etc.) may indicate the need for higher amounts of bike parking. This evaluation should be done in conjunction with the RTD Planning Department.

2.3.5 Motorized Vehicle Access (short-term parking – pick-up and drop off)

- A. All transit facilities, regardless of whether they have auto parking, shall also have a passenger loading zone when possible.
- B. Except where prevented by physical site constraints, the passenger loading zone shall not exceed a walk distance of 400 feet or 2-minute walk from the main boarding area.
- C. The passenger loading zone shall have a direct line of sight to the station entrance.

- D. Signage should direct both vehicles and passengers to drop-off/pick-up areas.

2.3.6 Motorized Vehicle Access (long-term parking at Rail and Bus Stations)

- A. A minimum of 50 percent of ADA accessible parking shall be located within a 200-foot maximum walk path distance of the center of the rail platform or the center bus gate location where feasible.
- B. A minimum of 50 percent of the long-term parking provided shall be within a 1000-foot maximum walk path distance or within less than a 5-minute walk of the center of the rail platform or the center bus gate location.
- C. A minimum of 75 percent of the long-term parking provided shall be within a 1500-foot maximum walk path distance or within less than a 7.5-minute walk of the center of the rail platform or the center bus gate location.
- D. All long-term parking provided shall be within a 2500-foot maximum walk path distance or within less than a 12.5-minute walk of the center of the rail platform or the center bus gate location.

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FIG 3.1 COMPOSITE SLOPE

FIG 3.2 BUS LOADING

SECTION 3 – BUS TRANSIT FACILITY DESIGN

3.1.0 GENERAL

This section provides the minimum design standards to be used in the design of RTD bus transit facilities. Facilities shall be designed in consideration of the safety of bus passengers and the general public, system reliability, passenger comfort and ease of maintenance. Construction and operation should cause minimum disruption to traffic, local businesses and communities. Bus transit facility design should be economical with respect to construction, maintenance and operations.

3.2.0 BUS RAPID TRANSIT (BRT)

3.2.1 General

The concept of Bus Rapid Transit (BRT) is currently evolving, and many types of systems are in operation, nationally and internationally. In general, BRT can be defined as rubber-tired mode that combines distinctive stations, vehicles, and services is designed to reduce travel time, increase reliability and increase the quality of passenger service and ride. The approaches that are used to achieve this include giving priority to transit vehicles, providing a limited number of bus stops, sharing High Occupancy Vehicle (HOV) or toll lanes, traveling in exclusive right-of-way (ROW) or designated bus lanes, using alternative fare collection systems level boarding, providing branded vehicles and using Intelligent Transportation Systems (ITS).

3.2.2 BRT Facility Design General Concepts

- A. BRT facilities shall be designed to accommodate RTD's current vehicle fleet, unless otherwise directed by RTD. Currently, RTD operates Transit, Intercity, and Articulated buses (see Section 3.5) that may be used for BRT service. Bus facilities shall be integrated into the surrounding roadway (local or highway) network, and designs shall be compatible with CDOT or local roadway design standards, as applicable. BRT facilities shall be designed to accommodate quick loading and unloading of passengers, and shall be designed to provide safe pedestrian access between the BRT stations and an adjacent Park-n-Ride (PnR). Pedestrian access routes between station platforms and PnR should provide the shortest walking distance possible. The walking distance to station platforms shall be in accordance with Section 2 of this criteria.
- B. BRT facilities shall be designed to accommodate support vehicles, such as tow trucks, street supervisor vans and maintenance vehicles.
- C. The BRT facility consists of roadway improvements, including priority lanes, acceleration and deceleration lanes and BRT stations.
- D. Coordinate BRT facility with bus, Kiss-n-Ride, Park-n-Ride, pedestrian and bike access.

- E. BRT stations include site access, parking (multi-modal access), transition area, platform, bus loading area and all appurtenances necessary to provide for the public safety, protection from the elements and public information. The station also serves as a gateway in and out of a community as the origin/destination source of passenger traffic.
- F. Coordinate BRT station design with neighboring community. Community involvement is necessary to establish a sense of place of the station in the community and to select a design for shelters, windscreens and other elements. As a part of the community development, RTD, its design team and community planners could facilitate a plan to develop transit oriented development (TOD) adjacent to the mass transit site. This is only viable if, the governing body has zoning ordinances in place that allow a mixed use TOD to occur. TOD however needs to occur with the balance toward providing a convenient and pleasant experience for the transit user as well as providing opportunities for mixed use development.
- G. Highway Running BRT station platforms will be designed to be located either on highway bus-only ramps (BRT slip ramp stations), on highway entrance or exit ramps (BRT pullout stations), Arterial running BRT will be designed located at the edge of non-highway roadways (BRT Superstops).

3.2.3 Highway BRT Slip Ramp Station or Highway BRT Bus Pullout Station Design

- A. BRT slip ramp and bus pull-out stations are typically located along highways adjacent to PnRs. The slip ramps and pullouts are constructed in pairs and may be located at interchange on or off-ramps or can be located along highways between interchanges.
- B. BRT slip ramp and bus pull-out station locations shall be coordinated with the location of the adjacent PnR, Access-a-Ride or Kiss-n-Ride that serves the station. Where stations are located between interchanges, acceleration and deceleration lanes shall be constructed in accordance with CDOT and AASHTO standards. Where slip ramps are located on interchange ramps, the interchange ramps should be evaluated for the need to modify existing acceleration or deceleration lane length per AASHTO standards.
- C. Slip ramp design shall include a 12 ft. wide bus stop area and 12 ft. wide bus bypass lane in front of the BRT station and shall include signage and pavement markings to discourage unauthorized vehicles from entering the ramp. Acceleration and deceleration lanes shall be a minimum of 18 ft. wide and shall have shoulders and gradual tapers to the BRT station platform.

- D. Bus pull-out design shall include a 12 ft. wide bus stop area and 12 foot bus bypass lane in front of the BRT station and shall include signage and pavement markings to prevent unauthorized vehicles from entering the BRT station area. Bus pull-outs located on interchange ramps shall be constructed with a minimum taper of 10:1 pulling into the BRT station platform area and a minimum taper of 10:1 and a 24' radius pulling out of the station platform area (see RTD Standard Drawings). The pullout area shall be separated from the main ramp lanes by a raised median.

3.2.4 Pedestrian Access

- A. Slip ramp station platforms shall have a pedestrian access between the station platforms. See Section 3.6 when a grade-separated structure is warranted.
- B. Existing overpasses or underpasses with pedestrian facilities may be used for access between station platforms, if approved by RTD and the owner of the facility. Refer to Section 5.3.5 "Vertical Circulation/Access" of 2013 Light Rail Design Criteria for vertical circulation and conveyance requirements.

3.2.5 Station Architecture

BRT Stations consist of a canopy building and other ancillary buildings as necessary, and shall fulfill the following requirements on building placement, configuration and materials.

- A. Placement: Architecture shall be placed in relation to its context by addressing visibility and accessibility. The designer shall take into account all site constraints and assets including predetermined sight-lines and view corridors, and shall determine how perceptible (or imperceptible) the station architecture needs to be. Access to the station architecture is equivalent to access to the station platform and must conform to the Americans with Disability Act Standards for Accessible Design (ADASAD), applicable codes in the jurisdiction and RTD design criteria.
- B. Configuration: BRT architecture shall be shaped and detailed according to its setting and shall be conceived as a component of the civic fabric of the place. Architectural shape shall respond in scale to the local and corridor context, as well as to the micro-climate conditions of the site by providing adequate wind, rain and solar protection. Street furniture including benches, trash receptacles, bicycle parking and information kiosks shall be coordinated with the overall site architecture.
- C. Materials: Architecture shall be durable, easy to maintain and cost-effective. Materials selection shall correspond to the culture of the place and to a uniform architectural concept for the corridor. Architectural

components shall be designed to facilitate the replacement of parts such as glass panels and partitions.

3.2.6 Highway BRT Station Platforms

- A. BRT station platforms shall be 120 feet long, which will accommodate two 45-foot buses. If articulated buses are planned for the station, then the platform length shall be 160 feet. Longer platforms may be required depending on the number of buses expected to access the facility at the same time, as determined by RTD. The Design Engineer shall verify the platform length requirements with RTD prior to design. Platforms shall be constructed of concrete. Station platform width shall be determined by the requirements of NFPA 130 and the dimensional requirements for elevators and stairs.
- B. The access to station platforms and access from transit plaza areas or adjacent PnRs shall be in accordance with current editions of the International Building Codes or local jurisdiction requirements as applicable, ANSI 117.1, ADASAD and other relevant codes.
- C. Detectable warning surfaces shall not be used unless BRT buses/platforms utilize level boarding as per ADASAD.
- D. Station areas shall include adjacent Kiss-n-Ride facilities for passenger drop-off (see Section 2.3.5).
- E. BRT stations may have a distinctive look and may include benches, passenger shelters and windscreens, trash receptacles, bike amenities, signage, schedule boards or stand-alone schedule structure, and newsletter condos. BRT stations shall also include a supporting infrastructure necessary to accommodate RTD fare collection technology (TVM, RFID, Smart CARD, etc.), public information displays (PIDs), emergency phones (E-phones), CCTV security system, parking pay stations, and adequate lighting (see Section 10).

3.2.7 BRT Superstop

- A. BRT Superstops are BRT stations that are located on the roadway system of the local jurisdiction, typically on arterial streets. Superstops may also serve the local or limited bus system in addition to the BRT service. Superstops shall be designed to accommodate all vehicles that will use the facility.
- B. Superstops shall be designed to differentiate the station from stops that serve only local routes by using urban design elements such as special shelter design or special paving to differentiate them from local bus stops. Superstop platforms shall be accessible in accordance with ADASAD or other more restrictive local standards. Transit plaza areas

may include the fare collection technology in use by RTD (TVM, RFID, SmartCard, etc.). Superstops shall be a minimum of 70 feet long for accommodation of one bus at a time, or as designated by RTD service planners. Platforms shall be located so that buses maneuver through a minimum taper of 10:1 pulling into the bus stop and a minimum taper of 10:1 and a 24' radius pulling out of the bus stop (see RTD Standard Drawings). If Superstops are located in an area with on-street parking, they may be designed as bus bulbs. Where the Superstop is located adjacent to an asphalt pavement street, a concrete bus pad shall be placed adjacent to the sidewalk (see RTD Standard Drawings).

- C. Superstops shall be located at the far side of street intersections, where possible. Near side stops may be used where bus movements will not conflict with auto traffic right turning movements. "Queue-jumping" (priority bus movement) signals may be used in conjunction with near side stops to provide priority movement for buses traveling in general traffic lanes. Signals shall be designed in coordination with the local traffic authority.
- D. A bus bulb, also known as a curb extension or bus island, is a section of sidewalk that extends from the curb of a parking lane to the edge of a through lane. In regard to traffic operations, bus bulbs operate similarly to curbside bus stops. Buses stop in the traffic lane instead of weaving into a parking-lane curbside stop. A major advantage of using bus bulbs is the creation of additional plaza space at bus stops. This space allows for the inclusion of bus patron amenities such as shelters and benches where the inclusion of such amenities would otherwise be limited by lack of space. The motivation for installing bus bulbs is to reduce sidewalk congestion, and to eliminate bus access weaving maneuvers into a parking-lane curbside stop (also called a bus bay stop). Bus bulbs are suitable for sites with high patron volumes, crowded city sidewalks and curbside parking. Bus bulbs shall be designed to allow ADA access and boarding, and shall be designed with particular attention to providing adequate storm drainage.

3.3.0 BUS STOPS

- 1. Bus stops shall be located as directed by RTD. Bus stops shall be located either at the far or near side of intersections, with the preference being the far side and, if possible, should be placed in locations where longitudinal street grades are less than 4%. The location of a bus stop at a parking lane curbside stop (also called a pull out or bus bay stop) should provide room for a bus to maneuver through a minimum taper of 7:1 pulling into the bus stop and a minimum taper of 4:1 and a 24' radius pulling out of the bus stop (see RTD Standard Drawings). If the bus stop is located adjacent to a street with asphalt pavement, a concrete bus pad shall be placed adjacent to the gutter pan. See RTD Standard Drawings for a typical bus pad.

2. When bus stops are located along detached sidewalks, a concrete boarding area shall be installed between the back of curb and front of sidewalk (see standard drawings). When bus stops are located along attached sidewalks, and attached sidewalks are less than 9 feet wide, a concrete boarding area shall be added behind the sidewalk so that a minimum 8 feet wide area (9 feet is preferred) is provided. At locations where there exists curb and gutter, concrete boarding areas shall be a minimum of 6 feet in length and shall comply with ADA standards. Where bus alightings warrant, concrete boarding areas shall be a minimum of 30 feet in length (40 feet for articulated buses). Where curb and gutter does not exist, the length of the concrete boarding area shall also be a minimum of 6 feet, and where bus alightings warrant, the concrete boarding area shall be a minimum of 30 feet in length (40 feet for articulated buses). See RTD Standard Drawings for additional information.
3. The maximum cross slope of all boarding areas shall be 2%. The longitudinal slope shall match the adjacent roadway. See Section 4.7.2 for additional information.
4. Signage shall comply with MUTCD. Street furniture shall be carefully placed a minimum of 5 feet from the back of curb and shall take into account pedestrian movements (see Section 4.6). Deployment of bus ADA ramps shall be checked and verified.
5. Generally, shelter placement shall be evaluated at bus stops where ridership exceeds 40 passenger boardings per day, and as determined by RTD's shelter installation criteria evaluation process. The criteria include span of service, scheduling, physical space, safety and others as specified.
6. Where there are known to be bicycle pass-up problems (i.e. full bus bike rack), bike parking shall be provided so that customers may safely lock and store their bike. See Section 6 for bicycle facility design criteria.

3.4.0 TRANSFER STATIONS

3.4.1 General

Transfer stations shall be designed for the safe and efficient movement of vehicles and pedestrians. Transfer station access shall be designed to provide rapid, safe and efficient movement of vehicles between the transfer station and local traffic.

3.4.2 Design Characteristics

Transfer station facilities shall be separated from the main travel lanes of adjacent roadways. Walkways and plaza areas shall be provided for pedestrian movement between bus bays.

Transfer station grades shall be designed in accordance with the provisions of Section 4.7.2 of this Manual. Bus bays shall be constructed with sawtooth geometry (see RTD Standard Drawings), unless alternative configurations are approved by RTD. Bus travel and bypass lanes shall have a minimum width of 12 feet.

Transfer station facilities shall be designed to accommodate support vehicles, such as tow trucks, street supervisor vans and maintenance vehicles. A driver relief station (DRS) including water and sanitary sewer service, bicycle parking and pedestrian amenities (i.e., shelters, benches, lighting, trash receptacles, information holders and map case) shall be provided at all transfer stations.

3.5.0 BUS DESIGN CHARACTERISTICS

3.5.1 General

Buses in use by RTD are categorized as city, intercity and articulated buses. Some smaller, special transit buses are in use on local routes. Bus transit facilities shall be designed for the largest bus that could use the facility.

3.5.2 Design Characteristics

Table 3A presents the characteristics of the vehicle fleet currently in use by RTD. Figure 3A shows the measurement characteristics. The geometry of all bus facilities should be checked against these characteristics so that vehicles may maneuver through facilities without causing damage to either the vehicles or facilities. All of the vehicles listed below operate on city streets with a 6-inch-high curb with the exception of the Mall shuttle vehicles, which typically are operated on streets with a 4-inch-high curb. All buses, except Mall shuttles, Free MetroRide buses, and paratransit vehicles, are equipped with bike racks to transport a limited number of bicycles during the patrons' commute.

Because RTD continually acquires and retires portions of its bus fleet, the Design Engineer shall confirm existing or anticipated bus characteristics for use at the time of site construction.

TABLE 3A Bus Design Characteristics

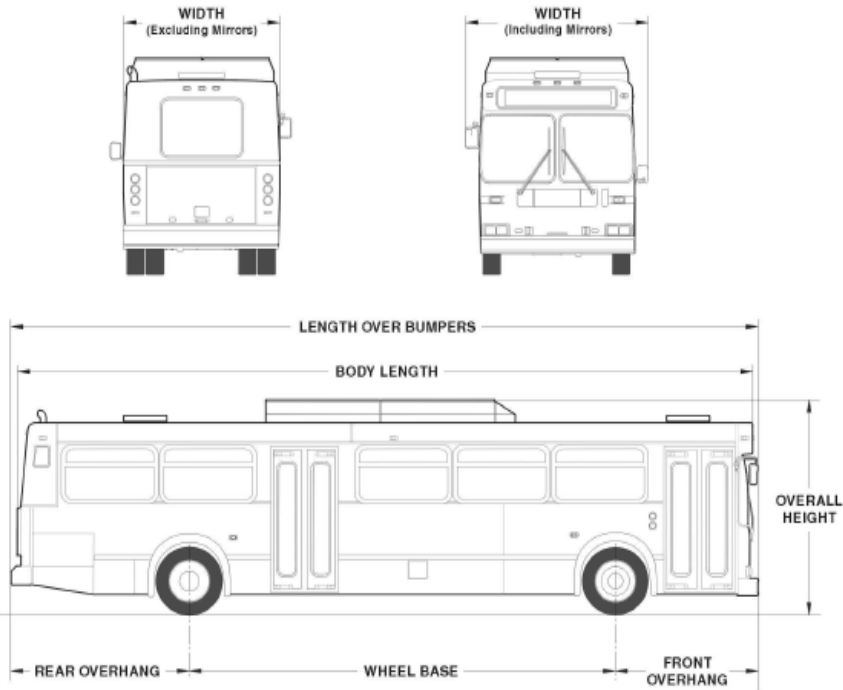
Bus Type *	30' High Floor Transit Bus	30' Low Floor Transit Bus	40' High Floor Transit Bus	40' Low Floor Transit Bus	Mall Shuttle TransTeq	Mall Shuttle DesignLine	High Floor Articulated Bus	Low Floor Articulated Bus	45' Intercity Bus MCI	45' Intercity Bus Neoplan	45' Intercity Bus Blue Bird
Bus Features											
Body Width, in. **	102"	102"	102"	102"	102"	102"	102"	102"	102"	102"	102"
Body Length, ft.	31'4"	30'	40'	40'11.5"	45'	45'	60'	60'	45'	45'	45'
Wheelbase, in.											
Axle 1-2	170"	162.5"	280"	279"	276"	311"	263.8"	229.2"	318"	274.5"	296"
Axle 2-3	NA	NA	NA	NA	NA	NA	233.3"	292.8"	48"	54"	50"
Turning Radius, Outer Wheels, ft.	30'3"	29'	40'6"	43'3"	46'	46'	44'	44'	47'	46'	43'4"
Height, in.	120"	120"	121"	122"	136"	124"	129"	126"	138"	140"	145"
Ground Clearance, in.	11.3"	10.2"	13"	11.8"	9"	9"	12"	10"	10"	11"	11"
Axle Clearance, in.	8.8"	6"	9"	8.5"	4.5"	4.5"	8"	5.6"	8.5"	7"	8.5"
Curb Weight, lb. ***	26,220	23,100	28,600	28,200	25,000	28,300	43,120	39,700	38,900	40,000	39,380
Gross Veh. Weight Rating (GVWR), lb. ****	39,600	34,220	39,600	36,289	44,000	43,420	66,000	66,800	52,500	48,600	52,000
Approach Angle, deg.	9	8.2	10	9	7	7	9	9	9.5	9	7.6
Departure Angle, deg.	10	8.6	9	9	6	7	9	9	6.2	8.5	6.4
Seating Capacity	29	26	43	36	18	15	63	55	57	55	55

* The Design Engineer shall confirm bus overhang (front and rear) and include bicycle rack deployment length for all designs.

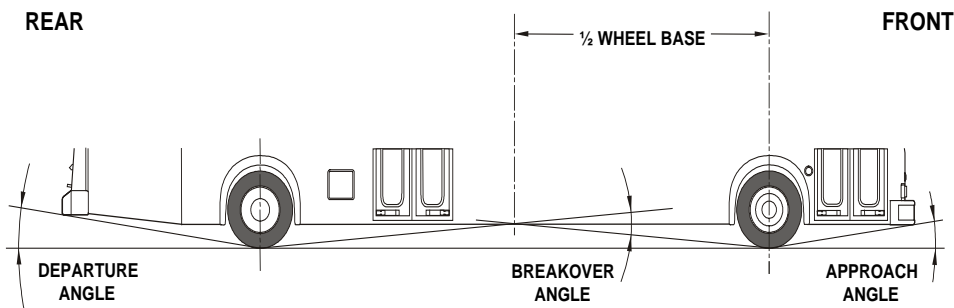
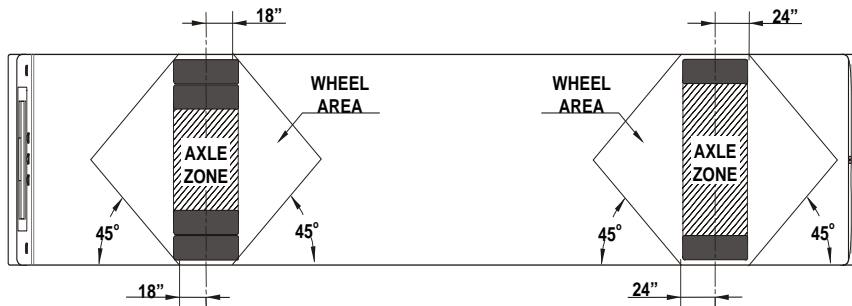
** Maximum Width - This width does not include rear view mirrors, bumpers, signal lights or rub rail. Add 18" to each side of the bus for rear view mirrors.

*** Maximum Curb Weight - Curb Weight is the weight of vehicle, including maximum fuel, oil and coolant; and all equipment required for operation. See vehicle specifications for the weight distribution by axle.

**** Gross Vehicle Weight equals curb weight plus gross load. See vehicle specifications for the weight distribution by Axle.



TRANSIT COACH EXTERIOR DIMENSIONS



TRANSIT BUS MINIMUM ROAD CLEARANCE

FIGURE 3A BUS CHARACTERISTICS

3.6.0 GRADE-SEPARATED PEDESTRIAN ACCESS

Grade separated pedestrian accesses will be constructed wherever pedestrian traffic traveling between elements of the transit system must be protected from vehicular traffic. In general, bridges are preferable to tunnel access. All accesses shall be designed in accordance with the most current version of ADASAD, or other local, more restrictive accessibility standards. Ramps, stairs and elevators shall be included in order to satisfy ADA requirements, emergency egress requirements and to provide convenient and efficient mobility between transit system elements. Elevators shall be capable of accommodating bicycles and emergency medical equipment (gurneys). Pedestrian bridges shall include enclosed walkways and covered stairs (where applicable) in order to protect the users from the weather. Grade separated accesses shall include provisions for periodic cleaning, maintenance and inspection of structural members. Grade separated access shall be designed with consideration of economical construction and maintenance. Design guidelines for grade-separated pedestrian access facilities are provided in Section 7 of this Manual.

3.7.0 PARK AND RIDE (PnR) DESIGN

1. Park-n-Rides (PnR) are provided for the use of transit patrons using personal vehicles to reach the transit system. A PnR should provide convenient facilities for access to the transit system and for transit patrons to leave personal vehicles long term.
2. Park-n-Rides are provided in locations as designated by RTD service planners or where indicated by specific corridor studies. Typical PnR locations are at light rail or commuter rail stations, adjacent to BRT stations and at locations that can be conveniently accessed by multiple local and express routes or by regional bus routes.
3. A PnR shall typically provide individually marked parking stalls and access drives, passenger pick-up and drop off facilities (kiss-n-Ride, short term parking), bus transfer facilities including bus bays for loading and unloading, a drivers relief station (DRS) if required, shelters, benches, trash receptacles, bicycle parking, lighting, information kiosks, emergency telephones and security features. Facilities shall be paved, landscaped and designed to provide safe and convenient parking and bus transfer facilities for transit patrons. A PnR shall be designed with consideration for efficiency of use, economical site construction and convenient maintenance activities. The site design shall meet the requirements of the local jurisdiction.

3.7.1 Bus Transfer Areas

- A. Bus transfer areas can be internal to the site or may be located at the edge of an adjacent roadway.
- B. Where transfer facilities are located adjacent to the site on the local roadway system, bus pads shall be constructed in accordance with RTD

Standard Drawings. The location of bus pads shall be coordinated with the local roadway authority.

- C. Where transfer areas are located on site, integrated with a PnR, bus transfer areas shall be separated wherever possible from parking areas so that bus traffic and private vehicle traffic do not share drive lanes. The bus waiting area shall be constructed with concrete pavement and concrete curb and gutter, and individual bus loading bays shall be designed in accordance with RTD Standard Drawings. The number of bus bays provided in the waiting area shall be as designated by RTD's service development division.
- D. Access to the bus transfer areas shall, wherever possible, be located at signalized intersections. Two points of access shall be provided, if possible. All access shall be designed so that buses may enter and exit the transfer facility without reverse movement. Access to the site shall be coordinated with the local roadway authority. Bus access from the local roadway to the site shall be constructed with the use of curb returns or curb cuts, as required by local jurisdictions. The use of curb cuts shall be avoided. Curb return and drive lane minimum radii shall be designed in accordance with Section 4.7.10 of this Manual. Bus facility turning radii shall be designed for the radius of the most restrictive vehicle that could access the facility.
- E. A DRS shall be located within a convenient distance (50 feet or less) from the bus waiting area, unless site constraints require a longer distance, which shall be coordinated with RTD.
- F. Bus transfer area facilities, including site fixtures, pavement, lighting, DRS, utilities, bike facilities, drainage, and urban design and landscaping shall be designed in accordance with the appropriate sections of this Design Criteria and local requirements.

3.7.2 Parking Areas

- A. Parking areas can be constructed as surface lots or as multi-story parking structures. Wherever possible, parking areas shall be constructed as surface lots. If parking demand is high and ROW is unavailable, parking structures shall be considered. For planning purposes, the designer shall assume a ratio of 75 parking spaces per acre for surface lots (see Section 1.1.0).
- B. The PnR shall have access from public roadways from at least two locations. Full movement access must be available from at least one signalized intersection, if possible. Right-in-right-out (RI/RO) and three-quarter movements may be acceptable for additional access points. Drive lanes that mix bus traffic with private vehicle traffic shall be avoided. Site access shall be coordinated with the local roadway authority.

- C. Parking areas shall be constructed of concrete or asphalt and shall include concrete curb and gutter. The type of pavement shall be based on recommendations from a geotechnical study or pavement design and as directed by RTD. See Section 4 of this Manual for site design standards. Parking area facilities, including pavement, lighting, security, drainage and landscaping shall be designed in accordance with the appropriate section of this Design Criteria and local requirements. See Section 7 of this Manual and below for parking structure criteria.

3.8.0 PARKING STRUCTURES

3.8.1 Objectives

The design criteria for this section were derived from an evaluation and review of design manuals, agency criteria and existing parking structures that service transit agencies, including RTD.

The objective of this section shall provide the basis for design decisions. The objectives shall be used in the design of new and renovated facilities.

In addition to safety and functionality, the design objectives shall consider these four factors:

1. Budget
2. Architecture
3. Intermodal Transfer
4. Community Integration

3.8.1.1 Budget

The established construction budget shall take precedence over all other factors other than safety and functionality.

3.8.1.2 Architecture

1. Create a civic architecture that is permanent, functional and pleasant. The structure should contribute to the RTD context – one that is not entirely derivative of the transit system, but complimentary of the neighborhoods and community within which it is located and within budget constraints. The structure should maintain an overall system or corridor identity.
2. All designs must conform to current editions of all applicable codes (e.g., UBC, IBC, ANSI, and ADASAD).
3. Make transit safe, secure, friendly and accessible to all, including the disabled.
4. Design systems that use sustainable, consistent and maintainable materials that minimize life cycle costs.

5. Provide an architectural and urban design framework that defines and encourages TOD opportunities.

3.9.1.3 Intermodal Transfer

1. Provide a safe, efficient, and convenient parking structure configuration for intermodal transfer.
2. Provide clear and understandable directional signage.
3. Develop operational efficiencies that simplify modal transfers and commuter accessibility.
4. Provide the best service possible at a reasonable cost.

3.8.1.4 Community Integration

1. Protect, maintain and enhance existing community values.
2. Support TOD that fosters neighborhood friendly and desirable facilities.
3. Support transit-related uses that are proximate to the transit facilities.
4. Initiate and coordinate programs with the community that limit local traffic impacts and minimize disruption during and after the implementation phase.
5. Utilize local jurisdictional processes and agencies throughout project design and implementation.

3.8.2 Modal Hierarchy

Parking structures shall be located to minimize the total passenger access time from all modes and, as applicable, enhance TOD potential.

Access modes for and around parking structures shall be located relative to rail platforms and bus bays in the following hierarchy:

1. Light Rail Transit/Commuter Rail
2. Fixed route feeder bus
3. Other fixed route buses
4. Taxi and paratransit (private or flexible route bus) drop off
5. Auto drop off
6. Bicycle parking
7. Auto parking

8. Motorcycle parking
9. Offsite Pedestrian

3.8.3 Parking Structure Context

The “context” is the state of development that surrounds a prospective parking structure site. It can be residential, commercial, industrial, agricultural, suburban, urban, or rural. The character, quality, land use and future of the context shall direct the site planning and design of parking structures.

While all parking structures are to be compatible with existing RTD facilities each parking structure will also be a derivative of the neighborhoods and communities of which it is a part; therefore, parking structures should:

1. Contribute to the character and quality of their context.
2. Help establish new development patterns where appropriate.
3. Reinforce and guide desired and established development patterns.
4. Recognize development patterns that can be complemented.
5. Establish development patterns in rural areas by providing focus and structure for future development.

3.8.4 Design Goals

Design of parking structures and site planning shall include:

3.8.4.1 Vehicle and Passenger Flow Accommodation:

1. Minimize crowding, travel obstructions, conflicts, disorientation, level changes and physical barriers.
2. Maximize safety, reliability and the ability to accommodate emergencies.

3.8.4.2 Passenger Environmental Accommodation:

1. Provide adequate lighting, personal comfort, aesthetic quality, weather protection and security.

3.8.4.3 Design Flexibility

1. Allow for future operating changes with minimal reconstruction.
2. Coordinate with RTD during concept design phase on needs for future vertical or horizontal expansion of the structure.

3.8.4.4 Community Enhancement:

1. Minimize impacts on local vehicular and pedestrian traffic.

2. Promote desired growth.
3. Neighborhood context.

3.8.5 Performance Standards

1. Durability – Durable and cost-effective materials shall be used that have consistent wear, strength and weathering qualities. Materials shall be capable of good appearance throughout a 50-year useful life.
2. Low Maintenance – Life cycle maintenance costs shall be considered in the evaluation of all materials and finishes.
3. Quality of Appearance – Materials shall be appealing and harmonious in appearance and texture. They shall reinforce system continuity while relating to local context.
4. Drainage – Positive drainage shall be provided for all surfaces within the structure. Grades shall not be less than 1 % unless otherwise approved by RTD in order to eliminate construction related sump (bird bath, pond) conditions. Ponding water within the parking structure is not acceptable.
5. Cleaning – Materials that do not soil nor stain easily shall be used and shall have surfaces that are easily cleaned in a single operation. All porous finishes subject to public contact shall be treated or finished in a manner that allows easy recovery from “casual vandalism.”
6. Repair or Replacement – Inventory and maintenance costs shall be minimized. Materials shall be standardized as much as possible for easy repair or replacement without undue cost or operational disruption. For example, hose bibs, electrical outlets, lighting fixtures and lamps, glass or plastic lights, information panels, signs, shelter material, etc., shall be standardized using commonly available sizes and finishes for easy inventory stocking and installation.
7. Nonslip – Entrances, stairways, and areas around equipment shall have high nonslip properties. Floor finishes shall be nonslip even when wet. This is particularly important at stairs, elevators, and other areas near station entrances as well as platform areas.
8. Protection from the Elements – Stair towers and elevator entrances shall be protected from the elements.
9. Corrosion Resistance – Because of moisture and the electrical currents associated with transit operation, special consideration must be given to prevent corrosion. Non-corrosive metals shall be utilized. Structures near the LRT guideway shall be grounded. Stairs shall either be precast or cast in place concrete. The top level of the

parking structure shall be sealed with a penetrating sealer to increase durability.

10. Compatibility – Selected materials shall be compatible with the Denver area climate.
11. Availability – Selection of materials shall permit competitive bidding and encourage regional products and processes.
12. Graffiti resistant products shall be used to protect surfaces susceptible to graffiti. The designer shall coordinate with RTD on which surfaces require protection.
13. Openness – Parking structures shall be designed as “open parking garages” allowing the use of stand pipes rather than dry systems wherever possible. If dry system is required, a nitrogen generator to fill the system should be provided.

3.8.6 Functional Design

Parking facility design shall consider the following:

1. Access
2. User type
3. Pedestrian needs
4. Wayfinding Signage
5. Floor-to-floor height
6. Dimensions of site
7. Parking geometrics
8. Peak-hour volumes
9. Flow capacity
10. Lighting
11. Fire Protection

3.8.6.1 Level of Service

Vehicular Level of Service (LOS) shall be considered for parking structure entry/exits, geometrics, flow capacity, travel distance, turning radii, and floor slopes. For typical parking structures the LOS can range from A to D with D being the lowest.

The level of service at the access to public ROW shall not be less than C. This may require extra drive/access lanes.

3.8.6.2 Circulation Systems

Circulation systems shall be oriented with drive aisles parallel to pedestrian flows along the shortest routes to station platforms or bus bays, whenever practical, in order to encourage pedestrians to walk along aisles where they can be easily seen by vehicle drivers.

Perpendicular aisles will be considered on a case-by-case basis with RTD approval. The need for pedestrian sidewalks and crosswalks shall be evaluated by the designer during conceptual planning.

3.8.6.3 Stall Widths and Parking Modules

In general, parking structures shall utilize 90 degree parking depending on site constraints and parking structure grid layout. For two-way drive aisles, with 90 degree parking, stalls shall be 8.5 feet by 18 feet with an aisle width of 24 feet. The parking module (i.e. two parking aisles and drive aisle) shall be 60 feet wide. One-way traffic with angled parking may be considered on a case-by-case basis, with RTD approval.

3.8.7 Access Design

Entry/exit areas for parking structures are critical locations. Care must be taken to determine where entrances and exits will be placed with relation to access roadways, bus lanes, and pedestrian movement, TOD and bicycle paths. Primary pedestrian paths through the parking structure shall not be located near entry/exits areas.

Entry/exit areas shall be designed for the parking peak and daily loads. Additionally, entry/exit lane lengths and widths shall be designed to accommodate future revenue control equipment. Depending on peak loads and total parking capacity, more than one access point shall be considered.

Kiss-n-rides (short term parking) shall be incorporated into the parking structure design. Kiss-n-rides located within the parking structures must not interfere with other vehicles trying to move through the facility. When RTD surface parking is located adjacent to a parking structure, kiss-n-rides shall be located within the surface lot.

3.8.8 Security

See Section 13 of this Manual for security requirements at parking structures.

3.8.9 Lighting

Lighting for parking structures shall meet the minimum requirements set forth in Section 10 of this Manual.

These standards recommend minimum illuminance criteria for the safe movement of vehicle traffic and pedestrians within a parking structure. They also recognize the need to deter criminal activity and meet energy

constraints. The lighting must also be adequate for CCTV usage within the facility.

Lamp and fixture selections will be governed by RTD. Refer to Section 10 of this Manual for additional information.

3.8.10 Signage and Graphics

Signage provides directions, identification, and warnings, as well as other information to the users of the parking structure. Graphics are the means by which the information is presented on a sign. It is the intention of RTD that the signage in the parking facilities is plain, concise and simple.

Signage shall be in accordance with the requirements of the local jurisdiction, MUTCD, ADA and shall be clear, understandable and provide total coverage.

3.8.11 Structure

Structural systems for parking structures shall generally be cast in place post tensioned concrete or precast concrete. RTD at its discretion may limit the structural system to a single type for a parking structure project. The structural elements shall be consistent and replicated from one zone to the next, in order to simplify construction and minimize costs. Refer to Section 7 of this Manual for additional information. Parking structures shall be designed and built as "open parking garages" as defined by the IBC unless otherwise approved by RTD.

3.8.12 Architecture

The architecture of parking structures consist of a cast-in-place structural frame, building cladding, vertical circulation components and ancillary uses, and shall fulfill the following requirements on configuration and materials.

1. Configuration: parking structures cladding design shall be agreeable with the local context and regulations and may be used to prevent vehicle headlight glare trespassing if no other measures are taken. Vertical circulation components, stairs and elevators, shall be differentiated from the rest of the building and shall follow RTD criteria, including visibility for safety and weather protection.
2. Materials: shall be durable, easy to maintain and cost-effective. Materials selection shall correspond to the culture of the place.

3.8.13 Fire Protection

New parking structures and renovation projects shall be designed to incorporate efficient, cost-effective passive and automatic fire protection systems. These systems are effective in detecting, containing, and controlling and/or extinguishing a fire incident in the early stages. Fire protection engineers shall be involved in all aspects of the design in order to ensure an acceptable degree of protection of human life from fire and the

products of combustion as well as to reduce the potential loss from fire (i.e., real and personal property, operations).

Planning for fire protection in and around a building involves an integrated systems approach that enables the designer to analyze all of the building's components as a total building fire safety system package. The analysis requires more than code compliance or meeting the minimum legal responsibilities for protecting a building. Design consideration should endeavor to discourage the use of dry systems wherever feasible. Therefore, it is necessary to creatively and efficiently integrate code requirements with other fire safety measures as well as other design strategies to achieve a balanced design that will provide the desired levels of safety, including and most importantly, coordination with the local fire authority.

Refer to Section 13 and the following for specific requirements:

1. NFPA 88A, Standard for Parking Structures
2. Uniform Fire Code
3. Local jurisdiction fire and building codes

3.8.14 Maintenance Objectives

1. Maximize ease of replacement
2. Maximize ease of construction
3. Minimize the potential for vandalism
4. Maximize ease of cleaning
5. Minimize operating and maintenance costs
6. Maximize the use of available materials and finishes
7. Maximize the use of durable materials and finishes
8. Maximize the use of similar materials, finished and components.
9. Maximize the use of new improved materials and finishes
10. Minimize the number of unique and different components
11. Minimize the number of shapes
12. Minimize life cycle costs

3.8.15 ADASAD

Parking structures shall be designed to conform to all regulations in accordance with ADASAD. This will include accessible paths and number of ADA parking stalls.

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SECTION 4 – CIVIL DESIGN

4.1.0 GENERAL

This Design Criteria establishes the minimum standards to be used in the design of RTD bus transit facilities. This section is intended to direct the Design Engineer in the civil engineering design at all RTD bus transit facilities.

4.2.0 SURVEY

An ALTA survey is required for design advances for all new facilities and expansions of existing ones, unless one already exists that is less than 2 years old or it is otherwise determined by RTD that none is required (i.e., small or limited service facilities for street-side stops). The scope of survey is determined by its intended purpose, and the availability of information about built conditions from other sources, RTD's minimum requirement from an ALTA Survey includes items 1-15 from Table A of the latest edition of ALTA/ACSM Land Title Survey, and shall include the following or additional items:

1. Item #9 – Identify striping, number & type of parking spaces.
2. Item #11(b) – Include horizontal and vertical locations for Storm Sewers (elevation of rims and pipe inverts at manholes, inlets and outlets), Sanitary Sewers (elevation of rims and pipe inverts at manholes); horizontal locations based on paint marks of all underground utilities such as Communications underground (fiber optic, telephone, and cable TV, Electric underground, gas mains, steam lines, and water mains. Potholes are not required for every utility. The need for potholes depends on what RTD proposes to do with the information. Pothole depth shall be taken to the top of each of the buried facilities that information is required in order to determine their exact location; horizontal locations of all appurtenances shall be obtained as well as horizontal locations for all overhead utilities and poles. Include, for each utility (overhead and underground) the name of the Utility Owner, the size of the pipe or conduit, and the material of the facility if known.
3. Item #12 – Per the requirements of the local jurisdiction.
4. Include any other physical planimetric features including landscaping and fences, and also topography, as stipulated, within fifty (50) feet of the site. Topography shall include 1-foot contours and spot elevations as appropriate.
5. Include easements, rights-of-way (ROW) and other jurisdictional, utility, railroad or special district encumbrances.

The electronic format of the survey shall be in a matching project/world coordinate system, project base point and scale. RTD's standard vertical datum is the North American Vertical Datum of 1988 (NAVD 88) and shall be used unless written permission has been received from RTD to use another datum.

Survey shall also provide the calculations to RTD's GIS coordinate system, and any other coordinate system required by local agencies.

4.3.0 GEOTECHNICAL

4.3.1 Pavement Design

A geotechnical investigation and pavement designs are required for new or expanded major facilities (i.e., PnR, BRT stops and transfer station) unless a relevant report acceptable to RTD already exists for the area under consideration. Pavement designs are required for both patron vehicle and bus loadings and shall include recommendations for both Portland Cement Concrete (PCC) and Hot Bituminous Pavement (HBP). Pavement designs shall be based on the 20-year 18,000-pound equivalent single axle load (18K ESAL). Pavement designs shall be prepared in accordance with the Metropolitan Government Pavement Engineers Council (MGPEC) criteria and shall include a life cycle cost analysis.

Recommendations of “over excavating” for the subgrade preparation of surface parking areas that exceed 1 foot in depth should be avoided and alternative solutions explored. Subgrade preparation (i.e., moisture treatment, lime stabilization or other) in excess of 1 foot shall be evaluated on a case-by-case basis and alternative solutions shall be explored. In all cases the subgrade should be evaluated to determine its structural bearing capacity. Additional geotechnical investigations shall include determining “R” value, plastic/liquid limit and plasticity index (PL/LL/PI), shrink-swell potential and other applicable criteria based on site conditions.

Geotechnical investigations (including sampling frequencies) for pavement design purposes shall be conducted in accordance with MGPEC criteria.

There are three typical load carrying pavements at a facility:

1. The first (heaviest load-carrying) pavement is for bus lanes and bays. To lessen pavement rolling and rutting, they shall be PCC 11-inch depth, or as recommended by a pavement design prepared by a registered Professional Engineer. All PCC pavements shall include curb and gutters that are monolithically poured and tied to the PCC pavement with dowels per RTD Standard Drawings. Pavement thicknesses less than 11” depth for bus lanes and bays shall be approved by RTD in writing.
2. The second pavement type is for patron vehicle circulation or parking. It may be constructed with hot bituminous pavement (HBP) or PCC. PCC pavement is preferred, but HBP may be better for specific applications due to light reflectivity or cost considerations. The minimum circulation route pavement thickness is 8 inches, or as recommended by a pavement design prepared by a registered Professional Engineer.
3. The third pavement shall be for walkway, plaza and other pedestrian areas. It shall be constructed with PCC, 6-inch thick, capable of

bearing maintenance and snow removal vehicles up to 10,000 pounds.

Concrete for PCC pavement shall be CDOT mix design class "P", 4200 psi at 28 days. CDOT mix design class "B", 4500 psi at 28 days, may be used for walkways, plazas and curb and gutter with approval from RTD. All PCC shall be reinforced with polypropylene fiber mesh.

Hot bituminous pavement shall be in accordance with the MGPEC Pavement Design Standards and Construction Specifications. Generally, hot bituminous pavement grading "SX" should be used for the top lift of pavement and grading "S" for the lower lifts. The Design Engineer shall include a completed MGPEC Form 9 as part of the Technical Specifications for specifying hot bituminous pavement.

Temporary parking lots may be paved with gravel, crusher fines or recycled materials, as allowed by local jurisdictions and directed by RTD. They shall be stabilized with a minimum 6-inch thick layer of compacted recycled asphalt. Temporary facilities may be excluded from the requirement of a geotechnical report and pavement design with approval from RTD.

All pavement subgrade shall be treated with a soil sterilant to inhibit future vegetative growth.

4.3.2 Soils and Foundation Investigations and Pavement Designs

A Professional Engineer shall prepare a foundation report for all pavements, structures and retaining walls, and gather appropriate information for a stable design, which, in addition to field work, shall include a review of preliminary structure plans, previous foundation reports, as-built plans and historic subsurface conditions information for the proposed structure area. The prior information review shall focus the analysis towards areas of concern before starting fieldwork.

A bore-hole plan approved by RTD shall be established on a site plan layout and shall be relative to proposed foundation, pavement or excavation locations. A drill crew shall collect undisturbed soil samples for laboratory testing and perform appropriate in-situ soil tests.

An engineer or geologist working under the direction and supervision of a registered Professional Engineer shall collect soil samples, perform in-situ and other manual field tests and observations, compile the results, document and record the data, and provide the necessary information to develop the project boring log and final geotechnical report. The report shall include geotechnical design recommendations based on the collected data. The report shall be signed and sealed by the registered Professional Engineer.

After completing the test borings log, the registered Professional Engineer shall analyze geotechnical surface and subsurface information, prepare a geotechnical report, as discussed above, and submit a signed and sealed copy to RTD, which shall include the recommended foundation type, and all pertinent geological foundation design parameters.

The report, at a minimum, shall include:

1. Site conditions (current and historic)
2. Geologic conditions
3. Site investigations
4. Subsurface conditions
5. Recommendations
6. Limitations
7. Surficial geology
8. Surficial geology map legend
9. Plan location of exploratory bore holes
10. Bore-hole logs with depth and geologic stratigraphy
11. Legends and notes of exploratory borings
12. Ground water potential, depth and possible fluctuations
13. Summary of laboratory test results
14. Soil corrosiveness potential test results
15. Sulfide content
16. Swell compression test results
17. Gradation test results (sieve analysis)
18. R value
19. Liquid and Plastic Limits (LL and PL)
20. Plasticity Index (PI)
21. Moisture density relationships (dry density and optimum moisture content)
22. AASHTO T-99, T-180 (modified and standard proctor applications)
23. Dewatering requirements and recommendations
24. Monitoring requirements and recommendations
25. Potential utility conflicts
26. Pavement Designs

27. Other items as determined for the specific site conditions

4.4.0 DRAINAGE, EROSION CONTROL AND WATER QUALITY

4.4.1 General

Drainage design shall be in accordance with the design standards and technical criteria of the local jurisdictional agency. Whenever the work is located within CDOT right-of-way, CDOT standards as specified in the latest edition of the CDOT Drainage Design Manual shall be followed. Where local jurisdictions have no codes or standards, the design standards and technical criteria provided in the latest copies of the Urban Drainage and Flood Control District's (UDFCD) Urban Storm Drainage Criteria Manual (USDCM) and the CDOT Drainage Design Manual shall be used.

A drainage report shall be prepared to define the drainage impact of the proposed facility by describing the existing conditions and the facilities necessary to conform to the criteria of the local jurisdiction as described above.

Storm water control and conveyance system design shall not adversely impact adjacent properties upstream or downstream of RTD facilities beyond historic and legal allowances without consent and documented approval from adjacent property owners and governing jurisdictions.

Work within regulatory floodplains shall meet the requirements of the local jurisdiction and FEMA.

4.4.2 Hydrologic Criteria

Stormwater design flows shall be determined using methods specified by the design standards and technical criteria of the local jurisdiction. If no methods are specified, flows shall be determined using the Rational Method or the Colorado Urban Hydrograph Procedure (CUHP) and the EPA SWMM/UDSWM Model as described in the latest USDCM, as applicable.

All bus transit facilities, including parking lots and roadway improvements shall be designed in accordance with the design storm frequencies as specified by the technical criteria of the local jurisdiction. If design storm frequencies are not specified, the minor storm system shall be designed for the 5-year storm and the major storm system shall be designed for the 100-year storm. CDOT criteria use only the 100-year storm for major highway crossings. Storm water design shall not adversely impact adjacent properties upstream or downstream of RTD facilities. Drainage design shall consider flows from adjacent properties and shall be designed to accept historic flows from upstream areas. Where stormwater flows from upstream properties cross RTD facilities, the emergency overflow pathway through RTD facilities shall be evaluated and accounted for in site design. Storm sewers, culverts

and inlets shall be designed to convey the typical 5-year minor design storm event, unless the local jurisdiction, or unusual conditions require larger conveyance elements.

Facilities that cross, or that are located within, or adjacent to a FEMA-regulated flood zone (Zone AE, etc.) shall use FEMA jurisdictional flows for facility design. Facilities shall be designed in accordance with the floodplain ordinance of the local drainage authority. The design shall include preparation and submittal of CLOMR and LOMR documentation, if required by the local drainage authority and/or FEMA.

4.4.3 Hydraulic Criteria

All storm sewer, hydraulic structures and appurtenances shall be designed in accordance with the design standards and technical criteria of the local jurisdiction as modified by this design manual.

Stormwater may be conveyed in a system that includes curb and gutter and storm sewer. Stormwater flows in gutter located adjacent to designated pedestrian walkways shall be minimized. The depth of flow in curb and gutter in the minor storm shall be a maximum of 6 inches to prevent inundation and damage to landscaped areas and other adjacent improvements. All runoff from proposed facilities shall be discharged in a manner similar to existing conditions in both location and quantity.

Necessary replacement of existing storm drainage facilities shall, at a minimum, provide services equivalent to the existing facilities. New facilities shall be designed in accordance with the current design standards of the jurisdictional authority. Services to adjoining properties shall be maintained at all times during construction.

Retaining wall drainage shall be coordinated with the retaining wall structural designer. Runoff from slopes above the retaining walls including concentrated flows shall not be allowed to discharge behind any retaining wall or pass over the top of any retaining wall.

Innovative runoff reduction methods including Low Impact Development (LID) and Best management Practices (BMP) facilities may be considered on a case-by-case basis.

4.4.4 Storm Sewer

Storm sewer shall be constructed with Class III reinforced concrete pipe (RCP) with a minimum pipe diameter of 18 inches. Where conditions will provide inadequate cover material or excessive structural loading is expected, the class of pipe shall be evaluated and upgraded, if required. Storm sewer crossing LRT and CRT shall be Class V RCP.

New storm drainage facilities shall be designed for an expected functional life of 50 years as a minimum, and pipe systems shall be designed to minimize future maintenance requirements. The maximum allowable design velocity for storm sewer pipes shall be 18 ft/sec, and the minimum design velocity shall be 3 ft/sec at half-full pipe hydraulic conditions.

Pipe material other than concrete, including polyethylene, polyvinyl chloride (PVC) or ductile iron, shall not be used without prior approval from RTD. Area drains within landscaped areas may be constructed with polyethylene or PVC, if they do not cross beneath or drain paved areas and if they do not connect to concrete pipe upstream.

Storm sewer culverts and culverts that cross under RTD bus access, LRT and Commuter rail trackway shall cross at a 90-degree angle to the bus/trackway whenever possible and have a maximum headwater depth ratio of 1.5. The EGL in all culverts adjacent to the bus/trackway shall be below the top of the subgrade.

At manholes and/or inlets where pipes of differing diameter enter and exit the junction, the design engineer shall match the crown elevations of the incoming and out-going pipes. For junctions where the incoming and out-going pipes are the same diameter, the design engineer shall provide a minimum 0.2-foot drop across the incoming and out-going pipe invert elevation within the junction.

4.4.5 Inlets

Type R inlets, as modified by RTD Standard Drawings, shall be used to collect stormwater from curbed areas in accordance with local jurisdictional requirements. Other types of inlets, including Type 13, Type C, slotted-vaned grates and combination inlets, shall not be used without prior approval from RTD. Inlets shall be designed to accept design flows with no more than 6 inches of ponding over the inlet. Inlets shall be placed in sump conditions when possible. The use of on-grade inlets will be allowed, but is discouraged in most circumstances. In public right-of-way, published jurisdictional standards shall take precedence.

Inlet grates in pedestrian areas shall be heel-proof and non-slip, and shall meet all requirements of the ADASAD.

Any structures that vary from agency or RTD standards, including manholes, junction boxes, inlets, vaults or other structures shall require prior approval by RTD. Inlet grates in the wheel path of buses shall be secured to prevent movement.

4.4.6 Detention Facilities

Detention facilities shall be provided as required by the local jurisdiction, and shall be designed in accordance with the design standards and technical criteria of the local jurisdiction and Urban Drainage and Flood Control District (UDFCD). Rip-rap, cobbles or other similarly rocky material used for landscaping, erosion control or storm drainage management shall be designed to prevent vandalism. This may include the use of grout, top-soil cover, or large or heavy stones, which preclude manual lifting, or other agreed-upon alternatives. RTD approval shall be obtained prior to specifying these materials. Detention ponding may extend into parking areas to a maximum depth of 6 inches, if allowed by the design standards and technical criteria of the local jurisdiction. Detention ponding shall not extend into designated pedestrian routes or bus circulation areas. **Parking areas which are designed to be inundated by detention ponding shall be signed to warn patrons of possible standing water.** Underground detention shall not be used unless approved by RTD and the local jurisdiction. Detention pond outlet structures shall be designed in accordance with UDFCD and/or as approved and shown in RTD Standard Drawings.

4.4.7 Permanent Water Quality Facilities

Permanent water quality facilities shall be provided unless the site is served by regional water quality facilities with adequate capacity for the proposed construction. Water quality facilities shall be integrated into the detention pond, if applicable. Facilities shall be designed in accordance with the design standards of the USDCM Volume 3. Stormwater retention facilities are not allowed unless approved by RTD and the local jurisdiction.

Water quality facilities requiring special maintenance provisions (including facilities constructed with underground vaults) shall not be used unless approved by RTD.

4.4.8 Erosion Control

The designer shall prepare erosion control plans following local jurisdiction standard Best Management Practices (BMP) for all of the proposed project facilities. If the local jurisdiction has no design standards, plans shall be prepared in accordance with UDFCD USDCM Volume 3 or as directed by RTD. These plans will be provided to the construction contractor for their use.

The construction contractor shall prepare erosion control plans and Storm Water management Plans (SWMPs) for various phases of construction and for the completed project, or as required by the local jurisdiction. The construction contractor is responsible for obtaining all necessary permits, and may utilize the designer's erosion control plans as the basis for preparing the plans required for permits and inspections. Erosion control

and/or SWMP plans shall meet the requirements of the local jurisdiction and the State of Colorado Department of Public Health and Environment (CDPHE).

4.4.9 Easements

All storm sewers crossing RTD property that serve upstream properties shall become the ownership of the local jurisdiction. Where such storm sewer facilities are located outside of public right-of-way, license agreements shall be prepared for the conduit crossing.

The designer shall identify any temporary or permanent easements required to construct and maintain storm water drainage facilities, and shall coordinate with RTD's Property Management Division to prepare any required agreements.

4.4.10 Permits

404 Permit – Acquisition of an individual or nationwide permit required for the construction of the bus transit facility and appurtenant facilities shall be the responsibility of the Design Engineer, unless otherwise directed.

Erosion Control Permits – The Design Engineer shall prepare materials as necessary for inclusion of the bus transit facility into RTD's Municipal Separate Storm Sewer permit. Acquisition of the state and local stormwater discharge permits required for construction shall be the responsibility of the Construction Contractor, unless otherwise specified in the Contract Requirements.

4.4.11 Variances to Criteria

The design of drainage systems using criteria contained herein is to protect the RTD facilities from storm-runoff damage and to protect RTD from liability for damage to property from storm runoff either passing through or caused by construction. It is RTD's goal to design all drainage facilities in accordance with the Drainage Criteria. Deviations from the Drainage Criteria shall be evaluated only if meeting the requirements of the drainage criteria is determined by RTD to be impractical – not capable of being done within natural, social or economic constraints.

Any deviation, discrepancy, or unusual solution must be approved by RTD before it can be included in the design. It is the responsibility of the Design Engineer to identify, explain and justify any deviation from the established criteria and to secure the necessary approvals from RTD. All variance to the Drainage Criteria shall be approved by RTD's Senior Manager of Engineering.

4.5.0 UTILITIES

4.5.1 Introduction

This section establishes design criteria for both existing and proposed Utilities within the RTD ROW. Utility Facilities designed to be installed or relocated within RTD's ROW, are to be in accord with the provisions of this Design Criteria.

All utilities specifically designed for RTD projects should meet the criteria, codes and requirements of the local jurisdiction where the project is located. Where Utility company criteria, public laws, or other standards applicable to the specific Utility require a higher degree of protection, these laws and standards will take precedence over these Design Criteria. RTD has the right to amend or waive these Design Criteria requirements.

4.5.2 General Location Criteria Requirements

4.5.2.1 Horizontal Placement

- (a) The horizontal location of new utilities and relocated utilities thru Park-n-Ride facilities, where possible, should be within inner-PnR roads and drive isles, and should avoid crossing under bus-bays.
- (b) Utility Facilities should be located to avoid future conflict with planned programmed changes within RTD's ROW. Known future conflicts will be identified by RTD.
- (c) Horizontal clearances of Utilities shall be designed to conform to specific Utility company requirements and shall be sufficient so that any work on a Utility does not compromise any RTD facilities or other Utilities.

4.5.2.2 Vertical Placement

- (a) Overhead Utilities shall not be allowed within RTD ROW. Exceptions shall be made for electric transmissions lines and where utilities are attached to bridge structures.
- (b) Vertical clearances shall conform to specific Utility company requirements and shall be sufficient so that any work on a Utility does not compromise the RTD facilities or other Utilities.

4.5.2.3 Utility Appurtenances

- (a) Surfaces and subsurface Utility Appurtenances shall be designed in such a manner to allow automobile and pedestrian traffic safe sight lines to see approaching and departing buses and shall be placed outside public pathways where they do not block pedestrian movements or create safety hazards.
- (b) Surface and subsurface Utility Appurtenances shall be located at a sufficient distance from bus bays to allow for future maintenance to be

performed by Utility Companies without disruption to the operations or maintenance of the RTD facilities.

- (c) Subsurface Utility Appurtenances (such as valves, handholes, manholes, clean outs, and vaults) shall be located outside of the drive lanes of buses, unless absolutely unavoidable for required utility design.

4.5.2.4 Utility Surveys and Markers

- (a) All existing Utilities within the RTD project site shall be located and marked. Field locate marks and all above ground utilities shall be surveyed and shown and owner identified on the survey drawing. Pothole where necessary to provide exact horizontal and vertical location as required for design (see Sec 4.2.0 Survey).
- (b) Utility locations shall be marked in accordance with UNCC and the project specifications.
- (c) Tracer Wire (color coded electronically continuous tracer wire) with access points shall be installed on all underground utilities and services, unless otherwise noted. The wire shall be installed in such a manner as to be able to properly trace all utilities without the loss or deterioration of signal or without the transmitted signal migrating off the tracer wire. For locations where valve boxes, vaults, or similar access points are not present, underground terminal boxes shall be installed. Tracer wire and access points shall be installed in accordance with contract specifications.
- (d) As-built plans of new, abandoned, retire, relocated, protect-in-place, adjusted, and or modified utilities shall show the final location of each utility and shall be submitted to RTD in accord with the project specifications.

4.5.3 Design

4.5.3.1 Design General

Coordination between disciplines shall minimize and attempt to avoid utility relocations where possible.

4.5.3.2 Design Loads

The material, class, thickness, and depth of all buried Utility Facilities including carrier pipes, conduit and casings shall be designed to withstand the full range of expected internal and external pressures and loads, including internal pressures ranging from zero to maximum expected pressure, and external loads from bus vehicle loads, retaining walls, and all other structural loads. Designs shall be appropriate to support existing and future load conditions. Design load calculations will be subject to review by RTD.

4.5.3.3 Specifications

Design of Utility installations shall conform to the current published issues, governing their specific type of Utility as well as local jurisdictional applicable codes, as applicable:

- (1) The design of electric power communication facilities shall conform to the National Electric Safety Code and National Electric Code.
- (2) The design of pipelines shall conform to the applicable provisions of the industry codes and standards.
- (3) The design of liquid petroleum pipelines shall conform to the recommended practice of the American Petroleum Institute for pipelines crossing under railroads and highways.
- (4) The design of any pipeline carrying natural or other gas shall conform to the rules and regulations of the U.S. Department of Transportation, Title 49, CFR, Part 192.
- (5) The design of any pipeline carrying hazardous liquids shall conform to the rules and regulations of the U.S. Department of Transportation governing the transportation of such materials, Title 49, CFR, Part 195.

4.5.3.4 Material

The materials designed for Utility Facilities shall conform to accepted practices and industry standards and shall be designed for long service life and shall be relatively free from routine servicing and maintenance.

All new Utility Facilities shall be free of asbestos and asbestos containing material.

4.5.3.5 Service Interruptions

Utility designs shall identify planned utility service interruptions as coordinated with utility owners and service interruption restrictions as directed by utility owners. The number and length of service interruption should be limited to only what is critically necessary.

4.5.3.6 Betterments

Utility relocation designs shall provide service equal to that offered by the existing Utility. Betterments shall not be included in the design, unless approved by RTD and paid for by the party requesting the betterment.

4.5.3.7 Abandon, Retire, and Decommissioned Utilities

- (a) Existing Abandoned and existing Retired Utilities shall be capped, plugged, filled, removed, or otherwise addressed in a manner deemed necessary and as directed by RTD to protect the transportation facility and/or traveling public.
- (b) Proposed Abandoned and proposed Retired Utilities shall be taken out of service using proper utility owner and/or industry standard procedures as

directed and approved by RTD. In determining whether to allow proposed Abandoned or Retired facilities to remain in place rather than require the Utility Owner to remove the facility, RTD will consider such factors as: present or potential congestion of Utility installations; bus bay construction or maintenance requirements; cost and difficulty of removal; whether or not the facilities contain any hazardous materials, such as asbestos; the potential for the facilities to have to be removed by RTD itself at some future date; and traffic and safety requirements.

- (c) Utility Facilities containing asbestos may not be abandoned in-place. The design of Utility Facilities that contain existing asbestos shall include taking the Utility out of service and removing it from the RTD site or ROW. On a case-by-case basis, RTD may allow such Utility Facilities to be retired in-place, with the owner retaining full legal ownership and responsibility for the Utility Facility.
- (d) Decommissioned Utilities shall be designed to conform to the same criteria as active facilities. If a Decommissioned Utility conflicts with an RTD structure or facility, the Utility shall be relocated, modified, or protected in place as design requires.

4.5.3.8 Protect Utilities In-Place

Where buried Utility Facilities may be potentially subjected to damage from construction, operations, or maintenance of the Bus facility, additional protective measures should be required, such as steel casing, concrete cap, permanent shoring, or other appropriate measures.

Where maintenance of buried Utility Facilities may impact bus operations, casing shall be considered.

Where Utility facilities are suspended from or in a structure, water, high-pressure gas, or hazardous material, pipelines shall be in a casing pipe.

4.5.3.9 Encasement

- (a) Casing length shall extend to allow access to the Utility without interrupting bus operations.
- (b) Where the ends of a casing are below ground, the casing shall be sealed to the outside of the carrier pipe to prevent the intrusion of foreign material which might prevent removal of the carrier pipe.
- (c) Light poles shall be sized to accommodate conduits. Minimum six inches.

4.5.3.10 Cathodic Protection

Where the bus transit facility is adjacent to RTD Light Rail (LRT) or Commuter Rail (CRT) all metallic Utility carrier pipes within 15 feet of the centerline of the nearest rail /or to the latest criteria requirements for LRT or

CRT shall be designed with appropriate cathodic protection measures for internal and external corrosion in accordance with RTD Corrosion Control criteria in the LRT or CRT Design Criteria.

4.5.3.11 Restoration of ROW

Utility trench backfill shall adhere to street compaction and materials requirements as defined by local jurisdiction criteria.

Design and construction of Utility work in earthen areas within and immediately adjacent to the RTD project site or ROW that will disturb existing ground conditions shall include seeding or other protection methods as specified by RTD to control erosion.

Utility work in hardscape areas within or adjacent to the RTD site that will damage concrete, asphalt, stone, or other hard surface shall include restoring the disturbed areas to their original or RTD approved in-kind condition.

4.5.4 Water Service

The size of the water service taps and meters shall be determined by the demand for both irrigation and domestic uses on site. The cost of the water and sewer taps and post-construction service rates shall be analyzed, and the most economical combination of domestic and irrigation water taps and sanitary sewer service taps shall be purchased for the site from the local utility district(s). In some cases, it may be more economical to purchase a separate irrigation tap.

Water service shall be provided to the Drivers Relief Station (DRS) building. The service line shall be constructed in accordance with local criteria. Service lines shall be constructed with Type K copper. If the construction of a water main is required, the water main shall be constructed in accordance with the standards and criteria of the local utility authority.

Where community water service is not available to the site, a domestic well may be constructed. The design of water well facilities, if required, shall be coordinated with RTD on a case-by-case basis. State permitting and adjudication requirements shall be coordinated with the State Engineer's Office and the Colorado Department of Public Health and Environment, as required.

The need for fire lines shall be evaluated and coordinated with local Fire districts. If Fire Hydrants (FH) are required for the new site development, the quantity and placement of FHs, size of water lines, and location of water loops, shall be coordinated with the local Fire district and the local water department.

4.5.5 Sanitary Sewer

Sanitary sewer service shall be provided to the DRS. Service lines shall be constructed in accordance with the design standards of the local utility district.

If the construction of a sanitary sewer main is required, the sanitary main shall be designed and constructed in accordance with the local utility authority standards and criteria.

If community sanitary sewer service is not available, alternate waste disposal facilities (self-contained DRS or leach field) may be designed. The design of alternate facilities shall be coordinated with RTD, the Colorado Department of Public Health and Environment, Tri-County Health Department, local County Health Departments and local jurisdiction as required, Written Variance approval from RTD is required.

4.5.6 Electrical

Site electrical service shall be constructed in accordance with applicable local and National Codes. The designer shall coordinate with the electrical service provider to install any conduits or utility sleeves that may be required in order to provide service to the site.

4.5.7 Telephone and Communication Services

The local service provider in coordination with RTD shall provide emergency telephone service at all major facilities. Smaller street stops are excluded, unless otherwise warranted. The Design Engineer shall coordinate with the local service provider to locate utility sleeves or conduits to provide service to the site.

A minimum of one emergency phone shall be provided. Emergency phones shall be placed in a well-lit portion of the passenger plaza waiting area, preferably adjacent to the main pedestrian pathways. Construction sequencing and phasing typically require the contractor to install only the phone conduit and respective pull cord, "mule" rope or tape.

Emergency telephones shall be installed as outlined in Section 13 of this Manual.

Video surveillance and associated equipment, conduits, duct-banks, pull boxes and appurtenances shall be installed as outlined in Section 13 of this Manual.

Communications service to the DRS shall be coordinated with the local service provider to include a minimum 24-pair phone cable. See Section 8 for DRS communications service design criteria. See Section 5 for the irrigation systems communications (remote monitoring) requirements.

4.5.8 RTD Utility Agreements

Non-RTD Utility facilities that enter into RTD ROW or cross under or over RTD facilities may require an RTD Utility Agreement to allow the Utility facility to be built, operated, and maintained.

4.6.0 SITE FURNISHINGS

Site furnishings (benches, trash receptacles, newspaper racks, etc.) shall be specified and installed in accordance with Section 5 of this Manual and RTD Standard Drawings. The designer shall coordinate with local jurisdictions to assure that both local and RTD design criteria are met.

Site furnishings shall be installed a minimum of 5 feet behind the face of curb in passenger boarding zones, except in ADA boarding zones, where site furnishings shall be installed a minimum of 9 feet behind the face of curb.

4.7.0 SITE LAYOUT

While each facility project has its own unique set of design objectives and constraints and must be looked at on a case-by-case basis, there are certain design parameters that should be adhered to in order to achieve a proper design that is consistent with RTD requirements.

4.7.1 Access and Circulation

Bus, pedestrian and private vehicle access onto and through the site should be separated. There should be at least two separate and distinct points of private vehicle ingress and full movement egress that are separate from the bus and pedestrian movements. If this is not feasible, the Design Engineer shall coordinate site access with RTD. The exits and entrances should be located on different streets; however, if site conditions require that they be located on the same street, refer to the local jurisdictions design standards for the minimum separation and further coordinate with RTD. Circulation aisles shall be considered for Park-n-Rides (PnRs) in excess of 200 spaces and should be located at the periphery of the parking area to minimize pedestrian and vehicle conflicts. One-way circulation is discouraged for surface lots.

4.7.2 Grading

Local topography shall influence the grading of a site. To ensure functionality of the site, the following grading parameters shall apply. A 1.5 to 2.0% grade is the most desirable for bus lanes. The allowable composite grade for parking stalls, circulation and access aisles shall be a minimum of 1.0% and a maximum of 5.0%. Mountainous terrain grades for circulation aisles may utilize a maximum 8% grade. Bus access grades shall not exceed 4%. The parking stalls and access aisles for ADA accessible parking shall not exceed a 2% composite grade.

Horizontal and vertical control and grading shall be shown, measured and designed to curb and gutter flow lines rather than to the top back of curb or any other design feature. Spot elevations shall be shown at all significant surface locations such as plaza areas, walkways, stairs, curb returns, drive cuts, surface drainage features, exposed pipe inverts, swales, pans, gutters, structural elements, finished floor, top and bottom of walls, slopes, and all locations that are designed with minimum or maximum grades, major or minor elevation changes, and areas that are crowded with many graphic elements, numerous lines, tight contours and a variety of functional features.

All travel way (pedestrian or vehicular) slopes shall include gradient percents shown on the drawings. All non-travel way natural, landscaped, cut, fill or existing slopes shall include horizontal to vertical (H:V) grade ratios shown on the drawings. Both travel and non-travel slopes shall include directional arrows showing "+" (up-slopes) and "--" (down-slopes) relative to stationing, as applicable. Emphasis shall be placed on all access locations, curb returns, drive lanes, walkways, mixed-use paths, ramps, landscaped areas, drainage swales, side-slopes, ridges and all features with grades that are less than 1% or greater than 3%.

In general, grading for landscape areas should not exceed a slope of 3:1 (H:V) and shall be used only to minimize retaining walls or to maximize adjacent non-landscaped areas. The preferred maximum cut, fill, natural or landscaped slope is 4:1 (H:V). See Section 5, Urban and Landscape Design Elements, for additional criteria about grading in landscape areas.

Parking aisles should be aligned parallel to the primary direction of pedestrian flow. When the topography of the land or site conditions require grades in the facility to exceed 3% in one direction, consideration should be given to aligning parking stalls perpendicular to the grade of the lot.

Passenger boarding zones are defined as the area directly adjacent to the bus bay where passengers queue for buses. Passenger boarding zones shall be located on a defined accessible route of travel, which should be the shortest possible route to the ADA accessible parking spaces. The grades within the passenger boarding zones and the ADA-accessible parking spaces should have a minimum slope of 1.0% and may not exceed 2.0% in any direction. Accessible routes shall include ramps and handrails as required by ADA and ADASAD.

Passenger boarding zones are usually located adjacent to plaza areas, which are relatively broad areas that accommodate pedestrian pass thru and passenger waiting sites, often with shelters. Plaza areas shall be relatively flat and, excluding the passenger boarding zones, shall have a 1.0% minimum and 2.0% maximum allowable grade in both the parallel and perpendicular directions for the plaza area. A PnR design should have grades that do not exceed 2.0% in both the parallel and perpendicular directions for the passenger boarding zones, plaza areas and the defined accessible route of travel. The grades of the bus bay, the adjacent passenger boarding zones

and plaza areas need to be reviewed in conjunction with each other to assure that a situation has not been created that interferes with use of the wheel chair lifts on the buses. The walking distance from the plaza area to the most distant parking stall shall comply with Section 2.3.6.

4.7.3 Islands

A raised island, typically 10 feet (may be reduced if other constraints prevail) wide (FL to FL), should be placed at the ends of each parking row to provide adequate sight distance, aesthetic appearance and meet jurisdictional requirements. The use of painted islands in lieu of a raised island with curb and gutter is discouraged and requires RTD approval. However, if a painted island is used, the width should not exceed 4 feet in order to discourage its use as a parking space and no unprotected signage should be installed in the painted at grade islands.

4.7.4 Parking Stalls

Standard parking stall dimensions are 9 feet wide by 18 feet deep. RTD does not normally use compact parking stalls at surface lots, however if site constraints require reduced depths, and the parking spaces are adjacent and perpendicular to a curb, and sufficient depth is available behind the curb, the stall depth can be reduced by 2 feet to 16 feet. If this configuration is used, a 2-foot paved platform behind the curb shall be included to lessen landscape maintenance restrictions. The curb head height for a 16-foot deep parking stall shall not exceed 6 inches. Reduced depth parking stalls are only allowable when permitted by the local jurisdiction and approved by RTD.

Parking stall widths may be reduced to 8.5 feet within a parking structure and shall include double striping. The length of parking stalls within a structure shall be 18 feet. Double striping shall include two 4-inch wide stripes placed 12" on center on both sides. Standard striping may be used within parking structures with approval from RTD.

4.7.5 ADA Accessible Parking

ADA accessible parking and access shall conform to the ADASAD (see Section 1.10.1).

4.7.6 Bicycle Parking

See Section 6 for bicycle parking criteria.

4.7.7 Motorcycle Parking

The number of spaces that should be dedicated for motorcycle parking is unique to each location and shall be determined by demographics and the size of the facility. During conceptual design, a ratio of motorcycle parking to automobile parking shall be 1 to 50 respectively.

See the RTD Standard Drawings for the layout of motorcycle parking. Motorcycle parking can damage asphalt pavement, therefore concrete pavement shall be used for motorcycle parking spaces.

4.7.8 Kiss-n-Ride (short-term parking)

The use of Kiss-n-Rides is required for all PnR facilities (see Section 2.3.5). Their parking stalls should face and be located near bus loading zones or rail platforms. Locate Kiss-n-Ride parking stalls near the ADA parking area. The number of Kiss-n-Ride spaces is unique to each location, as determined by area demographics and ridership and will be as directed by RTD.

Signage indicating that the stall shall be used only as a Kiss-n-Ride or a sign limiting the time, typically 15 minutes, should be used.

4.7.9 Bus Bays and Saw Tooth Geometry

The standard parallel dimensions for bus loading bays are nominally 12 feet by 50 feet for 45-foot long buses, and 12 feet by 70 feet for an articulated bus. The standard access taper is 7:1, and egress taper is 4:1 with a 24' radius. Refer to RTD Standard Drawings for additional geometric layout information.

4.7.10 Internal Lane and Aisle Criteria

Orthogonal parking is the preferred geometry for stalls, curbs and circulation lanes.

As required by limited space, angled (e.g. 45 degrees) parking will be considered on a case-by-case basis in coordination with RTD during the concept design phase. When angled parking is used, aisle direction and width shall be one-way and 15 feet (for 45 degree parking), respectively.

The following acceptable and desirable drive lane widths and curb return FL radii shall apply to two-way drive lanes/aisles:

- Parking Aisle
 - width – 24 feet minimum
 - radius – 2 feet minimum, 5 feet desirable
- Circulation Aisle
 - width – 24 feet minimum, 30 feet desirable
 - radius – 15 feet minimum
- Bus lane
 - width – 30 feet minimum
 - radius – 35 feet minimum
 - Turn lane – 30 feet minimum (inner)
 - Turn lane – 55 feet minimum (outer)
 - Turnaround – 65 feet minimum (outer)

4.7.11 Plaza Layout

The layout of the plaza areas shall be coordinated with local jurisdictions to assure that both local and RTD design criteria are met. Refer to Section 5, Urban and Landscape Design Elements.

4.8.0 ACCESSIBILITY STANDARDS

Specific attention shall be given to the most recent version of the Americans with Disabilities Act (ADA), the ADASAD, and the ADA Accessibility Guidelines for Transportation Vehicles, and to any supplements that may be issued. Their applicability is noted in several sections of this Manual where apparent or appropriate significance apply. ADA adherence is required for all areas of this Manual, regardless of explicit, implied or lack of reference herein.

4.9.0 ROADWAY IMPROVEMENTS

4.9.1 General

Based on the requirements of the local jurisdictional authority or site traffic analysis findings, adjacent street improvements shall be designed to accommodate additional traffic accessing proposed bus transit facilities. Such improvements may include turn lanes or a traffic signal, for example. Since these improvements are most likely to be on public right of way, they shall be designed in close coordination with the local jurisdiction.

4.9.2 Street Improvements

Unless otherwise specified, all road and street design shall be in accordance with the current specifications and design guidelines of the local jurisdictions. For those cases where the local jurisdictions have no design guidelines, the most current versions of the Colorado Department of Transportation (CDOT) Roadway Design Guide, and/or the Policy on Geometric Design of Highways and Streets by the American Association of State Highway and Transportation Officials (AASHTO) shall be used and coordinated with RTD design staff.

4.9.3 Traffic Signals and Control Devices

Traffic signals and control devices shall be designed in accordance with local jurisdiction criteria and the Manual on Uniform Traffic Control Devices (MUTCD). The design shall be based on a traffic study and coordinated with the local jurisdiction to ensure compatibility with adjacent traffic signals and traffic patterns. The power source for the signal shall be coordinated with the local utility provider and jurisdiction. When possible, existing easements should be utilized for location of the power service. New easements should be avoided where feasible.

4.10.0 SNOW STORAGE AREAS

The Design Engineer shall consider snow removal procedures, maneuvering requirements, and storage for walkways, plazas, roads, drives and parking lots. Designated snow storage areas shall be provided at all RTD bus transit facilities and shall be located within or directly adjacent to areas requiring snow removal. Snow storage areas shall be placed to minimize ice accumulation on the pedestrian walkways and in the transit plaza. Heated walkways are not allowed except for elevator landings. Snow storage areas shall be sized to equal 10% of the areas requiring snow removal, which is based on a design storm of 6 inches and a pile height of 5 feet, excluding consolidation of snow. For larger storms, snow storage will be coordinated with RTD.

Snow storage areas shall be located down gradient and in the vicinity of storm water collection and conveyance features such as curb and gutter, inlets, curb cuts, swales, detention ponds and broad grassy landscaped areas. Snow storage area to have pan only, or slope low profile curb for easy access to push snow. Locate storage areas to protect structures, roadways, parking lots, walkways or plazas from snow melt runoff. The Design Engineer shall coordinate the location of snow storage areas with landscaping design so that landscaping is not damaged during snow removal and storage.

Designated snow storage areas shall not impact parking, bus bays, pedestrian traffic or vehicular circulation. Parking areas for snow storage shall be considered on a case by case basis and used only upon receiving written RTD approval. Snow storage areas shall be signed so as to adhere to the design intent.

At structure locations snow railings and chutes shall be constructed for top level only, they shall be included in the structural design of the structure and shall be designated with signage as snow removal locations. Chutes shall be placed where it does not affect anything on the site around the structure and shall be coordinated with RTD as to location and design. The gate should be fabricated off of the structure surface such that snow can be pushed under, but stays in place to keep the vehicle or machine from going off the roof.

4.11.0 EXCAVATION

Excavation adjacent to any bus facility shall comply with the standard shown to protect the integrity of the facility. All excavation activities shall comply with OSHA standards. Shoring may be used in lieu of the excavation requirements shown but must be approved prior to excavation activities by RTD.

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SECTION 5 – URBAN AND LANDSCAPE DESIGN ELEMENTS

5.1.0 GENERAL

This section is intended to direct the Design Engineer and Landscape Architect in the design of urban design elements at RTD bus transit facilities. This Design Criteria establishes the minimum standards to be used in the design of RTD bus transit facilities.

5.2.0 LANDSCAPE DESIGN, INSTALLATION AND MAINTENANCE

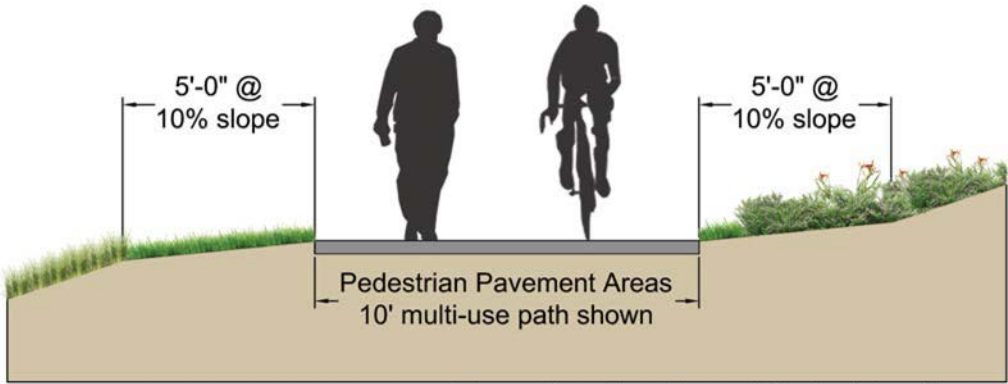
5.2.1 Landscape Requirements and Ordinances

Landscape installation and maintenance at facilities is desirable for aesthetic as well as ecological reasons and should consist of plantings that will be compatible with the operation of the facility. An area with a well maintained landscape is perceived as being safer than those which are bare of vegetation. Plants are to be used for directing site movement, creating comfortable environments, screening objectionable neighboring land uses and to enhance the appearance and function of the facilities.

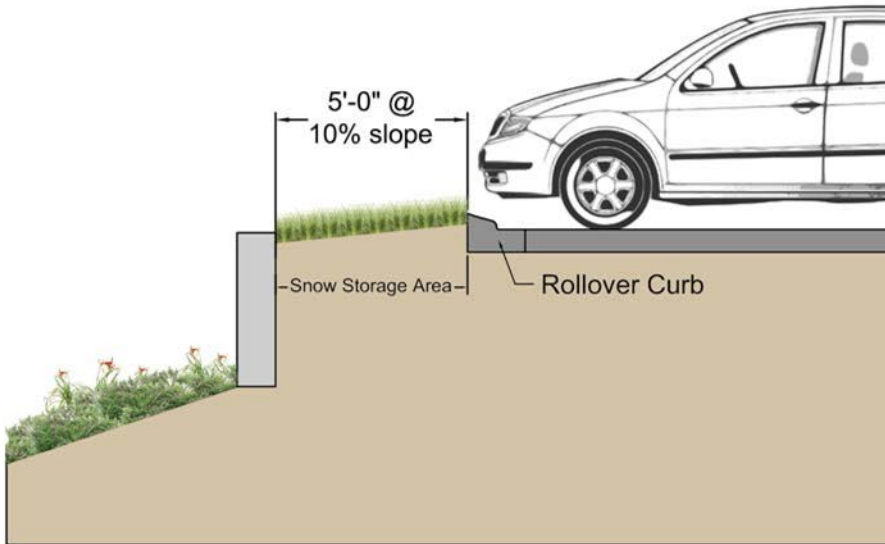
Most governing agencies within the Regional Transportation District have landscape requirements or ordinances that dictate the amount and type of landscape to be installed and maintained on a particular site. Each jurisdiction has its own requirements, however, all require live plant material be used in the facility design.

Generally, trees will be placed within parking lot islands, at the perimeter of the facility, at entryways, on plaza areas and not on adjacent station platforms. Trees and shrubs in plaza areas shall be installed in curb or wall protected raised planting beds to provide adequate planting space and to reduce the amount of snow melting agents and debris being pushed into planting areas. In many situations, raised planting beds can also function as seating. When raised planting beds are not possible, trees within hardscape plaza or paved pedestrian areas shall be planted in interconnected grated surface planting pits in lieu of individual grated tree pits.

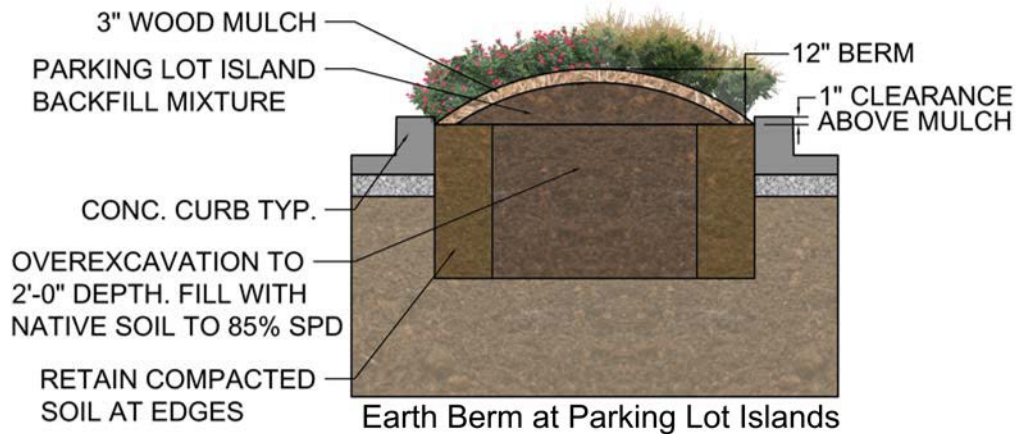
Landscape area slopes that are planted with sod or seed shall not exceed a 3:1 (H:V) gradient so that safe, convenient and efficient mowing and other maintenance operations can occur. The preferred slope is 4:1 (H:V) or flatter if not controlled by limited area or other site constraints. Include a minimum 5' wide 10% slope transition grading area adjacent to all pedestrian paved surfaces and parking areas. Include earth bermed landscape islands within parking lots. Grading and associated planting design should allow for snow storage. Where appropriate, landscape grading should conserve water resources directing water via bioswales to rain gardens and porous landscaped water quality ponds.



Transition Grading at Pedestrian Areas



Transition Grading/Snow Storage at Parking Areas



5.2.2 Crime Prevention Through Environmental Design

The design shall incorporate Crime Prevention Through Environmental Design (CPTED) strategies to the entire design. Refer to Section 13.12.0 for CPTED guidelines.

5.2.3 Landscape Design and Xeriscape Principals

Planning and Design

Site layout is critical to a successful landscape. Site layout will influence the landscape design concept and watering zone requirements as well as to identify which locations are most extreme for plant survival. Parking facilities are particularly difficult as the plants are primarily installed in locations that are surrounded by reflective hard surfaces, steep slopes or along roadways where exhaust fumes are more prevalent. Coordinate planting design with site grading to allow water harvesting, direct pedestrian movement, and ensure maintainable landscape areas. Avoid creating small (less than 4' wide) landscape strips that are difficult to irrigate. Berm parking lot islands to allow for visibility, plant protection and suitable rooting space for shade trees. Landscape designs should strive to conserve 40% of the irrigation water that would be applied to a 100% bluegrass turf landscape.

Soil Improvement

Proper soil preparation is the key to successful water conservation. An agricultural soils analysis is required for all landscape planting projects. If the soil is sandy, water and nutrients will be lost due to leaching below the root

zone. If the soil is heavy clay, water will be lost through runoff. Heavy clay soils tend to repel surface water resulting in runoff. The water that does get into these soils is held so tightly by the clay itself that plants cannot use it. Plants in a clay soil, even though moist often tend to wilt from lack of moisture. Plant roots also need air to thrive. In clay soils, air spaces are small and may fill with water, so plants suffer from oxygen starvation.

In very sandy soils, the opposite is true. Sandy soils have very large pore spaces. Because the particles are large, there is little surface area to hold the water, so sandy soils tend to lose water rapidly.

In general, for planting beds tilling 3 cubic yards of soil amendments such as well decomposed organic compost 6" deep into existing disturbed site soils will aid soil conditioning and plant growth. For areas seeded, tilling 2 cubic yards of soil amendments or adding soluble micronutrients/fertilizer may also prove beneficial.

Efficient Irrigation

Proper irrigation practices can lead to significant water savings. Different plant types should be watered with different irrigation zones. The system needs to be designed to fit the landscape, minimizing overlap onto streets, sidewalks and parking areas. Plant types need to be installed in zones that have similar water needs. This will optimize the irrigation system, saving significant amounts of water.

Drip zones are to be used in locations that are shrubs and trees only. Provide drip irrigation to trees within dryland seed areas.

Permanent subsurface irrigation for all dryland seed areas is required – during the first two years after installation, this irrigation will assist with soil stabilization and grass establishment, After two years dryland seed area irrigation may be limited to periods of excessive drought.

Provide rain sensors and flow meters within all irrigation systems.

Allow irrigation system to manually drain. Provide manual drain valves within each zone at pipe low point with one cubic foot geotextile wrapped drainage stone sump.

Zoning of Plants

Plants of similar water use requirements need to be grouped together to take advantage of water savings. Selecting plants that will do well depending on the site exposure is also important. The use of the most water conserving plants on south and western slopes and those that require more moisture can be placed close to drainage ways and low lying areas. Grouping plants appropriately will minimize water waste.

Mulches

Mulching helps keep plant roots cool, prevents soil from crusting, minimizes evaporation and reduces weed growth. Organic mulches such as shredded cedar should be placed 3 inch thick. Inorganic mulches and landscape/geotextile fabrics are generally not used at RTD facilities.

Turf Alternatives

RTD encourages the use of alternative turf grasses to reduce the amount of water needed to keep an area looking attractive and green. A variety of success has been achieved with drought tolerant cool and warm season grasses including, blue gramma, wheatgrass fescue and hybrid bluegrass blends. Seeded areas should include wildflowers within the mixture.

Appropriate Maintenance

Regular scheduled maintenance shall be in accordance with the contract documents. A Landscape Maintenance Plan is required to accompany all Landscape Planting Plans. The Landscape Maintenance Plan direct tasks and scheduled frequency of weed control, pruning, water management, fertilization, pest control, irrigation system maintenance and plant replacement.

5.2.4 Standard Landscape Elements

The standard landscape elements to be included in PNR and station design include trees, shrubs, groundcovers, perennials, grasses, mulch, decorative landscape boulders, concrete edging, patterned concrete, decorative pavers, , site furniture, planters, irrigation systems and pedestrian shelters. These elements shall correspond to local requirements and meet local jurisdiction requirements.

5.2.5 Acceptable Landscape Plant Material

The plants contained in the following references are either native or adapted species known to survive in local conditions. This should not be considered a comprehensive or exclusive list as there are other species and varieties which may also be appropriate. Acceptance will be through RTD Planting Plan review.

1. City of Denver Parks and Recreation – Approved Street Tree List for Denver’s Rights of Way.
2. City of Aurora Parks and Open Space Department – Xeriscape Plant List.

Additional plant requirements:

- As the RTD district encompasses many jurisdictions, the selection of plant material for each pnR should reflect the local jurisdictional requirements.
- Minimum plant sizes: Shade trees to be 2.5" caliper, evergreen trees to be a 25/75 mixture of 6' and 8' height respectively, Ornamental trees to be 2" caliper, shrubs/ornamental grasses to be 5 gallon container, specialty shrubs/ornamental grasses (less than 3' mature height) to be 2 gallon container, and perennial flowers and groundcover plants to 1 gallon containers.
- All plants should be hardy to USDA zone 5b and be readily accessible or acclimatized through local nursery sources.
- Trees with non-persistent fruit over ½" diameter or large seed pods are not allowed at PNRs or passenger boarding locations.

5.2.6 Turf and Native Grasses

There are a number of varieties of turf grasses available as alternatives to a standard bluegrass blend. Even though bluegrass is a fairly hardy species, a few of the newer varieties can provide the look of bluegrass without the water requirements.

Native or low water grass species can also be used in many areas in lieu of bluegrass, however, many counties, municipalities and special districts require that all areas on a site be irrigated and maintained to establish an acceptable ground cover. This is to minimize the amount of weeds allowed to grow on a site in lieu of grasses in accordance with local ordinances and the Colorado Noxious Weed Act.

5.2.7 Maintenance Standards

Landscape maintenance tasks are the recurring procedures and duties required to ensure a viable, functional and attractive RTD facility environment. Landscape maintenance methods are the standards and practices of the landscape industry used to accomplish these tasks. Standard maintenance activities include aeration, fertilization, mowing, trimming, watering and pest and weed control for turf and native grass areas. Generally grasses should never have more than one third the blade length removed during one mowing. Maintaining a turf grass length of 2½-3 inches is the most desirable. Grass fertilization should be directed by an annual agricultural soils analysis that indicates the soil composition, pH and available nutrients within the soil. For bluegrass turf, this is generally accomplished by applying 0.5-1 lb of nitrogen 2-3 times per year per 1000

square feet of grass. Fertilizer application should follow the maintenance program established for each location.

Tree, shrub and perennial areas include weed, pest control, regular mulch application and fertilization. Occasional pruning of dead or dying branches or to encourage a natural shape and appearance is required. (A separate Landscape Management Plan is to serve as a more detailed guide for maintenance of RTD sites).

5.3.0 IRRIGATION

5.3.1 Standard Irrigation Components

The following is a list of acceptable irrigation system components or their approved equal to be used at RTD bus transit facilities:

Irrigation Heads:

1. Rainbird 1800 series pop-up spray heads
2. Hunter PGP, PGM or I-25 Rotor heads
3. Rainbird Bubbler

Drip Emitters:

1. Rainbird Xeribug
2. Agrifim emitters
3. Netafim drip line for turf
4. Rainbird dripline for shrubs and perennials

Controller:

1. Rainbird ESP or equal (commercial smart controller with cycle + soak feature, remote ready, and compatible with the Hermit Crab control system for irrigation system maintenance and testing). The remote control module shall be included in all installation of irrigation systems regardless of size. A Computer Monitoring System shall be included in park and ride facilities of 200 or more parking spaces or as determined by the Facilities Maintenance personnel and the design team. Mount controller in accessible location (to be approved by RTD Facilities Maintenance personnel).
2. Stainless Steel Pedestal or Wall Mount Enclosures in accessible location for outdoor Controller Installation
3. Master Valve (size to match mainline) normally closed.
4. Flow Sensor (size to match mainline)
5. Rainbird wireless Mini Click rain/freeze sensor

Valves:

1. Rainbird GB valves for spray and Rotor zones
2. Rainbird DV valves for drip or bubbler zones
3. Rainbird EFB-CP Series for non-potable/dirty water applications
4. Ametek or Carson Valve boxes
5. Strongbox stainless steel enclosure for backflow preventer on station platforms and other high visibility bus facility locations (at entries, near signage, near pedestrian walks). Use powder coated expanded metal lockable enclosures in non-visible locations.
6. Febco 825Y Reduced Pressure Backflow Preventer
7. Rainbird 44RC Quick Coupler Valve
8. Flow Sensor and Rainbird Flow Monitor

Pipe:

1. Class 200 PVC for mainline
2. Schedule 40 PVC connections
3. NSF Polyethylene pipe with 80 psi rating for laterals
4. UV resistant polyethylene pipe with 50 psi rating for capillary drip tubing

Remote Control:

1. Eicon Standard or equal maintenance controls

5.3.2 Remote Control Equipment

The controller shall be with removable backboard, terminal interface board, Eicon (or equal) remote connections for field remotes and 120 volt receptacle or approved equal. Flow control master valve and flow sensor with rain sensor. Field remotes shall be the Eicon Standard or approved equal.

5.3.3 Watering Restrictions and Watering Requirements

Irrigation Systems shall be designed and installed to accommodate various local agencies watering restrictions and include a rain sensor to turn systems off during rain storms.

5.3.4 Maintenance Standards

Standard maintenance practices for the facility irrigation systems shall include a two year commitment from the installer for regular bi-monthly irrigation checks and adjustments following initial acceptance of the system. A water management program is intended to maximize plant health, keep

water bills as low as possible, minimize water damage to hardscape areas and property and limit over watering and water runoff.

Bi-monthly maintenance shall include the adjustment of heads and watering times depending upon local weather conditions and soil moisture levels. Each zone valve shall be checked for leaks and operation efficiency. The entire system shall be activated in the spring and deactivated in the fall. Fall winterization procedure shall include the elimination of water in the system by means of blowing compressed air through each zone.

An irrigation-scheduling chart shall be provided by the irrigation designer and kept with the controller along with a site plan showing the zone numbers and locations. The chart and plan shall be legible and laminated. Scheduling of irrigation zones should be based upon an average application of 1.5 inches per week for turf grasses, 1.0 inch per week for trees, shrubs and groundcovers and 0.5 - 0.75 inches per week for native and natural grasses. These are the amounts that should be maintained during the peak of the season. A lower percentage is recommended for early spring and fall depending on local weather conditions and soil moisture content.

5.4.0 SHELTERS

5.4.1 Standard Shelter Design

The RTD Standard Shelter shall be Tolar – RTD Denver Model, Option 1 (open front), or approved equal as specified by RTD. The shelter is a modular design to allow for different combinations of wall panels. Standard Shelters include glass panels on the top portion of the enclosure and perforated steel panels on the bottom portion. Footings or foundations for the shelters vary depending on location, soil conditions and the final design, and shall be designed by a Professional Engineer on a site specific basis. Shelter concrete pads are typically 6 inch thick. The standard color for all RTD shelters is RAL 6009 (Fir Green). Shelters shall have the ability to be compartmentalized and modified.

5.4.2 Custom Shelter Design

Custom shelter designs are often requested by local agencies to better integrate the PNR facility with the neighborhood or provide identity for the local agency. RTD will consider the design and construction of custom shelters on a case by case basis and require that the local agency participate in the additional financial commitment necessary to install these custom shelters and toward the maintenance of the structure.

Custom shelters must meet all RTD criteria including safety and security requirements.

Custom shelters that pertain to RTD Board Action are to include maintenance of the structure.

5.5.0 FURNITURE AND FIXTURES

5.5.1 General

RTD standard shelters, benches, newspaper racks and trash receptacles shall all be color RAL 6009 (Fir Green). Alternative colors may be permitted with approval from RTD.

5.5.2 Benches

Benches at bus and rail facilities shall be Victor Stanley (RB-28 or RB-12 – backless) with a powder coated finish or approved equal. Benches shall have fully welded joints throughout. Total number of benches included at a station or PNR location is a factor of total number of patrons at a location. Generally one 6 foot bench per 50 PNR patrons is required. Most transit users tend to arrive a few minutes before their bus or train is scheduled to leave and will not dwell in an area for long periods of time, thereby reducing the need for large numbers of seating locations.

All benches shall include anti-sleep rails that prevent a person from lying down on the bench.

Benches shall have the following features:

1. 6-feet long, 17-inches high, with center arm rest to discourage sleeping. Legs shall be approximately 24-inches apart.
2. ½" thick by 2" wide steel end frames.
3. Steel straps are formed from sections of ¼" thick by 1½" solid steel bar.
4. Polished welds where the vertical steel straps meet at the top of bench shall form a continuous surface from the top tubular section to each strap.
5. Bench to be fully welded/assembled at factory.
6. All fabricated steel components to be shot-blasted, chemically etched and phosphated, preheated up to 400 degrees (F) and then electrostatically powder coated with 8-10 mils thick finish.
7. Mechanical post-powder coating acrylic sealer to be applied over every weld.
8. Minimum bench weight shall be 280 lbs.

9. Standard bench color shall be RAL 6009 (Fir Green).
10. Recycled material content to be at least 50 percent.
11. Unit shall be surface mounted using stainless steel or galvanized bolts, washers, and/or lock bolts.
12. Bench to be installed on 4-inch deep concrete slab or approved equal surface.
13. Bench shall either have a reverse contour-shaped back or be backless.

5.5.3 Trash Receptacles

Trash receptacles are an inexpensive way to control litter at the PnR and station facilities. The trash receptacle shall be Scurr 35 Gallon Guardian Series (HS350W-CS093) with clear sides, powder coated finish, dome lid, and latch door, or approved equal. Trash receptacles shall have fully welded joints throughout.

Department of Homeland Security Compliant Clear Sided Receptacles shall have the following features:

1. Trash receptacles must be Homeland Security (based on the following criteria) and ADA compliant.
2. Trash receptacles shall have modular construction for simple field replacement of panels and lids.
3. Unit must have a 35 gallon capacity.
4. 14-16 gauge galvanized steel frame and lid.
5. Trash receptacle shall be thermoset, hot coated, and TGIC polyester, custom color powder coated with RAL 6009 (Fir Green) inside and out at 8-10 mils thickness.
6. All latches, hinges, and hardware shall be made of stainless or zinc plated steel.
7. Side panels shall be made of clear .093 thick polycarbonate panels to provide complete visibility of the contents (to comply with the Department of Homeland Security directions).
8. Door panels shall have a latch to remain closed between collections. Side opening is required for each unit.

9. Trash receptacle shall be fully assembled with welds and 3/16" structural rivets at factory.
10. Unit shall be surface mounted on concrete base using stainless or zinc coated steel bolts.
11. Recycled content of galvanized steel is a minimum of 30%; with a 25% post-consumer recycled content.
12. In rural or mountainous areas, consider using bear-resistant trash receptacles.

Bear Proof Containers shall have the following features:

1. ADA compliant, single 32 gallon, bear proof trash container.
2. 12-14 gauge galvanized steel housing and doors.
3. Stainless steel or zinc plated steel for hinges, handles, and latches.
4. Trash receptacle shall be thermoset, hot coated, and TGIC polyester, custom color powder coated with RAL 6009 (Fir Green) inside and out at 8-10 mils thickness.
5. Interior plastic container shall be sized and secured for this use.
6. Unit shall be surface mounted using stainless steel or galvanized bolts, washers, and/or lock bolts.

The number of trash receptacles shall be no less than two. The final amount will depend upon overall site design and configuration of newspaper, ticket and vending machine and waiting areas. No trash receptacles will be located within designated parking areas.

The location of trash receptacles shall meet the security requirements in subsection 13.13.0 of this Manual.

Trash receptacles shall be Federal Green RAL 6009 color powder coat paint and mounted with stainless steel fasteners. Victor Stanley trash receptacles Model SD-42 Trash Receptacle Dome Top, tulip design with 36-gallon capacity, or approved equal, may be used at bus stop locations beyond 250 feet of a station's platform or as approved by RTD.

5.5.4 Emergency Telephones

A minimum of one emergency telephone with security camera observation shall be provided at each bus transit facility, PnR or station location for convenience and safety. The number and location of emergency telephones shall be in accordance with Section 13.9 of this Manual.

5.5.5 Newspaper Racks

Newspaper rack systems shall be provided for vendor use at each bus transit facility. These are installed to limit the number, types and colors of individual paper vending machines located at any one facility, and shall provide a neat and orderly appearance. The rack systems can be installed in groups of 4 or more to accommodate the number of vendors interested in providing a service. Modular newspaper rack systems available from RAK Systems, Inc. or approved equal.

Newspaper racks shall have the following features:

1. Standard newspaper rack color shall be RAL 6009 (Fir Green).
2. All fabricated components shall be steel shot-blasted, etched, phosphatized and electrostatically powder-coated with TGIC polyester powder coating finish.
3. Units shall have a padlock armored attachment with standard two-way key pull lock.
4. Modular units available in both free newspaper distribution boxes and coin-operated, paid newspaper boxes.
5. Units shall have locking and/or latching options.
6. Dome Top Padlock Armored Attachment is required with all coin operated racks having dome tops.
7. Unit shall be surface mounted using stainless steel or galvanized bolts, washers, and/or lock bolts.
8. All newspaper racks shall have a Sheet Metal Dome Top to prevent snow accumulation.
9. Unit shall be made of 12-14 gauge galvanized steel.

The location of newspaper rack systems shall meet the security requirements in subsection 13.13 of this Manual.

5.5.6 Food Vending Machines

Generally food vending machines are not included at RTD facilities. In situations where they are included, a special area shall be established with the proper electrical service, trash receptacles, access and cover.

5.5.7 Bike Lockers and Racks

See Section 5.

5.6.0 HARDSCAPE

5.6.1 Design Objective

The design objective of hardscape features at bus transit facilities shall be to develop elements for each location (some may be unique to the area) that provide a functional, aesthetically pleasing and maintainable site. Each element within the hardscape portion of the design shall be constructed of durable materials.

5.6.2 Access to Pedestrian Areas

Access to pedestrian plazas shall meet the requirements of ADA criteria (ADASAD), ANSI 117.1 or more restrictive requirements as determined by local, state or federal laws or codes. Provide accessible route plan for each station/PnR.

5.6.0 ART-N-TRANSIT

5.7.1 Art Selection Process

The location of public art shall be integrated into the overall design of the place and shall be approved in collaboration with the RTD Art-n-Transit coordinator. Each art project shall be selected based on its contribution to the place's cultural, ethnic social and historical assets, as well as its aesthetic and creative value. Where appropriate, the participation of stakeholders and citizens in the selection of public art is encouraged as this contributes to the sense of collective ownership.

Functional art and design enhancements, which are design elements incorporated into the facility and are not necessarily free-standing objects of art, are welcome and encouraged. These items do not need to be subject to a broad selection process as they are an integral part of the facility's design; however, coordination with local authorities and stakeholders is recommended.



“Tread Lightly” by Joshua Wiener at Oak Station



“Relay Houses” by Several Artists along the West Line



“Along the Way” Windscreens by Nancy O’Neil at nine West Rail stations from Decatur/Federal to Jeffco/Golden

Art-n-Transit is a safety certifiable item under RTD’s Safety Certification Program (refer to Section 13). As such, art-n-transit design and placement shall be approved by RTD’s Executive Safety and Security Committee.

SECTION 6 – BICYCLE FACILITIES

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SECTION 6 – BICYCLE FACILITIES

6.1.0 GENERAL

This Design Criteria establishes the minimum standards to be used in the design of RTD bus transit facilities. This section is intended to direct the Design Engineer in the design of bicycle facilities at all RTD bus transit facilities.

All bike lanes, including those in public roads, should be designed in compliance with AASHTO and MUTCD requirements.

6.2.0 BICYCLE PARKING

Bicycle parking shall be provided based upon the guidelines presented below for initial construction, but consideration should be given to potential future expansions or reductions of the bike facilities in case demand warrants.

6.2.1 Bike Racks

Bicycle racks shall be placed near bus loading areas. Ideally lighting shall be in conformance with requirements established for Specialty Areas as defined in Section 10 of these criteria. The preferred type of bicycle racks to be used is “inverted-U” racks. These racks are efficient for RTD use because they can be installed individually or in rows, as appropriate for different sites. Additionally, they are easily recognizable by patrons as bicycle parking. Bike trees are also a viable alternative that may be used in design and construction in lieu of/or in conjunction with the preferred bike racks.

Bike racks shall be located as close to passenger loading areas as possible without interfering with passenger or vehicle movement. Bike parking is less likely to be used if it is not conveniently located. Additionally, racks that are not situated in a visible location are more prone to theft.

6.2.2 Bike Lockers

Bike lockers shall be placed off the main plaza and bus loading area, while still being conveniently located. Like bike racks, bike lockers should be located close enough to bus passenger loading areas to facilitate use. Ideally this location would be no further than the closest non-ADA parking space, as well as be a well lit location, near moderate to high patron activity zones in order to increase the perception of a safe locker area and increase the sense of security of the user and their equipment. However, the location of bike lockers (and other publicly accessible receptacles) shall meet the security requirements in subsection 13.13 of this Manual, which require they shall not be placed within 250 feet of a station platform. Station area bike lockers may be placed within 250 feet of a station platform, if it is determined that the 250 feet separation is not practical. In these instances a

bomb resistant barrier separating the bike locker from the platform must be constructed. Written approval from RTD is required in these circumstances.

The preferred type of bike lockers for RTD facilities is a one piece no assembly composite bike locker with a fiber-reinforced polymer (FRP) composite enclosure. The preferred configuration for the lockers is a single rectangular unit that contains two triangular bays, each accessed from one end of the rectangular box. See RTD Standard Drawings for sample bike locker installation.

A minimum of 6 feet around the perimeter of bike lockers shall be maintained for user access and for snow removal equipment. If the locker cannot be secured to a concrete pad, a fiberglass composite locker floor shall be specified.

6.2.3 Bike Corrals and Bikestations

At sites with high bike traffic, with direction from RTD, a bike corral or bikestation shall be provided to accommodate the large number of bikes in a more attractive manner than expansive groups of racks and lockers.

6.2.3.1 Bike Corrals

Bike Corrals are sheltered and secured enclosures that can accommodate a large number of bikes efficiently. Riders can secure their bikes with individual locks, for added security, within the corral, which is designed to include a self-controlled access equipped with a smart-card or card-key locking mechanism. Bike corrals can be built to any specification, but generally take the form of an unused storage room or a fenced enclosure.

The size, location and design of any proposed bike corral will be site specific and shall be determined in conjunction with the RTD Bike Coordinator.

RTD does not provide power or maintenance to Bike Corrals.

6.2.3.2 Bikestations

Bikestations are bike corrals that are staffed by parking attendants and offer other services and amenities. For example, a bikestation could provide transit passengers access to bike parking as well as bike repairs, bike rentals, bike accessories, transit pass sales, restrooms, changing stalls and a snack bar or café.

The size, location and design of any proposed bikestation will be site specific and shall be determined in conjunction with the RTD Bike Coordinator.

RTD does not provide power or maintenance to Bikestations.

6.2.4 Selecting Type and Quantity of Bike Parking

There is no commonly accepted equation or model to establish the quantity or type of bike parking demand at bus transit facilities. Some factors that contribute to the demand are the level of transit service, surrounding land use, population demographics and proximity to bikeway facilities. General trends indicate that higher density areas have increased bicycle use. Similarly, younger populations (especially student populations) and lower income populations have a higher bike parking demand. Bus transit facilities in urbanized areas typically have higher bike parking demand than in suburban or rural areas. Communities that contain established bikeways often have increased bike parking demand. Facilities that serve multiple routes or routes with higher frequencies tend to have higher bike parking needs.

Table 6A provides general guidelines for bike parking based upon the size of the facility. These guidelines will be adjusted for a proposed site per the above-stated factors based upon the site and surrounding area. In addition to considering the general guidelines in Table 6A, an analysis of the station area shall be conducted that evaluates the existing bike facilities (lanes, trails, etc.) as well as the existing roadway network and land uses. This analysis shall be done by the RTD Bike Coordinator and will provide recommendations for quantities and types of bike parking needed for the specific site.

TABLE 6A – BIKE PARKING GUIDELINES BY TYPE OF FACILITY

Type of Facility	U Racks	Bike Lockers (# doors)	Bike Corral / Bikestation
Bus stop served by frequent bus service (optional)	1 – 2	n/a	n/a
Bus park-n-ride ≤ 25 auto spaces	1 – 2	n/a	n/a
Bus park-n-ride > 25 ≤ 50 auto spaces	2	2	n/a
Bus park-n-ride ≤ 100 auto spaces	4	4	n/a
Bus park-n-ride > 100 ≤ 300 auto spaces	5	6	n/a

Bus park-n-ride > 300 auto spaces	6 – 10	10 – 20	Potential Bike Corral
Major Transfer Facility/New Transit Center Concept	10 – 15	24 – 40	Potential Bike Corral or Bikestation

6.3.0 BIKEWAYS

6.3.1 Bikeway Connections

Local communities may have a variety of off-street paths or on-street bike lanes that will factor into determining the demand for bike parking facilities. When developing site layouts for a bus transit facility, the Design Engineer in conjunction with the RTD Bike Coordinator shall investigate and consider such bicycle connections.

RTD encourages joint collaborations with local jurisdictions and agencies to provide better bicycle access to transit facilities where regional and local bike routes intersect or come within near proximity to RTD bus transit facilities.

When designing bikeways on RTD sites, where bike routes come onto RTD property, jurisdictional standards for size and surface material shall be met or exceeded (budget permitting). For example, if the current standard for a municipality is to surface regional bike trails with crusher fines that would also be the minimum allowable surface within RTD’s site. If the project budget can accommodate upgrading the bike path to asphalt or concrete, it would be recommended to do so.

Geometric standards for bikeway design shall be based upon local jurisdictional requirements or the AASHTO “Guide for the Development of Bicycle Facilities” manual if the local jurisdiction has no standards that address bikeways.

6.3.2 Bicycle/Pedestrian Bridges

Bridges may be necessary at some public bus facilities if major barriers to site access exist (i.e.: highways, RR, rivers). Refer to Section 8 of this Manual for further information on the design of such structures.

RTD will determine the practicality for bicycle/pedestrian bridges on a case-by-case basis, depending upon the projected pedestrian traffic, the geography of the site and the anticipated project cost.

6.3.3 Bikeway Signage

Where regional paths are not directly adjacent to RTD property, there should be clear signage directing bike traffic to and from the transit facility. Coordination with the local jurisdiction will be necessary to place signs along the bike path that direct riders along the most convenient route to reach the bus facility. The signs shall meet local standards, RTD's signage requirements as stated in Section 9 of this Manual and be in conformance with the MUTCD.

SECTION 7 – STRUCTURAL DESIGN

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SECTION 7 – STRUCTURAL DESIGN CRITERIA

7.0 GENERAL

This section provides structural design criteria for buildings, vehicular and pedestrian bridges, retaining walls, and other general structure types required for RTD Bus Transit Facilities.

7.1. STRUCTURAL DESIGN REQUIREMENTS

All structural designs shall comply with the requirements of the RTD Engineering Design Guidelines. Contract documents for structures, including design calculations, drawings, and specifications, shall be checked by an engineer with qualifications equal or greater than the person who prepared the documents. Structural designs for structures other than bridges shall be checked by either independent design check or calculations checking. Bridge designs shall be checked by the independent design check method as described in the CDOT Bridge Design Manual. Contract documents including calculations, drawings and specifications shall be signed and sealed by a Professional Engineer registered in the State of Colorado. All revisions shall be reviewed, signed and sealed by a Professional Engineer registered in the State of Colorado.

7.1.1 Design Method

Load Factor Design, Allowable Stress Design and Load Resistance Factor Design (LRFD) are acceptable design methods. The designer shall coordinate the specific design method with RTD's structural engineer prior to beginning preliminary design.

7.1.2 Design Codes, Specifications, and Manuals

Design of structures for bus transit facilities shall comply with the most recent editions and interims of the following design references as appropriate for the structure type considered, and as referenced elsewhere in this Section:

International Building Code, as amended by local jurisdiction

International Fire Code, as amended by local jurisdiction

NFPA 101 Life Safety Code

ASCE-07 Minimum Design Loads for Buildings and Other Structures

ACI-318 Building Code Requirements for Structural Concrete

AISC Steel Construction Manual

AASHTO LRFD Bridge Design Specifications

AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges

AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

CDOT Bridge Design Manual

CDOT Standard Specifications for Road and Bridge Construction

Where the requirements of different design references that are applicable for a particular structure are in conflict, the provision that will result in a more conservative outcome shall apply unless otherwise approved by RTD.

7.2 STRUCTURE TYPES

Structure types and components will be restricted to those historically used by RTD or those that have been accepted for general use by other transportation authorities, and that can be demonstrated to perform well for the intent of the project and under the project's environmental conditions, including frequent freeze-thaw cycles. Experimental structure types will not be permitted. RTD reserves the right to accept or reject the use of any structure type for any given project.

7.3 EARTH RETAINING STRUCTURES

7.3.1 Geometry

Retaining wall layout shall address slope maintenance above and below the wall. Provide returns into the retained fill or cut at retaining wall ends where possible. Any residual wall batter should be into the fill. Design and construction shall consider surface and subsurface drainage. A drainage system shall be provided to intercept or prevent surface water from entering behind walls. A fence or pedestrian railing with a minimum height of 42 inches above a standing surface shall be provided at the top of walls 30 inches or higher. Reference RTD Light Rail Design Criteria Section 14.7.0 for additional fencing requirements.

7.3.2 Wall Types

Metal walls, including bin walls and sheet pile walls, and recycled material walls will not be permitted for permanent retaining walls. Timber walls will not be permitted for permanent retaining walls unless prior approval by RTD. Wall types, proposed for use, shall have successfully been used in similar geotechnical locations and environmental conditions.

7.3.3 Design Requirements

Retaining walls shall be designed in accordance with the applicable standards and references outlined in this Design Criteria. Lateral earth pressures used in design shall be consistent with backfill type shown on the plans, the geotechnical report, and the requirements of Section 206 of the CDOT Standard Specifications for Road and Bridge Construction. Appropriate drainage details shall be provided for all retaining walls. Retaining walls shall be designed and constructed to have a minimum service life of 75 years.

The design of MSE and modular walls near or in bodies of water shall account for soft saturated soils and scour, and shall be coordinated with project geotechnical and drainage engineering disciplines.

All project walls near irrigation lines for landscaping shall account for the additional hydrostatic load due to a waterline break. The use of free draining backfill material and/or leak detection devices to reduce hydrostatic loads on retaining walls shall be provided at these walls.

7.3.4 Characteristics

Mechanically Stabilized Earth (MSE) Walls

MSE walls shall be designed and constructed in accordance with AASHTO LRFD Bridge Design Specifications.

Concrete panel facing shall be used at MSE walls subject to any of the following conditions: 1) Walls that support elevated roadway; 2) Walls that retain a fill height greater than 6 feet including height of sloping surcharge; 3) Walls at secondary locations that retain a fill height greater than 15 feet including sloping backfill height.

MSE walls with concrete block facing, and modular walls with or without soil reinforcement, may be used under conditions that do not include the preceding.

Wall panels shall be constructed of reinforced concrete. Provide corrosion protection for prestressing or post-tensioning steel. Cover to reinforcing steel shall be a minimum of 2 inches. All reinforcing, mild or prestressed, shall be galvanized or epoxy coated in splash zones of adjacent roadways. Panel joints shall accommodate differential settlement.

Mechanical connection of soil reinforcement to the wall facing for soil reinforcement shall be provided; friction connections relying on gravity alone will not be acceptable.

Soil reinforcement for MSE and modular walls shall be galvanized, epoxy coated steel, or geogrid meeting the creep requirements of AASHTO Specifications. Design shall account for any item projecting through the soil reinforcement. Avoid placing culverts and utilities perpendicular to soil reinforcement within the reinforced soil mass

Consideration should be given to placing the uppermost level of reinforcing elements below the depth of excavation that would be reached in the placement of utilities within the ROW. Alternately, conduits for utilities should be placed during the MSE construction.

Excavation to, or below, the top level of reinforcing elements shall not be allowed following the construction of the MSE.

Cast-in-Place Walls - Cast in place walls shall be designed and constructed in accordance with the current AASHTO LRFD specifications and the CDOT Bridge Design Manual and standards. Expansion joints and weakened planes shall be provided as necessary to accommodate differential movements.

Anchored Walls - Anchored wall design and construction shall use FHWA-IF-99-015, Geotechnical Engineering Circular No. 4, "Ground Anchors and Anchored Systems" as a guideline. Anchors shall be encapsulated with

plastic sheathing. Proof load tests for anchors shall be provided in accordance with the above FHWA guidelines. Shotcrete shall meet the aesthetic requirements set by RTD.

Soil Nail Walls - Soil nail walls may be used when top-down construction is warranted. Soil nail walls shall not be used if ground water seepage will be a problem. Design and construction shall use FHWA-NH1-14-007, Geotechnical Engineering Circular No. 4, "Soil Nail Walls – Reference Manual" as a guideline. Load testing of soil nails shall be provided in accordance with the above FHWA guidelines. Shotcrete shall meet the aesthetic requirements, including final finish, as established by RTD.

STRUCTURAL DIAPHRAGM AND CAISSON WALLS - STRUCTURAL DIAPHRAGM WALLS AND CAISSON WALLS MAY BE USED WHEN TOP-DOWN CONSTRUCTION IS WARRANTED. DESIGN AND CONSTRUCTION SHALL COMPLY WITH AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS AND WITH CDOT STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION.

7.4.0 PEDESTRIAN STRUCTURES

7.4.1 Pedestrian Bridges

Pedestrian bridges shall be designed in accordance with the AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, the AASHTO LRFD Bridge Design Specifications, and the CDOT Bridge Design Manual.

Except as otherwise specified by RTD, stay-in-place steel deck forms for pedestrian bridges shall be galvanized and coated with polymer sheeting on upper and lower surfaces. Deck forms meeting these requirements are available as Rhino-Dek as manufactured by Metal Dek Group.

7.4.2 Pedestrian Tunnels

Pedestrian Tunnels shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications.

Pedestrian tunnels shall provide a minimum clear width of 14 feet and a minimum of 10 feet in height for pedestrian movement. Tunnels longer than 50 feet may require greater width, as determined by RTD.

Lighting for pedestrian bridges and tunnels shall comply with the requirements of Section 10 of this Design Criteria. Security cameras shall be provided at pedestrian structures in accordance with Section 13 of this Design Criteria.

7.5.0 VEHICULAR STRUCTURES

7.5.1 Vehicular structures include structures or structural elements that are intended to carry vehicles or that may be incidentally subject to supporting vehicular loads. Vehicular structures include, but are not limited to: bridges, culverts, parking structures, and at-grade slabs that are not fully supported by underlying soils. Determination of requirement for or exclusion from design for incidental vehicle loading shall consider possible access by fire truck, delivery truck, or maintenance vehicle, and shall be subject to approval by RTD.

7.5.2 Design for vehicular structures other than parking structures shall comply with AASHTO LRFD Bridge Design Specifications. Design live load shall be AASHTO HL-93 unless otherwise specified by RTD. For slabs in areas handling pedestrian loading and snow loads, design shall include truck loading equal to 75% of the HL-93 truck loading. Reinforcing steel in areas exposed to weather and de-icing chemicals shall be galvanized or epoxy coated.

7.5.3 Parking structures shall be designed to comply with the requirements and guidelines of the appropriate codes and manuals listed in Part 7.1.2 of this Section, including ASCE-07, ACI 318, AISC Steel Construction Manual, PCI Design Handbook and PCI Parking Structures Manual.

7.6.0 TEMPORARY STRUCTURES

Temporary structures including falsework and shoring systems shall be designed and constructed to comply with CDOT requirements for vehicular collision resistance,

All materials for temporary structures both above and below ground shall be removed unless given specific permission from RTD to leave in place.

7.7.0 REINFORCED CONCRETE

Reinforced concrete design shall be consistent with the design method established under Part 7.1.1 of this Section, and shall comply with the requirements of the appropriate design specification listed in Part 7.1.2.

Concrete shall be specified in construction documents in conformance with concrete class and strength designations provided in Section 601 of CDOT Standard Specification for Road and Bridge Construction, unless otherwise approved by RTD.

The use of lightweight concrete in structural members is not allowed.

Detailing of concrete reinforcement shall comply with the requirements of the applicable design specification of Part 7.1.2 of this Section, and for bridges, shall be consistent with CDOT Standard Specifications for Road and Bridge Construction.

Epoxy coated reinforcing steel shall be used in all bridges, walls, tunnels and box culverts as required to comply with the CDOT Bridge Design Manual, Subsection No. 8.1, Table 1. The design category for anticipated level of de-icing salt application shall be "High" unless otherwise specified by RTD.

Epoxy coated reinforcement shall be used at other types of reinforced concrete structures and structure components that are expected to be exposed to de-icing salts such as stairways, bus pads, and slabs on grade. Protection of reinforcement for these structures shall be based on the criteria provided in Table 9.1 as noted above, using an anticipated level of de-icing salt application agreed upon by RTD.

7.8.0 STRUCTURAL STEEL

Structural steel design shall be consistent with the design method established under Part 7.1.1 of this Section, and shall comply with the requirements of the appropriate design specification listed in Part 7.1.2.

Steel structures shall be designed to use shop welded connections and field bolted connections to the extent practical. Shop bolted connections may be used when welding would cause difficulty with fabrication. Field welding of structural steel is discouraged due to increased difficulty in the control of welding processes, and related potential for weakened base metal and weld, and potentially reduced quality and effectiveness of protective coating on steel. Field welded connections may be used only when requested in writing by the design consultant or contractor and approved by RTD. Quality control requirements for all welding shall be submitted to RTD for approval.

Structural steel, including steel components embedded in concrete, shall be protected against corrosion with consideration of potential exposure to de-icing salts.

The use of weathering steel is discouraged and may be used only with the approval of RTD. Weathering steel shall not be used at structures with anticipated exposure to de-icing salts greater than "low".

Structural steel components that are at or near grade and will be exposed to de-icing salts, including posts and rails, shall be hot-dip galvanized after fabrication. Galvanized surfaces shall be prepared for painting in accordance with ASTM D6386, and shall be prepared for powder coating in accordance with ASTM D7803.

Structural steel embedded in concrete, including fabricated embeds, anchor bolts and anchor rods, shall be hot-dip galvanized. Threaded anchors shall be supplied with hot-dip galvanized nuts and washers. Stainless steel anchors and hardware may use as an alternative to hot-dip galvanized.

Structural steel other than weathering steel shall be painted or powder coated. The type of coating selected shall be subject to the approval of RTD. Paint or powder coating shall consist of a coating system from a single manufacturer as described in the following. Paint on bare steel shall consist of a three-component system including zinc rich primer, epoxy based 2nd coat, and polyurethane based 3rd coat. Paint on galvanized steel shall consist of a two-component system consisting of an epoxy based 1st coat and polyurethane based 2nd coat. Powder coating shall consist of a zinc rich epoxy powder primer and a polyester based topcoat.

Handrail shall be stainless steel unless otherwise directed by RTD. Stainless steel pipe shall comply with ASTM A312, Grade TP316L. Stainless steel plate and sheet steel shall comply with ASTM A666 Type 316L.

7.9.0 PRECAST AND PRESTRESSED CONCRETE

Design of precast and prestressed concrete components for bridges and retaining walls shall comply with AASHTO LRFD Bridge Design Specifications and the CDOT Bridge Design Manual. Design of precast prestressed concrete for parking structures and buildings shall comply with the requirements of ACI 318 Building Code Requirements for Structural Concrete, as amended by the PCI Design Handbook section "PCI Standard Practice."

7.10.0 POST-TENSIONED CONCRETE

Design of post-tensioned concrete for bridges shall comply with AASHTO LRFD Bridge Design Specifications and the CDOT Bridge Design Manual, and shall be consistent with CDOT Standard Specifications for Road and Bridge Construction. Design of post-tensioned

concrete for parking structures and buildings shall comply with the requirements of ACI 318 Building Code Requirements for Structural Concrete, and shall be consistent with the Post-Tensioning Institute construction procedures and specifications.

Corrosion protection for unbonded post-tensioning tendons at structures other than enclosed buildings shall comply with Post Tensioning Institute specifications for aggressive environment.

All post-tensioning components shall be produced by Post-Tensioning Institute certified plants.

7.11.0 TIMBER

For timber structures other than structures subjected to highway loading, the National Design Specification for Wood Construction, by the National Forest Products Association shall be followed. Timber structures with over 20 feet of span length shall not be allowed for permanent structures.

7.12.0 GEOTECHNICAL INVESTIGATIONS AND REPORTS

Geotechnical investigations and reports may be provided for preliminary design as well as for final design, as appropriate for the project and as approved by RTD. Preliminary geotechnical reports should provide sufficient information to support structure type selection and preliminary level structure design. Preliminary reports should be based on site-specific information, may employ limited testing, and should include recommendations for additional exploration, testing, and other information to be included in the final geotechnical investigation when appropriate. Final reports should provide all necessary site-specific information for structure design and construction.

Recommendations for frequency and depth of exploratory borings shall be provided by the geotechnical engineering consultant for approval by RTD prior to beginning the geotechnical investigation. Boring frequency for preliminary design shall consider localized subsurface irregularities and should be sufficient to provide general foundation design parameters and to identify potential problem areas. Exploratory boring plans shall be developed by the geotechnical engineer and shall be subject to the review and approval of RTD.

Guidelines for report content provided in this section are intended for use in combination with the geotechnical engineer's professional judgment to provide suitable information for structure design and construction. Geotechnical reports should generally include the following where appropriate for structure type and site conditions:

1. Site conditions (current and historic)
2. Geologic conditions
3. Subsurface conditions
4. Surficial geology
5. Plan location of borings
6. Bore logs with depth and geologic stratigraphy
7. Previous borings information
8. Legends and notes of exploratory borings
9. Groundwater potential, depth and possible fluctuations

10. Summary of laboratory test results
11. Soil corrosive potential test results
12. Sulfide content
13. Swell compression test results
14. Gradation test results
15. Liquid and Plastic Limits (LL and PL)
16. Plasticity Index (PI)
17. Moisture density relationships (dry density and optimum moisture content)
18. Modified and Standard Proctor tests
19. Dewatering requirements and recommendations
20. Monitoring requirements and recommendations
21. Potential utility conflicts
22. Structure foundation recommendations
23. Retaining wall recommendations
24. Foundation vertical capacity criteria
25. Foundation lateral capacity parameters
26. Lateral earth pressures
27. Subgrade improvement requirements for shallow foundations
28. Swelling soils mitigation recommendations
29. Seismic site class and design parameters
30. Soil corrosion assessment and mitigation measures
31. Soil sulfate evaluation and cement type recommendation
32. Other items as determined for specific site conditions

7.13.0 LOADS AND LOAD COMBINATIONS

Design loads and load combinations for structures shall comply with the appropriate codes and specifications listed in Part 7.1.2 of this Section. Load combinations for steel structures shall comply with ASCE-07 or IBC instead of the AISC Steel Manual unless otherwise approved by RTD.

Wind speed shall be taken as the higher of the values from the report “Colorado Front Range Gust Map”, dated February 28, 2006, and the local jurisdiction building code.

7.14.0 PARKING STRUCTURES

Structural systems for parking structures shall generally be precast concrete or cast-in-place concrete. RTD, at its discretion, may limit the structural system to a single type for a particular parking structure project.

Parking structures shall be designed and built as “open parking garages” as defined by the IBC unless otherwise approved by RTD.

Parking structure design shall be completed by RTD, or by a recognized parking structure design specialty firm subject to the acceptance of RTD.

Parking structure design shall generally conform to the criteria provided in ACI 362 “Guide for the Design of Durable Parking Structures” and to applicable portions of PCI MNL-129 “Parking Structures: Recommended Practice for Design and Construction”.

The use of precast concrete parking structures shall require that the Precast Concrete Manufacturer (PCM), in addition to the design, manufacture, and installation of all precast components, shall perform or supervise the following:

1. Design and installation of field-placed composite concrete topping, when used, including slopes for drainage and the construction of all control joints, which shall be tooled.
2. Construction of tooled control joints at each double tee flange at field placed concrete topping (saw-cut joints are prohibited).
3. For field-topped or pre-topped systems, the supply and installation of high quality elastomeric sealant, and in addition at field topped systems, backer rod at each double tee flange joint, including the intersection of beams, walls and spandrel panels.

Potential for bird roosting in cast-in-place or precast parking structures shall be minimized by avoiding the use of ledges and horizontal projections. Precast concrete elements shall use bearing pockets or individual corbels at bearing locations.

Lateral resisting systems shall be comprised of moment frames and light-walls to the extent practical, to promote open line-of-sight within the structure.

The ceiling or under-decking portion of parking structures shall be painted/stained white in color in order to enhance lighting reflectivity. Lighting calculations shall be determined in absence of the paint or stain. RTD will review this requirement on a case by case basis.

The designer shall evaluate the potential for requiring an extended warranty for the parking structure structural system, including system function and structural integrity.

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SECTION 8 ANCILLIARY STRUCTURES AT PnRs

(DRIVER RELIEF STATIONS / ELEVATORS)

8.1.0 GENERAL

This Design Criteria establishes the minimum standards to be used in the design of RTD bus transit facilities. This section is intended to direct the Design Engineer in the design of structures used at bus transit facilities for various applications that are necessary for RTD employees to carry out their assignments. These structures are the Drivers Relief Station (DRS) and Elevators. The purpose of the DRS is to contain a toilet and sink, exclusively for District employees (primarily drivers). Depending on the site requirements, these structures may also include rooms for maintenance storage and site security equipment. The purpose of elevators is to provide vertical circulation and access to RTD facilities where the use of other options is not available or cost effective.

All DRS buildings shall be designed in accordance with ADA and ADASAD.

8.2.0 LOCATION

The DRS shall be located adjacent to bus loading areas. Specific locations will vary from site to site and the Design Engineer shall consider the location of utilities when selecting an appropriate location. The building design shall be in accordance with the following criteria:

1. Convenient access for drivers, but placed beyond pedestrian traffic flow paths in the bus loading and plaza areas.
2. All sides shall provide a clear zone for maintenance and repair.
3. All sides with access doors shall have a 6 foot (minimum) clearance for snow removal equipment.

8.3.0 SIZE AND CONFIGURATION

There are three basic configuration options for the DRS, as described below. Please reference the RTD Standard Drawings for more details regarding each configuration. Based upon special needs or site conditions, the standard configurations may be customized for a specific location, but where possible, one of the three following options should be utilized. All three standard configurations are shown in the RTD Standard Drawings.

8.3.1 Small (Lavatory and Mechanical Room) – DRS II

The basic, and most common, DRS building constructed on site will be this configuration, which contains a lavatory and a mechanical room. These two components will be found in all DRS buildings.

8.3.2 Medium (Lavatory, Mechanical and Security Rooms) – DRS III

When security equipment that needs to be housed in a secured enclosure is required on site, an additional room will be included in the DRS.

8.3.3 Large (Lavatory, Mechanical, Security and Maintenance Storage Rooms) – DRS IV

Some sites will require additional storage for maintenance equipment and supplies. When this is the case, it is preferable to have this space included as part of the DRS building rather than in a separate storage shed.

8.4.0 MATERIALS AND EQUIPMENT

8.4.1 General

The DRS shall be constructed of insulated concrete masonry units with either a convex or sloped metal roof. Each building shall be equipped with a backflow preventer in the mechanical room, or wrapped with heat tape and insulation (in a locked, weatherproof cabinet) to prevent freezing. The use of heated enclosers is discouraged, unless there is no other option.

A hose bib shall be provided within or near the DRS.

Gutters and downspouts shall be schedule 40 or 60 painted steel, and not galvanized steel, which are often damaged during installation.

Downspouts shall not discharge onto public walkways or plazas. Underdrains or chases may be necessary.

8.4.2 Lavatory

The restroom shall contain all the following components:

1. Depending on its design size, the water service to the building shall start from a public water main with a corporation stop, a tee fitting tap (dry) or a wet tap; continue to the water meter, (typically installed by the local water utility), and connect to the structure water control valve and building potable plumbing.
2. Domestic sewer service shall connect to a public sewer main a tee or wye tap (dry), or a wet tap saddle and wye, and connect to the building service sanitary plumbing.
3. The domestic water service to the building from the water meter shall be a minimum of 3/4-inch diameter, continuous non-spliced Type K copper.
4. The toilet shall be equipped with a pressure vessel in the tank. (If a one-inch, or larger, water service line is required to serve the site, the lavatory shall contain a Sloan valve tankless toilet or equal instead, with a 1 inch line to the DRS.) The tankless toilet shall be Dura Ware 2105 Series model number 2105-w-1-ULF-FVBO-HS-OFCL or approved equal. Include current model number and manufacturer. Toilet shall have a vandal resistant seat and lockable tank cover.
- ~~5.~~ A cool white fluorescent or an equivalent LED light fixture recessed in the ceiling should be used to light this room.
6. The light and exhaust fan shall be controlled by an infrared detector switch in the restroom.
7. Wall-mounted electric heating elements with fans.

8. Stainless steel mirror and sink.
9. The interior walls should be finished with two (2) coats of epoxy over block filler on the CMU wall.
10. Floors shall be painted with a slip resistant industrial grade Epoxy paint.
11. The lavatory door shall be equipped with an electronic proximity card reader and lock that is activated by RTD employee HID identification cards only. Contact RTD Facilities Maintenance and Safety & Security to determine the current lockset that is being used.
12. The use of skylights or sola tubes is discouraged due to difficulties encountered with roof curbing.
13. Electrically powered hand dryer.
14. ADA compliant grab bars shall be stainless steel.
15. Insulated hollow metal door and frame, with grout filled frame.
16. Attic insulation shall have a minimum R rating of 37
17. Toilet paper dispenser
18. Floor drain

8.4.3 Mechanical Room

The mechanical room shall contain all the following components:

1. Wall-mounted electric heating elements with fans.
2. The electrical panel for the DRS, as well as site lighting and security equipment.
3. Bosch Tronic, 3000 TES 2.5, 2 ½ gallon or equal instantaneous electric water heater shall be installed with a 0.75 GPM minimum flow rate. This heater shall not be manufactured out of plastic since the debris in the water supply may reduce the water flow, which causes the plastic parts to deform and leak.
4. The mechanical room door shall be equipped with a key lock. Contact both RTD Facilities Maintenance and Safety & Security to determine the current lockset that is being used.
5. A 24-pair phone cable shall be run to and installed within the mechanical room. The installation shall include an appropriate panel board that meets Qwest requirements for security communications. Contact both RTD Facilities Maintenance and Safety & Security to determine the current requirements.
6. Floor Drain
7. Containment and isolation back flow devices, other than for irrigation.

8.4.4 Security Room

The components necessary for the security room will vary from site to site.

The security room door shall be equipped with a key lock. Contact both RTD Facilities Maintenance and Safety & Security to determine the current lockset that is being used.

Provisions for current and future CAT 6 or fiber optic needs as well as security cameras should be considered. Contact RTD Safety and Security for the latest requirements.

8.4.5 Maintenance Storage Room

The maintenance storage room shall contain the following items:

1. A 6 foot wide, steel roll up door, or doublewide door without an astragal.
2. Properly ventilated storage space for maintenance equipment and 3 to 5 gallon fuel tanks containing gasoline or diesel fuel.
3. The door shall be equipped with a key lock. Contact both RTD Facilities Maintenance and Safety & Security to determine the current lockset that is being used.

8.5.0 ELEVATORS

8.5.1 General

Elevators will comply with Sections 6.2, 6.3.5, and 6.6.6 of the Light Rail Design Criteria with the following amendments.

8.5.1.1 Elevator Placement, add the following:

1. In addition to studying each location for prevailing wind conditions, sun exposure with respect to solar heat gain on the elevator doors should also be looked at. Improper orientation of elevators with regard to solar heat gain has caused warping of the elevator door skin, causing the elevator to malfunction.
2. If the elevators cannot be adequately positioned to protect the doors from rain, snow, wind and sun, the use of a vestibule or screening is required.

8.5.1.2 Elevator Car

1. Replace in the 3rd paragraph, the 2nd sentence "Doors shall be of hollow metal reinforced metal" with "Doors shall be of hollow reinforced metal with a stainless steel skin on the exterior side."

8.5.1.3 Specific Design Requirements, add the following:

1. Ground hole hydraulic elevators will be allowed on a site by site basis with the approval of RTD's Facilities Maintenance Division of the Safety and Security Department and the Engineering Division of Capital Programs Department.
2. In addition to the hoistway, also perform sizing calculations for the Machine Room for its mechanical and climate control equipment taking into account minimum and maximum operating temperatures of the installed equipment.

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SECTION 9 – SIGNAGE

9.1.0 GENERAL

This Design Criteria establishes the minimum standards to be used in the design of RTD bus transit facilities. This section is intended to direct the Design Engineer in the design signage at all RTD bus transit facilities. Close coordination with the RTD's Marketing Division and RTD's sign shop is required. RTD's sign shop fabricates and installs many of the wayfinding, information, and regulatory signs that are used in the PnRs and bus stops throughout the District.

9.2.0 PARK-N-RIDES AND TRANSFER FACILITIES

9.2.1 Site Identification Sign

Site identification signage is located at the entrance or entrances to the site. Sign dimensions and design shall be in accordance with the standard drawings. Location and size of the signs shall be determined on a site specific basis and shall be coordinated with RTD's Marketing Division.

Site identification signage shall be oriented to the heaviest volume of traffic approaching. The size of a sign may be restricted by local sign ordinances and may be adjusted as required by the local jurisdiction and with approval from RTD.

Variations from the standard signs (such as back-lit, instead of painted sign panels, or major modifications to the size) require prior approval from RTD.

When access points to PnRs are shared with commercial uses, the identification signs shall be combined whenever possible. This is done in an effort to create a more attractive, less cluttered look, which will be beneficial to all sites served by the access. Use of combined signage will require RTD approval and coordination with other owners.

9.2.2 Plaza Signage

Signage on the plaza area will consist of information kiosks, directional signs and bus stop signs. All plaza signage shall be in accordance with ADA and MUTCD.

Bus stop signs at transfer stations are to be located at each bus bay and will contain identification stickers for all the bus routes that stop at that bay. See section 9.3.0 for more information regarding these signs.

When plaza shelters do not contain sufficient space for route maps and schedules, additional information kiosks will be provided in the plaza area.

Information kiosks should be located adjacent to major pedestrian flow. They should be located in such a way as to not impede passenger circulation patterns between connecting bus services or restrict ADA accessibility.

When six (6) or more bus routes serve a site, there shall also be signs placed at either end of the plaza area that identify the gate assignments for each route.

Some sites may also contain variable message signs (VMS) that display real-time bus arrival information. RTD will determine where these signs will be located on a site-by-site basis.

9.2.3 Traffic Signage/Circulation

All vehicular traffic signage shall be in accordance with the Manual on Uniform Traffic Control Devices (MUTCD).

Some customization of the standard MUTCD signs may be necessary to specifically address bus traffic. For example, "BUSES EXCEPTED" might be added to a "DO NOT ENTER" sign on designated bus loops within a Park-n-Ride or transfer facility.

All pavement striping and markings shall be in accordance with the MUTCD.

9.2.4 Directional "Wayfinding Signage" Signs

Obvious, simple and clear directional signage for bus bays and between modes of transportation reduces confusion and frustration while increasing patron comfort. Signage shall conform to the latest ADA standards, the MUTCD, and RTD's Light Rail Systems Signage Standards latest version, if applicable.

When appropriate, signs will be installed to direct vehicular traffic to the PnR site. For example, when a PnR is located between interchanges on a highway, directional signs shall be placed at the nearest interchanges indicating patrons should exit there to access the PnR. If necessary, subsequent wayfinding signs shall be placed along the access route to instruct drivers where to turn. All such sign placement must be coordinated with CDOT or local jurisdictions as appropriate.

9.3.0 BUS STOP SIGNAGE

9.3.1 Sign Requirements

Red and white bus stop signs indicate stops along all RTD bus routes. Larger, more detailed signs which identify all the bus routes using that stop will be necessary at higher ridership points where numerous different routes stop. All standard red and white bus stop signs should contain at least one route number sticker.

Sign panels will be provided by RTD's sign shop and route number stickers will be added by RTD following installation.

Where bus stops include a passenger shelter, additional information displays that contain route information and schedules are typically provided.

9.3.2 Sign Location

When appropriate, the bus stop sign should be placed on existing features – i.e.: light poles, power poles. Otherwise, a new post shall be installed. If a passenger shelter is to be provided at the bus stop, the sign should be attached to the front part of the shelter, unless site constraints, visibility or other requirements specify another location.

When a bus stop requires a new sign to be installed (on a new post), the sign should be located 3 feet from the curb flowline directly in front of the bus boarding area.

The bottom of pole mounted signs shall be located 7 feet above finished grade. The pole or post shall be aluminum, or galvanized and powder coated installed in a vertical concrete aluminum sleeve that shall be exposed to a height that is below the break-away joint. The embedded sleeve shall be exposed with “three holes” above ground.

9.4.0 INFORMATION KIOSKS

Information kiosks refer to informational signs with a display surface that require a structure to support it. It can also refer to small booths and free-standing computer terminals, or interactive touchscreens.

The purpose of information kiosks is to display bus and train route maps and schedules, way-finding diagrams and area maps. Because of the relevance of the information displayed and the location of the sign, information kiosks shall be distinct pieces of urban furniture and shall be designed to contribute to the urban landscape in which they are set.

Information kiosks shall be placed in prominent locations, such as plazas and concourses at a reachable location without impeding the natural pedestrian and service movements.

Information kiosks shall be designed in accordance with all pertinent codes, regulations, local jurisdiction requirements and particular attention shall be given to the Americans with Disabilities Act Standards for Accessible Design.

Information kiosks shall be designed for ease of maintenance and durability; a life span of 30 years is recommended.

Information kiosks shall be designed to respond to the principles of “crime prevention through environmental design” and if necessary incorporate lighting and other defensible measures.

The contractor shall provide the framed kiosk, and RTD shall provide the information panels. They shall be located at convenient locations on the plaza without impeding pedestrian traffic flow, but still provide the most exposure.

In certain instances, RTD may require that the contractor provide the structure and its appurtenances, and RTD would provide the sign display, in such case, a coordinated process shall be established to guarantee a seamless assembly.

The location and design of the information kiosks shall be coordinated with the Marketing Division of the Communications Department and approved by RTD Engineering.

9.5.0 COMMEMORATIVE PLAQUES

9.5.1 General

At some facilities a commemorative plaque will be included in the design. In such cases, the design and construction of the plaza area need to incorporate an appropriate location for placement of the plaque (which is generally provided by RTD). All plaque appurtenances shall be corrosion resistant. Site requirements and plaque specifications will vary, so this element shall be coordinated with RTD's Planning Department and the Capital Programs Department.

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SECTION 10 – LIGHTING AND ELECTRICAL

10.1.0 GENERAL

The Design Criteria establish the minimum standards to be used in the design of RTD bus transit facilities. This section is intended to direct the Design Engineer in the design of lighting and electrical improvements at all RTD bus transit facilities. The procurement, construction and installation of all components required from the site transformer to their respective placement locations within the facility shall be designed, specified and shown on the appropriate design and construction drawings.

The procurement, construction and installation of all components required to the site transformer shall be the responsibility of the appropriate utility company and shall be coordinated by the Design Engineer and RTD.

10.2.0 SITE LIGHTING REQUIREMENTS

10.2.1 Light Pole Locations

The placement of lighting fixtures will be unique to each site and will be coordinated with RTD's Engineering Division. The Design Engineer shall utilize a combination of light distributions (types II, III, IV and V) to efficiently meet photometric requirements. The design shall address perimeter lighting by including placement of light poles around the perimeter of the PnR.

Passenger shelters at bus transit facilities shall be lit by "spill-light" that emanates from lighting that is placed in passenger waiting areas. Shelters shall not be lit from within.

10.2.2 Standard Equipment

In order to minimize equipment stocking requirements and to simplify the labor maintenance training and expertise, generally only Light Emitting Diode (LED) lighting fixture shall be used at all public bus transit facilities. Alternative fixtures may be used as required by the local authority or in conformance with surrounding transit oriented development with approval from RTD. Lighting fixtures within parking structures shall be LED. Fixture type shall be determined by the initial photometrics during the preliminary design phase.

The standard light pole at RTD bus transit facilities shall be steel, round, tapered with internal vibration damper. Poles shall be finished to match the lighting fixture. Pole base plates shall have a minimum inside diameter to accommodate four 1-inch electrical conduits and one 2-inch electrical conduit per RTD standard drawings.

Standard parking lot lights shall be mounted on 25 foot poles with foundations that are set 3 feet above the paved parking surface. All lights poles located within landscaped areas shall be set 3 feet above the surrounding landscaped area. The site fixtures shall consistently be 28 feet above finished grade.

Standard plaza lights shall be mounted on 14 foot poles. Plaza light pole foundations shall be set six inches (6") above the surrounding plaza paving. A collar shall be set at the base of the light pole, and shall be the same color as the light pole. The collar shall provide a finished look, enhance the aesthetic appearance of the area, and shall conceal possible minor plaza heaves or settlements. Caulking shall be applied at the base of the pole and its base plate to preclude infiltration and to isolate metallic surfaces from snow-melt salts and associated corrosion. The light poles shall be a minimum of six inches in diameter to accommodate the minimum number of conduits required.

The Design Engineer shall consider the impacts of wind for the design of light poles and pole foundations and how wind varies at elevation for poles mounted on the top tier of parking structures. Light poles shall have a minimum wind speed rating of 100 mph or higher depending on local requirements. Steel poles, rather than aluminum poles, are required.

Lighting fixtures shall permit relamping and driver replacement without the use of specialized tools. Fixtures shall be designed so that relamping or driver replacement can be accomplished in a timely manner.

10.3.0 PHOTOMETRIC REQUIREMENTS

10.3.1 Minimum and Maximum Light Levels

TABLE 10A - REQUIRED ILLUMINATION LEVELS

LOCATION <i>Reference Area Definitions for more information</i>	HORIZONTAL MAINTAINED ILLUMINANCE		
	foot-candles (fc)	uniformity	ratios
	AVERAGE >	AVG/MIN <	MAX/MIN <
Station Platform - Areas used for Train or Bus Loading, as well as Specialty Areas (See NOTE #7)	6	2:1	5:1
Transition Plaza - Adjacent to platforms providing light level transition to other areas	4	2:1	5:1
Pedestrian Access - Path or Walkway from adjacent property to Plazas and other areas	3	3:1	7:1
Surface Parking - Includes single level, outdoor parking lots and a structure's roof top parking area	2	4:1	10:1

Structure Parking - Parking spaces, drive lanes or walkways within a parking garage (open or closed)	3	3:1	7:1
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NOTES:

1. Industry recognized design guidelines or best practices shall be met where practical. These include, but not limited to, energy efficiency, maintenance and life cycle, other transit agencies' lighting systems, organizations and affiliations.
2. RTD light pole standards shall be met unless restricted by jurisdictional codes. Increased pole height is allowed to improve lighting design if it does not compromise RTD Safety, Security, Maintenance or Operational requirements.
3. Maximum initial lighting level at property line shall be $\leq 0.2\text{fc}$, unless higher values are approved by RTD.
4. All light fixtures shall be Full Cut-Off, providing down cast lighting unless required by architectural or aesthetics provisions.
5. "Maintained" luminance values are determined by multiplying a Light Loss Factor by the fixture's "initial" lumen output. LLF for each type of fixture is provided by the manufacturer(s). Other industry recognized means of calculating or the use of common approximations are allowed, if justifiable. LLF must be included in the luminaire schedules.
6. The "Initial" luminance for each location shall be calculated, after the design is complete. The lowest measured point found within a specific location shall be \geq the designed "maintained" minimum.
7. Specialty Areas include ramps, landings, safety and security equipment, bike lockers, emergency phones, information kiosks, fare verification equipment, specialty rooms for elevator equipment, electrical and communication devices. This category may also be applied to special provisions and project specific applications such as daylight adaptation, emergency egress from occupied building.
8. Nominal values for Color Rendering Index (CRI) and Correlated Color Temperature (CCT) shall be ≥ 70 and range from, 3500K to 4300K, respectively. Color Matching within a lighting system, shall require manufacturer's available chromaticity coordinates and LED binning options allowing color matching tolerance range of +/- 300K.
9. Location photometric calculation grid points shall be based on a 5ft minimum spacing.
10. Photometric values shall be computed at ground level and verified after installation.
11. Contractor shall provide RTD with all assumptions made and backup calculations for photometric layouts, including but not limited to, light loss factor (including lamp lumen depreciation and luminaire dirt depreciation), initial lumens, boundaries of illumination locations, average horizontal maintained illuminance (if foot-candles) and average/minimum and maximum/minimum uniformity ratios.

10.3.2 Light Trespass

All light poles located adjacent to property lines shall have house side shields to restrict spill light from adjacent property. The maximum initial lighting level measured at the property line shall not exceed 0.2 foot-candles or the maximum established by the local authority.

10.3.3 Light Pollution/Dark Skies Initiative

Some local authorities have passed ordinances that restrict the type of luminaires that may be used for site lighting. Mountain and rural communities tend to be more sensitive about this issue and therefore have much more stringent requirements related to site lighting. The Design Engineer should investigate if these restrictions exist and design the lighting accordingly. In general, luminaires with downcast cut-off light distributions will be acceptable to most local authorities.

For light-sensitive areas, provisions can also be negotiated that will require/allow RTD to turn off up to half of the parking lot lights after the last bus serving the site has left for the night. The plaza lights are not to be included in this arrangement, but shall remain on during all hours of darkness.

10.4.0 CONDUITS

10.4.1 Plaza Lighting and Electrical Conduits

Conduit shall be provided to and from the mechanical room of the Drivers Relief Station (DRS) building, where the site electrical panel will be located. Plaza lighting fixtures shall be linked with a minimum of three 1-inch conduit.

10.4.2 Parking Lot Lighting and Electrical Conduits

Parking lot lighting fixtures shall be connected with a minimum of two 1-inch conduits.

When Communications System equipment is required to be located on a light pole, the additional communications raceway requirements listed in section 10 of this Manual shall also be included within the pole. Those Communications conduits shall run from the hand hole on the light pole, through the light pole base, and terminate into a core raceway pull-box nearby.

Within light poles and structures where communications devices are indicated in the design, the power cabling shall be run within flexible metallic conduit that terminates at the luminaire or other electrical load and is grounded at the base of the pole or structure. The additional Communications raceway will terminate at the pole or structure hand hole or junction box and the communications cabling will be run within the pole or structure and terminate at the end device.

10.5.0 EASEMENTS

10.5.1 Electric Easements

Whenever possible, exclusive electrical easements for other entities should be avoided. Non-exclusive, existing utility easements should be utilized where possible. Should an easement be required for the electrical service or transformer for another entity, it will require the approval of RTD's Board of Directors.

During the design process, the Design Engineer shall coordinate service needs with Xcel, or other power providers for the proposed improvements.

Easements and license agreements are issued through RTD's Real Property Division. These items shall be coordinated with RTD to ensure obtaining, issuing and recording the appropriate documents.

10.6.0 AS-BUILT PLANS

10.6.1 Final "As-Built" Plans

Since RTD typically bids the lighting components of bus transit facilities as a "lump sum" item, "as-built" plan requirements shall be emphasized in the design plans and technical specifications.

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SECTION 11 – COMMUNICATIONS AND FARE COLLECTION

11.1.0 GENERAL

This Design Criteria establishes the minimum standards to be used in the design of RTD bus transit facilities. This section is intended to direct the Design Engineer in the design of communication elements, fare collection devices and associated appurtenances at all RTD bus transit facilities.

Communications elements are defined in Section 11 and the video surveillance, emergency telephone, and ancillary equipment within Section 13 of this Manual.

Fare collection devices are defined as all equipment and supporting infrastructure needed to accomplish collection or documentation of fares, which are not located on the designated transit vehicle.

Power requirements shall consist of all electrical alternating current (AC) power, equipment and conduits needed to energize a specific site.

11.2.0 PARK-N-RIDES AND TRANSFER FACILITIES

11.2.1 Communication and Fare Collection Device Locations

Park-n-Ride (PnR) communication elements and fare collection devices shall be located in areas that are convenient for the transit patron. They shall be near boarding areas, shelter areas and other public congregation and circulation areas. The size of the element or device shall be industry standard, but may vary depending upon specific needs and local ordinances.

Electronic communication information devices shall be located near bus boarding areas.

11.2.2 Plaza Signage

See Section 9.2.2 of this Manual.

11.2.3 Communication Elements

See Section 13 of this Manual for emergency telephone (ETEL), closed-circuit television (CCTV) for security, and parking management CCTV requirements.

Conduits for the communication lines shall be installed by the respective site contractor. Conduits shall be shown on the engineering drawings in both the civil section and the electrical sections.

Communication elements shall include a variety of Intelligent Transportation System (ITS) devices, which shall be integrated into each facility on a unique site-by-site basis in order to improve the overall system performance in terms of travel time, reliability, convenience, operational efficiency, safety and security. ITS items that shall be considered include: devices that

enhance vehicle priority, operations and maintenance management, operator communications, real-time passenger information, parking management pay stations, and safety and security systems. SCADA systems shall be considered for all facilities. The final determination shall be coordinated and approved by RTD during the preliminary design phase.

11.2.4 Fare Collection Devices

Bus fare collection currently occurs by submitting on-board cash directly into the bus fare box or by showing pre-purchased tickets, passes or transfers that are acknowledged by the bus operator.

Ticket Vending Machines (TVM) are not currently a bus transit fare collection option. However, with the introduction of bus rapid transit (BRT), and in an effort to improve and enhance fare collection efficiencies, "smart cards," RFID readers and cards, and TVMs are being evaluated by RTD for future bus service applications.

It is unlikely that street-side standard bus stops will utilize TVMs. TVMs are probable for BRT stops, major PnRs and major transfer facilities.

Design Engineers, in coordination with and approval by RTD or RTD representatives, shall incorporate flexible options to include future TVM installations, which shall include consideration of device, location and conduit placement.

The Design Engineer shall coordinate with and obtain approval from RTD or RTD representatives on the need and design for TVM enclosures and canopies.

11.3.0 BRT AND STANDARD STREET SIDE BUS STOPS

11.3.1 Sign Requirements

Communication signage at BRT stops shall be similar to plaza areas for PnR and LRT station stops.

Street side standard bus stop signage is discussed in Section 9. In general, electronic information signage will not be used at these locations unless technology and special circumstances dictate otherwise.

Sign panels, maps, schedule, route and fare information shall be provided and installed by RTD. Route number stickers shall be placed by RTD after the sign installation is complete.

Map and route information (schedules, maps and fare listing) shall be placed within cases that are part of bus stop passenger shelters or other required locations.

11.3.2 Sign Location

Bus information signage and communication devices shall be placed in areas that experience high passenger movement and shall comply with ADA requirements. If a passenger shelter is to be provided at the site, then a case for signs should be attached to the shelter.

See Section 9 for more information on signs at street side bus stops.

When a bus stop requires a new sign to be installed (on a new post), the sign should be located according to RTD Standard Drawings.

11.3.3 Communication Elements

Safety and Security systems for video surveillance and emergency telephones shall also be installed at major BRT stops, but not at standard street side stops. See Section 13 of this Manual for security CCTV and Emergency Telephone requirements.

11.3.4 Fare Collection Devices

The infrastructure for fare collection devices shall be included in the design of BRT stops, but not for standard street side stops.

11.4.0 INFORMATION KIOSKS

See Section 9.4.0 of this Manual.

11.5.0 COMMUNICATIONS POWER AND RACEWAY REQUIREMENTS

11.5.1 General

The power and raceway requirements hereafter shall be in addition to other electrical and raceway requirements throughout this manual and shall be dedicated to the Communications System elements. The safety and security equipment indicated in Section 13 of this Manual shall be a part of the Communications System and supported by the Communications power and raceway subsystems.

Within light poles and structures where communications devices are indicated in the design, the power cabling shall be run within flexible metallic conduit that terminates at the luminaire or other electrical load and is grounded at the base of the pole or structure. The additional Communications raceway will terminate at the pole or structure hand hole or junction box and the communications cabling will be run within the pole or structure and terminate at the end device.

11.5.2 Power

The placement of electrical devices and fixtures will be unique for each site and shall be coordinated and approved through RTD's Engineering Division. The power needs for each site shall be individually evaluated. A minimum 50% power reserve shall be designed for each site. All of the necessary transformers, electric panels and appurtenances shall be designed according

to the unique needs of each site, and coordinated with the respective power utility company.

11.5.3 Communications Raceway

The Communications Raceway shall provide paths for both power and data cabling throughout the bus and any associated parking facilities to the communications equipment. The communications cabling shall be segregated from power cabling including within conduits, pull boxes, handholes, manholes, light poles, and structures.

Conduits shall be detailed by the designers. Conduits shall be furnished and installed by the respective contractor. All conduits shall be labeled, documented within an as-built plan set, and have pull rope installed.

Unless otherwise approved by RTD's engineering department, the power conduit shall be provided to/from the mechanical or utility room of the DRS, where the site electrical panel shall be located.

Parking lot, plaza and station communication devices and TVMs or other fare collection devices shall each be linked with the following typical raceway system. The raceway system, all throughout, shall be divided to provide separation between communications and power cable. There shall be a core part of the raceway that shall continue through appropriate-sized and designed pull-boxes, handholes, and manholes. Pull boxes, hand holes or other similar access boxes, placed in plaza or other paved areas, shall be rated for vehicular loading. The core raceway system shall traverse the facility and terminate at key locations such as: DRS building; communications house or case; parking garage security rooms for communications, power, or security; major power sources or loads; and into any other adjacent RTD building or raceway system. This core raceway shall consist of a minimum of three 2-inch conduits, or 50% of the designed cable capacity, whichever is greater and shall receive all lateral conduits to be terminated into this core raceway to support interconnection of all end devices, power sources, loads, and control panels. All raceway design and sizing shall follow the NEC guidance for raceway cable fill calculations with regard to communications cable. The core raceway shall include an appropriately-sized pull box at the termination points, close by end devices where lateral raceway terminates into the core raceway, at major intersections, and where future elements are expected to terminate into the core raceway.

Parking Structures shall have a combination of lateral raceway as earlier described as well as vertical risers from the centrally located security room and first level junction boxes. The raceways will consist of wall mounted junction boxes a minimum of 8' Above Finished Floor. The junction boxes will contain power circuits, plywood backing, DIN rails and other devices as necessary to support the end devices. The details will be determined depending on the particular application. The wall mounted junction boxes will connect to smaller ceiling mounted junction boxes with a minimum of

one 2" conduit to extend the raceway to all appropriate parts of the parking garage. Pull-rope will be installed in all conduits. In the case of distance limitations outside of the parking garage, Comm Cases will be used to extend the lateral network raceway as appropriate.

The security camera vendor will then extend the raceway from the ceiling mounted junction boxes using 1" conduit for each camera that is placed in the parking garage whose placement is approved by RTD Security Administrator.

Lateral conduit to end devices for ITS, SCADA, bus information variable message boards, public announcement devices, communications elements, station structures, or light poles shall include conduit of a minimum size of 1-inch, depending on design. Lateral conduit runs should terminate into the core raceway system as described above. All conduits shall include pull-ropes and shall be clearly marked for the intended use and so identified through the run from the source point of connection to the termination at the specified device. Each end device shall have the following minimum lateral raceway:

1. Security cameras: 1-1" comm and 1-1" power conduits (end device shall be within the Ethernet permanent link distance to the closest network switch)
2. ETEs: 1-1" power and 1-1" comm
3. Parking Pay Stations: 1-1" power and 1-1" comm
4. TVMs: 1-2" power and 1-2" comm
5. Validators: 1-1" power and 1-1" comm
6. Parking management cameras: 1-1" power and 1-1" comm

All equipment shall be properly grounded.

All station structural elements, including canopies and wind screens, shall include both communications and power conduit to support contractor's scope as well as for RTD's future expansion.

Any conduit that is stubbed up through a paved, or otherwise finished surface, shall be terminated flush with the surface with a coupling and either a plug for future use, or a riser that continues to extend the conduit up to the final termination.

To the maximum extent possible, each bus facility that is near, or adjacent to another RTD facility, shall be interconnected with the existing facility for communications purposes. This should help minimize the need for RTD to have to rely on public infrastructure such as telephone company services to communicate between facilities.

See Section 10 of this Manual for additional criteria.

11.5.4 Parking Management Pay Stations

Stations and Park-n-Ride design and requirements shall be based on the latest revision of the RTD Design Criteria. The Contractor shall provide separate circuits consisting of 20 Amp breakers, wiring and associated conduits from the Station Power Control Cabinet for the following:

1. A circuit to provide power for pay station and its associated canopy lighting
2. A circuit to the parking structure or surface lot entrances
3. A circuit to the parking structure or surface lot parking exits

The location for the pay station is near the Ticket Vending Machines, but the exact location as well as the entrance and exit parking locations shall be coordinated at the appropriate point in design when the layout of other features and pedestrian flow are known. The Contractor shall install a handhole just prior to the stubbed up flush conduits for power and communication, which are to be furnished with a PVC/GRSC elbow, coupling, and a cap for future expansion. Circuit cabling shall be installed between the PCC and handhole, labeled on both ends of the circuit and include 5 feet of slack cable on each end. Communication cabling shall be installed by a future contract. A future Contractor will make the connection to the 20 Amp breakers inside the PCC and pull the cable from the handhole up to the stub-up.

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SECTION 12 - CONSTRUCTION DOCUMENTS

12.1.0 GENERAL

Prior to obtaining construction plan approval, development improvement plans must be submitted and formally approved by local governing bodies, which may include any combination of a Planning Board, Planning and Zoning Commission/Committee, Public Works/Engineering, Board of Adjustment, City Council or County Commissioners. In rare cases, approval from a similarly designated State Commission or Board is required for developments on State land. Local development improvement approvals generally require the following reports and plans:

1. Concept Plan
2. Master Plan
3. Subdivision Plat, if not legally subdivided
4. Local Development Improvement Plan*
5. Drainage Report
6. Traffic Impact Study
7. Soils Report
8. Utility Report
9. Geologic Hazards
10. Archeological and Historic Artifacts Report
11. Others, as specified by local jurisdiction ordinance, code or development criteria

*The formal name of a local development improvement plan varies by jurisdiction. Common designations are Subdivision Improvement Plan (SIP), Final Development Plan (FDP), General Development Plan (GDP), and others as prescribed by the entity. The elements typically required with a development improvement plan drawings, but which may vary by jurisdiction, include the following items:

1. Cover Sheet
2. Project Scope/Extent
3. Existing Conditions Plan (survey)
4. Site Plan
5. Grading Plan
6. Erosion Control Plan
7. Utility Plan
8. Architectural Building Elevations
9. Photometric Plan

10. Landscape Plan

11. Construction Details

See RTD CADD Standards found under separate cover for examples and drawing style formats that shall apply in terms of placing a map index, scale, north arrow, title block, electronic file designations, etc.

12.2.0 BID DOCUMENTS

A set of Bid Document drawings shall typically contain the elements listed below. The set shall be broken into four key sections, General, Civil, Details and Systems. Depending upon the scope of the project, some of these elements may be eliminated or especially on smaller projects, combined onto a single sheet (i.e., Cover Sheet and Sheet Index). Conversely, large or complex projects may require several sheets per element.

General

1. Cover Sheet
2. Sheet Index
3. Standard Abbreviations and Symbols
4. RTD Standard Plan List
5. CDOT Standard Plan List
6. General Notes
7. Approximate Quantities

Civil

1. Project Scope/Extent
2. Existing Conditions Plan (survey)
3. Site Plan
4. Demolition Plan
5. Detour / Temporary Access Plan
6. Grading Plan
7. Erosion Control Plan (SWMP)
 - a. Erosion Control Details
8. Plaza Plan
9. Horizontal and Vertical Control Sheet
10. Paving Plan
11. Paving Details
12. Plaza Paving Details

- a. Pavement Markings and Signage Plan
- 13. Utility Plan and Profile
- 14. Storm Sewer
- 15. Water Service
- 16. Sanitary Sewer
- 17. Utility Details
- 18. Landscape Plan
 - a. Landscape Details
- 19. Irrigation Plan
 - a. Irrigation Details
- 20. Retaining Wall Layout
- 21. Retaining Wall Elevations
 - a. Retaining Wall Details
- 22. Drivers Relief Station
- 23. Foundation / Structural
- 24. Mechanical
- 25. Architectural
- 26. Traffic Signal Plan
- 27. Foundation / Structural
- 28. Traffic Signal Details

Details

- 1. Miscellaneous Details
- 2. ID Signs
- 3. Project Sign
- 4. Pedestrian Shelter Details

Systems

- 1. Electrical Legend and Schedules
- 2. Show all components from site transformer to area of use
- 3. Show contractor service connect/disconnect cabinet and switch
- 4. Electrical One-Line Diagram
- 5. Electrical Site Plan
- 6. Drivers Relief Station Electrical Plan

7. Electrical Details

12.3.0 ISSUED FOR CONSTRUCTION (IFC) DRAWINGS

A set of IFC Drawings shall be exactly the same as the Bid Set, with the following exceptions:

1. Cover Sheet shall have the title of Bid Set replaced with Construction Drawings.
 - a. Shall include the signatures of appropriate design Professional Engineer (PE) and RTD management.
 - b. Appropriate sheets within the set shall be signed and sealed by the discipline Professional Engineer or Registered Architect.
 - c. An original set of drawings shall be signed and sealed.
 - d. Comments during the bidding phase will be addressed.
2. As required, drawings shall be signed and sealed. This may also involve getting stamps or signatures from a local jurisdiction to indicate acceptance from building department, public works, engineering, etc.
3. Any sheets that were modified or added by addendum shall be inserted into the plan set with the original sheets removed and replaced.
4. If a sheet has been eliminated by addendum from the plan set, the name of the plan sheet shall be stricken through in the sheet index and the phrase **INTENTIONALLY OMITTED** added in a bold font and the sheet removed without renumbering the subsequent sheets in the set.
5. Revisions shall be noted and dated consecutively in the revisions block.
6. Sheet additions shall have a subscript attached to the sheet number (ie. 5A) and shall be noted and dated in the revision block.

12.4.0 DRAWING SCALE

While projects vary greatly in size, a site plan for a typical bus transit facility is usually drawn at scales of 1 inch = 30 or 40 feet. Care must be taken when choosing the scale of a drawing to assure that details and text will be readable on a half size drawing. When it is necessary to break up a plan view onto several sheets in order to obtain a workable scale, a key map shall be included on each sheet, with the appropriate sheet on the key map being shaded in.

See RTD CADD Standards for additional information regarding drawing scales and font sizes.

12.5.0 SPECIFICATIONS

CDOT Technical Specifications will be the basis for the Technical Specifications. Project specifications shall be prepared which are project specific for elements not addressed or are modified from the CDOT Technical Specifications. Design Engineers shall modify these Master Specifications to be site and project specific.

Where RTD Master Specifications do not exist for certain items of work, the Design Engineer shall be responsible for developing Technical Specifications (in CSI format) or as required for specific projects.

12.6.0 BID PACKAGE

The Technical Specifications, approved plans and contractual terms and conditions shall be included with all bid packages for constructing park-n-Rides and transfer facilities.

A summary of approximate planned quantities and an independent cost estimate shall be prepared, reviewed and approved prior to issuing a set of construction plans for bidding and construction.

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SECTION 13 – SYSTEM SAFETY AND SYSTEM SECURITY

13.1.0 GENERAL

The design shall address system elements according to the requirements of the applicable standards listed. This section shall apply to transit centers, bus stations, and parking structures, etc. This section shall not apply to curb side bus stops. Should any standard or requirement conflict, the most stringent standard shall apply. In accordance with RTD's System Safety and System Security Program Plan, RTD's Executive Safety and Security Committee must review and accept all design and any subsequent changes or modifications. Standards, specifications, regulations, design handbooks, safety design checklists and other sources of design guidance will be reviewed for pertinent safety design requirements applicable to the system. The design shall establish criteria derived from all applicable information. Some general system safety design requirements are:

1. Identified hazards shall be eliminated or associated risk shall be reduced through design, including material selection or substitution. When potentially hazardous materials must be used, such materials selected shall pose the least risk throughout the life cycle of the system.
2. Hazardous substances, components and operations shall be isolated from other activities, areas, personnel and incompatible materials.
3. Equipment shall be located so that access during operations, servicing, maintenance, repair or adjustment minimizes personnel exposure to hazards (e.g. hazardous chemicals, high voltage, electromagnetic radiation, cutting edges or sharp points).
4. Risk resulting from excessive environmental conditions (e.g. temperature, pressure, noise, toxicity, acceleration and vibration) shall be minimized.
5. Risk resulting from human error in system operation and support shall be minimized as part of the design effort.
6. In the case of risk from hazards that cannot be eliminated, alternatives that will minimize such risk shall be considered. (e.g. interlocks, redundancy, fail safe design, system protection, fire suppression and other protective measures, such as clothing, equipment, devices and procedures.)
7. Power sources, controls and critical components of redundant subsystems shall be protected by physical separation or shielding, or by other suitable methods mutually agreeable to the design and RTD.
8. When alternate design approaches cannot eliminate the hazard, safety and warning devices and warning and cautionary notes shall be provided in assembly, operations, maintenance and repair instructions, and distinctive markings shall be provided on hazardous components, equipment and facilities to ensure personnel and equipment protection. These shall be standardized in accordance with commonly accepted commercial practice or, if none exists, normal procedures. Where no such common practice exists, the design shall propose the method or methods to be used to RTD for review and approval. The design shall provide all warnings, cautions and distinctive markings proposed to RTD for review and

comment.

The severity of personnel injury or damage to equipment as a result of a mishap shall be minimized.

Software controlled or monitored functions shall ensure minimal initiation of hazardous events or mishaps.

Design criteria shall not include inadequate or overly restrictive requirements regarding safety. Where there is appropriate supporting information, recommend new safety criteria as required.

The raceway and conduit required for the safety and security elements listed herein shall be in accordance with the requirements of the communications system section 11.5.0 POWER AND CONDUIT REQUIREMENTS of this criteria.

13.2.0 APPLICABLE STANDARDS

The design of bus transit facilities shall be in accordance with the following standards. Should the standards requirements conflict, the most stringent requirement shall apply.

TABLE 13A – STANDARDS

Document	Title	Required (R) Guidance (G)
NFPA 101	Life Safety Code	R
Latest Revision	Americans with Disabilities Act	R
	Uniform Fire Code	R
	Local jurisdiction fire and building codes	R
Latest Revision	RTD’s System Safety and System Security Program Plan	R
Latest Revision	RTD Safety Certification Program	R
Latest Revision	RTD’s LRT Design Criteria Manual	R
MIL-STD-882D	U.S. Department of Defense – Standard Practice for System Safety	G
NFPA 70	National Electric Safety Code	R
U.S. Department of Transportation (DOT), FTA, latest revision	Transit Threat Level Response Recommendation	G
U.S. Department of Transportation (DOT), FTA, November 2002	Handbook for Transit Safety and Security Certification	R

Document	Title	Required (R) Guidance (G)
U.S. Department of Transportation (DOT), January 2000	Hazard Analysis Guidelines for Transit Projects	G
29CFR1910	Federal Occupational Safety and Health Standards (General Industry)	R
29CFR1926	Federal Occupational Safety and Health Standards (Construction Industry)	R
MIL-STD-1472D	Human Engineering Design Criteria for Military Systems, Equipment and Facilities	G
U.S. Department of Transportation (DOT), November 2004	Transit Security Design Considerations	R

13.3.0 DEFINITION OF SAFETY CONDITIONS

13.3.1 Unacceptable Conditions

The following safety critical conditions are considered unacceptable. Positive action and implementation verification is required to reduce the risk to an acceptable level.

- a. Single component failure, common mode failure, human error or design features, which could cause a mishap of catastrophic or critical severity.
- b. Dual independent component failures, dual human errors or a combination of a component failure and a human error involving safety critical command and control functions, which could cause a mishap of catastrophic or critical severity.
- c. Generation of hazardous ionizing/non-ionizing radiation or energy when no provisions have been made to protect personnel or sensitive subsystems from damage or adverse effects.
- d. Packaging or handling procedures and characteristics which could cause a mishap for which no controls have been provided to protect personnel or sensitive equipment.
- e. Hazard level categories that are specified as unacceptable.

Unacceptable hazardous conditions will be identified according to the hazard resolution matrix. Hazard classification at this level is a formal process for determining which hazards are acceptable, acceptable with review by management staff, undesirable or unacceptable. Hazard severity is a

subjective measure of the worst credible mishap resulting from personnel error, environmental conditions, design inadequacies and/or procedural efficiencies for system, subsystem or component failure or malfunction. Hazard probability is defined as the probability that a specific hazard will occur during the planned life expectancy of the system element, subsystem or component. The categories of hazard severity, hazard probability and their definitions follow:

Hazard Severity Definition

- a. Catastrophic – Death or system loss
- b. Critical – Severe injury, severe occupational illness or major system damage
- c. Marginal – Minor injury, minor occupational illness or minor system damage
- d. Negligible – Less than minor injury, occupational illness or system damage

Hazard Probability Definition

- a. Frequent – Likely to occur frequently; continuously experienced
- b. Probable – Will occur several times in the life of an item; will occur frequently in fleet/inventory
- c. Occasional – Likely to occur sometime in the life of an item; will occur several times in fleet inventory
- d. Remote – Unlikely but possible to occur in the life of an item; unlikely but can be expected to occur in fleet/inventory
- e. Improbable – So unlikely, it can be assumed occurrence may not be experienced; unlikely to occur, but possible in fleet

The following table (of the RTD System Safety and System Security Program Plan) demonstrates the relationship between severity and probability to define an unacceptable hazardous condition.

TABLE 13B – HAZARD RESOLUTION MATRIX

	Catastrophic (I)	Critical (II)	Marginal (III)	Negligible (IV)
Frequent (A)	Unacceptable	Unacceptable	Unacceptable	Acceptable/WR
Probable (B)	Unacceptable	Unacceptable	Undesirable	Acceptable/WR
Occasional (C)	Unacceptable	Undesirable	Undesirable	Acceptable
Remote (D)	Undesirable	Undesirable	Acceptable/WR	Acceptable
Improbable (E)	Acceptable/WR	Acceptable/WR	Acceptable/WR	Acceptable

Acceptable/WR means acceptable with management review.

13.3.2 Acceptable Conditions

The following approaches are considered acceptable for correcting unacceptable conditions and will require no further analysis once controlling actions are implemented and verified.

- a. For non-safety critical command and control functions; a system design that requires two or more independent human errors, or that requires two or more independent failures, or a combination of independent failure and human error.
- b. For safety critical command and control functions; a system design that requires at least three independent failures, or three human errors or a combination of three independent failures and human errors.
- c. System designs which positively prevent errors in assembly, installation or connections which could result in a mishap.
- d. System designs, which positively prevent damage propagation from one component to another or prevent sufficient energy propagation to cause a mishap.
- e. System design limitations on operation, interaction or sequencing that preclude occurrence of a mishap.
- f. System designs that provide an approved safety factor or fixed design allowance which limit, to an acceptable level, possibilities of structural failure or release of energy sufficient to cause a mishap.
- g. System designs that control energy build-up which could potentially cause a mishap (fuses, relief valves, electrical explosion proofing, etc.).
- h. System designs in which component failure can be temporarily tolerated because of residual strength or alternate operating paths so that operations can continue with a reduced but acceptable safety margin.

- i. System designs that positively alert the controlling personnel to a hazardous situation for which the capability for operator reaction has been provided.
- j. System designs which limit/control the use of hazardous materials.

13.4.0 HAZARD IDENTIFICATION, ANALYSIS, AND RESOLUTION

The Design Engineer shall develop and implement a Hazard Identification, Analysis, and Resolution process in accordance with the minimum criteria outlined in this section. The purpose of hazard analysis and resolution during the design and engineering phase of the project is several fold: to minimize or eliminate potential hazards; support early hazard identification; integrate safe operating procedures into system design and service; and provide for constant and continuous safety evaluation and assessment.

The Design Engineer shall use the requirements established in the following documents:

1. APTA Guideline's Hazard Resolution Matrix, American Public Transit Association, Manual for the Development of Bus System Safety Program Plans.
2. Military Standard 882D (MIL-STD-882D).
3. Hazard Analysis Guidelines for Transit Projects, January 2000, U.S. Department of Transportation.

Subsequent to performing the initial hazard analysis, the Design Engineer shall recommend resolution or mitigation factors to reduce the classification of identified hazards and reclassify identified hazards considering the recommended resolution.

In applying resolution to identified hazards, the Design Engineer shall utilize the following system safety precedence:

1. Design for minimum risk.
2. Incorporate safety devices.
3. Provide warning devices.
4. Develop procedures and training.

13.5.0 PRELIMINARY HAZARD ANALYSIS (PHA)

The Preliminary Hazard Analysis (PHA) activity is the engineering function, which is performed to identify the hazards and their preliminary causal factors of the system in development. The hazards are formally documented to include information regarding the description of the hazard, causal factors, the effects of the hazard, and preliminary design considerations for hazard control by mitigating each cause. Performing the analysis includes assessing hazardous components, safety-related interfaces between subsystems, environmental constraints, operation, test and support activities, emergency procedures, test and support facilities, and safety-related equipment and safeguards.

The analysis also provides an initial assessment of hazard severity and probability of occurrence. The probability assessment at this point is usually subjective and qualitative. To support the tasks and activities of a safety effort, the "causes" of the root hazard must be assessed and analyzed. These causes should be separated in four separate categories:

1. Hardware initiated causes
2. Software initiated causes
3. Human error initiated causes
4. Human error causes that were influenced by software input to the user/operator

The Design Engineer shall conduct a PHA process for the project design. PHA work shall begin upon project initiation and continue throughout the project. The Design Engineer shall provide PHA progress reports according to a mutually agreeable schedule. The Design Engineer shall provide a draft and final PHA report on the preliminary engineering. Subsequent to the preliminary engineering, the Design Engineer shall conduct a draft and final PHA report on the final design.

The PHA document itself is a living document, which must be revised and updated as the design and development progresses. It becomes the input document and information for all other hazard analyses performed on the system.

13.6.0 SAFETY AND SECURITY CERTIFICATION

Safety certification is the process of verifying that system elements comply with a formal list of safety requirements. The requirements are defined by design criteria, contract requirements, applicable codes and industry safety standards. The Design Engineer shall develop a preliminary list of safety and security certifiable items and associated design requirements based on the preliminary engineering. The safety certification process shall apply to all elements.

The Design Engineer shall identify those system elements and design standards to comply with the major steps in the safety certification process. These steps are implemented beginning with design and continue through the start of revenue operation.

1. Define and identify those safety and security elements to be certified
2. Define and identify those security-related elements to be certified
3. Define and develop a Certifiable Items List (CIL)
4. Identify safety and security requirements for each certifiable item
5. Verify and document design compliance with the safety and security requirements

The Design Engineer shall define and identify certifiable items relating to the elements listed in the following table.

Safety Certifiable Elements (minimum)

1. System Elements

Communications - Central Control System (CCS)

Comm- Supervisory Control & Data Acquisition (SCADA)

Ticket Vending Machines (TVM)

- Signaling - Bus Control
- Bus Way Signals, Gates, Crossings, Entrances and Exits
- Fire Protection & Suppression Systems
- Auxiliary Vehicles
- Grade Crossing Fixtures & Traffic Control System
- Emergency Response Equipment
- Intrusion Detection System
- Signage
- Tunnel Ventilation Control System (if req.)

2. Facility Elements

- Tunnel
- Structures
- Bus Way
- Each Station
- Parking Structures/Lots
- Control or Dispatch Center
- Maintenance Facility
- Art in Transit

3. Security Elements

- Video Surveillance (CCTV)
- Parking Structure design
- Park-n-Ride design
- Incorporation of Crime Prevention Through Environmental Design (CPTED) applied to entire design
- Station design
- Emergency telephones with blue LED light (and Radio)
- Lighting – Stations, patron areas, park-n-Rides
- Security of stairwells and elevators
- Access Control
- Portal Protection

Each certifiable item shall have a verification form consisting of a minimum of two major sections with the following minimum requirements.

Section 1 -- Design Requirements and Design Verification

The Design Engineer shall identify and define each certifiable item, design requirement(s), requirement source, applicability, and provide name and signature of person and Design Engineer responsible for identifying element and defining requirements. The Design Engineer shall separately verify design requirements and provide name and signature of person and Design Engineer responsible for concurrence for design review. For each certifiable item, the Design shall define a basis from which to judge compliance with safety requirements.

The Design Engineer shall verify that design complies with identified requirements and supporting documentation, and shall provide name and signature of person responsible and Design Engineer responsible for design verification.

Section 2 -- Construction Verification

The Design Engineer shall supply a signature section on the form or checklist for future verification that construction complies with design through inspection, testing and the provision of documentation to serve as evidence that construction complies with design.

SYSTEM SAFETY AND SECURITY WORKING GROUP (SSWG)

The Contractor shall initiate and maintain a Safety and Security Working Group (SSWG) beginning at project initiation and continuing through project completion. The SSWG shall consist of contractor personnel and RTD personnel. The Contractor shall be responsible for coordinating meetings, tracking action items, meeting agendas, and generating, maintaining and distributing meeting minutes. The SSWG shall meet at a minimum every two months, more often as needed, to address the following: system safety and security issues; Safety Open Items List (SOILs); safety and security certification progress reports; fire-life safety issues; and any other safety or security-related issue. The Contractor shall create a safety open items list for formal tracking of project safety and security issues. The SOIL shall include relevant information such as; item description, date added, current status, task assigned to, date closed. Some elements may be related to other Contracts, coordination with the other Contractors will be required.

FIRE AND LIFE SAFETY COMMITTEE (FLSC)

The Contractor shall initiate a Fire-Life Safety Committee (FLSC) beginning at project initiation and continuing through project completion. The FLSC shall consist of contractor personnel, RTD personnel and community first responders. The Contractor shall be responsible for coordinating meetings, tracking action items, meeting agendas, and generating, maintaining and distributing meeting minutes. The Contractor shall be responsible for coordinating first responder drills prior to revenue service. The FLSC shall meet at a minimum every two months, more often as needed, to address fire-life safety issues of the first responder community. Some elements may be related to other Contracts, coordination with the other Contractors will be required.

SAFETY AND SECURITY CERTIFICATION VERIFICATION REPORT

After each element is certified, the appropriate certification forms and requisite supporting item certifications, including exception lists, will be forwarded to the SSWG for review.

The SSWG will then forward the documents to the ESSC with a recommendation for approval. The ESSC will then review and approve the documents. Any questions on, or problems with, the submitted certification package will be resolved by the ESSC directly with the senior manager responsible for certifying the element. After all elements are safety and security certified to their satisfaction, the Contractor will prepare the safety and security certification verification report (SSCVR).

The SSCVR will include a copy of each signed element certification form and a master list of exceptions. For those exceptions with work-arounds, each work-around will be fully described. If a work-around will be temporary, the SSCVR will indicate the estimated duration and how full certification will be achieved. If the work-around is being recommended as an alternate to specified criteria, the SSCVR will offer justification for its acceptance as providing safety and security equivalent to the specified criteria.

If there are restrictions to the certification of any element, the SSCVR will describe the reason for the restriction, the impact of the restriction on operations, and demonstrate that the restricted operation will be safe and secure. It will also provide the estimated duration of the restricted operation and explain how certification for full operation will be achieved.

The SSCVR will also include a form listing all hazards and threats and vulnerabilities not addressed by the design criteria and the resolution or mitigation implemented for each. After approval of the SSCVR, the SSCVR will then be submitted to the General Manager for approval and signature to certify the project as safe and secure for revenue operation.

13.7.0 BUS RAPID TRANSIT RIGHT-OF-WAY FENCING AND BARRIERS

Right-of-Way (ROW) fencing and/or barriers shall be provided along the entire BRT alignment for highway oriented BRT lanes. The fencing and barriers shall be designed to address the following:

1. Act as a safety barrier to prevent vehicles, trucks, and other highway/roadway users from accidentally entering the BRT envelope
2. Shall be of sufficient height to prevent trespass
3. Shall be designed to prevent debris and roadway snow removal activity (snow plows throwing slush, ice and other debris) from entering BRT envelope and transit station areas
4. Shall incorporate safety considerations on elevated sections with respect to fall protection and providing adequate space for maintenance-of-way workers.

There may be areas where different fencing or barriers may be more appropriate and aesthetic. In these areas, the fencing and/or barrier design shall be determined on a case by case basis and the design shall be accepted by the RTD Bus Operations, System Safety and the Project Manager. Where different types of fencing/barriers connect, e.g. at-grade to elevated transition points, or at-grade to retaining wall transition points, the design shall accommodate a seamless transition accommodating the integrity of the fence/barrier. For example, a section of ROW may have a three foot jersey barrier with a six foot fence (total height nine feet) that meets up to a three foot MSE wall with a three foot fence (total height six feet). The fencing shall be designed so it tapers from the higher requirement to the lower requirement and meets the performance requirement of this section. No gaps

between transitions are allowed. For example, if the fencing/barrier terminates at a bridge monument, the fencing shall be attached to the monument. At locations where the right of way is controlled by CDOT, CDOT shall control the type of right of way fence that will be installed.

13.8.0 VIDEO SURVEILLANCE

The design shall incorporate video surveillance into the project. The video surveillance system shall be capable of transmitting real-time (30 frames per second per camera) video to RTD’s Security Command Center via RTD’s IT network and any additions or modifications required to integrate new work into RTD’s existing video management system at the Security Command Center (SCC). The design shall include all system elements including communication houses, transmission infrastructure, color digital IP cameras, and digital network video recorders. All cameras shall have low light and wide dynamic capabilities and shall produce a clear video resolution in excess of one megapixel. The design shall incorporate video surveillance covering station platforms, emergency telephones with blue LED light, elevator waiting areas, stairwell entries, parking structures, pedestrian tunnels, pedestrian bridges, and other scenes pertinent to RTD security.

All points of revenue transactions such as parking pay stations, ticket vending equipment, and payment kiosks shall have a dedicated fixed security camera positioned to capture the transaction with the customer and either the vending equipment or RTD personnel. Subject to approval by the RTD Security Systems Administrator, one camera could be sufficient where the design includes or accommodates an ETEL or equipment handling revenue transactions in close proximity and the camera can adequately capture the transactions on all devices as determined by RTD security.

The minimum number of cameras to provide coverage of these transit elements is as follows. During the review process, RTD security may require locations in addition to the below as spare to support future expansion.

TABLE 13C – MINIMUM CAMERA COVERAGE

Single level at grade station (LRT & BRT) platform of 300 feet or less *		
Platform type	Fixed color camera	Pan-Tilt-Zoom color camera
Center platform	4	2
Side/Center platform	6	2
Side/Side platform	4	4
Triple platform (side with two centers)	10	3

*For stations with vertical circulation, the minimum number of cameras is as stated above plus: one fixed color camera per elevator waiting area per floor, one fixed color camera per stairwell entry per floor, and one fixed color camera per each emergency telephone.

*For stations greater than 300 feet in length additional cameras will be required. The exact number will be dependent on the station design.

TABLE 13D – PARKING STRUCTURE CAMERAS

Vehicle spaces	Vehicle entrance	Vehicle exit	Elevator waiting area*	Stairwell entrance area*	Emergency telephone*
1 camera per 35 vehicle spaces	1 camera per vehicle entrance <u>lane</u> Cameras shall be fixed	1 camera per vehicle exit <u>lane</u> Cameras shall be fixed	1 camera per waiting area per floor	1 camera per entrance area per floor	1 camera per emergency telephone Cameras shall be fixed

*Subject to approval by the RTD Security Systems Administrator, if the design accommodates a cluster of the elevator waiting area, stairwell entrance, and emergency telephone, a single camera may be used if the video coverage of all three elements is satisfactory.

**All parking structure cameras are color, pan-tilt-zoom or 360 cameras subject to RTD approval.

TABLE 13E – PEDESTRIAN TUNNEL CAMERAS

Pedestrian Tunnel* (all cameras are color, pan-tilt-zoom, 4 cameras minimum per tunnel)	
1 camera focused on each portal entrance/exit (2 cameras)	1 camera inside each tunnel portal entrance/exit focused inside the tunnel (2 cameras)

*For tunnels in excess of 150 feet, additional cameras will be required. If a tunnel has a bend or turn, additional cameras will be required. The RTD Security Systems Administrator will determine the number of additional cameras necessary for coverage.

TABLE 13F – PEDESTRIAN BRIDGE CAMERAS

Pedestrian Bridge (all cameras are color, pan-tilt-zoom, 2 cameras minimum per bridge)
1 camera inside each bridge portal entrance/exit focused inside the tunnel

*For bridges in excess of 150 feet, additional cameras will be required. If a bridge has a bend or turn, additional cameras will be required. The RTD Security Systems Administrator will determine the number of additional cameras necessary for coverage

TABLE 13G – SURFACE PARK-N-RIDE CAMERAS

Surface park-n-ride			
Vehicle spaces	Vehicle entrance	Vehicle exit	Pan-tilt-zoom color camera*
1 fixed color camera per 25 vehicle spaces	1 fixed color camera per vehicle entrance <u>lane</u>	1 fixed color camera per vehicle exit <u>lane</u>	Minimum of 1 camera, than 1 camera per 250 spaces

*In addition to the network of fixed cameras, each Park-n-Ride shall have a minimum of one pan-tilt-zoom color camera, then 1 additional camera per 250 vehicle spaces.

Pole mount camera shall have a minimum mounting height of 12’ unless otherwise directed by RTD Security.

All camera locations shall be presented to RTD’s Security Systems Administrator for review and approval.

The video surveillance system shall be consistent with existing RTD equipment and software packages including elements such as cameras, digital network video recorders, Power Over Ethernet switches, routers, and operating system. The additional licenses required by the RTD Nice camera system shall be provided. The system shall be capable of providing real time video (30 full frames per second per camera) at RTD’s Security Command Center. The system shall record images consistent with RTD’s existing system at 15 full frames per second per camera, and shall provide recorded archive storage of 30 days at 15 full frames per second per camera. Both real-time viewing and recording shall be at full resolution of the camera.

13.9.0 EMERGENCY TELEPHONES WITH BLUE LED LIGHT

The design shall incorporate emergency telephones with blue LED light into the project. The emergency telephones with blue LED light shall be consistent with existing RTD units and meet performance requirements of RTD’s existing emergency telephone network. The design shall incorporate emergency telephones with blue LED light covering station platforms, elevator waiting areas, stairwell entries, parking structures, Park-n-Rides, pedestrian tunnels and pedestrian bridges. 120 VAC power shall be provided to each of the LED Blue Lights. The ability to provide for VOIP Emergency telephones in lieu of specified standard POTS line telephone service shall be incorporated in the design. UPS backup is required for all NVRs and emergency telephones. This includes any network devices that are used for the ETELS as well as blue lights. Emergency telephones with blue LED light shall be placed as follows.

TABLE 13H – EMERGENCY TELEPHONES WITH BLUE LED LIGHT AT STATIONS

Single level at grade station platform* (LRT & BRT)	
Platform type	Emergency telephones with blue LED light
Center platform	1
Side/ center platform	1
Side/Side platform	2
Triple platform (side with two centers)	2

* For stations with vertical circulation, one additional emergency telephone shall be placed per floor.

TABLE 13I - EMERGENCY TELEPHONES WITH BLUE LED LIGHT AT PARKING STRUCTURES

Parking Structure	
Elevator waiting area*	Stairwell entrance area*
1 emergency telephone per waiting area per floor	1 emergency telephone per stairwell entrance area per floor (if two stairwells, then 2 ET's per floor, etc.)

Subject to approval by the RTD Security Systems Administrator, if the design accommodates the elevator waiting area and stairwell entrance being adjacent to one another, a single emergency telephone may be used for that location.

For surface Park-n-Rides, a minimum of one emergency telephone shall be placed in the design, and then one additional emergency telephone per each 300 spaces. This placement and frequency of emergency phones shall be coordinated with RTD during the concept and preliminary engineering design.

If pedestrian overpasses or underpasses are incorporated into design, a minimum of one emergency telephone shall be provided for each overpass/underpass. If the overpass or bridge is isolated from other transit elements, additional emergency telephones with blue LED light may be necessary.

The emergency telephone when activated shall connect to RTD's Security Command Center (SCC) unless otherwise directed by RTD Security.

Installed Emergency telephones with blue LED light shall be constructed pursuant to a minimum NEMA 3R rating (see below) and be Underwriter Laboratory and FCC approved and ADA compliant. The phones shall draw power from the phone line and require no additional power line attachments. The phones shall be capable of off-site live monitoring of emergency conversations. The emergency phones shall be part of a networked management system that is operated by a PC, and the most updated version of Windows currently in use by RTD used for this purpose. The software management system will:

1. Establish an automatic connection with each phone on a prearranged schedule. Phones will be tested at least one time in every twenty-four hours. The connection shall be initiated either by the PC or the telephone.
2. Print an exception report at designated intervals highlighting use and malfunctions.
3. Archive and maintain all reporting both of normal functioning and malfunctions.
4. Log and archive all call activity at each phone.
5. Identify all call activity by date and time, type of activity, and location of data within memory.
6. Establish Automatic Maintenance Monitoring which reports stuck buttons, power interruption, microprocessor testing, call interrupt, handset integrity and functioning, handset off hook notification and phone line current.

NEMA 3R – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, and that will be undamaged by the external formation of ice on the enclosure. Phones will operate in a temperature range of -40 °C to +60 °C.

All emergency telephone locations shall be presented to RTD's Security Systems Administrator for review and approval.

13.10.0 CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN

The design shall incorporate Crime Prevention Through Environmental Design (CPTED) strategies to the entire design. The purpose of CPTED is to minimize potential threats and vulnerabilities to the transit system, facilities and patrons and maximize safety and security through engineering and design. Good CPTED strategies include: maximizing visibility of people, parking areas, patron flow areas and building/structure areas; providing adequate lighting minimizing shadows; graffiti guards; Mylar shatter guard protection for glass windows; landscape plantings that maximize visibility; gateway treatments; decorative fencing; perimeter control; fencing; minimizing park-n-ride and parking structure access points; elimination of structural hiding places; open lines of sight; visible stairwells and elevators meaning the exterior walls are constructed of transparent material; and painting with light.

Examples of CPTED strategy include:

1. See Section 10 for lighting levels.
2. When using shrubs, use species with a maximum height or spread that will minimize visibility obstructions. The preliminary design shall be approved by RTD prior to final design and implementation.
3. When using trees, use deciduous trees with branches no lower than six feet from ground surface.

The design shall incorporate CPTED strategies into the Threat and Vulnerability Analysis and Resolution process described in the following section, 13.11.0 Threat and Vulnerability Analysis and Resolution.

13.11.0 THREAT AND VULNERABILITY ANALYSIS AND RESOLUTION

The design shall incorporate a Threat and Vulnerability Analysis and Resolution process in accordance with the minimum criteria outlined in this section. A risk assessment is a comprehensive study of a system to identify those components most vulnerable to disruption or destruction and to assess the likely impact that such disruption or destruction would have on passengers, employees, and the RTD system. Threat and vulnerability analysis (TVA) work shall begin upon project initiation and continue throughout the project. The design shall incorporate TVA progress reports according to a mutually agreeable schedule. The design shall include a draft and final TVA report on the preliminary engineering. The TVA document itself is a living document, which must be revised and updated as the system design and development progresses. It becomes the input document and information for all other TVA performed on the system.

The process shall assign values to design elements based on their criticality to the transit system operations. The four level risk classification system listed below will be used to assess risk levels.

13.11.1 Severity Categories

See Section 13.3.1, Hazard Severity Definitions.

13.11.2 Transit Risk Assessment Levels

TABLE 13J - TRANSIT RISK ASSESSMENT LEVELS

Category	Characteristic
1	Loss of life, loss of critical information, loss of critical assets, significant impairment of mission, loss of system
2	Severe injury to employee or other individual, loss of information and physical equipment resulting from undetected or unacceptable mission delays, unacceptable system and operations unauthorized access, disruption
3	Minor injury not requiring hospitalization, undetected or delay in the detection of unauthorized entry resulting in limited access to assets or sensitive materials, no mission impairment, minor system and operations disruption
4	Less than minor injury, undetected or delay in the detection of unauthorized entry system or operations disruption

13.11.3 Probability Categories

TABLE 13K – PROBABILITY CATEGORIES

Category	Level	Specific Event
A	Certain	Possibility of Repeated Incidents
B	Highly Probable	Possibility of Isolated Incidents
C	Moderately Probable	Possibility of Occurring Sometime
D	Improbable	Practically Impossible

The design shall incorporate a risk and vulnerability assessment to determine any potential hazards or high-risk areas. The table below is an example of the type of assessment to determine risk and vulnerability.

TABLE 13L - ASSESSMENT OF RISK & VULNERABILITY (RAIL)

Public Transportation Assets	Criticality People	Criticality System
Transit Centers & Stations	High	Potentially High ²
Rail		
Track/Track Structure/Signals	Low	Potentially High ²
Cars	High ¹	
Maintenance Yards	Low	Medium
Switching Stations	Low	Medium
Electric Power		
Source for System	Medium	High
Substations	Low	Medium
Command Control Center	Low ³	High
Revenue Collection Center	Low ³	Medium
Bridges	Medium	Medium ²
Tunnels	Medium	Medium ²

Fans	Low	Medium
Vents	Low	Medium
Emergency Hatches	Low	Medium

TABLE 13M - ASSESSMENT OF RISK & VULNERABILITY (BUS)

Public Transportation Assets	Criticality People	Criticality System
Bus Terminals	High ¹	Potentially High ²
Bus Vehicles	High ¹	Low
Bus Stops/Shelters	Medium	Low
Maintenance Structures	Low ³	Medium
Fuel Storage Facility	Low	High
Command Control Center	Low ³	High
Revenue Collection Center	Low ³	Medium

¹Depends on what time of day incident occurs. Greater impact would be experienced during rush hour than non-rush hours

²Depends on location in the system where an incident occurs. An incident at a crossover or main junction would have greater impact than one at an outlying station or track segment. Also depend on the alternatives available, such as redundancies, rerouting capabilities, and other factors.

³Affects employees only

The design process shall identify any threats that have been located. These identified threats could include:

1. Criminal Activity
2. Terrorism
3. Natural disasters
4. Emergency Response

Identified risks and hazards shall be resolved to acceptable levels. The matrix below provides a source for mitigating hazards based on frequency of occurrence and severity. The matrix condenses risk resolution into a table and prioritizes the risks that are evaluated.

TABLE 13N – SEVERITY OF LOSS

Assessed Rating	Probability of Loss	1 Catastrophic	2 Very Serious	3 Moderately Serious	4 Not Serious
A	Certain				
B	Highly Probable				
C	Moderately Probable				
D	Improbable				
	1A. 1B. 1C. 2A.			Unacceptable: Implement Countermeasures to Reduce	
	2D. 2C. 2D. 3B.			Acceptable with Management Review	
	3D. 4A. 4B. 4C.			Acceptable	

The design shall present several options to the RTD in order to decrease the hazards located in the assessment. These options shall be based on the system security precedence:

1. Design the system to eliminate the risk
2. Design the system to control the risk
3. Add safety or security devices to control the risk
4. Add warning devices to control the risk
5. Institute special procedures or training to control the risk

13.12.0 PARK-N-RIDES, PARKING STRUCTURES, AND ENCLOSED UNDERGROUND OR BELOW GRADE TRANSIT FACILITIES

13.12.1 Surface Park-n-Rides

In addition to the items already listed in this chapter, design for surface park-n-Rides shall consider safety and security of patrons and the protection of property. Park-n-Ride design shall incorporate good visibility throughout the Park-n-Ride, and good visibility from surrounding streets into the Park-n-Ride for patrols by law enforcement and security personnel.

The use of landscaping shall consider maximizing visibility and eliminating hiding places and shadows. Shrubs shall not impede visibility in height and trees shall bear no branches below 6 feet from ground surface. Evergreen trees shall only be used on a limited basis and shall be placed in such a manner that

hiding spaces and visual obstructions are not created. Landscape placement shall be subject to approval by the RTD Security Systems Administrator.

Adequate and appropriate lighting is the single most effective deterrent for minimizing crime at Park-n-Rides. Lighting shall be provided in accordance with the criteria provided in Section 10 of this Manual.

The control and design of Park-n-Ride entrances and exits is important to maintaining security of Park-n-Rides. Entrances and exits shall be limited to as few as practically possible to control access and egress from the park-n-Ride site and minimize the number of entrance and exit cameras. To complement the effective use of video surveillance, traffic calming features (i.e. speed bumps) shall be considered at entrances and exits on a case-by-case basis to slow the vehicles as they enter and exit to allow adequate time for automobile license plates to be captured by video surveillance. Where speed bumps are used for these purposes, they shall include two speed bumps separated by one and one half standard vehicle lengths.

13.12.2 Parking Structures

In addition to the items already listed in this chapter, design for parking structures shall consider safety and security of patrons and the protection of property. Parking structure design shall incorporate good visibility throughout the structure, and good visibility from surrounding streets into the structure for patrols by law enforcement and security personnel. Walls inside the structure shall be limited to increase visibility and minimize hiding places throughout the structure. Openings in interior walls between levels or ramps shall be protected by mesh or chain link fencing. Openings in exterior walls at the ground level and at below grade level shall be protected by mesh, chain link fence or other treatment to prevent pedestrians from entering or exiting the structure through these openings.

The control and design of parking structure entrances and exits is important to maintaining security of the structures. Entrances and exits shall be limited to as few as practically possible to control access and egress from the structure and minimize the number of entrance and exit cameras.

Stairwell and elevator design shall maximize the interior visibility of the stairwell, elevator and elevator shaft. Materials of wall construction for these elements shall be transparent such as glass and allow visibility from at least three sides.

Each parking structure shall include a security room/office for security or law enforcement personnel.

See Section 10 for lighting criteria.

13.12.3 Underground and Below Grade Transit Facilities

Enclosed, underground, and below grade transit facilities present unique security design challenges. Design of these facilities shall maximize patron safety and security by the inclusion of counterterrorism measures. Each enclosed, underground or below grade facility shall be covered by video surveillance including: its perimeter, portals, entrances, exits, interior, and fare vending areas.

Patron station areas in these facilities shall be designed as paid fare zones. Thus, patron circulation design shall consider the availability to purchase fare media prior to entering the paid fare zones.

Where facilities serve more than one mode of transportation, the design shall incorporate a means to physically separate modal areas using automatic doors. Each modal area shall also have a separate ventilation system. This design shall allow one modal area to operate in the event of a major incident occurring in an adjacent modal area and prevent cross contamination.

Facility access control is an important aspect of design and shall be designed as follows. All access points (entrances and exits) to the facility and all interior doors shall be controlled by proximity reader access control. The proximity reader access control system shall be a Lenel system as currently installed at RTD facilities and shall be networked into the existing system. All access points or portals capable of accommodating a motor vehicle shall be equipped with automatic portal protection that will prevent unauthorized vehicles from entering the facility. The portal protection shall have a K-12 rating, shall include a guard shack, and shall be located at a minimum distance of 150 feet from the facility entry portal. Portals for train access shall include intrusion detection capable of distinguishing between an authorized train and any other unauthorized vehicle or person attempting to gain access through the train portal. Intrusion detection alarm notification shall be sent to light rail central control and RTD Security Command Center. The facility design shall incorporate a means to establish a vehicle checkpoint at a minimum distance of 150 feet from each facility vehicle entry portal.

The design shall protect the facility from progressive collapse. In the event of an internal explosion, the design shall prevent progressive collapse due to the loss of one primary column. Column design shall consider sizing, reinforcement or protection so that the threat charge will not cause the column to be critically damaged.

Loading docks and shipping/receiving areas are prohibited in underground and below grade facilities. All deliveries shall be accommodated for at the exterior of the facility above grade.

Each enclosed, underground or below grade facility shall include a security room/office for security or law enforcement personnel.

13.13.0 PUBLICLY ACCESSIBLE RECEPTACLES

Publicly accessible receptacles are any receptacle with a void space that the public can access. Examples include but are not limited to trash receptacles, bike lockers, and news racks. Placement of publicly accessible receptacles shall be subject to threat and vulnerability analysis and shall not be placed within 250 feet of a station, station area or patron gathering area for outside locations. Exceptions to this are the use of see through trash receptacles with clear plastic bags as detailed in the standard drawings, or the use of an explosion resistant trash receptacle. An explosion resistant trash receptacle shall be capable of containing an explosion of four (4) pounds of TNT or the C4 equivalent and shall be third party tested or certified. Other exceptions will be considered for bike lockers that are placed closer

than 250 feet to the platform, if it is determined that the 250 feet from the platform is not practical. In these instances a bomb resistant barrier (resisting 4 pounds of TNT or the C4 equivalent) separating the bike lockers from the platform must be constructed. In no instance shall the bike locker be placed on the platform. The location for the bike locker must be approved by RTD in writing if it is closer than the required 250 feet as this is considered a variance to the criteria. For enclosed areas, underground, or below grade transit stations, facilities, structures and tunnels, placement of publicly accessible receptacles is strictly prohibited. In parking structures, placement of publicly accessible receptacles is strictly prohibited.

13.14.0 CONFIGURATION MANAGEMENT

Any change or deviation to these design criteria must be approved by RTD in writing. Variances to the criteria must be approved by the Executive Safety and Security Committee. All project design shall be reviewed and accepted by RTD, and variances shall require the approval signature of the following personnel: Assistant General Manager, Bus Operations; Sr. Manager of Engineering; and Assistant General Manager, Safety, Security and Facilities. The signature review and acceptance procedure shall be applied at each design phase or milestone. Any change to an accepted design, shall also be subject to a signature review and acceptance process by the same personnel.

13.15.0 PARKING MANAGEMENT VIDEO

In addition to the security video requirements listed above in section 13.8, all parking structures and lots shall have parking management cameras at all entrances and exits positioned to accomplish License Plate Recognition. There shall be one parking management camera placed for each entrance and exit lane. Parking management equipment and infrastructure shall be reviewed and approved by RTD's parking management administrator.

