CHAPTER 1
GENERAL PROVISIONS

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LIST OF ATTACHMENTS – APPENDIX A

1.1 PURPOSE

These Engineering Design Standards and Construction Specifications, also called the “Standards” or “Engineering Standards”, are established by the Engineering Division of the Public Works Department for the design and construction of public and private improvements in the Town of Breckenridge (Town).

The purpose of these Standards is to set forth certain rules and regulations so there is reasonable degree of assurance that the development of public and private improvements will be completed so that the health, safety, welfare and property of the Town and citizens will be safeguarded and protected; and to assure there will be a certain uniformity in performance with respect to design and construction of public and private improvements; and thereby securing for the present and future residents of the Town the beneficial effects of public and private development, while protecting the community against actions that would deteriorate the quality of the natural and manmade environment. These Standards are established to serve the following objectives:

1. Update Town Standards to reflect changes in the engineering and construction industries
2. Provider greater consistency with local, state, federal, and other agency codes
3. Provide consistent design and construction basis for infrastructure within the Town
4. Ensure public welfare and promote efficient development that considers the future of the community
5. Protect the water quality of the Blue River and its tributaries
6. Protect wetlands and other sensitive habitats in a mountain environment
7. Mitigate traffic caused by development
8. Improve pedestrian and bicycle facilities
9. Provide improved access for people with disabilities
10. Provide guidelines on navigating the Engineering Division development review process
11. Protect the public by establishing the minimum acceptable level for design and construction of infrastructure

To provide consistency in the design of infrastructure within the Town, these Standards generally follow criteria or design methodology that are in conformance with regulations and laws established by the following agencies. Where no requirement is given in the Town Engineering Standards, the following documents shall govern.

1. American Association of State Highway and Transportation (AASHTO)
2. Colorado Department of Transportation (CDOT)
3. Colorado Revised Statutes (CRS)
4. Federal Americans with Disabilities Act (ADA) Regulations
5. Federal Highway Administration (FHWA)
6. Federal Statutes and Regulations (CFR)
7. Mile High Flood District (MHFD)
8. National Cooperative Highway Research Program (NCHRP)
9. U.S. Department of Transportation, Manual of Uniform Traffic Control Devices (MUTCD)
10. United States Access Board (PROWAG and ADAAG)
11. National Cooperative Highway Research Program (NCHRP)

Additionally, the following guides and manuals listed below shall be referenced and used in conjunction with these Standards. Where no requirement is given in the Town Engineering Standards, the following documents shall govern. In the event of a conflict between Town Engineering Standards and the following documents, the more stringent requirement shall typically govern. The most recent version of the documents below shall govern.

1. AASHTO Green Book
2. AASHTO Roadside Design Guide
3. CDOT Roadway Design Guide
4. CDOT Bridge Design Manual
5. CDOT Pavement Design Manual
6. CDOT Drainage Design Manual
7. FEMA National Flood Insurance Program (NFIP)
8. International Fire Code (IFC), 2018
9. ITE Trip Generation Manual, 10th Edition, Institute of Transportation Engineers, 2017
10. ITE Trip Generation Handbook, 3rd Edition, Institute of Transportation Engineers, 2017
11. Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis, Transportation Research Board, 2016
12. State Highway Access Code, State of Colorado, March 2002
13. Manual on Uniform Traffic Control Devices, 2009 with Revisions 1 and 2, Federal Highway Administration, May 2012
14. Mile High Flood District (MHFD) Design Manuals

The following Town Documents shall be referenced and used in conjunction with these Town Engineering Standards. In the event of a conflict between Town Engineering Standards and the following documents, the more stringent requirement shall typically govern. The most recent version of the documents below shall govern.

1. Title 9 of the Breckenridge Town Code, also referred to as the Town Development Code

~~1.~~2. Blue River Walkway Improvements Plan

~~2.~~3. Breckenridge Free Ride Transit Master Plan (2020)

~~3.~~4. Breckenridge Sidewalk Master Plan

~~4.~~5. Breckenridge Transit Master Plan (2020)

~~5.~~6. Cucumber Gulch Recreation Master Plan

~~6.~~7. Handbook of Design Standards

~~7.~~8. Joint Upper Blue Master Plan

~~8.~~9. Park Ave SH 9 Roundabout Modeling and Construction Feasibility Study (2017)

~~9.~~10. Sustainable Breckenridge Plan

~~10.~~11. The Arts District of Breckenridge Master Plan

~~11.~~12. Town of Breckenridge Capital Improvements Program

~~12.~~13. Town of Breckenridge Code of Ordinances (Including the most recent versions of Titles, Chapters, and Ordinances Pending Codification)

~~13.~~14. Town of Breckenridge Comprehensive Plan ~~2008~~

~~14.~~15. Town of Breckenridge Goals and Objectives Report

~~15.~~16. Town of Breckenridge Open Space and Trails Master Plan

~~16.~~17. Town of Breckenridge Small Cell Procedures and Design Guidelines ~~(May 2019)~~

~~17. Town of Breckenridge Trails Plan (revised August 2008)~~

~~18. Town of Breckenridge Trail Standards and Guidelines~~

~~19.~~18. Town of Breckenridge Vision Plan (2002)

~~20.~~19. Town of Breckenridge Water Construction Standards

~~21.~~20. Transportation, Parking, and Urban Design Study (2016)

~~22.~~21. Upper Blue Nordic Master Plan (revised 2011)

Additional standards and documents referenced for construction specifications are included in Chapter 9. See Chapter 9 for additional information on construction standards and specifications.

Several modifications were made to the criteria in the documents listed above to include flexibility, encourage context-sensitive design, and reflect the local values of the Town. The modifications recognize the constraints of the Town's topography, the desire to maintain and enhance natural drainageways, and the mountain environment of the community. The Town of Breckenridge Engineering Standards supplement or modify the above criteria.

These Standards provide the minimum acceptable standards for safe, consistent, effective, and economical infrastructure. Actual site design may require additional detail or more conservative design parameters to address site-specific issues.

1.2 AUTHORITY

These Standards have been developed by the Engineering Division of the Public Works Department of the Town of Breckenridge. Authority for review and approval required for these Standards shall be per 10-1-3 of the Town Code. Per Section 10-1-3, the Town Engineer has the authority to administratively formulate, update, amend, and add regulations to these standards.

1.3 JURISDICTION

These Standards shall apply to all projects, both private and public, in the Town of Breckenridge, except where superseded by other government regulations.

1.4 AMENDMENTS & REVISIONS

The Engineering Division may periodically update these Standards to reflect current practices or policy revisions per Section 10-1-3 of the Town Code.

1.5 OTHER STANDARDS

Where no requirement is given, the current edition of the AASHTO, CDOT, Urban Storm Drainage Criteria Manual (USDCM), Manual of Uniform Traffic Control Devices (MUTCD), Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG) design standards, or ADA Accessibility Guidelines (ADAAG) or other agency/document listed in Section 1.2 of these Standards shall govern unless otherwise approved by the Engineering Division. Where the Town's documents do not cover a specific situation, consult the Engineering Division to confirm the appropriate standards. If a specific situation is not covered by these, the applicant shall propose a design standard for the Town to review and approve before proceeding with development. In addition to these Standards, designers, developers, and contractors are responsible for following all other applicable federal, state, and local regulations. Where there is a conflict between these Standards and other codes or regulations, the more stringent standard shall generally apply unless otherwise approved by the Town Engineer.

1.6 RIGHT TO ENFORCE OTHER STANDARDS

These Standards may not include all requirements necessary for future development. Special site conditions, project types, or other conditions may warrant the use of additional standards and criteria not included in these Standards. The Town reserves the right, in the Town's best interest, to issue and enforce more stringent criteria when appropriate as determined by the Town Engineer.

1.7 RIGHT TO REQUIRE PUBLIC IMPROVEMENTS

The Town Engineer may require public improvements due to direct or indirect impacts of development. Public improvements may include utilities, streets, sidewalks, trails, open space, parks, bridges, street lights, transit improvements, detention and water quality, wetland enhancements, stream restoration, and any other public improvements as determined by the Town Engineer. Utility work may include Town water, Town fiber (supply and install of equipment), sanitary sewer, storm sewer, street lights, and other utilities as determined necessary. All construction costs of public improvements shall be the responsibility of the development. The Town shall not be responsible for any of the design, development, and construction costs of the public improvements. See the following chapters of these Standards for additional public improvement standards.

1.8 REVIEW & APPROVAL

The Engineering Division will review submittals for general compliance with these Standards per Chapter 2 of these Standards. An approval by the Town does not relieve the owner, contractor, engineer, or designer from responsibility of ensuring that calculations, plans, specifications, and construction are accurate and in compliance with these Standards, accepted engineering practices, or other applicable requirements and regulations.

1.9 CONSTRUCTION SPECIFICATIONS

Construction specifications and details are included in Chapter 9 of these Standards and may be frequently updated. If the Town does not have a required construction specification or detail, CDOT construction specifications and the CDOT M&S Standards shall be used. If neither the Town nor CDOT has a construction specification or detail required for a project, the proposed specifications and details shall be submitted to the Engineering Division for review per Chapter 2 of these Standards.

1.10 VARIANCES

All applications for designs varying from these Standards shall obtain written approval of the variance from the Town Engineer on the Town's Variance Request Form prior to final approval of the plans. The following will be considered when evaluating variances:

1. Site-specific constraints,
2. Effect on safety,
3. Right-of-way constraints,
4. Public benefit,
5. Availability of other alternatives, and
7. Need for mitigation measures.

Variances must be requested in writing using the Town's Variance Request Form (included as an attachment to this chapter) and at a minimum include plans, text, and supporting documentation as necessary to support the information provided in the Variance Request Form.

The variance request must be prepared by or under the direct supervision of a Colorado-licensed professional engineer and be stamped and signed certifying that the variance will not result in any hazard to the public or increase the likelihood of damage to any public or private properties.

Upon receipt of a written request for a variance from a particular provision of these Standards, the Town Engineer will issue a determination on whether the variance should be granted or denied given the specific circumstances for which it was requested. The Town Engineer will provide a copy of the determination to the applicant. Determinations made by the Town Engineer in interpreting and enforcing these Standards involve the considered application of professional engineering and transportation planning judgment and skill in the context of each situation. If a variance request is denied, the applicant may appeal the denial per the provisions of the Town Code.

1.11 GLOSSARY

When the following words, phrases, or abbreviations appear in these Standards, they shall have the following definition and meaning. Where a word, phrase, or abbreviation appear in these Standards, but are not defined below, the definitions and meanings shall be assigned per the Town Code, other referenced standards, or industry accepted definitions.

100-year storm and 2-year storm: These terms refer to the statistical recurrence interval of different types of storms. A recurrence interval is a statistically determined average period of time within which a given rainfall intensity and duration will be equaled or exceeded only once. For example, the 100-year storm refers to the intensity and duration of rainfall which, on the average, will be equaled or exceeded once during a 100-year period. The larger the recurrence interval, the higher the intensity. The 100-year storm will have a higher intensity and total volume than the 2-year storm.

100-year flow/flood: a peak discharge that can be expected to be equaled or exceeded once every hundred years. This event has a 1% chance of occurring during any given year. Discharge rates, water surface elevations, and floodplain boundaries for the Blue River and its major tributaries are provided in the FEMA Flood Insurance Study. .

AASHTO: American Association of State Highway and Transportation Officials

ABC: Aggregate Base Course.

acceleration lane: a speed change lane, including tapered areas, for the purpose of enabling a vehicle entering a roadway to increase its speed to a rate at which it can more safely merge with through traffic.

access: driveway or other point of access such as a street, road, or highway that connects to the general street system. Where two public roadways intersect, the secondary roadway will be the access.

acre foot: a measurement of water volume. An acre foot equals the amount of water necessary to cover an acre at a depth of one foot (43,560 cubic feet).

ADT: Average Daily Traffic. The total bidirectional volume of traffic passing through a given point during a given time period, divided by the number of days in that time period.

alley: Minor public street adjacent to the side or rear of residential, commercial, or industrial property and used for vehicle access.

applicant: The person or designated agent responsible for preparation of Town permit applications and associated permit responsibilities. The terms “applicant” and “developer” may be used interchangeably.

approach: the portion of an intersection leg which is used by traffic approaching the intersection.

auxiliary lane: the portion of the roadway adjoining the traveled way for speed change, turning, weaving, truck climbing, maneuvering of entering and leaving traffic, and other purposes supplementary to through- traffic movement.

ASTM: American Society for Testing and Materials.

basin: an area of land, so defined by a physical boundary that when rain falls upon this area, all the resulting stormwater runoff will drain by gravity toward a common watercourse (natural stream, reach, river, or manmade channel, ditch, gutter, etc.) and ultimately exits the area at the specific point (known as the outfall).

bicycle facilities: a general term denoting improvements and provisions made by public agencies to accommodate or encourage safe and efficient bicycling or other alternative modes of transportation.

bicycle lane (bike lane): the portion of the roadway that has been designated by striping, signing, pavement markings, colored pavement, or other markings for the preferential or exclusive use of bicycles.

bridge: any structure conveying a roadway or path over a body of water or other feature. Structures shall be designed to carry a combination of loading per appropriate codes and designed by a registered professional engineer. Arch culverts, large diameter culverts, and other structures may be classified as bridges.

building permit: a written document issued by the Town Building Division to allow a developer or contractor to complete building improvements per building codes.

CAD: abbreviation for Autodesk AutoCAD software. Town requires submittals as .dwg extenstion electronic files compatible with the most recent version of Autodesk AutoCAD Civil 3D software.

capacity: the maximum number of vehicles that have a reasonable expectation of passing over a given roadway or section of roadway in one direction during a given time period under prevailing roadway and traffic conditions.

CDOT: Colorado Department of Transportation

commercial: an area of the Town in which all or a portion of the development is for commercial use. An area may be defined as commercial, even if the majority of the area is zoned as residential use, but there is a sufficient amount of commercial development to generate many commercial pedestrian and vehicle trips.

chicane: offset curb extensions which change the path of vehicular travel from straight to curvilinear and promote traffic calming.

civil construction drawings: detailed engineering plans required for all projects with public infrastructure.

CMP: corrugated metal pipe

CO: Certificate of Occupancy. A written document issued by the Building Division indicating that a building or site is in a condition suitable for occupancy.

code: the latest official adopted ordinance, policies, codes, and/or regulations of Town of Breckenridge or other agencies.

construction: any grading, excavation, earth disturbing activities, roadway work, paving, vertical building, utility work, directional boring, and any other alteration or modification to a site or right-of-way.

consultant engineer: a Colorado licensed professional engineer working on behalf of the Developer.

contract documents: the executed contract agreement, approved plans, technical specifications, and permits, and all other documents prepared by a Colorado licensed professional engineer for construction a facility

contractor: the person, firm, or organization to whom a construction contract is awarded by the Developer, or who has been issued a right-of-way work permit. Contractor may be the same entity as the Applicant or Developer, or may be a separate entity.

contour interval: a contour is a line drawn on a map through points of equal elevation. A contour interval is the elevation difference between contour lines.

critical volume: a traffic volume (or combination of volumes) for a given street which produces the greatest utilization of capacity for that street in terms of passenger cars or mixed vehicles per hour.

cross-section: a view of the interior or horizontal cut through a roadway, structure, or object and includes a representation of all relevant elements.

cross-slope: slope of the pavement surface, exclud~~s~~ing gutter, measured perpendicular to the street centerline.

cross-street flow: flow of stormwater runoff across the traffic lanes of a street from external sources, as distinguished from sheet flow of water falling on pavement surface.

culvert: a covered channel or pipe that takes a watercourse under a road, through the downstream embankment of a detention facility or below ground. Some “culverts” may also be classified as “bridges”.

days: calendar days, not normal working days unless stipulated as working days.

deceleration lane: a speed change lane, including tapered areas, for the purpose of enabling a vehicle that is to make an exit turn from a roadway to slow to a safe turning speed after it has left the main stream of faster moving traffic.

design hour volume: hourly traffic volume used for street design and capacity analysis, usually one or more peak hours during a 24-hour period.

design speed: the typical vehicle rate in miles per hour (mph) which a street is designed to accommodate. Design speed shall typically match the posted street speed limit.

design vehicle: the vehicle a street must consider and accommodate for acceptable speed, turning movements, loading, and other considerations.

designer: the person, firm, or organization responsible for the creation and submission of contract documents or construction plans for the construction of a facility. Designer shall be a Colorado licensed professional engineer.

detached sidewalk: a sidewalk that is offset from the roadway and curb by a minimum distance of four feet.

detail: an engineered drawing illustrating all features and requirements for construction of a structure or facility.

detention facility: a basin or structure designed for the storage of stormwater runoff that allows for slower, controlled release during or immediately following a storm. A typical facility consists of a detention pond with an embankment on the downstream side, and a pipe or concrete box outlet. The size of the pond is based on a specific design storm and the amount of water that can be discharged through the outlet. Design features may be incorporated into detention facilities to allow them to function as sediment ponds.

developer: the private person, partnership, or corporation legally responsible for the construction of streets, subdivisions, infrastructure, or any other public or private improvement. Developer shall secure all required approvals and permits from the Town and assume full and complete responsibility for the project. The terms “owner,” “applicant,” and “permit holder” may be used in place of “developer” and hold the same definitions and responsibilities.

development: construction of improvements on land that is vacant or containing minimal infrastructure or improvements.

development code: title 9 – land use and development, of the Town of Breckenridge Code.

development permit: a written document from the Town community development department to complete development per codes, standards, and other documents.

drainageway: a route or course along which water moves or may move to drain an area. A “natural” drainageway refers to the route or course in an area prior to the construction of any urban improvements.

drainage easement: a grant to the Town of the right to control development, access, or maintenance of a drainage right-of-way or an area subject to periodic flooding.

driveway: a constructed access serving three or less units and connecting to a street or adjacent driveway. May also be called a “private access.”

easement: the portion of public or private land dedicated to the public or another entity for the installation, maintenance, and use of utilities, drainage, vehicle access, pedestrian access, snow storage, or other public uses. Easements may be granted through a subdivision plat or other legal instrument as approved by the Town Attorney. Easements shall grant the legal right of use of the property by the grantee. Easements may grant the Town the ability to complete maintenance work, but does not require the Town to complete maintenance.

Encroachment License Agreement: A written document granting a property owner the ability to construct and maintain private improvements within a Town ROW or easement. The encroachment license is revocable and sets many requirements of the property owner for the encroachment.

EPA: United States Environmental Protection Agency.

ESA: Environmentally sensitive areas. An area such as wetlands, streams, lakes, ponds, Cucumber Gulch Wildlife Preserve, and other special wildlife habitat areas which require special requirements to protect their sensitive nature during development.

fees: monetary charges which compensate the Town for services rendered or infrastructure constructed.

FEMA: Federal Emergency Management Agency.

FHWA: Federal Highway Administration, Department of Transportation.

field order: a written notice given by the Town to the Designer, Contractor, or Developer detailing a change, request, mandate, or corrective action necessary to conform to these Standards, approved plans, or other applicable Local Entity Codes.

final acceptance: the written notification from the Town, after the Town finds the warranty period to be satisfactorily completed, that all public improvements are free of defects and the Town releases the Developer from future maintenance obligations.

FIRM: Flood Insurance Rate Map.

floodplain development permit: a document granted to developers or contractors to construct improvements or complete earthwork activities within 100 feet of the 100-year floodplain.

freeboard: the elevation difference between the normal maximum level of water surface and the bottom of the confining structure, which is provided so debris may more readily pass through the structure without creating blockage and waves and other movements of the water will not overtop such confining structures.

grade: the inclination or slope of a channel, canal, conduit, street, etc., or other natural ground surface, usually expressed in terms of the percentage or number of units of vertical rise (or fall) per unit of horizontal distance.

grading plan: a detailed engineering plan showing contours, slopes, existing elevations, proposed elevations, retaining walls, and other grading features for a site.

HCM: Highway Capacity Manual. Publication of the Transportation Research Board of the National Academies of Science which defines the ideal conditions of uninterrupted traffic flow.

HMA: Hot Mix Asphalt.

HEC: Hydrologic Engineering Center, an element of the USACE, Institute for Water Resources (CEIWR) that supports the nation in its water resources management responsibilities by increasing technical capability in hydrologic engineering and water resources planning and management.

HMS: Hydrologic Modeling System (HEC-HMS) developed by the USACE to simulate the complete hydrologic processes of dendritic watershed systems.

LOS: level of service. A qualitative measures used to relate the quality of motor or pedestrian vehicle traffic service; usually measured from a LOS A to LOS F.

initial acceptance: the Town’s process to initially accept ownership after the Developer has completed all proposed improvements identified in the approved plans and agreements, and after the Town has inspected and approved improvements. Initial acceptance begins the two year warranty period.

infrastructure: public roadways, sidewalks, pedestrian routes, trails, stormwater improvements, potable water improvements, sanitary sewer improvements, lighting, irrigation, fiber optic cable and conduit, other utilities, stormwater management, transit facilities, retaining walls, signage, and any other structures, improvements, or installations as determined by the Town Engineer.

inlet: 1) an opening into a storm sewer system for the entrance of surface storm runoff; 2) a structure at the upstream end of a conduit; or 3) the upstream connection between the surface of the ground and a drain or sewer for the admission of surface or storm water.

inspector: an authorized representative of the Town Engineer, assigned to make inspections to assure work is completed in compliance with plans, standards and specifications.

intersection sight distance: the minimum distance required for the driver of a motor vehicle stopped at a stop sign on a minor street or driveway to see approaching vehicles, pedestrians, and bicyclists along the intersecting major street and have sufficient space to make any allowed move to cross the major street or merge with traffic on the major street without causing vehicles, pedestrians, or bicyclists traveling at or near the design speed on the major street to slow down.

ITE: Institute of Transportation Engineers

landscaping: materials including, without limitation, grass, ground cover, shrubs, trees, perennials, annuals, non-living material commonly used in landscape development, and irrigation systems.

LTS: Level of Traffic Stress. A measure which quantifies the amount of discomfort which bicyclists experience near vehicular traffic.

MHFD: Mile High Flood District, formerly the Urban Drainage and Flood Control District (UDFCD).

MHT: Method of Handling Traffic. “MHT” may also be referred to as a “Traffic Control Plan (TCP)”. Detailed drawings outlining the layout of traffic control devices for a project and signed by a TCS.

MUTCD: Manual on Uniform Traffic Control Devices.

minor storm and major storm: these terms refer to the recurrence intervals of storms used to design stormwater infrastructure. The minor storm (also called the initial storm) is the 2- to 10-year storm depending on land use at the design location. The major storm is the 100-year storm, and the uncontrolled runoff from this storm could possibly cause major property damage or even loss of life.

multimodal: inclusion of several different modes of transportation. Examples include vehicular, pedestrian, bicycle, bus transit, gondolas, and other public transit modes.

NFIP: National Flood Insurance Program.

NRCS: Natural Resource Conservation Service.

open channel: a watercourse which conveys stormwater runoff within the drainage basin to the outfall of the basin. It has a defined bed and banks that confine the runoff, but it has a surface open to the atmosphere and cannot develop pressurized flow.

ordinance: a law established by the Town of Breckenridge.

O&M Plan: operations and maintenance plan. A written document defining work and maintenance procedures to maintain infrastructure and facilities to function per the original design intent.

OSHA: Occupational Safety and Health Administration.

PAR: Pedestrian Access Route. A continuous and unobstructed path of travel provided for pedestrians with disabilities within or coinciding with a pedestrian circulation path.

PDF: Portable Document Format. Town requires electronic file submittals to be a PDF compatible with the most recent version of Adobe Acrobat.

PE: a Colorado licensed professional engineer.

peak hour: the hour in a day which produces the highest volume of vehicle or pedestrian traffic for a portion of roadway, intersection, or pedestrian route in a day.

pedestrian: a person afoot or in a wheel chair or other pedestrian mobility device.

permitee: the holder of a valid permit for the Town of Breckenridge. "Permitee" may be used interchangeably with "developer".

PHF: Peak Hour Factor. A calculation used to convert the hourly traffic volume into the flow rate that represents the busiest 15 minutes of the peak hour. PHF is calculated through the following equation: (total hourly volume) / [(peak 15-minute volume within the hour x 4)].

plans: construction plans completed and stamped by Colorado licensed professional engineer for public or private improvements.

PLS: a Colorado licensed professional land surveyor

private Improvements: any land, structures, infrastructure, or other object to be used, owned, and maintained by a private person, partnership, or corporation.

project: the public or private improvements designated in the approved plans, which are to be constructed in conformance with these standards. "project" includes private projects, public capital projects, utility projects, ROW projects, and any other improvements in the Town.

private street: a roadway serving four or more units or lots. Private streets are not owned or maintained by the Town of Breckenridge.

project engineer: the professional engineer, registered in the State of Colorado, assigned to a project by a Town permit holder to inspect and observe construction and to complete and sign and stamp construction inspection and observation reports.

public improvement: any land, structures, infrastructure, or other object dedicated to the Town, public, or other agency. Public improvements are typically conveyed to the Town and subsequently owned and maintained by the Town. Also include facilities which will be privately owned but serve the public, or private facilities serving a large number of people, such as utilities and stormwater drainage.

punch list: a written list of work items, compiled by the inspector, which do not conform to these Standards, the plans, specifications, or other codes that govern the project. The developer is responsible for completing the list of work items prior to initial acceptance.

rational method: a design method which determines a peak runoff rate based on drainage area, rainfall intensity, and imperviousness for watersheds of 90 acres or less.

record drawings: design drawings updated by a professional engineer, depicting all modifications from the design that occurred during construction.

redevelopment: removal or modification of existing improvements, remodeling, and construction of new improvements on a site which has existing improvements. Sites with minimal existing improvements is not considered redevelopment.

report: a document containing analyses, surveys, tests, exhibits, and other pertinent data prepared by a Colorado licensed professional engineer.

road: the entire width of a public right-of-way, including the roadway, pedestrian routes, landscaped areas, shoulders, and other areas within the right-of-way.

ROW: right-of-way. Land owned by the Town for the use of a public street, alley, sidewalk, path, or other use.

ROW permit: right-of-way permit. A document granted by the Town to a developer or contractor to construct any public or private improvements in the ROW, or for any equipment, materials, or encroachment in the ROW, or disruption to pedestrians or vehicles within a ROW.

SCS: Soil Conservation Service. A hydrological method that uses geographical rainfall time distributions, curve numbers and time of concentration to determine peak runoff that may be used for water sheds of any size or when hydrograph routing is required for design.

SCS method: Soil Conservation Service method.

SFHA: Special Flood Hazard Area. An area identified by FEMA as an area having flood-related hazards and where the NFIP floodplain management regulations must be enforced.

shared use path: a paved path at least 10 feet wide for pedestrians, bicyclists, and other non-motorized transportation uses.

SIA: Subdivision Improvement Agreement. A written document establishing a surety and requirements for a developer to complete improvements in the Town.

sidewalk: paved path for pedestrian use within a ROW or easement and separated from the roadway by a curb or detached at least four feet.

sight distance: the length of roadway which is visible to a vehicle operator.

site plan: a detailed engineering drawing showing proposed improvements to a site.

snow storage: additional area within a right-of-way, easements, or private property for stacking and storing snow and ice. May also be called snow stacking areas.

specifications: a written document describing in detail the scope of work, materials to be used, methods of installation, and quality of workmanship for construction work.

stable channel/ditch: a streambed, drainageway, or ditch in which sediment transport conditions are in balance, neither acquiring significant deposits of sediments nor experiencing significant erosion.

standards: these Town of Breckenridge Engineer Standards, inclusive of all attachments, amendments, and referenced/supplemental codes and standards.

stop work order: a written directive from the Town revoking the developer's and contractor's rights to continue work on the project due to nonconformance with these standards, plans, specifications, or other project documents.

SSD: Stopping Sight Distance. The minimum length of roadway required to be visible for a vehicle operator to safely recognize an object within a roadway and stop the vehicle prior to colliding with the object. SSD can also be defined as the sum of the braking distance and the distance traversed by a vehicle during the reaction time.

storage lane: additional lane footage added to a deceleration lane to store the maximum number of vehicles likely to accumulate during a critical period without interfering with the through lanes.

stormwater runoff: the water from precipitation running off from the surface during and immediately following a period of rain.

storm sewer system: also called a storm drain system; a system of inlets, manholes, and conduits that conveys runoff to drainageways and natural channels. Storm sewers are necessary whenever the street capacity to carry the design storm runoff is exceeded by either the minor or the major storm.

street: the entire width of a public right-of-way, including the roadway, pedestrian routes, landscaped areas, shoulders, and other areas within the right-of-way.

street flow: the total flow of stormwater runoff in a street, usually the sum of the gutter flows on each side of the street.

subdivision: a tract of land surveyed and divided into separate parcels or lots. "Subdivision" may also refer to a neighborhood or several adjoining lots in the Town.

subdivision permit: a type of development permit issued by the Town Community Development Department for dividing a tract of land into separate parcels or lots.

substantial completion: the period when the work has progressed to the point where it is sufficiently complete so some or all of it can be utilized for the purposes which it is intended.

SUE: subsurface utility engineering. The Colorado Senate Bill 18-167 that amended Title 9, Article 1.5 of the Colorado Revised Statutes to improve safety by modifying requirements associated with the location underground utilities prior to construction.

surcharged: a condition when the hydraulic grade line within a storm sewer rises above the elevation of an inlet.

surety: a financial instrument, such as cash, bond, letter of credit, or other instrument acceptable in form to the Town Attorney, securing the developer's responsibility to complete construction of improvements for a project. Surety shall also be a financial instrument to secure the Developer's obligations through the warranty period.

SWMM: Storm Water Management Model, developed by the EPA and used for hydrologic and hydraulic analysis.

SWMP: Stormwater Management Plan. A construction plan and associated written narrative required for construction sites to prevent pollution, contamination, or degradation of waters of the State and to prevent discharge of pollutants from a project site.

TDM: Transportation Demand Management. A set of strategies aimed at reducing travel demand or to redistribute the demand in space or in time.

TCS: certified Traffic Control Supervisor.

Town: abbreviation for the Town of Breckenridge. Town may refer to the entire municipality, the Town Engineering Division, or other Town Departments and Divisions.

Town Code: The Town of Breckenridge Municipal Code. Includes all codification and ordinances pending codification. Town Code is a collection of laws passed by the Town and have the force and effect of law for the Town. The Town Code can be found online.

Town Engineer: the Town of Breckenridge Town Engineer or Town Engineering Representative selected by the Town Engineer.

TIS: Traffic Impact Study. An assessment of the adequacy of the existing or future transportation infrastructure to accommodate additional trips generated by a proposed development, redevelopment, or land rezoning which is prepared and stamped by a Colorado licensed Professional Engineer.

Traffic calming: the combination or mainly physical measures that reduced the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users.

trail: any path used by pedestrians or bicyclists within a ROW or easement.

UBSD: Upper Blue Sanitation District.

USACE: United States Army Corps of Engineers.

USDCM: Urban Storm Drainage Criteria Manual, published by the MHFD.

USGS: United States Geological Survey.

utility: a network of infrastructure supplying a service to the Town. Examples include gas, electric, sewer, water, and communication.

variance: an approved deviation from these Standards or other rules of the Town of Breckenridge.

vehicle: an instrument for the purpose of conveying people or objects. Vehicles are typically motorized. Wheelchairs and other pedestrian mobility devices are not considered vehicles.

warranty: a written guarantee from developer or contractor guaranteeing all improvements from material and workmanship defects.

warranty period: the two year period of time after the initiation acceptance when the developer or contractor is responsible for warranty of improvements.

wetlands: areas including lakes, streams, ponds, areas of seasonal standing water, and other bodies of water with a predominance of wetlands vegetation (such as willows, rushes, or sedges), or areas with boggy soils. Wetlands definitions and delineations shall be consistent with those of the Army Corps of Engineers.

wheel path: the three foot wide portion on both sides of a roadway travel lane starting two feet from the center of the lane.

work: all construction activity, including materials, labor, supervision, use of tools and equipment, and all other effort required to complete the project in full compliance with these standards, approved plans, specifications, and other documents.

CHAPTER 2
SUBMITTAL REQUIREMENTS & PERMITS

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2.1 INTRODUCTION

This chapter of the Engineering Standards establishes the requirements and review process for preconstruction submittals to the Engineering Division of the Public Works Department. The engineering submittals specified in this chapter are for Planning Development Permits, Infrastructure Permits, Floodplain Development Permits, Right-of-Way Permits, civil construction drawings, Preliminary and Final Drainage Reports, Traffic Impact Studies, and Stormwater Management Plans (SWMP).

The Infrastructure Permit issued by the Engineering Division is generally required for projects involving roadways, sidewalks and trails, stormwater infrastructure, potable water infrastructure, sanitary sewer infrastructure, lighting, irrigation, fiber optic cable and conduit, other utilities, stormwater management, transit facilities, retaining walls, signage, and any other public improvements. Single Family Homes (SFH) typically do not require an Infrastructure Permit, but one may be required by the Town Engineer depending on the project scope.

This chapter also includes the Engineering Division submittal requirements for a Building Permit and a Right-of-Way Permit. Planning submittals, including landscaping, architectural, historical, and mineral rights submittal requirements, can be found in Title 9 the Town Code. See Title 9 of the Town Code for additional information on the Town's planning process, the types of development permits listed below, how to obtain a development permit, scheduling pre-application meetings, and other planning related items. This chapter discusses the submittal and approval process prior to construction for the Engineering Division. Chapter 8 of these Standards details inspections and acceptance during and after construction.

A permit process flowchart is included as an attachment in Appendix B.

2.2 GENERAL FORMATTING

All drawing sheets, regardless of content, shall be scalable, clear and legible when printed on 11" x 17" paper. Drawings shall be prepared in AutoCAD or a compatible program approved by Town in the Colorado State Plane Central (unmodified) coordinate system for easy incorporation into the Town's GIS database.

Contents shall be drawn to a scale of multiples of ten (e.g. 1" = 10'; 1" = 30'). To preserve the scale when plotting at both full size and half size, drawings may be produced in AutoCAD with an 11" x 17" format. A larger exterior border may then be used with a 24" x 36" format, with an effective area of 22" x 34", to result in an exact doubling of the 11" x 17" half-sized drawings.

Hard copies of plans are not required. All plans shall be provided electronically, in DWG and in PDF in a format that will print to scale on 11" x 17" paper. DWG files shall be provided in a version of AutoCAD specified by the Town.

Each drawing sheet shall include a title block, scale, north arrow, original and revision dates, and professional engineer's stamp when applicable. Title blocks shall be along the bottom or right margin of each drawing.

Hard copies of reports and specifications are not required. All reports shall be provided in electronic format in PDF so that pages of report text will print to scale on 8.5" x 11" paper. Exhibits may be created to print to scale on 11" x 17" paper.

2.3 ENGINEERING SUBMITTALS

Table 2.1 summarizes the Engineering Division submittals required for subdivision permits, development permits, engineering permits, building permits, and right-of-way permits. See the Town Code for Community Development and Building Department submittal requirements. See the Town of Breckenridge Water Construction Standards for Town of Breckenridge Water Division submittals. Contact other agencies and utility companies (including Red White & Blue Fire Protection District, Upper Blue Sanitation District, and Xcel Energy) for applicable codes and design criteria. A brief cover letter should be submitted with all Engineering Division submittals that includes the following information. A cover letter is not required for single family home projects without an infrastructure permit.

1. Project title
2. Project description including street address, subdivision, lot, and block
3. Owner contact information
4. Engineer contact information
5. Written justification for any required items omitted from the submittal.

There are several types of submittals requiring both a preliminary and a final submittal. Requirements for these are specified in Table 2.1 and the respective subsection for each submittal type. All the submittals listed in Table 2.1 may not be required for a specific project; consult with the Engineering Division to confirm which submittals are required for a project. Table 2.2 summarizes which checklists shall be referenced for different types of projects. Checklists are included as attachments in Appendix B. Any work of any nature within the Town must have at least one of the following permits before starting work: an Infrastructure Permit, a Building Permit, or a Right-of-Way Permit. All three may be required depending on the nature of the work. Permits are discussed in more detail in Section 2.4. No work of any kind, including demolition, removal, or grading, may begin until the applicable permit(s) listed above have been obtained.

Table 2.1. Engineering Division Submittal Requirements

Permit Type	Engineering Division Submittals									
	Site & Grading Plans	Civil Drawings	Drainage Report	Geotech Report	Traffic Impact Study	MHT *	SWMP **	CMP ***	Tech Specs	Other Agency Permits
Class A/B Development Permit Preliminary Submittal	X									
Class A/B Development Permit Final Submittal; Class A/B/C Subdivision Permit Preliminary & Final Submittal; & Class C/D Development Permit	X		X							
Infrastructure Permit	X	X	X	X	X	X	X		X	X
Building Permit (without Infrastructure Permit)	X	X		X		X		X		X
Right-of-Way Permit	X	X				X		X		X

*Method of Handling Traffic/ Traffic Control Plan
**Stormwater Management Plan
***Construction Management Plan

Table 2.2. Project Checklist Reference

Project or Permit Type	Checklist
Development/Subdivision Permit	Checklist 1: Site and Grading Plan Requirements
Infrastructure Permit for grading, drainage, utilities, streets, or sidewalks	Checklist 2: Civil Construction Drawings Requirements Checklist 3: Drainage Report Requirements Checklist 4: Traffic Study Requirements Checklist 6: Ownership & Maintenance Plan Requirements
Any land disturbance	Checklist 5: Stormwater Management Plan Requirements
Building Permit (without Infrastructure Permit)	Checklist 7: Building Permit (Without Infrastructure Permit) Requirements

2.3.1 Site and Grading Plans

Site and grading Plans are required to be submitted to the Engineering Division when a Subdivision or Development Permit is required by the Community Development Department. The preliminary site and grading Plans are required for preliminary Development Permit submittals. Final site and grading plans are required to be submitted with the final Development Permit submittal. Requirements for site and grading plans are listed in Checklist 1. Grading and site plans may be combined for small projects where less detail is needed to clearly understand the intent of the grading plan.

The Community Development Department lists Planning requirements for site plans in Title 9 of the Town Code. If the Applicant can satisfy the Engineering and Planning requirements on a single set, then only one site plan is required. If the Applicant cannot satisfy both sets of requirements on one set, then two submittals are required.

2.3.2 Civil Construction Drawings

Complete civil construction drawings are required for any project that includes public infrastructure. Public infrastructure includes roadways, sidewalks and trails, stormwater infrastructure, potable water infrastructure, sanitary sewer infrastructure, lighting, irrigation, fiber optic cable and conduit, other utilities, transit facilities, retaining walls, signage, and any other public improvements. Both a preliminary and a final submittal of civil construction drawings are required for the Infrastructure Permit (discussed later in this chapter). In general, the preliminary submittal of civil construction drawings shall be at least 60% complete while the final submittal shall be construction-ready and stamped by a professional engineer. For small projects that require an Infrastructure Permit, a single submittal is acceptable with prior approval from the Town Engineer.

Civil construction drawing requirements for most types of construction and grading are specified in Checklist 2, Civil Construction Drawing Requirements. The checklist is provided to guide the content and format of the construction drawings. The drawings must meet the minimum content standards so the Town can thoroughly review the design of the improvements and confirm the design is in accordance with these Standards and with all other applicable standards. Adherence to applicable design standards provides for the health, safety, welfare, and property of the Town and its citizens to be safeguarded and protected.

Depending on the scope of the project, the contents of one or more drawings specified by the checklist may be more efficiently shown on a single drawing. Required contents may be combined or separated as necessary to provide a clear and concise set of construction drawings that provides all the required information.

The design of improvements included in the construction drawings must be completed in accordance with these Standards. The plans will be reviewed for compliance and resubmittal will be required if any aspect of the design of the improvements is not in compliance with the applicable standards and criteria.

2.3.3 Drainage Reports

A drainage report is required for new public storm sewer infrastructure or for private storm sewers that connect to existing public storm sewer infrastructure. A drainage report is also required for private infrastructure if a site's impervious area increases by 0.1 acres or more from existing conditions, regardless of whether new infrastructure is constructed. ~~Both a preliminary and a final drainage report are required.~~ For small projects, an abbreviated drainage memo may be acceptable with prior approval from the Town Engineer. A drainage memo may also be required for commercial redevelopment that does not increase impervious area, but ~~does disturb~~ includes site disturbance of ~~at least~~ 0.15 acres or greater. In general, the preliminary drainage report shall be at least 60% complete while the final drainage report shall be accompanied by construction-ready drawings. Guidance on drainage and water quality design and the Town's drainage and water quality criteria are in Chapter 6 of these Standards.

Both a preliminary and a final drainage report are required. The preliminary drainage report shall be submitted with the final development and final Subdivision Permit applications and shall also meet the requirements of Section 9-1-18 of the Town Code. The final drainage report shall be submitted with the Infrastructure Permit. Requirements for drainage reports are specified in Checklist 3, Drainage Report Requirements. Chapter 6 of these Standards discusses design requirements for stormwater infrastructure within the Town.

2.3.4 Geotechnical Report

A Geotechnical Report is required for an Infrastructure Permit. The Building Department also requires documentation of the bearing capacity of the soils used for foundation design in accordance with the International Building Code (IBC) and the International Residential Code (IRC). The Town may review geotechnical reports and the associated subsurface explorations and analyses to check for slope stability or soil issues, but it shall not be the responsibility or liability of the Town to make an assessment of the soils. It shall be the responsibility of the applicant and their geotechnical engineer to make an assessment of any soil or slope stability issues. The Geotechnical Report shall generally contain the following findings and supporting data. Certain projects may not require all the items listed below depending on the scope of the work.

1. Relative density type and extent of material likely to be encountered.
2. Anticipated excavation issues and proposed solutions.
3. Location and extent of excavation.
4. Suitability of excavated materials for use as backfill or bedding.
5. Compaction characteristics of the soils.
6. Groundwater level and conditions.
7. Soils infiltration testing results if any infiltration facility is proposed.
8. Soils resistively, moisture content, pH, degree of variation, presence of sulfates, and the likelihood of stray, direct currents.
9. Soil bearing capacity and foundation design recommendations.
10. Recommended pavement type and thickness, base course type and thickness, and any additional subgrade requirements.
11. Test holes to a depth of at least two feet below the subgrade of the proposed improvements; the spacing of test holes shall be as recommended by the geotechnical engineer to adequately define the subgrade.

2.3.5 Traffic Impact Study (TIS)

A Traffic Impact Study (TIS) may be required. Chapter 4 - Traffic Impact Studies of these Standards specifies when a TIS is required. TIS requirements are specified in Checklist 4 of Appendix B.

2.3.6 Method of Handling Traffic (MHT)

A Method of Handling Traffic (MHT) or Traffic Control Plan (TCP) prepared by a certified Traffic Control Supervisor (TCS) is required for work performed within the public right-of-way (ROW) that will impact traffic lanes, shoulders, or sidewalks. A full MHT shall be submitted to the Engineering Division that includes lane closures, vehicular and pedestrian detours, cones, barriers, signage, and any other traffic maintenance devices required. Lane closures, signage, and traffic patterns must meet MUTCD and CDOT requirements. Efforts shall be made to maintain at least one lane of traffic to the extent possible. When one lane cannot safely be maintained, the length and duration of the full road closure shall be minimized to the extent possible. See Chapter 3 of these Standards for additional requirements of when a ROW permit or MHT is required.

2.3.7 Stormwater Management Plan (SWMP)

A Stormwater Management Plan (SWMP) is required when the area disturbed during construction is one acre or more. Construction best management practices must be used to prevent erosion and control sediment. Permanent water quality best management practices are not included in the SWMP but are to be included in the civil construction drawings. Requirements for permanent water quality are specified in Chapter 6 of these Standards. Items required to be included in the SWMP are specified in Checklist 5 - Stormwater Management Plan Requirements of Appendix B. Construction Stormwater Standards are detailed in Section 6.11. See additional permitting requirements in Section 2.4 below for projects disturbing one acre or more.

2.3.8 Construction Management Plan (CMP)

A Construction Management Plan (CMP) is required for projects disturbing less than one acre during construction. Projects disturbing less than one acre, but part of a larger project or development disturbing one acre or more, will still require a SWMP to be submitted. The CMP must be developed to prevent erosion and control sediment. Permanent water quality best management practices are not included in the CMP but are to be included in the civil construction drawings. The CMP shall show the following at a minimum:

1. Best Management Practices (BMPS) to prevent erosion and control sediment from leaving site.
2. Revegetation notes or other final stabilization plans.
3. Construction fencing location.
4. Material and equipment staging locations.
5. Dumpster and portalet locations
6. Vehicle parking locations and construction access location.

2.3.9 Construction Specifications

The Town has adopted standard construction specifications that shall be used on all projects. Project special provisions that vary from the Town Specifications shall be included with the Infrastructure Permit application. For special conditions or construction types which are not addressed by the Town Specifications, the Applicant shall submit proposed specifications for the Town's review.

2.3.10 Subsurface Utility Engineering (SUE)

Colorado Senate Bill 18-167 amended Title 9, Article 1.5 of the Colorado Revised Statutes to improve safety by modifying the requirements associated with the location of underground utilities prior to construction and implementing an enforcement program associated with the new requirements. The new requirements must be met if a project meets all four of the following criteria:

1. Project involves a construction contract with a public entity, construction in the public ROW, infrastructure that will be dedicated to the Town, or other work as determined by the Town Engineer.
2. Project primarily involves horizontal construction and does not primarily involve the construction of buildings.
3. Anticipated excavation footprint exceeds two feet in depth and is at least a contiguous 1,000 square feet (excluding fencing and signing projects) or involves utility boring.
4. Project requires the design services of a licensed professional engineer.

If all the above criteria are met, subsurface utility engineering documentation shall be provided with the Infrastructure Permit application that includes:

1. Notification to 811 that there is an upcoming SUE required project.
2. Depiction of utilities on stamped plans in such a way that they meet or exceed ASCE 38 or provide documented reasons from a licensed professional engineer why they do not meet or exceed Quality Level B.
3. Meeting or exceed Quality Level A for underground facilities at the point of a potential conflict with a gravity fed system including sanitary and/or stormwater facilities.

Quality-level requirements for subsurface utility engineering vary by project phase and are as follows:

1. Project Planning – Quality Level D
2. Preliminary Design – Quality Level B
3. Final Design – Quality Level A

   The above Quality Levels provide general guidance for project planning. Refer to Colorado Senate Bill 18-167 for exact Quality Level requirements. Quality Level A is generally required at potential conflicts for gravity fed utilities. Quality Level A may not be required in areas without any sanitary sewer, storm sewer, other potential utility conflicts, or grading conflicts. A Colorado licensed Professional Engineer must determine the appropriate Quality Level based on Colorado Senate Bill 18-167 and document the reasons why any facilities were not located to the particular Quality Level.

Definitions of the Quality Levels are as follows:

1. Quality Level D is the most basic level of investigation and includes verbal recollections and review of existing records such as as-built drawings, utility system drawings, permit logs, field sketches, site visit log books, old surveys, one-call marks, and prior SUE investigations by others.
2. Quality Level C includes surveying those utilities that are visible above ground and use of surface features that indicate subsurface alignment such as valve covers, fire hydrants, pull boxes, manholes, and telephone pedestals. These should be reconciled to ASCE Quality Level D records.

3. Quality Level B includes the use of geophysical methods to determine the existence and horizontal position of all subsurface utilities. Quality Level B can be assigned to a utility segment or subsurface feature whose existence and position are based upon geophysical methods combined with professional judgment and whose location is tied to the project survey datum. Quality Level B is sometimes referred to as designating.
4. Quality Level A requires precise mapping via exposure of the utility. It provides type, size, condition, and material of the utility. Quality Level A includes using nondestructive excavating equipment at critical points to determine the precise horizontal and vertical position, type, size, condition, material, and any other characteristics of underground utilities. The utility should be vertically and horizontally tied to the project datum. Quality Level A is sometimes called locating.

2.3.11 Permanent Survey Monumentation

Permanent survey monuments are required in accordance with Chapter 3 of these Standards. A brief narrative covering the procedures and pertinent information used to establish permanent monumentation must be submitted to the Town Engineer as part of the Infrastructure Permit. GPS survey data shall include a detailed description of the post processing procedure which was used to establish the monument. Permanent survey monuments shall be considered properly positioned and represented only after the Town Engineer has approved all survey procedures and calculations and has verified conformance to standards and specifications for Class 2 surveys or greater. If found to be deficient, the Land Surveyor submitting the final plat and documentation may be required to perform additional work to bring the monumentation into conformance, regardless whether the final plat is recorded or not.

Survey control points, permanent monumentation, and the basis of horizontal and vertical control shall be shown on all plans. Property corners and other survey monuments shall be shown on the plat in accordance with the Town Code.

2.3.12 Ownership and Maintenance Plan

An Ownership and Maintenance Plan (O&M Plan) is required for all detention and permanent water quality facilities. An example O&M Plan, including a template for required plan notes, is included as an attachment to this chapter. Checklist 6, O&M Plan Requirements, is also included as an attachment to this chapter. O&M plans may be required by the Town Engineer for other public or private infrastructure.

2.4 PERMITS

A development permit must be issued by the Community Development Department prior to the applicant applying for any of the permits listed below; an exception may be granted for projects consisting of work contained entirely within Town right-of-way. Any work within the Town must have at least one of the following permits before starting, and all three may be required depending on the nature of the work. Exceptions may be made for Class D minor permits; contact the Engineering Division prior to beginning work to confirm permitting requirements. Additional permits may be required in addition to the three permits listed below.

1. Infrastructure Permit
2. Building Permit
3. Right-of-Way Permit
4. Floodplain Development Permit

Additionally, work within 30’ of a special flood hazard area (SFHA) will require a Floodplain Development Permit as part of the permitting process. Table 2.3 summarizes the types of permits that are required for different types of projects and the subsections below discuss each of these in more detail.

All applicable county, state, and federal permits must be obtained and submitted to the Engineering Division prior to the Town issuing the Infrastructure, Building, or Right-of-Way Permit.

Table 2.3. Project Permits

Project or Permit Type	Permit
Any infrastructure improvements	Infrastructure Permit
Any building construction, remodel, or addition	Building Permit
Any work within the public right-of-way	Right-of-Way Permit (ROW Permit)
Any work within 30’ of a SFHA	Floodplain Development Permit

2.4.1 Infrastructure Permit

An Infrastructure Permit is required for projects that occur within public right-of-way, projects that disturb one acre or more, and for public & private developments that involve public roadways, sidewalks, trails, stormwater infrastructure, potable water infrastructure, sanitary sewer infrastructure, lighting, irrigation, fiber optic cable and conduit, heated paver, asphalt, and concrete snowmelt systems, other utilities, stormwater management, transit facilities, retaining walls, signage, and any other improvements. If ~~storm sewer~~ infrastructure is being installed on private property and is being connected to public infrastructure, an Infrastructure Permit will be required. An Infrastructure Permit may also be required for other types of work at the discretion of the Engineering Division. An Infrastructure Permit may be obtained at the same time or prior to the Building Permit if a Building Permit is required. Refer to the permit process flow chart in the attachments to this chapter for the permitting process. The Infrastructure Permit application form is also included as an attachment to this chapter. The Engineering Division will review each Infrastructure Permit application and issue the Infrastructure Permit once the application is approved. If any work is proposed within existing Town right-of-way, a separate Right-of-Way Permit will be required in addition to an Infrastructure Permit.

Work exempted from an infrastructure permit includes single-family homes with a building permit, driveway repaving, and minor work entirely within a right-of-way.

A list of submittals required for the Infrastructure Permit is listed on the Infrastructure Permit Application form attached to this chapter.

2.4.2 Building Permit (without Infrastructure Permit)

If the Engineering Division determines that an Infrastructure Permit is not required, final construction plans shall be approved through a Town Building Permit. Refer to the Town Code for other Town Division submittal requirements. A Building Permit or Infrastructure Permit must be obtained prior to beginning any construction activities (including any staging, demolition, excavation, removals, or grading).

In cases where an applicant desires to begin demolition prior to a building permit or infrastructure permit, they shall contact the Building and Engineering Divisions for approval. Engineering will review these requests and will only allow a demolition permit if the associated site and grading work is minimal.

A checklist of Engineering Division submittals required for Building Permits (Without Infrastructure Permit) is listed in Checklist 7 at the end of this chapter.

2.4.3 Right-of-Way Permit

Any excavation or encroachment into the Town right-of-way requires a Town Right-of-Way Permit from the Public Works Department. The Right-of-Way Permit shall be obtained prior to starting any work within Town right-of-way. Right-of-way regulations are specified in Chapter 3. The permit application and guidance can be found at the Town of Breckenridge Public Works website.

A list of submittals required for the Right-of-Way Permit is listed on the Right-of-Way Permit Application form on the Town website.

2.4.4 Floodplain Development Permit

All work within a Special Flood Hazard Area (SFHA), often referred to as the floodplain, and within areas removed from the floodplain by the issuance of a FEMA Letter of Map Revision based on Fill (LOMR-F) must meet the requirements of the 2018 Breckenridge Flood Damage Prevention Ordinance. A Floodplain Development Permit is required for all work in these areas, regardless of whether a building is being constructed or redeveloped. Work includes, but is not limited to, subsurface and surface utilities, grading, changes to surfacing, infrastructure of any kind, and signage. The Floodplain Development Permit application is included as an attachment to this chapter.

If work in the floodplain will cause any increase in the regulatory floodplain elevation or any decrease in the regulatory floodplain elevation of more than 0.3 feet, a Conditional Letter of Map Revision (CLOMR) issued by FEMA is required. If a CLOMR is issued, the permittee must also submit a Letter of Map Revision (LOMR) to FEMA, and receive approval, once the work has been completed, for the work to be accepted by the Town. The CLOMR submittal and approval from FEMA is required prior to CO or final permit signoff.

A list of submittals required for the Floodplain Development Permit is listed on the Floodplain Development Permit Application form attached to Appendix B.

2.4.5 Additional Local Permits

Work within Summit County right-of-way requires a Summit County Right-of-Way Permit. The application for this permit and submittal instructions are available on the County website via an internet search for “Summit County ROW Permit.” Other local permits include a Summit County Grading and Excavation Permit and Summit County Development Permits. Applicants shall review jurisdictional boundaries shown on the Summit County GIS website and determine if their property and adjacent road or the jurisdiction of Town of Breckenridge or Summit County.

2.4.6 State Permits

There are several state permits that may be required. A CDOT Utility/Special Use Permit is required for the installation of utilities and the performance of any other types of work within the state highway right-of-way. A CDOT Access Permit is required to construct or new access to a state highway or to modify an existing access to a state highway.

The Colorado Department of Public Health and Environment (CDPHE) issues several permits to maintain a high level of water quality during construction activities that include one or more acres of disturbance. The two most common permits are for stormwater discharges associated with construction activities and construction dewatering. Information on the various permits issued by the CDPHE and their applicability can be found via an internet search for “CDPHE construction permits.”

The Applicant shall submit copies of all required state permits to the Town Engineering Division.

2.4.7 Federal Permits

In addition to the FEMA requirements for working on floodplains discussed above, the most common federal permit is the US Army Corps of Engineers Section 404 Permit. A 404 Permit is required to discharge fill material into waters of the US. Waters of the US include tributaries, lakes, rivers, streams, creeks, and wetlands. The Applicant shall submit copies of all required federal permits to the Town Engineering Division.

2.5 EMERGENCY WORK

Emergency work is defined as work of an urgent nature to repair or mitigate damage that is creating an immediate hazard to the community, including hazards to the health, safety, and welfare of the Town, environment, or citizens. If emergency work is required, the Engineering Division shall be contacted immediately and all pertinent information shall be conveyed. The Engineering Division will expedite a review of the information and determine if the work qualifies as emergency work. If an emergency work determination is made, the Engineering Division will expedite the review process and may not require all submittals and reviews listed in this chapter. The permit process may be abbreviated, but permits shall still be required in most cases. The review process and required submittals will be determined on a project basis dependent on the nature of the hazard and the work.

2.6 ENCROACHMENT LICENSE AGREEMENTS

The Town does not generally allow private structures, landscaping, or other private improvements within Town right-of-way or easements. If the Town Engineer reviews and approves private improvements within the Town right-of-way or easement, a revocable encroachment license shall be submitted to the Town. The encroachment license agreement shall be acceptable in form and substance to the Town Attorney for the improvements extending into the right-of-way or easement and must be approved by the Town and executed prior to the issuance of a Building Permit, Infrastructure Permit, or Right-of-Way Permit. See Sections 10-2-1-2 and 11-6 of the Town Code for additional information on encroachment license agreements.

2.7 POST-CONSTRUCTION SUBMITTALS (SEE CHAPTER 8)

Post-construction inspections and documentation are discussed in Chapter 8.

CHAPTER 3
RIGHT-OF-WAY & EASEMENTS

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3.1 PURPOSE

This chapter of the Engineering Standards establishes the requirements for public right-of-way (ROW) and easements. A Right-of-Way Permit is required whenever construction, encroachment during construction, installation, or disturbance is proposed within Town ROW. A Right-of-Way Permit is required to ensure utilities, roadway reconstruction, and other work is completed to Town specifications and to provide for public health, safety, and welfare. Examples of work requiring a Right-of-Way Permit are included below:

1. Utility work, including directional boring and drilling
2. Pavement cuts and installation of new roadway or sidewalk improvements
3. Installation of trails, landscaping, signs, lights, transit improvements, or any other surface or subsurface improvements
4. Traffic counts (vehicle or pedestrian) conducted in the ROW
5. Access changes for proposed or existing driveways and roadway accesses
6. Work outside of the ROW, but requiring parking, staging, or traffic control within the ROW
7. Installation of driveway culverts, swales, ponds, and storm sewer infrastructure

Replacement of driveway pavement shall not require a Right-of-Way Permit, provided the driveway cut width does not increase from existing width, no snow melt system is added to the driveway, and no culvert is being installed beneath the driveway.

ROW and easements shall be dedicated for public streets and other infrastructure as needed in accordance with current master plans and development approval requirements. Specific procedural requirements for ROW and easement dedication or vacation are listed in the Town Code. The purpose of this chapter is to provide more detail for completing work in the ROW and guidance on when an easement is required. See Titles 9 through 11 of Town Code for additional information on ROW and easements.

3.2 WORK IN RIGHT-OF-WAY

It shall be unlawful for any person, other than an officer or employee of the Town in the course of his or her employment, to make, cause, or permit any construction in, on, under, or within a public right-of-way of the Town unless such person first obtains a Right-of-Way Permit from the Town Engineer. All work in the ROW shall be performed in conformity with the permit and the terms and provisions of this chapter. For all work within the ROW, the contractor is responsible for obtaining utility locates and any other permits and approvals necessary to complete the work. Submittal requirements for a Right-of-Way Permit are specified in Chapter 2, Submittal Requirements & Permits. Any work performed in the ROW without a permit, work performed outside of allowable dates outlined below, or work not performed in accordance with these Standards is subject to fines, penalties, and enforcement as set forth in the Town Code.

3.3 ACCESS TO RIGHT-OF-WAY

Any new access or any modification of an existing access to a public street or Town ROW shall require a Town Right-of-Way Permit. A new access to a state highway, or a modification of an existing access to a state highway, requires a CDOT Access Permit. New access or modification of an existing access to a county road requires a Summit County Right-of-Way Permit. New access spacing shall meet the minimum requirements listed in Chapter 5 of these Standards.

3.4 RIGHT-OF-WAY RULES AND REGULATIONS

The sections below provide an overview of rules, regulations, and specifications for work in the right-of-way. See Town Code and Chapter 9 of these Standards for additional requirements for work within Town right-of-way.

A. Work authorized by the Right-of-Way Permit shall be performed between the hours of 7:00 a.m. and 7:00 p.m., Monday through Friday (except holidays), unless the contractor obtains written consent from the Town Engineer to work earlier or later than the stated hours or on a weekend or holiday.

B. Street pavement cuts will not be allowed between November 1 and April 30, except when:

   1. There is a public utility emergency with notification and approval by Town Engineer, or

   2. Special or unforeseen circumstances arise as determined by the Town Engineer.

   If the Town Engineer approves a pavement cut between November 1 and April 30 due to one of the conditions above, a special provisions memo must be prepared and submitted to the Town Engineer to accommodate pavement patching during winter conditions. Pavement repairs completed during this period shall be considered temporary and be removed and replaced as soon as conditions permit after April 30.

C. TOWN OF BRECKENRIDGE 2018 DIG ONCE ORDINANCE

   See Title 11, Chapter 9 of the Town Code for the TOWN OF BRECKENRIDGE 2018 DIG ONCE ORDINANCE. The purpose of this ordinance is to coordinate work in the right-of-way and to minimize the number of excavations and pavement cuts. If the Right-of-Way Permit applicant proposes utility work in the right-of-way, the Town may require the applicant to install additional conduit in the work area with the direct cost of the additional conduit installation to be paid by the Town.

D. Work authorized by a Right-of-Way Permit shall meet the following conditions:

   1. Work shall be conducted in a manner which ensures the least possible obstruction and hazard to the traveling public. The permit holder shall provide for the safety and reasonable accommodation of the residents and users along the rights-of-way where work is being performed, and for the protection of persons and property at all times. The permit holder shall plan work so it does not create safety hazards or maintenance problems.

   2. An MHT or traffic control plan shall be submitted prior to approval of the Right-of-Way Permit in compliance with the MUTCD, CDOT S Standards, and these Standards. The plan shall be signed by a certified Traffic Control Supervisor. See the Right-of-Way Permit application for a full list of submittal requirements.

   3. The applicant shall provide all submittals, including the traffic control plan, at least 5 calendar days prior to the start of the scheduled roadway work. During the work, the permit holder shall notify the Town of any changes to the traffic control plan, schedule, closures, or any other changes at least 5 calendar days prior to implementing the closures. The permit holder shall provide advance signing and notify appropriate agencies of any road closures and detours at least 5 calendar days prior to actual road closure.

E. All street pavement cuts shall meet the following conditions:

   1. Pavement cuts shall be mechanically cut to form a clean vertical edge. Final pavement cuts shall not be made until immediately prior to paving.

   2. Pavement cuts shall be a minimum width of two feet.

   3. Pavement cuts shall extend 12 inches minimum beyond the edge of trenching or excavation.

4. Pavement cuts shall be exactly perpendicular or parallel to the travel lane.
5. Pavement cuts parallel to the travel lane shall not be located in wheel paths for vehicles or bicycles.
6. If a pavement cut parallel to the travel lane exceeds 150 linear feet, the pavement for the entire lane width shall be milled or removed and overlaid.

F. All street pavement patches shall meet the following conditions:

1. All excavations made in paved streets, sidewalks, or paths shall be completely restored within 15 calendar days of the pavement removal. In the event weather conditions preclude paving by permanent hot bituminous pavement or concrete, temporary repairs may be made by tamping and rolling into place cold mix asphalt.
2. Pavement patch depth shall match the existing pavement depth or have a minimum depth of 4 inches, whichever is greater.
3. Transverse joints on pavement patches shall be perpendicular to travel lane and shall be constructed using a transverse butt joint or tee patch detail.
4. If the pavement patch is on a roadway which has been paved in the previous 36 months, then all patches shall be full lane width and shall be patched with infrared patching equipment. If a pavement patch exceeds 500 square feet, a “tee patch” detail may be used in place of an infrared patch.
5. Joint lines and concrete control joints shall not be allowed in bicycle paths, unless joints are perpendicular to the direction of travel.
6. The surface of the finished pavement shall be free from any depression exceeding three-sixteenths (3/16) inch in ten (10) feet as measured by a ten (10) foot straight edge measured in any direction or an automobile mounted recording profilometer. The pavement surface shall be flush with existing pavement and shall not be raised from existing pavement.
7. Damaged pavement shall be repaired by appropriate methods as determined by the Town Engineer.
8. Permit holder shall contract with a geotechnical engineering consultant to provide backfill density testing and pavement testing. Permit holder and tester shall confirm material testing meets Town specifications for compaction and pavement and submit all results to the Town.

G. Utility work, potholing, and boring shall meet the following conditions:

1. Utility potholing shall be completed with non-destructive excavation methods.
2. Utility potholes, geotechnical borings, and other subsurface exploration shall not be placed in wheel tracks of roadways, unless required to comply with SUE for a utility conflict point.
3. Potholes and borings shall be backfilled with low strength flowable fill. Native material shall not be reused in the excavations.
4. Pavement patching for potholes and borings shall meet the requirements above for pavement patches.
5. Utility excavation, trenching, backfill, and compaction shall meet requirements of Chapters 5 and 8 of these Standards, the Town Standard Details, and private utility requirements.
6. The minimum bury depth for any utility shall be 24 inches (measured from top of pavement/surface to top of utility).

~~5.~~7. The minimum trench width for any utility shall be 12 inches (measured at the narrowest section of trench).

~~6.~~8. Directional boring and drilling of utilities will be allowed with approval by Town Engineer. Directional boring requires a Right-of-Way Permit.

H. All work in the right-of-way shall meet the following additional conditions:

1. All disturbance in the right-of-way shall be repaired upon completion of work, including pavement, landscaping, utilities, irrigation, street lights, shouldering, signage, and striping.

2. A financial guarantee (surety) shall be required for work within the right-of-way. The surety shall warranty and guarantee the right-of-way work for a period of two years after completion of improvements. See Chapter 8 for inspection requirements and see the Right-of-Way Permit application on the Town website for additional information on submittal and financial guarantee requirements.

I. Additional requirements for coordinating construction activities within the public ROW are specified in the Right-of-Way Permit application, Chapters 8 and 9 of these Standards, and in the Town Code.

3.5 SNOW STORAGE

Snow storage areas shall be provided for all public rights-of-way. Snow storage areas shall be adequate to provide storage of average snowfalls from the months of November through April. Snow storage areas shall provide actual storage volumes of approximately 48 cubic feet per foot for each 12-foot lane of traffic. For a typical lane width, this equates to 9.6 square feet of snow storage required per linear foot of lane. Maximum snow storage height allowed will be 5 feet. Snow shall not be stored in locations that will limit sight distance at intersections in accordance with AASHTO design criteria. Consideration for extra snow storage areas at intersections and cul-de-sacs will be required. The Town Code provides additional guidance on internal site snow storage requirements.

Additional requirements for coordinating construction activities within the public ROW are specified in Title 11 Chapter 9 of the Town Code.

3.6 PERMANENT SURVEY MONUMENTS

Construction of infrastructure for all new subdivisions requires the installation of permanent survey monumentation. All external boundaries of all subdivisions, blocks, and lots shall be monumented with a permanent monument by a registered land surveyor in accordance with State of Colorado Revised Statutes. Any survey monuments established on dredge tailings by a land survey shall be solidly embedded in concrete per details approved by the Town Engineer and shall be in addition to the minimum standards for surveys set forth in the Colorado Revised Statutes. Additional requirements for the installation and documentation of survey monuments, as well as penalties for damaging survey monuments, are specified in the Town Code.

No point within the subdivision shall be more than one-half mile from a permanent survey monument. See the Town Code for additional spacing requirements. At least two survey control monuments or two corners or points on or near the perimeter of the subdivision traverse must be tied to, or monumented with, permanent survey monuments tied to the Town of Breckenridge survey network (currently under development). The location of permanent survey monuments showing ties to the network currently under development must be provided with the following:

1. Colorado State Plane Central Meridian

2. Delta Alpha and combined sea level and scale factor at the point or for the centroid of the parcel of the subdivided land

3. Vertical elevation in NAVD 88
4. Horizontal coordinates in NAD 83

Permanent survey monuments must be brass caps set in an acceptable base. Caps shall bear the registration number of the surveyor establishing the point and identifying letters or numbers approved by the Town Engineer. This information must be stamped permanently into the cap and must be shown on the final plat for which the survey is performed. Submittal requirements for permanent survey monuments are specified in Chapter 2.

3.7 RIGHT-OF-WAY WIDTHS

Minimum right-of-way widths for the various roadway classifications and sections are discussed in Chapter 5, Street Standards.

3.8 EASEMENTS

Easements shall be dedicated for all public utilities, roadways, drainage facilities, snow storage, sidewalks, shared use paths, trails, public retaining walls, public open space, and all other public improvements if they are not located within the public right-of-way. Easements shall be dedicated for the purpose of all activities associated with installing, operating, maintaining, repairing, and replacing the facility.

No new work or modifications within an easement may occur without approval granted through the Town development process. Trees and landscaping that might interfere with the operation or maintenance of, or access to, any facilities, either immediately after installation or in the future, shall not be located within an easement. Any landscaping or other improvements proposed in an easement shall be approved through a Town encroachment license. The Town is not liable for damage to any landscaping or other improvements located within the easement. No permanent structures shall be located within the easement.

Where easements are required during development, public easements shall be granted to the Town at no charge. Easements shall be granted through the subdivision plat process or other instrument acceptable to the Town Attorney.

The Town Engineer may require additional easements in addition to those listed in this section and may enforce additional requirements depending on the type of facility, location, and other factors specific to the improvements. The Town Engineer may require dedication of an easement during the Infrastructure Permit process.

Additional easement requirements are specified in Titles 9 through 12 of the Town Code.

3.8.1 Access Easements

Right-of-way shall be dedicated to the Town for all new roadways through the subdivision plat process. See Chapter 5 for minimum right-of-way widths for roadways. Where improvements are proposed to an existing roadway outside of the existing right-of-way, an easement is also required. Transit facilities, sidewalks, trails, and shared use paths shall be located within a public easement. Easement widths shall be sufficient to accommodate the facility, drainage, signage, and repair and maintenance of the facility. The minimum width of the easement will be dependent on the facility and determined by the Town Engineer.

Access easements are required for private roads and driveways serving two or more adjoining lots. Access easements may also be required for fire and emergency access or for any other reason as determined by the Town Engineer.

Easements may be required which prohibit driveway or roadway accesses on the major road. Examples include roadway areas near curves, steep grades, limited sight distance, or other hazards.

3.8.2 Drainage Easements

Drainage easements shall be dedicated for all stormwater detention and permanent stormwater quality treatment facilities. Drainage easements are also required for all streams, channels, ditches, culverts, and storm sewers (if not in a general utility easement) conveying public drainage outside of right-of-way or conveying private drainage across two or more lots. The drainage easements shall be sufficient to allow for construction, operation, repair, and maintenance of the entire facility. The minimum drainage easement width shall be 20 feet.

While each property owner is required to maintain all facilities within the easements on his or her property, easements must be dedicated to allow the Town to maintain the facilities and invoice the owner for all costs incurred if the owner fails to complete the maintenance obligations. Chapter 6 includes maintenance requirements specific to permanent detention and water quality facilities.

3.8.3 Utility Easements

All public utilities not located within the public right-of-way shall be located within a public utility easement. Public utilities include, but are not limited to, water, sanitary sewer, storm sewer (if not in a drainage easement), electric, gas, and communication utilities. Easement widths shall be sufficient for the installation, operation, and maintenance of the utility. Easement width shall be dependent on type, number, and depth of utilities. The minimum utility easement width shall be 20 feet. Easements for shallow utilities may be reduced below 20 feet if installation, operations, and maintenance can be completed reasonably at a smaller width.

3.8.4 Snow Storage Easements

A minimum width of 10 feet shall be provided for snow storage along all roadways outside the shoulder. If the right-of-way does not provide adequate snow storage width, a snow storage easement shall be dedicated to meet the snow storage requirements of Section 3.5, or a 10’ easement width, whichever is greater. Additional snow storage widths and easements may be required based on roadway classification, terrain, the presence or need for turnarounds, and roadway geometry. See Title 9 of the Town Code for internal site snow storage requirements. Easements shall be sized and located for reasonable access and use by snow removal equipment. No structures, trees, or other facilities that may impact the ability to store snow may be located within the snow storage easement.

CHAPTER 4
TRAFFIC IMPACT STUDIES

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4.1 PURPOSE

The purpose of this document is to outline a standard format for preparing a Traffic Impact Study (TIS) in the Town of Breckenridge.

A Traffic Impact Study assesses the effects of a proposed development on the Town's transportation system. The study identifies if the transportation system can operate efficiently with the development, if there are existing conditions that need to be improved, or if improvements are required to mitigate site impacts.

The owner/developer of a project site is responsible for contracting a traffic consultant to assess project traffic impacts and for providing any necessary mitigation measures as part of the development, when required by Section 4.3 of these Standards.

The requirements listed in this document are applicable for all developments in the Town of Breckenridge. In addition to the requirements of this document, owners/developers with sites having access to or within the influence area of a State Highway (for example SH 9) must contact the Colorado Department of Transportation (CDOT) for specific requirements related to access permits, construction permits, or work in the CDOT right-of-way.

Development and installation of pedestrian systems which integrate with existing and future Town pedestrian systems and with the systems of adjacent developments is required. This will include the provision of sidewalks, where required, and the provision of pedestrian walkways pursuant to the Town trails plan.

It is the policy of the Town to require bicycle and pedestrian paths to be dedicated to the Town as a component of the town's alternative transportation network and to provide recreational opportunities. Subdivision proposals shall include, as a component of the required public improvements, a pedestrian and bicycle path system designed to preserve existing paths, integrate with existing improvements, and provide service appropriate to the character and magnitude of the proposed development.

The inclusion of or the contribution to a permanent nonauto transit system, designed to facilitate the movement of persons to and from Breckenridge or within the Town, is strongly encouraged. Nonauto transit system elements in the Town of Breckenridge include, but are not limited to, buses and bus stops, transit shelters, both public and private, gondola lifts, ski lifts, surface lifts, trams, bicycles, electric bicycles, and other alternative transit systems that have the primary purpose of providing access from high density residential areas or major parking lots of the Town to other destinations of the Town. Any development which interferes with the community's ability to provide nonauto oriented transportation elements is discouraged.

4.2 REFERENCE DOCUMENTS

Any new infrastructure or modifications to existing infrastructure and any new development plans shall be in accordance with the most current adopted version of the Town's Related Planning Documents. Traffic references used in the traffic impact study shall be the most current version available, unless otherwise authorized by the Town Engineer.

4.2.1 Related Town Planning Documents

See Chapter 1, Section 1.1 of these Standards.

4.2.2 Traffic References

1. ITE Trip Generation Manual, 10th Edition, Institute of Transportation Engineers, 2017
2. ITE Trip Generation Handbook, 3rd Edition, Institute of Transportation Engineers, 2017

3. Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis, Transportation Research Board, 2016
4. State Highway Access Code, State of Colorado, March 2002
5. Manual on Uniform Traffic Control Devices, 2009 with Revisions 1 and 2, Federal Highway Administration, May 2012

4.3 THRESHOLDS REQUIRING A TRAFFIC IMPACT STUDY

A Traffic Impact Study may be required as part of the submittal documents for annexation, development plan, final development plan, rezoning, plat, reuse/remodel, or other development application. To determine whether a Traffic Impact Study is required, as well as the category of study, the applicant must first estimate the number of peak hour trip ends generated by the development. A vehicle that stops at a gas station, for example, results in two trip ends at the development: one entering trip and one exiting trip.

A Traffic Impact Study is required for any development, redevelopment, reuse, or remodel that increases peak hour traffic by more than 10 trips. Developments increasing commercial gross floor area by 1,000 square feet or the number of residential/lodging units by 10 may exceed this trip threshold. A Traffic Impact Study is also required where any of the following conditions exist:

1. The site increases peak hour traffic volume by more than 20% at a point of State Highway access
2. The site is part of a larger development
3. Site-specific traffic issues require evaluation, as so determined by the Town Engineer
4. Project study area includes an intersection with planned improvements such as:
   a. South Park Ave/Main Street
   b. Park Ave/Village Road
   c. Park Ave/French Street
   d. Park Ave/Airport Road
   e. SH 9/CR 450
   f. SH 9/Ridge Street

4.3.1 Study Not Required

A site expected to generate 10 or fewer trips per hour. Typical examples include single-family developments with fewer than 10 homes, a 5,000 square foot office, or a 2,000 square foot retail establishment (not including gas stations, restaurants, or the like).

4.3.2 Trip Generation Letter

A site expected to generate more than 10 and less than 25 trips per hour. Typical examples include single-family developments with fewer than 20 homes, an office of less than 6,000 square feet, or a retail establishment of less than 5,000 square feet (not including gas stations, restaurants, convenience stores, auto washes, or other services expected to generate more than 10 trips per hour).

In areas that have not been recently studied or located in an area with planned road improvements or identified potential lane additions. a Short-Term Traffic Study may be required.

4.3.3 Short-Term Traffic Impact Study

A site generating between 25 and 50 trips in the peak hour. The site will typically be developed in a single construction phase with anticipated completion in less than three years from the time of development plan approval. Short-term traffic studies shall be required to evaluate traffic conditions at year-of-opening, and 5 years post-development. Typical examples include single-family developments of approximately 30 homes, an office or retail establishment of 10,000 square feet.

4.3.4 Long-Term Traffic Impact Study

Development sites generating over 50 trips in the peak hour or sites that are developed in more than one phase. For phased development, a master traffic study will be prepared prior to the first phase of development and a build-out period not longer than 20 years should be assumed. All subsequent phases will need to prepare a trip generation letter comparing the proposed development with the development type and density projected for the site in the master study. The letter may need to include additional analysis if there is a significant difference between the original development concept and the newly proposed development.

In addition to meeting all the requirements for a short-term traffic study, a long-term traffic study shall evaluate traffic conditions 20-years post-development.

Typical examples include single-family developments with over 50 homes and an office or a retail establishment greater than 12,000 square feet.

The Town Engineer may require long-term traffic studies for developments smaller than the thresholds listed above, depending on the size, location, and type of development.

4.4 TRAFFIC IMPACT STUDY REQUIREMENTS

When a Traffic Impact Study is required it shall be included with the development application. Studies will not be accepted prior to development application. After the Town's initial review of the draft study, the traffic professional shall address Town comments and submit a final study for Town approval. The final Traffic Impact Study shall include the PE's stamp, date, and signature. The final Traffic Impact Study must be approved by the Town Engineer prior to Issuance of an infrastructure or building permit.

If the development application includes a proposal for an uncontrolled or mid-block pedestrian crossing, the traffic study shall include a pedestrian traffic analysis as described in Section 5.14.

Submit one PDF electronic copy of all final traffic impact studies to the Engineering Division.

For sites with access to or within the influence area of state highways, the applicant is also required to contact CDOT for requirements and to get approval for the project from CDOT.

https://www.codot.gov/business/permits/accesspermits/regional-offices.html#Region2-3

4.4.1 Traffic Impact Study Submittals

A checklist is provided in Chapter 2 of these Standards that delineates the requirements of the Traffic Impact Study. Not all study elements will be required for every traffic impact study. Content must be specific to the situation and determined based on professional engineering judgment. Where content is specific to a traffic impact study type, that is identified in the checklist.

4.4.2 Land Use Scenarios

Required land use scenarios for the short- and long-term traffic impact studies are summarized in the following:

4.4.2.1 Short-Term Traffic Impact Study

Year of Opening w/o Development: This scenario represents area land use as it presently exists. The purpose of this scenario is to identify existing deficiencies and to provide a baseline for comparison with the scenario that includes development.

Year-of-Opening w/Development: This scenario represents area land use as it is projected to exist upon year-of-opening of the development, plus the inclusion of the development. The purpose of this scenario is to identify traffic conditions as they are anticipated to exist with the development.

5-Year Horizon w/o Development: This scenario represents area land use as it is projected to exist at the study's horizon year (5 years), without the development. The purpose of this scenario is to identify anticipated transportation deficiencies and to provide a baseline for comparison with the scenario that includes development.

5-Year Horizon w/Development: This scenario represents area land use as it is projected to exist at the study's horizon year (5 years after year of opening) plus the inclusion of the development. The purpose of this scenario is to identify traffic conditions as they are anticipated to exist with the development upon full-build out.

4.4.2.2 Long-Term Traffic Impact Study

Year of Opening w/o Development: This scenario represents area land use as it presently exists. The purpose of this scenario is to identify existing deficiencies and to provide a baseline for comparison with the scenario that includes development.

Year-of-Opening w/Development: This scenario represents area land use as it is projected to exist upon year-of-opening of the development, plus the inclusion of the development. Only the parts of development expect to be complete upon opening year shall be included in the analysis. The purpose of this scenario is to identify traffic conditions as they are anticipated to exist upon the opening of the development.

5-Year and 20-Year Horizon w/o Development: These scenarios represent area land use as it is projected to exist 5 and 20 years after the opening year of the development if the development were not built. The purpose of these scenarios is to identify anticipated transportation deficiencies expected to occur regardless of the development, and to provide a baseline for comparison with the scenarios that include the development.

5-Year and 20-Year Horizon w/Development: These scenarios represent area land use as it is projected to exist 5 and 20 years after the opening of the development. The 5-year scenario will include the parts of the development expected to be complete 5 years after of year of opening, while the 20-year scenario will include the parts of the development expected to be completed 20 years after year of opening (typically this represents full build-out). These scenarios will be compared to the 5-year and 20-year horizon without development scenarios to assess the effects that the development will have on the traffic conditions.

4.4.3 Analysis Periods

Conceptually, the design hourly volume for transportation systems is based upon the 30^{th} highest hour of the year. In other words, the traffic volumes used in the study should be sufficiently conservative to ensure that most of the time actual traffic conditions are anticipated to be less than those described in the traffic study. For this reason, traffic data taken off-peak must be factored to peak conditions as described in Section 4.5.1.

With respect to times-of-day, the most important time periods to analyze in the Town of Breckenridge are the weekday PM Peak hour, Saturday AM Peak Hour, and Saturday PM Peak Hour.

In addition to the peak hour, an analysis period should be completed for approximately the median hour in Breckenridge (the hour represent the average traffic volume on a non-peak hour). When comparing traffic conditions and proposed improvements, the peak hour and median hour shall be analyzed for LOS, safety, and other factors. One traffic solution may provide benefits at the peak hour, while a different solution provides benefits at the median hour, resulting in an analysis to compare the benefits and which solution is more favorable when considering all traffic conditions.

4.4.4 Study Area

The study area should include all intersections and access points that may experience a change in traffic operations due to the project. This typically includes all site access points, adjacent local intersections, and the nearest highway intersection(s) used by the generated trips to go to/from the site. If the generated trips are projected to increase a turning movement at a more distant intersection enough to potentially effect overall intersection operations, that intersection shall be analyzed as well.

4.4.5 Multimodal

The traffic study should consider not only potential impacts for motorized traffic, but also whether there are impacts to existing nonauto modes including pedestrian, bicycle, and transit. This section of the report should identify the potential for the project to generate nonauto traffic and to evaluate whether nonauto traffic can be accommodated by the existing environment.

In the multimodal analysis, the study should describe how the site provides opportunities for pedestrians, bicycles, and transit, and also include demand management strategies when relevant. The extent and type of existing and planned infrastructure required for multimodal connectivity to the site, such as sidewalks, trails, transit stops/routes, and alternative modes of transportation, should also be described. The multimodal Level of Service (LOS) for the site should be calculated as described in Section 4.5.4. Where multimodal LOS is not acceptable, the study should recommend on or off-site improvements that can be made to improve LOS. Off-site mitigation shall be consistent with street standards and planning documents referenced in Section 4.2.1.

4.4.6 Impact Analysis

This portion of the study evaluates the impacts that the traffic generated by the project will have on the community. In accordance with Town policy, developments which will generate a volume of vehicular trips which exceed or disproportionately consume the capacity of the external circulation system may have conditions imposed which address the need to provide sufficient traffic carrying capacity to meet this excess demand. This may include a requirement to either provide the necessary improvements at time of development or at some later date, including participating in Improvement Districts, if applicable.

Where the LOS falls below acceptable levels, mitigation will be required. Acceptable mitigation measures may include capacity and access improvements, signalization, signal operation improvements, street widening, additional connections, or other physical improvements. Where existing conditions prevent physical improvements (i.e., steep terrain, adjacent buildings, limited right-of-way, etc.), a project may be required to reduce density, implement transportation demand management (TDM) measures to minimize the demand for vehicle trips and encourage alternate mode use, and/or provide cash-in-lieu of the improvement as described in Section 4.5.7. The TDM strategies may include incentives for carpooling, transit ridership, enhanced bicycle or pedestrian facilities, provisions for telecommuting, or addition of use mixes to increase internal trips.

In addition to evaluating transportation facilities external to the development, the Traffic Impact Study shall include a discussion of the adequacy of the site accesses to accommodate projected site traffic. This may include but not be limited to a review of vehicle turning paths, stacking distances, and the design layout's ability to control speeds and provide safe and efficient circulation.

4.4.7 Existing Street and Access Analysis

This portion of the study shall evaluate the condition and configuration of the existing street providing access to the development. This section shall analyze the street access for all requirements of Chapter 5 of these standards. These requirements shall include, but are not limited to, intersection geometry, sight distance, roadway horizontal and vertical geometry, street widths, street classifications, adjacent access spacing, roadway drainage, vehicle & pedestrian lighting, signage, pedestrian route, transit access, acceleration lanes, deceleration lanes, and clear zone widths.

The Town Engineer may require improvements to existing streets, due to development impacts to the streets, increased demand on existing improvements, or existing streets serving new developments not meeting current standards. Improvements may include, but are not limited to, intersection improvements, sight distance improvements, street widening, adjustments to horizontal and vertical street geometry, drainage improvements, vehicle and pedestrian lighting, signage, pedestrian routes, acceleration lanes, deceleration lanes, clear zone widening, shoulder improvements, and transit improvements.

Existing streets providing access to a new development must be upgraded to current standards if both of the following conditions are met:

1. The existing street does not meet current Town of Breckenridge Engineering Standards.
2. The proposed development will increase the Average Daily Traffic (ADT) of the street by 25% or more.
3. Or as directed by the Town Engineer.

Existing streets must also be upgraded to current standards if a development changes the street classification. An example would be a development increasing the volume of a roadway from a local street to a collector.

4.4.7 Study Findings

This portion of the study provides an overview of the conclusions reached based upon the data and analysis performed and the professional engineering judgment of the author. It includes a factual restatement of the study's primary findings, including summaries of:

1. Development characteristics, including type and density of land use, hours of operation (if known), means of vehicular access, plan for implementation, and any other relevant data or information
2. Existing traffic conditions at study area intersections for each analysis period, including identified LOS, safety, or other operational deficiencies (auto as well as nonauto)
3. Development traffic generation, for peak hours as well as over an average weekday and weekend day for each development phase
4. Traffic impacts of the development, including identification of locations requiring mitigation to address existing or proposed LOS, safety, or other operational deficiencies
5. Extent to which study recommendations address development traffic impacts and existing or proposed deficiencies

4.4.8 Recommendations

Include a list of any improvements needed or proposed, noting who will construct and fund the improvements. Identify if right-of-way is available or is needed to construct the improvements.

Clearly identify study recommendations, including:

1. Proposed mitigation to address identified impacts
2. Other mitigation as identified
3. Improvements needed but not proposed by development

4.4.9 Certification

A short-term or long-term Traffic Impact Study shall be prepared under the responsible charge of a traffic engineer. A trip generation letter may be prepared under the responsible charge of any engineer familiar with procedures for using the *Trip Generation Manual* published by the Institute of Transportation Engineers. All traffic studies and letters shall be sealed and signed by a professional engineer licensed in the state of Colorado.

4.5 TECHNICAL GUIDELINES

4.5.1 Data Collection

The Town Engineer shall be notified at least five (5) calendar days in advance of the proposed locations, days of week and times of day that data will be collected. A Town Right-of-Way Permit shall be obtained prior to placing tubes, cameras, or any other equipment or materials in the right-of-way. Town staff will inform the applicant of any activities that may render the counts invalid such as school holidays, road work, local festivals, or other reasons, in order that the applicant may come up with an alternative plan. Tube counts are not permitted between Labor Day and Memorial Day and may otherwise only occur with prior approval of the Town Engineer.

New traffic counts shall be taken in locations where existing traffic counts are missing or over two years old. Intersection turning movement counts (a record of all vehicle movements including U-turns, left-turns, through movements, and right-turns) should capture the time periods expected to have the highest volumes, typically the weekday PM peak (4-6 PM), and the Saturday AM (8-10 AM) and PM (3-5 PM) peaks. If the changes proposed by the traffic study will have the greatest impact on traffic operations during a time period other than the typical peaks, or the highest overall network volume is expected to occur in a different time period, additional turning movement counts shall be collected during those periods. Turning movement counts shall include pedestrians and bicyclists.

Traffic volumes in Breckenridge are highly seasonal, with the winter and summer months traditionally having the highest volumes. Traffic counts shall be factored to reflect conditions typical to the month of January using the Town's ADT conversion table. This table was developed using CDOT Count Station Data for CO-9. To account for changing traffic patterns throughout the year, a separate factor shall be used for each time period (e.g., traffic counts taken during the AM and PM time periods on a Saturday in May would be multiplied by 2.37 and 2.04, respectively, to reflect volumes typically seen in January). Several types of developments, such as schools or athletic fields, often see peak volumes outside the network peak hours. If, for example, a school is being analyzed, the traffic counts shall be conducted during the school's arrival and dismissal time. If a traffic count is taken outside of one of the specific time periods shown in the table below, the counts shall be multiplied by the monthly average shown in the chart below. Continuing with the example of a school, a count taken between 2:00 and 3:00 PM on a weekday in April would be multiplied by 1.34 to approximate that same time period during a peak season (January) school day.

Table 4.1. Monthly ADT Data Conversion Table

Month	Saturday AM	Saturday PM	Weekday PM	Monthly Average
January	1.00	1.00	1.00	1.00
February	1.00	1.00	1.00	1.01

March	1.13	1.14	0.95	1.02
April	1.64	1.67	1.26	1.34
May	2.10	1.98	1.32	1.45
June	1.61	1.48	1.08	1.14
July	1.32	1.20	0.95	0.96
August	1.37	1.18	0.95	0.99
September	1.53	1.23	1.02	1.07
October	2.04	1.59	1.14	1.30
November	1.57	1.49	1.18	1.28
December	1.27	1.13	1.01	1.06

Per Highway Capacity Manual (HCM) recommendations, a peak hour shall be modeled for each time period analyzed. For studies containing multiple intersections, a system peak hour shall be selected when an intersection affects operations at adjacent intersections (e.g., coordinated signals, travel times runs, microsimulations). Individual peak hours should be used in networks where intersection operations have minimal effects on the operations of nearby intersections (e.g., stop-controlled intersections, non-coordinated signals, roundabouts). The selected peak hour should represent the hour with the worst traffic operations for the study area, typically the hour with the highest total traffic volume. If the primary focus of the traffic study is to analyze side street operations, or a critical movement whose peak may not coincide with the intersection peak (e.g., school, event hall), the selected peak hour should be based on that movement(s) highest volume, rather highest overall volume. A separate peak hour factor (PHF) shall be used for each intersection approach when possible. If the PHF is not available, a default of 0.92 shall be used. Section 4-3 of the HCM 6th Edition should be referenced for further clarification of the peak hour factor.

4.5.2 Trip Generation

Trip generation shall be calculated using the most recent version of the Institute of Transportation Engineers (ITE) Trip Generation Manual. Parts of the procedure discussed in this section cannot be completed with a ITE Trip Generation Manual older than the 10th Edition. For developments within downtown Breckenridge, the “dense multi-use urban” setting/location should be used, and for developments in more isolated locations, the “urban/suburban” setting/location should be used. If a land use option does not have a setting/location option, the default shall be used. The trip rate equation shall be used when provided, otherwise, the flat rate shall be used. The trip generation summary shall include weekday AM and PM data, as well as data for the Saturday peak period. If the exact land use of a development is not included in the ITE Trip Generation Manual, a comparable land use should be used. If the ITE Trip Generation Manual does not contain a comparable land use, other sources may be used, such as previous traffic studies or traffic counts at a similar development.

Capture trips are trips that visit multiple land uses in the same development during the same outing. In locations where this is a frequent occurrence, the number of capture trips shall be calculated and incorporated into the trip generation calculations to avoid double counting trips. Engineering judgment shall be used to determine whether a development will have capture trips (e.g. hotel & restaurant), or whether each land use will generate its own trips independently (e.g. office building & movie theatre). A spreadsheet tool which performs many of the required capture trip calculations can be downloaded in the Trip and Parking Generation section of the ITE website. Some of the land uses in the ITE Trip Generation Manual already account for capture trips, such as shopping centers or office parks with retail. In the cases where the land use from the Trip Generation Manual is mixed use, it is not necessary to calculate the number of capture trips.

Pass-by trips are defined as vehicles that stop at a development on the way to their destination without changing their originally planned route. Gas stations are an example of land uses with high percentages of pass-by trips. While pass-by trips are added to the volume entering and exiting a site, they are not to be added to the traffic volume along the adjacent road, as they would have been traveling on that road anyway. If a development is expected to attract a high percentage of pass-by trips, a reduction factor should be applied to the generated trips on the adjacent roads. The reduction can be found in Chapter 10 of the ITE Trip Generation Handbook.

4.5.3 Trip Distribution

The distribution of site generated trips shall be based on existing turning movement data or link volumes on the adjacent roadways. In cases where trip distribution is expected to differ from the existing trip distribution through the network (e.g. if a school is located on the edge of the school zone, trips to and from the school will not follow the same directional patterns as network traffic), engineering judgment is to be used. If the trip generation calculations incorporate captured trips or pass-by trips, these assumptions shall be reflected in the trip distribution.

4.5.4 Multimodal

When evaluating operations at a signal with pedestrian crossings, the crossing times shall be compliant with the pedestrian clearance interval requirements outlined in the *Manual on Uniform Traffic Control Devices* (MUTCD). In a coordinated signal network, if there are two or more pedestrian crossings on one leg in an hour, the signal timings should be such that a pedestrian crossing will not force the signal out of coordination.

If the location of a development offers multimodal options of transportation (e.g., bus routes, bike paths/sidewalks, etc.), a portion of the trips generated from the site will likely use multimodal forms of transportation, thus reducing the number of vehicle trips generated. Selecting the appropriate setting/location in the ITE Trip Generation Manual (e.g., general urban/suburban, dense multi-use urban, center city core) will account for this. If a development is planned in an area with easy access to multimodal transportation, and the projected number of generated trips came from outside the ITE Trip Generation Manual without a multimodal factor, a multimodal reduction rate shall be used. These rates can be found in ITE Trip Generation Manual and reduce the number of vehicle trips by a factor that is specific to the location and the development, as some types of developments are more likely than others to generate multimodal trips. Prior to using the multimodal reduction rates, engineering judgment should be used to determine whether a development is in a location, and is the type of development, to generate multimodal trips. The use of a vehicle reduction rate shall be documented.

To fully account for the multimodal function of the transportation system, LOS beyond those calculations described in the *Highway Capacity Manual* shall be considered along development sites and for transportation facilities. New development shall have a minimum multimodal LOS C. LOS D – F shall not be acceptable. While LOS ~~D~~ C is acceptable for multimodal LOS, site development should target the best LOS achievable. The site pedestrian and transit LOS shall be evaluated using a directness ratio, as follows:

$$\mathrm{D} = (\mathrm{W} + \mathrm{U})/\mathrm{C} \qquad (4.1)$$

Where:

- D = the site's directness ratio
- W = the total walking distance along a trail, public street, or sidewalk from the site's entrance or furthest building to the destination
- U = the distance along the walking route not designed for pedestrians. This includes areas where the pedestrian must walk in the street or shoulder, along unpaved or rough paths, paths less than 4 feet wide, and unmarked crossings of vehicular travel ways
- C = the straight-line distance from the site's entrance or furthest building to the destination

The directness ratio for residential or lodging sites will be measured to the nearest public school, park, or restaurant. For all other uses, the directness ratio will be measured to the nearest public multi-use trail or sidewalk. The directness ratio for Transit LOS will be measured to the nearest transit stop. The resulting LOS from the site directness ratio calculation is shown below. LOS is F where the walking distance exceeds ½ mile, regardless of the site directness ratio.

Table 4.2. Site Directness Ratio

Pedestrian and Transit Level of Service	Site Directness Ratio
A	≤ 1.2
B	>1.2 – 1.4
C	>1.4 – 1.6
D	>1.6 – 1.8
E	>1.8 – 2.0
F	>2.0 or walking distance greater than ½ mile

Bicycle LOS shall be evaluated by evaluated the Level of Traffic Stress (LTS) for each street or trail running along and internal to the site. LTS for each facility is rated from 1 to 5, with 1 meaning that there is low stress for cyclists and 5 meaning that it is a high stress environment. The road characteristics for each LTS is shown in the table below:

Table 4.3. Bicycle Level of Traffic Stress (LTS)

Level of Traffic Stress	Shared Lanes	Bike Lanes	Trails
1	2 lanes <2k ADT ≤ 25 mph	2-3 lanes ≤ 25 mph	Greenway
2	2 lanes 2-4k ADT ≤ 30 mph	2-3 lanes ≤ 30 mph	Sidepath (low ped volume)
3	2 lanes 4-6k ADT ≤ 35 mph	3-4 lanes ≤ 35 mph	Sidepath (high ped volume)
4	≥ 3 lanes > 6k ADT > 35 mph	> 4 lanes > 35 mph	
5	≥ 4 lanes > 6k ADT > 40 mph	> 4 lanes > 40 mph Bike lane < 4 ft	

Once LTS has been evaluated, the LOS will be determined by the length weighted average of the facilities along the site. For example, assume a particular site has a roadway bordering it on two sides. One of the roadways fronts 150-ft of the site and is a two-lane local road with 25 MPH speed limit and an Average Daily Traffic (ADT) of 1,500 vehicles per day. The other road fronts 100-ft of the site and is a four-lane collector with bike lanes and a posted speed of 30 MPH. The length weighted average LTS is:

$$[(150\text{-ft} \times 1) + (100\text{-ft} \times 3)] / (150\text{-ft} + 100\text{-ft}) = 1.8.$$

From Table 4.4 the bicycle LOS is C.

Table 4.4. Bicycle LOS

Bicycle Level of Service	Site Bicycle Level of Traffic Stress
A	1.0
B	>1.0 – 1.5
C	>1.5 – 2.0
D	>2.0 – 2.5
E	>2.5– 3.0
F	>3.0

4.5.5 Traffic Forecasts

CDOT's Online Transportation Information System (OTIS) count stations shall be used when forecasting the background growth for state highways.

https://dtdapps.coloradodot.info/otis

The ITE Trip Generation Manual shall be used to calculate the number of generated trips, which will be added to the background growth. When projecting background growth on Town roads, if the road is a through street, the OTIS growth rate for SH 9 may be used. If the road is not a through street, background traffic growth should be based on the trip generation potential for any undeveloped land or known planned development along the local road in addition to the OTIS growth rate for SH 9. For the purposes of this section, "through" streets connect to other roadways and therefore may experience traffic volumes that originate from outside the street in question. If no development (or redevelopment) is expected along a local road, the background growth may be assumed to be zero.

4.5.6 Impact Analysis

Traffic analyses shall be conducted in accordance with procedures outlined in the Highway Capacity Manual, with the Level of Service (LOS) being the primary metric for evaluating intersection operations. LOS is a measure of the quality of traffic flow and ranges from LOS A (nearly ideal traffic conditions with very little delay for motorists) to LOS F (poor traffic conditions with long motorist delays). LOS C is typically considered a "good" traffic condition. LOS D or better conditions are typically desirable during peak traffic periods. A LOS of E or F during peak traffic periods is unacceptable for overall intersections; however, LOS E and F conditions are not uncommon for side street traffic movements at full movement, unsignalized intersections with high volume arterial roadways. In situations where a side street movement operates at LOS E or F, the volume to capacity (V/C) ratio shall be reported as well. If the side street is nearing or at capacity, mitigation measures shall be identified. The Town Engineer may require improvements to any street or intersection projected to operate at a LOS E or F, regardless of whether the movement is a side street. Additionally, the Town Engineer may require mitigation to any drop in LOS (e.g.~~,~~ a reduction from LOS A to LOS C).

A minimum of two future scenarios shall be modeled when assessing the impacts that a development or proposed roadway changes will have on traffic operations. A "w/o Development" scenario, analyzing traffic conditions without the changes proposed by the traffic study, will be compared to the "w/Development" scenario for the same year, analyzing traffic conditions with the proposed changes. If an intersection is expected to operate acceptably for the "w/o Development" scenario, but unacceptably for the "w/Development" scenario (e.g., a signalized intersection or roundabout operating at LOS E or F, or a stop-controlled intersection operating at LOS E or F as well as being near or at capacity), it is the responsibility of the developer to implement intersection improvements in order to ensure acceptable traffic operations at the intersections.

Short-term traffic studies shall be required to evaluate traffic conditions at year-of-opening and 5-years post-development. Long-term traffic studies shall evaluate traffic conditions at year-of-opening, 5-years post-development, and 20-years post-development. In addition, long-term traffic studies that include phased development shall evaluate traffic conditions at completion of each interim phase.

If an unsignalized intersection has high side street volumes, resulting in poor operational conditions, a signal warrant study shall be conducted in a manner consistent with procedures outlined in the MUTCD.

The need for auxiliary lanes on state highways shall be assessed in accordance with the State Highway Access Code requirements. Turning movements that meet the State Highway Access Code standards are required to have an auxiliary lane. If a movement does not meet the required volume, an auxiliary lane may still be installed, if deemed helpful to safety or traffic operations. On local roads, auxiliary lanes shall be installed in locations where they will provide a benefit to traffic operations or safety.

4.5.7 Improvement Recommendations

If the Town Engineer determines that the installation of a needed improvement is not feasible, a cash contribution determined based upon the magnitude of the development's impacts and the capital cost of the needed improvement shall be assessed. Feasibility shall be determined based on physical, schedule, and financial constraints, as well as consideration for other projects and proposed future improvements. The cash contribution shall be in lieu of the improvement and/or land dedications and in proportion to the impacts attributable to the development. A development's proportional share shall be determined by the percent of total trips triggering the need for an improvement that are made up of site generated trips (e.g., if there is a left turning movement of 14 vehicles per hour, warranting a left turn lane, and 7 of those trips are generated from the development, the developments share of the cost will be 50%). The higher percentage between the AM and PM peak hours will be used to determine the developments required contribution. A development's contribution towards a traffic signal will be determined by the percent of the total trips on the higher volume side street made up of development generated trips. If there is a free right turn lane, it may be excluded from the calculations. The higher percentage between the AM and PM peak hours will be used to determine the contribution.

Cash contributions shall be held by the town solely for the acquisition and improvement of transportation mobility (nonauto as well as auto) alternatives within the community. Because of the small size of the community, the provision of transportation mobility improvements anywhere within the Breckenridge Comprehensive Plan boundary shall be deemed to meet the needs of the proposed project.

4.5.8 Intersection Improvement Recommendations

If an intersection is forecasted to operate unacceptably and intersection improvements are required, the Town has a strong preference for the installation of roundabouts, mini-roundabouts, or other geometric treatments. If intersection improvements are required at an intersection identified in the 2017 Park Ave SH 9 Roundabout Modeling and Construction Feasibility Study, then the Developer will be required to construct improvements per the recommendations of that study.

Studies conducted by the Town and other agencies have identified many benefits of roundabouts, including:

- Roundabouts reduced injury crashes by 75 percent at intersections where stop signs or signals were previously used for traffic control (IIHS Study).
- Typical signalized intersections have 32 vehicle-to-vehicle conflict points and 24 vehicle-to-pedestrian conflict points. Typical roundabouts only have 8 vehicle-to-vehicle conflict points and 8 vehicle-to-pedestrian conflict points.

- Roundabouts are designed with geometric curves which force vehicles to reduce speeds through the intersection. At traffic signals, vehicles may speed up to “beat the light”, resulting in higher speeds and the potential for more serious collisions.
- Roundabouts often operate at a comparable or better level of service when compared to signalized or stop controlled intersections. Even at high traffic volumes, roundabouts permit traffic to continue moving instead of creating long stops and standing queues, as may be seen at signalized intersections.
- Roundabouts result in economic benefits for the Town, resulting in approximately $10,000 of savings in maintenance and electrical costs when compared to a signalized intersection. Additionally, roundabouts do not suffer issues from power outages or malfunctioning due to weather.
- In many cases, roundabouts provide environmental and sustainability benefits by reducing stop and go conditions when compared to traffic signals and stop signs, resulting in less fuel consumption, vehicle wear, and improved air quality.
- Roundabouts provide aesthetic benefits by providing increased landscaped areas in intersections and providing a more natural aesthetic than traffic signals, helping to preserve and maintain the historic character of Breckenridge.

CHAPTER 5
STREET STANDARDS

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5.1 INTRODUCTION

Street design addresses safe and efficient movement of vehicles, pedestrians, bicycles, and transit while also incorporating landscaping, utilities, and storm drainage. Low impact drainage systems are encouraged where feasible. The street and trails network create multiple travel routes and minimize the distance required for pedestrians and bicycles to access primary activity sites. This section sets forth the minimum standards for street design and construction. Developers and engineers are encouraged to design above the minimum standards and in some cases due to site specific conditions the Town Engineer may require design above the minimum standards. The purpose and intent of this chapter is to provide safe travel for vehicles and pedestrians, efficient traffic flow which minimizes traffic congestion, and minimizes maintenance concerns.

Chapter 5 also includes access management, which is the coordinated planning, regulation, and design of access between roadways and land development. It involves the systematic control of the location, spacing, design, and operation of accesses, median openings, interchanges, and street connections. Access management provides the means to balance good mobility along the street network with local access needs of businesses and residents. Implementation of access management principles and techniques on transportation networks can provide the following long-term benefits for highway users, communities, and businesses.

These standards apply to the design, construction, and maintenance of both public and private streets, driveways, pedestrian paths, and on-street parking in the Town of Breckenridge. These standards also apply to all construction, whether completed by a private Developer or the Town of Breckenridge. All Town streets, whether new construction or upgrading of existing infrastructure, shall be built in accordance with these standards.

5.2 OTHER STANDARDS

A significant portion of the criteria used by the Town for Street Standards is taken from the 2018 edition of the American Association of State Highway and Transportation Officials (AASHTO) publication *A Policy on Geometric Design of Highways and Streets*. Throughout the rest of Chapter 5, this document will be referred to as the *AASHTO Green Book*. Where no requirement is given in this chapter, the newest additions of the following standards shall govern, unless otherwise approved by the Engineering Division:

1. AASHTO Green Book
2. AASHTO Roadside Design Guide
3. Manual of Uniform Traffic Control Devices (MUTCD)
4. CDOT Roadway Design Guide
5. CDOT Bridge Design Manual
6. CDOT Pavement Design Manual
7. CDOT Drainage Design Manual
8. United States Access Board (PROWAG and ADAAG)

Construction standards for street related improvements are outlined in Chapter ~~7~~ 9 of the standards. Right of Way requirements for work within existing streets and Right of Ways are outlined in Chapter 3 of these standards. Off-street parking requirements are outlined in the Town Code.

5.3 GENERAL DESIGN GUIDELINES

The Town of Breckenridge is located in a mountainous valley with heavy annual snowfall. Due to the terrain, street design poses unique challenges to meet design requirements. The following guidelines shall be followed for designing in this unique environment:

1. Streets shall be designed to maximize southern exposure and minimize north facing or shaded areas, especially on steeper slopes.
2. Street grades shall be minimized to the extent possible, while also minimizing switchbacks and site disturbance.
3. Streets shall be designed to avoid impacting wetlands and other environmentally sensitive areas. Design shall minimize impacts to the environment.
4. Streets shall be designed to retain as many trees and vegetation as possible. Design shall strive to retain or create vegetative buffers between streets and adjacent properties.
5. Drainage in winter shall be considered and icing of roadways and pedestrian routes shall be considered in the design.
6. Impacts of snow and ice to striping, parking, signage, signal sensors and other improvements shall be considered in the design.

5.4 STREET CLASSIFICATION

Town streets are classified according to function. Functional classifications shall be established by the Town Engineer. The Town Engineer has the authority to make the determination for road classification. For planning purposes, the town uses the following functional categories to classify its roads.

5.4.1 Arterial

An arterial street is a high-capacity roadway. The primary function of an arterial street is to deliver traffic from collector streets to freeways or expressways and provide for travel through and between communities. These streets primarily serve through traffic, and access to adjacent property is limited.

An arterial street generally has the following characteristics:

1. Posted speed limit greater than or equal to 35 mph
2. 4-lane minimum width, plus additional turn lanes
3. 10,000 vehicles per day (vpd) expected minimum traffic volume when the land served by the arterial is fully developed
4. Limited access to adjacent parcels of land
5. No back-out drives are permitted

The only arterial street within the Town is Colorado State Highway 9. Since the Town has no existing or planned arterial streets, the design standards in this chapter will not cover their design. Consult the Colorado Department of Transportation Roadway Design Guide for design of arterial streets on the Colorado State Highway System.

5.4.2 Major Collector

A major collector street is a moderate-capacity street which serves to move traffic from local streets and minor collector streets to arterial streets. The major collector balances both through-travel needs and access to adjacent property favoring more access control and higher speeds.

A major collector street generally has the following characteristics:

1. Posted speed limit from 30 mph to 40 mph
2. Traffic volumes generally between 3,000 and 10,000 vehicles per day when the land served by the major collector is fully developed
3. Designed to handle traffic volumes loading from and onto local, other collector, and arterial streets

4. No back-out drives are permitted

Refer to typical section in Standard Details.

5.4.3 Minor Collector

A minor collector street is a low-to-moderate-capacity street which serves to move traffic from local streets and major collector streets to arterial streets. The minor collector balances both through-travel needs and access to adjacent property favoring a higher level of access and lower speeds than a major collector.

A minor collector street generally has the following characteristics:

1. Posted speed limit from 25 mph to 35 mph
2. Traffic volumes generally between 1,000 and 3,000 vehicles per day when the land served by the major collector is fully developed
3. Designed to handle traffic volumes loading from and onto local, other collector, and arterial streets
4. No back-out drives are permitted

Refer to typical section in Standard Details.

5.4.4 Local

A local street provides direct access from abutting properties to alley, major collector, minor collector, or arterial streets. While it provides for some through travel, the primary purpose is to provide access to individual properties.

A local street generally has the following characteristics.

1. Posted speed limit from 15 mph to 25 mph
2. Traffic volumes up to 1,000 vehicles per day
3. Designed for the safety of pedestrians, bicyclists, and the ease of access to adjacent parcels of land
4. Back-out drives may be permitted for single family homes and duplexes

Refer to typical section in Standard Details.

5.5 DESIGN CONTROLS

5.5.1 Design Vehicles

The street design shall accommodate the turning movements of the design vehicle as listed in Table 5.1 below. The design should allow the design vehicle to make turns at intersections without encroaching into the oncoming lanes. The need for vehicles greater than the design vehicle to turn into oncoming lanes shall be reviewed and the design modified if appropriate based on nearby land use or business operations. Existing, proposed, or potential future transit routes as determined by the Transit Superintendent shall be designed to accommodate the design transit vehicle. The design engineer shall confirm that any local fire district turning requirements are also met.

Table 5.1. Design Vehicles

Street Classification	Design Vehicle
Major Collector	Intermediate Semitrailer (WB-40)
Minor Collector	Intercity Bus (BUS-45)
Local	Single-Unit Truck (SU-30)
Transit Facilities	Intercity Bus (BUS-45)
Commercial Access	Single-Unit Truck (SU-30)*
Multi-family Residential Access	Single-Unit Truck (SU-30)
Single-family Residential Access	Passenger Car (P)

* Commercial accesses that routinely use vehicles larger than a SU-30 should select and appropriate design vehicles for the onsite operations.

Additional details on these and other design vehicles can be found in Chapter 2 of the *AASHTO Green Book*.

5.5.2 Design Speed

The choice of design speed is influenced principally by the character of terrain, roadway classifications, and traffic volume. A roadway in the valley floor justifies a higher design speed than a roadway through steep mountainous terrain.

The design speed for streets in the Town will generally be equal to the posted speed. Under certain conditions, the Town Engineer may require that a design speed exceed the posted speed. Refer to Section 5.2 for the posted speed ranges of each street classification.

5.5.3 Right-of-Way Widths

The width of right-of-way depends on the street cross section to be used, topography in the area, and other physical controls. It is important to acquire sufficient right-of-way to facilitate future widening and other improvements as traffic warrants.

Minimum right-of-way widths to be dedicated for street construction in the Town are listed in Table 5.2 below. These minimums may be increased where necessary to meet side slope requirements, roadside drainage ditch requirements, transit facilities, roundabouts, intersection improvements, and other considerations requiring additional public right-of-way for the street.

The minimum clearance from the right-of-way line to the catch point of a cut or fill slope should be 5 feet for all types of cross sections. When feasible, 10 feet of clearance should be provided. Restrictive easements may be provided in lieu of dedicated right-of-way if approved by the Town Council.

Table 5.2. Right-of-Way Widths

Street Classification	Minimum Right-of-Way Width (feet)
Major Collector	80
Minor Collector	70
Local	50

5.5.4 Traffic Considerations

The design of a street and its features should be based upon consideration of the traffic volumes and characteristics to be served. In urban areas, these characteristics usually are dominated by vehicular traffic demands, but the design should also consider pedestrian, bicycle, and transit uses. Information for all current and projected user modes should be considered jointly. Vehicular traffic volumes typically drive the need for street improvements and will affect the geometric design.

5.5.5 Capacity Considerations

The level of congestion that is considered acceptable for a street or intersection will vary. The Level of Service (LOS) is intended to characterize the operating condition of a street or intersection in terms of speed, travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. The results of the LOS should be a key consideration in the design process. Consult Chapter 4 of this manual for more information regarding traffic considerations for street projects.

5.6 DESIGN ELEMENTS

The alignment of a street produces a great impact on the environment, the fabric of the community, and the street user. The alignment consists of a variety of design elements that combine to create a facility that serves traffic safely and efficiently, consistent with the facility's intended function. Principal elements of design include sight distance, horizontal alignment, superelevation, vertical alignment, and cross section elements.

5.6.1 Sight Distance

Sight distance is the length of roadway visible to a driver. Sight distance is required for safe and efficient operation of a vehicle on a highway. The path and speed of motor vehicles on streets are subject to the control of drivers whose ability, training and experience vary greatly. The available sight distance on a roadway should be sufficiently long to enable a vehicle traveling at or near the design speed to stop before reaching an object in its path.

5.6.1.1 Stopping Sight Distance

Stopping sight distance is the sum of two distances: (1) the distance traversed by the vehicle from the instant a driver sights an object necessitating a stop to the instant the brakes are applied, and (2) the distance needed to stop the vehicle from the instant the brakes application begins. These are referred to brake reaction distance and braking distance, respectively. Table 5.3 contains the stopping sight distances on level roadways based on design speed.

Table 5.3. Stopping Sight Distance on Level Roadways

Design Speed (mph)	Brake Reaction Distance (ft)	Braking Distance on Level (ft)	Stopping Sight Distance	
			Calculated (ft)	Design (ft)
15	55.1	21.6	76.7	80
20	73.5	38.4	111.9	115
25	91.9	60.0	151.9	155
30	110.3	86.4	196.7	200
35	128.6	117.6	246.2	250
40	147.0	153.6	300.6	305
45	165.4	194.4	359.8	360

The roadway grade has a significant effect on the braking distance due to gravity. The braking distances are longer for downgrades and shorter on upgrades compared to a level roadway. Table 5.4 contains the revised stopping sight distances based on grades that exceed an upgrade or downgrade of 3 feet rise or fall per 100 feet longitudinally, or 3%. For grades steeper than 9%, stopping sight distance shall be calculated using equations in the AASHTO green book.

Table 5.4. Stopping Sight Distance on Grades

Design Speed (mph)	Stopping Sight Distance (ft)					
	Downgrades			Upgrades		
	3%	6%	9%	3%	6%	9%
15	80	82	85	75	74	73
20	116	120	126	109	107	104
25	158	165	173	147	143	140
30	205	215	227	200	184	179
35	257	271	287	237	229	222
40	315	333	354	289	278	269
45	378	400	427	334	331	320

5.6.1.2 Sight Distance Measurement Criteria

Sight distance is the distance along a roadway throughout which an object of specified height is continuously visible to the driver. This distance is dependent on the height of the driver's eye above the road surface, the specified object height above the road surface, and the height and lateral position of sight obstructions within the driver's line of sight.

5.6.1.2.1 Height of Driver's Eye

For all sight distance calculations involving passenger vehicles, the height of the driver's eye is considered to be 3.50 feet above the road surface. For large trucks, including single-unit trucks and semi-trailers, the recommended value of a truck driver's eye height is 7.60 feet above the road surface.

5.6.1.2.2 Height of Object

For stopping sight distance calculations, a 2.00 feet object height is used. For intersection sight distance calculations, an object height of 3.50 feet is used.

5.6.1.3 Sight Distance on Horizontal Curves

For general use in design of a horizontal curve, the sight line is a chord of the curve, and the stopping sight distance is measured along the centerline of the inside lane along the curve. The value of the horizontal sight line offset (HSO) are determined by setting S, as shown in the diagrammatic sketch in Figure 5.1 and Equation 5.1, equal to the stopping sight distance (SSD). Alternatively, horizontal sight distance for existing conditions can be measured graphically using a computer automated drafting (CAD) program.

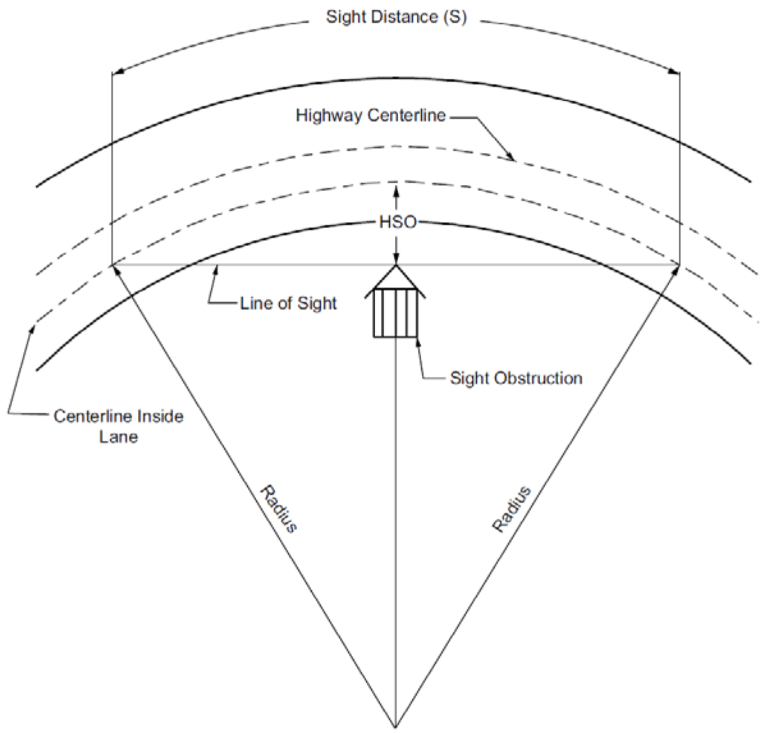

Figure 5.1. Diagram Illustrating Components to Determine Sight Distance

$$\mathrm{HSO} = \mathrm{R}\left[1 - \cos\left(\frac{28.65\,\mathrm{S}}{\mathrm{R}}\right)\right] \tag{5.1}$$

Where:

HSO = horizontal sight offset (ft)

S = sight distance (ft)

R = radius of curve (ft)

5.6.1.4 Sight Distance on Vertical Curves

The controlling vertical curve design criteria found in Section 5.4.3.3 is based on sight distance. Vertical sight distance for existing conditions can be measured graphically using a computer automated drafting (CAD) program.

5.6.1.5 Intersection Sight Distance

Each intersection has the potential for several different types of vehicular conflicts. The possibility of these conflicts actually occurring can be greatly reduced through the provision of proper sight distances and appropriate traffic controls. The avoidance of conflicts and the efficiency of traffic operations still depend on the judgement, capabilities, and response of each individual driver.

Stopping sight distance is provided continuously along each roadway so that drivers have a view of the roadway ahead that is sufficient to allow drivers to stop. The provision of stopping sight distance at all locations along each roadway, including intersection approaches, is fundamental to intersection operation.

Mid-block or uncontrolled crosswalks shall meet minimum intersection sight distance requirements. Case B1 (Table 9-6 of AASHTO Greenbook) shall be used for minimum values.

5.6.1.5.1 Sight Triangles

Specified areas along intersection approach legs and across their included corners should be clear of obstructions that might block a driver's view of potentially conflicting vehicles. These specified areas are known as clear sight triangles. The dimensions of the legs of the sight triangles depend on the design speeds of the intersection roadways and the type of traffic control used at the intersection. These dimensions are based on observed driver behavior and are documented by space-time profiles and speed choices of drivers on intersection approaches. Two types of clear sight triangles are considered in intersection design-approach sight triangles and departure sight triangles.

5.6.1.5.2 Approach Sight Triangles (Uncontrolled or Yield-Controlled Intersection)

Each quadrant of an intersection should contain a triangular area free of obstructions that might block an approaching driver's view of potentially conflicting vehicles. The length of the legs of this triangular area, along both intersection roadways, should be such that the drivers can see any potentially conflicting vehicles in sufficient time to slow or stop before colliding within the intersection. Figure 5.2 shows typical clear sight triangles to the left and to the right for a vehicle approaching an uncontrolled or yield-controlled intersection.

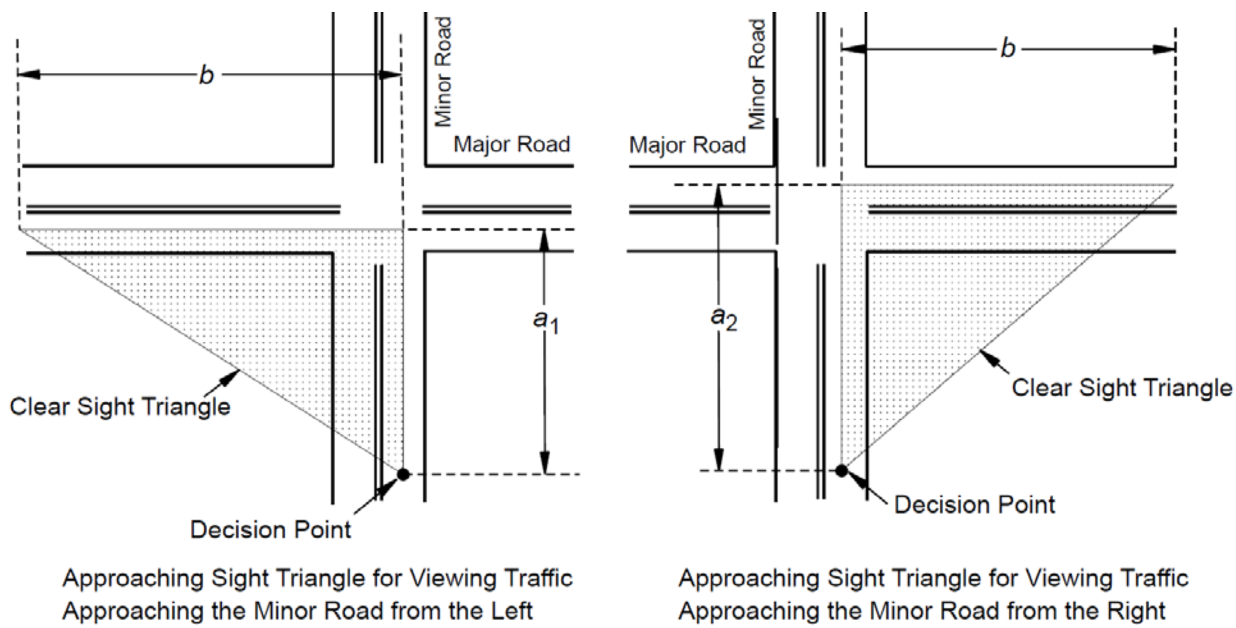

Figure 5.2. Approach Sight Triangles at Intersections (Uncontrolled or Yield-Controlled)

The length of the legs of the approach sight triangle shall be determined in accordance with the practices and standards established in Chapter 9 of the *AASHTO Greenbook.*

5.6.1.5.3 Departure Sight Triangles (Stop Controlled Intersection)

A second type of clear sight triangle provides sight distance sufficient for a stopped driver on a minor-road approach to depart from the intersection and enter or cross the major road. Figure 5.3 shows typical departure sight triangles to the left and to the right of the location of a stopped vehicle on the minor road. Departure Sight Triangles should be provided in each quadrant of each intersection approach controlled by stop or yield signs. Departure sight triangles should also be provided for some signalized intersection approaches.

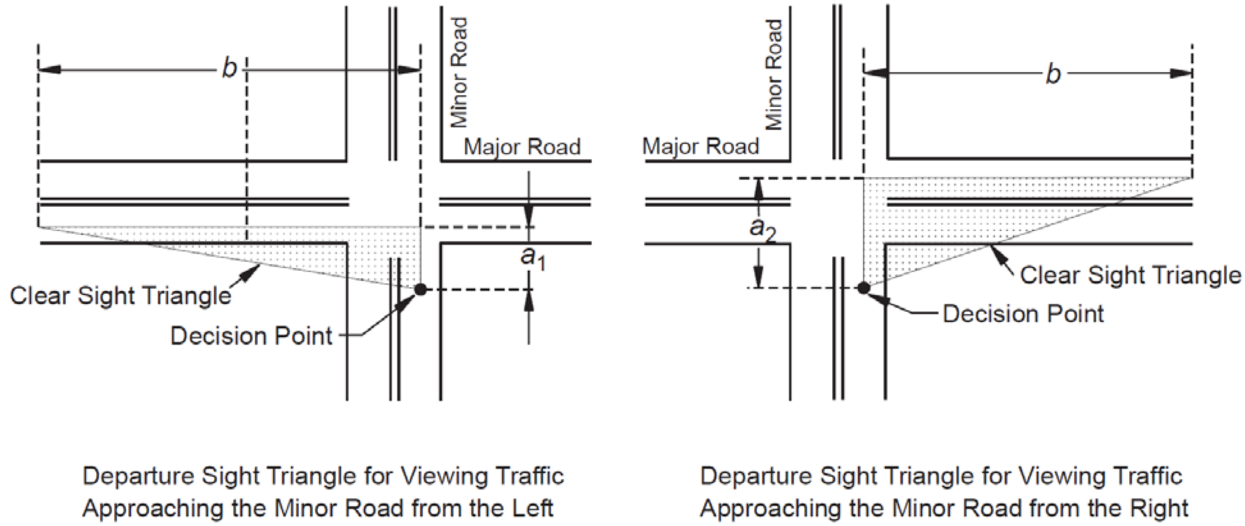

Figure 5.3. Departure Sight Triangles at Intersections (Stop-Controlled)

The length of the legs of the approach sight triangle shall be determined in accordance with the practices and standards established in Chapter 9 of the *AASHTO Greenbook.*

5.6.1.5.4 Identification of Sight Obstructions within Sight Triangles

The profiles of the intersection roadways should be designed to provide the recommended sight distances for drivers on the intersection approaches. Within a sight triangle, any object at a height above the elevation of the adjacent roadways that would obstruct the driver's view should be removed or lowered, if practical. Such objects may include buildings, parked vehicles, roadway structures, roadside hardware, hedges, trees, bushes, unmowed vegetation, tall crops, walls, fences, stored snow and the terrain itself. No objects or improvements shall be allowed over 3.5 feet tall within the sight triangles, with the exception of regulatory signs, signals, or street lights. If landscaping elements are proposed within the identified sight triangles, landscaping must be maintained so that it does not become an obstruction over 3.5 feet tall. Maintenance responsibilities must be agreed upon with the Town Engineer. Sight triangles shall be shown on all roadway and site design plans.

5.6.2 Horizontal Alignment

Street layout is designed to bear a logical relationship with the topography, connect to existing and planned area streets, and provide reasonable access to adjacent parcels. Street layout shall be designed to fit the context of the development and serve vehicle, pedestrian, transit, and bicycle users. Street layout shall avoid long, straight sections to minimize the potential for speeding.

5.6.2.1 Traffic Calming

ITE defines traffic calming as "the combination of mainly physical measures that reduced the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users." Local roads in residential neighborhoods shall be designed with traffic calming features. Intersection improvements and pedestrian crossing enhancements are encouraged for pedestrian safety. Major and minor collectors shall be analyzed for traffic calming and may require traffic calming features. Traffic calming encompasses a wide range of different features and methods; the appropriate features for a specific roadway is dependent on a variety of project specific features such as the design speed, traffic volume, development type, maintenance concerns, location within Town, and site constraints. The following hierarchy of traffic calming methods are listed in order from the generally most preferred method to the least preferred method.

1. Horizontal geometry (appropriate radius curves, chicanes, lane narrowing, and other geometry features to promote use of the roadway at the design speed)
2. Raised crosswalks at intersections
3. Intersection bulb-outs
4. Rectangular Rapid-Flashing Beacon or other light emitting hardware at pedestrian crossings
5. Roadway signage per MUTCD
6. Radar speed signs
7. Striping & thermoplastic markings
8. Median islands
9. Speed Humps

All traffic calming features shall be designed per MUTCD, ADA, and all other relevant standards. Features shall accommodate drainage and shall consider maintenance issues and effectiveness during winter conditions.

Traffic calming requests, studies, and design shall comply with the Town of Breckenridge Traffic Calming Policy, which may be obtained from the Engineering Division. Refer to Section 5.14 for traffic calming measures related to uncontrolled pedestrian crossings.

5.6.2.2 Horizontal Curves

Horizontal curve design should be based on an appropriate relationship between design speed, right-of-way, profile grades, and construction costs—and on their joint relationships with superelevation and side friction. Curves are not required when the delta angle (total central angle of the circular curve) is less than 1 degree. Curves should be at least 500 feet long for a central angle of 5 degrees, and the minimum length should be increased 100 feet for each 1 degree decrease in the central angle. The formula can be found in the *AASHTO Greenbook* and the CDOT M & S Standard Plans. Designers should use every effort to exceed the minimum curve radius when practical. Broken back, compound, spirals, or reverse curves are not recommended. Table 5.5 below gives the minimum horizontal curve radius for a normal crown of 2%. For superelevated roadways, refer to Section 5.4.2.3.

Table 5.5. Minimum Horizontal Curve Radius (Normal Crown)

Design Speed (mph)	Minimum Horizontal Curve Radius (ft)
15	50
20	110
25	200
30	335
35	510
40	765
45	1000

5.6.2.3 Superelevation

Local streets utilize standard crown sections and do not require superelevation. Superelevation may be considered on collector streets to address unique horizontal geometry, drainage, or grade issues. At intersections, grades of the minor street shall be warped to transition to the grades of the major street. If a street design requires the use of superelevation, factors controlling the use of superelevation include climate conditions, terrain conditions, classification of the street, and the frequency of slow-moving vehicles on the roadway. In general, a lower rate of superelevation is used in urban areas. The maximum allowable superelevation rate is 6%.

The superelevation transition section consists of the superelevation runoff and tangent runout sections. The superelevation runoff is the length of roadway needed to accomplish a change in outside lane cross slope from zero to full superelevation, or vice versa. The tangent runout section is the length of roadway needed to accomplish a change in outside lane cross slope from normal cross slope rate to zero, or vice versa. Additional information pertaining to the lengths and use of transitions for simple and spiral curves can be found in the *AASHTO Greenbook*. Refer to *CDOT M Standard – Superelevation Streets* for design requirements.

5.6.3 Vertical Alignment

The design should take into consideration the impact the vertical grade has on the operation of the facility. Designers should consider stopping sight distance requirements for the given speed limit and the challenges of large cut-and-fill sections. Vertical curves are classified as either sag or crest curves. Typically, sag curves are controlled by nighttime driving conditions with headlight visibility restrictions, and crest curves are controlled by stopping sight distances. Vertical curves should be simple in application and should result in a design that is safe and comfortable in operation, aesthetically pleasing, and adequate for drainage—especially when a curb and gutter are used.

5.6.3.1 Terrain

Proposed roads shall follow the natural terrain of the existing area whenever possible.

5.6.3.2 Grades

Grade lines are typically controlled by topography and structure clearances, but very flat grade can be controlled by drainage considerations. Other factors that should be considered are street classifications, design speed, safety, and construction costs. A minimum value of 1.0% should be used for street sections with curbs and gutters. In certain conditions, 0.5% may be used. The designer should consider the ultimate design of the roadway, recognizing if a curb and gutter may be required in the future, and design for those conditions during the interim design. Grades 4% or steeper may require special consideration for drainage or erosion protection.

Maximum grades of streets shall not exceed 6%. Major collectors shall flatten to 2% slope for intersections and shall meet the requirements of vertical curves at the intersections. Minor collectors and local roads shall flatten to 4% slope at intersections and shall meet the requirements of vertical curves at the intersections.

5.6.3.3 Vertical Curves

When using combinations of horizontal and vertical curves, it is important to recognize the driver's perspective. Sharp horizontal curvature should not be introduced at or near the top of a pronounced crest vertical curve. If unavoidable, the horizontal curve should be made longer than the vertical curve to help minimize the driver's inability to perceive the horizontal change, especially at night (For further details, see *AASHTO Greenbook* and the *CDOT Roadway Design Guide*). The length of vertical curves can be determined by dividing the rate of vertical curvature by the grade change or algebraic difference in intersecting grades.

$$\mathrm{L} = \mathrm{K}/\mathrm{A} \tag{5.2}$$

Where:

L = length of the vertical curve (ft)

K = rate of curvature

A = grade change (%)

A vertical curve is not required when a grade change or the algebraic difference is equal to or less than 0.2%. The preferred minimum length of a vertical curve is 300 feet. The allowed minimum is 3 times the roadway design speed. Table 5.6 below gives the minimum K values based on design speed.

Table 5.6. Minimum K Values for Vertical Curves

Design Speed (mph)	Minimum K Value (Crest)	Minimum K Value (Sag)
15	3	10
20	7	17
25	12	26
30	19	37
35	29	49
40	44	64

5.6.3.4 Vertical Clearance to Obstructions

Private overhead structures are not permitted in the public ROW and consideration of such structures shall be limited. Signal height clearances shall be per the current MUTCD. For other structures, there shall be a minimum 18-foot clearance on streets. For sidewalks and shared use paths, there shall be a minimum 10-foot clearance.

5.6.4 Cross Section Elements

5.6.4.1 Traveled Way

5.6.4.1.1 Cross Slope

Cross slope is necessary to ensure adequate drainage. The preferred value for a cross slope is 2% for paved streets. Undivided streets should have a normal crown that is a two-way cross slope, with the high point of the cross section located on the street centerline. Divided streets should have a cross slope on each side of the divide, with the high point of each section located where the pavement meets the median. Cross slopes of 2% are permissible on concrete roadways. Intersections of streets with curbs and gutters sometimes require the use of cross-pans for drainage. At these areas, the normal two-way 3% cross slope shall transition to a one-way slope adjacent to the cross pan, with a slope range of 1% to 2%. Cross-pans shall not be allowed on major collectors and are discouraged on minor collectors.

5.6.4.1.2 Lane Widths

Lane widths shall be 11 feet minimum asphalt width in the Town of Breckenridge historic district, and 12 feet minimum asphalt width outside of the historic district, unless a variance is granted by the Town Engineer. The Breckenridge Historic District is defined in Title 9 of the Town Code and the “Breckenridge Handbook of Design Standards. The limits of the Historic District are shown on the Town’s website. The curb, valley pan, or shoulder is not counted in the lane width dimension.

5.6.4.2 Shoulders

Shoulder width shall be 2 feet minimum of compacted aggregate base course plus 4 feet of recoverable zone with only grass vegetation (6-foot wide total clear zone).

Shoulder width for Major Collectors and Arterials shall 4 feet minimum of aggregate compacted base course plus 10 feet of recoverable zone with only grass vegetation (14-foot wide total clear zone).

5.6.4.3 Roadside Design

5.6.4.3.1 Cut and Fill Slopes

Cut and fill slopes for roadway embankment of 3:1 or flatter are preferred. Maximum cut and fill slopes shall be 2:1. Consideration should be given to snow removal problems and snow storage in slope design. It is considered advisable to use flatter slopes in cuts on the southerly side of the roadway where this will provide additional exposure of the pavement to the sun. Flatter slopes shall be considered to reduce erosion, maintenance costs, and to facilitate vegetation. If steeper slopes are needed, side slope material shall be evaluated based on drainage needs to determine appropriate material for stabilization of the slope. See Chapter 7 of these standards for further guidance on temporary and permanent stabilization measures.

The tops of all cut slopes shall be rounded where the material is other than solid rock. A layer of earth overlying a rock cut shall also be rounded.

5.6.4.3.2 Roadside Ditches

See Chapter 6 for Roadside ditch information and design.

5.6.4.3.3 Clear Zone

All fixed objects should be located outside the clear zone as defined in the *AASHTO Roadside Design Guideline*s. The design should provide a clear zone as wide as practical within constraints per the latest version of the *AASHTO Roadside Design Guidelines.* For low speed, low volume roadways a minimum clear recovery zone area of 7 feet in width shall be provided for roadways without curb and 2 feet in width for all roadways with curb.

5.6.4.3.4 Obstructions

Mailboxes, address monuments, landscaping, stone headwalls, and other objects shall not be located within the right of way. If any improvements are allowed in the ROW, an encroachment license shall be filed prior to issuance of permit.

5.6.4.3.5 Roadside Barriers

The installation of roadside barriers on embankments and adjacent to fixed objects may reduce the combined effect of severity and frequency of “run-off-road” type crashes. Roadside barriers reduce crash severity only when the overall severity of striking the guardrail is less than the severity of going down an embankment or striking a fixed object. They should not be installed if they are likely to create a greater hazard than running off the street. To the extent possible, streets shall be designed to eliminate the need for roadside barriers by eliminating obstructions, steep grades, and other hazards from the clear zone. Evaluating installation of roadside barriers shall consider crash experience, street objectives, functional classification of streets, design speed, traffic volume and type, street cross section, height of embankment, steepness of fill slope, horizontal curvature, gradient or profile conditions, street side conditions, climatic conditions, and degree of projected injury from traveling off the street. Special consideration shall be given to winter and icy conditions which might necessitate a roadside barrier that would not be needed under normal conditions. Refer to the *AASHTO Roadside Design Guide* for roadside barrier best practices. Refer to the *CDOT M Standards* for roadside barrier installation and construction requirements.

Guardrails and concrete barriers shall typically be colored brown and rails shall not be made of galvanized or reflective materials (reflector tabs and other reflective devices shall be installed per AASHTO and CDOT standards). Custom guardrails or barriers utilizing natural materials shall meet AASHTO and CDOT standards and be impact rated.

When roadside barrier is considered for installation, especially in extended lengths, provisions shall be made for adequate snow storage and removal. Flared end treatments are preferred over non-flared end treatments for snow removal operations.

5.6.4.3.6 Retaining Walls

Retaining walls and abutments are discouraged within the publicly maintained right-of-way. All designs of retaining walls, foundations, and abutments exceeding 48 inches in height (measured from finished grade) will require a sealed geotechnical design and a sealed structural design. Both designs will need to be prepared by registered professional engineers in the State of Colorado prior to the any approval of the retaining wall and abutment. Retaining wall and abutments retain earth with lateral support or at the end of a bridge span, respectively. The design of these structures depends upon type, function, and anticipated service life of retaining wall, earth pressure exerted on the wall by the retained backfill, geometry, strength and deformability of the ground, groundwater, and welling pressure in clay backfills. Four types of retaining wall systems are discussed in this section: conventional retaining walls and abutments, anchored walls, mechanically stabilized earth walls, and prefabricated modular walls.

Wall aesthetics shall be approved by the Town Engineer. Local Home Owner’s Association (HOA) requirements may apply in certain instances.

Retaining walls needed to support private improvements shall not be located in the public right-of-way.

Full or partial height walls shall not be located closer than the outer edge of shoulder. When the top of the retaining wall is at the level of a roadway, the face of the parapet wall or rail shall be at least 4 feet from the edge of the traveled way.

1. Conventional Retaining Walls and Abutments: Conventional retaining walls and abutments are proportioned to provide stability against bearing capacity failure, overturning, and sliding. Retaining walls are discouraged within the public right-of-way. They will be allowed only when necessary to support public improvements. Design of conventional retaining walls and abutments shall satisfy the following loading factors:
    a. Lateral earth and water pressures, including any live and dead load surcharges.
    b. The weight of the wall.
    c. Temperature and shrinkage effects.
    d. Seismic loads.
2. Anchored Walls: Anchored walls provide additional lateral resistance with the use of anchors. Their design is based on the suitability of the subsurface soil and rock conditions. Design of anchored walls shall satisfy the following loading factors:
    a. Lateral earth and water pressures, including any live and dead load surcharges.
    b. The weight of the wall.
    c. Seismic loads.
3. Mechanically Stabilized Earth Walls: Mechanically Stabilized Earth Walls (MSEW) are flexible composites of granular soil and tensile inclusions that behave as earth embankments with vertical or nearly vertical faces. MSEW are proportioned to provide stability against overturning

and sliding. Bearing pressure generally governs design. An MSEW should be used where substantial total and differential settlement is expected. This type of wall may also be used where conventional gravity, cantilever, or counterforted concrete retaining walls are considered. An MSEW shall not be used where utilities other than highway drainage are to be constructed within the reinforced zone or floodplain erosion or scour may undermine the reinforced fill zone or any supporting footing. An MSEW shall not be used where surface or groundwater contaminated by acid mine drainage or other industrial pollutants is present. Design of MSEWs shall satisfy the following loading factors:

a. Lateral earth and water pressures, including any live and dead load surcharges.
b. The weight of the wall.
c. Seismic loads.

4. Prefabricated Modular Walls: Prefabricated modular walls employ soil-filled interlocking modules to resist earth pressures. Stability of modular walls depends upon the weight and strength of the fill soil. Each module level shall be investigated for sliding and overturning. A prefabricated modular wall may be used where conventional gravity, cantilever, or counterforted concrete retaining walls are considered. A prefabricated modular wall shall not be used on curves with radius less than 800 feet, unless the chord can be substituted with a series of chords, or where groundwater or surface runoff is contaminated with acid. Design of prefabricated modular walls shall satisfy the following loading factors:

   a. Lateral earth and water pressures, including any live and dead load surcharges.
   b. The weight of the wall.
   c. Seismic loads.
   d. Earth pressure shall be computed on a plane surface where modules form an
   e. irregular, stepped surface. Ka, used to compute lateral thrust, shall be computed based on the friction angle of the backfill behind the modules.

5.6.4.4 Curbs

Curb and gutter is required at the following locations:

1. On all streets in flat or rolling terrain within subdivision or any similar-type developments where high densities have been planned.
2. Where required by drainage, traffic, or public safety.
3. To replace existing curb.

Refer to the Street Standard Drawings for approved curb and gutter types.

5.6.4.5 Medians

Medians other than those listed within the street cross-sections are generally not permitted on new Town streets and must be approved by the Town Engineer. Medians shall be designed with plowable noses.

5.7 INTERSECTIONS

See Section 5.4.1.5 for intersection sight distance requirements.

5.7.1 Alignment and Profile

Streets must intersect one another at 90-degree angles or as close to 90 degrees as the topography allows. Angles less than 90 degrees must be approved by the Town Engineer. Angles less than 80 degrees are not permitted. Intersecting streets shall remain perpendicular for a minimum of 50 feet from the intersection.

In general, grades for intersecting roads should be as flat as possible to provide for storage platforms and sight distance. Grades shall not exceed 2 percent across a pedestrian access route (PAR) if the intersection is controlled by a stop sign or yield condition. Grades exceeding 2% across a PAR are permissible at signalized intersections or uncontrolled intersection legs, but every effort should be made to minimize the grade to meet 2%. Approach grades greater than 4 percent should be avoided. Grades that may need to be steeper to accommodate cases where the existing terrain does not allow for flatter intersections must be approved by the Town Engineer.

Parking shall not be located within 20 feet of an intersection.

5.7.2 Corner Radii

Radii of 15 to 25 feet are adequate for passenger vehicles. These radii may be provided at minor cross streets where there is little occasion for trucks to turn or at minor intersections where there are parking lanes. Where the street has sufficient capacity to retain the curb lane as a parking lane for the foreseeable future, parking should be restricted for appropriate distances from the crossing.

Radii of 15 feet or more at minor cross streets should be provided on new construction and on reconstruction where space permits.

Radii of 20 feet or more at major cross streets should be provided where feasible so that an occasional truck can turn without too much encroachment.

Radii of 30 feet or more should be provided where large truck combinations and buses turn frequently. Longer radii are also desirable where speed reductions would cause problems.

Curb radii should be coordinated with crosswalk distances or special designs to make crosswalks safe for all pedestrians. Designs which can minimize the corner radii for pedestrians and passenger vehicles, while still allowing trucks to make turning movements, are encourages. Examples include truck blisters, rollover curb, and eliminating any structures or other objects behind the curb but within the truck radius.

5.7.3 Functional Intersection Area

Functional intersection area is the area upstream and downstream of an intersection where intersection operation and conflicts influence driver behavior, vehicle operations, or traffic conditions. Separation of access points should not be less than the functional area of the intersection.

The upstream distance is a combination of the storage length, deceleration and taper length, and the perception-reaction distance required for the speed of the segment. The downstream distance is measured as either acceleration length or decision sight distance. Providing acceleration length allows vehicles to accelerate to normal speed without conflict. Providing decision sight distance allows drivers to pass through an intersection before considering potential conflicts at the next intersection. Functional intersection area is demonstrated below in Figure 5.4.

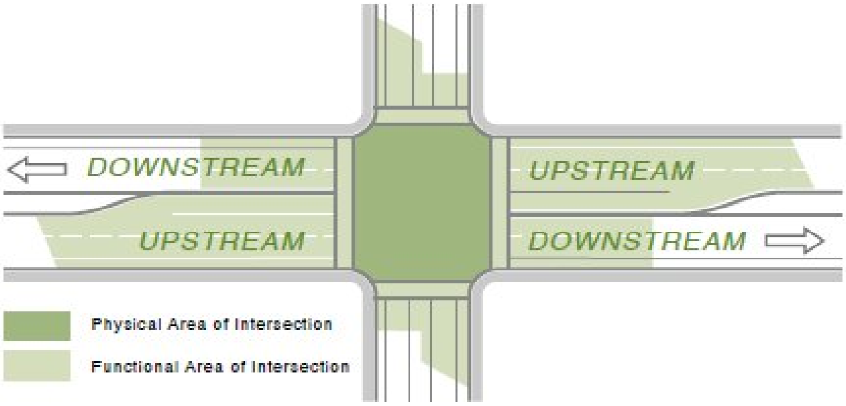

Figure 5.4. Functional Intersection Area

5.7.4 Channelization

5.7.4.1 Islands

Islands are general not permitted on new Town streets, and must be approved by the Town Engineer. Exceptions are made for roundabouts. Islands shall be designed with plowable noses.

5.7.4.2 Medians

Medians are generally not permitted on new Town streets and must be approved by the Town Engineer. Exceptions are made for roundabouts. Medians shall be designed with plowable noses.

5.7.5 Auxiliary Lanes

Auxiliary lanes are useful in maintaining the safety, traffic flow, and operation of a roadway or access. When auxiliary lanes are required by the Town or warranted by information obtained during the development review process, the applicant is responsible for design, installation, and any purchase of right-of-way to accommodate the required lane width. Auxiliary lanes are required when unique location factors (e.g., roadway speed and traffic density, access volume, the volume of commercial trucks, the influence of nearby accesses, existing auxiliary lanes close to the proposed access, nearby traffic control devices, available stopping sight distance, and other topographic or roadway design factors) exist that determine the need for auxiliary lanes. Auxiliary lanes are required to mitigate specifically identified and documented locations with safety and operation issues.

5.7.5.1 Deceleration Lanes

A left deceleration lane, also called a left-turn lane, with storage length plus taper length, is required for any access with a projected peak hour left ingress turning volume greater than 25 vph. If the posted speed is greater than 40 mph, a deceleration lane and taper is required for any access with a projected peak hour left ingress turning volume greater than ~~10~~ 15 vph. The taper length will be included within the deceleration length. A left deceleration lane is not required when the opposing projected peak hour traffic volume is less than 150 vph.

A right deceleration lane, also called a right-turn lane, with storage length plus taper length, is required for any access with a projected peak hour right ingress turning volume greater than 50 vph. If the posted speed is greater than 40 mph, a right turn deceleration lane and taper is required for any access with a projected peak hour right ingress turning volume greater than 25 vph. The taper length will be included within the deceleration length. A right deceleration lane is not required when the advancing projected peak hour traffic volume is less than 400 vph.

5.7.5.1.1 Storage Length

The storage length for an auxiliary lane can be determined by the information summarized in Table 5.7. These lengths are based on the average length of a passenger vehicle and the estimated turning vehicles per hour. Estimated lengths for buses, larger trucks, and recreational vehicles must be determined and submitted to the Town for review. The basis for designing the length of required storage is to provide sufficient length for vehicles to queue within the lane without affecting other movements. Table 5.8 provides the required storage lengths for stop-controlled and signal-controlled intersections. If the Department of Public Works determines that meeting the required storage length is impractical or will result in an unsafe condition, the minimum storage length shall be based on the mean arrival rate. But in no case shall the minimum auxiliary lane length be less than 50 feet.

Table 5.7. Acceleration/Deceleration Lane Design Criteria

Posted Speed Limit (mph)	25	30	35	40	45
Deceleration length (ft)	180	250	310	370	435
Acceleration length (ft)	N/A	190	270	380	550
Transition taper (ratio)	7.5:1	8:1	10:1	12:1	13.5:1
Straight taper (ratio)	15:1	15:1	20:1	30:1	45:1

Table 5.8. Auxiliary Lane Storage Lengths

Turning vehicles per hour	<30	30-59	60-100	>100
Minimum required storage length (ft)	25	40	50	100

5.7.5.1.2 Tapers

Auxiliary lanes typically consist of one or more of the following: transition taper, full width auxiliary lane, and storage length. The use of these components varies based on the type of access, through street classification, and site-specific conditions (grades). To determine the required acceleration and deceleration lane and transition taper length, see design criteria presented in Table 5.7. The length of the required transition taper is determined by multiplying the distance offset by the transition taper ratio value associated with the posted speed. The beginning and ending point of all tapers shall be rounded.

Transition tapers: The purpose of a transition taper is to provide sufficient length for a vehicle to accelerate or decelerate to the appropriate speed and merge into and out of the through traffic lanes without disrupting traffic flow. The length of a transition taper is calculated by multiplying the width of the lane by a standard ratio. The beginning and ending point of all tapers shall be rounded.

Redirect or straight tapers: Redirect tapers shall be used where an exclusive turn lane, median, or other redirection of vehicles is necessary and where redirection of the flow of traffic is necessary to accommodate the exclusive turn lane or median. If the redirect taper would result in a horizontal curve design deficiency for the through movement, the horizontal curve shall be corrected. Redirect tapers should be designed as straight tapers with the beginning and ending points rounded.

5.7.5.2 Acceleration Lanes

Acceleration lanes are required at any access with a project peak hour right turn volume of greater than 50 vph and a posted speed of 40 mph or greater. The purpose of an acceleration lane and transition taper is to provide sufficient length for a vehicle to accelerate to the appropriate speed and merge into the through traffic lanes without disrupting traffic flow. Table 5.7 above provides the required acceleration lane and transition taper lengths by design speed. Acceleration lane lengths shall be adjusted for a grade of 3% or more. The total length of the acceleration lane includes the values of both the lane and transition taper. Shorter acceleration lanes are not permitted, as they are not used properly by most of the traveling public.

5.7.5.3 Two-way Left Turn Lanes

Two-way left turn lanes should be used sparingly. Two-way left turn lanes may be considered on arterial roadways in areas where several low-volume commercial accesses are closely spaced. Two-way left turn lanes shall be 12-16 feet wide.

5.8 DEAD END STREETS (CUL-DE-SACS)

Dead-end streets are discouraged and shall be avoided unless topographic or other unique site constraints limit construction of interconnected streets. The design of cul-de-sacs will be reviewed following the Street Standard Drawings. Any public street or private street that dead ends shall terminate in a cul-de-sac. All cul-de-sacs shall include signage within fifty feet of the inlet indicating that the street is a dead-end street.

5.9 BRIDGES

Bridges, arch culverts, and other structures shall be designed per the CDOT Bridge Design Manual and AASHTO standards. Bridges shall be designed to accommodate the full lane widths, shoulders, curbs, sidewalks, ROW widths, and other improvements detailed in this chapter. Future development and improvements shall be considered when designing bridges. Pedestrian bridges shall exceed the width of the pedestrian route it is serving and shall be 8' minimum width for shared use paths and 12' minimum width for shared use paths.

See Town of Breckenridge Open Space and Trail standards for requirements on bridges for soft surface trails.

See Chapter 6 of these standards for hydrologic requirements of bridge structures.

5.10 ACCESS CONTROL AND MANAGEMENT

An access is defined as a privately owned connection to a Town street or right-of-way and may also be referred to as an access road or driveway. A Town, County, or CDOT owned roadway is not classified as an access. Establishing access criteria and the application of access management techniques is highly desirable on public streets. Effective access management enhances the capacity and safety of a street and preserves those elements as the corridor develops further. While access to adjacent properties are required, the Town should attempt to limit the number of access points and their locations, especially on intersection approaches.

5.10.1 Private Access

Private accesses service ~~three~~ four or less single-family homes ~~or~~, one multi-family property, or one commercial property. An access serving five or more homes shall be classified as either a public or private street and not an access (see Section 5.19.1). Private accesses are not owned, maintained, or plowed by the Town. They are the sole responsibility of the property owner. A private access that serves multiple lots shall be located in an easement or common area. The easement or common area width shall accommodate the access width, drainage, construction requirements (slopes, etc.), snow storage, and other appropriate design elements. Cross parcel access easement shall not be less than 30 feet wide. Private access design shall also incorporate International Fire Code (IFC), Red, White, and Blue Fire Department, and development code parking lot design requirements, which are listed those respective standards and codes.

5.10.1.1 Commercial

A commercial private access ~~road~~ is the ~~internal access drive system~~paved vehicle access route for a commercial lot or development and may include the access ~~drives~~driveways ~~,~~ and parking areas that serve the development.

5.10.1.2 Residential

A residential private access ~~road~~ is the ~~internal access drive system~~paved vehicle access route for four or less single-family homes, two duplexes, one triplex, or a multi-family development and may include the access ~~drives~~driveways, and parking areas that serve the development. An access to multiple duplexes or townhomes shall be a public road.

~~5.10.2 Access Management Principles~~

~~Access management is the coordinated planning, regulation, and design of access between roadways and land development. It involves the systematic control of the location, spacing, design, and operation of accesses, median openings, interchanges, and street connections. Access management provides the means to balance good mobility along the street network with local access needs of businesses and residents. Implementation of access management principles and techniques on transportation networks can provide the following long-term benefits for highway users, communities, and businesses.~~

~~5.10.4~~5.10.2 Access Changes

Access changes on Town of Breckenridge streets will typically require a Town Development Permit and a Right of Way permit. Access changes on State Highway 9 will require a CDOT access permit. Access changes on a Town Street (not directly located on a State Highway), but increasing traffic at the nearest State Highway 9 intersection by at least 20%, will also require a CDOT access permit.

~~5.10.4.1~~5.10.2.1 Number of Accesses

Only one access shall be provided per lot for safe ingress and egress. Where topographic or other site conditions exist, shared access between lots may be required.

Additional accesses may be approved off local streets that meet the minimum spacing requirements shown in Table 5.9. Accesses for a collector or arterial street frontage wherein a traffic impact study demonstrates a need for a second access based on traffic volumes, unique site or constraints or site requirements that generates the need for the second access; No feasible design alternatives are available to eliminate the need for a second access. Additional accesses may be allowed if required per IFC code requirements, or for large commercial developments. If an additional access is allowed, the second access shall be added from the minor street. Access from the major street shall be limited to the greatest extent possible.

Where an existing access is required to be removed, the owner is required to remove the driveway, the driveway connection to the public road, driveway apron, and other associated driveway improvements. Where the access crosses a sidewalk, owner will be required to remove the driveway cut and construct curb across the access. Owner will also be required to add any landscaping or block vehicle access with grading, landscaping, or other obstructions.

~~5.10.4.2~~5.10.2.2 Location

Access shall be from the lowest classification street. Lots with alley frontage shall have access from the alley only. When sites adjacent to an alley redevelop, propose a significant remodel or addition, or add a secondary unit, accesses and parking on an adjacent street shall be removed and access shall be solely from the alley. Accesses on a cul-de-sac shall be located to provide room for snow storage and shared access may be required. Exception: where there is an existing garage served by the street that shall remain without changes, the street access can remain to serve the garage. If feasible that access should be upgraded to meet current standards.

One driveway shall be allowed per lot unless otherwise permitted by the Town Engineer. Circular driveways, consisting of two curb cuts onto a street, are not permitted. A second driveway access is only allowed when required by IFC or RWB fire requirements.

All intersection and driveway accesses shall intersect the roadway at a ninety-degree angle.

No backout movements shall be permitted on arterial, major collectors, and minor collectors. Driveways on minor collector streets and above shall have internal circulation provided to allow turnaround movements within the driveway.

One-way accesses are discouraged.

Access location shall be configured to optimize sight distance, separation from adjacent intersections and driveways, and grade at the intersecting road (avoid steeper portions of adjacent roadway).

Commercial or multi-family residential accesses may not be allowed on roadway grades exceeding 6%. On roads exceeding 6%

~~5.10.5~~5.10.3 Access Management Techniques

Several access management techniques may be used to implement best management practices. Techniques include, but are not limited to the following:

1. Consolidate access by reducing the number of access points that serve a single property or by providing joint access for multiple properties at or near a shared property line.
2. Connect adjacent properties to provide circulation between properties and increase access opportunities for multiple properties.
3. Define driveways to provide clear identification of entrance and exit locations.
4. Locate access to a side street (local road) instead of a major road (arterial or collector) to reduce vehicle conflict on the major road.

~~5.10.6~~5.10.4 Sight Distance

Sight distance at accesses must comply with Chapter 9 of the *AASHTO Greenbook*. Table 5.9 identifies the appropriate design vehicle to be used for sight distance calculations. Where existing objects obstruct the AASHTO sight distance for single family or duplex homes, the sight distance triangle may be reduced from 14 feet to 10 feet from the edge of the roadway.

Table 5.9 Design Vehicle Selection for Access Sight Distance

Land Uses Served by Access	Design Vehicles (for sight distance calculations)
Residential (Non-School Bus Route)	Passenger Cars, Pickup Trucks
Part of Any School Bus Route Regardless of Land Use	No Less Than Single Unit Trucks
Office	Single Unit Trucks

Recreational	Single Unit Trucks
Commercial/Retail	Multi-Unit Trucks*
Industrial	Multi-Unit Trucks*
Municipal Streets & County Roads	Multi-Unit Trucks*
Agricultural Field Approaches <1 Per Day	Single Unit Trucks

*If Less Than 2 Multi-Unit Truck Trips Per Day (Average), Use Single Unit Truck

~~5.10.7~~5.10.5 Access Spacing

Table 5.10. provides access spacing requirements based on street classification. Access spacing and offset requirements shall be measured from the edges of the nearest curb returns or pavement radii terminations.

Table 5.10 Access Spacing Requirements

	Street Classification of Road being accessed by Driveway			
Design Element	**Arterial**	**Major Collector**	**Minor Collector**	**Local**
~~Minimum Street Intersection Spacing~~Offset between Street Intersections	¼ ~~½~~ Mile	1000' ~~¼ Mile~~	500' ~~⅛ Mile~~	300'
Offset between adjacent Major Access Driveways (≥100 trips per day)	300'	150'	100'	50'
Offset between adjacent Minor Access Driveways or one Major Access Driveway and one Minor Access Driveway (<100 trips per day)	150'	75'	50'	30'
Offset between Major or Minor access and street intersection	300'	150'	100'	50'

~~5.10.8~~5.10.6 Access Width

Table 5.11 provides access width requirements.

Table 5.11 Access Width Requirements

Layout Parameters	**Residential-1 Unit**	**Residential-2 Units**	**Residential-3-4 Units**	**Residential (Multi-Family Greater than 4 units)**	**Residential Private Street**	**Commercial or Industrial Private Access**

Minimum Width	12’	12’	12’	12’	24’	12’
Maximum Width (Includes flared pavement radius at edge of roadway)	20’**	20’**	24’	24’	24’	32’*
Pavement Return Radius	0’-5’	0’-5’	0’-10’	0’-10’	10’-20’	10’-20’
Maximum Slope (Centerline)	8%	8%	8%	8%	6%	8%

*Utilization of maximum width shall be approved by the Town Engineer.

**Maximum width shall include pavement return radius

~~5.10.9~~5.10.7 Access Type

~~5.10.9.1~~5.10.7.1 Curb Cut Driveway

In general, if there is a pedestrian sidewalk path along the roadway where an access is proposed, the sidewalk shall continue across the driveway. Refer to the Street Standard Drawings for curb cut driveway requirements and details. Exceptions can be made when the single unit and multi-unit truck peak hour volume is greater than 5.

~~5.10.9.2~~5.10.7.2 Radius Driveway

A radius driveway is defined as an access with curb ramps and without a continuous sidewalk across the access. Radius driveways shall be designed in accordance with intersection requirements of this chapter. With a radius driveway, access radii shall be per Table 5.11. If the design vehicle intended to use the access daily is a single-unit exceeding 30 feet, multi-unit, or another vehicle requiring a larger radius, the minimum turn radius accommodating this design vehicle shall be used. Access radii shall allow safe maneuvers without intrusion into adjacent highway travel lanes. In instances where multiple larger vehicles are likely to oppose each other at the access, the radii should be adequate to accommodate both vehicles without conflict. Radius shall balance vehicle access while also promoting slowing of vehicles. Smaller radii should be used where an access crosses a pedestrian route to encourage slower speeds.

~~5.10.10~~5.10.8 Access Design Details

~~5.10.10.1~~5.10.8.1 Access Profile

Driveways shall match the roadway cross-slope for the first five feet, shall not exceed 4% for the following 15 feet, and shall not exceed 8% for the remainder of the driveway.

If a pedestrian access route crosses the driveway, the driveway cross-slope shall be a maximum of 2% for the width of the pedestrian access route (minimum 4 feet wide).

~~5.10.10.2~~5.10.8.2 Access Geometry

Driveways shall meet adjacent streets, alleys, or driveways at a ninety degree angle and remain perpendicular for a minimum of 10 feet from the intersection. Driveways shall have a minimum inside turning radius of 26 feet and outside radius of 38 feet for fire department access, unless an alternate fire access is provided.

~~5.10.10.3~~5.10.8.3 Access Surfacing

All accesses shall be paved. Pavement placement shall occur prior to issuance of certificate of occupancy or sooner if required to meet Fire Department or utility requirements. All accesses serving more than four units or lots shall be maintained in proper working condition to prevent potholes and overall surface deterioration. All access and parking areas shall be paved with asphalt, concrete, recycled asphalt, or other all-weather drivable surface approved by the Town Engineer. Access flexible pavement sections shall match the roadway pavement section for a minimum of 10 feet from the edge of the traveled way. Concrete accesses shall either terminate 4 feet from the edge of asphalt on Public Streets with a 3-inch thick minimum asphalt apron constructed between the concrete access and the public street., or concrete can be placed to the edge of asphalt if it is even with or 1 inch lower than the top of asphalt and an expansion joint is provided between the asphalt/concrete interface.

Asphalt pavement shall be a minimum of 3" asphalt on 4" aggregate base course between the roadway and edge of right of way.

5.10.8.4 Access Drainage

Any access connecting to a road with curb and gutter or valley pans shall have a concrete cross-pan installed across the driveway. Any access connecting to a road with an existing road side ditch shall have an 18 inch culvert installed beneath the driveway. The roadside ditch shall be re-graded as needed from the ends of the culvert until the ditch daylights at a 1% slope. Where an access is added to the downhill side of a road and there is no curb, valley pans, or ditches on the existing road, the access may be exempted from the cross pan and culvert requirement.

5.10.9 Access Maintenance

An access does not typically require an encroachment license in the right-of-way. The access and all associated improvements (pavement, culvert, cross pan, flared end sections) shall not be owned or maintained by the Town. All ownership, maintenance, and replacement work shall be the responsibility of the owner. The Town is not liable for any damage incurred by the Town or others to driveway improvements within the right-of-way. The Town shall not be responsible for any damage caused by snow removal, Town vehicles, maintenance, or any other causes. The Town shall have the right to work on the access improvements within the right-of-way as required, such as clearing sediment from culverts and connecting to the access pavement when re-paving the public road, but the Town shall be under no obligation to complete any repair or maintenance.

5.11 PARKING AREAS (ON-STREET PARKING WITHIN RIGHT-OF-WAY)

Section 5.11 sets minimum standards for on-street parking. ~~See Development Code for off-street parking requirements.~~ See Chapter 3 of Title 9 of the Town Code for off-street parking requirements.

~~5.11.2~~5.11.1 On-street Parking

On-Street Parking shall be provided as shown within the street classification cross sections. On-street parking may be provided along streets when approved as part of the ~~Land~~ Development permit approval ~~process~~. All eligible on-street parking areas shall be clearly depicted on a plan. Such parking areas shall not conflict with any turning movements or obstruct access to any street, sidewalk, crosswalk, alley, access, or fire hydrant. ~~To accommodate on-street parking, a credit toward satisfying minimum off-street parking requirements shall be granted~~~~can be considered~~ ~~for any development that creates additional on-street parking spaces along a public street through the elimination of existing curb-cuts or driveways. See the Development Code for detailed parking requirements based upon existing land use.~~

~~5.11.3~~5.11.2 Parking Area Surfacing

All parking areas shall be paved with asphalt, concrete, recycled asphalt, or other all-weather drivable surface approved by the Town Engineer.

~~5.11.4~~5.11.3 Parking Grades

Parking areas shall have a maximum grade of 4% and a minimum grade of 1%. ADA parking spaces shall have a maximum grade of 2% in any direction.

~~5.11.5~~5.11.4 Parking Stall Requirements

Minimum parking stall size requirements are described below. Parking shall not encroach onto sidewalk, bike lanes, or other pedestrian facilities.

1. The minimum stall size shall be 18 feet long by 9 feet wide for 90 degree or angled parking. Actual striping dimensions shall be adjusted for angled parking to fit the minimum stall size.
2. Parallel parking: 25 feet long by 8 feet wide. Parallel parking stall at the end of a block may be reduced to 20 feet. Accessible parallel parking spaces shall be located near a curb ramp and shall be in an area that is not obstructed by trees or other objects behind the curb.
3. Accessible parking: 18 feet long by 8 feet wide, with a 5- to 8-foot accessibility lane (8 feet is required for van parking). An ADA accessible route shall be provided from the accessible ~~handicap~~ stalls to the businesses being served or the nearest pedestrian route. ADA parking space location, frequency, slopes, and other requirements shall meet PROWAG standards.

~~5.11.6~~5.11.5 Parking Construction Requirements

Construction of on street parking shall meet all standards and specifications of the adjacent street, including pavement thickness, compaction, and other construction specifications. See Chapter 9 of these standards for additional construction requirements.

5.12 PEDESTRIAN AND BICYCLE FACILITIES

Increasing congestion and mode conflict is accompanied by growing public awareness of the need of safe and convenient multi-modal facilities to promote alternative transportation and healthy lifestyles. This section provides for the design of pedestrian, bicycle and transit facilities that play a key role in providing improved accessibility, mobility, and transportation system continuity.

This section shall be used in combination with the AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, AASHTO Guide for the Development of Bicycle Facilities, CDOT Roadway Design Guide (Chapters 12 and 14), Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG), and ADA Accessibility Guidelines (ADAAG) for the design and installation of all pedestrian and bicycle facilities. Where no requirement is given, the current edition of the design standards listed above shall govern.

Section 5.12 applies to both public and private streets. Internal circulation (outside of right-of-way or private street) for individual single family homes or duplexes, and other private development, as determined by the Town Engineer, may be exempted from the requirements of 5.12.

5.12.1 Pedestrian Facilities

All local, minor collector, and major collector roads shall have a minimum of one sidewalk. Town Engineer may require additional sidewalks, shared use paths, and other pedestrian facilities. Sidewalks and other pedestrian facilities shall be installed per the Town's Sidewalk Master Plan, these standards, and as determined by the Town Engineer.

5.12.1.1 Pedestrian Environmental Impact

Sidewalks shall be designed to fit the existing topography and vegetation and minimize site disturbance, removal of vegetation, and disturbance to sensitive environmental areas.

5.12.1.2 Pedestrian Facility Widths

Sidewalks shall be a minimum of 5 feet wide for local roads. Major and minor collector pedestrian facilities shall be a minimum of 6 feet wide.

Soft surface trails intended for ADA accessibility shall have a minimum width of 4 feet wide.

5.12.1.3 Pedestrian Pavement Thickness

Concrete sidewalks shall be a minimum of 5 inches thick. Sidewalks within a driveway shall be a minimum of 6 inches thick and reinforced with welded wire reinforcement. Sidewalks crossing a driveway with heavy commercial loading shall be a minimum of 8 inches thick. All concrete sidewalk pavement shall be placed on a minimum thickness of a 4 inch aggregate base course layer.

5.12.1.4 Horizontal and Vertical Clearance

Sidewalk vertical clearance shall be a minimum of 8 feet. Sidewalk horizontal clearance shall be 3 feet preferred and 2 feet minimum. No structures or other objects shall extend into the clearance offsets.

5.12.1.5 Sidewalk Widening

When a sidewalk is required to be widened, the widening must be a minimum width of 4 feet or more. If the required added width is less than 4 feet, the existing sidewalk shall be removed and reconstructed to the required width.

5.12.1.6 Slope

The minimum cross slope of a sidewalk is 1% and the maximum cross slope is 2%, measured perpendicular to the sidewalk or path alignment. The cross-slope shall generally be towards the roadway, unless drainage facilities are provided behind the sidewalk. The maximum running slope for sidewalk not aligned with a roadway is 5%. If the sidewalk is aligned with the roadway, the sidewalk may match the slope of the roadway. See Section 5.13 of this chapter for ADA requirements of sidewalks and curb ramps. Sidewalks shall be accessible and shall have directional curb ramps.

5.12.1.7 Sidewalk Shouldering

Sidewalks shall have a compacted aggregate base course shoulder of 1-foot minimum width. The shoulder shall be sloped at a minimum of 1% away from the sidewalk. Landscaping may extend to the edge of the sidewalk only if the area is graded at 1%, grass or plantings are selected that do not cause maintenance issues, and the landscaping does not extend horizontally into the landscaping. Short grasses are typically the only landscaping allowed in the shoulder area.

5.12.1.8 Sidewalk Stormwater

Sidewalk shall be designed to handle runoff and provide positive drainage away from the sidewalk, typically towards the roadway. Obstructions shall not be placed at the edge of the sidewalk which obstruct stormwater flow. Low points in the sidewalk should be avoided to the extent possible due to ponding and freezing conditions in the winter.

5.12.1.9 Sidewalk Alignment

Standalone sidewalks and trail connections are encouraged in developments where their additions provide a shorter connection for pedestrians. Sidewalk alignments shall strive to provide the shortest distances between locations in order to promote efficiency of pedestrian transportation and to prevent pedestrians from walking outside the sidewalks.

5.12.1.10 Heated Sidewalks

This section only applies to heated sidewalks located within the Town right-of-way. For private snow melt systems, see Section 5.19.2 of this chapter and section 9-1-19-33A and 33R of the Town Code. Heated sidewalks located within Town right-of-way shall be designed by a Colorado licensed Professional Engineer. Heated sidewalks shall be designed with the following requirements:

- Snowmelt systems shall be hydronic snowmelt systems designed to produce a minimum of 125 BTU/SF and hydronic tubing loops shall be a maximum of 300 linear feet, unless an alternate design of acceptable performance is submitted by a Professional Engineer.
- Manifolds shall be located in traffic rated boxes placed outside of the concrete pavement.
- Concrete shall be a minimum of 5” thick.
- High PSI (60 psi) board insulation shall be placed beneath sidewalks which do not receive heavy traffic loads. In areas are expected to experience heavy truck traffic, astrofoil or other non-compressible insulation shall be placed beneath pavement.
- Welded wire mesh or other reinforcement shall be installed in traffic areas.
- Cold joints, where heated pavement meets non-heated pavement, shall be filled with backer rod and sealant to limit moisture infiltration.
- Heated pavement shall be doweled or connected by other means to non-heated pavement to minimize differential settlement and prevent trip hazards. Doweling is not required adjacent to curb, buildings, walls, or other locations that are not within the pedestrian path.
- Heated pavement shall be graded with a cross-slope and shall not drain onto non-heated pavement, creating any icing or safety hazards. Drainage shall be directed to an inlet, swale, drywell, or other approved connection point.

5.12.1.11 Trail Connections

Soft surface trail connections are encouraged and shall be installed per the Breckenridge ~~Trails~~ Open Space and Trails Master Plan and as required by the Town Engineer. Soft surface trails provide connections to existing trails, open spaces, parks, and other community destinations for pedestrians, bicyclists, and other non-motorized uses. Soft surface trails shall be designed and installed to limit grading impacts, tree removals, and other disturbance. Additional design and install details shall be coordinated and approved by the Town of Breckenridge Open Space and Trails ~~Department~~Division.

5.12.1.12 Pedestrian Bridges

Pedestrian bridges shall be a minimum width of 8 feet. Pedestrian bridges on the Blue River Rec Path shall be a minimum of 14 feet. Pedestrian railings shall be provided along bridges. See Chapter 6 for hydrologic requirements of pedestrian bridges. Pedestrian bridges on the Blue River Rec Path or bridges being maintained by the Town shall be designed to accommodate a 20 TON design vehicle. All pedestrian bridges shall be designed for the snow loads per Breckenridge Building Code. See Open Space and Trail standards for bridge requirements serving soft surface trails.

5.12.1.13 Pedestrian Railings

Hazards located near a sidewalk shall require a pedestrian railing or other barrier at the edge of the path. Examples of hazards include 2:1 slopes and vertical drops exceeding 30 inches.

5.12.1.14 Pedestrian Easements

All pedestrian facilities and trails not located within ROW shall be located within an access easement. Pedestrian facilities and trails shall have a 5-foot minimum distance from back of sidewalk/trail to edge of ROW/easement to accommodate drainage, signage, lighting, and utilities.

5.12.2 Bicycle & Shared-use Facilities

Bicycle & Shared-use facilities shall be installed per the Breckenridge Open Space and Trails Master Plan, Sidewalk Master Plan, and by the direction of the Town Engineer, and any other applicable requirements. Bicycle facility design shall follow the AASHTO Guide for the Development of Bicycle Facilities, current edition and the CDOT Roadway Design Guide for Bicycle and Pedestrian Facilities. Sight distance, vertical geometry, and horizontal geometry shall meet the requirements of AASHTO and CDOT.

For this chapter, the term shared-use will apply to both shared-use facilities and bicycle facilities.

5.12.2.1 Shared-use Environmental Impact

Shared-use paths shall be designed to fit the existing topography and vegetation and minimize site disturbance, removal of vegetation, and disturbance to sensitive environmental areas.

5.12.2.2 Design Speed

The design speed for shared-use paths on grades of 4% or less shall be 20 mph. The design speed for sections of shared use-paths exceeding 4% shall be 30 mph. For shared-use paths near intersections, underpasses, or other hazards where traffic calming is warranted, a lower design speed may be submitted to the Town Engineer for approval.

5.12.2.3 Shared-use Facility Widths

Shared use paths shall be at least 10 feet wide; the Blue River Recreation Path shall be at least 14 feet wide. Underpass widths shall be at least 14 feet wide.

5.12.2.4 Shared-use Pavement Thickness

Concrete shared-use paths shall be a minimum of 5 inches thick. Shared-use paths within a driveway shall be a minimum of 6 inches thick and reinforced with welded wire reinforcement. Shared-use paths crossing a driveway with heavy commercial loading shall be a minimum of 8 inches thick. Longitudinal joints in the concrete shall not be allowed in shared use paths. Transverse joints shall be sawcut and shall not be tooled.

Asphalt pavement for shared-use paths shall be a minimum of 3 inches thick and placed in two lifts. Asphalt shared-use paths within a driveway shall be a minimum of 4 inches thick.

All concrete sidewalk pavement shall be placed on a minimum thickness of a 4 inch aggregate base course layer.

Concrete and asphalt pavements for shared use paths shall be designed by a professional engineer licensed in the state of Colorado.

5.12.2.5 Shared-use Horizontal and Vertical Clearance

Shared-use paths shall have a minimum vertical clearance of 10 feet. Shared-use paths shall have a minimum horizontal clearance of 3 feet from the edge of pavement. No structures or other objects shall extend into the clearance offsets.

5.12.2.6 Shared-use Widening

When a shared-use path is to be widened or a pavement cut is planned, the full width of pavement shall be removed and replaced. No longitudinal joints will be allowed in concrete or asphalt shared-use paths.

5.12.2.7 Shared-use Slope

The minimum cross slope of a shared-use path is 1% and the maximum cross slope is 2%. The maximum running slope for a shared-use path not aligned with a roadway is 5%. If the shared-use path is aligned with the roadway, the sidewalk may match the slope of the roadway. See Section 5.13 of this chapter for ADA requirements of curb ramps. Shared-use paths shall be accessible and shall have directional curb ramps.

5.12.2.8 Shared-use Shouldering

Shared-use paths shall have a compacted shoulder with a minimum width of 2 feet wide. The shoulder shall be sloped at a minimum of 1% and a maximum of 16% away from the shared-use path.

5.12.2.9 Shared-use Stormwater

Shared-use path design shall consider runoff and provide positive drainage away from the path. Obstructions shall not be placed at the edge of the path which obstructs stormwater flow. Low points in the path should be avoided to the extent possible due to ponding and freezing conditions in the winter.

5.12.2.10 Shared-use Alignment

Standalone shared-use paths and trail connections are encouraged in developments where their additions provide a shorter connection for pedestrians. Shared-use alignments shall strive to provide the shortest distances between locations in order to promote efficiency of pedestrian transportation and to prevent pedestrians from walking outside the sidewalks.

5.12.2.11 Shared-use Bridges

Shared-use bridges shall be a minimum width of 10 feet. Bridges on the Blue River Rec Path shall be a minimum width of 14 feet. Pedestrian railings shall be provided along bridges. See Chapter 6 for hydrologic requirements of pedestrian bridges.

5.12.2.12 Shared-use Railings

Hazards located within the clear zone of the shared-use path shall require a pedestrian railing or other barrier at the edge of the path. Examples of hazards include 2:1 slopes, vertical drops exceeding 30 inches, and structures in the clear zone.

5.12.2.13 Shared-use Easements

All shared-use facilities and trails not located within ROW shall be located within an access easement. Pedestrian facilities and trails shall have a 5-foot minimum distance from back of shared-use path/trail to edge of ROW/easement to accommodate drainage, signage, lighting, and utilities.

Where outside of the ROW, the bicycle facility shall be in a public access easement of sufficient width to allow for repairs to the facility, accommodate any drainage, and allow for installation of any required signs.

All arterial and collector street cross sections include bike lanes on both sides of the street or a shared use path. The minimum width of the bike lanes is 5 feet.

Bicycle lanes on streets without on-street parking shall be at least 5 feet wide, exclusive of the curb pan, or 6.5' from the face of any curb. On existing streets where on-street bike lanes are being added and available right-of-way or improvements space is restricted, the width of the bicycle lane may be reduced to at least 5 feet wide, inclusive of the curb pan. Bicycle lanes on streets with on-street parking shall be at least 5 feet wide, exclusive of the parking lane, or 13 feet from the face of any curb. On existing streets where on-street bike lanes are being added and available right-of-way or improvements space is restricted, the width of the bicycle lane may be reduced to at least 4 feet wide, exclusive of the parking lane, or 12 feet from the face of any curb.

5.13 ACCESSIBLE PEDESTRIAN DESIGN

Curb Ramps on sidewalks shall be designed to comply with *Public Rights-of-Way Accessibility Guidelines* including detectable warnings. Where feasible separate ramps shall be provided for each crossing direction. Where site constraints prohibit separate ramps, a single multidirectional ramp may be used. Refer to *CDOT M & S Standard Plans* for ramp details. The standard detectable warning shall be cast iron, natural finish plates or approved equal.

5.13.1 ADA Accessibility Requirements, Standards, and Guidelines

The ADAAG and the PROWAG are not requirements of the ADA but serve as the standards and guidelines by which compliance of the law is measured. Generally, the ADA law requires:

1. New construction to be accessible
2. Alterations to existing facilities that are within the scope of a project to provide accessibility to the maximum extent feasible
3. Existing facilities that have not been altered shall not deny access to persons with disabilities

All new construction projects where a pedestrian demand is exhibited shall incorporate appropriate pedestrian facilities that are accessible to persons with disabilities. New construction projects have the ability to mitigate constraints through good planning and design practices. Project budget or limited scopes are not an acceptable reason to fail to provide compliant accessible facilities during new construction.

5.13.2 Technical Requirements for Accessible Design

The pedestrian access route (PAR) is a continuous and unobstructed path of travel provided for pedestrians with disabilities within or coinciding with a pedestrian circulation path.

The continuous width of the PAR shall be 5 feet minimum, exclusive of the curb. Where a pedestrian access route makes a 90-degree turn, it should be widened to 5 feet to accommodate the continuous passage of a wheelchair (i.e. pedestrian design vehicle). If the clear width of the PAR is less than 5 feet, passing spaces shall be provided at a maximum of 200-foot intervals. If passing spaces are provided, they shall be 5 feet by 5 feet minimum. The clear width of a pedestrian refuge island shall be 5 feet minimum.

Pedestrian facilities shall have a maximum running slope of 5%. If the grade of the roadway is steeper than 5%, then running slopes are permitted to match the grade of the roadway.

Pinch points should generally be avoided. Pinch points within the PAR shall not be less than 34 inches in width and not exceed 24 inches in the direction of pedestrian travel.

5.13.3 Curb Ramp Types

See the Street Standard Details for approved curb ramp types.

5.13.4 Curb Ramp Technical Requirements

5.13.4.1 Ramps

Curb ramps shall have a maximum running slope of 8.33%. The running slope of a curb ramp is measured in the center of the ramp run in the direction of pedestrian travel. If the surrounding terrain requires a ramp to chase grade, the ramp is required to be no longer than 15 feet, regardless of the resulting slope.

5.13.4.2 Landings and Turning Spaces

Landings and turning spaces allow users to maneuver on and off the curb ramp and are required at the top or bottom of a curb ramp. Turning spaces are required at the top of a perpendicular curb ramp and at the bottom of a parallel curb ramp. The maximum running slope and cross slope of landings and turning spaces shall be 2.0%. At mid-block crossings or locations without yield or stop control, the cross slope of the turning space can equal the street or highway grade. Turning spaces shall be 4 feet by 4 feet minimum. If the turning space is constrained by a vertical element on one or more sides, provide 5 feet in the direction of the street crossing.

When the profile of the roadway being crossed has an excessive slope, the curb ramp cross slope should be transitioned slowly to the turning space. The transition shall be spread evenly over the length of the curb ramp. See Curb Ramp Standard Details.

5.13.4.3 Cross Slopes

Cross slopes of all pedestrian facilities shall be a minimum of 1% and shall not exceed 2%.

5.13.5 Detectable Warning Surfaces

Detectable warning surfaces shall be made of untreated steel plates. Brick pavers are not permitted for detectable warnings. See CDOT M-Standards for Curb Ramps for detectable warning requirements.

5.13.6 Pedestrian Crossings at Controlled Intersections

Refer to Section 5.10 for Pedestrian Crossings at uncontrolled or mid-block crossings.

5.13.6.1 Signalized Intersection Crossing Controls

If an intersection under signal control has sidewalks, then marked crosswalks should be provided. In urbanized areas pedestrian signals are recommended at all intersections where sidewalks are provided on the approaches to a signalized intersection. STOP lines shall be placed a minimum of 4 feet in advance of the crosswalks. Consideration may be given to providing advance right turn STOP lines to improve the visibility of pedestrians coming from the motorist's left.

Pedestrian push buttons shall be accessible to pedestrians via an accessible pedestrian route in compliance with the ADA.

The draft PROWAG requires that whenever pedestrian signals are installed, accessible pedestrian push buttons be installed. Push buttons shall be connected to a fully-accessible pedestrian signal that complies with the *2009 MUTCD with amendments,* with the ability to enable or disable accessible features. The Town Engineer will decide on which functions to activate at each accessible pedestrian crossing on a case-by-case basis.

At intersections with high volumes of pedestrians, consideration should be given to restricting the right turn on red movement.

5.13.6.2 Stop and Yield Crossing Controls

At a minimum, marked crosswalks should be provided wherever a sidewalk crosses a street under stop or yield control. STOP or YIELD lines shall be placed a minimum of 4 feet in advance of the crosswalks.

5.13.6.3 Roundabout Crossing Controls

Requirements for roundabout crossings shall reference the latest version of *NCHRP Report 672 – Roundabouts: An Informational Guide* and the PROWAG.

5.13.7 ADA Curb Ramp Variance Process

It can be impractical to make facilities fully compliant with the standards due to existing site constraints. Improvements at locations can be deemed "Technically Infeasible" when sound engineering judgement is exercised. When full compliance is deemed technically infeasible, facilities being altered should be made accessible to the maximum extent practicable. If a site cannot meet accessibility standards, the proper documentation procedures should be followed.

Examples of site constraints that may make it technically infeasible to make a facility fully compliant include:

1. Adjacent development or buildings that would need to be moved or altered to make a facility fully compliant.
2. Required improvements that would alter the status of a Historic property.
3. Drainage that could not be maintained if an area is made fully accessible.
4. Underlying terrain that would require significant expansion of the project scope to achieve full compliance. An example would be altering a roadway profile to make the cross slope of a crosswalk fully compliant.

Project scope, not cost, should determine when existing constraints make an item technically infeasible.

To submit a curb ramp variance, the Town's Variance Request Form must be completed and signed by a licensed professional engineer documenting why the curb ramp was deemed technically infeasible and every effort was made to design the curb ramp to meet ADA compliance. The request will be reviewed by the Town Engineer, and once approved, will be filed with the Town in the instance that an ADA complaint is received by the Town.

5.14 PEDESTRIAN CROSSING CRITERIA FOR UNCONTROLLED OR MID-BLOCK CROSSINGS

The purpose of Section 5.14 is to serve as a policy to determine where uncontrolled pedestrian crossings should be located, and how to improve existing uncontrolled pedestrian street crossings within the Town.

5.14.1 Definitions

Uncontrolled pedestrian crossings are defined as:

1. Legal crossings that are located at an intersection without a traffic signal
2. Legal crossings without STOP or YIELD signs.

Mid-block crossings are defined as crossings that do not occur at an intersection and are marked to indicate that the location is a legal crossing.

Crossings can be marked with traffic control markings or unmarked with no traffic control markings present.

5.14.2 References

The newest versions of the following references shall be used for guidance in determining location, design elements, and requirements:

1. *The Manual on Uniform Traffic Control Devices 2009 Edition* including Revisions 1 and 2.
2. *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (FHWA, 2018)*.
3. *NCHRP Research Report 841 Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments (2017).*
4. *Evaluation of R1-6 Gateway Treatment Alternatives for Pedestrian Crossings: Follow-Up Report (Roadway Safety Institute, 2017).*
5. *TCRP Report 112 / NCHRP Report 562 Improving Pedestrian Safety at Unsignalized Crossings (2006).*
6. *CDOT Roadway Design Guide, Chapter 14 (2018)*
7. *CDOT Standard Plan S-614-14 for Rectangular Rapid Flashing Beacon requirements (hard-wired only)*

References listed above can be utilized in instances where this document does not specifically include requirements or guidance on a particular topic.

5.14.3 Pedestrian Traffic Analysis and Recommendations

An engineering study should be performed at the discretion of the Town Engineer before a crosswalk is installed at a location away from a traffic signal or an approach controlled by a STOP or YIELD sign. If a pedestrian crossing is part of a development application, then a traffic study may also be required as described in Chapter 4 and the traffic studies may be combined. The engineering study shall be stamped by a professional engineer. The following steps are required as part of the Pedestrian Traffic Analysis:

1. Complete the worksheet shown in Table 5.12. If worksheet result is yes, proceed with developing the Pedestrian Traffic Analysis. If the worksheet result is no, no additional analysis is required.
2. Include number of lanes, presence of a median, distance from adjacent signalized intersections, average daily traffic (ADT), posted or statutory speed limit (85th-percentile or mean speed), crash history, geometry of the location, possible consolidation of multiple crossing points, availability of street lighting, and any other factors deemed appropriate by engineering judgement.
3. Provide pedestrian volumes and delays (see Section 5.10.3.1)
4. Crossing treatment recommendations based on criteria and sound engineering judgement (see Section 5.10.3.2)
5. Conclusion of results.

5.14.3.1 Pedestrian Volumes and Delays

Pedestrian volumes and delays will typically involve AM, mid-day, and PM peak hours. Locations near schools may only require two hours of data collection (AM and PM peak hours corresponding to school opening and closing times). All pedestrian volumes should include and differentiate between pedestrians and bicyclists and should note separately the number of young, elderly, and/or disabled pedestrians. For locations where school crossing traffic is anticipated, the volume of student pedestrians (school age pedestrians on their way to/from school) should also be separately noted.

Whenever possible, pedestrian and bicycle volumes should be collected in the appropriate season when volumes may be close to or at their peak. Counts should be scheduled at a time when nearby businesses are open. If school traffic is an issue, the counts should be scheduled on school days when classes are in session. Given the potential fluctuation in pedestrian traffic from day to day, it may be necessary to collect up to three days of data to determine if an enhanced pedestrian crossing treatment is warranted as follows:

1. Collect pedestrian data on day one. If the minimum pedestrian volume threshold (20 pedestrians per hour accounting for a 1.33 multiplier used if vulnerable populations are present) is exceeded, no further pedestrian data collection is needed. If the threshold has not been exceeded, but at least 50% of the minimum pedestrian volume was observed, proceed to a second day of data collection.
2. Collect pedestrian data on day two. If the minimum pedestrian volume threshold is exceeded, no further pedestrian data collection is needed. If the threshold has not been met but again the volume is at least 50% of the minimum threshold, proceed to a third day of data collection.
3. Collect pedestrian data on day three. If the minimum pedestrian volume still has not been met, then no marked pedestrian crossing treatment is warranted by pedestrian crossing volume.

Pedestrian delays should be measured using procedures from the latest version of the Highway Capacity Manual.

5.14.3.2 Crossing Treatment Criteria

The following criteria shall be used in determining if crossing treatments are to be considered and shall be used to complete the worksheet shown in Table 5.12. If a crossing treatment should be considered, Section 5.10.5 shall be used to determine what type(s) of treatment is/are appropriate.

5.14.3.2.1 Criterion A

When vehicle volume is less than 5,000 vehicles per day or the average vehicle speed does not exceed 10 mph over the posted speed, crosswalk enhancements will be considered when there is a crossing pedestrian volume of at least 20 pedestrians per hour. When vehicle volume is greater than or equal to 5,000 vehicles per day or the average vehicle speed is 10 mph greater than the posted speed limit, crosswalk enhancements will be considered when there is a crossing pedestrian volume of at least 10 pedestrians per hour. A multiplication factor of 1.33 can be applied to the hour pedestrian volume if the volume consists of vulnerable populations (children, elderly, persons with disabilities, etc.). See lines (1) through (3) of Table 5.12.

5.14.3.2.2 Criterion B

Crosswalks enhancements will be considered when they could directly service or are adjacent to an existing shared-use path or trail, park, school, hospital, senior center, recreation center, library, or other facility with sensitive populations as determined by the Town Engineer. The minimum hourly pedestrian volume criterion may be waived if this criterion is satisfied. See line (4) of Table 5.12.

5.14.3.2.3 Criterion C

Crosswalk enhancements will be considered in locations where there are greater than 1 non-motorized (vehicle to pedestrian or vehicle to bicycle) crashes within the last 3 years. The minimum hourly pedestrian volume criterion may be waived if this criterion is satisfied. See line (5) of Table 5.12.

5.14.3.2.4 Criterion D

If criterion A, B, or C is met, the location must then also meet the following criteria:

1. The minimum stopping sight distance is available and free from obstructions. The minimum stopping sight distance shall be calculated using intersection sight distance per Section 5.6.1.5.
2. The crossing should match the grade of the existing roadway. More detail regarding maximum roadway grade can be found in Section 5.4.3.2.
3. The distance to the nearest existing marked or controlled crosswalk is at least 300 feet. If an existing marked or controlled crosswalk is within 300 feet, care should be given to direct pedestrian traffic to said crosswalk.
4. The existing roadway shall have a maximum slope of 6% in the downhill direction for a minimum distance of 200 feet. If the slope exceeds 6%, a crossing will not be allowed or the road must be re-graded to reduce the slope.

See lines (6) through (9) of Table 5.12.

5.14.4 Crossing Enhancement Eligibility Worksheet

The following table shall be used to determine if an uncontrolled or mid-block crossing is eligible for enhancement. A blank version of this worksheet can be found in Appendix E to assist with documentation of location decisions at the discretion of the Town Engineer.

Table 5.12 Crossing Enhancement Eligibility Worksheet

Criterion	Line	Criteria	Value	Eligibility Requirement
A	(1)	Average daily vehicle traffic	#	*See (5)*
	(2)	Mean vehicle speed differential from posted speed limit	#	*See (5)*
	(3)	Number of pedestrians per hour	#	*See (5)*
	(4)	Does the location serve a vulnerable population (children, elderly, persons with disabilities, etc.)?	Yes/No	*See (5)*
	(5)	Adjusted number of pedestrians per hour	#	*If (4) is Yes, then value = (3)*1.33, otherwise value = (3)* *Eligibility Requirement: When (1) < 5,000 or (2) < 10, then ≥ 20* *When (1) ≥ 5,000 or (2) ≥ 10, then ≥ 10*
B	(6)	Does the location directly serve or is adjacent to one of the following: Existing shared-use path or trail; park; school; hospital; senior center; recreation center; library?	Yes/No	*If Yes, then (5) eligibility requirement is waived*
C	(7)	Number of non-motorized crashes in the last three years	#	*If ≥6, then (5) eligibility requirement is waived*
D	(8)	Is the minimum stopping sight distance available (see Section 5.6.1.5)?	Yes/No	*Eligibility Requirement: Yes*

	(9)	Will the crossing match the existing roadway grade or less?	Yes/No	*Eligibility Requirement: Yes, cannot be greater*
	(10)	Distance to nearest existing marked or controlled crossing (feet)	#	*Eligibility Requirement ≥300'*
	(11)	Is the maximum grade of the roadway 6% or less in the downhill direction for a minimum 200' distance?	Yes/No	*Eligibility Requirement: Yes, or the road can be re-graded to meet*
	(12)	**Eligible for Treatment?**	**Yes/No**	*Yes = Criterion A, B, or C is met and Criterion D is met*

If eligible for treatment, see Section 5.10.5 for applicable crosswalk enhancements.

5.14.5 Pedestrian Crossing Enhancements

Once a determination has been made that a pedestrian crossing enhancement is recommended at a particular location, several design treatments can be considered.

Roadway traffic calming treatments should be considered in conjunction with pedestrian crossing enhancements as a means to enhance the effectiveness of one another. See Section 5.6 for more information on traffic calming treatments.

5.14.5.1 Pavement Markings and Conventional Signs

NCHRP Research Report 841 Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments (2017) states, "Recent research has found no safety benefit associated with various types of crosswalk markings, and the inappropriate use of marked crosswalks alone (without other substantial safety measures) can increase crash risk for pedestrians." This shall be considered when choosing to implement crosswalk markings at uncontrolled intersections or mid-block locations.

5.14.5.1.1 Standard Continental Crosswalk Markings

Standard continental crosswalk markings are pavement markings rectangular in shape. They shall be a minimum of 6 feet long and 1 to 2 feet wide. The alignment of the markings shall connect the curb ramps and be oriented so that they are parallel with the direction of travel. Markings shall be recessed into the pavement placed so that they avoid the anticipated vehicle wheel path to improve longevity of the markings. They can be spaced 1 to 5 feet apart. Crosswalk markings are to be used in conjunction with appropriate signing as defined in this section, because research shows that markings alone do not improve pedestrian crash rates. Decorative crosswalk markings are not recommended. Crosswalk markings shall be made retroreflective with glass beads or other approved methods. See Chapter 9 for construction requirements.

5.14.5.1.2 High Visibility Markings

High Visibility Markings are wider pavement markings that can be applied in the area of a crossing if the area is unlit and peak pedestrian traffic volumes occur during unlit times.

5.14.5.1.3 Advanced Yield or Stop Markings and Signs

Advanced yield or stop markings and signs may be used in conjunction with a crosswalk marking on major collector roadways with speeds of 40 mph and where placement of advanced markings and signs does not conflict with other intersections or traffic control. Refer to Section 3B.16 of the MUTCD for further standards and guidance.

5.14.5.1.4 Pedestrian Sign Assembly

The following list includes pedestrian signing options that should be utilized in combination with pedestrian markings listed in section

1. Pedestrian Crossing Sign Assembly (W11-2 with W16-7P) - shall be used in combination with crosswalk marking treatment. Sign structure shall be mounted at the roadside in accordance with MUTCD 2C.50.
2. Yield/Stop Here for Pedestrians Signs (R1-5) - may be used in conjunction with a crosswalk marking, advanced yield or stop markings, and a typical pedestrian crossing sign assembly on roadways with multiple lanes. Refer to Section 2B.11 of the MUTCD for further standards and guidance.
3. In-Street Pedestrian Crossing Signs (R1-6) - may be used when pedestrian crossing volumes are greater or equal to 20 pedestrians per hour OR when the mean vehicle speed at the crossing location is 5 mph greater than the posted speed limit. This treatment shall be used in conjunction with a crosswalk marking, a pedestrian crossing sign assembly, and a roadway centerline marking.

5.14.5.2 Physical Geometric Treatments

The following physical roadway geometric treatments can be considered to provide additional crossing safety and visibility as approved by the Town Engineer. Refer to the Town of Breckenridge's *Traffic Calming Policy* for additional treatment information regarding coordination and design considerations.

5.14.5.2.1 Refuge Islands

Refuge islands provide a space in the center of the traveled way for pedestrians to rest as they wait to cross each direction of vehicular travel independently. Refuge islands should be considered at pedestrian crossing locations on roads where one or both directions of travel are high volume, and see the most benefit with four or more lanes of traffic and speeds of 35 mph or greater. They can be paired with additional crossing enhancements provided in this section. Refuge islands shall be a minimum 10 feet wide from back of curb to back of curb. They shall be designed to allow for positive drainage and for adequate snow removal around the island and be ADA compliant. If the installation of a refuge island requires a shift in the traveled way, appropriate lane transition rates shall apply for the redirection of traffic around the island. Delineation markers may be required for snow removal activities.

5.14.5.2.2 Curb Extensions (Bulb-Outs)

Curb extensions extend the pedestrian sidewalk and curb out into the shoulder or parking lane of the roadway to reduce the crossing distance. This reduces the amount of time that pedestrians need to cross the traveled way, and provide additional space for curb ramps. They also can assist in reducing speeds of vehicular traffic. Curb extensions should allow for a minimum 11-foot travel lane. Curb extensions shall be designed to allow for positive drainage and for adequate snow removal around the extension. Delineation markers may be required for snow removal activities.

5.14.5.2.3 Raised Crosswalks

Raised crosswalks are ramped speed tables placed at mid-block crossing locations that assist with driver visibility of pedestrian crossings. They also provide traffic calming benefits. Raised crosswalks shall be flush with the sidewalk it is connecting on either side of the crossing, and shall be a minimum of 10 feet wide. They can be considered on minor collector and local roadways with a speed of 30 mph or less. Raised crosswalks shall generally be 6" tall, wings shall be 8% max, cross slopes shall be 2% maximum and meet ADA requirements, and storm sewer inlets shall be installed on the uphill side of the crosswalk. Raised crosswalks shall be designed to allow for positive drainage, and noise considerations should be made prior to proposing a location. Delineation markers may be required for snow removal activities.

5.14.5.3 Rectangular Rapid Flashing Beacon (RRFB)

RRFBs should be used sparingly and are typically only installed when other crossing enhancements have proven ineffective. An RRFB may be installed when all of the following criteria are met:

1. Marking and signing enhancements in Section 5.10.5.1 have been implemented but a perceived or actual pedestrian/vehicle conflict issue still persists
2. Pedestrian crossing volumes are between 60 and 160 pedestrians per hour
3. Crosswalk length from curb to curb is greater than 32 feet.
4. Roadway speeds are between 30 mph and 45 mph, or mean vehicle speed at the crossing location is 5 mph greater than the posted speed limit.
5. Roadway volume is greater than 6,700 vehicles per day.

The RRFB treatment is a combination of signing, markings and pedestrian activated strobe and feedback devices at uncontrolled pedestrian crossings. Refer to CDOT Standard Plan S-614-14 for requirements. RRFBs shall be hard-wired. Solar is not permitted. Signing for the RRFB typically includes advance PEDESTRIAN WARNING signs (W11-2) with AHEAD supplemental plaques (W16-9p), and PEDESTRIAN WARNING signs (W11- 2) with down arrow supplemental plaques (W16-7p). Pavement markings include yield lines. The pedestrian activated treatments would be the W11-2 signs with built in rectangular strobe flashers. Additionally, pedestrian visible strobes and a recorded message inform pedestrians when the crossing is activated and instruct them to wait for motorists to yield. The R1-5 (YIELD HERE TO PED) shall be placed so that it does not restrict motorists' visibility of the RRFB at the crosswalk. For the placement of advance stop lines and advance warning signs, refer to the MUTCD. High visibility crosswalks are to be used with the RRFB crossing treatment. Timing of the flashing beacon should allow for pedestrians to scan for motorists, step from the side of the road and completely cross the street. Depending upon pedestrian volumes, 5 to 10 seconds should be provided for pedestrians to scan for gaps and enter the roadway. For areas with very high pedestrian volumes (more than 10 pedestrians crossing simultaneously), additional startup time should be provided. A minimum of 3.5 feet per second crossing speed should be assumed for pedestrians.

A median refuge area should be considered, refer to Section 5.10.5.2.1.

5.14.5.4 Pedestrian Hybrid Beacon

Pedestrian hybrid beacons are not generally recommended in the Town of Breckenridge. This treatment may be applied if all of the following criteria are met:

1. Warrants and guidance from Chapter 4F of the MUTCD deem a PHB may be appropriate, and
2. Written approval has been given by the Town Engineer.

5.14.5.5 Grade Separated Crossing

A grade separated crossing treatment is typically applied for roadways meeting one of the following requirements:

1. Posted speeds greater than 40 mph, crossing lengths greater than 48 feet, and average daily traffic volumes greater than 10,000 vehicles per day
2. When removing sight distance obstructions is not feasible
3. The majority of users are expected to be non-traditional pedestrians (skiers, snowboarders, bicyclists, skateboards, etc.)

4. The proposed crossing is within CDOT ROW and the pedestrian volume exceeds 60 pedestrians per hour
5. Pedestrian volumes exceed 200 pedestrians per hour.
6. An at-grade crossing is expected to cause traffic impediment along the roadway and lower the LOS of the roadway.

Within CDOT ROW, new crossings with pedestrian volumes exceeding 60 pedestrians per hour will require a grade separated crossing. If the pedestrian volume is less than 60 pedestrians per hour, the Town Engineer will review the proposed crossing and determine if an at-grade crossing will be allowed.

Prior to implementing a grade separated crossing, additional study should be performed to determine if other at-grade solutions may be preferable. Written approval from the Town Engineer is required for all grade separated crossings.

Grade separated crossings shall generally be designed for ADA compliance, include physical barriers to prevent at-grade crossing, light enhancements inside the crossing, and include pedestrian routes entering and exiting the crossing which are intuitive and natural routes for pedestrians resulting in high compliance of use.

5.15 TRANSIT FACILITIES

Streets shall be designed to accommodate transit facilities where transit routes are identified during the development process. Transit facilities, including transit stops, waiting areas, transit shelters, and other transit improvements are encouraged and may be required as determined by the Town Engineer. Transit stops shall be located to minimize impact on through traffic, provide efficient arrival and departure for the transit vehicle, and bear a logical relationship to the population served. New transit stops and facilities shall be connected to the adjacent developments via sidewalks and trails.

Where required by the Town Engineer, transit stops shall be located where direct pedestrian access is provided from the street and adjacent sidewalk or surrounding area to the stop. Transit stops shall include a paved waiting area with a direct connection to the adjacent sidewalk. As each site is unique, the waiting area dimensions shall be determined by the Town Engineer.

Bus pull outs shall be located on the downstream side of an intersection wherever possible designed to provide a 30-foot loading area per bus and a 3:1 exiting taper. The pavement in the bus pull out lane shall be designed per a pavement evaluation report to account for the expected bus traffic; minimum concrete thickness of 10 inches shall be provided. Bus pullouts shall be per the standard detail and shall be a minimum of 10 feet wide, 40- to 60-foot long tapers with a 50-foot minimum radius and 2% cross slope.

5.16 PAVEMENT DESIGN

This section provides the criteria used for the design of pavements and will ensure adequate strength and durability to carry the predicted traffic loads for the design life of each project. The street pavement design evaluation shall be established for each project in a geotechnical report following the latest *CDOT M-E Pavement Design Manual*. The pavement design will be based on a Design Equivalent Single Axle Loads (ESAL) which is determined on average daily traffic count (ADT), vehicle classification, traffic equivalence load factors, traffic growth rate, design period, and lane factor. Private streets and accesses may be asphalt, concrete, or other impervious surface approved by the Town Engineer. Sidewalks and bus pullouts shall be concrete.

5.16.1 Soils Testing for Pavement Design

To design pavements for approval and acceptance by the Town, sampling and testing must be performed under the direct supervision of a registered Professional Engineer to evaluate the soil characteristics. Samples shall be taken at least 5 feet below proposed subgrade (10 feet on arterial roadways) at spacing of 250 feet or less, unless specified by a geotechnical engineer. Test holes shall properly evaluate all changes in soil character. Samples shall be taken at the minimum depth which will serve as subgrade for new street construction.

When joining to an existing paved street, cores of the existing pavement and base structure shall be made and analyzed to determine whether overlayment is feasible or reconstruction is necessary.

5.16.2 Flexible Pavement Design

Flexible pavements shall be designed, installed, constructed, maintained and repaired in accordance with these standards and with the latest editions of the *CDOT M-E Pavement Design Manual* and Standard Specifications for Road and Bridge Construction or the AASHTO Guide for the Design of Pavement Structures. In the event of discrepancies between these standards and the referenced publications, the more stringent shall take precedence.

A minimum of four inches of aggregate base course (ABC) shall be used as a base on roadways. If the design truck traffic is greater than 500 trucks per day, a minimum of six inches of ABC shall be used as a base. The minimum pavement thickness for all roadways shall be four inches. However, each roadway pavement section proposed in the Town shall be designed per a geotechnical report to determine actual recommended thickness and pavement mix. The minimum pavement thickness shall be per Table 5.13 below. These values only provide preliminary minimum values; the final pavement thickness shall be designed per the geotechnical report.

Table 5.13 Pavement Thickness Minimums

Street Type	Min. Asphalt Depth (Inches)	Min. Class 6 Aggregate Base Course Depth (Inches)
Private Roadway	4	4
Local	4	4
Minor Collector	5	6
Major Collector	6	6

The minimum lift thickness of flexible pavement shall be 1.5 inches and the maximum lift thickness shall be three inches.

5.16.3 Rigid Pavement Design

Rigid pavements shall be designed, installed, constructed, maintained and repaired in accordance with these standards and with the latest editions of the *CDOT M-E Pavement Design Manual* and Standard Specifications for Road and Bridge Construction or the AASHTO Guide for the Design of Pavement Structures. In the event of discrepancies between these standards and the referenced publications, the more stringent shall take precedence.

Rigid pavement shall have a minimum ABC thickness of six inches and a minimum concrete pavement thickness of seven inches.

5.17 Traffic Control Devices

Traffic control device designs shall be prepared by a Colorado licensed professional engineer experienced in traffic engineering. The designs shall be prepared in accordance with the latest version of the *Manual on Uniform Traffic Control Devices (MUTCD)*.

Striping plans are required for Collectors and Arterials, but may not be required for local subdivision streets. However, sign plans are required for all subdivisions. All signing and striping plans shall conform to the most current edition of the *MUTCD*. All traffic control devices shall be fabricated and installed in accordance with the *MUTCD*. Permanent signage and striping shall be complete and in place before any new roadway is opened to the public for use.

5.17.1 Street Name Signs

New streets in the Town of Breckenridge shall be named by the Town of Breckenridge in accordance with Town and Summit County naming procedures. The Town and County GIS Departments shall be used to ensure that each street name is unique and does not match or closely resemble another street name in the Town of Breckenridge or within Summit County.

Street name signs are required at the intersections of all public and private (serving four or more units) streets. Driveways serving three or less units may not install street name signs in the right of way.

Street name signs shall be fabricated to match existing Town of Breckenridge street signs. Color, size, font, and dimensions of the signs shall match existing Town street signs. The Town of Breckenridge Streets Department shall be consulted for street sign specifications.

5.17.2 Stop Signs

Stop signs or other traffic control devices shall be installed at the intersections of all public and private streets (access serving four or more units) and shall meet MUTCD requirements. Stop signs are not required at driveways serving three or less units.

5.17.3 Private Signage

No private signage shall be permitted within the ROW. No private signage shall be permitted on private property which attempts to direct traffic or parking. Business name signs and address signs may be installed outside of the ROW per requirements in the Town Code.

5.17.4 Signage Requests

Requests for additional signage for traffic calming, speed limit signs, children playing signs, parking signs, and other signage will be considered based on MUTCD standards, proximity to other signage, and local conditions. However, additional signage can create "signage clutter", a term for a condition when there is too much competing signage along a street causing driver confusion, reduced effectiveness of signage, distraction, and decreased aesthetics of a street. The Town of Breckenridge approves signage at that minimum level required to provide for safe and efficient travel of vehicles of pedestrians.

~~5.19~~5.18 STREET LIGHTING

The purpose of streetlight installations shall be to illuminate the public traveled ways to a level that provides for the safe passage of public traffic, both vehicle and pedestrian. Arterial and Collector streets shall require street lighting at intersections. Pedestrian lighting will be required near all sidewalks, pedestrian routes & facilities, crosswalks, and transit facilities. All fixtures, poles, and designs will be reviewed and approved by the Engineering Division and the power provider.

~~5.19.1.1~~5.18.1.1 Equipment Type and Location

~~The Town's standard Newport fixture, Providence Fixture, or Promenade Fixture shall be installed depending on the location within the Town. Typically, Newport fixtures are installed in the historic district, Providence fixtures are installed outside the historic district, and Promenade fixtures are~~

~~installed at critical intersections along SH 9. The Town Engineer will determine the appropriate light fixture depending on the location of the development. Typical spacing of light poles is 75 feet along pedestrian routes. Light pole spacing may be reduced to 110 feet along local road sidewalks. In residential areas, along a portion of road without a sidewalk, street light spacing may be further reduced to 300 feet. Typical pole height is 9 feet tall along pedestrian routes and 12 feet tall at intersection and crosswalks. The photometric analysis shall be completed to determine exact spacing, location, and pole height at all crosswalks and intersections. The type of area should also be considered when determining the equipment type and location. The Town staff can provide additional guidance on the type of illumination equipment that is required depending on the location of the project. Standard details for foundations, poles, fixtures, and luminaires are included in the standard details attached to Chapter 9 of these Standards.~~

The Town's standard Providence Fixture or Promenade Fixture shall be installed depending on the location within the Town. The Providence Fixture is the typical fixture installed in the Town, while the Promenade fixture is typically reserved for SH 9 and critical intersections or crosswalks. The Welsbach fixture (also called a Newport fixture) is installed in various locations within the Historic District of Breckenridge. No new Welsbach (Newport) fixtures will be installed unless a variance is granted by the Town Engineer. The Town Engineer will determine the appropriate light fixture depending on the location of the development. Standard details for foundations, poles, fixtures, and luminaires are included in the standard details attached to Chapter 9 of these Standards.

All new fixtures shall be dark sky compliant and shall have the capability to be automatically dimmable. All new street lights shall meet the following requirements:

1. Fixtures shall be certified dark sky compliant by the International Dark-Sky Association.
2. Fixtures shall be automatically dimmable. Fixtures in residential areas shall be programmed to dim at 10 pm and commercial areas shall be programmed to dim at 2:30 am. Fixtures at intersections and crosswalks shall have the capability to dim, but shall be programmed to remain and the same lumens throughout the night (no dimming).
3. New streets and development shall be designed to have a maximum 50,000 lumens/acre in commercially zoned areas and a maximum of 25,000 lumens/acre for residentially zoned areas. Area with traffic safety concerns, major collector roads, roundabouts, high pedestrian areas, crosswalks, and other areas of safety concern as determined by the Town Engineer shall be exempted from the maximum lumen requirements.
4. Light pole spacing shall be 75 feet along pedestrian routes. Light pole spacing may be reduced to 110 feet on roads classified as Local. On residential local roads without a sidewalk, street light spacing may be reduced to 300 feet. Light pole spacing may be modified for safety concerns or guidance from a photometric analysis.
5. Pole height shall be 9 feet tall along pedestrian routes and 12 feet tall at intersections and crosswalks. Pole height may be further increased for safety concerns with a photometric analysis.
6. Lights shall meet all requirements of Title 9, Chapter 12 (Exterior Lighting Regulations) and all other dark sky compliance regulations.
7. Photometric analysis (if determined necessary by Town Engineer).
8. Additional requirements as determined by the Town Engineer due to vehicle or pedestrian traffic, safety concerns, intersections, or other reasons.

~~5.19.1.2~~5.18.1.2 Positioning at Intersections

In general, the nighttime visibility of a pedestrian or hazardous object within an intersection is enhanced by increased contrast between the object and the surrounding street area. Street lights at intersections are required to be placed on the upstream side of the intersecting street, as viewed by a motorist approaching the intersection in the lane directly beneath the luminaries. The positioning of light standards at intersecting streets shall be up to two street lights per corner of intersection, depending on street geometry and crosswalk location.

~~5.19.1.3~~5.18.1.3 Roundabout Lighting

Lighting columns should be arranged around the perimeter of the roundabout in a simple ring, with the lights equidistant from the center and from each other. Lighting should extend at least 197 feet back along each approach road. Mounting height should be uniform throughout the intersection and not less than on any approach road. The minimum illuminance required should not be less than the highest level of lighting for any of the approach roads. Lights near roundabouts shall not be located closer than 6 feet from the face of curb and shall not be located in the center of median islands.

~~5.19.1.4~~5.18.1.4 Light Pole Offset Distances

Distance behind back of walk for local streets shall be at least 3 feet and must be within easements or right-of-way on Local residential streets. For Collector and Arterial streets, the light must be offset at least 3 feet from the back of curb and provide a clearance space between the light pole and edge of walk that equals or exceeds the required sidewalk width.

~~5.19.1.5~~5.18.1.5 Underground Service

Street lighting shall be installed with underground electric service on all newly developed dedicated public streets in the Town. The Developer is responsible for coordinating with the appropriate utility company all aspects of design and installation. Junction boxes and other structures shall not be installed in sidewalks, curbs, or curb ramps.

~~5.19.2~~5.18.2 Pedestrian Lighting

Install street lighting behind sidewalks where sidewalks attached to the curb are used. For sidewalks detached from the curb, install street lighting with a minimum of 3 feet clearance from back of curb to roadway side of support pole and 3 feet clear from all walks. All bridge underpasses, where vehicles, pedestrians, bicyclists, or equestrians may be present, shall require lighting.

Lighting for trails should be evaluated based on safety and the type of trail. Lighting will generally be required for primary trails at primary trailheads, underpasses, mid-block crossings. Where sidewalks and trails are located near or adjacent to streets, lighting shall be coordinated with street lighting requirements.

~~5.19.3~~5.18.3 Dark Sky Ordinance

The Town has adopted an exterior lighting policy generally adhering to a Dark Sky Ordinance. See *Exterior Lighting Regulations* in Title 9, Chapter 12 of the Town Code.

~~5.19.4~~5.18.4 Residential Areas

Street lights shall be shielded with house side shields or other measures to minimize light shining on residential areas.

~~5.20~~5.19 PRIVATE FACILITIES

Private streets, alleys, and accesses are typically utilized by an individual, group of individuals, or private business to access private property. It is the responsibility of the private landowner to maintain the private facility.

~~5.20.1~~5.19.1 Private Streets

A private street is an access serving five~~four~~ or more units or lots. Private streets are discouraged because they create a cost burden to residents. Private streets shall meet the same design standards as public streets. Private streets are not owned, maintained, or plowed by the Town. They are the sole responsibility of the property owner. A private street requires the approval of a variance request form by the Town Engineer.

~~5.20.2~~5.19.2 Private Snow Melt Systems

~~Driveway~~ Private heated pavement systems, also called snowmelt systems, shall terminate at the property line with no components located in the right-of-way. See section 9-1-19-33A and 33R of the Town Code for additional regulations. The following requirements shall be met for snowmelt systems:

1. Infrastructure permit shall be submitted for any private snowmelt system (even if located entirely on private land).
2. The snowmelt system shall stop 5 feet from the edge of a public roadway or 1 foot from the back of public sidewalk.
3. Drainage from the snowmelt system shall be captured on the premises and shall not drain across public pedestrian facilities or roadways. The drainage shall be designed to infiltrate or runoff without freezing. Examples include heated trench drains and inlets to storm pipes and drywells. Drywells shall be designed appropriately to infiltrate all runoff. Drainage shall not drain across public pedestrian facilities or roadways.

If the Town Engineer allows the snow melt system to encroach into the right-of-way, the following conditions shall be met in addition to the conditions above:

1. A separate mechanical zone shall be dedicated for the portion of the snowmelt system within the right-of-way
2. ~~The snowmelt system shall stop 5 feet from the edge of roadway or at the back of sidewalk~~
3. ~~Drainage from the snowmelt system shall be captured and shall not drain across pedestrian facilities or roadways~~

~~4.~~2. Expansion joint material shall be installed at the edge of heated concrete

~~5.~~3. A revocable encroachment license agreement, acceptable in form and substance to the Town Attorney for the components of the system extending into the ROW, must be approved by the Town and executed prior to the issuance of building permit

~~6.~~4. Other requirements as determined by the Town Engineer to reduce the impacts of the snow/melted interface

~~5.21~~5.20 UTILITIES

Utilities in ROW shall be located to minimize roadway disturbance. Utility lines shall be located to minimize the need for future adjustment and shall consider future extensions of the street system. Utility structures above grade shall be placed in easements outside of the ROW, or as close to the edge of the Right of Way as possible, and at least 6 feet from the edge of roadway and 3 feet from the edge of sidewalk. Utilities shall be buried a minimum of 2 feet below finished grade. Utility rings and covers within pavement areas shall be 0.25 to 0.50 inches below top of pavement. Manholes, valves, junction boxes, and other structures shall not be located in curbs or sidewalks.

Utilities shall typically be installed in the roadway shoulder to avoid pavement removal. If the utility must be placed beneath pavement, the utility should be installed at the center or at the edge of travel lanes. Utilities shall not be placed beneath wheel paths of roads. Utilities shall not be located in drainage swales. Utilities shall be installed to meet all applicable standards and requirements for bury depths, offsets, crossings, separation, and insulation. Utility crossings shall be perpendicular to street and pavements cuts shall be perpendicular to roadway. Pavement patches shall extend 1' minimum beyond trench and edge of patch shall not be located within wheel paths. See Chapter 3 of these standards for additional trenching and patching details.

All utilities (including storm sewer) shall be electronically locatable for the entire length of the utility. All wires and cables shall be buried in rigid conduits and backfilled with warning tape placed 1 foot above the conduits. Utilities and utility structures shall be located outside of ROW and within utility easements where feasible.

~~5.22~~5.21 DESIGN CRITERIA TABLE BY STREET CLASSIFICATION

Table 5.14 Design Criteria by Street Classification

Street Classification						
	Major Collector					
		Minor Collector				
				Local		
Posted Speed	40 mph	35 mph	30 mph	25 mph	20 mph	15 mph
Design Speed	40 mph	35 mph	30 mph	25 mph	20 mph	15 mph
Min. Horizontal Curve Radius (normal crown)	770'	510'	350'	200'	110'	50'
Min. Tangent Between Curves	150'	150'	100'	50'	20'	20'
Max. Super Elevation	6%	6%	6%	N/A	N/A	N/A
Cross-slope	2%	2%	2%	2%	2%	2%
Minimum Stopping Sight Distance	305'	250'	200'	155'	115'	80'
Min. Grade	1%	1%	1%	1%	1%	1%
Max. Grade	6%	6%	6%	6%	6%	6%
Min. K-Crest	44	29	19	12	7	3
Min. K-Sag	64	49	37	26	17	10

CHAPTER 6
STORMWATER STANDARDS

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6.1 PURPOSE

The purpose of this Chapter is to set forth design standards and criteria for storm drainage infrastructure so there is reasonable degree of assurance that the health, safety, welfare, and property of the Town and citizens may be safeguarded and protected through the proper control and drainage of stormwater, the water quality of the Blue River and its tributaries will be protected, and there will be a certain uniformity in performance with respect to design and construction of drainage facilities.

Additionally, the Town of Breckenridge's mountain environment is known for steep grades, wetland areas, perennial streams, reservoirs, and the Blue River. This unique environment and topography results in grading, slope stability, stormwater runoff contamination, and phosphorus contamination concerns. This chapter establishes standards to safeguard public health and safety, protect environmentally sensitive areas, and protect the water quality of the Blue River, its tributaries, and Dillon Reservoir.

The design Standards presented herein are intended to aid in the design of stormwater infrastructure and outline the minimum standards required.

6.2 OTHER STANDARDS

The Mile High Flood District (MHFD), formerly known as the Urban Drainage and Flood Control District (UDFCD), has developed detailed permanent water quality design guidance and criteria in Volume 3 of the *Urban Storm Drainage Criteria Manual* (USDCM). This document is referenced extensively in this section and provides extensive discussion on the topic of stormwater quality treatment. When used for design, the most recent version shall be referenced as the MHFD continually updates Volume 3 of the USDCM based on performance and maintainability of the treatment facilities discussed.

6.2 SUBMITTALS

An Infrastructure Permit is required for all construction projects involving storm drainage infrastructure. Requirements for an Infrastructure Permit are summarized in Chapter 2. Other submittals may be required in accordance with Chapter 2 or as determined by the Town Engineer.

6.3 RAINFALL

A rainfall analysis was completed for the Town of Breckenridge using the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 data. The equations and data in this section are based on this analysis. A detailed memo regarding the evaluation of NOAA Atlas 14 is available from the Town upon request.

6.3.1 Rainfall Intensity

Equation 6.1 shall be used to calculate rainfall intensity for a given time of concentration or to develop intensity-duration-frequency curves for runoff analysis using the Rational Method as discussed in Section 6.4.

$$\mathrm{I} = \mathrm{P}_1 \frac{40.81}{(t+7.63)^{0.881}} \tag{6.1}$$

Where:

I = rainfall intensity (in/hr)

P_1 = 1-hour rainfall depth (in), see Table 6.1

t = storm duration, time of concentration (min)

Rainfall intensities as a function of storm duration and recurrence interval are provided in Table 6.1. This table was developed using Equation 6.1. The values in Table 6.1 are subject to revision and users of these Standards are encouraged to check for updates.

Table 6.1. Intensity-Duration-Frequency Data

Return Period	P_1	Peak Rainfall Intensity for Storm Duration (in/hr)				
		5-min	10-min	15-min	30-min	60-min
2-year	0.546	2.39	1.78	1.43	0.91	0.54
5-year	0.749	3.27	2.44	1.96	1.25	0.75
10-year	0.939	4.10	3.06	2.45	1.57	0.94
25-year	1.23	5.37	4.01	3.21	2.05	1.23
50-year	1.49	6.51	4.85	3.89	2.49	1.48
100-year	1.76	7.69	5.73	4.60	2.94	1.75
500-year	2.5	10.92	8.14	6.53	4.17	2.49

6.3.2 Rainfall Distribution

The 6-hour rainfall depths provided in Table 6.2 shall be used to develop a 6-hour SCS Type II rainfall distribution for runoff analyses that use hydrographs as discussed in Sections 6.4.4 and 6.4.5.

Table 6.2. 6-Hour Rainfall Depths for SCS Type II Distribution

Return Period	6-hour Rainfall Depth (in)
2-year	0.859
5-year	1.070
10-year	1.28
25-year	1.61
50-year	1.89
100-year	2.21
500-year	3.07

6.3.3 Design Storms

The objectives of establishing the minor and major design storms are to minimize inconvenience, protect against recurring minor damage, reduce maintenance costs caused by the minor storm, and eliminate substantial property damage and loss of life caused by the major storm. The goal is a functional drainage system at a reasonable cost. The storm drainage system may include streets, curb and gutter, roadside ditches, inlets, storm sewers, open drainageways, culverts, and detention facilities. In the Town of Breckenridge, the minor storm is the 10-year event and the major storm is the 100-year event.

6.4 RUNOFF

The hydrologic analysis of a site shall be based on the proposed land use for that site, as opposed to existing conditions. Calculation of contributing runoff from offsite upstream areas shall be based on the existing land use and topography. Flows specified in the Flood Insurance Study, Town of

Breckenridge (2011) shall be incorporated in the analysis where applicable and with the approval of the Town Engineer.

6.4.1 Approved Hydrologic Methods

All hydrologic methods have limitations and should be used only for appropriate scenarios. Accepted hydrologic methods are the Rational Method, the Soil Conservation Service (SCS) Dimensionless Unit Hydrograph Method, and the SCS Runoff Method. The last two methods are referred to collectively herein as the SCS Method developed by the Natural Resource Conservation Service (NRCS). The Rational Method may be used for watersheds of 90 acres or less and when only peak flows, as opposed to a hydrograph, are required for design (e.g., pipes, culverts, inlets). The SCS Method may be used for watersheds of any size or when hydrograph routing is required for design (e.g., detention ponds and volume-based water quality facilities). Information on the computer models that may be used to develop and route hydrographs is included later in this section.

6.4.2 Subwatershed Sizing

Determination of peak runoff at any downstream design point is affected by the size, number, and characteristics of the upstream subwatersheds within the overall drainage basin. Typically, the more homogenous each of the subwatersheds is, the more accurate the calculated peak flow is when compared to analysis of a single, larger watershed. Recommended guidelines are:

1. For an overall watershed of up to 100 acres, the maximum subwatershed size should be approximately 20 acres. Delineation should be conducted so that imperviousness, slope, and land use are similar for each subwatershed.
2. For an overall watershed over 100 acres, increasingly larger subwatersheds may be used provided the land use and surface characteristics within each subwatershed are homogeneous. In addition, the subwatershed sizing should be consistent with the level of detail needed to determine peak flow rates at various design points within the larger watershed.

6.4.3 Rational Method

The Rational Method uses Equation 6.2 to determine a peak runoff rate based on drainage area, rainfall intensity, and imperviousness. Imperviousness is represented by a coefficient, C.

$$\mathrm{Q} = \mathrm{CIA} \qquad (6.2)$$

Where:

Q = peak rate of runoff (cfs)

C = runoff coefficient

I = rainfall intensity (in/hr)

A = drainage area (acres)

The rainfall intensity is given by Equation 6.1 or Table 6.1 based on the design storm and storm duration, which is assumed to be equal to the total time of concentration to the design point being analyzed. Determining values for the runoff coefficient, C, is discussed in the section below.

6.4.3.1 Runoff Coefficient

The runoff coefficient is based on land cover and soil classification. Soils are classified by the NRCS as belonging to Hydrologic Soil Group A, B, C, or D. The Hydrologic Soil Group(s) present at a site can be found using the Web Soil Survey tool available via an internet search for *NRCS Web Soil Survey*. Types of land use and their typical corresponding imperviousness are summarized in Table 6.3. Composite imperviousness should be obtained for each subwatershed that is not completely homogenous. The runoff coefficient, C, can then be calculated using the equations in Table 6.4. The coefficients are dependent on the Hydrologic Soil Group, composite imperviousness, and the return period of the design storm. The values below are approximations of average imperviousness for typical land uses. If a development's land use does not match a land use in the table below, or if the development's imperviousness does not match the values in the table below, imperviousness may be calculated for each subbasin within the site by dividing the total impervious area within the subbasin by the total subbasin area.

Table 6.3. Land Use Imperviousness

Land Use	Imperviousness (%, i_p)	Land Use	Imperviousness (%, i_p)
Urban:		Playgrounds	25
Downtown Area	95	Schools	55
Suburban Area	75	Parks, Cemeteries	10
Residential Single-family:		Paved Streets	100
2.5 acres or larger	15	Drive and Walks	90
0.75 - 2.5 acres	20	Roofs	90
0.25 - 0.75 acres	30	Lawns	2
0.25 acres or less	50	Undeveloped Areas:	
Apartments/Duplex/Townhomes	75	Historic Flow Analysis	2
Industrial:		Greenbelts, Agricultural	2
Light Areas	80	Off-site Flow Analysis (land use not defined)	45
Heavy Areas	90		

Table 6.4. Runoff Coefficient Equations

NRCS Soil Group	Storm Return Period			
	2-year	5-year	10-year	25-year
A	$C=0.84i_p^{1.302}$	$C=0.86i_p^{1.276}$	$C=0.87i_p^{1.232}$	$C=0.88i_p^{1.124}$
B	$C=0.84i_p^{1.169}$	$C=0.86i_p^{1.088}$	$C=0.81i_p+0.057$	$C=0.63i_p+0.249$
C/D	$C=0.83i_p^{1.122}$	$C=0.82i_p+0.035$	$C=0.74i_p+0.132$	$C=0.56i_p+0.319$

NRCS Soil Group	Storm Return Period		
	50-year	100-year	500-year
A	$C=0.85i_p+0.025$	$C=0.78i_p+0.110$	$C=0.65i_p+0.254$
B	$C=0.56i_p+0.328$	$C=0.47i_p+0.426$	$C=0.37i_p+0.536$
C/D	$C=0.49i_p+0.393$	$C=0.41i_p+0.484$	$C=0.32i_p+0.588$

6.4.3.2 Time of Concentration

The storm duration used in Equation 6.1 is the time required for runoff to flow from the most hydraulically distant point within the subwatershed to the design point of interest. This time is known as the time of concentration. Time of concentration is calculated by adding the flow times for each type of flow along most hydraulically distant flow path. Types of flow include sheet flow and shallow concentrated, or channelized flow. Time of concentration for the Rational Method is calculated using Equations 6.3 through 6.5.

$$t_c = t_i + t_t \tag{6.3}$$

Where:

t_c = time of concentration (min), minimum is 5 min in urban areas, 10 min in rural areas

t_i = initial or overland sheet flow time (min)

t_t = travel time for shallow concentrated flow in a ditch, channel, gutter, pipe, etc. (min)

Initial or overland flow is the sheet flow that occurs at the beginning of the flow path characterized by a flow depth less than 0.1 feet. It can be calculated using Equation 6.4 for flow path lengths up to 500 feet in rural areas and 300 feet in urban areas. However, in highly urbanized areas, the overland flow path is typically shorter than 300 feet because of the presence of drainage systems that collect and convey runoff.

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_o^{0.33}} \tag{6.4}$$

Where:

t_i = initial or overland sheet flow time (min)

C_5 = runoff coefficient for 5-year return period (see Table 6.4)

L_i = length of overland flow segment (ft)

S_o = average slope along the overland flow path (ft/ft)

Travel time for shallow concentrated flow is calculated based on the hydraulic properties of the conveyance element. The channelized travel time, t_t, is estimated by dividing the length of conveyance by the velocity. Equation 6.5 can be used to determine travel time in conjunction with the conveyance factors in Table 6.5.

$$t_t = \frac{L_t}{60K\sqrt{S_o}} = \frac{L_t}{60V_t} \tag{6.5}$$

Where:

t_t = travel time for shallow concentrated flow in a ditch, channel, gutter, pipe, etc. (min)

L_t = shallow concentrated flow path length (ft)

S_o = average slope of shallow concentrated flow path (ft/ft)

K = NRCS conveyance factor (see Table 6.5)

V_t = travel time velocity (ft/s) = $K\sqrt{S_o}$

For shallow concentrated flow in a pipe or well defined channel, Manning's Equation for open channel flow in Section 6.5 may be used to calculate velocity. The time of concentration, t_c, is then the sum of the initial flow time, t_i, and the travel time for shallow concentrated flow, t_t.

Table 6.5. NRCS Conveyance Factors, K

Land Surface	Conveyance Factor, K
Heavy meadow	2.5
Tillage/field	5

Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

Reference: NRCS (1986)

6.4.3.3 Limitations and Considerations

The minimum time of concentration in urban areas is 5 minutes. The minimum time of concentration in rural areas is 10 minutes. A common mistake in urban areas is to assume travel velocities that are too slow. Another is to not check the runoff peak resulting from only part of the design catchment. Sometimes a portion of the design catchment closer to the design point or a highly impervious area will produce a larger peak design flow than that computed for the entire catchment. This most often happens when the catchment is long and narrow, or when the upper portion is undeveloped while the lower portion is, or will be, fully developed.

6.4.4 SCS Method

For drainage areas larger than 90 acres, the SCS Method is one method than can be used to develop hydrographs. The procedures used in the SCS Method are described in Technical Release 20 (TR-20) and Technical Release 55 (TR-55) both prepared by the NRCS. Three parameters are needed to use the SCS Method: rainfall, curve number, and time of concentration. This section provides some general information needed to use the SCS Method in a hydrologic model. However, the reader should refer to TR-20 and TR-55 for more detail describing the SCS Method; the applicable hydrologic equations and theory; and all other background information.

6.4.4.1 SCS Method - Rainfall

The SCS Method includes four rainfall time distributions that are assigned geographically across the country. The SCS Type II storm distribution is applicable to the entire State of Colorado and therefore should be used when preparing hydrologic analysis for the Town. The rainfall distribution is based on a 24-hour duration.

The 24-hour distribution was developed to include the maximum intensities of all smaller duration storms; the 24-hour storm theoretically includes the 2-hour, 6- hour, etc. distributions within one longer distribution and can be used to estimate peak flows for all storm events. However, it will typically overestimate the volume of a storm event with a duration less than 24 hours. Therefore, the SCS also developed a 6-hour storm distribution, which was derived from the original 24-hour distribution. The 6-hour distribution can be used if the drainage area being modeled has a total time of concentration less than 6 hours. The total rainfall depths should be taken from NOAA Atlas 14 for the project design storm return period.

6.4.4.2 SCS Method – Curve Number

The SCS Method curve number (CN) is a variable used to predict infiltration and runoff based on land use and soil types. When using the SCS Method in a hydrologic model, the user will be required to input the percent imperviousness and CN for each watershed or subwatershed modeled. The CN is dependent on land cover and the NRCS Hydrologic Soil Group (A, B, C, or D). The modeled watershed or subwatersheds may be composed of multiple land uses and soil types. In these cases, a composite CN must be calculated as the representative CN for the area. Refer to Tables 6.6 and 6.7 for CN values for specific land uses and hydrologic soil groups.

The initial abstraction is another important parameter used in the CN analysis. It represents all the losses that occur prior to runoff including infiltration, interception, depression storage, and evaporation. The hydrologic model will calculate the default initial abstraction based on the selected CN. However, in some unique cases it may be desirable to provide a user-defined initial abstraction based on the site conditions.

The table below provides runoff curve numbers for typical land uses based on average imperviousness. If a development's land use does not match a land use in the table below, or if the development's imperviousness does not match the values in the table below, curve numbers for each subbasin within the development may be calculated using TR-20 and TR-55.

Table 6.6. Runoff Curve Numbers

Land Use or Surface Characteristic	Average Imperviousness (percent)	Runoff Curve Number by Soil Type			
		A	B	C	D
Commercial/Mixed Use					
Downtown and Base Areas*	95	95	96	97	97
All Other Commercial Areas	75	83	89	92	94
Residential Single Family					
2.5 acres or larger lot size	12	46	65	77	82
0.75 – 2.5 acres lot size	20	51	68	79	84
0.25 – 0.75 acres lot size	30	74	83	88	91
0.25 acres or smaller lot size	45	66	78	85	88
Multifamily and Resort Residential	75	83	89	92	94
Industrial					
Light	80	86	91	93	94
Heavy	90	92	94	96	96
Public Facilities/Open Spaces					
Parks, cemeteries	10	45	63	75	81
Playgrounds	25	45	63	75	81
Schools	55	69	80	86	89
Lawns and golf courses	2	40	62	74	80
Undeveloped Areas					
Pre-development conditions	2	40	62	74	80
Greenbelts, agriculture	2	40	62	74	80
Off-site analysis, unknown land use	45	66	78	85	88
Outcrops	70	80	87	91	93
Streets/Roads & Surfacing					
Paved	100	98	98	98	98
Road base or recycled asphalt	80	86	91	93	94
Gravel (uniformly graded)	40	63	76	84	87
Drives/Walks	90	92	94	96	96
Roofs	90	92	94	96	96

Reference: Values are from a combination of UDFCD (2016) and USDA NRCS (2004)

Table 6.7. Runoff Curve Numbers for Arid and Semiarid Rangelands

Cover Type	Hydrologic Condition[1]	Runoff Curve Number for Soil Type			
		A[2]	B	C	D
Herbaceous – mixture of grass, weeds and low-growing brush, with brush the minor element	Poor Fair Good		80 71 62	87 81 74	93 89 85
Oak-aspen – mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Poor Fair Good		66 48 30	74 57 41	79 63 48
Coniferous, general; grass understory	Poor Fair Good		75 58 41	85 73 61	89 80 71
Sage-grass – sage with an understory of grass	Poor Fair Good		67 51 35	80 63 47	85 70 55

1. Poor: <30% cover (litter, grass, and brush overstory); Fair: 30 to 70% cover; Good: >70% cover
2. Curve numbers for group A have not been developed for these types of cover

Reference: USDA NRCS (2004)

6.4.4.3 SCS Method – Time of Concentration

The time of concentration (T_c) is defined as the time it takes for water to travel from the most hydraulically distant point in the watershed to the point of interest. The SCS Method for calculating T_c is done by splitting the watershed into three distinct flow types: sheet flow, shallow concentrated flow, and open channel flow.

6.4.4.3.1 Sheet Flow

Sheet flow occurs in the upper part of the basin where there is not yet a defined channel. The assumption is that the depth of flow is very shallow, less than 0.1 feet, and that the total flow length is less than 300 feet. The equation for sheet flow is as follows:

$$T_t = \frac{0.007(nL)^{0.8}}{(s^{0.4})(P_2{}^{0.5})} \qquad (6.6)$$

Where:

T_t = travel time (hr)

n = Manning's n roughness coefficient (refer to TR-55 for example values)

L = flow length (ft)

P_2 = 2-year, 24-hour rainfall (in)

s = slope of hydraulic grade line (land slope, ft/ft)

6.4.4.3.2 Shallow Concentrated Flow

Travel time for shallow concentrated flow is estimated by multiplying the average velocity by the total length of flow. Average velocity is found using the Figure 6.1 below.

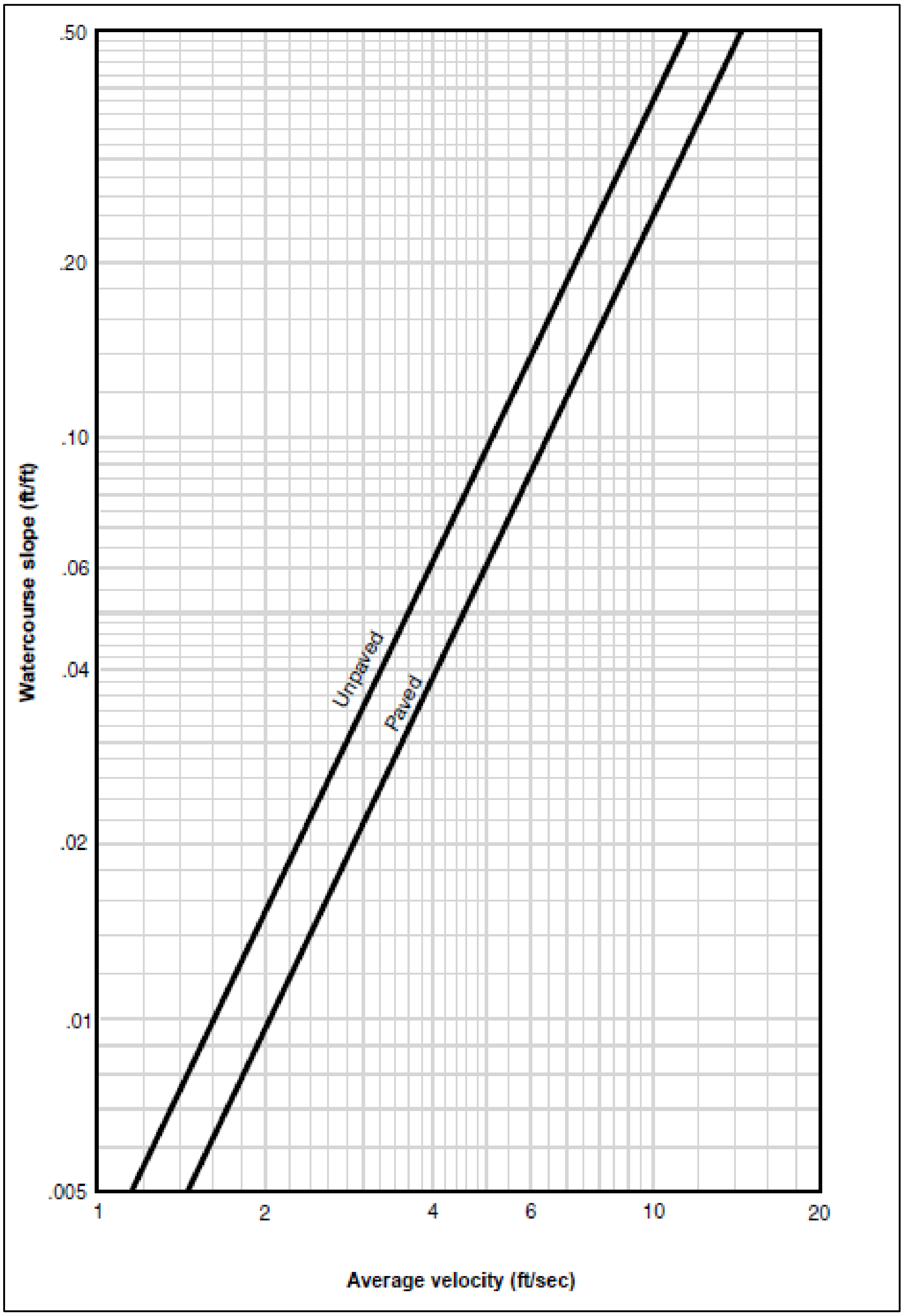


Figure 6.1. Average Velocities for Shallow Concentrated Flow
Reference: TR-55

6.4.4.3.3 Open Channel Flow

Open channel flow begins where there is a visible channel conveying storm water. Average velocity in the channel is estimated assuming the bank full flow. Velocity at bank full flow is calculated using Manning's equation or other available hydraulic modeling for the stream.

The total T_c is calculated as the sum of the three flows: sheet flow, shallow concentrated flow, and open channel flow. Some hydrologic models represent T_c as the lag time for the watershed. Lag time is defined as follows:

$$\text{Lag Time} = 0.6 * T_c \tag{6.7}$$

Where:

T_c = time of concentration (hr)

6.4.5 Hydrograph Development and Routing Models

Runoff hydrographs can be developed using CUHP, SWMM, or HEC-HMS modeling software. CUHP, which stands for Colorado Urban Hydrograph Program, was developed by the Mile High Flood District for use within SWMM. SWMM, which stands for Stormwater Management Model, was developed by the United States Environmental Protection Agency (EPA). SWMM can route hydrographs developed internally or those developed with CUHP. HMS, which stands for Hydrologic Modeling System, was developed by the United States Army Corps of Engineers' Hydrologic Engineering Center (HEC). HEC-HMS can also route the hydrographs it develops.

SWMM and HEC-HMS can evaluate runoff through larger or less homogenous basins or through complex drainage systems by routing flows through these elements. Other routing programs may be used if they are approved by the Town Engineer. The SCS Method should be used within HEC-HMS to generate runoff hydrographs. The EPA developed its own runoff method inherent to the SWMM software program. The SCS Type II storm distribution and NOAA Atlas 14 rainfall depths should be used to develop the hyetograph for input into the model. Other methodology may be used if it is better suited to site characteristics. A narrative describing the selected hydrologic methodology and the reasons for its selection should be included with the Drainage Report.

Basins should be divided into smaller and more homogeneous subwatersheds. The runoff hydrographs from upper subwatersheds are then routed through and combined with hydrographs from the lower subwatersheds, channels, detention basins, or other elements to develop a runoff hydrograph for the entire watershed.

The sizing of the detention storage may be based upon hydrograph storage routing techniques rather than direct calculation of volume and discharge requirements. A HEC or EPA SWMM model shall be used when reservoir routing of hydrographs is conducted, such as for the design of a detention pond. A HEC or SWMM model shall be used when channel routing of hydrographs is required.

6.4.5.1 HEC-HMS

HEC-HMS simulates the complete hydrologic process of a watershed system. The software includes traditional hydrologic analyses including infiltration, unit hydrographs, and hydraulic routing including through detention facilities. HEC-HMS also provides analysis tools for snowmelt. It should be noted that when using the SCS Type II storm distribution, the model is assuming that the storm distribution is for a 24-hour storm. If a 6-hour storm is desired, then the hyetograph must be input as a user-defined table.

6.4.5.2 EPA SWMM

SWMM is a rainfall-runoff model that analyzes a collection of subwatersheds that receive a rainfall hyetograph and generates runoff hydrographs at design points. SWMM can route runoff hydrographs through a system of pipes, channels, basins, and storage elements such as detention ponds; track the quantity of runoff generated at each design point; and track the flow rate and depth of water in each element over a specified simulation time. EPA SWMM is typically used for larger watersheds; for designing detention basins and water quality facilities; and for modeling large storm sewer systems. Runoff hydrographs can be developed internally or within CUHP.

6.4.5.3 CUHP

CUHP is a rainfall-runoff model that analyzes a collection of subwatersheds that receive a rainfall hyetograph and generates runoff hydrographs and total runoff volumes at design points. The runoff hydrographs are then routed by SWMM through a system of pipes, channels, basins, and storage elements such as detention ponds to determine peak flows and volumes.

6.4.6 FEMA Flows

FEMA has established regulatory 100-year peak flow rates for some of the larger streams within the Town. Where these flow rates have been established, the Town Engineer should be consulted to determine the validity of these flow rates as it is not uncommon for them to be outdated. In some instances, a new hydrologic study may be required to evaluate current peak 100-year flow rates along FEMA-regulated streams. This study would then be submitted to FEMA for review and approval to revise the regulatory flow rates. The 2018 Breckenridge Flood Damage Prevention Ordinance presents the Town's requirements for work near FEMA floodplains and shall be consulted prior to design of any work near a FEMA floodplain.

6.5 OPEN CHANNELS

Open channel flow occurs when water has its surface exposed to the atmosphere. Open channels can be natural waterways, canals, ditches, swales, culverts, flumes, and gravity pipes that are not flowing full. Once water fully fills a closed conduit, flow in that conduit becomes pressure flow. This section discusses types of open channel flow and gives general design guidance for open channels including roadside ditches. Any work in natural channels may be subject to FEMA floodplain regulations. Chapter 2 (Section 2.4) discusses the permits that will be required for work in open channels as well as the applicability of the 2018 Breckenridge Flood Damage Prevention Ordinance to work in open channels.

For a more thorough discussion of open channel design principles, the user is encouraged to review the most recent version of the Urban Storm Drainage Criteria Manual (USDCM) by the Mile High Flood District (MHFD).

6.5.1 Open Channel Hydraulics

The hydraulics of an open channel can be complex, ranging from steady state uniform flow to unsteady, rapidly varied flow. Most drainage design involves uniform, gradually varied, or rapidly varied flow states. Steady uniform flow occurs when the depth of flow remains constant. The calculations for both uniform and gradually varied flow are relatively simple and assume parallel streamlines. In contrast, rapidly varied flow calculations, for hydraulic elements like hydraulic jumps and flow over spillways, have solutions that are generally empirical in nature. This section presents basic equations and computational procedures for uniform, critical, gradually varied, and rapidly varied flow for hydraulic jumps and weirs.

6.5.1.1 Uniform Flow

Open channel flow is considered uniform if the depth of flow is the same at every section of the channel. For a given channel geometry, roughness, discharge, and slope, there is only one possible depth for maintaining uniform flow. This is called the normal depth. For a prismatic channel cross section, the water surface will be parallel to the channel bottom during uniform flow. Uniform flow rarely occurs in nature and is difficult to achieve, even in a laboratory. However, channels are designed by assuming uniform flow as an approximation that is adequate for planning purposes.

Calculations for normal flow depth shall be based on Manning's equation shown as Equation 6.8. A spreadsheet can be developed for this equation as an effective tool for quick analysis.

$$Q = \frac{1.49}{n} A^{5/3} P^{-2/3} \sqrt{s} = \frac{1.49}{n} A R^{2/3} \sqrt{s} \tag{6.8}$$

Where:

Q = flow rate (ft^3/s)

n = Manning's roughness coefficient (see Table 6.8)

A = area (ft^2)

R = A/P = hydraulic radius (ft)

P = wetted perimeter (ft)

S = Channel or pipe slope (ft/ft)

Open channel flow velocity can be more easily calculated by rearranging Equation 6.8 to yield Equation 6.9. Equation 6.9 may be used to calculate travel time for the Rational Method. It may also be used to design channel revetment.

$$V = \frac{1.49 R^{2/3} S^{1/2}}{n} \tag{6.9}$$

Where:

V = average velocity (fps)

For prismatic channels with uniform flow, the slope of the energy grade line (EGL), hydraulic grade line (HGL), and bottom of channel are assumed to be equal. Table 6.8 provides recommended Manning roughness coefficients for various channel linings and conditions. As channel roughness increases, a given flow rate will have a greater depth and slower velocity. Decreased roughness results in shallower depth and faster velocity. Selection of roughness coefficients for both the main channel and the overbanks is a critical part of the design and evaluation of an open channel, but it is also based on engineering judgement. Two engineers may look at the same natural channel and assign different Manning's n values.

Manning's n values may be selected to be slightly conservative for the variable being calculated. For example, when calculating a channel velocity, a slightly lower Manning's n value will result in a slightly higher calculated velocity, ensuring that channel revetment is adequately sized. When calculating channel capacity, a slightly higher Manning's n value will result in a slightly larger channel cross section, offering a factor of safety for channel sizing. Another factor to consider might be the anticipated long-term condition of the channel, as Manning's n values are prone to increasing if the channel is not properly maintained. Ultimately the Manning's n value selected by the design engineer must be defensible given the values presented in Table 6.8.

Table 6.8. Manning's Roughness Coefficients for Channels

Type of Channel & Description	Manning's n	Type of Channel & Description	Manning's n
Excavated or Dredged		**Lined or Built-Up Channels**	
Earth, straight & uniform		Riprap	
Clean, recently completed	.018	Riprap	Eq. 6.12
Clean, after weathering	.022	Concrete	
Gravel, uniform section, clean	.025	Trowel Finish	.013
With short grass, few weeds	.027	Float Finish	.015
Earth, winding & sluggish		Gunite, good section	.019
No vegetation	.025	Gunite, wavy section	.022
Grass, some weeds	.030	Concrete Bottom	
Dense weeds in deep channels	.035	Dressed stone in mortar	.017
Earth bottom & rubble sides	.030	Random stone in mortar	.020
Stony bottom & weedy banks	.035	Dry rubble or riprap	.030
Cobble bottom & clean sides	.40	Asphalt	
Dragline-excavated or dredged		Smooth	.013
No vegetation	.035	Rough	.023
Light brush on banks	.040	Gravel bottom with sides of	
Rock cuts		Formed concrete	.020
Smooth & uniform	.035	Random stone in mortar	.013
Jagged & irregular	.040	Dry rubble or riprap	.016
Channels not maintained, weeds & brush		Grassed	
Dense weeds	.080	Short grass prairie	0.15
Clean bottom, brush on sides	.050	Dense grasses	0.24
Natural Channels		Range (natural)	0.13
Natural channels, good condition	0.025	Wooded	
Natural channels, stones & weeds	0.035	Light underbrush	0.4
Natural channels, poor condition	0.06	Dense underbrush	0.8

References: Chow, V.T., Open Channel Hydraulics (1959), NRCS (1986)

For riprap lined channels, Equation 6.10 shall be used to calculate Manning's n value.

$$n = 0.0395 D_{50}^{1/6} \qquad (6.10)$$

Where:

D_{50} = mean riprap stone size (ft)

6.5.1.2 Critical Flow

Critical flow in an open channel is characterized by the following conditions:

1. The specific energy is at a minimum for a given discharge.
2. The discharge is at a maximum for a given specific energy.
3. The specific force is at a minimum for a given discharge.
4. The velocity head is equal to half the hydraulic depth in a channel with a minimal slope.
5. The Froude Number (Fr) is equal to 1.0.

When critical flow exists for uniform flow, the channel slope is at the critical slope. A slope flatter than critical will cause subcritical flow and result in a Froude number smaller than 1.0. A slope steeper than critical will cause supercritical flow and result in a Froude number larger than 1.0. When flow is at or near critical, it is unstable because minor changes in specific energy, such as from channel debris, will cause a major change in depth. Equation 6.11 should be used to calculate the Froude Number for all open channel designs.

$$\mathrm{Fr} = \frac{\mathrm{v}}{\sqrt{\mathrm{g}D_\mathrm{h}}} \tag{6.11}$$

Where:

Fr = Froude number (dimensionless)

v = velocity (ft/s)

g = gravitational acceleration (32.2 ft/s^2)

D_h = hydraulic depth, A/T (ft)

A = channel flow area (ft^2)

T = top width of flow area (ft)

6.5.1.3 Gradually Varied Flow

Gradually varied flow is most often seen as backwater created by culverts, inlets, and channel constrictions. For these conditions, flow depth will be greater than normal depth in the channel and the water surface profile must be computed using a backwater technique—either the direct step or the standard step method. The direct step method is best suited to the analysis of simple prismatic channels, whereas the standard step method is best suited for irregular or nonuniform cross-sections.

Hydrologic Engineering Center's River Analysis System (HEC-RAS), developed by the U.S. Army Corps of Engineers, is recommended for calculating water surface profiles in the Town of Breckenridge. If a designer would like to compute water surface profiles by hand, the methodology for using both the direct-step and standard-step methods can be found in the HEC-RAS Hydraulic Reference Manual (Brummer, 2016), as well as in Open Channel Hydraulics (Chow, 1959).

6.5.1.4 Rapidly Varied Flow

Rapidly varied flow has a very pronounced curvature of the streamlines. The change in curvature may be so abrupt that the flow profile is virtually broken, resulting in high turbulence. Common instances of rapidly varied flow include weir flow, orifice flow, and hydraulic jumps. Only hydraulic jumps will be discussed in this section. In the Town, weir and orifice flow are used almost exclusively for detention pond outlets and will be discussed in Section 6.9.

Hydraulic jumps may occur at grade control structures, inside storm drains or culverts, and at the outlet of a spillway and can be very erosive and affect hydraulic capacity. For grassed channels, the forces from a hydraulic jump must be controlled to prevent serious damage. Drops or other grade control structures can be used to direct the jump to an area specifically designed to resist the forces that come with it.

Jump locations within storm drain systems can be approximated by intersecting the energy grade line of the supercritical and subcritical flow reaches. There is little threat of damage to storm drains, but pipe capacity may be impacted. The effect on pipe capacity can be determined by evaluating the energy grade line and accounting for the energy lost by the jump. In general, for Froude Numbers less than 2.0, energy loss is less than 10%. For long concrete boxes, the concerns of the jump are the same as for storm drains. However, the jump can be adequately defined for box conduits and for spillways using the jump characteristics of rectangular sections. These Standards do not include a detailed evaluation of hydraulic jumps, but the USDCM has procedures that can be used. Calculations must be included with the required submittals in accordance with Chapter 2.

6.5.2 Open Channel Design

The design standards for all open channels in the Town, except for roadside ditches addressed in Section 6.5.3, are those in the most recent edition of the USDCM. The design standards in the USDCM include channel centerline alignment and cross section layout, hydraulic analysis, and using rocks and boulders for protection from erosion. The design process for an open channel can be somewhat circular because of a wide range of options available for materials, typical cross section, channel slope, and the frequency and height of drop structures.

6.5.2.1 Channel Selection Factors

Each type of channel must be evaluated for hydraulic, structural, environmental, sociological, maintenance, economic, and regulatory factors. Table 6.9 summarizes the multi-disciplinary factors that should be used when selecting the channel that is most suitable for a specific site.

Table 6.9. Factors to Consider for Channel Design

Hydraulic	Structural	Environmental	Sociological	Maintenance	Regulatory
Topography	Cost	Habitat	Pedestrian	Lifespan	Federal
Capacity	Shear Stress	Water Quality	Recreation	Accessibility	State
Slope	Momentum	Traffic Patterns	Demographics	Repair	Local
Offsite Drainage	Seepage & Uplift	Aesthetics	Social Patterns	Reconstruction	Right-of-Way
Basin Sediment Yield	Material Availability	Wetland Mitigation		Maintenance Activities	
	Haul Off Site	Green Area Need			

6.5.2.2 General Design Guidelines

Except for roadside ditches and the additional criteria in these Standards, all open channel improvements shall be designed in accordance with the latest versions of the Open Channels, Hydraulic Structures, and Stream Access and Recreational Channels chapters of the USDCM.

All open channels within the Town shall be designed to convey both the minor and major design storms in a subcritical flow condition with a Froude number of less than 0.80. The major storm shall not result in a flow depth greater than 4.0 feet at any point along the channel reach. All open channels shall also be designed with public safety in mind and adequate maintenance access shall be provided.

Natural channels and grass-lined channels are preferred, and concrete-lined and riprap-lined channels are discouraged. Channel improvements that drastically change the look, shape, lining, alignment, or flow characteristics of the existing channel should be avoided. Improvements to natural channels should strive to maintain the capacity and alignment of the existing channel. In the event an entirely new channel is required, such as through a new development, it should closely mimic natural channels in the surrounding area with the same capacity.

The design components that have the greatest potential effect on the performance and cost of the improvements should be evaluated early on to guide the design process. High cost items include riprap channel linings and boulder drop structures, and the engineer should strive to design open channels to minimize the need for and use of these elements. Consideration should also be given to long term maintenance and repair costs.

6.5.2.3 High Gradient Channels

In mountainous areas, natural channels can have steep grades with cobble or rock along their bottoms. While uniform flow calculations with standard channel roughness values generally predict supercritical flow, field observations show that these channels are often protected by natural armoring. Field investigations have resulted in procedures for estimating hydraulic roughness for these streams that result in lower calculated velocities than those obtained with the Manning's equation using a uniform roughness coefficient. The designer is encouraged to review Determination of Roughness Coefficients for Streams in Colorado by Robert D. Jarrett in cooperation with the Colorado Water Conservation Board.

Equation 6.12 may be used as an aid in predicting the roughness coefficient of a high-gradient channel provided the following conditions are met.

1. The channel must be a natural channel that has a relatively stable bank material and a cobble or boulder bed material.
2. The channel friction slope must be between 0.01 and 0.04 feet per foot and the hydraulic radius must be between 0.5 and 7 feet.
3. The channel must not be affected by backwater.

$$n = 0.39 S_f^{0.38} R^{-0.16} \tag{6.12}$$

Where:

n = Manning's roughness coefficient

S_f = channel friction slopes (ft/ft)

R = hydraulic radius, A/P (ft)

Additionally, while mountainous channels may have high average grades, they have often achieved this by cutting very steep drops interspersed along what are otherwise flatter reaches. The analysis of a natural mountain stream requires a careful topographical investigation. The hydraulic model must recognize that friction slope, hydraulic radius, and n value may change frequently along the length of the channel and take this into account by dividing the channel into reach lengths of reasonably uniform discharge, depth, slope, and channel and floodplain geometry. Determination of Roughness Coefficients for Streams in Colorado gives an in-depth discussion of suggested reach lengths and subdivision of cross sections to be used in the hydraulic model.

Natural channels have typically reached a reasonable state of equilibrium based on the amount of peak runoff they are accustomed to receiving. Although a new development may not encroach on the floodplain of a natural channel, it is also critically important that it does not increase the peak runoff the channel receives. This could easily cause erosion of the channel and require costly remediation.

If site conditions suggest use of Equation 6.12 might be appropriate, the designer shall consult with the Town to confirm its applicability and discuss any additional specific site concerns regarding the stability of the natural channel. Development shall be planned around natural channels so they remain in place in their natural alignment. If a Developer believes there is a benefit to realigning a natural channel, the proposed modifications shall be submitted to the Town Engineer for review. If the average slope of an existing natural channel through a development is greater than 1.0%, the existing natural channel should not be reconfigured either in horizontal or vertical alignment to suit development unless a geotechnical investigation identifies that the channel is unstable in its current condition. Rather, development should be planned to accommodate the location of the natural channel and its existing floodplain.

6.5.2.4 Ecological Channel Design Guidelines

The USDCM puts a considerable amount of emphasis on preserving and restoring natural stream corridors. The Town of Breckenridge strongly supports using ecological concepts to preserve and restore local channels. Ecological channel design includes bioengineering practices that utilize vegetation in a combination with natural structural measures to stabilize and protect stream banks while providing habitat.

Ecological channel design can have numerous public and environmental benefits when applied in an appropriate location, but care should be taken in selecting the location and completing design calculations to ensure an ecological channel design will hold up under the stream forces it is intended to withstand. Numerous types of bioengineering components can be used. Table 6.10 lists some of the potential advantages and disadvantages of an ecological channel design, as opposed to more traditional riprap and concrete design concepts. The potential for every channel restoration project to include ecological components shall be examined and discussed with the Town.

Table 6.10. Ecological Channel Design Advantages and Disadvantages

Advantages	Disadvantages
Environmental clearances (may facilitate permits)	Potentially more expensive
Aesthetically pleasing	Specialized vegetation
Fish passage	Additional maintenance required
Habitat for fish, birds, and macroinvertebrates	Susceptible to failure during larger storms
Open space creation and preservation	May require a larger footprint
Water temperature moderation	Specific hydrologic conditions required
Water quality enhancement	

Ecological channel design may be applied when the overall channel design is firmly rooted in engineering principles and when the following conditions are met:

1. Hydrologic conditions are favorable for establishment and successful growth of vegetation.
2. Designs are conservative in nature, and bioengineered features are used to provide redundancy.
3. Maintenance responsibilities are clearly defined.
4. Adequate structural elements are provided for stable conveyance of the major storm runoff.
5. Species are selected based on individual site characteristics.

It is important to note that bioengineered elements are commonly designed to withstand flows from more frequently occurring storms. Design events are typically between the 1.5-year to 10-year storm, with the 100-year storm occasionally being a consideration. While designing for a larger event is prudent, stability during such events may often be achieved by traditional engineering techniques because bioengineered elements may not remain stable above a certain threshold. If stability is critical at a given location, such as at bridge piers, bioengineering measures may not be enough without the addition of traditional engineering techniques. Bioengineering techniques can be incorporated into almost all traditional engineering projects, often to great ecological benefit. The design approach must balance ecological function with the need for channel stability when selecting a design discharge. Both the Town and the design engineer should discuss and agree upon the various ecological and hydraulic criteria the design will meet.

The key elements to consider in an ecological channel design include hydrology, hydraulics, geomorphology, physiochemistry, and biology. Each of the following elements should be addressed when designing the channel:

1. Future hydrologic changes associated with urbanization
2. Channel stability
3. Hydrology to support vegetation
4. Supplemental structural measures

The USDCM should be reviewed as part of the design process because it offers valuable guidance on typical minimum standards. The Natural Channel Design Review Checklist published by the US Fish and Wildlife Service should also be reviewed to ensure that all appropriate parameters have been considered.

No specific criteria or design guidance is included in these Standards because each site is unique and will require a solution based on the characteristics of and goals for each site. However, there are publications that offer guidance on ecological channel design, and these should be consulted to ensure the design will stand up to the chosen design hydraulic event. The Technical Supplements contained in *Stream Restoration Design* (National Engineering Handbook 654) (NRCS, 2007) offer extensive and detailed guidance on the physical design of ecological channels. Specifically, Technical Supplement 14, letters I through O, offer design guidance and equations for soil bioengineering, using large woody material for habitat and bank protection, vegetated rock walls, fish passage, and fish lunkers, among many other components.

Monitoring and maintenance should be performed throughout the life of the ecological channel design. The following list consists of four periods when a bioengineered structure is most at risk:

1. Immediately after construction
2. During the driest time of the year
3. During high magnitude discharge events
4. When a shift in plant community occurs away from plants chosen for biostabilization.

6.5.2.5 Revegetation

To achieve the highest likelihood of establishment of the specified vegetation, a 3-year maintenance plan from a certified landscaping company that understands native vegetation is required. The Town shall be consulted to provide a site-specific seed mix for each project. Plantings need to be completed in the fall or late winter to provide the best odds of establishment. Depending on the site, irrigation may also be required. Other techniques to improve the odds of successful vegetation establishment are in Chapter 7.

6.5.3 Roadside Ditch Design

Much like the design of any open channel, design of roadside ditches is a balance of several design components, including velocity, capacity, available right-of-way, slope, and cross-sectional geometry. Chapter 5 discusses several constraints and factors to consider when laying out a roadside ditch. The capacity requirements of a roadside ditch are based on the roadway encroachment criteria discussed in Section 6.6.

This section discusses permissible velocities and Froude numbers for a roadside ditch. Roadside ditch hydraulic calculations will be completed using Manning's equation. The Manning's roughness coefficients for calculating velocity, Froude number, shear stress, and capacity included in Table 6.8 will be used for all roadside ditch calculations. The designer should note that if a ditch is expected to be vegetated there is a much higher potential for erosion until revegetation is complete. The use of erosion control measures such as turf reinforcing mat prior to revegetation will minimize this potential.

Roadside ditch flow with design depths less than or equal to 1.0 feet have no Froude number or velocity limitations. For ditch flow depths greater than 1.0 feet, velocity shall not exceed 7.0 feet per second, and the Froude number shall not exceed 0.8. These criteria are shown in Table 6.11.

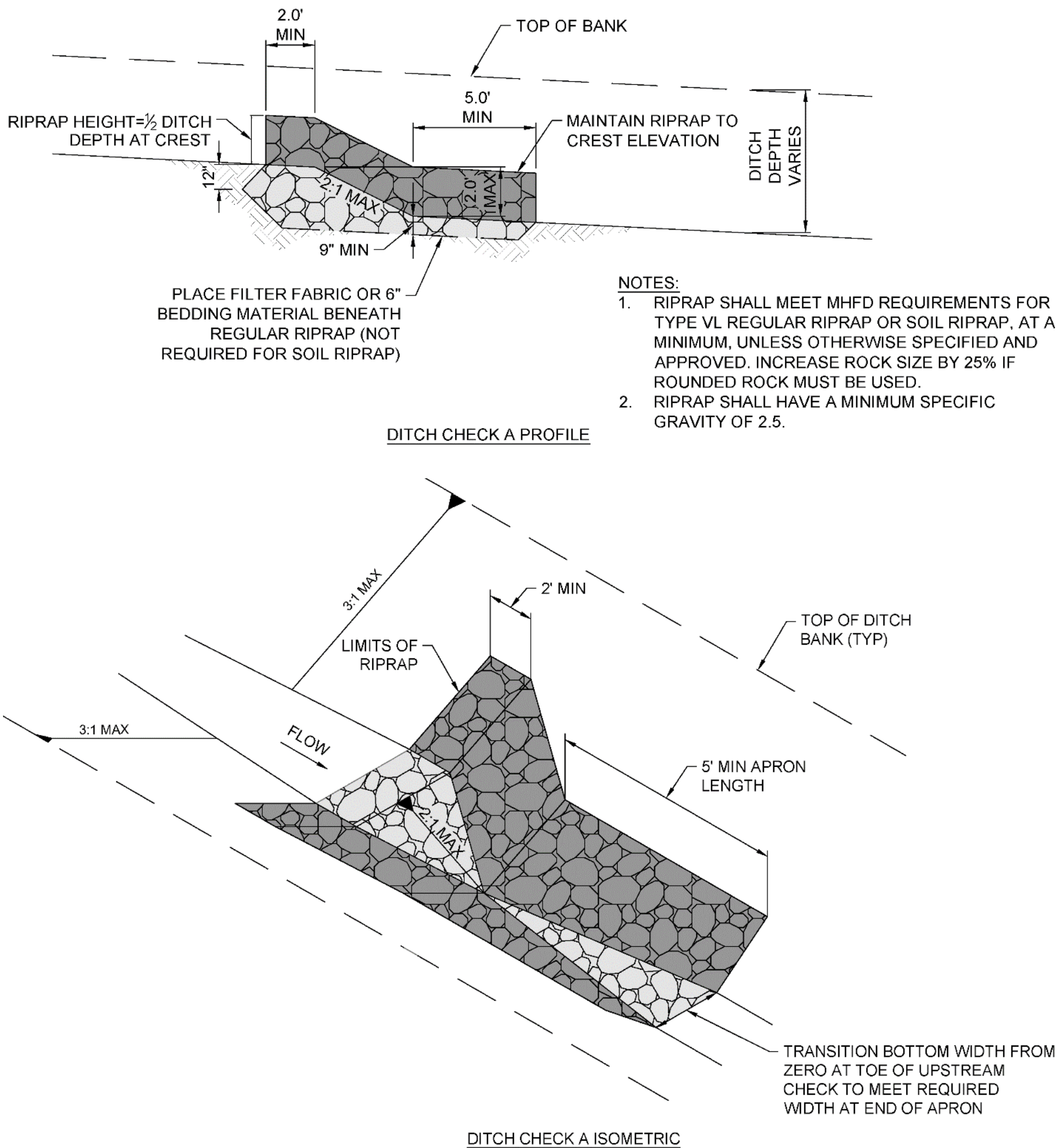
Table 6.11. Allowable Velocity and Froude Number for Roadside Ditches

Design Component	Maximum Allowable Values	
	Flow Depth ≤ 1.0 feet	Flow Depth > 1.0 feet
Velocity	No maximum	7 ft/s
Froude Number	No maximum	0.8

It is preferable that roadside ditches have side slopes no steeper than 3H:1V. If right-of-way is constrained, the ditch slope may be steepened to 2H:1V. Slopes steeper than 3H:1V shall be stabilized with erosion netting or stabilized with a method approved by the Town Engineer. Where right-of-way allows, roadside ditches will have a flat bottom at least two feet wide, but ditches may be V-shaped if right-of-way is constrained, with approval of the Town Engineer. Roadside ditches should ideally be designed as grass-lined channels without the need for riprap revetment. If riprap revetment is required, buried soil riprap shall be used in accordance with the design guidance in the USDCM and the ditch shall be revegetated.

Where roadway slopes are too steep to accommodate a ditch design that will meet velocity or Froude number criteria, a flattened ditch slope may be used with ditch checks placed at intervals to make up for grade discrepancies. An example of a ditch check is shown in Figure 6.2. In no case shall a roadside ditch have a slope steeper than 4%, regardless of whether allowable velocity and Froude number values are met.

Figure 6.2. Ditch Check Schematic



6.6 STREETS AND ROADSIDE CONVEYANCE

The primary function of public streets is the movement of traffic. The use of streets as part of the drainage system must be limited to prevent interference with traffic. Streets also typically convey runoff collected on the street surface as well as from some limited portion of the surrounding area. Streets must be capable of conveying that runoff to either a storm drain or open channel system. The drainage system in many parts of the Town is an open channel system with roadside ditches, which are discussed in Section 6.5. In dense and newly developed areas, an enclosed storm drain system is more appropriate, as discussed in Section 6.7.

This section presents the limitations on stormwater in public streets regardless of the type of roadside conveyance used. Limitations are established with roadway function and public safety in mind and are presented in terms of ponding depths at the curb face, the depth of flow permitted at the roadway crown, and the width of roadway that must remain clear during a storm event. Criteria vary based on the design storm and the roadway classification. When runoff in the street exceeds the allowable limits, a storm drain system, an open channel, or a combination of both is required to convey the excess flow. In all cases, the most stringent criteria will apply.

6.6.1 Allowable Flow Depth and Spread

Each street or roadway in the Town of Breckenridge is classified based on its role in connecting and providing access within and between various land uses. These classifications are available from the Town. The extent to which runoff from the minor or major design storm may encroach onto a roadway is based on that roadway's classification. Limiting the encroachment of stormwater onto a roadway section is the primary criteria by which public safety is maintained during a storm event.

Although many roads will utilize a roadside ditch to convey stormwater along the road, some will have a curb and gutter section. Using a curb and gutter or roadside ditch to convey flow along a street does not affect encroachment criteria because safety concerns remain the same for all types of roadways. The allowable encroachment onto the roadway for each roadway classification is presented in Table 6.12. These criteria may include the width of the roadway that must remain free of water or the allowable depth of flow at certain points along the roadway cross section. Curb overtopping criteria applies only to streets with a curb and gutter section.

In no case shall any roadway improvement, reconstruction, or expansion cause more flow encroachment on a parcel or structure outside the public right-of-way than currently exists. These criteria apply to roads with roadside ditches, curb and gutter sections, and culvert crossings. They do not apply to bridge crossings. Criteria for bridges are included separately in Section 6.8. Street inundation during both the minor and major storms must be analyzed for compliance with the criteria in this section.

Table 6.12. Maximum Allowable Flow Depth and Encroachment

Roadway Classification	Minor Storm Encroachment	Major Storm Encroachment
Arterial	10 feet clear each way; No curb overtopping; No encroachment on adjacent property	15 feet clear in center; Ponding below finished floor of all occupied structures
Major Collector	10 feet clear in center; No curb overtopping; No encroachment on adjacent property	Allowable depth at crown = 3 inches; Ponding below finished floor of all occupied structures
Minor Collector	10 feet clear in center; No curb overtopping; No encroachment on adjacent property	Allowable depth at crown = 6 inches; Ponding below finished floor of all occupied structures
Local	Flow may spread to crown; No curb overtopping; No encroachment on adjacent property	Allowable depth at crown = 9 inches; Ponding below finished floor of all occupied structures

Where roadside ditches are used to convey flow, they shall have sufficient capacity to meet the maximum encroachment and flow depth criteria in Table 6.12. Ditch geometry requirements are in Section 6.5 Open Channels.

6.6.2 Minimum and Maximum Grades

The minimum concrete or paved gutter grade shall be 0.5%. The minimum open channel grade shall be 1.0%. Maximum grades in roadside ditches shall meet criteria in Section 6.5 Open Channels.

6.6.3 Cross Street Flow

For all roadway classifications, flow in cross pans shall not exceed the limits set forth in Table 6.12.

6.6.4 Calculations

For roadway drainage, the minor and major storm must be evaluated separately for each side of the street using a Manning's n value of 0.016 for the gutter and street flow areas and a Manning's n value of 0.025 for sidewalk and grass areas, if needed. When a roadside ditch is used, a Manning's n value must be assigned based on the ditch lining.

6.6.4.1 Streets with Curb and Gutter

Design calculations can be performed manually, but this section assumes UD-Inlet will be used to calculate street capacity for those streets with curb and gutter. The USDCM provides additional details on the equations and methodologies that have been incorporated into the UD-Inlet spreadsheet, and guidance in the most recent version of the USDCM can be used for manual design. Note that as the MHFD updates their design spreadsheets they may change the prefix from UD to MHFD. The most recent version of UD-Inlet or MHFD-Inlet should be used.

A reduction factor from Figure 6.3 must also be applied to streets with curb and gutter, which will reduce effective street capacity. The reduction factor accounts for the increased effect on capacity that items like debris and parked cars can have at steeper roadway slopes. UD-Inlet includes these reduction factors automatically.

Street capacity calculations for the minor and major event shall be based on the following procedure:

1. Calculate the theoretical street capacity based on the allowable spread in Table 6.12.
2. Calculate the theoretical street capacity based on the allowable depth in Table 6.12.
3. Apply the appropriate reduction factor from Figure 6.3 to the theoretical flow rate based on allowable depth.
4. The lesser value from steps 1 and 3 is the allowable street capacity.
5. An inlet should be added whenever the runoff reaching the street exceeds the allowable street capacity for the major or minor event.

6.6.4.2 Streets with Roadside Ditches

Design calculations for streets with roadside ditches can be completed with a spreadsheet using Manning's equation in accordance with the design procedures in Section 6.5 Open Channels. The flow areas for the roadway and ditch must be separated so the appropriate Manning's n values can be used for each.

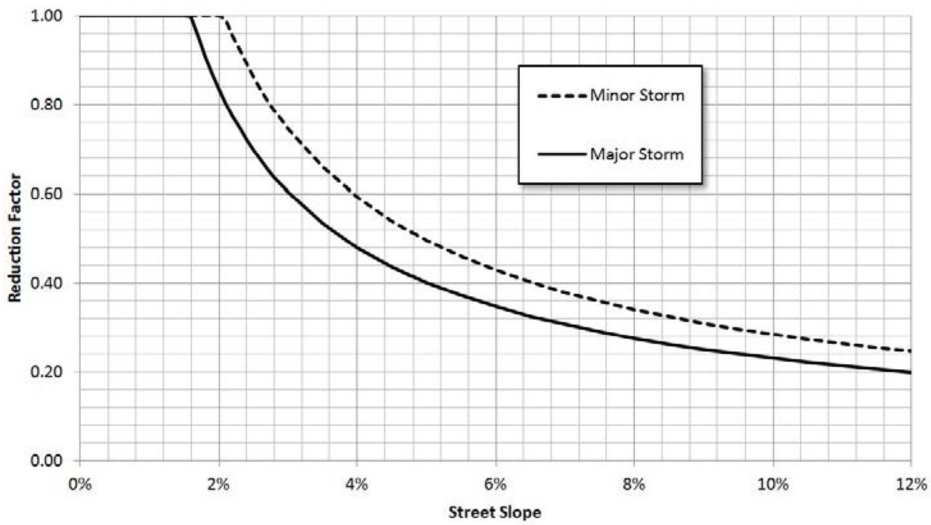


Figure 6.3. Reduction Factor for Gutter Flow
(UDFCD, 2018)

6.7 STORM DRAIN SYSTEMS

The criteria presented in this section shall be used to design and evaluate storm drain systems in the Town. A storm drain system refers to the system of inlets, pipes, manholes or junctions, outlets, and other appurtenant structures that are designed to collect and convey the initial or minor storm runoff. The storm drain system is a part of the local drainage system, which may also include curb and gutter, streets, roadside ditches, swales, and channels. This section presents both technical criteria and the general procedures for design and evaluation of pipes and inlets. Allowable roadway encroachment is in Section 6.6.

6.7.1 Storm Drain Design Criteria

A storm drain system is required when the allowable street capacity is exceeded during the minor storm event, or as required to eliminate the need for cross pans, or to prevent ponding/icing issues on roads. All criteria and guidelines below apply to the minor storm event unless site conditions offer no viable overflow option for the major storm event. Storm drain systems shall also be required where sump conditions exist and on major collectors and arterials to eliminate cross pans and ponding and icing near intersections.

6.7.1.1 Construction Materials

Pipe materials suitable for storm drains include reinforced concrete and high density polyethylene (HDPE). If the Town Engineer has reason to believe that pipe corrosion may be a problem, the Town Engineer may require a soils report to evaluate the corrosive potential of the soils and groundwater to be determined in the Geotechnical Report.

All pipe joint fillers, sealing compounds, gaskets, and the installation thereof, shall be in accordance with CDOT specifications. Rubber gaskets shall be used at pipe joints where the HGL is five feet higher or more than the pipe crown.

6.7.1.2 Pipe Size

The minimum allowable pipe diameter for storm drains shall be 18 inches for trunk lines and 15 inches for laterals. The minimum inside diameter of all pipes shall be no less than 14 inches for elliptical and arch pipe. In areas where debris, sediment deposition, adjacent wildfire burn area, or freezing are potential problems, the Town Engineer may require larger pipes. There is no maximum pipe size;

however, using multiple smaller barrels in lieu of very large pipes may be physically or economically advisable under some circumstances. For pipes below 5' diameter, a single barrel pipe is preferred over multiple smaller barrel pipes.

6.7.1.3 Horizontal and Vertical Alignment

Storm drains shall be designed and installed with sufficient cover to support an HS-20-44 loading in accordance with the pipe manufacturer's recommendations. Minimum and maximum cover are determined by the size, material, and class of pipe, as well as by the characteristics of the cover material and the expected surface loading. The designer should consult appropriate data sources to determine these values, but the minimum cover in all instances shall be greater than 24 inches of cover.

To prevent freezing issues, the following cover requirements shall be met as well, where feasible. In areas that are regularly plowed, storm sewers shall have a minimum cover of 5 feet. In areas not typically plowed, storm sewers shall have a minimum cover of 4 feet. Less cover may be allowed if winter flows are diverted and an alternate means of flow disposal is provided, such as a dry-well. If utility conflicts or grade restrictions do not allow the minimum values above, additional measures may be required to prevent freezing, including insulation around pipes, slotted pipes, deep inlets that are perforated or bottomless, and other measures as determined by the Town Engineer.

The following resources should be consulted to assist the designer in determining cover requirements:

1. Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, Section 700 (Materials Details)
2. Concrete Pipe Design Manual (ACPA)
3. Handbook of Steel Drainage and Highway Construction Products (AISI)
4. Pipe Manufacturer Specifications
5. Other applicable references

Trench installations, including bedding, shall be in accordance with the most recent edition of the CDOT M&S Standard Plans. In manholes and junction boxes, the lowest inlet pipe invert elevation must be at least 0.2 feet higher than the outlet pipe invert elevation. In cases where inlet pipes are smaller than outlet pipes, the top of the inlet pipes shall be at least 0.2 feet higher than the top of the outlet pipes.

6.7.1.4 Utility Crossings

The Town's required minimum clearance between storm drains and other utilities is 12 inches, regardless of whether the crossing utility is above or below the storm drain. If either the storm drain or crossing utility is encased, the minimum clearance may be reduced to 6 inches. In all cases, backfill material, compaction, and additional protection shall be designed and provided to prohibit settling or failure of either the storm drain or crossing utility.

When storm drains cross above or within 18 inches below water mains, the storm crossing shall be constructed of a 20-foot section of pipe centered on the water main alignment, and the bounding joints shall be encased. Storm drain joints shall also be encased at all locations less than 10 feet horizontally from a water main. Encasement shall be a reinforced concrete collar, 6 inches thick, extended to 12 inches on either side of the joint. The minimum reinforcement shall be a minimum of four continuous #4 bars, equally spaced around the pipe, and tied with #3 bars around the pipe at 8 inches on center.

All work shall be in accordance with these Standards, the Town's Standard Drawings, CDOT M&S Standard Plans, or other approved details, and the design must be approved by both the Town and the utility owner. Utility owners may have more stringent requirements and local utilities shall be consulted to ensure these requirements are met.

6.7.1.5 Inlets and Manholes

The standard inlets permitted in the Town are a CDOT Type 13 combination inlet, a CDOT Type 13 valley inlet, and a CDOT Type C grated inlet. Type 13 combination inlets may also be called a Type 16 inlet. Type 13 combination inlets shall be used with a 6-inch vertical curb and gutter section and installed with a localized depression at least 2 inches below the gutter flowline elevation. Type 13 combination inlets shall be located, at a minimum, just upstream of curb ramps, and never in the ramp itself. Type C inlets shall be used in roadside ditches and installed in accordance with the CDOT standard plans, including creating a sump condition where one does not naturally exist. Type C inlets are not traffic rated and shall not be placed in roadways. Type C inlets may not be placed in sidewalks or other pedestrian routes. Other types of inlets, including those made of PVC, HDPE, or other materials are only allowed in landscaped areas outside of roadway and sidewalk clear zones.

Table 6.13 provides the maximum allowable manhole or junction box spacing for storm drains. Manholes are also required where there is a change in pipe size, vertical or horizontal alignment, elevation, or slope, and where there is a junction of two or more pipes or laterals. All manholes and junction boxes must provide access to the storm drain system for maintenance and inspection. All manhole and junction box inverts shall be formed with a minimum of a half bench to provide more hydraulically efficient flow through the manhole.

Table 6.13. Maximum Allowable Manhole Spacing

Vertical Pipe Dimension	Maximum Manhole or Junction Spacing
15 to ≤ 36 inches	400 feet
> 36 to ≤ 60 inches	500 feet
> 60 inches	750 feet

The required diameter of the manhole barrel is dependent upon the size of the largest pipe connecting to it. Minimum manhole sizes are in Table 6.14 and assume the storm drain alignment passes straight through the manhole with no incoming lateral lines. If a storm drain system changes alignment or must accommodate incoming lateral lines at a manhole, the manhole may need to be larger.

Table 6.14. Manhole Sizing

Maximum Pipe Dimension	Minimum Manhole Size
≤ 24 inches	4-foot diameter
> 24 to ≤ 42 inches	5-foot diameter
> 42 inches	6-foot diameter or box base

6.7.1.6 Capacity and Velocity

Minimum velocities are required in storm drains to reduce sedimentation and promote positive drainage through the pipe at all flow depths. Public and private storm drains shall have a minimum flow velocity of 3 feet per second when normal flow in the pipe is at 0.25D and never be constructed at less than 0.40% slope. Public and private storm drains shall have a maximum flow velocity of 16 feet per second for all storm events, although care should be taken with velocities this high as there is a higher risk for hydraulic jumps and extreme head loss through junctions.

The storm drain system shall be designed to convey the minor storm without resulting in pressure flow, and the energy grade line (EGL) for the minor storm shall be at or below finished grade at all manholes, inlets, or other junctions. Pressure flow during the major storm is discouraged, but if it does occur, it must not create a surcharged condition at any inlet. Where the 100-year hydraulic grade line (HGL) is above any manhole rim, or if any manhole or inlet is in a floodplain, all manhole and inlet covers must be bolted down.

The EGL and HGL for both the minor and major storm events shall be calculated and plotted for all storm drain systems. Hydraulic losses will include friction, expansion, contraction, and junction losses at a minimum. The methods for estimating these losses are presented in the following sections. Manning's n values for capacity and velocity calculations for storm drains shall be the values in Table 6.15. The design of storm drain outlets into open channels, including revetment shall meet the requirements of Section 6.8 for culvert outlets.

Table 6.15. Manning's Roughness Coefficients for Storm Drain Conduits

Pipe Interior	Manning's n
RCP (newer)	0.013
RCP (older)	0.015
RCP (preliminary design)	0.015
Smooth Plastic (HDPE)	0.011

When a planned storm drain system connects directly into the Town's existing storm drain system, an analysis must be provided showing the additional flow from the proposed project does not result in the capacity of the existing storm drain system being exceeded. The requirement for detention in Section 6.9 is intended to facilitate meeting this requirement.

6.7.2 Storm Drain Hydraulics

This section presents the general aspects of hydraulic design and evaluation of storm drains. Hydraulic design calculations can be performed manually with a spreadsheet or by using a computer model. Both methods are briefly discussed below. The user is assumed to possess a basic working knowledge of storm drain hydraulics and is encouraged to review technical literature available on the subject as needed.

6.7.2.1 Manual Calculations

Manual storm drain hydraulic calculations shall be performed in accordance with the HEC-22 (Brown et al., 2013) or the latest version of the USDCM. HEC-22 includes a discussion of both open channel and pressure flow and includes a design example.

Two of the critical design elements of a storm drain system are the HGL and the EGL. The HGL is a line that represents the water surface elevation along an open channel, including open channel flow within a pipe. In pressure flow, the HGL is the level to which water would rise in a vertical tube at any point along the pipe. The EGL is an imaginary line that represents the total energy at any point in the system. Total energy includes elevation head, velocity head, and pressure head and is the HGL plus the velocity head ($V^2/2g$). The total energy at any location equals the energy at any downstream location plus the losses that occur between the two locations.

Losses are typically classified as either friction or form losses. Friction losses occur as water flows along the length of a pipe. Form losses occur at the exit from the system and at junction structures within the system. Because the Town does not allow transitions or bends outside of manholes, form losses will be restricted to exit losses when flow leaves the system, and structure losses, such as through inlets or manholes. These are referred to by HEC-22 as inlet and access hole losses.

6.7.2.2 Computer Model Calculations

Computer models are often used to calculate the HGL and EGL of storm drain systems. The benefits of using a computer model include consistency, speed, and the ability to check the validity of the model with relative ease. One disadvantage of computer modeling is that errors can occur and be hidden when the model user is inexperienced. Three common programs used throughout Colorado include those listed below. Additional software may be used as approved by the Town provided it utilizes industry standard calculation methods:

1. UD-Sewer 2009, a simple and free program developed by the MHFD that is easy to learn. Note that while UD-Sewer is still provided on the MHFD website and may still be used for new projects, the MHFD no longer supports this program.
2. Storm and Sanitary Analysis, a more complex design tool which runs within the AutoCAD Civil 3D design software package by Autodesk.
3. StormCAD, a more complex design tool which runs within the MicroStation design software package by Bentley Systems or within AutoCAD.

This section provides specific guidance for UD-Sewer 2009. The program uses Manning's equation to analyze and size storm sewer systems. The program can also use the Rational Method to calculate runoff, perform HGL and EGL calculations, and provide plots of the storm drain, ground line, HGL, and EGL. The user's manual is embedded in the software, which can be obtained from the MHFD website (https://mhfd.org/resources/software) or via an internet search for "MHFD UD-Sewer."

6.7.2.2.1 Rational Method

UD-Sewer 2009 uses the Rational Method to calculate runoff based on input parameters provided by the user. The user can override Rational Method calculations by manually entering known flows that have been calculated separately; however, values must be entered for Rational Method parameters or the program will give an error.

6.7.2.2.2 Bend and Lateral Loss Coefficients

UD-Sewer 2009 requires bend and lateral loss coefficients for each storm drain segment within a model. Bend and lateral losses both occur at a manhole or inlet junction. Bend losses are the result of the angle between the incoming storm drain and the exiting trunk line at a junction. Lateral losses are the result of turbulence or eddies that occur from lateral flows joining a trunk line. These coefficients are calculated by the program based on user inputs that define the geometry of the system.

To calculate the bend loss coefficient, the user must select the shape of the manhole invert and enter the angle between the incoming and downstream pipe segments. To calculate the lateral loss coefficient, the user must enter the angle between the incoming lateral and downstream trunk line. When entering the angle, the user must select main line or lateral line. Lateral loss is only applied to the main lines of a storm sewer system in UD-Sewer 2009. For all lateral lines, the user should select lateral line and the program will default to zero. If more than one lateral enters a manhole, the user must exercise judgment to determine the appropriate loss coefficient. .

6.7.3 Inlet Hydraulics

This section presents the general procedures for sizing and spacing inlets for a storm drain system. Design calculations can be done manually, but this section focuses on the use of UD-Inlet to calculate street and inlet capacity. The USDCM provides additional details on the equations and methodologies that have been incorporated into the UD-Inlet spreadsheet, and guidance in the most recent version of the USDCM shall be used for manual design. Note that as the MHFD updates their design spreadsheets they may change the prefix from UD to MHFD. The most recent version of UD-Inlet or MHFD-Inlet should be used.

6.7.3.1 Introduction

Inlets on a continuous grade result in uncaptured flow bypassing the inlet and continuing to the next inlet in the system. Sump inlets are located at low points in the roadway vertical alignment which are known as sags or sumps; there is no way for excess water to bypass a sump curb inlet. A sump condition can occur at a change in street grade from positive to negative or at an intersection due to the crown of the cross street.

6.7.3.2 Inlet Capacity

Inlet capacity may be calculated using the UD-Inlet spreadsheet developed by the MHFD. UD-Inlet is an Excel-based program that calculates both street and inlet capacities based on several parameters entered by the user. In general, the procedure consists of defining the amount and depth of flow in the gutter and determining the theoretical flow interception by the inlet. The calculations within the spreadsheet program are based on physical research completed at Colorado State University. The most recent version of UD-Inlet can be obtained via an internet search for “UD-Inlet MHFD” or from the MHFD website (https://mhfd.org/resources/software).

Information required by the UD-Inlet spreadsheet includes design flow; height of curb; distance from curb face to street crown; gutter width; street cross and longitudinal slopes; gutter cross slope; Manning’s n for the street; maximum allowable spread from gutter flow line; maximum allowable depth at gutter flow line; and allowable flow depth at the street crown. Additionally, if flow is allowed behind the curb, the allowable spread width, side slope, and Manning’s n behind the curb must be entered. The spreadsheet can use the Rational Method to calculate a design flow at the inlet or will accept a flow entered by the user. If the inlet receives bypass from an upstream inlet, the bypass flow can be entered or referenced from another UD-Inlet worksheet. Default clogging factors included in the UD-Inlet spreadsheet shall be used to account for potential debris clogging, pavement overlaying, and varying design assumptions.

6.7.3.3 Continuous Grade Condition

The capacity of an inlet on grade is dependent on street slope, depth of flow in the gutter, height and length of curb opening, street cross slope, and the amount of local inlet depression. Cost effective inlet design allows for some bypass. The amount of bypass or carryover flow must be included in the drainage facility evaluation as well as in the design of the inlet.

6.7.3.4 Sump Condition

Due to frequent freezing conditions and the associated hazards, sump conditions will only be allowed where no practical alternatives for grading and drainage exist. Where a sump condition is unavoidable, sump inlets shall be sized to have twice the capacity as otherwise required by these Standards to decrease the likelihood of ice buildup preventing the inlet from functioning.

6.7.3.5 Inlet Spacing

The optimum spacing of storm inlets is dependent upon several factors, including traffic requirements, contributing land use, street slope, allowable street capacity, and distance to the nearest outfall system. The suggested sizing and spacing of the inlets is based on an ideal interception rate of 70% to 80%. This spacing has been found to be more efficient than a spacing that will accomplish a 100% interception rate; although, the downstream-most inlet will still need to be designed to intercept 100% of the flow.

Inlet spacing is typically an iterative process, and the designer may have to move inlet locations multiple times before determining the appropriate spacing to meet design criteria and maintain efficiency. After initial inlet locations are determined, the designer should recalculate the peak flow to each inlet and check that the allowable street capacity has not been exceeded at any location. If the actual flow is less than the allowable street capacity, inlets may be spaced further apart to prevent overdesign of a system. Locating inlets is a balance between meeting criteria and efficient design. It is not usually possible to have optimum inlet spacing throughout an entire storm drain system The inlets must be spaced so that no portion of a roadway exceeds the spread criteria of this chapter.

6.7.3.6 Inlet Grates

All grates used on storm inlets in the Town will be bicycle-safe grates in accordance with the most recent version of the AASHTO Guide for the Development of Bicycle Facilities. Grates shall be Type L vane grates or approved equal style meeting AASHTO bicycle and ADA requirements. Grates shall be cast iron and rated to withstand HS-20-44 loading.

6.7.4 Design of a Storm Drain System

This section presents the general procedure used to design a storm drain system from preliminary through final design. A typical local drainage system consists of flow in the storm drain and allowable flow in the gutter and street. These flows are ultimately discharged to a larger drainage system or an open channel with capacity for a much larger event.

6.7.4.1 Preliminary Design

The preliminary design of the storm drain system begins after a preliminary development plan has been prepared that delineates the general development areas, major drainage paths, and drainage outfall locations. Allocation of space for drainage facilities and considerations shall be incorporated into the preliminary development plan. The drainage engineer must have input into the development plan to ensure proper drainage planning.

1. The first step in any drainage project is the collection of basic data. Information typically required includes:
    a. Topographic maps of the development and drainage basins that show existing and proposed roadways, existing and proposed land uses, major drainage features such as creeks and streams, development area, and property boundaries
    b. Typical street cross sections
    c. Preliminary grading information, such as contours, profiles, and control elevations
    d. Soils information
    e. Existing and proposed utilities
    f. Existing irrigation and raw water facilities and requirements for maintaining facilities
    g. Rainfall information
2. Perform the hydrologic evaluation of the basin(s) for both the minor and major storms, typically using the Rational Method. Divide each basin into smaller subbasins and calculate the peak design flow for each hydrologic point of interest or potential inlet location. The degree of basin subdivision will depend on the detail of information available and the experience of the licensed professional drainage engineer.
3. Complete preliminary sizing for the minor storm. Beginning at the upper end of the basin, calculate the flow in the street until the allowable capacity of the street as calculated in Section 6.6 matches the design runoff. The storm drain system will typically start at this point. Removal of all street flow by inlets is not required, except at sump locations, and is typically not

economical. The sum of the flow in the storm drain and the street must be less than or equal to allowable capacity.

4. Assign a diameter, pipe material, and slope for preliminary sizing. Manning's n values should be those in Table 6.15. A profile may be required to check for utility conflicts or to confirm compatibility with the receiving drainage system. The preliminary vertical alignment should not be steeper than the proposed street grade. The designer should also be aware of existing utility locations, especially when crossing water and sanitary main and service lines.
5. After sizing the system for the minor storm, route the major storm through the system and evaluate the results. The combined total of the allowable street capacity and the storm drain capacity during the major storm should equal or exceed the 100-year runoff. A plan and profile of the pipes and minor and major storm EGL and HGL is required. If the combined allowable capacity is less than the design flow, some or all the following actions may be taken:
   a. Increase storm drain sizes and/or the number and size of inlets
   b. Increase street grade within acceptable limits or revise street cross-sectional geometry to allow additional capacity
   c. Provide additional onsite detention within the development to decrease peak flow.
6. Evaluate the preliminary design for costs and benefits. The impact of the system on downstream properties must be evaluated and mitigated as needed.

6.7.4.2 Final Design

Final design consists of final revisions to the storm drain system model and preparation of plans, profiles, and specifications for the storm drain system in enough detail for construction. Basic data, hydrologic analysis, and inlet sizing performed during preliminary design should be reviewed and verified. Drainage subbasin boundaries should be confirmed or revised as necessary, and design peak flows should be recalculated. The pipe and inlet sizes and locations are finalized while accounting for final street and storm drain grades, locations of existing and proposed utilities, and the design of the major drainage system. The EGL and HGL should be revised with updated energy losses at manholes and any other structures.

6.8 CULVERTS AND BRIDGES

Culverts and bridges convey surface water through or beneath an embankment such as a roadway, railroad, or canal. The size, alignment, and support structures of a culvert or bridge directly affect the capacity of the drainage system. An undersized culvert or bridge will force water out of the channel and cause flooding and damage. Culverts and bridges may significantly influence upstream and downstream flood risks, floodplain management, and public safety.

The criteria presented in this section shall be used to evaluate and design culverts and bridges in the Town, regardless of whether they are located within public right-of-way. The review of all submittals will be based on the criteria in this section. Stormwater crossings of CDOT roadways may have additional requirements.

6.8.1 Culvert Design Standards

Culverts shall be designed and constructed to the following standards. All proposed culverts, regardless of whether they are in public right-of-way, are subject to review and approval by the Town Engineer.

6.8.1.1 Materials and Structural Design

Allowable materials for culverts include HDPE and reinforced concrete. The culvert materials and joints shall meet the most recent versions of the standards listed in Table 6.16 for each type of culvert.

Each culvert installation shall be designed to maintain its full shape and function under an HS-20-44 loading in accordance with the design procedures in the latest edition of the AASHTO Standard Specifications for Highway Bridges, or appropriate ASTM standard, and with the pipe manufacturer's recommendations. For roadway crossing culverts, the minimum cover shall be 24 inches measured from the top of the pavement. For culverts crossing private driveways, the minimum cover shall be 8 inches. In all cases, minimum cover over roadway crossing culverts shall also include at least 6 inches of aggregate base course under the pavement. Total minimum cover may need to be increased for thicker pavement sections. In all cases, the minimum and maximum cover shall be in accordance with the manufacturer's recommendations. Trench installations shall be in accordance with the most recent edition of the CDOT M&S Standard Plans.

Table 6.16. Applicable Culvert Standards

Culvert Type	Standard
Reinforced Concrete Pipe—Round	ASTM C76 or AASHTO M 170
Reinforced Concrete Pipe—Elliptical	ASTM C507 or AASHTO M 207
Reinforced Concrete Pipe—Joints	ASTM C443 or AASHTO M 198
Reinforced Concrete Box Culvert—Joints	ASTM C1677
Reinforced Concrete Pipe—Arch	ASTM C506 or AASHTO M 206
Precast Concrete Box Culverts	ASTM C1433/C1577 or AASHTO M 259/M 273
Concrete for Cast-in-place culverts	CDOT 601
High Density Polyethylene Pipe (HDPE)	ASTM F2306
Gaskets for Joining Plastic Pipe (HDPE)	ASTM F477

6.8.1.2 Minimum Size

The minimum pipe diameter for culverts in the public right-of-way that are not driveway culverts shall be 18 inches. The minimum vertical pipe dimension shall be 18 inches where elliptical or arch pipe is used. Equivalent sizes for a 24-inch round pipe are a 29-inch by 18-inch arch and a 30-inch by 19-inch elliptical section.

Roadside ditch culverts crossing private driveways shall have a minimum diameter of 18 inches. Roadside ditches shall be re-graded if necessary to provide positive drainage below the culvert and prevent ponding or a sump condition near the culvert. The developer is responsible for re-grading and reconditioning existing swales to prevent ponding or a sump condition. If existing conditions prohibit the installation of an 18" culvert, the Town Engineer may grant a variance to allow a smaller culvert.

6.8.1.3 Allowable Headwater

Ponding above culvert entrances can cause property or roadway damage, culvert clogging, saturation of fills, detrimental upstream deposits of debris, an increase in floodplain elevation, or inundation of existing or future facilities. The maximum headwater for the 100-year design flow shall be 2.0 times the culvert diameter or culvert rise dimension for shapes other than round ($H_W/D \leq 2.0$) for culverts with a rise dimension less than or equal to 36 inches. For culverts with larger rise dimensions, the headwater to depth ratio for the 100-year design flow shall be less than 1.5. There is no maximum headwater value for the minor storm. Table 6.17 lists these criteria. The criteria in Table 6.17 are in addition to roadway encroachment and overtopping criteria, and do not apply to detention, water quality, or sedimentation facility outlets.

Table 6.17. Allowable Headwater

Culvert Diameter or Rise	100-Year Maximum Headwater/Diameter (H_W/D)
≤ 36 inches	2.0
> 36 inches	1.5

6.8.1.4 Roadway Overtopping

No overtopping of any public roadway at a roadway culvert crossing is permitted during the minor storm. Roadway overtopping of up to 6 inches may occur at culvert crossings of local roads during the major storm. Overtopping at arterial, major collector, and minor collector roadways may not occur during the major storm. Overtopping of driveways at culverts in roadside ditches may not result in roadway encroachment that exceeds that specified in Section 6.6. These criteria should be considered as headwater limitations in addition to those in Table 6.17 above.

Additionally, culverts under arterial and major collector roadways, or those conveying flows from drainage areas larger than 0.50 square miles shall pass the 100-year storm assuming 20% of the inlet is plugged.

The depth of roadway overtopping is assumed to be the difference between the headwater elevation and the roadway crown elevation along the centerline of the culvert. Where overtopping is not permitted, but some amount of encroachment is permitted, the culvert headwater elevation can be set at the elevation corresponding to the limits of encroachment.

During roadway overtopping, the roadway crown is assumed to act as a broad-crested weir. A weir coefficient of 2.8 shall be assumed along with a weir length not to exceed 100 feet, regardless of roadway geometry. The designer should first calculate weir flow using the allowable overtopping depth for the major storm. The designer should then calculate flow through the culvert in accordance with these Standards, with culvert headwater set at the allowable overtopping elevation. If the calculated weir flow plus the flow through the culvert exceeds the design flow, the allowable overtopping condition has been met.

6.8.1.5 Velocity and Outlet Protection

A minimum flow velocity within the culvert of 3 feet per second is required to prevent sediment from accumulating in the culvert. The minimum flow velocity should be calculated using Manning's equation with a flow depth equal to 0.25 times the vertical dimension of the culvert. Manning's n values are presented in Table 6.15 above. Regardless of calculated flow velocity, the minimum slope of any culvert shall be 0.40%.

Culvert design must include revetment to protect the outlet from erosion if exit velocity exceeds 6 feet per second during the 100-year event as calculated in accordance with these Standards. The most common type of outlet protection is riprap, either as a riprap apron or as a low tailwater basin. Procedures for designing a riprap apron or low tailwater basin downstream of a culvert outlet, including for multiple conduit installations, can be found in the USDCM. Culverts should not be designed with 100-year outlet velocities greater than 16 feet per second.

An economical culvert design that meets allowable headwater requirements should not result in a Froude number larger than 2.5 when design velocities are kept below 16 feet per second. Culvert slopes should be as flat as practicable to limit the amount of revetment required at the outlet. A riprap apron is typically used when the culvert discharges to a well-defined channel that can be expected to have a tailwater elevation equal to at least one-third of the height of the culvert. A low tailwater basin is typically used when the receiving channel may have little or no tailwater or where the receiving channel is not well defined.

6.8.1.6 Headwalls, Wingwalls, and End Sections

Except for private driveway culverts, all culverts in the public right-of-way shall be designed with headwalls and wingwalls or flared end sections at the inlet and outlet to minimize head loss. Stone headwalls and wingwalls are not allowed in roadside ditches. Private driveway culverts less than 36 inches in equivalent diameter may have projecting ends. Headwalls, wingwalls, and end sections shall be in accordance with the most recent edition of the CDOT M&S Standard Plans. Headwalls or end sections shall be located to provide a grade no steeper than 3H:1V between the back of the structure and the edge of the roadway shoulder or back of walk. Ditch and channel sections and profiles shall be transitioned at culvert inlets and outlets to allow for adequate cover over the culvert and to provide inlet and outlet conditions that will not cause erosion or sediment deposition.

6.8.1.7 Grates

Where a clear and present danger exists such as a siphon, a drop in elevation adjacent to a sidewalk or road, a long pipe with one or more manholes, or at pipes which are near playgrounds, parks and residential areas, a grate at the inlet and outlet of the culvert may be required. For most pipes through embankments and under streets, grates will not be required.

6.8.1.8 Location and Alignment

Culverts shall be located to completely drain all rainfall and snowmelt runoff where drainageways intersect a roadway or sidewalk. All areas that water could be impounded, or flow restricted, by the new embankment must be identified and considered for culvert locations. Culverts shall be aligned to give drainageways a linear entrance and exit. Abrupt changes in alignment at either end of a culvert may retard flow and make a larger structure necessary. If possible, a culvert shall have the same alignment as the channel it conveys. If this is not practical, and the water must be turned into a culvert, headwalls, wingwalls, and aprons shall be used as protection against scour and to provide a more hydraulically efficient inlet.

Where the natural channel alignment would result in a culvert alignment skewed more than 30 degrees from perpendicular to a roadway, modification may be necessary. Such modifications will change the natural stability of the channel, and an investigation into other options is recommended. Although economic factors are important, hydraulic effectiveness of the culvert must be given primary consideration.

Roadway alignment also affects culvert design. The vertical alignment of roadways may define the maximum culvert diameter that can be used. Low vertical clearance may require the use of elliptical or arched culverts or the use of multiple barrels.

6.8.2 Bridge Design Standards

Based on hydraulic capacity requirements, bridges may be required to cross major open channels. Sizing bridge openings is of great importance. Improperly designed bridges may cause excessive scour or deposition or may not be able to pass the design flow. Backwater caused by bridges can cause flooding of upstream property, overtopping of roadways, or costly maintenance. Bridge openings should have as little effect on the flow characteristics as is reasonable, consistent with good design and economics. The criteria in this section apply to bridges on public and private roads in the Town. The Town will review bridge designs based on the guidance in this section.

It is possible that a bridge designed to meet the criteria of these Standards may be on a roadway that becomes flooded during the storm event the bridge is designed to pass. New bridges shall be designed to these Standards regardless of adjacent roadway flooding because roadways that experience frequent flooding may be reconstructed at a higher elevation in the future to achieve an overall greater level of protection.

6.8.2.1 Bridge Sizing

The low chord of all bridges must provide a minimum freeboard. All bridges on arterial and major collector roadways, or above the Blue River or its major tributaries, shall have a low chord elevation set at least 3 feet above the HGL. All other bridges shall have a low chord elevation at least 1 foot above the HGL. Arch culverts, large diameter culverts, or other structures may be classified as a bridge and subject to freeboard requirements. Freeboard requirements apply to both vehicular bridges, pedestrian bridges, and any other structures spanning a floodway.

6.8.2.2 Hydraulic Analysis

Hydraulic analysis and design calculations for all bridges must be prepared and certified by a licensed Colorado Professional Engineer. The procedures for design as outlined in the Federal Highway Administration (FHWA) publication *Hydraulic Design of Safe Bridges* shall be used for the hydraulic analysis of the proposed design. HEC-RAS may be used to complete the hydraulic analysis of bridge openings provided the guidance in the publication is followed. All bridges are assumed to remain in place during all storm events and shall not be assumed to break away or otherwise be removed from any modeling scenario. Design flow rates shall be those specified by FEMA or as calculated in accordance with these Standards.

6.8.2.3 Inlet and Outlet Configuration

Where bridge abutments and foundations are located below the 100-year water surface elevation, concrete wingwalls shall be tied to the existing side slopes to prevent erosion behind the abutments and to provide slope stabilization from the top of the embankment to the toe of slope. Riprap protection on the inlet and outlet transition slopes shall be provided to prevent erosion caused by eddy currents.

6.8.2.4 Scour Analysis and Countermeasures

Velocity limitations through the bridge opening are intended to limit potential scour. Regardless of the results of the scour analysis, a maximum 100-year average channel velocity of 16 feet per second shall be allowed through a bridge opening. Whenever a new or replacement bridge is designed, it is critical that scour depths at piers and abutments be estimated. The scour estimate must consider subsurface data and a hydraulic analysis of the proposed design.

The FHWA has published a set of Hydraulic Engineering Circulars (HEC) to provide guidance for bridge scour and stream stability analysis. The set includes HEC-18, Evaluating Scour at Bridges, HEC-20, Stream Stability at Highway Structures, and HEC-23, Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance. Latest editions of each shall be used in concert with each other to evaluate stream stability, potential scour, and appropriate scour countermeasures. HEC-RAS may be used to provide the raw data required for the HEC-18 equations. HEC-RAS may also be used to evaluate scour, but the user must be experienced in the nuances HEC-RAS presents in evaluating scour and the potential errors that can occur. Using HEC-RAS default values will cause inaccurate results.

The potential for local scour (pier and abutment) and general scour (contraction, stream degradation, and pressure) should be evaluated using HEC-18 to determine the extent of the various types of scour as applicable to each site. HEC-20 should be consulted to determine the general stability of the stream and whether lateral channel movement should be anticipated. If there is potential for scour during the scour design storm shown in Table 6.18, countermeasures shall be designed in accordance with HEC-

23. In all cases, the length of bridge piles shall be such that the design structural load may be safely supported entirely below the probable scour depth.

Table 6.18. Bridge Scour Design Standards

Roadway Classification	Design Storm for Abutment, Pier Cap, and Retaining Wall Design	Design Storm for Foundation Design
Arterial	500-year	500-year
Major Collector	100-year	500-year
Minor Collector	100-year	500-year
Local	50-year	500-year

6.8.2.5 Structural Design

The type of bridge foundation and foundation elevations should be determined by the bridge structural design engineer. During the design of the bridge foundations, the design engineer shall consider the design loading, the findings of the geotechnical investigation, scour depth as calculated using the procedures in HEC-18, anticipated frost depth, pressure flow during the 100-year event, and any other factors the engineer considers appropriate in his or her professional judgement. If scour is anticipated, the engineer can either design scour countermeasures using the procedures in HEC-23 for the applicable design storm or locate the bridge foundations below the anticipated depth of scour by a distance that provides a sufficient factor of safety in his or her professional judgement. Scour countermeasures will be required if anticipated scour depth is more than 5 feet.

Structural, scour, and foundation design calculations must be accompanied by a certification statement that is signed and sealed by a professional engineer licensed in the State of Colorado and submitted to the Town for review. The certification statement shall read as follows.

> I hereby affirm that the design calculations and plans for the bridge at [insert address] were prepared by me, or under my direct supervision, for the owners thereof, in accordance with the requirements of the International Building Code, the Breckenridge Town Code, the Breckenridge Town Standards, any approved variances and exceptions thereto, and my professional engineering judgment. I understand that the Town of Breckenridge does not and will not assume liability for facilities, structures, or improvements designed by others.
>
> Registered Professional Engineer [Affix Seal]
>
> State of Colorado No. __________

All assumptions made by the bridge design engineer shall be provided in the calculations. Furthermore, the design of bridges may be subject to review by a third party at the Town's discretion. When located within a FEMA floodplain, all bridges are subject to requirements of the National Flood Insurance Program (NFIP) and local floodplain management regulations.

The Town recognizes that in certain limited instances, it may be exceptionally difficult to conform to these Standards. In these instances, the applicant may submit a variance request in accordance with the requirements in Chapter 1. The request must be signed and sealed by a professional engineer licensed in the State of Colorado.

6.8.3 Culvert Hydraulics

Presented in this section are the general procedures that shall be used for hydraulic design and analysis of culverts. The user is assumed to possess a basic working knowledge of culvert hydraulics and is encouraged to review the technical literature on the subject that is included in Hydraulic Design Series 5 (HDS-5), *Hydraulic Design of Highway Culverts*, published by the FHWA). The two primary types of culvert flow are inlet control and outlet control. Under inlet control, the cross-sectional area of the barrel, inlet geometry, and headwater are the factors that affect capacity. Outlet control involves the additional consideration of tailwater and the slope, roughness, and length of the culvert barrel. The Culvert Design Form, included as an attachment to this chapter, is a template for culvert hydraulic analysis that can be used with the information and equations below. All culvert designs shall include an analysis to determine whether inlet or outlet control conditions govern for both minor and major storm runoff.

6.8.3.1 Inlet Control Calculation

Under inlet control conditions, the slope of the culvert is steep enough that the culvert does not flow full. The control section of a culvert operating under inlet control is located just inside the entrance. Inlets may be either unsubmerged or submerged. In an unsubmerged condition, the headwater is high enough to submerge the top of the culvert and the culvert slope is supercritical. In a submerged condition, the headwater submerges the top of the culvert, but the pipe does not flow full. In this situation, the culvert inlet acts like an orifice.

In the submerged inlet condition, the equation governing the culvert capacity is the orifice flow equation. However, because of the uncertainty in estimating the orifice coefficient for a submerged culvert inlet, it is recommended that the inlet control nomographs published in HDS-5 be used to determine headwater for submerged inlets operating under inlet control. Nomographs may be found online in the second edition of HDS-5, publication number FHWA-NHI-01-020. Later editions do not have as many nomographs. Table 6.19 provides the appropriate inlet control nomograph to use for various types of culverts and end treatments. The FHWA has not published inlet control nomographs for plastic pipe. In their absence, the nomographs for concrete may be used for round HDPE with a smooth interior wall.

Table 6.19. Inlet Control Nomograph Selection

Material	Cross Section	End Treatment	Chart
Concrete/HDPE	Circular	None (Projecting), Headwall	1B
Concrete/HDPE	Circular	Flared end section	55B
Concrete	Horizontal Elliptical	Headwall or Projecting (use scale 1 for end section)	29B
Concrete	Rectangular	Wingwalls, angle and headwall bevel varies	8B-13B

6.8.3.2 Outlet Control Calculation

Outlet control occurs when the culvert barrel is not capable of conveying as much flow as the inlet opening will accept. Either subcritical or pressure flow exists in the culvert barrel under these conditions. Outlet control will govern if the headwater is deep enough, the culvert slope is sufficiently flat, or the culvert is sufficiently long.

Outlet control generally exists under two conditions. The first, and less common, occurs when headwater is not high enough to submerge the top of the culvert and the culvert slope is subcritical. The more common outlet control condition exists when the culvert is flowing full. A culvert with a submerged inlet and an unsubmerged outlet may also operate under outlet control, especially if it has a long barrel length or a flat enough slope. Culverts under outlet control may flow full or partly full, depending on various combinations of hydraulic factors.

Culvert capacity under outlet control is calculated using Bernoulli's equation. An energy balance is determined between the headwater at the culvert inlet and at the culvert outlet and includes inlet losses, friction losses, and velocity head. The general equation is expressed as:

$$\mathrm{H} = \mathrm{h_e} + \mathrm{h_f} + \mathrm{h_v} \tag{6.13}$$

Where:

H = total energy head (headwater elevation minus tailwater elevation) (ft)

h_e = entrance head loss (ft), $K_e V^2/2g$

h_f = friction losses (ft)

h_v = velocity head (ft), $V^2/2g$

K_e = entrance loss coefficient per Table 6.20

Friction loss is the energy required to overcome the culvert barrel roughness and is calculated by the following equation.

$$\mathrm{h_f} = (29\mathrm{n}^2\mathrm{L}/\mathrm{R}^{1.33})(\mathrm{V}^2/2\mathrm{g}) \tag{6.14}$$

Where:

n = Manning's coefficient per Table 6.15

L = length of culvert (ft)

R = hydraulic radius (ft)

V = velocity of flow (ft/s)

g = gravitational acceleration, 32.2 ft/s^2

Table 6.20. Culvert Entrance Loss Coefficients, K_e, for Outlet Control Calculations

Structure and Entrance Type	Ke	Structure and Entrance Type	Ke
RCP		RCB	
Headwall, socket end of pipe	0.2	Wingwalls at 30° to 75° to barrel	
Headwall, square edge	0.5	Square edge at crown	0.4
Projecting from fill, socket end	0.2	Rounded or beveled top edge	0.2
Projecting from fill, square cut end	0.5	Wingwalls at 10° to 25° to barrel	
Mitered to conform to fill slope	0.7	Square edge at crown	0.5
Side- or slope-tapered inlet	0.2	Wingwalls parallel (side extensions)	
Beveled edges, 33.7° or 45° bevels	0.2	Square edge at crown	0.7
Rounded (radius = D/12)	0.2	Side- or slope-tapered inlet	0.2
End section that conforms to fill slope[(1)]	0.5	No wingwalls	
HDPE [(2)]		Square edge on 3 sides	0.5
Projecting from fill	0.9	Rounded or beveled on 3 sides	0.2

[(1)] End sections that conform to fill slope are the sections commonly available from manufacturers. From limited hydraulic tests, they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections, which incorporate a closed taper in their design, have a superior hydraulic performance. These latter sections can be designed by using the information given for the beveled inlet.

[(2)] Conditions not listed specifically for HDPE with a smooth interior wall have the same coefficient as RCP. The "projecting from fill" value given for HDPE is an approximation based on published values for CMP.

Combining the equations yields the following equation, which can be used to calculate culvert capacity directly only when the tailwater is at or above the crown of the culvert outlet.

$$H = (K_e + 1 + 29n^2L/R^{1.33})(V^2/2g) \tag{6.15}$$

When the tailwater is below the culvert outlet crown, the tailwater depth used for calculations shall be the larger of the tailwater anticipated in the downstream channel at the culvert outlet and the average of the critical depth in the culvert and the culvert diameter, $(D+d_c)/2$. The FHWA has determined the average of the critical depth and the culvert diameter to be an adequate approximation for tailwater depth for culverts that flow partially full. Critical depth calculation is a direct process for a box culvert but an iterative one for a circular pipe that is easily accomplished with a spreadsheet. Critical depth occurs when the Froude number is equal to 1.0. The flow area and top width will be those that occur at critical depth in the pipe. Many online tutorials are available.

$$Fr = \frac{v}{\sqrt{gD_h}} \tag{6.16}$$

Where:

Fr = Froude number (dimensionless)

v = velocity (ft/s)

D_h = hydraulic depth (ft), A/T

A = flow area (ft^2)

T = top width of flow area (ft)

g = gravitational acceleration, 32.2 ft/s^2

In addition to equation 6.15, outlet control nomographs published by the FHWA in HDS-5 can also be used to calculate the required headwater under outlet control conditions where the outlet is submerged. Outlet control nomographs can be found online in the second edition of HDS-5, publication number FHWA-NHI-01-020. Later editions do not have as many nomographs. Table 6.21 provides the appropriate outlet control nomograph to use for various types of culverts. The FHWA has not published outlet control nomographs for plastic pipe. In their absence, the nomographs for concrete may be used for round HDPE with a smooth interior wall. End treatments do not affect outlet control.

Table 6.21. Outlet Control Nomograph Selection

Material	Cross Section	Chart
Concrete/HDPE	Circular	5B
Concrete	Rectangular	15B
Concrete	Horizontal Elliptical	33B

Culvert capacity shall be computed using the Culvert Design Form, included as an attachment to this chapter. Two example calculations for culvert sizing are at the end of this section. The first is for a roadway crossing culvert and the second is for a driveway culvert in a roadside ditch. HDS-5 offers extensive guidance on the design of culverts that are under roadways and that may be used in conjunction with the requirements of these Standards.

6.8.3.3 Evaluation of Results

If the culvert selected will not fit the site, return to the design process, and select another culvert. Repeat the design process until an acceptable culvert configuration is determined. Compare the headwater elevations calculated for inlet and outlet control. The higher of the two is the controlling headwater elevation. The culvert can be expected to operate with that higher headwater for at least part of the time.

If outlet control governs and the headwater depth is less than 1.2D, it is possible that the barrel flows partly full through its entire length. In this case, caution should be used in applying the approximate method of setting the downstream elevation based on the greater of tailwater or (d_c + D)/2. If an accurate headwater is necessary, backwater calculations should be used to check the result from the approximate method. If the headwater depth falls below 0.75D, backwater calculations are required.

6.8.3.4 Outlet Velocity Calculation

The outlet velocity may be calculated as follows:

1. If the controlling headwater is based on inlet control, determine the normal depth and velocity in the culvert barrel. The velocity at normal depth is assumed to be the outlet velocity.
2. If the controlling headwater is based on outlet control, determine the area of flow at the outlet based on the barrel geometry and the following:
    a. Critical depth if the tailwater is below critical depth.
    b. Tailwater depth if the tailwater is between critical depth and the top of the barrel.
    c. Height of the barrel if the tailwater is above the top of the barrel.

6.8.3.5 Computer Applications

While it is possible to use the procedures and nomographs for analyzing culvert hydraulics, it is more common to design culverts using computer applications. Among the applications approved for use by the Town is the FHWA’s HY-8 Culvert Analysis Program and the Mile High Flood District’s MHFD-Culvert spreadsheet, both of which may be used to calculate roadway overtopping, inlet and exit velocity, and hydraulic grade line.

6.8.4 Design Examples

Two design examples are included in this section. The first example is the analysis of an existing roadway cross culvert using the Culvert Design Form. Calculations from this design example are shown in the Culvert Design Form Example, included as an attachment to this chapter. The second example is the design of a private driveway culvert in a roadside ditch.

6.8.4.1 Crossing Culvert Analysis Example

The procedure to evaluate culverts is based on the procedures presented in HDS-5. The methodology consists of evaluating the culvert headwater requirements for both inlet and outlet control. The type of flow control that results in a larger required headwater is the governing flow condition.

An example calculation for rating an existing culvert is presented in the Culvert Design Form Example, included as an attachment to this chapter. The culvert is a 48-inch RCP. The length is 150 feet. The upstream invert elevation is 8540.0, and the downstream invert elevation is 8535.5. The slope is 0.030. The low point of the embankment over the culvert has an elevation of 8551.90. The n value is 0.015, in accordance with Table 6.15 for older concrete pipes. The culvert has flared end sections on each end. All depths are in feet unless noted otherwise.

The tailwater rating values are provided for this example and shown in Column 5. If the tailwater condition is unknown, it must be computed using the normal depth (subcritical or critical only) of a trapezoidal channel approximating the existing drainageway. A HEC-RAS model of the site could also be used to determine the tailwater rating curve.

The entrance loss coefficient, K_e, is determined from Table 6.20 as 0.5 for an end section that conforms to fill slope, which is the category used to represent a common flared end section. The full flow and the velocity are calculated from these values for comparison. The rating then proceeds in the following sequence:

1. The culvert design process begins with selecting a range of discharges or headwater depths and then using an inlet control nomograph to determine the corresponding flow values. This example begins with a range of headwater depths that are entered in Column 3. Headwater to pipe diameter ratios (H_W/D) are calculated and entered in Column 2. If the culvert is not circular, the culvert height is used for the calculation. Note that for design of new culverts, the Town has restrictions on the headwater-to-depth ratio in Table 6.17.
2. For each H_W/D ratio, inlet capacity is read from the appropriate inlet control nomograph (Chart 55B for this example because of the flared end sections) and entered in Column 1. Scale (1) for concrete should be used on Chart 55B to determine discharges, which then completes the inlet control rating.
3. For outlet control, the Q values that have been entered in Column 1 are used to determine the head values (H) in Column 4 from the appropriate outlet control nomograph, Chart 5B in this case. Note that flared end sections do not affect outlet control calculations. The first line drawn in Chart 5B is between the pipe diameter and the pipe length. The second line connects the Q value and passes through the turning line where the first line crossed it to determine H.
4. The known tailwater depths (T_W) for normal flow in the downstream channel are then entered into Column 5 for each Q value in Column 1. The depths have been provided in this example but must be calculated if they are not available using the normal depth of a trapezoidal channel approximating the existing drainageway downstream of the culvert. If the tailwater depth is less than the diameter of the culvert, Columns 6 and 7 must be calculated per Step 5, and the larger of the tailwater depth and the value of Column 7 shall be used as h_o. If the tailwater depth is greater than the diameter of the culvert, the tailwater values in Column 5 are entered into Column 8 as the values for h_o, and Step 6 should begin (Step 5 being skipped).
5. Approximate tailwater depths are calculated when tailwater depths in the downstream channel are less than the diameter of the culvert. The critical depth, d_c, for each Q value in Column 1 is calculated and entered in Column 6. For a circular pipe, the Froude number calculation is completed iteratively using a spreadsheet until the Froude number is 1. Alternately, Chart 4B from HDS-5 can be used to determine d_c for the pipe size and Q value. The average of the critical depth and the culvert diameter is calculated and entered in Column 7 as the approximate h_o value.
6. The headwater values (H_W) in Column 9 are calculated according to Equation 6.17:

$$H_W = H + h_o - LS_o \qquad (6.17)$$

   where H is from Column 4 and h_o is either the value from Column 8 where $T_W \geq D$ or the larger value of Column 5 and Column 7 where $T_W < D$. L is the length of the culvert barrel and S_o is its slope.

7. The final step is to compare the inlet and outlet control headwater requirements (Columns 3 and 9) and record the higher of the two values in Column 10. The type of flow control is recorded in Column 11. The upstream water surface elevation is then calculated by adding the controlling headwater (Column 10) to the upstream invert elevation. Add this value to Column 12. The culvert rating curve can then be plotted from the values in Columns 12 and 1.

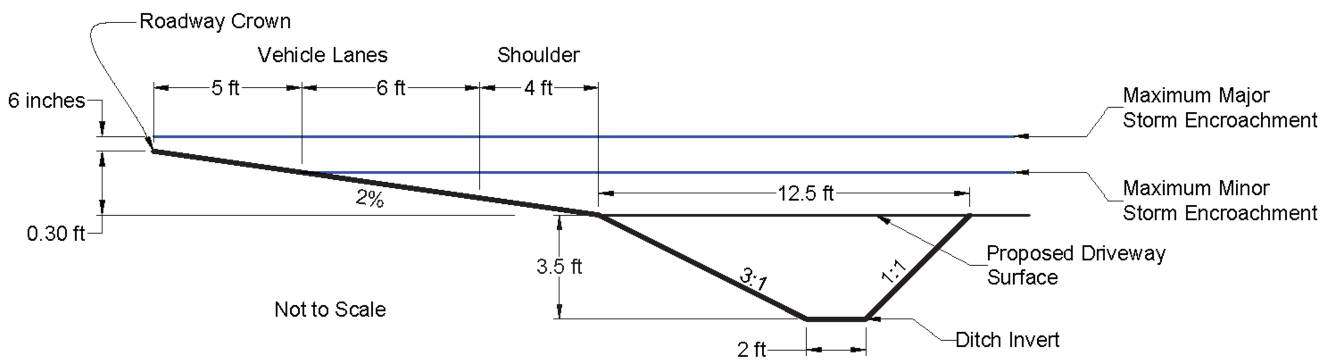
Outlet velocity for designing downstream protection can be computed using V = Q/A. For full flow conditions, the culvert area is the full cross sectional area of the culvert. For partially full conditions, the culvert area is the area calculated at a depth of h_o. Channel protection shall be in accordance with guidance in the USDCM. Velocity values are not shown in the Culvert Design Form but should be calculated for the 100-year event.

To size a culvert crossing, the same form can be used, with some variation in the basic data. First, a design Q is selected, and the maximum allowable headwater is determined. An inlet type is selected, and the invert elevations and culvert slope are estimated based on site constraints. A culvert type and size is then selected and rated for both inlet and outlet control. If the controlling headwater exceeds the maximum allowable headwater, the design data must be modified, and the procedure repeated, until the desired results are achieved.

6.8.4.2 Private Driveway Culvert Design Example

A driveway is planned to provide access to a new residence from a minor collector roadway with an existing roadside ditch. The minor collector has a transverse slope of 2%. The roadside ditch is trapezoidal with a 3:1 side slope down from the road, a 1:1 backslope, a 2-foot bottom width, and a 3.5-foot depth as shown in Figure 6.4.

Figure 6.4. Private Driveway Culvert Example Ditch Geometry



The driveway is assumed to have no slope over the ditch for calculation purposes. The calculated peak flow is 28 cfs for the major storm and 12 cfs for the minor storm. Floodwater encroachment onto the road must not exceed the limitations set forth in Table 6.12 of these Standards. Inlet control is assumed for this example; however, actual projects should use the Culvert Design Form to determine if culverts are under inlet or outlet control.

1. During the major storm, water on a minor collector may be 6 inches deep at the crown of the road. The depth of the water from the allowable water surface to the ditch invert is 4.3 feet. This value is assumed as the headwater depth.

2. For the major storm, calculate the discharge through an 18-inch HDPE (D = 1.5 feet) with projecting ends and a headwater depth of 4.3 feet using Chart 1B:

   $$\mathrm{H_W/D = 4.3\ ft/1.5\ ft = 2.9}$$

   A H_W/D ratio of 2.9 on Scale 3 of Chart 1B for projecting culvert ends gives a discharge of 18.0 cfs for an 18-inch HDPE.

3. Calculate weir flow over the road and driveway during the major storm. Flow over the road and over the driveway are calculated independently. Because the road grade is sloped across the cross section, the average depth of flow over the road is used. Flow outside the top of the ditch side slope is assumed to be negligible for this example, but it may be considered if the designer feels it is appropriate. Assume a weir coefficient of 2.8.

   $$\mathrm{Q_{weir} = Q_{road} + Q_{drive}}$$

$$Q_{\mathrm{weir}} = \mathrm{CLH}^{3/2} + \mathrm{CLH}^{3/2}$$

$$Q_{\mathrm{weir}} = (2.8)(15)((0.85 + 0.50)/2)^{3/2} + (2.8)(12.5)(0.85)^{3/2}$$

$$Q_{\mathrm{weir}} = 23.3\ \mathrm{cfs} + 27.4\ \mathrm{cfs} = 50.7\ \mathrm{cfs}$$

Total flow over the road and driveway is 50.7 cfs.

4. The combined flow through the 18-inch HDPE and over the road/driveway is 68.7 cfs, which is significantly more than the major storm design flow of 28 cfs. Encroachment onto the minor collector will not exceed allowable and the chosen culvert is acceptable for the major storm. If the combined flow would have been less than the major storm flow, a larger culvert would be required, and Steps 2–3 would be repeated using a 24-inch HDPE. In this case, a shallower ditch or a smaller pipe may be considered.

   Verify that the design meets the minor storm criteria. During the minor storm, flow may spread to within 5 feet of the crown of a minor collector to allow a single 10-foot lane to remain clear during the minor storm. Assuming encroachment extends only to within 5 feet of the roadway crown yields a headwater depth of 3.7 feet and a H_W/D ratio of 2.5.

5. Scale 3 of Chart 1B indicates a discharge of 16.0 cfs for an 18-inch HDPE with a H_W/D ratio of 2.5, which is greater than the 12 cfs peak flow during the minor storm. The design will meet the minor storm criteria.
6. Verify that the culvert has a minimum 8 inches of cover. The driveway surface is 3.5 feet or 42 inches above the ditch invert. The 18-inch HDPE has more than the minimum 8 inches of cover and meets all criteria for this location.

6.9 DETENTION

The imperviousness of any site typically increases when it is developed. Roof areas, sidewalks, and parking all contribute to site imperviousness. Rain falling on this added impervious area cannot infiltrate into the ground after development. The rainfall discharges from the site instead, impacting adjacent properties, storm drain capacity, and even the capacity of larger drainageways when development is considered in the aggregate. The purpose of detention facilities is to store the additional runoff volume associated with development and discharge it from the developed site at the rate experienced during pre-development conditions. Detention helps to minimize peak flows in urbanized areas. Detention can include individual site options such as small landscaped basins and larger regional options that serve multiple sites. Detention facilities can also be dual purpose when they are designed to meet water quality requirements as well as hydraulic detention requirements. This section presents the Town's criteria and guidance for designing detention ponds.

6.9.1 Applicability

Detention is required for all new development and redevelopment. Subdivided developments may use a single detention facility provided it captures runoff from the entire development. All detention facilities in the Town are subject to oversight by the Town. A maximum of 5% of the total development site may discharge directly from the site, without hydraulic detention, provided the peak site discharge does not exceed the peak historic discharge from the site.

Exemptions from the detention requirement may be granted if the project has either of the following characteristics, provided the additional undetained runoff will cause no adverse impacts to any downstream properties.

1. Impervious area is increased by no more than 0.10 acres or 4360 square feet.

2. Other situations as may be determined by the Town to be in the best interest of the Town.

Exemptions may also be provided for single family homes in subdivisions without regional detention provided low-impact development principles are included in the design to minimize the increase in runoff and not aggravate flooding or erosion problems. Low impact development principles include using pervious pavers or pavement for driveways and walkways, minimizing directly connected impervious areas, and routing drainage from impervious areas such as roofs and driveways through infiltrating swales or across vegetated pervious areas prior to discharging it from the site. Detailed guidance on low impact development can be found in Volume 3 of the USDCM.

Supporting analysis and certification by a professional engineer that exclusion from the detention requirement will not cause any adverse downstream impacts must be submitted to the Town Engineer for consideration if an exemption is requested. An exemption to provide detention issued by the Town does not eliminate potential liability to others.

Although development increasing impervious area by less than 0.10 acres is exempted from detention requirements, any new development or redevelopment is required to analyze and correct any inadequate drainage, including insufficient drainage away from buildings, runoff adversely affecting downstream properties, inadequately sized drywells, drainage exceeding existing storm drains, pipes, or other conveyance, or other drainage concerns identified by the Town Engineer.

6.9.2 Detention Facility Design

All detention facilities shall be designed as full-spectrum detention facilities. The Mile High Flood District has developed detailed design guidance for detention basins. The USDCM provides discussion on the applicability of detention; an explanation for why full-spectrum detention is the preferred approach; and calculations for sizing a detention facility and designing the outlet structure.

The most recent versions of the USDCM and the design tool MHFD-Detention.xlsm (formerly UD-Detention.xlsm) may be used for sizing and designing all detention facilities in the Town. Detention facilities in the Town may be extended detention basins, sand filters, and rain gardens. Constructed wetlands may also be used provided water rights are accommodated. The USDCM also includes weir and orifice equations for the design of detention basin outlets that may also be used for other applications within these Standards as needed. Guidance on the use of MHFD-Detention within the Town is included in this section.

6.9.2.1 Historic Flow Rates

The policy of the Town is to require detention storage of stormwater runoff to limit peak discharges from new development and redevelopment sites to historic rates. Detention facilities shall be designed to release stored runoff volumes at or below the calculated historic peak rate for the 2-, 5-, 10-, 25-, 50-, and 100-year storms.

For new development, historic peak runoff rates per acre shall be calculated in accordance with the procedures in these Standards using a site imperviousness of 2% to represent historic conditions in accordance with Table 6.3. For redeveloped areas, historic rates shall be those calculated for the condition immediately prior to redevelopment in accordance with these Standards unless other criteria are specified by the Town Engineer in writing. Calculated historic rates will vary based on the methodology chosen to calculate peak flow, whether it is the Rational Method, the SCS Method, or a computer model. Calculated historic rates for each storm event shall be presented as part of the drainage analysis in the Drainage Report.

Post-development peak runoff from a site may not be greater than pre-development runoff from a site for any storm event. Total site runoff is typically a combination of detention basin release and direct runoff from areas not draining to a detention facility, both of which must be considered. A maximum of

5% of the total site area may contribute direct runoff. Note that the allowable peak discharge from a detention facility will be less than the allowable peak runoff from the whole site unless the entire site drains to the detention facility.

For redevelopment sites, any existing detention facilities shall be factored into the runoff calculations and accounted for with the revised runoff characteristics to preserve the pre-development runoff rates as identified in any previous drainage studies. If a HEC model of the watershed exists, it can be used to generate historic runoff rates by changing the imperviousness of the watershed to historic conditions.

6.9.2.2 MHFD-Detention

The last three tabs in the MHFD-Detention spreadsheet contain helpful information on how to use the MHFD-Detention spreadsheet as a design tool. Users are highly encouraged to thoroughly review the information in these tabs, including the video provided before beginning design. For designing detention facilities within the Town, the following inputs shall be used in lieu of default values.

1. While most detention basins in the Town will include water quality treatment, the first drop down menu on the Basin worksheet below Watershed Information should be set to Flood Control Only if no water quality treatment is to be provided. If water quality treatment is to be provided within the detention facility, the user should select the type of facility being designed.
2. Location for 1-hr Rainfall Depths on the Basin worksheet shall be set to User input and the P_1 values from Table 6.1 of these Standards shall be entered into the appropriate, blue-shaded cells on the Basin worksheet.
3. In the three cells used to Define Zones and Basin Geometry in the Basin worksheet, the Zone 1 Volume shall be the WQCV if water quality treatment will be provided. If water quality will not be provided, the Zone 1 Volume shall be the 2-year event. In all cases, the Zone 2 Volume shall be set to EURV – Zone 1, and the Zone 3 Volume shall be set to 100-year minus Zones 1 & 2.
4. The remainder of the user inputs on the basin worksheet tab shall follow the recommended guidelines indicated as notes in each cell. Assuming the design of the facility was completed in accordance with guidelines in the USDCM, the design values for these inputs will be within the recommended ranges of values for each variable. Note that the Total Available Detention Depth should be set at the maximum allowable 100-year water surface, not at the downstream embankment crest, to allow for design freeboard.
5. On the Outlet Structure worksheet, an Outlet Type must be selected from the drop down menu at the top of the worksheet for each Zone. When water quality treatment is provided, the lowest outlet is typically an orifice plate, which is a plate with multiple smaller orifices cut into it. When water quality treatment is not provided, the lowest outlet may be a vertical orifice, which is also a plate, but with a single, larger hole cut into it. The options available in the drop down menu for Outlet Type will automatically only be those applicable to the design completed up to that point. The user should only enter additional design values into the User Input rows in the remainder of this worksheet that correspond to the Outlet Types selected at the top of the worksheet. For example, if there is no orifice plate, there is no need for the user to enter data describing an orifice plate. But each Outlet Type selected must have its design data entered for the worksheet to yield correct results.
6. Several rows of hydraulic results are presented at the bottom of the Outlet Structure worksheet. While several of the values are of interest, there are only a handful that are critical for detention facilities in the Town. If these criteria are not met, the design must be adjusted until they are.
    a. Peak Outflow for each design storm may not exceed the historic rates calculated for the site.

b. Time to Drain 97% of Inflow Volume must not exceed 72 hours after the end of a 5-year storm.

c. Time to Drain 99% of Inflow Volume must not exceed 120 hours after the end of storms greater than the 5-year storm.

d. Maximum Ponding Depth must be at or below the emergency spillway and at least 12 inches below the surrounding embankment.

6.9.4 Snow Storage in Detention Ponds

If it is intended that a detention pond will serve as a snow storage area, the calculation of the pond's required volume must be increased by 50% of the full design snow storage volume and the pond must provide permanent water quality treatment in the form of the water quality outlet.

6.9.5 Maintenance

The performance of detention facilities is extremely sensitive to a lack of maintenance, and all detention facilities must be designed to facilitate maintenance. Section 6.10 of these Standards includes design guidance related to maintenance. It is the responsibility of all private detention facility owners to regularly maintain their detention facilities, except as modified by a recorded agreement. Outlets, especially, must be regularly maintained to ensure the basins do not detain water longer than allowed by Colorado water law.

The Town may require an enforceable Ownership and Maintenance (O&M) Agreement to be in place for detention and water quality facilities before issuing any applicable local permits. The O&M Agreement must include the party responsible for maintaining the facility, inspection frequency, and proposed maintenance activities in an Operations and Maintenance Plan (O&M Plan). Should the responsible party fail to adequately maintain the detention facility, the Town shall have the right to enter the property for the purpose of maintenance. All such maintenance costs and associated legal fees will be assessed to the property owner. Guidance on maintenance frequency for various types of facilities is included in Section 6.10. Guidance on the development of the O&M Plan is included in Chapter 2.

6.9.6 Detention and Water Rights

Senate Bill 15-212 became effective on August 5, 2015, as Colorado Revised Statute (CRS) §37-92-602 (8), *Concerning a Determination that Water Detention Facilities Designed to Mitigate the Adverse Effects of Storm Water Runoff Do Not Materially Injure Water Rights*. This statute provides legal protection for any stormwater detention and infiltration facility in Colorado, provided the facility does not materially injure water rights and meets the following criteria.

1. It is owned or operated by a governmental entity or is subject to oversight by a governmental entity.
2. It continuously releases or infiltrates at least 97% of all the runoff from a rainfall event that is less than or equal to a 5-year storm within 72 hours after the end of the event.
3. It continuously releases or infiltrates as quickly as practicable, but in all cases releases or infiltrates at least 99% of the runoff within 120 hours after the end of events greater than a 5-year storm.
4. It operates passively and does not subject the stormwater runoff to any active treatment process such as coagulation, flocculation, and disinfection.

There are reporting requirements for any owner or operator of any detention facility constructed after August 5, 2015 that seeks protection under the new statute. A data sheet and online map-based compliance portal website has been developed that will allow owners and operators in the Town to upload the required notification information. The notification requirement applies only to facilities constructed after August 5, 2015. Facilities in existence before August 5, 2015, are defined in the statute as materially noninjurious to water rights and do not require notification.

The compliance portal can be found online (*https://maperture.digitaldataservices.com/gvh/?viewer=cswdif*). A document containing frequently asked questions, links to a video tutorial, and the link to the compliance portal can be found online (*http://www.crgov.com/DocumentCenter/View/12225*) or via an internet search for "Colorado water rights compliance portal." The owner or operator must report new detention via the portal, and the county must approve the portal entry once it is complete. The owner or operator shall inform the county once the portal documentation is ready for approval.

6.9.7 Jurisdictional Dams

Detention facilities with a downstream embankment height in excess of 10 feet, 100-year water surface area in excess of 20 acres, or 100-year volume in excess of 100 acre feet are considered jurisdictional dams and require approval by the State Engineer's office.

6.10 PERMANENT WATER QUALITY

The naming convention for facilities that treat stormwater quality after construction has varied over time. These facilities have been called both best management practices (BMPs) and control measures by various entities. The Town's term for these facilities is permanent stormwater treatment facilities. The term treatment facilities may also be used. This term distinguishes these facilities from those used during construction.

The goal of the requirements in this section is to keep the Town's streams and drainageways healthy. This section presents runoff reduction and site planning principles, the applicability of the requirements for permanent water quality treatment, design requirements for permanent stormwater treatment facilities, and design requirements associated with maintenance.

6.10.1 Planning Principles

Increases in impervious area that typically come with development can negatively impact flow volumes, temperature, and stormwater quality. To minimize these impacts, site planning should consider how the site will be used as well as how stormwater runoff will be conveyed and treated. While no specific design criteria is associated with many of these guidelines, general site planning goals for every development include:

1. Considering stormwater quality needs early in the development process to better integrate stormwater treatment facilities into the site.
2. Minimizing impacts to the natural environment including water quality, air quality, wildlife habitat, vegetation, and natural landforms and protecting areas with high ecological value such as those with mature trees, stream corridors, wetlands, and soils with high infiltration rates.
3. Developing creative site layouts to reduce the extent of paved and other impervious areas.
4. Reducing runoff from the site and maximizing infiltration by minimizing directly connected or continuous impervious areas and slowing runoff through pervious and/or vegetated areas. Developing the layout of a site to reduce runoff will also reduce the required size of WQCV treatment facilities.
5. Centralizing water quality treatment for larger developments and integrating them with site operations to minimize land use, achieve greater economy of scale, and reduce the number of treatment facilities requiring maintenance.

6. Developing operational procedures to minimize the risk of spills and designing the site layout to prevent any spills from leaving sites with operations that include washing, fueling, manufacturing, materials storage, and vehicle maintenance, among others.
7. Using pervious drainage conveyances where appropriate, routing downspouts across pervious areas, and incorporating vegetated areas into locations that generate and convey runoff like parking lots and driveways. Grass buffers, grass swales, and bioretention can all be used.
8. Discharging site runoff across a vegetated area prior to discharge from the site. No impervious area should discharge directly into wetlands, the Blue River, or one of its tributaries.
9. Maintaining natural drainage patterns and implement sheet flow.
10. Selecting permanent stormwater treatment facilities based on expected pollutant type.
11. Providing areas for snow storage so that snow melt will not be a nuisance and will drain to a permanent water quality facility.

Chapter 1 of Volume 3 of the USDCM includes a section on ways to minimize the adverse impacts of development on water quality, including ideas to minimize site runoff. This document should be reviewed to gain a better understanding of planning principles as they relate to water quality. A discussion on how design of the site minimizes site runoff and the impacts to water quality shall be included in the permanent water quality portion of the Drainage Report.

6.10.2 Applicability

Permanent stormwater treatment facilities are required to be designed and installed for all new development and redevelopment sites that meet one of the following criteria:

1. Disturb at least one acre of land.
2. Disturb less than one acre but are part of a larger common development plan. In these cases, the individual development need not provide a permanent stormwater treatment facility, provided the larger common development provides a centralized facility that will provide treatment for all the sites within it.
3. Increase impervious area by more than 0.10 acres or 4360 square feet.
4. Include any of the following land uses: auto service station, auto repair, auto body work/paint, auto wash/polish, equipment repair, lumberyard, nursery, asphalt plant, concrete batch plant, industry, manufacturing, crushing gravel/rock, milling, mining, sawmill, silviculture, junkyard, sludge, sanitary landfill, truck terminals, impound yard, motor vehicles parking/storage, or storage of pesticides, herbicides, fertilizer, or other potentially hazardous materials.

New development is classified as any land disturbing activity or construction of any building or structure. Redevelopment is any creation, addition, or removal and replacement of any impervious area, or any building construction or land disturbing activity, on a site that is already substantially developed.

For sites that require permanent stormwater quality treatment, treatment must be provided for at least 80% of the added impervious area on the site. At least 80% of the disturbed site pervious area must also be treated unless justification is provided showing that runoff from these areas will not negatively impact water quality within the Town. An area larger than the minimum required may necessarily drain to the treatment facility, and this runoff must be accounted for in the design of the facility. Calculations documenting this has been achieved shall be included in the permanent water quality portion of the Drainage Report.

~~Although certain d~~Development that is exempted from permanent water quality requirements~~, any new development or redevelopment is~~ may still be required by the Town to analyze and correct any inadequate drainage, including insufficient drainage away from buildings, runoff adversely affecting downstream properties, inadequately sized drywells, drainage exceeding existing storm drains, pipes, or other conveyance, or other drainage concerns identified by the Town Engineer.

6.10.3 Treatment Facility Types

There are three basic methods by which stormwater quality can treated in the Town.

1. Collecting and storing the water quality capture volume (WQCV) and releasing it slowly, thereby settling out pollutants in the stormwater instead of discharging them downstream,
2. Infiltrating the WQCV into the ground within a given time, and
3. Using a proprietary vault or structure that has been developed to treat stormwater quality.

Volume 3 of the USDCM provides graphics that offer some general guidance as to the treatment facilities that are typically used for sites having specific characteristics. Details for the design of each type of treatment facility, as well as design constraints, are in the next section.

6.10.4 Design Criteria

The Town's general criteria for permanent water quality treatment is 80% removal of the 60 micron particle from the WQCV of the area being treated or from the peak runoff rate from the 2-year return period storm over the area being treated, depending on the type of treatment facility being designed. For sites that require permanent stormwater quality treatment, treatment must be provided by one of the methods in Section 6.10.3. Meeting the criteria in this section for each type of treatment mechanism is assumed to result in this criteria being met. Supporting calculations must be included in the Drainage Report.

6.10.4.1 Tributary Offsite Area

When offsite area is tributary to a permanent stormwater treatment facility there are two options. The first option is to intercept the offsite flow and route it around or through the site in a separate conveyance system. The second option, if offsite flow cannot be separated, is to size the treatment facility for the entire tributary area. This could mean a much larger design volume or a larger peak runoff rate.

6.10.4.2 Right-of-Way Restrictions

Privately owned and maintained treatment facilities must be located outside the public right-of-way and offline from public stormwater conveyance systems. Easements are required for the area occupied by all facilities located outside the public right-of-way including for access.

6.10.4.3 WQCV Storage and Release

The WQCV is a volume of water designated for treatment that has been determined to provide the most water quality benefit for the cost to construct the improvements required to treat it. Volume 3 of the USDCM provides detailed discussion on the development of the WQCV. Capturing, storing, and slowly releasing the WQCV of a site will meet the Town's requirements for permanent water quality treatment by storing it long enough that pollutants settle out. WQCV treatment facilities acceptable for use in the Town include extended detention basins, sand filter basins, rain gardens, and infiltration galleries and trenches. Other types of facilities may be considered on a case-by-case basis.

The first step in designing a WQCV facility is calculating the WQCV. Two variables are required to calculate the WQCV. The first is the total imperviousness of the area draining to the treatment facility.

Recommended imperviousness values are in Section 7.5. The total imperviousness of a site can be determined by taking an area-weighted average of the different imperviousness values for the site. Total imperviousness can also be adjusted to an effective imperviousness if certain practices are implemented as part of the site design. Effective imperviousness applicability and calculations are discussed below the calculation for the WQCV.

The second variable is the design drain time of the treatment facility. Recommendations for design drain time for different types of WQCV treatment facilities can be found in Volume 3 of the USDCM. The most common WQCV facility is an extended detention basin, for which the recommended drain time is 40 hours. WQCV drain time coefficients are in Table 6.22 below. The general equation to calculate the WQCV in Breckenridge is expressed as:

$$\mathrm{WQCV} = 0.84\mathrm{Aa}(0.91\mathrm{I}^3 - 1.19\mathrm{I}^2 + 0.78\mathrm{I})/12 \qquad (6.18)$$

Where:

WQCV = water quality capture volume (acre-feet)

a = WQCV drain time coefficient

I= imperviousness as a decimal percentage

A = area draining to the treatment facility in acres

Table 6.22. Drain Time Coefficients for WQCV Calculations

Drain Time	Coefficient, a
12 hours	0.8
24 hours	0.9
40 hours	1.0

The WQCV equation was initially developed based on rainfall data from the Denver metro area. However, the precipitation depth of the average runoff producing storm in Breckenridge is 0.36 while in Denver it is 0.43. The WQCV equation above includes a coefficient of 0.84 to adjust the equation for use in Breckenridge. A map showing the variance in the average runoff producing storm across Colorado is shown as Figure 6.5.

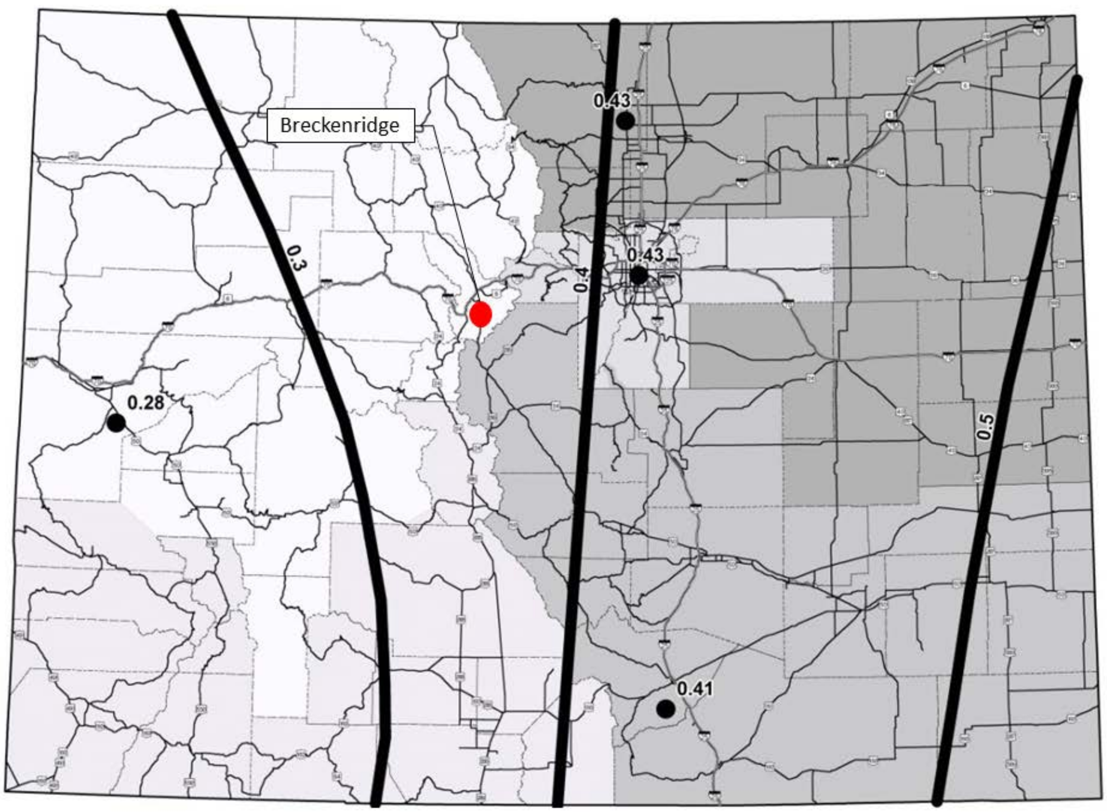


Figure 6.5. Map of the Average Runoff Producing Storm's Depth
(Modified from UDFCD, 2016)

Guidance on how to design extended detention basins, sand filter basins, and rain gardens to meet the WQCV standard are included in the Fact Sheets in Volume 3 of the USDCM. Sand filter basins are referred to as simply sand filters and rain gardens are referred to as bioretention.

6.10.4.3.1 Effective Imperviousness

The imperviousness value used in the WQCV calculation for sites that implement low impact development (LID) principles such as green infrastructure and MDCIA may be reduced to reflect the site's effective imperviousness. The effective imperviousness is dependent on the level of MDCIA implemented for high-level planning applications. Level 1 includes designing impervious surfaces to drain over a grass buffer or other pervious surface prior to reaching any stormwater conveyance system. Level 2 is an enhancement to Level 1 and includes eliminating curb and gutter or using slotted curbs; low-velocity pervious grass- or rock-lined swales instead of storm sewers, and pervious street shoulders. Guidance on calculating effective imperviousness for Level 1 and Level 2 MDCIA can be found in Volume 3 of the USDCM.

Where a detailed site plan has been developed and the square footage of directly connected impervious area, unconnected impervious area, receiving pervious area, and separate pervious area have all been defined, a more detailed effective imperviousness can be determined using the methods in Volume 3 of the USDCM.

6.10.4.3.2 Design Volume and Bypass Capacity

If it is intended that a WQCV treatment facility will serve as a snow storage area, the calculation of the required volume must be increased by 50% of the full design snow storage volume.

WQCV treatment facilities will likely receive more runoff than they were designed to treat during larger storm events. The design of any treatment facility designed to store and release the WQCV must include bypass capacity for the 100-year peak inflow rate into the facility. This is often provided in the form of an overflow weir set at the elevation of the design WQCV. Deign guidance is provided in the Fact Sheets in Volume 3 of the USDCM.

6.10.4.3.3 Detention

When a site requires detention in addition to permanent water quality treatment, a single facility may be designed to serve both needs. Detention facilities that are also water quality treatment facilities have outlets to provide for both the stormwater quality treatment and detention release rates. For these facilities, the guidance in the USDCM for Excess Urban Runoff Volume (EURV) facilities shall be followed. Section 7.12 discusses detention further.

6.10.4.4 Infiltration

It is common within the Town of Breckenridge for the subgrade soils to have a high infiltration rate. Infiltration testing is required when infiltration facilities are planned. Infiltration rates must be established by a double ring infiltrometer test performed by a geotechnical engineer at each proposed infiltration site at the proposed elevation of the bottom of the filter material prior to beginning detailed design. Treatment facilities acceptable for use in the Town that can be designed to infiltrate the WQCV include sand filter basins, rain gardens, drywells, infiltration trenches, and infiltration galleries. Other types of facilities may be considered on a case-by-case basis. ~~Note that~~However, if ~~it~~ the same area ~~is intended~~being used as ~~that~~ an infiltration treatment facility will~~to~~ serve as a snow storage area, the calculation of the required volume must be increased by an additional 50% of the full design snow storage volume.

Infiltration facilities must have a high enough subsoil permeability to infiltrate the entire WQCV of the area draining to them within 6 hours without the use of underdrains. Infiltration facilities shall be designed to drain 150% of the WQCV (see attached fact sheet for more information) within 72 hours. Infiltration facilities are not allowed within 300 feet of any active waterway without appropriate pretreatment prior to infiltration (examples include sand filters, water quality vaults, detention basins, and rain gardens). Infiltration facilities located between 300 and 1000 feet from an active waterway must not drain the WQCV in less than 4 hours unless appropriate pretreatment is designed. If subgrade soils at these facilities result in infiltration of the WQCV in less than 4 hours, a sand layer must be designed to slow the infiltration of the WQCV to a minimum of 4 hours. There are no ~~additional~~ restrictions on infiltration facilities located more than 1000 feet from an active waterway.

Guidance on how to design sand filter basins and rain gardens to infiltrate the WQCV standard are included in the Fact Sheets in Volume 3 of the USDCM. Sand filter basins are referred to as simply sand filters, rain gardens are referred to as bioretention. Guidance on how to design drywells, ~~and~~ infiltration trenches and galleries ~~is~~ are included in the Fact Sheets ~~included as~~ attachment~~s~~ to this chapter.

Permeable pavements may be considered with a legally binding maintenance agreement in place as alternative to conventional pavement in pedestrian areas and lower-speed vehicle areas. They will not be allowed for treatment of tributary areas with high sediment yields that could easily clog the system and they are not allowed in the public right-of-way. Permeable pavements will not be allowed on steep slopes or in areas receiving runoff from bare or nearly bare earth. Permeable pavements will be considered impervious materials for detention and water quality calculations and must be designed in accordance with manufacturer's recommendation.

See the subsurface infiltration facility fact sheet in Appendix D of these Standards for additional information and requirements for designing infiltration facilities.

6.10.4.5 Proprietary Structures

Proprietary structures are designed to treat a design flow rate instead of a design volume, and typically function by gravitational separation, vortex separation, filtration, or by screening and retaining pollutants within the structure. The use of proprietary facilities is acceptable but generally discouraged as more frequent maintenance is typically required to maintain adequate performance, proprietary structures often have high long-term costs, and they are often very large while treating only a small flow rate. Proprietary facilities that require removable or replacement cartridges and those that require confined space entry procedures or remote camera operation for routine inspections may be considered on a case-by-case basis.

The two most recognized national programs that test the TSS removal of proprietary structures are in Washington state and New Jersey. Proprietary structures acceptable for use in the Town are those that have been tested by one of these programs and have received one of the following:

1. General or Conditional Use Level Designation for the Pretreatment or Basic test protocols of the Washington State Department of Ecology (WSDOE) Test Assessment Protocol – Ecology (TAPE) for emerging stormwater treatment technologies
2. Certification by the New Jersey Department of Environmental Protection (NJDEP) with verification by the New Jersey Corporation for Advanced Technology (NJCAT) that the manufactured treatment device (MTD) is adequate for TSS removal.

The Town may consider allowing a proprietary structure that is not approved by WSDOE or NJCAT provided that, as part of the drainage report, a qualified professional engineer submits adequate documentation, as determined by the Town, of the manufacturer's test data showing similar performance to that required by either the WSDOE or the NJCAT. The level of scrutiny during review for approval of such devices may be significant.

Proprietary structures must be designed to provide water quality treatment for the 2-year peak design flow rate from the area they are treating. Bypass capacity must be included for the 100-year peak flow rate from this same area. If bypass capacity is not included within the structure, it must be provided before the structure in the form of a diversion for higher flows provided the first flush flows pass to the treatment facility.

6.10.4.6 Treatment in Series

Treatment in series is a very effective way to provide water quality treatment and is highly encouraged. Treatment in series, also referred to as a treatment train, involves passing stormwater from one treatment facility to the next, with each facility providing additional treatment. The facilities used in a treatment train are positioned so facilities that can handle a larger, coarser pollutant load are first, while those facilities that are more suited to a smaller, finer pollutant load are last. This allows for longer periods between required maintenance, especially for the facilities that provide more refined removal.

One option for calculating TSS removal rates is presented in the *Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality* (EPA,1986). The development of this manual was supported by the EPA Nationwide Urban Runoff Program (NURP). While the entire document is worth reviewing, Chapter 4.2.1 of this document presents an analytical method under which TSS removal can be evaluated under the dynamic conditions expected in permanent stormwater treatment facilities. Removal due to sedimentation in a dynamic system is expressed by the equation below.

$$R = 1 - \left[1 + \frac{1}{n} * \frac{V_s}{Q/A}\right]^{-n} \tag{6.19}$$

Where:

R = fraction of solids removed

V_s = settling velocity of particles

Q/A = rate of applied flow divided by surface area

n = turbulence parameter

The turbulence factor offers a way to factor in poor performance caused by turbulence and short circuiting, with n=1 representing very poor performance and n=5 or more indicating very good performance. With n equal to infinity, removal efficiency is linked to detention time. This equation is useful in areas without enough relief to drain a pond that could hold the entire WQCV, or to design basins in series or those receiving inflow that may have already been partially treated by a different type of upstream treatment facility.

Particle settling velocity is calculated as the submerged weight of a particle minus the drag. This calculation requires the minimum particle size of interest be specified. It also requires the viscosity of water, which varies with temperature. To meet Town requirements, a spherical particle with a diameter of 60 microns may be used. A water temperature of 40 degrees Fahrenheit may be assumed, having a viscosity of 1.664×10^5 ft^2/s.

Given the Town requirement for 80% removal of the 60 micron particle, an appropriate treatment train composed of any types of permanent treatment facilities discussed herein may be designed using the equation above. Grass buffers and grass swales are especially helpful at the upstream end of a treatment train. Each of the facilities in the treatment train must include physical components in accordance with these Standards and with the manufacturer's recommendations for permeable pavement, if applicable. A Treatment Train Example Calculation is included as an attachment to this chapter.

6.10.5 Designing for Inspection and Maintenance Requirements

Long-term maintenance requirements are a critical component of treatment facility selection and design because facilities that are not properly maintained do not function properly and/or do not treat stormwater runoff to the extent required by the Town. All new facilities shall be designed to facilitate maintenance operations.

Maintenance considerations that must be evaluated during the selection and design process include accessibility, required equipment, frequency of maintenance, special required training, the freeze/thaw nature of the Town's climate, and the need for replacement materials.

Property owners shall be responsible for the maintenance of stormwater detention and water quality facilities to ensure proper functioning. See Section 6.10.5.7 for additional maintenance requirements.

6.10.5.1 Access

An easement shall be provided to allow Town staff to access the facility if the responsible agency is negligent. Access roads shall be provided to all structures including forebays, outfalls, inlets, micropools, outlet structures, and proprietary facilities. Access roads must support an 80,000-pound vehicle load, be at least 10 feet wide, and have an inside turning radius of at least 25 feet. Access roads must pass close enough to each treatment facility component needing maintenance (forebays, micropools, subgrade vaults, etc.) that the equipment to be used will be able to reach the structure. For example, a backhoe with a reach of 25 feet must be able to pass within 25 feet of the structure without leaving the access road. The Town's vacuum truck has a reach of only 5 feet. If a vacuum truck is required for maintenance, the access road must pass within 5 feet of the facility being maintained. If the access road cannot pass close enough to the structure for the equipment to reach, a concrete access ramp or similar supportable material, such as a 6-inch layer of angular 4-inch-minus riprap, shall be provided at a slope no steeper than 10:1. Concrete ramps shall be scored for wet weather traction.

6.10.5.2 Forebays

Accessible forebays shall be provided at all concentrated inflow points of extended detention basins and sand filter basins for removal of accumulated sediment and floatables. The forebay must be designed in accordance with the Fact Sheets in Volume 3 of the USDCM.

6.10.5.3 Stockpile Areas

Facilities should be designed with stockpile areas for temporary storage and drying of mucked out material. A stockpile area should be directly adjacent to each structure to be cleaned out. Stockpile areas shall be located outside the low flow area and should be as flat as possible. Total stockpile area shall be twice the square footage of all forebays and the micropool.

6.10.5.4 Extended Detention Basins

Extended detention basins shall include a micropool with a hard bottom against which to excavate that is accessible to a vacuum truck or backhoe. Extended detention basins shall include a trickle channel at least 48 inches wide with no cross slope. Trickle channels shall have a concrete bottom and sides at least 6 inches high to allow access for lightweight maintenance equipment if the trickle channel longitudinal slope is less than 5%. If there is a desire for a more aesthetically natural trickle channel, the Town Engineer shall be consulted to discuss and determine maintenance requirements and protocols.

6.10.5.5 Infiltration Facilities

Sand filter basins, rain gardens, drywells, and infiltration trenches have a short lifespan before needing replacement filter material. These facilities shall include pretreatment to remove trash and larger sediment. If located next to a roadway, infiltration facilities shall also include a barrier to prevent degradation of the roadway subgrade. Infiltration testing is required prior to facility design if an infiltration facility is planned. Infiltration testing shall also be conducted after construction and prior to acceptance to ensure the facility functions as intended.

During construction and maintenance operations, special care shall be taken to avoid compaction of subsurface soils that will reduce infiltration rates. If a full infiltration basin is not used, an underdrain system including a loading evaluation will be required and cleanouts must be provided every 300 feet.

Guidance on how to design drywells and infiltration trenches and galleries is included in the Fact Sheets included as attachments to this chapter.

6.10.5.6 Proprietary Structures

Proprietary structures must not require confined space entry procedures for maintenance. Careful design of access to vaults and use of a vacuum truck may eliminate confined space entry requirements.

6.10.5.7 Ownership and Maintenance Plan and Agreement

Treatment and detention facilities require regular inspection and maintenance, to be completed by the property owner. Table 6.23 lists the minimum required inspection and maintenance schedule and typical maintenance activities and operational protocols for various types of treatment and detention facilities. Based on site conditions, the design engineer may require additional maintenance measures, a more frequent schedule, or unique protocols for a site. Volume 3 of the USDCM should be consulted when determining the maintenance schedule, activities, and protocols to be included on the O&M Plan.

An Ownership and Maintenance (O&M) Plan must be developed, submitted, and approved as part of the Drainage Report and then also included as part of the Ownership and Maintenance (O&M) Agreement. An executed O&M Agreement may be required prior to facility approval and project close out. The Town will have the right to access the property to maintain the treatment or detention facility and invoice the owner for the cost of such work if the owner fails to maintain the facility. An example O&M Plan, including a template for the O&M Plan text, and an O&M Plan checklist are included as attachments to Chapter 2. Town staff is available for consultation during the treatment and/or detention facility selection and design process to ensure the design meets the requirements of these Standards. Minimum required components for maintenance are presented in Table 6.23 below.

Town staff will routinely inspect facilities or respond to complaints relating to facilities that may not be performing properly. Facility owners should expect notification of inspections and subsequent findings to be communicated by inspection personnel.

Table 6.23. Recommended Inspection and Maintenance Schedule

Extended Detention Basin	
Activity	**Required Frequency**
Inspection for debris at outlet, sediment in the forebay, and damage to structures or embankments; maintain or repair as necessary.	Twice annually
Remove sediment from forebay, trickle channel(s), and micropool; aeration of vegetated areas	Annually
Mowing	As needed to maintain 6” height and control weeds
Irrigation and application of fertilizer, herbicide, and pesticide	As needed to maintain vegetative health

Notes: Maintenance frequency is highly dependent on construction activity within the tributary area, associated erosion control measures, and the design of the facility. More frequent removal of accumulated sediment may be required, but detention basins are generally low maintenance facilities.

Sand Filter Basin, Rain Gardens, Dry Wells, and Infiltration Trenches and Galleries	
Activity	**Required Frequency**
Inspection to confirm infiltration rate after rainfall; maintain as necessary. Debris and litter removal.	Twice annually
Mowing, plant care, irrigation, and application of fertilizer, herbicide, and pesticide (for bioretention only)	As needed to maintain vegetative health
Mulch replacement (for rain gardens only)	As needed to maintain 3” depth
Inspection of underdrain	When ponding lasts longer than 24 hours
Sediment removal and replacement of media	When ponding lasts longer than 24 hours and underdrain is not clogged

Proprietary Structure	
Activity	**Required Frequency**
Inspection for debris that may cause bypass of design treatment flow rate; maintain as necessary.	Quarterly for first 2 years, as indicated based on first 2 years after that

Filter cartridge inspection; replace as necessary.	Twice annually
Debris removal, filter cartridge replacement, and vacuuming	As recommended by the manufacturer

6.11 CONSTRUCTION STORMWATER MANAGEMENT

Management of stormwater runoff from construction sites in the Town of Breckenridge contributes to our community goal of protecting and maintaining water quality within our local watercourses. A significant amount of sediment can be discharged with stormwater runoff from a construction site. This sediment has the potential to end up in receiving streams, lakes, and rivers, negatively impacting the riparian and aquatic habitat. Establishing a program to minimize untreated runoff from construction sites is essential to keeping streams and drainageways healthy and to minimizing impacts from pollutants and litter.

This section presents the Town's requirements regarding the control of stormwater runoff quality from construction sites, the applicability of the requirements, design guidance for selected BMPs, and references that provide additional information and details. The goal of the requirements in this section is to keep the Town's streams and drainageways healthy. Volume 3 of the USDCM includes a substantial amount of guidance on construction stormwater management and is referenced throughout this section.

The naming convention for facilities or practices that treat stormwater quality during construction has varied over time and between documents. These facilities and practices have been called best management practices (BMPs) in the past. While some more recent documents refer to them as control measures or temporary control measures, these Standards will continue to refer to them as BMPs.

6.11.1 Applicable Codes and Permits

The Town requires applicable construction activity to obtain at least one permit from the Town prior to beginning construction activity. See Chapter 2 for permit requirements. A Stormwater Management Plan (SWMP) or Construction Site Management Plan (CSMP) is required as part of these permits. CSMP requirements are in the Town Code.

Applicable construction projects must apply for a permit from the CDPHE to be covered by the CDPS General Permit for Stormwater Discharges Associated with Construction Activity (Permit No. COR400000). For activity involving dewatering operations, a Construction Dewatering Permit from the CDPHE is required. Information on these permits, and others that may be required during construction, can be found at the CDPHE's webpage for water quality construction permits.

CDOT Erosion Control and Stormwater Quality Field Guide will be used to ensure compliance designing, installing and maintaining BMPs through construction.

6.11.2 Applicability within the Town

The Town's requirements depend on the area disturbed by the project. Applicable projects must develop a Stormwater Management Plan (SWMP). Non-applicable projects, those disturbing less than one acre including any commercial, multi-family, or applicable single family/duplex development, must develop a Construction Site Management Plan (CSMP). CSMP requirements are in the Town Code

A SWMP consists of construction plans and details, specifications for BMPs, and a narrative report that collectively indicate how a construction site will implement structural, non-structural, and planning measures to reduce erosion at the source and prevent pollutants such as sediment and litter from leaving the site. Detailed SWMP requirements are included later in this section.

The Town also requires a Construction Site Management Plan (CSMP) for certain projects. For sites disturbing one acre or more, the CSMP applies only to traffic and site access control. For sites disturbing less than one acre, the CSMP applies to traffic, site access, and erosion and sediment control. Criteria in this section for the design of BMPs and for site inspections apply to sites that require a SWMP and those that require a CSMP.

6.11.3 Stormwater Management Plan Requirements

The intent of a Stormwater Management Plan (SWMP) for construction activities is to prevent pollution, contamination, or degradation of waters of the State and to prevent discharge of pollutants from a project site. Appropriate BMPs must be implemented prior to the start of construction activity, must control potential pollutants during each phase of construction, and must be maintained in operational condition through final stabilization. BMPs must be selected, designed, installed, implemented, and maintained to provide control of all potential pollutants including sediment, construction site waste, trash, discarded building materials, concrete truck washout water and materials, chemicals, sanitary waste, and contaminated soils in discharges from the site. The SWMP will include the following at a minimum:

6.11.3.1 SWMP Report

The SWMP Report is a narrative description and summary of the project site and proposed improvements, how construction activities will be conducted, and the erosion and sediment control practices, procedures, and physical BMPs that will be installed or implemented on site. Items to be included in the SWMP Report are:

1. Administrative Information: Include the project name, location, owner, operator, qualified stormwater manager that will conduct inspections, and the CDPHE certification number.
2. Existing Site Information: Include a description of the existing site, the existing site vegetation and percent density, and the name of the receiving water.
3. Proposed Improvements: Include a description of the proposed project, a description of construction activities, the total area of planned disturbance including access, staging, and storage areas, a sequence of major activities, an approximate construction schedule, and a description of how the project site will be phased.
4. Structural Control Measures: Include a description of the structural BMPs for each stage of construction. Each site must provide structural BMPs that:
    a. Trap sediment before it leaves the site or enters the municipal storm sewer system or watercourse. These shall be installed prior to initiating earth disturbances. Examples include check dams, inlet protection, sediment basins, sediment control logs, and silt fence. Sediment basins are required for sites that have more than 3 acres of tributary area or are directly adjacent to a wetland or major tributary.
    b. Capture and retain runoff from vehicle and equipment washing operations, such as cleaning of concrete trucks, chutes, and associated equipment. An example is the concrete washout. Equipment wash water may not be discharged to State waters or storm sewer systems.
    c. Stop erosion at the source and minimize off-site vehicle tracking of sediment. These include BMPs that stabilize earth disturbances with vegetation or soil stabilization techniques after grading is substantially complete on any portion of the site or for any portion of the site that is inactive for a certain duration of time. Examples include surface roughening, mulching, vehicle tracking control, and installation of blankets, straw wattles, tackifiers, netting, and matting.
    d. Provide bulk storage and prevent spills of petroleum products and other chemicals or fertilizers and contain storm runoff from construction wastes to a designated area, if

applicable. These BMPs shall be able to contain all spills and prevent any spilled material from entering State waters. Secondary storage must be provided, and all bulk storage shall be located as far away from State waters as possible.

e. Provide final stabilization of a site. These may include sod, seed, mulch, landscape plantings, decorative rock, or hard surfacing such as pavers, concrete, or asphalt. Seed mixes must be provided. An anticipated schedule must be provided. If a site is to be winterized, discuss temporary stabilization measures to be utilized. The Town may require a revegetation and stabilization bond for some projects.

5. Non-Structural Control Measures: Include a description of the non-structural BMPs that will be used throughout construction. This section of the report must include:

   a. Discussion about how the following operations will be conducted: trash management; dust and particulate management; materials loading and unloading; vehicle and equipment maintenance and fueling; building materials, chemical, fertilizer, and stockpile storage; routine maintenance involving fertilizers, pesticides, detergents, petroleum products, and solvents; and concrete and batch plants.

   b. A plan to remove from the site and dispose of all waste composed of building materials in licensed disposal facilities. No building material waste or unused building materials shall be buried, dumped, or discharged at the site.

   c. A program and schedule for regular inspection and maintenance of BMPs.

6. Include a description of how construction will be sequenced to reduce the duration any disturbed areas are exposed. Temporary disturbed areas and disturbed areas that will be permanently stabilized shall be exposed no longer than 30 days.

7. Addition Potential Pollutants: Identify and address pollutant sources associated with any other areas or operations not included above where spills can occur. Identify other non-stormwater discharges not included above including construction dewatering not covered under the Construction Dewatering Discharges general permit and wash water that may contribute pollutants to Town waters.

6.11.3.2 SWMP Plans

The SWMP Plans are construction plans that locate and identify the number, extent, and installation details of the structural and nonstructural BMPs included and discussed in the SWMP Report. The SWMP plans must also include property boundaries, construction site boundaries, existing and proposed utilities, limits of cut and fill, stockpile areas, porta-let locations, arrows to depict the direction runoff will flow, and the locations of all receiving waters and drainages.

6.11.3.3 SWMP Specifications

BMP materials specifications and installation requirements may be provided with the BMPs installation details included with the SWMP Plans or as separate technical specifications in the project manual. Installation and implementation specifications must be provided for all structural BMPs in one of these two documents.

6.11.4 SWMP Submittal, Inspection, & Maintenance

For applicable sites, a SWMP must be submitted to the Town for review and approval prior to construction. Once the SWMP is approved and construction begins, regular inspection and maintenance of the BMPs will proceed throughout the duration of construction. The subsections below provide more detail on these requirements and processes.

6.11.4.1 SWMP Submittal Requirements

SWMP plans are construction plans that depict the type and location of structural and procedural BMPs that will be implemented on site during various stages of construction. SWMP plans must be submitted to the Town for review and approval. A SWMP shall be developed by a qualified stormwater professional.

Each SWMP must have separate sheets for the initial/interim and final phases of construction as well as detail sheets with a design and installation detail for each BMP specified in the SWMP. A legend shall be provided that includes all abbreviations used (e.g. CWA is used for concrete washout area) as well as all symbols, blocks, and line types that represent various BMPs. Each kind of symbol, block, or line type shall be labeled at least once on each sheet on which it is used. Text on all SWMP plan sheets, including the detail sheets, shall be legible when the SWMP plan set is printed on 11 x 17 paper, using at least a 9-point font. In the case of overlapping or adjacent project sites that are separately managed, the SWMP shall include at least one plan sheet that clearly shows the site area managed as part of the submitted permit. If more than one sheet is required for each phase of the SWMP plan set, the first sheet of the initial phase shall match the first sheet of the interim phase, and so forth. For project sites that are adjacent to or within construction activity that is not being performed by the same owner or operator, the SWMP shall delineate the exact project site boundaries that each owner or operator is responsible for.

6.11.4.1.1 Initial SWMP Plan

Initial SWMP plans include all BMPs that will be installed before construction begins. These shall include vehicle tracking at all exits from the site and enough stabilized staging area to accommodate the site’s operations. Initial SWMP plans will also include any construction fence, inlet protection, curb socks, perimeter controls, or concrete washout areas that are required on site. Initial BMPs shall be identified on the initial SWMP plan by their two- or three-letter abbreviation and a quantity such as linear feet (LF) or square feet (SF), where applicable. The initial plan may be combined with the interim plan for small sites that do not have complex phasing. Sites disturbing 40 acres or more must have separate initial and interim SWMP plan sheets that detail the planned phasing of the site, and it is likely that more than one of each will be required to cover the larger area at a reasonable scale.

6.11.4.1.2 Interim SWMP Plan

Interim SWMP plans include all BMPs that will be installed as construction progresses. These include all BMPs such as temporary stream diversions, check dams, sediment basins, stockpile areas, sediment control logs on exposed slopes, and culvert outlet protection, among others. The interim SWMP plan should include all the BMPs shown on the initial SWMP plan, but they should have their dimensions removed for clarity. Like the initial SWMP plan, interim BMPs shall be identified on the interim SWMP plan by their two- or three-letter abbreviation and a quantity such as linear feet (LF) or square feet (SF), where applicable. Operators are encouraged to phase construction sites to minimize erosion. A complicated site may require more than one interim SWMP plan. The interim plan may be combined with the initial plan for small sites that do not have complex phasing. Sites disturbing 40 acres or more must have separate initial and interim SWMP plan sheets that detail the planned phasing of the site, and it is likely that more than one of each will be required to cover the larger area at a reasonable scale.

6.11.4.1.3 Final SWMP Plan

Final SWMP plans include final stabilization BMPs such as seeding, mulching, and erosion control blanket. For some sites, the landscape plan, if it is comprehensive and included in the construction plan set, may be used as the final SWMP plan, provided the required information is included. In other cases, a separate final SWMP plan will be required. The final SWMP plan should generally not include initial and interim BMPs and abbreviation labels. If an initial or interim BMP is to remain, it shall be included on the final SWMP plan and noted to remain. Otherwise all initial and interim BMPs shall be assumed to removed.

6.11.4.1.4 SWMP Details

Details for all BMPs specified shall be provided on SWMP plan detail sheets. Details shall be in accordance with CDOT or MHFD standard details.

6.11.4.2 SWMP and CSMP Inspection

Each SWMP permittee shall designate a qualified stormwater manager to inspect the BMPs on the construction site. Inspections should occur either weekly or every 14 days and after each runoff-producing storm event to confirm they are installed and functioning as intended, beginning with an inspection of the initial BMPs prior to any excavation and ending with final approval of the site by the Town. The stormwater manager shall be an individual knowledgeable in the principles and practices of erosion and sediment control and pollution prevention, and with the skills to assess: 1) conditions at construction sites that could impact stormwater quality and 2) the effectiveness of stormwater controls implemented to meet the requirements of this permit.

The stormwater manager should keep a record of all inspections including the date and time of the inspection, recent precipitation, required maintenance activities to be completed, and a summary of maintenance completed since the previous inspection. The stormwater manager shall update the SWMP (or CSMP) plans to reflect current conditions by showing changes made to the location and/or type of BMPs based on their performance and/or inspection reports throughout the duration of construction. An updated set of SWMP plans, including installation details, shall be on site during construction activities.

The Town will periodically inspect construction sites for conformance to the SWMP, to confirm installation, maintenance, and function of the BMPs are adequate, and to assure compliance with the Town's permit(s) and Town Code. Work that is not in compliance with the Town's Standards, the SWMP, the CSMP, or the Town Code is subject to enforcement action.

6.11.4.3 SWMP Maintenance

Maintenance of BMPs is typically ongoing for the duration of construction. The SWMP permittee shall schedule any required maintenance noted during regular inspections to be completed prior to the next inspection or reinspection. The SWMP must be updated as needed to reflect current site conditions and be maintained on site. Possible modifications may include replacing and adding BMPs and identifying additional pollution sources. Hand-written notations, initialed and dated, are adequate for most plan updates.

6.11.4.4 SWMP Adequacy

If BMPs installed on the site are inadequate to properly control pollutants during construction as evidenced by their performance during or after storm events or as identified during inspections, the SWMP permittee shall immediately complete any modifications required to properly control pollutants or those noted during inspection. Modifications completed shall be physically noted in the SWMP plans. BMPs, or lack thereof, identified as inadequate based on a Town inspection shall be rehabilitated immediately.

6.11.5 Temporary BMPs

Temporary BMPs are structural or site planning BMPs that are utilized to minimize sediment or other pollutants during construction activities. These BMPs shall be removed from the site upon completion of site stabilization unless they are designated to remain by the SWMP or by the Town because, for example, they do not impede use or maintenance of the site or will biodegrade. This section presents some specific structural and site planning BMPs that are to be used during construction. It also offers several reference documents that provide design and construction details for BMPs that are not specifically discussed in this section.

6.11.5.1 Vehicle Tracking

Vehicle tracking pads are an essential part of preventing sediment from leaving a construction site. Vehicle tracking pads shall be implemented at every exit point to the site, regardless of the type of equipment that will be exiting at each location. The stone used should be hard, durable, angular stone, resistant to weathering with a long dimension not less than 3 inches. Larger stone is preferable, and stone should have a minimum specific gravity of 2.6. Other means of keeping sediment on site may be acceptable with proper documentation and provided performance is maintained. Any damage to sidewalk, curb, or gutter shall be replaced by the permittee. The minimum dimension for each vehicle tracking pad is 20 feet wide by 50 feet long by 6 inches thick, although more length may be required if the minimum size does not provide adequate performance.

6.11.5.2 Sediment Basins

Sediment basins to capture construction site runoff shall be installed on construction sites that disturb more than 3 acres. Runoff is detained in sediment basins and slowly drained so that sediment may settle out before the runoff leaves the site.

For sites with less than 40 acres of disturbance, at least 66% of disturbed area shall drain to a sediment basin. Multiple basins may be more efficient to achieve this requirement than a single basin, depending on the site configuration. Each basin must have a way to drain detained runoff as well as an emergency overflow with a revetted overflow path for runoff exceeding the sediment basin design volume. Sediment basins should drain passively through an outlet structure designed to drain the full basin volume within 12 hours. Designs for outlet structures should be per the criteria references provided in 6.11.5.7. Sediment basin storage volume may also be actively drained by pumping through a sediment bag with the basin being pumped empty when the basin volume reaches 50% of capacity or when rain is forecasted within 24 hours. When pumping is proposed in lieu of a passive outlet structure but is not performed per this criteria, the owner and operator are subject to enforcement action for improperly maintaining the selected BMP.

Each sediment basin shall provide 1600 cubic feet of storage per acre of tributary area provided it is not utilized as a BMP during the months of March, April, or May. If a sediment basin is utilized as a BMP during March, April, or May, it shall provide 3200 cubic feet of storage per acre of tributary area.

For sites with 40 acres or more of disturbance, every acre of disturbance exceeding 40 acres shall drain to a sediment basin. For example, a site with 39.9 acres of disturbance would be required to drain 26.3 of those disturbed acres to a sediment basin. A site with 45 acres of disturbance would be required to drain 31.7 of those disturbed acres to a sediment basin. This criteria encourages owners and operators to minimize the area of site disturbance at any one time to less than 40 acres.

Sediment basin design elements that must be in accordance with the Volume 3 of the USDCM include a spillway crest length based on tributary drainage area, a 12-inch minimum distance between the overflow crest and the surrounding embankment, outlet protection for the spillway, outlet works, and embankment slopes.

6.11.5.3 Check Dams

Check dams may be used to slow runoff in drainageways to limit erosion and sediment transport. Different agencies have specified different cross sections for check dams in their BMP details, however, all agencies specify that the elevation of the crest of the downstream check dam should be equal to the downstream toe of the next upstream check dam. This may become unreasonable in because of the steep grades of some drainageways. For check dams in Breckenridge, the following criteria apply.

1. For preliminary sizing and spacing, check dam height above existing grade shall be a minimum of 18 inches and a maximum of 3 feet. Check dams shall be spaced along the drainageway such that the crest of the downstream check dam is at the same elevation as the downstream toe of the next upstream check dam.
2. If preliminary sizing results in a check dam spacing of less than 200 feet (i.e. the drainageway is steeper than 1.5%), Check dam height may be increased to 4 feet or may spacing may be less than 200 feet for slopes up to 2%. If drainageway slope exceeds 2%, the SWMP preparer shall propose a check dam height and spacing that he or she believes will meet the intent of the intended purpose of the check dam. The proposal shall be discussed during a SWMP review meeting with the Town.
3. Check dam embedment in the underlying ground shall be at least 12 inches and stones used in the check dam shall have a D50 of at least 12 inches.
4. A plan view and sections of a typical check dam used on the site will be provided with the SWMP plan as an initial BMP.
5. All check dams must be removed as part of final stabilization unless designated or approved to remain by the Town.

6.11.5.4 Materials Storage and Stockpiles

Construction materials that are not earth or aggregate shall be stored on a stabilized staging area. Earth and aggregate may be stockpiled outside of a stabilized staging area, but earth materials must be bounded by silt fence or some other BMP that will prevent sediment from escaping the stockpile during a runoff event.

The stabilized staging areas shall be large enough to store all required materials, provide parking for vehicles and equipment on site, and accommodate loading and unloading activities. The stabilized staging area must be installed as an initial BMP, prior to any other construction activities. The size of the stabilized staging area will vary with each site but may be required to be enlarged if inspections show it is not sized sufficiently to contain all required items and activities. Each stabilized staging area shall consist of granular material at least 3 inches thick unless it is demonstrated that native materials provide adequate stabilization. If rutting occurs, or if the underlying subgrade becomes exposed, additional granular material will be required. Once construction is complete, the granular material shall be removed, and the site shall be stabilized in accordance with the final SWMP plan or landscape plan.

6.11.5.5 Temporary Stabilization and Winterization

All areas disturbed by construction or stockpiles shall be stabilized as soon as possible to reduce the duration bare soil is exposed to runoff. All disturbed areas which are either final graded or will remain inactive for a period of more than 30 days shall be stabilized after the completion of the grading activities. Acceptable temporary stabilization BMPs include surface roughening, seeding and mulching, erosion control blankets or turf reinforcement matting, and tarping for stockpiles. Temporary stabilization by revegetating should take place progressively as the project moves forward and as soon as feasible.

To prevent damage during spring runoff, all disturbed areas shall be temporarily stabilized with one of the acceptable methods listed above prior to winter. While the Town requires winterization activities by completed by December 1, it is recommended that winterization be completed by November 1.

6.11.5.6 Erosion Blanket

Any embankment, cut, or fill slope that is in its final graded state and steeper than 3H:1V shall be seeded and covered with erosion blanket within 30 days of final grading being completed. Erosion blanket installation shall be in accordance with the manufacturer's details and specifications which shall be included on the SWMP plan detail sheet.

6.11.5.7 Control Measure Specifications and Details

Unless the Town has included its own temporary BMP details or design guidance in this section, construction details and design procedures shall be as presented in the most recent version of one or more of the following references. Note that these documents are updated regularly and can be found via an internet search.

1. Colorado Department of Transportation Erosion Control and Stormwater Quality Guide and Standard Plan M-208-1.
2. Urban Drainage & Flood Control District Urban Storm Drainage Criteria Manual, Volume 3 Stormwater Quality.
3. Southeast Metro Stormwater Authority Grading, Erosion, and Sediment Control Manual.

The BMPs presented in the documents referenced above shall be designated in the SWMP where appropriate, and details for each BMP specified shall be included in the SWMP. Use of alternate BMPs not specified above is subject to approval by the Town.

6.11.6 Construction Site Inactivity

Temporary stabilization must be implemented for earth disturbing activities on any portion of the site where ground disturbing construction activity has permanently ceased, or temporarily ceased for more than 30 calendar days. Temporary stabilization methods may include, but are not limited to, hydromulching, tarps, soil tackifier, hydroseed, and erosion control blankets. The permittee may exceed the 30-day schedule when either the function of the specific area of the site requires it to remain disturbed, or physical characteristics of the terrain and climate prevent stabilization. The SWMP must document the constraints necessitating the alternative schedule, provide the alternate stabilization schedule, and identify all locations where the alternative schedule is applicable on the site map.

6.11.7 Final Stabilization

Final stabilization is reached when all surface disturbing activities at the site are complete and a uniform vegetative cover has been established with a plant density of at least 70% of pre-disturbance levels, or an equivalent amount of permanently stable surface has been constructed. Permanently stable surfaces include landscape rock, wood mulch, and landscape pavers. Only the vegetation specified in the SWMP planting plan or seed mix shall count toward plant density.

CHAPTER 7
GRADING & EXCAVATION

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LIST OF ATTACHMENTS – APPENDIX E

7.1 PURPOSE

Development sites within the Town of Breckenridge's mountain environment frequently contain steep slopes, wetland areas, and perennial streams and may be located close to the Blue River. This chapter establishes standards and regulations for development to protect the environment and public health and safety. The standards in this section provide the minimum regulations for grading, excavation, and drainage. Special site conditions or constraints may justify additional requirements from the Town Engineer.

7.2 OTHER STANDARDS

This section provides standards and regulations for general grading, excavation, and drainage for all construction and property development, including work in the right-of-way, single family home development, large residential developments, and commercial property development. Additional grading and excavation standards are provided in the following standards:

1. Chapter 2 of these Standards provides submittal requirements for various types of grading and excavation projects.
2. Chapter 5 of these Standards provides grading requirements within or near streets and driveways.
3. Chapter 6 of these Standards provides information on grading of open channels, detention facilities, and stormwater features.
4. The Subsurface Infiltration Facilities Fact Sheet, included as an attachment to Chapter 6, provides additional requirements for subsurface infiltration facilities.
5. Chapter 8 of these Standards provides requirements and procedures for inspection and acceptance of grading and excavation work.
6. Chapter 9 of these Standards provides construction specifications pertaining to grading and excavation.
7. OSHA provides requirements for temporary trenching, grading, shoring, and other construction requirements.

7.3 PERMITS

Any grading or excavation work of any kind requires a permit prior to commencing work. An infrastructure permit, right-of-way permit, or building permit is required before beginning any grading or excavation activities. Additional Town, County, State, or Federal permits may be required as well. See Chapter 2 (Section 2.4) of these Standards for additional guidance on permits.

7.4 GRADING

The sections below set minimum grading requirements, including geotechnical engineering requirements, slope stability, maximum slopes, earthen berm requirements, detention ponds, retaining walls, and revegetation requirements.

7.4.1 Geotechnical Engineer

Sites with existing grades exceeding a 3H:1V slope will require a geotechnical report analyzing slope stability that is stamped by a geotechnical engineer licensed in the State of Colorado. The geotechnical engineer shall analyze the slope stability for the existing site, proposed structures, and driveways, and examine any impacts to adjacent structures or properties.

Sites with unique conditions, high groundwater, poor or expansive soils, previously mined areas, or any other geotechnical concerns shall require a geotechnical report stamped by a geotechnical engineer licensed in the State of Colorado.

7.4.2 Maximum Slope

A maximum slope of 3H:1V is recommended and preferred for all development in the Town. If existing topography makes it infeasible to provide 3H:1V slopes, slopes of 2H:1V may be allowed. Slopes exceeding 3H:1V require erosion netting or other erosion control systems as approved by the Town Engineer. Slopes should be designed at a maximum of 2.5H:1V, as 2H:1V design slopes often result in localized areas with slopes steeper than 2H:1V, which will not meet code nor pass inspection.

7.4.3 Earthen Berms

Earthen berms constructed for landscaping, screening, or sound mitigation shall be constructed at a maximum slope of 3H:1V. Berms shall be designed to appear natural and match surrounding topography; this should be accomplished through the following design standards:

1. Berms shall be designed with vertical and horizontal undulation. Vertical undulations shall be 50% of the maximum berm height and horizontal undulations shall be 25% of the maximum berm width. A variance may be granted for berms shorter than 100 feet.
2. Maximum height of berm shall be 10 feet.
3. Berms shall be connected to the existing grades at the bottom gradually with a vertical curve to make the berm more natural appearing.
4. Berms shall flatten near the top to appear more natural.

7.4.4 Detention and Water Quality Features

Detention and water quality feature grading shall be designed to balance aesthetics and maintenance. Grading shall be designed to add horizontal undulations so the features appear more natural and match the natural landscape, provided that the undulations do not negatively impact maintenance of the facility.

7.4.5 Retaining Walls

The maximum slope of unretained finished grades shall be 2H:1V. Slopes with proposed grading that will result in grades steeper than 2H:1V will require retaining walls. All retaining walls taller than 4 feet (measured from finished grade at bottom of wall to top of wall) shall be engineered. Engineered walls require the following to be submitted to the Engineering Division from a professional engineer licensed in the State of Colorado:

1. Detailed plan by Colorado professional engineer showing retaining wall details and stamped
2. Inspections during construction certifying all aspects of retaining wall construction meet plan requirements and good engineering practices
3. Final certification of the retaining wall construction by Colorado professional engineer

Multiple retaining walls constructed close to each other will be treated as a single wall for height calculation purposes unless the horizontal distance between the walls exceeds the height of the taller wall. For example, two 4-foot walls separated by only 3 horizontal feet will be treated as a single 8-foot wall and must meet the requirements for an engineered wall.

Walls designed to be less than 4 feet tall and not engineered, but ultimately constructed over 4 feet tall due to site grading, shall be documented, inspected, and certified by a registered professional engineer during construction. A single inspection post-construction will not meet the certification requirements for retaining walls over 4 feet tall.

All retaining walls, including walls less than 4 feet tall, shall be designed with free-draining, granular material for wall backfill.~~, and foundation drains shall be installed behind the wall.~~

Retaining walls connected to buildings or building egresses shall have railings installed and meet requirements of Title 8 of the Town Code (Building Regulations).

See Chapter 5 of these Standards for additional information on retaining walls. See Town Code for planning requirements related to retaining walls.

7.4.6 Site Stabilization

All disturbed areas shall be stabilized prior to final acceptance by Town and should be stabilized as soon as possible after completion of earth disturbance activities and no longer than 14 days after completion of earth work. For larger projects, grading shall be completed in phases and stabilized immediately after completion of a phase. Final stabilization must be a permanent feature designed and installed to prevent erosion and sediment runoff. Final stabilization methods shall be installed and maintained following good engineering, hydrologic, and pollution control practices. The following is a list of acceptable site stabilization methods in Breckenridge. Additional methods not listed below may be submitted to and approved by the Town Engineer.

1. Revegetation with native grass achieving an individual plant density of at least 70% of pre-disturbance levels. Pre-disturbance levels refer to pre-disturbance vegetation that would represent the naturally supported vegetation density in the area. See Section 6.12.1.7 below for additional information on revegetation.
2. Permanent Pavement and Buildings, including roofed buildings, concrete, and hot mix asphalt are considered final stabilized surfaces. Aggregate base course, fine gravel, and asphalt millings are generally not considered permanent pavement and shall not be used for final stabilization.
3. Hardscape surfaces, such as flagstone pavers.
4. Rip-rap, cobble, and large rock. A scour analysis shall be included in the drainage report when required for rock installed on steep slopes.
5. Other landscaping materials, including trees, shrubs, perennials, wood mulch, rock mulch, and turf grass. It is recommended that a landscape architect be used to design landscaping plans.

7.4.7 Revegetation

It is recommended that a revegetation plan be developed by a licensed professional landscape architect to develop a site specific revegetation and landscaping plan. The Town shall be consulted for approval of site specific topsoil and native seed requirements. A list of pre-approved seed mixes are included in Appendix G.

To achieve the highest likelihood of establishment of the specified vegetation, a 2-year maintenance plan from a certified landscaping company that understands native vegetation is required. Plantings shall be completed in the fall or late winter to provide the best odds of establishment. Irrigation is generally required for trees, shrubs, and perennials. Temporary irrigation systems are recommended to establish native grasses. The Town shall be consulted for approval of site specific topsoil and native seed requirements. General requirements to improve successful vegetation establishment include the following:

1. Seeding all disturbed areas with an approved weed free native seed mix. Approved seed mixes for most sites in the Town of Breckenridge include the Middle Park Conservation District "Forest Mix" and the NRCS "Forest Mix." Alternative seed mixes may be required near environmentally sensitive areas, such as wetlands and the Cucumber Gulch Wildlife Preserve. Diverse early-serial seed mixes with the potential to fully occupy the site's botanical niches shall be selected. Alternate seed mixes shall be approved by Town Engineer.
2. Adequate seeding rates and seeding techniques coupled with soil amendments and fertilizer as determined by proper soil testing and Town construction specifications.
3. Preparing disturbed areas with a minimum depth of 3 inches of topsoil. Topsoil shall be free of rocks, weeds, and other invasive plant species.
4. Pretreating disturbed areas to remove invasive or noxious species.
5. Minimizing or eliminating the use of nitrogen as exotic weeds are often preferentially stimulated over native species.
6. Monitoring for non-target species and noxious weed seeds that are often present in a seed mix.
7. Developing an iterative weed management plan based on regularly scheduled monitoring.

See Chapter 9 for additional information on revegetation specifications.

7.5 DRAINAGE

The sections below set minimum grading and excavation requirements pertaining to drainage and stormwater flow patterns. These sections provide general guidance for site drainage and do not provide standards for water quality or detention requirements. See Chapter 6 of these Standards for water quality, detention, and other drainage requirements.

7.5.1 Positive Drainage

All residential and commercial buildings shall be graded with positive drainage away from building foundations. Positive drainage is defined as a minimum 2% grade perpendicular away from the building foundation for a minimum of 10 feet. Where pavement is adjacent to a building, the minimum slope may be reduced to 1%. Drainage swales, drywells, infiltration facilities, foundation drain pipe daylights, detention and water quality facilities, and all other drainage structures shall be a minimum of 10 feet from the edge of any building foundation or structural element. Foundation drains shall not daylight in roadside ditches, on adjacent parcels, or areas that will drain directly onto adjacent parcels.

7.5.2 Offsite Drainage

Drainage from new development shall be designed to discharge to an infiltration facility, drainage swale, storm sewer, regional detention facility, stream, or other drainage conveyance. Grading shall be designed to prevent any developed drainage or altered drainage flows from crossing onto a neighboring property parcel unless a drainage easement exists on that parcel. Subdivisions shall be platted to add drainage easements for all areas where runoff drainage flows onto another parcel. In no case shall development worsen drainage issues for any downstream properties. Grading shall be designed to prevent erosion and any damage to adjacent structures, streets, or storm sewer infrastructure. Infiltration may be utilized in areas where applicable. Stormwater may drain into an approved location in the Town right-of-way, but it shall not drain directly onto streets, sidewalks, pedestrian paths, trails, or other areas where it could create public safety hazards. Infiltration facilities shall be used in areas where drainage would otherwise cross a street, sidewalk, or other facility. See the subsurface infiltration facility fact sheet attached to Chapter 6 for additional information.

Drainage from existing developments shall be designed with preliminary stormwater treatment prior to discharging directly to a stream, wetland, or other body of water.

Snow storage areas for all development, including single family homes, shall be designed ~~not~~ to drain ~~toward~~ away from foundations, ~~nor directly onto~~ roadways, sidewalks, pedestrian paths, trails, or other areas where it could create public safety hazards. Snow storage shall be designed to drain into a permanent water quality facility or onto a vegetated area prior to discharging to a stormwater conveyance facility.

New development and redevelopment are both required to analyze and correct any existing inadequate drainage, including insufficient drainage away from buildings, runoff adversely affecting downstream properties, inadequately sized drywells, drainage exceeding storm sewer inlets, pipes, or other conveyance, or other drainage concerns identified by the Town Engineer.

7.5.3 Spa and Pool Drainage

Spas, swimming pools, and other water features installed through new development (existing homes replacing existing spas are exempted) shall meet the following drainage requirements:

1. Pools and spas shall be connected to a drywell meeting all requirements of these Standards. Pools and spas shall not drain into storm sewers, roads, or surface flow off property. Pools, spas, and their drainage shall not be located near environmentally sensitive areas. Within the Cucumber Gulch Protected Management Area (PMA), the Upper Blue Sanitation District may allow spas to be connected to the sanitary sewer. If the sanitary sewer connection is allowed, a drywell is not required.
2. Drains shall be designed to maintain a maximum flow rate of 10 gallons per minute. Drywell infiltration rate shall be designed to exceed the drainage flow rate.
3. Prior to draining a pool or spa, no chlorine, salts, or other chemicals shall be added to the water for a period of at least five days.

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7.6 ENVIRONMENTALLY SENSITIVE AREAS (ESA)

Environmentally sensitive areas (ESA) are defined as wetlands, streams, lakes, ponds, Cucumber Gulch Wildlife Preserve, and other special wildlife habitat areas. These areas require special requirements to protect their sensitive nature during development. The Town and the developer shall work in conjunction with the Environmental Protection Agency (EPA), Army Corps of Engineers (USACE), State Engineer's Office Water Commissioner, and the Natural Resource Conservation Service (NRCS). For floodplain development regulations, see Title 10 of the Town Code.

7.6.1 Setbacks

No structures or soil disruption shall be located within 25 feet of the top of the banks or delineated boundary of all ESAs. The setback requirements also apply to all channels draining 20 acres or more. Exceptions to the setback requirements may be allowed if one of the following conditions is met and approved by the Town Engineer:

1. Development sites with the most recent plat being recorded prior to January 1, 1986 and platted in a manner which does not allow a feasible development option meeting the 25-foot disturbance setback. This exception only applies if the disturbance setback prohibits any feasible development and the developer demonstrates there are no feasible alternatives to

eliminate disturbance within the setback. Additionally, sites that were platted prior to January 1, 1986, but that were re-platted after January 1, 1986, do not qualify for this exemption.

2. The ESA has previously been mined or extensively disturbed in the area adjacent to the proposed development, resulting in dredge tailings in the area. In this case, the setback may be waived if the developer submits a plan to implement channel, wetland, environmental, or other water body improvements which serve to reclaim, stabilize, revegetate, or enhance the ESA.
3. Work is proposed in the 25-foot setback area (but not within the ESA boundary), the work is considered minor (no permanent structures) in the setback area, and acceptable measures are implemented to prevent an increase of sediment or other contaminants that exceeds historical rates as determined by the Town Engineer.
4. Areas where there are no other feasible methods for development without encroachment into the ESA setback and the encroachment is necessary for critical infrastructure. To meet this exemption, the developer must demonstrate there are no feasible alternatives to eliminate disturbance within the setback. Only infrastructure, such as roads and utilities, will be considered within the ESA. Residences and structures will generally not be granted an exemption to be constructed within an ESA.
5. The wetlands or other environmentally sensitive areas have encroached into a detention, stormwater quality, or another type of stormwater feature since the development of the feature. Maintenance activities within the stormwater feature shall be allowed in these cases.

If any of the above exemptions to the setback requirement is granted by the Town Engineer, the following requirements shall be met:

1. Acceptable measures shall be designed, installed, and maintained to prevent an increase of sediment or other contaminants that exceeds historical rates, both during construction and in the final condition.
2. If ESA improvements are approved per condition 2 above, the water body shall be hydrologically contained to limit impacts until the improvements are completed. For stream restoration improvements, a bypass channel shall be designed for the 25-year storm and for a minimum distance of 25 feet above and below the channel restoration work. The bypass channel shall either be a plastic, metal, or concrete culvert or shall be an open channel stabilized with scour protection designed for the 25-year storm.
3. If wetlands are disturbed, wetland mitigation shall be completed at a minimum of a 1:1 ratio or the ratio required by the USACE, whichever is greater. Wetland mitigation for Waters of the US shall meet all requirements of the USACE. A financial guarantee shall be submitted to the Town guaranteeing the wetlands mitigation for a minimum period of 3 years to ensure successful plant establishment for all wetland plantings. A wetland mitigation plan shall be submitted which includes the following:
    a. The amount, location, and acreage of wetland fill, removal or other alteration proposed.
    b. The proposed mitigation improvements.
    c. A grading, erosion control, and revegetation plan, including plant material to be used for revegetation and soil stabilization measures.
    d. A narrative explaining how there are no feasible alternatives to disturbing the wetlands, how the wetland disturbance is being minimized to the extent possible, how the wetlands will be mitigated, and how the project will not violate an applicable laws or regulations.

e. Other applicable permits such as a USACE 404 permits (if site is determined to be a jurisdictional wetland).

4. Disturbed areas within the ESA or ESA setback shall be revegetated with an appropriate seed mix. Revegetation of ESA and ESA setbacks shall be monitored and certified at revegetation.

7.6.2 Wetland Delineation Surveys

Wetland boundaries shall be shown on all subdivision plats within the Town of Breckenridge. If the Town believes there is any evidence that a site subject to ~~disturbance~~ any ~~sized~~ development may contain wetlands, either not shown on the plat or with an incorrect boundary, the Town may require the developer to obtain and submit a wetlands delineation survey completed in accordance with Corps of Engineers Wetlands Delineation Manual and all USACE guidelines.~~by an independent third party consultant specializing in wetlands delineations as recognized by the USACE.~~

If a developer believes that a wetland shown on a plat is incorrect, the developer may obtain a wetlands survey ~~by an independent third party consultant specializing in wetlands delineations as recognized by the USACE~~in accordinace with the Corps of Engineers Wetlands Delineation and submit it to the Town Engineer for review. The wetlands survey shall be conducted during the months of June, July, or August.

Wetland delineations shall be updated after 5 years to reflect current wetland conditions. Wetland boundaries shown on plats and other locations will be considered outdated after 5 years and will require a new wetlands survey delineation completed in accordinace with the Corps of Engineers Wetlands Delineation Manual. ~~by an independent third party consultant specializing in wetlands delineations as recognized by the USACE~~~~by the developer.~~

CHAPTER 8
INSPECTION & ACCEPTANCE

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LIST OF ATTACHMENTS – APPENDIX F

8.1 INTRODUCTION

This chapter includes information about the Engineering Division inspection and acceptance procedures and protocols for different types of projects. It also includes information on occupancy requirements and how different types of permits and projects may be closed. This information is intended to apply to activities that occur after initial permits are issued.

8.2 REFERENCES TO OTHER DOCUMENTS

Titles 9 and 10 of the Town Code offer additional information on inspections and acceptance. Chapter 2 of these Standards includes information on the types of permits required by the Town and the submittals required to receive those permits. This chapter only includes the inspection and acceptance procedures of the Engineering Division; permit holders shall reference the Town Code and contact the Community Development Department for additional requirements. Permit holders shall also reference County, State, and Federal regulations for procedures on inspection and acceptance requirements relating to those permits.

8.3 INSPECTION AND ACCEPTANCE PROCESS

The Engineering Division inspection and acceptance process for each type of permit, from permit issuance to final acceptance, is outlined below. Section 8.3.1 to Section 8.3.3 provides an overview of the inspection and acceptance steps for each type of permit; the subsequent sections provide additional detail on the inspections and acceptance steps outlined in Section 8.3. The intent of this section is to provide a summary of steps that must be completed once each permit is issued.

8.3.1 Infrastructure Permit

The infrastructure permit holder shall follow the steps below after receiving an infrastructure permit:

1. Preconstruction Meeting – A preconstruction meeting with the Engineering Division is required prior to beginning construction activities.
2. Begin Construction – Construction activities may begin only after permit holder has obtained all necessary permits, satisfied all requirements of the Breckenridge Town Code and these Standards, and attended a preconstruction meeting with the Engineering Division.
3. Subdivision Improvement Agreement – A Subdivision Improvement Agreement (SIA) will be required if the project requires a subdivision plat and all subdivision improvements are not completed prior to the subdivision plat being recorded. See Title 9 of Town Code for more information on Subdivision Improvement Agreements.
4. Inspections Prior to Initial Acceptance – The Engineering Division shall complete inspections throughout the construction process. See Section 8.4 below for the Engineering inspections required for different permit types.
5. Completion of Work – Permit holders shall notify the Engineering Division once all improvements required by the construction plans and all agreements have been completed.
6. Initial Acceptance Inspection – The Engineering Division shall inspect the improvements for compliance with Standards, plans, specifications, and agreements.
7. Correction of Deficiencies – If the Engineering Division finds any improvements not to be in compliance with the Standards, plans, specifications, or any agreements, the Engineering Division will notify the permit holder who then must correct the deficiencies and notify the Engineering Division when the site is ready for another inspection.

8. Record Drawings – The permit holder shall submit record drawings (also referred to as As-Built Drawings) to the Engineering Division in accordance with the requirements in Section 8.7.
9. Initial Acceptance – After the permit holder satisfactorily corrects deficiencies, submits record drawings and the warranty surety, the Engineering Division shall grant Initial Acceptance.
10. Warranty Period – The warranty period shall last for two years after initial acceptance. The permit holder shall maintain the improvements during this period. Private infrastructure shall not require a warranty period.
11. Final Acceptance – The permit holder shall request a final inspection of improvements no later than 45 days prior to the end of the warranty period. The permit holder shall repair any deficiencies prior to the end of warranty period. Once deficiencies are corrected, the Engineering Division shall grant final acceptance and release the warranty surety.

8.3.2 Building Permit (without associated infrastructure permit)

The building permit holder shall follow the steps below after receiving a building permit when there is no associated infrastructure permit:

1. Begin Construction – Construction activities may begin only after permit holder has obtained all necessary permits and satisfied all requirements of the Breckenridge Town Code and these Standards.
2. Inspections Prior to Certificate of Occupancy – The Engineering Division shall complete inspections throughout the construction process. See Section 8.4 below for the Engineering Division inspections required for different permit types.
3. Certificate of Occupancy – The Certificate of Occupancy inspection shall be requested when all improvements are completed.
4. Completion Guarantee – Permit holders are encouraged to complete all site work prior to October 31st. If the permit holder does not complete all improvements by October 31st, and desires to obtain the certificate of occupancy prior to May 1st, a preliminary Certificate of Occupancy inspection shall be scheduled by the permit holder with Engineering. Engineering will require a financial guarantee (surety) in the form of a ~~letter of credit, bond, or~~ cash deposit ~~shall be submitted to the Engineering Division~~. The Town Engineer shall determine the financial guarantee amount by either assessing 125% of the remaining work value or assessing a general completion amount of $5,000 if the scope of the uncompleted work cannot be determined. Once all improvements are complete, the permit holder shall request ~~an~~ a final inspection. The surety will be released once the Engineering Division determines improvements are complete.

Commented [JP1]: Planning does not do anything other than a cash deposit unless Engineering does something separate in the SIAs etc...

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8.3.3 Right of Way Permit

The right-of-way permit holder shall follow the steps below after receiving a right-of-way permit:

1. Begin Construction – Construction activities may begin only after permit holder has obtained all necessary permits and satisfied all requirements of the Breckenridge Town Code and these Standards.
2. Inspections Prior to Initial Acceptance – The Engineering Division shall complete inspections throughout the construction process. See Section 8.4 below for the Engineering Division inspections required for different permit types.
3. Completion Inspection – The completion inspection shall be requested when all improvements are completed.
4. Warranty Period – The warranty period may begin once the completion inspection has been passed.

5. Two Year Bond Re-Inspection - The permit holder shall request a final inspection of improvements no later than 45 days prior to the end of the warranty period. The permit holder shall repair any deficiencies prior to the end of warranty period. Once deficiencies are corrected, the Engineering Division shall grant final acceptance and release the warranty surety.

8.4 ENGINEERING DIVISION INSPECTIONS

Inspections are required at key steps of the construction process to help provide general compliance with plans and specifications. However, inspections completed by the Engineering Division do not provide final assurance of compliance with specifications and do not preclude the Engineering Division from imposing corrective actions in the future. The Engineering Division may require the permit holder to remove, replace, or repair items, or to perform other corrective actions if improvements are ever found to not comply with plans, specifications, or Town Standards.

The permit holder is required to schedule all inspections with the Engineering Division, other than those for stormwater management, at the time indicated for each permit using the contact information on the applicable permit. Failure of the permit holder to schedule inspections at the appropriate time may result in stop work orders, removal and replacement of improvements, fines, or other penalties. The stormwater management inspections shall be scheduled by the Engineering Division. The sections below detail the permits that will require an inspection from the Engineering Division.

8.4.1 Building Permit

A Building Permit may require up to four separate inspections from the Engineering Division, as detailed in this section. Inspections from the Community Development Department will also be required. The Community Development Department shall be contacted to confirm the required inspections. Inspections for building permits are encouraged to be completed between May 1 and November 1. If a final inspection is required outside these dates, a ~~completion bond~~cash deposit (surety) may be required. Building permit inspections shall be scheduled through the contact information provided on the building permit form. Permit holders may request additional inspections at critical steps during construction if needed.

8.4.1.1 Pre-Pavement/Pre-Landscaping Inspection

The building permit holder shall schedule a pre-pavement/pre-landscaping inspection with the Engineering Division prior to placement of pavement, final topsoil, seeding, and landscaping. Inspection shall generally include the items shown on the inspection form included in Appendix H.

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8.4.1.2 Preliminary Certificate of Occupancy Inspection

The preliminary Certificate of Occupancy inspection only applies to projects completed between November 1st and April 31st of each year. If site work cannot be completed by November 1st, the permit holder shall schedule a preliminary inspection prior to November 1st. Any incomplete work shall require a financial guarantee per Section 8.3.2.

8.4.1.~~2~~3 Certificate of Occupancy Inspection

The building permit holder shall schedule a certificate of occupancy inspection with the Engineering Division after completion of all grading, pavement, landscaping, site stabilization, and all other site work. Inspection shall generally include the items shown on the inspection form included in Appendix H.

8.4.1.~~3~~4 Stormwater Management Inspection

The Engineering Division will conduct stormwater management inspections of sites to ensure that stormwater controls have been installed per the approved plans and are functioning adequately. Inspections will be scheduled periodically throughout construction and may occur without notice.

8.4.1.~~4~~5 Bond Release Inspection

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If there is completion bond for the project, the building permit holder will schedule a bond release inspection with the Engineering Division for any work completed after the issuance of the certificate of occupancy.

8.4.2 Right-of-Way Permit

A Right-of-Way Permit may require up to four separate inspections from the Engineering Division. No work in the right-of-way or right-of-way inspections shall occur between November 1 and May 1. The types of inspections from the Engineering Division that may be required for a right-of-way permit are detailed in the sections below. Right-of-way permit inspections shall be scheduled through the contact information provided on the permit form.

8.4.2.1 Utility Inspection

The Engineering Division will determine utility inspection requirements prior to start of the project. Utility inspections may be required prior to backfill of utilities to ensure utilities are constructed in accordance with the appropriate construction specifications. Major features shall be inspected prior to utility backfill. The right-of-way permit holder shall call to schedule an inspection at least 48 hours prior to the utility being backfilled.

8.4.2.2 Pre-Pavement Inspection

The right-of-way permit holder shall call to schedule a pre-pavement inspection at least 48 hours prior to the placement of concrete, asphalt, or other types of pavement. Inspection items shall include grading, subgrade, and concrete forms for sidewalks, curbs, curb ramps, and driveway curb cuts.

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8.4.2.3 Completion Inspection

The right-of-way permit holder shall call to schedule a completion inspection after completion of all improvements, pavement, site stabilization, and restoration. Inspection shall generally include the items shown on the inspection form. Once the site passes the completion inspection, the 2-year bond and warranty period process can be initiated.

8.4.2.4 Stormwater Management Inspection

The Engineering Division will conduct stormwater management inspections of sites to ensure that stormwater controls have been installed per the approved plans and are functioning adequately. Inspections will be scheduled periodically throughout construction and may occur without notice.

8.4.2.5 Two Year Bond Re-Inspection

The Engineering Division will schedule an inspection of all improvements one month before the end of the two-year warranty bond period. If defects are found in any of the improvements, the right-of-way permit holder shall be notified, and defects shall be repaired by the permit holder.

8.4.3 Infrastructure Permit

The types of inspections that may be required for an infrastructure permit are detailed below.

8.4.3.1 Utility Inspection

The Engineering Division will determine utility inspection requirements prior to start of the project. Utility inspections may be required prior to backfill of utilities to ensure utilities are constructed in accordance with the appropriate construction specifications. If an inspection is required prior to utility backfill, the right-of-way permit holder shall call to schedule an inspection at least 48 hours prior to the utility being backfilled.

8.4.3.2 Pre-Pavement Inspection

The infrastructure permit holder shall call to schedule a pre-pavement inspection at least 48 hours prior to the placement of concrete, asphalt, or other types of pavement. Inspection items shall include grading, subgrade, and concrete forms for sidewalks, curbs, curb ramps, and driveway curb cuts.

8.4.3.3 Initial Acceptance Inspection

The infrastructure permit holder shall call to schedule an initial acceptance inspection after all improvements, pavement, site stabilization, and restoration are complete. Inspection shall include all infrastructure, public improvements to be conveyed to the Town, private improvements, utilities, detention and permanent stormwater quality features, and all other site work. Once the site passes the initial acceptance inspection, the 2-year bond and warranty period process can be initiated. The initial acceptance process is discussed in more detail in Section 8.5.

8.4.3.4 Other Inspections

The Engineering Division will determine if additional inspections are necessary during the pre-construction meeting and will establish those with the developer. The Engineering Division also may require additional inspections throughout the project duration. These may include structural concrete, structural steel, reinforcing steel, and backfill compaction inspections.

8.4.3.5 Stormwater Management Inspection

The Engineering Division will conduct stormwater management inspections of sites to monitor that stormwater controls have been installed per the approved plans and functioning adequately. Inspections will be scheduled by the Engineering Division periodically throughout construction and may also occur without notice.

8.4.3.6 Final Acceptance Inspection

The Engineering Division will schedule an inspection of all improvements at the end of the two-year warranty bond period. If defects are found in any of the improvements, the infrastructure permit holder shall be notified, and defects shall be repaired by the permit holder.

8.5 INITIAL ACCEPTANCE

For all projects that are issued an infrastructure permit, initial acceptance generally indicates that the project has been completed to the satisfaction of the Engineering Division and that the 2-year bond (surety) process (warranty period) can be initiated. Initial acceptance requires the following at a minimum:

1. Construction Plans – Plans shall be submitted for approval clearly identifying public improvements to be conveyed to Town.
2. Preconstruction Meeting – A pre-construction meeting between an Engineering Division representative, the Project Engineer, developer, and contractor shall be held prior to the start

of construction. The meeting shall confirm the scope of work, inspection requirements, and testing requirements for the project.

3. Initial Acceptance Submittals:
   a. Material testing reports & testing firm letter – Material testing shall be completed in accordance with the Town specifications. An example testing firm letter is included as an attachment to Appendix H and shall be signed and stamped by a Colorado Professional Engineer to certify that all test procedures were in conformance with the approved plans and specifications.
   b. Inspection & construction observation reports – Inspection and construction observation required to be performed by the Project Engineer shall be established during the pre-construction meeting. Reports shall be certified by the Project Engineer and shall certify that construction was in conformance with approved plans and specifications.
   c. Engineering Record Drawings – Prior to issuance of initial acceptance, record drawings shall be submitted to the Engineering Division that meet the requirements of Section 8.7.
   d. As-built survey of detention and water quality facilities and certification by a professional engineer licensed in the state of Colorado certifying the facility meets the detention and water quality requirements.
   e. As-built survey of main features of underground utilities. Examples include utility surface locates, manholes, valves, inlets, hydrants, junction boxes, and other exposed features. Survey of underground facilities prior to backfill may be required at critical locations. The surveyed features shall be drawn electronically and submitted in DWG and PDF formats.
   f. Other documentation – Additional documentation, as required by Town Engineer, shall be submitted to the Engineering Division prior to initial acceptance.
4. Initial Acceptance Request – An initial acceptance request shall be submitted in writing to request an initial acceptance inspection after all initial acceptance submittals have been submitted. An improvements summary letter shall be submitted with the initial acceptance request. An example improvements summary letter is included as an attachment to Appendix H. The initial acceptance request shall only be submitted if the work has been fully completed in accordance with the approved plans and specifications. All work and known punch list items must be complete prior to submitting the request.
   a. Work Acceptable. If the work has been completed satisfactorily for initial acceptance, the Town Engineer will issue a written notice of initial acceptance to the permit holder.
   b. Work not Acceptable. If the work has not been completed satisfactorily, the Town Engineer will provide the permit holder with a punch list of items to be completed. Once the punch list items are completed, the permit holder may request a subsequent inspection.
5. Warranty Surety – If the permit holder fails to complete punch list items satisfactorily within 30 days, the Town may utilize the warranty surety to complete improvements. The Town may also withhold additional permits or certificates of occupancy.

8.6 WARRANTY

For permits requiring a warranty, the permit holder shall warrant that all public improvements shall remain free from defects for a period of two years from the date the Town issues initial acceptance of the improvements. This period may be referred to as the two-year warranty period, warranty period, the two-year bond period, or initial acceptance period. During the two-year warranty period, any defect determined to exist with respect to such improvements shall be repaired or the improvement replaced at the sole cost of the permit holder.

The permit holder shall be required to file a warranty surety in the form of a warranty bond, cash bond, or irrevocable letter of credit with the Town in a form acceptable to the Town Attorney, prior to initial acceptance of any public improvements, in an amount equal to 25% of the original cost of the public improvements, in order to assure the satisfactory maintenance of the improvements for a period of two years after the date of initial acceptance by the Town. Such bond shall guarantee all public improvements constructed by the permit holder remain free from defect for the required two-year period.

If initial acceptance is reached prior to obtaining final site stabilization (70% revegetation), the permit holder shall be responsible for maintenance of all temporary and permanent stormwater quality features until final stabilization of the site is achieved. This shall include sweeping of street and sidewalks, and maintenance of detention ponds, water quality features, and storm sewer infrastructure. The permit holder shall be responsible for the maintenance of trees, shrubs, and other landscaping features during the two year warranty period.

8.7 RECORD DRAWINGS

Record drawings, also called as-built drawings, are to be submitted to and accepted by the Town Engineer prior to final acceptance of any public improvements. As-built drawings shall be produced under the direction of and stamped by a Colorado registered professional engineer to assure compliance with original design drawings. Certification shall be presented along with the as-built drawings stating such compliance.

One set of as-built drawings shall be submitted to the Engineering Division within 30 days of completion of construction (initial acceptance). Drawings shall be submitted electronically in DWG and PDF format so that they will print to scale on 11” x 17” paper. Each drawing sheet shall include a title block, scale, north arrow, original and revision dates, and professional engineer’s stamp when applicable. Title blocks shall be along the bottom or right margin of each drawing. Survey control and project benchmarks including datum shall be included.

Manufacturer’s literature and product data, including catalog sheets, descriptive literature, product warranties, and any O&M manuals, for all materials and equipment used, shall be provided with as-built drawings.

The construction plans shall be updated with all design changes that occurred after issuance of infrastructure permit. Record drawings shall also identify actual constructed locations and dimensions of street improvements, signage, striping, street lights, swales, WQ/detention ponds, inlets, stormwater improvements, and other infrastructure. For detention and water quality facilities, record drawings shall identify the as-built locations of all inlets and outlets, the as-built grading of the site for all ponds, and as-built details of the outlet structure including the sizes and elevations of all orifices and weirs that may convey water out of the facility. Record drawings shall also document locations and elevations of underground utilities. Record drawings shall identify any other conditions that vary from the approved plans and specifications, or any other information requested by the Town Engineer.

Detention and water quality facilities shall be surveyed, added to the record drawings, and stamped by the engineer certifying the facilities are in compliance with the design.

Underground utilities shall be surveyed and added to the record drawings submitted by surveying surface utility locates, manholes, valves, inlets, hydrants, junction boxes, and other exposed features. Survey of underground facilities prior to backfill may be required at critical locations.

8.8 FINAL ACCEPTANCE

Final acceptance requires the following at a minimum:

1. Final Acceptance Inspection Request – The permit holder shall request a final acceptance inspection in writing within 45 days of the expiration of the warranty period.
2. Final Acceptance Inspection and Punch List – The Engineering Division shall inspect all public improvements for the project and shall compile a written final punch list of items requiring repair or replacement and any defective or unsatisfactory conditions resulting from materials or workmanship that are defective, inferior, or not in accordance with project plans and specifications.
3. Re-Inspection – If repair or replacement of public infrastructure is required, the permit holder shall complete such repair or replacement within 30 calendar days. Once completed, the permit holder shall contact the Engineering Division for re-inspection.
4. Notice of Final Acceptance – Once all punch list items are completed to the satisfaction of the Engineering Division, and after the record drawings have been submitted and accepted by the Town Engineer, the Town Engineer shall issue a written notice of final acceptance of improvements and shall release warranty surety.
5. Warranty Surety – If the permit holder fails to complete the punch list items satisfactorily within 30 calendar days, the Engineering Division may utilize the warranty surety to complete the punch list items. The Engineering Division may also withhold additional permit approval or certificates of occupancy.

CHAPTER 9
CONSTRUCTION SPECIFICATIONS

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TOWN REVISIONS AND REPLACEMENTS OF ROAD AND BRIDGE CONSTRUCTION STANDARDS

9.1 PURPOSE

This chapter of the Engineering Standards establishes the construction specifications that shall be used within the Town for various categories of construction. These specifications shall be used for all public projects in the Town, as well as all private projects constructing public infrastructure to be owned by the Town. Construction specifications are not design standards. Construction specifications, also known as construction standards, include items such as materials requirements, construction procedures and tolerances, ~~and~~ required testing and performance metrics. ~~The Town expects to update this chapter and the attachments over time as the unique goals and values of the Town and local physical conditions dictate.~~ Project special specifications may be submitted by the developer for unique or project-specific conditions. The Town Engineer may also require additional specifications for different projects.

9.2 TOWN CONSTRUCTION SPECIFICATIONS

The most recent edition of the documents included in Table 9.1 are hereby adopted by reference as the Town of Breckenridge Construction Specifications, except as specifically amended by the provisions of this chapter, for the types of construction shown in Table 9.1.

Where the Town of Breckenridge Construction Specifications in Table 9.1 do not include a specification required for the type of construction listed, the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction shall apply.

The documents in Table 9.1 shall apply unless they are superseded by revisions or replacements the Town develops included herein. The most recent revision of each document listed in Table 9.1 shall be used. Each user of these Engineering Standards is encouraged to review this chapter frequently as it may be updated regularly.

Where two different construction specifications overlap or conflict, the more stringent specification shall apply. Consult with the engineering division for any conflicts or inconsistencies between different specifications.

Table 9.1. Town Construction Specifications by Type of Construction

Type of Construction	Town Construction Specifications
Water Line	Town of Breckenridge Water Construction Standards
Sanitary Sewer	Upper Blue Sanitation District Construction Standards
Open Channels	Mile High Flood District (MHFD) Construction Specifications (Division 3 – 33)
Vegetation	Mile High Flood District (MHFD) Construction Specifications (Division 3 – 33) Appendix H of these Standards (Seed Mixes)
Residential Building	Title 8 of Town Code
Commercial Building	Title 8 of Town Code
Industrial Facility	Title 8 of Town Code
Streets	CDOT Standard Specifications for Road and Bridge Construction

9.3 REVISIONS AND REPLACEMENTS OF CONSTRUCTION SPECIFICATIONS

To reflect the Town's unique goals and values or address local physical conditions, the Town may choose to amend, revise, or replace some or all of any of the Town Construction Specifications included in Table 9.1 per the sections below.

9.3.1 Town of Breckenridge Water Construction Standards

Retain all sections.

9.3.2 Upper Blue Sanitation District Construction Standards

Retain all sections.

9.3.3 MHFD Construction Specifications (Divisions 3 – 33)

Retain all sections.

9.3.4 Title 8 of Town Code

Retain all sections.

9.3.5 CDOT Standard Specification for Road and Bridge Construction

Revisions and replacements of the CDOT Standard Specification for Road and Bridge Construction are included in Appendix H~~I~~.

9.4 TOWN STANDARD DETAILS

The Town uses the standard construction details listed in Table 9.3. It is anticipated this list will be updated as new standard details are developed. The Town's standard details are included as attachments to this chapter.

Table 9.3. Town Standard Details

Detail	Title	Number of Pages
Drawing 1	Transit Turnouts	1
Drawing 2	Cul-De-Sac	1
Drawing 3	Driveway Details	3
Drawing 4	Curb, Gutter, Sidewalk, and Pavement Details	5
Drawing 5	Curb Ramp Details	26
Drawing 6	Asphalt Details	2
Drawing 7	Utility Trench Details	3
Drawing 8	Lighting Details	7
Drawing 9	Typical Roadway Sections	4

CHECKLIST 7

BUILDING PERMIT (WITHOUT INFRASTRUCTURE PERMIT) REQUIREMENTS

This is the checklist of items to be submitted to the Engineering Division for building permit applications without an associated infrastructure permit. Refer to the Town Code for other Town Division submittal requirements.

All applicable items shall be included with the submittal. The table below may not contain all information necessary for a project, and the Town Engineer may require additional information. Any items not applicable shall be specified and justified in the comments section at the bottom of the checklist.

Building permit applications shall be obtained and submitted through the Town of Breckenridge Building Department. Town of Breckenridge Community Development Department and Building Department shall be contacted for a list of their submittal requirements.

For questions about these requirements or to schedule a meeting, please email the Town of Breckenridge Engineering Division at engineeringinspection@townofbreckenridge.com

Project Name:______________________________________

Project Address:____________________________________

Submittal (circle one): Preliminary Final

Provided	Not Applicable	Plan Items	Office use
		General Formatting (all plan sheets)	
		Project title in which project is to be filed	
		Date of drawing preparation & revisions	
		North arrow & drawing scale	
		Site Plan	
		Plat Compliance	
		Legal description of property & physical street address. Legal description may be found through the Summit County online GIS parcel query tool	
		Existing & proposed property lines	
		Existing & proposed right-of-way & dimensions	
		Existing & proposed easements & dimensions	
		Temporary & permanent survey monuments	
		Building footprint (show foundations & roof eaves), envelope, & building setbacks	
		Utilities	
		Existing & Proposed Utilities. Show existing & proposed location of all utilities & connections including all boxes, poles, structures, & utility alignments for electric, gas, cable, telephone, fiber, sewer, & water. Utility structures shall be in easements	
		Wetlands, Floodplains, & other Hazard Areas	

Provided	Not Applicable	Plan Items	Office use
		Wetland boundaries & 25’ wetland setback boundaries	
		100-year floodplain & other flood hazard area boundaries	
		25’ setback boundaries from top of stream banks, lakes, & other water bodies	
		Protective Management Area (PMA) limits & other special protective or hazard areas	
		Identification of areas with slope stability concerns	
		Identification of areas with geotechnical, environmental, archaeological, or historical significance	
		Identification of any hazardous concerns	
		Grading & Drainage	
		Existing topography (1-foot contours) prepared by a registered surveyor	
		Proposed Topography (1-foot contours showing finished grade)	
		Maximum 2:1 slope allowed on all finished grading (3:1 preferred)	
		Retaining wall heights & locations (retaining walls > 4 feet in height require design by Colorado licensed Professional Engineer)	
		Culvert locations, material, & dimensions. (18” minimum diameter & 1% minimum slope for culverts in ROW)	
		Foundation drain locations & daylight	
		Drywell location (10’ minimum from building) and detail. See drywell fact sheet in Chapter 6 for additional requirements & guidance.	
		Proposed outfall locations of developed drainage, drainage arrows, & swale locations	
		Positive drainage shown around building	
		Detention & permanent water quality features shown (if required)	
		CDPHE Stormwater Discharge Permit (for projects resulting in at least one acre of disturbance)	
		Driveway & Parking	
		Maximum 8% grade at any point along centerline of driveway alignment	
		Maximum 4% grade for first 20’ from roadway intersection	
		Match cross slope of roadway for first 5’ of driveway from roadway intersection	
		Driveways dimensions meet requirements of Chapter 5 (12’ min width & 20’ max width for SFH)	
		Sidewalk driveway cut meets Town standard detail	
		Driveway intersections roadway at 90 degrees	
		Driveway surface & section dimensions shown	
		One driveway access allowed (no duplicate or circular driveway cuts)	
		Minimum driveway separation met from neighboring driveway (30’ min for SFH)	

Provided	Not Applicable	Plan Items	Office use
		Snow storage areas shown (see Town Code for snow storage requirements)	
		Parking spaces & vehicle turnaround areas shown (see Town Code for parking requirements). Vehicles able to turnaround/back out of garage	
		Minimum Sight Distance for driveway access (200' min)	
		Easement submitted for shared driveway access with neighboring property	
		Landscaping	
		Landscaping plan shall be submitted in accordance with requirements in Town Code	
		Landscaping in snow storage easements shall not obstruct ability to stack snow	
		Landscaping not located in ROW	
		Landscaping located in easements meets requirements of Chapter 3	
		ROW	
		No retaining walls, boulders, stone headwalls, or small rock located in ROW	
		No address monuments or mail boxes in ROW	
		Snowmelt system in or near ROW meets requirements of Chapter 5	
		No fences, private lighting, trees, landscaping, signage, or any other structures shown in ROW without Engineering approval & encroachment license submitted	
		Other	
		Existing & proposed sidewalks, trails, street lights, signage, & any other structures or significant features shown on plans	
		Construction details as required for construction of improvements	
		Construction Management Plan	
		Construction Stormwater Management (wattles, silt fence, tracking pads, etc.)	
		Construction Stormwater BMP Details (wattles, silt fence, etc.)	
		Revegetation notes or other final stabilization plans	
		Construction fencing location	
		Material & equipment staging locations	
		Dumpster & portalet locations	
		Vehicle parking locations & construction access location	
		Other Submittals	
		Soils report & other site reports	
		Floodplain Development Permit	
		Encroachment License Agreement (required for any permanent improvements proposed within Town ROW)	

Provided	Not Applicable	Plan Items	Office use
		Town Right of Way Permit (required for any roadway cuts or temporary encroachments into Town ROW)	
		CDOT Special Use Permit (required for any work with State Highway 9)	
		Other permits, reports, or submittals	

Comments and justification for any items listed above not submitted:

Applicant Signature:________________________________ Date:________________________

Application ID Number: ____________

TOWN OF BRECKENRIDGE
INFRASTRUCTURE PERMIT APPLICATION

This application form shall be filled out and submitted to the Engineering Division before an Infrastructure Permit will be issued.

Project Name: ___________________________________ Development Permit #:___________________

Property Owner: ____

Applicant/Agent (If different than Owner):____

Mailing Address:______________________________________ Phone Number:____________________

Email Address:____

Street Address of Property:____

Legal Description of Property:____

Project Description:

Approximate area of disturbance: _______________

Will there be development or grading in a floodplain? Yes___ No___

Will there be work within a Town Right-of-Way? Yes___ No___

Will there be work within CDOT Right-of-Way? Yes___ No___

Will there be wetlands disturbance? Yes___ No___

Will there be utility work? If yes, describe utility types, approximate lengths, and if there is a planned connection to the Town of Breckenridge water or storm sewer system:

____

____

____

Is stormwater detention required? Yes___ No___

Is permanent water quality required? Yes___ No____

Anticipated construction start date: ____

Is preconstruction meeting scheduled with the Engineering Division? Yes___ No____

Anticipated length of construction: ____

The applicable items in the table below must be included with the Infrastructure Permit application. Failure to do so will result in denial of the Infrastructure Permit and a requirement to resubmit. Any items not applicable to the project shall be noted and justified below. Additional details on the requirements of the Infrastructure Permit are in Chapter 2.

Provided	Not Applicable	Infrastructure Permit Items	Office use
		Infrastructure Permit application form	
		Completed a~~A~~pplicable checklists 1 – 6 for various submittals	
		Final civil construction drawings	
		Technical specifications	
		Final Drainage Report	
		Final Traffic Impact Study	
		Method of Handling Traffic (MHT) or Traffic Control Plan (TCP)	
		Stormwater Management Plan (SWMP) and/or CSMP	
		Development Permit	
		Building Permit	
		Right-of-Way Permit	
		Floodplain Development Permit	
		CDPHE Stormwater Construction Permit	
		ACOE, CDOT, Summit County, or other permits as applicable	
		Subsurface Utility Engineering documentation	
		Permanent Survey Monumentation documentation	

List of submittal items not applicable to project and justification for non-applicability:

The undersigned certifies that the information provided is correct and that this application does not authorize work until an infrastructure permit is granted. The undersigned further certifies that s/he will comply with all inspections and acceptance procedures in the Town's Engineering Standards:

Applicant Signature:___________________________________Date:_________________________

Permit Status: Granted ___________ Denied _____________

Reason for denial:____

Staff Signature: ______________________________ Title: ______________________________________

Printed Name: __________________________________ Date: ___________________________________

TOWN OF BRECKENRIDGE

FACT SHEET
SUBSURFACE INFILTRATION FACILITIES

1.0 Definition

This fact sheet provides design standards for drywells, infiltration trenches, infiltration galleries, and other subsurface infiltration structures used for permanent stormwater treatment facilities in areas with natural high infiltration rates. These types of subgrade infiltration facilities will collectively be known as drywells by this document. Drywells provide either stormwater quality treatment or stormwater detention by collecting surface stormwater runoff, temporarily storing it underground, and then discharging it primarily through infiltration into the surrounding soils. Drywells vary in form and include underground concrete structures, trenches or other excavations filled with granular material.

2.0 Purpose

The purpose of drywells is to provide stormwater quality treatment or stormwater detention through temporary subsurface storage and subsequent infiltration into surrounding soils. Drywells are typically selected for single family homes, small or constrained sites, and steep sites. On sites where space and topography permits, above ground detention and water quality facilities are preferred over drywells for ease of inspection and maintenance.

3.0 Drywell Advantages

1. Utilize the typically highly permeable soils in Breckenridge to provide groundwater recharge
2. Meet the stormwater detention and permanent water quality requirements of Chapter 6
3. Filter contaminants through filtration
4. Utilize site area efficiently
5. Provide environmental benefits by augmenting low flows in streams and reducing the thermal impacts of above ground detention facilities

4.0 Drywell Disadvantages

1. Susceptible to clogging and reduced infiltration rates
2. Difficult to inspect and maintain, increasing the potential for clogging or reduced performance
3. Risk being neglected because they are not readily visible, reducing maintenance frequency
4. Create potential for groundwater contamination issues
5. Require pretreatment to reduce high sediment loads quickly reducing infiltration capacity

5.0 Site Suitability

Drywells are not suitable for all sites where they may have negative impacts to other structures and properties. Drywells will not meet the requirements of Chapter 6 or function adequately for their full life cycle unless the site and the drywell meet certain requirements. Drywells and sites must meet the following criteria to be allowable as detention or stormwater treatment facilities:

1. Area draining to the drywell must be less than one acre.
2. A pretreatment facility is required upstream of the drywell.
3. Existing soils must be hydrological group A or B and infiltration must be at least 1 inch per hour as tested at the proposed elevation of the bottom of the drywell.

4. Drywells must be located at least 10 feet from building foundations or other structures, at least 10 feet from water lines and at least 100 feet from water source wells.
5. Drywells must be located at least 300 feet from an active waterway.
6. Drywells must be located a sufficient distance (at least 25 feet) from wetlands and other sensitive areas to prevent harmful effects.
7. Runoff draining to the drywell must not be contaminated with pollutants other than sediment. Runoff exposed to other pollutants such as oils, fuels, detergents, industrial or agricultural chemicals, etc. may not drain to a drywell.
8. Bottom of drywell shall be at least 3 feet above the seasonally high groundwater as measured by a geotechnical investigation.

6.0 Design

The following design guidelines are typical standards required for drywell design. Special site conditions may lead to additional requirements as determined by the Town Engineer. Each drywell design~~, except those used for an individual single family home site, ~~shall be designed and stamped by a Colorado Licensed Professional Engineer. ~~Drywells for an individual single family home, which primarily receive runoff from foundation and roof drains, are exempted from several of the requirements below. ~~Drywells serving multiple single family homes are not exempt from the requirements.

7.0 Infiltration Test

Testing shall be conducted by a geotechnical engineer on the site to determine infiltration rates and soil types at the location and depth of the proposed drywells. Infiltration tests shall be conducted at a minimum of every 75 feet for infiltration trenches. The lowest infiltration rate shall be used for design. Drywells for single family home sites may be exempt from an infiltration test; however, soils shall be analyzed from soils reports and other sources to evaluate their suitability to infiltrate runoff. Single family homes may be exempted from the infiltration test requirement if the drywell only receives water from roof drainage and foundation drains.

8.0 Pretreatment

Drywells cannot receive stormwater that has not been pretreated, unless the only source of the stormwater is roof runoff and/or foundation drainage. Pretreatment is required to allow coarse sediment and trash to settle out and prevent premature clogging and failure of drywell. Examples of pretreatment include forebays, concrete manholes with BMP snout and bioskirt, sediment basins, and vegetated buffer strips. Single family home sites are exempt from pretreatment. Single family homes are exempted from the pretreatment requirement if the drywell only receives water from roof drainage and foundation drains.

9.0 Depth and Location

Drywells shall be located at least 10 feet from building foundations and 100 feet from water wells. The bottom of each drywell shall be at least 9 feet below the surface or extend to clean cobble rock without fines (minimum rock size greater than 2 inches in diameter) to prevent freezing during winter.

10.0 Design Details

Drywells designs vary widely and include concrete manholes without a bottom and drain holes in the walls, excavated pits backfilled with clean rock, linear trenches backfilled with clean rock, and underground perforated pipes surrounded by a clean aggregate layer. An engineered drywell detail shall be designed and submitted for all installations, including single family homes. Below is a list of design considerations for various drywells:

1. Drywells in areas receiving vehicular traffic shall be HS-20 rated.
2. Drywell manholes shall have 24-inch inlet grates. If grates are located near a roadway or pedestrian area, the grate shall meet AASHTO bicycle and ADA guidelines.
3. Drywell manholes shall be backfilled outside the structure with 1.5-inch to 3-inch crushed and washed stone with a minimum of 40% porosity for a minimum distance of 18 inches.
4. Drywell manholes shall contain perforations with a 1-inch minimum diameter and shall not have a bottom.
5. Trenches shall be backfilled with 1.5-inch to 3-inch crushed and washed stone with a minimum of 40% porosity.
6. Trenches may have filter fabric installed 12 inches below surface to assist with maintenance.
7. Filter fabric shall not be installed at the bottom of drywells.
8. A 6-inch to 12-inch sand layer shall be installed under the bottom of drywells if infiltration rates exceed 4 inches per hour or if the drywell is installed near a sensitive area, such as wetlands, the Blue River, perennial streams, or Cucumber Gulch PMA.
9. Overflow outlets are required to convey flows that exceed the capacity of the drywell. Overflow outlets shall convey runoff to a swale or storm sewer and shall be designed to prevent erosion and damage to neighboring properties.

11.0 Volume

The appropriate WQCV or detention volume shall be calculated using the guidance in Chapter 6. A factory of safety of 1.5 shall be applied to the calculated volume to account for clogging and reductions in the infiltration rate. Drywells shall be designed to infiltrate the entire design volume within 72 hours.

12.0 Maintenance

An Operations and Maintenance Plan (O&M Plan) shall be submitted that meets the requirements of Chapter 6. Minimum requirements include:

- Drywells shall not be placed in service until construction is complete and revegetation of the site is established.
- Drywells shall be inspected and maintained annually for sediment and debris.
- Drywells shall be inspected after storms exceeding 1 inch to ensure it is functioning properly and that no water is ponding above the drywell.
- Pretreatment facilities shall be inspected twice annually and sediment and debris shall be removed.
- If a drywell clogs or fails, complete rehabilitation is required to restore storage capacity and infiltration rates.

TOWN OF BRECKENRIDGE, COLORADO
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION
ROAD AND BRIDGE CONSTRUCTION SPECIFICATIONS

GENERAL STATEMENT

Sections 100 through 717 of the Standard Specifications for Road and Bridge Construction, 2022 edition, or most recent version, published by the Colorado Department of Transportation (CDOT), State of Colorado, supplemented or amended by the State and by these specifications, shall govern all road and bridge construction work within Town jurisdiction or ownership. In cases of conflict between the CDOT specifications and other specifications, the supplements and amendments listed below or in the project Special Provisions shall govern. The Special Provisions (if any) contained in the Bid Documents shall have precedence over all other specifications.

When a reference is made to ASTM, AWWA, AASHTO, or other specifications or methods, it shall be understood to mean the latest edition or revision of said specification as amended and issued at the time of the Invitation to Bid.

The Method of Measurement and Basis of Payment for the items of work specified herein and in the CDOT specifications apply only to Town of Breckenridge projects and are not required to be used on projects which are administered and paid for by private developers or other agencies. References to the Town of Breckenridge General Conditions apply only to Town of Breckenridge projects are not required to be used on private development projects.

The Method of Measurement and Basis of Payment will be based on CDOT specification except where modified in these Documents.

The current CDOT Standard Specifications for Road and Bridge Construction can be accessed here:

https://www.codot.gov/business/designsupport/cdot-construction-specifications/2022-construction-specifications/2022-specs-book/2022-standard-specifications-book

STANDARD SPECIAL PROVISIONS

All CDOT Standard Special Provisions published at the time of construction commencement shall apply and be included as part of these specifications.

PROJECT SPECIAL PROVISIONS

The following Project Special Provisions apply to this project and shall take precedence over specifications or plans and supplement or amend the CDOT Standard Specifications and the Town modifications listed below:

DIVISION 100
GENERAL PROVISIONS

SECTION 101: DEFINITION AND TERMS

Retain Section 101 and add the following:

Where Department, Department of Transportation, CDOT or any other reference to the Colorado Department of Transportation is used within these Specifications, replace with “Town”. Any reference to CDOT engineer, personnel, or form shall be replaced with the appropriate Town engineer, personnel, or form. Town Engineer refers to the Town of Breckenridge Town Engineer or Town Engineering Representative selected by the Town Engineer. Where these Specifications reference Section 100, replace with “Town of Breckenridge General Contract Conditions.”

101.01 Abbreviations. Add the following abbreviations:

CAPA	Colorado Asphalt Pavement Association
HMA	Hot Mix Asphalt
SSFRB	Town of Breckenridge Standard Specifications for Road and Bridge Construction (latest edition)
TEDS	Transportation Engineering Design Standards (latest edition)
QAT	Quality Assurance Technician

101.02 Definitions, alphabetically

ADD or REVISE Definitions as Follows:

Award. REPLACE “Department” WITH “Town”.

Bidder. In the CDOT definition REPLACE “Department” WITH “Town”’.

CDOT Resident Engineer. DELETE in its entirety and REPLACE WITH: “Town Engineer”.

Contract. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Contract Modification Order. DELETE in its entirety. See “change order” definition in the *Town General Contract Conditions*.

Contract Time. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Contractor. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Department. REVISE to read: “Department of Public Works, Town of Breckenridge, Colorado.”

Engineer. DELETE in its entirety and REPLACE WITH “The Project Engineer, who may be a Town employee or hired consultant who has been appointed or authorized by the Town to oversee the technical aspects of the work and to administer the Contract on behalf of the Town. The term “Engineer” may also apply to a Professional Engineer hired by a developer to design and/or administer the construction of public infrastructure in accordance with a development approved by or contracted for/or with the Town.”

Force Account Work. REVISE to read: “Work paid for on the basis of actual costs plus approved additives, in accordance with the General Contract Conditions.”

Laboratory. REVISE to read: “Any testing laboratory designated by the Engineer.”

Planned Force Account. DELETE in its entirety.

Plans. REPLACE “Department” WITH “Town”.

Pre-construction Conference. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Project. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Project Engineer. REPLACE “Chief Engineer’s” WITH “Town’s”. REPLACE “CDOT” WITH “Town”. REPLACE “Resident” with “Town.”

Proposal Form. REVISE to read: “The documents furnished by the Town on which the offer of a bidder is submitted. Also called Bid Proposal or Bid Form.”

Proposal Guaranty. REVISE to read: “Bid guaranty as defined in the *Town General Contract Conditions.”*

Region Transportation Director. DELETE in its entirety.

Shop Drawings. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Specifications. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

State. DELETE and replace with Town of Breckenridge acting through its authorized representative.

Supplemental Specifications. DELETE in its entirety. See definition of Supplementary Conditions in the *Town General Contract Conditions*.

TOWN. Town of Breckenridge, Colorado.

Work. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Workplace Violence. REPLACE “CDOT” WITH “Town”.

SECTION 102: BIDDING REQUIRMENETS AND CONDITIONS

Retain Section 102.03

DELETE and REPLACE remainder of Section 102 with the Town of Breckenridge, General Contract Conditions.

SECTION 103: AWARD AND EXECUTION OF CONTRACT

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 104: SCOPE OF WORK

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 105: CONTROL OF WORK

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 106: CONTROL OF MATERIAL

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 107: LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 108: PROSECUTION AND PROGRESS

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 109: MEASUREMENT AND PAYMENT

109.01 RETAIN and ADD: “Measurement and payment shall be made per the contract and technical specifications. The contractor shall be responsible, in the presence of the Owner, or Owner’s representative, for verifying all measurements and quantities required for payment by the unit price method. Contractor shall provide necessary equipment, workers, and survey personnel as required for measurements.

Payment shall not be made for defective work and rejected work.

Items paid by Lump Sum shall not be measured. Unit price shall include all costs to complete all work shown in plans, regardless of whether all items are written in work description.

Quantities stated in the contract are estimated quantities only and it is understood the actual quantities in the field may vary from those estimated. Actual quantities will be measured in the field, unless specified otherwise in the bid item descriptions. Work required in this section includes all expenses to complete the individual bid items per the plans and specifications. Unit bid prices, as quoted in the bid schedule, shall constitute full compensation for materials, labor, equipment, rentals, permits, overhead, profit, incidentals, risk, loss, damage, and all other items of work and expense required for the complete construction of each pay item per the plans and specifications. Any items or like item not specifically mentioned as a bid item is considered incidental to the project and all costs associated with these items must be included in the bid items listed.”

DELETE and REPLACE remainder of Section 109 with the Town of Breckenridge, General Contract Conditions.

DIVISION 200
EARTHWORK

SECTION 201: CLEARING AND GRUBBING

201.02 DELETE the first paragraph of 201.02 and replace with “The Contractor shall meet with Town Representative and designate all trees, shrubs, and plants to be removed. Every object not designated for removal shall be protected by Contractor. Any object not designated for removal that is damaged shall be repaired or replaced as directed at the Contractor’s expense.”

ADD: “Trees designated to be cleared, removed or limbed shall be the property of the Contractor.

As the property of the Contractor, all cleared stumps, roots, willows, shrubs, and limbs shall be disposed of by the Contractor.

Hand grubbing may be required in roadway sections to ensure that no organic materials will be present in the road section.

Any tree, shrub, or other object that is designated to remain and is damaged shall be repaired or replaced as directed by the Town Engineer, at the Contractor’s expense. All surface objects, trees, stumps, roots, and other protruding obstructions not designated to remain shall be cleared and grubbed, including mowing, as required. Undisturbed stumps, roots, and nonperishable solid objects located two feet or more below subgrade or embankment slope may remain in place. Except in areas to be excavated, all holes resulting from the removal of obstructions shall be backfilled with suitable material and compacted. No material or debris shall be disposed of within the project limits. Branches or shrubs shall be removed as directed. All trimming shall be done in accordance with good tree surgery practices, and Town of Breckenridge direction.”

SECTION 202: REMOVAL OF STRUCTURES AND OBSTRUCTIONS

202.02 ADD: “Excess material generated by the installation of the drains, sewers and water mains shall be removed and disposed of by the Contractor. Final grade at the trenches shall match subgrade of the road reconstruction.” This work shall be incidental of paying for installation services.

202.03 ADD: Any salvable material, including signs, sign poles, street light poles, luminaires, hydrants, and other materials shall be hauled and delivered by the Contractor to Town’s Public Works Yard at 1095 Airport Road. The Town Representative shall determine if materials encountered during the work are salvable and whether the Town desires to keep the material. The Town reserves the right to retain ownership of any materials encountered, including boulders, excavated material, gold, historic materials, and any other materials, artifacts, or equipment encountered.

202.07 ADD: New concrete shall match existing concrete. The vertical difference between new and existing concrete shall be less than 1/16”. The Contractor shall grind existing concrete where needed to provide a smooth transition with no vertical differences greater than 1/16”. Existing concrete shall be doweled into new concrete.

202.09 ADD: “Milling is the same operation as planing.

The designated asphalt shall be removed and disposed of by the Contractor.

Irregularities and distresses on the milled or unfinished surface, such as, but not limited to, delamination, raveling, and potholes that are identified by the Project Manager shall be repaired as soon as possible. Asphalt identified by the Town Engineer as distressed after milling shall be removed and patched as directed by the Town Engineer. Additional patching shall be paid separately. Milled surfaces shall be drivable and shall not have any vertical drops (temporary asphalt shall be tapered at edges of milled areas). Milled edges shall be clean vertical faces and may require re-milling, saw cutting, or other methods to reestablish vertical edges prior to paving.

New asphalt shall match existing asphalt. The vertical difference between new and existing asphalt shall be less than 1/16". The contractor shall grind existing asphalt pavement where needed to provide a smooth transition with no vertical differences greater than 1/16"."

SECTION 203: EXCAVATION AND EMBANKMENT

203.06 DELETE the first paragraph of Section 203.06 and REPLACE with the following:

"When Contractor Process Control is required, the Contractor's Process Control Representative shall be certified with CDOT's Excavation, Embankment, and Soil Inspection certification course."

DELETE the third paragraph of Section 203.06 and REPLACE with the following

"Unless a thickness is otherwise specified in the Contract, the upper 3 inches of the ground surface will be considered topsoil and shall be removed in accordance with Section 207 prior to placement of embankment fill."

203.12 DELETE Pay Item "Blading", "Dozing", and "Proof Rolling". Costs of Blading, Dozing, and Proof Rolling shall not be paid separately. All costs associated this work shall be included in Unclassified Excavation and Embankment Material unit costs.

SECTION 206: EXCAVATION AND BACKFILL FOR STRUCTURES

206.06 DELETE paragraph (b) and replace with the following:

For pipes, a profile will be made along the bottom of the center line extending 18 inches beyond the end of the structure, including end sections. Material excavated between this profile and existing grade will not be measured for payment but shall be included in the pipe unit cost. Backfill placed between the pipe profile and the existing grades will not be measured for payment but shall be included in the pipe unit cost. In embankment sections, fill placed above the existing ground will be paid through the embankment unit cost.

206.07 Delete pay item "Bed Course Material" and "Filter Material". All costs of bed course material and filter material shall be included in the unit cost of the pipe/structure.

SECTION 207: TOPSOIL

RETAIN all sections.

SECTION 208: EROSION CONTROL

208.03 ADD the following:

“The Town Engineer may combine the Environmental pre-construction conference with the project pre-construction meeting”

208.04 DELETE paragraph (c)

208.12 DELETE section in its entirety and replace with the following:

“Erosion Control items will not be paid separately but shall be paid as a Lump Sum. The Erosion Control unit cost shall include all equipment, materials, labor, and other costs to complete all erosion control shown on the plans and to comply with Town and CDPHE standards. Unit cost shall include wattles, silt fence, aggregate bags, erosion logs, vehicle tracking pads, inlet protection, concrete washouts, sweeping, and all other work required.”

SECTION 209: WATERING AND DUST PALLIATIVES

209.07 ADD the following:

“Water will be provided by the Town of Breckenridge Water Division through its bulk water station at 1095 Airport Road, Breckenridge, CO or through a hydrant near the site. If an on-site hydrant is to be used, a hydrant valve and meter shall be obtained from the Town of Breckenridge Water Division. The Contractor will be responsible for obtaining a meter and all paperwork from the Water Division. Water will be metered. Payment shall not be made separately for water.

209.08 DELETE “Water” and “Water (Landscaping)” pay items. Water will not be paid for separately but shall be included in the cost of the work.

SECTION 210: RESET STRUCTURES

210.10 ADD the following:

The Contractor shall replace all valve boxes, manholes, and other structures damaged during construction at the cost of the Contractor. Contractor shall remove and clean any debris that enters valve boxes and manholes during construction.

210.13 ADD the following:

Payment will be made under:

Pay Item	**Pay Unit**
Adjust Valve Box/ Manhole	Each

Adjustments that include adding, removing, or replacing a manhole cone or barrel section will be paid for under the Section 210 pay item, Modify Manhole.

Cleaning designated valve boxes will be paid for under the Section 202 pay item, Clean Valve Box.

ADD the following section immediately after 210.13:

210.14 Heated Pavement Systems. Heated pavement systems, also referred to as snowmelt systems, damaged or modified from construction, shall be reset and repaired by Contractor. Contractor shall place two layers of welded wire fabric, 25 psi insulation, pex tubing, expansion joint and dowels at connection to existing. Contractor shall charge the system with glycol, pressure test for 24 hours and complete all other concrete and mechanical work required. If the snowmelt system is required to be modified per the contract documents, the work will be paid under repair snowmelt system or heated pavement pay item. If the Contractor damages a snowmelt system not intended for removal, repair, or modification per the contract documents, the Contractor shall be responsible for all costs of repair. The Contractor shall be responsible for the following mechanical requirements:

1. PEX tubes shall be spliced and pressure tested for a minimum of 24 hours by a licensed mechanical contractor.
2. Pressure test shall be at least 1.5 times operating pressure and 100 psi minimum.
3. Piping and splices shall be per Town Building Code and current edition of International Mechanical Code.
4. Town Engineering and Town Building Divisions to inspect splices and pressure test.
5. Insulation and welded wire fabric to be installed beneath tubing.
6. Snowmelt system to be under pressure during placement and cure of concrete.

SECTION 212: SEEDING, FERTILIZER, SOIL CONDITIONER, AND SODDING

212.05 ADD the following at the end of paragraph (a):

"6" of approved topsoil shall be placed on the prepared ground prior to placing any sod."

212.06 ADD the following at the end of paragraph (a):

"3" minimum of approved topsoil shall be placed on the prepared ground prior to planting native grass."

SECTION 213: MULCHING

213.03 ADD the following to paragraph (e):

Wood chip mulch shall be a natural, non-stained, shredded cedar mulch. Non-plastic weed control fabric, 5 oz minimum weight, shall be installed beneath the mulch and included in the unit cost of the mulch.

SECTION 214: PLANTING

214.02 ADD the following:

After delivery of plant material, the Contractor shall contact the Engineer for approval of all plant material. The Contractor shall remove and replace rejected materials immediately from the site at their expense.

214.03 ADD the following to paragraph (a):

Installation of plant materials will not be permitted until earthwork, topsoil and adjacent site improvements are substantially complete.

ADD the following to the end of section 214.03:

No trees shall be removed from the project site until marked for removal with Town Representative. All new landscaping, including trees, shrubs, grass, perennials, and mulch, shall be marked with flags or marking paints and approved by Town Representative prior to planting.

Contractor shall implement weed control measures to prevent and remove weed growth from all disturbed areas throughout the establishment period. Weed control measures may include the following:

i. Watering topsoil prior to seeding and applying acceptable herbicides to topsoil prior to planting
ii. Installation of weed control barriers in mulch beds
iii. Application of localized herbicides to eliminate weed growth
iv. Mechanical removal of weeds

214.04 DELETE "Establishment period begins immediately and lasts a period of 12 months" and replace with:

> ”The establishment period shall be two years, or the duration of time from installation until all plant material maintains a healthy and vigorous growing condition, whichever is greater. The warranty period for plantings shall equal the establishment period."

REPLACE paragraph (1) with the following:

(1) "Watering in Irrigated Areas. Trees and shrubs planted at all locations on the project shall be watered within four hours of planting and then daily for the first month. After the first month, trees and shrubs shall be watered twice a week until the end of the establishment period. Between the months November through April, watering is not required."

214.06 DELETE Pay Item "Landscape Maintenance" and add the following:

Landscape maintenance and all associated costs for the establishment period per Section 214 shall be included in the tree, shrub, perennial, or other individual landscape pay item.

SECTION 215: TRANSPLANTING

RETAIN all sections.

SECTION 216: SOIL RETENTION COVERING

RETAIN all sections.

SECTION 217: HERBICIDE TREATMENT

RETAIN all sections.

SECTION 250: ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT

RETAIN all sections.

DIVISION 300

BASES

SECTION 304: AGGREGATE BASE COURSE

304.04 DELETE AND REPLACE with: “Following utility construction, base materials shall be placed to the minimum depth as shown on the plans. If the required compacted depth of the aggregate base course exceeds 6 inches, it shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed 6 inches. When vibratory or other approved types of special compacting equipment are used, the compacted depth of a single layer may be increased to 8 inches upon approval of TOB representative, provided that specified density is achieved.

SECTION 306: RECONDITIONING

RETAIN all sections.

SECTION 307: LIME TREATED SUBGRADE

307.04 DELETE and REPLACE the first sentence of the first paragraph so that it reads: “The Contractor shall construct one or more compacted courses of treated material, to the depth specified in the Contract and/or Construction Drawings.”

307.12 REPLACE Table 307-1 with the following:

Table 307-1

SCHEDULE FOR MINIMUM SAMPING AND TESTING

In Place Soil Density and Moisture Content	AASHTO T 191 ASTM D 2167	One test for each 1,000 square yards (not less than one test per day).
	AASHTO T 239 AASHTO T 238 ASTM D 2216 AASHTO T 191 and ASTM D 2216	Shall be performed every tenth nuclear method density test
Atterberg Limits	AASHTO T89 & T90	One test per 2,000 tons
Moisture-Density	AASHTO T180	One test per soil type Relationships
Gradation	AASHTO T27 and T11	One test per 2,000 tons
Thickness		One test per 5,000 square yards
Resilient Modulus	AASHTO T 294	Upon request by the Agency

SECTION 308: MECHANICAL STABILIZED SUBGRADE

DESCRIPTION

308.01 Item 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 contract drawings. Work consists of:

A. Purpose

The purpose of the work shall be to provide a stabilized paving platform section on which paving materials can be placed. 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.

MATERIALS

308.02. Definitions

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 or base material required, provide a stiff working platform for pavement construction, or combination of these.

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.

Multi-Layer Geogrid: A geogrid product consisting of multiple layers of grid which are not integrally connected throughout.

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.

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.

Minimum Average Roll Value (MARV): Value based on testing and determined in accordance with ASTM D4759-92.

True Initial Modulus in Use: The ratio of tensile strength to corresponding zero strain. The tensile strength is measured via ASTM D6637 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 D6637

Junction Strength: Breaking tensile strength of junctions when tested in accordance with GRI-GG2 as modified by AASHTO Standard Specification for

Highway Bridges, 1997 Interim, 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.

Flexural Stiffness (also known as Flexural Rigidity): Resistance to bending force measured via ASTM D1388-96, Option A, using specimen dimensions of 864 millimeters in length by 1 aperture in width. Values shown are MARVs. For multilayer 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.

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.

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 ½ inches, and less than 10% fines (passing the #200 sieve). Recycled concrete may be used as granular fill to stabilize subgrade. Recycled concrete shall have a sulfate content of less than 3000 ppm. Recycled concrete shall be mixed and placed per the contract documents or the guidance of the project geotechnical engineer.

308.03 Manufacturers. All manufacturers will be considered provided they meet the submittal process as per Item 6.6 and per Table 308.04 (All values are minimum average roll values unless a range or characteristic is indicated):

308.04 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 308.04

Table 308.04

Property	Test Method	Units	Type 1	Type 2
Aperture Stability Modulus at 20 cm-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 [2]	Mg-cm	250,000	750,000
Minimum Tensile Strength @ 2% Strain:	ASTM D6637-01 [4]			
- MD[3]		Lb/ft	280	410
- CMD[3]		Lb/ft	450	620
Minimum Tensile Strength @ 5% Strain:	ASTM D6637-01 [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 D6637 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.

B. Geotextile materials shall not be considered as an alternate to geogrid materials for subgrade improvement or base or 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.

308.05 Execution

A. Examination

The CONTRACTOR shall check the geogrid upon delivery to verify that the proper material has been received. The geogrid shall be inspected by the CONTRACTOR to be free of flaws or damage occurring during manufacturing, shipping, or handling.

308.06 Delivery, Storage, and Handling

A. Storage and Protection

Prevent excessive mud, wet concrete, epoxy, or other deleterious materials from coming in contact with and affixing to the geogrid materials.

Store at temperatures above -20 degrees F (-29 degrees C).

Rolled materials may be laid flat or stood on end.

Geogrid materials should not be left directly exposed to sunlight for a period longer than the period recommended by the manufacturer (as per ASTM D4355).

B. Preparation

The subgrade soil elevation shall be prepared at the proper elevation and alignment as directed by the engineer or as indicated on the construction drawings.

C. Installation

The geogrid shall be installed in accordance with the installation guidelines provided by the manufacturer or as directed by the engineer.

The geogrid may be temporarily secured in place with ties, staples, pins, sand bags or backfill as required by fill properties, fill placement procedures or weather conditions or as directed by the engineer.

D. Granular Fill

Compaction – Standard compaction methods may be used unless the soils are very soft. In these cases, static instead of vibratory compaction is prudent, particularly over silty subgrades. Compaction is then achieved using a light roller. Keeping fill moisture content near optimum will make compaction more efficient. Water spray is most effective with sand fill. Compact aggregate fill to project specifications, after it has been graded smooth and before it is subject to accumulated traffic.

Vehicle Operation Over Geogrids- A minimum loose fill thickness of 6 inches is required prior to operation of vehicles over the geogrid. Turning of vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid. When underlying substrate is trafficable with minimal rutting, rubber-tired equipment may pass over the geogrid reinforcement at slow speeds (less than 10 mph) when integrally-formed geogrids are used.

This shall not be allowed with coated geogrids and sharp turning movements shall be avoided.

E. Inspection

The owner or owner’s representative may randomly inspect geogrid before, during and after (using test pits) installation.

Any damaged or defective geogrid (i.e. frayed coating, separated junctions, separated layers, tears, etc.) will be repaired/replaced in accordance with Item 308.06F.

F. Repair

Any roll of geogrid damaged before, during and after installation shall be replaced by the CONTRACTOR at no additional cost to the OWNER.

Proper replacement shall consist of replacing the affected area adding 3ft (1m) of geogrid to either side of the affected area.

308.07 Submittals

A. Submittal Procedure – 30 days prior to Notice to Proceed.

1. Submit geogrid product sample approximately 4 inches by 7 inches or larger three days prior to installation.

2. Submit geogrid product data sheet, certification, and/or independent full scale laboratory testing from the manufacturer that the geogrid product supplied meets the requirements of Table 6.4-1

3. Submit manufacturer's installation instructions and general recommendations.

4. A list of 5 comparable projects that are similar in terms of size and application, within the state of Colorado, and where the results of using the specific geogrid material can be verified after a minimum of 1 year of service life.

5. Additional information as requested by the engineer to fully evaluate the product.

B. Quality Assurance

Pre-Construction Conference - Prior to the installation of the geogrid, the CONTRACTOR shall arrange a meeting at the site with the geogrid material supplier and, where applicable, the geogrid installer. The OWNER and the ENGINEER shall be notified at least 3 days in advance of the time of the meeting. A representative of the geogrid supplier shall be available on an "as needed" basis during construction.

308.08 Construction Platform Design

Construction platform design shall be performed under supervision of and signed by a Professional Engineer registered in the State of Colorado. The recommended procedure shall be derived by the Giroud-Han, Method (ASCE, August 2004).

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 Departments of Transportation and Government Agencies such as the Federal Highway Administration and Army Corps of Engineers.

For general guidance purposes only, Table 308.08-1 and 308.08-2 present a guide for estimating subgrade soil strength and minimum construction platform recommendations based on a range of subgrade strengths, respectively. 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 engineer.

Table 308.08-1

Guide for Estimating Subgrade Soil Strengths (Fine Grained Soils)

Estimate Consistency by:		Test by:				Correlates to:			
Feel	Equipment/Visual	Standard Penetration Test (blows/ft)	Dynamic Cone Penetrometer (mm/blow)			Shear Strength c_u		R Value	CBR
			SC, SM, SP	CL	CH	(kPa)	(tsf)		
Very Soft	Man standing sinks > 3"	< 2	—	—	—	< 12	< 0.125	—	< 0.4
Soft	Man walking sinks ≈ 2 - 3"	2 - 4	—	—	—	12 - 24	0.125 - 0.25	< 0.36	0.4 - 0.8
Medium	Man walking sinks ≈ 1"	4 - 8	—	> 66	—	24 - 48	0.25 - 0.50	0.36 - 2.5	0.8 - 1.6
Stiff	Pickup truck ruts ≈ 1/2 - 1"	8 - 15	> 100	66 - 46	—	48 - 96	0.50 - 1.0	2.5 - 6.8	1.6 - 3.2
Very Stiff	Loaded dump truck ruts ≈ 1 - 3"	15 - 30	100 - 56	46 - 33	> 109	96 - 193	1.0 - 2.0	6.8 - 15.5	3.2 - 6.4
Hard	Insignificant rutting by loaded dump truck	> 30	56 - 27	33 - 23	109 - 54	> 193	> 2.0	> 15.5	> 6.4

References: After Portland Cement Association, E.I. Dupont Literature and McCarthy, David F., "Essentials of Soil Mechanics and Foundations," 1977, and Tensar 1998.
Webster, Personal Communication 2001, "DCP vrs. CBR Correlations".
AASHTO, "1993 Guide for Design of Pavement Structures," Van Till et. al. NCHRP 128.

Table 308.08-2

Recommended Aggregate Fill Thickness Feel / CBR Value with Geogrid Mechanical Reinforcement				
Soil Strength [1]	CBR	Aggregate Fill Thickness (in.) [2]		
Feel	approx.	Type 1 Geogrid [3]	Type 2 Geogrid [3]	*Unreinforced*
Very Soft	< 0.4	37"	34"	52"
Soft	0.6	30"	26"	42"
Medium	1.2	20"	16"	29"
Stiff	2.5	14"	9"	22"
Very Stiff	4	12"	6"	20"

Notes:

1. Soil Strength is based in Table 308.08-1. The soil strength used is general for these purposes.

2. Results of aggregate fill thickness were derived using the published Giroud-Han (2004) Methodology. Average values for fill thickness are used. Aggregate fill was assumed to have a minimum R-value of 30.

3. Type 1 and Type 2 geogrid structural properties used were a minimum as derived from Table 308.04-1.

308.09 Payment. Payment shall be made at the contract unit price per square yard based upon plan quantities for the stabilization. The price shall be full compensation for furnishing all material and for all preparation of the subgrade, delivering, installation, and incidentals necessary to complete this item. Paving platform found deficient shall be removed and replaced. At the option of the TOWN, the pavement structural section shall be adjusted to compensate for any deficiency in the paving platform thickness and strength at the CONTRACTOR's expense as noted in Item 308.06F. Granular fill will be paid for at the contract unit price per cubic yard. Unit price will be held constant regardless of deviation from actual quantities.

308.10 Wicking Geotextile

A. Submittals. Submit the following:

1. Certification: The contractor shall provide to the Engineer a certificate stating the name of the manufacturer, product name, style number, and chemical composition of the filaments or yarns and other pertinent information to fully describe the geotextile. The Certification shall state that the furnished geotextile meets MARV requirements of the specification as evaluated under the Manufacturer's quality control program. The Certification shall be attested to by a person having legal authority to bind the Manufacturer. Certifications from Private Label distributors will not be accepted.

2. If an alternate product is submitted full scale performance testing performed by an Independent testing Town shall be completed.

3. Coefficient of Interaction (C_I) test results performed by a lab with GRI accreditation should be provided to confirm conformance to the specified value.

4. Manufacturer's installation Guidelines shall be provided.

5. One 1' x 1'sample shall be provided.

6. Quality Standards: The contractor shall provide to the Engineer the Manufacturer's Quality Control Plan along with their current GAI-LAP and ISO 9001:2015 certificates.

7. Alternate products must be submitted to the Town 15 days prior to bid date and should include information on five similar projects in size and scope.

B. Quality Assurance

Manufacturer Qualifications:

1. The geotextile Manufacturer shall have all the following credentials:

   a. ISO 9001:2015 Quality Management System
   b. Geosynthetic Accreditation Institute (GAI) Laboratory Accreditation Program (LAP)

2. The geotextile Manufacturer shall have a GAI-LAP accredited laboratory at the location of production capable of performing the ASTM tests as outlined in the specification.

C. Delivery, Storage, and Handling

1. Geotextile labeling, shipment, and storage shall follow ASTM D4873. Product labels shall be color-coded to specifically identify each product and clearly show the Manufacturer's name, style name, and roll number.

2. Each geotextile roll shall be wrapped with a material that will protect the geotextile from

damage due to shipment, water, sunlight, and contaminants.

3. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, excess temperatures, and any other environmental conditions that may damage the physical property values of the geotextile.

D. Products

1. The geotextile shall be woven from super high-tenacity polypropylene yarns in conjunction with wicking yarns with a weave pattern to maximize strength, water flow, soil interaction, wicking capabilities and soil retention. The yarns shall be from high-tenacity long-chain synthetic polymers composed of at least 95 percent by weight of polyolefins or polyamids. They shall form a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

2. Geosynthetic must be able to directionally draw water via capillary action.

3. The geotextile shall meet the requirements of Table 1. All numeric values in Table 1 except AOS represent MARV in the specified direction. Values for AOS represent maximum measured opening size.

TABLE 308.10 – SOIL STABILIZATION AND WICKING GEOTEXTILE

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	**CD**
Wide Width Tensile Strength	ASTM D4595	lbs/ft (kN/m)	5280 (77.0)	5280 (77.0)
Wide Width Tensile Strength @ 2% strain	ASTM D4595	lbs/ft (kN/m)	480 (7.0)	1080 (15.8)
			Maximum Opening Size	
Apparent Opening Size (AOS)	ASTM D4751	U.S. Sieve (mm)	40 (0.425)	
			Minimum Roll Value	
Permittivity	ASTM D4491	sec^{-1}	0.4	
Flow Rate	ASTM D4491	gal/min/ft^2 (l/min/m^2)	30 (1222)	
			Minimum Test Value	
Pore Size (050)	ASTM D6767	microns	85	
Pore Size (095)	ASTM D6767	microns	195	
Wet Front Movement [1] (24 minutes)	ASTM C1559[2]	inches	6.0 Vertical direction	
Wet Front Movement [1] (983 minutes) Zero Gradient	ASTM C1559[2]	inches	73.3 Horizontal direction	

[1] 'STP': Standard Temperature and Pressure, Tested Value

[2] Modified

When sewn, seams are required, refer to Manufacturer's Installation Guidelines for overlap / seam requirements.

E. Quality Control

1. Manufacturing Quality Control: Testing shall be performed at an on-site laboratoryaccredited by GAI-LAP for tests required for the geotextile, at frequency meeting or exceeding ASTM D4354.

2. Manufacturer's certifications and testing of quality assurance samples obtained using Procedure B of ASTM D4354. A lot size for conformance or quality assurance sampling shall be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.

F. Execution. See Manufacturer's Installation guidelines provided in the submittal.

SECTION 309 FULL DEPTH RECLAMATION

ADD Section 309 Full Depth Reclamation to these specifications.

ADD the following:

DESCRIPTION

309.01 This work consists of pulverizing the existing asphalt mat and mixing the pulverized asphalt mat with the existing base course, to the specified depth, and grading and compacting the mixed material in accordance with, and at locations as shown in the Contract.

CONSTRUCTION REQUIREMENTS

309.02 The Contractor shall develop a written method to maintain the centerline geometry, profile elevations, and cross slope of the existing roadway. The plan shall be submitted to the Engineer for approval a minimum of two weeks prior to starting work. The plan shall include, but is not limited to, the following:

1. Mobilization of equipment to haul and place material
2. The estimated length of roadway (both travel lanes) that can have existing pavement structure removed, embankment cut to new elevation, and placement of Aggregate Base Course material so that the difference in elevation between lanes is 1 inch or less at the end of the work shift
3. Contractor's plan to address stabilization of soft spots
4. Contractor's method to keep the road open for two-way traffic after the pavement and/or base is removed, and before or during a major precipitation event
5. Method of Handling Traffic to be used during the operation
6. Contractor's implementation of Revision of Section 104.04 - Maintaining Traffic

Reclamation of the existing asphalt pavement shall not commence until the Contractor has an approved design mix for Hot Mix Asphalt.

The existing asphalt mat shall be cut at neat lines as shown in the plans by the use of a cutting wheel attached to a blade or by another approved method. The existing asphalt mat shall be pulverized and mixed with the existing base course to a specified depth or as directed by the Engineer, with a self-propelled rotary type mixing machine. *Optimal speed for the reclaimer shall be 11.5 feet per minute, and it shall be the responsibility of the Contractor to assure the Town this rate is not exceeded.* Deviations must be made by the Engineer in the field.

The mixing machine shall make as many passes as required to uniformly mix the asphalt and existing base course to the required thickness. Mixing of the different materials shall create a homogenous mixture. The particle size of the pulverized asphalt mat shall be a minimum of 99 percent passing the 1-1/4 inch sieve. When the addition of water is necessary for initial compaction purposesit shall be added through the mixing machine with the capability to uniformly distribute water through the mixed materials.

When proper mixing has been accomplished, the mixture shall then be bladed, shaped, wetted or dried, and rolled to meet a minimum of 95 percent of the maximum wet density determined in accordance with AASHTO T-180 Method D. The soils moisture-density curve will be developed using wet densities and the percent compaction will be calculated using wet density.

The maximum depth to be compacted in one lift is 8 inches. If the depth of the reclaimed material exceeds 8 inches, the Contractor shall remove the material in excess of 8 inches and compact the material in layers not exceeding 8 inches. Thickness will be determined in the field with the Engineer at the beginning of work.

Grading equipment used to establish the final surface elevations shall have automatic controls for transverse slope. The transverse slope controls shall be capable of maintaining the final surface within 0.1 percent of the specified slope. Variations from the subgrade plane shall not be more than ¼ inch. The work shall be maintained and tested for conformance to these requirements immediately prior to placing additional pavement layers.

The minimum quantity for acceptance testing will be based on a random schedule of 1/1000 square yards of reclaimed material. Every 5,000 square yards a verification point will be tested to confirm the accuracy of the moisture-density curve.

The maximum time a portion of the roadway will be unpaved is ten (10) working days unless otherwise specified. The exposed longitudinal joint between the existing asphalt mat and the processed mat shall not remain in place for more than one day unless approved by the Engineer. When additional aggregate base course is imported and placed before processing begins, the full width of the roadway shall be completed daily. Joint construction and maintenance shall conform to subsection 401.16.

METHOD OF MEASUREMENT

309.03 Full Depth Reclamation of Hot Mix Asphalt Pavement will be measured by the square yard of roadway treated, completed and accepted.

BASIS OF PAYMENT

309.04 The accepted quantities of Full Depth Reclamation of Hot Mix Asphalt Pavement will be paid for at the contract unit price per square yard for Full Depth Reclamation of Hot Mix Asphalt Pavement, for the depth shown in the project plans. The depth shown in the plans is based on cores obtained from the existing pavement, and the Contractor should be aware that the depth will vary and, in some locations, will be either less or more than the depth range shown in the plans. The pay item shown in the plans shall be that used for the entire project, regardless of variations discovered during construction.

Pay Item		**Pay Unit**
Full Depth Reclamation of Hot Mix Asphalt Pavement	SY	Square Yard

Payment for Full Depth Reclamation of Hot Mix Asphalt Pavement will be full compensation for all work necessary to complete the item including cutting of the existing asphalt mat, pulverizing the existing asphalt mat, mixing the pulverized asphalt mat into the existing base course, moving the pulverized material and existing base course, wetting and compacting the mixed pulverized asphalt mat and base course, blading, shaping, haul, water, and maintenance of the riding surface.

DIVISION 400

PAVEMENTS

SECTION 401 PLANT MIX PAVEMENTS - GENERAL

401.07 RETAIN the first paragraph and Table 401-3. DELETE the remainder of Section 401.07 and REPLACE with the following:

"Temporary asphalt ramps shall be placed at all vertical milled edges greater than 1". The Contractor shall maintain the temporary asphalt throughout the project. Distress in milled surfaces which affects the ride, safety, or serviceability of the road shall receive a temporary asphalt layer. Asphalt shall not placed between November 1st and April 30th. When emergency work requires asphalt placement between November and April the asphalt will be considered temporary and shall be replaced the following year after May 1st."

401.08 ADD the following sentence to the end of paragraph one:

"Asphalt mixing and storage plant operations shall comply with ASTM D995 for materials storage, control, mixing, and for plant equipment and operation."

401.11 DELETE AND REPLACE with: "A tack coat shall be applied between pavement courses, at vertical edges of pavement, and at all vertical faces of concrete abutting the pavement at a rate of 0.05 to 0.15 gal/sq. yd. and paid for in accordance with Section 407. A prime coat at the subgrade shall not be required."

401.12 ADD the following: "All manholes and valve boxes shall be set to ½ inch below final grade prior to paving of streets."

401.17 Add the following to the end of paragraph one:

"After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened. Asphalt surface temperature shall be below 160 degrees.

Erect barricade to protect paving from traffic until mixture has cooled and attained its maximum degree of hardness."

DELETE all references to compaction pavement test section (CTS). ADD the following: "Compaction pavement test section not required. Unless specified by the Contract, pavement cores are only required for longitudinal joints."

401.20 DELETE and REPLACE entire section with following:

Town representative will inspect paving operations to ensure surface smoothness. On roads below 35 mph, the Town will not inspect small deviations in smoothness. On roads above or equal to 35 mph, Town will inspect smoothness using 10 foot level and measure any deviations greater than 3/16". Contractor will be required to grind deviations. If smoothness is excessively poor, the Town will require Contractor to mill and replacement pavement.

SECTION 403 HOT MIX ASPHALT

ADD the following Table

Table 403.01

Minimum Materials Sampling and Testing for Process Control and Owners Acceptance

Test	Standard	Minimum Frequency
Sampling	AASHTO T168, ASTM D 979 and ASTM D3665	One test per day, per mix design.
Density (Nuclear Gauge)	AASHTO T 166, T 355	One test every 250 lineal feet, per lane, per mix design.
Total Thickness (Core or non destructive method	ASTM D3549 or approved non destructive method	IF requested by the **AGENCY**, not to exceed one test per day.
Gradation	AASHTO T 27, T 11	One test per day, per mix design.
Binder Content	AASHTO T 308 or other methods agreed upon between Agency and Contractor. AASHTO 308	One test per day per mix design.
Maximum Theoretical Specific Gravity (Rice)	AASHTO T 209	One test per day, per mix design.

SECTION 405 HEATING AND SCARIFYING TREATMENT

RETAIN all sections.

SECTION 406 COLD ASPHALT PAVEMENT (RECYCLE)

DELETE Section 406

SECTION 407 PRIME COAT, TACK COAT, AND REJUVINATING AGENT

RETAIN all sections.

SECTION 408 JOINT AND CRACK SEALANT

RETAIN all sections.

SECTION 409 CHIP SEAL

DELETE Section 409

SECTION 410: SLURRY SEAL

DESCRIPTION

410.01 The slurry seal shall consist of a mixture of an approved emulsified asphalt, mineral aggregate, water and specific additives, proportioned, mixed and uniformly spread over a properly prepared surface in accordance with the plans and specifications. The complete slurry seal shall leave a homogeneous mat, adhere firmly to the prepared surface, and have a friction resistant surface texture throughout its service life.

MATERIALS

410.02

A. Emulsified Asphalt

The emulsified asphalt shall conform to Grade SS-1h, CSS-1h, CQS-1h as specified in ASTM D 977, D 2397, AASHTO M 140 and M 208. The cement mixing test is waived. Each load of emulsified asphalt shall be accompanied with a Certificate of Compliance.

Table 410.02-1 Emulsified Asphalt

Test	Quality	Specification
AASHTO T59	Residue after distillation	60% Min.
AASHTO T49[1]	Penetration at 77° F (25° C)	40 to 90
AASHTO T 59	Saybolt Furol Viscosity 77° F (25° C)	15 to 90 Sec.

[1]Test on Residue

B. Aggregate

The aggregate shall be manufactured 100 percent crushed stone such as granite, slag, limestone, chert, or other high quality aggregate, or combination thereof. All aggregates shall have at least two fractured faces.

Table 410.02-2 Aggregates

Test	Quality	Specification
AASHTO T176*	Sand Equivalent	55 Min.
AASHTO T104	Soundness	15% Max. using NA2 SO4 or 25% Max. using MgSO4
AASHTO T96	Abrasion Resistance	25% Max. Grading D

* Moisture condition sample at least 24 hours prior to running the test.

When tested in accordance to AASHTO T 27 and AASHTO T 11, the aggregate gradation (including the mineral filler) shall be within the following bands. Note: Selection of Type II or Type III shall be designated by the Town and shown on the plans.

Table 410.02-3 Aggregate Gradation

Sieve Size	Percent Passing		Job Tolerance
	Type II	Type III	
1/2"	100	100	± 0
No. 4	90 to 100	70 to 90	± 4
No. 8	65 to 90	45 to 70	± 4
No. 16	45 to 70	28 to 50	± 3
No.30	30 to 50	19 to 34	± 3
No. 50	18 to 30	2 to 25	± 3
No. 100	10 to 21	7 to 18	± 3
No 200	5 to 15	5 to 15	± 2

The stockpile shall be accepted based on an average of five gradation tests according to AASHTO T 2. Note requirement of 26.2E.

C. Mineral Filler

Portland cement, hydrated lime, limestone dust, fly ash or other approved filler meeting the requirements of AASHTO M 17 or ASTM D 242 shall be used if required by the mix design. They shall be considered as part of the dry aggregate.

D. Water

The water shall be free of salts and contaminates and shall be tested and conform to AASHTO T 26. Potable water testing is not required.

E. Additives

Liquid additives may be used to accelerate or retard the break-set of the slurry seal, or improve the resulting finished surface. The use of liquid additives in the slurry mix (or individual materials) shall be made initially in quantities predetermined by the mix design with field adjustments if required, after approval by the Town.

410.03 Mix Design

The CONTRACTOR shall submit to the Town, for approval, a mix design prepared and signed by a Professional Engineer registered in the State of Colorado, performed by a laboratory who has experience in designing Emulsified Asphalt Slurry Seal Surfacing. Compatibility of the aggregate, emulsion, mineral filler, and other additives shall be verified by the mix design. The mix design shall be made with the same materials and gradation that the CONTRACTOR will provide on the project. After the mix design has been approved, no substitution will be permitted. Minimum requirements are as follows:

Table 410.03-1 Recommended Mix Properties

Test	Description	Specification
ISSA T106	Slurry Seal Consistency	--
ISSA TB-139 (for quick-set systems)	Wet Cohesion 30 minutes Min. (set) 4 hour Min. (traffic)	12 kg-cm Min. 20 kg-cm Min.
ISSA TB-139 (for quick- traffic systems)	Wet Cohesion 60 minutes Min	20 kg-cm Min.
ISSA TB-109	Excess Asphalt by LWT Sand Adhesion	50 g/ft^2 Max.
ISSA TB-114	Wet Stripping 10 minutes boiling water	Pass (90% Min.)
ISSA TB-100	Wet Track Abrasion Loss One hour soak 6-Day soak	 50 gm^2 Max. 75 g/ft^2 Max.
ISSA TB-113	Mix Time	*
Residual Asphalt	6.5% to 12.0%	---
Mineral Filler	0.5% to 2.0%	

*The mixing test and set time test shall be done to anticipate the highest temperatures expected during construction. This will include 180 seconds mix time at 77° F and 70 seconds mix time minimum at 100° F.

The laboratory shall also report the quantitative effects of moisture content on the unit weight of the aggregate (bulking effect). The report must clearly show the proportions of aggregate, mineral filler (minimum and maximum), water (minimum and maximum), additive(s) (usage), and asphalt emulsion based on the dry weight of the aggregate. The report shall be sealed and signed by a Professional Engineer registered in the State of Colorado.

410.04 Equipment

A. General

All equipment, tools, and machines used in performance of this work shall be maintained in satisfactory working condition at all times to ensure a high quality product.

B. Mixing Equipment

The machine shall be specifically designed and manufactured to lay slurry seal. The material shall be mixed by a self-propelled slurry seal mixing machine of either truck mounted or continuous run design. Continuous run machines are those that are equipped to self load materials while continuing to lay slurry seal. Either type machine shall be able to accurately deliver and proportion the aggregate, emulsified asphalt, mineral filler, control setting additive, and water to a revolving mixer and discharge the mixed product on a continuous flow basis.

The machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral filler, control additive and water to maintain an adequate supply to the proportioning controls. If continuous run equipment is used, the machine shall be equipped to allow the operator to have full control of the forward and reverse speed during application of the slurry seal. It shall be equipped with a self-loading device, opposite side driver stations, and forward and reverse speed controls.

C. Proportioning Devices

Individual volume or weight controls for proportioning each material to be added to the mix (i.e. aggregate, mineral filler, emulsified asphalt and additive) shall be provided and property marked.

The proportioning devices are required to be in working order and shall be capable of determining the material output at any time.

D. Spreading Equipment

The mixture shall be spread uniformly by means of a conventional surfacing spreader box attached to the mixer and equipped to agitate and spread the material evenly throughout the box. A front seal shall be provided to ensure no loss of the mixture at the road contact point. The rear seal shall act as final strike-off and shall be adjustable. The spreader box and rear strike-off shall be so designed and operated that a uniform consistency is achieved to produce a free flow of material to the rear strike-off. The spreader box shall have suitable means provided to side shift the box to compensate for variations in the pavement geometry. A burlap drag or other approved screed may be attached to the rear of the spreader box to provide a uniform, highly textured mat. The drag pulled behind the spreader box shall not be stiffened or hardened by slurry or asphalt.

E. Auxiliary Equipment

Suitable surface preparation equipment, traffic control equipment, hand tools, power brooms, sweepers, and any other support equipment shall be provided as necessary to perform the work.

Equipment shall be approved by the TOWN. 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.

410.05 Calibration

Each mixing unit to be used in performance of the work shall be calibrated in the presence of the engineer prior to construction. Previous calibration documentation covering the exact materials to be used may be acceptable, provided they were made during the calendar year. A one-point calibration check may be required at the start of production. The documentation shall include an individual calibration of each material at various settings, which can be related to the machine’s metering devices. No machine will be allowed to work on the project until the calibration has been completed and/or accepted.

A. Verification

Test strips will be made by each machine after calibration and prior to construction. Test strips shall be a portion of the project. Samples of the slurry seal will be taken and verification made as to mix consistency and proportioning. Verification of rate of application will also be made. Upon failure of any of these tests, additional test strips, at no cost to the TOWN, will be required until each

unit is authorized to work. Any unit failing to pass the tests after the third trial, will not be permitted to work on the project. Test strips must be accepted or rejected within 24 hours after application.

410.06 Weather Limitations

The slurry seal shall not be applied if either the pavement or air temperature is below 50° F and falling, but may be applied when both pavement and air temperature are above 45° F and rising. No slurry seal shall be applied when there is danger that the finished product will freeze before 24 hours. The mixture shall not be applied when weather conditions prolong opening to traffic beyond a reasonable time.

410.07 Surface Preparation

A. General

Immediately prior to applying the slurry seal the surface shall be cleared of all loose material, oil spots, vegetation, and other objectionable material. Any standard cleaning method will be acceptable. If water is used, cracks shall be allowed to dry thoroughly before slurry surfacing.

Manholes, valve boxes, drop inlets and other service entrances shall be protected form the slurry seal by a suitable method. The TOWN shall approve the surface preparation prior to surfacing.

B. Tack Coat

If a tack coat is required it should consist of one part emulsified asphalt and three parts water. The emulsified asphalt should be the same as used in the mix. The distributor shall be capable of applying the dilution evenly at a rate of 0.05 to 0.10 gallons per square yard (0.15 to 0.35 liters per square meter). The tack coat shall be allowed to cure before application of the slurry seal.

C. Joint and Crack Sealant

Joints and crack shall be sealed in accordance with the requirements in Item 23.

410.08 Application

The slurry seal mixture shall be of proper consistency at all times so as to provide the application rate required by the surface condition. The average application rate shall be 18 to 30 pounds per square yard (8.16 to 13.6 kgs/m2).

Application rates are affected by the unit weight of the aggregate, the gradation of the aggregate and the demand of the surface to which the slurry seal is being applied.

A. General

When required by local conditions, the surface shall be pre wetted by fogging ahead of the spreader box.

The rate of application of the fog spray shall be adjusted during the day to suit temperatures, surface texture, humidity, and dryness of the pavement.

The slurry seal shall be of the desired consistency upon leaving the mixer. A sufficient amount of material shall be carried in all parts of the spreader at all times so that a complete coverage is obtained. Overloading of the spreader shall be avoided.

No lumping, balling, or unmixed aggregate shall be permitted.

No streaks, such as those caused by oversized aggregate shall be left in the finished surface. If excess oversize develops, the job will be stopped until the CONTRACTOR proves to the engineer that the situation has been corrected.

Some situations may require screening the aggregate just prior to loading it into the units going from the stockpile area to the laydown operations.

410.09 Joints

No excess buildup, uncovered areas, or unsightly appearance shall be permitted on longitudinal or transverse joints. The CONTRACTOR shall provide suitable width spreading equipment to produce a minimum number of longitudinal joints throughout the project. When possible, longitudinal joints shall be placed on lane lines. Half passes and odd width passes will be used only in minimum amounts. If half passes are used, they shall not be the last pass of any paved area. A maximum of 4 inches (152 mm) shall be allowed for overlap of longitudinal lane line joints. The paper shall be used at transverse joints to ensure a straight line.

410.10 Mix Stability

The slurry seal shall possess sufficient stability so that premature breaking of the material in the spreader box does not occur. The mixture shall be homogeneous during and following mixing and spreading. It shall be free of excess water and emulsion and free of segregation of the emulsion and aggregate fines from the coarser aggregate.

Spraying of additional water into the spreader box or addition of excess water will not be permitted.

410.11 Hand Work

Areas which cannot be reached with slurry seal machines shall be surfaced using hand squeegees to provide complete and uniform coverage. The area to be hand worked shall be lightly dampened prior to mix placement and the slurry worked immediately. Care shall be exercised to leave no unsightly appearance from handwork. The same type finish as applied by the spreader box shall be required. Handwork shall be completed during machine applying process.

410.13 Lines

Care shall be taken to ensure straight lines along shoulders. No runoff on these areas will be permitted. Lines at intersections will be kept straight to provide good appearance.

410.14 Rolling

At the option of the TOWN, the roadway shall be rolled by a self propelled 10 ton pneumatic roller with a tire pressure of 50 psi (3.4 atms.) and equipped with a water spray system. The surfaced areas shall be subjected to a minimum of two full coverage passes by the roller.

Rolling should not commence until the slurry has cured enough so that it will not pick up on the tires of the roller.

410.15 Clean-up

All areas, such as manways, gutters and intersections, shall have the slurry seal removed as specified by the Town. The CONTRACTOR shall remove any debris associated with the performance of the work on a daily basis.

410.16 Tolerances

Tolerances for individual materials as well as the slurry seal mixture are as follows:

After the designed residual asphalt content is determined, a plus or minus one percentage point variation will be permitted.

The percentage of aggregate passing each sieve shall be within stockpile tolerance range as stated and within the master range of Table 26.2B-2.

The percentage of aggregate passing shall not go from the high end to the low end of the specified range of any two successive sieves.

The slurry consistency shall not vary more than +/-0.5 cm from the job mix formula after field adjustments.

The rate of application once determined by the engineer shall not vary more than +2 pounds per square yard, while remaining within the design application rate.

If any two successive tests fail on the stockpile material, the job shall be stopped. It is the responsibility of the CONTRACTOR, at his own expense, to prove to the TOWN that the conditions have been corrected. If any two successive tests on the mix from the same machine fail, the use of the machine shall be suspended. It will be the responsibility of the CONTRACTOR, at his own expense, to prove the TOWN that the problems have been corrected and that the machine is working properly.

410.17 Measurement

The area of slurry seal shall be measured by the square yard per plan quantities completed in place and accepted.

410.18 Testing and Inspection

Testing and inspection shall be performed in accordance with Table 410.18-1.

Table 410.18-1 Schedule for Minimum Slurry Seal Materials Sampling and Testing

Test Type	Test Standard	Minimum Frequency of Tests
Residue after distillation	AASHTO T 59	One test each 5,000 square yards of slurry seal
Extraction and Gradation	AASHTO T 164 AASHTO T 30	One test each 5,000 square yards of slurry seal
Application Rate		One test each 5,000 square yards of slurry seal

410.19 Payment

The slurry seal shall be measured and paid for by the contract unit price per square yard (SY). The price shall be full compensation for furnishing all materials and for preparation, mixing and applying these materials, and for all labor, equipment, tools, test design, clean-up and incidentals necessary to complete and warrant the job as specified herein.

SECTION 411 ASPHALT MATERIALS

DELETE Section 411.05 and REPLACE with the following: “Asphalt cement, emulsified asphalt, and other asphalt materials will not be paid separately but shall be included in the unit price for TONS of Hot Mix Asphalt or other appropriate mix.”

SECTION 412 PORTLAND CEMENT CONCRETE PAVEMENT

412.17 REVISE as follows “Roadway smoothness will not be tested on roads with speed limits below 35 mph. On roads at or above 35 mph, Town shall use a ten foot level to measure high spots greater than 3/16”. Contractor shall diamond grind areas exceeding 3/16”.

412.21 DELETE and REPLACE with the following: “Pavement thickness shall be measured by Town measuring the depth prior to placement of pavement. Contractor shall assist with setting string lines, forms, and other methods to measure thickness. Cores shall not be used unless requested by the Engineer.”

SECTION 420 GEOSYNTHETICS

420.02 DELETE the first sentence and replace with the following: “Geotextiles and geomembranes shall meet the applicable requirements of subsection 308.”

DIVISION 500
STRUCTURES

SECTION 501 STEEL SHEET PILING

RETAIN all sections.

SECTION 502 PILING

RETAIN all sections.

SECTION 503 DRILLED SHAFTS

RETAIN all sections.

SECTION 504 WALLS

ADD the following to Section 504.01: “For stone or boulder walls, Contractor shall deliver samples of stone to the site for approval by Town. Contractor shall construct a short section of wall as a mockup for Town review and approval. If mockup does not meet requirements of contract documents, the Contractor shall removal and replace wall at their expense.”

SECTION 506 RIPRAP

RETAIN all sections.

SECTION 507 SLOPE AND DITCH PAVING

RETAIN all sections.

SECTION 508 TIMBER STRUCTURES

RETAIN all sections.

SECTION 509 STEEL STRUCTURES

RETAIN all sections.

SECTION 510 STRUCTURAL PLATE STRUCTURES

RETAIN all sections.

SECTION 512 BEARING DEVICE

RETAIN all sections.

SECTION 514 PEDESTRIAN AND BIKEWAY RAILING

RETAIN all sections.

SECTION 515 WATERPROOF MEMBRANE

RETAIN all sections.

SECTION 516 DAMPPROOFING

RETAIN all sections.

SECTION 517 WATERPROOFING

RETAIN all sections.

SECTION 518 WATERSTOPS AND EXPANSION JOINTS

RETAIN all sections.

DIVISION 600

MISCELLANEOUS CONSTRUCTION

SECTION 601 STRUCTURAL CONCRETE

ADD the following to Section 601.02: “w/cm ratio for Concrete Class B,D, and P shall be 0.38 to 0.42.

SECTION 602 REINFORCING STEEL

RETAIN all sections

SECTION 603 CULVERTS AND SEWERS

ADD the following to Section 603.01: “For any sanitary sewer work, delete Section 603 in its entirety and replace with the Upper Blue Sanitation District Sewer Standards.”

ADD the following to Section 603.13: “Structure excavation and backfill shall not be paid separately, but shall be included in the cost of the pipe.”

SECTION 604 MANHOLES, INLETS, AND METER VAULTS

RETAIN all sections

SECTION 605 SUBSURFACE DRAINS

RETAIN all sections

SECTION 606 GUARDRAIL

RETAIN all sections

SECTION 607 FENCES

RETAIN all sections

SECTION 608 SIDEWALKS AND BIKEWAYS

ADD the following to Section 608.03: “All concrete sidewalk shall be a minimum of 5” thick. Control joints shall be placed at 6’ intervals and shall be sawcut joints. Joints shall be sawcut immediately after curing. Expansion joint shall be added between new concrete sidewalk and existing concrete sidewalk”

SECTION 609 CURB AND GUTTER

RETAIN all sections

SECTION 610 MEDIAN COVER MATERIAL

RETAIN all sections

SECTION 611 CATTLE GUARDS

RETAIN all sections

SECTION 612 DELINEATORS AND REFLECTORS

RETAIN all sections

SECTION 613 LIGHTING

RETAIN all sections

SECTION 614 TRAFFIC CONTROL DEVICES

RETAIN all sections

SECTION 615 WATER CONTROL DEVICES

RETAIN all sections

SECTION 616 SIPHONS

RETAIN all sections

SECTION 618 PRESTRESSED CONCRETE

RETAIN all sections

SECTION 619 WATER LINES

DELETE and REPLACE with the following: “Water lines and appurtenances shall be constructed in accordance with the Town of Breckenridge Water Construction Standards.”

SECTION 620 FIELD FACILITIES

RETAIN all sections

SECTION 622 REST AREAS AND BUILDINGS

DELETE Section 622 in its entirety.

SECTION 623 IRRIGATION SYSTEMS

RETAIN all sections

SECTION 624 DRAINAGE PIPE

624.02 ADD “High Density Polyethylene Corrugated Pipe with Smooth Interior” to the list of pipe materials under the Plastic Heading. ADD the abbreviation as HDPE.

Table 624-1. ADD [7] to the Table: “Plastic Pipe and fittings shall be manufactured from high density polyethylene resin which shall meet or exceed the requirements of Type III, Category 4 or 5, Grade P33 or P34, Class C per ASTM D1248. HDPE storm pipe shall be ADSN-12 WT-1B (water tight or approved equal.”

SECTION 625 CONSTRUCTION SURVEYING

RETAIN all sections

SECTION 626 MOBILIZATION

RETAIN all sections

SECTION 627 PAVEMENT MARKING

RETAIN all sections

SECTION 629 SURVEY MONUMENTATION

RETAIN all sections

SECTION 630 CONSTRUCTION ZONE TRAFFIC CONTROL

ADD the following to Section 630.01:

<u>“Construction Under Traffic</u>

Contractor shall maintain a minimum of one lane of traffic to greatest extent possible. When one lane cannot safely be maintained, the length and duration of the full road closure shall be minimized to the extent possible and shall be approved by the Town Engineer.

Two lanes of traffic shall be reopened during evenings and weekends. Full road closures during nights and weekends shall be submitted for review and approval by Town Engineer. Access to all residences and businesses shall be maintained at all times during construction. Flaggers shall be used to assist with construction access and pedestrian traffic control.

Pedestrian traffic shall be maintained through the construction zones. Temporary curb ramps shall be installed consisting of compacted base course. Pedestrian routes shall be a minimum of 5’ wide, meet ADA requirements, and be separated from traffic by approved barriers.

Flaggers shall be used to assist with construction access and pedestrian traffic control.

The Contractor shall provide to the Town a detailed phasing plan, schedule, Traffic Control Plan and MHT for each anticipated phase of construction.

Flagging

The contractor shall provide competent certified flaggers to direct traffic when work is being done in the street ROW or intersection that is open to traffic. The Contractor shall provide a minimum of one flagger while construction activities are occurring. The flaggers will be required to direct vehicular traffic and construction vehicles. Pedestrian and vehicular traffic shall be the priority of the "minimum" required flaggers. Certified flaggers, additional to the "minimum" required, may be utilized at the Contractor's discretion to assist with the Contractor construction activities. Flagging shall conform to the requirements of the MUTCD. The cost of the "minimum" flaggers and additional flaggers utilized by the Contractor shall be included in the unit price of the bid item, Traffic Control.

Traffic Control Supervisor (TCS)

When required by the Contract, the contractor shall provide a competent CCA or ATSSA certified Traffic Control Supervisor (TCS) on site for any set up, moving, reconfiguration, and removal of all traffic control devices required for the project. The TCS may be utilized as a flagger, and be recognized as one of the "minimum" required flaggers if the work is contained within a reasonable work zone length. The TCS shall monitor and make repairs and adjustments to the traffic control devices daily. The Traffic Control Supervisor shall conform to the requirements of the MUTCD, and will be included in the cost of the bid item, Traffic Control

Traffic Control Devices

The Contractor shall furnish, erect, and maintain all barricades, construction signing, lights, and other traffic control devices in conformity to the Manual of Uniform Traffic Control Devices for Streets and Highways and as called for in the plans and drawings. All signs and barricades to be paid for by the owner shall be in good condition and acceptable to the project engineer. All required traffic control devices, signs and flaggers shall be in place through the construction area prior to beginning and work.

The use of Type "A" low intensity warning lights shall be as shown in the contract and are incidental to the price of each barricade.

All construction signing shall be black on reflective orange and per MUTCD standards unless otherwise specified.

Maintenance

The Traffic Control Supervisor shall conduct daily inspections (three times per day minimum on working days) of all traffic control devices to ensure proper placement and condition of all signs, barricades and channelization devices, and shall log placement, inspection, maintenance, and replacement of all traffic control devices. Copies of the contractor's daily traffic control logs shall be given to the engineer once per week.

All construction signing, barricades, channelization devices, temporary pavement markings, and other construction traffic control devices shall be kept clean, legible, visible, and in proper position at all times. Damaged traffic control devices shall be repaired or replaced immediately.

Method of Handling Traffic (MHT)

To implement the Traffic Control Plan the Contractor will prepare and submit a Method of Handling Traffic (MHT) to the Engineer for approval at least one week prior to commencement of any demolition work. The Contractor shall implement the MHT in accordance with the plans and specifications. Any variance from those plans will require the approval of the Engineer.

The MHT shall be drawn specific to each project. The MHT shall be drawn reasonably close to scale and shall show representative project landmarks, streets and salient features. The Engineer, upon request from the Contractor, will furnish to the Contractor base mapping for preparation of the MHT. An individual MHT shall be submitted for each phase of work.

The MHT shall include the following as a minimum:

1. Detailed diagrams showing the size and location of all proposed traffic control devices.
2. Access plan for all businesses.
3. Access plan for pedestrians.
4. Emergency vehicle access plan.
5. Supporting documentation as required.
6. Flagger number and locations.

The key elements of the Contractor's method of handling traffic (MHT) are outlined in subsection 630.10(a).

The components of the TCP for this project are included in Subsection 104.04 and Section 630 of the specifications.

Unless otherwise approved by the Engineer, the Contractor’s equipment shall follow normal and legal traffic movements. The Contractor’s ingress and egress of the work area shall be accomplished with as little disruption to traffic as possible. Traffic control devices shall be removed by picking up the devices in a reverse sequence to that used for installation. This may require moving backwards through the work zone. When located behind barrier or at other locations shown on approved traffic control plans, equipment may operate in a direction opposite to adjacent traffic.

SECTION 641 SHOTCRETE

RETAIN all sections

DIVISION 700

MATERIALS DETAILS

SECTION 701 HYDRAULIC CEMENT

Add the following to Section 701.02:

Fly ash or natural pozzolans shall conform to ASTM C618, for Class C, F, N, or AASHTO M321 for High Reactivity Pozzolans. Class C fly ash may only be used for Class 0 sulfate resistance and if the calcium oxychloride is determined to be less than 15g CaOXY/100g cementitious paste in accordance with AASHTO T 365.

SECTION 702 BITUMINOUS MATERIALS

RETAIN all sections

SECTION 703 AGGREGATES

703.07 DELETE and REPLACE Paragraph (a) as follows: “(a) Bed course material for curbing, sidewalks and bike/pedestrian paths shall be 6 inches of aggregate base course Class 6 unless otherwise approved by the Engineer.”

SECTION 704 MASONRY UNITS

RETAIN all sections

SECTION 705 JOINT, WATERPROOFING AND BEARING MATERIAL

705.01 ADD the following to paragraph (a) JOINT SEALANT WITH BACKER ROD:

“The following sealants are approved for sealing concrete joints:

Sika Group - Sikaflex-1c SL

Dow Corning - Dow 890-SL

Pecora Corporation - Pecora 300 SL

Tremco incorporated - Spectrem 900-SL

Sonneborn – Sonalastic SL1

The color of the joint sealant shall match the color of the concrete unless otherwise specified or approved.”

ADD the following to paragraph (b) PREFORMED JOINT FILLERS:

“Preformed joint fillers conforming to AASHTO M 153 Type IV – Polyurethane bonded recycled rubber, are approved.”

SECTION 706 CONCRETE AND CLAY PIPE

RETAIN all sections

SECTION 707 METAL PIPE

RETAIN all sections

SECTION 708 PAINTS

RETAIN all sections

SECTION 709 REINFORCING STEEL AND WIRE ROPE

RETAIN all sections

SECTION 710 FENCE AND GUARDRAIL

RETAIN all sections

SECTION 711 CONCRETE CURING MATERIALS AND ADMIXTURES

711.01 ADD the following: “Liquid membrane-forming curing compound shall be a V.O.C. compliant, dissipating resin, conforming to AASHTO M-148, Type 2 for uncolored concrete or Type 1 (clear) for colored concrete. The following curing compounds are approved:

Dayton Superior - Day-Chem White Pigmented Cure (J-10-W)

Dayton Superior - White Dissipating Cure EF

Euclid – Kurez DR VOX”

711.03 ADD the following:

“**Accelerating Admixtures**: Set accelerating admixtures shall be non-chloride liquid conforming the ASTM C 494 Type C. The following accelerating admixtures are approved:

BASF Chemical Company - Pozzolith NC 534

Grace Construction Products - Daraset 200, 400 or HES

Euclid Chemical Company – Eucon NCA or Eucon ACN

Evaporation Retardants. The following evaporation retardants are approved:

BASF Chemical Company - CONFILM

Dayton Superior - Sure Film J-74

Euclid Chemical Company - EucoBar

Color Additive for Colored Concrete shall be manufactured by DAVIS Colors, 3700 East Olympic Blvd., Los Angeles, CA or an approved substitute.

SECTION 712 MISCELLANEOUS

712.13 ADD paragraph (e) and include the following:

"High Density Polyethylene Corrugated Pipe with Smooth Interior for Storm Sewers, Culverts, and Drains.

(1) ASTM F-405: Standard Specification for Corrugated Polyethylene Tubing and Fittings
(2) ASTM F-667: Large Diameter Corrugated Polyethylene Tubing
(3) AASHTO M 252-851: Standard Specifications for Corrugated Polyethylene Drainage Tubing
(4) AASHTO M 294-851: Corrugated Polyethylene Pip, 12 to 24 inch Diameter
(5) The nominal size of the pipe is based on the nominal inside diameter of the pipe.
(6) The tolerance on the specified inside diameter shall be +3%, -1.5%, or ½ inch, whichever is less. Lengths shall be no less than 99% of stated quantity.
(7) Pipe shall be joined by split corrugated couplings at least 7 corrugations wide and exceeding the soil tightness requirements of the AASHTO Standard Specification for Highwater Bridges, Section 23 (2.23.3).

(8) Pipe Stiffness

The pipe shall have a minimum pipe stiffness at 5% deflection as follows:

Diameter (inches)	Pipe Stiffness (PSI)
12	45
15	42
18	40
24	34

Tests shall be in accordance with ASTM D2412 with a minimum one diameter sample length, a loading rate of 0.5"/min., and readings at 5% deflection.

(9) Hydraulics

The pipe shall have a minimum tested Mannings "n" value of 0.012.

(10) Perforations

Where perforated pipe is specified, the perforations shall conform to the requirements of Class 1, unless otherwise specified in the order. Class 1 perforations are for pipe intended to be used for subsurface drainage or combination storm and underdrain. The perforations shall be cleanly cut so as not to restrict the inflow of water. Pipe connected by couplings or bands may be unperforated within 4 inches (100 mm) of each end of each length of pipe.

A. Class I Perforations: The perforations shall be approximately circular and shall have nominal diameters of not less than 3/16 inch (4.8 mm) nor greater than 3/8 inch (9.5 mm) and shall be arranged in rows parallel to the axis of the pipe.

   The perforations shall be located in the external valleys with perforations in each row for each corrugation. The rows of perforations shall be arranged in two equal groups placed symmetrically on either side of the lower unperforated segment corresponding to the flow line of the pipe. The spacing of the rows shall be uniform. The distance between the center lines of the rows shall not be less than 1 inch (25 mm).

(11) Retest and Rejection

If any failure to conform to these specifications occurs, the pipe or fittings may be retested to establish conformity in accordance with agreement between the purchaser and seller. Individual results, not averages, constitute failure."

SECTION 713 TRAFFIC CONTROL MEASURES

RETAIN all sections

SECTION 714 PRESTRESSED UNIT MATERIALS

RETAIN all sections

SECTION 715 LIGHTING AND ELECTRICAL MATERIALS

ADD the following to Section 715.03:

"Light poles shall meet the following requirements:

Manufacturer: Mountain States Lighting or Approved Equal

Part#: 9SRS-3.5-NO TENON-11.50" BOLT CIRCLE-BLACK or Approved Equal

Height: 9' Pole or 12' Pole (near intersections)

Base: 44" Slipover decorative base cover, Die-Cast Aluminum Alloy 356HMLC, High Strength, Copper Free, 10" Hex, 10 ¾" Point to Point, Separate Anchor Bolt Covers

Handhole: 2" x 5" Handhole opening in base of pole

Ladder Rest: 4" OD, 3.5" ID ladder rest, black finish, per Town Details

ADD the following to Section 715.04:

Luminaires and Lamps shall be one of the following per the Contract Documents:

PROV-T3-32LED-3K-700-LDL-HSS-PCA-T (Providence or Approved Equal)

F660-GX919-40-277-T2 or T5 (Newport, Welsbach, or Approved Equal)

PRMD2-72L-335-3K7-3-BLT-FTG-TRA5D-MOD 4.5" (Promenade or Approved Equal)

SECTION 716 WATER LINE MATERIALS

DELETE Section 716 in its entirety and REPLACE with the Town of Breckenridge Water Construction Standards

SECTION 717 REST AREA AND BUILDING MATERIALS

DELETE Section 717 in its entirety.

CHAPTER 1
GENERAL PROVISIONS

TABLE OF CONTENTS

LIST OF ATTACHMENTS – APPENDIX A

1.1 PURPOSE

These Engineering Design Standards and Construction Specifications, also called the “Standards” or “Engineering Standards”, are established by the Engineering Division of the Public Works Department for the design and construction of public and private improvements in the Town of Breckenridge (Town).

The purpose of these Standards is to set forth certain rules and regulations so there is reasonable degree of assurance that the development of public and private improvements will be completed so that the health, safety, welfare and property of the Town and citizens will be safeguarded and protected; and to assure there will be a certain uniformity in performance with respect to design and construction of public and private improvements; and thereby securing for the present and future residents of the Town the beneficial effects of public and private development, while protecting the community against actions that would deteriorate the quality of the natural and manmade environment. These Standards are established to serve the following objectives:

1. Update Town Standards to reflect changes in the engineering and construction industries
2. Provider greater consistency with local, state, federal, and other agency codes
3. Provide consistent design and construction basis for infrastructure within the Town
4. Ensure public welfare and promote efficient development that considers the future of the community
5. Protect the water quality of the Blue River and its tributaries
6. Protect wetlands and other sensitive habitats in a mountain environment
7. Mitigate traffic caused by development
8. Improve pedestrian and bicycle facilities
9. Provide improved access for people with disabilities
10. Provide guidelines on navigating the Engineering Division development review process
11. Protect the public by establishing the minimum acceptable level for design and construction of infrastructure

To provide consistency in the design of infrastructure within the Town, these Standards generally follow criteria or design methodology that are in conformance with regulations and laws established by the following agencies. Where no requirement is given in the Town Engineering Standards, the following documents shall govern.

1. American Association of State Highway and Transportation (AASHTO)
2. Colorado Department of Transportation (CDOT)
3. Colorado Revised Statutes (CRS)
4. Federal Americans with Disabilities Act (ADA) Regulations
5. Federal Highway Administration (FHWA)
6. Federal Statutes and Regulations (CFR)
7. Mile High Flood District (MHFD)
8. National Cooperative Highway Research Program (NCHRP)
9. U.S. Department of Transportation, Manual of Uniform Traffic Control Devices (MUTCD)
10. United States Access Board (PROWAG and ADAAG)
11. National Cooperative Highway Research Program (NCHRP)

Additionally, the following guides and manuals listed below shall be referenced and used in conjunction with these Standards. Where no requirement is given in the Town Engineering Standards, the following documents shall govern. In the event of a conflict between Town Engineering Standards and the following documents, the more stringent requirement shall typically govern. The most recent version of the documents below shall govern.

1. AASHTO Green Book
2. AASHTO Roadside Design Guide
3. CDOT Roadway Design Guide
4. CDOT Bridge Design Manual
5. CDOT Pavement Design Manual
6. CDOT Drainage Design Manual
7. FEMA National Flood Insurance Program (NFIP)
8. International Fire Code (IFC), 2018
9. ITE Trip Generation Manual, 10th Edition, Institute of Transportation Engineers, 2017
10. ITE Trip Generation Handbook, 3rd Edition, Institute of Transportation Engineers, 2017
11. Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis, Transportation Research Board, 2016
12. State Highway Access Code, State of Colorado, March 2002
13. Manual on Uniform Traffic Control Devices, 2009 with Revisions 1 and 2, Federal Highway Administration, May 2012
14. Mile High Flood District (MHFD) Design Manuals

The following Town Documents shall be referenced and used in conjunction with these Town Engineering Standards. In the event of a conflict between Town Engineering Standards and the following documents, the more stringent requirement shall typically govern. The most recent version of the documents below shall govern.

1. Title 9 of the Breckenridge Town Code, also referred to as the Town Development Code

~~1.~~2. Blue River Walkway Improvements Plan
~~2.~~3. Breckenridge Free Ride Transit Master Plan (2020)
~~3.~~4. Breckenridge Sidewalk Master Plan
~~4.~~5. Breckenridge Transit Master Plan (2020)
~~5.~~6. Cucumber Gulch Recreation Master Plan
~~6.~~7. Handbook of Design Standards
~~7.~~8. Joint Upper Blue Master Plan
~~8.~~9. Park Ave SH 9 Roundabout Modeling and Construction Feasibility Study (2017)
~~9.~~10. Sustainable Breckenridge Plan
~~10.~~11. The Arts District of Breckenridge Master Plan
~~11.~~12. Town of Breckenridge Capital Improvements Program
~~12.~~13. Town of Breckenridge Code of Ordinances (Including the most recent versions of Titles, Chapters, and Ordinances Pending Codification)
~~13.~~14. Town of Breckenridge Comprehensive Plan ~~2008~~

~~14.~~15. Town of Breckenridge Goals and Objectives Report

~~15.~~16. Town of Breckenridge Open Space and Trails Master Plan

~~16.~~17. Town of Breckenridge Small Cell Procedures and Design Guidelines ~~(May 2019)~~

~~17. Town of Breckenridge Trails Plan (revised August 2008)~~

~~18. Town of Breckenridge Trail Standards and Guidelines~~

~~19.~~18. Town of Breckenridge Vision Plan (2002)

~~20.~~19. Town of Breckenridge Water Construction Standards

~~21.~~20. Transportation, Parking, and Urban Design Study (2016)

~~22.~~21. Upper Blue Nordic Master Plan (revised 2011)

Additional standards and documents referenced for construction specifications are included in Chapter 9. See Chapter 9 for additional information on construction standards and specifications.

Several modifications were made to the criteria in the documents listed above to include flexibility, encourage context-sensitive design, and reflect the local values of the Town. The modifications recognize the constraints of the Town's topography, the desire to maintain and enhance natural drainageways, and the mountain environment of the community. The Town of Breckenridge Engineering Standards supplement or modify the above criteria.

These Standards provide the minimum acceptable standards for safe, consistent, effective, and economical infrastructure. Actual site design may require additional detail or more conservative design parameters to address site-specific issues.

1.2 AUTHORITY

These Standards have been developed by the Engineering Division of the Public Works Department of the Town of Breckenridge. Authority for review and approval required for these Standards shall be per 10-1-3 of the Town Code. Per Section 10-1-3, the Town Engineer has the authority to administratively formulate, update, amend, and add regulations to these standards.

1.3 JURISDICTION

These Standards shall apply to all projects, both private and public, in the Town of Breckenridge, except where superseded by other government regulations.

1.4 AMENDMENTS & REVISIONS

The Engineering Division may periodically update these Standards to reflect current practices or policy revisions per Section 10-1-3 of the Town Code.

1.5 OTHER STANDARDS

Where no requirement is given, the current edition of the AASHTO, CDOT, Urban Storm Drainage Criteria Manual (USDCM), Manual of Uniform Traffic Control Devices (MUTCD), Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG) design standards, or ADA Accessibility Guidelines (ADAAG) or other agency/document listed in Section 1.2 of these Standards shall govern unless otherwise approved by the Engineering Division. Where the Town's documents do not cover a specific situation, consult the Engineering Division to confirm the appropriate standards. If a specific situation is not covered by these, the applicant shall propose a design standard for the Town to review and approve before proceeding with development. In addition to these Standards, designers, developers, and contractors are responsible for following all other applicable federal, state, and local regulations. Where there is a conflict between these Standards and other codes or regulations, the more stringent standard shall generally apply unless otherwise approved by the Town Engineer.

1.6 RIGHT TO ENFORCE OTHER STANDARDS

These Standards may not include all requirements necessary for future development. Special site conditions, project types, or other conditions may warrant the use of additional standards and criteria not included in these Standards. The Town reserves the right, in the Town's best interest, to issue and enforce more stringent criteria when appropriate as determined by the Town Engineer.

1.7 RIGHT TO REQUIRE PUBLIC IMPROVEMENTS

The Town Engineer may require public improvements due to direct or indirect impacts of development. Public improvements may include utilities, streets, sidewalks, trails, open space, parks, bridges, street lights, transit improvements, detention and water quality, wetland enhancements, stream restoration, and any other public improvements as determined by the Town Engineer. Utility work may include Town water, Town fiber (supply and install of equipment), sanitary sewer, storm sewer, street lights, and other utilities as determined necessary. All construction costs of public improvements shall be the responsibility of the development. The Town shall not be responsible for any of the design, development, and construction costs of the public improvements. See the following chapters of these Standards for additional public improvement standards.

1.8 REVIEW & APPROVAL

The Engineering Division will review submittals for general compliance with these Standards per Chapter 2 of these Standards. An approval by the Town does not relieve the owner, contractor, engineer, or designer from responsibility of ensuring that calculations, plans, specifications, and construction are accurate and in compliance with these Standards, accepted engineering practices, or other applicable requirements and regulations.

1.9 CONSTRUCTION SPECIFICATIONS

Construction specifications and details are included in Chapter 9 of these Standards and may be frequently updated. If the Town does not have a required construction specification or detail, CDOT construction specifications and the CDOT M&S Standards shall be used. If neither the Town nor CDOT has a construction specification or detail required for a project, the proposed specifications and details shall be submitted to the Engineering Division for review per Chapter 2 of these Standards.

1.10 VARIANCES

All applications for designs varying from these Standards shall obtain written approval of the variance from the Town Engineer on the Town's Variance Request Form prior to final approval of the plans. The following will be considered when evaluating variances:

1. Site-specific constraints,
2. Effect on safety,
3. Right-of-way constraints,
4. Public benefit,
5. Availability of other alternatives, and
7. Need for mitigation measures.

Variances must be requested in writing using the Town's Variance Request Form (included as an attachment to this chapter) and at a minimum include plans, text, and supporting documentation as necessary to support the information provided in the Variance Request Form.

The variance request must be prepared by or under the direct supervision of a Colorado-licensed professional engineer and be stamped and signed certifying that the variance will not result in any hazard to the public or increase the likelihood of damage to any public or private properties.

Upon receipt of a written request for a variance from a particular provision of these Standards, the Town Engineer will issue a determination on whether the variance should be granted or denied given the specific circumstances for which it was requested. The Town Engineer will provide a copy of the determination to the applicant. Determinations made by the Town Engineer in interpreting and enforcing these Standards involve the considered application of professional engineering and transportation planning judgment and skill in the context of each situation. If a variance request is denied, the applicant may appeal the denial per the provisions of the Town Code.

1.11 GLOSSARY

When the following words, phrases, or abbreviations appear in these Standards, they shall have the following definition and meaning. Where a word, phrase, or abbreviation appear in these Standards, but are not defined below, the definitions and meanings shall be assigned per the Town Code, other referenced standards, or industry accepted definitions.

<u>100-year storm</u> and <u>2-year storm</u>: These terms refer to the statistical recurrence interval of different types of storms. A recurrence interval is a statistically determined average period of time within which a given rainfall intensity and duration will be equaled or exceeded only once. For example, the 100-year storm refers to the intensity and duration of rainfall which, on the average, will be equaled or exceeded once during a 100-year period. The larger the recurrence interval, the higher the intensity. The 100-year storm will have a higher intensity and total volume than the 2-year storm.

<u>100-year flow/flood</u>: a peak discharge that can be expected to be equaled or exceeded once every hundred years. This event has a 1% chance of occurring during any given year. Discharge rates, water surface elevations, and floodplain boundaries for the Blue River and its major tributaries are provided in the FEMA Flood Insurance Study. .

<u>AASHTO</u>: American Association of State Highway and Transportation Officials

<u>ABC</u>: Aggregate Base Course.

<u>acceleration lane</u>: a speed change lane, including tapered areas, for the purpose of enabling a vehicle entering a roadway to increase its speed to a rate at which it can more safely merge with through traffic.

<u>access</u>: driveway or other point of access such as a street, road, or highway that connects to the general street system. Where two public roadways intersect, the secondary roadway will be the access.

<u>acre foot</u>: a measurement of water volume. An acre foot equals the amount of water necessary to cover an acre at a depth of one foot (43,560 cubic feet).

<u>ADT:</u> Average Daily Traffic. The total bidirectional volume of traffic passing through a given point during a given time period, divided by the number of days in that time period.

<u>alley</u>: Minor public street adjacent to the side or rear of residential, commercial, or industrial property and used for vehicle access.

<u>applicant</u>: The person or designated agent responsible for preparation of Town permit applications and associated permit responsibilities. The terms “applicant” and “developer” may be used interchangeably.

<u>approach</u>: the portion of an intersection leg which is used by traffic approaching the intersection.

<u>auxiliary lane:</u> the portion of the roadway adjoining the traveled way for speed change, turning, weaving, truck climbing, maneuvering of entering and leaving traffic, and other purposes supplementary to through- traffic movement.

<u>ASTM</u>: American Society for Testing and Materials.

<u>basin</u>: an area of land, so defined by a physical boundary that when rain falls upon this area, all the resulting stormwater runoff will drain by gravity toward a common watercourse (natural stream, reach,

river, or manmade channel, ditch, gutter, etc.) and ultimately exits the area at the specific point (known as the outfall).

bicycle facilities: a general term denoting improvements and provisions made by public agencies to accommodate or encourage safe and efficient bicycling or other alternative modes of transportation.

bicycle lane (bike lane): the portion of the roadway that has been designated by striping, signing, pavement markings, colored pavement, or other markings for the preferential or exclusive use of bicycles.

bridge: any structure conveying a roadway or path over a body of water or other feature. Structures shall be designed to carry a combination of loading per appropriate codes and designed by a registered professional engineer. Arch culverts, large diameter culverts, and other structures may be classified as bridges.

building permit: a written document issued by the Town Building Division to allow a developer or contractor to complete building improvements per building codes.

CAD: abbreviation for Autodesk AutoCAD software. Town requires submittals as .dwg extenstion electronic files compatible with the most recent version of Autodesk AutoCAD Civil 3D software.

capacity: the maximum number of vehicles that have a reasonable expectation of passing over a given roadway or section of roadway in one direction during a given time period under prevailing roadway and traffic conditions.

CDOT: Colorado Department of Transportation

commercial: an area of the Town in which all or a portion of the development is for commercial use. An area may be defined as commercial, even if the majority of the area is zoned as residential use, but there is a sufficient amount of commercial development to generate many commercial pedestrian and vehicle trips.

chicane: offset curb extensions which change the path of vehicular travel from straight to curvilinear and promote traffic calming.

civil construction drawings: detailed engineering plans required for all projects with public infrastructure.

CMP: corrugated metal pipe

CO: Certificate of Occupancy. A written document issued by the Building Division indicating that a building or site is in a condition suitable for occupancy.

code: the latest official adopted ordinance, policies, codes, and/or regulations of Town of Breckenridge or other agencies.

construction: any grading, excavation, earth disturbing activities, roadway work, paving, vertical building, utility work, directional boring, and any other alteration or modification to a site or right-of-way.

consultant engineer: a Colorado licensed professional engineer working on behalf of the Developer.

contract documents: the executed contract agreement, approved plans, technical specifications, and permits, and all other documents prepared by a Colorado licensed professional engineer for construction a facility

contractor: the person, firm, or organization to whom a construction contract is awarded by the Developer, or who has been issued a right-of-way work permit. Contractor may be the same entity as the Applicant or Developer, or may be a separate entity.

contour interval: a contour is a line drawn on a map through points of equal elevation. A contour interval is the elevation difference between contour lines.

critical volume: a traffic volume (or combination of volumes) for a given street which produces the greatest utilization of capacity for that street in terms of passenger cars or mixed vehicles per hour.

cross-section: a view of the interior or horizontal cut through a roadway, structure, or object and includes a representation of all relevant elements.

cross-slope: slope of the pavement surface, exclud~~s~~ing gutter, measured perpendicular to the street centerline.

cross-street flow: flow of stormwater runoff across the traffic lanes of a street from external sources, as distinguished from sheet flow of water falling on pavement surface.

culvert: a covered channel or pipe that takes a watercourse under a road, through the downstream embankment of a detention facility or below ground. Some “culverts” may also be classified as “bridges”.

days: calendar days, not normal working days unless stipulated as working days.

deceleration lane: a speed change lane, including tapered areas, for the purpose of enabling a vehicle that is to make an exit turn from a roadway to slow to a safe turning speed after it has left the main stream of faster moving traffic.

design hour volume: hourly traffic volume used for street design and capacity analysis, usually one or more peak hours during a 24-hour period.

design speed: the typical vehicle rate in miles per hour (mph) which a street is designed to accommodate. Design speed shall typically match the posted street speed limit.

design vehicle: the vehicle a street must consider and accommodate for acceptable speed, turning movements, loading, and other considerations.

designer: the person, firm, or organization responsible for the creation and submission of contract documents or construction plans for the construction of a facility. Designer shall be a Colorado licensed professional engineer.

detached sidewalk: a sidewalk that is offset from the roadway and curb by a minimum distance of four feet.

detail: an engineered drawing illustrating all features and requirements for construction of a structure or facility.

detention facility: a basin or structure designed for the storage of stormwater runoff that allows for slower, controlled release during or immediately following a storm. A typical facility consists of a detention pond with an embankment on the downstream side, and a pipe or concrete box outlet. The size of the pond is based on a specific design storm and the amount of water that can be discharged through the outlet. Design features may be incorporated into detention facilities to allow them to function as sediment ponds.

developer: the private person, partnership, or corporation legally responsible for the construction of streets, subdivisions, infrastructure, or any other public or private improvement. Developer shall secure all required approvals and permits from the Town and assume full and complete responsibility for the project. The terms “owner,” “applicant,” and “permit holder” may be used in place of “developer” and hold the same definitions and responsibilities.

development: construction of improvements on land that is vacant or containing minimal infrastructure or improvements.

development code: title 9 – land use and development, of the Town of Breckenridge Code.

development permit: a written document from the Town community development department to complete development per codes, standards, and other documents.

drainageway: a route or course along which water moves or may move to drain an area. A "natural" drainageway refers to the route or course in an area prior to the construction of any urban improvements.

drainage easement: a grant to the Town of the right to control development, access, or maintenance of a drainage right-of-way or an area subject to periodic flooding.

driveway: a constructed access serving three or less units and connecting to a street or adjacent driveway. May also be called a "private access."

easement: the portion of public or private land dedicated to the public or another entity for the installation, maintenance, and use of utilities, drainage, vehicle access, pedestrian access, snow storage, or other public uses. Easements may be granted through a subdivision plat or other legal instrument as approved by the Town Attorney. Easements shall grant the legal right of use of the property by the grantee. Easements may grant the Town the ability to complete maintenance work, but does not require the Town to complete maintenance.

Encroachment License Agreement: A written document granting a property owner the ability to construct and maintain private improvements within a Town ROW or easement. The encroachment license is revocable and sets many requirements of the property owner for the encroachment.

EPA: United States Environmental Protection Agency.

ESA: Environmentally sensitive areas. An area such as wetlands, streams, lakes, ponds, Cucumber Gulch Wildlife Preserve, and other special wildlife habitat areas which require special requirements to protect their sensitive nature during development.

fees: monetary charges which compensate the Town for services rendered or infrastructure constructed.

FEMA: Federal Emergency Management Agency.

FHWA: Federal Highway Administration, Department of Transportation.

field order: a written notice given by the Town to the Designer, Contractor, or Developer detailing a change, request, mandate, or corrective action necessary to conform to these Standards, approved plans, or other applicable Local Entity Codes.

final acceptance: the written notification from the Town, after the Town finds the warranty period to be satisfactorily completed, that all public improvements are free of defects and the Town releases the Developer from future maintenance obligations.

FIRM: Flood Insurance Rate Map.

floodplain development permit: a document granted to developers or contractors to construct improvements or complete earthwork activities within 100 feet of the 100-year floodplain.

freeboard: the elevation difference between the normal maximum level of water surface and the bottom of the confining structure, which is provided so debris may more readily pass through the structure without creating blockage and waves and other movements of the water will not overtop such confining structures.

grade: the inclination or slope of a channel, canal, conduit, street, etc., or other natural ground surface, usually expressed in terms of the percentage or number of units of vertical rise (or fall) per unit of horizontal distance.

grading plan: a detailed engineering plan showing contours, slopes, existing elevations, proposed elevations, retaining walls, and other grading features for a site.

HCM: Highway Capacity Manual. Publication of the Transportation Research Board of the National Academies of Science which defines the ideal conditions of uninterrupted traffic flow.

HMA: Hot Mix Asphalt.

HEC: Hydrologic Engineering Center, an element of the USACE, Institute for Water Resources (CEIWR) that supports the nation in its water resources management responsibilities by increasing technical capability in hydrologic engineering and water resources planning and management.

HMS: Hydrologic Modeling System (HEC-HMS) developed by the USACE to simulate the complete hydrologic processes of dendritic watershed systems.

LOS: level of service. A qualitative measures used to relate the quality of motor or pedestrian vehicle traffic service; usually measured from a LOS A to LOS F.

initial acceptance: the Town's process to initially accept ownership after the Developer has completed all proposed improvements identified in the approved plans and agreements, and after the Town has inspected and approved improvements. Initial acceptance begins the two year warranty period.

infrastructure: public roadways, sidewalks, pedestrian routes, trails, stormwater improvements, potable water improvements, sanitary sewer improvements, lighting, irrigation, fiber optic cable and conduit, other utilities, stormwater management, transit facilities, retaining walls, signage, and any other structures, improvements, or installations as determined by the Town Engineer.

inlet: 1) an opening into a storm sewer system for the entrance of surface storm runoff; 2) a structure at the upstream end of a conduit; or 3) the upstream connection between the surface of the ground and a drain or sewer for the admission of surface or storm water.

inspector: an authorized representative of the Town Engineer, assigned to make inspections to assure work is completed in compliance with plans, standards and specifications.

intersection sight distance: the minimum distance required for the driver of a motor vehicle stopped at a stop sign on a minor street or driveway to see approaching vehicles, pedestrians, and bicyclists along the intersecting major street and have sufficient space to make any allowed move to cross the major street or merge with traffic on the major street without causing vehicles, pedestrians, or bicyclists traveling at or near the design speed on the major street to slow down.

ITE: Institute of Transportation Engineers

landscaping: materials including, without limitation, grass, ground cover, shrubs, trees, perennials, annuals, non-living material commonly used in landscape development, and irrigation systems.

LTS: Level of Traffic Stress. A measure which quantifies the amount of discomfort which bicyclists experience near vehicular traffic.

MHFD: Mile High Flood District, formerly the Urban Drainage and Flood Control District (UDFCD).

MHT: Method of Handling Traffic. "MHT" may also be referred to as a "Traffic Control Plan (TCP)". Detailed drawings outlining the layout of traffic control devices for a project and signed by a TCS.

MUTCD: Manual on Uniform Traffic Control Devices.

minor storm and major storm: these terms refer to the recurrence intervals of storms used to design stormwater infrastructure. The minor storm (also called the initial storm) is the 2- to 10-year storm depending on land use at the design location. The major storm is the 100-year storm, and the uncontrolled runoff from this storm could possibly cause major property damage or even loss of life.

multimodal: inclusion of several different modes of transportation. Examples include vehicular, pedestrian, bicycle, bus transit, gondolas, and other public transit modes.

NFIP: National Flood Insurance Program.

NRCS: Natural Resource Conservation Service.

open channel: a watercourse which conveys stormwater runoff within the drainage basin to the outfall of the basin. It has a defined bed and banks that confine the runoff, but it has a surface open to the atmosphere and cannot develop pressurized flow.

ordinance: a law established by the Town of Breckenridge.

O&M Plan: operations and maintenance plan. A written document defining work and maintenance procedures to maintain infrastructure and facilities to function per the original design intent.

OSHA: Occupational Safety and Health Administration.

PAR: Pedestrian Access Route. A continuous and unobstructed path of travel provided for pedestrians with disabilities within or coinciding with a pedestrian circulation path.

PDF: Portable Document Format. Town requires electronic file submittals to be a PDF compatible with the most recent version of Adobe Acrobat.

PE: a Colorado licensed professional engineer.

peak hour: the hour in a day which produces the highest volume of vehicle or pedestrian traffic for a portion of roadway, intersection, or pedestrian route in a day.

pedestrian: a person afoot or in a wheel chair or other pedestrian mobility device.

permitee: the holder of a valid permit for the Town of Breckenridge. “Permitee” may be used interchangeably with “developer”.

PHF: Peak Hour Factor. A calculation used to convert the hourly traffic volume into the flow rate that represents the busiest 15 minutes of the peak hour. PHF is calculated through the following equation: (total hourly volume) / [(peak 15-minute volume within the hour x 4)].

plans: construction plans completed and stamped by Colorado licensed professional engineer for public or private improvements.

PLS: a Colorado licensed professional land surveyor

private Improvements: any land, structures, infrastructure, or other object to be used, owned, and maintained by a private person, partnership, or corporation.

project: the public or private improvements designated in the approved plans, which are to be constructed in conformance with these standards. “project” includes private projects, public capital projects, utility projects, ROW projects, and any other improvements in the Town.

private street: a roadway serving four or more units or lots. Private streets are not owned or maintained by the Town of Breckenridge.

project engineer: the professional engineer, registered in the State of Colorado, assigned to a project by a Town permit holder to inspect and observe construction and to complete and sign and stamp construction inspection and observation reports.

public improvement: any land, structures, infrastructure, or other object dedicated to the Town, public, or other agency. Public improvements are typically conveyed to the Town and subsequently owned and maintained by the Town. Also include facilities which will be privately owned but serve the public, or private facilities serving a large number of people, such as utilities and stormwater drainage.

punch list: a written list of work items, compiled by the inspector, which do not conform to these Standards, the plans, specifications, or other codes that govern the project. The developer is responsible for completing the list of work items prior to initial acceptance.

rational method: a design method which determines a peak runoff rate based on drainage area, rainfall intensity, and imperviousness for watersheds of 90 acres or less.

record drawings: design drawings updated by a professional engineer, depicting all modifications from the design that occurred during construction.

redevelopment: removal or modification of existing improvements, remodeling, and construction of new improvements on a site which has existing improvements. Sites with minimal existing improvements is not considered redevelopment.

report: a document containing analyses, surveys, tests, exhibits, and other pertinent data prepared by a Colorado licensed professional engineer.

road: the entire width of a public right-of-way, including the roadway, pedestrian routes, landscaped areas, shoulders, and other areas within the right-of-way.

ROW: right-of-way. Land owned by the Town for the use of a public street, alley, sidewalk, path, or other use.

ROW permit: right-of-way permit. A document granted by the Town to a developer or contractor to construct any public or private improvements in the ROW, or for any equipment, materials, or encroachment in the ROW, or disruption to pedestrians or vehicles within a ROW.

SCS: Soil Conservation Service. A hydrological method that uses geographical rainfall time distributions, curve numbers and time of concentration to determine peak runoff that may be used for water sheds of any size or when hydrograph routing is required for design.

SCS method: Soil Conservation Service method.

SFHA: Special Flood Hazard Area. An area identified by FEMA as an area having flood-related hazards and where the NFIP floodplain management regulations must be enforced.

shared use path: a paved path at least 10 feet wide for pedestrians, bicyclists, and other non-motorized transportation uses.

SIA: Subdivision Improvement Agreement. A written document establishing a surety and requirements for a developer to complete improvements in the Town.

sidewalk: paved path for pedestrian use within a ROW or easement and separated from the roadway by a curb or detached at least four feet.

sight distance: the length of roadway which is visible to a vehicle operator.

site plan: a detailed engineering drawing showing proposed improvements to a site.

snow storage: additional area within a right-of-way, easements, or private property for stacking and storing snow and ice. May also be called snow stacking areas.

specifications: a written document describing in detail the scope of work, materials to be used, methods of installation, and quality of workmanship for construction work.

stable channel/ditch: a streambed, drainageway, or ditch in which sediment transport conditions are in balance, neither acquiring significant deposits of sediments nor experiencing significant erosion.

standards: these Town of Breckenridge Engineer Standards, inclusive of all attachments, amendments, and referenced/supplemental codes and standards.

stop work order: a written directive from the Town revoking the developer's and contractor's rights to continue work on the project due to nonconformance with these standards, plans, specifications, or other project documents.

SSD: Stopping Sight Distance. The minimum length of roadway required to be visible for a vehicle operator to safely recognize an object within a roadway and stop the vehicle prior to colliding with the object. SSD can also be defined as the sum of the braking distance and the distance traversed by a vehicle during the reaction time.

storage lane: additional lane footage added to a deceleration lane to store the maximum number of vehicles likely to accumulate during a critical period without interfering with the through lanes.

stormwater runoff: the water from precipitation running off from the surface during and immediately following a period of rain.

storm sewer system: also called a storm drain system; a system of inlets, manholes, and conduits that conveys runoff to drainageways and natural channels. Storm sewers are necessary whenever the street capacity to carry the design storm runoff is exceeded by either the minor or the major storm.

street: the entire width of a public right-of-way, including the roadway, pedestrian routes, landscaped areas, shoulders, and other areas within the right-of-way.

street flow: the total flow of stormwater runoff in a street, usually the sum of the gutter flows on each side of the street.

subdivision: a tract of land surveyed and divided into separate parcels or lots. "Subdivision" may also refer to a neighborhood or several adjoining lots in the Town.

subdivision permit: a type of development permit issued by the Town Community Development Department for dividing a tract of land into separate parcels or lots.

substantial completion: the period when the work has progressed to the point where it is sufficiently complete so some or all of it can be utilized for the purposes which it is intended.

SUE: subsurface utility engineering. The Colorado Senate Bill 18-167 that amended Title 9, Article 1.5 of the Colorado Revised Statutes to improve safety by modifying requirements associated with the location underground utilities prior to construction.

surcharged: a condition when the hydraulic grade line within a storm sewer rises above the elevation of an inlet.

surety: a financial instrument, such as cash, bond, letter of credit, or other instrument acceptable in form to the Town Attorney, securing the developer's responsibility to complete construction of improvements for a project. Surety shall also be a financial instrument to secure the Developer's obligations through the warranty period.

SWMM: Storm Water Management Model, developed by the EPA and used for hydrologic and hydraulic analysis.

SWMP: Stormwater Management Plan. A construction plan and associated written narrative required for construction sites to prevent pollution, contamination, or degradation of waters of the State and to prevent discharge of pollutants from a project site.

TDM: Transportation Demand Management. A set of strategies aimed at reducing travel demand or to redistribute the demand in space or in time.

TCS: certified Traffic Control Supervisor.

Town: abbreviation for the Town of Breckenridge. Town may refer to the entire municipality, the Town Engineering Division, or other Town Departments and Divisions.

Town Code: The Town of Breckenridge Municipal Code. Includes all codification and ordinances pending codification. Town Code is a collection of laws passed by the Town and have the force and effect of law for the Town. The Town Code can be found online.

Town Engineer: the Town of Breckenridge Town Engineer or Town Engineering Representative selected by the Town Engineer.

TIS: Traffic Impact Study. An assessment of the adequacy of the existing or future transportation infrastructure to accommodate additional trips generated by a proposed development, redevelopment, or land rezoning which is prepared and stamped by a Colorado licensed Professional Engineer.

Traffic calming: the combination or mainly physical measures that reduced the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users.

trail: any path used by pedestrians or bicyclists within a ROW or easement.

UBSD: Upper Blue Sanitation District.

USACE: United States Army Corps of Engineers.

USDCM: Urban Storm Drainage Criteria Manual, published by the MHFD.

USGS: United States Geological Survey.

utility: a network of infrastructure supplying a service to the Town. Examples include gas, electric, sewer, water, and communication.

variance: an approved deviation from these Standards or other rules of the Town of Breckenridge.

vehicle: an instrument for the purpose of conveying people or objects. Vehicles are typically motorized. Wheelchairs and other pedestrian mobility devices are not considered vehicles.

warranty: a written guarantee from developer or contractor guaranteeing all improvements from material and workmanship defects.

warranty period: the two year period of time after the initiation acceptance when the developer or contractor is responsible for warranty of improvements.

wetlands: areas including lakes, streams, ponds, areas of seasonal standing water, and other bodies of water with a predominance of wetlands vegetation (such as willows, rushes, or sedges), or areas with boggy soils. Wetlands definitions and delineations shall be consistent with those of the Army Corps of Engineers.

wheel path: the three foot wide portion on both sides of a roadway travel lane starting two feet from the center of the lane.

work: all construction activity, including materials, labor, supervision, use of tools and equipment, and all other effort required to complete the project in full compliance with these standards, approved plans, specifications, and other documents.

CHAPTER 2
SUBMITTAL REQUIREMENTS & PERMITS

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2.1 INTRODUCTION

This chapter of the Engineering Standards establishes the requirements and review process for preconstruction submittals to the Engineering Division of the Public Works Department. The engineering submittals specified in this chapter are for Planning Development Permits, Infrastructure Permits, Floodplain Development Permits, Right-of-Way Permits, civil construction drawings, Preliminary and Final Drainage Reports, Traffic Impact Studies, and Stormwater Management Plans (SWMP).

The Infrastructure Permit issued by the Engineering Division is generally required for projects involving roadways, sidewalks and trails, stormwater infrastructure, potable water infrastructure, sanitary sewer infrastructure, lighting, irrigation, fiber optic cable and conduit, other utilities, stormwater management, transit facilities, retaining walls, signage, and any other public improvements. Single Family Homes (SFH) typically do not require an Infrastructure Permit, but one may be required by the Town Engineer depending on the project scope.

This chapter also includes the Engineering Division submittal requirements for a Building Permit and a Right-of-Way Permit. Planning submittals, including landscaping, architectural, historical, and mineral rights submittal requirements, can be found in Title 9 the Town Code. See Title 9 of the Town Code for additional information on the Town's planning process, the types of development permits listed below, how to obtain a development permit, scheduling pre-application meetings, and other planning related items. This chapter discusses the submittal and approval process prior to construction for the Engineering Division. Chapter 8 of these Standards details inspections and acceptance during and after construction.

A permit process flowchart is included as an attachment in Appendix B.

2.2 GENERAL FORMATTING

All drawing sheets, regardless of content, shall be scalable, clear and legible when printed on 11" x 17" paper. Drawings shall be prepared in AutoCAD or a compatible program approved by Town in the Colorado State Plane Central (unmodified) coordinate system for easy incorporation into the Town's GIS database.

Contents shall be drawn to a scale of multiples of ten (e.g. 1" = 10'; 1" = 30'). To preserve the scale when plotting at both full size and half size, drawings may be produced in AutoCAD with an 11" x 17" format. A larger exterior border may then be used with a 24" x 36" format, with an effective area of 22" x 34", to result in an exact doubling of the 11" x 17" half-sized drawings.

Hard copies of plans are not required. All plans shall be provided electronically, in DWG and in PDF in a format that will print to scale on 11" x 17" paper. DWG files shall be provided in a version of AutoCAD specified by the Town.

Each drawing sheet shall include a title block, scale, north arrow, original and revision dates, and professional engineer's stamp when applicable. Title blocks shall be along the bottom or right margin of each drawing.

Hard copies of reports and specifications are not required. All reports shall be provided in electronic format in PDF so that pages of report text will print to scale on 8.5" x 11" paper. Exhibits may be created to print to scale on 11" x 17" paper.

2.3 ENGINEERING SUBMITTALS

Table 2.1 summarizes the Engineering Division submittals required for subdivision permits, development permits, engineering permits, building permits, and right-of-way permits. See the Town Code for Community Development and Building Department submittal requirements. See the Town of Breckenridge Water Construction Standards for Town of Breckenridge Water Division submittals. Contact other agencies and utility companies (including Red White & Blue Fire Protection District, Upper Blue Sanitation District, and Xcel Energy) for applicable codes and design criteria. A brief cover letter should be submitted with all Engineering Division submittals that includes the following information. A cover letter is not required for single family home projects without an infrastructure permit.

1. Project title
2. Project description including street address, subdivision, lot, and block
3. Owner contact information
4. Engineer contact information
5. Written justification for any required items omitted from the submittal.

There are several types of submittals requiring both a preliminary and a final submittal. Requirements for these are specified in Table 2.1 and the respective subsection for each submittal type. All the submittals listed in Table 2.1 may not be required for a specific project; consult with the Engineering Division to confirm which submittals are required for a project. Table 2.2 summarizes which checklists shall be referenced for different types of projects. Checklists are included as attachments in Appendix B. Any work of any nature within the Town must have at least one of the following permits before starting work: an Infrastructure Permit, a Building Permit, or a Right-of-Way Permit. All three may be required depending on the nature of the work. Permits are discussed in more detail in Section 2.4. No work of any kind, including demolition, removal, or grading, may begin until the applicable permit(s) listed above have been obtained.

Table 2.1. Engineering Division Submittal Requirements

Permit Type	Engineering Division Submittals									
	Site & Grading Plans	Civil Drawings	Drainage Report	Geotech Report	Traffic Impact Study	MHT *	SWMP **	CMP ***	Tech Specs	Other Agency Permits
Class A/B Development Permit Preliminary Submittal	X									
Class A/B Development Permit Final Submittal; Class A/B/C Subdivision Permit Preliminary & Final Submittal; & Class C/D Development Permit	X		X							
Infrastructure Permit	X	X	X	X	X	X	X		X	X
Building Permit (without Infrastructure Permit)	X	X		X		X		X		X
Right-of-Way Permit	X	X				X		X		X

*Method of Handling Traffic/ Traffic Control Plan
**Stormwater Management Plan
***Construction Management Plan

Table 2.2. Project Checklist Reference

Project or Permit Type	Checklist
Development/Subdivision Permit	Checklist 1: Site and Grading Plan Requirements
Infrastructure Permit for grading, drainage, utilities, streets, or sidewalks	Checklist 2: Civil Construction Drawings Requirements Checklist 3: Drainage Report Requirements Checklist 4: Traffic Study Requirements Checklist 6: Ownership & Maintenance Plan Requirements
Any land disturbance	Checklist 5: Stormwater Management Plan Requirements
Building Permit (without Infrastructure Permit)	Checklist 7: Building Permit (Without Infrastructure Permit) Requirements

2.3.1 Site and Grading Plans

Site and grading Plans are required to be submitted to the Engineering Division when a Subdivision or Development Permit is required by the Community Development Department. The preliminary site and grading Plans are required for preliminary Development Permit submittals. Final site and grading plans are required to be submitted with the final Development Permit submittal. Requirements for site and grading plans are listed in Checklist 1. Grading and site plans may be combined for small projects where less detail is needed to clearly understand the intent of the grading plan.

The Community Development Department lists Planning requirements for site plans in Title 9 of the Town Code. If the Applicant can satisfy the Engineering and Planning requirements on a single set, then only one site plan is required. If the Applicant cannot satisfy both sets of requirements on one set, then two submittals are required.

2.3.2 Civil Construction Drawings

Complete civil construction drawings are required for any project that includes public infrastructure. Public infrastructure includes roadways, sidewalks and trails, stormwater infrastructure, potable water infrastructure, sanitary sewer infrastructure, lighting, irrigation, fiber optic cable and conduit, other utilities, transit facilities, retaining walls, signage, and any other public improvements. Both a preliminary and a final submittal of civil construction drawings are required for the Infrastructure Permit (discussed later in this chapter). In general, the preliminary submittal of civil construction drawings shall be at least 60% complete while the final submittal shall be construction-ready and stamped by a professional engineer. For small projects that require an Infrastructure Permit, a single submittal is acceptable with prior approval from the Town Engineer.

Civil construction drawing requirements for most types of construction and grading are specified in Checklist 2, Civil Construction Drawing Requirements. The checklist is provided to guide the content and format of the construction drawings. The drawings must meet the minimum content standards so the Town can thoroughly review the design of the improvements and confirm the design is in accordance with these Standards and with all other applicable standards. Adherence to applicable design standards provides for the health, safety, welfare, and property of the Town and its citizens to be safeguarded and protected.

Depending on the scope of the project, the contents of one or more drawings specified by the checklist may be more efficiently shown on a single drawing. Required contents may be combined or separated as necessary to provide a clear and concise set of construction drawings that provides all the required information.

The design of improvements included in the construction drawings must be completed in accordance with these Standards. The plans will be reviewed for compliance and resubmittal will be required if any aspect of the design of the improvements is not in compliance with the applicable standards and criteria.

2.3.3 Drainage Reports

A drainage report is required for new public storm sewer infrastructure or for private storm sewers that connect to existing public storm sewer infrastructure. A drainage report is also required for private infrastructure if a site's impervious area increases by 0.1 acres or more from existing conditions, regardless of whether new infrastructure is constructed. ~~Both a preliminary and a final drainage report are required.~~ For small projects, an abbreviated drainage memo may be acceptable with prior approval from the Town Engineer. A drainage memo may also be required for commercial redevelopment that does not increase impervious area, but ~~does disturb~~ includes site disturbance of ~~at least~~ 0.15 acres or greater. In general, the preliminary drainage report shall be at least 60% complete while the final drainage report shall be accompanied by construction-ready drawings. Guidance on drainage and water quality design and the Town's drainage and water quality criteria are in Chapter 6 of these Standards.

Both a preliminary and a final drainage report are required. The preliminary drainage report shall be submitted with the final development and final Subdivision Permit applications and shall also meet the requirements of Section 9-1-18 of the Town Code. The final drainage report shall be submitted with the Infrastructure Permit. Requirements for drainage reports are specified in Checklist 3, Drainage Report Requirements. Chapter 6 of these Standards discusses design requirements for stormwater infrastructure within the Town.

2.3.4 Geotechnical Report

A Geotechnical Report is required for an Infrastructure Permit. The Building Department also requires documentation of the bearing capacity of the soils used for foundation design in accordance with the International Building Code (IBC) and the International Residential Code (IRC). The Town may review geotechnical reports and the associated subsurface explorations and analyses to check for slope stability or soil issues, but it shall not be the responsibility or liability of the Town to make an assessment of the soils. It shall be the responsibility of the applicant and their geotechnical engineer to make an assessment of any soil or slope stability issues. The Geotechnical Report shall generally contain the following findings and supporting data. Certain projects may not require all the items listed below depending on the scope of the work.

1. Relative density type and extent of material likely to be encountered.
2. Anticipated excavation issues and proposed solutions.
3. Location and extent of excavation.
4. Suitability of excavated materials for use as backfill or bedding.
5. Compaction characteristics of the soils.
6. Groundwater level and conditions.
7. Soils infiltration testing results if any infiltration facility is proposed.
8. Soils resistively, moisture content, pH, degree of variation, presence of sulfates, and the likelihood of stray, direct currents.
9. Soil bearing capacity and foundation design recommendations.
10. Recommended pavement type and thickness, base course type and thickness, and any additional subgrade requirements.
11. Test holes to a depth of at least two feet below the subgrade of the proposed improvements; the spacing of test holes shall be as recommended by the geotechnical engineer to adequately define the subgrade.

2.3.5 Traffic Impact Study (TIS)

A Traffic Impact Study (TIS) may be required. Chapter 4 - Traffic Impact Studies of these Standards specifies when a TIS is required. TIS requirements are specified in Checklist 4 of Appendix B.

2.3.6 Method of Handling Traffic (MHT)

A Method of Handling Traffic (MHT) or Traffic Control Plan (TCP) prepared by a certified Traffic Control Supervisor (TCS) is required for work performed within the public right-of-way (ROW) that will impact traffic lanes, shoulders, or sidewalks. A full MHT shall be submitted to the Engineering Division that includes lane closures, vehicular and pedestrian detours, cones, barriers, signage, and any other traffic maintenance devices required. Lane closures, signage, and traffic patterns must meet MUTCD and CDOT requirements. Efforts shall be made to maintain at least one lane of traffic to the extent possible. When one lane cannot safely be maintained, the length and duration of the full road closure shall be minimized to the extent possible. See Chapter 3 of these Standards for additional requirements of when a ROW permit or MHT is required.

2.3.7 Stormwater Management Plan (SWMP)

A Stormwater Management Plan (SWMP) is required when the area disturbed during construction is one acre or more. Construction best management practices must be used to prevent erosion and control sediment. Permanent water quality best management practices are not included in the SWMP but are to be included in the civil construction drawings. Requirements for permanent water quality are specified in Chapter 6 of these Standards. Items required to be included in the SWMP are specified in Checklist 5 - Stormwater Management Plan Requirements of Appendix B. Construction Stormwater Standards are detailed in Section 6.11. See additional permitting requirements in Section 2.4 below for projects disturbing one acre or more.

2.3.8 Construction Management Plan (CMP)

A Construction Management Plan (CMP) is required for projects disturbing less than one acre during construction. Projects disturbing less than one acre, but part of a larger project or development disturbing one acre or more, will still require a SWMP to be submitted. The CMP must be developed to prevent erosion and control sediment. Permanent water quality best management practices are not included in the CMP but are to be included in the civil construction drawings. The CMP shall show the following at a minimum:

1. Best Management Practices (BMPS) to prevent erosion and control sediment from leaving site.
2. Revegetation notes or other final stabilization plans.
3. Construction fencing location.
4. Material and equipment staging locations.
5. Dumpster and portalet locations
6. Vehicle parking locations and construction access location.

2.3.9 Construction Specifications

The Town has adopted standard construction specifications that shall be used on all projects. Project special provisions that vary from the Town Specifications shall be included with the Infrastructure Permit application. For special conditions or construction types which are not addressed by the Town Specifications, the Applicant shall submit proposed specifications for the Town's review.

2.3.10 Subsurface Utility Engineering (SUE)

Colorado Senate Bill 18-167 amended Title 9, Article 1.5 of the Colorado Revised Statutes to improve safety by modifying the requirements associated with the location of underground utilities prior to construction and implementing an enforcement program associated with the new requirements. The new requirements must be met if a project meets all four of the following criteria:

1. Project involves a construction contract with a public entity, construction in the public ROW, infrastructure that will be dedicated to the Town, or other work as determined by the Town Engineer.
2. Project primarily involves horizontal construction and does not primarily involve the construction of buildings.
3. Anticipated excavation footprint exceeds two feet in depth and is at least a contiguous 1,000 square feet (excluding fencing and signing projects) or involves utility boring.
4. Project requires the design services of a licensed professional engineer.

If all the above criteria are met, subsurface utility engineering documentation shall be provided with the Infrastructure Permit application that includes:

1. Notification to 811 that there is an upcoming SUE required project.
2. Depiction of utilities on stamped plans in such a way that they meet or exceed ASCE 38 or provide documented reasons from a licensed professional engineer why they do not meet or exceed Quality Level B.
3. Meeting or exceed Quality Level A for underground facilities at the point of a potential conflict with a gravity fed system including sanitary and/or stormwater facilities.

Quality-level requirements for subsurface utility engineering vary by project phase and are as follows:

1. Project Planning – Quality Level D
2. Preliminary Design – Quality Level B
3. Final Design – Quality Level A

   The above Quality Levels provide general guidance for project planning. Refer to Colorado Senate Bill 18-167 for exact Quality Level requirements. Quality Level A is generally required at potential conflicts for gravity fed utilities. Quality Level A may not be required in areas without any sanitary sewer, storm sewer, other potential utility conflicts, or grading conflicts. A Colorado licensed Professional Engineer must determine the appropriate Quality Level based on Colorado Senate Bill 18-167 and document the reasons why any facilities were not located to the particular Quality Level.

Definitions of the Quality Levels are as follows:

1. Quality Level D is the most basic level of investigation and includes verbal recollections and review of existing records such as as-built drawings, utility system drawings, permit logs, field sketches, site visit log books, old surveys, one-call marks, and prior SUE investigations by others.
2. Quality Level C includes surveying those utilities that are visible above ground and use of surface features that indicate subsurface alignment such as valve covers, fire hydrants, pull boxes, manholes, and telephone pedestals. These should be reconciled to ASCE Quality Level D records.

3. Quality Level B includes the use of geophysical methods to determine the existence and horizontal position of all subsurface utilities. Quality Level B can be assigned to a utility segment or subsurface feature whose existence and position are based upon geophysical methods combined with professional judgment and whose location is tied to the project survey datum. Quality Level B is sometimes referred to as designating.
4. Quality Level A requires precise mapping via exposure of the utility. It provides type, size, condition, and material of the utility. Quality Level A includes using nondestructive excavating equipment at critical points to determine the precise horizontal and vertical position, type, size, condition, material, and any other characteristics of underground utilities. The utility should be vertically and horizontally tied to the project datum. Quality Level A is sometimes called locating.

2.3.11 Permanent Survey Monumentation

Permanent survey monuments are required in accordance with Chapter 3 of these Standards. A brief narrative covering the procedures and pertinent information used to establish permanent monumentation must be submitted to the Town Engineer as part of the Infrastructure Permit. GPS survey data shall include a detailed description of the post processing procedure which was used to establish the monument. Permanent survey monuments shall be considered properly positioned and represented only after the Town Engineer has approved all survey procedures and calculations and has verified conformance to standards and specifications for Class 2 surveys or greater. If found to be deficient, the Land Surveyor submitting the final plat and documentation may be required to perform additional work to bring the monumentation into conformance, regardless whether the final plat is recorded or not.

Survey control points, permanent monumentation, and the basis of horizontal and vertical control shall be shown on all plans. Property corners and other survey monuments shall be shown on the plat in accordance with the Town Code.

2.3.12 Ownership and Maintenance Plan

An Ownership and Maintenance Plan (O&M Plan) is required for all detention and permanent water quality facilities. An example O&M Plan, including a template for required plan notes, is included as an attachment to this chapter. Checklist 6, O&M Plan Requirements, is also included as an attachment to this chapter. O&M plans may be required by the Town Engineer for other public or private infrastructure.

2.4 PERMITS

A development permit must be issued by the Community Development Department prior to the applicant applying for any of the permits listed below; an exception may be granted for projects consisting of work contained entirely within Town right-of-way. Any work within the Town must have at least one of the following permits before starting, and all three may be required depending on the nature of the work. Exceptions may be made for Class D minor permits; contact the Engineering Division prior to beginning work to confirm permitting requirements. Additional permits may be required in addition to the three permits listed below.

1. Infrastructure Permit
2. Building Permit
3. Right-of-Way Permit
4. Floodplain Development Permit

Additionally, work within 30’ of a special flood hazard area (SFHA) will require a Floodplain Development Permit as part of the permitting process. Table 2.3 summarizes the types of permits that are required for different types of projects and the subsections below discuss each of these in more detail.

All applicable county, state, and federal permits must be obtained and submitted to the Engineering Division prior to the Town issuing the Infrastructure, Building, or Right-of-Way Permit.

Table 2.3. Project Permits

Project or Permit Type	Permit
Any infrastructure improvements	Infrastructure Permit
Any building construction, remodel, or addition	Building Permit
Any work within the public right-of-way	Right-of-Way Permit (ROW Permit)
Any work within 30’ of a SFHA	Floodplain Development Permit

2.4.1 Infrastructure Permit

An Infrastructure Permit is required for projects that occur within public right-of-way, projects that disturb one acre or more, and for public & private developments that involve public roadways, sidewalks, trails, stormwater infrastructure, potable water infrastructure, sanitary sewer infrastructure, lighting, irrigation, fiber optic cable and conduit, heated paver, asphalt, and concrete snowmelt systems, other utilities, stormwater management, transit facilities, retaining walls, signage, and any other improvements. If ~~storm sewer~~ infrastructure is being installed on private property and is being connected to public infrastructure, an Infrastructure Permit will be required. An Infrastructure Permit may also be required for other types of work at the discretion of the Engineering Division. An Infrastructure Permit may be obtained at the same time or prior to the Building Permit if a Building Permit is required. Refer to the permit process flow chart in the attachments to this chapter for the permitting process. The Infrastructure Permit application form is also included as an attachment to this chapter. The Engineering Division will review each Infrastructure Permit application and issue the Infrastructure Permit once the application is approved. If any work is proposed within existing Town right-of-way, a separate Right-of-Way Permit will be required in addition to an Infrastructure Permit.

Work exempted from an infrastructure permit includes single-family homes with a building permit, driveway repaving, and minor work entirely within a right-of-way.

A list of submittals required for the Infrastructure Permit is listed on the Infrastructure Permit Application form attached to this chapter.

2.4.2 Building Permit (without Infrastructure Permit)

If the Engineering Division determines that an Infrastructure Permit is not required, final construction plans shall be approved through a Town Building Permit. Refer to the Town Code for other Town Division submittal requirements. A Building Permit or Infrastructure Permit must be obtained prior to beginning any construction activities (including any staging, demolition, excavation, removals, or grading).

In cases where an applicant desires to begin demolition prior to a building permit or infrastructure permit, they shall contact the Building and Engineering Divisions for approval. Engineering will review these requests and will only allow a demolition permit if the associated site and grading work is minimal.

A checklist of Engineering Division submittals required for Building Permits (Without Infrastructure Permit) is listed in Checklist 7 at the end of this chapter.

2.4.3 Right-of-Way Permit

Any excavation or encroachment into the Town right-of-way requires a Town Right-of-Way Permit from the Public Works Department. The Right-of-Way Permit shall be obtained prior to starting any work within Town right-of-way. Right-of-way regulations are specified in Chapter 3. The permit application and guidance can be found at the Town of Breckenridge Public Works website.

A list of submittals required for the Right-of-Way Permit is listed on the Right-of-Way Permit Application form on the Town website.

2.4.4 Floodplain Development Permit

All work within a Special Flood Hazard Area (SFHA), often referred to as the floodplain, and within areas removed from the floodplain by the issuance of a FEMA Letter of Map Revision based on Fill (LOMR-F) must meet the requirements of the 2018 Breckenridge Flood Damage Prevention Ordinance. A Floodplain Development Permit is required for all work in these areas, regardless of whether a building is being constructed or redeveloped. Work includes, but is not limited to, subsurface and surface utilities, grading, changes to surfacing, infrastructure of any kind, and signage. The Floodplain Development Permit application is included as an attachment to this chapter.

If work in the floodplain will cause any increase in the regulatory floodplain elevation or any decrease in the regulatory floodplain elevation of more than 0.3 feet, a Conditional Letter of Map Revision (CLOMR) issued by FEMA is required. If a CLOMR is issued, the permittee must also submit a Letter of Map Revision (LOMR) to FEMA, and receive approval, once the work has been completed, for the work to be accepted by the Town. The CLOMR submittal and approval from FEMA is required prior to CO or final permit signoff.

A list of submittals required for the Floodplain Development Permit is listed on the Floodplain Development Permit Application form attached to Appendix B.

2.4.5 Additional Local Permits

Work within Summit County right-of-way requires a Summit County Right-of-Way Permit. The application for this permit and submittal instructions are available on the County website via an internet search for “Summit County ROW Permit.” Other local permits include a Summit County Grading and Excavation Permit and Summit County Development Permits. Applicants shall review jurisdictional boundaries shown on the Summit County GIS website and determine if their property and adjacent road or the jurisdiction of Town of Breckenridge or Summit County.

2.4.6 State Permits

There are several state permits that may be required. A CDOT Utility/Special Use Permit is required for the installation of utilities and the performance of any other types of work within the state highway right-of-way. A CDOT Access Permit is required to construct or new access to a state highway or to modify an existing access to a state highway.

The Colorado Department of Public Health and Environment (CDPHE) issues several permits to maintain a high level of water quality during construction activities that include one or more acres of disturbance. The two most common permits are for stormwater discharges associated with construction activities and construction dewatering. Information on the various permits issued by the CDPHE and their applicability can be found via an internet search for “CDPHE construction permits.”

The Applicant shall submit copies of all required state permits to the Town Engineering Division.

2.4.7 Federal Permits

In addition to the FEMA requirements for working on floodplains discussed above, the most common federal permit is the US Army Corps of Engineers Section 404 Permit. A 404 Permit is required to discharge fill material into waters of the US. Waters of the US include tributaries, lakes, rivers, streams, creeks, and wetlands. The Applicant shall submit copies of all required federal permits to the Town Engineering Division.

2.5 EMERGENCY WORK

Emergency work is defined as work of an urgent nature to repair or mitigate damage that is creating an immediate hazard to the community, including hazards to the health, safety, and welfare of the Town, environment, or citizens. If emergency work is required, the Engineering Division shall be contacted immediately and all pertinent information shall be conveyed. The Engineering Division will expedite a review of the information and determine if the work qualifies as emergency work. If an emergency work determination is made, the Engineering Division will expedite the review process and may not require all submittals and reviews listed in this chapter. The permit process may be abbreviated, but permits shall still be required in most cases. The review process and required submittals will be determined on a project basis dependent on the nature of the hazard and the work.

2.6 ENCROACHMENT LICENSE AGREEMENTS

The Town does not generally allow private structures, landscaping, or other private improvements within Town right-of-way or easements. If the Town Engineer reviews and approves private improvements within the Town right-of-way or easement, a revocable encroachment license shall be submitted to the Town. The encroachment license agreement shall be acceptable in form and substance to the Town Attorney for the improvements extending into the right-of-way or easement and must be approved by the Town and executed prior to the issuance of a Building Permit, Infrastructure Permit, or Right-of-Way Permit. See Sections 10-2-1-2 and 11-6 of the Town Code for additional information on encroachment license agreements.

2.7 POST-CONSTRUCTION SUBMITTALS (SEE CHAPTER 8)

Post-construction inspections and documentation are discussed in Chapter 8.

CHAPTER 3
RIGHT-OF-WAY & EASEMENTS

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3.1 PURPOSE

This chapter of the Engineering Standards establishes the requirements for public right-of-way (ROW) and easements. A Right-of-Way Permit is required whenever construction, encroachment during construction, installation, or disturbance is proposed within Town ROW. A Right-of-Way Permit is required to ensure utilities, roadway reconstruction, and other work is completed to Town specifications and to provide for public health, safety, and welfare. Examples of work requiring a Right-of-Way Permit are included below:

1. Utility work, including directional boring and drilling
2. Pavement cuts and installation of new roadway or sidewalk improvements
3. Installation of trails, landscaping, signs, lights, transit improvements, or any other surface or subsurface improvements
4. Traffic counts (vehicle or pedestrian) conducted in the ROW
5. Access changes for proposed or existing driveways and roadway accesses
6. Work outside of the ROW, but requiring parking, staging, or traffic control within the ROW
7. Installation of driveway culverts, swales, ponds, and storm sewer infrastructure

Replacement of driveway pavement shall not require a Right-of-Way Permit, provided the driveway cut width does not increase from existing width, no snow melt system is added to the driveway, and no culvert is being installed beneath the driveway.

ROW and easements shall be dedicated for public streets and other infrastructure as needed in accordance with current master plans and development approval requirements. Specific procedural requirements for ROW and easement dedication or vacation are listed in the Town Code. The purpose of this chapter is to provide more detail for completing work in the ROW and guidance on when an easement is required. See Titles 9 through 11 of Town Code for additional information on ROW and easements.

3.2 WORK IN RIGHT-OF-WAY

It shall be unlawful for any person, other than an officer or employee of the Town in the course of his or her employment, to make, cause, or permit any construction in, on, under, or within a public right-of-way of the Town unless such person first obtains a Right-of-Way Permit from the Town Engineer. All work in the ROW shall be performed in conformity with the permit and the terms and provisions of this chapter. For all work within the ROW, the contractor is responsible for obtaining utility locates and any other permits and approvals necessary to complete the work. Submittal requirements for a Right-of-Way Permit are specified in Chapter 2, Submittal Requirements & Permits. Any work performed in the ROW without a permit, work performed outside of allowable dates outlined below, or work not performed in accordance with these Standards is subject to fines, penalties, and enforcement as set forth in the Town Code.

3.3 ACCESS TO RIGHT-OF-WAY

Any new access or any modification of an existing access to a public street or Town ROW shall require a Town Right-of-Way Permit. A new access to a state highway, or a modification of an existing access to a state highway, requires a CDOT Access Permit. New access or modification of an existing access to a county road requires a Summit County Right-of-Way Permit. New access spacing shall meet the minimum requirements listed in Chapter 5 of these Standards.

3.4 RIGHT-OF-WAY RULES AND REGULATIONS

The sections below provide an overview of rules, regulations, and specifications for work in the right-of-way. See Town Code and Chapter 9 of these Standards for additional requirements for work within Town right-of-way.

A. Work authorized by the Right-of-Way Permit shall be performed between the hours of 7:00 a.m. and 7:00 p.m., Monday through Friday (except holidays), unless the contractor obtains written consent from the Town Engineer to work earlier or later than the stated hours or on a weekend or holiday.

B. Street pavement cuts will not be allowed between November 1 and April 30, except when:

   1. There is a public utility emergency with notification and approval by Town Engineer, or

   2. Special or unforeseen circumstances arise as determined by the Town Engineer.

   If the Town Engineer approves a pavement cut between November 1 and April 30 due to one of the conditions above, a special provisions memo must be prepared and submitted to the Town Engineer to accommodate pavement patching during winter conditions. Pavement repairs completed during this period shall be considered temporary and be removed and replaced as soon as conditions permit after April 30.

C. TOWN OF BRECKENRIDGE 2018 DIG ONCE ORDINANCE

   See Title 11, Chapter 9 of the Town Code for the TOWN OF BRECKENRIDGE 2018 DIG ONCE ORDINANCE. The purpose of this ordinance is to coordinate work in the right-of-way and to minimize the number of excavations and pavement cuts. If the Right-of-Way Permit applicant proposes utility work in the right-of-way, the Town may require the applicant to install additional conduit in the work area with the direct cost of the additional conduit installation to be paid by the Town.

D. Work authorized by a Right-of-Way Permit shall meet the following conditions:

   1. Work shall be conducted in a manner which ensures the least possible obstruction and hazard to the traveling public. The permit holder shall provide for the safety and reasonable accommodation of the residents and users along the rights-of-way where work is being performed, and for the protection of persons and property at all times. The permit holder shall plan work so it does not create safety hazards or maintenance problems.

   2. An MHT or traffic control plan shall be submitted prior to approval of the Right-of-Way Permit in compliance with the MUTCD, CDOT S Standards, and these Standards. The plan shall be signed by a certified Traffic Control Supervisor. See the Right-of-Way Permit application for a full list of submittal requirements.

   3. The applicant shall provide all submittals, including the traffic control plan, at least 5 calendar days prior to the start of the scheduled roadway work. During the work, the permit holder shall notify the Town of any changes to the traffic control plan, schedule, closures, or any other changes at least 5 calendar days prior to implementing the closures. The permit holder shall provide advance signing and notify appropriate agencies of any road closures and detours at least 5 calendar days prior to actual road closure.

E. All street pavement cuts shall meet the following conditions:

   1. Pavement cuts shall be mechanically cut to form a clean vertical edge. Final pavement cuts shall not be made until immediately prior to paving.

   2. Pavement cuts shall be a minimum width of two feet.

   3. Pavement cuts shall extend 12 inches minimum beyond the edge of trenching or excavation.

4. Pavement cuts shall be exactly perpendicular or parallel to the travel lane.
5. Pavement cuts parallel to the travel lane shall not be located in wheel paths for vehicles or bicycles.
6. If a pavement cut parallel to the travel lane exceeds 150 linear feet, the pavement for the entire lane width shall be milled or removed and overlaid.

F. All street pavement patches shall meet the following conditions:

1. All excavations made in paved streets, sidewalks, or paths shall be completely restored within 15 calendar days of the pavement removal. In the event weather conditions preclude paving by permanent hot bituminous pavement or concrete, temporary repairs may be made by tamping and rolling into place cold mix asphalt.
2. Pavement patch depth shall match the existing pavement depth or have a minimum depth of 4 inches, whichever is greater.
3. Transverse joints on pavement patches shall be perpendicular to travel lane and shall be constructed using a transverse butt joint or tee patch detail.
4. If the pavement patch is on a roadway which has been paved in the previous 36 months, then all patches shall be full lane width and shall be patched with infrared patching equipment. If a pavement patch exceeds 500 square feet, a “tee patch” detail may be used in place of an infrared patch.
5. Joint lines and concrete control joints shall not be allowed in bicycle paths, unless joints are perpendicular to the direction of travel.
6. The surface of the finished pavement shall be free from any depression exceeding three-sixteenths (3/16) inch in ten (10) feet as measured by a ten (10) foot straight edge measured in any direction or an automobile mounted recording profilometer. The pavement surface shall be flush with existing pavement and shall not be raised from existing pavement.
7. Damaged pavement shall be repaired by appropriate methods as determined by the Town Engineer.
8. Permit holder shall contract with a geotechnical engineering consultant to provide backfill density testing and pavement testing. Permit holder and tester shall confirm material testing meets Town specifications for compaction and pavement and submit all results to the Town.

G. Utility work, potholing, and boring shall meet the following conditions:

1. Utility potholing shall be completed with non-destructive excavation methods.
2. Utility potholes, geotechnical borings, and other subsurface exploration shall not be placed in wheel tracks of roadways, unless required to comply with SUE for a utility conflict point.
3. Potholes and borings shall be backfilled with low strength flowable fill. Native material shall not be reused in the excavations.
4. Pavement patching for potholes and borings shall meet the requirements above for pavement patches.
5. Utility excavation, trenching, backfill, and compaction shall meet requirements of Chapters 5 and 8 of these Standards, the Town Standard Details, and private utility requirements.
6. The minimum bury depth for any utility shall be 24 inches (measured from top of pavement/surface to top of utility).

~~5.~~7. The minimum trench width for any utility shall be 12 inches (measured at the narrowest section of trench).

~~6.~~8. Directional boring and drilling of utilities will be allowed with approval by Town Engineer. Directional boring requires a Right-of-Way Permit.

H. All work in the right-of-way shall meet the following additional conditions:

1. All disturbance in the right-of-way shall be repaired upon completion of work, including pavement, landscaping, utilities, irrigation, street lights, shouldering, signage, and striping.
2. A financial guarantee (surety) shall be required for work within the right-of-way. The surety shall warranty and guarantee the right-of-way work for a period of two years after completion of improvements. See Chapter 8 for inspection requirements and see the Right-of-Way Permit application on the Town website for additional information on submittal and financial guarantee requirements.

I. Additional requirements for coordinating construction activities within the public ROW are specified in the Right-of-Way Permit application, Chapters 8 and 9 of these Standards, and in the Town Code.

3.5 SNOW STORAGE

Snow storage areas shall be provided for all public rights-of-way. Snow storage areas shall be adequate to provide storage of average snowfalls from the months of November through April. Snow storage areas shall provide actual storage volumes of approximately 48 cubic feet per foot for each 12-foot lane of traffic. For a typical lane width, this equates to 9.6 square feet of snow storage required per linear foot of lane. Maximum snow storage height allowed will be 5 feet. Snow shall not be stored in locations that will limit sight distance at intersections in accordance with AASHTO design criteria. Consideration for extra snow storage areas at intersections and cul-de-sacs will be required. The Town Code provides additional guidance on internal site snow storage requirements.

Additional requirements for coordinating construction activities within the public ROW are specified in Title 11 Chapter 9 of the Town Code.

3.6 PERMANENT SURVEY MONUMENTS

Construction of infrastructure for all new subdivisions requires the installation of permanent survey monumentation. All external boundaries of all subdivisions, blocks, and lots shall be monumented with a permanent monument by a registered land surveyor in accordance with State of Colorado Revised Statutes. Any survey monuments established on dredge tailings by a land survey shall be solidly embedded in concrete per details approved by the Town Engineer and shall be in addition to the minimum standards for surveys set forth in the Colorado Revised Statutes. Additional requirements for the installation and documentation of survey monuments, as well as penalties for damaging survey monuments, are specified in the Town Code.

No point within the subdivision shall be more than one-half mile from a permanent survey monument. See the Town Code for additional spacing requirements. At least two survey control monuments or two corners or points on or near the perimeter of the subdivision traverse must be tied to, or monumented with, permanent survey monuments tied to the Town of Breckenridge survey network (currently under development). The location of permanent survey monuments showing ties to the network currently under development must be provided with the following:

1. Colorado State Plane Central Meridian
2. Delta Alpha and combined sea level and scale factor at the point or for the centroid of the parcel of the subdivided land

3. Vertical elevation in NAVD 88
4. Horizontal coordinates in NAD 83

Permanent survey monuments must be brass caps set in an acceptable base. Caps shall bear the registration number of the surveyor establishing the point and identifying letters or numbers approved by the Town Engineer. This information must be stamped permanently into the cap and must be shown on the final plat for which the survey is performed. Submittal requirements for permanent survey monuments are specified in Chapter 2.

3.7 RIGHT-OF-WAY WIDTHS

Minimum right-of-way widths for the various roadway classifications and sections are discussed in Chapter 5, Street Standards.

3.8 EASEMENTS

Easements shall be dedicated for all public utilities, roadways, drainage facilities, snow storage, sidewalks, shared use paths, trails, public retaining walls, public open space, and all other public improvements if they are not located within the public right-of-way. Easements shall be dedicated for the purpose of all activities associated with installing, operating, maintaining, repairing, and replacing the facility.

No new work or modifications within an easement may occur without approval granted through the Town development process. Trees and landscaping that might interfere with the operation or maintenance of, or access to, any facilities, either immediately after installation or in the future, shall not be located within an easement. Any landscaping or other improvements proposed in an easement shall be approved through a Town encroachment license. The Town is not liable for damage to any landscaping or other improvements located within the easement. No permanent structures shall be located within the easement.

Where easements are required during development, public easements shall be granted to the Town at no charge. Easements shall be granted through the subdivision plat process or other instrument acceptable to the Town Attorney.

The Town Engineer may require additional easements in addition to those listed in this section and may enforce additional requirements depending on the type of facility, location, and other factors specific to the improvements. The Town Engineer may require dedication of an easement during the Infrastructure Permit process.

Additional easement requirements are specified in Titles 9 through 12 of the Town Code.

3.8.1 Access Easements

Right-of-way shall be dedicated to the Town for all new roadways through the subdivision plat process. See Chapter 5 for minimum right-of-way widths for roadways. Where improvements are proposed to an existing roadway outside of the existing right-of-way, an easement is also required. Transit facilities, sidewalks, trails, and shared use paths shall be located within a public easement. Easement widths shall be sufficient to accommodate the facility, drainage, signage, and repair and maintenance of the facility. The minimum width of the easement will be dependent on the facility and determined by the Town Engineer.

Access easements are required for private roads and driveways serving two or more adjoining lots. Access easements may also be required for fire and emergency access or for any other reason as determined by the Town Engineer.

Easements may be required which prohibit driveway or roadway accesses on the major road. Examples include roadway areas near curves, steep grades, limited sight distance, or other hazards.

3.8.2 Drainage Easements

Drainage easements shall be dedicated for all stormwater detention and permanent stormwater quality treatment facilities. Drainage easements are also required for all streams, channels, ditches, culverts, and storm sewers (if not in a general utility easement) conveying public drainage outside of right-of-way or conveying private drainage across two or more lots. The drainage easements shall be sufficient to allow for construction, operation, repair, and maintenance of the entire facility. The minimum drainage easement width shall be 20 feet.

While each property owner is required to maintain all facilities within the easements on his or her property, easements must be dedicated to allow the Town to maintain the facilities and invoice the owner for all costs incurred if the owner fails to complete the maintenance obligations. Chapter 6 includes maintenance requirements specific to permanent detention and water quality facilities.

3.8.3 Utility Easements

All public utilities not located within the public right-of-way shall be located within a public utility easement. Public utilities include, but are not limited to, water, sanitary sewer, storm sewer (if not in a drainage easement), electric, gas, and communication utilities. Easement widths shall be sufficient for the installation, operation, and maintenance of the utility. Easement width shall be dependent on type, number, and depth of utilities. The minimum utility easement width shall be 20 feet. Easements for shallow utilities may be reduced below 20 feet if installation, operations, and maintenance can be completed reasonably at a smaller width.

3.8.4 Snow Storage Easements

A minimum width of 10 feet shall be provided for snow storage along all roadways outside the shoulder. If the right-of-way does not provide adequate snow storage width, a snow storage easement shall be dedicated to meet the snow storage requirements of Section 3.5, or a 10’ easement width, whichever is greater. Additional snow storage widths and easements may be required based on roadway classification, terrain, the presence or need for turnarounds, and roadway geometry. See Title 9 of the Town Code for internal site snow storage requirements. Easements shall be sized and located for reasonable access and use by snow removal equipment. No structures, trees, or other facilities that may impact the ability to store snow may be located within the snow storage easement.

CHAPTER 4
TRAFFIC IMPACT STUDIES

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LIST OF ATTACHMENTS - APPENDIX B

4.1 PURPOSE

The purpose of this document is to outline a standard format for preparing a Traffic Impact Study (TIS) in the Town of Breckenridge.

A Traffic Impact Study assesses the effects of a proposed development on the Town's transportation system. The study identifies if the transportation system can operate efficiently with the development, if there are existing conditions that need to be improved, or if improvements are required to mitigate site impacts.

The owner/developer of a project site is responsible for contracting a traffic consultant to assess project traffic impacts and for providing any necessary mitigation measures as part of the development, when required by Section 4.3 of these Standards.

The requirements listed in this document are applicable for all developments in the Town of Breckenridge. In addition to the requirements of this document, owners/developers with sites having access to or within the influence area of a State Highway (for example SH 9) must contact the Colorado Department of Transportation (CDOT) for specific requirements related to access permits, construction permits, or work in the CDOT right-of-way.

Development and installation of pedestrian systems which integrate with existing and future Town pedestrian systems and with the systems of adjacent developments is required. This will include the provision of sidewalks, where required, and the provision of pedestrian walkways pursuant to the Town trails plan.

It is the policy of the Town to require bicycle and pedestrian paths to be dedicated to the Town as a component of the town's alternative transportation network and to provide recreational opportunities. Subdivision proposals shall include, as a component of the required public improvements, a pedestrian and bicycle path system designed to preserve existing paths, integrate with existing improvements, and provide service appropriate to the character and magnitude of the proposed development.

The inclusion of or the contribution to a permanent nonauto transit system, designed to facilitate the movement of persons to and from Breckenridge or within the Town, is strongly encouraged. Nonauto transit system elements in the Town of Breckenridge include, but are not limited to, buses and bus stops, transit shelters, both public and private, gondola lifts, ski lifts, surface lifts, trams, bicycles, electric bicycles, and other alternative transit systems that have the primary purpose of providing access from high density residential areas or major parking lots of the Town to other destinations of the Town. Any development which interferes with the community's ability to provide nonauto oriented transportation elements is discouraged.

4.2 REFERENCE DOCUMENTS

Any new infrastructure or modifications to existing infrastructure and any new development plans shall be in accordance with the most current adopted version of the Town's Related Planning Documents. Traffic references used in the traffic impact study shall be the most current version available, unless otherwise authorized by the Town Engineer.

4.2.1 Related Town Planning Documents

See Chapter 1, Section 1.1 of these Standards.

4.2.2 Traffic References

1. ITE Trip Generation Manual, 10th Edition, Institute of Transportation Engineers, 2017
2. ITE Trip Generation Handbook, 3rd Edition, Institute of Transportation Engineers, 2017

3. Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis, Transportation Research Board, 2016
4. State Highway Access Code, State of Colorado, March 2002
5. Manual on Uniform Traffic Control Devices, 2009 with Revisions 1 and 2, Federal Highway Administration, May 2012

4.3 THRESHOLDS REQUIRING A TRAFFIC IMPACT STUDY

A Traffic Impact Study may be required as part of the submittal documents for annexation, development plan, final development plan, rezoning, plat, reuse/remodel, or other development application. To determine whether a Traffic Impact Study is required, as well as the category of study, the applicant must first estimate the number of peak hour trip ends generated by the development. A vehicle that stops at a gas station, for example, results in two trip ends at the development: one entering trip and one exiting trip.

A Traffic Impact Study is required for any development, redevelopment, reuse, or remodel that increases peak hour traffic by more than 10 trips. Developments increasing commercial gross floor area by 1,000 square feet or the number of residential/lodging units by 10 may exceed this trip threshold. A Traffic Impact Study is also required where any of the following conditions exist:

1. The site increases peak hour traffic volume by more than 20% at a point of State Highway access
2. The site is part of a larger development
3. Site-specific traffic issues require evaluation, as so determined by the Town Engineer
4. Project study area includes an intersection with planned improvements such as:
   a. South Park Ave/Main Street
   b. Park Ave/Village Road
   c. Park Ave/French Street
   d. Park Ave/Airport Road
   e. SH 9/CR 450
   f. SH 9/Ridge Street

4.3.1 Study Not Required

A site expected to generate 10 or fewer trips per hour. Typical examples include single-family developments with fewer than 10 homes, a 5,000 square foot office, or a 2,000 square foot retail establishment (not including gas stations, restaurants, or the like).

4.3.2 Trip Generation Letter

A site expected to generate more than 10 and less than 25 trips per hour. Typical examples include single-family developments with fewer than 20 homes, an office of less than 6,000 square feet, or a retail establishment of less than 5,000 square feet (not including gas stations, restaurants, convenience stores, auto washes, or other services expected to generate more than 10 trips per hour).

In areas that have not been recently studied or located in an area with planned road improvements or identified potential lane additions. a Short-Term Traffic Study may be required.

4.3.3 Short-Term Traffic Impact Study

A site generating between 25 and 50 trips in the peak hour. The site will typically be developed in a single construction phase with anticipated completion in less than three years from the time of development plan approval. Short-term traffic studies shall be required to evaluate traffic conditions at year-of-opening, and 5 years post-development. Typical examples include single-family developments of approximately 30 homes, an office or retail establishment of 10,000 square feet.

4.3.4 Long-Term Traffic Impact Study

Development sites generating over 50 trips in the peak hour or sites that are developed in more than one phase. For phased development, a master traffic study will be prepared prior to the first phase of development and a build-out period not longer than 20 years should be assumed. All subsequent phases will need to prepare a trip generation letter comparing the proposed development with the development type and density projected for the site in the master study. The letter may need to include additional analysis if there is a significant difference between the original development concept and the newly proposed development.

In addition to meeting all the requirements for a short-term traffic study, a long-term traffic study shall evaluate traffic conditions 20-years post-development.

Typical examples include single-family developments with over 50 homes and an office or a retail establishment greater than 12,000 square feet.

The Town Engineer may require long-term traffic studies for developments smaller than the thresholds listed above, depending on the size, location, and type of development.

4.4 TRAFFIC IMPACT STUDY REQUIREMENTS

When a Traffic Impact Study is required it shall be included with the development application. Studies will not be accepted prior to development application. After the Town's initial review of the draft study, the traffic professional shall address Town comments and submit a final study for Town approval. The final Traffic Impact Study shall include the PE's stamp, date, and signature. The final Traffic Impact Study must be approved by the Town Engineer prior to Issuance of an infrastructure or building permit.

If the development application includes a proposal for an uncontrolled or mid-block pedestrian crossing, the traffic study shall include a pedestrian traffic analysis as described in Section 5.14.

Submit one PDF electronic copy of all final traffic impact studies to the Engineering Division.

For sites with access to or within the influence area of state highways, the applicant is also required to contact CDOT for requirements and to get approval for the project from CDOT.

https://www.codot.gov/business/permits/accesspermits/regional-offices.html#Region2-3

4.4.1 Traffic Impact Study Submittals

A checklist is provided in Chapter 2 of these Standards that delineates the requirements of the Traffic Impact Study. Not all study elements will be required for every traffic impact study. Content must be specific to the situation and determined based on professional engineering judgment. Where content is specific to a traffic impact study type, that is identified in the checklist.

4.4.2 Land Use Scenarios

Required land use scenarios for the short- and long-term traffic impact studies are summarized in the following:

4.4.2.1 Short-Term Traffic Impact Study

Year of Opening w/o Development: This scenario represents area land use as it presently exists. The purpose of this scenario is to identify existing deficiencies and to provide a baseline for comparison with the scenario that includes development.

Year-of-Opening w/Development: This scenario represents area land use as it is projected to exist upon year-of-opening of the development, plus the inclusion of the development. The purpose of this scenario is to identify traffic conditions as they are anticipated to exist with the development.

5-Year Horizon w/o Development: This scenario represents area land use as it is projected to exist at the study's horizon year (5 years), without the development. The purpose of this scenario is to identify anticipated transportation deficiencies and to provide a baseline for comparison with the scenario that includes development.

5-Year Horizon w/Development: This scenario represents area land use as it is projected to exist at the study's horizon year (5 years after year of opening) plus the inclusion of the development. The purpose of this scenario is to identify traffic conditions as they are anticipated to exist with the development upon full-build out.

4.4.2.2 Long-Term Traffic Impact Study

Year of Opening w/o Development: This scenario represents area land use as it presently exists. The purpose of this scenario is to identify existing deficiencies and to provide a baseline for comparison with the scenario that includes development.

Year-of-Opening w/Development: This scenario represents area land use as it is projected to exist upon year-of-opening of the development, plus the inclusion of the development. Only the parts of development expect to be complete upon opening year shall be included in the analysis. The purpose of this scenario is to identify traffic conditions as they are anticipated to exist upon the opening of the development.

5-Year and 20-Year Horizon w/o Development: These scenarios represent area land use as it is projected to exist 5 and 20 years after the opening year of the development if the development were not built. The purpose of these scenarios is to identify anticipated transportation deficiencies expected to occur regardless of the development, and to provide a baseline for comparison with the scenarios that include the development.

5-Year and 20-Year Horizon w/Development: These scenarios represent area land use as it is projected to exist 5 and 20 years after the opening of the development. The 5-year scenario will include the parts of the development expected to be complete 5 years after of year of opening, while the 20-year scenario will include the parts of the development expected to be completed 20 years after year of opening (typically this represents full build-out). These scenarios will be compared to the 5-year and 20-year horizon without development scenarios to assess the effects that the development will have on the traffic conditions.

4.4.3 Analysis Periods

Conceptually, the design hourly volume for transportation systems is based upon the 30th highest hour of the year. In other words, the traffic volumes used in the study should be sufficiently conservative to ensure that most of the time actual traffic conditions are anticipated to be less than those described in the traffic study. For this reason, traffic data taken off-peak must be factored to peak conditions as described in Section 4.5.1.

With respect to times-of-day, the most important time periods to analyze in the Town of Breckenridge are the weekday PM Peak hour, Saturday AM Peak Hour, and Saturday PM Peak Hour.

In addition to the peak hour, an analysis period should be completed for approximately the median hour in Breckenridge (the hour represent the average traffic volume on a non-peak hour). When comparing traffic conditions and proposed improvements, the peak hour and median hour shall be analyzed for LOS, safety, and other factors. One traffic solution may provide benefits at the peak hour, while a different solution provides benefits at the median hour, resulting in an analysis to compare the benefits and which solution is more favorable when considering all traffic conditions.

4.4.4 Study Area

The study area should include all intersections and access points that may experience a change in traffic operations due to the project. This typically includes all site access points, adjacent local intersections, and the nearest highway intersection(s) used by the generated trips to go to/from the site. If the generated trips are projected to increase a turning movement at a more distant intersection enough to potentially effect overall intersection operations, that intersection shall be analyzed as well.

4.4.5 Multimodal

The traffic study should consider not only potential impacts for motorized traffic, but also whether there are impacts to existing nonauto modes including pedestrian, bicycle, and transit. This section of the report should identify the potential for the project to generate nonauto traffic and to evaluate whether nonauto traffic can be accommodated by the existing environment.

In the multimodal analysis, the study should describe how the site provides opportunities for pedestrians, bicycles, and transit, and also include demand management strategies when relevant. The extent and type of existing and planned infrastructure required for multimodal connectivity to the site, such as sidewalks, trails, transit stops/routes, and alternative modes of transportation, should also be described. The multimodal Level of Service (LOS) for the site should be calculated as described in Section 4.5.4. Where multimodal LOS is not acceptable, the study should recommend on or off-site improvements that can be made to improve LOS. Off-site mitigation shall be consistent with street standards and planning documents referenced in Section 4.2.1.

4.4.6 Impact Analysis

This portion of the study evaluates the impacts that the traffic generated by the project will have on the community. In accordance with Town policy, developments which will generate a volume of vehicular trips which exceed or disproportionately consume the capacity of the external circulation system may have conditions imposed which address the need to provide sufficient traffic carrying capacity to meet this excess demand. This may include a requirement to either provide the necessary improvements at time of development or at some later date, including participating in Improvement Districts, if applicable.

Where the LOS falls below acceptable levels, mitigation will be required. Acceptable mitigation measures may include capacity and access improvements, signalization, signal operation improvements, street widening, additional connections, or other physical improvements. Where existing conditions prevent physical improvements (i.e., steep terrain, adjacent buildings, limited right-of-way, etc.), a project may be required to reduce density, implement transportation demand management (TDM) measures to minimize the demand for vehicle trips and encourage alternate mode use, and/or provide cash-in-lieu of the improvement as described in Section 4.5.7. The TDM strategies may include incentives for carpooling, transit ridership, enhanced bicycle or pedestrian facilities, provisions for telecommuting, or addition of use mixes to increase internal trips.

In addition to evaluating transportation facilities external to the development, the Traffic Impact Study shall include a discussion of the adequacy of the site accesses to accommodate projected site traffic. This may include but not be limited to a review of vehicle turning paths, stacking distances, and the design layout's ability to control speeds and provide safe and efficient circulation.

4.4.7 Existing Street and Access Analysis

This portion of the study shall evaluate the condition and configuration of the existing street providing access to the development. This section shall analyze the street access for all requirements of Chapter 5 of these standards. These requirements shall include, but are not limited to, intersection geometry, sight distance, roadway horizontal and vertical geometry, street widths, street classifications, adjacent access spacing, roadway drainage, vehicle & pedestrian lighting, signage, pedestrian route, transit access, acceleration lanes, deceleration lanes, and clear zone widths.

The Town Engineer may require improvements to existing streets, due to development impacts to the streets, increased demand on existing improvements, or existing streets serving new developments not meeting current standards. Improvements may include, but are not limited to, intersection improvements, sight distance improvements, street widening, adjustments to horizontal and vertical street geometry, drainage improvements, vehicle and pedestrian lighting, signage, pedestrian routes, acceleration lanes, deceleration lanes, clear zone widening, shoulder improvements, and transit improvements.

Existing streets providing access to a new development must be upgraded to current standards if both of the following conditions are met:

1. The existing street does not meet current Town of Breckenridge Engineering Standards.
2. The proposed development will increase the Average Daily Traffic (ADT) of the street by 25% or more.
3. Or as directed by the Town Engineer.

Existing streets must also be upgraded to current standards if a development changes the street classification. An example would be a development increasing the volume of a roadway from a local street to a collector.

4.4.7 Study Findings

This portion of the study provides an overview of the conclusions reached based upon the data and analysis performed and the professional engineering judgment of the author. It includes a factual restatement of the study’s primary findings, including summaries of:

1. Development characteristics, including type and density of land use, hours of operation (if known), means of vehicular access, plan for implementation, and any other relevant data or information

2. Existing traffic conditions at study area intersections for each analysis period, including identified LOS, safety, or other operational deficiencies (auto as well as nonauto)

3. Development traffic generation, for peak hours as well as over an average weekday and weekend day for each development phase

4. Traffic impacts of the development, including identification of locations requiring mitigation to address existing or proposed LOS, safety, or other operational deficiencies

5. Extent to which study recommendations address development traffic impacts and existing or proposed deficiencies

4.4.8 Recommendations

Include a list of any improvements needed or proposed, noting who will construct and fund the improvements. Identify if right-of-way is available or is needed to construct the improvements.

Clearly identify study recommendations, including:

1. Proposed mitigation to address identified impacts
2. Other mitigation as identified
3. Improvements needed but not proposed by development

4.4.9 Certification

A short-term or long-term Traffic Impact Study shall be prepared under the responsible charge of a traffic engineer. A trip generation letter may be prepared under the responsible charge of any engineer familiar with procedures for using the *Trip Generation Manual* published by the Institute of Transportation Engineers. All traffic studies and letters shall be sealed and signed by a professional engineer licensed in the state of Colorado.

4.5 TECHNICAL GUIDELINES

4.5.1 Data Collection

The Town Engineer shall be notified at least five (5) calendar days in advance of the proposed locations, days of week and times of day that data will be collected. A Town Right-of-Way Permit shall be obtained prior to placing tubes, cameras, or any other equipment or materials in the right-of-way. Town staff will inform the applicant of any activities that may render the counts invalid such as school holidays, road work, local festivals, or other reasons, in order that the applicant may come up with an alternative plan. Tube counts are not permitted between Labor Day and Memorial Day and may otherwise only occur with prior approval of the Town Engineer.

New traffic counts shall be taken in locations where existing traffic counts are missing or over two years old. Intersection turning movement counts (a record of all vehicle movements including U-turns, left-turns, through movements, and right-turns) should capture the time periods expected to have the highest volumes, typically the weekday PM peak (4-6 PM), and the Saturday AM (8-10 AM) and PM (3-5 PM) peaks. If the changes proposed by the traffic study will have the greatest impact on traffic operations during a time period other than the typical peaks, or the highest overall network volume is expected to occur in a different time period, additional turning movement counts shall be collected during those periods. Turning movement counts shall include pedestrians and bicyclists.

Traffic volumes in Breckenridge are highly seasonal, with the winter and summer months traditionally having the highest volumes. Traffic counts shall be factored to reflect conditions typical to the month of January using the Town's ADT conversion table. This table was developed using CDOT Count Station Data for CO-9. To account for changing traffic patterns throughout the year, a separate factor shall be used for each time period (e.g., traffic counts taken during the AM and PM time periods on a Saturday in May would be multiplied by 2.37 and 2.04, respectively, to reflect volumes typically seen in January). Several types of developments, such as schools or athletic fields, often see peak volumes outside the network peak hours. If, for example, a school is being analyzed, the traffic counts shall be conducted during the school's arrival and dismissal time. If a traffic count is taken outside of one of the specific time periods shown in the table below, the counts shall be multiplied by the monthly average shown in the chart below. Continuing with the example of a school, a count taken between 2:00 and 3:00 PM on a weekday in April would be multiplied by 1.34 to approximate that same time period during a peak season (January) school day.

Table 4.1. Monthly ADT Data Conversion Table

Month	Saturday AM	Saturday PM	Weekday PM	Monthly Average
January	1.00	1.00	1.00	1.00
February	1.00	1.00	1.00	1.01

March	1.13	1.14	0.95	1.02
April	1.64	1.67	1.26	1.34
May	2.10	1.98	1.32	1.45
June	1.61	1.48	1.08	1.14
July	1.32	1.20	0.95	0.96
August	1.37	1.18	0.95	0.99
September	1.53	1.23	1.02	1.07
October	2.04	1.59	1.14	1.30
November	1.57	1.49	1.18	1.28
December	1.27	1.13	1.01	1.06

Per Highway Capacity Manual (HCM) recommendations, a peak hour shall be modeled for each time period analyzed. For studies containing multiple intersections, a system peak hour shall be selected when an intersection affects operations at adjacent intersections (e.g., coordinated signals, travel times runs, microsimulations). Individual peak hours should be used in networks where intersection operations have minimal effects on the operations of nearby intersections (e.g., stop-controlled intersections, non-coordinated signals, roundabouts). The selected peak hour should represent the hour with the worst traffic operations for the study area, typically the hour with the highest total traffic volume. If the primary focus of the traffic study is to analyze side street operations, or a critical movement whose peak may not coincide with the intersection peak (e.g., school, event hall), the selected peak hour should be based on that movement(s) highest volume, rather highest overall volume. A separate peak hour factor (PHF) shall be used for each intersection approach when possible. If the PHF is not available, a default of 0.92 shall be used. Section 4-3 of the HCM 6th Edition should be referenced for further clarification of the peak hour factor.

4.5.2 Trip Generation

Trip generation shall be calculated using the most recent version of the Institute of Transportation Engineers (ITE) Trip Generation Manual. Parts of the procedure discussed in this section cannot be completed with a ITE Trip Generation Manual older than the 10th Edition. For developments within downtown Breckenridge, the “dense multi-use urban” setting/location should be used, and for developments in more isolated locations, the “urban/suburban” setting/location should be used. If a land use option does not have a setting/location option, the default shall be used. The trip rate equation shall be used when provided, otherwise, the flat rate shall be used. The trip generation summary shall include weekday AM and PM data, as well as data for the Saturday peak period. If the exact land use of a development is not included in the ITE Trip Generation Manual, a comparable land use should be used. If the ITE Trip Generation Manual does not contain a comparable land use, other sources may be used, such as previous traffic studies or traffic counts at a similar development.

Capture trips are trips that visit multiple land uses in the same development during the same outing. In locations where this is a frequent occurrence, the number of capture trips shall be calculated and incorporated into the trip generation calculations to avoid double counting trips. Engineering judgment shall be used to determine whether a development will have capture trips (e.g. hotel & restaurant), or whether each land use will generate its own trips independently (e.g. office building & movie theatre). A spreadsheet tool which performs many of the required capture trip calculations can be downloaded in the Trip and Parking Generation section of the ITE website. Some of the land uses in the ITE Trip Generation Manual already account for capture trips, such as shopping centers or office parks with retail. In the cases where the land use from the Trip Generation Manual is mixed use, it is not necessary to calculate the number of capture trips.

Pass-by trips are defined as vehicles that stop at a development on the way to their destination without changing their originally planned route. Gas stations are an example of land uses with high percentages of pass-by trips. While pass-by trips are added to the volume entering and exiting a site, they are not to be added to the traffic volume along the adjacent road, as they would have been traveling on that road anyway. If a development is expected to attract a high percentage of pass-by trips, a reduction factor should be applied to the generated trips on the adjacent roads. The reduction can be found in Chapter 10 of the ITE Trip Generation Handbook.

4.5.3 Trip Distribution

The distribution of site generated trips shall be based on existing turning movement data or link volumes on the adjacent roadways. In cases where trip distribution is expected to differ from the existing trip distribution through the network (e.g. if a school is located on the edge of the school zone, trips to and from the school will not follow the same directional patterns as network traffic), engineering judgment is to be used. If the trip generation calculations incorporate captured trips or pass-by trips, these assumptions shall be reflected in the trip distribution.

4.5.4 Multimodal

When evaluating operations at a signal with pedestrian crossings, the crossing times shall be compliant with the pedestrian clearance interval requirements outlined in the *Manual on Uniform Traffic Control Devices* (MUTCD). In a coordinated signal network, if there are two or more pedestrian crossings on one leg in an hour, the signal timings should be such that a pedestrian crossing will not force the signal out of coordination.

If the location of a development offers multimodal options of transportation (e.g., bus routes, bike paths/sidewalks, etc.), a portion of the trips generated from the site will likely use multimodal forms of transportation, thus reducing the number of vehicle trips generated. Selecting the appropriate setting/location in the ITE Trip Generation Manual (e.g., general urban/suburban, dense multi-use urban, center city core) will account for this. If a development is planned in an area with easy access to multimodal transportation, and the projected number of generated trips came from outside the ITE Trip Generation Manual without a multimodal factor, a multimodal reduction rate shall be used. These rates can be found in ITE Trip Generation Manual and reduce the number of vehicle trips by a factor that is specific to the location and the development, as some types of developments are more likely than others to generate multimodal trips. Prior to using the multimodal reduction rates, engineering judgment should be used to determine whether a development is in a location, and is the type of development, to generate multimodal trips. The use of a vehicle reduction rate shall be documented.

To fully account for the multimodal function of the transportation system, LOS beyond those calculations described in the *Highway Capacity Manual* shall be considered along development sites and for transportation facilities. New development shall have a minimum multimodal LOS C. LOS D – F shall not be acceptable. While LOS ~~D~~ C is acceptable for multimodal LOS, site development should target the best LOS achievable. The site pedestrian and transit LOS shall be evaluated using a directness ratio, as follows:

$$D = (W + U)/C \tag{4.1}$$

Where:

- D = the site's directness ratio
- W = the total walking distance along a trail, public street, or sidewalk from the site's entrance or furthest building to the destination
- U = the distance along the walking route not designed for pedestrians. This includes areas where the pedestrian must walk in the street or shoulder, along unpaved or rough paths, paths less than 4 feet wide, and unmarked crossings of vehicular travel ways
- C = the straight-line distance from the site's entrance or furthest building to the destination

The directness ratio for residential or lodging sites will be measured to the nearest public school, park, or restaurant. For all other uses, the directness ratio will be measured to the nearest public multi-use trail or sidewalk. The directness ratio for Transit LOS will be measured to the nearest transit stop. The resulting LOS from the site directness ratio calculation is shown below. LOS is F where the walking distance exceeds ½ mile, regardless of the site directness ratio.

Table 4.2. Site Directness Ratio

Pedestrian and Transit Level of Service	Site Directness Ratio
A	≤ 1.2
B	>1.2 – 1.4
C	>1.4 – 1.6
D	>1.6 – 1.8
E	>1.8 – 2.0
F	>2.0 or walking distance greater than ½ mile

Bicycle LOS shall be evaluated by evaluated the Level of Traffic Stress (LTS) for each street or trail running along and internal to the site. LTS for each facility is rated from 1 to 5, with 1 meaning that there is low stress for cyclists and 5 meaning that it is a high stress environment. The road characteristics for each LTS is shown in the table below:

Table 4.3. Bicycle Level of Traffic Stress (LTS)

Level of Traffic Stress	Shared Lanes	Bike Lanes	Trails
1	2 lanes <2k ADT ≤ 25 mph	2-3 lanes ≤ 25 mph	Greenway
2	2 lanes 2-4k ADT ≤ 30 mph	2-3 lanes ≤ 30 mph	Sidepath (low ped volume)
3	2 lanes 4-6k ADT ≤ 35 mph	3-4 lanes ≤ 35 mph	Sidepath (high ped volume)
4	≥ 3 lanes > 6k ADT > 35 mph	> 4 lanes > 35 mph	
5	≥ 4 lanes > 6k ADT > 40 mph	> 4 lanes > 40 mph Bike lane < 4 ft	

Once LTS has been evaluated, the LOS will be determined by the length weighted average of the facilities along the site. For example, assume a particular site has a roadway bordering it on two sides. One of the roadways fronts 150-ft of the site and is a two-lane local road with 25 MPH speed limit and an Average Daily Traffic (ADT) of 1,500 vehicles per day. The other road fronts 100-ft of the site and is a four-lane collector with bike lanes and a posted speed of 30 MPH. The length weighted average LTS is:

$$[(150\text{-ft} \times 1) + (100\text{-ft} \times 3)] / (150\text{-ft} + 100\text{-ft}) = 1.8.$$

From Table 4.4 the bicycle LOS is C.

Table 4.4. Bicycle LOS

Bicycle Level of Service	Site Bicycle Level of Traffic Stress
A	1.0
B	>1.0 – 1.5
C	>1.5 – 2.0
D	>2.0 – 2.5
E	>2.5– 3.0
F	>3.0

4.5.5 Traffic Forecasts

CDOT's Online Transportation Information System (OTIS) count stations shall be used when forecasting the background growth for state highways.

https://dtdapps.coloradodot.info/otis

The ITE Trip Generation Manual shall be used to calculate the number of generated trips, which will be added to the background growth. When projecting background growth on Town roads, if the road is a through street, the OTIS growth rate for SH 9 may be used. If the road is not a through street, background traffic growth should be based on the trip generation potential for any undeveloped land or known planned development along the local road in addition to the OTIS growth rate for SH 9. For the purposes of this section, "through" streets connect to other roadways and therefore may experience traffic volumes that originate from outside the street in question. If no development (or redevelopment) is expected along a local road, the background growth may be assumed to be zero.

4.5.6 Impact Analysis

Traffic analyses shall be conducted in accordance with procedures outlined in the Highway Capacity Manual, with the Level of Service (LOS) being the primary metric for evaluating intersection operations. LOS is a measure of the quality of traffic flow and ranges from LOS A (nearly ideal traffic conditions with very little delay for motorists) to LOS F (poor traffic conditions with long motorist delays). LOS C is typically considered a "good" traffic condition. LOS D or better conditions are typically desirable during peak traffic periods. A LOS of E or F during peak traffic periods is unacceptable for overall intersections; however, LOS E and F conditions are not uncommon for side street traffic movements at full movement, unsignalized intersections with high volume arterial roadways. In situations where a side street movement operates at LOS E or F, the volume to capacity (V/C) ratio shall be reported as well. If the side street is nearing or at capacity, mitigation measures shall be identified. The Town Engineer may require improvements to any street or intersection projected to operate at a LOS E or F, regardless of whether the movement is a side street. Additionally, the Town Engineer may require mitigation to any drop in LOS (e.g.,~~,~~ a reduction from LOS A to LOS C).

A minimum of two future scenarios shall be modeled when assessing the impacts that a development or proposed roadway changes will have on traffic operations. A "w/o Development" scenario, analyzing traffic conditions without the changes proposed by the traffic study, will be compared to the "w/Development" scenario for the same year, analyzing traffic conditions with the proposed changes. If an intersection is expected to operate acceptably for the "w/o Development" scenario, but unacceptably for the "w/Development" scenario (e.g., a signalized intersection or roundabout operating at LOS E or F, or a stop-controlled intersection operating at LOS E or F as well as being near or at capacity), it is the responsibility of the developer to implement intersection improvements in order to ensure acceptable traffic operations at the intersections.

Short-term traffic studies shall be required to evaluate traffic conditions at year-of-opening and 5-years post-development. Long-term traffic studies shall evaluate traffic conditions at year-of-opening, 5-years post-development, and 20-years post-development. In addition, long-term traffic studies that include phased development shall evaluate traffic conditions at completion of each interim phase.

If an unsignalized intersection has high side street volumes, resulting in poor operational conditions, a signal warrant study shall be conducted in a manner consistent with procedures outlined in the MUTCD.

The need for auxiliary lanes on state highways shall be assessed in accordance with the State Highway Access Code requirements. Turning movements that meet the State Highway Access Code standards are required to have an auxiliary lane. If a movement does not meet the required volume, an auxiliary lane may still be installed, if deemed helpful to safety or traffic operations. On local roads, auxiliary lanes shall be installed in locations where they will provide a benefit to traffic operations or safety.

4.5.7 Improvement Recommendations

If the Town Engineer determines that the installation of a needed improvement is not feasible, a cash contribution determined based upon the magnitude of the development's impacts and the capital cost of the needed improvement shall be assessed. Feasibility shall be determined based on physical, schedule, and financial constraints, as well as consideration for other projects and proposed future improvements. The cash contribution shall be in lieu of the improvement and/or land dedications and in proportion to the impacts attributable to the development. A development's proportional share shall be determined by the percent of total trips triggering the need for an improvement that are made up of site generated trips (e.g., if there is a left turning movement of 14 vehicles per hour, warranting a left turn lane, and 7 of those trips are generated from the development, the developments share of the cost will be 50%). The higher percentage between the AM and PM peak hours will be used to determine the developments required contribution. A development's contribution towards a traffic signal will be determined by the percent of the total trips on the higher volume side street made up of development generated trips. If there is a free right turn lane, it may be excluded from the calculations. The higher percentage between the AM and PM peak hours will be used to determine the contribution.

Cash contributions shall be held by the town solely for the acquisition and improvement of transportation mobility (nonauto as well as auto) alternatives within the community. Because of the small size of the community, the provision of transportation mobility improvements anywhere within the Breckenridge Comprehensive Plan boundary shall be deemed to meet the needs of the proposed project.

4.5.8 Intersection Improvement Recommendations

If an intersection is forecasted to operate unacceptably and intersection improvements are required, the Town has a strong preference for the installation of roundabouts, mini-roundabouts, or other geometric treatments. If intersection improvements are required at an intersection identified in the 2017 Park Ave SH 9 Roundabout Modeling and Construction Feasibility Study, then the Developer will be required to construct improvements per the recommendations of that study.

Studies conducted by the Town and other agencies have identified many benefits of roundabouts, including:

- Roundabouts reduced injury crashes by 75 percent at intersections where stop signs or signals were previously used for traffic control (IIHS Study).
- Typical signalized intersections have 32 vehicle-to-vehicle conflict points and 24 vehicle-to-pedestrian conflict points. Typical roundabouts only have 8 vehicle-to-vehicle conflict points and 8 vehicle-to-pedestrian conflict points.

- Roundabouts are designed with geometric curves which force vehicles to reduce speeds through the intersection. At traffic signals, vehicles may speed up to “beat the light”, resulting in higher speeds and the potential for more serious collisions.
- Roundabouts often operate at a comparable or better level of service when compared to signalized or stop controlled intersections. Even at high traffic volumes, roundabouts permit traffic to continue moving instead of creating long stops and standing queues, as may be seen at signalized intersections.
- Roundabouts result in economic benefits for the Town, resulting in approximately $10,000 of savings in maintenance and electrical costs when compared to a signalized intersection. Additionally, roundabouts do not suffer issues from power outages or malfunctioning due to weather.
- In many cases, roundabouts provide environmental and sustainability benefits by reducing stop and go conditions when compared to traffic signals and stop signs, resulting in less fuel consumption, vehicle wear, and improved air quality.
- Roundabouts provide aesthetic benefits by providing increased landscaped areas in intersections and providing a more natural aesthetic than traffic signals, helping to preserve and maintain the historic character of Breckenridge.

CHAPTER 5
STREET STANDARDS

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5.1 INTRODUCTION

Street design addresses safe and efficient movement of vehicles, pedestrians, bicycles, and transit while also incorporating landscaping, utilities, and storm drainage. Low impact drainage systems are encouraged where feasible. The street and trails network create multiple travel routes and minimize the distance required for pedestrians and bicycles to access primary activity sites. This section sets forth the minimum standards for street design and construction. Developers and engineers are encouraged to design above the minimum standards and in some cases due to site specific conditions the Town Engineer may require design above the minimum standards. The purpose and intent of this chapter is to provide safe travel for vehicles and pedestrians, efficient traffic flow which minimizes traffic congestion, and minimizes maintenance concerns.

Chapter 5 also includes access management, which is the coordinated planning, regulation, and design of access between roadways and land development. It involves the systematic control of the location, spacing, design, and operation of accesses, median openings, interchanges, and street connections. Access management provides the means to balance good mobility along the street network with local access needs of businesses and residents. Implementation of access management principles and techniques on transportation networks can provide the following long-term benefits for highway users, communities, and businesses.

These standards apply to the design, construction, and maintenance of both public and private streets, driveways, pedestrian paths, and on-street parking in the Town of Breckenridge. These standards also apply to all construction, whether completed by a private Developer or the Town of Breckenridge. All Town streets, whether new construction or upgrading of existing infrastructure, shall be built in accordance with these standards.

5.2 OTHER STANDARDS

A significant portion of the criteria used by the Town for Street Standards is taken from the 2018 edition of the American Association of State Highway and Transportation Officials (AASHTO) publication *A Policy on Geometric Design of Highways and Streets*. Throughout the rest of Chapter 5, this document will be referred to as the *AASHTO Green Book*. Where no requirement is given in this chapter, the newest additions of the following standards shall govern, unless otherwise approved by the Engineering Division:

1. AASHTO Green Book
2. AASHTO Roadside Design Guide
3. Manual of Uniform Traffic Control Devices (MUTCD)
4. CDOT Roadway Design Guide
5. CDOT Bridge Design Manual
6. CDOT Pavement Design Manual
7. CDOT Drainage Design Manual
8. United States Access Board (PROWAG and ADAAG)

Construction standards for street related improvements are outlined in Chapter ~~7~~ 9 of the standards. Right of Way requirements for work within existing streets and Right of Ways are outlined in Chapter 3 of these standards. Off-street parking requirements are outlined in the Town Code.

5.3 GENERAL DESIGN GUIDELINES

The Town of Breckenridge is located in a mountainous valley with heavy annual snowfall. Due to the terrain, street design poses unique challenges to meet design requirements. The following guidelines shall be followed for designing in this unique environment:

1. Streets shall be designed to maximize southern exposure and minimize north facing or shaded areas, especially on steeper slopes.
2. Street grades shall be minimized to the extent possible, while also minimizing switchbacks and site disturbance.
3. Streets shall be designed to avoid impacting wetlands and other environmentally sensitive areas. Design shall minimize impacts to the environment.
4. Streets shall be designed to retain as many trees and vegetation as possible. Design shall strive to retain or create vegetative buffers between streets and adjacent properties.
5. Drainage in winter shall be considered and icing of roadways and pedestrian routes shall be considered in the design.
6. Impacts of snow and ice to striping, parking, signage, signal sensors and other improvements shall be considered in the design.

5.4 STREET CLASSIFICATION

Town streets are classified according to function. Functional classifications shall be established by the Town Engineer. The Town Engineer has the authority to make the determination for road classification. For planning purposes, the town uses the following functional categories to classify its roads.

5.4.1 Arterial

An arterial street is a high-capacity roadway. The primary function of an arterial street is to deliver traffic from collector streets to freeways or expressways and provide for travel through and between communities. These streets primarily serve through traffic, and access to adjacent property is limited.

An arterial street generally has the following characteristics:

1. Posted speed limit greater than or equal to 35 mph
2. 4-lane minimum width, plus additional turn lanes
3. 10,000 vehicles per day (vpd) expected minimum traffic volume when the land served by the arterial is fully developed
4. Limited access to adjacent parcels of land
5. No back-out drives are permitted

The only arterial street within the Town is Colorado State Highway 9. Since the Town has no existing or planned arterial streets, the design standards in this chapter will not cover their design. Consult the Colorado Department of Transportation Roadway Design Guide for design of arterial streets on the Colorado State Highway System.

5.4.2 Major Collector

A major collector street is a moderate-capacity street which serves to move traffic from local streets and minor collector streets to arterial streets. The major collector balances both through-travel needs and access to adjacent property favoring more access control and higher speeds.

A major collector street generally has the following characteristics:

1. Posted speed limit from 30 mph to 40 mph
2. Traffic volumes generally between 3,000 and 10,000 vehicles per day when the land served by the major collector is fully developed
3. Designed to handle traffic volumes loading from and onto local, other collector, and arterial streets

4. No back-out drives are permitted

Refer to typical section in Standard Details.

5.4.3 Minor Collector

A minor collector street is a low-to-moderate-capacity street which serves to move traffic from local streets and major collector streets to arterial streets. The minor collector balances both through-travel needs and access to adjacent property favoring a higher level of access and lower speeds than a major collector.

A minor collector street generally has the following characteristics:

1. Posted speed limit from 25 mph to 35 mph
2. Traffic volumes generally between 1,000 and 3,000 vehicles per day when the land served by the major collector is fully developed
3. Designed to handle traffic volumes loading from and onto local, other collector, and arterial streets
4. No back-out drives are permitted

Refer to typical section in Standard Details.

5.4.4 Local

A local street provides direct access from abutting properties to alley, major collector, minor collector, or arterial streets. While it provides for some through travel, the primary purpose is to provide access to individual properties.

A local street generally has the following characteristics.

1. Posted speed limit from 15 mph to 25 mph
2. Traffic volumes up to 1,000 vehicles per day
3. Designed for the safety of pedestrians, bicyclists, and the ease of access to adjacent parcels of land

4. Back-out drives may be permitted for single family homes and duplexes

Refer to typical section in Standard Details.

5.5 DESIGN CONTROLS

5.5.1 Design Vehicles

The street design shall accommodate the turning movements of the design vehicle as listed in Table 5.1 below. The design should allow the design vehicle to make turns at intersections without encroaching into the oncoming lanes. The need for vehicles greater than the design vehicle to turn into oncoming lanes shall be reviewed and the design modified if appropriate based on nearby land use or business operations. Existing, proposed, or potential future transit routes as determined by the Transit Superintendent shall be designed to accommodate the design transit vehicle. The design engineer shall confirm that any local fire district turning requirements are also met.

Table 5.1. Design Vehicles

Street Classification	Design Vehicle
Major Collector	Intermediate Semitrailer (WB-40)
Minor Collector	Intercity Bus (BUS-45)
Local	Single-Unit Truck (SU-30)
Transit Facilities	Intercity Bus (BUS-45)
Commercial Access	Single-Unit Truck (SU-30)*
Multi-family Residential Access	Single-Unit Truck (SU-30)
Single-family Residential Access	Passenger Car (P)

* Commercial accesses that routinely use vehicles larger than a SU-30 should select and appropriate design vehicles for the onsite operations.

Additional details on these and other design vehicles can be found in Chapter 2 of the *AASHTO Green Book*.

5.5.2 Design Speed

The choice of design speed is influenced principally by the character of terrain, roadway classifications, and traffic volume. A roadway in the valley floor justifies a higher design speed than a roadway through steep mountainous terrain.

The design speed for streets in the Town will generally be equal to the posted speed. Under certain conditions, the Town Engineer may require that a design speed exceed the posted speed. Refer to Section 5.2 for the posted speed ranges of each street classification.

5.5.3 Right-of-Way Widths

The width of right-of-way depends on the street cross section to be used, topography in the area, and other physical controls. It is important to acquire sufficient right-of-way to facilitate future widening and other improvements as traffic warrants.

Minimum right-of-way widths to be dedicated for street construction in the Town are listed in Table 5.2 below. These minimums may be increased where necessary to meet side slope requirements, roadside drainage ditch requirements, transit facilities, roundabouts, intersection improvements, and other considerations requiring additional public right-of-way for the street.

The minimum clearance from the right-of-way line to the catch point of a cut or fill slope should be 5 feet for all types of cross sections. When feasible, 10 feet of clearance should be provided. Restrictive easements may be provided in lieu of dedicated right-of-way if approved by the Town Council.

Table 5.2. Right-of-Way Widths

Street Classification	Minimum Right-of-Way Width (feet)
Major Collector	80
Minor Collector	70
Local	50

5.5.4 Traffic Considerations

The design of a street and its features should be based upon consideration of the traffic volumes and characteristics to be served. In urban areas, these characteristics usually are dominated by vehicular traffic demands, but the design should also consider pedestrian, bicycle, and transit uses. Information for all current and projected user modes should be considered jointly. Vehicular traffic volumes typically drive the need for street improvements and will affect the geometric design.

5.5.5 Capacity Considerations

The level of congestion that is considered acceptable for a street or intersection will vary. The Level of Service (LOS) is intended to characterize the operating condition of a street or intersection in terms of speed, travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. The results of the LOS should be a key consideration in the design process. Consult Chapter 4 of this manual for more information regarding traffic considerations for street projects.

5.6 DESIGN ELEMENTS

The alignment of a street produces a great impact on the environment, the fabric of the community, and the street user. The alignment consists of a variety of design elements that combine to create a facility that serves traffic safely and efficiently, consistent with the facility's intended function. Principal elements of design include sight distance, horizontal alignment, superelevation, vertical alignment, and cross section elements.

5.6.1 Sight Distance

Sight distance is the length of roadway visible to a driver. Sight distance is required for safe and efficient operation of a vehicle on a highway. The path and speed of motor vehicles on streets are subject to the control of drivers whose ability, training and experience vary greatly. The available sight distance on a roadway should be sufficiently long to enable a vehicle traveling at or near the design speed to stop before reaching an object in its path.

5.6.1.1 Stopping Sight Distance

Stopping sight distance is the sum of two distances: (1) the distance traversed by the vehicle from the instant a driver sights an object necessitating a stop to the instant the brakes are applied, and (2) the distance needed to stop the vehicle from the instant the brakes application begins. These are referred to brake reaction distance and braking distance, respectively. Table 5.3 contains the stopping sight distances on level roadways based on design speed.

Table 5.3. Stopping Sight Distance on Level Roadways

Design Speed (mph)	Brake Reaction Distance (ft)	Braking Distance on Level (ft)	Stopping Sight Distance	
			Calculated (ft)	Design (ft)
15	55.1	21.6	76.7	80
20	73.5	38.4	111.9	115
25	91.9	60.0	151.9	155
30	110.3	86.4	196.7	200
35	128.6	117.6	246.2	250
40	147.0	153.6	300.6	305
45	165.4	194.4	359.8	360

The roadway grade has a significant effect on the braking distance due to gravity. The braking distances are longer for downgrades and shorter on upgrades compared to a level roadway. Table 5.4 contains the revised stopping sight distances based on grades that exceed an upgrade or downgrade of 3 feet rise or fall per 100 feet longitudinally, or 3%. For grades steeper than 9%, stopping sight distance shall be calculated using equations in the AASHTO green book.

Table 5.4. Stopping Sight Distance on Grades

Design Speed (mph)	Stopping Sight Distance (ft)					
	Downgrades			Upgrades		
	3%	6%	9%	3%	6%	9%
15	80	82	85	75	74	73
20	116	120	126	109	107	104
25	158	165	173	147	143	140
30	205	215	227	200	184	179
35	257	271	287	237	229	222
40	315	333	354	289	278	269
45	378	400	427	334	331	320

5.6.1.2 Sight Distance Measurement Criteria

Sight distance is the distance along a roadway throughout which an object of specified height is continuously visible to the driver. This distance is dependent on the height of the driver's eye above the road surface, the specified object height above the road surface, and the height and lateral position of sight obstructions within the driver's line of sight.

5.6.1.2.1 Height of Driver's Eye

For all sight distance calculations involving passenger vehicles, the height of the driver's eye is considered to be 3.50 feet above the road surface. For large trucks, including single-unit trucks and semi-trailers, the recommended value of a truck driver's eye height is 7.60 feet above the road surface.

5.6.1.2.2 Height of Object

For stopping sight distance calculations, a 2.00 feet object height is used. For intersection sight distance calculations, an object height of 3.50 feet is used.

5.6.1.3 Sight Distance on Horizontal Curves

For general use in design of a horizontal curve, the sight line is a chord of the curve, and the stopping sight distance is measured along the centerline of the inside lane along the curve. The value of the horizontal sight line offset (HSO) are determined by setting S, as shown in the diagrammatic sketch in Figure 5.1 and Equation 5.1, equal to the stopping sight distance (SSD). Alternatively, horizontal sight distance for existing conditions can be measured graphically using a computer automated drafting (CAD) program.

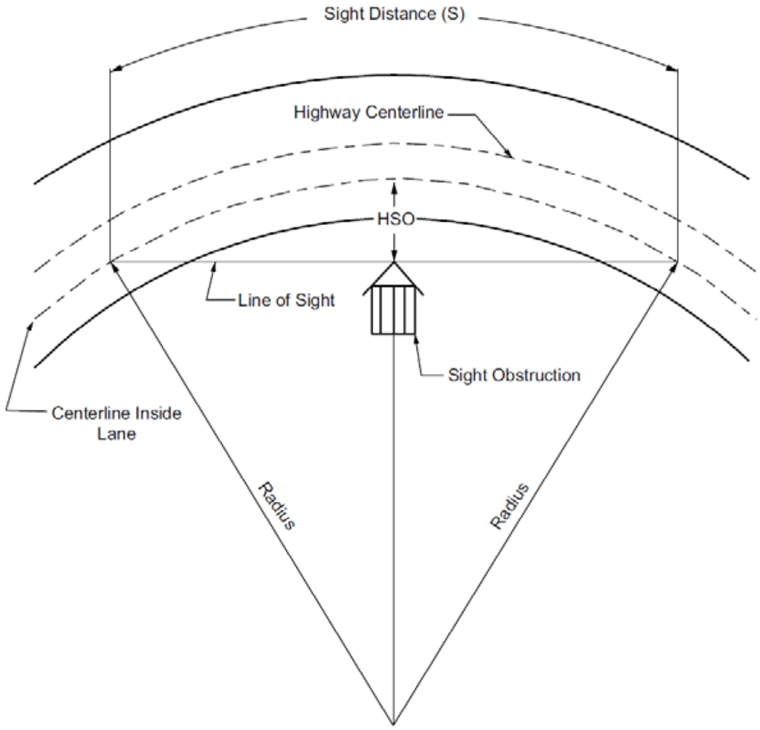

Figure 5.1. Diagram Illustrating Components to Determine Sight Distance

$$\mathrm{HSO} = \mathrm{R}\left[1 - \cos\left(\frac{28.65\ \mathrm{S}}{\mathrm{R}}\right)\right] \qquad (5.1)$$

Where:

HSO = horizontal sight offset (ft)

S = sight distance (ft)

R = radius of curve (ft)

5.6.1.4 Sight Distance on Vertical Curves

The controlling vertical curve design criteria found in Section 5.4.3.3 is based on sight distance. Vertical sight distance for existing conditions can be measured graphically using a computer automated drafting (CAD) program.

5.6.1.5 Intersection Sight Distance

Each intersection has the potential for several different types of vehicular conflicts. The possibility of these conflicts actually occurring can be greatly reduced through the provision of proper sight distances and appropriate traffic controls. The avoidance of conflicts and the efficiency of traffic operations still depend on the judgement, capabilities, and response of each individual driver.

Stopping sight distance is provided continuously along each roadway so that drivers have a view of the roadway ahead that is sufficient to allow drivers to stop. The provision of stopping sight distance at all locations along each roadway, including intersection approaches, is fundamental to intersection operation.

Mid-block or uncontrolled crosswalks shall meet minimum intersection sight distance requirements. Case B1 (Table 9-6 of AASHTO Greenbook) shall be used for minimum values.

5.6.1.5.1 Sight Triangles

Specified areas along intersection approach legs and across their included corners should be clear of obstructions that might block a driver's view of potentially conflicting vehicles. These specified areas are known as clear sight triangles. The dimensions of the legs of the sight triangles depend on the design speeds of the intersection roadways and the type of traffic control used at the intersection. These dimensions are based on observed driver behavior and are documented by space-time profiles and speed choices of drivers on intersection approaches. Two types of clear sight triangles are considered in intersection design-approach sight triangles and departure sight triangles.

5.6.1.5.2 Approach Sight Triangles (Uncontrolled or Yield-Controlled Intersection)

Each quadrant of an intersection should contain a triangular area free of obstructions that might block an approaching driver's view of potentially conflicting vehicles. The length of the legs of this triangular area, along both intersection roadways, should be such that the drivers can see any potentially conflicting vehicles in sufficient time to slow or stop before colliding within the intersection. Figure 5.2 shows typical clear sight triangles to the left and to the right for a vehicle approaching an uncontrolled or yield-controlled intersection.

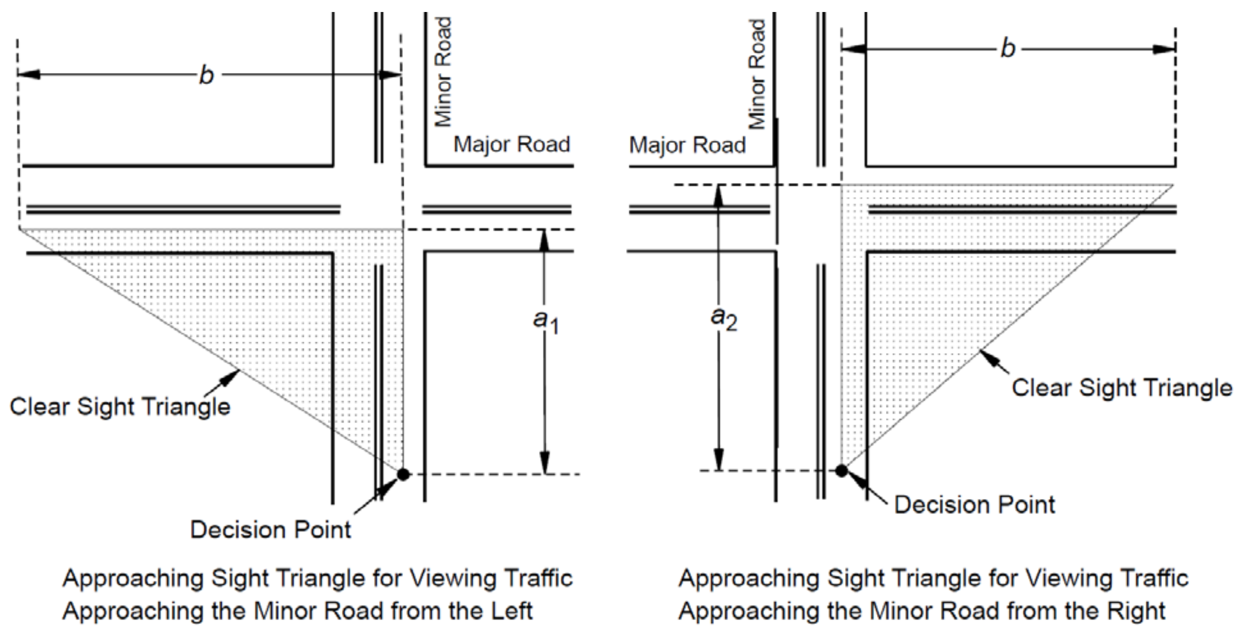

Figure 5.2. Approach Sight Triangles at Intersections (Uncontrolled or Yield-Controlled)

The length of the legs of the approach sight triangle shall be determined in accordance with the practices and standards established in Chapter 9 of the *AASHTO Greenbook.*

5.6.1.5.3 Departure Sight Triangles (Stop Controlled Intersection)

A second type of clear sight triangle provides sight distance sufficient for a stopped driver on a minor-road approach to depart from the intersection and enter or cross the major road. Figure 5.3 shows typical departure sight triangles to the left and to the right of the location of a stopped vehicle on the minor road. Departure Sight Triangles should be provided in each quadrant of each intersection approach controlled by stop or yield signs. Departure sight triangles should also be provided for some signalized intersection approaches.

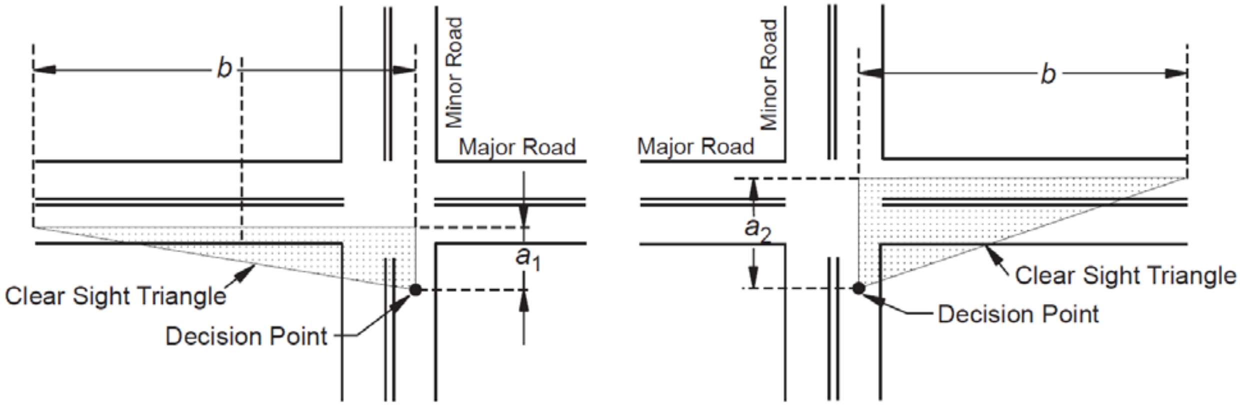

Figure 5.3. Departure Sight Triangles at Intersections (Stop-Controlled)

The length of the legs of the approach sight triangle shall be determined in accordance with the practices and standards established in Chapter 9 of the *AASHTO Greenbook.*

5.6.1.5.4 Identification of Sight Obstructions within Sight Triangles

The profiles of the intersection roadways should be designed to provide the recommended sight distances for drivers on the intersection approaches. Within a sight triangle, any object at a height above the elevation of the adjacent roadways that would obstruct the driver’s view should be removed or lowered, if practical. Such objects may include buildings, parked vehicles, roadway structures, roadside hardware, hedges, trees, bushes, unmowed vegetation, tall crops, walls, fences, stored snow and the terrain itself. No objects or improvements shall be allowed over 3.5 feet tall within the sight triangles, with the exception of regulatory signs, signals, or street lights. If landscaping elements are proposed within the identified sight triangles, landscaping must be maintained so that it does not become an obstruction over 3.5 feet tall. Maintenance responsibilities must be agreed upon with the Town Engineer. Sight triangles shall be shown on all roadway and site design plans.

5.6.2 Horizontal Alignment

Street layout is designed to bear a logical relationship with the topography, connect to existing and planned area streets, and provide reasonable access to adjacent parcels. Street layout shall be designed to fit the context of the development and serve vehicle, pedestrian, transit, and bicycle users. Street layout shall avoid long, straight sections to minimize the potential for speeding.

5.6.2.1 Traffic Calming

ITE defines traffic calming as “the combination of mainly physical measures that reduced the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users.” Local roads in residential neighborhoods shall be designed with traffic calming features. Intersection improvements and pedestrian crossing enhancements are encouraged for pedestrian safety. Major and minor collectors shall be analyzed for traffic calming and may require traffic calming features. Traffic calming encompasses a wide range of different features and methods; the appropriate features for a specific roadway is dependent on a variety of project specific features such as the design speed, traffic volume, development type, maintenance concerns, location within Town, and site constraints. The following hierarchy of traffic calming methods are listed in order from the generally most preferred method to the least preferred method.

1. Horizontal geometry (appropriate radius curves, chicanes, lane narrowing, and other geometry features to promote use of the roadway at the design speed)
2. Raised crosswalks at intersections
3. Intersection bulb-outs
4. Rectangular Rapid-Flashing Beacon or other light emitting hardware at pedestrian crossings
5. Roadway signage per MUTCD
6. Radar speed signs
7. Striping & thermoplastic markings
8. Median islands
9. Speed Humps

All traffic calming features shall be designed per MUTCD, ADA, and all other relevant standards. Features shall accommodate drainage and shall consider maintenance issues and effectiveness during winter conditions.

Traffic calming requests, studies, and design shall comply with the Town of Breckenridge Traffic Calming Policy, which may be obtained from the Engineering Division. Refer to Section 5.14 for traffic calming measures related to uncontrolled pedestrian crossings.

5.6.2.2 Horizontal Curves

Horizontal curve design should be based on an appropriate relationship between design speed, right-of-way, profile grades, and construction costs—and on their joint relationships with superelevation and side friction. Curves are not required when the delta angle (total central angle of the circular curve) is less than 1 degree. Curves should be at least 500 feet long for a central angle of 5 degrees, and the minimum length should be increased 100 feet for each 1 degree decrease in the central angle. The formula can be found in the *AASHTO Greenbook* and the CDOT M & S Standard Plans. Designers should use every effort to exceed the minimum curve radius when practical. Broken back, compound, spirals, or reverse curves are not recommended. Table 5.5 below gives the minimum horizontal curve radius for a normal crown of 2%. For superelevated roadways, refer to Section 5.4.2.3.

Table 5.5. Minimum Horizontal Curve Radius (Normal Crown)

Design Speed (mph)	Minimum Horizontal Curve Radius (ft)
15	50
20	110
25	200
30	335
35	510
40	765
45	1000

5.6.2.3 Superelevation

Local streets utilize standard crown sections and do not require superelevation. Superelevation may be considered on collector streets to address unique horizontal geometry, drainage, or grade issues. At intersections, grades of the minor street shall be warped to transition to the grades of the major street. If a street design requires the use of superelevation, factors controlling the use of superelevation include climate conditions, terrain conditions, classification of the street, and the frequency of slow-moving vehicles on the roadway. In general, a lower rate of superelevation is used in urban areas. The maximum allowable superelevation rate is 6%.

The superelevation transition section consists of the superelevation runoff and tangent runout sections. The superelevation runoff is the length of roadway needed to accomplish a change in outside lane cross slope from zero to full superelevation, or vice versa. The tangent runout section is the length of roadway needed to accomplish a change in outside lane cross slope from normal cross slope rate to zero, or vice versa. Additional information pertaining to the lengths and use of transitions for simple and spiral curves can be found in the *AASHTO Greenbook*. Refer to *CDOT M Standard – Superelevation Streets* for design requirements.

5.6.3 Vertical Alignment

The design should take into consideration the impact the vertical grade has on the operation of the facility. Designers should consider stopping sight distance requirements for the given speed limit and the challenges of large cut-and-fill sections. Vertical curves are classified as either sag or crest curves. Typically, sag curves are controlled by nighttime driving conditions with headlight visibility restrictions, and crest curves are controlled by stopping sight distances. Vertical curves should be simple in application and should result in a design that is safe and comfortable in operation, aesthetically pleasing, and adequate for drainage—especially when a curb and gutter are used.

5.6.3.1 Terrain

Proposed roads shall follow the natural terrain of the existing area whenever possible.

5.6.3.2 Grades

Grade lines are typically controlled by topography and structure clearances, but very flat grade can be controlled by drainage considerations. Other factors that should be considered are street classifications, design speed, safety, and construction costs. A minimum value of 1.0% should be used for street sections with curbs and gutters. In certain conditions, 0.5% may be used. The designer should consider the ultimate design of the roadway, recognizing if a curb and gutter may be required in the future, and design for those conditions during the interim design. Grades 4% or steeper may require special consideration for drainage or erosion protection.

Maximum grades of streets shall not exceed 6%. Major collectors shall flatten to 2% slope for intersections and shall meet the requirements of vertical curves at the intersections. Minor collectors and local roads shall flatten to 4% slope at intersections and shall meet the requirements of vertical curves at the intersections.

5.6.3.3 Vertical Curves

When using combinations of horizontal and vertical curves, it is important to recognize the driver's perspective. Sharp horizontal curvature should not be introduced at or near the top of a pronounced crest vertical curve. If unavoidable, the horizontal curve should be made longer than the vertical curve to help minimize the driver's inability to perceive the horizontal change, especially at night (For further details, see *AASHTO Greenbook* and the *CDOT Roadway Design Guide*). The length of vertical curves can be determined by dividing the rate of vertical curvature by the grade change or algebraic difference in intersecting grades.

$$\mathrm{L} = \mathrm{K}/\mathrm{A} \tag{5.2}$$

Where:

L = length of the vertical curve (ft)

K = rate of curvature

A = grade change (%)

A vertical curve is not required when a grade change or the algebraic difference is equal to or less than 0.2%. The preferred minimum length of a vertical curve is 300 feet. The allowed minimum is 3 times the roadway design speed. Table 5.6 below gives the minimum K values based on design speed.

Table 5.6. Minimum K Values for Vertical Curves

Design Speed (mph)	Minimum K Value (Crest)	Minimum K Value (Sag)
15	3	10
20	7	17
25	12	26
30	19	37
35	29	49
40	44	64

5.6.3.4 Vertical Clearance to Obstructions

Private overhead structures are not permitted in the public ROW and consideration of such structures shall be limited. Signal height clearances shall be per the current MUTCD. For other structures, there shall be a minimum 18-foot clearance on streets. For sidewalks and shared use paths, there shall be a minimum 10-foot clearance.

5.6.4 Cross Section Elements

5.6.4.1 Traveled Way

5.6.4.1.1 Cross Slope

Cross slope is necessary to ensure adequate drainage. The preferred value for a cross slope is 2% for paved streets. Undivided streets should have a normal crown that is a two-way cross slope, with the high point of the cross section located on the street centerline. Divided streets should have a cross slope on each side of the divide, with the high point of each section located where the pavement meets the median. Cross slopes of 2% are permissible on concrete roadways. Intersections of streets with curbs and gutters sometimes require the use of cross-pans for drainage. At these areas, the normal two-way 3% cross slope shall transition to a one-way slope adjacent to the cross pan, with a slope range of 1% to 2%. Cross-pans shall not be allowed on major collectors and are discouraged on minor collectors.

5.6.4.1.2 Lane Widths

Lane widths shall be 11 feet minimum asphalt width in the Town of Breckenridge historic district, and 12 feet minimum asphalt width outside of the historic district, unless a variance is granted by the Town Engineer. The Breckenridge Historic District is defined in Title 9 of the Town Code and the “Breckenridge Handbook of Design Standards. The limits of the Historic District are shown on the Town’s website. The curb, valley pan, or shoulder is not counted in the lane width dimension.

5.6.4.2 Shoulders

Shoulder width shall be 2 feet minimum of compacted aggregate base course plus 4 feet of recoverable zone with only grass vegetation (6-foot wide total clear zone).

Shoulder width for Major Collectors and Arterials shall 4 feet minimum of aggregate compacted base course plus 10 feet of recoverable zone with only grass vegetation (14-foot wide total clear zone).

5.6.4.3 Roadside Design

5.6.4.3.1 Cut and Fill Slopes

Cut and fill slopes for roadway embankment of 3:1 or flatter are preferred. Maximum cut and fill slopes shall be 2:1. Consideration should be given to snow removal problems and snow storage in slope design. It is considered advisable to use flatter slopes in cuts on the southerly side of the roadway where this will provide additional exposure of the pavement to the sun. Flatter slopes shall be considered to reduce erosion, maintenance costs, and to facilitate vegetation. If steeper slopes are needed, side slope material shall be evaluated based on drainage needs to determine appropriate material for stabilization of the slope. See Chapter 7 of these standards for further guidance on temporary and permanent stabilization measures.

The tops of all cut slopes shall be rounded where the material is other than solid rock. A layer of earth overlying a rock cut shall also be rounded.

5.6.4.3.2 Roadside Ditches

See Chapter 6 for Roadside ditch information and design.

5.6.4.3.3 Clear Zone

All fixed objects should be located outside the clear zone as defined in the *AASHTO Roadside Design Guideline*s. The design should provide a clear zone as wide as practical within constraints per the latest version of the *AASHTO Roadside Design Guidelines.* For low speed, low volume roadways a minimum clear recovery zone area of 7 feet in width shall be provided for roadways without curb and 2 feet in width for all roadways with curb.

5.6.4.3.4 Obstructions

Mailboxes, address monuments, landscaping, stone headwalls, and other objects shall not be located within the right of way. If any improvements are allowed in the ROW, an encroachment license shall be filed prior to issuance of permit.

5.6.4.3.5 Roadside Barriers

The installation of roadside barriers on embankments and adjacent to fixed objects may reduce the combined effect of severity and frequency of “run-off-road” type crashes. Roadside barriers reduce crash severity only when the overall severity of striking the guardrail is less than the severity of going down an embankment or striking a fixed object. They should not be installed if they are likely to create a greater hazard than running off the street. To the extent possible, streets shall be designed to eliminate the need for roadside barriers by eliminating obstructions, steep grades, and other hazards from the clear zone. Evaluating installation of roadside barriers shall consider crash experience, street objectives, functional classification of streets, design speed, traffic volume and type, street cross section, height of embankment, steepness of fill slope, horizontal curvature, gradient or profile conditions, street side conditions, climatic conditions, and degree of projected injury from traveling off the street. Special consideration shall be given to winter and icy conditions which might necessitate a roadside barrier that would not be needed under normal conditions. Refer to the *AASHTO Roadside Design Guide* for roadside barrier best practices. Refer to the *CDOT M Standards* for roadside barrier installation and construction requirements.

Guardrails and concrete barriers shall typically be colored brown and rails shall not be made of galvanized or reflective materials (reflector tabs and other reflective devices shall be installed per AASHTO and CDOT standards). Custom guardrails or barriers utilizing natural materials shall meet AASHTO and CDOT standards and be impact rated.

When roadside barrier is considered for installation, especially in extended lengths, provisions shall be made for adequate snow storage and removal. Flared end treatments are preferred over non-flared end treatments for snow removal operations.

5.6.4.3.6 Retaining Walls

Retaining walls and abutments are discouraged within the publicly maintained right-of-way. All designs of retaining walls, foundations, and abutments exceeding 48 inches in height (measured from finished grade) will require a sealed geotechnical design and a sealed structural design. Both designs will need to be prepared by registered professional engineers in the State of Colorado prior to the any approval of the retaining wall and abutment. Retaining wall and abutments retain earth with lateral support or at the end of a bridge span, respectively. The design of these structures depends upon type, function, and anticipated service life of retaining wall, earth pressure exerted on the wall by the retained backfill, geometry, strength and deformability of the ground, groundwater, and welling pressure in clay backfills. Four types of retaining wall systems are discussed in this section: conventional retaining walls and abutments, anchored walls, mechanically stabilized earth walls, and prefabricated modular walls.

Wall aesthetics shall be approved by the Town Engineer. Local Home Owner’s Association (HOA) requirements may apply in certain instances.

Retaining walls needed to support private improvements shall not be located in the public right-of-way.

Full or partial height walls shall not be located closer than the outer edge of shoulder. When the top of the retaining wall is at the level of a roadway, the face of the parapet wall or rail shall be at least 4 feet from the edge of the traveled way.

1. Conventional Retaining Walls and Abutments: Conventional retaining walls and abutments are proportioned to provide stability against bearing capacity failure, overturning, and sliding. Retaining walls are discouraged within the public right-of-way. They will be allowed only when necessary to support public improvements. Design of conventional retaining walls and abutments shall satisfy the following loading factors:
   a. Lateral earth and water pressures, including any live and dead load surcharges.
   b. The weight of the wall.
   c. Temperature and shrinkage effects.
   d. Seismic loads.
2. Anchored Walls: Anchored walls provide additional lateral resistance with the use of anchors. Their design is based on the suitability of the subsurface soil and rock conditions. Design of anchored walls shall satisfy the following loading factors:
   a. Lateral earth and water pressures, including any live and dead load surcharges.
   b. The weight of the wall.
   c. Seismic loads.
3. Mechanically Stabilized Earth Walls: Mechanically Stabilized Earth Walls (MSEW) are flexible composites of granular soil and tensile inclusions that behave as earth embankments with vertical or nearly vertical faces. MSEW are proportioned to provide stability against overturning

and sliding. Bearing pressure generally governs design. An MSEW should be used where substantial total and differential settlement is expected. This type of wall may also be used where conventional gravity, cantilever, or counterforted concrete retaining walls are considered. An MSEW shall not be used where utilities other than highway drainage are to be constructed within the reinforced zone or floodplain erosion or scour may undermine the reinforced fill zone or any supporting footing. An MSEW shall not be used where surface or groundwater contaminated by acid mine drainage or other industrial pollutants is present. Design of MSEWs shall satisfy the following loading factors:

a. Lateral earth and water pressures, including any live and dead load surcharges.
b. The weight of the wall.
c. Seismic loads.

4. Prefabricated Modular Walls: Prefabricated modular walls employ soil-filled interlocking modules to resist earth pressures. Stability of modular walls depends upon the weight and strength of the fill soil. Each module level shall be investigated for sliding and overturning. A prefabricated modular wall may be used where conventional gravity, cantilever, or counterforted concrete retaining walls are considered. A prefabricated modular wall shall not be used on curves with radius less than 800 feet, unless the chord can be substituted with a series of chords, or where groundwater or surface runoff is contaminated with acid. Design of prefabricated modular walls shall satisfy the following loading factors:

   a. Lateral earth and water pressures, including any live and dead load surcharges.
   b. The weight of the wall.
   c. Seismic loads.
   d. Earth pressure shall be computed on a plane surface where modules form an
   e. irregular, stepped surface. Ka, used to compute lateral thrust, shall be computed based on the friction angle of the backfill behind the modules.

5.6.4.4 Curbs

Curb and gutter is required at the following locations:

1. On all streets in flat or rolling terrain within subdivision or any similar-type developments where high densities have been planned.
2. Where required by drainage, traffic, or public safety.
3. To replace existing curb.

Refer to the Street Standard Drawings for approved curb and gutter types.

5.6.4.5 Medians

Medians other than those listed within the street cross-sections are generally not permitted on new Town streets and must be approved by the Town Engineer. Medians shall be designed with plowable noses.

5.7 INTERSECTIONS

See Section 5.4.1.5 for intersection sight distance requirements.

5.7.1 Alignment and Profile

Streets must intersect one another at 90-degree angles or as close to 90 degrees as the topography allows. Angles less than 90 degrees must be approved by the Town Engineer. Angles less than 80 degrees are not permitted. Intersecting streets shall remain perpendicular for a minimum of 50 feet from the intersection.

In general, grades for intersecting roads should be as flat as possible to provide for storage platforms and sight distance. Grades shall not exceed 2 percent across a pedestrian access route (PAR) if the intersection is controlled by a stop sign or yield condition. Grades exceeding 2% across a PAR are permissible at signalized intersections or uncontrolled intersection legs, but every effort should be made to minimize the grade to meet 2%. Approach grades greater than 4 percent should be avoided. Grades that may need to be steeper to accommodate cases where the existing terrain does not allow for flatter intersections must be approved by the Town Engineer.

Parking shall not be located within 20 feet of an intersection.

5.7.2 Corner Radii

Radii of 15 to 25 feet are adequate for passenger vehicles. These radii may be provided at minor cross streets where there is little occasion for trucks to turn or at minor intersections where there are parking lanes. Where the street has sufficient capacity to retain the curb lane as a parking lane for the foreseeable future, parking should be restricted for appropriate distances from the crossing.

Radii of 15 feet or more at minor cross streets should be provided on new construction and on reconstruction where space permits.

Radii of 20 feet or more at major cross streets should be provided where feasible so that an occasional truck can turn without too much encroachment.

Radii of 30 feet or more should be provided where large truck combinations and buses turn frequently. Longer radii are also desirable where speed reductions would cause problems.

Curb radii should be coordinated with crosswalk distances or special designs to make crosswalks safe for all pedestrians. Designs which can minimize the corner radii for pedestrians and passenger vehicles, while still allowing trucks to make turning movements, are encourages. Examples include truck blisters, rollover curb, and eliminating any structures or other objects behind the curb but within the truck radius.

5.7.3 Functional Intersection Area

Functional intersection area is the area upstream and downstream of an intersection where intersection operation and conflicts influence driver behavior, vehicle operations, or traffic conditions. Separation of access points should not be less than the functional area of the intersection.

The upstream distance is a combination of the storage length, deceleration and taper length, and the perception-reaction distance required for the speed of the segment. The downstream distance is measured as either acceleration length or decision sight distance. Providing acceleration length allows vehicles to accelerate to normal speed without conflict. Providing decision sight distance allows drivers to pass through an intersection before considering potential conflicts at the next intersection. Functional intersection area is demonstrated below in Figure 5.4.

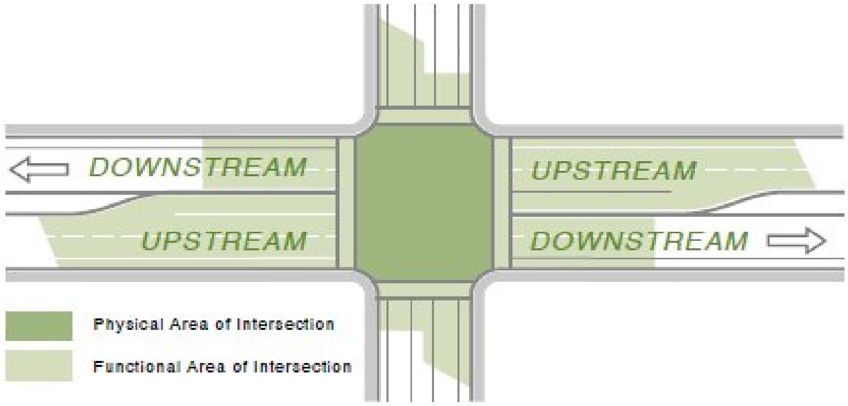

Figure 5.4. Functional Intersection Area

5.7.4 Channelization

5.7.4.1 Islands

Islands are general not permitted on new Town streets, and must be approved by the Town Engineer. Exceptions are made for roundabouts. Islands shall be designed with plowable noses.

5.7.4.2 Medians

Medians are generally not permitted on new Town streets and must be approved by the Town Engineer. Exceptions are made for roundabouts. Medians shall be designed with plowable noses.

5.7.5 Auxiliary Lanes

Auxiliary lanes are useful in maintaining the safety, traffic flow, and operation of a roadway or access. When auxiliary lanes are required by the Town or warranted by information obtained during the development review process, the applicant is responsible for design, installation, and any purchase of right-of-way to accommodate the required lane width. Auxiliary lanes are required when unique location factors (e.g., roadway speed and traffic density, access volume, the volume of commercial trucks, the influence of nearby accesses, existing auxiliary lanes close to the proposed access, nearby traffic control devices, available stopping sight distance, and other topographic or roadway design factors) exist that determine the need for auxiliary lanes. Auxiliary lanes are required to mitigate specifically identified and documented locations with safety and operation issues.

5.7.5.1 Deceleration Lanes

A left deceleration lane, also called a left-turn lane, with storage length plus taper length, is required for any access with a projected peak hour left ingress turning volume greater than 25 vph. If the posted speed is greater than 40 mph, a deceleration lane and taper is required for any access with a projected peak hour left ingress turning volume greater than ~~10~~ 15 vph. The taper length will be included within the deceleration length. A left deceleration lane is not required when the opposing projected peak hour traffic volume is less than 150 vph.

A right deceleration lane, also called a right-turn lane, with storage length plus taper length, is required for any access with a projected peak hour right ingress turning volume greater than 50 vph. If the posted speed is greater than 40 mph, a right turn deceleration lane and taper is required for any access with a projected peak hour right ingress turning volume greater than 25 vph. The taper length will be included within the deceleration length. A right deceleration lane is not required when the advancing projected peak hour traffic volume is less than 400 vph.

5.7.5.1.1 Storage Length

The storage length for an auxiliary lane can be determined by the information summarized in Table 5.7. These lengths are based on the average length of a passenger vehicle and the estimated turning vehicles per hour. Estimated lengths for buses, larger trucks, and recreational vehicles must be determined and submitted to the Town for review. The basis for designing the length of required storage is to provide sufficient length for vehicles to queue within the lane without affecting other movements. Table 5.8 provides the required storage lengths for stop-controlled and signal-controlled intersections. If the Department of Public Works determines that meeting the required storage length is impractical or will result in an unsafe condition, the minimum storage length shall be based on the mean arrival rate. But in no case shall the minimum auxiliary lane length be less than 50 feet.

Table 5.7. Acceleration/Deceleration Lane Design Criteria

Posted Speed Limit (mph)	25	30	35	40	45
Deceleration length (ft)	180	250	310	370	435
Acceleration length (ft)	N/A	190	270	380	550
Transition taper (ratio)	7.5:1	8:1	10:1	12:1	13.5:1
Straight taper (ratio)	15:1	15:1	20:1	30:1	45:1

Table 5.8. Auxiliary Lane Storage Lengths

Turning vehicles per hour	<30	30-59	60-100	>100
Minimum required storage length (ft)	25	40	50	100

5.7.5.1.2 Tapers

Auxiliary lanes typically consist of one or more of the following: transition taper, full width auxiliary lane, and storage length. The use of these components varies based on the type of access, through street classification, and site-specific conditions (grades). To determine the required acceleration and deceleration lane and transition taper length, see design criteria presented in Table 5.7. The length of the required transition taper is determined by multiplying the distance offset by the transition taper ratio value associated with the posted speed. The beginning and ending point of all tapers shall be rounded.

Transition tapers: The purpose of a transition taper is to provide sufficient length for a vehicle to accelerate or decelerate to the appropriate speed and merge into and out of the through traffic lanes without disrupting traffic flow. The length of a transition taper is calculated by multiplying the width of the lane by a standard ratio. The beginning and ending point of all tapers shall be rounded.

Redirect or straight tapers: Redirect tapers shall be used where an exclusive turn lane, median, or other redirection of vehicles is necessary and where redirection of the flow of traffic is necessary to accommodate the exclusive turn lane or median. If the redirect taper would result in a horizontal curve design deficiency for the through movement, the horizontal curve shall be corrected. Redirect tapers should be designed as straight tapers with the beginning and ending points rounded.

5.7.5.2 Acceleration Lanes

Acceleration lanes are required at any access with a project peak hour right turn volume of greater than 50 vph and a posted speed of 40 mph or greater. The purpose of an acceleration lane and transition taper is to provide sufficient length for a vehicle to accelerate to the appropriate speed and merge into the through traffic lanes without disrupting traffic flow. Table 5.7 above provides the required acceleration lane and transition taper lengths by design speed. Acceleration lane lengths shall be adjusted for a grade of 3% or more. The total length of the acceleration lane includes the values of both the lane and transition taper. Shorter acceleration lanes are not permitted, as they are not used properly by most of the traveling public.

5.7.5.3 Two-way Left Turn Lanes

Two-way left turn lanes should be used sparingly. Two-way left turn lanes may be considered on arterial roadways in areas where several low-volume commercial accesses are closely spaced. Two-way left turn lanes shall be 12-16 feet wide.

5.8 DEAD END STREETS (CUL-DE-SACS)

Dead-end streets are discouraged and shall be avoided unless topographic or other unique site constraints limit construction of interconnected streets. The design of cul-de-sacs will be reviewed following the Street Standard Drawings. Any public street or private street that dead ends shall terminate in a cul-de-sac. All cul-de-sacs shall include signage within fifty feet of the inlet indicating that the street is a dead-end street.

5.9 BRIDGES

Bridges, arch culverts, and other structures shall be designed per the CDOT Bridge Design Manual and AASHTO standards. Bridges shall be designed to accommodate the full lane widths, shoulders, curbs, sidewalks, ROW widths, and other improvements detailed in this chapter. Future development and improvements shall be considered when designing bridges. Pedestrian bridges shall exceed the width of the pedestrian route it is serving and shall be 8’ minimum width for shared use paths and 12’ minimum width for shared use paths.

See Town of Breckenridge Open Space and Trail standards for requirements on bridges for soft surface trails.

See Chapter 6 of these standards for hydrologic requirements of bridge structures.

5.10 ACCESS CONTROL AND MANAGEMENT

An access is defined as a privately owned connection to a Town street or right-of-way and may also be referred to as an access road or driveway. A Town, County, or CDOT owned roadway is not classified as an access. Establishing access criteria and the application of access management techniques is highly desirable on public streets. Effective access management enhances the capacity and safety of a street and preserves those elements as the corridor develops further. While access to adjacent properties are required, the Town should attempt to limit the number of access points and their locations, especially on intersection approaches.

5.10.1 Private Access

Private accesses service ~~three~~ four or less single-family homes ~~or~~, one multi-family property, or one commercial property. An access serving five or more homes shall be classified as either a public or private street and not an access (see Section 5.19.1). Private accesses are not owned, maintained, or plowed by the Town. They are the sole responsibility of the property owner. A private access that serves multiple lots shall be located in an easement or common area. The easement or common area width shall accommodate the access width, drainage, construction requirements (slopes, etc.), snow storage, and other appropriate design elements. Cross parcel access easement shall not be less than 30 feet wide. Private access design shall also incorporate International Fire Code (IFC), Red, White, and Blue Fire Department, and development code parking lot design requirements, which are listed those respective standards and codes.

5.10.1.1 Commercial

A commercial private access ~~road~~ is the ~~internal access drive system~~paved vehicle access route for a commercial lot or development and may include the access ~~drives~~driveways ~~,~~ and parking areas that serve the development.

5.10.1.2 Residential

A residential private access ~~road~~ is the ~~internal access drive system~~paved vehicle access route for four or less single-family homes, two duplexes, one triplex, or a multi-family development and may include the access ~~drives~~driveways, and parking areas that serve the development. An access to multiple duplexes or townhomes shall be a public road.

~~5.10.2 Access Management Principles~~

~~Access management is the coordinated planning, regulation, and design of access between roadways and land development. It involves the systematic control of the location, spacing, design, and operation of accesses, median openings, interchanges, and street connections. Access management provides the means to balance good mobility along the street network with local access needs of businesses and residents. Implementation of access management principles and techniques on transportation networks can provide the following long-term benefits for highway users, communities, and businesses.~~

~~5.10.4~~5.10.2 Access Changes

Access changes on Town of Breckenridge streets will typically require a Town Development Permit and a Right of Way permit. Access changes on State Highway 9 will require a CDOT access permit. Access changes on a Town Street (not directly located on a State Highway), but increasing traffic at the nearest State Highway 9 intersection by at least 20%, will also require a CDOT access permit.

~~5.10.4.1~~5.10.2.1 Number of Accesses

Only one access shall be provided per lot for safe ingress and egress. Where topographic or other site conditions exist, shared access between lots may be required.

Additional accesses may be approved off local streets that meet the minimum spacing requirements shown in Table 5.9. Accesses for a collector or arterial street frontage wherein a traffic impact study demonstrates a need for a second access based on traffic volumes, unique site or constraints or site requirements that generates the need for the second access; No feasible design alternatives are available to eliminate the need for a second access. Additional accesses may be allowed if required per IFC code requirements, or for large commercial developments. If an additional access is allowed, the second access shall be added from the minor street. Access from the major street shall be limited to the greatest extent possible.

Where an existing access is required to be removed, the owner is required to remove the driveway, the driveway connection to the public road, driveway apron, and other associated driveway improvements. Where the access crosses a sidewalk, owner will be required to remove the driveway cut and construct curb across the access. Owner will also be required to add any landscaping or block vehicle access with grading, landscaping, or other obstructions.

~~5.10.4.2~~5.10.2.2 Location

Access shall be from the lowest classification street. Lots with alley frontage shall have access from the alley only. When sites adjacent to an alley redevelop, propose a significant remodel or addition, or add a secondary unit, accesses and parking on an adjacent street shall be removed and access shall be solely from the alley. Accesses on a cul-de-sac shall be located to provide room for snow storage and shared access may be required. Exception: where there is an existing garage served by the street that shall remain without changes, the street access can remain to serve the garage. If feasible that access should be upgraded to meet current standards.

One driveway shall be allowed per lot unless otherwise permitted by the Town Engineer. Circular driveways, consisting of two curb cuts onto a street, are not permitted. A second driveway access is only allowed when required by IFC or RWB fire requirements.

All intersection and driveway accesses shall intersect the roadway at a ninety-degree angle.

No backout movements shall be permitted on arterial, major collectors, and minor collectors. Driveways on minor collector streets and above shall have internal circulation provided to allow turnaround movements within the driveway.

One-way accesses are discouraged.

Access location shall be configured to optimize sight distance, separation from adjacent intersections and driveways, and grade at the intersecting road (avoid steeper portions of adjacent roadway).

Commercial or multi-family residential accesses may not be allowed on roadway grades exceeding 6%. On roads exceeding 6%

~~5.10.5~~5.10.3 Access Management Techniques

Several access management techniques may be used to implement best management practices. Techniques include, but are not limited to the following:

1. Consolidate access by reducing the number of access points that serve a single property or by providing joint access for multiple properties at or near a shared property line.
2. Connect adjacent properties to provide circulation between properties and increase access opportunities for multiple properties.
3. Define driveways to provide clear identification of entrance and exit locations.
4. Locate access to a side street (local road) instead of a major road (arterial or collector) to reduce vehicle conflict on the major road.

~~5.10.6~~5.10.4 Sight Distance

Sight distance at accesses must comply with Chapter 9 of the *AASHTO Greenbook*. Table 5.9 identifies the appropriate design vehicle to be used for sight distance calculations. Where existing objects obstruct the AASHTO sight distance for single family or duplex homes, the sight distance triangle may be reduced from 14 feet to 10 feet from the edge of the roadway.

Table 5.9 Design Vehicle Selection for Access Sight Distance

Land Uses Served by Access	Design Vehicles (for sight distance calculations)
Residential (Non-School Bus Route)	Passenger Cars, Pickup Trucks
Part of Any School Bus Route Regardless of Land Use	No Less Than Single Unit Trucks
Office	Single Unit Trucks

Recreational	Single Unit Trucks
Commercial/Retail	Multi-Unit Trucks*
Industrial	Multi-Unit Trucks*
Municipal Streets & County Roads	Multi-Unit Trucks*
Agricultural Field Approaches <1 Per Day	Single Unit Trucks

*If Less Than 2 Multi-Unit Truck Trips Per Day (Average), Use Single Unit Truck

~~5.10.7~~5.10.5 Access Spacing

Table 5.10. provides access spacing requirements based on street classification. Access spacing and offset requirements shall be measured from the edges of the nearest curb returns or pavement radii terminations.

Table 5.10 Access Spacing Requirements

	Street Classification of Road being accessed by Driveway			
Design Element	**Arterial**	**Major Collector**	**Minor Collector**	**Local**
~~Minimum Street Intersection Spacing~~Offset between Street Intersections	¼ ~~½~~ Mile	1000' ~~¼ Mile~~	500' ~~⅛ Mile~~	300'
Offset between adjacent Major Access Driveways (≥100 trips per day)	300'	150'	100'	50'
Offset between adjacent Minor Access Driveways or one Major Access Driveway and one Minor Access Driveway (<100 trips per day)	150'	75'	50'	30'
Offset between Major or Minor access and street intersection	300'	150'	100'	50'

~~5.10.8~~5.10.6 Access Width

Table 5.11 provides access width requirements.

Table 5.11 Access Width Requirements

Layout Parameters	**Residential-1 Unit**	**Residential-2 Units**	**Residential-3-4 Units**	**Residential (Multi-Family Greater than 4 units)**	**Residential Private Street**	**Commercial or Industrial Private Access**

Minimum Width	12’	12’	12’	12’	24’	12’
Maximum Width (Includes flared pavement radius at edge of roadway)	20’**	20’**	24’	24’	24’	32’*
Pavement Return Radius	0’-5’	0’-5’	0’-10’	0’-10’	10’-20’	10’-20’
Maximum Slope (Centerline)	8%	8%	8%	8%	6%	8%

*Utilization of maximum width shall be approved by the Town Engineer.
**Maximum width shall include pavement return radius

~~5.10.9~~5.10.7 Access Type

~~5.10.9.1~~5.10.7.1 Curb Cut Driveway

In general, if there is a pedestrian sidewalk path along the roadway where an access is proposed, the sidewalk shall continue across the driveway. Refer to the Street Standard Drawings for curb cut driveway requirements and details. Exceptions can be made when the single unit and multi-unit truck peak hour volume is greater than 5.

~~5.10.9.2~~5.10.7.2 Radius Driveway

A radius driveway is defined as an access with curb ramps and without a continuous sidewalk across the access. Radius driveways shall be designed in accordance with intersection requirements of this chapter. With a radius driveway, access radii shall be per Table 5.11. If the design vehicle intended to use the access daily is a single-unit exceeding 30 feet, multi-unit, or another vehicle requiring a larger radius, the minimum turn radius accommodating this design vehicle shall be used. Access radii shall allow safe maneuvers without intrusion into adjacent highway travel lanes. In instances where multiple larger vehicles are likely to oppose each other at the access, the radii should be adequate to accommodate both vehicles without conflict. Radius shall balance vehicle access while also promoting slowing of vehicles. Smaller radii should be used where an access crosses a pedestrian route to encourage slower speeds.

~~5.10.10~~5.10.8 Access Design Details

~~5.10.10.1~~5.10.8.1 Access Profile

Driveways shall match the roadway cross-slope for the first five feet, shall not exceed 4% for the following 15 feet, and shall not exceed 8% for the remainder of the driveway.

If a pedestrian access route crosses the driveway, the driveway cross-slope shall be a maximum of 2% for the width of the pedestrian access route (minimum 4 feet wide).

~~5.10.10.2~~5.10.8.2 Access Geometry

Driveways shall meet adjacent streets, alleys, or driveways at a ninety degree angle and remain perpendicular for a minimum of 10 feet from the intersection. Driveways shall have a minimum inside turning radius of 26 feet and outside radius of 38 feet for fire department access, unless an alternate fire access is provided.

~~5.10.10.3~~5.10.8.3 *Access Surfacing*

All accesses shall be paved. Pavement placement shall occur prior to issuance of certificate of occupancy or sooner if required to meet Fire Department or utility requirements. All accesses serving more than four units or lots shall be maintained in proper working condition to prevent potholes and overall surface deterioration. All access and parking areas shall be paved with asphalt, concrete, recycled asphalt, or other all-weather drivable surface approved by the Town Engineer. Access flexible pavement sections shall match the roadway pavement section for a minimum of 10 feet from the edge of the traveled way. Concrete accesses shall either terminate 4 feet from the edge of asphalt on Public Streets with a 3-inch thick minimum asphalt apron constructed between the concrete access and the public street., or concrete can be placed to the edge of asphalt if it is even with or 1 inch lower than the top of asphalt and an expansion joint is provided between the asphalt/concrete interface.

Asphalt pavement shall be a minimum of 3" asphalt on 4" aggregate base course between the roadway and edge of right of way.

5.10.8.4 Access Drainage

Any access connecting to a road with curb and gutter or valley pans shall have a concrete cross-pan installed across the driveway. Any access connecting to a road with an existing road side ditch shall have an 18 inch culvert installed beneath the driveway. The roadside ditch shall be re-graded as needed from the ends of the culvert until the ditch daylights at a 1% slope. Where an access is added to the downhill side of a road and there is no curb, valley pans, or ditches on the existing road, the access may be exempted from the cross pan and culvert requirement.

5.10.9 Access Maintenance

An access does not typically require an encroachment license in the right-of-way. The access and all associated improvements (pavement, culvert, cross pan, flared end sections) shall not be owned or maintained by the Town. All ownership, maintenance, and replacement work shall be the responsibility of the owner. The Town is not liable for any damage incurred by the Town or others to driveway improvements within the right-of-way. The Town shall not be responsible for any damage caused by snow removal, Town vehicles, maintenance, or any other causes. The Town shall have the right to work on the access improvements within the right-of-way as required, such as clearing sediment from culverts and connecting to the access pavement when re-paving the public road, but the Town shall be under no obligation to complete any repair or maintenance.

5.11 PARKING AREAS (ON-STREET PARKING WITHIN RIGHT-OF-WAY)

Section 5.11 sets minimum standards for on-street parking. ~~See Development Code for off-street parking requirements.~~ See Chapter 3 of Title 9 of the Town Code for off-street parking requirements.

~~5.11.2~~5.11.1 On-street Parking

On-Street Parking shall be provided as shown within the street classification cross sections. On-street parking may be provided along streets when approved as part of the ~~Land~~ Development permit approval ~~process~~. All eligible on-street parking areas shall be clearly depicted on a plan. Such parking areas shall not conflict with any turning movements or obstruct access to any street, sidewalk, crosswalk, alley, access, or fire hydrant. ~~To accommodate on-street parking, a credit toward satisfying minimum off-street parking requirements shall be granted~~can be considered ~~for any development that creates additional on-street parking spaces along a public street through the elimination of existing curb-cuts or driveways. See the Development Code for detailed parking requirements based upon existing land use.~~

~~5.11.3~~5.11.2 Parking Area Surfacing

All parking areas shall be paved with asphalt, concrete, recycled asphalt, or other all-weather drivable surface approved by the Town Engineer.

~~5.11.4~~5.11.3 Parking Grades

Parking areas shall have a maximum grade of 4% and a minimum grade of 1%. ADA parking spaces shall have a maximum grade of 2% in any direction.

~~5.11.5~~5.11.4 Parking Stall Requirements

Minimum parking stall size requirements are described below. Parking shall not encroach onto sidewalk, bike lanes, or other pedestrian facilities.

1. The minimum stall size shall be 18 feet long by 9 feet wide for 90 degree or angled parking. Actual striping dimensions shall be adjusted for angled parking to fit the minimum stall size.
2. Parallel parking: 25 feet long by 8 feet wide. Parallel parking stall at the end of a block may be reduced to 20 feet. Accessible parallel parking spaces shall be located near a curb ramp and shall be in an area that is not obstructed by trees or other objects behind the curb.
3. Accessible parking: 18 feet long by 8 feet wide, with a 5- to 8-foot accessibility lane (8 feet is required for van parking). An ADA accessible route shall be provided from the accessible ~~handicap~~ stalls to the businesses being served or the nearest pedestrian route. ADA parking space location, frequency, slopes, and other requirements shall meet PROWAG standards.

~~5.11.6~~5.11.5 Parking Construction Requirements

Construction of on street parking shall meet all standards and specifications of the adjacent street, including pavement thickness, compaction, and other construction specifications. See Chapter 9 of these standards for additional construction requirements.

5.12 PEDESTRIAN AND BICYCLE FACILITIES

Increasing congestion and mode conflict is accompanied by growing public awareness of the need of safe and convenient multi-modal facilities to promote alternative transportation and healthy lifestyles. This section provides for the design of pedestrian, bicycle and transit facilities that play a key role in providing improved accessibility, mobility, and transportation system continuity.

This section shall be used in combination with the AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, AASHTO Guide for the Development of Bicycle Facilities, CDOT Roadway Design Guide (Chapters 12 and 14), Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG), and ADA Accessibility Guidelines (ADAAG) for the design and installation of all pedestrian and bicycle facilities. Where no requirement is given, the current edition of the design standards listed above shall govern.

Section 5.12 applies to both public and private streets. Internal circulation (outside of right-of-way or private street) for individual single family homes or duplexes, and other private development, as determined by the Town Engineer, may be exempted from the requirements of 5.12.

5.12.1 Pedestrian Facilities

All local, minor collector, and major collector roads shall have a minimum of one sidewalk. Town Engineer may require additional sidewalks, shared use paths, and other pedestrian facilities. Sidewalks and other pedestrian facilities shall be installed per the Town's Sidewalk Master Plan, these standards, and as determined by the Town Engineer.

5.12.1.1 Pedestrian Environmental Impact

Sidewalks shall be designed to fit the existing topography and vegetation and minimize site disturbance, removal of vegetation, and disturbance to sensitive environmental areas.

5.12.1.2 Pedestrian Facility Widths

Sidewalks shall be a minimum of 5 feet wide for local roads. Major and minor collector pedestrian facilities shall be a minimum of 6 feet wide.

Soft surface trails intended for ADA accessibility shall have a minimum width of 4 feet wide.

5.12.1.3 Pedestrian Pavement Thickness

Concrete sidewalks shall be a minimum of 5 inches thick. Sidewalks within a driveway shall be a minimum of 6 inches thick and reinforced with welded wire reinforcement. Sidewalks crossing a driveway with heavy commercial loading shall be a minimum of 8 inches thick. All concrete sidewalk pavement shall be placed on a minimum thickness of a 4 inch aggregate base course layer.

5.12.1.4 Horizontal and Vertical Clearance

Sidewalk vertical clearance shall be a minimum of 8 feet. Sidewalk horizontal clearance shall be 3 feet preferred and 2 feet minimum. No structures or other objects shall extend into the clearance offsets.

5.12.1.5 Sidewalk Widening

When a sidewalk is required to be widened, the widening must be a minimum width of 4 feet or more. If the required added width is less than 4 feet, the existing sidewalk shall be removed and reconstructed to the required width.

5.12.1.6 Slope

The minimum cross slope of a sidewalk is 1% and the maximum cross slope is 2%, measured perpendicular to the sidewalk or path alignment. The cross-slope shall generally be towards the roadway, unless drainage facilities are provided behind the sidewalk. The maximum running slope for sidewalk not aligned with a roadway is 5%. If the sidewalk is aligned with the roadway, the sidewalk may match the slope of the roadway. See Section 5.13 of this chapter for ADA requirements of sidewalks and curb ramps. Sidewalks shall be accessible and shall have directional curb ramps.

5.12.1.7 Sidewalk Shouldering

Sidewalks shall have a compacted aggregate base course shoulder of 1-foot minimum width. The shoulder shall be sloped at a minimum of 1% away from the sidewalk. Landscaping may extend to the edge of the sidewalk only if the area is graded at 1%, grass or plantings are selected that do not cause maintenance issues, and the landscaping does not extend horizontally into the landscaping. Short grasses are typically the only landscaping allowed in the shoulder area.

5.12.1.8 Sidewalk Stormwater

Sidewalk shall be designed to handle runoff and provide positive drainage away from the sidewalk, typically towards the roadway. Obstructions shall not be placed at the edge of the sidewalk which obstruct stormwater flow. Low points in the sidewalk should be avoided to the extent possible due to ponding and freezing conditions in the winter.

5.12.1.9 Sidewalk Alignment

Standalone sidewalks and trail connections are encouraged in developments where their additions provide a shorter connection for pedestrians. Sidewalk alignments shall strive to provide the shortest distances between locations in order to promote efficiency of pedestrian transportation and to prevent pedestrians from walking outside the sidewalks.

5.12.1.10 Heated Sidewalks

This section only applies to heated sidewalks located within the Town right-of-way. For private snow melt systems, see Section 5.19.2 of this chapter and section 9-1-19-33A and 33R of the Town Code. Heated sidewalks located within Town right-of-way shall be designed by a Colorado licensed Professional Engineer. Heated sidewalks shall be designed with the following requirements:

- Snowmelt systems shall be hydronic snowmelt systems designed to produce a minimum of 125 BTU/SF and hydronic tubing loops shall be a maximum of 300 linear feet, unless an alternate design of acceptable performance is submitted by a Professional Engineer.
- Manifolds shall be located in traffic rated boxes placed outside of the concrete pavement.
- Concrete shall be a minimum of 5” thick.
- High PSI (60 psi) board insulation shall be placed beneath sidewalks which do not receive heavy traffic loads. In areas are expected to experience heavy truck traffic, astrofoil or other non-compressible insulation shall be placed beneath pavement.
- Welded wire mesh or other reinforcement shall be installed in traffic areas.
- Cold joints, where heated pavement meets non-heated pavement, shall be filled with backer rod and sealant to limit moisture infiltration.
- Heated pavement shall be doweled or connected by other means to non-heated pavement to minimize differential settlement and prevent trip hazards. Doweling is not required adjacent to curb, buildings, walls, or other locations that are not within the pedestrian path.
- Heated pavement shall be graded with a cross-slope and shall not drain onto non-heated pavement, creating any icing or safety hazards. Drainage shall be directed to an inlet, swale, drywell, or other approved connection point.

5.12.1.11 Trail Connections

Soft surface trail connections are encouraged and shall be installed per the Breckenridge ~~Trails~~ Open Space and Trails Master Plan and as required by the Town Engineer. Soft surface trails provide connections to existing trails, open spaces, parks, and other community destinations for pedestrians, bicyclists, and other non-motorized uses. Soft surface trails shall be designed and installed to limit grading impacts, tree removals, and other disturbance. Additional design and install details shall be coordinated and approved by the Town of Breckenridge Open Space and Trails ~~Department~~Division.

5.12.1.12 Pedestrian Bridges

Pedestrian bridges shall be a minimum width of 8 feet. Pedestrian bridges on the Blue River Rec Path shall be a minimum of 14 feet. Pedestrian railings shall be provided along bridges. See Chapter 6 for hydrologic requirements of pedestrian bridges. Pedestrian bridges on the Blue River Rec Path or bridges being maintained by the Town shall be designed to accommodate a 20 TON design vehicle. All pedestrian bridges shall be designed for the snow loads per Breckenridge Building Code. See Open Space and Trail standards for bridge requirements serving soft surface trails.

5.12.1.13 Pedestrian Railings

Hazards located near a sidewalk shall require a pedestrian railing or other barrier at the edge of the path. Examples of hazards include 2:1 slopes and vertical drops exceeding 30 inches.

5.12.1.14 Pedestrian Easements

All pedestrian facilities and trails not located within ROW shall be located within an access easement. Pedestrian facilities and trails shall have a 5-foot minimum distance from back of sidewalk/trail to edge of ROW/easement to accommodate drainage, signage, lighting, and utilities.

5.12.2 Bicycle & Shared-use Facilities

Bicycle & Shared-use facilities shall be installed per the Breckenridge Open Space and Trails Master Plan, Sidewalk Master Plan, and by the direction of the Town Engineer, and any other applicable requirements. Bicycle facility design shall follow the AASHTO Guide for the Development of Bicycle Facilities, current edition and the CDOT Roadway Design Guide for Bicycle and Pedestrian Facilities. Sight distance, vertical geometry, and horizontal geometry shall meet the requirements of AASHTO and CDOT.

For this chapter, the term shared-use will apply to both shared-use facilities and bicycle facilities.

5.12.2.1 Shared-use Environmental Impact

Shared-use paths shall be designed to fit the existing topography and vegetation and minimize site disturbance, removal of vegetation, and disturbance to sensitive environmental areas.

5.12.2.2 Design Speed

The design speed for shared-use paths on grades of 4% or less shall be 20 mph. The design speed for sections of shared use-paths exceeding 4% shall be 30 mph. For shared-use paths near intersections, underpasses, or other hazards where traffic calming is warranted, a lower design speed may be submitted to the Town Engineer for approval.

5.12.2.3 Shared-use Facility Widths

Shared use paths shall be at least 10 feet wide; the Blue River Recreation Path shall be at least 14 feet wide. Underpass widths shall be at least 14 feet wide.

5.12.2.4 Shared-use Pavement Thickness

Concrete shared-use paths shall be a minimum of 5 inches thick. Shared-use paths within a driveway shall be a minimum of 6 inches thick and reinforced with welded wire reinforcement. Shared-use paths crossing a driveway with heavy commercial loading shall be a minimum of 8 inches thick. Longitudinal joints in the concrete shall not be allowed in shared use paths. Transverse joints shall be sawcut and shall not be tooled.

Asphalt pavement for shared-use paths shall be a minimum of 3 inches thick and placed in two lifts. Asphalt shared-use paths within a driveway shall be a minimum of 4 inches thick.

All concrete sidewalk pavement shall be placed on a minimum thickness of a 4 inch aggregate base course layer.

Concrete and asphalt pavements for shared use paths shall be designed by a professional engineer licensed in the state of Colorado.

5.12.2.5 Shared-use Horizontal and Vertical Clearance

Shared-use paths shall have a minimum vertical clearance of 10 feet. Shared-use paths shall have a minimum horizontal clearance of 3 feet from the edge of pavement. No structures or other objects shall extend into the clearance offsets.

5.12.2.6 Shared-use Widening

When a shared-use path is to be widened or a pavement cut is planned, the full width of pavement shall be removed and replaced. No longitudinal joints will be allowed in concrete or asphalt shared-use paths.

5.12.2.7 Shared-use Slope

The minimum cross slope of a shared-use path is 1% and the maximum cross slope is 2%. The maximum running slope for a shared-use path not aligned with a roadway is 5%. If the shared-use path is aligned with the roadway, the sidewalk may match the slope of the roadway. See Section 5.13 of this chapter for ADA requirements of curb ramps. Shared-use paths shall be accessible and shall have directional curb ramps.

5.12.2.8 Shared-use Shouldering

Shared-use paths shall have a compacted shoulder with a minimum width of 2 feet wide. The shoulder shall be sloped at a minimum of 1% and a maximum of 16% away from the shared-use path.

5.12.2.9 Shared-use Stormwater

Shared-use path design shall consider runoff and provide positive drainage away from the path. Obstructions shall not be placed at the edge of the path which obstructs stormwater flow. Low points in the path should be avoided to the extent possible due to ponding and freezing conditions in the winter.

5.12.2.10 Shared-use Alignment

Standalone shared-use paths and trail connections are encouraged in developments where their additions provide a shorter connection for pedestrians. Shared-use alignments shall strive to provide the shortest distances between locations in order to promote efficiency of pedestrian transportation and to prevent pedestrians from walking outside the sidewalks.

5.12.2.11 Shared-use Bridges

Shared-use bridges shall be a minimum width of 10 feet. Bridges on the Blue River Rec Path shall be a minimum width of 14 feet. Pedestrian railings shall be provided along bridges. See Chapter 6 for hydrologic requirements of pedestrian bridges.

5.12.2.12 Shared-use Railings

Hazards located within the clear zone of the shared-use path shall require a pedestrian railing or other barrier at the edge of the path. Examples of hazards include 2:1 slopes, vertical drops exceeding 30 inches, and structures in the clear zone.

5.12.2.13 Shared-use Easements

All shared-use facilities and trails not located within ROW shall be located within an access easement. Pedestrian facilities and trails shall have a 5-foot minimum distance from back of shared-use path/trail to edge of ROW/easement to accommodate drainage, signage, lighting, and utilities.

Where outside of the ROW, the bicycle facility shall be in a public access easement of sufficient width to allow for repairs to the facility, accommodate any drainage, and allow for installation of any required signs.

All arterial and collector street cross sections include bike lanes on both sides of the street or a shared use path. The minimum width of the bike lanes is 5 feet.

Bicycle lanes on streets without on-street parking shall be at least 5 feet wide, exclusive of the curb pan, or 6.5' from the face of any curb. On existing streets where on-street bike lanes are being added and available right-of-way or improvements space is restricted, the width of the bicycle lane may be reduced to at least 5 feet wide, inclusive of the curb pan. Bicycle lanes on streets with on-street parking shall be at least 5 feet wide, exclusive of the parking lane, or 13 feet from the face of any curb. On existing streets where on-street bike lanes are being added and available right-of-way or improvements space is restricted, the width of the bicycle lane may be reduced to at least 4 feet wide, exclusive of the parking lane, or 12 feet from the face of any curb.

5.13 ACCESSIBLE PEDESTRIAN DESIGN

Curb Ramps on sidewalks shall be designed to comply with *Public Rights-of-Way Accessibility Guidelines* including detectable warnings. Where feasible separate ramps shall be provided for each crossing direction. Where site constraints prohibit separate ramps, a single multidirectional ramp may be used. Refer to *CDOT M & S Standard Plans* for ramp details. The standard detectable warning shall be cast iron, natural finish plates or approved equal.

5.13.1 ADA Accessibility Requirements, Standards, and Guidelines

The ADAAG and the PROWAG are not requirements of the ADA but serve as the standards and guidelines by which compliance of the law is measured. Generally, the ADA law requires:

1. New construction to be accessible
2. Alterations to existing facilities that are within the scope of a project to provide accessibility to the maximum extent feasible
3. Existing facilities that have not been altered shall not deny access to persons with disabilities

All new construction projects where a pedestrian demand is exhibited shall incorporate appropriate pedestrian facilities that are accessible to persons with disabilities. New construction projects have the ability to mitigate constraints through good planning and design practices. Project budget or limited scopes are not an acceptable reason to fail to provide compliant accessible facilities during new construction.

5.13.2 Technical Requirements for Accessible Design

The pedestrian access route (PAR) is a continuous and unobstructed path of travel provided for pedestrians with disabilities within or coinciding with a pedestrian circulation path.

The continuous width of the PAR shall be 5 feet minimum, exclusive of the curb. Where a pedestrian access route makes a 90-degree turn, it should be widened to 5 feet to accommodate the continuous passage of a wheelchair (i.e. pedestrian design vehicle). If the clear width of the PAR is less than 5 feet, passing spaces shall be provided at a maximum of 200-foot intervals. If passing spaces are provided, they shall be 5 feet by 5 feet minimum. The clear width of a pedestrian refuge island shall be 5 feet minimum.

Pedestrian facilities shall have a maximum running slope of 5%. If the grade of the roadway is steeper than 5%, then running slopes are permitted to match the grade of the roadway.

Pinch points should generally be avoided. Pinch points within the PAR shall not be less than 34 inches in width and not exceed 24 inches in the direction of pedestrian travel.

5.13.3 Curb Ramp Types

See the Street Standard Details for approved curb ramp types.

5.13.4 Curb Ramp Technical Requirements

5.13.4.1 Ramps

Curb ramps shall have a maximum running slope of 8.33%. The running slope of a curb ramp is measured in the center of the ramp run in the direction of pedestrian travel. If the surrounding terrain requires a ramp to chase grade, the ramp is required to be no longer than 15 feet, regardless of the resulting slope.

5.13.4.2 Landings and Turning Spaces

Landings and turning spaces allow users to maneuver on and off the curb ramp and are required at the top or bottom of a curb ramp. Turning spaces are required at the top of a perpendicular curb ramp and at the bottom of a parallel curb ramp. The maximum running slope and cross slope of landings and turning spaces shall be 2.0%. At mid-block crossings or locations without yield or stop control, the cross slope of the turning space can equal the street or highway grade. Turning spaces shall be 4 feet by 4 feet minimum. If the turning space is constrained by a vertical element on one or more sides, provide 5 feet in the direction of the street crossing.

When the profile of the roadway being crossed has an excessive slope, the curb ramp cross slope should be transitioned slowly to the turning space. The transition shall be spread evenly over the length of the curb ramp. See Curb Ramp Standard Details.

5.13.4.3 Cross Slopes

Cross slopes of all pedestrian facilities shall be a minimum of 1% and shall not exceed 2%.

5.13.5 Detectable Warning Surfaces

Detectable warning surfaces shall be made of untreated steel plates. Brick pavers are not permitted for detectable warnings. See CDOT M-Standards for Curb Ramps for detectable warning requirements.

5.13.6 Pedestrian Crossings at Controlled Intersections

Refer to Section 5.10 for Pedestrian Crossings at uncontrolled or mid-block crossings.

5.13.6.1 Signalized Intersection Crossing Controls

If an intersection under signal control has sidewalks, then marked crosswalks should be provided. In urbanized areas pedestrian signals are recommended at all intersections where sidewalks are provided on the approaches to a signalized intersection. STOP lines shall be placed a minimum of 4 feet in advance of the crosswalks. Consideration may be given to providing advance right turn STOP lines to improve the visibility of pedestrians coming from the motorist’s left.

Pedestrian push buttons shall be accessible to pedestrians via an accessible pedestrian route in compliance with the ADA.

The draft PROWAG requires that whenever pedestrian signals are installed, accessible pedestrian push buttons be installed. Push buttons shall be connected to a fully-accessible pedestrian signal that complies with the *2009 MUTCD with amendments,* with the ability to enable or disable accessible features. The Town Engineer will decide on which functions to activate at each accessible pedestrian crossing on a case-by-case basis.

At intersections with high volumes of pedestrians, consideration should be given to restricting the right turn on red movement.

5.13.6.2 Stop and Yield Crossing Controls

At a minimum, marked crosswalks should be provided wherever a sidewalk crosses a street under stop or yield control. STOP or YIELD lines shall be placed a minimum of 4 feet in advance of the crosswalks.

5.13.6.3 Roundabout Crossing Controls

Requirements for roundabout crossings shall reference the latest version of *NCHRP Report 672 – Roundabouts: An Informational Guide* and the PROWAG.

5.13.7 ADA Curb Ramp Variance Process

It can be impractical to make facilities fully compliant with the standards due to existing site constraints. Improvements at locations can be deemed "Technically Infeasible" when sound engineering judgement is exercised. When full compliance is deemed technically infeasible, facilities being altered should be made accessible to the maximum extent practicable. If a site cannot meet accessibility standards, the proper documentation procedures should be followed.

Examples of site constraints that may make it technically infeasible to make a facility fully compliant include:

1. Adjacent development or buildings that would need to be moved or altered to make a facility fully compliant.
2. Required improvements that would alter the status of a Historic property.
3. Drainage that could not be maintained if an area is made fully accessible.
4. Underlying terrain that would require significant expansion of the project scope to achieve full compliance. An example would be altering a roadway profile to make the cross slope of a crosswalk fully compliant.

Project scope, not cost, should determine when existing constraints make an item technically infeasible.

To submit a curb ramp variance, the Town's Variance Request Form must be completed and signed by a licensed professional engineer documenting why the curb ramp was deemed technically infeasible and every effort was made to design the curb ramp to meet ADA compliance. The request will be reviewed by the Town Engineer, and once approved, will be filed with the Town in the instance that an ADA complaint is received by the Town.

5.14 PEDESTRIAN CROSSING CRITERIA FOR UNCONTROLLED OR MID-BLOCK CROSSINGS

The purpose of Section 5.14 is to serve as a policy to determine where uncontrolled pedestrian crossings should be located, and how to improve existing uncontrolled pedestrian street crossings within the Town.

5.14.1 Definitions

Uncontrolled pedestrian crossings are defined as:

1. Legal crossings that are located at an intersection without a traffic signal
2. Legal crossings without STOP or YIELD signs.

Mid-block crossings are defined as crossings that do not occur at an intersection and are marked to indicate that the location is a legal crossing.

Crossings can be marked with traffic control markings or unmarked with no traffic control markings present.

5.14.2 References

The newest versions of the following references shall be used for guidance in determining location, design elements, and requirements:

1. *The Manual on Uniform Traffic Control Devices 2009 Edition* including Revisions 1 and 2.
2. *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (FHWA, 2018)*.
3. *NCHRP Research Report 841 Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments (2017).*
4. *Evaluation of R1-6 Gateway Treatment Alternatives for Pedestrian Crossings: Follow-Up Report (Roadway Safety Institute, 2017).*
5. *TCRP Report 112 / NCHRP Report 562 Improving Pedestrian Safety at Unsignalized Crossings (2006).*
6. *CDOT Roadway Design Guide, Chapter 14 (2018)*
7. *CDOT Standard Plan S-614-14 for Rectangular Rapid Flashing Beacon requirements (hard-wired only)*

References listed above can be utilized in instances where this document does not specifically include requirements or guidance on a particular topic.

5.14.3 Pedestrian Traffic Analysis and Recommendations

An engineering study should be performed at the discretion of the Town Engineer before a crosswalk is installed at a location away from a traffic signal or an approach controlled by a STOP or YIELD sign. If a pedestrian crossing is part of a development application, then a traffic study may also be required as described in Chapter 4 and the traffic studies may be combined. The engineering study shall be stamped by a professional engineer. The following steps are required as part of the Pedestrian Traffic Analysis:

1. Complete the worksheet shown in Table 5.12. If worksheet result is yes, proceed with developing the Pedestrian Traffic Analysis. If the worksheet result is no, no additional analysis is required.
2. Include number of lanes, presence of a median, distance from adjacent signalized intersections, average daily traffic (ADT), posted or statutory speed limit (85th-percentile or mean speed), crash history, geometry of the location, possible consolidation of multiple crossing points, availability of street lighting, and any other factors deemed appropriate by engineering judgement.
3. Provide pedestrian volumes and delays (see Section 5.10.3.1)
4. Crossing treatment recommendations based on criteria and sound engineering judgement (see Section 5.10.3.2)
5. Conclusion of results.

5.14.3.1 Pedestrian Volumes and Delays

Pedestrian volumes and delays will typically involve AM, mid-day, and PM peak hours. Locations near schools may only require two hours of data collection (AM and PM peak hours corresponding to school opening and closing times). All pedestrian volumes should include and differentiate between pedestrians and bicyclists and should note separately the number of young, elderly, and/or disabled pedestrians. For locations where school crossing traffic is anticipated, the volume of student pedestrians (school age pedestrians on their way to/from school) should also be separately noted.

Whenever possible, pedestrian and bicycle volumes should be collected in the appropriate season when volumes may be close to or at their peak. Counts should be scheduled at a time when nearby businesses are open. If school traffic is an issue, the counts should be scheduled on school days when classes are in session. Given the potential fluctuation in pedestrian traffic from day to day, it may be necessary to collect up to three days of data to determine if an enhanced pedestrian crossing treatment is warranted as follows:

1. Collect pedestrian data on day one. If the minimum pedestrian volume threshold (20 pedestrians per hour accounting for a 1.33 multiplier used if vulnerable populations are present) is exceeded, no further pedestrian data collection is needed. If the threshold has not been exceeded, but at least 50% of the minimum pedestrian volume was observed, proceed to a second day of data collection.
2. Collect pedestrian data on day two. If the minimum pedestrian volume threshold is exceeded, no further pedestrian data collection is needed. If the threshold has not been met but again the volume is at least 50% of the minimum threshold, proceed to a third day of data collection.
3. Collect pedestrian data on day three. If the minimum pedestrian volume still has not been met, then no marked pedestrian crossing treatment is warranted by pedestrian crossing volume.

Pedestrian delays should be measured using procedures from the latest version of the Highway Capacity Manual.

5.14.3.2 Crossing Treatment Criteria

The following criteria shall be used in determining if crossing treatments are to be considered and shall be used to complete the worksheet shown in Table 5.12. If a crossing treatment should be considered, Section 5.10.5 shall be used to determine what type(s) of treatment is/are appropriate.

5.14.3.2.1 Criterion A

When vehicle volume is less than 5,000 vehicles per day or the average vehicle speed does not exceed 10 mph over the posted speed, crosswalk enhancements will be considered when there is a crossing pedestrian volume of at least 20 pedestrians per hour. When vehicle volume is greater than or equal to 5,000 vehicles per day or the average vehicle speed is 10 mph greater than the posted speed limit, crosswalk enhancements will be considered when there is a crossing pedestrian volume of at least 10 pedestrians per hour. A multiplication factor of 1.33 can be applied to the hour pedestrian volume if the volume consists of vulnerable populations (children, elderly, persons with disabilities, etc.). See lines (1) through (3) of Table 5.12.

5.14.3.2.2 Criterion B

Crosswalks enhancements will be considered when they could directly service or are adjacent to an existing shared-use path or trail, park, school, hospital, senior center, recreation center, library, or other facility with sensitive populations as determined by the Town Engineer. The minimum hourly pedestrian volume criterion may be waived if this criterion is satisfied. See line (4) of Table 5.12.

5.14.3.2.3 Criterion C

Crosswalk enhancements will be considered in locations where there are greater than 1 non-motorized (vehicle to pedestrian or vehicle to bicycle) crashes within the last 3 years. The minimum hourly pedestrian volume criterion may be waived if this criterion is satisfied. See line (5) of Table 5.12.

5.14.3.2.4 Criterion D

If criterion A, B, or C is met, the location must then also meet the following criteria:

1. The minimum stopping sight distance is available and free from obstructions. The minimum stopping sight distance shall be calculated using intersection sight distance per Section 5.6.1.5.
2. The crossing should match the grade of the existing roadway. More detail regarding maximum roadway grade can be found in Section 5.4.3.2.
3. The distance to the nearest existing marked or controlled crosswalk is at least 300 feet. If an existing marked or controlled crosswalk is within 300 feet, care should be given to direct pedestrian traffic to said crosswalk.
4. The existing roadway shall have a maximum slope of 6% in the downhill direction for a minimum distance of 200 feet. If the slope exceeds 6%, a crossing will not be allowed or the road must be re-graded to reduce the slope.

See lines (6) through (9) of Table 5.12.

5.14.4 Crossing Enhancement Eligibility Worksheet

The following table shall be used to determine if an uncontrolled or mid-block crossing is eligible for enhancement. A blank version of this worksheet can be found in Appendix E to assist with documentation of location decisions at the discretion of the Town Engineer.

Table 5.12 Crossing Enhancement Eligibility Worksheet

Criterion	Line	Criteria	Value	Eligibility Requirement
A	(1)	Average daily vehicle traffic	#	*See (5)*
	(2)	Mean vehicle speed differential from posted speed limit	#	*See (5)*
	(3)	Number of pedestrians per hour	#	*See (5)*
	(4)	Does the location serve a vulnerable population (children, elderly, persons with disabilities, etc.)?	Yes/No	*See (5)*
	(5)	Adjusted number of pedestrians per hour	#	*If (4) is Yes, then value = (3)*1.33, otherwise value = (3)* *Eligibility Requirement: When (1) < 5,000 or (2) < 10, then ≥ 20* *When (1) ≥ 5,000 or (2) ≥ 10, then ≥ 10*
B	(6)	Does the location directly serve or is adjacent to one of the following: Existing shared-use path or trail; park; school; hospital; senior center; recreation center; library?	Yes/No	*If Yes, then (5) eligibility requirement is waived*
C	(7)	Number of non-motorized crashes in the last three years	#	*If ≥6, then (5) eligibility requirement is waived*
D	(8)	Is the minimum stopping sight distance available (see Section 5.6.1.5)?	Yes/No	*Eligibility Requirement: Yes*

	(9)	Will the crossing match the existing roadway grade or less?	Yes/No	*Eligibility Requirement: Yes, cannot be greater*
	(10)	Distance to nearest existing marked or controlled crossing (feet)	#	*Eligibility Requirement ≥300'*
	(11)	Is the maximum grade of the roadway 6% or less in the downhill direction for a minimum 200' distance?	Yes/No	*Eligibility Requirement: Yes, or the road can be re-graded to meet*
	(12)	**Eligible for Treatment?**	**Yes/No**	*Yes = Criterion A, B, or C is met and Criterion D is met*

If eligible for treatment, see Section 5.10.5 for applicable crosswalk enhancements.

5.14.5 Pedestrian Crossing Enhancements

Once a determination has been made that a pedestrian crossing enhancement is recommended at a particular location, several design treatments can be considered.

Roadway traffic calming treatments should be considered in conjunction with pedestrian crossing enhancements as a means to enhance the effectiveness of one another. See Section 5.6 for more information on traffic calming treatments.

5.14.5.1 Pavement Markings and Conventional Signs

NCHRP Research Report 841 Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments (2017) states, "Recent research has found no safety benefit associated with various types of crosswalk markings, and the inappropriate use of marked crosswalks alone (without other substantial safety measures) can increase crash risk for pedestrians." This shall be considered when choosing to implement crosswalk markings at uncontrolled intersections or mid-block locations.

5.14.5.1.1 Standard Continental Crosswalk Markings

Standard continental crosswalk markings are pavement markings rectangular in shape. They shall be a minimum of 6 feet long and 1 to 2 feet wide. The alignment of the markings shall connect the curb ramps and be oriented so that they are parallel with the direction of travel. Markings shall be recessed into the pavement placed so that they avoid the anticipated vehicle wheel path to improve longevity of the markings. They can be spaced 1 to 5 feet apart. Crosswalk markings are to be used in conjunction with appropriate signing as defined in this section, because research shows that markings alone do not improve pedestrian crash rates. Decorative crosswalk markings are not recommended. Crosswalk markings shall be made retroreflective with glass beads or other approved methods. See Chapter 9 for construction requirements.

5.14.5.1.2 High Visibility Markings

High Visibility Markings are wider pavement markings that can be applied in the area of a crossing if the area is unlit and peak pedestrian traffic volumes occur during unlit times.

5.14.5.1.3 Advanced Yield or Stop Markings and Signs

Advanced yield or stop markings and signs may be used in conjunction with a crosswalk marking on major collector roadways with speeds of 40 mph and where placement of advanced markings and signs does not conflict with other intersections or traffic control. Refer to Section 3B.16 of the MUTCD for further standards and guidance.

5.14.5.1.4 Pedestrian Sign Assembly

The following list includes pedestrian signing options that should be utilized in combination with pedestrian markings listed in section

1. Pedestrian Crossing Sign Assembly (W11-2 with W16-7P) - shall be used in combination with crosswalk marking treatment. Sign structure shall be mounted at the roadside in accordance with MUTCD 2C.50.
2. Yield/Stop Here for Pedestrians Signs (R1-5) - may be used in conjunction with a crosswalk marking, advanced yield or stop markings, and a typical pedestrian crossing sign assembly on roadways with multiple lanes. Refer to Section 2B.11 of the MUTCD for further standards and guidance.
3. In-Street Pedestrian Crossing Signs (R1-6) - may be used when pedestrian crossing volumes are greater or equal to 20 pedestrians per hour OR when the mean vehicle speed at the crossing location is 5 mph greater than the posted speed limit. This treatment shall be used in conjunction with a crosswalk marking, a pedestrian crossing sign assembly, and a roadway centerline marking.

5.14.5.2 Physical Geometric Treatments

The following physical roadway geometric treatments can be considered to provide additional crossing safety and visibility as approved by the Town Engineer. Refer to the Town of Breckenridge's *Traffic Calming Policy* for additional treatment information regarding coordination and design considerations.

5.14.5.2.1 Refuge Islands

Refuge islands provide a space in the center of the traveled way for pedestrians to rest as they wait to cross each direction of vehicular travel independently. Refuge islands should be considered at pedestrian crossing locations on roads where one or both directions of travel are high volume, and see the most benefit with four or more lanes of traffic and speeds of 35 mph or greater. They can be paired with additional crossing enhancements provided in this section. Refuge islands shall be a minimum 10 feet wide from back of curb to back of curb. They shall be designed to allow for positive drainage and for adequate snow removal around the island and be ADA compliant. If the installation of a refuge island requires a shift in the traveled way, appropriate lane transition rates shall apply for the redirection of traffic around the island. Delineation markers may be required for snow removal activities.

5.14.5.2.2 Curb Extensions (Bulb-Outs)

Curb extensions extend the pedestrian sidewalk and curb out into the shoulder or parking lane of the roadway to reduce the crossing distance. This reduces the amount of time that pedestrians need to cross the traveled way, and provide additional space for curb ramps. They also can assist in reducing speeds of vehicular traffic. Curb extensions should allow for a minimum 11-foot travel lane. Curb extensions shall be designed to allow for positive drainage and for adequate snow removal around the extension. Delineation markers may be required for snow removal activities.

5.14.5.2.3 Raised Crosswalks

Raised crosswalks are ramped speed tables placed at mid-block crossing locations that assist with driver visibility of pedestrian crossings. They also provide traffic calming benefits. Raised crosswalks shall be flush with the sidewalk it is connecting on either side of the crossing, and shall be a minimum of 10 feet wide. They can be considered on minor collector and local roadways with a speed of 30 mph or less. Raised crosswalks shall generally be 6" tall, wings shall be 8% max, cross slopes shall be 2% maximum and meet ADA requirements, and storm sewer inlets shall be installed on the uphill side of the crosswalk. Raised crosswalks shall be designed to allow for positive drainage, and noise considerations should be made prior to proposing a location. Delineation markers may be required for snow removal activities.

5.14.5.3 Rectangular Rapid Flashing Beacon (RRFB)

RRFBs should be used sparingly and are typically only installed when other crossing enhancements have proven ineffective. An RRFB may be installed when all of the following criteria are met:

1. Marking and signing enhancements in Section 5.10.5.1 have been implemented but a perceived or actual pedestrian/vehicle conflict issue still persists
2. Pedestrian crossing volumes are between 60 and 160 pedestrians per hour
3. Crosswalk length from curb to curb is greater than 32 feet.
4. Roadway speeds are between 30 mph and 45 mph, or mean vehicle speed at the crossing location is 5 mph greater than the posted speed limit.
5. Roadway volume is greater than 6,700 vehicles per day.

The RRFB treatment is a combination of signing, markings and pedestrian activated strobe and feedback devices at uncontrolled pedestrian crossings. Refer to CDOT Standard Plan S-614-14 for requirements. RRFBs shall be hard-wired. Solar is not permitted. Signing for the RRFB typically includes advance PEDESTRIAN WARNING signs (W11-2) with AHEAD supplemental plaques (W16-9p), and PEDESTRIAN WARNING signs (W11- 2) with down arrow supplemental plaques (W16-7p). Pavement markings include yield lines. The pedestrian activated treatments would be the W11-2 signs with built in rectangular strobe flashers. Additionally, pedestrian visible strobes and a recorded message inform pedestrians when the crossing is activated and instruct them to wait for motorists to yield. The R1-5 (YIELD HERE TO PED) shall be placed so that it does not restrict motorists' visibility of the RRFB at the crosswalk. For the placement of advance stop lines and advance warning signs, refer to the MUTCD. High visibility crosswalks are to be used with the RRFB crossing treatment. Timing of the flashing beacon should allow for pedestrians to scan for motorists, step from the side of the road and completely cross the street. Depending upon pedestrian volumes, 5 to 10 seconds should be provided for pedestrians to scan for gaps and enter the roadway. For areas with very high pedestrian volumes (more than 10 pedestrians crossing simultaneously), additional startup time should be provided. A minimum of 3.5 feet per second crossing speed should be assumed for pedestrians.

A median refuge area should be considered, refer to Section 5.10.5.2.1.

5.14.5.4 Pedestrian Hybrid Beacon

Pedestrian hybrid beacons are not generally recommended in the Town of Breckenridge. This treatment may be applied if all of the following criteria are met:

1. Warrants and guidance from Chapter 4F of the MUTCD deem a PHB may be appropriate, and
2. Written approval has been given by the Town Engineer.

5.14.5.5 Grade Separated Crossing

A grade separated crossing treatment is typically applied for roadways meeting one of the following requirements:

1. Posted speeds greater than 40 mph, crossing lengths greater than 48 feet, and average daily traffic volumes greater than 10,000 vehicles per day
2. When removing sight distance obstructions is not feasible
3. The majority of users are expected to be non-traditional pedestrians (skiers, snowboarders, bicyclists, skateboards, etc.)

4. The proposed crossing is within CDOT ROW and the pedestrian volume exceeds 60 pedestrians per hour
5. Pedestrian volumes exceed 200 pedestrians per hour.
6. An at-grade crossing is expected to cause traffic impediment along the roadway and lower the LOS of the roadway.

Within CDOT ROW, new crossings with pedestrian volumes exceeding 60 pedestrians per hour will require a grade separated crossing. If the pedestrian volume is less than 60 pedestrians per hour, the Town Engineer will review the proposed crossing and determine if an at-grade crossing will be allowed.

Prior to implementing a grade separated crossing, additional study should be performed to determine if other at-grade solutions may be preferable. Written approval from the Town Engineer is required for all grade separated crossings.

Grade separated crossings shall generally be designed for ADA compliance, include physical barriers to prevent at-grade crossing, light enhancements inside the crossing, and include pedestrian routes entering and exiting the crossing which are intuitive and natural routes for pedestrians resulting in high compliance of use.

5.15 TRANSIT FACILITIES

Streets shall be designed to accommodate transit facilities where transit routes are identified during the development process. Transit facilities, including transit stops, waiting areas, transit shelters, and other transit improvements are encouraged and may be required as determined by the Town Engineer. Transit stops shall be located to minimize impact on through traffic, provide efficient arrival and departure for the transit vehicle, and bear a logical relationship to the population served. New transit stops and facilities shall be connected to the adjacent developments via sidewalks and trails.

Where required by the Town Engineer, transit stops shall be located where direct pedestrian access is provided from the street and adjacent sidewalk or surrounding area to the stop. Transit stops shall include a paved waiting area with a direct connection to the adjacent sidewalk. As each site is unique, the waiting area dimensions shall be determined by the Town Engineer.

Bus pull outs shall be located on the downstream side of an intersection wherever possible designed to provide a 30-foot loading area per bus and a 3:1 exiting taper. The pavement in the bus pull out lane shall be designed per a pavement evaluation report to account for the expected bus traffic; minimum concrete thickness of 10 inches shall be provided. Bus pullouts shall be per the standard detail and shall be a minimum of 10 feet wide, 40- to 60-foot long tapers with a 50-foot minimum radius and 2% cross slope.

5.16 PAVEMENT DESIGN

This section provides the criteria used for the design of pavements and will ensure adequate strength and durability to carry the predicted traffic loads for the design life of each project. The street pavement design evaluation shall be established for each project in a geotechnical report following the latest *CDOT M-E Pavement Design Manual*. The pavement design will be based on a Design Equivalent Single Axle Loads (ESAL) which is determined on average daily traffic count (ADT), vehicle classification, traffic equivalence load factors, traffic growth rate, design period, and lane factor. Private streets and accesses may be asphalt, concrete, or other impervious surface approved by the Town Engineer. Sidewalks and bus pullouts shall be concrete.

5.16.1 Soils Testing for Pavement Design

To design pavements for approval and acceptance by the Town, sampling and testing must be performed under the direct supervision of a registered Professional Engineer to evaluate the soil characteristics. Samples shall be taken at least 5 feet below proposed subgrade (10 feet on arterial roadways) at spacing of 250 feet or less, unless specified by a geotechnical engineer. Test holes shall properly evaluate all changes in soil character. Samples shall be taken at the minimum depth which will serve as subgrade for new street construction.

When joining to an existing paved street, cores of the existing pavement and base structure shall be made and analyzed to determine whether overlayment is feasible or reconstruction is necessary.

5.16.2 Flexible Pavement Design

Flexible pavements shall be designed, installed, constructed, maintained and repaired in accordance with these standards and with the latest editions of the *CDOT M-E Pavement Design Manual* and Standard Specifications for Road and Bridge Construction or the AASHTO Guide for the Design of Pavement Structures. In the event of discrepancies between these standards and the referenced publications, the more stringent shall take precedence.

A minimum of four inches of aggregate base course (ABC) shall be used as a base on roadways. If the design truck traffic is greater than 500 trucks per day, a minimum of six inches of ABC shall be used as a base. The minimum pavement thickness for all roadways shall be four inches. However, each roadway pavement section proposed in the Town shall be designed per a geotechnical report to determine actual recommended thickness and pavement mix. The minimum pavement thickness shall be per Table 5.13 below. These values only provide preliminary minimum values; the final pavement thickness shall be designed per the geotechnical report.

Table 5.13 Pavement Thickness Minimums

Street Type	Min. Asphalt Depth (Inches)	Min. Class 6 Aggregate Base Course Depth (Inches)
Private Roadway	4	4
Local	4	4
Minor Collector	5	6
Major Collector	6	6

The minimum lift thickness of flexible pavement shall be 1.5 inches and the maximum lift thickness shall be three inches.

5.16.3 Rigid Pavement Design

Rigid pavements shall be designed, installed, constructed, maintained and repaired in accordance with these standards and with the latest editions of the *CDOT M-E Pavement Design Manual* and Standard Specifications for Road and Bridge Construction or the AASHTO Guide for the Design of Pavement Structures. In the event of discrepancies between these standards and the referenced publications, the more stringent shall take precedence.

Rigid pavement shall have a minimum ABC thickness of six inches and a minimum concrete pavement thickness of seven inches.

5.17 Traffic Control Devices

Traffic control device designs shall be prepared by a Colorado licensed professional engineer experienced in traffic engineering. The designs shall be prepared in accordance with the latest version of the *Manual on Uniform Traffic Control Devices (MUTCD)*.

Striping plans are required for Collectors and Arterials, but may not be required for local subdivision streets. However, sign plans are required for all subdivisions. All signing and striping plans shall conform to the most current edition of the *MUTCD*. All traffic control devices shall be fabricated and installed in accordance with the *MUTCD*. Permanent signage and striping shall be complete and in place before any new roadway is opened to the public for use.

5.17.1 Street Name Signs

New streets in the Town of Breckenridge shall be named by the Town of Breckenridge in accordance with Town and Summit County naming procedures. The Town and County GIS Departments shall be used to ensure that each street name is unique and does not match or closely resemble another street name in the Town of Breckenridge or within Summit County.

Street name signs are required at the intersections of all public and private (serving four or more units) streets. Driveways serving three or less units may not install street name signs in the right of way.

Street name signs shall be fabricated to match existing Town of Breckenridge street signs. Color, size, font, and dimensions of the signs shall match existing Town street signs. The Town of Breckenridge Streets Department shall be consulted for street sign specifications.

5.17.2 Stop Signs

Stop signs or other traffic control devices shall be installed at the intersections of all public and private streets (access serving four or more units) and shall meet MUTCD requirements. Stop signs are not required at driveways serving three or less units.

5.17.3 Private Signage

No private signage shall be permitted within the ROW. No private signage shall be permitted on private property which attempts to direct traffic or parking. Business name signs and address signs may be installed outside of the ROW per requirements in the Town Code.

5.17.4 Signage Requests

Requests for additional signage for traffic calming, speed limit signs, children playing signs, parking signs, and other signage will be considered based on MUTCD standards, proximity to other signage, and local conditions. However, additional signage can create “signage clutter”, a term for a condition when there is too much competing signage along a street causing driver confusion, reduced effectiveness of signage, distraction, and decreased aesthetics of a street. The Town of Breckenridge approves signage at that minimum level required to provide for safe and efficient travel of vehicles of pedestrians.

~~5.19~~5.18 STREET LIGHTING

The purpose of streetlight installations shall be to illuminate the public traveled ways to a level that provides for the safe passage of public traffic, both vehicle and pedestrian. Arterial and Collector streets shall require street lighting at intersections. Pedestrian lighting will be required near all sidewalks, pedestrian routes & facilities, crosswalks, and transit facilities. All fixtures, poles, and designs will be reviewed and approved by the Engineering Division and the power provider.

~~5.19.1.1~~5.18.1.1 Equipment Type and Location

~~The Town’s standard Newport fixture, Providence Fixture, or Promenade Fixture shall be installed depending on the location within the Town. Typically, Newport fixtures are installed in the historic district, Providence fixtures are installed outside the historic district, and Promenade fixtures are~~

~~installed at critical intersections along SH 9. The Town Engineer will determine the appropriate light fixture depending on the location of the development. Typical spacing of light poles is 75 feet along pedestrian routes. Light pole spacing may be reduced to 110 feet along local road sidewalks. In residential areas, along a portion of road without a sidewalk, street light spacing may be further reduced to 300 feet. Typical pole height is 9 feet tall along pedestrian routes and 12 feet tall at intersection and crosswalks. The photometric analysis shall be completed to determine exact spacing, location, and pole height at all crosswalks and intersections. The type of area should also be considered when determining the equipment type and location. The Town staff can provide additional guidance on the type of illumination equipment that is required depending on the location of the project. Standard details for foundations, poles, fixtures, and luminaires are included in the standard details attached to Chapter 9 of these Standards.~~

The Town's standard Providence Fixture or Promenade Fixture shall be installed depending on the location within the Town. The Providence Fixture is the typical fixture installed in the Town, while the Promenade fixture is typically reserved for SH 9 and critical intersections or crosswalks. The Welsbach fixture (also called a Newport fixture) is installed in various locations within the Historic District of Breckenridge. No new Welsbach (Newport) fixtures will be installed unless a variance is granted by the Town Engineer. The Town Engineer will determine the appropriate light fixture depending on the location of the development. Standard details for foundations, poles, fixtures, and luminaires are included in the standard details attached to Chapter 9 of these Standards.

All new fixtures shall be dark sky compliant and shall have the capability to be automatically dimmable. All new street lights shall meet the following requirements:

1. Fixtures shall be certified dark sky compliant by the International Dark-Sky Association.
2. Fixtures shall be automatically dimmable. Fixtures in residential areas shall be programmed to dim at 10 pm and commercial areas shall be programmed to dim at 2:30 am. Fixtures at intersections and crosswalks shall have the capability to dim, but shall be programmed to remain and the same lumens throughout the night (no dimming).
3. New streets and development shall be designed to have a maximum 50,000 lumens/acre in commercially zoned areas and a maximum of 25,000 lumens/acre for residentially zoned areas. Area with traffic safety concerns, major collector roads, roundabouts, high pedestrian areas, crosswalks, and other areas of safety concern as determined by the Town Engineer shall be exempted from the maximum lumen requirements.
4. Light pole spacing shall be 75 feet along pedestrian routes. Light pole spacing may be reduced to 110 feet on roads classified as Local. On residential local roads without a sidewalk, street light spacing may be reduced to 300 feet. Light pole spacing may be modified for safety concerns or guidance from a photometric analysis.
5. Pole height shall be 9 feet tall along pedestrian routes and 12 feet tall at intersections and crosswalks. Pole height may be further increased for safety concerns with a photometric analysis.
6. Lights shall meet all requirements of Title 9, Chapter 12 (Exterior Lighting Regulations) and all other dark sky compliance regulations.
7. Photometric analysis (if determined necessary by Town Engineer).
8. Additional requirements as determined by the Town Engineer due to vehicle or pedestrian traffic, safety concerns, intersections, or other reasons.

~~5.19.1.2~~5.18.1.2 Positioning at Intersections

In general, the nighttime visibility of a pedestrian or hazardous object within an intersection is enhanced by increased contrast between the object and the surrounding street area. Street lights at intersections are required to be placed on the upstream side of the intersecting street, as viewed by a motorist approaching the intersection in the lane directly beneath the luminaries. The positioning of light standards at intersecting streets shall be up to two street lights per corner of intersection, depending on street geometry and crosswalk location.

~~5.19.1.3~~5.18.1.3 Roundabout Lighting

Lighting columns should be arranged around the perimeter of the roundabout in a simple ring, with the lights equidistant from the center and from each other. Lighting should extend at least 197 feet back along each approach road. Mounting height should be uniform throughout the intersection and not less than on any approach road. The minimum illuminance required should not be less than the highest level of lighting for any of the approach roads. Lights near roundabouts shall not be located closer than 6 feet from the face of curb and shall not be located in the center of median islands.

~~5.19.1.4~~5.18.1.4 Light Pole Offset Distances

Distance behind back of walk for local streets shall be at least 3 feet and must be within easements or right-of-way on Local residential streets. For Collector and Arterial streets, the light must be offset at least 3 feet from the back of curb and provide a clearance space between the light pole and edge of walk that equals or exceeds the required sidewalk width.

~~5.19.1.5~~5.18.1.5 Underground Service

Street lighting shall be installed with underground electric service on all newly developed dedicated public streets in the Town. The Developer is responsible for coordinating with the appropriate utility company all aspects of design and installation. Junction boxes and other structures shall not be installed in sidewalks, curbs, or curb ramps.

~~5.19.2~~5.18.2 Pedestrian Lighting

Install street lighting behind sidewalks where sidewalks attached to the curb are used. For sidewalks detached from the curb, install street lighting with a minimum of 3 feet clearance from back of curb to roadway side of support pole and 3 feet clear from all walks. All bridge underpasses, where vehicles, pedestrians, bicyclists, or equestrians may be present, shall require lighting.

Lighting for trails should be evaluated based on safety and the type of trail. Lighting will generally be required for primary trails at primary trailheads, underpasses, mid-block crossings. Where sidewalks and trails are located near or adjacent to streets, lighting shall be coordinated with street lighting requirements.

~~5.19.3~~5.18.3 Dark Sky Ordinance

The Town has adopted an exterior lighting policy generally adhering to a Dark Sky Ordinance. See *Exterior Lighting Regulations* in Title 9, Chapter 12 of the Town Code.

~~5.19.4~~5.18.4 Residential Areas

Street lights shall be shielded with house side shields or other measures to minimize light shining on residential areas.

~~5.20~~5.19 PRIVATE FACILITIES

Private streets, alleys, and accesses are typically utilized by an individual, group of individuals, or private business to access private property. It is the responsibility of the private landowner to maintain the private facility.

~~5.20.1~~5.19.1 Private Streets

A private street is an access serving five~~four~~ or more units or lots. Private streets are discouraged because they create a cost burden to residents. Private streets shall meet the same design standards as public streets. Private streets are not owned, maintained, or plowed by the Town. They are the sole responsibility of the property owner. A private street requires the approval of a variance request form by the Town Engineer.

~~5.20.2~~5.19.2 Private Snow Melt Systems

~~Driveway~~ Private heated pavement systems, also called snowmelt systems, shall terminate at the property line with no components located in the right-of-way. See section 9-1-19-33A and 33R of the Town Code for additional regulations. The following requirements shall be met for snowmelt systems:

1. Infrastructure permit shall be submitted for any private snowmelt system (even if located entirely on private land).
2. The snowmelt system shall stop 5 feet from the edge of a public roadway or 1 foot from the back of public sidewalk.
3. Drainage from the snowmelt system shall be captured on the premises and shall not drain across public pedestrian facilities or roadways. The drainage shall be designed to infiltrate or runoff without freezing. Examples include heated trench drains and inlets to storm pipes and drywells. Drywells shall be designed appropriately to infiltrate all runoff. Drainage shall not drain across public pedestrian facilities or roadways.

~~-~~If the Town Engineer allows the snow melt system to encroach into the right-of-way, the following conditions shall be met in addition to the conditions above:

1. A separate mechanical zone shall be dedicated for the portion of the snowmelt system within the right-of-way
~~2. The snowmelt system shall stop 5 feet from the edge of roadway or at the back of sidewalk~~
~~3. Drainage from the snowmelt system shall be captured and shall not drain across pedestrian facilities or roadways~~
~~4.~~2. Expansion joint material shall be installed at the edge of heated concrete
~~5.~~3. A revocable encroachment license agreement, acceptable in form and substance to the Town Attorney for the components of the system extending into the ROW, must be approved by the Town and executed prior to the issuance of building permit
~~6.~~4. Other requirements as determined by the Town Engineer to reduce the impacts of the snow/melted interface

~~5.21~~5.20 UTILITIES

Utilities in ROW shall be located to minimize roadway disturbance. Utility lines shall be located to minimize the need for future adjustment and shall consider future extensions of the street system. Utility structures above grade shall be placed in easements outside of the ROW, or as close to the edge of the Right of Way as possible, and at least 6 feet from the edge of roadway and 3 feet from the edge of sidewalk. Utilities shall be buried a minimum of 2 feet below finished grade. Utility rings and covers within pavement areas shall be 0.25 to 0.50 inches below top of pavement. Manholes, valves, junction boxes, and other structures shall not be located in curbs or sidewalks.

Utilities shall typically be installed in the roadway shoulder to avoid pavement removal. If the utility must be placed beneath pavement, the utility should be installed at the center or at the edge of travel lanes. Utilities shall not be placed beneath wheel paths of roads. Utilities shall not be located in drainage swales. Utilities shall be installed to meet all applicable standards and requirements for bury depths, offsets, crossings, separation, and insulation. Utility crossings shall be perpendicular to street and pavements cuts shall be perpendicular to roadway. Pavement patches shall extend 1’ minimum beyond trench and edge of patch shall not be located within wheel paths. See Chapter 3 of these standards for additional trenching and patching details.

All utilities (including storm sewer) shall be electronically locatable for the entire length of the utility. All wires and cables shall be buried in rigid conduits and backfilled with warning tape placed 1 foot above the conduits. Utilities and utility structures shall be located outside of ROW and within utility easements where feasible.

~~5.22~~5.21 DESIGN CRITERIA TABLE BY STREET CLASSIFICATION

Table 5.14 Design Criteria by Street Classification

Street Classification						
	Major Collector					
		Minor Collector				
				Local		
Posted Speed	40 mph	35 mph	30 mph	25 mph	20 mph	15 mph
Design Speed	40 mph	35 mph	30 mph	25 mph	20 mph	15 mph
Min. Horizontal Curve Radius (normal crown)	770'	510'	350'	200'	110'	50'
Min. Tangent Between Curves	150'	150'	100'	50'	20'	20'
Max. Super Elevation	6%	6%	6%	N/A	N/A	N/A
Cross-slope	2%	2%	2%	2%	2%	2%
Minimum Stopping Sight Distance	305'	250'	200'	155'	115'	80'
Min. Grade	1%	1%	1%	1%	1%	1%
Max. Grade	6%	6%	6%	6%	6%	6%
Min. K-Crest	44	29	19	12	7	3
Min. K-Sag	64	49	37	26	17	10

CHAPTER 6
STORMWATER STANDARDS

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6.1 PURPOSE

The purpose of this Chapter is to set forth design standards and criteria for storm drainage infrastructure so there is reasonable degree of assurance that the health, safety, welfare, and property of the Town and citizens may be safeguarded and protected through the proper control and drainage of stormwater, the water quality of the Blue River and its tributaries will be protected, and there will be a certain uniformity in performance with respect to design and construction of drainage facilities.

Additionally, the Town of Breckenridge's mountain environment is known for steep grades, wetland areas, perennial streams, reservoirs, and the Blue River. This unique environment and topography results in grading, slope stability, stormwater runoff contamination, and phosphorus contamination concerns. This chapter establishes standards to safeguard public health and safety, protect environmentally sensitive areas, and protect the water quality of the Blue River, its tributaries, and Dillon Reservoir.

The design Standards presented herein are intended to aid in the design of stormwater infrastructure and outline the minimum standards required.

6.2 OTHER STANDARDS

The Mile High Flood District (MHFD), formerly known as the Urban Drainage and Flood Control District (UDFCD), has developed detailed permanent water quality design guidance and criteria in Volume 3 of the *Urban Storm Drainage Criteria Manual* (USDCM). This document is referenced extensively in this section and provides extensive discussion on the topic of stormwater quality treatment. When used for design, the most recent version shall be referenced as the MHFD continually updates Volume 3 of the USDCM based on performance and maintainability of the treatment facilities discussed.

6.2 SUBMITTALS

An Infrastructure Permit is required for all construction projects involving storm drainage infrastructure. Requirements for an Infrastructure Permit are summarized in Chapter 2. Other submittals may be required in accordance with Chapter 2 or as determined by the Town Engineer.

6.3 RAINFALL

A rainfall analysis was completed for the Town of Breckenridge using the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 data. The equations and data in this section are based on this analysis. A detailed memo regarding the evaluation of NOAA Atlas 14 is available from the Town upon request.

6.3.1 Rainfall Intensity

Equation 6.1 shall be used to calculate rainfall intensity for a given time of concentration or to develop intensity-duration-frequency curves for runoff analysis using the Rational Method as discussed in Section 6.4.

$$I = P_1 \frac{40.81}{(t+7.63)^{0.881}} \qquad (6.1)$$

Where:

I = rainfall intensity (in/hr)

P_1 = 1-hour rainfall depth (in), see Table 6.1

t = storm duration, time of concentration (min)

Rainfall intensities as a function of storm duration and recurrence interval are provided in Table 6.1. This table was developed using Equation 6.1. The values in Table 6.1 are subject to revision and users of these Standards are encouraged to check for updates.

Table 6.1. Intensity-Duration-Frequency Data

Return Period	P_1	Peak Rainfall Intensity for Storm Duration (in/hr)				
		5-min	10-min	15-min	30-min	60-min
2-year	0.546	2.39	1.78	1.43	0.91	0.54
5-year	0.749	3.27	2.44	1.96	1.25	0.75
10-year	0.939	4.10	3.06	2.45	1.57	0.94
25-year	1.23	5.37	4.01	3.21	2.05	1.23
50-year	1.49	6.51	4.85	3.89	2.49	1.48
100-year	1.76	7.69	5.73	4.60	2.94	1.75
500-year	2.5	10.92	8.14	6.53	4.17	2.49

6.3.2 Rainfall Distribution

The 6-hour rainfall depths provided in Table 6.2 shall be used to develop a 6-hour SCS Type II rainfall distribution for runoff analyses that use hydrographs as discussed in Sections 6.4.4 and 6.4.5.

Table 6.2. 6-Hour Rainfall Depths for SCS Type II Distribution

Return Period	6-hour Rainfall Depth (in)
2-year	0.859
5-year	1.070
10-year	1.28
25-year	1.61
50-year	1.89
100-year	2.21
500-year	3.07

6.3.3 Design Storms

The objectives of establishing the minor and major design storms are to minimize inconvenience, protect against recurring minor damage, reduce maintenance costs caused by the minor storm, and eliminate substantial property damage and loss of life caused by the major storm. The goal is a functional drainage system at a reasonable cost. The storm drainage system may include streets, curb and gutter, roadside ditches, inlets, storm sewers, open drainageways, culverts, and detention facilities. In the Town of Breckenridge, the minor storm is the 10-year event and the major storm is the 100-year event.

6.4 RUNOFF

The hydrologic analysis of a site shall be based on the proposed land use for that site, as opposed to existing conditions. Calculation of contributing runoff from offsite upstream areas shall be based on the existing land use and topography. Flows specified in the Flood Insurance Study, Town of

Breckenridge (2011) shall be incorporated in the analysis where applicable and with the approval of the Town Engineer.

6.4.1 Approved Hydrologic Methods

All hydrologic methods have limitations and should be used only for appropriate scenarios. Accepted hydrologic methods are the Rational Method, the Soil Conservation Service (SCS) Dimensionless Unit Hydrograph Method, and the SCS Runoff Method. The last two methods are referred to collectively herein as the SCS Method developed by the Natural Resource Conservation Service (NRCS). The Rational Method may be used for watersheds of 90 acres or less and when only peak flows, as opposed to a hydrograph, are required for design (e.g., pipes, culverts, inlets). The SCS Method may be used for watersheds of any size or when hydrograph routing is required for design (e.g., detention ponds and volume-based water quality facilities). Information on the computer models that may be used to develop and route hydrographs is included later in this section.

6.4.2 Subwatershed Sizing

Determination of peak runoff at any downstream design point is affected by the size, number, and characteristics of the upstream subwatersheds within the overall drainage basin. Typically, the more homogenous each of the subwatersheds is, the more accurate the calculated peak flow is when compared to analysis of a single, larger watershed. Recommended guidelines are:

1. For an overall watershed of up to 100 acres, the maximum subwatershed size should be approximately 20 acres. Delineation should be conducted so that imperviousness, slope, and land use are similar for each subwatershed.
2. For an overall watershed over 100 acres, increasingly larger subwatersheds may be used provided the land use and surface characteristics within each subwatershed are homogeneous. In addition, the subwatershed sizing should be consistent with the level of detail needed to determine peak flow rates at various design points within the larger watershed.

6.4.3 Rational Method

The Rational Method uses Equation 6.2 to determine a peak runoff rate based on drainage area, rainfall intensity, and imperviousness. Imperviousness is represented by a coefficient, C.

$$\mathrm{Q} = \mathrm{CIA} \qquad (6.2)$$

Where:

Q = peak rate of runoff (cfs)

C = runoff coefficient

I = rainfall intensity (in/hr)

A = drainage area (acres)

The rainfall intensity is given by Equation 6.1 or Table 6.1 based on the design storm and storm duration, which is assumed to be equal to the total time of concentration to the design point being analyzed. Determining values for the runoff coefficient, C, is discussed in the section below.

6.4.3.1 Runoff Coefficient

The runoff coefficient is based on land cover and soil classification. Soils are classified by the NRCS as belonging to Hydrologic Soil Group A, B, C, or D. The Hydrologic Soil Group(s) present at a site can be found using the Web Soil Survey tool available via an internet search for *NRCS Web Soil Survey*. Types of land use and their typical corresponding imperviousness are summarized in Table 6.3. Composite imperviousness should be obtained for each subwatershed that is not completely homogenous. The runoff coefficient, C, can then be calculated using the equations in Table 6.4. The coefficients are dependent on the Hydrologic Soil Group, composite imperviousness, and the return period of the design storm. The values below are approximations of average imperviousness for typical land uses. If a development's land use does not match a land use in the table below, or if the development's imperviousness does not match the values in the table below, imperviousness may be calculated for each subbasin within the site by dividing the total impervious area within the subbasin by the total subbasin area.

Table 6.3. Land Use Imperviousness

Land Use	Imperviousness (%, i_p)	Land Use	Imperviousness (%, i_p)
Urban:		Playgrounds	25
Downtown Area	95	Schools	55
Suburban Area	75	Parks, Cemeteries	10
Residential Single-family:		Paved Streets	100
2.5 acres or larger	15	Drive and Walks	90
0.75 - 2.5 acres	20	Roofs	90
0.25 - 0.75 acres	30	Lawns	2
0.25 acres or less	50	Undeveloped Areas:	
Apartments/Duplex/Townhomes	75	Historic Flow Analysis	2
Industrial:		Greenbelts, Agricultural	2
Light Areas	80	Off-site Flow Analysis (land use not defined)	45
Heavy Areas	90		

Table 6.4. Runoff Coefficient Equations

NRCS Soil Group	Storm Return Period			
	2-year	5-year	10-year	25-year
A	$C=0.84i_p^{1.302}$	$C=0.86i_p^{1.276}$	$C=0.87i_p^{1.232}$	$C=0.88i_p^{1.124}$
B	$C=0.84i_p^{1.169}$	$C=0.86i_p^{1.088}$	$C=0.81i_p+0.057$	$C=0.63i_p+0.249$
C/D	$C=0.83i_p^{1.122}$	$C=0.82i_p+0.035$	$C=0.74i_p+0.132$	$C=0.56i_p+0.319$

NRCS Soil Group	Storm Return Period		
	50-year	100-year	500-year
A	$C=0.85i_p+0.025$	$C=0.78i_p+0.110$	$C=0.65i_p+0.254$
B	$C=0.56i_p+0.328$	$C=0.47i_p+0.426$	$C=0.37i_p+0.536$
C/D	$C=0.49i_p+0.393$	$C=0.41i_p+0.484$	$C=0.32i_p+0.588$

6.4.3.2 Time of Concentration

The storm duration used in Equation 6.1 is the time required for runoff to flow from the most hydraulically distant point within the subwatershed to the design point of interest. This time is known as the time of concentration. Time of concentration is calculated by adding the flow times for each type of flow along most hydraulically distant flow path. Types of flow include sheet flow and shallow concentrated, or channelized flow. Time of concentration for the Rational Method is calculated using Equations 6.3 through 6.5.

$$t_c = t_i + t_t \tag{6.3}$$

Where:

t_c = time of concentration (min), minimum is 5 min in urban areas, 10 min in rural areas

t_i = initial or overland sheet flow time (min)

t_t = travel time for shallow concentrated flow in a ditch, channel, gutter, pipe, etc. (min)

Initial or overland flow is the sheet flow that occurs at the beginning of the flow path characterized by a flow depth less than 0.1 feet. It can be calculated using Equation 6.4 for flow path lengths up to 500 feet in rural areas and 300 feet in urban areas. However, in highly urbanized areas, the overland flow path is typically shorter than 300 feet because of the presence of drainage systems that collect and convey runoff.

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_o^{0.33}} \tag{6.4}$$

Where:

t_i = initial or overland sheet flow time (min)

C_5 = runoff coefficient for 5-year return period (see Table 6.4)

L_i = length of overland flow segment (ft)

S_o = average slope along the overland flow path (ft/ft)

Travel time for shallow concentrated flow is calculated based on the hydraulic properties of the conveyance element. The channelized travel time, t_t, is estimated by dividing the length of conveyance by the velocity. Equation 6.5 can be used to determine travel time in conjunction with the conveyance factors in Table 6.5.

$$t_t = \frac{L_t}{60K\sqrt{S_o}} = \frac{L_t}{60V_t} \tag{6.5}$$

Where:

t_t = travel time for shallow concentrated flow in a ditch, channel, gutter, pipe, etc. (min)

L_t = shallow concentrated flow path length (ft)

S_o = average slope of shallow concentrated flow path (ft/ft)

K = NRCS conveyance factor (see Table 6.5)

V_t = travel time velocity (ft/s) = $K\sqrt{S_o}$

For shallow concentrated flow in a pipe or well defined channel, Manning's Equation for open channel flow in Section 6.5 may be used to calculate velocity. The time of concentration, t_c, is then the sum of the initial flow time, t_i, and the travel time for shallow concentrated flow, t_t.

Table 6.5. NRCS Conveyance Factors, K

Land Surface	Conveyance Factor, K
Heavy meadow	2.5
Tillage/field	5

Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

Reference: NRCS (1986)

6.4.3.3 Limitations and Considerations

The minimum time of concentration in urban areas is 5 minutes. The minimum time of concentration in rural areas is 10 minutes. A common mistake in urban areas is to assume travel velocities that are too slow. Another is to not check the runoff peak resulting from only part of the design catchment. Sometimes a portion of the design catchment closer to the design point or a highly impervious area will produce a larger peak design flow than that computed for the entire catchment. This most often happens when the catchment is long and narrow, or when the upper portion is undeveloped while the lower portion is, or will be, fully developed.

6.4.4 SCS Method

For drainage areas larger than 90 acres, the SCS Method is one method than can be used to develop hydrographs. The procedures used in the SCS Method are described in Technical Release 20 (TR-20) and Technical Release 55 (TR-55) both prepared by the NRCS. Three parameters are needed to use the SCS Method: rainfall, curve number, and time of concentration. This section provides some general information needed to use the SCS Method in a hydrologic model. However, the reader should refer to TR-20 and TR-55 for more detail describing the SCS Method; the applicable hydrologic equations and theory; and all other background information.

6.4.4.1 SCS Method - Rainfall

The SCS Method includes four rainfall time distributions that are assigned geographically across the country. The SCS Type II storm distribution is applicable to the entire State of Colorado and therefore should be used when preparing hydrologic analysis for the Town. The rainfall distribution is based on a 24-hour duration.

The 24-hour distribution was developed to include the maximum intensities of all smaller duration storms; the 24-hour storm theoretically includes the 2-hour, 6- hour, etc. distributions within one longer distribution and can be used to estimate peak flows for all storm events. However, it will typically overestimate the volume of a storm event with a duration less than 24 hours. Therefore, the SCS also developed a 6-hour storm distribution, which was derived from the original 24-hour distribution. The 6-hour distribution can be used if the drainage area being modeled has a total time of concentration less than 6 hours. The total rainfall depths should be taken from NOAA Atlas 14 for the project design storm return period.

6.4.4.2 SCS Method – Curve Number

The SCS Method curve number (CN) is a variable used to predict infiltration and runoff based on land use and soil types. When using the SCS Method in a hydrologic model, the user will be required to input the percent imperviousness and CN for each watershed or subwatershed modeled. The CN is dependent on land cover and the NRCS Hydrologic Soil Group (A, B, C, or D). The modeled watershed or subwatersheds may be composed of multiple land uses and soil types. In these cases, a composite CN must be calculated as the representative CN for the area. Refer to Tables 6.6 and 6.7 for CN values for specific land uses and hydrologic soil groups.

The initial abstraction is another important parameter used in the CN analysis. It represents all the losses that occur prior to runoff including infiltration, interception, depression storage, and evaporation. The hydrologic model will calculate the default initial abstraction based on the selected CN. However, in some unique cases it may be desirable to provide a user-defined initial abstraction based on the site conditions.

The table below provides runoff curve numbers for typical land uses based on average imperviousness. If a development's land use does not match a land use in the table below, or if the development's imperviousness does not match the values in the table below, curve numbers for each subbasin within the development may be calculated using TR-20 and TR-55.

Table 6.6. Runoff Curve Numbers

Land Use or Surface Characteristic	Average Imperviousness (percent)	Runoff Curve Number by Soil Type			
		A	B	C	D
Commercial/Mixed Use					
Downtown and Base Areas*	95	95	96	97	97
All Other Commercial Areas	75	83	89	92	94
Residential Single Family					
2.5 acres or larger lot size	12	46	65	77	82
0.75 – 2.5 acres lot size	20	51	68	79	84
0.25 – 0.75 acres lot size	30	74	83	88	91
0.25 acres or smaller lot size	45	66	78	85	88
Multifamily and Resort Residential	75	83	89	92	94
Industrial					
Light	80	86	91	93	94
Heavy	90	92	94	96	96
Public Facilities/Open Spaces					
Parks, cemeteries	10	45	63	75	81
Playgrounds	25	45	63	75	81
Schools	55	69	80	86	89
Lawns and golf courses	2	40	62	74	80
Undeveloped Areas					
Pre-development conditions	2	40	62	74	80
Greenbelts, agriculture	2	40	62	74	80
Off-site analysis, unknown land use	45	66	78	85	88
Outcrops	70	80	87	91	93
Streets/Roads & Surfacing					
Paved	100	98	98	98	98
Road base or recycled asphalt	80	86	91	93	94
Gravel (uniformly graded)	40	63	76	84	87
Drives/Walks	90	92	94	96	96
Roofs	90	92	94	96	96

Reference: Values are from a combination of UDFCD (2016) and USDA NRCS (2004)

Table 6.7. Runoff Curve Numbers for Arid and Semiarid Rangelands

Cover Type	Hydrologic Condition[1]	Runoff Curve Number for Soil Type			
		A[2]	B	C	D
Herbaceous – mixture of grass, weeds and low-growing brush, with brush the minor element	Poor Fair Good		80 71 62	87 81 74	93 89 85
Oak-aspen – mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Poor Fair Good		66 48 30	74 57 41	79 63 48
Coniferous, general; grass understory	Poor Fair Good		75 58 41	85 73 61	89 80 71
Sage-grass – sage with an understory of grass	Poor Fair Good		67 51 35	80 63 47	85 70 55

1. Poor: <30% cover (litter, grass, and brush overstory); Fair: 30 to 70% cover; Good: >70% cover
2. Curve numbers for group A have not been developed for these types of cover

Reference: USDA NRCS (2004)

6.4.4.3 SCS Method – Time of Concentration

The time of concentration (T_c) is defined as the time it takes for water to travel from the most hydraulically distant point in the watershed to the point of interest. The SCS Method for calculating T_c is done by splitting the watershed into three distinct flow types: sheet flow, shallow concentrated flow, and open channel flow.

6.4.4.3.1 Sheet Flow

Sheet flow occurs in the upper part of the basin where there is not yet a defined channel. The assumption is that the depth of flow is very shallow, less than 0.1 feet, and that the total flow length is less than 300 feet. The equation for sheet flow is as follows:

$$T_t = \frac{0.007(nL)^{0.8}}{(s^{0.4})(P_2{}^{0.5})} \qquad (6.6)$$

Where:

T_t = travel time (hr)

n = Manning's n roughness coefficient (refer to TR-55 for example values)

L = flow length (ft)

P_2 = 2-year, 24-hour rainfall (in)

s = slope of hydraulic grade line (land slope, ft/ft)

6.4.4.3.2 Shallow Concentrated Flow

Travel time for shallow concentrated flow is estimated by multiplying the average velocity by the total length of flow. Average velocity is found using the Figure 6.1 below.

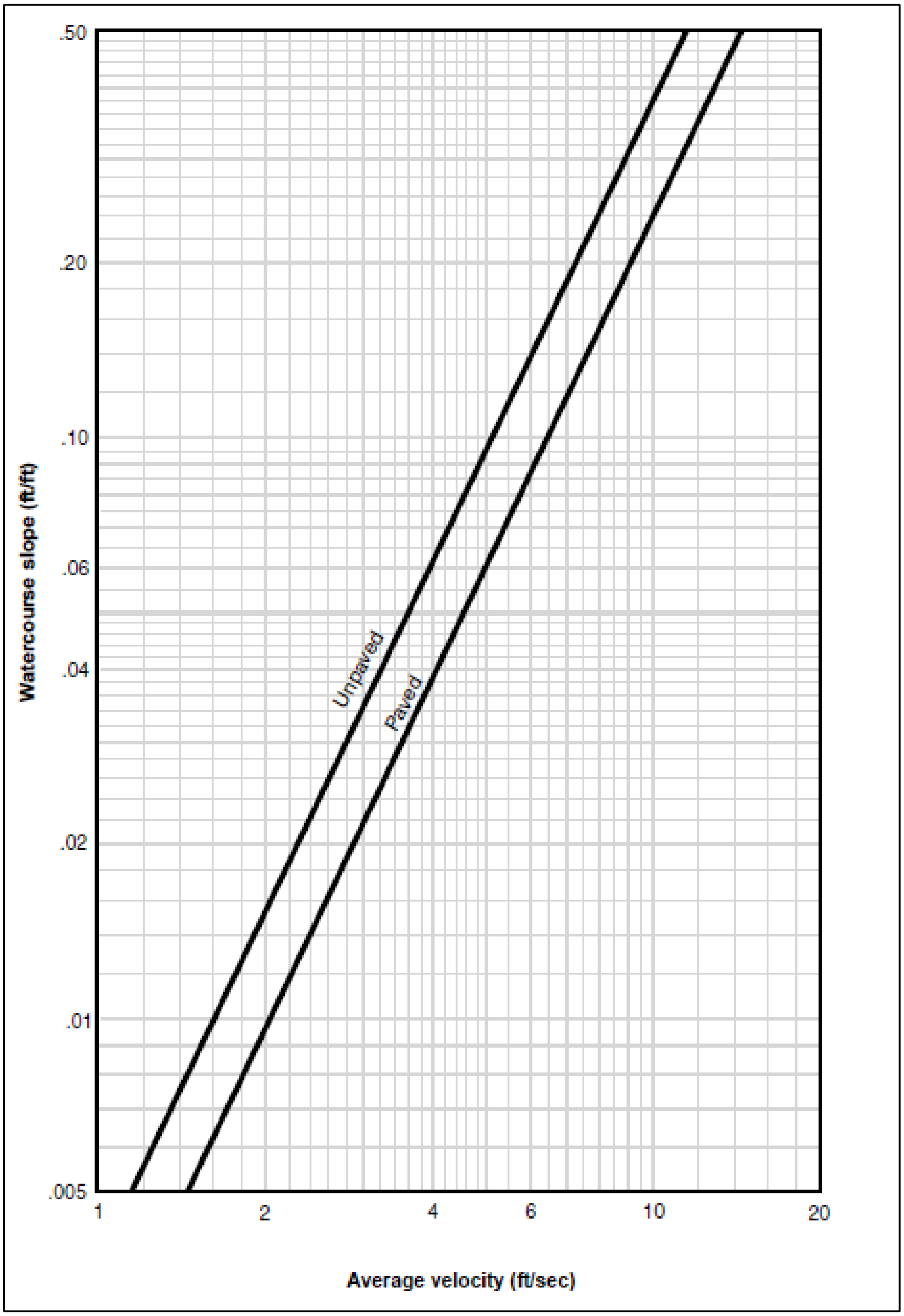


Figure 6.1. Average Velocities for Shallow Concentrated Flow
Reference: TR-55

6.4.4.3.3 Open Channel Flow

Open channel flow begins where there is a visible channel conveying storm water. Average velocity in the channel is estimated assuming the bank full flow. Velocity at bank full flow is calculated using Manning's equation or other available hydraulic modeling for the stream.

The total T_c is calculated as the sum of the three flows: sheet flow, shallow concentrated flow, and open channel flow. Some hydrologic models represent T_c as the lag time for the watershed. Lag time is defined as follows:

$$\text{Lag Time} = 0.6 * T_c \tag{6.7}$$

Where:

T_c = time of concentration (hr)

6.4.5 Hydrograph Development and Routing Models

Runoff hydrographs can be developed using CUHP, SWMM, or HEC-HMS modeling software. CUHP, which stands for Colorado Urban Hydrograph Program, was developed by the Mile High Flood District for use within SWMM. SWMM, which stands for Stormwater Management Model, was developed by the United States Environmental Protection Agency (EPA). SWMM can route hydrographs developed internally or those developed with CUHP. HMS, which stands for Hydrologic Modeling System, was developed by the United States Army Corps of Engineers' Hydrologic Engineering Center (HEC). HEC-HMS can also route the hydrographs it develops.

SWMM and HEC-HMS can evaluate runoff through larger or less homogenous basins or through complex drainage systems by routing flows through these elements. Other routing programs may be used if they are approved by the Town Engineer. The SCS Method should be used within HEC-HMS to generate runoff hydrographs. The EPA developed its own runoff method inherent to the SWMM software program. The SCS Type II storm distribution and NOAA Atlas 14 rainfall depths should be used to develop the hyetograph for input into the model. Other methodology may be used if it is better suited to site characteristics. A narrative describing the selected hydrologic methodology and the reasons for its selection should be included with the Drainage Report.

Basins should be divided into smaller and more homogeneous subwatersheds. The runoff hydrographs from upper subwatersheds are then routed through and combined with hydrographs from the lower subwatersheds, channels, detention basins, or other elements to develop a runoff hydrograph for the entire watershed.

The sizing of the detention storage may be based upon hydrograph storage routing techniques rather than direct calculation of volume and discharge requirements. A HEC or EPA SWMM model shall be used when reservoir routing of hydrographs is conducted, such as for the design of a detention pond. A HEC or SWMM model shall be used when channel routing of hydrographs is required.

6.4.5.1 HEC-HMS

HEC-HMS simulates the complete hydrologic process of a watershed system. The software includes traditional hydrologic analyses including infiltration, unit hydrographs, and hydraulic routing including through detention facilities. HEC-HMS also provides analysis tools for snowmelt. It should be noted that when using the SCS Type II storm distribution, the model is assuming that the storm distribution is for a 24-hour storm. If a 6-hour storm is desired, then the hyetograph must be input as a user-defined table.

6.4.5.2 EPA SWMM

SWMM is a rainfall-runoff model that analyzes a collection of subwatersheds that receive a rainfall hyetograph and generates runoff hydrographs at design points. SWMM can route runoff hydrographs through a system of pipes, channels, basins, and storage elements such as detention ponds; track the quantity of runoff generated at each design point; and track the flow rate and depth of water in each element over a specified simulation time. EPA SWMM is typically used for larger watersheds; for designing detention basins and water quality facilities; and for modeling large storm sewer systems. Runoff hydrographs can be developed internally or within CUHP.

6.4.5.3 CUHP

CUHP is a rainfall-runoff model that analyzes a collection of subwatersheds that receive a rainfall hyetograph and generates runoff hydrographs and total runoff volumes at design points. The runoff hydrographs are then routed by SWMM through a system of pipes, channels, basins, and storage elements such as detention ponds to determine peak flows and volumes.

6.4.6 FEMA Flows

FEMA has established regulatory 100-year peak flow rates for some of the larger streams within the Town. Where these flow rates have been established, the Town Engineer should be consulted to determine the validity of these flow rates as it is not uncommon for them to be outdated. In some instances, a new hydrologic study may be required to evaluate current peak 100-year flow rates along FEMA-regulated streams. This study would then be submitted to FEMA for review and approval to revise the regulatory flow rates. The 2018 Breckenridge Flood Damage Prevention Ordinance presents the Town's requirements for work near FEMA floodplains and shall be consulted prior to design of any work near a FEMA floodplain.

6.5 OPEN CHANNELS

Open channel flow occurs when water has its surface exposed to the atmosphere. Open channels can be natural waterways, canals, ditches, swales, culverts, flumes, and gravity pipes that are not flowing full. Once water fully fills a closed conduit, flow in that conduit becomes pressure flow. This section discusses types of open channel flow and gives general design guidance for open channels including roadside ditches. Any work in natural channels may be subject to FEMA floodplain regulations. Chapter 2 (Section 2.4) discusses the permits that will be required for work in open channels as well as the applicability of the 2018 Breckenridge Flood Damage Prevention Ordinance to work in open channels.

For a more thorough discussion of open channel design principles, the user is encouraged to review the most recent version of the Urban Storm Drainage Criteria Manual (USDCM) by the Mile High Flood District (MHFD).

6.5.1 Open Channel Hydraulics

The hydraulics of an open channel can be complex, ranging from steady state uniform flow to unsteady, rapidly varied flow. Most drainage design involves uniform, gradually varied, or rapidly varied flow states. Steady uniform flow occurs when the depth of flow remains constant. The calculations for both uniform and gradually varied flow are relatively simple and assume parallel streamlines. In contrast, rapidly varied flow calculations, for hydraulic elements like hydraulic jumps and flow over spillways, have solutions that are generally empirical in nature. This section presents basic equations and computational procedures for uniform, critical, gradually varied, and rapidly varied flow for hydraulic jumps and weirs.

6.5.1.1 Uniform Flow

Open channel flow is considered uniform if the depth of flow is the same at every section of the channel. For a given channel geometry, roughness, discharge, and slope, there is only one possible depth for maintaining uniform flow. This is called the normal depth. For a prismatic channel cross section, the water surface will be parallel to the channel bottom during uniform flow. Uniform flow rarely occurs in nature and is difficult to achieve, even in a laboratory. However, channels are designed by assuming uniform flow as an approximation that is adequate for planning purposes.

Calculations for normal flow depth shall be based on Manning's equation shown as Equation 6.8. A spreadsheet can be developed for this equation as an effective tool for quick analysis.

$$Q = \frac{1.49}{n} A^{5/3} P^{-2/3} \sqrt{s} = \frac{1.49}{n} A R^{2/3} \sqrt{s} \qquad (6.8)$$

Where:

Q = flow rate (ft^3/s)

n = Manning's roughness coefficient (see Table 6.8)

A = area (ft^2)

R = A/P = hydraulic radius (ft)

P = wetted perimeter (ft)

S = Channel or pipe slope (ft/ft)

Open channel flow velocity can be more easily calculated by rearranging Equation 6.8 to yield Equation 6.9. Equation 6.9 may be used to calculate travel time for the Rational Method. It may also be used to design channel revetment.

$$V = \frac{1.49 R^{2/3} S^{1/2}}{n} \qquad (6.9)$$

Where:

V = average velocity (fps)

For prismatic channels with uniform flow, the slope of the energy grade line (EGL), hydraulic grade line (HGL), and bottom of channel are assumed to be equal. Table 6.8 provides recommended Manning roughness coefficients for various channel linings and conditions. As channel roughness increases, a given flow rate will have a greater depth and slower velocity. Decreased roughness results in shallower depth and faster velocity. Selection of roughness coefficients for both the main channel and the overbanks is a critical part of the design and evaluation of an open channel, but it is also based on engineering judgement. Two engineers may look at the same natural channel and assign different Manning's n values.

Manning's n values may be selected to be slightly conservative for the variable being calculated. For example, when calculating a channel velocity, a slightly lower Manning's n value will result in a slightly higher calculated velocity, ensuring that channel revetment is adequately sized. When calculating channel capacity, a slightly higher Manning's n value will result in a slightly larger channel cross section, offering a factor of safety for channel sizing. Another factor to consider might be the anticipated long-term condition of the channel, as Manning's n values are prone to increasing if the channel is not properly maintained. Ultimately the Manning's n value selected by the design engineer must be defensible given the values presented in Table 6.8.

Table 6.8. Manning's Roughness Coefficients for Channels

Type of Channel & Description	Manning's n	Type of Channel & Description	Manning's n
Excavated or Dredged		**Lined or Built-Up Channels**	
Earth, straight & uniform		Riprap	
Clean, recently completed	.018	Riprap	Eq. 6.12
Clean, after weathering	.022	Concrete	
Gravel, uniform section, clean	.025	Trowel Finish	.013
With short grass, few weeds	.027	Float Finish	.015
Earth, winding & sluggish		Gunite, good section	.019
No vegetation	.025	Gunite, wavy section	.022
Grass, some weeds	.030	Concrete Bottom	
Dense weeds in deep channels	.035	Dressed stone in mortar	.017
Earth bottom & rubble sides	.030	Random stone in mortar	.020
Stony bottom & weedy banks	.035	Dry rubble or riprap	.030
Cobble bottom & clean sides	.40	Asphalt	
Dragline-excavated or dredged		Smooth	.013
No vegetation	.035	Rough	.023
Light brush on banks	.040	Gravel bottom with sides of	
Rock cuts		Formed concrete	.020
Smooth & uniform	.035	Random stone in mortar	.013
Jagged & irregular	.040	Dry rubble or riprap	.016
Channels not maintained, weeds & brush		Grassed	
Dense weeds	.080	Short grass prairie	0.15
Clean bottom, brush on sides	.050	Dense grasses	0.24
Natural Channels		Range (natural)	0.13
Natural channels, good condition	0.025	Wooded	
Natural channels, stones & weeds	0.035	Light underbrush	0.4
Natural channels, poor condition	0.06	Dense underbrush	0.8

References: Chow, V.T., Open Channel Hydraulics (1959), NRCS (1986)

For riprap lined channels, Equation 6.10 shall be used to calculate Manning's n value.

$$\text{n} = 0.0395 D_{50}^{1/6} \qquad (6.10)$$

Where:

D_{50} = mean riprap stone size (ft)

6.5.1.2 Critical Flow

Critical flow in an open channel is characterized by the following conditions:

1. The specific energy is at a minimum for a given discharge.
2. The discharge is at a maximum for a given specific energy.
3. The specific force is at a minimum for a given discharge.
4. The velocity head is equal to half the hydraulic depth in a channel with a minimal slope.
5. The Froude Number (Fr) is equal to 1.0.

When critical flow exists for uniform flow, the channel slope is at the critical slope. A slope flatter than critical will cause subcritical flow and result in a Froude number smaller than 1.0. A slope steeper than critical will cause supercritical flow and result in a Froude number larger than 1.0. When flow is at or near critical, it is unstable because minor changes in specific energy, such as from channel debris, will cause a major change in depth. Equation 6.11 should be used to calculate the Froude Number for all open channel designs.

$$\mathrm{Fr} = \frac{\mathrm{v}}{\sqrt{\mathrm{g}\mathrm{D_h}}} \qquad (6.11)$$

Where:

Fr = Froude number (dimensionless)

v = velocity (ft/s)

g = gravitational acceleration (32.2 ft/s^2)

D_h = hydraulic depth, A/T (ft)

A = channel flow area (ft^2)

T = top width of flow area (ft)

6.5.1.3 Gradually Varied Flow

Gradually varied flow is most often seen as backwater created by culverts, inlets, and channel constrictions. For these conditions, flow depth will be greater than normal depth in the channel and the water surface profile must be computed using a backwater technique—either the direct step or the standard step method. The direct step method is best suited to the analysis of simple prismatic channels, whereas the standard step method is best suited for irregular or nonuniform cross-sections.

Hydrologic Engineering Center's River Analysis System (HEC-RAS), developed by the U.S. Army Corps of Engineers, is recommended for calculating water surface profiles in the Town of Breckenridge. If a designer would like to compute water surface profiles by hand, the methodology for using both the direct-step and standard-step methods can be found in the HEC-RAS Hydraulic Reference Manual (Brummer, 2016), as well as in Open Channel Hydraulics (Chow, 1959).

6.5.1.4 Rapidly Varied Flow

Rapidly varied flow has a very pronounced curvature of the streamlines. The change in curvature may be so abrupt that the flow profile is virtually broken, resulting in high turbulence. Common instances of rapidly varied flow include weir flow, orifice flow, and hydraulic jumps. Only hydraulic jumps will be discussed in this section. In the Town, weir and orifice flow are used almost exclusively for detention pond outlets and will be discussed in Section 6.9.

Hydraulic jumps may occur at grade control structures, inside storm drains or culverts, and at the outlet of a spillway and can be very erosive and affect hydraulic capacity. For grassed channels, the forces from a hydraulic jump must be controlled to prevent serious damage. Drops or other grade control structures can be used to direct the jump to an area specifically designed to resist the forces that come with it.

Jump locations within storm drain systems can be approximated by intersecting the energy grade line of the supercritical and subcritical flow reaches. There is little threat of damage to storm drains, but pipe capacity may be impacted. The effect on pipe capacity can be determined by evaluating the energy grade line and accounting for the energy lost by the jump. In general, for Froude Numbers less than 2.0, energy loss is less than 10%. For long concrete boxes, the concerns of the jump are the same as for storm drains. However, the jump can be adequately defined for box conduits and for spillways using the jump characteristics of rectangular sections. These Standards do not include a detailed evaluation of hydraulic jumps, but the USDCM has procedures that can be used. Calculations must be included with the required submittals in accordance with Chapter 2.

6.5.2 Open Channel Design

The design standards for all open channels in the Town, except for roadside ditches addressed in Section 6.5.3, are those in the most recent edition of the USDCM. The design standards in the USDCM include channel centerline alignment and cross section layout, hydraulic analysis, and using rocks and boulders for protection from erosion. The design process for an open channel can be somewhat circular because of a wide range of options available for materials, typical cross section, channel slope, and the frequency and height of drop structures.

6.5.2.1 Channel Selection Factors

Each type of channel must be evaluated for hydraulic, structural, environmental, sociological, maintenance, economic, and regulatory factors. Table 6.9 summarizes the multi-disciplinary factors that should be used when selecting the channel that is most suitable for a specific site.

Table 6.9. Factors to Consider for Channel Design

Hydraulic	Structural	Environmental	Sociological	Maintenance	Regulatory
Topography	Cost	Habitat	Pedestrian	Lifespan	Federal
Capacity	Shear Stress	Water Quality	Recreation	Accessibility	State
Slope	Momentum	Traffic Patterns	Demographics	Repair	Local
Offsite Drainage	Seepage & Uplift	Aesthetics	Social Patterns	Reconstruction	Right-of-Way
Basin Sediment Yield	Material Availability	Wetland Mitigation		Maintenance Activities	
	Haul Off Site	Green Area Need			

6.5.2.2 General Design Guidelines

Except for roadside ditches and the additional criteria in these Standards, all open channel improvements shall be designed in accordance with the latest versions of the Open Channels, Hydraulic Structures, and Stream Access and Recreational Channels chapters of the USDCM.

All open channels within the Town shall be designed to convey both the minor and major design storms in a subcritical flow condition with a Froude number of less than 0.80. The major storm shall not result in a flow depth greater than 4.0 feet at any point along the channel reach. All open channels shall also be designed with public safety in mind and adequate maintenance access shall be provided.

Natural channels and grass-lined channels are preferred, and concrete-lined and riprap-lined channels are discouraged. Channel improvements that drastically change the look, shape, lining, alignment, or flow characteristics of the existing channel should be avoided. Improvements to natural channels should strive to maintain the capacity and alignment of the existing channel. In the event an entirely new channel is required, such as through a new development, it should closely mimic natural channels in the surrounding area with the same capacity.

The design components that have the greatest potential effect on the performance and cost of the improvements should be evaluated early on to guide the design process. High cost items include riprap channel linings and boulder drop structures, and the engineer should strive to design open channels to minimize the need for and use of these elements. Consideration should also be given to long term maintenance and repair costs.

6.5.2.3 High Gradient Channels

In mountainous areas, natural channels can have steep grades with cobble or rock along their bottoms. While uniform flow calculations with standard channel roughness values generally predict supercritical flow, field observations show that these channels are often protected by natural armoring. Field investigations have resulted in procedures for estimating hydraulic roughness for these streams that result in lower calculated velocities than those obtained with the Manning's equation using a uniform roughness coefficient. The designer is encouraged to review Determination of Roughness Coefficients for Streams in Colorado by Robert D. Jarrett in cooperation with the Colorado Water Conservation Board.

Equation 6.12 may be used as an aid in predicting the roughness coefficient of a high-gradient channel provided the following conditions are met.

1. The channel must be a natural channel that has a relatively stable bank material and a cobble or boulder bed material.
2. The channel friction slope must be between 0.01 and 0.04 feet per foot and the hydraulic radius must be between 0.5 and 7 feet.
3. The channel must not be affected by backwater.

$$\mathrm{n} = 0.39\mathrm{S}_\mathrm{f}^{0.38}\mathrm{R}^{-0.16} \tag{6.12}$$

Where:

n = Manning's roughness coefficient

S_f = channel friction slopes (ft/ft)

R = hydraulic radius, A/P (ft)

Additionally, while mountainous channels may have high average grades, they have often achieved this by cutting very steep drops interspersed along what are otherwise flatter reaches. The analysis of a natural mountain stream requires a careful topographical investigation. The hydraulic model must recognize that friction slope, hydraulic radius, and n value may change frequently along the length of the channel and take this into account by dividing the channel into reach lengths of reasonably uniform discharge, depth, slope, and channel and floodplain geometry. Determination of Roughness Coefficients for Streams in Colorado gives an in-depth discussion of suggested reach lengths and subdivision of cross sections to be used in the hydraulic model.

Natural channels have typically reached a reasonable state of equilibrium based on the amount of peak runoff they are accustomed to receiving. Although a new development may not encroach on the floodplain of a natural channel, it is also critically important that it does not increase the peak runoff the channel receives. This could easily cause erosion of the channel and require costly remediation.

If site conditions suggest use of Equation 6.12 might be appropriate, the designer shall consult with the Town to confirm its applicability and discuss any additional specific site concerns regarding the stability of the natural channel. Development shall be planned around natural channels so they remain in place in their natural alignment. If a Developer believes there is a benefit to realigning a natural channel, the proposed modifications shall be submitted to the Town Engineer for review. If the average slope of an existing natural channel through a development is greater than 1.0%, the existing natural channel should not be reconfigured either in horizontal or vertical alignment to suit development unless a geotechnical investigation identifies that the channel is unstable in its current condition. Rather, development should be planned to accommodate the location of the natural channel and its existing floodplain.

6.5.2.4 Ecological Channel Design Guidelines

The USDCM puts a considerable amount of emphasis on preserving and restoring natural stream corridors. The Town of Breckenridge strongly supports using ecological concepts to preserve and restore local channels. Ecological channel design includes bioengineering practices that utilize vegetation in a combination with natural structural measures to stabilize and protect stream banks while providing habitat.

Ecological channel design can have numerous public and environmental benefits when applied in an appropriate location, but care should be taken in selecting the location and completing design calculations to ensure an ecological channel design will hold up under the stream forces it is intended to withstand. Numerous types of bioengineering components can be used. Table 6.10 lists some of the potential advantages and disadvantages of an ecological channel design, as opposed to more traditional riprap and concrete design concepts. The potential for every channel restoration project to include ecological components shall be examined and discussed with the Town.

Table 6.10. Ecological Channel Design Advantages and Disadvantages

Advantages	Disadvantages
Environmental clearances (may facilitate permits)	Potentially more expensive
Aesthetically pleasing	Specialized vegetation
Fish passage	Additional maintenance required
Habitat for fish, birds, and macroinvertebrates	Susceptible to failure during larger storms
Open space creation and preservation	May require a larger footprint
Water temperature moderation	Specific hydrologic conditions required
Water quality enhancement	

Ecological channel design may be applied when the overall channel design is firmly rooted in engineering principles and when the following conditions are met:

1. Hydrologic conditions are favorable for establishment and successful growth of vegetation.
2. Designs are conservative in nature, and bioengineered features are used to provide redundancy.
3. Maintenance responsibilities are clearly defined.
4. Adequate structural elements are provided for stable conveyance of the major storm runoff.
5. Species are selected based on individual site characteristics.

It is important to note that bioengineered elements are commonly designed to withstand flows from more frequently occurring storms. Design events are typically between the 1.5-year to 10-year storm, with the 100-year storm occasionally being a consideration. While designing for a larger event is prudent, stability during such events may often be achieved by traditional engineering techniques because bioengineered elements may not remain stable above a certain threshold. If stability is critical at a given location, such as at bridge piers, bioengineering measures may not be enough without the addition of traditional engineering techniques. Bioengineering techniques can be incorporated into almost all traditional engineering projects, often to great ecological benefit. The design approach must balance ecological function with the need for channel stability when selecting a design discharge. Both the Town and the design engineer should discuss and agree upon the various ecological and hydraulic criteria the design will meet.

The key elements to consider in an ecological channel design include hydrology, hydraulics, geomorphology, physiochemistry, and biology. Each of the following elements should be addressed when designing the channel:

1. Future hydrologic changes associated with urbanization
2. Channel stability
3. Hydrology to support vegetation
4. Supplemental structural measures

The USDCM should be reviewed as part of the design process because it offers valuable guidance on typical minimum standards. The Natural Channel Design Review Checklist published by the US Fish and Wildlife Service should also be reviewed to ensure that all appropriate parameters have been considered.

No specific criteria or design guidance is included in these Standards because each site is unique and will require a solution based on the characteristics of and goals for each site. However, there are publications that offer guidance on ecological channel design, and these should be consulted to ensure the design will stand up to the chosen design hydraulic event. The Technical Supplements contained in *Stream Restoration Design* (National Engineering Handbook 654) (NRCS, 2007) offer extensive and detailed guidance on the physical design of ecological channels. Specifically, Technical Supplement 14, letters I through O, offer design guidance and equations for soil bioengineering, using large woody material for habitat and bank protection, vegetated rock walls, fish passage, and fish lunkers, among many other components.

Monitoring and maintenance should be performed throughout the life of the ecological channel design. The following list consists of four periods when a bioengineered structure is most at risk:

1. Immediately after construction
2. During the driest time of the year
3. During high magnitude discharge events
4. When a shift in plant community occurs away from plants chosen for biostabilization.

6.5.2.5 Revegetation

To achieve the highest likelihood of establishment of the specified vegetation, a 3-year maintenance plan from a certified landscaping company that understands native vegetation is required. The Town shall be consulted to provide a site-specific seed mix for each project. Plantings need to be completed in the fall or late winter to provide the best odds of establishment. Depending on the site, irrigation may also be required. Other techniques to improve the odds of successful vegetation establishment are in Chapter 7.

6.5.3 Roadside Ditch Design

Much like the design of any open channel, design of roadside ditches is a balance of several design components, including velocity, capacity, available right-of-way, slope, and cross-sectional geometry. Chapter 5 discusses several constraints and factors to consider when laying out a roadside ditch. The capacity requirements of a roadside ditch are based on the roadway encroachment criteria discussed in Section 6.6.

This section discusses permissible velocities and Froude numbers for a roadside ditch. Roadside ditch hydraulic calculations will be completed using Manning's equation. The Manning's roughness coefficients for calculating velocity, Froude number, shear stress, and capacity included in Table 6.8 will be used for all roadside ditch calculations. The designer should note that if a ditch is expected to be vegetated there is a much higher potential for erosion until revegetation is complete. The use of erosion control measures such as turf reinforcing mat prior to revegetation will minimize this potential.

Roadside ditch flow with design depths less than or equal to 1.0 feet have no Froude number or velocity limitations. For ditch flow depths greater than 1.0 feet, velocity shall not exceed 7.0 feet per second, and the Froude number shall not exceed 0.8. These criteria are shown in Table 6.11.

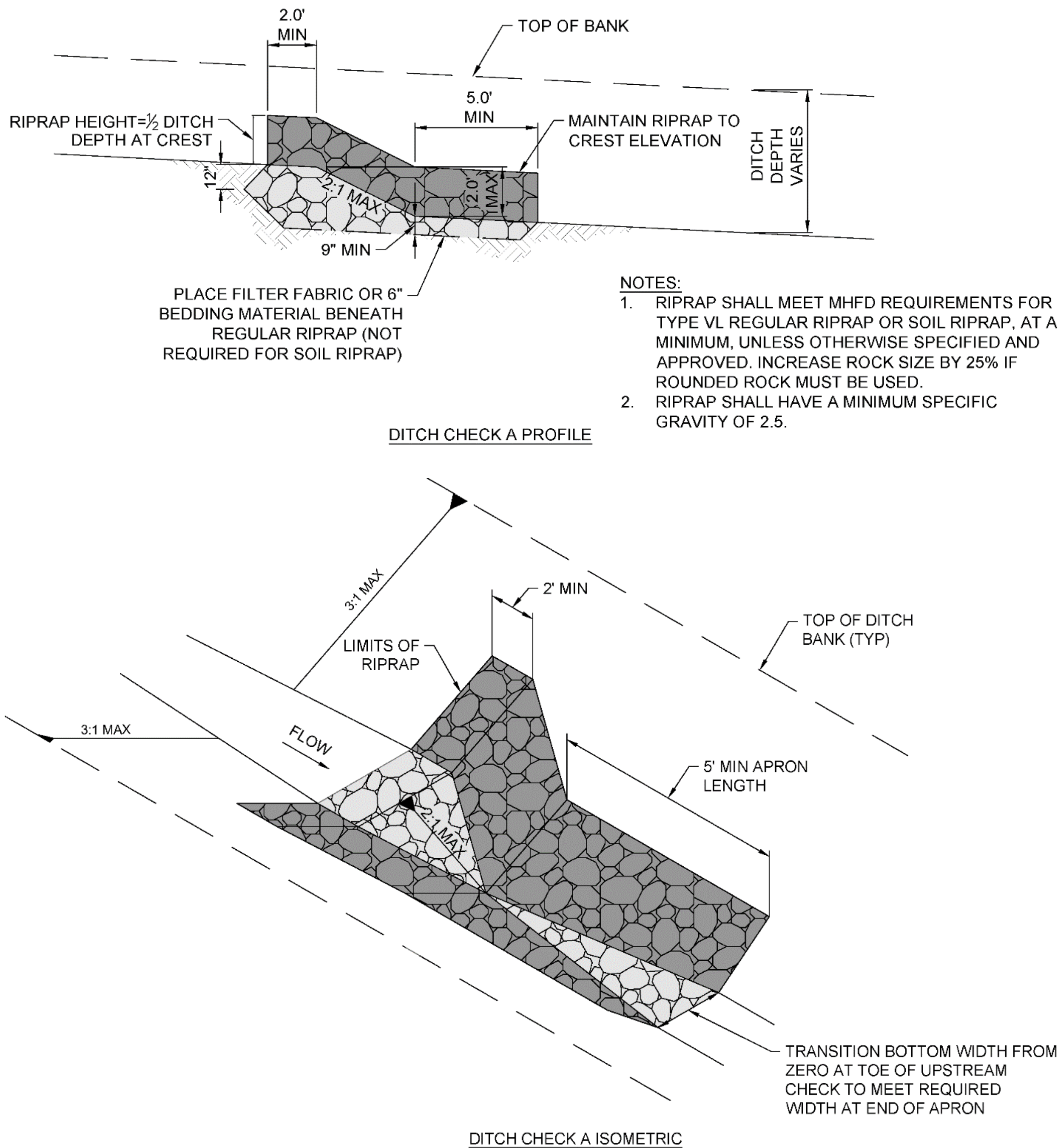
Table 6.11. Allowable Velocity and Froude Number for Roadside Ditches

Design Component	Maximum Allowable Values	
	Flow Depth ≤ 1.0 feet	Flow Depth > 1.0 feet
Velocity	No maximum	7 ft/s
Froude Number	No maximum	0.8

It is preferable that roadside ditches have side slopes no steeper than 3H:1V. If right-of-way is constrained, the ditch slope may be steepened to 2H:1V. Slopes steeper than 3H:1V shall be stabilized with erosion netting or stabilized with a method approved by the Town Engineer. Where right-of-way allows, roadside ditches will have a flat bottom at least two feet wide, but ditches may be V-shaped if right-of-way is constrained, with approval of the Town Engineer. Roadside ditches should ideally be designed as grass-lined channels without the need for riprap revetment. If riprap revetment is required, buried soil riprap shall be used in accordance with the design guidance in the USDCM and the ditch shall be revegetated.

Where roadway slopes are too steep to accommodate a ditch design that will meet velocity or Froude number criteria, a flattened ditch slope may be used with ditch checks placed at intervals to make up for grade discrepancies. An example of a ditch check is shown in Figure 6.2. In no case shall a roadside ditch have a slope steeper than 4%, regardless of whether allowable velocity and Froude number values are met.

Figure 6.2. Ditch Check Schematic



6.6 STREETS AND ROADSIDE CONVEYANCE

The primary function of public streets is the movement of traffic. The use of streets as part of the drainage system must be limited to prevent interference with traffic. Streets also typically convey runoff collected on the street surface as well as from some limited portion of the surrounding area. Streets must be capable of conveying that runoff to either a storm drain or open channel system. The drainage system in many parts of the Town is an open channel system with roadside ditches, which are discussed in Section 6.5. In dense and newly developed areas, an enclosed storm drain system is more appropriate, as discussed in Section 6.7.

This section presents the limitations on stormwater in public streets regardless of the type of roadside conveyance used. Limitations are established with roadway function and public safety in mind and are presented in terms of ponding depths at the curb face, the depth of flow permitted at the roadway crown, and the width of roadway that must remain clear during a storm event. Criteria vary based on the design storm and the roadway classification. When runoff in the street exceeds the allowable limits, a storm drain system, an open channel, or a combination of both is required to convey the excess flow. In all cases, the most stringent criteria will apply.

6.6.1 Allowable Flow Depth and Spread

Each street or roadway in the Town of Breckenridge is classified based on its role in connecting and providing access within and between various land uses. These classifications are available from the Town. The extent to which runoff from the minor or major design storm may encroach onto a roadway is based on that roadway's classification. Limiting the encroachment of stormwater onto a roadway section is the primary criteria by which public safety is maintained during a storm event.

Although many roads will utilize a roadside ditch to convey stormwater along the road, some will have a curb and gutter section. Using a curb and gutter or roadside ditch to convey flow along a street does not affect encroachment criteria because safety concerns remain the same for all types of roadways. The allowable encroachment onto the roadway for each roadway classification is presented in Table 6.12. These criteria may include the width of the roadway that must remain free of water or the allowable depth of flow at certain points along the roadway cross section. Curb overtopping criteria applies only to streets with a curb and gutter section.

In no case shall any roadway improvement, reconstruction, or expansion cause more flow encroachment on a parcel or structure outside the public right-of-way than currently exists. These criteria apply to roads with roadside ditches, curb and gutter sections, and culvert crossings. They do not apply to bridge crossings. Criteria for bridges are included separately in Section 6.8. Street inundation during both the minor and major storms must be analyzed for compliance with the criteria in this section.

Table 6.12. Maximum Allowable Flow Depth and Encroachment

Roadway Classification	Minor Storm Encroachment	Major Storm Encroachment
Arterial	10 feet clear each way; No curb overtopping; No encroachment on adjacent property	15 feet clear in center; Ponding below finished floor of all occupied structures
Major Collector	10 feet clear in center; No curb overtopping; No encroachment on adjacent property	Allowable depth at crown = 3 inches; Ponding below finished floor of all occupied structures
Minor Collector	10 feet clear in center; No curb overtopping; No encroachment on adjacent property	Allowable depth at crown = 6 inches; Ponding below finished floor of all occupied structures
Local	Flow may spread to crown; No curb overtopping; No encroachment on adjacent property	Allowable depth at crown = 9 inches; Ponding below finished floor of all occupied structures

Where roadside ditches are used to convey flow, they shall have sufficient capacity to meet the maximum encroachment and flow depth criteria in Table 6.12. Ditch geometry requirements are in Section 6.5 Open Channels.

6.6.2 Minimum and Maximum Grades

The minimum concrete or paved gutter grade shall be 0.5%. The minimum open channel grade shall be 1.0%. Maximum grades in roadside ditches shall meet criteria in Section 6.5 Open Channels.

6.6.3 Cross Street Flow

For all roadway classifications, flow in cross pans shall not exceed the limits set forth in Table 6.12.

6.6.4 Calculations

For roadway drainage, the minor and major storm must be evaluated separately for each side of the street using a Manning's n value of 0.016 for the gutter and street flow areas and a Manning's n value of 0.025 for sidewalk and grass areas, if needed. When a roadside ditch is used, a Manning's n value must be assigned based on the ditch lining.

6.6.4.1 Streets with Curb and Gutter

Design calculations can be performed manually, but this section assumes UD-Inlet will be used to calculate street capacity for those streets with curb and gutter. The USDCM provides additional details on the equations and methodologies that have been incorporated into the UD-Inlet spreadsheet, and guidance in the most recent version of the USDCM can be used for manual design. Note that as the MHFD updates their design spreadsheets they may change the prefix from UD to MHFD. The most recent version of UD-Inlet or MHFD-Inlet should be used.

A reduction factor from Figure 6.3 must also be applied to streets with curb and gutter, which will reduce effective street capacity. The reduction factor accounts for the increased effect on capacity that items like debris and parked cars can have at steeper roadway slopes. UD-Inlet includes these reduction factors automatically.

Street capacity calculations for the minor and major event shall be based on the following procedure:

1. Calculate the theoretical street capacity based on the allowable spread in Table 6.12.
2. Calculate the theoretical street capacity based on the allowable depth in Table 6.12.
3. Apply the appropriate reduction factor from Figure 6.3 to the theoretical flow rate based on allowable depth.
4. The lesser value from steps 1 and 3 is the allowable street capacity.
5. An inlet should be added whenever the runoff reaching the street exceeds the allowable street capacity for the major or minor event.

6.6.4.2 Streets with Roadside Ditches

Design calculations for streets with roadside ditches can be completed with a spreadsheet using Manning's equation in accordance with the design procedures in Section 6.5 Open Channels. The flow areas for the roadway and ditch must be separated so the appropriate Manning's n values can be used for each.

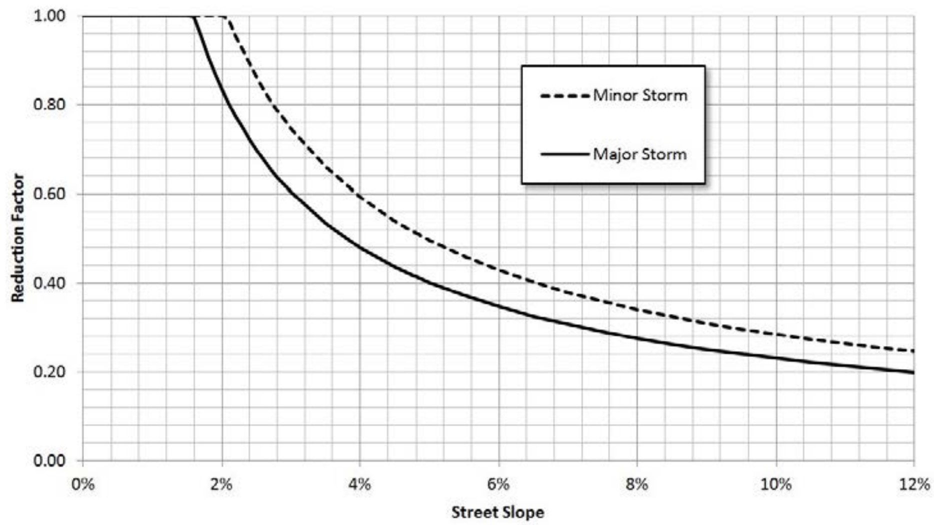


Figure 6.3. Reduction Factor for Gutter Flow
(UDFCD, 2018)

6.7 STORM DRAIN SYSTEMS

The criteria presented in this section shall be used to design and evaluate storm drain systems in the Town. A storm drain system refers to the system of inlets, pipes, manholes or junctions, outlets, and other appurtenant structures that are designed to collect and convey the initial or minor storm runoff. The storm drain system is a part of the local drainage system, which may also include curb and gutter, streets, roadside ditches, swales, and channels. This section presents both technical criteria and the general procedures for design and evaluation of pipes and inlets. Allowable roadway encroachment is in Section 6.6.

6.7.1 Storm Drain Design Criteria

A storm drain system is required when the allowable street capacity is exceeded during the minor storm event, or as required to eliminate the need for cross pans, or to prevent ponding/icing issues on roads. All criteria and guidelines below apply to the minor storm event unless site conditions offer no viable overflow option for the major storm event. Storm drain systems shall also be required where sump conditions exist and on major collectors and arterials to eliminate cross pans and ponding and icing near intersections.

6.7.1.1 Construction Materials

Pipe materials suitable for storm drains include reinforced concrete and high density polyethylene (HDPE). If the Town Engineer has reason to believe that pipe corrosion may be a problem, the Town Engineer may require a soils report to evaluate the corrosive potential of the soils and groundwater to be determined in the Geotechnical Report.

All pipe joint fillers, sealing compounds, gaskets, and the installation thereof, shall be in accordance with CDOT specifications. Rubber gaskets shall be used at pipe joints where the HGL is five feet higher or more than the pipe crown.

6.7.1.2 Pipe Size

The minimum allowable pipe diameter for storm drains shall be 18 inches for trunk lines and 15 inches for laterals. The minimum inside diameter of all pipes shall be no less than 14 inches for elliptical and arch pipe. In areas where debris, sediment deposition, adjacent wildfire burn area, or freezing are potential problems, the Town Engineer may require larger pipes. There is no maximum pipe size;

however, using multiple smaller barrels in lieu of very large pipes may be physically or economically advisable under some circumstances. For pipes below 5' diameter, a single barrel pipe is preferred over multiple smaller barrel pipes.

6.7.1.3 Horizontal and Vertical Alignment

Storm drains shall be designed and installed with sufficient cover to support an HS-20-44 loading in accordance with the pipe manufacturer's recommendations. Minimum and maximum cover are determined by the size, material, and class of pipe, as well as by the characteristics of the cover material and the expected surface loading. The designer should consult appropriate data sources to determine these values, but the minimum cover in all instances shall be greater than 24 inches of cover.

To prevent freezing issues, the following cover requirements shall be met as well, where feasible. In areas that are regularly plowed, storm sewers shall have a minimum cover of 5 feet. In areas not typically plowed, storm sewers shall have a minimum cover of 4 feet. Less cover may be allowed if winter flows are diverted and an alternate means of flow disposal is provided, such as a dry-well. If utility conflicts or grade restrictions do not allow the minimum values above, additional measures may be required to prevent freezing, including insulation around pipes, slotted pipes, deep inlets that are perforated or bottomless, and other measures as determined by the Town Engineer.

The following resources should be consulted to assist the designer in determining cover requirements:

1. Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, Section 700 (Materials Details)
2. Concrete Pipe Design Manual (ACPA)
3. Handbook of Steel Drainage and Highway Construction Products (AISI)
4. Pipe Manufacturer Specifications
5. Other applicable references

Trench installations, including bedding, shall be in accordance with the most recent edition of the CDOT M&S Standard Plans. In manholes and junction boxes, the lowest inlet pipe invert elevation must be at least 0.2 feet higher than the outlet pipe invert elevation. In cases where inlet pipes are smaller than outlet pipes, the top of the inlet pipes shall be at least 0.2 feet higher than the top of the outlet pipes.

6.7.1.4 Utility Crossings

The Town's required minimum clearance between storm drains and other utilities is 12 inches, regardless of whether the crossing utility is above or below the storm drain. If either the storm drain or crossing utility is encased, the minimum clearance may be reduced to 6 inches. In all cases, backfill material, compaction, and additional protection shall be designed and provided to prohibit settling or failure of either the storm drain or crossing utility.

When storm drains cross above or within 18 inches below water mains, the storm crossing shall be constructed of a 20-foot section of pipe centered on the water main alignment, and the bounding joints shall be encased. Storm drain joints shall also be encased at all locations less than 10 feet horizontally from a water main. Encasement shall be a reinforced concrete collar, 6 inches thick, extended to 12 inches on either side of the joint. The minimum reinforcement shall be a minimum of four continuous #4 bars, equally spaced around the pipe, and tied with #3 bars around the pipe at 8 inches on center.

All work shall be in accordance with these Standards, the Town's Standard Drawings, CDOT M&S Standard Plans, or other approved details, and the design must be approved by both the Town and the utility owner. Utility owners may have more stringent requirements and local utilities shall be consulted to ensure these requirements are met.

6.7.1.5 Inlets and Manholes

The standard inlets permitted in the Town are a CDOT Type 13 combination inlet, a CDOT Type 13 valley inlet, and a CDOT Type C grated inlet. Type 13 combination inlets may also be called a Type 16 inlet. Type 13 combination inlets shall be used with a 6-inch vertical curb and gutter section and installed with a localized depression at least 2 inches below the gutter flowline elevation. Type 13 combination inlets shall be located, at a minimum, just upstream of curb ramps, and never in the ramp itself. Type C inlets shall be used in roadside ditches and installed in accordance with the CDOT standard plans, including creating a sump condition where one does not naturally exist. Type C inlets are not traffic rated and shall not be placed in roadways. Type C inlets may not be placed in sidewalks or other pedestrian routes. Other types of inlets, including those made of PVC, HDPE, or other materials are only allowed in landscaped areas outside of roadway and sidewalk clear zones.

Table 6.13 provides the maximum allowable manhole or junction box spacing for storm drains. Manholes are also required where there is a change in pipe size, vertical or horizontal alignment, elevation, or slope, and where there is a junction of two or more pipes or laterals. All manholes and junction boxes must provide access to the storm drain system for maintenance and inspection. All manhole and junction box inverts shall be formed with a minimum of a half bench to provide more hydraulically efficient flow through the manhole.

Table 6.13. Maximum Allowable Manhole Spacing

Vertical Pipe Dimension	Maximum Manhole or Junction Spacing
15 to ≤ 36 inches	400 feet
> 36 to ≤ 60 inches	500 feet
> 60 inches	750 feet

The required diameter of the manhole barrel is dependent upon the size of the largest pipe connecting to it. Minimum manhole sizes are in Table 6.14 and assume the storm drain alignment passes straight through the manhole with no incoming lateral lines. If a storm drain system changes alignment or must accommodate incoming lateral lines at a manhole, the manhole may need to be larger.

Table 6.14. Manhole Sizing

Maximum Pipe Dimension	Minimum Manhole Size
≤ 24 inches	4-foot diameter
> 24 to ≤ 42 inches	5-foot diameter
> 42 inches	6-foot diameter or box base

6.7.1.6 Capacity and Velocity

Minimum velocities are required in storm drains to reduce sedimentation and promote positive drainage through the pipe at all flow depths. Public and private storm drains shall have a minimum flow velocity of 3 feet per second when normal flow in the pipe is at 0.25D and never be constructed at less than 0.40% slope. Public and private storm drains shall have a maximum flow velocity of 16 feet per second for all storm events, although care should be taken with velocities this high as there is a higher risk for hydraulic jumps and extreme head loss through junctions.

The storm drain system shall be designed to convey the minor storm without resulting in pressure flow, and the energy grade line (EGL) for the minor storm shall be at or below finished grade at all manholes, inlets, or other junctions. Pressure flow during the major storm is discouraged, but if it does occur, it must not create a surcharged condition at any inlet. Where the 100-year hydraulic grade line (HGL) is above any manhole rim, or if any manhole or inlet is in a floodplain, all manhole and inlet covers must be bolted down.

The EGL and HGL for both the minor and major storm events shall be calculated and plotted for all storm drain systems. Hydraulic losses will include friction, expansion, contraction, and junction losses at a minimum. The methods for estimating these losses are presented in the following sections. Manning's n values for capacity and velocity calculations for storm drains shall be the values in Table 6.15. The design of storm drain outlets into open channels, including revetment shall meet the requirements of Section 6.8 for culvert outlets.

Table 6.15. Manning's Roughness Coefficients for Storm Drain Conduits

Pipe Interior	Manning's n
RCP (newer)	0.013
RCP (older)	0.015
RCP (preliminary design)	0.015
Smooth Plastic (HDPE)	0.011

When a planned storm drain system connects directly into the Town's existing storm drain system, an analysis must be provided showing the additional flow from the proposed project does not result in the capacity of the existing storm drain system being exceeded. The requirement for detention in Section 6.9 is intended to facilitate meeting this requirement.

6.7.2 Storm Drain Hydraulics

This section presents the general aspects of hydraulic design and evaluation of storm drains. Hydraulic design calculations can be performed manually with a spreadsheet or by using a computer model. Both methods are briefly discussed below. The user is assumed to possess a basic working knowledge of storm drain hydraulics and is encouraged to review technical literature available on the subject as needed.

6.7.2.1 Manual Calculations

Manual storm drain hydraulic calculations shall be performed in accordance with the HEC-22 (Brown et al., 2013) or the latest version of the USDCM. HEC-22 includes a discussion of both open channel and pressure flow and includes a design example.

Two of the critical design elements of a storm drain system are the HGL and the EGL. The HGL is a line that represents the water surface elevation along an open channel, including open channel flow within a pipe. In pressure flow, the HGL is the level to which water would rise in a vertical tube at any point along the pipe. The EGL is an imaginary line that represents the total energy at any point in the system. Total energy includes elevation head, velocity head, and pressure head and is the HGL plus the velocity head ($V^2/2g$). The total energy at any location equals the energy at any downstream location plus the losses that occur between the two locations.

Losses are typically classified as either friction or form losses. Friction losses occur as water flows along the length of a pipe. Form losses occur at the exit from the system and at junction structures within the system. Because the Town does not allow transitions or bends outside of manholes, form losses will be restricted to exit losses when flow leaves the system, and structure losses, such as through inlets or manholes. These are referred to by HEC-22 as inlet and access hole losses.

6.7.2.2 Computer Model Calculations

Computer models are often used to calculate the HGL and EGL of storm drain systems. The benefits of using a computer model include consistency, speed, and the ability to check the validity of the model with relative ease. One disadvantage of computer modeling is that errors can occur and be hidden when the model user is inexperienced. Three common programs used throughout Colorado include those listed below. Additional software may be used as approved by the Town provided it utilizes industry standard calculation methods:

1. UD-Sewer 2009, a simple and free program developed by the MHFD that is easy to learn. Note that while UD-Sewer is still provided on the MHFD website and may still be used for new projects, the MHFD no longer supports this program.
2. Storm and Sanitary Analysis, a more complex design tool which runs within the AutoCAD Civil 3D design software package by Autodesk.
3. StormCAD, a more complex design tool which runs within the MicroStation design software package by Bentley Systems or within AutoCAD.

This section provides specific guidance for UD-Sewer 2009. The program uses Manning's equation to analyze and size storm sewer systems. The program can also use the Rational Method to calculate runoff, perform HGL and EGL calculations, and provide plots of the storm drain, ground line, HGL, and EGL. The user's manual is embedded in the software, which can be obtained from the MHFD website (https://mhfd.org/resources/software) or via an internet search for "MHFD UD-Sewer."

6.7.2.2.1 Rational Method

UD-Sewer 2009 uses the Rational Method to calculate runoff based on input parameters provided by the user. The user can override Rational Method calculations by manually entering known flows that have been calculated separately; however, values must be entered for Rational Method parameters or the program will give an error.

6.7.2.2.2 Bend and Lateral Loss Coefficients

UD-Sewer 2009 requires bend and lateral loss coefficients for each storm drain segment within a model. Bend and lateral losses both occur at a manhole or inlet junction. Bend losses are the result of the angle between the incoming storm drain and the exiting trunk line at a junction. Lateral losses are the result of turbulence or eddies that occur from lateral flows joining a trunk line. These coefficients are calculated by the program based on user inputs that define the geometry of the system.

To calculate the bend loss coefficient, the user must select the shape of the manhole invert and enter the angle between the incoming and downstream pipe segments. To calculate the lateral loss coefficient, the user must enter the angle between the incoming lateral and downstream trunk line. When entering the angle, the user must select main line or lateral line. Lateral loss is only applied to the main lines of a storm sewer system in UD-Sewer 2009. For all lateral lines, the user should select lateral line and the program will default to zero. If more than one lateral enters a manhole, the user must exercise judgment to determine the appropriate loss coefficient. .

6.7.3 Inlet Hydraulics

This section presents the general procedures for sizing and spacing inlets for a storm drain system. Design calculations can be done manually, but this section focuses on the use of UD-Inlet to calculate street and inlet capacity. The USDCM provides additional details on the equations and methodologies that have been incorporated into the UD-Inlet spreadsheet, and guidance in the most recent version of the USDCM shall be used for manual design. Note that as the MHFD updates their design spreadsheets they may change the prefix from UD to MHFD. The most recent version of UD-Inlet or MHFD-Inlet should be used.

6.7.3.1 Introduction

Inlets on a continuous grade result in uncaptured flow bypassing the inlet and continuing to the next inlet in the system. Sump inlets are located at low points in the roadway vertical alignment which are known as sags or sumps; there is no way for excess water to bypass a sump curb inlet. A sump condition can occur at a change in street grade from positive to negative or at an intersection due to the crown of the cross street.

6.7.3.2 Inlet Capacity

Inlet capacity may be calculated using the UD-Inlet spreadsheet developed by the MHFD. UD-Inlet is an Excel-based program that calculates both street and inlet capacities based on several parameters entered by the user. In general, the procedure consists of defining the amount and depth of flow in the gutter and determining the theoretical flow interception by the inlet. The calculations within the spreadsheet program are based on physical research completed at Colorado State University. The most recent version of UD-Inlet can be obtained via an internet search for “UD-Inlet MHFD” or from the MHFD website (https://mhfd.org/resources/software).

Information required by the UD-Inlet spreadsheet includes design flow; height of curb; distance from curb face to street crown; gutter width; street cross and longitudinal slopes; gutter cross slope; Manning’s n for the street; maximum allowable spread from gutter flow line; maximum allowable depth at gutter flow line; and allowable flow depth at the street crown. Additionally, if flow is allowed behind the curb, the allowable spread width, side slope, and Manning’s n behind the curb must be entered. The spreadsheet can use the Rational Method to calculate a design flow at the inlet or will accept a flow entered by the user. If the inlet receives bypass from an upstream inlet, the bypass flow can be entered or referenced from another UD-Inlet worksheet. Default clogging factors included in the UD-Inlet spreadsheet shall be used to account for potential debris clogging, pavement overlaying, and varying design assumptions.

6.7.3.3 Continuous Grade Condition

The capacity of an inlet on grade is dependent on street slope, depth of flow in the gutter, height and length of curb opening, street cross slope, and the amount of local inlet depression. Cost effective inlet design allows for some bypass. The amount of bypass or carryover flow must be included in the drainage facility evaluation as well as in the design of the inlet.

6.7.3.4 Sump Condition

Due to frequent freezing conditions and the associated hazards, sump conditions will only be allowed where no practical alternatives for grading and drainage exist. Where a sump condition is unavoidable, sump inlets shall be sized to have twice the capacity as otherwise required by these Standards to decrease the likelihood of ice buildup preventing the inlet from functioning.

6.7.3.5 Inlet Spacing

The optimum spacing of storm inlets is dependent upon several factors, including traffic requirements, contributing land use, street slope, allowable street capacity, and distance to the nearest outfall system. The suggested sizing and spacing of the inlets is based on an ideal interception rate of 70% to 80%. This spacing has been found to be more efficient than a spacing that will accomplish a 100% interception rate; although, the downstream-most inlet will still need to be designed to intercept 100% of the flow.

Inlet spacing is typically an iterative process, and the designer may have to move inlet locations multiple times before determining the appropriate spacing to meet design criteria and maintain efficiency. After initial inlet locations are determined, the designer should recalculate the peak flow to each inlet and check that the allowable street capacity has not been exceeded at any location. If the actual flow is less than the allowable street capacity, inlets may be spaced further apart to prevent overdesign of a system. Locating inlets is a balance between meeting criteria and efficient design. It is not usually possible to have optimum inlet spacing throughout an entire storm drain system The inlets must be spaced so that no portion of a roadway exceeds the spread criteria of this chapter.

6.7.3.6 Inlet Grates

All grates used on storm inlets in the Town will be bicycle-safe grates in accordance with the most recent version of the AASHTO Guide for the Development of Bicycle Facilities. Grates shall be Type L vane grates or approved equal style meeting AASHTO bicycle and ADA requirements. Grates shall be cast iron and rated to withstand HS-20-44 loading.

6.7.4 Design of a Storm Drain System

This section presents the general procedure used to design a storm drain system from preliminary through final design. A typical local drainage system consists of flow in the storm drain and allowable flow in the gutter and street. These flows are ultimately discharged to a larger drainage system or an open channel with capacity for a much larger event.

6.7.4.1 Preliminary Design

The preliminary design of the storm drain system begins after a preliminary development plan has been prepared that delineates the general development areas, major drainage paths, and drainage outfall locations. Allocation of space for drainage facilities and considerations shall be incorporated into the preliminary development plan. The drainage engineer must have input into the development plan to ensure proper drainage planning.

1. The first step in any drainage project is the collection of basic data. Information typically required includes:
    a. Topographic maps of the development and drainage basins that show existing and proposed roadways, existing and proposed land uses, major drainage features such as creeks and streams, development area, and property boundaries
    b. Typical street cross sections
    c. Preliminary grading information, such as contours, profiles, and control elevations
    d. Soils information
    e. Existing and proposed utilities
    f. Existing irrigation and raw water facilities and requirements for maintaining facilities
    g. Rainfall information
2. Perform the hydrologic evaluation of the basin(s) for both the minor and major storms, typically using the Rational Method. Divide each basin into smaller subbasins and calculate the peak design flow for each hydrologic point of interest or potential inlet location. The degree of basin subdivision will depend on the detail of information available and the experience of the licensed professional drainage engineer.
3. Complete preliminary sizing for the minor storm. Beginning at the upper end of the basin, calculate the flow in the street until the allowable capacity of the street as calculated in Section 6.6 matches the design runoff. The storm drain system will typically start at this point. Removal of all street flow by inlets is not required, except at sump locations, and is typically not

economical. The sum of the flow in the storm drain and the street must be less than or equal to allowable capacity.

4. Assign a diameter, pipe material, and slope for preliminary sizing. Manning's n values should be those in Table 6.15. A profile may be required to check for utility conflicts or to confirm compatibility with the receiving drainage system. The preliminary vertical alignment should not be steeper than the proposed street grade. The designer should also be aware of existing utility locations, especially when crossing water and sanitary main and service lines.
5. After sizing the system for the minor storm, route the major storm through the system and evaluate the results. The combined total of the allowable street capacity and the storm drain capacity during the major storm should equal or exceed the 100-year runoff. A plan and profile of the pipes and minor and major storm EGL and HGL is required. If the combined allowable capacity is less than the design flow, some or all the following actions may be taken:
    a. Increase storm drain sizes and/or the number and size of inlets
    b. Increase street grade within acceptable limits or revise street cross-sectional geometry to allow additional capacity
    c. Provide additional onsite detention within the development to decrease peak flow.
6. Evaluate the preliminary design for costs and benefits. The impact of the system on downstream properties must be evaluated and mitigated as needed.

6.7.4.2 Final Design

Final design consists of final revisions to the storm drain system model and preparation of plans, profiles, and specifications for the storm drain system in enough detail for construction. Basic data, hydrologic analysis, and inlet sizing performed during preliminary design should be reviewed and verified. Drainage subbasin boundaries should be confirmed or revised as necessary, and design peak flows should be recalculated. The pipe and inlet sizes and locations are finalized while accounting for final street and storm drain grades, locations of existing and proposed utilities, and the design of the major drainage system. The EGL and HGL should be revised with updated energy losses at manholes and any other structures.

6.8 CULVERTS AND BRIDGES

Culverts and bridges convey surface water through or beneath an embankment such as a roadway, railroad, or canal. The size, alignment, and support structures of a culvert or bridge directly affect the capacity of the drainage system. An undersized culvert or bridge will force water out of the channel and cause flooding and damage. Culverts and bridges may significantly influence upstream and downstream flood risks, floodplain management, and public safety.

The criteria presented in this section shall be used to evaluate and design culverts and bridges in the Town, regardless of whether they are located within public right-of-way. The review of all submittals will be based on the criteria in this section. Stormwater crossings of CDOT roadways may have additional requirements.

6.8.1 Culvert Design Standards

Culverts shall be designed and constructed to the following standards. All proposed culverts, regardless of whether they are in public right-of-way, are subject to review and approval by the Town Engineer.

6.8.1.1 Materials and Structural Design

Allowable materials for culverts include HDPE and reinforced concrete. The culvert materials and joints shall meet the most recent versions of the standards listed in Table 6.16 for each type of culvert.

Each culvert installation shall be designed to maintain its full shape and function under an HS-20-44 loading in accordance with the design procedures in the latest edition of the AASHTO Standard Specifications for Highway Bridges, or appropriate ASTM standard, and with the pipe manufacturer's recommendations. For roadway crossing culverts, the minimum cover shall be 24 inches measured from the top of the pavement. For culverts crossing private driveways, the minimum cover shall be 8 inches. In all cases, minimum cover over roadway crossing culverts shall also include at least 6 inches of aggregate base course under the pavement. Total minimum cover may need to be increased for thicker pavement sections. In all cases, the minimum and maximum cover shall be in accordance with the manufacturer's recommendations. Trench installations shall be in accordance with the most recent edition of the CDOT M&S Standard Plans.

Table 6.16. Applicable Culvert Standards

Culvert Type	Standard
Reinforced Concrete Pipe—Round	ASTM C76 or AASHTO M 170
Reinforced Concrete Pipe—Elliptical	ASTM C507 or AASHTO M 207
Reinforced Concrete Pipe—Joints	ASTM C443 or AASHTO M 198
Reinforced Concrete Box Culvert—Joints	ASTM C1677
Reinforced Concrete Pipe—Arch	ASTM C506 or AASHTO M 206
Precast Concrete Box Culverts	ASTM C1433/C1577 or AASHTO M 259/M 273
Concrete for Cast-in-place culverts	CDOT 601
High Density Polyethylene Pipe (HDPE)	ASTM F2306
Gaskets for Joining Plastic Pipe (HDPE)	ASTM F477

6.8.1.2 Minimum Size

The minimum pipe diameter for culverts in the public right-of-way that are not driveway culverts shall be 18 inches. The minimum vertical pipe dimension shall be 18 inches where elliptical or arch pipe is used. Equivalent sizes for a 24-inch round pipe are a 29-inch by 18-inch arch and a 30-inch by 19-inch elliptical section.

Roadside ditch culverts crossing private driveways shall have a minimum diameter of 18 inches. Roadside ditches shall be re-graded if necessary to provide positive drainage below the culvert and prevent ponding or a sump condition near the culvert. The developer is responsible for re-grading and reconditioning existing swales to prevent ponding or a sump condition. If existing conditions prohibit the installation of an 18" culvert, the Town Engineer may grant a variance to allow a smaller culvert.

6.8.1.3 Allowable Headwater

Ponding above culvert entrances can cause property or roadway damage, culvert clogging, saturation of fills, detrimental upstream deposits of debris, an increase in floodplain elevation, or inundation of existing or future facilities. The maximum headwater for the 100-year design flow shall be 2.0 times the culvert diameter or culvert rise dimension for shapes other than round ($H_W/D \leq 2.0$) for culverts with a rise dimension less than or equal to 36 inches. For culverts with larger rise dimensions, the headwater to depth ratio for the 100-year design flow shall be less than 1.5. There is no maximum headwater value for the minor storm. Table 6.17 lists these criteria. The criteria in Table 6.17 are in addition to roadway encroachment and overtopping criteria, and do not apply to detention, water quality, or sedimentation facility outlets.

Table 6.17. Allowable Headwater

Culvert Diameter or Rise	100-Year Maximum Headwater/Diameter (H_W/D)
≤ 36 inches	2.0
> 36 inches	1.5

6.8.1.4 Roadway Overtopping

No overtopping of any public roadway at a roadway culvert crossing is permitted during the minor storm. Roadway overtopping of up to 6 inches may occur at culvert crossings of local roads during the major storm. Overtopping at arterial, major collector, and minor collector roadways may not occur during the major storm. Overtopping of driveways at culverts in roadside ditches may not result in roadway encroachment that exceeds that specified in Section 6.6. These criteria should be considered as headwater limitations in addition to those in Table 6.17 above.

Additionally, culverts under arterial and major collector roadways, or those conveying flows from drainage areas larger than 0.50 square miles shall pass the 100-year storm assuming 20% of the inlet is plugged.

The depth of roadway overtopping is assumed to be the difference between the headwater elevation and the roadway crown elevation along the centerline of the culvert. Where overtopping is not permitted, but some amount of encroachment is permitted, the culvert headwater elevation can be set at the elevation corresponding to the limits of encroachment.

During roadway overtopping, the roadway crown is assumed to act as a broad-crested weir. A weir coefficient of 2.8 shall be assumed along with a weir length not to exceed 100 feet, regardless of roadway geometry. The designer should first calculate weir flow using the allowable overtopping depth for the major storm. The designer should then calculate flow through the culvert in accordance with these Standards, with culvert headwater set at the allowable overtopping elevation. If the calculated weir flow plus the flow through the culvert exceeds the design flow, the allowable overtopping condition has been met.

6.8.1.5 Velocity and Outlet Protection

A minimum flow velocity within the culvert of 3 feet per second is required to prevent sediment from accumulating in the culvert. The minimum flow velocity should be calculated using Manning's equation with a flow depth equal to 0.25 times the vertical dimension of the culvert. Manning's n values are presented in Table 6.15 above. Regardless of calculated flow velocity, the minimum slope of any culvert shall be 0.40%.

Culvert design must include revetment to protect the outlet from erosion if exit velocity exceeds 6 feet per second during the 100-year event as calculated in accordance with these Standards. The most common type of outlet protection is riprap, either as a riprap apron or as a low tailwater basin. Procedures for designing a riprap apron or low tailwater basin downstream of a culvert outlet, including for multiple conduit installations, can be found in the USDCM. Culverts should not be designed with 100-year outlet velocities greater than 16 feet per second.

An economical culvert design that meets allowable headwater requirements should not result in a Froude number larger than 2.5 when design velocities are kept below 16 feet per second. Culvert slopes should be as flat as practicable to limit the amount of revetment required at the outlet. A riprap apron is typically used when the culvert discharges to a well-defined channel that can be expected to have a tailwater elevation equal to at least one-third of the height of the culvert. A low tailwater basin is typically used when the receiving channel may have little or no tailwater or where the receiving channel is not well defined.

6.8.1.6 Headwalls, Wingwalls, and End Sections

Except for private driveway culverts, all culverts in the public right-of-way shall be designed with headwalls and wingwalls or flared end sections at the inlet and outlet to minimize head loss. Stone headwalls and wingwalls are not allowed in roadside ditches. Private driveway culverts less than 36 inches in equivalent diameter may have projecting ends. Headwalls, wingwalls, and end sections shall be in accordance with the most recent edition of the CDOT M&S Standard Plans. Headwalls or end sections shall be located to provide a grade no steeper than 3H:1V between the back of the structure and the edge of the roadway shoulder or back of walk. Ditch and channel sections and profiles shall be transitioned at culvert inlets and outlets to allow for adequate cover over the culvert and to provide inlet and outlet conditions that will not cause erosion or sediment deposition.

6.8.1.7 Grates

Where a clear and present danger exists such as a siphon, a drop in elevation adjacent to a sidewalk or road, a long pipe with one or more manholes, or at pipes which are near playgrounds, parks and residential areas, a grate at the inlet and outlet of the culvert may be required. For most pipes through embankments and under streets, grates will not be required.

6.8.1.8 Location and Alignment

Culverts shall be located to completely drain all rainfall and snowmelt runoff where drainageways intersect a roadway or sidewalk. All areas that water could be impounded, or flow restricted, by the new embankment must be identified and considered for culvert locations. Culverts shall be aligned to give drainageways a linear entrance and exit. Abrupt changes in alignment at either end of a culvert may retard flow and make a larger structure necessary. If possible, a culvert shall have the same alignment as the channel it conveys. If this is not practical, and the water must be turned into a culvert, headwalls, wingwalls, and aprons shall be used as protection against scour and to provide a more hydraulically efficient inlet.

Where the natural channel alignment would result in a culvert alignment skewed more than 30 degrees from perpendicular to a roadway, modification may be necessary. Such modifications will change the natural stability of the channel, and an investigation into other options is recommended. Although economic factors are important, hydraulic effectiveness of the culvert must be given primary consideration.

Roadway alignment also affects culvert design. The vertical alignment of roadways may define the maximum culvert diameter that can be used. Low vertical clearance may require the use of elliptical or arched culverts or the use of multiple barrels.

6.8.2 Bridge Design Standards

Based on hydraulic capacity requirements, bridges may be required to cross major open channels. Sizing bridge openings is of great importance. Improperly designed bridges may cause excessive scour or deposition or may not be able to pass the design flow. Backwater caused by bridges can cause flooding of upstream property, overtopping of roadways, or costly maintenance. Bridge openings should have as little effect on the flow characteristics as is reasonable, consistent with good design and economics. The criteria in this section apply to bridges on public and private roads in the Town. The Town will review bridge designs based on the guidance in this section.

It is possible that a bridge designed to meet the criteria of these Standards may be on a roadway that becomes flooded during the storm event the bridge is designed to pass. New bridges shall be designed to these Standards regardless of adjacent roadway flooding because roadways that experience frequent flooding may be reconstructed at a higher elevation in the future to achieve an overall greater level of protection.

6.8.2.1 Bridge Sizing

The low chord of all bridges must provide a minimum freeboard. All bridges on arterial and major collector roadways, or above the Blue River or its major tributaries, shall have a low chord elevation set at least 3 feet above the HGL. All other bridges shall have a low chord elevation at least 1 foot above the HGL. Arch culverts, large diameter culverts, or other structures may be classified as a bridge and subject to freeboard requirements. Freeboard requirements apply to both vehicular bridges, pedestrian bridges, and any other structures spanning a floodway.

6.8.2.2 Hydraulic Analysis

Hydraulic analysis and design calculations for all bridges must be prepared and certified by a licensed Colorado Professional Engineer. The procedures for design as outlined in the Federal Highway Administration (FHWA) publication *Hydraulic Design of Safe Bridges* shall be used for the hydraulic analysis of the proposed design. HEC-RAS may be used to complete the hydraulic analysis of bridge openings provided the guidance in the publication is followed. All bridges are assumed to remain in place during all storm events and shall not be assumed to break away or otherwise be removed from any modeling scenario. Design flow rates shall be those specified by FEMA or as calculated in accordance with these Standards.

6.8.2.3 Inlet and Outlet Configuration

Where bridge abutments and foundations are located below the 100-year water surface elevation, concrete wingwalls shall be tied to the existing side slopes to prevent erosion behind the abutments and to provide slope stabilization from the top of the embankment to the toe of slope. Riprap protection on the inlet and outlet transition slopes shall be provided to prevent erosion caused by eddy currents.

6.8.2.4 Scour Analysis and Countermeasures

Velocity limitations through the bridge opening are intended to limit potential scour. Regardless of the results of the scour analysis, a maximum 100-year average channel velocity of 16 feet per second shall be allowed through a bridge opening. Whenever a new or replacement bridge is designed, it is critical that scour depths at piers and abutments be estimated. The scour estimate must consider subsurface data and a hydraulic analysis of the proposed design.

The FHWA has published a set of Hydraulic Engineering Circulars (HEC) to provide guidance for bridge scour and stream stability analysis. The set includes HEC-18, Evaluating Scour at Bridges, HEC-20, Stream Stability at Highway Structures, and HEC-23, Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance. Latest editions of each shall be used in concert with each other to evaluate stream stability, potential scour, and appropriate scour countermeasures. HEC-RAS may be used to provide the raw data required for the HEC-18 equations. HEC-RAS may also be used to evaluate scour, but the user must be experienced in the nuances HEC-RAS presents in evaluating scour and the potential errors that can occur. Using HEC-RAS default values will cause inaccurate results.

The potential for local scour (pier and abutment) and general scour (contraction, stream degradation, and pressure) should be evaluated using HEC-18 to determine the extent of the various types of scour as applicable to each site. HEC-20 should be consulted to determine the general stability of the stream and whether lateral channel movement should be anticipated. If there is potential for scour during the scour design storm shown in Table 6.18, countermeasures shall be designed in accordance with HEC-

23. In all cases, the length of bridge piles shall be such that the design structural load may be safely supported entirely below the probable scour depth.

Table 6.18. Bridge Scour Design Standards

Roadway Classification	Design Storm for Abutment, Pier Cap, and Retaining Wall Design	Design Storm for Foundation Design
Arterial	500-year	500-year
Major Collector	100-year	500-year
Minor Collector	100-year	500-year
Local	50-year	500-year

6.8.2.5 Structural Design

The type of bridge foundation and foundation elevations should be determined by the bridge structural design engineer. During the design of the bridge foundations, the design engineer shall consider the design loading, the findings of the geotechnical investigation, scour depth as calculated using the procedures in HEC-18, anticipated frost depth, pressure flow during the 100-year event, and any other factors the engineer considers appropriate in his or her professional judgement. If scour is anticipated, the engineer can either design scour countermeasures using the procedures in HEC-23 for the applicable design storm or locate the bridge foundations below the anticipated depth of scour by a distance that provides a sufficient factor of safety in his or her professional judgement. Scour countermeasures will be required if anticipated scour depth is more than 5 feet.

Structural, scour, and foundation design calculations must be accompanied by a certification statement that is signed and sealed by a professional engineer licensed in the State of Colorado and submitted to the Town for review. The certification statement shall read as follows.

> I hereby affirm that the design calculations and plans for the bridge at [insert address] were prepared by me, or under my direct supervision, for the owners thereof, in accordance with the requirements of the International Building Code, the Breckenridge Town Code, the Breckenridge Town Standards, any approved variances and exceptions thereto, and my professional engineering judgment. I understand that the Town of Breckenridge does not and will not assume liability for facilities, structures, or improvements designed by others.
>
> Registered Professional Engineer [Affix Seal]
>
> State of Colorado No. __________

All assumptions made by the bridge design engineer shall be provided in the calculations. Furthermore, the design of bridges may be subject to review by a third party at the Town's discretion. When located within a FEMA floodplain, all bridges are subject to requirements of the National Flood Insurance Program (NFIP) and local floodplain management regulations.

The Town recognizes that in certain limited instances, it may be exceptionally difficult to conform to these Standards. In these instances, the applicant may submit a variance request in accordance with the requirements in Chapter 1. The request must be signed and sealed by a professional engineer licensed in the State of Colorado.

6.8.3 Culvert Hydraulics

Presented in this section are the general procedures that shall be used for hydraulic design and analysis of culverts. The user is assumed to possess a basic working knowledge of culvert hydraulics and is encouraged to review the technical literature on the subject that is included in Hydraulic Design Series 5 (HDS-5), *Hydraulic Design of Highway Culverts*, published by the FHWA). The two primary types of culvert flow are inlet control and outlet control. Under inlet control, the cross-sectional area of the barrel, inlet geometry, and headwater are the factors that affect capacity. Outlet control involves the additional consideration of tailwater and the slope, roughness, and length of the culvert barrel. The Culvert Design Form, included as an attachment to this chapter, is a template for culvert hydraulic analysis that can be used with the information and equations below. All culvert designs shall include an analysis to determine whether inlet or outlet control conditions govern for both minor and major storm runoff.

6.8.3.1 Inlet Control Calculation

Under inlet control conditions, the slope of the culvert is steep enough that the culvert does not flow full. The control section of a culvert operating under inlet control is located just inside the entrance. Inlets may be either unsubmerged or submerged. In an unsubmerged condition, the headwater is high enough to submerge the top of the culvert and the culvert slope is supercritical. In a submerged condition, the headwater submerges the top of the culvert, but the pipe does not flow full. In this situation, the culvert inlet acts like an orifice.

In the submerged inlet condition, the equation governing the culvert capacity is the orifice flow equation. However, because of the uncertainty in estimating the orifice coefficient for a submerged culvert inlet, it is recommended that the inlet control nomographs published in HDS-5 be used to determine headwater for submerged inlets operating under inlet control. Nomographs may be found online in the second edition of HDS-5, publication number FHWA-NHI-01-020. Later editions do not have as many nomographs. Table 6.19 provides the appropriate inlet control nomograph to use for various types of culverts and end treatments. The FHWA has not published inlet control nomographs for plastic pipe. In their absence, the nomographs for concrete may be used for round HDPE with a smooth interior wall.

Table 6.19. Inlet Control Nomograph Selection

Material	Cross Section	End Treatment	Chart
Concrete/HDPE	Circular	None (Projecting), Headwall	1B
Concrete/HDPE	Circular	Flared end section	55B
Concrete	Horizontal Elliptical	Headwall or Projecting (use scale 1 for end section)	29B
Concrete	Rectangular	Wingwalls, angle and headwall bevel varies	8B-13B

6.8.3.2 Outlet Control Calculation

Outlet control occurs when the culvert barrel is not capable of conveying as much flow as the inlet opening will accept. Either subcritical or pressure flow exists in the culvert barrel under these conditions. Outlet control will govern if the headwater is deep enough, the culvert slope is sufficiently flat, or the culvert is sufficiently long.

Outlet control generally exists under two conditions. The first, and less common, occurs when headwater is not high enough to submerge the top of the culvert and the culvert slope is subcritical. The more common outlet control condition exists when the culvert is flowing full. A culvert with a submerged inlet and an unsubmerged outlet may also operate under outlet control, especially if it has a long barrel length or a flat enough slope. Culverts under outlet control may flow full or partly full, depending on various combinations of hydraulic factors.

Culvert capacity under outlet control is calculated using Bernoulli's equation. An energy balance is determined between the headwater at the culvert inlet and at the culvert outlet and includes inlet losses, friction losses, and velocity head. The general equation is expressed as:

$$\mathrm{H} = \mathrm{h_e} + \mathrm{h_f} + \mathrm{h_v} \qquad (6.13)$$

Where:

- H = total energy head (headwater elevation minus tailwater elevation) (ft)
- h_e = entrance head loss (ft), $K_e V^2/2g$
- h_f = friction losses (ft)
- h_v = velocity head (ft), $V^2/2g$
- K_e = entrance loss coefficient per Table 6.20

Friction loss is the energy required to overcome the culvert barrel roughness and is calculated by the following equation.

$$\mathrm{h_f} = (29\mathrm{n}^2\mathrm{L}/\mathrm{R}^{1.33})(\mathrm{V}^2/2\mathrm{g}) \qquad (6.14)$$

Where:

- n = Manning's coefficient per Table 6.15
- L = length of culvert (ft)
- R = hydraulic radius (ft)
- V = velocity of flow (ft/s)
- g = gravitational acceleration, 32.2 ft/s^2

Table 6.20. Culvert Entrance Loss Coefficients, K_e, for Outlet Control Calculations

Structure and Entrance Type	Ke	Structure and Entrance Type	Ke
RCP		RCB	
Headwall, socket end of pipe	0.2	Wingwalls at 30° to 75° to barrel	
Headwall, square edge	0.5	Square edge at crown	0.4
Projecting from fill, socket end	0.2	Rounded or beveled top edge	0.2
Projecting from fill, square cut end	0.5	Wingwalls at 10° to 25° to barrel	
Mitered to conform to fill slope	0.7	Square edge at crown	0.5
Side- or slope-tapered inlet	0.2	Wingwalls parallel (side extensions)	
Beveled edges, 33.7° or 45° bevels	0.2	Square edge at crown	0.7
Rounded (radius = D/12)	0.2	Side- or slope-tapered inlet	0.2
End section that conforms to fill slope[1]	0.5	No wingwalls	
HDPE [2]		Square edge on 3 sides	0.5
Projecting from fill	0.9	Rounded or beveled on 3 sides	0.2

[1] End sections that conform to fill slope are the sections commonly available from manufacturers. From limited hydraulic tests, they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections, which incorporate a closed taper in their design, have a superior hydraulic performance. These latter sections can be designed by using the information given for the beveled inlet.

[2] Conditions not listed specifically for HDPE with a smooth interior wall have the same coefficient as RCP. The "projecting from fill" value given for HDPE is an approximation based on published values for CMP.

Combining the equations yields the following equation, which can be used to calculate culvert capacity directly only when the tailwater is at or above the crown of the culvert outlet.

$$H = (K_e + 1 + 29n^2L/R^{1.33})(V^2/2g) \tag{6.15}$$

When the tailwater is below the culvert outlet crown, the tailwater depth used for calculations shall be the larger of the tailwater anticipated in the downstream channel at the culvert outlet and the average of the critical depth in the culvert and the culvert diameter, $(D+d_c)/2$. The FHWA has determined the average of the critical depth and the culvert diameter to be an adequate approximation for tailwater depth for culverts that flow partially full. Critical depth calculation is a direct process for a box culvert but an iterative one for a circular pipe that is easily accomplished with a spreadsheet. Critical depth occurs when the Froude number is equal to 1.0. The flow area and top width will be those that occur at critical depth in the pipe. Many online tutorials are available.

$$Fr = \frac{v}{\sqrt{gD_h}} \tag{6.16}$$

Where:

Fr = Froude number (dimensionless)

v = velocity (ft/s)

D_h = hydraulic depth (ft), A/T

A = flow area (ft^2)

T = top width of flow area (ft)

g = gravitational acceleration, 32.2 ft/s^2

In addition to equation 6.15, outlet control nomographs published by the FHWA in HDS-5 can also be used to calculate the required headwater under outlet control conditions where the outlet is submerged. Outlet control nomographs can be found online in the second edition of HDS-5, publication number FHWA-NHI-01-020. Later editions do not have as many nomographs. Table 6.21 provides the appropriate outlet control nomograph to use for various types of culverts. The FHWA has not published outlet control nomographs for plastic pipe. In their absence, the nomographs for concrete may be used for round HDPE with a smooth interior wall. End treatments do not affect outlet control.

Table 6.21. Outlet Control Nomograph Selection

Material	Cross Section	Chart
Concrete/HDPE	Circular	5B
Concrete	Rectangular	15B
Concrete	Horizontal Elliptical	33B

Culvert capacity shall be computed using the Culvert Design Form, included as an attachment to this chapter. Two example calculations for culvert sizing are at the end of this section. The first is for a roadway crossing culvert and the second is for a driveway culvert in a roadside ditch. HDS-5 offers extensive guidance on the design of culverts that are under roadways and that may be used in conjunction with the requirements of these Standards.

6.8.3.3 Evaluation of Results

If the culvert selected will not fit the site, return to the design process, and select another culvert. Repeat the design process until an acceptable culvert configuration is determined. Compare the headwater elevations calculated for inlet and outlet control. The higher of the two is the controlling headwater elevation. The culvert can be expected to operate with that higher headwater for at least part of the time.

If outlet control governs and the headwater depth is less than 1.2D, it is possible that the barrel flows partly full through its entire length. In this case, caution should be used in applying the approximate method of setting the downstream elevation based on the greater of tailwater or (d_c + D)/2. If an accurate headwater is necessary, backwater calculations should be used to check the result from the approximate method. If the headwater depth falls below 0.75D, backwater calculations are required.

6.8.3.4 Outlet Velocity Calculation

The outlet velocity may be calculated as follows:

1. If the controlling headwater is based on inlet control, determine the normal depth and velocity in the culvert barrel. The velocity at normal depth is assumed to be the outlet velocity.
2. If the controlling headwater is based on outlet control, determine the area of flow at the outlet based on the barrel geometry and the following:
   a. Critical depth if the tailwater is below critical depth.
   b. Tailwater depth if the tailwater is between critical depth and the top of the barrel.
   c. Height of the barrel if the tailwater is above the top of the barrel.

6.8.3.5 Computer Applications

While it is possible to use the procedures and nomographs for analyzing culvert hydraulics, it is more common to design culverts using computer applications. Among the applications approved for use by the Town is the FHWA's HY-8 Culvert Analysis Program and the Mile High Flood District's MHFD-Culvert spreadsheet, both of which may be used to calculate roadway overtopping, inlet and exit velocity, and hydraulic grade line.

6.8.4 Design Examples

Two design examples are included in this section. The first example is the analysis of an existing roadway cross culvert using the Culvert Design Form. Calculations from this design example are shown in the Culvert Design Form Example, included as an attachment to this chapter. The second example is the design of a private driveway culvert in a roadside ditch.

6.8.4.1 Crossing Culvert Analysis Example

The procedure to evaluate culverts is based on the procedures presented in HDS-5. The methodology consists of evaluating the culvert headwater requirements for both inlet and outlet control. The type of flow control that results in a larger required headwater is the governing flow condition.

An example calculation for rating an existing culvert is presented in the Culvert Design Form Example, included as an attachment to this chapter. The culvert is a 48-inch RCP. The length is 150 feet. The upstream invert elevation is 8540.0, and the downstream invert elevation is 8535.5. The slope is 0.030. The low point of the embankment over the culvert has an elevation of 8551.90. The n value is 0.015, in accordance with Table 6.15 for older concrete pipes. The culvert has flared end sections on each end. All depths are in feet unless noted otherwise.

The tailwater rating values are provided for this example and shown in Column 5. If the tailwater condition is unknown, it must be computed using the normal depth (subcritical or critical only) of a trapezoidal channel approximating the existing drainageway. A HEC-RAS model of the site could also be used to determine the tailwater rating curve.

The entrance loss coefficient, K_e, is determined from Table 6.20 as 0.5 for an end section that conforms to fill slope, which is the category used to represent a common flared end section. The full flow and the velocity are calculated from these values for comparison. The rating then proceeds in the following sequence:

1. The culvert design process begins with selecting a range of discharges or headwater depths and then using an inlet control nomograph to determine the corresponding flow values. This example begins with a range of headwater depths that are entered in Column 3. Headwater to pipe diameter ratios (H_W/D) are calculated and entered in Column 2. If the culvert is not circular, the culvert height is used for the calculation. Note that for design of new culverts, the Town has restrictions on the headwater-to-depth ratio in Table 6.17.
2. For each H_W/D ratio, inlet capacity is read from the appropriate inlet control nomograph (Chart 55B for this example because of the flared end sections) and entered in Column 1. Scale (1) for concrete should be used on Chart 55B to determine discharges, which then completes the inlet control rating.
3. For outlet control, the Q values that have been entered in Column 1 are used to determine the head values (H) in Column 4 from the appropriate outlet control nomograph, Chart 5B in this case. Note that flared end sections do not affect outlet control calculations. The first line drawn in Chart 5B is between the pipe diameter and the pipe length. The second line connects the Q value and passes through the turning line where the first line crossed it to determine H.
4. The known tailwater depths (T_W) for normal flow in the downstream channel are then entered into Column 5 for each Q value in Column 1. The depths have been provided in this example but must be calculated if they are not available using the normal depth of a trapezoidal channel approximating the existing drainageway downstream of the culvert. If the tailwater depth is less than the diameter of the culvert, Columns 6 and 7 must be calculated per Step 5, and the larger of the tailwater depth and the value of Column 7 shall be used as h_o. If the tailwater depth is greater than the diameter of the culvert, the tailwater values in Column 5 are entered into Column 8 as the values for h_o, and Step 6 should begin (Step 5 being skipped).
5. Approximate tailwater depths are calculated when tailwater depths in the downstream channel are less than the diameter of the culvert. The critical depth, d_c, for each Q value in Column 1 is calculated and entered in Column 6. For a circular pipe, the Froude number calculation is completed iteratively using a spreadsheet until the Froude number is 1. Alternately, Chart 4B from HDS-5 can be used to determine d_c for the pipe size and Q value. The average of the critical depth and the culvert diameter is calculated and entered in Column 7 as the approximate h_o value.

6. The headwater values (H_W) in Column 9 are calculated according to Equation 6.17:

$$H_W = H + h_o - LS_o \tag{6.17}$$

   where H is from Column 4 and h_o is either the value from Column 8 where $T_W \geq D$ or the larger value of Column 5 and Column 7 where $T_W < D$. L is the length of the culvert barrel and S_o is its slope.

7. The final step is to compare the inlet and outlet control headwater requirements (Columns 3 and 9) and record the higher of the two values in Column 10. The type of flow control is recorded in Column 11. The upstream water surface elevation is then calculated by adding the controlling headwater (Column 10) to the upstream invert elevation. Add this value to Column 12. The culvert rating curve can then be plotted from the values in Columns 12 and 1.

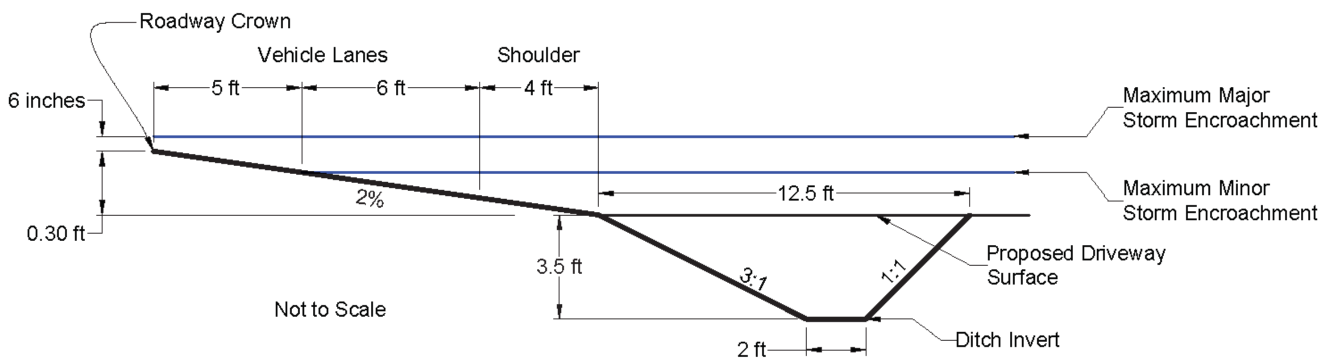
Outlet velocity for designing downstream protection can be computed using V = Q/A. For full flow conditions, the culvert area is the full cross sectional area of the culvert. For partially full conditions, the culvert area is the area calculated at a depth of h_o. Channel protection shall be in accordance with guidance in the USDCM. Velocity values are not shown in the Culvert Design Form but should be calculated for the 100-year event.

To size a culvert crossing, the same form can be used, with some variation in the basic data. First, a design Q is selected, and the maximum allowable headwater is determined. An inlet type is selected, and the invert elevations and culvert slope are estimated based on site constraints. A culvert type and size is then selected and rated for both inlet and outlet control. If the controlling headwater exceeds the maximum allowable headwater, the design data must be modified, and the procedure repeated, until the desired results are achieved.

6.8.4.2 Private Driveway Culvert Design Example

A driveway is planned to provide access to a new residence from a minor collector roadway with an existing roadside ditch. The minor collector has a transverse slope of 2%. The roadside ditch is trapezoidal with a 3:1 side slope down from the road, a 1:1 backslope, a 2-foot bottom width, and a 3.5-foot depth as shown in Figure 6.4.

Figure 6.4. Private Driveway Culvert Example Ditch Geometry



The driveway is assumed to have no slope over the ditch for calculation purposes. The calculated peak flow is 28 cfs for the major storm and 12 cfs for the minor storm. Floodwater encroachment onto the road must not exceed the limitations set forth in Table 6.12 of these Standards. Inlet control is assumed for this example; however, actual projects should use the Culvert Design Form to determine if culverts are under inlet or outlet control.

1. During the major storm, water on a minor collector may be 6 inches deep at the crown of the road. The depth of the water from the allowable water surface to the ditch invert is 4.3 feet. This value is assumed as the headwater depth.

2. For the major storm, calculate the discharge through an 18-inch HDPE (D = 1.5 feet) with projecting ends and a headwater depth of 4.3 feet using Chart 1B:

$$\mathrm{H_W/D = 4.3\ ft/1.5\ ft = 2.9}$$

   A H_W/D ratio of 2.9 on Scale 3 of Chart 1B for projecting culvert ends gives a discharge of 18.0 cfs for an 18-inch HDPE.

3. Calculate weir flow over the road and driveway during the major storm. Flow over the road and over the driveway are calculated independently. Because the road grade is sloped across the cross section, the average depth of flow over the road is used. Flow outside the top of the ditch side slope is assumed to be negligible for this example, but it may be considered if the designer feels it is appropriate. Assume a weir coefficient of 2.8.

$$\mathrm{Q_{weir} = Q_{road} + Q_{drive}}$$

$$Q_{\text{weir}} = \text{CLH}^{3/2} + \text{CLH}^{3/2}$$

$$Q_{\text{weir}} = (2.8)(15)((0.85 + 0.50)/2)^{3/2} + (2.8)(12.5)(0.85)^{3/2}$$

$$Q_{\text{weir}} = 23.3 \text{ cfs} + 27.4 \text{ cfs} = 50.7 \text{ cfs}$$

Total flow over the road and driveway is 50.7 cfs.

4. The combined flow through the 18-inch HDPE and over the road/driveway is 68.7 cfs, which is significantly more than the major storm design flow of 28 cfs. Encroachment onto the minor collector will not exceed allowable and the chosen culvert is acceptable for the major storm. If the combined flow would have been less than the major storm flow, a larger culvert would be required, and Steps 2–3 would be repeated using a 24-inch HDPE. In this case, a shallower ditch or a smaller pipe may be considered.

   Verify that the design meets the minor storm criteria. During the minor storm, flow may spread to within 5 feet of the crown of a minor collector to allow a single 10-foot lane to remain clear during the minor storm. Assuming encroachment extends only to within 5 feet of the roadway crown yields a headwater depth of 3.7 feet and a H_W/D ratio of 2.5.

5. Scale 3 of Chart 1B indicates a discharge of 16.0 cfs for an 18-inch HDPE with a H_W/D ratio of 2.5, which is greater than the 12 cfs peak flow during the minor storm. The design will meet the minor storm criteria.
6. Verify that the culvert has a minimum 8 inches of cover. The driveway surface is 3.5 feet or 42 inches above the ditch invert. The 18-inch HDPE has more than the minimum 8 inches of cover and meets all criteria for this location.

6.9 DETENTION

The imperviousness of any site typically increases when it is developed. Roof areas, sidewalks, and parking all contribute to site imperviousness. Rain falling on this added impervious area cannot infiltrate into the ground after development. The rainfall discharges from the site instead, impacting adjacent properties, storm drain capacity, and even the capacity of larger drainageways when development is considered in the aggregate. The purpose of detention facilities is to store the additional runoff volume associated with development and discharge it from the developed site at the rate experienced during pre-development conditions. Detention helps to minimize peak flows in urbanized areas. Detention can include individual site options such as small landscaped basins and larger regional options that serve multiple sites. Detention facilities can also be dual purpose when they are designed to meet water quality requirements as well as hydraulic detention requirements. This section presents the Town's criteria and guidance for designing detention ponds.

6.9.1 Applicability

Detention is required for all new development and redevelopment. Subdivided developments may use a single detention facility provided it captures runoff from the entire development. All detention facilities in the Town are subject to oversight by the Town. A maximum of 5% of the total development site may discharge directly from the site, without hydraulic detention, provided the peak site discharge does not exceed the peak historic discharge from the site.

Exemptions from the detention requirement may be granted if the project has either of the following characteristics, provided the additional undetained runoff will cause no adverse impacts to any downstream properties.

1. Impervious area is increased by no more than 0.10 acres or 4360 square feet.

2. Other situations as may be determined by the Town to be in the best interest of the Town.

Exemptions may also be provided for single family homes in subdivisions without regional detention provided low-impact development principles are included in the design to minimize the increase in runoff and not aggravate flooding or erosion problems. Low impact development principles include using pervious pavers or pavement for driveways and walkways, minimizing directly connected impervious areas, and routing drainage from impervious areas such as roofs and driveways through infiltrating swales or across vegetated pervious areas prior to discharging it from the site. Detailed guidance on low impact development can be found in Volume 3 of the USDCM.

Supporting analysis and certification by a professional engineer that exclusion from the detention requirement will not cause any adverse downstream impacts must be submitted to the Town Engineer for consideration if an exemption is requested. An exemption to provide detention issued by the Town does not eliminate potential liability to others.

Although development increasing impervious area by less than 0.10 acres is exempted from detention requirements, any new development or redevelopment is required to analyze and correct any inadequate drainage, including insufficient drainage away from buildings, runoff adversely affecting downstream properties, inadequately sized drywells, drainage exceeding existing storm drains, pipes, or other conveyance, or other drainage concerns identified by the Town Engineer.

6.9.2 Detention Facility Design

All detention facilities shall be designed as full-spectrum detention facilities. The Mile High Flood District has developed detailed design guidance for detention basins. The USDCM provides discussion on the applicability of detention; an explanation for why full-spectrum detention is the preferred approach; and calculations for sizing a detention facility and designing the outlet structure.

The most recent versions of the USDCM and the design tool MHFD-Detention.xlsm (formerly UD-Detention.xlsm) may be used for sizing and designing all detention facilities in the Town. Detention facilities in the Town may be extended detention basins, sand filters, and rain gardens. Constructed wetlands may also be used provided water rights are accommodated. The USDCM also includes weir and orifice equations for the design of detention basin outlets that may also be used for other applications within these Standards as needed. Guidance on the use of MHFD-Detention within the Town is included in this section.

6.9.2.1 Historic Flow Rates

The policy of the Town is to require detention storage of stormwater runoff to limit peak discharges from new development and redevelopment sites to historic rates. Detention facilities shall be designed to release stored runoff volumes at or below the calculated historic peak rate for the 2-, 5-, 10-, 25-, 50-, and 100-year storms.

For new development, historic peak runoff rates per acre shall be calculated in accordance with the procedures in these Standards using a site imperviousness of 2% to represent historic conditions in accordance with Table 6.3. For redeveloped areas, historic rates shall be those calculated for the condition immediately prior to redevelopment in accordance with these Standards unless other criteria are specified by the Town Engineer in writing. Calculated historic rates will vary based on the methodology chosen to calculate peak flow, whether it is the Rational Method, the SCS Method, or a computer model. Calculated historic rates for each storm event shall be presented as part of the drainage analysis in the Drainage Report.

Post-development peak runoff from a site may not be greater than pre-development runoff from a site for any storm event. Total site runoff is typically a combination of detention basin release and direct runoff from areas not draining to a detention facility, both of which must be considered. A maximum of

5% of the total site area may contribute direct runoff. Note that the allowable peak discharge from a detention facility will be less than the allowable peak runoff from the whole site unless the entire site drains to the detention facility.

For redevelopment sites, any existing detention facilities shall be factored into the runoff calculations and accounted for with the revised runoff characteristics to preserve the pre-development runoff rates as identified in any previous drainage studies. If a HEC model of the watershed exists, it can be used to generate historic runoff rates by changing the imperviousness of the watershed to historic conditions.

6.9.2.2 MHFD-Detention

The last three tabs in the MHFD-Detention spreadsheet contain helpful information on how to use the MHFD-Detention spreadsheet as a design tool. Users are highly encouraged to thoroughly review the information in these tabs, including the video provided before beginning design. For designing detention facilities within the Town, the following inputs shall be used in lieu of default values.

1. While most detention basins in the Town will include water quality treatment, the first drop down menu on the Basin worksheet below Watershed Information should be set to Flood Control Only if no water quality treatment is to be provided. If water quality treatment is to be provided within the detention facility, the user should select the type of facility being designed.
2. Location for 1-hr Rainfall Depths on the Basin worksheet shall be set to User input and the P_1 values from Table 6.1 of these Standards shall be entered into the appropriate, blue-shaded cells on the Basin worksheet.
3. In the three cells used to Define Zones and Basin Geometry in the Basin worksheet, the Zone 1 Volume shall be the WQCV if water quality treatment will be provided. If water quality will not be provided, the Zone 1 Volume shall be the 2-year event. In all cases, the Zone 2 Volume shall be set to EURV – Zone 1, and the Zone 3 Volume shall be set to 100-year minus Zones 1 & 2.
4. The remainder of the user inputs on the basin worksheet tab shall follow the recommended guidelines indicated as notes in each cell. Assuming the design of the facility was completed in accordance with guidelines in the USDCM, the design values for these inputs will be within the recommended ranges of values for each variable. Note that the Total Available Detention Depth should be set at the maximum allowable 100-year water surface, not at the downstream embankment crest, to allow for design freeboard.
5. On the Outlet Structure worksheet, an Outlet Type must be selected from the drop down menu at the top of the worksheet for each Zone. When water quality treatment is provided, the lowest outlet is typically an orifice plate, which is a plate with multiple smaller orifices cut into it. When water quality treatment is not provided, the lowest outlet may be a vertical orifice, which is also a plate, but with a single, larger hole cut into it. The options available in the drop down menu for Outlet Type will automatically only be those applicable to the design completed up to that point. The user should only enter additional design values into the User Input rows in the remainder of this worksheet that correspond to the Outlet Types selected at the top of the worksheet. For example, if there is no orifice plate, there is no need for the user to enter data describing an orifice plate. But each Outlet Type selected must have its design data entered for the worksheet to yield correct results.
6. Several rows of hydraulic results are presented at the bottom of the Outlet Structure worksheet. While several of the values are of interest, there are only a handful that are critical for detention facilities in the Town. If these criteria are not met, the design must be adjusted until they are.
    a. Peak Outflow for each design storm may not exceed the historic rates calculated for the site.

b. Time to Drain 97% of Inflow Volume must not exceed 72 hours after the end of a 5-year storm.

c. Time to Drain 99% of Inflow Volume must not exceed 120 hours after the end of storms greater than the 5-year storm.

d. Maximum Ponding Depth must be at or below the emergency spillway and at least 12 inches below the surrounding embankment.

6.9.4 Snow Storage in Detention Ponds

If it is intended that a detention pond will serve as a snow storage area, the calculation of the pond's required volume must be increased by 50% of the full design snow storage volume and the pond must provide permanent water quality treatment in the form of the water quality outlet.

6.9.5 Maintenance

The performance of detention facilities is extremely sensitive to a lack of maintenance, and all detention facilities must be designed to facilitate maintenance. Section 6.10 of these Standards includes design guidance related to maintenance. It is the responsibility of all private detention facility owners to regularly maintain their detention facilities, except as modified by a recorded agreement. Outlets, especially, must be regularly maintained to ensure the basins do not detain water longer than allowed by Colorado water law.

The Town may require an enforceable Ownership and Maintenance (O&M) Agreement to be in place for detention and water quality facilities before issuing any applicable local permits. The O&M Agreement must include the party responsible for maintaining the facility, inspection frequency, and proposed maintenance activities in an Operations and Maintenance Plan (O&M Plan). Should the responsible party fail to adequately maintain the detention facility, the Town shall have the right to enter the property for the purpose of maintenance. All such maintenance costs and associated legal fees will be assessed to the property owner. Guidance on maintenance frequency for various types of facilities is included in Section 6.10. Guidance on the development of the O&M Plan is included in Chapter 2.

6.9.6 Detention and Water Rights

Senate Bill 15-212 became effective on August 5, 2015, as Colorado Revised Statute (CRS) §37-92-602 (8), *Concerning a Determination that Water Detention Facilities Designed to Mitigate the Adverse Effects of Storm Water Runoff Do Not Materially Injure Water Rights*. This statute provides legal protection for any stormwater detention and infiltration facility in Colorado, provided the facility does not materially injure water rights and meets the following criteria.

1. It is owned or operated by a governmental entity or is subject to oversight by a governmental entity.
2. It continuously releases or infiltrates at least 97% of all the runoff from a rainfall event that is less than or equal to a 5-year storm within 72 hours after the end of the event.
3. It continuously releases or infiltrates as quickly as practicable, but in all cases releases or infiltrates at least 99% of the runoff within 120 hours after the end of events greater than a 5-year storm.
4. It operates passively and does not subject the stormwater runoff to any active treatment process such as coagulation, flocculation, and disinfection.

There are reporting requirements for any owner or operator of any detention facility constructed after August 5, 2015 that seeks protection under the new statute. A data sheet and online map-based compliance portal website has been developed that will allow owners and operators in the Town to upload the required notification information. The notification requirement applies only to facilities constructed after August 5, 2015. Facilities in existence before August 5, 2015, are defined in the statute as materially noninjurious to water rights and do not require notification.

The compliance portal can be found online (*https://maperture.digitaldataservices.com/gvh/?viewer=cswdif*). A document containing frequently asked questions, links to a video tutorial, and the link to the compliance portal can be found online (*http://www.crgov.com/DocumentCenter/View/12225*) or via an internet search for "Colorado water rights compliance portal." The owner or operator must report new detention via the portal, and the county must approve the portal entry once it is complete. The owner or operator shall inform the county once the portal documentation is ready for approval.

6.9.7 Jurisdictional Dams

Detention facilities with a downstream embankment height in excess of 10 feet, 100-year water surface area in excess of 20 acres, or 100-year volume in excess of 100 acre feet are considered jurisdictional dams and require approval by the State Engineer's office.

6.10 PERMANENT WATER QUALITY

The naming convention for facilities that treat stormwater quality after construction has varied over time. These facilities have been called both best management practices (BMPs) and control measures by various entities. The Town's term for these facilities is permanent stormwater treatment facilities. The term treatment facilities may also be used. This term distinguishes these facilities from those used during construction.

The goal of the requirements in this section is to keep the Town's streams and drainageways healthy. This section presents runoff reduction and site planning principles, the applicability of the requirements for permanent water quality treatment, design requirements for permanent stormwater treatment facilities, and design requirements associated with maintenance.

6.10.1 Planning Principles

Increases in impervious area that typically come with development can negatively impact flow volumes, temperature, and stormwater quality. To minimize these impacts, site planning should consider how the site will be used as well as how stormwater runoff will be conveyed and treated. While no specific design criteria is associated with many of these guidelines, general site planning goals for every development include:

1. Considering stormwater quality needs early in the development process to better integrate stormwater treatment facilities into the site.
2. Minimizing impacts to the natural environment including water quality, air quality, wildlife habitat, vegetation, and natural landforms and protecting areas with high ecological value such as those with mature trees, stream corridors, wetlands, and soils with high infiltration rates.
3. Developing creative site layouts to reduce the extent of paved and other impervious areas.
4. Reducing runoff from the site and maximizing infiltration by minimizing directly connected or continuous impervious areas and slowing runoff through pervious and/or vegetated areas. Developing the layout of a site to reduce runoff will also reduce the required size of WQCV treatment facilities.
5. Centralizing water quality treatment for larger developments and integrating them with site operations to minimize land use, achieve greater economy of scale, and reduce the number of treatment facilities requiring maintenance.

6. Developing operational procedures to minimize the risk of spills and designing the site layout to prevent any spills from leaving sites with operations that include washing, fueling, manufacturing, materials storage, and vehicle maintenance, among others.
7. Using pervious drainage conveyances where appropriate, routing downspouts across pervious areas, and incorporating vegetated areas into locations that generate and convey runoff like parking lots and driveways. Grass buffers, grass swales, and bioretention can all be used.
8. Discharging site runoff across a vegetated area prior to discharge from the site. No impervious area should discharge directly into wetlands, the Blue River, or one of its tributaries.
9. Maintaining natural drainage patterns and implement sheet flow.
10. Selecting permanent stormwater treatment facilities based on expected pollutant type.
11. Providing areas for snow storage so that snow melt will not be a nuisance and will drain to a permanent water quality facility.

Chapter 1 of Volume 3 of the USDCM includes a section on ways to minimize the adverse impacts of development on water quality, including ideas to minimize site runoff. This document should be reviewed to gain a better understanding of planning principles as they relate to water quality. A discussion on how design of the site minimizes site runoff and the impacts to water quality shall be included in the permanent water quality portion of the Drainage Report.

6.10.2 Applicability

Permanent stormwater treatment facilities are required to be designed and installed for all new development and redevelopment sites that meet one of the following criteria:

1. Disturb at least one acre of land.
2. Disturb less than one acre but are part of a larger common development plan. In these cases, the individual development need not provide a permanent stormwater treatment facility, provided the larger common development provides a centralized facility that will provide treatment for all the sites within it.
3. Increase impervious area by more than 0.10 acres or 4360 square feet.
4. Include any of the following land uses: auto service station, auto repair, auto body work/paint, auto wash/polish, equipment repair, lumberyard, nursery, asphalt plant, concrete batch plant, industry, manufacturing, crushing gravel/rock, milling, mining, sawmill, silviculture, junkyard, sludge, sanitary landfill, truck terminals, impound yard, motor vehicles parking/storage, or storage of pesticides, herbicides, fertilizer, or other potentially hazardous materials.

New development is classified as any land disturbing activity or construction of any building or structure. Redevelopment is any creation, addition, or removal and replacement of any impervious area, or any building construction or land disturbing activity, on a site that is already substantially developed.

For sites that require permanent stormwater quality treatment, treatment must be provided for at least 80% of the added impervious area on the site. At least 80% of the disturbed site pervious area must also be treated unless justification is provided showing that runoff from these areas will not negatively impact water quality within the Town. An area larger than the minimum required may necessarily drain to the treatment facility, and this runoff must be accounted for in the design of the facility. Calculations documenting this has been achieved shall be included in the permanent water quality portion of the Drainage Report.

~~Although certain d~~Development that is exempted from permanent water quality requirements~~, any new development or redevelopment is~~ may still be required by the Town to analyze and correct any inadequate drainage, including insufficient drainage away from buildings, runoff adversely affecting downstream properties, inadequately sized drywells, drainage exceeding existing storm drains, pipes, or other conveyance, or other drainage concerns identified by the Town Engineer.

6.10.3 Treatment Facility Types

There are three basic methods by which stormwater quality can treated in the Town.

1. Collecting and storing the water quality capture volume (WQCV) and releasing it slowly, thereby settling out pollutants in the stormwater instead of discharging them downstream,
2. Infiltrating the WQCV into the ground within a given time, and
3. Using a proprietary vault or structure that has been developed to treat stormwater quality.

Volume 3 of the USDCM provides graphics that offer some general guidance as to the treatment facilities that are typically used for sites having specific characteristics. Details for the design of each type of treatment facility, as well as design constraints, are in the next section.

6.10.4 Design Criteria

The Town's general criteria for permanent water quality treatment is 80% removal of the 60 micron particle from the WQCV of the area being treated or from the peak runoff rate from the 2-year return period storm over the area being treated, depending on the type of treatment facility being designed. For sites that require permanent stormwater quality treatment, treatment must be provided by one of the methods in Section 6.10.3. Meeting the criteria in this section for each type of treatment mechanism is assumed to result in this criteria being met. Supporting calculations must be included in the Drainage Report.

6.10.4.1 Tributary Offsite Area

When offsite area is tributary to a permanent stormwater treatment facility there are two options. The first option is to intercept the offsite flow and route it around or through the site in a separate conveyance system. The second option, if offsite flow cannot be separated, is to size the treatment facility for the entire tributary area. This could mean a much larger design volume or a larger peak runoff rate.

6.10.4.2 Right-of-Way Restrictions

Privately owned and maintained treatment facilities must be located outside the public right-of-way and offline from public stormwater conveyance systems. Easements are required for the area occupied by all facilities located outside the public right-of-way including for access.

6.10.4.3 WQCV Storage and Release

The WQCV is a volume of water designated for treatment that has been determined to provide the most water quality benefit for the cost to construct the improvements required to treat it. Volume 3 of the USDCM provides detailed discussion on the development of the WQCV. Capturing, storing, and slowly releasing the WQCV of a site will meet the Town's requirements for permanent water quality treatment by storing it long enough that pollutants settle out. WQCV treatment facilities acceptable for use in the Town include extended detention basins, sand filter basins, rain gardens, and infiltration galleries and trenches. Other types of facilities may be considered on a case-by-case basis.

The first step in designing a WQCV facility is calculating the WQCV. Two variables are required to calculate the WQCV. The first is the total imperviousness of the area draining to the treatment facility.

Recommended imperviousness values are in Section 7.5. The total imperviousness of a site can be determined by taking an area-weighted average of the different imperviousness values for the site. Total imperviousness can also be adjusted to an effective imperviousness if certain practices are implemented as part of the site design. Effective imperviousness applicability and calculations are discussed below the calculation for the WQCV.

The second variable is the design drain time of the treatment facility. Recommendations for design drain time for different types of WQCV treatment facilities can be found in Volume 3 of the USDCM. The most common WQCV facility is an extended detention basin, for which the recommended drain time is 40 hours. WQCV drain time coefficients are in Table 6.22 below. The general equation to calculate the WQCV in Breckenridge is expressed as:

$$\mathrm{WQCV} = 0.84\mathrm{Aa}(0.91\mathrm{I}^3 - 1.19\mathrm{I}^2 + 0.78\mathrm{I})/12 \quad (6.18)$$

Where:

WQCV = water quality capture volume (acre-feet)

a = WQCV drain time coefficient

I= imperviousness as a decimal percentage

A = area draining to the treatment facility in acres

Table 6.22. Drain Time Coefficients for WQCV Calculations

Drain Time	Coefficient, a
12 hours	0.8
24 hours	0.9
40 hours	1.0

The WQCV equation was initially developed based on rainfall data from the Denver metro area. However, the precipitation depth of the average runoff producing storm in Breckenridge is 0.36 while in Denver it is 0.43. The WQCV equation above includes a coefficient of 0.84 to adjust the equation for use in Breckenridge. A map showing the variance in the average runoff producing storm across Colorado is shown as Figure 6.5.

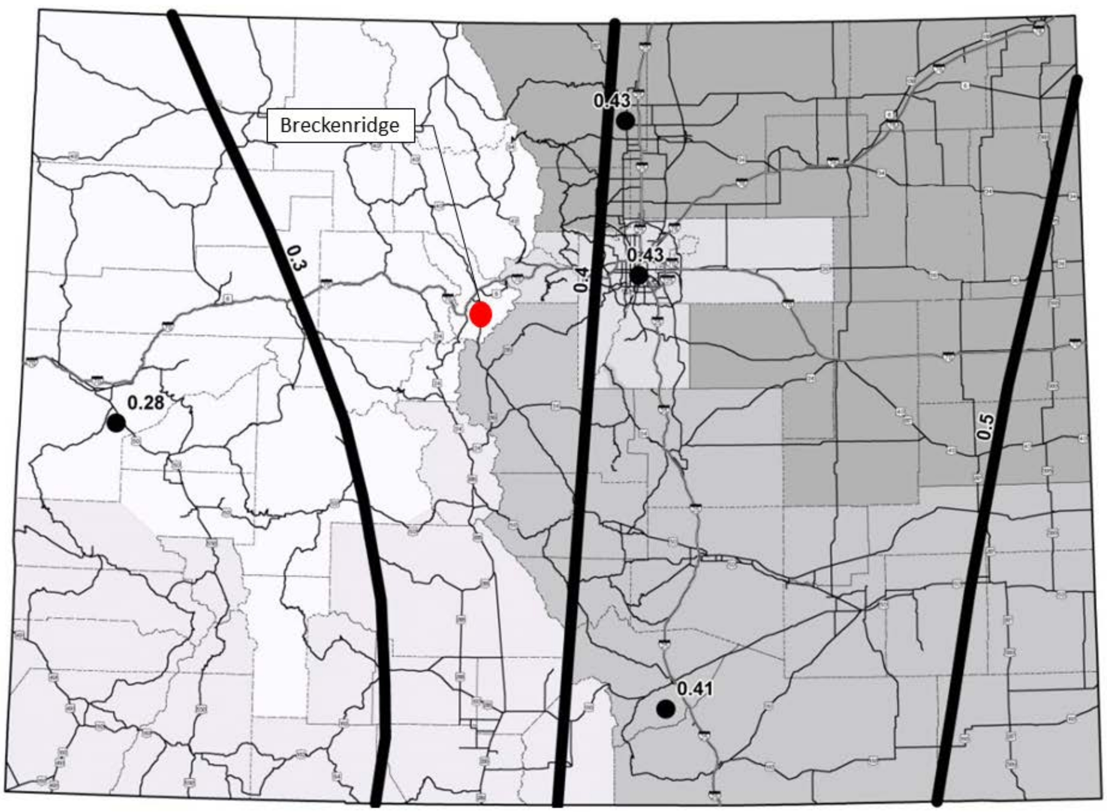


Figure 6.5. Map of the Average Runoff Producing Storm's Depth
(Modified from UDFCD, 2016)

Guidance on how to design extended detention basins, sand filter basins, and rain gardens to meet the WQCV standard are included in the Fact Sheets in Volume 3 of the USDCM. Sand filter basins are referred to as simply sand filters and rain gardens are referred to as bioretention.

6.10.4.3.1 Effective Imperviousness

The imperviousness value used in the WQCV calculation for sites that implement low impact development (LID) principles such as green infrastructure and MDCIA may be reduced to reflect the site's effective imperviousness. The effective imperviousness is dependent on the level of MDCIA implemented for high-level planning applications. Level 1 includes designing impervious surfaces to drain over a grass buffer or other pervious surface prior to reaching any stormwater conveyance system. Level 2 is an enhancement to Level 1 and includes eliminating curb and gutter or using slotted curbs; low-velocity pervious grass- or rock-lined swales instead of storm sewers, and pervious street shoulders. Guidance on calculating effective imperviousness for Level 1 and Level 2 MDCIA can be found in Volume 3 of the USDCM.

Where a detailed site plan has been developed and the square footage of directly connected impervious area, unconnected impervious area, receiving pervious area, and separate pervious area have all been defined, a more detailed effective imperviousness can be determined using the methods in Volume 3 of the USDCM.

6.10.4.3.2 Design Volume and Bypass Capacity

If it is intended that a WQCV treatment facility will serve as a snow storage area, the calculation of the required volume must be increased by 50% of the full design snow storage volume.

WQCV treatment facilities will likely receive more runoff than they were designed to treat during larger storm events. The design of any treatment facility designed to store and release the WQCV must include bypass capacity for the 100-year peak inflow rate into the facility. This is often provided in the form of an overflow weir set at the elevation of the design WQCV. Deign guidance is provided in the Fact Sheets in Volume 3 of the USDCM.

6.10.4.3.3 Detention

When a site requires detention in addition to permanent water quality treatment, a single facility may be designed to serve both needs. Detention facilities that are also water quality treatment facilities have outlets to provide for both the stormwater quality treatment and detention release rates. For these facilities, the guidance in the USDCM for Excess Urban Runoff Volume (EURV) facilities shall be followed. Section 7.12 discusses detention further.

6.10.4.4 Infiltration

It is common within the Town of Breckenridge for the subgrade soils to have a high infiltration rate. Infiltration testing is required when infiltration facilities are planned. Infiltration rates must be established by a double ring infiltrometer test performed by a geotechnical engineer at each proposed infiltration site at the proposed elevation of the bottom of the filter material prior to beginning detailed design. Treatment facilities acceptable for use in the Town that can be designed to infiltrate the WQCV include sand filter basins, rain gardens, drywells, infiltration trenches, and infiltration galleries. Other types of facilities may be considered on a case-by-case basis. ~~Note that~~However, if ~~it~~ the same area ~~is intended~~being used as ~~that~~ an infiltration treatment facility will~~to~~ serve as a snow storage area, the calculation of the required volume must be increased by an additional 50% of the full design snow storage volume.

Infiltration facilities must have a high enough subsoil permeability to infiltrate the entire WQCV of the area draining to them within 6 hours without the use of underdrains. Infiltration facilities shall be designed to drain 150% of the WQCV (see attached fact sheet for more information) within 72 hours. Infiltration facilities are not allowed within 300 feet of any active waterway without appropriate pretreatment prior to infiltration (examples include sand filters, water quality vaults, detention basins, and rain gardens). Infiltration facilities located between 300 and 1000 feet from an active waterway must not drain the WQCV in less than 4 hours unless appropriate pretreatment is designed. If subgrade soils at these facilities result in infiltration of the WQCV in less than 4 hours, a sand layer must be designed to slow the infiltration of the WQCV to a minimum of 4 hours. There are no ~~additional~~ restrictions on infiltration facilities located more than 1000 feet from an active waterway.

Guidance on how to design sand filter basins and rain gardens to infiltrate the WQCV standard are included in the Fact Sheets in Volume 3 of the USDCM. Sand filter basins are referred to as simply sand filters, rain gardens are referred to as bioretention. Guidance on how to design drywells, ~~and~~ infiltration trenches and galleries ~~is~~ are included in the Fact Sheets ~~included as~~ attachment~~s~~ to this chapter.

Permeable pavements may be considered with a legally binding maintenance agreement in place as alternative to conventional pavement in pedestrian areas and lower-speed vehicle areas. They will not be allowed for treatment of tributary areas with high sediment yields that could easily clog the system and they are not allowed in the public right-of-way. Permeable pavements will not be allowed on steep slopes or in areas receiving runoff from bare or nearly bare earth. Permeable pavements will be considered impervious materials for detention and water quality calculations and must be designed in accordance with manufacturer's recommendation.

See the subsurface infiltration facility fact sheet in Appendix D of these Standards for additional information and requirements for designing infiltration facilities.

6.10.4.5 Proprietary Structures

Proprietary structures are designed to treat a design flow rate instead of a design volume, and typically function by gravitational separation, vortex separation, filtration, or by screening and retaining pollutants within the structure. The use of proprietary facilities is acceptable but generally discouraged as more frequent maintenance is typically required to maintain adequate performance, proprietary structures often have high long-term costs, and they are often very large while treating only a small flow rate. Proprietary facilities that require removable or replacement cartridges and those that require confined space entry procedures or remote camera operation for routine inspections may be considered on a case-by-case basis.

The two most recognized national programs that test the TSS removal of proprietary structures are in Washington state and New Jersey. Proprietary structures acceptable for use in the Town are those that have been tested by one of these programs and have received one of the following:

1. General or Conditional Use Level Designation for the Pretreatment or Basic test protocols of the Washington State Department of Ecology (WSDOE) Test Assessment Protocol – Ecology (TAPE) for emerging stormwater treatment technologies
2. Certification by the New Jersey Department of Environmental Protection (NJDEP) with verification by the New Jersey Corporation for Advanced Technology (NJCAT) that the manufactured treatment device (MTD) is adequate for TSS removal.

The Town may consider allowing a proprietary structure that is not approved by WSDOE or NJCAT provided that, as part of the drainage report, a qualified professional engineer submits adequate documentation, as determined by the Town, of the manufacturer's test data showing similar performance to that required by either the WSDOE or the NJCAT. The level of scrutiny during review for approval of such devices may be significant.

Proprietary structures must be designed to provide water quality treatment for the 2-year peak design flow rate from the area they are treating. Bypass capacity must be included for the 100-year peak flow rate from this same area. If bypass capacity is not included within the structure, it must be provided before the structure in the form of a diversion for higher flows provided the first flush flows pass to the treatment facility.

6.10.4.6 Treatment in Series

Treatment in series is a very effective way to provide water quality treatment and is highly encouraged. Treatment in series, also referred to as a treatment train, involves passing stormwater from one treatment facility to the next, with each facility providing additional treatment. The facilities used in a treatment train are positioned so facilities that can handle a larger, coarser pollutant load are first, while those facilities that are more suited to a smaller, finer pollutant load are last. This allows for longer periods between required maintenance, especially for the facilities that provide more refined removal.

One option for calculating TSS removal rates is presented in the *Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality* (EPA,1986). The development of this manual was supported by the EPA Nationwide Urban Runoff Program (NURP). While the entire document is worth reviewing, Chapter 4.2.1 of this document presents an analytical method under which TSS removal can be evaluated under the dynamic conditions expected in permanent stormwater treatment facilities. Removal due to sedimentation in a dynamic system is expressed by the equation below.

$$\mathrm{R} = 1 - \left[1 + \frac{1}{\mathrm{n}} * \frac{\mathrm{V_s}}{\mathrm{Q/A}}\right]^{-\mathrm{n}} \tag{6.19}$$

Where:

- R = fraction of solids removed
- V_s = settling velocity of particles
- Q/A = rate of applied flow divided by surface area
- n = turbulence parameter

The turbulence factor offers a way to factor in poor performance caused by turbulence and short circuiting, with n=1 representing very poor performance and n=5 or more indicating very good performance. With n equal to infinity, removal efficiency is linked to detention time. This equation is useful in areas without enough relief to drain a pond that could hold the entire WQCV, or to design basins in series or those receiving inflow that may have already been partially treated by a different type of upstream treatment facility.

Particle settling velocity is calculated as the submerged weight of a particle minus the drag. This calculation requires the minimum particle size of interest be specified. It also requires the viscosity of water, which varies with temperature. To meet Town requirements, a spherical particle with a diameter of 60 microns may be used. A water temperature of 40 degrees Fahrenheit may be assumed, having a viscosity of 1.664×10^5 ft^2/s.

Given the Town requirement for 80% removal of the 60 micron particle, an appropriate treatment train composed of any types of permanent treatment facilities discussed herein may be designed using the equation above. Grass buffers and grass swales are especially helpful at the upstream end of a treatment train. Each of the facilities in the treatment train must include physical components in accordance with these Standards and with the manufacturer's recommendations for permeable pavement, if applicable. A Treatment Train Example Calculation is included as an attachment to this chapter.

6.10.5 Designing for Inspection and Maintenance Requirements

Long-term maintenance requirements are a critical component of treatment facility selection and design because facilities that are not properly maintained do not function properly and/or do not treat stormwater runoff to the extent required by the Town. All new facilities shall be designed to facilitate maintenance operations.

Maintenance considerations that must be evaluated during the selection and design process include accessibility, required equipment, frequency of maintenance, special required training, the freeze/thaw nature of the Town's climate, and the need for replacement materials.

Property owners shall be responsible for the maintenance of stormwater detention and water quality facilities to ensure proper functioning. See Section 6.10.5.7 for additional maintenance requirements.

6.10.5.1 Access

An easement shall be provided to allow Town staff to access the facility if the responsible agency is negligent. Access roads shall be provided to all structures including forebays, outfalls, inlets, micropools, outlet structures, and proprietary facilities. Access roads must support an 80,000-pound vehicle load, be at least 10 feet wide, and have an inside turning radius of at least 25 feet. Access roads must pass close enough to each treatment facility component needing maintenance (forebays, micropools, subgrade vaults, etc.) that the equipment to be used will be able to reach the structure. For example, a backhoe with a reach of 25 feet must be able to pass within 25 feet of the structure without leaving the access road. The Town's vacuum truck has a reach of only 5 feet. If a vacuum truck is required for maintenance, the access road must pass within 5 feet of the facility being maintained. If the access road cannot pass close enough to the structure for the equipment to reach, a concrete access ramp or similar supportable material, such as a 6-inch layer of angular 4-inch-minus riprap, shall be provided at a slope no steeper than 10:1. Concrete ramps shall be scored for wet weather traction.

6.10.5.2 Forebays

Accessible forebays shall be provided at all concentrated inflow points of extended detention basins and sand filter basins for removal of accumulated sediment and floatables. The forebay must be designed in accordance with the Fact Sheets in Volume 3 of the USDCM.

6.10.5.3 Stockpile Areas

Facilities should be designed with stockpile areas for temporary storage and drying of mucked out material. A stockpile area should be directly adjacent to each structure to be cleaned out. Stockpile areas shall be located outside the low flow area and should be as flat as possible. Total stockpile area shall be twice the square footage of all forebays and the micropool.

6.10.5.4 Extended Detention Basins

Extended detention basins shall include a micropool with a hard bottom against which to excavate that is accessible to a vacuum truck or backhoe. Extended detention basins shall include a trickle channel at least 48 inches wide with no cross slope. Trickle channels shall have a concrete bottom and sides at least 6 inches high to allow access for lightweight maintenance equipment if the trickle channel longitudinal slope is less than 5%. If there is a desire for a more aesthetically natural trickle channel, the Town Engineer shall be consulted to discuss and determine maintenance requirements and protocols.

6.10.5.5 Infiltration Facilities

Sand filter basins, rain gardens, drywells, and infiltration trenches have a short lifespan before needing replacement filter material. These facilities shall include pretreatment to remove trash and larger sediment. If located next to a roadway, infiltration facilities shall also include a barrier to prevent degradation of the roadway subgrade. Infiltration testing is required prior to facility design if an infiltration facility is planned. Infiltration testing shall also be conducted after construction and prior to acceptance to ensure the facility functions as intended.

During construction and maintenance operations, special care shall be taken to avoid compaction of subsurface soils that will reduce infiltration rates. If a full infiltration basin is not used, an underdrain system including a loading evaluation will be required and cleanouts must be provided every 300 feet.

Guidance on how to design drywells and infiltration trenches and galleries is included in the Fact Sheets included as attachments to this chapter.

6.10.5.6 Proprietary Structures

Proprietary structures must not require confined space entry procedures for maintenance. Careful design of access to vaults and use of a vacuum truck may eliminate confined space entry requirements.

6.10.5.7 Ownership and Maintenance Plan and Agreement

Treatment and detention facilities require regular inspection and maintenance, to be completed by the property owner. Table 6.23 lists the minimum required inspection and maintenance schedule and typical maintenance activities and operational protocols for various types of treatment and detention facilities. Based on site conditions, the design engineer may require additional maintenance measures, a more frequent schedule, or unique protocols for a site. Volume 3 of the USDCM should be consulted when determining the maintenance schedule, activities, and protocols to be included on the O&M Plan.

An Ownership and Maintenance (O&M) Plan must be developed, submitted, and approved as part of the Drainage Report and then also included as part of the Ownership and Maintenance (O&M) Agreement. An executed O&M Agreement may be required prior to facility approval and project close out. The Town will have the right to access the property to maintain the treatment or detention facility and invoice the owner for the cost of such work if the owner fails to maintain the facility. An example O&M Plan, including a template for the O&M Plan text, and an O&M Plan checklist are included as attachments to Chapter 2. Town staff is available for consultation during the treatment and/or detention facility selection and design process to ensure the design meets the requirements of these Standards. Minimum required components for maintenance are presented in Table 6.23 below.

Town staff will routinely inspect facilities or respond to complaints relating to facilities that may not be performing properly. Facility owners should expect notification of inspections and subsequent findings to be communicated by inspection personnel.

Table 6.23. Recommended Inspection and Maintenance Schedule

Extended Detention Basin	
Activity	**Required Frequency**
Inspection for debris at outlet, sediment in the forebay, and damage to structures or embankments; maintain or repair as necessary.	Twice annually
Remove sediment from forebay, trickle channel(s), and micropool; aeration of vegetated areas	Annually
Mowing	As needed to maintain 6” height and control weeds
Irrigation and application of fertilizer, herbicide, and pesticide	As needed to maintain vegetative health

Notes: Maintenance frequency is highly dependent on construction activity within the tributary area, associated erosion control measures, and the design of the facility. More frequent removal of accumulated sediment may be required, but detention basins are generally low maintenance facilities.

Sand Filter Basin, Rain Gardens, Dry Wells, and Infiltration Trenches and Galleries	
Activity	**Required Frequency**
Inspection to confirm infiltration rate after rainfall; maintain as necessary. Debris and litter removal.	Twice annually
Mowing, plant care, irrigation, and application of fertilizer, herbicide, and pesticide (for bioretention only)	As needed to maintain vegetative health
Mulch replacement (for rain gardens only)	As needed to maintain 3” depth
Inspection of underdrain	When ponding lasts longer than 24 hours
Sediment removal and replacement of media	When ponding lasts longer than 24 hours and underdrain is not clogged

Proprietary Structure	
Activity	**Required Frequency**
Inspection for debris that may cause bypass of design treatment flow rate; maintain as necessary.	Quarterly for first 2 years, as indicated based on first 2 years after that

Filter cartridge inspection; replace as necessary.	Twice annually
Debris removal, filter cartridge replacement, and vacuuming	As recommended by the manufacturer

6.11 CONSTRUCTION STORMWATER MANAGEMENT

Management of stormwater runoff from construction sites in the Town of Breckenridge contributes to our community goal of protecting and maintaining water quality within our local watercourses. A significant amount of sediment can be discharged with stormwater runoff from a construction site. This sediment has the potential to end up in receiving streams, lakes, and rivers, negatively impacting the riparian and aquatic habitat. Establishing a program to minimize untreated runoff from construction sites is essential to keeping streams and drainageways healthy and to minimizing impacts from pollutants and litter.

This section presents the Town's requirements regarding the control of stormwater runoff quality from construction sites, the applicability of the requirements, design guidance for selected BMPs, and references that provide additional information and details. The goal of the requirements in this section is to keep the Town's streams and drainageways healthy. Volume 3 of the USDCM includes a substantial amount of guidance on construction stormwater management and is referenced throughout this section.

The naming convention for facilities or practices that treat stormwater quality during construction has varied over time and between documents. These facilities and practices have been called best management practices (BMPs) in the past. While some more recent documents refer to them as control measures or temporary control measures, these Standards will continue to refer to them as BMPs.

6.11.1 Applicable Codes and Permits

The Town requires applicable construction activity to obtain at least one permit from the Town prior to beginning construction activity. See Chapter 2 for permit requirements. A Stormwater Management Plan (SWMP) or Construction Site Management Plan (CSMP) is required as part of these permits. CSMP requirements are in the Town Code.

Applicable construction projects must apply for a permit from the CDPHE to be covered by the CDPS General Permit for Stormwater Discharges Associated with Construction Activity (Permit No. COR400000). For activity involving dewatering operations, a Construction Dewatering Permit from the CDPHE is required. Information on these permits, and others that may be required during construction, can be found at the CDPHE's webpage for water quality construction permits.

CDOT Erosion Control and Stormwater Quality Field Guide will be used to ensure compliance designing, installing and maintaining BMPs through construction.

6.11.2 Applicability within the Town

The Town's requirements depend on the area disturbed by the project. Applicable projects must develop a Stormwater Management Plan (SWMP). Non-applicable projects, those disturbing less than one acre including any commercial, multi-family, or applicable single family/duplex development, must develop a Construction Site Management Plan (CSMP). CSMP requirements are in the Town Code

A SWMP consists of construction plans and details, specifications for BMPs, and a narrative report that collectively indicate how a construction site will implement structural, non-structural, and planning measures to reduce erosion at the source and prevent pollutants such as sediment and litter from leaving the site. Detailed SWMP requirements are included later in this section.

The Town also requires a Construction Site Management Plan (CSMP) for certain projects. For sites disturbing one acre or more, the CSMP applies only to traffic and site access control. For sites disturbing less than one acre, the CSMP applies to traffic, site access, and erosion and sediment control. Criteria in this section for the design of BMPs and for site inspections apply to sites that require a SWMP and those that require a CSMP.

6.11.3 Stormwater Management Plan Requirements

The intent of a Stormwater Management Plan (SWMP) for construction activities is to prevent pollution, contamination, or degradation of waters of the State and to prevent discharge of pollutants from a project site. Appropriate BMPs must be implemented prior to the start of construction activity, must control potential pollutants during each phase of construction, and must be maintained in operational condition through final stabilization. BMPs must be selected, designed, installed, implemented, and maintained to provide control of all potential pollutants including sediment, construction site waste, trash, discarded building materials, concrete truck washout water and materials, chemicals, sanitary waste, and contaminated soils in discharges from the site. The SWMP will include the following at a minimum:

6.11.3.1 SWMP Report

The SWMP Report is a narrative description and summary of the project site and proposed improvements, how construction activities will be conducted, and the erosion and sediment control practices, procedures, and physical BMPs that will be installed or implemented on site. Items to be included in the SWMP Report are:

1. Administrative Information: Include the project name, location, owner, operator, qualified stormwater manager that will conduct inspections, and the CDPHE certification number.
2. Existing Site Information: Include a description of the existing site, the existing site vegetation and percent density, and the name of the receiving water.
3. Proposed Improvements: Include a description of the proposed project, a description of construction activities, the total area of planned disturbance including access, staging, and storage areas, a sequence of major activities, an approximate construction schedule, and a description of how the project site will be phased.
4. Structural Control Measures: Include a description of the structural BMPs for each stage of construction. Each site must provide structural BMPs that:
    a. Trap sediment before it leaves the site or enters the municipal storm sewer system or watercourse. These shall be installed prior to initiating earth disturbances. Examples include check dams, inlet protection, sediment basins, sediment control logs, and silt fence. Sediment basins are required for sites that have more than 3 acres of tributary area or are directly adjacent to a wetland or major tributary.
    b. Capture and retain runoff from vehicle and equipment washing operations, such as cleaning of concrete trucks, chutes, and associated equipment. An example is the concrete washout. Equipment wash water may not be discharged to State waters or storm sewer systems.
    c. Stop erosion at the source and minimize off-site vehicle tracking of sediment. These include BMPs that stabilize earth disturbances with vegetation or soil stabilization techniques after grading is substantially complete on any portion of the site or for any portion of the site that is inactive for a certain duration of time. Examples include surface roughening, mulching, vehicle tracking control, and installation of blankets, straw wattles, tackifiers, netting, and matting.
    d. Provide bulk storage and prevent spills of petroleum products and other chemicals or fertilizers and contain storm runoff from construction wastes to a designated area, if

applicable. These BMPs shall be able to contain all spills and prevent any spilled material from entering State waters. Secondary storage must be provided, and all bulk storage shall be located as far away from State waters as possible.

e. Provide final stabilization of a site. These may include sod, seed, mulch, landscape plantings, decorative rock, or hard surfacing such as pavers, concrete, or asphalt. Seed mixes must be provided. An anticipated schedule must be provided. If a site is to be winterized, discuss temporary stabilization measures to be utilized. The Town may require a revegetation and stabilization bond for some projects.

5. Non-Structural Control Measures: Include a description of the non-structural BMPs that will be used throughout construction. This section of the report must include:
   a. Discussion about how the following operations will be conducted: trash management; dust and particulate management; materials loading and unloading; vehicle and equipment maintenance and fueling; building materials, chemical, fertilizer, and stockpile storage; routine maintenance involving fertilizers, pesticides, detergents, petroleum products, and solvents; and concrete and batch plants.
   b. A plan to remove from the site and dispose of all waste composed of building materials in licensed disposal facilities. No building material waste or unused building materials shall be buried, dumped, or discharged at the site.
   c. A program and schedule for regular inspection and maintenance of BMPs.
6. Include a description of how construction will be sequenced to reduce the duration any disturbed areas are exposed. Temporary disturbed areas and disturbed areas that will be permanently stabilized shall be exposed no longer than 30 days.
7. Addition Potential Pollutants: Identify and address pollutant sources associated with any other areas or operations not included above where spills can occur. Identify other non-stormwater discharges not included above including construction dewatering not covered under the Construction Dewatering Discharges general permit and wash water that may contribute pollutants to Town waters.

6.11.3.2 SWMP Plans

The SWMP Plans are construction plans that locate and identify the number, extent, and installation details of the structural and nonstructural BMPs included and discussed in the SWMP Report. The SWMP plans must also include property boundaries, construction site boundaries, existing and proposed utilities, limits of cut and fill, stockpile areas, porta-let locations, arrows to depict the direction runoff will flow, and the locations of all receiving waters and drainages.

6.11.3.3 SWMP Specifications

BMP materials specifications and installation requirements may be provided with the BMPs installation details included with the SWMP Plans or as separate technical specifications in the project manual. Installation and implementation specifications must be provided for all structural BMPs in one of these two documents.

6.11.4 SWMP Submittal, Inspection, & Maintenance

For applicable sites, a SWMP must be submitted to the Town for review and approval prior to construction. Once the SWMP is approved and construction begins, regular inspection and maintenance of the BMPs will proceed throughout the duration of construction. The subsections below provide more detail on these requirements and processes.

6.11.4.1 SWMP Submittal Requirements

SWMP plans are construction plans that depict the type and location of structural and procedural BMPs that will be implemented on site during various stages of construction. SWMP plans must be submitted to the Town for review and approval. A SWMP shall be developed by a qualified stormwater professional.

Each SWMP must have separate sheets for the initial/interim and final phases of construction as well as detail sheets with a design and installation detail for each BMP specified in the SWMP. A legend shall be provided that includes all abbreviations used (e.g. CWA is used for concrete washout area) as well as all symbols, blocks, and line types that represent various BMPs. Each kind of symbol, block, or line type shall be labeled at least once on each sheet on which it is used. Text on all SWMP plan sheets, including the detail sheets, shall be legible when the SWMP plan set is printed on 11 x 17 paper, using at least a 9-point font. In the case of overlapping or adjacent project sites that are separately managed, the SWMP shall include at least one plan sheet that clearly shows the site area managed as part of the submitted permit. If more than one sheet is required for each phase of the SWMP plan set, the first sheet of the initial phase shall match the first sheet of the interim phase, and so forth. For project sites that are adjacent to or within construction activity that is not being performed by the same owner or operator, the SWMP shall delineate the exact project site boundaries that each owner or operator is responsible for.

6.11.4.1.1 Initial SWMP Plan

Initial SWMP plans include all BMPs that will be installed before construction begins. These shall include vehicle tracking at all exits from the site and enough stabilized staging area to accommodate the site's operations. Initial SWMP plans will also include any construction fence, inlet protection, curb socks, perimeter controls, or concrete washout areas that are required on site. Initial BMPs shall be identified on the initial SWMP plan by their two- or three-letter abbreviation and a quantity such as linear feet (LF) or square feet (SF), where applicable. The initial plan may be combined with the interim plan for small sites that do not have complex phasing. Sites disturbing 40 acres or more must have separate initial and interim SWMP plan sheets that detail the planned phasing of the site, and it is likely that more than one of each will be required to cover the larger area at a reasonable scale.

6.11.4.1.2 Interim SWMP Plan

Interim SWMP plans include all BMPs that will be installed as construction progresses. These include all BMPs such as temporary stream diversions, check dams, sediment basins, stockpile areas, sediment control logs on exposed slopes, and culvert outlet protection, among others. The interim SWMP plan should include all the BMPs shown on the initial SWMP plan, but they should have their dimensions removed for clarity. Like the initial SWMP plan, interim BMPs shall be identified on the interim SWMP plan by their two- or three-letter abbreviation and a quantity such as linear feet (LF) or square feet (SF), where applicable. Operators are encouraged to phase construction sites to minimize erosion. A complicated site may require more than one interim SWMP plan. The interim plan may be combined with the initial plan for small sites that do not have complex phasing. Sites disturbing 40 acres or more must have separate initial and interim SWMP plan sheets that detail the planned phasing of the site, and it is likely that more than one of each will be required to cover the larger area at a reasonable scale.

6.11.4.1.3 Final SWMP Plan

Final SWMP plans include final stabilization BMPs such as seeding, mulching, and erosion control blanket. For some sites, the landscape plan, if it is comprehensive and included in the construction plan set, may be used as the final SWMP plan, provided the required information is included. In other cases, a separate final SWMP plan will be required. The final SWMP plan should generally not include initial and interim BMPs and abbreviation labels. If an initial or interim BMP is to remain, it shall be included on the final SWMP plan and noted to remain. Otherwise all initial and interim BMPs shall be assumed to removed.

6.11.4.1.4 SWMP Details

Details for all BMPs specified shall be provided on SWMP plan detail sheets. Details shall be in accordance with CDOT or MHFD standard details.

6.11.4.2 SWMP and CSMP Inspection

Each SWMP permittee shall designate a qualified stormwater manager to inspect the BMPs on the construction site. Inspections should occur either weekly or every 14 days and after each runoff-producing storm event to confirm they are installed and functioning as intended, beginning with an inspection of the initial BMPs prior to any excavation and ending with final approval of the site by the Town. The stormwater manager shall be an individual knowledgeable in the principles and practices of erosion and sediment control and pollution prevention, and with the skills to assess: 1) conditions at construction sites that could impact stormwater quality and 2) the effectiveness of stormwater controls implemented to meet the requirements of this permit.

The stormwater manager should keep a record of all inspections including the date and time of the inspection, recent precipitation, required maintenance activities to be completed, and a summary of maintenance completed since the previous inspection. The stormwater manager shall update the SWMP (or CSMP) plans to reflect current conditions by showing changes made to the location and/or type of BMPs based on their performance and/or inspection reports throughout the duration of construction. An updated set of SWMP plans, including installation details, shall be on site during construction activities.

The Town will periodically inspect construction sites for conformance to the SWMP, to confirm installation, maintenance, and function of the BMPs are adequate, and to assure compliance with the Town's permit(s) and Town Code. Work that is not in compliance with the Town's Standards, the SWMP, the CSMP, or the Town Code is subject to enforcement action.

6.11.4.3 SWMP Maintenance

Maintenance of BMPs is typically ongoing for the duration of construction. The SWMP permittee shall schedule any required maintenance noted during regular inspections to be completed prior to the next inspection or reinspection. The SWMP must be updated as needed to reflect current site conditions and be maintained on site. Possible modifications may include replacing and adding BMPs and identifying additional pollution sources. Hand-written notations, initialed and dated, are adequate for most plan updates.

6.11.4.4 SWMP Adequacy

If BMPs installed on the site are inadequate to properly control pollutants during construction as evidenced by their performance during or after storm events or as identified during inspections, the SWMP permittee shall immediately complete any modifications required to properly control pollutants or those noted during inspection. Modifications completed shall be physically noted in the SWMP plans. BMPs, or lack thereof, identified as inadequate based on a Town inspection shall be rehabilitated immediately.

6.11.5 Temporary BMPs

Temporary BMPs are structural or site planning BMPs that are utilized to minimize sediment or other pollutants during construction activities. These BMPs shall be removed from the site upon completion of site stabilization unless they are designated to remain by the SWMP or by the Town because, for example, they do not impede use or maintenance of the site or will biodegrade. This section presents some specific structural and site planning BMPs that are to be used during construction. It also offers several reference documents that provide design and construction details for BMPs that are not specifically discussed in this section.

6.11.5.1 Vehicle Tracking

Vehicle tracking pads are an essential part of preventing sediment from leaving a construction site. Vehicle tracking pads shall be implemented at every exit point to the site, regardless of the type of equipment that will be exiting at each location. The stone used should be hard, durable, angular stone, resistant to weathering with a long dimension not less than 3 inches. Larger stone is preferable, and stone should have a minimum specific gravity of 2.6. Other means of keeping sediment on site may be acceptable with proper documentation and provided performance is maintained. Any damage to sidewalk, curb, or gutter shall be replaced by the permittee. The minimum dimension for each vehicle tracking pad is 20 feet wide by 50 feet long by 6 inches thick, although more length may be required if the minimum size does not provide adequate performance.

6.11.5.2 Sediment Basins

Sediment basins to capture construction site runoff shall be installed on construction sites that disturb more than 3 acres. Runoff is detained in sediment basins and slowly drained so that sediment may settle out before the runoff leaves the site.

For sites with less than 40 acres of disturbance, at least 66% of disturbed area shall drain to a sediment basin. Multiple basins may be more efficient to achieve this requirement than a single basin, depending on the site configuration. Each basin must have a way to drain detained runoff as well as an emergency overflow with a revetted overflow path for runoff exceeding the sediment basin design volume. Sediment basins should drain passively through an outlet structure designed to drain the full basin volume within 12 hours. Designs for outlet structures should be per the criteria references provided in 6.11.5.7. Sediment basin storage volume may also be actively drained by pumping through a sediment bag with the basin being pumped empty when the basin volume reaches 50% of capacity or when rain is forecasted within 24 hours. When pumping is proposed in lieu of a passive outlet structure but is not performed per this criteria, the owner and operator are subject to enforcement action for improperly maintaining the selected BMP.

Each sediment basin shall provide 1600 cubic feet of storage per acre of tributary area provided it is not utilized as a BMP during the months of March, April, or May. If a sediment basin is utilized as a BMP during March, April, or May, it shall provide 3200 cubic feet of storage per acre of tributary area.

For sites with 40 acres or more of disturbance, every acre of disturbance exceeding 40 acres shall drain to a sediment basin. For example, a site with 39.9 acres of disturbance would be required to drain 26.3 of those disturbed acres to a sediment basin. A site with 45 acres of disturbance would be required to drain 31.7 of those disturbed acres to a sediment basin. This criteria encourages owners and operators to minimize the area of site disturbance at any one time to less than 40 acres.

Sediment basin design elements that must be in accordance with the Volume 3 of the USDCM include a spillway crest length based on tributary drainage area, a 12-inch minimum distance between the overflow crest and the surrounding embankment, outlet protection for the spillway, outlet works, and embankment slopes.

6.11.5.3 Check Dams

Check dams may be used to slow runoff in drainageways to limit erosion and sediment transport. Different agencies have specified different cross sections for check dams in their BMP details, however, all agencies specify that the elevation of the crest of the downstream check dam should be equal to the downstream toe of the next upstream check dam. This may become unreasonable in because of the steep grades of some drainageways. For check dams in Breckenridge, the following criteria apply.

1. For preliminary sizing and spacing, check dam height above existing grade shall be a minimum of 18 inches and a maximum of 3 feet. Check dams shall be spaced along the drainageway such that the crest of the downstream check dam is at the same elevation as the downstream toe of the next upstream check dam.
2. If preliminary sizing results in a check dam spacing of less than 200 feet (i.e. the drainageway is steeper than 1.5%), Check dam height may be increased to 4 feet or may spacing may be less than 200 feet for slopes up to 2%. If drainageway slope exceeds 2%, the SWMP preparer shall propose a check dam height and spacing that he or she believes will meet the intent of the intended purpose of the check dam. The proposal shall be discussed during a SWMP review meeting with the Town.
3. Check dam embedment in the underlying ground shall be at least 12 inches and stones used in the check dam shall have a D50 of at least 12 inches.
4. A plan view and sections of a typical check dam used on the site will be provided with the SWMP plan as an initial BMP.
5. All check dams must be removed as part of final stabilization unless designated or approved to remain by the Town.

6.11.5.4 Materials Storage and Stockpiles

Construction materials that are not earth or aggregate shall be stored on a stabilized staging area. Earth and aggregate may be stockpiled outside of a stabilized staging area, but earth materials must be bounded by silt fence or some other BMP that will prevent sediment from escaping the stockpile during a runoff event.

The stabilized staging areas shall be large enough to store all required materials, provide parking for vehicles and equipment on site, and accommodate loading and unloading activities. The stabilized staging area must be installed as an initial BMP, prior to any other construction activities. The size of the stabilized staging area will vary with each site but may be required to be enlarged if inspections show it is not sized sufficiently to contain all required items and activities. Each stabilized staging area shall consist of granular material at least 3 inches thick unless it is demonstrated that native materials provide adequate stabilization. If rutting occurs, or if the underlying subgrade becomes exposed, additional granular material will be required. Once construction is complete, the granular material shall be removed, and the site shall be stabilized in accordance with the final SWMP plan or landscape plan.

6.11.5.5 Temporary Stabilization and Winterization

All areas disturbed by construction or stockpiles shall be stabilized as soon as possible to reduce the duration bare soil is exposed to runoff. All disturbed areas which are either final graded or will remain inactive for a period of more than 30 days shall be stabilized after the completion of the grading activities. Acceptable temporary stabilization BMPs include surface roughening, seeding and mulching, erosion control blankets or turf reinforcement matting, and tarping for stockpiles. Temporary stabilization by revegetating should take place progressively as the project moves forward and as soon as feasible.

To prevent damage during spring runoff, all disturbed areas shall be temporarily stabilized with one of the acceptable methods listed above prior to winter. While the Town requires winterization activities by completed by December 1, it is recommended that winterization be completed by November 1.

6.11.5.6 Erosion Blanket

Any embankment, cut, or fill slope that is in its final graded state and steeper than 3H:1V shall be seeded and covered with erosion blanket within 30 days of final grading being completed. Erosion blanket installation shall be in accordance with the manufacturer's details and specifications which shall be included on the SWMP plan detail sheet.

6.11.5.7 Control Measure Specifications and Details

Unless the Town has included its own temporary BMP details or design guidance in this section, construction details and design procedures shall be as presented in the most recent version of one or more of the following references. Note that these documents are updated regularly and can be found via an internet search.

1. Colorado Department of Transportation Erosion Control and Stormwater Quality Guide and Standard Plan M-208-1.
2. Urban Drainage & Flood Control District Urban Storm Drainage Criteria Manual, Volume 3 Stormwater Quality.
3. Southeast Metro Stormwater Authority Grading, Erosion, and Sediment Control Manual.

The BMPs presented in the documents referenced above shall be designated in the SWMP where appropriate, and details for each BMP specified shall be included in the SWMP. Use of alternate BMPs not specified above is subject to approval by the Town.

6.11.6 Construction Site Inactivity

Temporary stabilization must be implemented for earth disturbing activities on any portion of the site where ground disturbing construction activity has permanently ceased, or temporarily ceased for more than 30 calendar days. Temporary stabilization methods may include, but are not limited to, hydromulching, tarps, soil tackifier, hydroseed, and erosion control blankets. The permittee may exceed the 30-day schedule when either the function of the specific area of the site requires it to remain disturbed, or physical characteristics of the terrain and climate prevent stabilization. The SWMP must document the constraints necessitating the alternative schedule, provide the alternate stabilization schedule, and identify all locations where the alternative schedule is applicable on the site map.

6.11.7 Final Stabilization

Final stabilization is reached when all surface disturbing activities at the site are complete and a uniform vegetative cover has been established with a plant density of at least 70% of pre-disturbance levels, or an equivalent amount of permanently stable surface has been constructed. Permanently stable surfaces include landscape rock, wood mulch, and landscape pavers. Only the vegetation specified in the SWMP planting plan or seed mix shall count toward plant density.

CHAPTER 7
GRADING & EXCAVATION

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LIST OF ATTACHMENTS – APPENDIX E

APPROVED SEED MIXES

7.1 PURPOSE

Development sites within the Town of Breckenridge's mountain environment frequently contain steep slopes, wetland areas, and perennial streams and may be located close to the Blue River. This chapter establishes standards and regulations for development to protect the environment and public health and safety. The standards in this section provide the minimum regulations for grading, excavation, and drainage. Special site conditions or constraints may justify additional requirements from the Town Engineer.

7.2 OTHER STANDARDS

This section provides standards and regulations for general grading, excavation, and drainage for all construction and property development, including work in the right-of-way, single family home development, large residential developments, and commercial property development. Additional grading and excavation standards are provided in the following standards:

1. Chapter 2 of these Standards provides submittal requirements for various types of grading and excavation projects.
2. Chapter 5 of these Standards provides grading requirements within or near streets and driveways.
3. Chapter 6 of these Standards provides information on grading of open channels, detention facilities, and stormwater features.
4. The Subsurface Infiltration Facilities Fact Sheet, included as an attachment to Chapter 6, provides additional requirements for subsurface infiltration facilities.
5. Chapter 8 of these Standards provides requirements and procedures for inspection and acceptance of grading and excavation work.
6. Chapter 9 of these Standards provides construction specifications pertaining to grading and excavation.
7. OSHA provides requirements for temporary trenching, grading, shoring, and other construction requirements.

7.3 PERMITS

Any grading or excavation work of any kind requires a permit prior to commencing work. An infrastructure permit, right-of-way permit, or building permit is required before beginning any grading or excavation activities. Additional Town, County, State, or Federal permits may be required as well. See Chapter 2 (Section 2.4) of these Standards for additional guidance on permits.

7.4 GRADING

The sections below set minimum grading requirements, including geotechnical engineering requirements, slope stability, maximum slopes, earthen berm requirements, detention ponds, retaining walls, and revegetation requirements.

7.4.1 Geotechnical Engineer

Sites with existing grades exceeding a 3H:1V slope will require a geotechnical report analyzing slope stability that is stamped by a geotechnical engineer licensed in the State of Colorado. The geotechnical engineer shall analyze the slope stability for the existing site, proposed structures, and driveways, and examine any impacts to adjacent structures or properties.

Sites with unique conditions, high groundwater, poor or expansive soils, previously mined areas, or any other geotechnical concerns shall require a geotechnical report stamped by a geotechnical engineer licensed in the State of Colorado.

7.4.2 Maximum Slope

A maximum slope of 3H:1V is recommended and preferred for all development in the Town. If existing topography makes it infeasible to provide 3H:1V slopes, slopes of 2H:1V may be allowed. Slopes exceeding 3H:1V require erosion netting or other erosion control systems as approved by the Town Engineer. Slopes should be designed at a maximum of 2.5H:1V, as 2H:1V design slopes often result in localized areas with slopes steeper than 2H:1V, which will not meet code nor pass inspection.

7.4.3 Earthen Berms

Earthen berms constructed for landscaping, screening, or sound mitigation shall be constructed at a maximum slope of 3H:1V. Berms shall be designed to appear natural and match surrounding topography; this should be accomplished through the following design standards:

1. Berms shall be designed with vertical and horizontal undulation. Vertical undulations shall be 50% of the maximum berm height and horizontal undulations shall be 25% of the maximum berm width. A variance may be granted for berms shorter than 100 feet.
2. Maximum height of berm shall be 10 feet.
3. Berms shall be connected to the existing grades at the bottom gradually with a vertical curve to make the berm more natural appearing.
4. Berms shall flatten near the top to appear more natural.

7.4.4 Detention and Water Quality Features

Detention and water quality feature grading shall be designed to balance aesthetics and maintenance. Grading shall be designed to add horizontal undulations so the features appear more natural and match the natural landscape, provided that the undulations do not negatively impact maintenance of the facility.

7.4.5 Retaining Walls

The maximum slope of unretained finished grades shall be 2H:1V. Slopes with proposed grading that will result in grades steeper than 2H:1V will require retaining walls. All retaining walls taller than 4 feet (measured from finished grade at bottom of wall to top of wall) shall be engineered. Engineered walls require the following to be submitted to the Engineering Division from a professional engineer licensed in the State of Colorado:

1. Detailed plan by Colorado professional engineer showing retaining wall details and stamped
2. Inspections during construction certifying all aspects of retaining wall construction meet plan requirements and good engineering practices
3. Final certification of the retaining wall construction by Colorado professional engineer

Multiple retaining walls constructed close to each other will be treated as a single wall for height calculation purposes unless the horizontal distance between the walls exceeds the height of the taller wall. For example, two 4-foot walls separated by only 3 horizontal feet will be treated as a single 8-foot wall and must meet the requirements for an engineered wall.

Walls designed to be less than 4 feet tall and not engineered, but ultimately constructed over 4 feet tall due to site grading, shall be documented, inspected, and certified by a registered professional engineer during construction. A single inspection post-construction will not meet the certification requirements for retaining walls over 4 feet tall.

All retaining walls, including walls less than 4 feet tall, shall be designed with free-draining, granular material for wall backfill.~~, and foundation drains shall be installed behind the wall.~~

Retaining walls connected to buildings or building egresses shall have railings installed and meet requirements of Title 8 of the Town Code (Building Regulations).

See Chapter 5 of these Standards for additional information on retaining walls. See Town Code for planning requirements related to retaining walls.

7.4.6 Site Stabilization

All disturbed areas shall be stabilized prior to final acceptance by Town and should be stabilized as soon as possible after completion of earth disturbance activities and no longer than 14 days after completion of earth work. For larger projects, grading shall be completed in phases and stabilized immediately after completion of a phase. Final stabilization must be a permanent feature designed and installed to prevent erosion and sediment runoff. Final stabilization methods shall be installed and maintained following good engineering, hydrologic, and pollution control practices. The following is a list of acceptable site stabilization methods in Breckenridge. Additional methods not listed below may be submitted to and approved by the Town Engineer.

1. Revegetation with native grass achieving an individual plant density of at least 70% of pre-disturbance levels. Pre-disturbance levels refer to pre-disturbance vegetation that would represent the naturally supported vegetation density in the area. See Section 6.12.1.7 below for additional information on revegetation.
2. Permanent Pavement and Buildings, including roofed buildings, concrete, and hot mix asphalt are considered final stabilized surfaces. Aggregate base course, fine gravel, and asphalt millings are generally not considered permanent pavement and shall not be used for final stabilization.
3. Hardscape surfaces, such as flagstone pavers.
4. Rip-rap, cobble, and large rock. A scour analysis shall be included in the drainage report when required for rock installed on steep slopes.
5. Other landscaping materials, including trees, shrubs, perennials, wood mulch, rock mulch, and turf grass. It is recommended that a landscape architect be used to design landscaping plans.

7.4.7 Revegetation

It is recommended that a revegetation plan be developed by a licensed professional landscape architect to develop a site specific revegetation and landscaping plan. The Town shall be consulted for approval of site specific topsoil and native seed requirements. A list of pre-approved seed mixes are included in Appendix G.

To achieve the highest likelihood of establishment of the specified vegetation, a 2-year maintenance plan from a certified landscaping company that understands native vegetation is required. Plantings shall be completed in the fall or late winter to provide the best odds of establishment. Irrigation is generally required for trees, shrubs, and perennials. Temporary irrigation systems are recommended to establish native grasses. The Town shall be consulted for approval of site specific topsoil and native seed requirements. General requirements to improve successful vegetation establishment include the following:

1. Seeding all disturbed areas with an approved weed free native seed mix. Approved seed mixes for most sites in the Town of Breckenridge include the Middle Park Conservation District “Forest Mix” and the NRCS “Forest Mix.” Alternative seed mixes may be required near environmentally sensitive areas, such as wetlands and the Cucumber Gulch Wildlife Preserve. Diverse early-serial seed mixes with the potential to fully occupy the site’s botanical niches shall be selected. Alternate seed mixes shall be approved by Town Engineer.
2. Adequate seeding rates and seeding techniques coupled with soil amendments and fertilizer as determined by proper soil testing and Town construction specifications.
3. Preparing disturbed areas with a minimum depth of 3 inches of topsoil. Topsoil shall be free of rocks, weeds, and other invasive plant species.
4. Pretreating disturbed areas to remove invasive or noxious species.
5. Minimizing or eliminating the use of nitrogen as exotic weeds are often preferentially stimulated over native species.
6. Monitoring for non-target species and noxious weed seeds that are often present in a seed mix.
7. Developing an iterative weed management plan based on regularly scheduled monitoring.

See Chapter 9 for additional information on revegetation specifications.

7.5 DRAINAGE

The sections below set minimum grading and excavation requirements pertaining to drainage and stormwater flow patterns. These sections provide general guidance for site drainage and do not provide standards for water quality or detention requirements. See Chapter 6 of these Standards for water quality, detention, and other drainage requirements.

7.5.1 Positive Drainage

All residential and commercial buildings shall be graded with positive drainage away from building foundations. Positive drainage is defined as a minimum 2% grade perpendicular away from the building foundation for a minimum of 10 feet. Where pavement is adjacent to a building, the minimum slope may be reduced to 1%. Drainage swales, drywells, infiltration facilities, foundation drain pipe daylights, detention and water quality facilities, and all other drainage structures shall be a minimum of 10 feet from the edge of any building foundation or structural element. Foundation drains shall not daylight in roadside ditches, on adjacent parcels, or areas that will drain directly onto adjacent parcels.

7.5.2 Offsite Drainage

Drainage from new development shall be designed to discharge to an infiltration facility, drainage swale, storm sewer, regional detention facility, stream, or other drainage conveyance. Grading shall be designed to prevent any developed drainage or altered drainage flows from crossing onto a neighboring property parcel unless a drainage easement exists on that parcel. Subdivisions shall be platted to add drainage easements for all areas where runoff drainage flows onto another parcel. In no case shall development worsen drainage issues for any downstream properties. Grading shall be designed to prevent erosion and any damage to adjacent structures, streets, or storm sewer infrastructure. Infiltration may be utilized in areas where applicable. Stormwater may drain into an approved location in the Town right-of-way, but it shall not drain directly onto streets, sidewalks, pedestrian paths, trails, or other areas where it could create public safety hazards. Infiltration facilities shall be used in areas where drainage would otherwise cross a street, sidewalk, or other facility. See the subsurface infiltration facility fact sheet attached to Chapter 6 for additional information.

Drainage from existing developments shall be designed with preliminary stormwater treatment prior to discharging directly to a stream, wetland, or other body of water.

Snow storage areas for all development, including single family homes, shall be designed ~~not~~ to drain ~~toward~~ away from foundations, ~~nor directly onto~~ roadways, sidewalks, pedestrian paths, trails, or other areas where it could create public safety hazards. Snow storage shall be designed to drain into a permanent water quality facility or onto a vegetated area prior to discharging to a stormwater conveyance facility.

New development and redevelopment are both required to analyze and correct any existing inadequate drainage, including insufficient drainage away from buildings, runoff adversely affecting downstream properties, inadequately sized drywells, drainage exceeding storm sewer inlets, pipes, or other conveyance, or other drainage concerns identified by the Town Engineer.

7.5.3 Spa and Pool Drainage

Spas, swimming pools, and other water features installed through new development (existing homes replacing existing spas are exempted) shall meet the following drainage requirements:

1. Pools and spas shall be connected to a drywell meeting all requirements of these Standards. Pools and spas shall not drain into storm sewers, roads, or surface flow off property. Pools, spas, and their drainage shall not be located near environmentally sensitive areas. Within the Cucumber Gulch Protected Management Area (PMA), the Upper Blue Sanitation District may allow spas to be connected to the sanitary sewer. If the sanitary sewer connection is allowed, a drywell is not required.
2. Drains shall be designed to maintain a maximum flow rate of 10 gallons per minute. Drywell infiltration rate shall be designed to exceed the drainage flow rate.
3. Prior to draining a pool or spa, no chlorine, salts, or other chemicals shall be added to the water for a period of at least five days.

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7.6 ENVIRONMENTALLY SENSITIVE AREAS (ESA)

Environmentally sensitive areas (ESA) are defined as wetlands, streams, lakes, ponds, Cucumber Gulch Wildlife Preserve, and other special wildlife habitat areas. These areas require special requirements to protect their sensitive nature during development. The Town and the developer shall work in conjunction with the Environmental Protection Agency (EPA), Army Corps of Engineers (USACE), State Engineer's Office Water Commissioner, and the Natural Resource Conservation Service (NRCS). For floodplain development regulations, see Title 10 of the Town Code.

7.6.1 Setbacks

No structures or soil disruption shall be located within 25 feet of the top of the banks or delineated boundary of all ESAs. The setback requirements also apply to all channels draining 20 acres or more. Exceptions to the setback requirements may be allowed if one of the following conditions is met and approved by the Town Engineer:

1. Development sites with the most recent plat being recorded prior to January 1, 1986 and platted in a manner which does not allow a feasible development option meeting the 25-foot disturbance setback. This exception only applies if the disturbance setback prohibits any feasible development and the developer demonstrates there are no feasible alternatives to

eliminate disturbance within the setback. Additionally, sites that were platted prior to January 1, 1986, but that were re-platted after January 1, 1986, do not qualify for this exemption.

2. The ESA has previously been mined or extensively disturbed in the area adjacent to the proposed development, resulting in dredge tailings in the area. In this case, the setback may be waived if the developer submits a plan to implement channel, wetland, environmental, or other water body improvements which serve to reclaim, stabilize, revegetate, or enhance the ESA.
3. Work is proposed in the 25-foot setback area (but not within the ESA boundary), the work is considered minor (no permanent structures) in the setback area, and acceptable measures are implemented to prevent an increase of sediment or other contaminants that exceeds historical rates as determined by the Town Engineer.
4. Areas where there are no other feasible methods for development without encroachment into the ESA setback and the encroachment is necessary for critical infrastructure. To meet this exemption, the developer must demonstrate there are no feasible alternatives to eliminate disturbance within the setback. Only infrastructure, such as roads and utilities, will be considered within the ESA. Residences and structures will generally not be granted an exemption to be constructed within an ESA.
5. The wetlands or other environmentally sensitive areas have encroached into a detention, stormwater quality, or another type of stormwater feature since the development of the feature. Maintenance activities within the stormwater feature shall be allowed in these cases.

If any of the above exemptions to the setback requirement is granted by the Town Engineer, the following requirements shall be met:

1. Acceptable measures shall be designed, installed, and maintained to prevent an increase of sediment or other contaminants that exceeds historical rates, both during construction and in the final condition.
2. If ESA improvements are approved per condition 2 above, the water body shall be hydrologically contained to limit impacts until the improvements are completed. For stream restoration improvements, a bypass channel shall be designed for the 25-year storm and for a minimum distance of 25 feet above and below the channel restoration work. The bypass channel shall either be a plastic, metal, or concrete culvert or shall be an open channel stabilized with scour protection designed for the 25-year storm.
3. If wetlands are disturbed, wetland mitigation shall be completed at a minimum of a 1:1 ratio or the ratio required by the USACE, whichever is greater. Wetland mitigation for Waters of the US shall meet all requirements of the USACE. A financial guarantee shall be submitted to the Town guaranteeing the wetlands mitigation for a minimum period of 3 years to ensure successful plant establishment for all wetland plantings. A wetland mitigation plan shall be submitted which includes the following:
    a. The amount, location, and acreage of wetland fill, removal or other alteration proposed.
    b. The proposed mitigation improvements.
    c. A grading, erosion control, and revegetation plan, including plant material to be used for revegetation and soil stabilization measures.
    d. A narrative explaining how there are no feasible alternatives to disturbing the wetlands, how the wetland disturbance is being minimized to the extent possible, how the wetlands will be mitigated, and how the project will not violate an applicable laws or regulations.

e. Other applicable permits such as a USACE 404 permits (if site is determined to be a jurisdictional wetland).

4. Disturbed areas within the ESA or ESA setback shall be revegetated with an appropriate seed mix. Revegetation of ESA and ESA setbacks shall be monitored and certified at revegetation.

7.6.2 Wetland Delineation Surveys

Wetland boundaries shall be shown on all subdivision plats within the Town of Breckenridge. If the Town believes there is any evidence that a site subject to ~~disturbance~~ any ~~sized~~ development may contain wetlands, either not shown on the plat or with an incorrect boundary, the Town may require the developer to obtain and submit a wetlands delineation survey completed in accordance with Corps of Engineers Wetlands Delineation Manual and all USACE guidelines.~~by an independent third party consultant specializing in wetlands delineations as recognized by the USACE.~~

If a developer believes that a wetland shown on a plat is incorrect, the developer may obtain a wetlands survey ~~by an independent third party consultant specializing in wetlands delineations as recognized by the USACE~~in accordinace with the Corps of Engineers Wetlands Delineation and submit it to the Town Engineer for review. The wetlands survey shall be conducted during the months of June, July, or August.

Wetland delineations shall be updated after 5 years to reflect current wetland conditions. Wetland boundaries shown on plats and other locations will be considered outdated after 5 years and will require a new wetlands survey delineation completed in accordinace with the Corps of Engineers Wetlands Delineation Manual. ~~by an independent third party consultant specializing in wetlands delineations as recognized by the USACEby the developer.~~

CHAPTER 8
INSPECTION & ACCEPTANCE

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8.1 INTRODUCTION

This chapter includes information about the Engineering Division inspection and acceptance procedures and protocols for different types of projects. It also includes information on occupancy requirements and how different types of permits and projects may be closed. This information is intended to apply to activities that occur after initial permits are issued.

8.2 REFERENCES TO OTHER DOCUMENTS

Titles 9 and 10 of the Town Code offer additional information on inspections and acceptance. Chapter 2 of these Standards includes information on the types of permits required by the Town and the submittals required to receive those permits. This chapter only includes the inspection and acceptance procedures of the Engineering Division; permit holders shall reference the Town Code and contact the Community Development Department for additional requirements. Permit holders shall also reference County, State, and Federal regulations for procedures on inspection and acceptance requirements relating to those permits.

8.3 INSPECTION AND ACCEPTANCE PROCESS

The Engineering Division inspection and acceptance process for each type of permit, from permit issuance to final acceptance, is outlined below. Section 8.3.1 to Section 8.3.3 provides an overview of the inspection and acceptance steps for each type of permit; the subsequent sections provide additional detail on the inspections and acceptance steps outlined in Section 8.3. The intent of this section is to provide a summary of steps that must be completed once each permit is issued.

8.3.1 Infrastructure Permit

The infrastructure permit holder shall follow the steps below after receiving an infrastructure permit:

1. Preconstruction Meeting – A preconstruction meeting with the Engineering Division is required prior to beginning construction activities.
2. Begin Construction – Construction activities may begin only after permit holder has obtained all necessary permits, satisfied all requirements of the Breckenridge Town Code and these Standards, and attended a preconstruction meeting with the Engineering Division.
3. Subdivision Improvement Agreement – A Subdivision Improvement Agreement (SIA) will be required if the project requires a subdivision plat and all subdivision improvements are not completed prior to the subdivision plat being recorded. See Title 9 of Town Code for more information on Subdivision Improvement Agreements.
4. Inspections Prior to Initial Acceptance – The Engineering Division shall complete inspections throughout the construction process. See Section 8.4 below for the Engineering inspections required for different permit types.
5. Completion of Work – Permit holders shall notify the Engineering Division once all improvements required by the construction plans and all agreements have been completed.
6. Initial Acceptance Inspection – The Engineering Division shall inspect the improvements for compliance with Standards, plans, specifications, and agreements.
7. Correction of Deficiencies – If the Engineering Division finds any improvements not to be in compliance with the Standards, plans, specifications, or any agreements, the Engineering Division will notify the permit holder who then must correct the deficiencies and notify the Engineering Division when the site is ready for another inspection.

8. Record Drawings – The permit holder shall submit record drawings (also referred to as As-Built Drawings) to the Engineering Division in accordance with the requirements in Section 8.7.
9. Initial Acceptance – After the permit holder satisfactorily corrects deficiencies, submits record drawings and the warranty surety, the Engineering Division shall grant Initial Acceptance.
10. Warranty Period – The warranty period shall last for two years after initial acceptance. The permit holder shall maintain the improvements during this period. Private infrastructure shall not require a warranty period.
11. Final Acceptance – The permit holder shall request a final inspection of improvements no later than 45 days prior to the end of the warranty period. The permit holder shall repair any deficiencies prior to the end of warranty period. Once deficiencies are corrected, the Engineering Division shall grant final acceptance and release the warranty surety.

8.3.2 Building Permit (without associated infrastructure permit)

The building permit holder shall follow the steps below after receiving a building permit when there is no associated infrastructure permit:

1. Begin Construction – Construction activities may begin only after permit holder has obtained all necessary permits and satisfied all requirements of the Breckenridge Town Code and these Standards.
2. Inspections Prior to Certificate of Occupancy – The Engineering Division shall complete inspections throughout the construction process. See Section 8.4 below for the Engineering Division inspections required for different permit types.
3. Certificate of Occupancy – The Certificate of Occupancy inspection shall be requested when all improvements are completed.
4. Completion Guarantee – Permit holders are encouraged to complete all site work prior to October 31st. If the permit holder does not complete all improvements by October 31st, and desires to obtain the certificate of occupancy prior to May 1st, a preliminary Certificate of Occupancy inspection shall be scheduled by the permit holder with Engineering. Engineering will require a financial guarantee (surety) in the form of a ~~letter of credit, bond, or~~ cash deposit ~~shall be submitted to the Engineering Division~~. The Town Engineer shall determine the financial guarantee amount by either assessing 125% of the remaining work value or assessing a general completion amount of $5,000 if the scope of the uncompleted work cannot be determined. Once all improvements are complete, the permit holder shall request ~~an~~ a final inspection. The surety will be released once the Engineering Division determines improvements are complete.

Commented [JP1]: Planning does not do anything other than a cash deposit unless Engineering does something separate in the SIAs etc...

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8.3.3 Right of Way Permit

The right-of-way permit holder shall follow the steps below after receiving a right-of-way permit:

1. Begin Construction – Construction activities may begin only after permit holder has obtained all necessary permits and satisfied all requirements of the Breckenridge Town Code and these Standards.
2. Inspections Prior to Initial Acceptance – The Engineering Division shall complete inspections throughout the construction process. See Section 8.4 below for the Engineering Division inspections required for different permit types.
3. Completion Inspection – The completion inspection shall be requested when all improvements are completed.
4. Warranty Period – The warranty period may begin once the completion inspection has been passed.

5. Two Year Bond Re-Inspection - The permit holder shall request a final inspection of improvements no later than 45 days prior to the end of the warranty period. The permit holder shall repair any deficiencies prior to the end of warranty period. Once deficiencies are corrected, the Engineering Division shall grant final acceptance and release the warranty surety.

8.4 ENGINEERING DIVISION INSPECTIONS

Inspections are required at key steps of the construction process to help provide general compliance with plans and specifications. However, inspections completed by the Engineering Division do not provide final assurance of compliance with specifications and do not preclude the Engineering Division from imposing corrective actions in the future. The Engineering Division may require the permit holder to remove, replace, or repair items, or to perform other corrective actions if improvements are ever found to not comply with plans, specifications, or Town Standards.

The permit holder is required to schedule all inspections with the Engineering Division, other than those for stormwater management, at the time indicated for each permit using the contact information on the applicable permit. Failure of the permit holder to schedule inspections at the appropriate time may result in stop work orders, removal and replacement of improvements, fines, or other penalties. The stormwater management inspections shall be scheduled by the Engineering Division. The sections below detail the permits that will require an inspection from the Engineering Division.

8.4.1 Building Permit

A Building Permit may require up to four separate inspections from the Engineering Division, as detailed in this section. Inspections from the Community Development Department will also be required. The Community Development Department shall be contacted to confirm the required inspections. Inspections for building permits are encouraged to be completed between May 1 and November 1. If a final inspection is required outside these dates, a ~~completion bond~~cash deposit (surety) may be required. Building permit inspections shall be scheduled through the contact information provided on the building permit form. Permit holders may request additional inspections at critical steps during construction if needed.

8.4.1.1 Pre-Pavement/Pre-Landscaping Inspection

The building permit holder shall schedule a pre-pavement/pre-landscaping inspection with the Engineering Division prior to placement of pavement, final topsoil, seeding, and landscaping. Inspection shall generally include the items shown on the inspection form included in Appendix H.

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8.4.1.2 Preliminary Certificate of Occupancy Inspection

The preliminary Certificate of Occupancy inspection only applies to projects completed between November 1st and April 31st of each year. If site work cannot be completed by November 1st, the permit holder shall schedule a preliminary inspection prior to November 1st. Any incomplete work shall require a financial guarantee per Section 8.3.2.

8.4.1.~~2~~3 Certificate of Occupancy Inspection

The building permit holder shall schedule a certificate of occupancy inspection with the Engineering Division after completion of all grading, pavement, landscaping, site stabilization, and all other site work. Inspection shall generally include the items shown on the inspection form included in Appendix H.

8.4.1.~~3~~4 Stormwater Management Inspection

The Engineering Division will conduct stormwater management inspections of sites to ensure that stormwater controls have been installed per the approved plans and are functioning adequately. Inspections will be scheduled periodically throughout construction and may occur without notice.

8.4.1.~~4~~5 Bond Release Inspection

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If there is completion bond for the project, the building permit holder will schedule a bond release inspection with the Engineering Division for any work completed after the issuance of the certificate of occupancy.

8.4.2 Right-of-Way Permit

A Right-of-Way Permit may require up to four separate inspections from the Engineering Division. No work in the right-of-way or right-of-way inspections shall occur between November 1 and May 1. The types of inspections from the Engineering Division that may be required for a right-of-way permit are detailed in the sections below. Right-of-way permit inspections shall be scheduled through the contact information provided on the permit form.

8.4.2.1 Utility Inspection

The Engineering Division will determine utility inspection requirements prior to start of the project. Utility inspections may be required prior to backfill of utilities to ensure utilities are constructed in accordance with the appropriate construction specifications. Major features shall be inspected prior to utility backfill. The right-of-way permit holder shall call to schedule an inspection at least 48 hours prior to the utility being backfilled.

8.4.2.2 Pre-Pavement Inspection

The right-of-way permit holder shall call to schedule a pre-pavement inspection at least 48 hours prior to the placement of concrete, asphalt, or other types of pavement. Inspection items shall include grading, subgrade, and concrete forms for sidewalks, curbs, curb ramps, and driveway curb cuts.

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8.4.2.3 Completion Inspection

The right-of-way permit holder shall call to schedule a completion inspection after completion of all improvements, pavement, site stabilization, and restoration. Inspection shall generally include the items shown on the inspection form. Once the site passes the completion inspection, the 2-year bond and warranty period process can be initiated.

8.4.2.4 Stormwater Management Inspection

The Engineering Division will conduct stormwater management inspections of sites to ensure that stormwater controls have been installed per the approved plans and are functioning adequately. Inspections will be scheduled periodically throughout construction and may occur without notice.

8.4.2.5 Two Year Bond Re-Inspection

The Engineering Division will schedule an inspection of all improvements one month before the end of the two-year warranty bond period. If defects are found in any of the improvements, the right-of-way permit holder shall be notified, and defects shall be repaired by the permit holder.

8.4.3 Infrastructure Permit

The types of inspections that may be required for an infrastructure permit are detailed below.

8.4.3.1 Utility Inspection

The Engineering Division will determine utility inspection requirements prior to start of the project. Utility inspections may be required prior to backfill of utilities to ensure utilities are constructed in accordance with the appropriate construction specifications. If an inspection is required prior to utility backfill, the right-of-way permit holder shall call to schedule an inspection at least 48 hours prior to the utility being backfilled.

8.4.3.2 Pre-Pavement Inspection

The infrastructure permit holder shall call to schedule a pre-pavement inspection at least 48 hours prior to the placement of concrete, asphalt, or other types of pavement. Inspection items shall include grading, subgrade, and concrete forms for sidewalks, curbs, curb ramps, and driveway curb cuts.

8.4.3.3 Initial Acceptance Inspection

The infrastructure permit holder shall call to schedule an initial acceptance inspection after all improvements, pavement, site stabilization, and restoration are complete. Inspection shall include all infrastructure, public improvements to be conveyed to the Town, private improvements, utilities, detention and permanent stormwater quality features, and all other site work. Once the site passes the initial acceptance inspection, the 2-year bond and warranty period process can be initiated. The initial acceptance process is discussed in more detail in Section 8.5.

8.4.3.4 Other Inspections

The Engineering Division will determine if additional inspections are necessary during the pre-construction meeting and will establish those with the developer. The Engineering Division also may require additional inspections throughout the project duration. These may include structural concrete, structural steel, reinforcing steel, and backfill compaction inspections.

8.4.3.5 Stormwater Management Inspection

The Engineering Division will conduct stormwater management inspections of sites to monitor that stormwater controls have been installed per the approved plans and functioning adequately. Inspections will be scheduled by the Engineering Division periodically throughout construction and may also occur without notice.

8.4.3.6 Final Acceptance Inspection

The Engineering Division will schedule an inspection of all improvements at the end of the two-year warranty bond period. If defects are found in any of the improvements, the infrastructure permit holder shall be notified, and defects shall be repaired by the permit holder.

8.5 INITIAL ACCEPTANCE

For all projects that are issued an infrastructure permit, initial acceptance generally indicates that the project has been completed to the satisfaction of the Engineering Division and that the 2-year bond (surety) process (warranty period) can be initiated. Initial acceptance requires the following at a minimum:

1. Construction Plans – Plans shall be submitted for approval clearly identifying public improvements to be conveyed to Town.
2. Preconstruction Meeting – A pre-construction meeting between an Engineering Division representative, the Project Engineer, developer, and contractor shall be held prior to the start

of construction. The meeting shall confirm the scope of work, inspection requirements, and testing requirements for the project.

3. Initial Acceptance Submittals:

   a. Material testing reports & testing firm letter – Material testing shall be completed in accordance with the Town specifications. An example testing firm letter is included as an attachment to Appendix H and shall be signed and stamped by a Colorado Professional Engineer to certify that all test procedures were in conformance with the approved plans and specifications.

   b. Inspection & construction observation reports – Inspection and construction observation required to be performed by the Project Engineer shall be established during the pre-construction meeting. Reports shall be certified by the Project Engineer and shall certify that construction was in conformance with approved plans and specifications.

   c. Engineering Record Drawings – Prior to issuance of initial acceptance, record drawings shall be submitted to the Engineering Division that meet the requirements of Section 8.7.

   d. As-built survey of detention and water quality facilities and certification by a professional engineer licensed in the state of Colorado certifying the facility meets the detention and water quality requirements.

   e. As-built survey of main features of underground utilities. Examples include utility surface locates, manholes, valves, inlets, hydrants, junction boxes, and other exposed features. Survey of underground facilities prior to backfill may be required at critical locations. The surveyed features shall be drawn electronically and submitted in DWG and PDF formats.

   f. Other documentation – Additional documentation, as required by Town Engineer, shall be submitted to the Engineering Division prior to initial acceptance.

4. Initial Acceptance Request – An initial acceptance request shall be submitted in writing to request an initial acceptance inspection after all initial acceptance submittals have been submitted. An improvements summary letter shall be submitted with the initial acceptance request. An example improvements summary letter is included as an attachment to Appendix H. The initial acceptance request shall only be submitted if the work has been fully completed in accordance with the approved plans and specifications. All work and known punch list items must be complete prior to submitting the request.

   a. Work Acceptable. If the work has been completed satisfactorily for initial acceptance, the Town Engineer will issue a written notice of initial acceptance to the permit holder.

   b. Work not Acceptable. If the work has not been completed satisfactorily, the Town Engineer will provide the permit holder with a punch list of items to be completed. Once the punch list items are completed, the permit holder may request a subsequent inspection.

5. Warranty Surety – If the permit holder fails to complete punch list items satisfactorily within 30 days, the Town may utilize the warranty surety to complete improvements. The Town may also withhold additional permits or certificates of occupancy.

8.6 WARRANTY

For permits requiring a warranty, the permit holder shall warrant that all public improvements shall remain free from defects for a period of two years from the date the Town issues initial acceptance of the improvements. This period may be referred to as the two-year warranty period, warranty period, the two-year bond period, or initial acceptance period. During the two-year warranty period, any defect determined to exist with respect to such improvements shall be repaired or the improvement replaced at the sole cost of the permit holder.

The permit holder shall be required to file a warranty surety in the form of a warranty bond, cash bond, or irrevocable letter of credit with the Town in a form acceptable to the Town Attorney, prior to initial acceptance of any public improvements, in an amount equal to 25% of the original cost of the public improvements, in order to assure the satisfactory maintenance of the improvements for a period of two years after the date of initial acceptance by the Town. Such bond shall guarantee all public improvements constructed by the permit holder remain free from defect for the required two-year period.

If initial acceptance is reached prior to obtaining final site stabilization (70% revegetation), the permit holder shall be responsible for maintenance of all temporary and permanent stormwater quality features until final stabilization of the site is achieved. This shall include sweeping of street and sidewalks, and maintenance of detention ponds, water quality features, and storm sewer infrastructure. The permit holder shall be responsible for the maintenance of trees, shrubs, and other landscaping features during the two year warranty period.

8.7 RECORD DRAWINGS

Record drawings, also called as-built drawings, are to be submitted to and accepted by the Town Engineer prior to final acceptance of any public improvements. As-built drawings shall be produced under the direction of and stamped by a Colorado registered professional engineer to assure compliance with original design drawings. Certification shall be presented along with the as-built drawings stating such compliance.

One set of as-built drawings shall be submitted to the Engineering Division within 30 days of completion of construction (initial acceptance). Drawings shall be submitted electronically in DWG and PDF format so that they will print to scale on 11” x 17” paper. Each drawing sheet shall include a title block, scale, north arrow, original and revision dates, and professional engineer’s stamp when applicable. Title blocks shall be along the bottom or right margin of each drawing. Survey control and project benchmarks including datum shall be included.

Manufacturer’s literature and product data, including catalog sheets, descriptive literature, product warranties, and any O&M manuals, for all materials and equipment used, shall be provided with as-built drawings.

The construction plans shall be updated with all design changes that occurred after issuance of infrastructure permit. Record drawings shall also identify actual constructed locations and dimensions of street improvements, signage, striping, street lights, swales, WQ/detention ponds, inlets, stormwater improvements, and other infrastructure. For detention and water quality facilities, record drawings shall identify the as-built locations of all inlets and outlets, the as-built grading of the site for all ponds, and as-built details of the outlet structure including the sizes and elevations of all orifices and weirs that may convey water out of the facility. Record drawings shall also document locations and elevations of underground utilities. Record drawings shall identify any other conditions that vary from the approved plans and specifications, or any other information requested by the Town Engineer.

Detention and water quality facilities shall be surveyed, added to the record drawings, and stamped by the engineer certifying the facilities are in compliance with the design.

Underground utilities shall be surveyed and added to the record drawings submitted by surveying surface utility locates, manholes, valves, inlets, hydrants, junction boxes, and other exposed features. Survey of underground facilities prior to backfill may be required at critical locations.

8.8 FINAL ACCEPTANCE

Final acceptance requires the following at a minimum:

1. Final Acceptance Inspection Request – The permit holder shall request a final acceptance inspection in writing within 45 days of the expiration of the warranty period.
2. Final Acceptance Inspection and Punch List – The Engineering Division shall inspect all public improvements for the project and shall compile a written final punch list of items requiring repair or replacement and any defective or unsatisfactory conditions resulting from materials or workmanship that are defective, inferior, or not in accordance with project plans and specifications.
3. Re-Inspection – If repair or replacement of public infrastructure is required, the permit holder shall complete such repair or replacement within 30 calendar days. Once completed, the permit holder shall contact the Engineering Division for re-inspection.
4. Notice of Final Acceptance – Once all punch list items are completed to the satisfaction of the Engineering Division, and after the record drawings have been submitted and accepted by the Town Engineer, the Town Engineer shall issue a written notice of final acceptance of improvements and shall release warranty surety.
5. Warranty Surety – If the permit holder fails to complete the punch list items satisfactorily within 30 calendar days, the Engineering Division may utilize the warranty surety to complete the punch list items. The Engineering Division may also withhold additional permit approval or certificates of occupancy.

CHAPTER 9
CONSTRUCTION SPECIFICATIONS

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LIST OF ATTACHMENTS – APPENDIX H

9.1 PURPOSE

This chapter of the Engineering Standards establishes the construction specifications that shall be used within the Town for various categories of construction. These specifications shall be used for all public projects in the Town, as well as all private projects constructing public infrastructure to be owned by the Town. Construction specifications are not design standards. Construction specifications, also known as construction standards, include items such as materials requirements, construction procedures and tolerances, ~~and~~ required testing and performance metrics. ~~The Town expects to update this chapter and the attachments over time as the unique goals and values of the Town and local physical conditions dictate.~~ Project special specifications may be submitted by the developer for unique or project-specific conditions. The Town Engineer may also require additional specifications for different projects.

9.2 TOWN CONSTRUCTION SPECIFICATIONS

The most recent edition of the documents included in Table 9.1 are hereby adopted by reference as the Town of Breckenridge Construction Specifications, except as specifically amended by the provisions of this chapter, for the types of construction shown in Table 9.1.

Where the Town of Breckenridge Construction Specifications in Table 9.1 do not include a specification required for the type of construction listed, the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction shall apply.

The documents in Table 9.1 shall apply unless they are superseded by revisions or replacements the Town develops included herein. The most recent revision of each document listed in Table 9.1 shall be used. Each user of these Engineering Standards is encouraged to review this chapter frequently as it may be updated regularly.

Where two different construction specifications overlap or conflict, the more stringent specification shall apply. Consult with the engineering division for any conflicts or inconsistencies between different specifications.

Table 9.1. Town Construction Specifications by Type of Construction

Type of Construction	Town Construction Specifications
Water Line	Town of Breckenridge Water Construction Standards
Sanitary Sewer	Upper Blue Sanitation District Construction Standards
Open Channels	Mile High Flood District (MHFD) Construction Specifications (Division 3 – 33)
Vegetation	Mile High Flood District (MHFD) Construction Specifications (Division 3 – 33) Appendix H of these Standards (Seed Mixes)
Residential Building	Title 8 of Town Code
Commercial Building	Title 8 of Town Code
Industrial Facility	Title 8 of Town Code
Streets	CDOT Standard Specifications for Road and Bridge Construction

9.3 REVISIONS AND REPLACEMENTS OF CONSTRUCTION SPECIFICATIONS

To reflect the Town's unique goals and values or address local physical conditions, the Town may choose to amend, revise, or replace some or all of any of the Town Construction Specifications included in Table 9.1 per the sections below.

9.3.1 Town of Breckenridge Water Construction Standards

Retain all sections.

9.3.2 Upper Blue Sanitation District Construction Standards

Retain all sections.

9.3.3 MHFD Construction Specifications (Divisions 3 – 33)

Retain all sections.

9.3.4 Title 8 of Town Code

Retain all sections.

9.3.5 CDOT Standard Specification for Road and Bridge Construction

Revisions and replacements of the CDOT Standard Specification for Road and Bridge Construction are included in Appendix H~~I~~.

9.4 TOWN STANDARD DETAILS

The Town uses the standard construction details listed in Table 9.3. It is anticipated this list will be updated as new standard details are developed. The Town's standard details are included as attachments to this chapter.

Table 9.3. Town Standard Details

Detail	Title	Number of Pages
Drawing 1	Transit Turnouts	1
Drawing 2	Cul-De-Sac	1
Drawing 3	Driveway Details	3
Drawing 4	Curb, Gutter, Sidewalk, and Pavement Details	5
Drawing 5	Curb Ramp Details	26
Drawing 6	Asphalt Details	2
Drawing 7	Utility Trench Details	3
Drawing 8	Lighting Details	7
Drawing 9	Typical Roadway Sections	4

CHECKLIST 7
BUILDING PERMIT (WITHOUT INFRASTRUCTURE PERMIT) REQUIREMENTS

This is the checklist of items to be submitted to the Engineering Division for building permit applications without an associated infrastructure permit. Refer to the Town Code for other Town Division submittal requirements.

All applicable items shall be included with the submittal. The table below may not contain all information necessary for a project, and the Town Engineer may require additional information. Any items not applicable shall be specified and justified in the comments section at the bottom of the checklist.

Building permit applications shall be obtained and submitted through the Town of Breckenridge Building Department. Town of Breckenridge Community Development Department and Building Department shall be contacted for a list of their submittal requirements.

For questions about these requirements or to schedule a meeting, please email the Town of Breckenridge Engineering Division at engineeringinspection@townofbreckenridge.com

Project Name:___________________________________

Project Address:_________________________________

Submittal (circle one): Preliminary Final

Provided	Not Applicable	Plan Items	Office use
		General Formatting (all plan sheets)	
		Project title in which project is to be filed	
		Date of drawing preparation & revisions	
		North arrow & drawing scale	
		Site Plan	
		Plat Compliance	
		Legal description of property & physical street address. Legal description may be found through the Summit County online GIS parcel query tool	
		Existing & proposed property lines	
		Existing & proposed right-of-way & dimensions	
		Existing & proposed easements & dimensions	
		Temporary & permanent survey monuments	
		Building footprint (show foundations & roof eaves), envelope, & building setbacks	
		Utilities	
		Existing & Proposed Utilities. Show existing & proposed location of all utilities & connections including all boxes, poles, structures, & utility alignments for electric, gas, cable, telephone, fiber, sewer, & water. Utility structures shall be in easements	
		Wetlands, Floodplains, & other Hazard Areas	

Provided	Not Applicable	Plan Items	Office use
		Wetland boundaries & 25’ wetland setback boundaries	
		100-year floodplain & other flood hazard area boundaries	
		25’ setback boundaries from top of stream banks, lakes, & other water bodies	
		Protective Management Area (PMA) limits & other special protective or hazard areas	
		Identification of areas with slope stability concerns	
		Identification of areas with geotechnical, environmental, archaeological, or historical significance	
		Identification of any hazardous concerns	
		Grading & Drainage	
		Existing topography (1-foot contours) prepared by a registered surveyor	
		Proposed Topography (1-foot contours showing finished grade)	
		Maximum 2:1 slope allowed on all finished grading (3:1 preferred)	
		Retaining wall heights & locations (retaining walls > 4 feet in height require design by Colorado licensed Professional Engineer)	
		Culvert locations, material, & dimensions. (18” minimum diameter & 1% minimum slope for culverts in ROW)	
		Foundation drain locations & daylight	
		Drywell location (10’ minimum from building) and detail. See drywell fact sheet in Chapter 6 for additional requirements & guidance.	
		Proposed outfall locations of developed drainage, drainage arrows, & swale locations	
		Positive drainage shown around building	
		Detention & permanent water quality features shown (if required)	
		CDPHE Stormwater Discharge Permit (for projects resulting in at least one acre of disturbance)	
		Driveway & Parking	
		Maximum 8% grade at any point along centerline of driveway alignment	
		Maximum 4% grade for first 20’ from roadway intersection	
		Match cross slope of roadway for first 5’ of driveway from roadway intersection	
		Driveways dimensions meet requirements of Chapter 5 (12’ min width & 20’ max width for SFH)	
		Sidewalk driveway cut meets Town standard detail	
		Driveway intersections roadway at 90 degrees	
		Driveway surface & section dimensions shown	
		One driveway access allowed (no duplicate or circular driveway cuts)	
		Minimum driveway separation met from neighboring driveway (30’ min for SFH)	

Provided	Not Applicable	Plan Items	Office use
		Snow storage areas shown (see Town Code for snow storage requirements)	
		Parking spaces & vehicle turnaround areas shown (see Town Code for parking requirements). Vehicles able to turnaround/back out of garage	
		Minimum Sight Distance for driveway access (200' min)	
		Easement submitted for shared driveway access with neighboring property	
		Landscaping	
		Landscaping plan shall be submitted in accordance with requirements in Town Code	
		Landscaping in snow storage easements shall not obstruct ability to stack snow	
		Landscaping not located in ROW	
		Landscaping located in easements meets requirements of Chapter 3	
		ROW	
		No retaining walls, boulders, stone headwalls, or small rock located in ROW	
		No address monuments or mail boxes in ROW	
		Snowmelt system in or near ROW meets requirements of Chapter 5	
		No fences, private lighting, trees, landscaping, signage, or any other structures shown in ROW without Engineering approval & encroachment license submitted	
		Other	
		Existing & proposed sidewalks, trails, street lights, signage, & any other structures or significant features shown on plans	
		Construction details as required for construction of improvements	
		Construction Management Plan	
		Construction Stormwater Management (wattles, silt fence, tracking pads, etc.)	
		Construction Stormwater BMP Details (wattles, silt fence, etc.)	
		Revegetation notes or other final stabilization plans	
		Construction fencing location	
		Material & equipment staging locations	
		Dumpster & portalet locations	
		Vehicle parking locations & construction access location	
		Other Submittals	
		Soils report & other site reports	
		Floodplain Development Permit	
		Encroachment License Agreement (required for any permanent improvements proposed within Town ROW)	

Provided	Not Applicable	Plan Items	Office use
		Town Right of Way Permit (required for any roadway cuts or temporary encroachments into Town ROW)	
		CDOT Special Use Permit (required for any work with State Highway 9)	
		Other permits, reports, or submittals	
Comments and justification for any items listed above not submitted:			

Applicant Signature:_______________________________ Date:_______________________

Application ID Number: ____________

TOWN OF BRECKENRIDGE
INFRASTRUCTURE PERMIT APPLICATION

This application form shall be filled out and submitted to the Engineering Division before an Infrastructure Permit will be issued.

Project Name: ___________________________________ Development Permit #:___________________

Property Owner: ____

Applicant/Agent (If different than Owner):____

Mailing Address:_______________________________________ Phone Number:____________________

Email Address:____

Street Address of Property:____

Legal Description of Property:____

Project Description:

Approximate area of disturbance: ________________

Will there be development or grading in a floodplain? Yes___ No___

Will there be work within a Town Right-of-Way? Yes___ No___

Will there be work within CDOT Right-of-Way? Yes___ No___

Will there be wetlands disturbance? Yes___ No___

Will there be utility work? If yes, describe utility types, approximate lengths, and if there is a planned connection to the Town of Breckenridge water or storm sewer system:

____

____

____

Is stormwater detention required? Yes___ No___

Is permanent water quality required? Yes___ No____

Anticipated construction start date: ____

Is preconstruction meeting scheduled with the Engineering Division? Yes___ No____

Anticipated length of construction: ____

The applicable items in the table below must be included with the Infrastructure Permit application. Failure to do so will result in denial of the Infrastructure Permit and a requirement to resubmit. Any items not applicable to the project shall be noted and justified below. Additional details on the requirements of the Infrastructure Permit are in Chapter 2.

Provided	Not Applicable	Infrastructure Permit Items	Office use
		Infrastructure Permit application form	
		Completed a~~A~~pplicable checklists 1 – 6 for various submittals	
		Final civil construction drawings	
		Technical specifications	
		Final Drainage Report	
		Final Traffic Impact Study	
		Method of Handling Traffic (MHT) or Traffic Control Plan (TCP)	
		Stormwater Management Plan (SWMP) and/or CSMP	
		Development Permit	
		Building Permit	
		Right-of-Way Permit	
		Floodplain Development Permit	
		CDPHE Stormwater Construction Permit	
		ACOE, CDOT, Summit County, or other permits as applicable	
		Subsurface Utility Engineering documentation	
		Permanent Survey Monumentation documentation	

List of submittal items not applicable to project and justification for non-applicability:

The undersigned certifies that the information provided is correct and that this application does not authorize work until an infrastructure permit is granted. The undersigned further certifies that s/he will comply with all inspections and acceptance procedures in the Town's Engineering Standards:

Applicant Signature:_________________________________Date:_______________________

Permit Status: Granted ___________ Denied _____________
Reason for denial:____
Staff Signature: _____________________________ Title: _____________________________________
Printed Name: _________________________________ Date: __________________________________

TOWN OF BRECKENRIDGE

FACT SHEET
SUBSURFACE INFILTRATION FACILITIES

1.0 Definition

This fact sheet provides design standards for drywells, infiltration trenches, infiltration galleries, and other subsurface infiltration structures used for permanent stormwater treatment facilities in areas with natural high infiltration rates. These types of subgrade infiltration facilities will collectively be known as drywells by this document. Drywells provide either stormwater quality treatment or stormwater detention by collecting surface stormwater runoff, temporarily storing it underground, and then discharging it primarily through infiltration into the surrounding soils. Drywells vary in form and include underground concrete structures, trenches or other excavations filled with granular material.

2.0 Purpose

The purpose of drywells is to provide stormwater quality treatment or stormwater detention through temporary subsurface storage and subsequent infiltration into surrounding soils. Drywells are typically selected for single family homes, small or constrained sites, and steep sites. On sites where space and topography permits, above ground detention and water quality facilities are preferred over drywells for ease of inspection and maintenance.

3.0 Drywell Advantages

1. Utilize the typically highly permeable soils in Breckenridge to provide groundwater recharge
2. Meet the stormwater detention and permanent water quality requirements of Chapter 6
3. Filter contaminants through filtration
4. Utilize site area efficiently
5. Provide environmental benefits by augmenting low flows in streams and reducing the thermal impacts of above ground detention facilities

4.0 Drywell Disadvantages

1. Susceptible to clogging and reduced infiltration rates
2. Difficult to inspect and maintain, increasing the potential for clogging or reduced performance
3. Risk being neglected because they are not readily visible, reducing maintenance frequency
4. Create potential for groundwater contamination issues
5. Require pretreatment to reduce high sediment loads quickly reducing infiltration capacity

5.0 Site Suitability

Drywells are not suitable for all sites where they may have negative impacts to other structures and properties. Drywells will not meet the requirements of Chapter 6 or function adequately for their full life cycle unless the site and the drywell meet certain requirements. Drywells and sites must meet the following criteria to be allowable as detention or stormwater treatment facilities:

1. Area draining to the drywell must be less than one acre.
2. A pretreatment facility is required upstream of the drywell.
3. Existing soils must be hydrological group A or B and infiltration must be at least 1 inch per hour as tested at the proposed elevation of the bottom of the drywell.

4. Drywells must be located at least 10 feet from building foundations or other structures, at least 10 feet from water lines and at least 100 feet from water source wells.
5. Drywells must be located at least 300 feet from an active waterway.
6. Drywells must be located a sufficient distance (at least 25 feet) from wetlands and other sensitive areas to prevent harmful effects.
7. Runoff draining to the drywell must not be contaminated with pollutants other than sediment. Runoff exposed to other pollutants such as oils, fuels, detergents, industrial or agricultural chemicals, etc. may not drain to a drywell.
8. Bottom of drywell shall be at least 3 feet above the seasonally high groundwater as measured by a geotechnical investigation.

6.0 Design

The following design guidelines are typical standards required for drywell design. Special site conditions may lead to additional requirements as determined by the Town Engineer. Each drywell design~~, except those used for an individual single family home site, ~~shall be designed and stamped by a Colorado Licensed Professional Engineer. ~~Drywells for an individual single family home, which primarily receive runoff from foundation and roof drains, are exempted from several of the requirements below. ~~Drywells serving multiple single family homes are not exempt from the requirements.

7.0 Infiltration Test

Testing shall be conducted by a geotechnical engineer on the site to determine infiltration rates and soil types at the location and depth of the proposed drywells. Infiltration tests shall be conducted at a minimum of every 75 feet for infiltration trenches. The lowest infiltration rate shall be used for design. Drywells for single family home sites may be exempt from an infiltration test; however, soils shall be analyzed from soils reports and other sources to evaluate their suitability to infiltrate runoff. Single family homes may be exempted from the infiltration test requirement if the drywell only receives water from roof drainage and foundation drains.

8.0 Pretreatment

Drywells cannot receive stormwater that has not been pretreated, unless the only source of the stormwater is roof runoff and/or foundation drainage. Pretreatment is required to allow coarse sediment and trash to settle out and prevent premature clogging and failure of drywell. Examples of pretreatment include forebays, concrete manholes with BMP snout and bioskirt, sediment basins, and vegetated buffer strips. Single family home sites are exempt from pretreatment. Single family homes are exempted from the pretreatment requirement if the drywell only receives water from roof drainage and foundation drains.

9.0 Depth and Location

Drywells shall be located at least 10 feet from building foundations and 100 feet from water wells. The bottom of each drywell shall be at least 9 feet below the surface or extend to clean cobble rock without fines (minimum rock size greater than 2 inches in diameter) ~~-~~to prevent freezing during winter.

10.0 Design Details

Drywells designs vary widely and include concrete manholes without a bottom and drain holes in the walls, excavated pits backfilled with clean rock, linear trenches backfilled with clean rock, and underground perforated pipes surrounded by a clean aggregate layer. An engineered drywell detail shall be designed and submitted for all installations, including single family homes. Below is a list of design considerations for various drywells:

1. Drywells in areas receiving vehicular traffic shall be HS-20 rated.
2. Drywell manholes shall have 24-inch inlet grates. If grates are located near a roadway or pedestrian area, the grate shall meet AASHTO bicycle and ADA guidelines.
3. Drywell manholes shall be backfilled outside the structure with 1.5-inch to 3-inch crushed and washed stone with a minimum of 40% porosity for a minimum distance of 18 inches.
4. Drywell manholes shall contain perforations with a 1-inch minimum diameter and shall not have a bottom.
5. Trenches shall be backfilled with 1.5-inch to 3-inch crushed and washed stone with a minimum of 40% porosity.
6. Trenches may have filter fabric installed 12 inches below surface to assist with maintenance.
7. Filter fabric shall not be installed at the bottom of drywells.
8. A 6-inch to 12-inch sand layer shall be installed under the bottom of drywells if infiltration rates exceed 4 inches per hour or if the drywell is installed near a sensitive area, such as wetlands, the Blue River, perennial streams, or Cucumber Gulch PMA.
9. Overflow outlets are required to convey flows that exceed the capacity of the drywell. Overflow outlets shall convey runoff to a swale or storm sewer and shall be designed to prevent erosion and damage to neighboring properties.

11.0 Volume

The appropriate WQCV or detention volume shall be calculated using the guidance in Chapter 6. A factory of safety of 1.5 shall be applied to the calculated volume to account for clogging and reductions in the infiltration rate. Drywells shall be designed to infiltrate the entire design volume within 72 hours.

12.0 Maintenance

An Operations and Maintenance Plan (O&M Plan) shall be submitted that meets the requirements of Chapter 6. Minimum requirements include:

- Drywells shall not be placed in service until construction is complete and revegetation of the site is established.
- Drywells shall be inspected and maintained annually for sediment and debris.
- Drywells shall be inspected after storms exceeding 1 inch to ensure it is functioning properly and that no water is ponding above the drywell.
- Pretreatment facilities shall be inspected twice annually and sediment and debris shall be removed.
- If a drywell clogs or fails, complete rehabilitation is required to restore storage capacity and infiltration rates.

TOWN OF BRECKENRIDGE, COLORADO
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION
ROAD AND BRIDGE CONSTRUCTION SPECIFICATIONS

GENERAL STATEMENT

Sections 100 through 717 of the Standard Specifications for Road and Bridge Construction, 2022 edition, or most recent version, published by the Colorado Department of Transportation (CDOT), State of Colorado, supplemented or amended by the State and by these specifications, shall govern all road and bridge construction work within Town jurisdiction or ownership. In cases of conflict between the CDOT specifications and other specifications, the supplements and amendments listed below or in the project Special Provisions shall govern. The Special Provisions (if any) contained in the Bid Documents shall have precedence over all other specifications.

When a reference is made to ASTM, AWWA, AASHTO, or other specifications or methods, it shall be understood to mean the latest edition or revision of said specification as amended and issued at the time of the Invitation to Bid.

The Method of Measurement and Basis of Payment for the items of work specified herein and in the CDOT specifications apply only to Town of Breckenridge projects and are not required to be used on projects which are administered and paid for by private developers or other agencies. References to the Town of Breckenridge General Conditions apply only to Town of Breckenridge projects are not required to be used on private development projects.

The Method of Measurement and Basis of Payment will be based on CDOT specification except where modified in these Documents.

The current CDOT Standard Specifications for Road and Bridge Construction can be accessed here:

https://www.codot.gov/business/designsupport/cdot-construction-specifications/2022-construction-specifications/2022-specs-book/2022-standard-specifications-book

STANDARD SPECIAL PROVISIONS

All CDOT Standard Special Provisions published at the time of construction commencement shall apply and be included as part of these specifications.

PROJECT SPECIAL PROVISIONS

The following Project Special Provisions apply to this project and shall take precedence over specifications or plans and supplement or amend the CDOT Standard Specifications and the Town modifications listed below:

DIVISION 100
GENERAL PROVISIONS

SECTION 101: DEFINITION AND TERMS

Retain Section 101 and add the following:

Where Department, Department of Transportation, CDOT or any other reference to the Colorado Department of Transportation is used within these Specifications, replace with “Town”. Any reference to CDOT engineer, personnel, or form shall be replaced with the appropriate Town engineer, personnel, or form. Town Engineer refers to the Town of Breckenridge Town Engineer or Town Engineering Representative selected by the Town Engineer. Where these Specifications reference Section 100, replace with “Town of Breckenridge General Contract Conditions.”

101.01 Abbreviations. Add the following abbreviations:

CAPA	Colorado Asphalt Pavement Association
HMA	Hot Mix Asphalt
SSFRB	Town of Breckenridge Standard Specifications for Road and Bridge Construction (latest edition)
TEDS	Transportation Engineering Design Standards (latest edition)
QAT	Quality Assurance Technician

101.02 Definitions, alphabetically

ADD or REVISE Definitions as Follows:

Award. REPLACE “Department” WITH “Town”.

Bidder. In the CDOT definition REPLACE “Department” WITH “Town”’.

CDOT Resident Engineer. DELETE in its entirety and REPLACE WITH: “Town Engineer”.

Contract. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Contract Modification Order. DELETE in its entirety. See “change order” definition in the *Town General Contract Conditions*.

Contract Time. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Contractor. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Department. REVISE to read: “Department of Public Works, Town of Breckenridge, Colorado.”

Engineer. DELETE in its entirety and REPLACE WITH “The Project Engineer, who may be a Town employee or hired consultant who has been appointed or authorized by the Town to oversee the technical aspects of the work and to administer the Contract on behalf of the Town. The term “Engineer” may also apply to a Professional Engineer hired by a developer to design and/or administer the construction of public infrastructure in accordance with a development approved by or contracted for/or with the Town.”

Force Account Work. REVISE to read: “Work paid for on the basis of actual costs plus approved additives, in accordance with the General Contract Conditions.”

Laboratory. REVISE to read: “Any testing laboratory designated by the Engineer.”

Planned Force Account. DELETE in its entirety.

Plans. REPLACE “Department” WITH “Town”.

Pre-construction Conference. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Project. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Project Engineer. REPLACE “Chief Engineer’s” WITH “Town’s”. REPLACE “CDOT” WITH “Town”. REPLACE “Resident” with “Town.”

Proposal Form. REVISE to read: “The documents furnished by the Town on which the offer of a bidder is submitted. Also called Bid Proposal or Bid Form.”

Proposal Guaranty. REVISE to read: “Bid guaranty as defined in the *Town General Contract Conditions.”*

Region Transportation Director. DELETE in its entirety.

Shop Drawings. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Specifications. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

State. DELETE and replace with Town of Breckenridge acting through its authorized representative.

Supplemental Specifications. DELETE in its entirety. See definition of Supplementary Conditions in the *Town General Contract Conditions*.

TOWN. Town of Breckenridge, Colorado.

Work. DELETE in its entirety. See definition in the *Town General Contract Conditions*.

Workplace Violence. REPLACE “CDOT” WITH “Town”.

SECTION 102: BIDDING REQUIRMENETS AND CONDITIONS

Retain Section 102.03

DELETE and REPLACE remainder of Section 102 with the Town of Breckenridge, General Contract Conditions.

SECTION 103: AWARD AND EXECUTION OF CONTRACT

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 104: SCOPE OF WORK

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 105: CONTROL OF WORK

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 106: CONTROL OF MATERIAL

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 107: LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 108: PROSECUTION AND PROGRESS

DELETE and REPLACE with the Town of Breckenridge, General Contract Conditions.

SECTION 109: MEASUREMENT AND PAYMENT

109.01 RETAIN and ADD: "Measurement and payment shall be made per the contract and technical specifications. The contractor shall be responsible, in the presence of the Owner, or Owner's representative, for verifying all measurements and quantities required for payment by the unit price method. Contractor shall provide necessary equipment, workers, and survey personnel as required for measurements.

Payment shall not be made for defective work and rejected work.

Items paid by Lump Sum shall not be measured. Unit price shall include all costs to complete all work shown in plans, regardless of whether all items are written in work description.

Quantities stated in the contract are estimated quantities only and it is understood the actual quantities in the field may vary from those estimated. Actual quantities will be measured in the field, unless specified otherwise in the bid item descriptions. Work required in this section includes all expenses to complete the individual bid items per the plans and specifications. Unit bid prices, as quoted in the bid schedule, shall constitute full compensation for materials, labor, equipment, rentals, permits, overhead, profit, incidentals, risk, loss, damage, and all other items of work and expense required for the complete construction of each pay item per the plans and specifications. Any items or like item not specifically mentioned as a bid item is considered incidental to the project and all costs associated with these items must be included in the bid items listed."

DELETE and REPLACE remainder of Section 109 with the Town of Breckenridge, General Contract Conditions.

DIVISION 200

EARTHWORK

SECTION 201: CLEARING AND GRUBBING

201.02 DELETE the first paragraph of 201.02 and replace with “The Contractor shall meet with Town Representative and designate all trees, shrubs, and plants to be removed. Every object not designated for removal shall be protected by Contractor. Any object not designated for removal that is damaged shall be repaired or replaced as directed at the Contractor’s expense.”

ADD: “Trees designated to be cleared, removed or limbed shall be the property of the Contractor.

As the property of the Contractor, all cleared stumps, roots, willows, shrubs, and limbs shall be disposed of by the Contractor.

Hand grubbing may be required in roadway sections to ensure that no organic materials will be present in the road section.

Any tree, shrub, or other object that is designated to remain and is damaged shall be repaired or replaced as directed by the Town Engineer, at the Contractor’s expense. All surface objects, trees, stumps, roots, and other protruding obstructions not designated to remain shall be cleared and grubbed, including mowing, as required. Undisturbed stumps, roots, and nonperishable solid objects located two feet or more below subgrade or embankment slope may remain in place. Except in areas to be excavated, all holes resulting from the removal of obstructions shall be backfilled with suitable material and compacted. No material or debris shall be disposed of within the project limits. Branches or shrubs shall be removed as directed. All trimming shall be done in accordance with good tree surgery practices, and Town of Breckenridge direction.”

SECTION 202: REMOVAL OF STRUCTURES AND OBSTRUCTIONS

202.02 ADD: “Excess material generated by the installation of the drains, sewers and water mains shall be removed and disposed of by the Contractor. Final grade at the trenches shall match subgrade of the road reconstruction.” This work shall be incidental of paying for installation services.

202.03 ADD: Any salvable material, including signs, sign poles, street light poles, luminaires, hydrants, and other materials shall be hauled and delivered by the Contractor to Town’s Public Works Yard at 1095 Airport Road. The Town Representative shall determine if materials encountered during the work are salvable and whether the Town desires to keep the material. The Town reserves the right to retain ownership of any materials encountered, including boulders, excavated material, gold, historic materials, and any other materials, artifacts, or equipment encountered.

202.07 ADD: New concrete shall match existing concrete. The vertical difference between new and existing concrete shall be less than 1/16”. The Contractor shall grind existing concrete where needed to provide a smooth transition with no vertical differences greater than 1/16”. Existing concrete shall be doweled into new concrete.

202.09 ADD: “Milling is the same operation as planing.

The designated asphalt shall be removed and disposed of by the Contractor.

Irregularities and distresses on the milled or unfinished surface, such as, but not limited to, delamination, raveling, and potholes that are identified by the Project Manager shall be repaired as soon as possible. Asphalt identified by the Town Engineer as distressed after milling shall be removed and patched as directed by the Town Engineer. Additional patching shall be paid separately. Milled surfaces shall be drivable and shall not have any vertical drops (temporary asphalt shall be tapered at edges of milled areas). Milled edges shall be clean vertical faces and may require re-milling, saw cutting, or other methods to reestablish vertical edges prior to paving.

New asphalt shall match existing asphalt. The vertical difference between new and existing asphalt shall be less than 1/16”. The contractor shall grind existing asphalt pavement where needed to provide a smooth transition with no vertical differences greater than 1/16”.”

SECTION 203: EXCAVATION AND EMBANKMENT

203.06 DELETE the first paragraph of Section 203.06 and REPLACE with the following:

“When Contractor Process Control is required, the Contractor’s Process Control Representative shall be certified with CDOT’s Excavation, Embankment, and Soil Inspection certification course.”

DELETE the third paragraph of Section 203.06 and REPLACE with the following

“Unless a thickness is otherwise specified in the Contract, the upper 3 inches of the ground surface will be considered topsoil and shall be removed in accordance with Section 207 prior to placement of embankment fill.”

203.12 DELETE Pay Item “Blading”, “Dozing”, and “Proof Rolling”. Costs of Blading, Dozing, and Proof Rolling shall not be paid separately. All costs associated this work shall be included in Unclassified Excavation and Embankment Material unit costs.

SECTION 206: EXCAVATION AND BACKFILL FOR STRUCTURES

206.06 DELETE paragraph (b) and replace with the following:

For pipes, a profile will be made along the bottom of the center line extending 18 inches beyond the end of the structure, including end sections. Material excavated between this profile and existing grade will not be measured for payment but shall be included in the pipe unit cost. Backfill placed between the pipe profile and the existing grades will not be measured for payment but shall be included in the pipe unit cost. In embankment sections, fill placed above the existing ground will be paid through the embankment unit cost.

206.07 Delete pay item “Bed Course Material” and “Filter Material”. All costs of bed course material and filter material shall be included in the unit cost of the pipe/structure.

SECTION 207: TOPSOIL

RETAIN all sections.

SECTION 208: EROSION CONTROL

208.03 ADD the following:

“The Town Engineer may combine the Environmental pre-construction conference with the project pre-construction meeting”

208.04 DELETE paragraph (c)

208.12 DELETE section in its entirety and replace with the following:

“Erosion Control items will not be paid separately but shall be paid as a Lump Sum. The Erosion Control unit cost shall include all equipment, materials, labor, and other costs to complete all erosion control shown on the plans and to comply with Town and CDPHE standards. Unit cost shall include wattles, silt fence, aggregate bags, erosion logs, vehicle tracking pads, inlet protection, concrete washouts, sweeping, and all other work required.”

SECTION 209: WATERING AND DUST PALLIATIVES

209.07 ADD the following:

“Water will be provided by the Town of Breckenridge Water Division through its bulk water station at 1095 Airport Road, Breckenridge, CO or through a hydrant near the site. If an on-site hydrant is to be used, a hydrant valve and meter shall be obtained from the Town of Breckenridge Water Division. The Contractor will be responsible for obtaining a meter and all paperwork from the Water Division. Water will be metered. Payment shall not be made separately for water.

209.08 DELETE “Water” and “Water (Landscaping)” pay items. Water will not be paid for separately but shall be included in the cost of the work.

SECTION 210: RESET STRUCTURES

210.10 ADD the following:

The Contractor shall replace all valve boxes, manholes, and other structures damaged during construction at the cost of the Contractor. Contractor shall remove and clean any debris that enters valve boxes and manholes during construction.

210.13 ADD the following:

Payment will be made under:

Pay Item	**Pay Unit**
Adjust Valve Box/ Manhole	Each

Adjustments that include adding, removing, or replacing a manhole cone or barrel section will be paid for under the Section 210 pay item, Modify Manhole.

Cleaning designated valve boxes will be paid for under the Section 202 pay item, Clean Valve Box.

ADD the following section immediately after 210.13:

210.14 Heated Pavement Systems. Heated pavement systems, also referred to as snowmelt systems, damaged or modified from construction, shall be reset and repaired by Contractor. Contractor shall place two layers of welded wire fabric, 25 psi insulation, pex tubing, expansion joint and dowels at connection to existing. Contractor shall charge the system with glycol, pressure test for 24 hours and complete all other concrete and mechanical work required. If the snowmelt system is required to be modified per the contract documents, the work will be paid under repair snowmelt system or heated pavement pay item. If the Contractor damages a snowmelt system not intended for removal, repair, or modification per the contract documents, the Contractor shall be responsible for all costs of repair. The Contractor shall be responsible for the following mechanical requirements:

1. PEX tubes shall be spliced and pressure tested for a minimum of 24 hours by a licensed mechanical contractor.
2. Pressure test shall be at least 1.5 times operating pressure and 100 psi minimum.
3. Piping and splices shall be per Town Building Code and current edition of International Mechanical Code.
4. Town Engineering and Town Building Divisions to inspect splices and pressure test.
5. Insulation and welded wire fabric to be installed beneath tubing.
6. Snowmelt system to be under pressure during placement and cure of concrete.

SECTION 212: SEEDING, FERTILIZER, SOIL CONDITIONER, AND SODDING

212.05 ADD the following at the end of paragraph (a):

"6" of approved topsoil shall be placed on the prepared ground prior to placing any sod."

212.06 ADD the following at the end of paragraph (a):

"3" minimum of approved topsoil shall be placed on the prepared ground prior to planting native grass."

SECTION 213: MULCHING

213.03 ADD the following to paragraph (e):

Wood chip mulch shall be a natural, non-stained, shredded cedar mulch. Non-plastic weed control fabric, 5 oz minimum weight, shall be installed beneath the mulch and included in the unit cost of the mulch.

SECTION 214: PLANTING

214.02 ADD the following:

After delivery of plant material, the Contractor shall contact the Engineer for approval of all plant material. The Contractor shall remove and replace rejected materials immediately from the site at their expense.

214.03 ADD the following to paragraph (a):

Installation of plant materials will not be permitted until earthwork, topsoil and adjacent site improvements are substantially complete.

ADD the following to the end of section 214.03:

No trees shall be removed from the project site until marked for removal with Town Representative. All new landscaping, including trees, shrubs, grass, perennials, and mulch, shall be marked with flags or marking paints and approved by Town Representative prior to planting.

Contractor shall implement weed control measures to prevent and remove weed growth from all disturbed areas throughout the establishment period. Weed control measures may include the following:

i. Watering topsoil prior to seeding and applying acceptable herbicides to topsoil prior to planting
ii. Installation of weed control barriers in mulch beds
iii. Application of localized herbicides to eliminate weed growth
iv. Mechanical removal of weeds

214.04 DELETE “Establishment period begins immediately and lasts a period of 12 months” and replace with:

> ”The establishment period shall be two years, or the duration of time from installation until all plant material maintains a healthy and vigorous growing condition, whichever is greater. The warranty period for plantings shall equal the establishment period.”

REPLACE paragraph (1) with the following:

(1) “Watering in Irrigated Areas. Trees and shrubs planted at all locations on the project shall be watered within four hours of planting and then daily for the first month. After the first month, trees and shrubs shall be watered twice a week until the end of the establishment period. Between the months November through April, watering is not required.”

214.06 DELETE Pay Item “Landscape Maintenance” and add the following:

Landscape maintenance and all associated costs for the establishment period per Section 214 shall be included in the tree, shrub, perennial, or other individual landscape pay item.

SECTION 215: TRANSPLANTING

RETAIN all sections.

SECTION 216: SOIL RETENTION COVERING

RETAIN all sections.

SECTION 217: HERBICIDE TREATMENT

RETAIN all sections.

SECTION 250: ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT

RETAIN all sections.

DIVISION 300

BASES

SECTION 304: AGGREGATE BASE COURSE

304.04 DELETE AND REPLACE with: “Following utility construction, base materials shall be placed to the minimum depth as shown on the plans. If the required compacted depth of the aggregate base course exceeds 6 inches, it shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed 6 inches. When vibratory or other approved types of special compacting equipment are used, the compacted depth of a single layer may be increased to 8 inches upon approval of TOB representative, provided that specified density is achieved.

SECTION 306: RECONDITIONING

RETAIN all sections.

SECTION 307: LIME TREATED SUBGRADE

307.04 DELETE and REPLACE the first sentence of the first paragraph so that it reads: “The Contractor shall construct one or more compacted courses of treated material, to the depth specified in the Contract and/or Construction Drawings.”

307.12 REPLACE Table 307-1 with the following:

Table 307-1

SCHEDULE FOR MINIMUM SAMPING AND TESTING

In Place Soil Density and Moisture Content	AASHTO T 191 ASTM D 2167	One test for each 1,000 square yards (not less than one test per day).
	AASHTO T 239 AASHTO T 238 ASTM D 2216 AASHTO T 191 and ASTM D 2216	Shall be performed every tenth nuclear method density test
Atterberg Limits	AASHTO T89 & T90	One test per 2,000 tons
Moisture-Density	AASHTO T180	One test per soil type Relationships
Gradation	AASHTO T27 and T11	One test per 2,000 tons
Thickness		One test per 5,000 square yards
Resilient Modulus	AASHTO T 294	Upon request by the Agency

SECTION 308: MECHANICAL STABILIZED SUBGRADE

DESCRIPTION

308.01 Item 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 contract drawings. Work consists of:

A. Purpose

The purpose of the work shall be to provide a stabilized paving platform section on which paving materials can be placed. 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.

MATERIALS

308.02. Definitions

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 or base material required, provide a stiff working platform for pavement construction, or combination of these.

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.

Multi-Layer Geogrid: A geogrid product consisting of multiple layers of grid which are not integrally connected throughout.

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.

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.

Minimum Average Roll Value (MARV): Value based on testing and determined in accordance with ASTM D4759-92.

True Initial Modulus in Use: The ratio of tensile strength to corresponding zero strain. The tensile strength is measured via ASTM D6637 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 D6637

Junction Strength: Breaking tensile strength of junctions when tested in accordance with GRI-GG2 as modified by AASHTO Standard Specification for

Highway Bridges, 1997 Interim, 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.

Flexural Stiffness (also known as Flexural Rigidity): Resistance to bending force measured via ASTM D1388-96, Option A, using specimen dimensions of 864 millimeters in length by 1 aperture in width. Values shown are MARVs. For multilayer 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.

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.

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 ½ inches, and less than 10% fines (passing the #200 sieve). Recycled concrete may be used as granular fill to stabilize subgrade. Recycled concrete shall have a sulfate content of less than 3000 ppm. Recycled concrete shall be mixed and placed per the contract documents or the guidance of the project geotechnical engineer.

308.03 Manufacturers. All manufacturers will be considered provided they meet the submittal process as per Item 6.6 and per Table 308.04 (All values are minimum average roll values unless a range or characteristic is indicated):

308.04 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 308.04

Table 308.04

Property	Test Method	Units	Type 1	Type 2
Aperture Stability Modulus at 20 cm-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 [2]	Mg-cm	250,000	750,000
Minimum Tensile Strength @ 2% Strain:	ASTM D6637-01 [4]			
- MD[3]		Lb/ft	280	410
- CMD[3]		Lb/ft	450	620
Minimum Tensile Strength @ 5% Strain:	ASTM D6637-01 [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 D6637 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.

B. Geotextile materials shall not be considered as an alternate to geogrid materials for subgrade improvement or base or 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.

308.05 Execution

A. Examination

The CONTRACTOR shall check the geogrid upon delivery to verify that the proper material has been received. The geogrid shall be inspected by the CONTRACTOR to be free of flaws or damage occurring during manufacturing, shipping, or handling.

308.06 Delivery, Storage, and Handling

A. Storage and Protection

Prevent excessive mud, wet concrete, epoxy, or other deleterious materials from coming in contact with and affixing to the geogrid materials.

Store at temperatures above -20 degrees F (-29 degrees C).

Rolled materials may be laid flat or stood on end.

Geogrid materials should not be left directly exposed to sunlight for a period longer than the period recommended by the manufacturer (as per ASTM D4355).

B. Preparation

The subgrade soil elevation shall be prepared at the proper elevation and alignment as directed by the engineer or as indicated on the construction drawings.

C. Installation

The geogrid shall be installed in accordance with the installation guidelines provided by the manufacturer or as directed by the engineer.

The geogrid may be temporarily secured in place with ties, staples, pins, sand bags or backfill as required by fill properties, fill placement procedures or weather conditions or as directed by the engineer.

D. Granular Fill

Compaction – Standard compaction methods may be used unless the soils are very soft. In these cases, static instead of vibratory compaction is prudent, particularly over silty subgrades. Compaction is then achieved using a light roller. Keeping fill moisture content near optimum will make compaction more efficient. Water spray is most effective with sand fill. Compact aggregate fill to project specifications, after it has been graded smooth and before it is subject to accumulated traffic.

Vehicle Operation Over Geogrids- A minimum loose fill thickness of 6 inches is required prior to operation of vehicles over the geogrid. Turning of vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid. When underlying substrate is trafficable with minimal rutting, rubber-tired equipment may pass over the geogrid reinforcement at slow speeds (less than 10 mph) when integrally-formed geogrids are used.

This shall not be allowed with coated geogrids and sharp turning movements shall be avoided.

E. Inspection

The owner or owner’s representative may randomly inspect geogrid before, during and after (using test pits) installation.

Any damaged or defective geogrid (i.e. frayed coating, separated junctions, separated layers, tears, etc.) will be repaired/replaced in accordance with Item 308.06F.

F. Repair

Any roll of geogrid damaged before, during and after installation shall be replaced by the CONTRACTOR at no additional cost to the OWNER.

Proper replacement shall consist of replacing the affected area adding 3ft (1m) of geogrid to either side of the affected area.

308.07 Submittals

A. Submittal Procedure – 30 days prior to Notice to Proceed.

1. Submit geogrid product sample approximately 4 inches by 7 inches or larger three days prior to installation.

2. Submit geogrid product data sheet, certification, and/or independent full scale laboratory testing from the manufacturer that the geogrid product supplied meets the requirements of Table 6.4-1

3. Submit manufacturer's installation instructions and general recommendations.

4. A list of 5 comparable projects that are similar in terms of size and application, within the state of Colorado, and where the results of using the specific geogrid material can be verified after a minimum of 1 year of service life.

5. Additional information as requested by the engineer to fully evaluate the product.

B. Quality Assurance

Pre-Construction Conference - Prior to the installation of the geogrid, the CONTRACTOR shall arrange a meeting at the site with the geogrid material supplier and, where applicable, the geogrid installer. The OWNER and the ENGINEER shall be notified at least 3 days in advance of the time of the meeting. A representative of the geogrid supplier shall be available on an "as needed" basis during construction.

308.08 Construction Platform Design

Construction platform design shall be performed under supervision of and signed by a Professional Engineer registered in the State of Colorado. The recommended procedure shall be derived by the Giroud-Han, Method (ASCE, August 2004).

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 Departments of Transportation and Government Agencies such as the Federal Highway Administration and Army Corps of Engineers.

For general guidance purposes only, Table 308.08-1 and 308.08-2 present a guide for estimating subgrade soil strength and minimum construction platform recommendations based on a range of subgrade strengths, respectively. 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 engineer.

Table 308.08-1

Guide for Estimating Subgrade Soil Strengths (Fine Grained Soils)

Estimate Consistency by:		Test by:				Correlates to:			
Feel	Equipment/Visual	Standard Penetration Test (blows/ft)	Dynamic Cone Penetrometer (mm/blow)			Shear Strength c_u		R Value	CBR
			SC, SM, SP	CL	CH	(kPa)	(tsf)		
Very Soft	Man standing sinks > 3"	< 2	—	—	—	< 12	< 0.125	—	< 0.4
Soft	Man walking sinks ≈ 2 - 3"	2 - 4	—	—	—	12 - 24	0.125 - 0.25	< 0.36	0.4 - 0.8
Medium	Man walking sinks ≈ 1"	4 - 8	—	> 66	—	24 - 48	0.25 - 0.50	0.36 - 2.5	0.8 - 1.6
Stiff	Pickup truck ruts ≈ 1/2 - 1"	8 - 15	> 100	66 - 46	—	48 - 96	0.50 - 1.0	2.5 - 6.8	1.6 - 3.2
Very Stiff	Loaded dump truck ruts ≈ 1 - 3"	15 - 30	100 - 56	46 - 33	> 109	96 - 193	1.0 - 2.0	6.8 - 15.5	3.2 - 6.4
Hard	Insignificant rutting by loaded dump truck	> 30	56 - 27	33 - 23	109 - 54	> 193	> 2.0	> 15.5	> 6.4

References: After Portland Cement Association, E.I. Dupont Literature and McCarthy, David F., "Essentials of Soil Mechanics and Foundations," 1977, and Tensar 1998.
Webster, Personal Communication 2001, "DCP vrs. CBR Correlations".
AASHTO, "1993 Guide for Design of Pavement Structures," Van Till et. al. NCHRP 128.

Table 308.08-2

Recommended Aggregate Fill Thickness Feel / CBR Value with Geogrid Mechanical Reinforcement				
Soil Strength [1]	CBR	Aggregate Fill Thickness (in.) [2]		
Feel	approx.	Type 1 Geogrid [3]	Type 2 Geogrid [3]	*Unreinforced*
Very Soft	< 0.4	37"	34"	52"
Soft	0.6	30"	26"	42"
Medium	1.2	20"	16"	29"
Stiff	2.5	14"	9"	22"
Very Stiff	4	12"	6"	20"

Notes:

1. Soil Strength is based in Table 308.08-1. The soil strength used is general for these purposes.

2. Results of aggregate fill thickness were derived using the published Giroud-Han (2004) Methodology. Average values for fill thickness are used. Aggregate fill was assumed to have a minimum R-value of 30.

3. Type 1 and Type 2 geogrid structural properties used were a minimum as derived from Table 308.04-1.

308.09 Payment. Payment shall be made at the contract unit price per square yard based upon plan quantities for the stabilization. The price shall be full compensation for furnishing all material and for all preparation of the subgrade, delivering, installation, and incidentals necessary to complete this item. Paving platform found deficient shall be removed and replaced. At the option of the TOWN, the pavement structural section shall be adjusted to compensate for any deficiency in the paving platform thickness and strength at the CONTRACTOR's expense as noted in Item 308.06F. Granular fill will be paid for at the contract unit price per cubic yard. Unit price will be held constant regardless of deviation from actual quantities.

308.10 Wicking Geotextile

A. Submittals. Submit the following:

1. Certification: The contractor shall provide to the Engineer a certificate stating the name of the manufacturer, product name, style number, and chemical composition of the filaments or yarns and other pertinent information to fully describe the geotextile. The Certification shall state that the furnished geotextile meets MARV requirements of the specification as evaluated under the Manufacturer's quality control program. The Certification shall be attested to by a person having legal authority to bind the Manufacturer. Certifications from Private Label distributors will not be accepted.

2. If an alternate product is submitted full scale performance testing performed by an Independent testing Town shall be completed.

3. Coefficient of Interaction (C_I) test results performed by a lab with GRI accreditation should be provided to confirm conformance to the specified value.

4. Manufacturer’s installation Guidelines shall be provided.

5. One 1’ x 1’sample shall be provided.

6. Quality Standards: The contractor shall provide to the Engineer the Manufacturer’s Quality Control Plan along with their current GAI-LAP and ISO 9001:2015 certificates.

7. Alternate products must be submitted to the Town 15 days prior to bid date and should include information on five similar projects in size and scope.

B. Quality Assurance

Manufacturer Qualifications:

1. The geotextile Manufacturer shall have all the following credentials:

   a. ISO 9001:2015 Quality Management System
   b. Geosynthetic Accreditation Institute (GAI) Laboratory Accreditation Program (LAP)

2. The geotextile Manufacturer shall have a GAI-LAP accredited laboratory at the location of production capable of performing the ASTM tests as outlined in the specification.

C. Delivery, Storage, and Handling

1. Geotextile labeling, shipment, and storage shall follow ASTM D4873. Product labels shall be color-coded to specifically identify each product and clearly show the Manufacturer’s name, style name, and roll number.

2. Each geotextile roll shall be wrapped with a material that will protect the geotextile from

damage due to shipment, water, sunlight, and contaminants.

3. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, excess temperatures, and any other environmental conditions that may damage the physical property values of the geotextile.

D. Products

1. The geotextile shall be woven from super high-tenacity polypropylene yarns in conjunction with wicking yarns with a weave pattern to maximize strength, water flow, soil interaction, wicking capabilities and soil retention. The yarns shall be from high-tenacity long-chain synthetic polymers composed of at least 95 percent by weight of polyolefins or polyamids. They shall form a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

2. Geosynthetic must be able to directionally draw water via capillary action.

3. The geotextile shall meet the requirements of Table 1. All numeric values in Table 1 except AOS represent MARV in the specified direction. Values for AOS represent maximum measured opening size.

TABLE 308.10 – SOIL STABILIZATION AND WICKING GEOTEXTILE

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Wide Width Tensile Strength	ASTM D4595	lbs/ft (kN/m)	5280 (77.0)	5280 (77.0)
Wide Width Tensile Strength @ 2% strain	ASTM D4595	lbs/ft (kN/m)	480 (7.0)	1080 (15.8)
			Maximum Opening Size	
Apparent Opening Size (AOS)	ASTM D4751	U.S. Sieve (mm)	40 (0.425)	
			Minimum Roll Value	
Permittivity	ASTM D4491	sec^{-1}	0.4	
Flow Rate	ASTM D4491	$gal/min/ft^2$ ($l/min/m^2$)	30 (1222)	
			Minimum Test Value	
Pore Size (050)	ASTM D6767	microns	85	
Pore Size (095)	ASTM D6767	microns	195	
Wet Front Movement [1] (24 minutes)	ASTM C1559[2]	inches	6.0 Vertical direction	
Wet Front Movement [1] (983 minutes) Zero Gradient	ASTM C1559[2]	inches	73.3 Horizontal direction	

[1] 'STP': Standard Temperature and Pressure, Tested Value

[2] Modified

When sewn, seams are required, refer to Manufacturer's Installation Guidelines for overlap / seam requirements.

E. Quality Control

1. Manufacturing Quality Control: Testing shall be performed at an on-site laboratoryaccredited by GAI-LAP for tests required for the geotextile, at frequency meeting or exceeding ASTM D4354.

2. Manufacturer's certifications and testing of quality assurance samples obtained using Procedure B of ASTM D4354. A lot size for conformance or quality assurance sampling shall be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.

F. Execution. See Manufacturer's Installation guidelines provided in the submittal.

SECTION 309 FULL DEPTH RECLAMATION

ADD Section 309 Full Depth Reclamation to these specifications.

ADD the following:

DESCRIPTION

309.01 This work consists of pulverizing the existing asphalt mat and mixing the pulverized asphalt mat with the existing base course, to the specified depth, and grading and compacting the mixed material in accordance with, and at locations as shown in the Contract.

CONSTRUCTION REQUIREMENTS

309.02 The Contractor shall develop a written method to maintain the centerline geometry, profile elevations, and cross slope of the existing roadway. The plan shall be submitted to the Engineer for approval a minimum of two weeks prior to starting work. The plan shall include, but is not limited to, the following:

1. Mobilization of equipment to haul and place material
2. The estimated length of roadway (both travel lanes) that can have existing pavement structure removed, embankment cut to new elevation, and placement of Aggregate Base Course material so that the difference in elevation between lanes is 1 inch or less at the end of the work shift
3. Contractor's plan to address stabilization of soft spots
4. Contractor's method to keep the road open for two-way traffic after the pavement and/or base is removed, and before or during a major precipitation event
5. Method of Handling Traffic to be used during the operation
6. Contractor's implementation of Revision of Section 104.04 - Maintaining Traffic

Reclamation of the existing asphalt pavement shall not commence until the Contractor has an approved design mix for Hot Mix Asphalt.

The existing asphalt mat shall be cut at neat lines as shown in the plans by the use of a cutting wheel attached to a blade or by another approved method. The existing asphalt mat shall be pulverized and mixed with the existing base course to a specified depth or as directed by the Engineer, with a self-propelled rotary type mixing machine. *Optimal speed for the reclaimer shall be 11.5 feet per minute, and it shall be the responsibility of the Contractor to assure the Town this rate is not exceeded.* Deviations must be made by the Engineer in the field.

The mixing machine shall make as many passes as required to uniformly mix the asphalt and existing base course to the required thickness. Mixing of the different materials shall create a homogenous mixture. The particle size of the pulverized asphalt mat shall be a minimum of 99 percent passing the 1-1/4 inch sieve. When the addition of water is necessary for initial compaction purposesit shall be added through the mixing machine with the capability to uniformly distribute water through the mixed materials.

When proper mixing has been accomplished, the mixture shall then be bladed, shaped, wetted or dried, and rolled to meet a minimum of 95 percent of the maximum wet density determined in accordance with AASHTO T-180 Method D. The soils moisture-density curve will be developed using wet densities and the percent compaction will be calculated using wet density.

The maximum depth to be compacted in one lift is 8 inches. If the depth of the reclaimed material exceeds 8 inches, the Contractor shall remove the material in excess of 8 inches and compact the material in layers not exceeding 8 inches. Thickness will be determined in the field with the Engineer at the beginning of work.

Grading equipment used to establish the final surface elevations shall have automatic controls for transverse slope. The transverse slope controls shall be capable of maintaining the final surface within 0.1 percent of the specified slope. Variations from the subgrade plane shall not be more than ¼ inch. The work shall be maintained and tested for conformance to these requirements immediately prior to placing additional pavement layers.

The minimum quantity for acceptance testing will be based on a random schedule of 1/1000 square yards of reclaimed material. Every 5,000 square yards a verification point will be tested to confirm the accuracy of the moisture-density curve.

The maximum time a portion of the roadway will be unpaved is ten (10) working days unless otherwise specified. The exposed longitudinal joint between the existing asphalt mat and the processed mat shall not remain in place for more than one day unless approved by the Engineer. When additional aggregate base course is imported and placed before processing begins, the full width of the roadway shall be completed daily. Joint construction and maintenance shall conform to subsection 401.16.

METHOD OF MEASUREMENT

309.03 Full Depth Reclamation of Hot Mix Asphalt Pavement will be measured by the square yard of roadway treated, completed and accepted.

BASIS OF PAYMENT

309.04 The accepted quantities of Full Depth Reclamation of Hot Mix Asphalt Pavement will be paid for at the contract unit price per square yard for Full Depth Reclamation of Hot Mix Asphalt Pavement, for the depth shown in the project plans. The depth shown in the plans is based on cores obtained from the existing pavement, and the Contractor should be aware that the depth will vary and, in some locations, will be either less or more than the depth range shown in the plans. The pay item shown in the plans shall be that used for the entire project, regardless of variations discovered during construction.

Pay Item		**Pay Unit**
Full Depth Reclamation of Hot Mix Asphalt Pavement	SY	Square Yard

Payment for Full Depth Reclamation of Hot Mix Asphalt Pavement will be full compensation for all work necessary to complete the item including cutting of the existing asphalt mat, pulverizing the existing asphalt mat, mixing the pulverized asphalt mat into the existing base course, moving the pulverized material and existing base course, wetting and compacting the mixed pulverized asphalt mat and base course, blading, shaping, haul, water, and maintenance of the riding surface.

DIVISION 400

PAVEMENTS

SECTION 401 PLANT MIX PAVEMENTS - GENERAL

401.07 RETAIN the first paragraph and Table 401-3. DELETE the remainder of Section 401.07 and REPLACE with the following:

"Temporary asphalt ramps shall be placed at all vertical milled edges greater than 1". The Contractor shall maintain the temporary asphalt throughout the project. Distress in milled surfaces which affects the ride, safety, or serviceability of the road shall receive a temporary asphalt layer. Asphalt shall not placed between November 1st and April 30th. When emergency work requires asphalt placement between November and April the asphalt will be considered temporary and shall be replaced the following year after May 1st."

401.08 ADD the following sentence to the end of paragraph one:

"Asphalt mixing and storage plant operations shall comply with ASTM D995 for materials storage, control, mixing, and for plant equipment and operation."

401.11 DELETE AND REPLACE with: "A tack coat shall be applied between pavement courses, at vertical edges of pavement, and at all vertical faces of concrete abutting the pavement at a rate of 0.05 to 0.15 gal/sq. yd. and paid for in accordance with Section 407. A prime coat at the subgrade shall not be required."

401.12 ADD the following: "All manholes and valve boxes shall be set to ½ inch below final grade prior to paving of streets."

401.17 Add the following to the end of paragraph one:

"After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened. Asphalt surface temperature shall be below 160 degrees.

Erect barricade to protect paving from traffic until mixture has cooled and attained its maximum degree of hardness."

DELETE all references to compaction pavement test section (CTS). ADD the following: "Compaction pavement test section not required. Unless specified by the Contract, pavement cores are only required for longitudinal joints."

401.20 DELETE and REPLACE entire section with following:

Town representative will inspect paving operations to ensure surface smoothness. On roads below 35 mph, the Town will not inspect small deviations in smoothness. On roads above or equal to 35 mph, Town will inspect smoothness using 10 foot level and measure any deviations greater than 3/16". Contractor will be required to grind deviations. If smoothness is excessively poor, the Town will require Contractor to mill and replacement pavement.

SECTION 403 HOT MIX ASPHALT

ADD the following Table

Table 403.01

Minimum Materials Sampling and Testing
for Process Control and Owners Acceptance

Test	Standard	Minimum Frequency
Sampling	AASHTO T168, ASTM D 979 and ASTM D3665	One test per day, per mix design.
Density (Nuclear Gauge)	AASHTO T 166, T 355	One test every 250 lineal feet, per lane, per mix design.
Total Thickness (Core or non destructive method	ASTM D3549 or approved non destructive method	IF requested by the **AGENCY**, not to exceed one test per day.
Gradation	AASHTO T 27, T 11	One test per day, per mix design.
Binder Content	AASHTO T 308 or other methods agreed upon between Agency and Contractor. AASHTO 308	One test per day per mix design.
Maximum Theoretical Specific Gravity (Rice)	AASHTO T 209	One test per day, per mix design.

SECTION 405 HEATING AND SCARIFYING TREATMENT

RETAIN all sections.

SECTION 406 COLD ASPHALT PAVEMENT (RECYCLE)

DELETE Section 406

SECTION 407 PRIME COAT, TACK COAT, AND REJUVINATING AGENT

RETAIN all sections.

SECTION 408 JOINT AND CRACK SEALANT

RETAIN all sections.

SECTION 409 CHIP SEAL

DELETE Section 409

SECTION 410: SLURRY SEAL

DESCRIPTION

410.01 The slurry seal shall consist of a mixture of an approved emulsified asphalt, mineral aggregate, water and specific additives, proportioned, mixed and uniformly spread over a properly prepared surface in accordance with the plans and specifications. The complete slurry seal shall leave a homogeneous mat, adhere firmly to the prepared surface, and have a friction resistant surface texture throughout its service life.

MATERIALS

410.02

A. Emulsified Asphalt

The emulsified asphalt shall conform to Grade SS-1h, CSS-1h, CQS-1h as specified in ASTM D 977, D 2397, AASHTO M 140 and M 208. The cement mixing test is waived. Each load of emulsified asphalt shall be accompanied with a Certificate of Compliance.

Table 410.02-1 Emulsified Asphalt

Test	Quality	Specification
AASHTO T59	Residue after distillation	60% Min.
AASHTO T49[1]	Penetration at 77° F (25° C)	40 to 90
AASHTO T 59	Saybolt Furol Viscosity 77° F (25° C)	15 to 90 Sec.

[1]Test on Residue

B. Aggregate

The aggregate shall be manufactured 100 percent crushed stone such as granite, slag, limestone, chert, or other high quality aggregate, or combination thereof. All aggregates shall have at least two fractured faces.

Table 410.02-2 Aggregates

Test	Quality	Specification
AASHTO T176*	Sand Equivalent	55 Min.
AASHTO T104	Soundness	15% Max. using NA2 SO4 or 25% Max. using MgSO4
AASHTO T96	Abrasion Resistance	25% Max. Grading D

* Moisture condition sample at least 24 hours prior to running the test.

When tested in accordance to AASHTO T 27 and AASHTO T 11, the aggregate gradation (including the mineral filler) shall be within the following bands. Note: Selection of Type II or Type III shall be designated by the Town and shown on the plans.

Table 410.02-3 Aggregate Gradation

Sieve Size	Percent Passing		Job Tolerance
	Type II	Type III	
1/2"	100	100	± 0
No. 4	90 to 100	70 to 90	± 4
No. 8	65 to 90	45 to 70	± 4
No. 16	45 to 70	28 to 50	± 3
No.30	30 to 50	19 to 34	± 3
No. 50	18 to 30	2 to 25	± 3
No. 100	10 to 21	7 to 18	± 3
No 200	5 to 15	5 to 15	± 2

The stockpile shall be accepted based on an average of five gradation tests according to AASHTO T 2. Note requirement of 26.2E.

C. Mineral Filler

Portland cement, hydrated lime, limestone dust, fly ash or other approved filler meeting the requirements of AASHTO M 17 or ASTM D 242 shall be used if required by the mix design. They shall be considered as part of the dry aggregate.

D. Water

The water shall be free of salts and contaminates and shall be tested and conform to AASHTO T 26. Potable water testing is not required.

E. Additives

Liquid additives may be used to accelerate or retard the break-set of the slurry seal, or improve the resulting finished surface. The use of liquid additives in the slurry mix (or individual materials) shall be made initially in quantities predetermined by the mix design with field adjustments if required, after approval by the Town.

410.03 Mix Design

The CONTRACTOR shall submit to the Town, for approval, a mix design prepared and signed by a Professional Engineer registered in the State of Colorado, performed by a laboratory who has experience in designing Emulsified Asphalt Slurry Seal Surfacing. Compatibility of the aggregate, emulsion, mineral filler, and other additives shall be verified by the mix design. The mix design shall be made with the same materials and gradation that the CONTRACTOR will provide on the project. After the mix design has been approved, no substitution will be permitted. Minimum requirements are as follows:

Table 410.03-1 Recommended Mix Properties

Test	Description	Specification
ISSA T106	Slurry Seal Consistency	--
ISSA TB-139 (for quick-set systems)	Wet Cohesion 30 minutes Min. (set) 4 hour Min. (traffic)	12 kg-cm Min. 20 kg-cm Min.
ISSA TB-139 (for quick- traffic systems)	Wet Cohesion 60 minutes Min	20 kg-cm Min.
ISSA TB-109	Excess Asphalt by LWT Sand Adhesion	50 g/ft^2 Max.
ISSA TB-114	Wet Stripping 10 minutes boiling water	Pass (90% Min.)
ISSA TB-100	Wet Track Abrasion Loss One hour soak 6-Day soak	50 gm^2 Max. 75 g/ft^2 Max.
ISSA TB-113	Mix Time	*
Residual Asphalt	6.5% to 12.0%	---
Mineral Filler	0.5% to 2.0%	

*The mixing test and set time test shall be done to anticipate the highest temperatures expected during construction. This will include 180 seconds mix time at 77° F and 70 seconds mix time minimum at 100° F.

The laboratory shall also report the quantitative effects of moisture content on the unit weight of the aggregate (bulking effect). The report must clearly show the proportions of aggregate, mineral filler (minimum and maximum), water (minimum and maximum), additive(s) (usage), and asphalt emulsion based on the dry weight of the aggregate. The report shall be sealed and signed by a Professional Engineer registered in the State of Colorado.

410.04 Equipment

A. General

All equipment, tools, and machines used in performance of this work shall be maintained in satisfactory working condition at all times to ensure a high quality product.

B. Mixing Equipment

The machine shall be specifically designed and manufactured to lay slurry seal. The material shall be mixed by a self-propelled slurry seal mixing machine of either truck mounted or continuous run design. Continuous run machines are those that are equipped to self load materials while continuing to lay slurry seal. Either type machine shall be able to accurately deliver and proportion the aggregate, emulsified asphalt, mineral filler, control setting additive, and water to a revolving mixer and discharge the mixed product on a continuous flow basis.

The machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral filler, control additive and water to maintain an adequate supply to the proportioning controls. If continuous run equipment is used, the machine shall be equipped to allow the operator to have full control of the forward and reverse speed during application of the slurry seal. It shall be equipped with a self-loading device, opposite side driver stations, and forward and reverse speed controls.

C. Proportioning Devices

Individual volume or weight controls for proportioning each material to be added to the mix (i.e. aggregate, mineral filler, emulsified asphalt and additive) shall be provided and property marked.

The proportioning devices are required to be in working order and shall be capable of determining the material output at any time.

D. Spreading Equipment

The mixture shall be spread uniformly by means of a conventional surfacing spreader box attached to the mixer and equipped to agitate and spread the material evenly throughout the box. A front seal shall be provided to ensure no loss of the mixture at the road contact point. The rear seal shall act as final strike-off and shall be adjustable. The spreader box and rear strike-off shall be so designed and operated that a uniform consistency is achieved to produce a free flow of material to the rear strike-off. The spreader box shall have suitable means provided to side shift the box to compensate for variations in the pavement geometry. A burlap drag or other approved screed may be attached to the rear of the spreader box to provide a uniform, highly textured mat. The drag pulled behind the spreader box shall not be stiffened or hardened by slurry or asphalt.

E. Auxiliary Equipment

Suitable surface preparation equipment, traffic control equipment, hand tools, power brooms, sweepers, and any other support equipment shall be provided as necessary to perform the work.

Equipment shall be approved by the TOWN. 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.

410.05 Calibration

Each mixing unit to be used in performance of the work shall be calibrated in the presence of the engineer prior to construction. Previous calibration documentation covering the exact materials to be used may be acceptable, provided they were made during the calendar year. A one-point calibration check may be required at the start of production. The documentation shall include an individual calibration of each material at various settings, which can be related to the machine's metering devices. No machine will be allowed to work on the project until the calibration has been completed and/or accepted.

A. Verification

Test strips will be made by each machine after calibration and prior to construction. Test strips shall be a portion of the project. Samples of the slurry seal will be taken and verification made as to mix consistency and proportioning. Verification of rate of application will also be made. Upon failure of any of these tests, additional test strips, at no cost to the TOWN, will be required until each

unit is authorized to work. Any unit failing to pass the tests after the third trial, will not be permitted to work on the project. Test strips must be accepted or rejected within 24 hours after application.

410.06 Weather Limitations

The slurry seal shall not be applied if either the pavement or air temperature is below 50° F and falling, but may be applied when both pavement and air temperature are above 45° F and rising. No slurry seal shall be applied when there is danger that the finished product will freeze before 24 hours. The mixture shall not be applied when weather conditions prolong opening to traffic beyond a reasonable time.

410.07 Surface Preparation

A. General

Immediately prior to applying the slurry seal the surface shall be cleared of all loose material, oil spots, vegetation, and other objectionable material. Any standard cleaning method will be acceptable. If water is used, cracks shall be allowed to dry thoroughly before slurry surfacing.

Manholes, valve boxes, drop inlets and other service entrances shall be protected form the slurry seal by a suitable method. The TOWN shall approve the surface preparation prior to surfacing.

B. Tack Coat

If a tack coat is required it should consist of one part emulsified asphalt and three parts water. The emulsified asphalt should be the same as used in the mix. The distributor shall be capable of applying the dilution evenly at a rate of 0.05 to 0.10 gallons per square yard (0.15 to 0.35 liters per square meter). The tack coat shall be allowed to cure before application of the slurry seal.

C. Joint and Crack Sealant

Joints and crack shall be sealed in accordance with the requirements in Item 23.

410.08 Application

The slurry seal mixture shall be of proper consistency at all times so as to provide the application rate required by the surface condition. The average application rate shall be 18 to 30 pounds per square yard (8.16 to 13.6 kgs/m2).

Application rates are affected by the unit weight of the aggregate, the gradation of the aggregate and the demand of the surface to which the slurry seal is being applied.

A. General

When required by local conditions, the surface shall be pre wetted by fogging ahead of the spreader box.

The rate of application of the fog spray shall be adjusted during the day to suit temperatures, surface texture, humidity, and dryness of the pavement.

The slurry seal shall be of the desired consistency upon leaving the mixer. A sufficient amount of material shall be carried in all parts of the spreader at all times so that a complete coverage is obtained. Overloading of the spreader shall be avoided.

No lumping, balling, or unmixed aggregate shall be permitted.

No streaks, such as those caused by oversized aggregate shall be left in the finished surface. If excess oversize develops, the job will be stopped until the CONTRACTOR proves to the engineer that the situation has been corrected.

Some situations may require screening the aggregate just prior to loading it into the units going from the stockpile area to the laydown operations.

410.09 Joints

No excess buildup, uncovered areas, or unsightly appearance shall be permitted on longitudinal or transverse joints. The CONTRACTOR shall provide suitable width spreading equipment to produce a minimum number of longitudinal joints throughout the project. When possible, longitudinal joints shall be placed on lane lines. Half passes and odd width passes will be used only in minimum amounts. If half passes are used, they shall not be the last pass of any paved area. A maximum of 4 inches (152 mm) shall be allowed for overlap of longitudinal lane line joints. The paper shall be used at transverse joints to ensure a straight line.

410.10 Mix Stability

The slurry seal shall possess sufficient stability so that premature breaking of the material in the spreader box does not occur. The mixture shall be homogeneous during and following mixing and spreading. It shall be free of excess water and emulsion and free of segregation of the emulsion and aggregate fines from the coarser aggregate.

Spraying of additional water into the spreader box or addition of excess water will not be permitted.

410.11 Hand Work

Areas which cannot be reached with slurry seal machines shall be surfaced using hand squeegees to provide complete and uniform coverage. The area to be hand worked shall be lightly dampened prior to mix placement and the slurry worked immediately. Care shall be exercised to leave no unsightly appearance from handwork. The same type finish as applied by the spreader box shall be required. Handwork shall be completed during machine applying process.

410.13 Lines

Care shall be taken to ensure straight lines along shoulders. No runoff on these areas will be permitted. Lines at intersections will be kept straight to provide good appearance.

410.14 Rolling

At the option of the TOWN, the roadway shall be rolled by a self propelled 10 ton pneumatic roller with a tire pressure of 50 psi (3.4 atms.) and equipped with a water spray system. The surfaced areas shall be subjected to a minimum of two full coverage passes by the roller.

Rolling should not commence until the slurry has cured enough so that it will not pick up on the tires of the roller.

410.15 Clean-up

All areas, such as manways, gutters and intersections, shall have the slurry seal removed as specified by the Town. The CONTRACTOR shall remove any debris associated with the performance of the work on a daily basis.

410.16 Tolerances

Tolerances for individual materials as well as the slurry seal mixture are as follows:

After the designed residual asphalt content is determined, a plus or minus one percentage point variation will be permitted.

The percentage of aggregate passing each sieve shall be within stockpile tolerance range as stated and within the master range of Table 26.2B-2.

The percentage of aggregate passing shall not go from the high end to the low end of the specified range of any two successive sieves.

The slurry consistency shall not vary more than +/-0.5 cm from the job mix formula after field adjustments.

The rate of application once determined by the engineer shall not vary more than +2 pounds per square yard, while remaining within the design application rate.

If any two successive tests fail on the stockpile material, the job shall be stopped. It is the responsibility of the CONTRACTOR, at his own expense, to prove to the TOWN that the conditions have been corrected. If any two successive tests on the mix from the same machine fail, the use of the machine shall be suspended. It will be the responsibility of the CONTRACTOR, at his own expense, to prove the TOWN that the problems have been corrected and that the machine is working properly.

410.17 Measurement

The area of slurry seal shall be measured by the square yard per plan quantities completed in place and accepted.

410.18 Testing and Inspection

Testing and inspection shall be performed in accordance with Table 410.18-1.

Table 410.18-1 Schedule for Minimum Slurry Seal Materials Sampling and Testing

Test Type	Test Standard	Minimum Frequency of Tests
Residue after distillation	AASHTO T 59	One test each 5,000 square yards of slurry seal
Extraction and Gradation	AASHTO T 164 AASHTO T 30	One test each 5,000 square yards of slurry seal
Application Rate		One test each 5,000 square yards of slurry seal

410.19 Payment

The slurry seal shall be measured and paid for by the contract unit price per square yard (SY). The price shall be full compensation for furnishing all materials and for preparation, mixing and applying these materials, and for all labor, equipment, tools, test design, clean-up and incidentals necessary to complete and warrant the job as specified herein.

SECTION 411 ASPHALT MATERIALS

DELETE Section 411.05 and REPLACE with the following: "Asphalt cement, emulsified asphalt, and other asphalt materials will not be paid separately but shall be included in the unit price for TONS of Hot Mix Asphalt or other appropriate mix."

SECTION 412 PORTLAND CEMENT CONCRETE PAVEMENT

412.17 REVISE as follows "Roadway smoothness will not be tested on roads with speed limits below 35 mph. On roads at or above 35 mph, Town shall use a ten foot level to measure high spots greater than 3/16". Contractor shall diamond grind areas exceeding 3/16".

412.21 DELETE and REPLACE with the following: "Pavement thickness shall be measured by Town measuring the depth prior to placement of pavement. Contractor shall assist with setting string lines, forms, and other methods to measure thickness. Cores shall not be used unless requested by the Engineer."

SECTION 420 GEOSYNTHETICS

420.02 DELETE the first sentence and replace with the following: "Geotextiles and geomembranes shall meet the applicable requirements of subsection 308."

DIVISION 500
STRUCTURES

SECTION 501 STEEL SHEET PILING

RETAIN all sections.

SECTION 502 PILING

RETAIN all sections.

SECTION 503 DRILLED SHAFTS

RETAIN all sections.

SECTION 504 WALLS

ADD the following to Section 504.01: “For stone or boulder walls, Contractor shall deliver samples of stone to the site for approval by Town. Contractor shall construct a short section of wall as a mockup for Town review and approval. If mockup does not meet requirements of contract documents, the Contractor shall removal and replace wall at their expense.”

SECTION 506 RIPRAP

RETAIN all sections.

SECTION 507 SLOPE AND DITCH PAVING

RETAIN all sections.

SECTION 508 TIMBER STRUCTURES

RETAIN all sections.

SECTION 509 STEEL STRUCTURES

RETAIN all sections.

SECTION 510 STRUCTURAL PLATE STRUCTURES

RETAIN all sections.

SECTION 512 BEARING DEVICE

RETAIN all sections.

SECTION 514 PEDESTRIAN AND BIKEWAY RAILING

RETAIN all sections.

SECTION 515 WATERPROOF MEMBRANE

RETAIN all sections.

SECTION 516 DAMPPROOFING

RETAIN all sections.

SECTION 517 WATERPROOFING

RETAIN all sections.

SECTION 518 WATERSTOPS AND EXPANSION JOINTS

RETAIN all sections.

DIVISION 600

MISCELLANEOUS CONSTRUCTION

SECTION 601 STRUCTURAL CONCRETE

ADD the following to Section 601.02: “w/cm ratio for Concrete Class B,D, and P shall be 0.38 to 0.42.

SECTION 602 REINFORCING STEEL

RETAIN all sections

SECTION 603 CULVERTS AND SEWERS

ADD the following to Section 603.01: “For any sanitary sewer work, delete Section 603 in its entirety and replace with the Upper Blue Sanitation District Sewer Standards.”

ADD the following to Section 603.13: “Structure excavation and backfill shall not be paid separately, but shall be included in the cost of the pipe.”

SECTION 604 MANHOLES, INLETS, AND METER VAULTS

RETAIN all sections

SECTION 605 SUBSURFACE DRAINS

RETAIN all sections

SECTION 606 GUARDRAIL

RETAIN all sections

SECTION 607 FENCES

RETAIN all sections

SECTION 608 SIDEWALKS AND BIKEWAYS

ADD the following to Section 608.03: “All concrete sidewalk shall be a minimum of 5” thick. Control joints shall be placed at 6’ intervals and shall be sawcut joints. Joints shall be sawcut immediately after curing. Expansion joint shall be added between new concrete sidewalk and existing concrete sidewalk”

SECTION 609 CURB AND GUTTER

RETAIN all sections

SECTION 610 MEDIAN COVER MATERIAL

RETAIN all sections

SECTION 611 CATTLE GUARDS

RETAIN all sections

SECTION 612 DELINEATORS AND REFLECTORS

RETAIN all sections

SECTION 613 LIGHTING

RETAIN all sections

SECTION 614 TRAFFIC CONTROL DEVICES

RETAIN all sections

SECTION 615 WATER CONTROL DEVICES

RETAIN all sections

SECTION 616 SIPHONS

RETAIN all sections

SECTION 618 PRESTRESSED CONCRETE

RETAIN all sections

SECTION 619 WATER LINES

DELETE and REPLACE with the following: “Water lines and appurtenances shall be constructed in accordance with the Town of Breckenridge Water Construction Standards.”

SECTION 620 FIELD FACILITIES

RETAIN all sections

SECTION 622 REST AREAS AND BUILDINGS

DELETE Section 622 in its entirety.

SECTION 623 IRRIGATION SYSTEMS

RETAIN all sections

SECTION 624 DRAINAGE PIPE

624.02 ADD “High Density Polyethylene Corrugated Pipe with Smooth Interior” to the list of pipe materials under the Plastic Heading. ADD the abbreviation as HDPE.

Table 624-1. ADD [7] to the Table: “Plastic Pipe and fittings shall be manufactured from high density polyethylene resin which shall meet or exceed the requirements of Type III, Category 4 or 5, Grade P33 or P34, Class C per ASTM D1248. HDPE storm pipe shall be ADSN-12 WT-1B (water tight or approved equal.”

SECTION 625 CONSTRUCTION SURVEYING

RETAIN all sections

SECTION 626 MOBILIZATION

RETAIN all sections

SECTION 627 PAVEMENT MARKING

RETAIN all sections

SECTION 629 SURVEY MONUMENTATION

RETAIN all sections

SECTION 630 CONSTRUCTION ZONE TRAFFIC CONTROL

ADD the following to Section 630.01:

“Construction Under Traffic

Contractor shall maintain a minimum of one lane of traffic to greatest extent possible. When one lane cannot safely be maintained, the length and duration of the full road closure shall be minimized to the extent possible and shall be approved by the Town Engineer.

Two lanes of traffic shall be reopened during evenings and weekends. Full road closures during nights and weekends shall be submitted for review and approval by Town Engineer. Access to all residences and businesses shall be maintained at all times during construction. Flaggers shall be used to assist with construction access and pedestrian traffic control.

Pedestrian traffic shall be maintained through the construction zones. Temporary curb ramps shall be installed consisting of compacted base course. Pedestrian routes shall be a minimum of 5’ wide, meet ADA requirements, and be separated from traffic by approved barriers.

Flaggers shall be used to assist with construction access and pedestrian traffic control.

The Contractor shall provide to the Town a detailed phasing plan, schedule, Traffic Control Plan and MHT for each anticipated phase of construction.

Flagging

The contractor shall provide competent certified flaggers to direct traffic when work is being done in the street ROW or intersection that is open to traffic. The Contractor shall provide a minimum of one flagger while construction activities are occurring. The flaggers will be required to direct vehicular traffic and construction vehicles. Pedestrian and vehicular traffic shall be the priority of the “minimum” required flaggers. Certified flaggers, additional to the “minimum” required, may be utilized at the Contractor’s discretion to assist with the Contractor construction activities. Flagging shall conform to the requirements of the MUTCD. The cost of the “minimum” flaggers and additional flaggers utilized by the Contractor shall be included in the unit price of the bid item, Traffic Control.

Traffic Control Supervisor (TCS)

When required by the Contract, the contractor shall provide a competent CCA or ATSSA certified Traffic Control Supervisor (TCS) on site for any set up, moving, reconfiguration, and removal of all traffic control devices required for the project. The TCS may be utilized as a flagger, and be recognized as one of the “minimum” required flaggers if the work is contained within a reasonable work zone length. The TCS shall monitor and make repairs and adjustments to the traffic control devices daily. The Traffic Control Supervisor shall conform to the requirements of the MUTCD, and will be included in the cost of the bid item, Traffic Control

Traffic Control Devices

The Contractor shall furnish, erect, and maintain all barricades, construction signing, lights, and other traffic control devices in conformity to the Manual of Uniform Traffic Control Devices for Streets and Highways and as called for in the plans and drawings. All signs and barricades to be paid for by the owner shall be in good condition and acceptable to the project engineer. All required traffic control devices, signs and flaggers shall be in place through the construction area prior to beginning and work.

The use of Type “A” low intensity warning lights shall be as shown in the contract and are incidental to the price of each barricade.

All construction signing shall be black on reflective orange and per MUTCD standards unless otherwise specified.

Maintenance

The Traffic Control Supervisor shall conduct daily inspections (three times per day minimum on working days) of all traffic control devices to ensure proper placement and condition of all signs, barricades and channelization devices, and shall log placement, inspection, maintenance, and replacement of all traffic control devices. Copies of the contractor’s daily traffic control logs shall be given to the engineer once per week.

All construction signing, barricades, channelization devices, temporary pavement markings, and other construction traffic control devices shall be kept clean, legible, visible, and in proper position at all times. Damaged traffic control devices shall be repaired or replaced immediately.

Method of Handling Traffic (MHT)

To implement the Traffic Control Plan the Contractor will prepare and submit a Method of Handling Traffic (MHT) to the Engineer for approval at least one week prior to commencement of any demolition work. The Contractor shall implement the MHT in accordance with the plans and specifications. Any variance from those plans will require the approval of the Engineer.

The MHT shall be drawn specific to each project. The MHT shall be drawn reasonably close to scale and shall show representative project landmarks, streets and salient features. The Engineer, upon request from the Contractor, will furnish to the Contractor base mapping for preparation of the MHT. An individual MHT shall be submitted for each phase of work.

The MHT shall include the following as a minimum:

1. Detailed diagrams showing the size and location of all proposed traffic control devices.
2. Access plan for all businesses.
3. Access plan for pedestrians.
4. Emergency vehicle access plan.
5. Supporting documentation as required.
6. Flagger number and locations.

The key elements of the Contractor's method of handling traffic (MHT) are outlined in subsection 630.10(a).

The components of the TCP for this project are included in Subsection 104.04 and Section 630 of the specifications.

Unless otherwise approved by the Engineer, the Contractor's equipment shall follow normal and legal traffic movements. The Contractor's ingress and egress of the work area shall be accomplished with as little disruption to traffic as possible. Traffic control devices shall be removed by picking up the devices in a reverse sequence to that used for installation. This may require moving backwards through the work zone. When located behind barrier or at other locations shown on approved traffic control plans, equipment may operate in a direction opposite to adjacent traffic.

SECTION 641 SHOTCRETE

RETAIN all sections

DIVISION 700

MATERIALS DETAILS

SECTION 701 HYDRAULIC CEMENT

Add the following to Section 701.02:

Fly ash or natural pozzolans shall conform to ASTM C618, for Class C, F, N, or AASHTO M321 for High Reactivity Pozzolans. Class C fly ash may only be used for Class 0 sulfate resistance and if the calcium oxychloride is determined to be less than 15g CaOXY/100g cementitious paste in accordance with AASHTO T 365.

SECTION 702 BITUMINOUS MATERIALS

RETAIN all sections

SECTION 703 AGGREGATES

703.07 DELETE and REPLACE Paragraph (a) as follows: "(a) Bed course material for curbing, sidewalks and bike/pedestrian paths shall be 6 inches of aggregate base course Class 6 unless otherwise approved by the Engineer."

SECTION 704 MASONRY UNITS

RETAIN all sections

SECTION 705 JOINT, WATERPROOFING AND BEARING MATERIAL

705.01 ADD the following to paragraph (a) JOINT SEALANT WITH BACKER ROD:

"The following sealants are approved for sealing concrete joints:

Sika Group - Sikaflex-1c SL

Dow Corning - Dow 890-SL

Pecora Corporation - Pecora 300 SL

Tremco incorporated - Spectrem 900-SL

Sonneborn – Sonalastic SL1

The color of the joint sealant shall match the color of the concrete unless otherwise specified or approved."

ADD the following to paragraph (b) PREFORMED JOINT FILLERS:

"Preformed joint fillers conforming to AASHTO M 153 Type IV – Polyurethane bonded recycled rubber, are approved."

SECTION 706 CONCRETE AND CLAY PIPE

RETAIN all sections

SECTION 707 METAL PIPE

RETAIN all sections

SECTION 708 PAINTS

RETAIN all sections

SECTION 709 REINFORCING STEEL AND WIRE ROPE

RETAIN all sections

SECTION 710 FENCE AND GUARDRAIL

RETAIN all sections

SECTION 711 CONCRETE CURING MATERIALS AND ADMIXTURES

711.01 ADD the following: “Liquid membrane-forming curing compound shall be a V.O.C. compliant, dissipating resin, conforming to AASHTO M-148, Type 2 for uncolored concrete or Type 1 (clear) for colored concrete. The following curing compounds are approved:

Dayton Superior - Day-Chem White Pigmented Cure (J-10-W)

Dayton Superior - White Dissipating Cure EF

Euclid – Kurez DR VOX”

711.03 ADD the following:

“**Accelerating Admixtures**: Set accelerating admixtures shall be non-chloride liquid conforming the ASTM C 494 Type C. The following accelerating admixtures are approved:

BASF Chemical Company - Pozzolith NC 534

Grace Construction Products - Daraset 200, 400 or HES

Euclid Chemical Company – Eucon NCA or Eucon ACN

Evaporation Retardants. The following evaporation retardants are approved:

BASF Chemical Company - CONFILM

Dayton Superior - Sure Film J-74

Euclid Chemical Company - EucoBar

Color Additive for Colored Concrete shall be manufactured by DAVIS Colors, 3700 East Olympic Blvd., Los Angeles, CA or an approved substitute.

SECTION 712 MISCELLANEOUS

712.13 ADD paragraph (e) and include the following:

“High Density Polyethylene Corrugated Pipe with Smooth Interior for Storm Sewers, Culverts, and Drains.

(1) ASTM F-405: Standard Specification for Corrugated Polyethylene Tubing and Fittings
(2) ASTM F-667: Large Diameter Corrugated Polyethylene Tubing
(3) AASHTO M 252-851: Standard Specifications for Corrugated Polyethylene Drainage Tubing
(4) AASHTO M 294-851: Corrugated Polyethylene Pip, 12 to 24 inch Diameter
(5) The nominal size of the pipe is based on the nominal inside diameter of the pipe.
(6) The tolerance on the specified inside diameter shall be +3%, -1.5%, or ½ inch, whichever is less. Lengths shall be no less than 99% of stated quantity.
(7) Pipe shall be joined by split corrugated couplings at least 7 corrugations wide and exceeding the soil tightness requirements of the AASHTO Standard Specification for Highwater Bridges, Section 23 (2.23.3).

(8) Pipe Stiffness

The pipe shall have a minimum pipe stiffness at 5% deflection as follows:

Diameter (inches)	Pipe Stiffness (PSI)
12	45
15	42
18	40
24	34

Tests shall be in accordance with ASTM D2412 with a minimum one diameter sample length, a loading rate of 0.5"/min., and readings at 5% deflection.

(9) Hydraulics

The pipe shall have a minimum tested Mannings "n" value of 0.012.

(10) Perforations

Where perforated pipe is specified, the perforations shall conform to the requirements of Class 1, unless otherwise specified in the order. Class 1 perforations are for pipe intended to be used for subsurface drainage or combination storm and underdrain. The perforations shall be cleanly cut so as not to restrict the inflow of water. Pipe connected by couplings or bands may be unperforated within 4 inches (100 mm) of each end of each length of pipe.

A. Class I Perforations: The perforations shall be approximately circular and shall have nominal diameters of not less than 3/16 inch (4.8 mm) nor greater than 3/8 inch (9.5 mm) and shall be arranged in rows parallel to the axis of the pipe.

   The perforations shall be located in the external valleys with perforations in each row for each corrugation. The rows of perforations shall be arranged in two equal groups placed symmetrically on either side of the lower unperforated segment corresponding to the flow line of the pipe. The spacing of the rows shall be uniform. The distance between the center lines of the rows shall not be less than 1 inch (25 mm).

(11) Retest and Rejection

If any failure to conform to these specifications occurs, the pipe or fittings may be retested to establish conformity in accordance with agreement between the purchaser and seller. Individual results, not averages, constitute failure."

SECTION 713 TRAFFIC CONTROL MEASURES

RETAIN all sections

SECTION 714 PRESTRESSED UNIT MATERIALS

RETAIN all sections

SECTION 715 LIGHTING AND ELECTRICAL MATERIALS

ADD the following to Section 715.03:

"Light poles shall meet the following requirements:

Manufacturer: Mountain States Lighting or Approved Equal

Part#: 9SRS-3.5-NO TENON-11.50" BOLT CIRCLE-BLACK or Approved Equal

Height: 9' Pole or 12' Pole (near intersections)

Base: 44" Slipover decorative base cover, Die-Cast Aluminum Alloy 356HMLC, High Strength, Copper Free, 10" Hex, 10 ¾" Point to Point, Separate Anchor Bolt Covers

Handhole: 2" x 5" Handhole opening in base of pole

Ladder Rest: 4" OD, 3.5" ID ladder rest, black finish, per Town Details

ADD the following to Section 715.04:

Luminaires and Lamps shall be one of the following per the Contract Documents:

PROV-T3-32LED-3K-700-LDL-HSS-PCA-T (Providence or Approved Equal)

F660-GX919-40-277-T2 or T5 (Newport, Welsbach, or Approved Equal)

PRMD2-72L-335-3K7-3-BLT-FTG-TRA5D-MOD 4.5" (Promenade or Approved Equal)

SECTION 716 WATER LINE MATERIALS

DELETE Section 716 in its entirety and REPLACE with the Town of Breckenridge Water Construction Standards

SECTION 717 REST AREA AND BUILDING MATERIALS

DELETE Section 717 in its entirety.