TRANSPORTATION DESIGN CRITERIA MANUAL

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Section 1

GENERAL PROVISIONS

1.1 GENERAL INFORMATION

1.1.1 Scope

This manual provides minimum design criteria for planning, designing, and preparing final plans for modifying and constructing transportation facilities within the Town of Castle Rock. It addresses traffic impact analysis, rights-of-way considerations, street geometrics, traffic signal design, signs and markings, transit amenities, bikeways, pedestrian facilities, neighborhood traffic calming, and pavement design. All development and redevelopment of sites, or any other proposed construction submitted for acceptance under the provisions of the ***Town of Castle Rock Development Procedures Manual*** (hereafter *Procedures Manual*) shall include adequate and appropriate transportation system planning, analysis, and design.

1.2 APPLICABILITY OF CRITERIA

These criteria and design standards together with all future amendments shall be known as the ***Town of Castle Rock Transportation Design Criteria Manual*** (hereafter "*Criteria*"). All reports, plans, analyses, and proposed transportation improvement designs submitted as a requirement of the *Procedures Manual* shall comply with these *Criteria*.

1.3 ENACTMENT AUTHORITY

The *Procedures Manual* has been adopted pursuant to the statutory authority conferred within: Article 28 of Title 30 (County Planning); Article 2 of Title 43 (State, County, and City Highway Systems); Article 67 of Title 24 (Planned Unit Development Act); Article 20 of Title 29 (Land Use Control and Conservation); and other applicable sections of Colorado Revised Statutes, as amended.

1.4 JURISDICTION

These *Criteria* shall apply to all land within the incorporated area of the Town of Castle Rock, including any public lands. These *Criteria* shall apply to all developments and facilities constructed in or on Town Rights-of-Way, easements dedicated for utilities across public or private property, easements for public use. These *Criteria* shall also apply to privately owned streets that have the same functionality as public streets i.e. streets that provide a direct thoroughfare between two public streets, excluding multi-family driveways.

1.5 INTERPRETATION AND APPLICATION OF CRITERIA

In the interpretation and application of the provisions of these *Criteria*, the following shall govern:

The provisions shall be regarded as the minimum requirements for the protection of the public health, safety, and welfare of the residents of the Town. These *Criteria* shall therefore be regarded as remedial and shall be liberally construed to further its underlying purposes.

Whenever a provision of these *Criteria* and any other provision of the *Procedures Manual* or any provision in any law, ordinance, resolution, rule or regulation of any kind, contains any requirement(s) covering any of the same subject matter, the requirements that are more restrictive or impose higher standards shall govern.

These *Criteria* shall not abrogate or annul any easements, permits, reports or construction drawings that are recorded, issued, or accepted by the Town prior to the effective date of these *Criteria*.

1.6 AMENDMENTS AND REVISIONS

The policies and criteria may be amended as new technology is developed or if experience gained in the use of these *Criteria* indicates a need for revision. All technical criteria and policy changes must be recommended by the Town Manager or designee. Minor revisions will require the approval of the Town Manager or designee. All major revisions will require adoption, by resolution, of the Town Council following a public hearing thereon. The Public Works Department shall monitor the performance and effectiveness of these *Criteria* and will recommend amendments and revisions as needed.

Examples of Minor and Major Revisions

Minor	**Major**
Grammar	Policy Changes
Submittal Requirements	
Clarifications	
Construction Detail Revision	
Technical Criteria Changes	

1.7 ENFORCEMENT RESPONSIBILITY

The Town shall review all reports, plans, analyses, and designs, submitted as a requirement of the *Procedures Manual*, for compliance with these *Criteria*. The *Procedures Manual* is enforced by the Town of Castle Rock and its authorized representatives.

1.8 REVIEW AND ACCEPTANCE

The Town shall review all proposed transportation and roadway improvements for general compliance with these *Criteria.* Approval by the Town does not relieve the owner, engineer, or designer from the responsibility of ensuring that the design, calculations, plans, specifications, construction, and record drawings are in compliance with these *Criteria* as stated in the owner's and engineer's certifications.

The Town may, but is not required to, refer submittals to other agencies that have an interest in or responsibility for transportation issues. Other review agencies may include regional, state, or federal agencies responsible for highways, streets, roadway, traffic and other transportation related issues.

1.9 RELATIONSHIP TO OTHER STANDARDS

If the State of Colorado, Federal Government, or other applicable regulatory agency imposes stricter criteria, standards, or requirements than those contained herein, such provisions shall be considered a part of the *Procedures Manual* and these *Criteria*.

1.10 PLANNING PRINCIPLES

The Town recognizes that every project is unique. The setting and character of the area, the needs of the residents and users of the transportation system are all factors that must be considered, along with the values of the community, to achieve a successful project.

The Town of Castle Rock Transportation Master Plan includes a Master Street Plan based on traffic volumes, land use and expected growth. The Master Street Plan classifies each roadway as a local, collector or arterial street. The following criteria apply to each classification. Typical roadway sections are presented in Appendix A of this manual.

1.10.1 Design Characteristics

A local circulation system functions as a traffic management method, implemented to convey vehicular, pedestrian and bicycle traffic through developed areas. Basic considerations in the design of local circulation systems must recognize the following factors:

Safety – for vehicular, pedestrian, and bicycle traffic.

Efficiency of Service – for all users including pedestrians and bicyclists.

Livability –as it is affected and shaped by traffic and transportation elements.

Economy – balancing the cost of providing the necessary infrastructure with the need to provide safe and efficient roadways and other transportation elements.

1.10.2 Principles

The following principles are an elaboration of these design characteristics. The principles are not intended as absolute criteria, as instances may occur where principles conflict. The principles should, therefore, be used as guidelines to design proper circulation systems layout.

Universal Design – The primary function of a local street is to serve the abutting properties and all street users including pedestrians, bicyclists, and drivers of passenger vehicles, waste removal vehicles, delivery trucks, and emergency vehicles. Street widths, placement of sidewalks, patterns of streets and number of intersections are related to the safe and efficient access to abutting lands. The typical street cross sections depicted in Appendix A are intended to accommodate and balance the needs of all users.

Minimize Through Trips – Through traffic on local and collector streets increases the average speed and volume and thus the accident potential, thereby reducing residential amenities. Through traffic can be discouraged by creating a circuitous route between neighborhoods and higher volume streets and by channeling or controlling median crossings along peripheral routes.

Control Access to Arterials – Local circulation systems and land development patterns should not detract from the efficiency of peripheral arterial facilities. Ideally, land development should occur so that no local residential streets require direct access to

arterial routes. The number of street access points between the local circulation system and arterial system should be minimized. Intersections along arterial routes should be properly spaced for efficient signalization and traffic flow. The streets that do intersect the arterial system will tend to have higher volumes since they are the only access points.

Vehicle Speeds are Controlled – All streets should be designed to eliminate excessive speed. On residential streets the ideal speed of vehicles should be no more than 25 mph. This can be accomplished through the use of curvilinear alignments and circuitous routes in the street system. Traffic calming devices placed along residential streets at distances no greater than 600 feet, along uninterrupted stretches, may also be utilized. The designer must utilize one or a combination of the above principles to keep the 85th percentile speed at or below 25 mph, for residential streets. The design criteria for the traffic "calming" elements included in these *Criteria* (See Section 11 – Neighborhood Traffic Management) are intended for use in the design of residential streets within newly developing neighborhoods. Traffic calming techniques and criteria to be used in existing neighborhoods are included in the Town's Neighborhood Traffic Calming Program that has been reviewed and approved by Town Council.

Minimize Pedestrian & Vehicular Conflicts – Pedestrian travel from within a residential area to points outside should require a minimum number of street crossings. This can often be achieved through proper design of street patterns, land use arrangements and pedestrian routes. Typical methods include use of cul-de-sacs, loop streets, special pedestrian routes or walkways and the proper placement of high pedestrian traffic generators. In general, while vehicular flow must be outward oriented to the peripheral arterials, pedestrian travel should be inward-oriented to avoid these heavier vehicular flows.

Minimize Space Devoted to Street Use – It is desirable to minimize local street widths to reduce construction and maintenance costs as well as to allow for the most economic land use. Streets should also have an appearance commensurate with their function. They should be in keeping with the residential character. The street cross section options provided by the Town are intended to achieve this goal.

Topography is Used to Its' Advantage – Local streets will be more attractive and economical if they are constructed to follow existing topography. Using the existing topography of the area can assist in limiting the needs for an extensive storm drainage piping system. The streets will also be more accessible during inclement weather.

Layout Streets to Achieve Optimum Subdivision of Land – The arrangement of streets should permit economical and practical patterns, shapes and sizes of development parcels. Distances between streets, the number of streets, and related elements all have a bearing on the efficiency of a subdivision. Access to adjoining properties and links to other streets is encouraged.

Phased Street Construction - Where streets longer than 150 feet temporarily dead end due to phasing, an interim turnaround shall be required. Each dead end shall be provisioned with signage per MUTCD.

Ensure Vehicular, Pedestrian and Bicycle Access –The complete transportation system should encourage and enhance bicycle, pedestrian and other non-motorized travel modes. Designers shall accommodate direct bicycle, pedestrian, and other non-motorized access through drainage channels tracts, dead ends, walls, cul-de-sacs, open space, and other barriers to reach neighborhood destinations such as homes, schools, parks, libraries, retail centers, civic spaces, and other trip generators. Where needed, as determined by the Town and to meet all current ADA standards, street designs shall include appropriate ramps, sidewalks, and other basic amenities to facilitate and encourage non-motorized transportation.

1.11 ACRONYMS

As used in these *Criteria*, the following acronyms shall apply:

ADT - Average Daily Traffic
ADAAG – American Disability Act Accessibility Guidelines
ANSI - American National Standards Institute
ASTM - American Society for Testing Materials
BMP – Best Management Practices
C&G – Curb and Gutter
CDOT – Colorado Department of Transportation
DRCOG – Denver Regional Council of Governments
DU – Dwelling Unit
e – Rate of Superelevation
FHWA – Federal Highway Administration
FL – flowline
Ft – Feet
GIS – Geographic Information Systems
HC – Horizontal Curve
HCM – Highway Capacity Manual
IREA – Intermountain Rural Electric Association

IES - Illuminating Engineering Society
ITE – Institute of Transportation Engineers
LOS – Level of Service
Max – Maximum
Min – Minimum
MGPEC - Metropolitan Government Pavement Engineering Council
mph - miles per hour
MUTCD - Manual on Uniform Traffic Control Devices
NFPA - National Fire Protection Association
P.E. - Professional Engineer
P.L.S. - Professional Land Surveyor
PCR - Point of Curb Return
PI - Point of Intersection
PVC - Polyvinyl Chloride Pipe
ROW - Right-of-Way
SD - Sight Distance
TCR - Town of Castle Rock
TDM - Transportation Demand Management
TRB – Transportation Research Board
US DOT – United States Department of Transportation
VPD - vehicles per day
VPH - vehicles per hour

1.12 DEFINTIONS

Criteria - Town of Castle Rock Transportation Design Criteria Manual

Procedures Manual - Town of Castle Rock Development Procedures Manual

Right-of-Way - Also "Public Right-of-Way", shall mean a public street, way, alley, sidewalk, easement, park, square, plaza, tract, and Town-owned lands or any other public property owned and controlled by the Town or dedicated to public use

Sight Distance Lines – The term “Sight Distance Lines” include Intersection Sight Distance Triangles, Sight Distance Easements and sight lines required for minimum Stopping Sight Distance. Each of these define areas that should be clear of obstructions that might block a driver’s view of potentially conflicting vehicles or pedestrians.

Stop Work Order – A written instruction/notice from the Town, revoking the Developer's Construction Permit and subsequent right to continue work on the project, due to non-conformance with these criteria.

1.13 REFERENCES

The most current version of the following codes are adopted as a secondary code to this Transportation Design Criteria Manual:

AASHTO - "A Policy on Geometric Design of Highways and Streets" (Greenbook)
AASHTO – "Guide for the Development of Bicycle Facilities"
AASHTO - "Guide for Design of Pavement Structures"
AASHTO – "Roadside Design Guide"
ADA – "ADA Standards for Accessible Design"
CDOT – "Roadway Design Guide"
CDOT – "M & S Standard Plans Book"
CDOT – "Model Traffic Code for Colorado"
CDOT – "Standard Specifications for Road and Bridge Construction"
CDOT - "State of Colorado - State Highway Access Code"
FHWA/U.S. DOT - "Manual on Uniform Traffic Control Devices" (MUTCD)
FHWA/U.S. DOT – "Roundabouts: An Informational Guide"
IES – "Design Guide for Roundabout Lighting"
ITE – "Traffic Access and Impact Studies for Site Development – A Recommended Practice"
ITE – "Traffic Control Devices Handbook: An ITE Informational Report"
ITE – "Trip Generation Handbook: An ITE Recommended Practice"
ITE – "Trip Generation – An ITE Informational Report"
MGPEC – "Pavement Design Standards and Construction Specifications Manual"
Town of Castle Rock – "Construction Methodology and Materials"
Town of Castle Rock – "Detail Plans List"
Town of Castle Rock – "Standard Special Provisions"
TRB – "Highway Capacity Manual" (HCM)

Section 2

ROADWAY DESIGN CRITERIA

2.1 GENERAL INFORMATION

2.1.1 Scope

This section sets forth the minimum design, technical criteria and specifications to be used in the preparation of all roadway plans.

2.1.2 Reference Materials

Within this section of the *Criteria*, "Green Book" refers to the current edition of "A Policy on Geometric Design of Highways and Streets". Other documents referenced within this section are listed in Section 1.

2.2 FUNCTIONAL CLASSIFICATION

2.2.1 Local Residential Streets (Single Family and Multi-Family)

1. Street Function and Characteristics:

A. Local residential street is a general term denoting a roadway that will serve a residential area. Its primary function is to provide direct access to adjacent residential properties and to uses normally found within residential areas, such as parks, schools, and community areas. These roadways should have limited continuity and be designed to discourage the through movement of vehicles, i.e. those vehicles having neither an origin nor a destination within the neighborhood.

B. Local residential streets should be designed to accommodate and encourage pedestrian and bicycle activity. When necessary, traffic calming measures may be required on streets where average vehicle speeds are expected to exceed the posted speed limit. This normally occurs when there are relatively straight, unobstructed street segments in excess of 600 ft. See Section 11 – Neighborhood Traffic Management.

C. Parking is allowed on this street classification, however parking is restricted within 30 feet of the PCR on approaches where traffic control is present. All other approaches and departures shall have no

parking or driveway access within 20-feet of the PCR. See Table 2.1 for minimum design standards.

2. Traffic control

Traffic control for this type of street will normally be limited to stop and yield signs. Roundabouts may be used in place of multi-way stop control. Although discouraged, traffic signals may be needed at intersections with collector streets. To prevent this, the design of the neighborhood street system should limit daily traffic volumes on streets to less than 1,500 vpd.

3. Access Conditions

Local residential streets should intersect with other local streets and minor collector streets. Local residential streets should not intersect with major collectors or arterial streets. In some cases, an entry street may be used to connect a local street to a major collector or arterial. Access to commercial properties will not be allowed. See Figure 3.1 for intersection spacing. See Section 3.2.6 for access criteria.

4. Sidewalks and Bike Lanes

Local residential streets shall have sidewalk on both sides of the street. See Table 2.1 for exceptions in neighborhoods where the housing density is considered Medium and Large Lot Residential. Streets proposed to have a single sidewalk must accommodate pedestrian transitions from neighboring areas with sidewalks on both sides. Bike lanes are not necessary on local residential streets. See Appendix A for typical cross sections. See Section 8 – Pedestrian and Bicycle Facilities.

5. Cul-de-sacs & Knuckles

Cul-de-sacs and knuckles may be incorporated into a neighborhood design. A cul-de-sac should have a maximum length of 600 ft. (measured from the right-of-way line of the intersecting street to the end of the cul-de-sac), and a maximum of 25 dwelling units. For cul-de-sac lengths in excess of 600 feet to be permitted, the Town of Castle Rock Fire Department shall determine the necessity of automatic sprinkler systems in structures beyond 600 feet. Any cul-de-sac in excess of 1,200 feet will require the approval of the Town of Castle Rock Fire Department. For cul-de-sacs in excess of 600 feet, a

maximum of 40 dwelling units will be permitted. See the Town of Castle Rock Detail Plans for cul-de-sacs and knuckle specifications and Section 2.9 for additional criteria.

6. Right-of-Way

See Appendix A for the typical sections showing the minimum right-of-way widths. Additional right-of-way may be required for auxiliary lanes. Sight distance triangles should be accounted for with restrictions, easements or within the right-of-way.

7. Technical Design Criteria:

The design criteria for local residential streets can be found in Tables 2.1, 2.2, 2.3, 2.4 and 2.5. Typical sections are shown in Appendix A.

Table 2.1
Residential Street Minimum Design Standards Matrix

Housing Density [7]	Dwelling Units per total lot acreage	Street Elements								
		Street Width [1] Parking on Both Sides	Street Width [1] Parking on One Side	Right-of-way Width [2]	Front Setback[3]	Curb Type	Sidewalk	Planting Strip	Street Trees	Traffic Calming
Residential-Large lot	2.0 or less	32' Min.	26' Min.	36' Min.	varies, based on PD	No Curb w/ 1' Edge Band [4], Mountable or Vertical Curb	Min. 2 sides [5] 5' min. each side	Optional for all neighborhood types Min. width (with overhead irrigation): 10' Min. width (with drip irrigation): 8' (See Town's Landscape & Irrigation Performance Standards and Criteria)	Incorporate into planting strips or on private property: 5' – 8' from back of walk (See Town's Landscape & Irrigation Performance Standards and Criteria)	Integrate into design as needed
Residential-Medium Lot	2.1 - 4.0	32' Min.	see note [6]	36' Min.	varies, based on PD	Mountable or Vertical Curb	Min. 2 sides [5] 5' min. each side			
Residential-Typical Suburban; **Multi-family;** **Small lot**	4.1 and Higher	32' Min.	n/a	36' Min.	varies, based on PD	Mountable or Vertical Curb	Min. 2 sides 5' min. each side			

1 - Street width is the flowline–flowline width. For streets without curb, width is measure from outside edge of edge band.
2 - Sidewalk and planting strip easements must be provided if minimum right-of-way width is utilized.
3 - The location of the sidewalk will be considered when determining the front setback. The setback should provide for parking in the driveway, without blocking the sidewalk.
4 - For streets without curb, roadside drainage swales will be necessary with drainage easements. The HOA, District or adjacent property owner will be required to maintain the roadside drainage swale and driveway culverts.
5 - Sidewalks on both sides of the street are required unless it is demonstrated that one sidewalk is adequate due to the character and/or density of the proposed neighborhood. For example: houses limited to one side of street; pedestrian routes are met through a separate trail network.
6 - 26' street widths will be considered for the lower densities of this category (2.1-3.0 DUs per acre). For 26' streets in higher densities (3.1–4.0 DUs per acre) the developer must demonstrate that parking is not necessary on both sides of the street due to circumstances such as: housing on one side of the street; housing product where on-street parking is less likely.
7 - The Town may apply different housing density categories to different neighborhoods of the same subdivision.

2.2.2 Local Mixed-Use Streets

1. Street Function and Characteristics:

A. A local mixed-use street is a general term denoting a roadway serving an area with intentionally mixed commercial and residential uses. These streets provide direct access to high density development with compatible uses separated horizontally or vertically within the same or multiple buildings.

B. The streets should be designed to accommodate and encourage pedestrian and bicycle activity. When necessary, traffic calming measures may be required on lengths of street where average vehicle speeds can be expected to exceed the posted speed limit. This will normally occur when there are unobstructed segments of street in excess of 600 ft. See Section 11 - Neighborhood Traffic Management.

C. Parking is allowed on this street classification, however parking is restricted within 30 feet of the PCR on approaches where traffic control is present. All other approaches and departures shall have no parking or driveway access within 20-feet of the PCR.

2. Traffic control

Traffic control for this type of street will normally be limited to stop and yield signs. Roundabouts may be used in place of multi-way stop control. Although discouraged, traffic signals may be needed at intersections with collector streets. The design of the mixed-use street system should limit daily traffic volumes on streets to less than 15,000 vpd.

3. Access Conditions

Local mixed-use streets should intersect with other local streets and minor collector streets. Local mixed-use streets should not intersect with major collectors or arterial streets. An entry street may be used to provide access with a major collector or arterial. See Appendix A for the entry street typical cross section. See Figure 3.1 for intersection spacing. See Section 3.2.6 for access criteria.

4. Sidewalks and Bike Lanes

Local mixed-use streets shall have sidewalk on both sides of the street. Bike lanes are not necessary on local mixed-use streets. See Appendix A for typical cross sections. See Section 8 – Pedestrian and Bicycle Facilities.

5. Cul-de-sacs & Knuckles

Cul-de-sacs and knuckles are not recommended for local mixed-use streets.

6. Right-of-Way

See Appendix A for the typical sections showing the minimum right-of-way widths. Additional right-of-way may be required for auxiliary lanes. Sight distance triangles should be accounted for with restrictions, easements or within the right-of-way.

7. Technical Design Criteria:

The technical design criteria for local mixed-use streets can be found in Tables 2.2, 2.3, 2.4 and 2.5. Typical sections are shown in Appendix A.

2.2.3 Industrial Streets

1. Street Function and Characteristics:

A. An industrial street is a general term denoting a roadway that will serve industrial properties. These streets will not provide access to single family, residential properties although access to multi-family properties may be permitted.

B. Properties being developed along these types of streets will be granted access based upon the existing conditions of the street, the amount of traffic expected at the access points, and the traffic impacts expected from the development. All of these factors must be described in the Traffic Impact Analysis (see Section 7).

2. Traffic control

Traffic control for this type of street will normally be stop signs. Roundabouts may be used in place of multi-way stop control. Traffic signals may be needed at intersections with collector and arterial streets, as warranted. The design of the industrial street system should limit daily traffic volumes on streets to less than 3,000 vpd.

3. Access Conditions

Industrial streets will connect with other industrial streets, collectors, and arterial streets. They will not intersect with residential streets. Intersection spacing will meet the criteria of local streets. See Figure 3.1 for intersection spacing.

4. Sidewalks and Bike Lanes

Industrial streets shall have sidewalks on both sides of the street. Bike lanes are typically not required unless the street is identified as a bicycle route in the Town's Transportation Master Plan. Additional pavement width & right-of-way is required to accommodate bike lanes, if necessary. See Appendix A for typical cross sections and Section 8 – Pedestrian and Bicycle Facilities.

5. Cul-de-sacs & Knuckles

Cul-de-sacs may be permitted if no other street layout is possible. Knuckles are not permitted. Cul-de-sacs may be a maximum of 600 feet in length, measured from the right-of-way line of the intersecting street to the end of the cul-de-sac, and shall have a maximum of 25 lots. For cul-de-sac lengths in excess of 600 feet to be permitted, the Town of Castle Rock Fire Department shall determine the necessity of automatic sprinkler systems in structures beyond 600 feet. Any cul-de-sac in excess of 1,200 feet will require the approval of the Town of Castle Rock Fire Department. For cul-de-sacs in excess of 600 feet, a maximum of 40 dwelling units will be permitted. The traffic impact analysis must be able to show that the maximum traffic volume on a cul-de-sac within this type of area will not serve more than 1,000 vpd. See the Town of Castle Rock Detail Plans for cul-de-sac specifications. See Section 2.9 for additional criteria.

6. Right-of-Way

See Appendix A for the typical sections showing the minimum right-of-way width. Additional right-of-way may be required for auxiliary lanes. Sight distance triangles should be accounted for with restrictions, easements or within the right-of-way.

7. Technical Design Criteria

The technical design criteria for industrial streets can be found in Tables 2.2, 2.3, 2.4 and 2.5. Typical sections are included in Appendix A.

2.2.4 Collector – Minor Residential

1. Street Function and Characteristics

A. A minor residential collector street is a general term denoting a street whose primary purpose is to move traffic through a residential area to major roadways outside of the neighborhood. While they should be continuous, care must be taken to ensure that they do not function as arterials or encourage "cut-through" traffic within residential neighborhoods.

B. The streets should accommodate both pedestrian and bicycle activity. Due to the fact that they may have traffic volumes higher than the residential streets they serve, parking should not be permitted. This type of street should have a maximum traffic volume of 7,000 vpd.

2. Traffic Control

Traffic control will normally be limited to stop signs, although when necessary, roundabouts will also be considered. At intersections with major collectors and arterials, traffic signals may also be required. Turn lanes may be required at major intersections.

3. Access Conditions

Minor residential collectors may intersect local residential and mixed-use streets, non-residential and major collectors, and arterial streets. There should be no house frontage or other accesses along the street.

See Figure 3.1 for Intersection Spacing and Section 3.2.5 for access criteria.

4. Sidewalks and Bike Lanes

Detached sidewalks will be installed along both sides of the street. A bike lane will be marked in each direction of travel. See Appendix A for the typical sections and Section 8 – Pedestrian and Bicycle Facilities.

5. Cul-de-sacs and Knuckles

Cul-de-sacs and "knuckles" shall not be permitted on this street classification.

6. Right-of-Way

See Appendix A for the typical sections showing the minimum right-of-way widths. Additional right-of-way may be required for auxiliary lanes. Sight distance triangles should be accounted for with restrictions, easements or within the right-of-way.

7. Technical Design Criteria

The technical design criteria for minor residential collector streets can be found in Tables 2.2, 2.3, 2.4 and 2.5. Typical sections are included in Appendix A.

2.2.5 Collector – Minor Non-residential

1. Street Function and Characteristics

A. A minor non-residential collector street is a general term that denotes a street whose primary purpose is to move traffic through a primarily non-residential area to major roadways outside of the neighborhood. This type of street may serve commercial, industrial and mixed-use developments.

B. A minor non-residential collector should have a maximum traffic volume of 7,000 vpd. On-street parking should not be permitted. Although they should be designed to accommodate larger volumes of traffic, care should be taken to not encourage through traffic from outside of the area to be served. A higher percentage of truck traffic

will be found on this classification of street than the residential collector.

2. Traffic Control

Traffic control will normally be limited to stop signs, although when practicable, roundabouts will also be considered. At intersections with major collectors and arterials, traffic signals may also be required. Turn lanes may be required at major intersections.

3. Access Conditions

Non-residential collectors may intersect with both local residential and mixed-use streets, residential and major collectors, and arterial streets. There should be no residential frontage permitted along this classification of street. Driveway access to commercial, industrial or mixed-use developments is permitted. See Figure 3.1 for Intersection Spacing and Section 3.2.5 for access criteria.

4. Sidewalks and Bike Lanes

Sidewalks will be located along both sides of the street to accommodate both pedestrian and bicycle traffic. Due to the larger volumes of truck and turning traffic, bike lanes will not be required except when the roadway is identified as a bicycle route in the Town's Transportation Master Plan. See Appendix A for the Typical Sections and Section 8 – Pedestrian and Bicycle Facilities.

5. Cul-de-sacs and Knuckles

Cul-de-sacs and "knuckles" shall not be permitted on this street classification.

6. Right-of-Way

See Appendix A for the typical sections showing the minimum right-of-way widths. Additional right-of-way may be required for auxiliary lanes. Sight distance triangles should be accounted for with restrictions, easements or within the right-of-way.

7. Technical Design Criteria

The technical design criteria for minor non-residential collector streets can be found in Tables 2.2, 2.3, 2.4 and 2.5. Typical sections are included in Appendix A.

2.2.6 Collector – Major

1. Street Function and Characteristics

A. A major collector's function is to provide access from the lower street classifications to the arterial street system. They will be continuous by design and provide for the unimpeded movement of traffic, but care should be taken to ensure that they do not function as arterial streets.

B. This classification of street will typically have 2 travel lanes and dedicated turn lanes. Collector streets having greater than 7,000 vpd should be considered "major" collectors. Parking shall not be permitted on this classification of street.

2. Traffic Control

Traffic control will include traffic signals, stop signs, and when practicable, roundabouts. Roundabouts should be used whenever possible so as to reduce delay. Turn lanes may be required at all intersections.

3. Access Conditions

Major collectors should be used to facilitate the movement of traffic and not to provide access to adjacent properties. They may be intersected by arterial, collector streets, and by local mixed-use categories of streets. There should be no residential frontage permitted along this classification of street. No driveway access is permitted, although curb cuts serving commercial, industrial or mixed-use developments may be permitted. See Section 3.2.5 for access criteria.

4. Sidewalks and Bike Lanes

Sidewalks will be located along both sides of the street to accommodate both pedestrian and bicycle traffic. Bike lanes will be

required for both directions of travel. See Appendix A for the Typical Sections and Section 8 – Pedestrian and Bicycle Facilities.

5. Cul-de-sacs and Knuckles

Cul-de-sacs and "knuckles" shall not be permitted on this street classification.

6. Right-of-Way

See Appendix A for the typical sections showing the minimum right-of-way widths. Additional right-of-way may be required for auxiliary lanes. Sight distance triangles should be accounted for with restrictions, easements or within the right-of-way.

7. Technical Design Criteria

The technical design criteria for major collector streets can be found in Tables 2.2, 2.3, 2.4 and 2.5. Typical sections are included in Appendix A.

2.2.7 Arterial – Minor

1. Street Function and Characteristics

A. The primary function of a minor arterial is the unimpeded movement of traffic through the Town. Minor arterials should be located adjacent to, but not within, neighborhoods. Arterials should form boundaries between developments and types of land uses.

B. A minor arterial street will be provided for traffic volumes either in excess, or expected to ultimately be in excess, of 12,000 vpd. It will typically have 2 traffic lanes in each direction with auxiliary turn lanes. Parking shall not be permitted on this classification of street.

2. Traffic Control

Traffic control will primarily be either through the use of roundabouts or traffic signals. Roundabouts should always be the first choice when practicable. When neither a traffic signal nor roundabout can be installed, access from side streets should be limited to right-in/right-out movements only.

3. Access Conditions

Control of access is a priority for this street classification. The spacing of access points/intersections should be limited to one-quarter mile intervals or more in order to optimize traffic signal progression. See Section 3.2.4 for access criteria.

4. Sidewalks and Bike Lanes

Detached sidewalks and on-street bike lanes will be provided on both sides of the street. See Appendix A for the typical sections and Section 8 – Pedestrian and Bicycle Facilities.

5. Cul-de-sacs and Knuckles

Cul-de-sacs and "knuckles" shall not be permitted on this street classification.

6. Right-of-Way

See Appendix A for the typical sections showing the minimum right-of-way widths. Additional right-of-way may be required for auxiliary lanes. Sight distance triangles should be accounted for with restrictions, easements or within the right-of-way.

7. Technical Design Criteria

The technical design criteria for minor arterial streets can be found in Tables 2.2, 2.3, 2.4 and 2.5. Typical sections are included in Appendix A.

2.2.8 Arterial – Major

1. Street Function and Characteristics

A. The function of a major arterial is the unimpeded movement of traffic through the Town. Major arterials should be located adjacent to, but not within, neighborhoods and form boundaries between developments and types of land uses.

B. A major arterial will be provided for traffic volumes either in excess, or expected to ultimately be in excess, of 15,000 vpd. It will have a

minimum of 2 traffic lanes in each direction with auxiliary turn lanes. Parking shall not be permitted on this classification of street.

2. Traffic Control

Traffic control will primarily be either through the use of roundabouts or traffic signals. Roundabouts should always be the first choice when practicable. When neither a traffic signal nor roundabout can be installed, access from side streets should be limited to right-in/right-out movements only.

3. Access Conditions

Control of access is a priority for this street classification. The spacing of access points/intersections should be limited to one-half mile intervals or more in order to optimize traffic signal progression. See Section 3.2.3 for access criteria.

4. Sidewalks and Bike Lanes

Detached sidewalks and on-street bike lanes will be provided on both sides of the street. See Appendix A for the typical sections and Section 8 – Pedestrian and Bicycle Facilities.

5. Cul-de-sacs and Knuckles

Cul-de-sacs and "knuckles" shall not be permitted on this street classification.

6. Right-of-Way

See Appendix A for the typical sections showing the minimum right-of-way widths. Additional right-of-way may be required for auxiliary lanes. Sight distance triangles should be accounted for with restrictions, easements or within the right-of-way.

7. Technical Design Criteria

The technical design criteria for minor arterial streets can be found in Tables 2.2, 2.3, 2.4 and 2.5. Typical sections are included in Appendix A.

Table 2.2 - Street Design Criteria

Criteria	Local		Industrial	Collector			Arterial	
	Residential	Mixed Use		Minor Residential	Minor Non-Residential	Major	Minor	Major
Average Daily Traffic (VPD)	< 1,500	< 15,000	< 3,000	< 7,000	< 7,000	> 7,000	> 12,000	> 15,000
Design Speed (mph)	25	25	30	30	30	35	40	45
Posted Speed (mph)	25	25	30	30	30	35	40	45
Minimum-Maximum Street Grade	1 - 8% [5, 8]	1 - 6% [8]	1 - 6% [8]	1 - 6% [8]	1 - 6% [8]	1 - 6% [8]	1 - 6% [8]	1 - 6% [8]
Minimum Center Line Radius (ft)	200'	200'	330'	330'	330'	510'	762'	1040'
Min. Tangent Between Reverse Curves	0'	0'	0'	50'	50'	100'	100'	See [1]
Vertical Curve Min. K-Value (Crest)	12	12	19	19	19	29	44	61
Vertical Curve Min. K-Value (Sag)	26	26	37	37	37	49	64	79
Min. Length Vert. Curve - Crest / Sag (ft)	See AASHTO Design Controls for Vertical Curves - Crest and Sag							
Min. Stopping Sight Distance (ft)	155' [7]	155' [7]	200' [7]	200' [7]	200' [7]	250' [7]	250' [7]	360' [7]
Min. Stopping Sight Distance at Intersections & Turning Roadways	Based on Design Speed of the Vehicle Path on the Curve (Applicable to Intersections, turning roadways and knuckles) [7]							
Travel Lane Width	See Typical Sections in Appendix							
Number of Travel Lanes								
Right-of-Way Width								
Paved Width								
Curb Type								
Sidewalk Width								
Roadway Cross Slope								
Parking Lane (Y/N)	Y	Y	Y	N	N	N	N	N
Parking Lane Width (ft)	See Typical Sections in Appendix			N/A	N/A	N/A	N/A	N/A
Bike Lane (Y/N)	N	N	N [6]	Y	N [6]	Y	Y	Y
Bike Lane Width (ft)	N/A	N/A	See Typical Sections in Appendix					
Median Width (ft)	N/A	N/A	N/A	See Typical Sections in Appendix				
Minimum Pavement Section	Based on Approved Pavement Design Report - See Pavement Design Section							
Curb Return Radii (ft) [4]								
Arterial Intersection	35' [2]	35' [2]	50'	35'	35'	35'	50'	50'
Collector Intersection	30'	30'	35'	30'	30'	30'	35'	35'
Industrial Intersection	35'	35'	35'	35'	35'	35'	50'	50'
Local Intersection	20'	30'	35'	30'	30'	30' [2]	35' [2]	35' [2]
Entry Street [3]	20'	30'	35'	30'	30'	30'	35'	35'
Intersection Spacing	See Figure 3.1							
Driveway and Street Access	See Section 3 - Access Requirements & Criteria							
Design Vehicle	SU	WB-50	WB-50	WB-50	WB-50	WB-50	WB-50	WB-67

Notes

1. Min. tangent length between curves shall be equal to or greater than the sum of Superelevation Runoff and Tangent lengths as per AASHTO Greenbook"
2. Arterial/Local and Major Collector/Local intersections are not allowed. An Entry Street may be necessary. Listed values may apply to existing intersections.
3. See Appendix A for Entry Street typical section
4. Curb returns must accommodate largest design vehicle so that conflicting approach lanes are not encroached upon.
5. The max. grade for Local Residental roads may be increased to 8% for southerly facing slopes between South 60° East and South 45° West.
6. Bike lanes shall be required when street is a proposed bike route in the Transportation Master Plan.
7. Stopping Sight Distance: The height of eye is 3.5 ft and the height of object is 2.0 ft.
8. To meet ADA Accessibility Guidelines (ADAAG) for accessible routes, a maximum grade of 5% is recommended (not required) for streets with adjacent sidewalk.

2.3 DESIGN CRITERIA - SIDEWALKS, CURB RAMPS, AND DRIVEWAYS

2.3.1 Sidewalks

1. Sidewalks or bicycle paths shall be constructed on both sides of all roadways unless specifically deleted by action of the Town Council. Per Table 2.1, some low density residential streets may limit sidewalks to one side of the street if it is demonstrated sidewalks on both sides are unnecessary. The site plan for these low density neighborhoods must be approved by Town Council.

2. Combination curb, gutter, and sidewalk shall be approved for use on local residential and industrial roadways only. Vertical curb, gutter and detached walk shall be used as shown on the typical sections in Appendix A.

2.3.2 Pedestrian Curb Ramps

1. Federal law requires ADA-compliant pedestrian curb ramps at all intersections and at certain mid-block locations for new construction or reconstruction of roadways, curb, and sidewalk. Ramps shall be constructed in accordance with the Town of Castle Rock Detail Plans.

2. Pedestrian curb ramps shall be installed at all curb returns and at all "T" intersections directly opposite either curb return.

3. Whenever referencing a handicap ramp, the designer shall call out the specific standard detail to be used to construct the ramp.

2.3.3 Driveways

1. When the number of parking spaces serviced by the driveway exceeds 10, radius returns may be required. The Town shall review the parking area size and location relative to the street, in addition to the anticipated type of vehicles, to approve the proposed type of street access; i.e. curb cut or curb returns. See Chapter 3 of these *Criteria* for entrance requirements.

2. Where curb cuts are allowed based on traffic considerations, concentrated storm water runoff must not be discharged across the sidewalk. These flows must be directed to storm sewers or a detention facility. If this is not possible due to grading restraints, radius returns and a crosspan must be used.

3. Driveway access to public streets shall be constructed in accordance with the Town of Castle Rock Detail Plans.

4. See Section 2.5.2 for driveway grades approaching public streets.

2.3.4 Design Criteria - Drainage

The storm drainage system shall be designed in accordance with the Town of Castle Rock's Storm Drainage Design and Technical Criteria Manual. In the case of a conflict caused by requirements of the Urban Storm Drainage Criteria Manual, the stricter drainage requirements should govern.

2.3.5 Crosspans

1. Crosspans are not permitted across entry streets, collectors (minor or major), or arterials (minor or major) but may occur parallel to these streets across a local street intersection. If there is storm sewer in the street within 100 feet, no crosspan shall be allowed across a local street.

2. Crosspans shall be constructed in accordance with the Town of Castle Rock Detail Plans.

3. If pavement is concrete, any drainage conveyance, such as crosspans, may be poured monolithically with the main line paving process.

4. Mid-block crosspans are not permitted.

5. Crosspans in public right-of-way shall have a minimum width of 8 feet.

2.3.6 Inlets

1. Inlets shall be located to intercept the curb flow at the point curb flow capacity is exceeded by the storm runoff. Refer to Storm Drainage Design and Technical Criteria Manual for additional details.

2. Inlets shall be installed to intercept cross-pavement flows at points of transition in superelevation. Roadways shall not be designed to allow water to sheet flow across the road pavement or across intersections.

3. Inlets are not allowed in the curb returns but will be located at or behind the tangent points of the curb returns.

4. Inlets shall be required as needed for medians with "catch" curb.

2.3.7 Cross Slope

1. Except at intersections, roadways shall be level from top of curb to top of curb (or flowline to flowline) and shall have a 2% crown.

2. Parabolic or curved crowns are not allowed. In no case shall the pavement cross slope at warped intersections exceed the grade of the through street.

3. The rate of change in pavement cross slope when warping side streets at intersections shall not exceed 1% for every 25 feet horizontally on a local roadway; 1% for every 37.5 feet horizontally on a collector roadway; or 1% for every 56.5 feet horizontally on arterial roadways.

4. Flowline profiles shall be provided wherever the flowline is not symmetrical with the street centerline profile.

2.3.8 Sidewalk Chase Drains

1. Storm water from concentrated points of discharge shall not be allowed to flow over sidewalks.

2. Sidewalk chase drains will only be allowed in special situations, on a case-by-case basis, as determined by the Town. Sidewalk chase drains, when permitted, are to be used to allow surface drainage to enter into the street gutter rather than being used to avoid the use of a standard inlet.

3. Sidewalk chase drains shall not be located within a curb cut or driveway.

4. Sidewalk chase drains shall be designed in accordance with the Town of Castle Rock Detail Plans.

2.3.9 Temporary Erosion Control

1. Temporary erosion control shall be provided in accordance with the Town's Grading, Erosion and Sediment Control Criteria.

2. Temporary erosion control is required along and at the ends of all roadways that are not completed due to project phasing, subdivision boundaries, etc. Such erosion control measures shall be maintained by the property owner in good working condition and at no cost to the Town.

2.4 HORIZONTAL ALIGNMENT

2.4.1 Horizontal Curves

Horizontal curves for all roadway types shall be designed in accordance with the latest version of the AASHTO design criteria or as shown in Table 2.2.

2.4.2 Design Speed

1. Horizontal alignment design speed shall be consistent with the requirement for vertical alignment design speed.

2. Design speed must be based on providing all geometric elements to maintain the design speed along the entire stretch of the road.

3. Drivers tend to travel somewhat faster in the downgrade than in the upgrade direction. This should be recognized in the designs for roadways on steep grades.

2.4.3 Superelevation

1. The use of superelevation shall not be allowed on any roadways with a design speed of 40 mph or less.

2. The use of superelevation on Town roadways with a design speed of 45 mph may be considered on a case-by-case basis as determined by the Public Works Department. If approved, such roadways shall be designed in conformance with these standards and the AASHTO "Green Book".

2.4.4 Sight Distance – Horizontal Alignment

1. The major considerations in alignment design are safety, grade, profile, road area, design speed, sight distance, topography, drainage, and performance of heavy-duty vehicles. Alignment should provide for safe and continuous operation at a uniform design speed. Road layout shall bear a logical relationship to existing or platted roads in adjacent properties.

2. The horizontal alignment must provide at least the minimum stopping distance for the design speed at all points. This includes visibility at intersections as well as around curves and roadside encroachments.

3. The lateral clearance, the distance from the inner edge of pavement to sight obstructions, for various radii of inner edge of pavement and design speeds, is shown graphically in the AASHTO "Green Book". The position of the driver's eye and the object sighted are assumed to be 6 feet from the inner edge of pavement, with the stopping sight distance being measured along this arc.

4. Whenever possible, intersections shall be made at right angles or radial to a curve. No intersecting angle less than 80 degrees will be allowed.

2.4.5 Stopping Sight Distance

1. See Table 2.2 for minimum stopping sight distance for the roads design speed.

2. The minimum stopping sight distance is the distance required by the driver of a vehicle traveling at the design speed to bring the vehicle to a stop after an object on the road becomes visible. Stopping sight distance is calculated in accordance with the AASHTO "Green Book", latest edition.

3. Where an object off the pavement restricts sight distance, the minimum radius of curvature is determined by the stopping sight distance. In no case shall the stopping sight distance be less than as specified in AASHTO "Green Book". A likely obstruction may be a bridge abutment, a line of columns, walls, fences, cut slopes, or buildings.

4. The sight distance design procedure shall assume a 6'–0" fence (as measured from actual finished grade) exists at all property lines except in the sight-distance triangles required at all intersections.

2.4.6 Approach Sight Distance

Intersections with yield signs or no traffic control

1. Sight Triangle – There shall be an unobstructed sight distance along both approaches of both sides at an intersection and across their included corners for distances sufficient to allow the operators of vehicles, approaching simultaneously, to see each other in time to prevent collisions at the intersection. The sight triangle shall meet requirements found in AASHTO "Green Book". See Section 2.4.8 for sight distance line criteria.

This criteria also requires the elimination of parking within the sight triangles on non-local roads and applies whether the intersecting roads are level or on grades.

2.4.7 Departure Sight Distance

Intersection Sight Distance from stop condition

1. The clear sight line for viewing traffic approaching from both the left and the right shall use the minimum intersection sight distance detailed in the AASHTO "Green Book". See Section 2.4.8 for sight triangle restrictions.

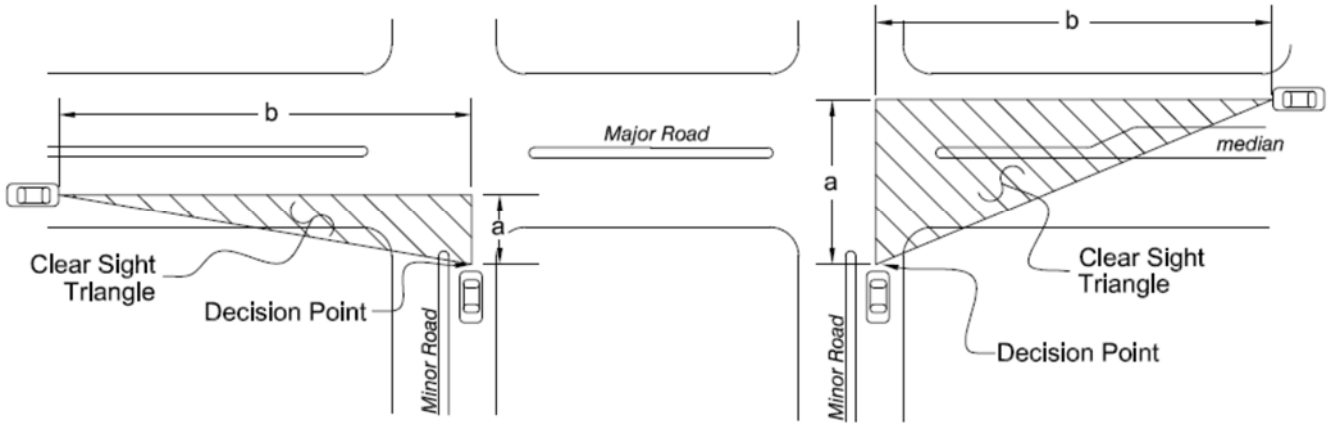
2. To determine the clear sight distance for viewing traffic approaching from the left, see AASHTO "Green Book" for the dimension of Leg "**b**" of the Departure Sight Triangle. Leg "**a"** for a two-lane road shall always be ½ of the lane width + 14.5 feet. See Figure 2.1

3. To determine the clear sight distance for viewing traffic approaching from the right, see AASHTO "Green Book" for the dimension of Leg "**b**" of the Departure Sight Triangle. Leg "**a**" for a two-lane roadway shall always be 1 lane + ½ of a lane width + 14.5 feet. The distance for Leg A and the distances shown in AASHTO "Green Book" will vary based on the width of the roadway. See Figure 2.1

4. For private driveways, a distance of 10 feet may be used in place of the 14.5 feet dimension in the Leg "a" formula above. For private driveways that have the same function of public streets (direct connection between

two public streets), the Leg "**a**" shall be the same as public street intersections.

5. The impacts of median height and landscaping on departure sight distance shall also be evaluated. The evaluation of the sight distance shall take into account both when the trees are newly planted and once mature.



Approach Sight Triangles for viewing traffic approaching the minor road from the left and the right.
(Minor Road is a Stop Condition - See Section 2.4.7 additional information)

Figure 2.1 – Intersection Sight Triangles

2.4.8 Sight Distance Line Criteria

1. No solid object (excluding fire hydrants and traffic control devices and traffic signs) exceeding thirty (30) inches in height above the flowline elevation of the adjacent street, including but not limited to buildings, utility cabinets, walls, fences, landscape plantings, crops, cut slopes, and berms, shall be placed within sight distance lines.

2. Within sight distance lines, trees with a caliper of no greater than twelve (12) inches and a branching height no less than eight (8) feet, as measured from the adjacent street flowline, will be allowed if it can be demonstrated that these trees will not negatively impact the vehicular sight distance. The tree species will be of a type that will naturally conform to these specifications when mature. All limbs must be maintained such that no branches fall below the 8 feet height.

3. Sight distance lines should be contained in the public right-of-way. In areas where sight lines unavoidably cross private property, a sight distance

easement shall be described and conveyed to the Town. In cases, where an off-site sight distance easement is necessary, the easement must be acquired by the developer and conveyed to the Town.

4. On local residential streets, the streets and lots should be designed to avoid sight lines crossing residential lots. Where sight lines on private lots are unavoidable, the sight distance line should have minimal impact on the residential lot. Sight distance lines in the front yards of residential lots shall not encroach more than five (5) feet.

5. All sight distance lines must be shown on the site plan and construction drawing plan/profile sheets.

2.4.9 Intersection Safety Triangle

At every intersection of two (2) or more existing or proposed streets, a safety triangle shall be calculated by extending a line twenty-five (25) feet in length at the point of the intersection of the edges of the driving surface of the corner property from the intersection corner and traversing across the property between the two (2) end points of such lines. Such a safety triangle shall be calculated for every corner of every intersection. Additionally, safety triangles shall be calculated at the intersections between all driveways or bike paths with streets and alleys utilizing a similar method with fifteen (15) foot lengths on the sides. Within these safety triangles there shall be no solid objects between two and one-half (2½) feet and ten (10) feet above street elevation. (Ord. 2001-37 §4, 2001)

2.4.10 Vertical Sight Distance

The vertical sight distance shall be verified to ensure that the sight distance along the major street is sufficient to allow a vehicle to cross or turn left, whichever is required. All vertical sight distance measurements must conform to AASHTO “Green Book” criteria.

2.5 VERTICAL ALIGNMENT

2.5.1 Vertical Curves

1. Vertical curves for all roadway types shall be designed in accordance with Table 2.2 or the latest version of the AASHTO design criteria.

2. K values exceeding 125 on curbed streets should be checked for drainage. Multiple inlets may be required within long sag vertical curves where the longitudinal slope is less than 0.4%.

2.5.2 Roadway Grades

1. See Table 2.2 for minimum and maximum street grades.

2. The use of grades breaks in lieu of vertical curves is discouraged. However, if a grade break is necessary and the algebraic difference in grade does not exceed one percent (1%) along the roadway, the grade break will be permitted.

3. The maximum grade break allowed at the point of tangency at a curb return for local and collector class roads shall be two percent (2%). For arterial class roads the maximum grade break at curb returns shall be one percent (1%).

4. See Table 2.3 for the maximum permissible centerline grade at intersections. These grades are maximum instantaneous flowline grades for each side of street of the minor (intersecting) street. Desirable intersection grades should be in the range of one (1) to three (3) percent for all intersecting streets with the limit of two (2) percent for arterials. ADAAG Standards for pedestrian crossings must be met at all intersections.

5. The intersection grade of the major (through) street at the intersection may be dictated by design considerations for that street. However, if the major street intersection grade exceeds 3% the type of access and access control will be dictated by the Town. See Table 2.4

6. The length of the maximum grade (4%) for private commercial/industrial driveways shall be a minimum of 25 feet measured from the flowline intersection of the public roadway.

Table 2.3
Maximum Permissible Intersection Grades for Minor Streets

		Major Street (Through Street)				
Minor Street		Local	Minor Collector	Major Collector	Minor Arterial	Major Arterial
	Local Industrial Entry Street	L – 95’ G – 4% [1]	100’ 4% [1]	100’ 4% [1]	125’ 4% [1]	125’ 4% [1]
	Minor Collector	L – G –	100’ 4% [1]	120’ 3% [1]	150’ 3% [1]	150’ 3% [1]
	Major Collector	L – G–		120’ 3% [1]	150’ 3% [1]	200’ 3% [1]
	Minor Arterial	L – G–			200’ 2%	200’ 2%
	Major Arterial	L – G–				200’ 2%

L = Minimum length of maximum permissible intersection grades for minor streets. (Measured from the flowline intersection of the minor and major street)
G = Maximum grade of the minor street within the “L” length

1 - Intersection grades shall meet the Americans with Disability Act Accessibility Guidelines (ADAAG) for maximum grades at intersections with respect to the cross slope of the crosswalks. The maximum grade may be less than shown for street approaches that have a stop condition.

Table 2.4
Maximum Permissible Intersection Grades for Major Streets

		Major Street (Through Street)					
Minor Street		Local	Industrial	Minor Collector	Major Collector	Minor Arterial	Major Arterial
	Local	5% [1]	5% [1]	5% [1]	5% [1]	5% [1]	5% [1]
	Industrial	N/A	5% [1]	5% [1]	5% [1]	5% [1]	5% [1]
	Entry Street	N/A	N/A	5% [1]	5% [1]	5% [1]	5% [1]
	Minor Collector	N/A	N/A	5% [1]	5% [1]	5% [1]	5% [1]
	Major Collector	N/A	N/A	N/A	5% [1]	5% [1]	5% [1]
	Minor Arterial	N/A	N/A	N/A	N/A	5% [1]	5% [1]
	Major Arterial	N/A	N/A	N/A	N/A	N/A	5% [1]

1 - Intersection grades shall meet the Americans with Disability Act Accessibility Guidelines (ADAAG) for maximum grades at intersections with respect to the cross slope of the crosswalks. The maximum grade may be less than shown for street approaches that have a stop condition.

2.5.3 Intersection Grades

1. The grade of the "through" street shall take precedence at intersections. At intersections of roadways with the same classification, the more important roadway, as determined by the Town of Castle Rock Public Works Department, shall have this precedence. The design should warp side streets to match through streets per Section 2.3.7.

2. The key criteria for determining the elevation of the curb return on the side street and the amount of warp needed on a side street transitioning to a through street are:

A. Pavement cross slope at the PCRs on the side street and permissible warp in pavement cross slope. (See Section 2.3.7 of these *Criteria*).

B. Normal vertical curve criteria (See Section 2.5 of these *Criteria*).

C. Vertical controls within the curb return itself (See Section 2.5.4 of these Standards).

3. The elevation at the PCR of the curb return on the through street is always set by the grade of the through street in conjunction with normal pavement cross slope allowances.

4. Carrying the crown of a side street into the through street is permitted only when drainage considerations warrant such a design.

5. Dipping the flowline to the extent that the lip of gutter is dipped is not permitted, except as specified by Town of Castle Rock Detail Plans concerning curb opening inlets. Tipping an inlet for the benefit of drainage is also not permitted.

6. A more detailed review shall be performed for arterial-arterial intersections to maximize drivability. Few arterial intersections will have a uniform 2.0% cross slope, the majority of them having one or more sides warped. (See Section 2.3.7 of these standards for rates of pavement warp allowed). A Plan View drawing of all arterial/arterial intersections will be required showing spot elevations on a 10-foot by 10-foot grid.

2.5.4 Curb Returns

1. Minimum fall around curb returns for flow along the curb line shall be as follows:

Table 2.5

Radius	MINIMUM FALL (FT)
15	0.30
20	0.40
25	0.50
30	0.60
35	0.70
40	0.80
50	1.00
Note	For Curb Returns where flows travel directly between the PCR and the PI of a crosspan, 1% is the minimum flowline grade. 1% may be used from the high point of the Curb Return to the PCR

2. Curb return profiles are required for all curb return radii equal to or greater than thirty (30) feet within the public right-of-way. A midpoint elevation along the arc length of the curb return shall be shown for all curb return radii. Curb return design shall be set in accordance with the following design procedure.

3. General standards for flowline control and profiles within the curb returns shall be as follows:

A. The point of tangency at each curb return shall be determined by the projected tangent grade beginning at the point of intersections (PI) of the flowlines.

B. The arc length of the curb return shall be computed and indicated on the drawing.

C. Show the corresponding flowline (or top of curb) grade for 25-feet on each roadway beyond the PCR.

D. Design the flowline of the curb return such that a maximum cross slope between the midpoint of the curve and the PI (tangent intersect) does not exceed eight (8) percent. Grade breaks at the PCRs will not exceed two (2) percent for local and collector streets and one (1) percent for arterials. The flowline design of the curb return will be accomplished within the return without affecting street grades beyond the PCR. Maximum vertical curves will equal the arc length of the curb return. The elevation and location of the high or low point within the return, if applicable, is to be called out in the profile.

E. Scale for the curb return profile shall match the plan and profile scale which the curb return is shown on.

2.5.5 Connections to Existing Roadways

1. Connections with existing roadways shall be smooth transitions conforming to normal vertical curve criteria if the algebraic difference in grade between the existing and proposed grade exceeds 1.0 % . When a vertical curve is used to make this transition, it shall be fully accomplished prior to the connection with the existing improvement, and also comply with the grade requirements at intersection approaches.

2. Existing grade shall be shown for at least three hundred (300) feet, with field verified record drawings, showing stations and elevations at twenty five (25) foot intervals. In the case of connection with an existing intersection, these record drawings are to be shown within a three-hundred (300) foot radius of the intersection. This information will be included in the plan and profile that shows the proposed roadway.

3. Previously approved designs are not acceptable means of establishing existing grades. However, they are to be referenced on the construction plans, where they occur.

4. The basis of the record drawing elevations shall be the same as the design elevation (i.e. either flowline or top of curb) when possible.

2.6 ROADSIDE DESIGN CRITERIA

2.6.1 Clear Zones and Recovery Zones

1. This section shall primarily apply to streets without curb, and streets with design speeds in excess of 45 mph. Clear zone mitigation may be applied in other situations where an unsafe condition is proposed or observed.

2. Roadside clear zones and recovery zones shall be designed utilizing the latest version of the AASHTO Roadside Design Guide.

3. The Recovery Zone is the area adjacent to a roadway that is needed to recover a vehicle when it leaves the roadway. This area must meet certain slope requirements and be clear from any obstructions or additional safety measures may be required. On foreslopes (also called fillslopes) a slope of 4:1 or flatter is considered recoverable. Non-recoverable foreslopes (slopes ranging from 3:1 to 4:1) shall be designed in accordance with the latest AASHTO Roadside Design Guide. Critical foreslopes (slopes steeper than 4:1) shall require guardrail or other form of roadside barrier if closer to the traveled roadway than the recommended clear zone distance.

4. The Clear Zone is the distance necessary to meet the recovery zone slope requirements for safe recovery of a motor vehicle in the event it leaves the roadway. Acceptable clear zone distance shall be determined utilizing the

latest version of the AASHTO Roadside Design Guide for determining clear zone distance.

2.6.2 Obstructions

Roadside obstructions include both non-traversable terrain and fixed objects (inlets, trees, buildings, pedestrians, etc.). Roadside obstructions within the clear zone are strongly discouraged. In the event that obstructions do exist within the clear zone, roadside barrier warrants shall be checked to determine if a roadside barrier is necessary. In the event warrants are met, the applicant shall be responsible for providing an acceptable type of roadside barrier.

2.6.3 Guard Rail

Guard Rail requirements shall meet or exceed the minimum standards set for in the AASHTO Roadside Design Guide. Guard Rail options may also be selected using the CDOT Standards.

2.7 OFFSITE DESIGN

1. The design grade, and existing ground at the design grade, of all roadways that dead end due to project phasing, subdivision boundaries, etc., shall be continued, in the same plan and profile as the proposed design, for at least five hundred (500) feet or to its intersection with an arterial roadway as determined by the Public Works Department. This limit shall be extended to one thousand (1,000) feet when arterial roadways are being designed.

2. If the offsite roadway, adjacent to the proposed development is not fully improved, the developer is responsible for the design and construction of a transition for the safe conveyance of traffic from the improved section to the existing roadway. The roadway transition should occur in the offsite area.

2.8 AUXILIARY LANES

2.8.1 Deceleration & Acceleration Lanes

1. The need for deceleration lanes shall be determined through an analysis in the approved Traffic Impact Analysis for the Site Plan or Final Development Plan.

2. Requests for exemption from the requirements for deceleration lanes shall be based upon a traffic engineering study that presents trip generation data for the proposed development in terms of impacts upon through traffic flows. Such requests shall be reviewed by the Town and may be approved, except if any of the following conditions exist during the long range traffic planning horizon:

A. For exemption of a right turn deceleration lan, the traffic volume in the travel lane must fall below 150 VPH during both the A.M. and P.M. peak hour.

B. For exemption of a left turn deceleration lane, the opposing traffic volume must fall below 100 VPH during both the A.M. and P.M. peak hour.

C. Other unique conditions that warrants special design consideration.

3. Deceleration lanes may be required along segments of collector streets if the proposed development constitutes a potential for creating a traffic hazard or unnecessarily impedes through traffic movements. In the event that deceleration lanes are required for a collector roadway, the designing engineer shall conform to all of the deceleration lane design standards detailed in the latest edition of the AASHTO “Green Book”.

4. Deceleration lanes shall have a minimum paved width of ten (10) feet.

5. The design standards for deceleration lanes on Arterial roadways were determined using the minimum standards set forth in the State of Colorado’s “State Highway Access Code - Volume 2”. The following tables detail the requirements for the determination of Roadway Classification, Acceleration and Deceleration Lengths, Taper Lengths, Storage Lengths and when each of the criteria should be accounted for in design.

6. The access classification should be determined by utilizing the Town’s Transportation Master Plan roadway designations and then determining the corresponding access classifications. The table below lists the Access Classification for Collectors and Arterial Roadways:

TABLE 2.6
ACCESS CLASSIFICATION
FOR COLLECTORS AND ARTERIALS

ROADWAY TYPE	ACCESS CLASSIFICATION
MINOR COLLECTOR	NR-C
MAJOR COLLECTOR	NR-C
MINOR ARTERIAL	NR-B
MAJOR ARTERIAL	NR-B

From the State of Colorado's State Highway Access Code Volume 2, Code Of Colorado Regulations 601-1.

7. The components of Speed Change Lanes vary based on the roadway access classification. The table below lists the components for speed change lanes for each access classification:

TABLE 2.7
COMPONENTS OF SPEED CHANGE LANES LENGTH
FOR COLLECTORS AND ARTERIALS

ACCESS CLASSIFICATION	LEFT TURN DECELERATION	RIGHT TURN DECELERATION	ACCELERATION
NR-B	TAPER + STORAGE	TAPER + STORAGE	ACCEL. LENGTH
NR-C	TAPER + STORAGE	TAPER + STORAGE	ACCEL. LENGTH

From the State of Colorado's State Highway Access Code Volume 2, Code Of Colorado Regulations 601-1.

8. The minimum Acceleration and Deceleration Lengths for Major Collectors and Arterials are detailed in the following table:

TABLE 2.8
ACCELERATION AND DECELERATION LENGTH
FOR MAJOR COLLECTORS AND ARTERIALS

DESIGN SPEED	MIN. LENGTH (FEET) ACCEL.	MIN LENGTH (FEET) DECEL.
30	190	250
35	270	310
40	380	370
45	550	435

9. Minimum storage length required based on turning vehicles per hour is detailed in the following Table 2.9. The required storage length may be distributed over multiple turn lanes.

TABLE 2.9
ACCELERATION AND DECELERATION STORAGE LENGTH
FOR COLLECTORS AND ARTERIALS

VEHICLES PER HOUR	BELOW 30	30	60	100	200	300
REQUIRED LANE LENGTH	25’	40’	50’	100’	200’	300’

10. The lead-in taper length for the deceleration lane shall be based upon the posted speed limit along the street, except that a minimum of one hundred sixty (160) feet shall be required. The following table details the taper ratios for each possible posted speed limit:

TABLE 2.10
DECELERATION TAPER LENGTH
FOR COLLECTORS AND ARTERIALS

POSTED SPEED (MPH)	**TAPER RATIO**
30	8:1
35	10:1
40	12:1
45	13.5:1
50	15:1

11. The deceleration lane and the associated signage and pavement marking shall be installed prior to the issuance of any Certificate of Occupancy within the development.

2.9 CUL-DE-SACS

2.9.1 Geometry

1. The following criteria shall be used for cul-de-sac horizontal geometry:

Minimum right-of-way radius	50 feet
Minimum flowline radius	43 feet
Maximum length of cul-de-sac, (as measured along and between the radius point and the ROW line of the abutting street whichever is greater)	1,200 feet or a maximum of 40 dwelling units

2. Cul-de-sac lengths over 600 feet require structures with built-in fire suppression. (for those structures beyond 600').

2.9.2 Number of Dwelling Units with a Single Access

The number of dwelling units with a single access shall generally be as described in Section 2.9.1.1. If an Entry street (main access to subdivision) is the single access to a group of homes, depending on the internal street alignments, up to 100 dwelling units may be allowed with written approval of the Fire Department. Factors that affect the allowable dwelling units with a single access are: the length of the streets from a through Collector or Arterial; if, after entering the Development, there is a circle drive so there is more than one way to get to a particular dwelling unit; topography; vegetation; and other considerations deemed important by the Town for emergency access.

2.10 ENTRY STREETS

1. Only minor collectors or entry streets may connect residential neighborhoods to major collectors or arterials. When minor collectors are not appropriate, entry streets shall be used and meet the following criteria:

A. A typical cross section for an entry street is shown in Appendix A. Entry streets shall be a minimum of 200' in length and/or shall extend to the

first intersection from the arterial or collector. No driveway access shall be allowed. Entry streets shall be posted "No Parking".

B. An "entry street" is considered a lower classification street than a collector but greater than a local street. Therefore, for example, entry street criteria for separation between intersections along a minor collector cannot be used to place a collector street within 160 feet of another intersection.

2.11 MEDIAN ISLANDS

1. No permanent improvements (trees, poles, large rocks, etc.) shall be placed within 10 feet of the traveled lane unless a raised planter box median (per Town of Castle Rock Detail Plans) is constructed. Permanent improvements shall not obstruct sight distance or violate clear zone requirements. Planter boxes may be allowed in raised medians on Entry Streets, Major Collectors and Arterials on a 'case-by-case' basis as approved by the Town.

2. The nose of the median island shall not extend past the curb return at the intersection. Each intersection with median islands must be designed using the appropriate design vehicle and associated turning clearance requirements for the functional classification of the roadway. The higher class roadway shall take precedence for design vehicle. Diagrams using turning templates of the design vehicle may be required as part of the roadway plan submittal. Tapered curbs should be included at the end of the median. Median islands shall be constructed with "catch" gutters and necessary storm inlets.

3. Landscaping on median islands shall have a mature height of 24 inches or less above the traveled way in areas around intersections to facilitate adequate sight distance (See Section 2.4.8) and will preferably be dry land or native vegetation. If irrigation is planned for a median island, mitigation shall be provided to protect the subgrade under the pavement from being saturated. The Town will consider proposals for mitigation including edge drains per CDOT M & S Standards.

4. A minimum flowline to flowline roadway dimension of 18 feet must be maintained on both sides of all median islands to accommodate disabled and emergency vehicles.

5. When median islands are designed for concrete streets and the island is hardscaped, two thicknesses of expansion material shall be installed on each side of the median between the back of curb and "hardscape" and sealed.

6. Median islands four (4) feet wide or less may not be landscaped and must be hardscaped. See the Town of Castle Rock Landscape and Irrigation Performance Standards and Criteria Manual for acceptable hardscapes.

2.12 SECONDARY ACCESS AND FIRE LANES

2.12.1 Design Criteria

1. Any secondary access roads, including fire lanes, not constructed as part of the public street system shall meet the following design criteria in addition to the roadway design criteria within this manual.

A. The slope of the access road shall be a minimum of 1% and a maximum of 8%.

B. The cross slope of the access road shall be a minimum of 1% and a maximum of 4%.

C. The lane width shall be a minimum of 20 feet.

D. There shall be a minimum of 18 feet of vertical clearance over the entire access road.

E. The surface of the roadway must be paved. All pavements shall be designed in accordance with Section 14 – Pavement Design.

F. The fire lane shall be equipped with a gate that is approved as a "break away" by the Fire Department. An electronic detection system (i.e. Opticom) may also be required.

G. The Owner shall be responsible for maintenance of the emergency access including snow plowing, gate and electronic detection system.

2.12.2 Fire Lanes

Fire lanes shall be required when safe access to structures within a project area is limited. Fire lanes require approval of the Town's Fire Department.

2.12.3 Alleys

Where proposed, alleys should be open at both ends of a block. An approved turnaround area, capable of accommodating fire department vehicles, shall be provided in dead-end alleys with lengths exceeding 150 feet.

2.13 RAILROAD CROSSINGS

All railroad crossings shall be designed in accordance with AASHTO "Green Book" and must be approved by the affected railroad company.

2.14 CONSTRUCTION TRAFFIC CONTROL

2.14.1 Vehicular Traffic

1. Construction work zone traffic shall be controlled by signs, barricades, detours, etc. which are designed and installed in accordance with the MUTCD, most recent edition, and applicable Castle Rock Traffic Standards.

2. A traffic control plan shall be submitted and approved by the Public Works Department prior to the start of any construction or work in the right-of-way.

3. All street closures will require a permit from the Town must be submitted 7 days prior to lane closure and 21 days prior to a street closing.

4. Newly constructed roadways shall not be opened until the roadway is conveyed to and accepted by the Town.

5. The MUTCD shall be the basis upon which the construction traffic control plan is designed. All necessary signing, striping, coning, barricading, flagging, etc., shall be shown on the plan.

6. Town streets shall not be closed overnight.

7. Street or lane closures will not occur before 8:30 a.m. or after 3:30 p.m. If exceptions to this are required, this shall be so noted on the construction traffic control plan.

8. Directional access on roadways may be restricted, but proper controls including flagging, are required.

9. Removal of on-street parking should be considered, and noted where applicable.

2.14.2 Pedestrian Traffic

1. Pedestrian access shall be maintained on the existing sidewalks at all times or as approved by the Town.

2. Where construction interrupts the continuity of the sidewalk, suitable bridge or deck facilities shall be provided, to be supplemented by the use of such devices and measures as prescribed in the Manual of Uniform Traffic Control Devices (MUTCD) most recent edition, for the safe and uninterrupted movement of pedestrian traffic.

3. The edges or ends of the pedestrian bridge or decking shall be beveled or chamfered to a thin edge to prevent tripping.

4. Temporary diversion walkways shall be hard surfaced and electric lighting shall be provided and kept continuously burning during hours of darkness.

5. Flagmen shall be provided for guidance as necessary.

6. Pedestrians shall not be channeled to walk on the traveled portion of a roadway.

7. Under certain conditions, it may be necessary to divert pedestrians to the sidewalk on the opposite side of the street. Such crossings shall only be made at intersections or marked pedestrian crossovers.

2.14.3 Barricades

1. Whenever roadways terminate due to project phasing, subdivision boundaries, etc., barricades shall be installed and maintained.

2. Design and installation shall comply with the requirements of the MUTCD, most recent edition.

3. The barricades shall be shown on the construction drawings.

Section 3

ACCESS REQUIREMENTS & CRITERIA

3.1 ACCESS APPROVAL PROCESS

3.1.1 Access to public right-of-way is approved through one of two processes:

1. For new development or development amendments, access is approved through the process outlined in the Town's *Procedures Manual*.

2. For properties modifying the access to public right-of-way, approval may be acquired through the Construction Permit process. These processes are explained in more detail below.

A. For new development or redevelopment of parcels in the Planned Development (PD) zones or Straight zones that require a Site Development Plan or a Site Development Plan Amendment, the new or altered access will be reviewed and approved through the Town's Site Development Plan process. A Site Development Plan application accompanied by appropriate plans for the access and technical justifications for its location, size, and extent of improvements will be necessary.

B. For existing developed parcels that are proposing minor changes to their access or changes that are only in the public right-of-way, and do not require a Site Development Plan Amendment, the access may be reviewed and approved through a Construction Permit process.

The Town's Technical Review Committee (TRC) is available to provide advice on the extent of technical justification required for any access request. It is recommended that this advice be sought prior to submitting any application.

3.2 CRITERIA FOR ACCESS ONTO ROADWAYS

3.2.1 Access onto State Highways

1. For specific technical criteria regarding access spacing, widths, turn lanes, alignment, grades and other roadway design criteria, see Section 2, Roadway Design and Technical Criteria.

2. The State Highway Access Code governs access onto State Highways.

3. All access onto State Highways is controlled by the CDOT. The Town of Castle Rock has no jurisdictional authority over access onto a State Highway. The Town reserves the right to deny any proposed access location, including access that may meet CDOT requirements. The Town is not the issuing authority for access permits on State Highways.

3.2.2 Interstate 25

1. CDOT and FHWA rules and regulations shall apply to all Interstate Highways.

2. CDOT and the FHWA control all accesses onto interstates. The Town has no jurisdictional authority over access onto an interstate. The Town reserves the right to deny any proposed access location, including access that may meet CDOT and FHWA requirements

3.2.3 Major Arterials

1. A detailed Traffic Impact Analysis (see Section 7) shall be completed for any proposed access point to a major arterial to ensure adequate levels of service can be maintained if the access is allowed to be constructed. An Access Management Plan may be required.

2. Generally, no private direct access onto major arterials shall be permitted unless a signal progression plan has been approved and it is determined that the proposed access will cause no significant impacts to traffic operations. Private direct access to a major arterial may be permitted only when the property in question has no other reasonable access to the general roadway network, or when denial of a direct access to a major arterial will cause unacceptable traffic conditions and/or safety problems on an alternative lower classified roadway. When direct private access must be provided on a major arterial roadway, the following shall be considered prior to approval of the proposed access location:

A. Such access shall continue only until such time that some other reasonable access to a lower classification roadway is available and permitted. The approval documents should specify the future reasonable access location, if known, and under what circumstances the modifications will be triggered and what changes will be required.

B. No more than one access shall be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that: (1) allowing only one access conflicts with safety regulations (i.e. Fire access), or (2) additional access would significantly benefit safety and operation of the major arterial and is necessary to the safe and efficient use of the property.

C. An access shall be limited to right-turn only movements, unless (1) it has the potential for future signalization or a roundabout, (2) left turns would not create unreasonable congestion or safety problems and lower the overall intersection level of service, and (3) alternatives to the left turn movements would cause unacceptable traffic conditions and safety problems to the general roadway network.

3. Direct public access onto a major arterial roadway, where left turns are permitted, shall meet the signalization spacing criteria in Section 3.2.3.4 Those that do not meet these requirements shall be limited to right turn only movements unless they meet the requirements in Section 3.2.3.4.C. No local streets shall be permitted to intersect with major arterials. However in some situations, Entry Streets may be used to transition from a local street to a major arterial.

4. Spacing and Signalization Criteria:

A. Refer to Figure 3.1 for spacing requirements.

B. In general terms, full access to major arterials shall be limited to one-half (1/2) mile intervals or more, plus or minus 200-feet, in order to achieve good speed, capacity and optimal signal progression.

C. An approved traffic engineering analysis of signal progression shall be completed to properly locate any proposed access that may require signalization. The consultant for the applicant shall contact the Town's Traffic Engineering Division for direction in preparing the signal progression analysis.

3.2.4 Minor Arterials

1. A detailed Traffic Impact Analysis shall be completed for any new proposed access point on a minor arterial to ensure adequate levels of service prior to issuance of an access permit.

2. Generally, no private direct access onto a minor arterial shall be permitted unless a signal progression plan has been approved and it is determined that the proposed access will cause no significant impacts to traffic conditions. Private direct access to a minor arterial may be permitted only when the property in question has no other reasonable access to the general roadway network, or when denial of a direct access to a minor arterial will cause unacceptable traffic operations and/or safety problems on an alternative lower classified roadway. When direct private access must be provided on a minor arterial roadway, the following shall be considered prior to approval of the proposed access location:

A. See 3.2.3.2 A , B, & C

B. Location has the potential for signalization or roundabout, if it meets spacing requirements for intersecting public roadways stated in 3.2.4.4 and does not interfere with the location, planning and operations of the general roadway network and access to nearby properties.

3. Public direct access onto a minor arterial roadway, where left turns are permitted, shall meet the signalization spacing criteria in Section 3.2.4.4. Those that do not meet these requirements shall be limited to right turn only movements, unless they meet the requirements in Section 3.2.3.2.C No local streets shall be permitted to intersect with minor arterials. However, in some situations, Entry Streets may be used to transition from a local street to a minor arterial.

4. Spacing and Signalization

A. Refer to Figure 3.1 for spacing requirements.

B. In general terms, full access onto minor arterials shall be limited to one-quarter (1/4) mile intervals, plus or minus approximately 200-feet, in order to achieve good speed, capacity and optimum signal progression.

C. However, to provide flexibility for both existing and future conditions, an approved traffic engineering analysis of signal progression shall be completed to properly locate any proposed access that may require signalization. The consultant for the applicant shall contact the Town's

Traffic Engineering Division for direction in preparing the signal progression analysis.

3.2.5 Major and Minor Collectors

1. Single-family residential access onto collectors is not permitted within new developments**.** See Section 3.3 Curb Opening and Driveway Criteria.

2. Public streets shall intersect minor collectors no closer than 330 feet from each other (centerline to centerline), and shall intersect major collectors no closer than 660 feet from each other (centerline-centerline). On minor collectors, the closest local street intersection to an arterial shall be 400 feet (centerline of arterial to centerline of a local street) and on major collectors shall be 660 feet from the arterial (centerline of arterial to centerline of a local street). Further study may be required at the discretion of Town Staff, regarding access location and spacing.

3.2.6 Local Streets

1. Residential driveway locations shall be no closer than 20-feet from the Point of Curb Return (PCR) of a local street intersection.

2. Public streets should not intersect local roadways closer than 150 feet from each other (centerline to centerline). On a local street, the closest intersection to a collector street shall be at least 200 feet (centerline to centerline). The developed portion of a lot should not face directly into the oncoming traffic of an intersecting street of a “T” intersection.

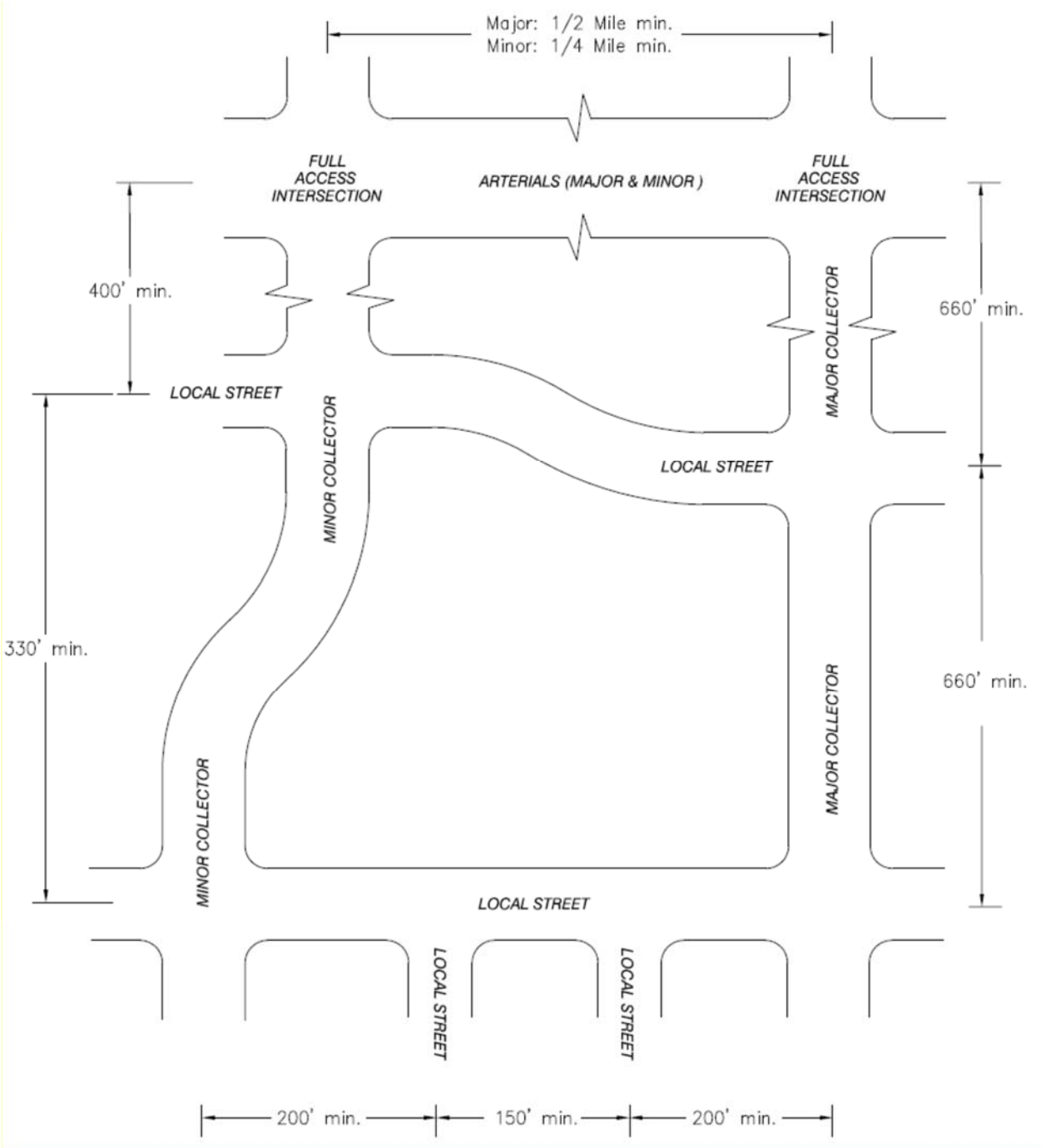


Figure 3.1 – Intersection Spacing

3.3 BASIC PRINCIPLES FOR CURB OPENINGS AND DRIVEWAYS

3.3.1 Curb Openings

1. Certain design criteria for curb openings and driveways require minimum dimensions in some instances and maximum dimensions in others. The design of curb openings and driveways within the range of these dimensions will provide for good service on the part of the motorist using the driveway while at the same time minimizing the interference to the traffic using the street. By controlling the location and width of openings or driveways along the street, it will be possible to avoid or eliminate long open stretches where motorists can indiscriminately access onto the street. The width of opening established in these *Criteria* is based on studies, which indicate that the various width openings will accommodate vehicles of maximum size authorized on our Town Streets. In case of conflict between requirements in the various sections of these Criteria, the more restrictive condition shall normally apply.

2. The curb opening or driveway width should be adequate to properly handle the anticipated traffic volume and traffic characteristics, as well as being within the limits specified for the type of property development.

3. The curb opening or driveway shall be designed to accommodate emergency response vehicles.

4. See Section 2.3.3 Driveways criteria.

3.3.2 Sight Distance

1. All openings for driveways shall be located at the point of optimum sight distance along the street. For openings and driveways to commercial establishments and service stations there shall be sufficient space reasonably cleared of any obstructions such that drivers entering the property will have sufficient sight distance to enable them to make proper and safe movements. The profile of a driveway approach and the grading of the adjacent area shall be such that when a vehicle is located on the driveway outside the traveled portion of the street the driver can see a sufficient distance in both directions so as to enable the driver to enter the street without creating a hazardous traffic situation. See Section 2.5.2 for maximum driveway grades.

2. Sight distance for curb openings to private property shall meet all sight triangle and sight line requirements detailed in Section 2.4. This does not apply to single-family residential driveways using mountable curb, gutter, and sidewalks.

3.3.3 Utility Conflicts and Abandoned Driveways

Any adjustments which must be made to utility poles, street light standards, fire hydrants, catch basins or inlets, traffic signs and signals, or other public improvements or installations which are necessary as the result of the curb openings or driveways shall be accomplished without any cost to the Town. Driveways shall not interfere with operations or locations of any drainage appurtenances or handicap ramps. Also, any curb opening or driveway, which has been abandoned, shall be restored by the property owner except where such abandonment has been made at the request of, or for the convenience of, the Town.

3.3.4 Entry/Exit Only Access

Driveway approaches, where the driveway is to serve as an entrance only or as an exit only, shall be appropriately signed by the property owner at their sole expense. The property owner will be required to provide some means of ensuring that the motorists will use the driveway as it is shown on the construction plans.

3.3.5 Access to Roadways with No Curb and Gutter

1. Driveways shall extend from the ROW line to edge of existing driving surface and shall be constructed of either:

A. A minimum of 3” thick asphalt pavement over 6” thick aggregate base material Class 6 or according to the pavement design report.

B. A minimum of 4” thick concrete pavement over 6” aggregate base material Class 6 or according to the pavement design report.

2. The driveway shall be a maximum of 30-feet wide in the Town ROW.

3. A minimum 24” diameter corrugated metal pipe (CMP) culvert shall be installed at the established roadside ditch flowline beneath the private

drive access. The applicant is responsible for providing adequate design sizing for the CMP culvert with the Drainage Study or as a separate document. At no time will it be acceptable for asphalt or concrete pavement to be placed directly on the culvert.

3.3.6 Maintenance of Private Access onto Town ROW

Maintenance of private driveway access within the public right-of-way shall be the responsibility of the property owner. Maintenance of drainage improvements described in Section 3.3.5 shall be the responsibility of the property owner.

3.3.7 Definition of Terms

Several terms are used herein, which have a somewhat distinct meaning. For the purpose of clarity, the definition of some of these terms is listed below:

1. **Width of Curb Opening –** The width of curb opening measured along the curb line excluding the curb returns.

2. **Edge Clearance –** the distance measured along the curb line from the nearest edge of the curb opening to a point where the property line extended intersects the curb.

3. **Corner Clearance –** At an intersecting street, the distance measured along the curb line from the projection of the intersection street flowline to the nearest edge of the curb opening.

4. **Setback –** The lateral distance measured perpendicular to the street right-of-way line and extending from the right-of-way line to the closest point on a structure.

5. **Frontage –** The distance along the street right-of-way line of a single property or development within the property lines. Corner property at an intersection would have separate frontage along each street.

6. **Residential –** Property used primarily for residential purposes such a single family, two family and multi-family units.

7. **Single Family (SF) Residential** – Single, detached family dwelling units or double bungalows or duplexes.

8. **Multi Family (MF) Residential** – Three or more attached dwelling units including townhouses, condominiums and apartments.

9. **Commercial –** Establishments where buying and selling of commodities, entertainment or services is carried on, excluding services stations. Included are such uses as office building, restaurants, hotels, motels, banks, grocery stores, theaters, parking lots, trailer courts, public buildings

10. **Industrial –** Establishments that manufacture or store an article or product.

11. **Service Station –** Any property where flammable liquids used as motor vehicle fuel are stored and dispensed from fixed equipment into fuel tanks of motor vehicles.

3.4 GENERAL ACCESS REQUIREMENTS

3.4.1 Number of Openings

1. **SF Residential –** In general, each SF residential property shall be limited to one access point. Additional access points shall be reviewed by the Town on a case by case basis.

2. **MF Residential** – In general, access shall be determined by information provided by owner/developer in the Traffic Impact Analysis and by comments generated during Town's review and acceptance of the traffic study.

3. **Commercial and Industrial** – In general, commercial and industrial properties having less than 150-feet of frontage and located mid-block shall be limited to one access point to the street. An exception to this rule may be where a building is constructed in the middle of the lot and parking is provided for on each side of the building. A second access point may be allowed for commercial property located on a corner for properties having greater than 150-feet of frontage, if the additional proposed access is determined by Town Staff to be acceptable and the proposal is justified in the Traffic Impact Analysis.

4. Properties may be required to combine and share access points to Town streets. See Section 3.4.5.

3.4.2 Amount of Curb Opening Permitted

The total length of curb opening on a roadway for access to a commercial property shall not exceed 35 feet. This requirement does not apply to residential type curb openings.

3.4.3 Entrance Angle

In general, the entrance angle for all driveways shall be perpendicular to the centerline of the street being accessed. The entrance angle may vary 10° from perpendicular or 10° from the radial bearing.

3.4.4 Minimum Space between Openings

The minimum spacing between curb openings shall be 35 feet measured at the curb line. This spacing will apply to the distance between drives serving a single property or adjoining properties. This does not apply to residential projects using mountable curb, gutter and sidewalks. 50-foot spacing applies to commercial openings.

3.4.5 Joint Entrances

Whenever possible and feasible, joint entrances shall be provided to serve two adjacent properties. Joint entrances should be centered on the common property line. Joint entrances shall require the execution of a Joint Access Easement Agreement between the adjacent property owners.

3.4.6 Access Approaches for Areas Requiring Backing Maneuvers

Access approaches shall not be permitted for parking or loading that requires backing maneuvers within Town right-of-way. All off-street parking areas must include on-sight maneuvering areas and aisles to permit user vehicles to enter and exit the site in forward direction.

3.4.7 Unused Access Points

If a parcel of land with direct access has been in a state of non-use for more than four years, recommencement of access use shall be considered a change in use. If the use of the access exceeds the design limitations of the access point or is non-conforming to present design criteria, a new permit may be required.

3.4.8 Changes in Access Use

If the use of existing access to Town right-of-way changes, or there is a change in the use of the property, the access type will be reviewed for compatibility with the proposed use in the Town's plan review process. Change in access or property use may include, but is not limited to, change in volume or type of traffic, structural modifications to the building, remodeling of the structure, change in type of business, expansion in an existing business, change in zoning or change in property division creating new parcels.

3.4.9 Control Dimensions

To accomplish the objectives of the basic principles stated earlier, certain control dimensions are necessary. There are many variables that affect these control dimensions. Some of the variables are as follows: type of roadway classification, type of property development, volume of traffic and width of right-of-way.

3.4.10 Width of Curb Opening

The total width of curb opening for properties on various roadway classifications shall be in conformance with Table 3.1

TABLE 3.1
WIDTH OF CURB OPENING - MAXIMUMS

	RESIDENTIAL				
	SF	**MF**	**COMMERCIAL /INDUSTRIAL**	**SERVICE STATION**	
MAJOR ARTERIAL	N/A				
MINOR ARTERIAL	N/A				
MAJOR COLLECTOR	N/A	30’	35’	40’	
MINOR COLLECTOR	N/A	30’	35’	35’	
LOCAL	30’	30’	35’	35’	

Notes: Curb openings of 30-feet or more must be constructed with radius curb returns. For curb return driveways, the measured width of the driveway does not include the curb returns.

3.4.11 Corner Clearance

It is important to locate driveways away from major intersections. This constraint is as much for the ability to enter and exit the property as for the benefit of intersection safety and operations. Exiting a driveway during peak hour conditions at a signalized intersection is difficult because the queue of standing or slow-moving vehicles may not allow a sufficient gap for entry from the driveway. See Figure 3.2 for acceptable corner clearance distances.

MINIMUM CORNER CLEARANCE			
	CLASS OF MAJOR ROADWAY		
ITEM	ARTERIAL	COLLECTOR	LOCAL
A	115	75	50
B	85	85	50
C	115	75	50
D	115	75	50
E	210	115	50
F	210	115	50
G	50	50	50
H	210	115	50

NOTE:
This table does not apply to single family residential driveways. Single family residential driveways must access on the street of the lowest classification and at the side of the lot furthest away from the intersection.

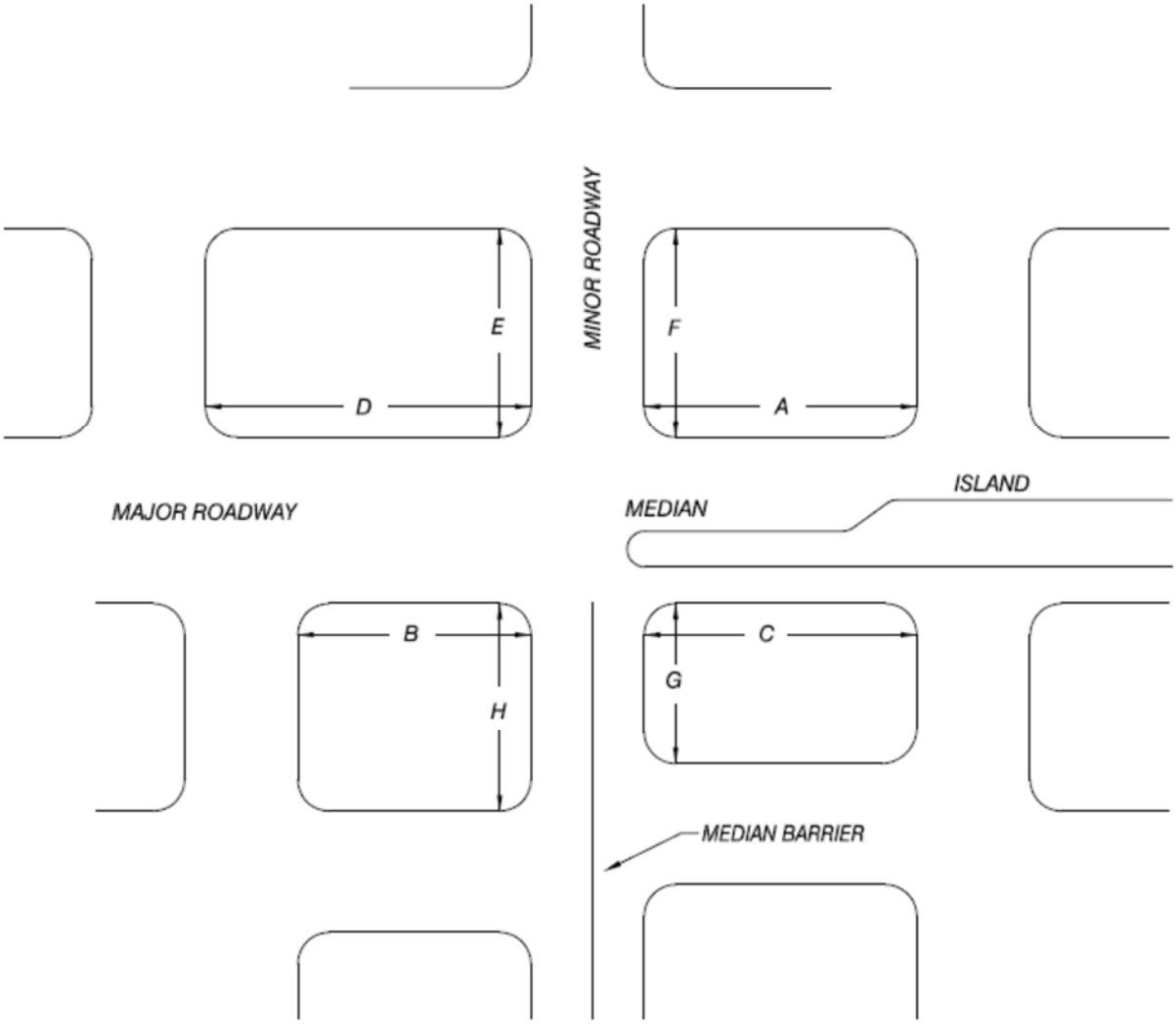


Figure 3.2 – Driveway Corner Clearances

3.5 UNPERMITTED ACCESS

Any access, driveway, or curb cut that is constructed within public ROW without the approval of the Town shall be subject to a "Stop Work Order" and shall be removed immediately. Failure to remove the unpermitted access may result in removal of said access by the Town (at the property owner's expense). Failure to comply with the "Stop Work Order" may result in Town legal action and prosecution of the violators.

Section 4

TRAFFIC SIGNAL DESIGN

4.1 GENERAL INFORMATION

4.1.1 Scope

This section describes general signal design requirements for use in the Town of Castle Rock. It is the intent of the Town to first consider methods of traffic control other than traffic signals to control traffic at intersections. Other desirable methods include the use of roundabouts.

4.1.2 Pre-Design Meeting with Traffic Engineering and Operations Division

Prior to beginning traffic signal design, a pre-design meeting may be requested by either the Town or the design consultant. A pre-design meeting is recommended.

4.2 TRAFFIC SIGNAL DESIGN CRITERIA

4.2.1 General Signal Design Requirements

1. All design elements must comply with the Manual on Uniform Traffic Control Devices (MUTCD) standards.

2. All traffic signal equipment, structures and foundations shall be designed in accordance with CDOT's Traffic Signals and Lighting, Town of Castle Rock Detail Plans and Signal Construction Specifications, and CDOT Standard Specifications for Road and Bridge Construction.

3. All equipment and materials specified must conform to current CDOT specifications and be submitted for approval to the Traffic Engineering and Operations Division, prior to signal construction.

4. A sufficient pedestrian landing area that meets the Americans with Disabilities Act (ADA) requirements must be provided.

5. All traffic signals for permanent installations shall use mast arm poles (Federal Green in color). Span wire applications may only be used for temporary signal installations.

6. All traffic signal poles, conduit and equipment must be located within public rights-of-way or easement.

4.2.2 Signal Head Placement and Sizes

1. All signal head placement and sizes shall comply with the latest MUTCD standards.

2. Far left and far right traffic signals should be provided. It is desirable to have a single head for each exclusive left turn lane and through lane. The need for one signal head per right turn lane should be determined on a site-specific basis.

3. Pedestrian signal heads should be provided for all marked crosswalks. Where pedestrian signal heads are provided, corresponding pedestrian push buttons shall be provided. All pedestrian signals shall be "countdown" type and shall meet ADA requirements. Pedestrian signals must be 16-inch LED "Man/Hand" indication.

4. Where left turn arrows are included, at least two signal heads with left arrow sections shall be provided, with one of these located on the far left pole. 4-section flashing yellow arrow signal heads will be required for permissive left turn operation. If no protected left turn is necessary, 3-section flashing yellow arrow signal heads shall be used.

5. All mast arm and span wire mounted signal heads shall have aluminum louvered back plates, black in color, with yellow reflective tape along the edges.

6. All signal heads shall have 12-inch lenses and shall be LED with tunnel visors. All indications shall be wide-angle, LED type lamps and meet ITE specifications for LED traffic signal indications. All pedestrian indications shall also be LED type lamps. Back plates and tunnel visors shall be installed on all signal faces and shall be black or green in color. The same color shall be used for all vehicular and pedestrian signals at an intersection.

7. Where mast arms extend over the left turn lane(s), "left turn only" sign(s) should be provided. Double lefts may be covered with one "left turn only" sign (R3-5) per lane, or one "double left turn only" sign located over the lane line between left turn lanes.

8. "Yield to pedestrian" sign(s), "right turn only" sign(s), and "combined through/right turn" lane use sign(s) shall be used if applicable.

4.2.3 Pole and Cabinet Placement

1. All signal poles, pedestals and cabinets shall be located so that there will be a minimum of 3 feet between the face of traffic signal equipment and the face of curb when curbing is present. The desirable separation is 5 feet.

2. The same separations noted above shall apply from face of traffic signal equipment to outside edge of shoulder when there is no curbing present. In this situation there should be a minimum of 5 feet between the face of traffic signal equipment and the edge of pavement. The desirable separation is 7 feet.

3. Poles shall be located so that pedestrian push-buttons shall be within 5 feet of the point at which pedestrians will begin their crossing maneuvers. Pedestrians will have unobstructed access to pedestrian signal pushbuttons. If a pole cannot be located within 5 feet, a separate pedestrian push-button post shall be installed.

4. The traffic control cabinet shall be placed in a location such that placement allows a technician working within the cabinet clear visibility of the intersection and approaching traffic from all directions. The cabinet should be located on the corner that does not block the view of side street traffic for 'right turn on red' vehicles.

4.2.4 Materials

1. The Controller shall be an Econolite Cobalt ATC traffic controller with ASC/3-LX software, or as specified at the time of design by the Town's Traffic Engineer.

2. The minimum cabinet size is to be 332, with "I", "J", and "K" files, with a single door on each side.

3. Vehicle detection is to be provided by a nonintrusive devise (video, radar, or infrared), as directed by the Town's Traffic Engineer. Inductive loops

shall not be utilized unless requested by the Traffic Engineering and Operations Division.

4. All materials must be approved by the Town prior to installation.

4.2.5 Pull Boxes and Signal Conduit

1. All pull boxes shall be fiber composite type, and marked “Traffic Signal” or “Traffic “on the lid.

2. Pull boxes shall not be placed in roadways or sidewalks. Conduit must be extended where necessary to relocate pull boxes to a non-traveled area.

3. A minimum of two (2), 2-inch conduits and one (1), 3-inch conduit shall be placed across each intersection approach. All conduits shall be Schedule 80 PVC. Any unused conduits must be sealed within the pull boxes.

4. All electrical service conductors shall be placed in a separate conduit from the traffic signal wiring.

5. Along all arterial roadways, one (1), 2-inch conduit must be placed within and parallel to the right-of-way to the nearest adjacent, existing traffic signal to allow for future signal coordination. Pull boxes must be placed a minimum of every 300’ along a conduit run, with conduit ends terminating within each box. The conduit ends shall be sealed to prevent debris build up.

4.2.6 Lighting

1. Luminaires shall be provided on all signal poles unless there is a utility conflict or unless directed otherwise by the Traffic Engineering and Operations Division.

2. Luminaire should be LED with lumen output equivalent to a 250 Watt metal halide bulb.

3. Luminaire wire connections will only be made in pull boxes and not brought into the signal controller cabinet.

4.2.7 Electrical Power

1. The signal designer shall contact the applicable power provider to determine the source for traffic signal power and to coordinate applicable requirements. At the time of construction, the location of the power connection may be revised if power has become available in closer or improved proximity to the proposed signal.

2. The electrical service shall have a separate meter and be addressed.

3. Circuit breakers and power disconnects should be located internal to service meter assemblies and signal controller cabinets, and should not be readily accessible to the public.

4.2.8 Emergency Vehicle Pre-emption

1. Emergency vehicle pre-emption shall be used for all directions and at all locations or as directed by the Town's traffic engineer. Additional sensors may be necessary if approaches are offset or vision is obstructed. Preemption must be compatible with the existing preemption system used in the Town.

2. Two (2) channel controls shall be provided at all intersections. The system shall be capable of controlling direction of travel, including arrow direction.

3. Two (2) emitters – one to the Fire and Rescue Department and one to the Police Department – shall be provided for each new signal.

4. Any upgrade or directional addition to an existing traffic signal shall include the installation of a traffic pre-emption system.

4.2.9 Signing and Striping

1. All regulatory, warning and route marker signs shall be provided with the traffic signal installation and shall be in accordance with the MUTCD.

2. Street name signs shall be installed for each approach. The lettering on the signs must conform to MUTCD standards. Sign colors and design shall also conform to Town specifications.

3. Illuminated street name signs shall be installed at all standard signal locations along the Town's "ring roads": Meadows Boulevard, Meadows Parkway, Founders Parkway, Ridge Road, Plum Creek Parkway, and Coachline Road. Other locations may be considered at the Town's discretion. Sign display location, style, colors, and design shall conform to current Town details and specifications.

4. All necessary striping shall be provided with the traffic signal installation and shall be in accordance with the MUTCD.

4.3 CONSTRUCTION PLANS AND SPECIFICATIONS/ PROVISIONS

4.3.1 Traffic Signal Plan Content

1. The designer shall prepare separate drawings of all traffic signal installation and incorporate it as an integral part of the construction plans.

2. Traffic signal plans shall be developed in accordance with Town construction specifications and CDOT's Traffic Signals and Lighting– Standard Drawings and CDOT Standard Specifications for Road and Bridge Construction. All elements must comply with the Manual on Uniform Traffic Control Devices (MUTCD) standards.

3. As a general guide, the traffic signal plans shall be drawn at a 1 inch = 20 feet scale, and shall include the following items:

A. Locate and identify all existing and/or proposed improvements, above and below ground, within 200 feet of the intersection including all utilities, traffic control boxes, pull boxes, signal poles and loops/vehicle detectors.

B. Locate and identify all existing and/or proposed pavement marking and signing.

C. Locate existing vegetation which could be in conflict with any proposed equipment locations or impact required signal visibility distances.

D. Provide a profile layout when vertical roadway alignment may impact

traffic signal visibility requirements. Provide roadway curve data if applicable.

E. Locate all traffic signal equipment (poles, controller cabinet, electric service cabinet, etc.).

F. Develop a phasing diagram for initial signal operation.

G. Provide Town as-builts, sealed by a professional engineer, upon completion.

4.4 SPECIFICATIONS

Traffic signal specifications shall be developed in accordance with Town and CDOT's Standard Specifications for Road and Bridge Construction. The designer will determine the need for project-specific construction special provisions. Notes may be added to the construction plans if the designer feels that it is necessary to clarify certain items.

Section 5

ROUNDABOUTS

5.1 GENERAL INFORMATION

5.1.1 Scope

Roundabouts can reduce accidents and improve traffic flow at intersections. The Town will consider the use of roundabouts on a case by case basis. Roundabouts are typically used as an alternative to traffic signals or to 4-way stop control. Roundabouts shall be constructed at all new collector/collector intersections or at intersections of roadways of a higher classification unless it can be demonstrated that a specific location is not a good candidate. This chapter provides the procedures and criteria for the design of roundabouts.

5.1.2 Use of National Standards

All roundabout designs will follow the most current guidelines for roundabouts, including proper treatment of pedestrian crossings, bicycle lanes and signage. See the Federal Highway Administration's Roundabouts: An Informational Guide (Latest Publication) and the Manual on Uniform Traffic Control Devices (MUTCD) for further information.

5.2 SITE DETERMINATION

The Town of Castle Rock considers the use of roundabouts as an essential element of traffic control, and shall consider each proposed roundabout on a case-by-case basis.

5.3 ROUNDABOUT DESIGN CRITERIA

5.3.1 General Design Criteria

1. The inscribed circle diameter shall be a minimum of 105 feet for single lane roundabouts and 150 feet for a two-lane roundabout. The inscribed circle diameter must be adequate to accommodate the anticipated vehicle types.

2. Design all legs to yield to traffic in center.

3. Provide channelized approaches/splitter islands for all legs. Vehicle deflection must be provided on all approaches at the splitter islands such

that vehicles cannot errantly continue straight into the interior circle roadway without hitting the splitter curb.

4. Intersection circle and splitter islands should follow the roadway design principles as described in the AASHTO Roadside Design Guide and should avoid structural elements that could likely be in the path of an errant driver.

5. Provide design geometry to slow speeds to less than 30 mph. The maximum speed difference between entering and circulating traffic should be 12 mph.

6. Discourage pedestrians from crossing to the center island. Provide pedestrian refuge in splitter islands. Pull the sidewalk away from curb near circle to encourage crossing at a splitter crossing. ADA requirements must be met. Multi-lane approaches must give careful consideration to treatments that can assist the visually impaired pedestrians.

7. Allow bikes to merge with vehicular traffic or exit to sidewalk/path or trail as available. Provide a directional curb ramp for bikes where the splitter island starts so that they have the option of using the sidewalk or mixing with the vehicles.

8. Accompanying design data must be provided that includes:

A. Existing weekday AM and PM peak hour

B. Peak hour of the generator turning volumes

C. Design year peak hour turning volumes (AM & PM weekday peak hours and peak hour of the generator)

D. Capacity calculations for existing 20 year projections

5.3.2 Design Vehicle Criteria

1. All intersections shall be designed to accommodate a WB-50 vehicle for all turning movements (which will accommodate fire trucks, sanitation trucks and most trailers). Larger vehicle types may be required to be accommodated on higher classification roadways. No entry or exit path overlap is permitted on any multi-lane approaches and exits.

2. Geometric layout should be checked with AutoTurn software or by a similar method.

5.3.3 Typical Signs and Markings

1. The following are the minimum number and type of signs/markings that may be required at an installation:

- Yield sign for each leg
- Offset regulator “One Way” signs in center island to line up with driver
- Pedestrian crossing signs in splitter/median
- Object marker and keep right sign at beginning of splitter/median
- Advance roundabout warning sign with advisory speed plaque
- Advance street name signs
- Lane use markings (“fish hook” style)

2. The requirements may vary due to the location of the roundabouts, the amount of traffic that is expected to be present and the presence of pedestrians.

5.3.4 Lighting

1. Lighting layouts at roundabouts must adhere to the latest FHWA design guide for roundabouts and/or publications of the Illuminating Engineering Society (IES) concerning roundabout lighting.

5.4 CONSTRUCTION PLANS AND SPECIFICATIONS/ PROVISIONS

5.4.1 Roundabout Plan Content

1. The designer shall prepare separate drawings of all roundabout designs and installation and incorporate them as an integral part of the construction plans.

2. Roundabout plans shall be developed in accordance with Town specifications and CDOT's Standard Drawings and CDOT Standard Specifications for Road and Bridge Construction. All signage elements must comply with the Manual on Uniform Traffic Control Devices (MUTCD) standards.

5.4.2 Specifications

Specifications shall be developed in accordance with Town specifications and CDOT's Standard Specifications for Road and Bridge Construction. The designer will determine the need for project-specific construction special provisions. Notes may be added to the construction plans if the designer feels that it is necessary to clarify certain items.

Section 6

TRAFFIC SIGNING AND PAVEMENT MARKINGS

6.1 GENERAL INFORMATION

6.1.1 Scope

This chapter provides the procedures and criteria for the design and installation of street signage, striping and pavement markings.

6.1.2 Use of National Standards

The following current publications are to be used in conjunction with the design criteria in this manual for the design of traffic signs, striping and markings.

1. Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)-USDOT/FHWA, current version

2. Colorado Model Traffic Code

6.2 SIGNAGE DESIGN CRITERIA

6.2.1 Signage - Regulatory, Warning and Advisory

1. Design is to be in accordance with the MUTCD. The requirements of the MUTCD shall be applied to privately owned facilities where the public is able to travel.

2. All sign posts shall be telespar, pre-punched square steel tubing, (3/8" diameter holes on 1-inch centers, galvanized). Posts must be of appropriate length to meet the MUTCD requirements for the location. They also must conform to CDOT Specifications and must meet the Federal breakaway standards. Installation boots are to be driven to within 4" of ground level. The boots shall not be driven below ground level.

3. The height to the bottom of the sign assembly shall be at least seven feet above the top of the sign boot.

4. ASTM Type IV Sheeting (minimum) shall be used for all sign types.

5. School warning signs and accompanying placards must be ASTM Type DG-3 high intensity prismatic fluorescent yellow green sheeting.

6. Where the approach has multiple lanes and/or the posted speed limit is 40 mph or faster, Stop signs (R1-1) shall have minimum dimensions of 36 inch by 36 inch. At other locations, stop signs shall have minimum dimensions of 30 inch x 30 inch or meet the minimum requirements in the MUTCD, whichever is greater.

7. Streetlight poles should be used for sign mounting when the light pole is within approximately 50 feet of the proposed sign location. This may not be possible for intersection control signs. Placement of signs shall be in accordance with the requirements of the MUTCD.

8. When No Parking signs are necessary, signs shall be installed in the direction of travel approximately every 250 feet unless specified closer by the MUTCD. Where possible, the sign face shall be oriented at an angle of 45 degrees to the direction of travel.

9. Speed limit signs (R2-1) are to be installed at 4 per side per mile or approximately every 900 feet in residential areas. Speed limit signs must also be placed where speed limit changes occur.

10. Backing plates shall be aluminum .080 gauge except for signs larger than 36'' x 36'', which shall be .100 or .125 gauge aluminum.

11. All proposed signage shall be located within the public right-of-way. If signage cannot be accommodated within public right-of-way, the signage will be located within an appropriate easement dedicated to the Town.

12. Each cul-de-sac shall include NO OUTLET signs. Cul-de-sacs longer than 150 LF (from nearest cross street flowline to furthest cul-de-sac flowline) shall feature 30-inch by 30-inch (W14-2) signs installed at the second property line entering the cul-de-sac. Shorter cul-de-sacs shall feature 36-inch by 8-inch (W14-2AR/W14-2AL) signs installed above the street name sign.

6.2.2 Signage - Street Name

1. Street names and 100-block designations (where applicable) shall be obtained from Douglas County through the Town's Geographic

Information Systems (GIS) Division. The County prescribes addressing in accordance with their existing policies.

2. Street name signs for all public streets shall be white lettering on a blue background. For all collector and arterial streets, the Town's logo shall be added to the street name signs. Additional criteria for street name signs are presented in Town standard detail ST-2. The Town logo may be obtained electronically by contacting the Town's Traffic Engineering and Operations Division.

3. For private streets, all street name signs shall be white lettering on a brown background. The Town logo is not allowed on private street name signs.

4. Lettering shall be a combination of upper case and lower case letters and shall conform to the MUTCD.

6.2.3 Signage - Street Name Assemblies

1. Street name assemblies should be located at the point of curvature of the corner radius and should be placed according to the following, as measured from the edge of the sign. When the street name assembly is combined with regulatory signs, sign placement for the regulatory sign shall govern.

2. If street name signs are the only sign on the post, the height to the bottom of the assembly shall be at least eight feet above the sign boot.

6.3 STRIPING DESIGN CRITERIA

6.3.1 Striping

1. All permanent longitudinal pavement striping on asphalt surfaces (centerlines, lane lines, bay lines, etc.) shall be installed using an approved reflective traffic paint or pavement marking tape. Reflective beads shall be applied in accordance with CDOT's Standard Specifications for Road and Bridge Construction and the manufacturer's requirements. When tape is used on an asphalt street, it shall be "rolled" into the final lift. On concrete surfaces tape shall be utilized with a contrasting black edge and grooved into the pavement.

2. All centerline striping shall be double yellow with each line being a minimum of 4 inches wide with 4 inches of separation. Other line widths shall be as specified by the Town. All turn lanes shall be 6 inches wide.

3. Paint material may be used upon approval by the Traffic Engineering and Operations Division if roadway geometry is not at full build out.

4. The type of material and the application process to be used must be approved by the Town's Traffic Engineering Division.

6.4 PAVEMENT MARKINGS DESIGN CRITERIA

6.4.1 Pavement Markings

1. Unless otherwise required by Town Public Works Department, all permanent lateral pavement striping (stop bars, crosswalk lines, etc.) shall be the paint type specified by the current CDOT standard. Reflective beads shall be applied in accordance with CDOT's Standard Specifications for Road and Bridge Construction and the manufacturer's requirements.

2. All stop bars shall be white and a minimum of 24 inches wide.

3. All pavement markings on concrete must be recessed tape with black edging.

4. Crosswalk bars shall be white. At signalized intersections, minimum crosswalk bar dimensions shall be 2 feet by 10 feet. At other locations, crosswalk bar dimensions shall be 2 feet by 6 feet.

6.5 TEMPORARY MARKINGS DESIGN CRITERIA

6.5.1 Temporary Pavement Markings & Striping

1. All temporary striping shall conform to the current edition of the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction.

2. All temporary pavement markings, including striping, shall be installed using reflective traffic paint.

3. All temporary markings shall be completely removed prior to the installation of the permanent markings.

4. Re-establish temporary striping periodically as required by Town Public Works Department.

6.6 CONSTRUCTION PLANS AND SPECIFICATIONS/ PROVISIONS

6.6.1 Signs and Markings Plan Content

1. The designer shall prepare separate drawings of all striping and signing and incorporate it as an integral part of the construction plans. Signing and pavement marking design should be shown in the same plan view on the same plan sheet if practical.

2. Plans shall be developed in accordance with Town specifications and CDOT's Standard Drawings and CDOT Standard Specifications for Road and Bridge Construction. All elements must comply with the Manual on Uniform Traffic Control Devices (MUTCD) standards.

3. Plan sheets are to be complete and to scale, no smaller than 1 inch = 40 feet.

4. The entire length of project is to be shown in plan view. Typical Sections representative of striping and/or signing will not be accepted.

5. Signing and pavement marking plans need to include all existing signing and pavement markings for a minimum of 300 feet past the limits of construction and include adequate transitions and tapers to existing pavement markings to maintain traffic at the design speed.

6. Rights-of-way lines are to be clearly identified.

6.6.2 Signing

1. All signs should be graphically depicted in the direction of travel. Signs shall be located within the right-of-way and at property lines where possible.

2. All signs shall be stationed and referenced to the appropriate MUTCD sign designation with size noted.

3. Speed limit signs should be posted in locations having adequate visibility to approaching traffic.

4. Existing or proposed roadway improvements, vegetation or structures shall not block traffic sign visibility.

5. Existing signs that are to remain, be removed, or be relocated and shall be identified by station and referenced by the appropriate MUTCD sign designation.

6. All existing signing applicable to the project shall be field verified and referenced as signs on the plan sheets, including location and/or station and proposed status of sign.

7. Where traffic calming devices are planned within the right-of-way, include warning signage along the approaches per MUTCD standards.

6.6.3 Striping

1. All existing striping that is to remain shall be fully shown (as screened lines or lightly inked pen lines), identified by type and width, and completely dimensioned across roadway.

2. Raised pavement markers shall be graphically shown in plan view and referenced by construction notation.

3. All new striping shall be clearly identified by color and line width. Beginning stations, ending stations and intermediate stations at all directional changes shall be noted.

4. Striping that is to be removed shall be identified as such on the plans.

5. All striping shall be fully dimensioned across roadway and tied to a construction centerline or monument line at each side of an intersection.

6. All pavement arrows, legends and crosswalks, etc., shall be located by station or dimension lines.

6.6.4 Specifications

Signs and markings specifications shall be developed in accordance with CDOT's Standard Specifications for Road and Bridge Construction. The designer will determine the need for project-specific construction special provisions. Notes may be added to the construction plans if the designer feels that it is necessary to clarify certain items.

Section 7

TRANSPORTATION IMPACT ANALYSIS

7.1 INTRODUCTION

The importance of comprehensive and coordinated transportation planning is critical to the Town in order to provide a balanced transportation system. The application of sound design principles for new streets, preserving street capacities in existing areas, ensuring smooth traffic flow, accommodating all transportation modes, and increased safety are goals the Town must attain. In order for the Town to evaluate the impacts of Development proposals on the Town's transportation system, a Transportation Impact Analysis (TIA) prepared by a Colorado licensed engineer may be required for all Development proposals. This chapter provides guidelines for the preparation of a Transportation Impact Analysis. In addition, the Town's Transportation Master Plan should be referenced for more detailed information.

7.2 PROCEDURE

The following steps outline the procedure the Town requires for the preparation and submittal of a TIA:

- Pre-Design Meeting
- Determination of Base Assumptions
- Submittal
- Town Comments and Recommendations

7.2.1 Scoping

At the Pre-Design Meeting, the Developer and the Town shall determine if a TIA will be required and to initiate the determination of the base assumptions to be utilized in the analysis.

A TIA requirement may be waived if the average daily trip generation of the proposed project is less than 200 vehicles per day of the generator or by special variance approved by the Town. If this condition is satisfied and Town does not have other concerns with the Transportation aspects of the proposed project, a memo shall be prepared by the Traffic Consultant Engineer showing the trip generation of the project and concluding that no transportation impacts are anticipated as a result of the proposed project.

At the Pre-Design Meeting, the Developer will provide information regarding:

1. Project description including type of land use (single family, fast food etc.) and size (number of dwelling units, square footage, etc.).

2. Preliminary project site plan showing all proposed access locations and proposed land uses.

3. Anticipated project completion date and project phasing.

The Town will review the applicant's project information and provide feedback as to any anticipated concerns regarding transportation issues, including but not limited to, access locations, types, potential impacts on adjacent neighborhoods, and initial identification of Study area. This initial scoping meeting will assist the Town and the Developer in determining the base assumptions and pedestrian analysis to be utilized in the TIA.

7.3 TRANSPORTATION IMPACT ANALYSIS

The intent of this TIA is to determine the potential impacts of the proposed Development upon the transportation system. Each TIA should address the following areas:

- Project Description
- Existing Conditions
- Future Background Traffic Projections
- Project Traffic
- Total Traffic Projections
- Site Circulation and Design Evaluation
- Transportation Impact Considerations
- Mitigation Measures to control speeding and cut-through traffic, and to improve pedestrian safety
- Neighborhood Transportation Impact Considerations
- Conclusions

7.3.1 Project Description

A description of the proposed project will be prepared and include the type of land use and size of the proposed project (number of dwelling units or building square footage). Any proposed phasing will be discussed and the anticipated completion date established. A figure depicting the proposed site plan will also be included and the proposed vehicular access locations will be described. This section will also include a description of how pedestrian and bicycle travel will be accommodated within the proposed site plan. This will include a discussion of types of sidewalks (attached/detached), pathways, and connections to location and perimeter destinations. Additionally, this will include a discussion of traffic calming methodologies included within the design of the project.

7.3.2 Existing Conditions

The TIA will establish the existing transportation system conditions. The assessment of existing conditions will include: a description of the surrounding roadway network, bicycle facilities, pedestrian facilities, and transit service; an evaluation of the AM/PM weekday peak hours, and peak hour of the generator.

1. Description of Existing Transportation System

A. The description of the roadway network will include:

- Number of travel lanes
- Street classifications per Town Transportation Master Plan
- Presence or not of pedestrian and bicycle facilities
- Posted speed limits
- Adjacent land use

B. Traffic data at the roadway network and Study intersections should be obtained through traffic counts and if possible from the Town's Traffic Engineering and Operations Division. Any recent (within the last one year) average daily traffic data that is available for the roadway network should be shown. Weekday AM & PM peak hour and peak hour of the generator traffic data at the study intersections should be no older than six months. Any additional traffic counts that may be necessary are the responsibility of the Developer. All traffic count data

should be included in an Appendix to the TIA. Forty-eight (48) hour traffic counts should be performed within Tuesday through Thursday and used to determine the "average daily traffic". Traffic counts shall not be done during a week containing a holiday.

C. The existing transit facilities within one-quarter mile of the project should be described.

D. The description of the existing bicycle and pedestrian facilities should include any facilities directly adjacent to the project site and within one-quarter mile. Analysis of pedestrian destinations, which are farther than one-quarter mile, may be necessary given particular site circumstances or the proposed project and land use (for example, the schools that will serve a residential development)

E. . If there are bicycle facilities, the type of facility (e.g. bike route, bike lane, sidepath, trail) should be described. If the facility does not meet accepted standards or the Town's criteria, the TIA needs to note this information.

F. Special attention should be given to the bicycle and pedestrian connections to specific uses such as schools, parks, transit stops, employment centers, commercial areas, shopping, and adjacent land uses.

2. Existing Levels of Service

A. The existing levels of service (LOS) of the transportation system adjacent to the project site should be determined. This includes the LOS for the adjacent roadways and for intersections within the study area. The study area shall be approved by the Town's Traffic Engineer and may include streets and intersections not immediately adjacent to the project. All LOS calculations shall be determined based upon procedures set forth in the latest edition of the HIGHWAY CAPACITY MANUAL.

B. All level of service worksheets should be included in the Appendices to the TIA report.

7.3.3 Future Background Traffic Projections

Background traffic projections shall be determined for each of the study years that are to be included in the TIA. These "future background" projections should account for the following:

- Transportation System Improvements
- Cumulative Projects
- Overall Traffic Growth

A description of any planned transportation system improvements should be provided. This should include such improvements as: signalization, intersection improvements, roadway widening, bicycle/pedestrian projects, and transit capital and operating/service improvements.

The future background traffic projections should include any individual development projects, that are within the Study area and that could impact the intersections being studied. Any major projects outside the Study area, that could impact the Study intersections, shall also be included in the background traffic calculations. All of the projects that have been included in the background traffic estimates should be listed in the TIA by location, size, and proposed land use.

The overall growth in traffic within the Study area should also be included in the future background traffic projections. Growth factors that should be applied to existing traffic within the study area will be provided by the Town or by DRCOG. Any projections should also reference any information taken from CDOT and Douglas County traffic models.

The resulting future peak hour traffic projections at the Study intersections should be depicted on a figure.

7.3.4 Project Traffic

The potential transportation impacts of the proposed Development project will be determined based upon the following process:

- Determination of Trip Generation
- Determination of Trip Distribution
- Assignment of Project Traffic

1. Trip Generation:

The trip generation of the proposed project will be determined and provided in tabular form. The trip generation needs to be determined for total build-out conditions and for any Development phases. The trip generation table should indicate the average daily trips and trips in the peak three hours (weekday AM, PM and peak hours of generator). This section of the TIA should also include a description of the mode split data, which was assumed for the trip generation estimates.

The development of trip generation estimates for the project should be based upon data from the latest edition of the Institute of Transportation Engineers' (ITE) Trip Generation Handbook. However, other data sources or trip generation rate studies may be utilized if the manual does not contain data for the proposed project or additional data is available which better reflects the trip generation characteristics of the project. The use of other trip generation rate sources must be discussed with the Town in the Pre-Design Scoping Meeting.

Adjustments to the standard trip generation of the proposed project may be made to account for internal site trips, pass-by trips, or other unique characteristics of the proposed project. The allowance for these reductions will be discussed with the Town and, in most cases, should follow guidelines set forth in documents such as the ITE Trip Generation Handbook referenced above or local data. The adjusted trip generation for the proposed project should be provided in tabular form.

2. Trip Distribution:

The trip distribution for the proposed project will be identified in the TIA. The distribution pattern will be based upon:

- The project's location within the Town
- Standard gravity model
- Existing traffic volume data
- Project marketing data
- Engineering judgment

3. Trip Assignment:

The project traffic will be assigned to the roadway system according to the trip distribution established above. The resulting project site-generated traffic will be depicted on figures for build-out conditions and any project phases. These figures will include daily and peak hour traffic volume information.

7.3.5 Total Traffic Projections

The total traffic projections will be determined for existing conditions and for each of the Study years identified earlier in the base assumptions. For existing conditions, the project-related traffic will be added to the existing three peak hours of traffic. The resulting total traffic projections for existing conditions will be depicted on a figure showing the project site, and the roadways within the study area. For each of the Study years, the total traffic projections will include the future background traffic plus the project-generated traffic. Background traffic will be developed by an annual growth rule obtained by the Town or obtained from the Town's Transportation Master Plan. The future total traffic projections will be depicted on figures for each Study year. Based upon the total traffic projections and the Roadway Design Criteria of this manual, the TIA shall provide roadway functional classification recommendations. For example, a roadway projected to carry between 3,500 and 5,000 vehicles per day would be recommended as a collector without parking, but if the projected traffic was less than 1,000 vehicles per day, it could be recommended to be a local street with parking.

7.3.6 Site Design and Circulation Evaluation

The project's site design should be analyzed to determine if the proposed circulation system serves pedestrians, bicyclists, transit users, and vehicles. The site design should be evaluated to determine if facilities for vehicles, pedestrians, bicycles and transit meet these *Criteria*.

The project's site design should be evaluated to determine if traffic flows can be adequately accommodated. The on-site traffic flows should be evaluated to minimize areas where motorists would tend to speed, minimize potential conflict areas between vehicles and pedestrians/bicyclists, and to determine if circulation patterns are designed so as to avoid unnecessary traffic congestion and conflict points.

7.3.7 Transportation Impact Considerations

The TIA will determine if the project will create any significant impacts at the study intersections and street segments surrounding the project site. In order to determine this, the peak hour levels of service at each of the study intersections will be evaluated for each of the following scenarios:

- Total Existing Traffic Conditions
- Future Total Traffic Conditions for each Study Year

The level of service analysis for each of the traffic scenarios and Study years need to include mode split assumptions. The level of service findings should be shown in the TIA in tabular form.

7.3.8 Minimum Acceptable Levels of Service

Minimum acceptable level of service (LOS) for all intersections in the Town shall be LOS D. Where the LOS of the individual movements can be calculated, no through movements shall operate worse than LOS D. No left turn movements shall operate worse than LOS E, nor have queues that block through traffic during any peak hour. When the LOS of an existing intersection doesn't meet these criteria, the LOS of the intersection cannot be further degraded by traffic that will be generated by the proposed project without appropriate mitigation measures taken to keep the LOS at existing levels.

7.3.9 Significant Impacts

This section applies primarily to vehicular-related impacts associated with the proposed project. A project is defined as significantly impacting a study intersection when one of the following conditions is expected to occur within the first year of the project being completed:

1. For Signalized Intersections:

A. When the added project traffic causes an intersection to fail the minimum acceptable level of service standard; or

B. When the background traffic conditions (without project traffic) causes an intersection to fail the minimum acceptable level of service standards; and the project traffic causes more than a 2 percent

increase in the intersection delay. The existing coordination timing plans are to be used in these assessments.

2. For Unsignalized Intersections:

A. When the added project traffic causes an intersection to fail the minimum acceptable level of service standard;

B. When vehicle queues to adjacent intersections would create impeded traffic flows and/or excessive congestion;

C. When added project traffic is determined to create potential safety problems.

7.3.10 Mitigation Measures

If the minimum LOS cannot be met once the project has been developed, the TIA shall include feasible measures to mitigate the project's impacts. The mitigation measures are intended to be **in addition to** the required improvements necessary to meet these *Criteria.* The goal of the mitigation measure(s) should be to minimize the demand for trips by single-occupant vehicles and to increase the use of alternative modes. Therefore, the following mitigation categories are listed in order of priority:

- Transportation demand management measures
- Transit capacity and access improvements
- Traffic signal operation improvements
- Street widening and other physical improvements
- Street restriping and parking regulations

The intersection LOS should be recalculated to reflect the effectiveness of the proposed mitigation measures: to show that the project-related impacts have been reduced; and to show that an acceptable LOS has been achieved. The LOS findings should be shown in tabular form.

A. Transportation Demand Management (TDM) Measures:

TDM measures are designed to facilitate the use of alternative transportation modes in an effort to decrease demand on the roadway system by single-occupant vehicles. Examples of TDM measures include the following:

- Vehicle trip reduction incentives and services offered by employers to encourage employees to utilize alternative modes of travel such as carpooling, vanpooling, bicycling, walking, telecommuting, etc.

- Financial support for the capital and/or operating costs of enhanced transit or vanpool service to the project.

- Site trip "cap" and/or parking "cap" including trip-monitoring agreements.

- A detailed description of the proposed TDM measures and implementation plan must be included in the TIA for any project seeking TDM-related trip reductions. If the TDM program is acceptable to the Town, the Developer will be allowed to reduce total project vehicle trips by an amount commensurate with applicable trip reduction policies.

B. Transit Capacity and Access Improvements

Suggested elements of a transit program should include:

- Contributions of equipment or funds to increase the capacity of existing transit systems

- Transit shuttles provided by applicant (e.g. bus, taxicab, van, etc.)

- Contributions toward transit stations or centers

C. Traffic Signal Operational Improvements

Traffic signal operational improvements could include upgrading the signal to add additional signal phases, or to signalize an adjacent intersection in order to provide relief to the study intersection. Signal improvements and/or installations must meet MUTCD signal warrants and be approved by the Town.

D. Street Widening and Other Physical Improvements

Street widening and other physical improvements must be demonstrated to be physically feasible and must meet minimum standards in these *Criteria* for both on- and off-site improvements.

E. Street Restriping and Parking Regulations

Any proposed striping and parking regulations must be approved by the Town. Generally, street restriping is not a preferred mitigation measure because it often requires that parking be removed. This can cause secondary impacts within commercial and residential areas. Therefore, any parking impacts should be clearly identified and mitigated to the extent feasible.

7.3.11 Neighborhood Transportation Impact Considerations

The TIA should include a focused analysis of the potential project-related impacts on adjacent residential areas. The need for this Study will be identified as part of the Base Assumptions. If it is determined that a neighborhood transportation impact review is required, the following procedure should be used:

- Examine the existing transportation conditions within the neighborhood. This should follow the same procedure as set forth earlier for the transportation impact consideration. Daily and peak hour traffic volumes should be collected for the local streets to be included in the analysis.
- Determine project-generated traffic for all modes within the neighborhood and show on a figure.
- Determine total traffic projections for the local streets. This should follow the same procedures as described earlier, including other projects and area-wide growth if applicable.
- Determine if the proposed project would create significant impacts to the residential streets using the conditions stated earlier.
- If necessary, develop measures including but not limited to traffic calming techniques to mitigate any significant impacts.

The neighborhood TIA should also discuss how pedestrians and bicyclists would access the proposed project to/from the adjacent neighborhood(s), and the need for special facilities to enhance direct pedestrian and bicycle connectivity.

7.3.12 Conclusions

The findings of the TIA should be provided in summary format, including the identification of any areas of significant impacts and recommended improvements/mitigation measures to achieve the LOS standards for all modes and for each analysis year.

Section 8

PEDESTRIAN & BICYCLE FACILITIES

8.1 GENERAL

This section sets forth the minimum criteria to be used in the design of all pedestrian and bicycle facilities within the Town of Castle Rock's rights-of-way or easements. This section does not apply to recreational use trails.

8.1.1 Definition of Terms

The different types of pedestrian and bicycle facilities referred to in this chapter are described below. Collectively these terms are referred to as pedestrian and bicycle facilities.

1. Multi-use trails – are located off-street in and through parks and open space areas. They are typically paved and 8-10 feet in width. They can accommodate a variety of users such as pedestrians, bicyclists and skaters.

2. Multi-use sidepaths – are located off-street next to arterial and collector streets. They are typically paved 8-10 feet wide and are located within the street right-of way. They can accommodate a variety of users such as pedestrians, bicyclists, and skaters.

3. On-street bike lanes – are located on streets and are normally 6 feet wide (measured from curb face) and are marked and signed for bicycle travel.

4. Sidewalks – are typically located in residential areas and are generally 5 feet in width. They are typically used by pedestrians.

8.1.2 General Criteria

1. All projects shall optimize pedestrian and bicycle travel within the Town by providing sidewalks, multi-use sidepaths, multi-use trails and on-street bike lanes in all new developments in accordance with the applicable development regulations, the Town's Transportation Master Plan and the Town's trails plan.

2. In this chapter the AASHTO's "Policy on Geometric Design of Highways and Streets ("Greenbook") and the "Guide for the Development of Bicycle Facilities" as published by the American Association of State Highway and Transportation Officials was used as a reference.

3. Off-site improvements may also be required to provide residents with access to schools and local commercial and community facilities.

4. Pedestrian and bicycle facilities where required by applicable Town ordinances, approved site plans, or development agreements shall be shown on the approved construction plans and shall meet, at a minimum, these *Criteria*.

5. The materials used in the construction of all pedestrian and bicycle facilities shall be in conformance to the Town of Castle Rock Detail Plans.

6. In locations within the development where pedestrian and bicycle facilities must be located on or across private property or coincide with private access facilities, the developer shall be required to provide the Town a public access easement through the private property. This will ensure that these facilities become part of the overall Town system and available for use by pedestrians and bicyclists from outside the development. The easement width shall be clearly indicated on the site plan and construction plans.

7. When pedestrian and bicycle facilities are to be constructed, their maintenance and operational responsibility will be determined during the site/subdivision plan approval process.

8. Manhole lids and other utility appurtenances should be located outside of the sidewalks, sidepaths, and trails, however, if it is necessary to construct within these improvements, the manhole lids or appurtenances shall be flush mounted and shall not create a tripping hazard.

9. Multi-Use Trails shall conform to ADA guidelines, in addition to AASHTO guidelines for bicycle facilities.

10. Storm inlet grates located in shoulders and bike lanes shall be “bike-friendly” type.

8.2 STANDARDS AND CRITERIA-OFF-STREET BICYCLE FACILITIES (Multi-Use Trails & Sidepaths)

Off-Street bicycle facilities consist of multi-use trails and sidepaths. In order to plan and construct multi-use trails and sidepaths in a consistent, usable and orderly fashion, it is necessary to establish basic standards and criteria. The

standards and criteria in this section shall be utilized in the design and review of multi-use trails and sidepaths for all development projects.

8.2.1 Multi-Use Trail and Sidepath Width, Type and Surface

1. Multi-use trail and sidepath widths and surfaces shall be determined by the Town based on site conditions and expected usage.

2. Multi-use trails shall have a minimum finished surface width of 10 feet for two-way facilities, and 8 feet for one-way facilities (where a bike path is present on each side of the street).

3. Multi-use sidepaths shall have a minimum width of 8 ft.

8.2.2 Multi-use Trail and Sidepath Location

1. Multi-use trail and sidepath locations shall be based on safety, circulation, and access considerations. Multi-use sidepaths designated on the Town's Transportation Master Plan that are generally parallel to existing or proposed roadways shall be constructed within the street right-of-way. Any location in which a sidepath is not within the dedicated street right-of-way must be privately maintained unless a sidepath easement dedicated to the Town of Castle Rock, is provided of sufficient width to allow for maintenance activities and equipment. The multi-use trail system shall make use of, but not be limited to, the drainage and open space areas.

2. Where needed, an easement with a minimum width of 25 feet shall be provided for multi-use trails.

8.2.3 Clearance

1. Where possible, multi-use trails and sidepaths shall be located so as to minimize the loss of trees and disruption of natural environmental conditions. A minimum of two feet (2') clear zone is required between the bike path/trail edge and any horizontal obstructions such as trees, utility poles, signs, fences or other obstacles. The clear zone shall be graded at a maximum 1:6 slope.

2. Regardless of multi-use trail surface, all vegetative material within 4 feet of the trail shall be removed prior to trail construction. This requirement is

to be verified by the developer's engineer and specified on the approved plans.

3. All multi-use trails shall have a minimum of 10' clear vertical distance above the path.

8.2.4 Grade

1. If the multi-use trail or sidepath profile differs from the adjacent roadway profile, a profile of the proposed construction shall be included in the construction plans or site plan. Typical cross sections shall be provided for all critical points along the length of the facility.

2. A minimum grade of six tenths of one percent (0.6%) is recommended except in sags where proper drainage is provided by cross slope.

3. A maximum sustained grade of five percent (5%) is recommended. However, steeper grades will be considered in accordance with the latest edition of the AASHTO "Guide for the Development of Bicycle Facilities" and ADA requirements. Short dips in grade or excessively long steep grades will not be approved.

8.2.5 Cross Slope

The cross slope shall be 2.0% (1/4" per foot). Sloping in one direction instead of crowning is required.

8.2.6 Sight Distance

Minimum stopping sight distance shall be provided for horizontal and vertical curves in accordance with the design criteria presented in AASHTO's "Guide for the Development of Bicycle Facilities".

8.2.7 Design Speed

1. For paved surfaces, a minimum design speed of 20 m.p.h. shall be used. Where grades exceed 4 percent, a design speed of 30 m.p.h. shall be used.

2. For unpaved surfaces, a minimum design speed of 5-10 m.p.h. shall be used. Where grades exceed 4 percent, a design speed of 20 m.p.h. shall be used.

8.2.8 Radius of Curvature

Turning radii in accordance with the following table shall be provided.

TABLE 8.1
Minimum Radii for Paved Bike Paths Based on 2% Superelevation

Design Speed (MPH)	Minimum Radius (FT)
12	30*
20	90
25	155
30	260

* Only to be used under constrained conditions and with Design Variance approval. Standard Warning signs and pavement markings shall be installed in accordance with the MUTCD. Pavement widening through curves may also be required.

8.2.9 Drainage

1. All sidepath or trail facility designs shall meet the storm drainage requirements contained in Section 2.4. All inlet grates used within the designs shall be approved for use with bikes. Multi-use sidepaths or trails located within the state highway right-of-way shall meet CDOT drainage standards.

2. As a general guide, where a sidepath or multi-use trail is cut into a hillside, a ditch shall be placed along the high side of the path to prevent sheet flow across the path. In some circumstances, at the discretion of the Town, water may be allowed to sheet flow across the trail facility.

8.2.10 Safety Considerations

1. A setback area is required between the edge of the multi-use sidepath and the back edge of curb and gutter. Five feet (5') is the minimum requirement. Multi-use trails shall not be constructed directly adjacent to street curb or street pavement, except at street intersections.

2. Multi-use sidepaths adjacent to streets with speed limits exceeding twenty-five (25) mph, and which have slopes greater than six percent (6%), may require special safety measures such as the installation of barriers or

other safety devices or an increase in the distance between the bike path and street.

3. Standard signing and markings from the MUTCD shall be included in the design and construction of the multi-use trails and sidepaths to alert users of potential hazards and to convey regulatory messages.

4. The Design Engineer shall address stopping and intersection sight distance at all path intersections, curves, and particularly where steep grades are proposed at roadway intersections. Obstructions to the visibility of motorists or path/trail users shall be removed or the path/trail shall be aligned around the obstruction to maximize visibility

5. Curb ramps conforming to ADA requirements will be provided at or near all curb crossings to allow continuity of use by bicyclists and persons with disabilities.

6. All multi-use trails that cross a drainage channel shall require either a bridge or a fair weather crossing. See Chapter 9, Bridges and Major Drainage Structures, for design requirements for bridges.

7. In accordance with the Town's Open Space and Trails Master Plan, grade-separated crossings of major collectors and arterials may be required. When an underpass or overpass is being considered a feasibility study will be required to assess the costs, the number of users, safety and operations of the proposed structure.

8. Railings, fences, or barriers on both sides of a multi-use trail or sidepath shall be at a minimum of 42" high. Smooth rub rails should be attached to the barriers at approximate handlebar height of 42" if the barrier is within 2 feet of the path. Barriers should not impede storm water runoff from the path.

9. All multi-use trail and sidepath bridge underpasses shall have lighting in accordance with Section 12, Lighting.

10. The minimum clearances for underpasses are as follows:

A. Horizontal: 12 feet

B. Vertical: 10 feet from trail surface to underside of bridge (8 feet for existing bridge structures), 12 feet if equestrian accommodation is required.

11. The trail surface elevation shall be at or above the high water mark for the 10-year storm.

8.2.11 Intersections

1. The following requirements apply to all multi-use trail and sidepath intersections with either streets or other pedestrian or bicycle facilities:

A. Curb Ramps

Curb ramps in accordance with ADA requirements shall be provided at each street/driveway intersection.

B. Sight Distance

Sight distance requirements shall be in conformance with AASHTO requirements. The Designer shall ensure sufficient stopping and intersection sight distance at all trail and sidepath intersections and curves, particularly where steep grades are proposed.

C. Turning Radius at Intersections

The minimum turning radius at bike path intersections shall be 15 feet.

8.3 STANDARDS AND CRITERIA - ON-STREET BIKE LANES

8.3.1 On-Street Bike Routes

Streets designated as on-street bicycle routes shall be designed to provide additional width for bike lanes.

8.3.2 Width and Cross Sections

The bike lane shall be designed per the width shown in standard typical street sections. See Appendix A.

8.3.3 Signage and Striping

All designated bike lanes shall be signed and striped, as required by the MUTCD and as required in Section 6, Traffic Signing and Pavement Markings.

8.3.4 Traffic Signal Detection

Separate signal detection may be required in bike lanes at signalized intersections. Where inductive loop detectors are used, quadra-pole-type loops are required. Where video detection is used, detectors shall be placed and calibrated in a manner to detect bicycles in their appropriate lane(s). The type and placement of the detection shall be approved by the Town.

8.3.5 Bike Lanes at Intersections

At the intersections where a separate right turn lane exists and is striped, the bicycle lane shall transition and be placed between the through lane and the right turn lane. The bike lane width shall remain the same as the approaching bike lane. Refer to the MUTCD for typical signing and pavement markings.

8.4 STANDARDS AND CRITERIA – PEDESTRIAN FACILITIES (Sidewalks, Sidepaths and Curb Ramps)

8.4.1 ADA Requirements

All pedestrian facilities shall be designed in accordance with American Disabilities Act (ADA) regulations and the requirements of these *Criteria*

8.4.2 Sidewalks / Sidepaths

1. Sidewalks shall be constructed within the street right-of-way in accordance with Town Standards. Any location in which sidewalk is not within the dedicated street right-of-way must be privately maintained unless a sidewalk easement dedicated to the Town of Castle Rock, is

provided of sufficient width to allow for maintenance activities and equipment.

2. A sidepath is a multi-use sidewalk having a minimum width of 8 ft. All design criteria for sidewalks, with the exception of width, shall apply to sidepaths. The Town has established a sidepath plan that complements the sidewalk/multi-use trail system. This plan is included in the Town's Transportation Master Plan. The developer must review the latest version of the plan. The requirement for sidepaths will eliminate the need for the sidewalks along the same segment of the street.

3. Sidewalks shall be installed at the time of roadway construction or widening unless otherwise approved through the development review process. The Public Works Department may allow the developer to pay a fee in lieu of constructing the sidewalk in certain locations. This fee must be paid prior to the issuance of the Construction Permit.

4. Sidewalk shall be provided along streets within new developments and expansions of existing developments.

5. The Town is receptive to reviewing alternate designs relative to the provision of pedestrian facilities. Such alternate designs may include greenways or a combination of sidewalks and greenways. The requirement for sidewalks may only be waived by the Town Council.

6. Where no curb and gutter exists on a road that requires sidewalks, the Town may require curb and gutter installation in addition to the installation of the sidewalk.

7. A sidewalk may be constructed so as to provide a gradual meander and to facilitate the installation of landscape material or to avoid existing obstacles such as power poles, trees, fire hydrants, street lights, etc.

8. The design of the sidewalk shall be such that pedestrian safety is provided and the usability of the sidewalk is not affected.

9. All sidewalks shall be constructed of concrete. Alternative type materials, such as asphalt, may be presented to the Town's Public Works Department for consideration. Pervious materials not meeting ADA requirements shall not be allowed due to concerns for pedestrian accessibility/usability and maintenance costs.

10. Pipes, drains, flumes or other concentrated stormwater devices shall not discharge across a sidewalk, but rather shall be piped or flumed under the sidewalk.

11. Minimum sidewalk widths for the various street classifications shall be as specified in Appendix A - Typical Cross Sections. The Town may require additional width within activity areas and for routes leading to and from these areas. The final sidewalk width shall be determined through additional study of higher pedestrian traffic areas.

12. All sidewalks that cross driveways and alleys shall be designed in accordance with ADA and AASHTO.

13. All street designs shall include sidewalks on both sides of the street.

14. In all existing areas previously developed, sidewalks, curbs, and gutters may be required to match existing conditions or standards, as determined by the Town.

15. When a sidewalk must be widened, the widening shall only be allowed for an increased width of 4 feet or more. If the added width needed is less than 4 feet, the existing walk shall be removed and reconstructed to the new required width.

16. Drainage shall meet the requirements specified in the "Storm Drainage Design and Technical Criteria Manual".

17. All detached sidewalks less than 8 feet in width and not within driveways shall be a minimum of 4-inch thick concrete. All detached sidewalks 8 feet and greater in width shall be 6 inches thick. All sidewalks within a driveway shall be a minimum of 6 inches thick. All attached sidewalks shall be a minimum of 6 inches thick. Sidewalks shall be a minimum of 8 inches thick where crossed by commercial or industrial traffic.

18. Slope:

A. Cross Slope. Maximum cross slope for sidewalks shall be 2%.

B. Longitudinal Slope. Longitudinal slope of attached sidewalks shall be consistent with the street slopes.

19. When required by the Town, grade separated pedestrian crossings (either underpass or overpass) shall be provided for regional paths and trails. These pedestrian crossings shall be coordinated with the appropriate Department.

20. Horizontal/vertical curves on all sidewalks shall follow the design criteria for bikeways.

21. Sidewalk vertical clearance shall be 10 feet.

22. Sidewalk horizontal clearance shall be meet AASHTO requirements.

23. The Town may require off-site sidewalk extensions to provide pedestrian connectivity to destinations within ¼ mile of the project as identified in the Transportation Impact Analysis. Additional off-site sidewalk construction extending greater than ¼ mile from the project may also be required in some circumstances such as when the project is within a school walking area boundary.

8.4.3 Curb Ramp Requirements

Curb ramps shall be installed at all intersections and at certain mid-block locations for all new construction or reconstruction of curb and sidewalk, as follows:

1. **4-Way Intersections**. Curb ramps shall be included at all intersections corners. Curb ramps shall be constructed in accordance with Town of Castle Rock Detail Plans.

2. **"T" - Intersections**. All "T" intersections shall have curb ramps for crossing both streets.

3. **Local Streets/Mid-Block**. Local Residential and Mixed-Use streets with block lengths longer than 600 feet will require mid-block curb ramps, which should be spaced approximately 300 feet apart.

4. **Trail Crossings**. If a public walkway or bikeway intersects the street, a ramp shall be provided to connect the walkway or bikeway to the street. The ramp should line up with the crosswalk.

5. **Detached Sidewalks**. Where sidewalks are detached from the curb, directional ramps should be used. On arterial streets with detached

sidewalks and corner radii greater than or equal to 35 feet, directional ramps shall be installed.

8.4.4 Use of Standard Drawings

Project drawings shall call out the specific detail from Town of Castle Rock Detail Plans to be used in construction for each curb ramp.

8.4.5 Sidewalk Chase Drains

Sidewalk drains shall not interfere with the pedestrian's use of the sidewalk. The chase drain shall be flush with the sidewalk surface and be securely fastened as specified. Sidewalk drains shall not be located within a curb ramp, curb cut, or driveway. This section also applies to bike paths, sidepaths, multi-use trails.

8.4.6 Curb Returns

In certain cases, the Town may require the radius of the curb return to be reduced from the values given in Table 2.2 (Chapter 2, Roadway Design and Technical Criteria), to reduce pedestrian travel time and distance.

8.4.7 Pedestrian Crossings

All crosswalks shall be marked in accordance with the MUTCD and Section 6, Traffic Signing and Pavement Markings. Crosswalk markings will be required at all signalized intersections, school areas, and high pedestrian areas as designated by the Town's Traffic Engineering and Operations Manager.

1. **Cross Slope -** Sidewalk cross slope shall be maintained at 2% across driveways.

2. **Crosspans -** Crosswalks shall not be located in crosspans.

3. **Maximum Crosswalk Length -** The maximum length for any non-signalized crosswalk shall be 56 feet. Any non-signalized street crossing wider than 56 feet shall be provided with pedestrian refuge area having a minimum width of 6 feet.

8.4.8 Traffic Signals

All pedestrian traffic signals shall be in accordance with the latest version of the MUTCD and Chapter 4, Traffic Signals. All traffic signals shall include pedestrian signal indications with countdown timers and pedestrian push buttons.

8.4.9 Pedestrian Refuge Areas

For arterials with raised medians and on splitter islands for roundabouts, a pedestrian refuge area shall be created in the median to increase pedestrian safety. The vehicle turning radii must be taken into account with the specific design of islands and medians. Curb ramps shall be aligned to guide the sight-impaired to the refuge area. The pedestrian refuge area should be eight (8) feet in width but no less than six (6) feet.

8.4.10 Pedestrian Minimum Clear Path

The minimum clear path around utility structures, street furniture and other encroachments shall be greater or equal to the sidewalk width listed in Table 2.2 (Section 2 – Roadway Design and Technical Criteria) for the applicable street classification.

Section 9

BRIDGES, CULVERTS & RETAINING WALLS

9.1 GENERAL INFORMATION

9.1.1 Scope

This chapter describes general bridge, culvert and retaining wall design requirements for use in the Town of Castle Rock.

9.1.2 Pre-Design Meeting

Prior to beginning a bridge or major culvert design, a pre-design meeting may be requested by either the Town or the design consultant. A pre-design meeting is recommended.

9.1.3 Independent Review of Plans

The applicant shall be responsible to contract with a reputable engineering firm to conduct an independent review of the design construction plans. Comments and corrections recommended by the independent review firm shall be incorporated into the final plans. The Town will issue a permit to allow construction only upon written verification of the independent review & comment incorporation process. All costs associated with this process shall be borne by the applicant.

9.1.4 Construction Inspection

The applicant shall be responsible to contract with a reputable engineering firm to conduct appropriate inspection of the bridge or major culvert construction. The applicant, through the engineering firm, shall be responsible for ensuring compliance of construction with the approved plans and specifications. The Town will issue a permit to allow construction only upon written verification that a contract is in place for this work. All costs associated with the inspection shall be borne by the applicant.

9.2 BRIDGE & CULVERT CRITERIA

9.2.1 General Design Requirements

1. All bridge and culvert elements shall be designed in accordance with:

A. AASHTO, "LRFD Standard Specifications for Transportation Materials and Methods of Sampling and Testing", latest edition and applicable interims.

B. CDOT, "Standard Specifications for Road and Bridge Construction", latest edition and Standard Special Provisions and Bridge-specific Project Special Provisions.

C. CDOT, "Bridge Manual", latest edition and Bridge Technical Memorandums.

2. Any structure over a 20 ft. span must be designed to current AASHTO vehicular live loading.

3. All box culverts and bridges shall have the year of construction permanently indentured on the downstream headwall face in legible numbers. The numbers shall be 3" high by 1½" deep in the headwall face.

4. Culvert and bridge waterway opening designs shall also conform to the parameters set forth in the "Town of Castle Rock Storm Drainage Design and Technical Criteria Manual", latest edition.

5. If a vehicular railing or safety-shaped barrier is within the clear zone as defined by AASHTO Roadside Design Guide, approach guardrails are to be installed on all approach ends in accordance with AASHTO guidelines.

6. The crown should be centered on the bridge except for 1-way bridges, where a straight cross slope in one direction may be used. The cross slope should match that of the approach pavement.

7. Approach railings are required at the ends of bridges exposed to approach traffic. The type of approach railing selected should match the rail to be used on the bridge. Approach railings must have an approved end treatment that meets current standards at any exposed end. (For detailed information see the AASHTO "Roadside Design Guide".)

8. Timber bridges are not allowed.

9. A safety railing is required on or adjacent to vertical faces such as retaining walls, wing-walls and abutments, etc., and where the vertical fall is 2 feet or more. The safety railing shall be placed on top of the vertical face structure of the vertical drop.

9.3 RETAINING WALL CRITERIA

1. Recommended types of retaining walls include reinforced concrete and structural masonry. Heavy timber construction is not encouraged. The walls need to include integral attachments for railings and weep drainage where applicable.

2. In general, the materials and design of retaining walls need to match or blend with the adjacent natural features, landscaping and/or buildings.

9.4 STRUCTURAL CLEARANCES

9.4.1 Horizontal Clearances

1. Clear roadside design is recommended for all arterials and collectors whenever practical. Where the roadway is curbed, the clearance between curb face to edge of the object should be a minimum of 3 feet. For further guidance, refer to the AASHTO “Roadside Design Guide”.

2. The horizontal clearance to bridge piers, abutments, headwalls and retaining walls on all streets can be no less than 10 feet from the edge of the traveled way and may require protection depending on the roadway design speed.

3. Drainage structures (pipes, box culverts, etc.) are to be extended to a distance of 10 feet from the edge of the travel way. A lesser clearance may only be allowed when rights-of way limitations make the desired clearance unreasonable and appropriate traffic barriers are installed in accordance with the AASHTO “Roadside Design Guide”.

9.4.2 Vertical Clearance

Minimum vertical clearance shall be 16.5 feet over the entire width of the traveled way of an arterial street or major collector street. On other streets, the minimum shall be 14.5 feet.

9.5 CONSTRUCTION PLANS AND SPECIFICATIONS

9.5.1 Bridge Plan Content

1. The designer shall prepare separate drawings of all bridge elements and incorporate them as an integral part of the construction plans.

2. As a general guide, the plans shall be drawn at a 1 inch = 20 feet scale, and shall include the following items:

3. Locate and identify all existing and/or proposed improvements, above and below ground, within 200 feet of the structure including all utilities.

4. Locate and identify all existing and/or proposed pavement marking and signing.

5. Locate existing vegetation.

6. Provide a profile layout and roadway curve data.

9.5.2 Specifications

Specifications shall be developed in accordance with CDOT's Standard Specifications for Road and Bridge Construction. The designer will determine the need for project-specific construction special provisions. Notes may be added to the construction plans if the designer feels that it is necessary to clarify certain items.

Section 10

TRANSIT FACILITIES

This section is reserved for future use when transit services are available in Castle Rock.

Section 11

NEIGHBORHOOD TRAFFIC MANAGEMENT

11.1 GENERAL INFORMATION

11.1.1 Scope

This section of the Transportation Design Criteria Manual presents acceptable methods for implementing neighborhood traffic management (traffic calming) for new local streets so that future neighborhoods are not negatively impacted by vehicular traffic.

11.2 TRAFFIC CALMING DESIGN CRITERIA

11.2.1 General Requirements

1. Proposed land uses, and their associated travel demands, shall be designed so that they do not negatively impact surrounding/adjacent residential neighborhoods.

2. The design of residential areas shall limit "unwanted" vehicle traffic while maintaining emergency access. "Unwanted" vehicle traffic is defined as any one of the following:

- Traffic operating at excessive speeds
- Vehicles with an origin and destination outside the neighborhood
- An excessive volume, as defined by the Town, of traffic on a local street.

3. All proposed local streets with long, uninterrupted segments shall incorporate traffic calming measures. Long uninterrupted segments are generally defined as relatively straight (curves allowing design speeds greater than 25 mph), and longer than 600 feet.

4. In general, the design guidelines for local street sections, as presented in Section 2 of this manual (Roadway Design Criteria), are intended to discourage high operating speeds, high volumes and cut-through traffic.

5. Yield and stop signs may be used to break up long stretches of streets only if they can be shown to be in conformance with the latest MUTCD. Traffic calming treatments must be utilized if intersection signage is not appropriate.

6. Traffic calming may be required for some collector class streets in areas of high pedestrian traffic, for example: schools & parks.

11.2.2 Traffic Calming Measures

1. The following traffic calming measures may be considered for incorporation into the design of new streets. The use of any of these measures shall require the prior approval of the Town Manager or designee.

A. Entry Island:

Entry Islands are typically at the perimeter of a neighborhood. They can incorporate neighborhood identification signing and monumentation.

B. Raised Pedestrian Crossing:

A flat-topped speed table built as a pedestrian crossing. Commonly includes a median refuge island, curb extensions, or both to shorten crossing and improve safety. May also include specialty pavement treatments. Note: Any vertical traffic calming element must be approved by the Town's Fire Department.

C. Curb Extensions:

Segments of roadway narrowing where roadway edges or curbs are extended toward the center of the roadway. Vehicles may slow as they pass through the narrowed section. Curb extensions can be used in conjunction with midblock pedestrian crossing treatments. May also be designed with curb chase to maintain existing flow line. Should not be used where they would encroach into bike lanes.

D. Partial Medians:

A raised median in the center of the roadway with one-way traffic on each side. Can only be constructed at mid-block locations to allow all turning movements at intersections.

E. Traffic Circle:

A raised circular medians in an intersection with counter-clockwise traffic flow. Vehicles must change their travel path to maneuver around the circle and are typically controlled by "Yield on Entry" on all approaches.

F. Speed humps and speed cushions:

Raising short sections of the street to control speeds. Note: Any vertical traffic calming element must be approved by the Town's Fire Department.

G. See examples of traffic calming in Appendix B.

11.3 CONSTRUCTION PLANS

11.3.1 Traffic Calming Plan Content

1. The designer shall include all traffic calming elements as an integral part of the construction plans.

2. All signage elements must comply with the MUTCD.

Section 12

LIGHTING

12.1 GENERAL INFORMATION

12.1.1 Scope

This chapter provides the procedures and criteria for the design and installation of street and pedestrian lighting.

12.2 LIGHTING DESIGN CRITERIA

12.2.1 General Lighting Design Requirements

1. All equipment and materials specified must conform to current IREA specifications. The Developer is responsible for coordinating all aspects of design and installation with IREA. If IREA offers multiple fixture choices, the Town must approve the fixture choice prior to installation.

2. All fixtures, poles, and designs must be reviewed and approved by the Town and IREA.

3. All lamps are to be either Metal Halide (MH) or Light Emitting Diode (LED). The Town reserves the right to specify which type will be used. On traffic signals, the lamps must conform to Section 4, Traffic Signal Design.

12.2.2 Light Spacing and Layout

1. This section only refers to lighting on all streets within the Town.

2. The lighting type and spacing shall be as follows:

TABLE 12.1
STREET LIGHT REQUIREMENTS AND SPACING

Roadway Classification	Luminaires	Staggered Spacing
Arterial	250-W MH, fiberglass pole, 32-foot mounting height	150 feet
Collector	150-W MH, fiberglass pole, 27-foot mounting height	200 feet
Local/Residential	70-W MH, fiberglass pole, 15-foot mounting height	300 feet

3. Street lighting shall be installed behind sidewalks where sidewalks are attached to the curb. Lighting on local residential streets shall be located a minimum of 12 inches behind the adjacent walk but must be within easements or right-of-way. For major collectors and arterials, the light must be offset a minimum of 24 inches from the curb face and yet leave at least 36 inches of clear space between the light pole and the edge of the sidewalk.

4. All lighting in residential areas shall be installed to minimize light shining on or negatively affecting the neighboring residences.

5. A street light is required in the turnaround area of a cul-de-sac.

12.2.3 Intersection Lighting

1. The positioning of light standards at intersecting streets. See Table 12.2.

TABLE 12.2
INTERSECTION LIGHT LOCATIONS

Intersection Type	Luminaires	Light Locations
Arterial/Arterial	250-W (or highest wattage available by IREA if less), fiberglass pole, 38-foot mounting height	4 lights, one on each corner
Collector/Arterial	250-W , fiberglass pole, 32-foot mounting height	4 lights, one on each corner
Collector/Collector	150-W , fiberglass pole, 27-foot mounting height	2 lights, one each on opposite corners
Local/Collector	70-W , fiberglass pole, 15-foot mounting height	2 lights, one each on opposite corners
Local/Local	70-W, fiberglass pole, 15-foot mounting height	1 light on one corner

2. Lighting locations at roundabouts will vary from the above chart. Lighting layouts at roundabouts must adhere to the latest FHWA design guide for roundabouts and/or publications of the Illuminating Engineering Society (IES) concerning roundabout lighting.

3. Signalized intersections will be lighted using combined streetlights and mast arms. Since these fixtures are owned by the Town, not IREA, the wattage for street light fixtures on signals shall be 250W with the fixture housing approved by the Town.

12.2.4 Installation

1. Street lighting shall be installed with underground electric service on all public streets in the Town. If existing lighting is served by overhead electric service, it may continue to be served in that manner.

2. It shall be the responsibility of the Developer of new or upgraded street improvements to install street lighting fixtures and the associated power sources to adequately light the public improvements. Street lighting fixtures are to be owned and operated by IREA. The developer is

responsible for all charges by IREA until all public improvements associated with the project are conveyed and accepted by the Town.

12.2.5 Other Lighting

1. Railroad crossing lighting will conform to FHWA's Railroad-Highway Grade Crossing Handbook.

2. All bridge or road underpasses, where vehicles, pedestrians, or bicyclists may be present, shall require lighting.

12.3 CONSTRUCTION PLANS AND SPECIFICATIONS

12.3.1 Lighting Plan Content

1. The designer shall show proposed lighting installations on the following sheets of the construction plans.

A. Overall Plan

B. Plan and profiles

C. Signing and Pavement Markings

Section 13

UTILITY INSTALLATION AND COORDINATION

13.1 GENERAL INFORMATION

13.1.1 Scope

This chapter provides the procedures and criteria for the installation and maintenance of public and private utilities within the Town's streets and/or rights-of-way. Coordination of utilities' installation and maintenance is required to ensure the most efficient use of the Town's rights-of-way and to prevent unnecessary disruptions to the public.

13.2 UTILITY FACILITIES CRITERIA

13.2.1 General Requirements

1. All utilities, including water, sanitary sewer and storm sewer, shall be stubbed out to the property line/edge of right-of-way at all locations that are planned for future tie-ins. Sanitary and storm sewer shall include a manhole at the property line to demarcate the limits of Town maintenance versus private maintenance. Water main shall include a valve at the property line for the same purpose. Other reasonable stub-outs may be requested by the Town based on sound engineering judgment and knowledge of adjacent Development.

2. Private utility companies shall install all facilities within a Schedule 40 PVC sleeve across all public streets to accommodate future repairs without street cuts. Sleeves shall be installed at a minimum depth of 36" to the top of the pipe from the top of the curb/pavement. A pull string and tracer wire shall be installed directly above the pipe. Sleeve location shall be determined on a case-by-case basis.

3. For conduits, the sleeve must also terminate into a pull box at each end.

4. All electric service shall be placed underground within the Town. If existing lighting is served by overhead electric service, it may continue to be served in that manner.

5. Trees or shrubs shall not be planted over buried utilities, within the sight distance triangle at intersections or accesses.

13.3 UTILITY LOCATION CRITERIA

13.3.1 Public Utilities

The locations of Water mains, Sanitary Sewer mains and Storm Sewer pipe in the public right-of-way are addressed in the Town's design criteria manual for each system.

13.3.2 Natural Gas Mains and Appurtenance

Gas mains shall be located either within the Right-of-Way or in an adjacent easement on the south and west sides of the street to ensure adequate utility separation. If the gas company wishes to run double mains (a main on each side of the street), the location of the double mains in relation to other utilities must be coordinated with and approved by the Town.

13.3.3 Electric, Telephone, Cable and Fiber Optic Lines and Appurtenances

Generally, electric, telephone, cable, fiber optic & any other dry utility lines shall be located within an easement adjacent to the right-of-way or along property lines. Some utilities have franchise agreements with the Town which allow the use of the street right-of-way for location of utilities.

13.4 Utility Appurtenances

1. Utility appurtenances (including but not limited to electric controls, sprinkler controls, valve boxes, signs, telephone or light poles, switching cabinets, etc.) shall not be placed within the public rights-of-way or easements in a manner that interferes with or obstructs the operation and maintenance of the roadway including any pedestrian and bicycle facilities. Any utility structures, appurtenances or other physical improvements may not interfere with or obstruct the sight lines of traffic along the roadway or at intersections.

2. The Town of Castle Rock is not responsible for repair of private irrigation within pubic right of ways. Irrigation sleeves may be placed across the street by permit from the Town. Irrigation sleeves shall be installed per the Town's Construction Specifications

3. Poles, signs and any other above-ground streetscape (except regulatory signs), shall be generally located within 5 feet of the Right-of-Way line or 10 feet from the edge of the travel lane (flowline), whichever is most restrictive.

4. All manhole lids, utility access covers and pull boxes shall be depressed ¼ inch to ½ inch below the adjacent finished street surface.

Section 14

PAVEMENT DESIGN CRITERIA

14.1 GENERAL

1. The structural design of a pavement system must be done with a clear understanding of the factors that affect the life and serviceability of the pavement. There are multiple factors in design and construction of a pavement system. This Pavement Design Criteria addresses those factors having a significant effect on the pavement life and serviceability. The objective is to obtain the best quality pavement system considering factors such as: subgrade, traffic loads, pavement material, future maintenance and special considerations such as swelling or collapse-prone soils, slope instabilities and frost susceptible soils. The design must be founded upon a sound theoretical and experience base since public monies are at risk and a direct fiduciary responsibility exists. This design manual assumes that all of the parts of the pavement section and subgrade, trench backfill, asphalt mixture, aggregate base course, etc. are constructed in accordance with the Town of Castle Rock Criteria.

2. This design methodology is prescriptive in nature and represents the minimum requirements of a design. The philosophy is to provide a design system which is easy to understand and use, but allows the Design Engineer flexibility to investigate alternatives. Alternatives, when proposed, must meet minimum design requirements and have sufficient data and analyses to allow the Town to evaluate the alternatives. The acceptance of any design is solely at the discretion of the Town. In the event the Town rejects a design, reasons for the rejection will be provided to the Design Engineer.

3. Pavement design reports and recommendations for new subdivision streets are submitted to the Development Services Department and reviewed by the Public Works Department. Pavement design reports and recommendations for Town capital projects are submitted directly to the Public Works Department.

4. The design methodology presented in this document is based upon the 1993 American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures. The objective is to provide design parameters for local materials and conditions, and to provide guidance on the use of AASHTO equations. Pavement designs obtained from this procedure are expected to result in equal life and serviceability provided the minimum material specifications are met,

construction recommendations are followed, and proper maintenance is provided. The design methodology presented is not meant to prevent the use of alternative methods as technology changes and additional pavement systems develop. Furthermore, with the Town's discretion and approval, the Town may accept designs based upon the most recent version of the CDOT Pavement Design Manual. The applicant shall obtain approval of alternate pavement methods or use of CDOT criteria prior to the geotechnical engineer's preparation of the design. Throughout this manual, ASTM and applicable AASHTO, or CDOT test standards apply interchangeably.

14.2 DESIGN REPORT

The Design Report is to consider the conditions after design of the pavement alignment and elevation, and after the street is cut to utility grade (utility grade, or "rough" grade, is defined as within +/-0.2 ft. of final grade).The nature of subgrade soils which expand or collapse due to wetting provide unique design problems which are best addressed during rough grading operations. A Preliminary Geotechnical Investigation of the street alignment is appropriate when expansive or collapsible soil conditions are present and when over-excavation, moisture treatment and re-compaction of the subgrade during mass site grading is expected to be appropriate. The preliminary investigation borings must be located in both cut and fill areas, and must be properly surveyed for both horizontal and vertical location. Borings must extend below finish subgrade elevations per boring depths as discussed in Section 14.3.

14.3 FIELD INVESTIGATION

The field investigation should be designed to evaluate subgrade soil types, determine ground water levels that may impact pavement performance, and investigate support conditions along the alignment. As a minimum:

1. Borings shall be made at not greater than 250-foot horizontal intervals for 2-lane roadways; and not greater than 250-foot intervals in each direction for roadways with multiple lanes in each direction.

2. Additional borings shall be made to investigate conditions such as filled drainage ways, obvious deflecting subgrade, subgrade material color

changes, unusual adjoining vegetation or other observable conditions which could affect pavement performance.

3. Borings are to be a minimum of 5 feet in depth below design subgrade, with every fourth (minimum of one) boring 10 feet in depth below rough roadway subgrade elevation.

4. All borings shall be sampled using "California “or split spoon type samplers at depths of 1 foot and 5 feet below rough cut subgrade elevation for each boring, and at a depth of 10 feet at every fourth boring. The blows per foot or length and recovery, boring number, and sample description shall be documented. Bulk samples of materials found in the upper 5 feet of the subgrade shall be obtained from each boring for each soil type. Should varying materials be found in the upper 5 feet samples of each material type shall be obtained for classification.

5. Boring logs shall include a description of soil types encountered, depths at which and types of samples taken, blow counts, moisture conditions, free water and anomalous conditions.

6. If circumstances warrant, test pits are allowed provided that the Engineer can provide adequate analysis for pavement design purposes meeting Town criteria.

14.4 LABORATORY TESTING

The purpose of the laboratory testing program is to classify subgrade material and evaluate support properties and moisture sensitivity (heave, collapse, softening) that can affect long-term pavement performance. Testing programs consist of classification testing (i.e., gradation analysis, Atterberg Limits and sulfate tests) and engineering properties testing (I.e., swell/consolidation, R-value, unconfined compressive strength, and Resilient Modulus Tests).

14.4.1 Soil Classification

All samples of the subgrade soils obtained shall be tested to evaluate classification using the AASHTO system. The minimum requirements are shown in Table 14.1.

Table 14.1 Subgrade Classification Testing

AASHTO Soil Classification, AASHTO M 145	Each soil type encountered in each boring
Natural Moisture/Density, AASHTO T 265 & AASHTO T 204	Each drive or Shelby sample
Maximum Dry Density and Optimum Moisture	Bulk sample of material governing pavement design
Liquid Limit, AASHTO T 89	Each soil type obtained in each boring
Plastic Limit AASHTO T 90	Each soil type obtained in each boring
Percent Passing No. 200, AASHTO T 11	Each soil type obtained in each boring
Gradation Analysis, AASHTO T 27	Each sample of A-1 to A-3 soils obtained in each boring
Sulfate Tests, CDOT, CPL 2103	1 test for each 1,000 lineal feet where A-6 or A-7-6 soils are found

Soils shall be grouped based upon the AASHTO classification system for each bulk material found in the upper 5 feet and the Group Index calculated. When a greater than 7 point disparity in Group Index is noted, the subgrade soil groups shall be subdivided into two or more groups. The content of soil groups shall be plotted on a project drawing. Soils which govern the design shall be those having the highest AASHTO soil classification (i.e., A-7-6 to A-2-4), lowest subgrade support or highest Group Index, within the design length of the roadway. Roadway design can be subdivided based upon the extent of subgrade materials found along the roadway length.

14.4.2 Swell/Consolidation Tests

Cohesive materials (A-4, A-5, A-6, and A-7) shall be tested to determine swell or consolidation potential. Tests shall be run on "California" or split spoon samples collected from 1 foot below the utility grade or subgrade in accordance with ASTM D 4546 at a vertical pressure of 200 pounds per square foot (psf). Testing frequency for these materials shall be in accordance with Table 14.2.

Table 14.2
Swell Testing Frequency

Number of Borings	Testing Frequency
Less than 5	Each boring
5-25	Minimum 5 samples
Greater than 25	Minimum 7 samples or 1 per 5 borings

The test results shall be plotted and the percent swell/consolidation and swell pressure (psf) shall be determined and reported. Test results which are suspected of being not representative of "typical" conditions shall not be considered in the design of the pavement but shall be reported. Any deletion of data shall be justified in the written report. The swell/consolidation potential for a given soil group shall be the calculated average of the group.

14.4.3 Subgrade Support Evaluation

For the material groups which govern the design (as determined in Section 14.4.1) of the pavement system, compaction and strength testing shall be performed on composite samples constructed using equal amounts of bulk sampled materials with the same classification and Group Index range specification in accordance with Table 14.3.

Table 14.3

Subgrade Strength Evaluation

Subgrade Compaction and Strength Testing	
Unconfined Compressive Strength Test on remolded sample, compacted at 2% above Proctor optimum moisture content in accordance with AASHTO T 99, or Remolded sample (AASHTO T193) compacted at 2% above Proctor optimum moisture content or Hveem Stabilometer (R-value), AASHTO T190	For all groups Classified as A-2-6, A-6, and A-7
Standard Proctor Compaction, ASTM D 698 Modified Proctor Compaction, AASHTO T 180	For all groups not classified below For groups classified as A-1, A-3, A-2-4, and A-2-5.

The design soil support value shall be determined to be the lowest value obtained from the testing. In the event the Design Engineer elects to remove and replace the lowest support value to a minimum depth of 2 feet below finish subgrade, the support value of the replacement fill can be used. Technical justification (calculations) for the removal and replacement shall be provided in the report.

14.5 PAVEMENT DESIGN

The design methodology is based upon the 1993 AASHTO Guide for Design of Pavement Structures equations and considers Traffic and Subgrade Resilient Modulus as the primary variables. Traffic loading requirements are presented in Section 14.5.1. The Subgrade Resilient Modulus and swell/consolidation analysis shall be determined in accordance with Section 14.5.2. The design equations for flexible and rigid pavements are presented in Section 14.5.3 and 14.5.4. Alternatives will be considered with advances in pavement design methods and paving material changes. Any deviation from guidelines presented in this document must be technically justified and approved by the Town.

14.5.1 Equivalent Single Axle Load (ESAL)

1. A primary factor in pavement design is the loading of traffic on the roadway. This is a combination of the volume of traffic and the weight of the vehicles on the street. This factor is described in terms of 18,000-

pound Equivalent Single Axle Loads (ESAL)'s. The calculation of ESAL's is based on the following information:

- ADT
- Lane distribution
- Truck volumes
- Truck weights and axle configurations

Since this information is not always readily available for all streets, this manual provides default ESAL values for Town street classifications and Town-wide truck volume estimates. The ESAL values to be used for lower street classifications are shown in Table 14.4. Without a cap on the allowed daily traffic on major collector and arterial streets, ESALs for these streets must be estimated in a site specific study.

2. Pavement design can be completed using a roadway specific ESAL value. ESAL can be calculated using the technique described in the most recent CDOT M-E Pavement Design manual. The calculations, input data, and any assumptions must be reviewed and accepted by the Public Works Department.

Table 14.4
Town Street ESAL Default Values

Street Classification	Flexible Pavement	Rigid Pavement
Local Residential	100,000	100,000
Local Mixed Use	750,000	1,000,000
Industrial	1,100,000	1,500,000
Minor Residential Collector	350,000	500,000
Minor Non-Residential Collector	700,000	1,000,000
Major Collector	N/A	N/A
Major and Minor Arterial	N/A	N/A

These are one-directional and per-lane ESAL values which may not be reduced for directional travel or lane distribution.

14.5.2 Subgrade Support Characterization

Subgrade characterization consists of evaluating subgrade and long-term support values. The degree of moisture sensitivity and deflection sensitivity is used to evaluate the depth of moisture treatment appropriate to reduce the deflection at the surface of the completed pavement system. The support value is expressed in the form of a Resilient Modulus as determined from unconfined compressive strength, R-value, or CBR testing.

1. Expansive Subgrade - Tests performed to determine swell (expansion) potential in accordance with Section 14.4.2 shall be averaged for each soil group. For the highest average swell the depth of moisture treatment shall be determined in accordance with Table 14.5. Using engineering judgment, locally differing values shall be addressed in the text of the report under the appropriate subgrade discussion section.

Table 14.5
Depth of Moisture Treatment for Expansive Soils

Swell %at 200 psf Subgrade Soil Samples	Depth of Moisture Treatment (feet)	
	Non-Arterials	Arterials
<2	--	--
2 to 3	--	2
3 to 4	--	2
4 to 5	2	3
5 to 6	2	3
6 to 8	3	4
8 to 10	3	4
Greater than 10	4	6

Moisture treatment is the process of removing the soil, adding moisture until the soil moisture content is between 1 and 3 percent above optimum as determined by AASHTO T 99 (ASTM D 698), and compacted to at least 95 percent of maximum Standard Proctor density. Soils requiring moisture

treatment per Table 14.5 will require a stabilized subgrade per Section 14.5.2.2. Moisture treatment shall extend to the back of curb as a minimum. Where monolithic/combination curb, gutter and sidewalk is planned, moisture treatment shall extend to the back of the attached sidewalk.

The "Effective Depth of Moisture Treatment" figure in the Colorado Department of Transportation Pavement Design Manual may be used in place of Table 14.5.

2. Subgrade Stabilization- Subgrade soils treated to have high moisture contents typically have low support values and will be soft and yielding during paving. Stabilization of at least the upper 12 inches by chemical or mechanical methods will be necessary. This depth includes any approved Chemically Treated Subgrade section (GS). The depth of treatment has to be determined by the design engineer in the design report, or as an addendum to the report, based upon the actual field conditions. Subgrade stabilization shall extend to the back of curb as a minimum. Where monolithic/combination curb, gutter and sidewalk is planned, moisture treatment shall extend to the back of the attached sidewalk.

A. Chemical Stabilization -Chemical stabilizing agents include lime, fly ash, cement, combinations of lime/fly ash, and lime/Portland cement. Other agents or combinations can be used with approval by the Town and provided the mix design requirements are satisfied. Laboratory mix designs shall meet the following criteria:

- For Lime treatment the pH shall be equal to or higher than 12.3 before compaction
- Unconfined Compressive Strength between 160 psi and 700 psi (ASTM 2166)
- Swell is less than one percent at 200 psf (ASTM D 4546)

When lime is used, the Plasticity Index is to be reported from initial to final construction to all interested parties (e.g., Stabilization Contractor, Geotechnical Engineer and Town Construction Inspector) and shall not be used for acceptance purposes.

If water soluble sulfate contents exceed 0.2 percent, the treatment shall be accomplished using a double application method. A double

application method consists of an initial treatment of Lime and allowing it to mellow for a minimum period of 7 days (with constant wetting). After the mellow period, the subgrade should be mechanically mixed prior to applying the remaining percentage of chemical stabilizer (Lime, Fly Ash or Cement). This shall be presented and discussed in the design report. All chemical stabilization shall be performed in accordance with Section 14.7.5.

B. Mechanical Stabilization - Soft, yielding soils may be stabilized mechanically using geogrids in conjunction with aggregate base course or recycled concrete to provide a stable construction platform. All mechanical stabilization shall be performed in accordance with Section 14.7.6.

3. Resilient Modulus - Subgrade support characteristics using the 1993 AASHTO design methodology consider the Resilient Modulus (M_R). Equipment to directly determine the Resilient Modulus may not be available to some local firms. A series of correlations and alternative equations are provided to aid firms that do not have the appropriate equipment to estimate the design M_R equations to estimate values using R-value for non-cohesive subgrade materials, a modified unconfined compressive strength procedure or CBR for cohesive subgrade materials are included with this document. The subgrade strength characteristics shall be evaluated in accordance with the requirements of Section 14.4 Laboratory Testing. These values can be converted into Resilient Modulus using the following equations:

<u>Unconfined Compressive Strength</u>

(A-2-6 soils) $M_R = 2.23 (q_u) (0.75)$

(A-6 soils) $M_R = 2.15 (q_u) (0.75)$

(A-7-6 soils) $M_R = 3.13 (q_u) (0.75)$

(Claystone) $M_R = 1.68 (q_u) (0.75)$

Where q_u = unconfined compressive strength in psf

<u>California Bearing Ratio</u>

$$M_R = 1500 * (CBR)$$

Hveem Stabilometer (R-Value)

$$M_R = 10^P \; Where \; P = \frac{S + 18.27}{6.24}$$

$$S = \frac{R - 5}{11.29} + 3$$

Where R is the R-value from Hveem stabilometer

14.5.3 Flexible Pavement Structural Section

The thickness of the pavement section shall be determined using the design traffic 20-year, 18-kip ESAL's obtained from Section 14.5.1, the Resilient Modulus obtained from Section 14.5.2.3 and the depth of moisture treatment and stabilization obtained from Section 14.5.2.1 and 14.5.2.2.

The Structural Number (SN) shall be determined using the AASHTO 1993 design methodology (or the design nomographs provided in Figure 14.2) with the input parameters presented in Table 14.7 and the strength coefficients provided in Table 14.6. Calculate pavement layer thicknesses with the following formula:

SN =a1(D1) + a2(D2) + ...+ an(Dn)

Where:

a1 =Strength coefficient for AM

a2, a3, a4...an = Strength coefficient for lower layers

D1=Thickness of AM

D2, D3, D4...Dn =Thickness of additional layers

Table 14.6
Material Strength Coefficients

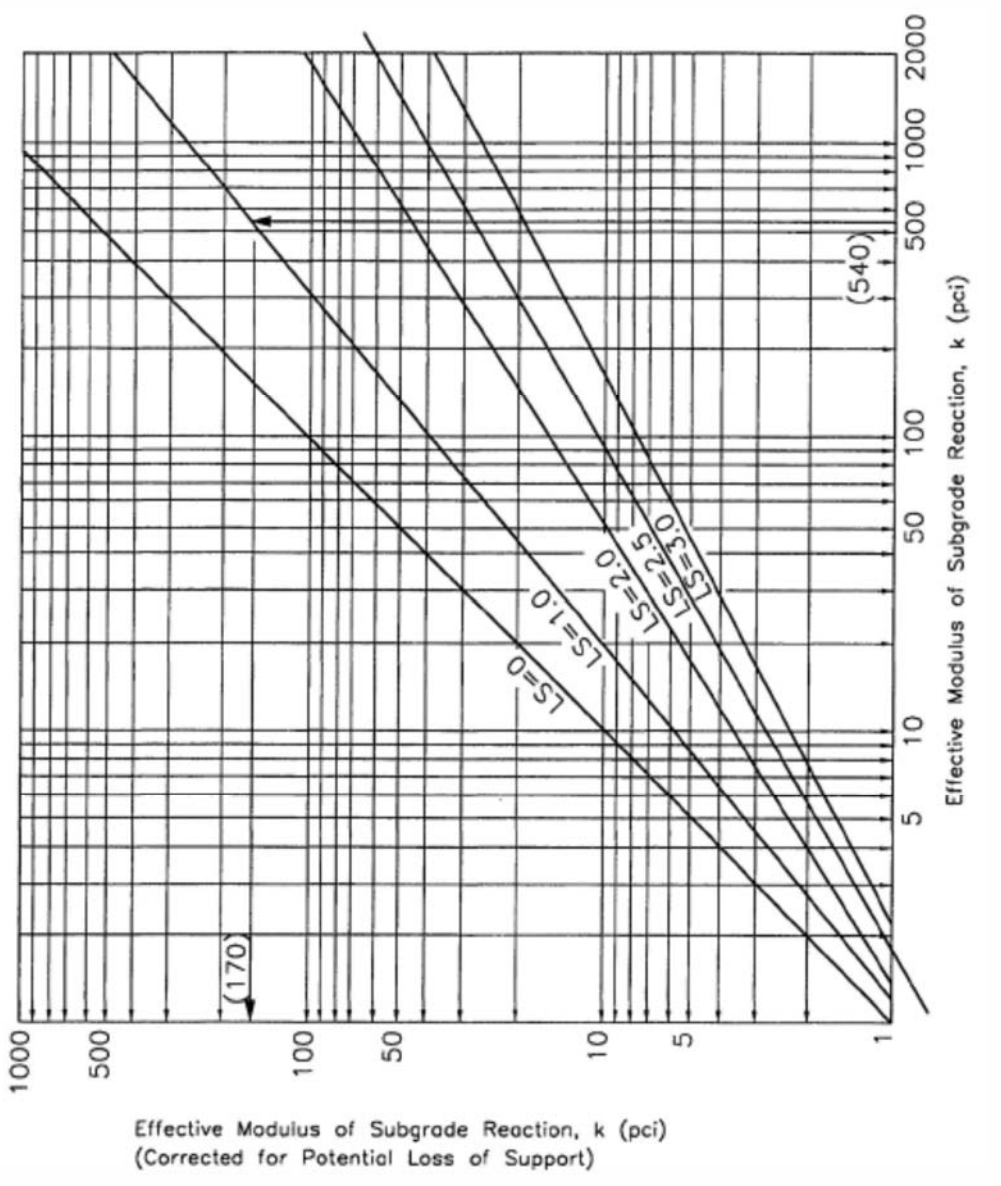
Material	Coefficient (a)
Asphalt Mixture (AM)	0.44
Existing Asphalt Mixture	0.24[1]
Aggregate Base Course/Recycled Concrete Base	0.12
Existing Aggregate Base Course	0.10
Granular Sub-base(R =50+,CBR = 15+)	0.07
Chemically Treated Subgrade (constructed in accordance with Section 14.7.5)	0.14

Note 1: Maximum value unless supported by testing

Table 14.7
Flexible Pavement Design Parameters

Input	Value
Reliability (R)	95% for arterials and all commercial frontage and industrial roadways 90% for collectors 85% for local roadways 80% for cul-de-sacs
Standard Deviation (So)	0.44 for flexible pavements
Initial Serviceability =4.5 Serviceability Loss (ΔPSI)	2.5 Locals, collectors, private drives, parking lots and public alleys 2.0 Arterials and all commercial frontage and industrial roadways

Figure 14.1
Correction of Effective Modulus of Subgrade Reaction for Loss of Support



14.5.4 Rigid Pavement Structural Section

The thickness of the pavement section shall be determined using the traffic ESAL's obtained from Section 14.5.1, a k-value, the depth of moisture treatment, and stabilization obtained from Section 14.5.2.1 and 14.5.2.2. For rigid pavement design, the Resilient Modulus (M_R in psi) must be converted to a Modulus of Subgrade Reaction (k-Value in pci) using the following formula:

k-value (pci) =Resilient Modulus (psi) /19.4

The effective k-value can be determined by correcting for Loss of Support (LS) (Figure 14.1) with the following assumptions:
LS = 0.0 for concrete over an existing pavement
LS = 0.0 - 1.0 for Chemically Treated Subgrades
LS = 0.0 - 1.0 for Natural Subgrade Materials
LS = 0.0 - 1.0 for 4-6” of Aggregate Base

The design thickness shall be determined using the AASHTO 1993 design methodology or using the design nomographs in the CDOT Pavement Design Manual with the input parameters presented in Table 14.8.

Table 14.8

Rigid Pavement Design Parameters

Input	Value
Reliability (R)	95% for arterials and all commercial frontage and industrial roadways 90% for collectors 85% for local roadways 80% for cui-de-sacs
Standard Deviation (So)	0.34 for rigid pavements
Concrete Elastic Modulus (Ec)	3,500,000 psi
Concrete Modulus of Rupture (S'c)	650 psi
Initial Serviceability =4.5 Serviceability Loss (ΔPSI)	2.5 Local, collectors, private drives, parking lots and public alleys 2.0 Arterials and all commercial frontage and industrial roadways
Load Transfer Coefficient (J)	See Below

Load Transfer Coefficients (J) for typical designs							
E-18's Millions	Doweled & Mesh		Aggregate Interlock Edge Support		Continuous Reinforcement		Class
	No	Yes	No	Yes	No	Yes	
Up to 0.3	3.2	2.7	3.2	2.8	-	-	Local Streets/Roads
0.3 to 1	3.2	2.7	3.4	3.0	-	-	Local Streets/Roads
1 to 3	3.2	2.7	3.6	3.1	-	-	Local Streets/ Roads
3 to 10	3.2	2.7	3.8	3.2	2.9	2.5	Arterials/Highway
10 to 30	3.2	2.7	4.1	3.4	3.0	2.6	Arterials/Highway
Over 30	3.2	2.7	4.3	3.6	3.1	2.6	Arterials/Highway

Joint spacing, doweling and tie bars shall be in accordance with American Concrete Pavement Association recommendations contained in Design and Construction of Joints for Concrete Streets. Dowels are required for industrial and arterial streets for longitudinal and expansion joints.

14.5.5 Minimum Pavement Sections

If the calculated pavement sections indicate sections thinner than the Minimum Pavement Sections shown below in Table 14.9, the Minimum Pavement Sections shall govern. The Town prefers the use of flexible pavement designed as a composite section of asphalt mixture over aggregate base course. Full depth pavement sections (flexible or rigid) are allowed subject to sufficient justification over chemically treated subgrade, or suitable subgrade as defined herein. Full depth pavement is not allowed over mechanically stabilized subgrade. Certain very sandy subgrade conditions may require applying a non-structural covering of aggregate base course for constructability to support the paving equipment. The Town may increase the minimum pavement section at any location if conditions warrant. Following in Table 14.9 are the minimum pavement thicknesses required by the Town:

Table 14.9
Minimum Pavement Thicknesses {inches)

	Flexible Pavement		Rigid Pavement
Classification	**AM+ABC[3]**	**AM+ CTS[2]**	**PCCP[1]**
Major Arterial	6"+ 8"	6"+ 12"	8"
Minor Arterial	5”+ 8"	5"+ 12"	8"
Major Collector (4 lane)	4"+ 6"	5"+ 8"	6"
Major Collector (2 lane)	4"+ 6"	5"+ 8"	6"
Minor Collector	4”+ 6"	4"+ 6"	6"
Local Residential	4"+ 6"	4"+ 6"	6"
Industrial/Commercial	4"+ 8"	4"+ 12"	6"
Frontage Road	4"+ 6"	4"+ 8"	6"

NOTES:

1. Full depth pavement (asphalt mixture) is only allowed over chemically treated subgrade. Full depth pavement is not allowed over mechanically stabilized expansive subgrade. See section 14.5.5.
2. CTS section as approved by the Town

3. The minimum thickness of ABC shall be six inches in any application

ABBREVIATIONS:

ABC= Aggregate Base Course

AM=Asphalt Mixture

CTS= Chemically Treated Subgrade

PCCP= Portland Cement Concrete Pavement

14.5.6 Alternate Pavement Designs

The Town understands the need to consider emerging technologies in pavement design. In light of this, any alternate pavement design will be reviewed and considered with respect to the following criteria:

- Initial construction cost
- Life cycle cost
- Construction delay and impact
- Facility maintenance and ease of repair
- Pavement noise, smoothness
- Industry capacity and local contractor capability
- Special design provisions such as edge drains behind the curbs[1] to intercept moisture from adjoining development and prevent it from adversely affecting the road subgrade and paving section.

Public Works reserves the right to make the pavement type selection using these and/or other criteria on Town funded projects.

Warm mix asphalt (WMA) is allowed as an alternate asphalt mixture provided that all material requirements and specification standards are met and as approved by the Town.

[1]**Special Drainage Considerations:** The design engineer should anticipate the future developed condition of the land adjacent to the roadway when making the paving design recommendations. Even when no shallow groundwater is present in the pre-developed condition it is expected that certain land uses such as single family homes and projects with irrigated landscaping present the possibility of water entering the road subgrade and adversely affecting the performance and longevity of the pavement. Public Works forces have to install retrofit underdrain systems in many streets to mitigate these kinds of problems. Appropriate design features to stop water from infiltrating into the pavement section are desired.

14.6 PAVEMENT DESIGN REPORT

All pavement design reports shall be prepared by or under the supervision of, and stamped and signed by, a Professional Engineer licensed in the State of Colorado.

14.6.1 Report Submittal

Pavement design reports for new subdivision streets are submitted to the Town. Pavement design reports for Public Works capital projects are submitted to the Public Works Project Manager.

If a street is to be built in phases (i.e., the center two lanes are built first, then at some later date, more lanes are added), a new pavement design investigation and report for the additional lanes will be required if it has been at least two years since the original design was made.

All reports shall contain the following items:

1. Description of the area of the project including the location land use, surface conditions, topography, site grading, extent of site development at the time of investigation, vegetation, and any unusual surface features.

2. Listing of the sampling and testing techniques and appropriate AASHTO or ASTM designations.

3. Table showing AASHTO, USCS and Group Index of the individual subgrade samples found within the drilling depths and of the groups which govern the pavement design.

4. Subgrade support testing sections shall include graphs of moisture/density relation tests, R-values, CBR tests, unconfined compressive strength, swell/consolidation tests and other tests deemed to be applicable for the conditions found performed. The subgrade-support test results shall be

shown along with the resulting calculated Resilient Modulus or k-Value and the equations used to determine the value.

5. Where moisture sensitive subgrade soils occur, the depth of moisture treatment and subgrade stabilization other than the depth determined from Section 14.5.2.1 shall be discussed and the analysis shown.

6. Where treatment is required due to expansive soils (Section 14.5.2.1), a stabilized subgrade is required (Section 14.5.2.2) and a report shall determine the stabilizing agent to be used. Any stabilizing agents not listed must be pre-approved by the Town. Special stabilization techniques required due to high water soluble sulfate contents or other conditions shall be presented. Where soils contain soluble sulfates in concentrations greater than 0.2 percent, a discussion on a double application method and sulfate resistant concrete shall be presented. Should any of these soils be stabilized, special construction precautions shall be presented (i.e., staged construction).

7. The design traffic in terms of ESALs shall be presented on a figure and discussed in the design report, including the source of traffic information.

8. Design pavement thicknesses including asphalt mixture, Portland cement concrete or composite sections shall be shown on a figure for the various street sections. If computer software is used to develop solutions, the print out from the software shall be included in the report. If nomographs are used, they shall be included in the design report for each soil group and traffic loading condition.

9. A discussion of design and construction concerns shall be presented, followed by specific recommendations to mitigate the concerns. Factors such as, but not limited to: swelling heave, frost heave, collapsing soils, difficult excavations, steeply dipping bedrock, organic soils, high water table, median landscaping, low density, collapse prone soils, or utility trench settlement effects must be presented, discussed, and mitigation recommendations presented.

10. Where two minor arterial or higher classification streets intersect the design should consider the combined traffic volumes. The use of Portland Cement Concrete Pavement at high traffic volume intersections may be deemed necessary by the Town. High volume asphalt mixture may also be

appropriate. The Town will determine the extent of the "high-volume" intersection treatments.

11. The report shall include a discussion of material requirements to meet the design assumptions. The report shall refer to appropriate Town of Castle Rock material and construction specifications. Asphalt mix design recommendations, in accordance with the Town of Castle Rock Asphalt Paving Specifications, shall also be included. CDOT requirements may also apply for high-volume traffic intersections.

12. Additional concerns with respect to design, construction, maintenance, and other project aspects should be presented and discussed as necessary.

13. For subdivision streets, issues identified in the Geologic Hazard Study relating to soil stability or special design requirements must be discussed.

14. Reference List

14.6.2 Figures

Each pavement design report shall include figures to present relevant information and design data. Each report must include the following:

1. Project location including:

A. A vicinity map showing the project location. The figure must include enough of the surrounding roadway network to readily and accurately determine the location of any proposed streets.

B. Locations of exploratory borings and the estimated extent of subgrade soil types by soil groups and AASHTO classifications.

C. Scaled maps of the location.

2. Graphical representation of exploratory borings:

A. Graphical boring logs shall be represented using AASHTO classifications for materials. Bedrock shall be represented in

accordance with local practice, i.e., sandstone, claystone, inter-bedded bedrock, weathered claystone.

B. The boring logs shall provide the following:

- Sampling depths and length, including blow count, push depth, and recovery
- Moisture content, dry density, percent swell/consolidation under 200 psf pressure
- Atterberg Limits (liquid limit, plasticity index)
- Fines Content (percent passing the No. 200 sieve)

C. Figures and/or graphs presenting results of relevant laboratory tests e.g. swell/consolidation, moisture/density, unconfined compressive strength, Hveem/stabilization, CBR.

D. Design pavement section alternatives and special alternatives

3. Recommended Pavement System:

A. The design alternatives shall be presented on a "Recommended Pavement Alternatives" figure, illustrating the geographic extent of each alternative pavement section. Include a legend describing each pavement alternative, the design ESAL, and the subgrade group used for the design.

B. Special considerations such as soft soils, organic materials, subgrade treatments shall be presented on the "Recommended Pavement Alternatives" figure.

C. Structures such as bridges, box culverts, interchanges, and turn lanes shall be shown on all site figures.

D. Where lanes have different pavement sections, the variations shall be clearly shown on the "Recommended Pavement Alternatives" figure.

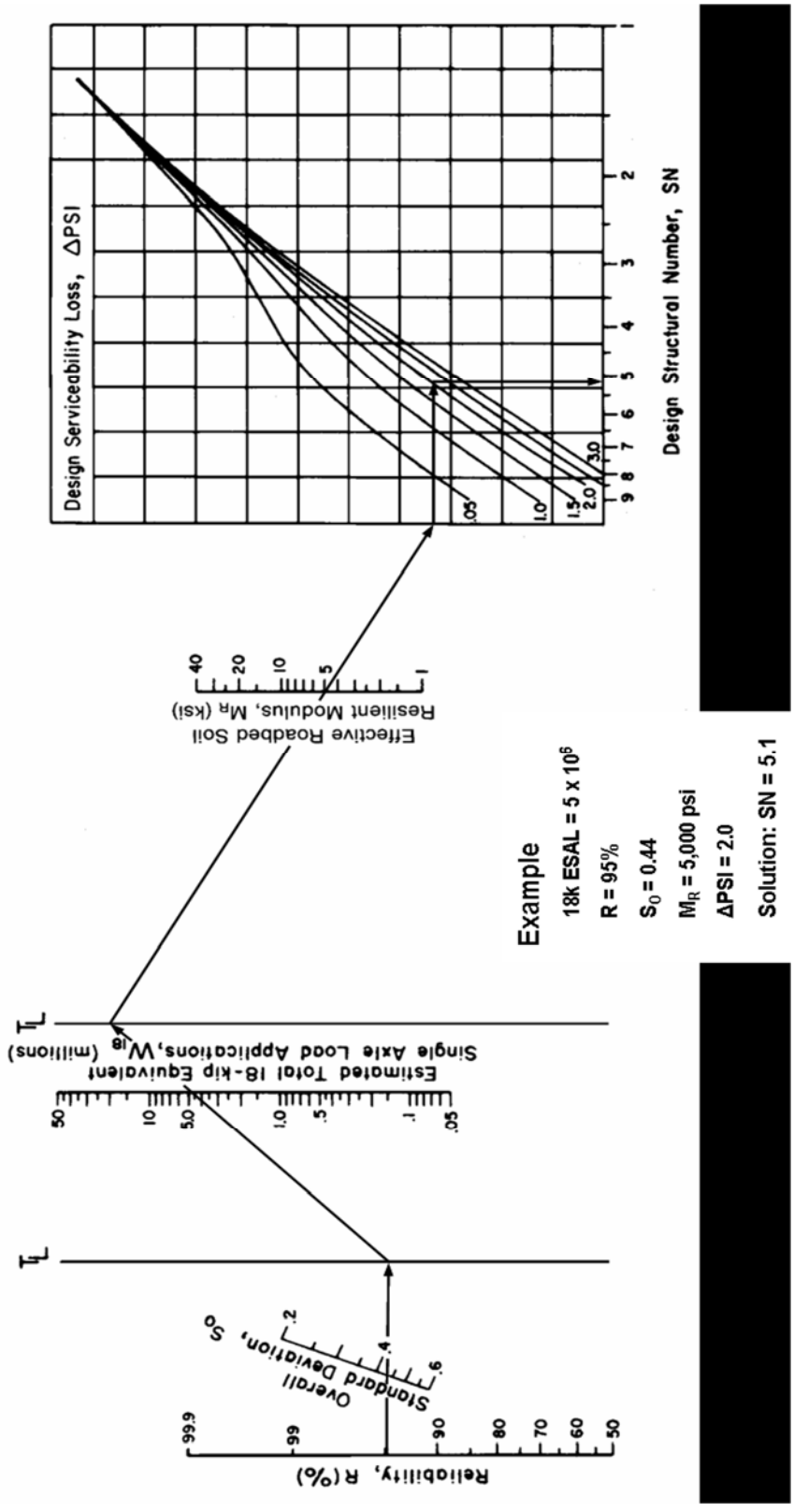


Figure 14.2

Design Nomograph for Flexible Pavements

14.7 CONSTRUCTION AND MATERIAL SPECIFICATIONS

The intent is to specify materials, equipment, methods and standards to be used for the construction of pavement systems as indicated on the plans. The design intent is to construct a pavement with adequate thickness and quality to provide a serviceable life of at least 20 years with normal maintenance. All workmanship and materials shall be in accordance with the requirements of these specifications and special provisions, and in conformity with the lines, grades, quantities and typical cross sections shown on the plans or as directed by the Town.

14.7.1 Asphalt Mixture

1. Asphalt Mix Selection

A. Mix Design & Mix Selection

The mix design consists of the following components.

- PG Asphalt Binder Selection
- Gyratory Compaction Level
- Aggregate Gradation and Physical Properties

B. PG Asphalt Binder Selection:

PG ASPHALT BINDER	SUGGESTED USE
PG 58-28	low volume roadways
PG 64-22	most commonly used PG grade, for low, moderate and high volume roadways

C. Gyratory Compaction Level

Asphalt mixes are designed in the laboratory using a Gyratory compactor. A 75 Gyration design is required unless approved or directed by the Engineer.

D. Aggregate Gradation & Lift Thickness

Four different mix types are allowed SG (1”), S (3/4”), and SX (1/2”) and SX (Fines). SG is reserved for bottom or lower lift paving in multi lift applications. Both S and SX mixes can be used for top mat paving and both can be used in high traffic conditions. The minimal thickness for an SG gradation should be 3”, 2-1/4” for S, and 1-1/2” for SX. Adjustments in mix design gradation should be considered when the lift thickness is less than the minimums shown. For thin lift overlays (less than 1-1/2”), the maximum aggregate size should be 100% passing the 3/8” sieve.

AGGREGATE GRADATION	MINIMUM LIFT THICKNESS	SUGGESTED USE
SX (Fines)	1”	Preventive Maintenance thin lift overlays, surface mixes
SX (1/2”)	1½”	Surface mixes, some intermediate mixes
S (3/4”)	2¼”	Bottom, intermediate and some surface mixes
SG (1”)	3”	Bottom mats for multi lift paving

Recycled Asphalt Pavement (RAP)

Recycled asphalt pavement (RAP) is allowed in accordance to CDOT standards for quality control, sampling and testing, and stockpile management. 25% RAP is allowed in lower lifts and 20% RAP in the top mat of paving.

14.7.2 Portland Cement Concrete

All Portland cement concrete must meet the material specifications and construction standards presented in the current version of the CDOT Standard Specifications.

14.7.3 Subgrade and Aggregate Base Course

All prepared subgrade and aggregate base course, including recycled concrete, must meet the material specifications and construction standards presented in the current version of the CDOT Standard Specifications. Aggregate base course shall extend to the back of curb as a minimum. If combination curb, gutter and sidewalk is planned, the prepared subgrade and aggregate base course shall extend to the back of the attached sidewalk.

14.7.4 Moisture Treatment for Expansive Soils

This work consists of removing, moisture conditioning, replacing, compaction, and shaping the existing expansive subgrade with moisture and density control to the extent shown on the plans. The purpose is to provide a zone of low swelling, strain absorbing material between the expansive subgrade and the pavement section. Moisture treatment shall extend to the back of curb as a minimum. The depth of removal and replacement with moisture treated subgrade shall be consistent with the plans regardless of cut fill or backfill.

A. **Equipment** - The contractor shall provide equipment in good operating condition that is specifically designed and manufactured for the purpose of excavating, hauling, mixing, watering, leveling and compacting subgrade materials. Mixing and watering equipment shall be capable of achieving uniform moisture content without wet or dry zones. Compaction equipment shall be adequately designed to obtain compaction requirements without adverse shoving, rutting, displacement or loosening of subgrade material. The equipment shall be available to perform the work specified within the time frames required and to be coordinated with other activities. The equipment shall be operated by skilled workman at a normal production rate for the specified type of work.

All equipment and machinery shall be kept in good working order, free of leaks and properly muffled. All taxes, licenses and fees shall have been paid and proper licenses and permits shall be posted as required by law.

B. Construction Methods

- Compaction - The existing subgrade shall be removed, uniformly moisture treated, mixed, replaced, and compacted. Each layer shall be compacted to at least 95 percent Standard Proctor density as determined by AASHTO T 99 at 1 to 3 percent above optimum moisture content. The thickness of layers, prior to compactions, shall depend upon the type of sprinkling, mixing and compacting equipment used. Moisture/density tests should be performed every 250 linear feet, alternating lanes, to verify subgrade density meets specifications.

  After each layer of fill is complete, tests must be made to confirm moisture content and required compaction. When the material fails to meet the compaction or moisture requirements or should the material lose the required compaction or moisture or finish before the next course is placed or the project is accepted, the layer shall be reprocessed. Reprocessing shall be done at the contractor's expense.

  The contractor may be required to excavate an area of the layer in order to facilitate the taking of density tests. Replacement and compaction of the removed material in the area shall be at the contractor's expense.

- Subgrade Stabilization - Moisture treatment may leave a soft yielding subgrade unsuitable for paving. Stabilization in accordance with Item 14.5.2.2, Subgrade Stabilization, shall be constructed as recommended by the geotechnical engineer in the design report.

C. Tolerances

- Grade Tolerances – Shall meet the requirements of CDOT Standard Specification 203.04. Deviations in excess of this tolerance shall be corrected by the contractor, at the contractor's expense, in a manner satisfactory to Public Works.

- Compaction Tolerances - Compaction below the specified minimum shall be corrected by re-compaction. Inadequate compaction shall be corrected by the contractor, at the contractor's expense.

- Moisture Tolerances - Any loss of moisture below the set limits shall be corrected by moisture conditioning and re-compaction. Loss of moisture shall be corrected by the contractor, at the contractor's expense.

D. Testing and Inspection

- Testing of moisture treated soils shall be performed in accordance with Table 14.10.

Table 14.10

Schedule for Minimum Materials Sampling and Testing

{Moisture Treated Soils}

Test Type	Test Standard	Minimum Frequency of Tests
In Place Soil Density And Moisture Content	AASHTO T191 ASTM D 2167 AASHTO T 238 ASTM D 2216 AASHTO T239	One test for each 250 lane feet (not less than one test per day).
Liquid Limit	AASHTO T89	One test per soil type
Plastic Limit	AASHTO T90	One test per soil type
Moisture-Density Relationships	AASHTO T99 AASHTOT 180	One test per soil type

14.7.5 Chemically Stabilized Subgrade

This work consists of the contractor constructing one or more courses of a mixture of subgrade soil approved stabilizing agent and water in substantial conformity with the design line, grades, thicknesses, and typical cross sections shown on the approved plans and the approved pavement thickness design.

Purpose - The purpose of the work shall be to provide a structural section on which paving materials can be placed and to meet design specifications, while at the same time, protecting the underlying moisture-treated subgrade soils.

Subgrade stabilization shall extend to the back of curb as a minimum. This specification can also be applied to achieve a stabilized paving platform without structural benefits.

1. Materials

A. Stabilizing Agents- The pre-approved stabilizing agents are listed in Table 14.11.

Various combinations of these materials may also be used, subject to a suitable mix design. Other agents may be used with prior written approval of the Town.

Table 14.11
Approved Chemical Stabilizing Agents

Pre-Approved Stabilizing Agents		
Agents	**Must conform to requirements of**	
Lime	ASTM	C 977,C110
Fly Ash (C and F)	ASTM	C 618
Portland Cement	ASTM	C 114

High-calcium quicklime shall conform to the requirements of ASTM C 977 and rate of slaking test shall produce a temperature rise of 20°C in 30 seconds and 35°C in 3 minutes per ASTM C110. Dolomitic quicklime, magnesia quicklime with magnesium oxide contents in excess of 4 percent or carbonated hydrated lime, shall not be used. High-calcium quicklime must be applied in slurry.

Fly ash may consist of Class C or Class F. Class F fly ash shall only be allowed in conjunction with lime or other cementitious stabilizing agents.

All stabilizing agents shall come from the same source as used in the design. If the source is changed, a new design must be submitted to Public Works for approval. Each lot of stabilizing agent furnished shall have the supplier's certificate of compliance.

B. Water - Water used for mixing or curing should be from a potable source. In the event potable water is not used, non-potable water shall be tested in accordance with and meet the requirements of AASHTO T 26 and used in the mix design.

C. Subgrade - The subgrade material to be stabilized shall be free of roots, sod, weeds, wood, construction debris, ice, snow, or other frozen materials, deleterious matter, and stones larger than 3 inches in size. Material in the stabilized zone shall have a water soluble sulfate content of less than 0.2 percent as per CPL 2103, Method B. lf the subgrade soils have a soluble sulfate content exceeding 0.2 percent, the mix design shall address the specific methodology used to prevent adverse effects of sulfate reactions (e.g. heaving subgrade, cracked pavement).

2. **Equipment** - All equipment shall be subject to approval by the Town. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled.

A. Dry Application Equipment - Equipment for spreading dry stabilizing agent shall be of an approved screw-type spreader box, mixer, or other semi-enclosed equipment which is equipped with a metering device. Spreading of stabilizing agents by aggregate spreaders or motor-graders will not be allowed.

B. Slurry Application Equipment - A distributor or truck applicator shall be used and be capable of continuous agitation to keep the slurry mixture uniform. The applicator shall be capable of uniformly metering the stabilizing agent during application.

C. Mixing Equipment - Mixing equipment shall be of sufficient size to adequately mix the stabilizing agent into the soil and to pulverize the mixture. The size of the mixer shall be adequate to mix and pulverize the mixture to a minimum depth of 12 inches in a single pass. Blades, discs, and similar equipment are not allowed.

D. Compaction Equipment - Compaction equipment shall be in good working order and of sufficient size and effective force to achieve the required compactive effort.

3. Construction Submittals - At least 15 days prior to commencing stabilization work, the contractor shall furnish the following information to Public Works:

A. The source and supplier of stabilizing agent and certifications, including purity of stabilizing agent, from the manufacturer's testing agency indicating that the stabilizing agent meets the appropriate requirements.

B. Description of the proposed construction equipment, construction methods, expected production rates and planned sequence of construction.

C. A mix design giving the Water Soluble Sulfate test results percentage of stabilizing agent, source of the agent, properties and any special considerations.

D. For each day's work, the contractor shall furnish the following information to the Construction Inspector by the following day:

- Certified truck weight tickets of stabilizing agent, delivered or used at the site.

- A summary of the amount of stabilizing agent used each day, areas stabilized and first mixed, areas second mixed and compacted, and areas with curing completed.

4. Stabilized Mix Design

Mix designs shall be performed under the supervision of and signed by a Professional Engineer licensed to practice in the State of Colorado practicing as a geotechnical engineer. Mix design shall comply with the requirements of Table 14.12.

Table 14.12

Stabilization Mix Design Requirements

Stabilization Mix Design Requirements			
Stabilization Agent	**Minimum pH (Notes 1 & 2)**	**Maximum Swell Potential (%) (Note 3)**	**Minimum Unconfined Compressive Strength (psi) (Note 4)**
Lime	12.0	1.0	160
Fly Ash	N/A	1.0	160
Cement Kiln Dust	N/A	1.0	160
Portland Cement	N/A	1.0	160
Lime-Fly Ash	12.3	1.0	160

Notes:

1. *When lime is used, the pH should be no less than 12.0 as measured after completion of initial mixing with stabilizing agent and at ambient temperature.*

2. Testing of pH is to be done in accordance with fades-Grim pH test method (AM 06276).

3. Swell Potential to be less than 1.0 percent at 200 psf ASTM D 4546.

4. Minimum of 160 psi (Mr > 34,800 psi, where Mr = 10,000+124qU) in five (5)days of moist curing at 100°F (38°C). Testing is in accordance with ASTM D 1633 Method A for pozzolanic agents and ASTM D5102 Procedure B for Hydrated Lime.

When lime is used, Plasticity Index is to be reported from initial to final construction to all interested parties and shall not be used for acceptance purposes. The design stabilizing agent percentage as determined by the designer shall be increased by 0.1 percent in the field to account for waste, inert materials, and construction variability.

5. **Processing Materials** - It is the primary requirement of this specification to secure a completed subgrade structural section containing a uniform stabilized mixture. The mixture is to have a uniform density and moisture content, free from loose or segregated areas, well bound for its full depth, well cured, and with a surface suitable for placing subsequent courses. It shall be the responsibility of the contractor to regulate the sequence of

their work, to use the proper amount of stabilizing agent, maintain the work, and rework the courses, as necessary, to meet the requirements.

A. Application - The subgrade shall not be treated when the ambient air temperature falls below 40°, or when the subgrade material is frozen, or when weather predictions suggest that subgrade material temperature may fall below freezing within 24 hours. Prior to beginning any treatment the subgrade shall also be constructed and finished to a smooth and uniform surface that is in conformity to the grade and typical section specified. Variation from the subgrade plan elevation specified shall not be more than ± 0.08 ft. The in-place density shall be at least 95% of maximum dry density as determined by ASTM D 698, Standard Proctor Density, and within 0 to 3% of optimum moisture content for fly ash or cement treated soils. For lime treated materials, the moisture content shall be at least 3% above optimum. Stabilizing agent shall be applied at the minimum rate specified by the mix design for the depth of stabilized subgrade shown on the plans. The rate shall be determined from a design using the on-site soils and shall meet the requirements found in Section 14.5.2.2.Rate of application shall be verified using area/quantity calculations or testing of stabilized subgrade. Stabilizing agent shall be spread only on that area where the first mixing operations can be completed during the same working day. Lime slurry shall not be left exposed to the air for more than six hours without initial mixing or as approved by the Town. The Town reserves the right to require variation of the rate of application of stabilizing agent from the mix design application rates during the progress of construction as necessary to maintain the desired characteristics of the stabilized subgrade.

Stabilizing agent shall be applied using the following methods:

- Slurry Placement - The distribution of stabilizing agent shall be attained by successive applications over a measured section of subgrade until the proper amount of agent has been spread. The amount spread shall be the amount required for mixing to the

specified depth, which will result in the percentage determined in the design. When quicklime is used in place of hydrated lime the amount of quicklime used will be determined by the certified lime purity for each load supplied as follows:

Quicklime delivered X % purity * 1.32 = A

Quicklime delivered *X % inert material= B

A + B = total hydrated lime available

Note: When a double treatment of lime is required, the first 50 percent of the agent shall be placed, moisture treated and allowed to mellow or cure for up to three weeks, as determined by the Design Engineer. The last half of the lime shall then be applied.

- Dry Placement (This method can be used for Fly Ash, cement, lime, and Portland cement) -The amount of stabilizing agent spread shall be the amount required for mixing to the specified depth, which will result in the percentage specified by the design. The stabilizing agent shall be distributed in such a manner that scattering by wind will be minimal. Agents shall not be applied when wind conditions, in the opinion of Construction Inspector, are detrimental to a proper application. The blended material shall be sprinkled or watered until moisture content is as specified in subgrade stabilization design. The combination of stabilizing agent, soil and water shall be called the "mixture". After spreading of stabilizing agent and during mixing, water shall be added to hydrate the agent and for dust control.

B. High Sulfate Treatment- Where sulfates are over 0.2 percent the designer must address the method of treatment.

C. Mixing - No stabilization shall take place when precipitation may cause damage to the subgrade. Mixing shall be continuous. The full depth of the treated subgrade material shall be mixed with an approved mixing machine to the specified depth below the bottom of the pavement structure and/or curb. The mixing machine shall make a sufficient

number of passes to adequately achieve 100 percent of the material passing the one-inch sieve and 60 percent passing the 1/4-inch sieve. Water shall be added to the subgrade during mixing to provide a moisture content of at least 3 percent above the optimum moisture of the mixture or as specified in subgrade stabilization design. Mixing and remixing will be performed, as necessary, to assist the stabilizing agent-soil reaction and produce a homogeneous mixture. Mixing and remixing shall continue until the combination of stabilizing agent and subgrade material is free of streaks or pockets of stabilizing agent.

D. Mellowing (lime or Lime/Fly Ash Only)- The moisture content of the subgrade mixture shall be maintained above optimum for a minimum of 2 days and until the subgrade stabilization design criteria is met. Remixing will be done as necessary to assist the reaction, as determined by the design engineer. Application of water shall be performed as necessary during the mellowing period; the material shall maintain a moisture content of at least 3 percent above optimum. The stabilized material shall not be subjected to traffic. If during the mellowing period the material is not in a semi-loose state, the chemical reaction process may slow and, therefore, require additional time and/or mixing as determined by the design engineer.

E. Final Mixing (Lime or Lime/Fly Ash Only) - Final mixing of the treated subgrade shall not occur if the temperature of the soil to be stabilized is below 40°F. The treated subgrade shall be maintained at a temperature of 40°F or above until the treated material has been compacted. The material shall be uniformly mixed by an approved method to meet the following requirements when tested dry by laboratory sieves:

Sieve Size	Minimum Percent Passing
l-inch sieve	100
No.4 sieve	60

6. Compaction - Compaction of the mixture, for the full depth of the stabilized subgrade shown on the plans, shall begin as soon as practical after final mixing. Stabilized subgrade with cementitious stabilization agent shall be completed within 90 minutes of the time the cementitious

stabilization agent and water are mixed. The field density of the compacted mixture shall be at least 95 percent of the maximum dry density of laboratory specimens prepared from samples taken from the treated subgrade material immediately prior to compacting. The specimens shall be compacted and tested in accordance with ASTM D 698 or ASTM D 558, as specified in the subgrade stabilization mix design. The in-place field density shall be determined in accordance with ASTM D 1556, ASTM D 2167 or ASTM D 2922.The moisture content of the mixture of shall be between 0 to 3 percent above the optimum moisture content The optimum moisture content shall be determined in accordance with ASTM D 698 or ASTM D 558, as specified in subgrade stabilization design. Initial compaction shall be done by means of a sheepsfoot or segmented wheel roller. Final compaction shall be by means of a smooth wheel or pneumatic tired roller. Areas inaccessible to a mechanical roller shall be compacted to the required density by other means acceptable to the design engineer. All irregularities, depressions, or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding or removing materials as required, and reshaping and re-compacting by moisture conditioning and rolling. Adding additional stabilized material to an initial cured section, resulting in lamination and potential slip plane, is not allowed. The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed thereon or the work is accepted. Should the material, due to any reason or cause, lose the required stability, density, and finish before the next course or pavement is placed, it shall be corrected and refinished at the sole expense of the contractor, as directed by the Town.

7. **Finishing and Curing**- After the final layer of stabilized subgrade has been compacted, the shape of the surface shall be achieved by blading. The surface shall be smooth and conform to the required lines, sections, and grades, in accordance with the plans and thoroughly cured, or to within a minimum of 0.1 foot above the finished subgrade elevation to allow for trimming to final grade prior to placement of surface coarse. The completed section shall then be finished by rolling with suitable pneumatic tired equipment with sufficiently light effort to prevent hairline cracking. Curing may be accomplished by periodic water application to maintain moisture content preventing sloughing or cracking of the surface of the stabilized subgrade to a depth no greater than 0.1 foot, or by the utilization of a bituminous seal. When bituminous seal is utilized, the

minimum application will be at the rate of 0.12 gallons per square yard, as directed and approved by the design engineer. The completed section shall be cured for a minimum of 5 days before further courses are added or any traffic is permitted, unless otherwise permitted by the design engineer. The moisture cure duration may be reduced if a non-yielding surface is obtained to support construction traffic and either the next layer of stabilized soils are placed or the pavement layer is constructed, as approved by the Engineer. If the surface of the finished layer is above the approved plan elevation tolerance specified in this section, the excess material shall be trimmed, removed, and disposed of. Any low areas will be replaced with the subsequent surface courses. No loose material shall be left in place after trimming. After trimming the stabilized subgrade surface shall be rolled again with a steel wheel or pneumatic tired roller to seal the surface.

8. Tolerances

A. Thickness- Stabilized zone thickness shall be verified by the use of phenolphthalein and shall be performed at intervals of approximately 500 feet in each lane. When the measurement of the thickness is deficient by more than 1 inch from the plan thickness, two additional locations shall be measured randomly within the deficient area and used in determining the average thickness. When the average thickness is deficient by more than 1 inch, the entire area shall be reprocessed to meet the design parameters or the roadway design section must be re-evaluated.

B. Grade- Prior to placement of surface course, shall meet the requirements of CDOT Standard Specification 203.04. Variations in excess of this tolerance shall be corrected by the contractor, at the contractor's expense, in a manner satisfactory to the Town. Thickness requirements shall be met in areas corrected for grade.

C. Strength- The stabilized subgrade must develop a laboratory compressive strength of at least 160 psi at 5 days. Samples shall be molded from stabilized soil within 1.5 hours of final mixing with the

material compacted per ASTM D 558 or ASTM D 698, as specified in subgrade stabilization design, at the field moisture content.

9. **Conformity with Plans and Specifications** - When thickness and/or strength criteria fail to meet design parameters, even after all possible attempts have been made to correct said deviations, remediation will be required as listed in Table 14.13. Evaluation of the roadway pavement section will be made by the Design Engineer with written approval of the Town. The pavement structural section shall be adjusted to compensate for any deficiency in the stabilized subgrade thickness and strength, at the contractor's expense. Placement of subsequent surface course will not occur until the stabilized subgrade has been accepted in writing by the Town.

Table 14.13

Conformity Specifications

Deficiency	Remediation
Less than 25% of design thickness	Evaluate roadway design section
Greater than 25% of design thickness	Remove and replace
Less than 25% of required strength	Evaluate roadway design section
Greater than 25% of required strength	Remove and replace

10. **Measurement -** The area of stabilized subgrade shall be measured by the plan quantities completed, in place, and accepted. No separate measurement of depth or area, except as required for thickness testing shall be performed. The quantity of stabilizing agent accepted and used shall be measured by the ton of fly ash, Portland cement kiln dust, or hydrated lime used (or the calculated dry hydrated lime content of the lime slurry).

11. **Testing and Inspection** - Testing and inspection shall be performed in accordance with Table 14.14.

Table 14.14

Schedule for Minimum Materials Sampling and Testing

{Chemically Stabilized Soils}

Test Type	Test Standard	Minimum Frequency of Tests
Sampling	AASHTO T 87	One per 2,500 square yards
Sample Preparation	ASTM D3551	
Maximum Dry Density and Optimum Moisture Content	ASTM D 698 (Lime) ASTM D558 (Cement)	Minimum of one per soil type or as directed by City Engineering
In Place Soil Density	ASTM D 1556 ASTM D 2167 ASTM D6938	One test for each 250 lane feet (not less than one test per day)
In Place Moisture Content	ASTM D 2216 ASTM D 6938	
Ph	ASTM D 6276	One test per 2,500 square yards
Swell	ASTM D4546 Method B	Minimum one test per 1,000 square yards or as directed by Town of Castle Rock
Unconfined Compressive Strength (Lime)	ASTM D 5102 (Procedure B)	One set of four cylinders per 2,500 square yards.
Compressive Strength Cementitious Agents	ASTM D 1633 (Method A)	One set of four cylinders per 2,500 square yards.
Atterberg Limits	AASHTO T 89 & T 90	One test per 2,500 square yards
Stabilization Thickness	As directed by testing agency	One test every 500 feet per lane

14.7.6 Mechanically Stabilized Subgrade

This work includes mechanically stabilized subgrade of base/subbase course and/or subgrade improvement in the construction of paved or unpaved roadways. Design details for geogrid reinforcement, such as geogrid type, fill thickness, pavement cross-section and associated details, shall be as shown on the project drawings or in the design report. The purpose of the work shall be to provide a stabilized paving platform section on which paving materials can be placed. Subgrade stabilization shall extend to the back of curb as a minimum. This item shall not be used to retain moisture in subgrades unless retaining moisture in the section can be assured. This specification shall be used for a construction platform and not as a means of mitigating swell.

1. Materials

Definitions

A. Mechanically Reinforced -Placement of a geogrid immediately over a soft subgrade soil in order to improve the bearing capacity and mitigate deformation of the subgrade soil. The goal of this application may be to reduce deeper excavation requirements, improve construction efficiency, reduce the amount of aggregate subbase/base material required, provide a stiff working platform for pavement construction, or combination of these.

B. Geogrid -A biaxial polymeric grid formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, or earth to function primarily as reinforcement

C. Multi-layer Geogrid- A geogrid product consisting of multiple layers of grid which are not integrally connected throughout.

D. Extruded Geogrid - A geogrid product formed by extrusion of a polypropylene or polypropylene/polyethylene copolymer sheet followed by its perforation with a precise arrangement of holes and subsequent stretching, or drawing, into the finished product.

E. Woven Geogrid -A geogrid product formed by weaving discrete strips of polymer into a network. These geogrids usually require a protective coating to protect the polymer from pre-mature degradation.

F. Minimum Average Roll Value (MARV) - Value based on testing and determined in accordance with ASTM 04759-92.

G. True Initial Modulus in Use - The ratio of tensile strength to corresponding zero strain. The tensile strength is measured via ASTM 06637 at a strain rate of 10 percent per minute. Values shown are MARVs. For multi-layer geogrid products, rib tensile testing shall be performed on the multi-layer configurations, as prescribed by ASTM 06637.

H. Junction Strength- Breaking tensile strength of junctions when tested in accordance with GRI-GG2 as modified by AASHTO Standard Specification for Highway Bridges, 19971nterim, using a single rib

having the greater of 3 junctions or a minimum 8 inch machine direction sample and tested at a strain rate of 10 percent per minute based on this gauge length, values shown are MARVs. For multi-layer geogrid products, junction strength testing shall be performed across junctions from each layer of grid individually, and results shall not be assumed as additive from single layers to multiple layers.

I. **Flexural Stiffness** (also known as Flexural Rigidity) - Resistance to bending force measured via ASTM 01388-96,Option A, using specimen dimensions of 864 millimeters in length by 1 aperture in width, values shown are MARVs. For multi-layer geogrid products, flexural stiffness testing shall be performed directly on the multi-layer configuration without using any connecting elements other than those used continuously throughout the actual product, and results shall not be assumed as additive from testing performed on a single layer of the multi-layer product.

J. **Aperture Stability Modulus** (also known as Torsional Rigidity or Torsional Stiffness) - Resistance to in-plane rotational movement measured by applying a 20 kg-cm (2.0 m-N) moment to the central junction of a 9-inch by 9-inch specimen restrained at its perimeter, values shown are MARVs. For multi-layer geogrid products, torsional stiffness testing shall be performed on each layer of grid individually, and results shall not be assumed as additive from single layers to multiple layers.

K. **Granular Fill Material**- The preferred gradation for base reinforcement application is well-graded crushed aggregate fill with a maximum particle size (100 percent passing) of 1 1/2 inches, and less than 10% fines (passing the #200 sieve).Recycled concrete may be used only with polypropylene geogrids in accordance with Federal Highway Administration (FHWA) 2001.

2. Manufacturers

All manufacturers will be considered provided they meet the submittal process.

3. Geogrid Material Properties

A. Structural Soil Reinforcement Geogrid - The geogrid shall be integrally formed and deployed as a single layer having the following characteristics according to Table 14.15 (all values are minimum average roll values unless a range or characteristic is indicated.)

B. Geotextile materials shall not be considered as an alternate to geogrid materials for subgrade improvement or base/sub-base reinforcement applications. A geotextile may be used in the cross-section to provide separation, filtration or drainage; however, no structural contribution shall be attributed to the geotextile.

Table 14.15

Recommended Geogrid Structural Properties

Property	Test Method	Units	Type 1	Type2
Aperture Stability Modulus at 20 em-kg (2.0 m-N)	Kinney (2001)	m-N/deg	0.32	0.65
Rib Shape	Observation	N/A	Rectangular or Square	Rectangular or Square
Rib Thickness	Calipered	In	0.03	0.05
Nominal Aperture Size	I.D. Calipered	In	1.0 to 1.5	1.0 to 1.5
Junction Strength	GRI-GG2-2000 [1]	ratio	Note [1]	Note [1]
Flexural Rigidity	ASTM D1388-96 Note [2]	Mg-cm	250,000	750,000
Minimum Tensile Strength@ 2% Strain:	ASTM D6637-01 Note [4]			
- MD [3]		Lb/ft	280	410
-CMD [3]		Lb/ft	450	620
Minimum Tensile Strength@ 5% Strain:	ASTM D6637-01 Note [4]			
- MD [3]		Lb/ft	580	810
-CMD [3]		Lb/ft	920	1,340

NOTES:

1. The ratio of Junction Strength/Ultimate Tensile Strength must meet or exceed 75%.

2. Resistance to bending force measured via ASTM D-5732-95, using specimens of width two ribs wide, with transverse ribs cut flush with exterior edges of longitudinal ribs (as a "ladder"), and of length sufficiently long to enable measurement of the overhang dimension.

3. MD= machine direction (along roll length); CMD =cross-machine direction (across roll width).

4. True resistance to elongation when initially subjected to a load determined in accordance with ASTM 06637 without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.

4. Construction Platform Design

Construction platform design shall be performed under supervision of and signed by a Professional Engineer registered in the State of Colorado practicing as a geotechnical engineer. The recommended procedure shall be followed as outlined in AASHTO PP 46-01. Appropriate partial safety factors shall be applied to results obtained using geogrids having properties or characteristics outside the range of rigorous model validation (Giroud and Han,2004).This method has been endorsed by numerous Department of Transportations and Government Agencies such as the Federal Highway Administration and Army Corps of Engineers. A piping ratio analysis (D15fill/D85subgrade) shall be performed to determine the need of a separation fabric. If the piping ratio is less than 5 then no separation fabric is required. If the piping ratio is greater than 5 then a separation fabric is required below the geogrid. Final determination of construction platform shall be approved by the Town.

5. Utility Cuts

Repair of utility cuts in geogrid material shall be accomplished per manufacturer specifications.

14.7.7 Proof Rolling

The Subgrade platform shall be thoroughly proof-rolled to the satisfaction of the Town Construction Inspector prior to placement of base course (or paving) and the base course shall be thoroughly proof- rolled to the satisfaction of the Town Construction Inspector prior to paving. Proof Rolling equipment should meet the requirements in CDOT Standard Specifications.

14.7.8 Water Testing

As soon as practical upon final pavement construction the finished pavement surface shall be water-tested to the satisfaction of the Town Construction Inspector to confirm positive surface drainage in all directions prior to acceptance of the street. Water shall be applied using a water truck spray bar or similar device at a rate adequate to demonstrate positive drainage flow across the crown and into the street gutters.

14.7.9 Definitions

AASHTO: American Association of State Highway and Transportation Officials

Adhesive Failure: Loss of bond between the joint sealant and the joint, or between the aggregate and the binder.

Agency: The jurisdiction or owner of the project and its representatives.

Aggregate Base (base course): Crushed stone or gravel immediately under the surface course.

Aggregate Interlock: Interaction of aggregate particles across cracks and joints to transfer load.

Alligator Cracks: Interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken wire.

Analysis Period: The period of time for which the economic analysis is to be made; ordinarily will include at least one rehabilitation activity.

Asphalt Emulsion Slurry Seal: A mixture of emulsified asphalt, fine aggregate and mineral filler, with water added to produce slurry consistency. Seals are used as a preventative maintenance treatment to provide a new wearing surface and to fill small cracks.

Asphalt leveling Course: A course (asphalt-aggregate mixture) of variable thickness used to eliminate irregularities in the contour of an existing surface prior to superimposed treatment or construction.

Asphalt Mixture: High-quality, thoroughly-controlled mixture of asphalt cement and well-graded, high quality aggregate, thoroughly compacted into a uniform dense mass.

Asphalt Overlay: One or more courses of asphalt construction on an existing pavement. The overlay generally includes a leveling course, to correct the contour of the old pavement followed by uniform course or courses to provide needed thickness.

Asphalt Tack Coat: A light application of emulsified asphalt applied to an existing asphalt or Portland cement concrete pavement surface. It is used to ensure a bond between the surface

being paved and the overlying course. Typically 0.10 gals/yd^2 of CSS1H.

ASTM: American Society for Testing Materials

Binder: Asphalt Cement used to hold stones together for paving.

Binder Course: The layer of asphalt cement concrete pavement underlying the surface course.

Bituminous: Like or from asphalt
Bleeding or Flushing: The upward movement of asphalt in an asphalt pavement resulting in the formation of a film on the pavement surface. It creates a shiny, glass-like, reflective surface that may be tacky to the touch in warm weather.

Block Cracking: The occurrence of cracks that divide the asphalt surface into approximately rectangular pieces, typically one square foot or more in size.

California Bearing Ratio Test (CBR): An empirical measure of bearing capacity used for evaluating bases, subbases, and subgrades for pavement thickness design.

Centerline: The painted line separating opposing traffic lanes. Channels: A ditch or canal adjacent the roadway.

Chipping: Breaking or cutting off small pieces from the surface.
Chip Seal: A thin layer of emulsified asphalt cement in which aggregate is embedded. The seal is placed to improve the texture of the pavement surface to increase skid resistance and decrease permeability of the surface.

Cohesive Failure: The loss of a material's ability to bond to itself or its substrate. Results in the material splitting or tearing apart from itself or its substrate (i.e. joint sealant splitting).

Composite Pavement: A pavement structure composed of an asphalt cement concrete pavement wearing surface over aggregate base course or treated subgrade.

Contractor: The land developer or its agents involved in the construction of the project.

Corrugations (Washboarding): A form of plastic movement typified by ripples across the pavement surface. Most common in aggregate surficial pavements but occurs in asphalt

cement concrete pavements as well.

Crack: Approximately vertical random cleavage of the pavement due to thermal or load action.

Crack Seal: An asphalt cement or similar material applied into a pavement crack to provide a non-permeable seal. The sealant must have adequate characteristics to provide bonding to each side of the crack.

CTS: Chemically Treated Subgrade

Deflection: The amount of downward vertical movement of a surface due to the application of a load to the surface.
• Rebound Deflection: The amount of vertical rebound of a surface that occurs when a load is removed from the surface.
• Representative Rebound Deflection: The mean value of measured rebound deflections in a test section plus two standard deviations, adjusted for temperature and most critical period of the year for pavement performance.
• Residual Deflection: The difference between original and final elevations of a surface resulting from the application to, and removal of one or more loads from, the surface.

Design ESAL: The total number of equivalent 80kN (18,000 Ib) single-axle load applications expected during the Design Period.

Design lane: The lane on which the greatest number of equivalent 80kN (18,000 Ib) single-axle loads is expected. Normally this will be either lane of a two-lane roadway or the outside lane of a multi-lane highway.

Design Period: The number of years from initial construction or rehabilitation until terminal service life. This term should not be confused with pavement life or Analysis Period. By adding asphalt overlays as required, pavement life may be extended indefinitely, or until geometric considerations or other factors make the pavement obsolete.

Disintegration: The breaking up of a pavement into small, loose fragments due to traffic or weathering.

Distortion: Any change of a pavement surface from its original shape.

Drainage Coefficients: Factors used to modify layer coefficients in flexible pavements or stresses in rigid pavements as a function of how well the pavement structure can handle the adverse effect of water infiltration.

Edge Cracking: Fracture and materials loss in pavements without paved shoulders which occur along the pavement perimeter. Caused by soil movement beneath the pavement.

Effective Thickness: The thickness that a pavement would be if it could be converted to Full-Depth asphalt cement concrete pavement.

Embankment (Embankment Soil): The prepared or natural soil underlying the pavement structure.

Embrittlement: Premature (surficial) cracking of an asphalt concrete pavement due to oxidative aging of the asphalt cement.

End Result Specifications: Specifications that require the contractor to take the entire responsibility for supplying a product or an item of construction. The highway agency's responsibility is to either accept or reject the final product or apply a price adjustment that compensates for the degree of compliance with the specifications.(End result specifications have the advantage of affording the contractor flexibility in exercising options for using new materials, techniques, and procedures to improve the quality and/ or economy of the end product.)

ESAL: Equivalent Single Axel load

ESAL to Failure: The number of design 18 kip (18,000 pound) axle load cycles required to produce approximately 40 percent fatigue cracking as calculated using AAMAS equations based on asphalt cement concrete pavement Resilient Modulus and tensile strain at the bottom of the ACCP layer.

Equivalent 80kN (18,000 lb) Single-Axle load (ESAL):The effect on pavement performance of any combination of axle loads of varying magnitude equated to the number of 80kN (18,000 lb) single-axle loads required to produce an equivalent effect.

Fatigue Cracking: A series of small, jagged, interconnecting cracks caused by failure of the asphalt cement concrete pavement surface under repeated traffic loading (also called alligator

cracking.)

Fault: Difference in elevation between opposing sides of a joint or crack.

Flexible Pavement: Pavement structures generally consisting of asphalt cement concrete pavement surfacing that maintains intimate contact with and distributes loads to the subbase or subgrade and depends upon aggregate interlock, particle friction, and cohesion for stability.

Flowable Backfill: A backfill material composed of a low-strength, self-leveling concrete material, composed of various combinations of cement fly ash, aggregate, water and chemical admixtures used to "flow" into areas requiring backfill that will provide density and strength without compaction.

Fog Seal: A thin layer of emulsified asphalt cement applied to the pavement surface. The seal is placed as a preventive treatment to rejuvenate the asphalt concrete pavement by improving flexibility and to decrease the permeability of the surface.

Free Edge: Pavement border that is able to move freely.

Full-Depth Asphalt Pavement: The term FULL-DEPTH (registered by the Asphalt Institute with the U.S. Patent Office) certifies that the pavement is one in which asphalt mixtures are employed for all courses above the subgrade or improved subgrade. A Full-Depth asphalt pavement is laid directly on the prepared subgrade.

Functional Classification: A method of separating and classifying streets according to their purpose or function in the network of streets, i.e. residential collectors, commercial collectors, residential locals.

Grade Depressions: Localized low areas of limited size which may or may not be accompanied by cracking.

Hairline Crack: A fracture that is very narrow in width, less than 3mm (0.12 in.).

Heavy Trucks: Two axle, six-tire trucks or larger. Pickup, panel and light four-tire trucks are not included. Trucks with heavy-duty, wide base tires are included.

Bituminous Pavement: See Asphalt Mixture

Hydroplaning: The dangerous action of a vehicle being driven on a pavement over which a film of rain or other water has formed; on reaching a certain speed, the vehicle's tires tend to ride upon the water surface rather than the pavement, drastically reducing the driver's control of the vehicle.

Incentive/Disincentive Provision (for quality): A pay adjustment schedule which functions to motivate the contractor to provide a high level of quality.(A pay adjustment schedule, even one which provides for pay increases, is not necessarily an incentive/ disincentive provision, as individual pay increases/decreases may not be of sufficient magnitude to motivate the contractor toward high quality).

Instability: The lack of resistance to forces tending to cause movement or distortion of a pavement structure.

Internal Vibration: Vibration by means of vibrating units located within the specified thickness of pavement section and a minimum distance ahead of the screed equal to the pavement thickness.

Lane Line: Boundary between travel lanes, usually a painted stripe.

Lane-to-Shoulder Drop-off: The difference in elevation between the traffic lane and shoulder.

Lane-to-Shoulder Separation: Widening of the joint between the traffic lane and the shoulder.

Layer Coefficient: The empirical relationship between structural number (SN) and layer thickness which expresses the relative ability of a material to function as a structural component of the pavement.

Lime Stabilized Subgrade: A prepared and mechanically compacted mixture or lime, water and soil below the pavement system.

Lime-Fly Ash Base: A blend of mineral aggregate, lime, fly ash and water, combined in proper proportions which, when compacted, produces a dense mass.

Lime-Fly Ash Stabilized Subgrade: A prepared and mechanically compacted mixture of lime, fly ash, water and soil below the pavement system.

Load Equivalency Factor (LF): A factor used to convert applications of axle loads of any magnitude to an equivalent number of80kN (18,000 I b) single axle loads.

Longitudinal: Parallel to the centerline of the pavement.

Longitudinal Crack: A crack that follows a course approximately parallel to the center line.

Maintenance: The preservation of the entire roadway, including surface, shoulders, roadsides, structures, and such traffic control devices as are necessary for its safe and efficient utilization.

Materials/Methods Specifications: Specifications that direct the contractor to use specified materials in definite proportions and specific types of equipment and methods to place the material.

Mechanically Stabilized Subgrade: Placement of a geogrid immediately over a soft subgrade soil in order to improve bearing capacity and mitigate deformation of the subgrade soil.

Method Specifications: See Materials/Methods Specifications.

Moisture Stabilized Subgrade: Swelling soils which have been stabilized to low or nil swell by addition of moisture.

Moisture Treatment: Addition of moisture at 1 to 3 percent above standard Proctor optimum moisture content and compaction to 95 percent density.

Parametric Analysis: A study of a set of physical properties whose values determine the characteristics or behavior of something; used to isolate the significance of individual variables.

Patch: An area where the existing pavement has been removed and replaced with a new material.

Patch Deterioration: Distress occurring within a previously repaired area.

Pavement Structure (Pavement): A combination of subbase, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.

Pavement Condition Indicator (PCI): A measure of the condition of an existing pavement section at a particular point in time, such as cracking measured in feet per mile, or faulting measured in inches of wheel path faulting per mile. When considered collectively, pavement condition indicators provide an estimate of the overall adequacy of a particular roadway.

Pavement Design (Design, Structure Design): The specifications for materials and thicknesses of the pavement components.

Pavement Distress Indicator: See Pavement Condition Indicator.

Pavement, Flexible: Pavement structures generally consisting of asphalt cement concrete pavement surfacing that maintains intimate contact with and distributes loads to the subbase or subgrade and depends upon aggregate interlock, particle friction, and cohesion for stability.

Pavement Performance: The trend of serviceability with load applications.

Pavement Rehabilitation: Work undertaken to extend the service life of an existing facility. This includes placement of additional surfacing material and/or other work necessary to return an existing roadway, including shoulders, to a condition of structural or functional adequacy. This could include the complete removal and replacement of the pavement structure.

Pavement, Rigid: A pavement structure consisting of Portland cement concrete pavement surfacing, with or without subbase.

Performance Period: See Design Period.

Performance Specifications: Specifications that describe how the finished product should perform over time. For highways, performance is typically described in terms of changes in physical condition of the surface and its response to load, or in terms of the cumulative traffic required bringing the pavement to a condition defined as "failure". Specifications containing warranty/guarantee clauses are a form of performance specifications. Other than the warranty/guarantee type, performance specifications have not been used for major highway pavement components (subgrades, bases, riding surfaces) because there have not been appropriate nondestructive tests to measure long-term performance immediately after construction. They have been used for some products (e.g., highway lighting, electrical components and joint sealant materials) for which there are test of performance that can be

rapidly conducted.

Performance-Based Specifications: Specifications that describe the desired levels of fundamental engineering properties (e.g., Resilient Modulus, creep properties, and fatigue properties) that are predictors of performance and appear in primary prediction relationships (i.e., models that can be used to predict pavement stress, distress, or performance from combinations of predictors that represent traffic, environmental roadbed, and structural conditions.) [Because most fundamental engineering properties associated with pavements are currently not amenable to timely acceptance testing, performance-based specifications have not found application in highway construction).

Performance-Related Specifications: Specifications that describe the desired levels of key materials and construction quality characteristics that have been found to correlate with fundamental engineering properties that predict performance. These characteristics (for example, air voids in asphaltic pavements, and strength of concrete cores) are amenable to acceptance testing at the time of construction. True performance-related specifications not only describe the desired levels of these quality characteristics, but also employ the quantified relationships containing the characteristics to predict subsequent pavement performance. They thus provide the basis for rational acceptance and/or price adjustment decisions.

Planned Stage Construction: The construction of roads and streets by applying successive layers of asphalt cement concrete pavement according to design and a predetermined time schedule.

Plant-Mix Base: A foundation course, produced in an asphalt mixing plant, which consists of a mineral aggregate uniformly coated with asphalt cement or emulsified asphalt

Portland Cement Concrete Pavement (PCCP): High quality, thoroughly controlled mixture of Portland cement, water, and well-graded, high quality aggregate, thoroughly mixed and placed as a uniform dense mass.

Pothole: A bowl-shaped depression of varying sizes in the pavement surface, resulting from localized disintegration. Term is also used for utility locates.

Prepared Roadbed: In-place roadbed soils compacted or stabilized according to provisions of applicable specifications.

Prescriptive Specifications: See Materials/Methods Specifications.

Present Serviceability: The ability of a specific section of pavement to serve, for the use intended, mixed traffic on the day of rating.

Present Serviceability Index (PSI): A mathematical combination of values, obtained from certain physical measurements of a large number of pavements, so formulated as to predict, within prescribed limits, the Present Serviceability Rating (PSR) for those pavements.

Present Serviceability Rating (PSR): The mean of the individual ratings made by the members of a specific panel selected for the purpose.

Proof Roll: A test method for subgrade soils in which a loaded truck (18,000 pound axle weight) is driven over the subject area to delineate soft or yielding areas.

QA/QC Specifications: See Quality Assurance Specifications. QC/QA Specifications: See Quality Assurance Specifications.

Quality Assurance: All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. Quality assurance addresses the overall problem of obtaining the quality of service, product, or facility in the most efficient, economical, and satisfactory manner possible. Within this broad context, quality assurance involves continued evaluation of the activities of planning, design, development of plans and specifications, advertising and awarding of contracts, construction, and maintenance, and the interactions of these activities.

Quality Assurance Specifications: A combination of end result specifications and materials and methods specifications. The contractor is responsible for quality control (process control), and the Agency is responsible for acceptance of the product. Quality assurance specifications typically are statistically based specifications that use methods such as random sampling and lot-by-lot testing, which let the contractor know if his operations are producing an acceptable product.

Quality Control: Those quality assurance actions and considerations necessary to assess production and construction processes so as to control the level of quality being produced in the end product This concept of quality control includes sampling and testing to monitor the process but usually does not include acceptance sampling and testing.

Raveling: The wearing away of the pavement surface caused by the dislodging of aggregate particles.

Reflection Cracking: Cracks in asphalt overlays that reflect the crack pattern in the pavement structure underneath.

Resilient Modulus Test: A measure of the modulus of elasticity of roadbed soil or other pavement material.

Resistance Value (R-value): A test for evaluating bases, subbases, and subgrades for pavement thickness design.

Roadbed: The graded portion of a highway between top and side slopes, prepared as a foundation for the pavement structure and shoulder.

Roadbed Material: The material below the subgrade in cuts and embankments and in embankment foundations, extending to such depth as affects the support of the pavement structure.

Roadway: All facilities on which motor vehicles are intended to travel such as secondary roads, interstate highways, streets and parking lots.

Roughometer: A single-wheeled trailer instrumented to measure the roughness of a pavement surface in accumulated millimeters (inches) per mile.

Rubberized Asphalt Cement: Blend of asphalt cement and pre-vulcanized rubber.

Rutting: Longitudinal surface depressions in the wheel paths.

Selected Material: A suitable native material obtained from a specified source such as a particular roadway cut or borrow area, of a suitable material having specified characteristics to be used for a specific purpose.

Serviceability: The ability at time of observation of a pavement to serve traffic (autos and trucks) which use the facility.

Shoving: Permanent, longitudinal displacement of a localized area of the pavement surface caused by traffic pushing against the pavement

Single Axle load: The total load transmitted by all wheels of a single axle extending the full width of the vehicle.

Skid Hazard: Any condition that might contribute to making a pavement slippery when wet.

Slippage Cracks: Cracks, sometimes crescent-shaped, that point in the direction of the thrust of wheels on the pavement surface.

SMA (Stone Matrix Asphalt, Split-Mastic Asphalt): An asphalt mix design composed of large stones creating a stone to stone matrix, often containing large percentages of asphalt cement and fillers.

Soil Cement Base: A hardened material formed by curing a mechanically compacted intimate mixture of pulverized soil, Portland cement and water, used as a layer in a pavement system to reinforce and protect the subgrade or subbase.

Stabilized Subgrade: A subgrade soil that has been altered by a chemical agent to make suitable for subgrade construction and pavement support.

Standard Deviation: The root-mean-square of the deviations about the arithmetic mean of a set of values.

Statistically Based Specifications: Specifications based on random sampling, and in which proper ties of the desired product or construction are described by appropriate statistical parameters.

Structural Number (SN): An index number derived from an analysis of traffic, roadbed soil conditions, and environment which may be converted to thickness of flexible pavement layers through the use of suitable layer coefficients related to the type of material being used in each layer of the pavement structure.

Subbase: The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base course.

Subbase (Subbase Course): The layer of graded sand-gravel or stabilized subgrade material between the surface of the embankment soil and the base course (and surfacing course when there is no base course).

Subgrade: The soil prepared to support a structure of a pavement system. It is the foundation for the pavement structure. The subgrade soil sometimes is called "basement soil" or "foundation soil".

Subgrade, Improved: Any course or courses of select or improved material between the subgrade soil and the pavement structure.

Subgrade Resilient Modulus: The modulus of the subgrade determined by repeated load triaxial compression tests on soil samples. It is the ratio of the amplitude of the accepted axial stress to the amplitude of the resultant recoverable axial strain.

Surface (Surface Course): One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and the disintegrating effects of climate. The top layer of flexible pavements is sometimes called the "wearing course':

Surface Thickness (Surfacing Thickness, Surface, Slab Thickness (Rigid)): The thickness of surfacing material, usually expressed in inches.

Swell Potential: The percent of volume changed expected for a soil sample when wetted, as measured through laboratory tests conducted using representative overburden pressures.

Tandem Axle load: The total load transmitted to the road by two consecutive axles extending across the full width of the vehicle.

Thermal Cracking: Cracking occurring in pavement material introduced within the material resulting from a change in temperature.

Traffic Equivalence Factor: A numerical factor that expresses the relationship of a given axle load to another axle load in terms of their effect on the serviceability of a pavement structure.

Transverse Crack: A crack that follows a course approximately at right angles to the centerline.

Triple (Tridem) Axle load: The total load transmitted to the road by three consecutive axles extending across the full width of the vehicle.

Truck Factor: The number of equivalent 80kN (18,000 Ib) single-axle load applications contributed by one usage of a vehicle. Truck Factors can apply to vehicles of a single type or class or to a group of vehicles of different types.

Twenty-Year ESAL: (ESAL20) The Equivalent Single Axle Load application for a twenty- year design. The value is the product of the Load Equivalency factor for each vehicle type, the number of each particular vehicle per day, 365 days per year, and a twenty-year period.

Upheaval: The localized upward displacement of a pavement due to swelling of the subgrade or some portion of the pavement structure.

USCS: Unified Soil Classification System.

Washboarding: See Corrugations.

Water Bleeding: Seepage of water from joints or cracks.

Weathering: The wearing away of the pavement surface caused by the loss of asphalt binder.

Section 15

SITE EARTHWORK AND GRADING

15.1 General

15.1.1 Scope

This Section provides general procedures and criteria for the grading and earthwork involved in the development of roadways. *Please consult the most recent version of the Town of Castle Rock Grading, Erosion, and Sediment Control (GESC) and Drainage Erosion, and Sediment Control (DESC) Manual. The manual can be found on the Town's website along with a related checklist and permit application.*

15.1.2 Grading and Earthwork Design Criteria

1. Trees and other plants which will remain shall be protected at all times. Grass, weeds, plants, and trees shall be grubbed to at least 6" below present grades.

2. Excavation of all materials shall be performed to the lines and grades shown on the drawings. Suitable material removed from the excavation may be used in the right-of-way or easement as permitted by the Town's inspector. Where material encountered within the right-of-way or easement, is considered unsuitable by the Town's inspector, such material shall be excavated below the grade shown on the drawings and replaced with suitable material.

3. Unused excess material shall be removed from the work site at no cost and requiring no incidental work by the Town.

4. Unless otherwise specified, the material obtained from the excavations will be suitable for use as fill or backfill, provided that all organic material, rubbish, debris, and other objectionable material contained therein is first removed. Rocks, concrete, and bituminous type pavement obtained from

the project excavations will be permitted in the backfill or fill with the following exceptions:

A. The maximum dimension of any piece used shall be 6".

B. Pieces larger than 4" shall not be placed within 12" of any structure.

C. Pieces larger than 3" shall not be placed within 12" of the subgrade for paving.

D. Voids caused by concentrations of large pieces shall not be permitted.

5. Before placing the material for the compacted fills, the subgrade shall be moistened, compacted and scarified, according to the requirements set forth for subsequent layers of fill. The fill material shall be placed in approximately horizontal, evenly-distributed layers not exceeding 8" in depth. Each layer of fill material should cover the full length and width of the entire area to be filled before the next higher layer of material is placed. After each layer of fill has been spread, worked and properly moistened, it shall be compacted to produce the specified density. Each layer should be keyed one layer to another. Grading shall be performed so that the finished surfaces are in uniform planes with no abrupt breaks in the surfaces.

6. Each layer of fill shall be moistened as necessary. Material, which is over optimum moisture content in amounts to cause "pumping" or "heaving", shall not be incorporated into the work. In case any layer of fill is too wet to attain the specified density, the compacting work shall be delayed until the material has dried sufficiently to attain said density. Moisture content shall not vary on the dry side by more than 2.0% of optimum.

7. Hauling material on or across existing roadways using scrapers or other non-wheeled heavy equipment will only be allowed on a case-by-case basis. Additional requirements related to protection and maintenance of the existing roadway(s) will be required before approval is granted.

Appendix A

TYPICAL STREET CROSS SECTIONS

Appendix B

TRAFFIC CALMING EXAMPLES