APPENDIX C:

RATIONALE FOR THE DESIGN CRITERIA AND THE PROPOSED IMPROVEMENTS FOR ALTERNATIVE 6 (THE PREFERRED ALTERNATIVE)

The information contained in this appendix provides the rationale for design criteria *as it was presented in the SDEIS.* Since the release of the SDEIS, Alternative 6, as it is presented in this FEIS, has been modified slightly (surface types and number of segments). This appendix does not reflect these minor modifications.

Determination of Design Criteria for Alternative 6 (The Preferred Alternative)

Various considerations influence the determination of design criteria for specific roadway projects. The primary considerations in roadway design are the intended function of the road (based in part on approved land management plans), the volume and type of vehicles to be accommodated, the type of terrain traversed, environmental constraints, and the desired user experience. These considerations are addressed through the selection and application of appropriate design controls and criteria. Design controls are those limiting characteristics, or situations, that the facility is intended to accommodate involving the vehicles, pedestrians, drivers, traffic, environmental conditions, etc. Design criteria are measurable values that relate to a level of performance, such as traffic volume, speed, road width, geometry, gradient, sight distance, etc. Controls and criteria are used in road design to ensure that the facility will safely and adequately accommodate the expected traffic use, and to encourage consistency of operation. The major design controls and criteria for rural roads such as the Guanella Pass Road are determined by the road's purpose, functional classification, design traffic volume, design speed, and design vehicle. Design criteria are based on established engineering practices and recent research. Highway design policies are developed through the continuing work of long-standing committees made up of the leading highway engineering professionals nationwide. For reconstruction projects, guidance is provided by *A Policy on Geometric Design of Highways and Streets, 1994,* published by the American Association of State Highway and Transportation Officials (AASHTO). For resurfacing, restoration or rehabilitation (3R) projects, guidance is provided by TRB Special Report 214, *Designing Safer Roads: Practices for Resurfacing, Restoration and Rehabilitation* and related publications. For Federally funded highway projects, Title 23 CFR Part 625 mandates that certain established design practices be used, based on the policies adopted by each State highway agency. In the case of the Guanella Pass Road, even though the road is under jurisdiction of local entities, the standards adopted by the Colorado Department of Transportation (CDOT) are applicable for any reconstruction or 3R work, and supercede the above references and publications.

The road should provide a design and environment consistent with the driving tasks required. Design consistency is recognized as critical to safety and operations, and is defined in the AASHTO publication *Highway Safety Design and Operations Guide, 1997,* as "the avoidance of abrupt changes in geometric features for contiguous highway elements and the use of design elements in combinations that meet driver expectations." Design consistency is best achieved by selecting design criteria for all critical elements (roadway width, design speed, gradient) on a corridor rather than individual location basis. Drivers' experiences with the highway, roadside, and operational features (intersections, pullouts, signs, markings) along the road are the factors that establish their expectations and influence their behavior. Consistent highway design is extremely important to drivers because through past experiences they have learned how to react to common situations. Drivers will react in a consistent manner to familiar situations; conversely, if drivers experience new situations or situations they are not expecting, their responses are delayed and can be improper or detrimental. Inconsistencies in the design of such features as highway alignment, roadway width (including shoulders), intersection layout, roadside access, and roadside hardware (such as signs, guardrail) violate driver expectations and contribute to indecision or error. Coordinating the various design elements and roadway features to the drivers' expectations and avoiding abrupt changes in the design criteria greatly supports the driving task.

Design standards represent a set of minimum numerical values (e.g. sight distance, curve radius, lane and shoulder width) that should be provided to allow a given level of performance. A comprehensive matrix of minimum design standards has been established by AASHTO and adopted by the CDOT and FHWA for various types of highways, ranging from local roads to interstate freeways, and for various types of conditions. Given the wide range of highway types and conditions, some flexibility can be exercised in the selection of the applicable design standards to be used for a particular road. For any type of highway, the design should strive for the highest practical level of performance, within economic and environmental constraints, to allow for a margin of error in the design assumptions, provide additional tolerance for unanticipated conditions, and extend the function and service life of the facility. For any given design standard, minimum numerical values have been established for the designer's use; however, safer design values (above minimum) should be provided whenever it is feasible and economical to do so considering the constraints encountered.

Summary of The Preferred Alternative Design Criteria

The cross-section elements of the proposed design criteria are illustrated in Figures II-5a, b, and c of the FEIS. The proposed roadway design criteria are:

Functional Classification:	Rural Local Road [DEIS proposal is Collector]
Travel Lanes:	2.7 m (9 feet) throughout [DEIS proposal is 3.0 meter (10 feet) for reconstruction areas and 2.7 m for rehabilitation areas]
Shoulders:	0.6 m (2 feet) [same as DEIS proposal]
Structural Section:	150 mm (6 inches) maximum thickness for rehabilitation areas and 250 mm (10 inches) maximum thickness for reconstruction areas [DEIS proposal is 50-100 mm (2-4 inches) thickness for rehabilitation areas and 250 mm thickness for reconstruction areas]
Foreslopes:	1.0 m (3 feet) for reconstruction areas, 0.6 m (2 feet) for rehabilitation areas [DEIS proposal is 1.0 m (3 feet) for both reconstruction and rehabilitation areas]
Ditches:	0.6 to 1.2 m (2 to 4 feet) past the foreslope for graded ditch, or 0.6 to 1.2 m (2 to 4 feet) past the roadway shoulder for paved ditch in reconstruction areas, and variable (no minimum) beyond foreslope in rehabilitation areas [DEIS proposal is 1.2 m (4 feet) past the foreslope for graded ditch; same for paved ditch]
Design Speed*:	Ranges from 30 km/h (19 mph) to 50 km/h (31 mph) (with exceptions at switchbacks to 20 km/h (13 mph) [DEIS proposal ranges from 40 km/h (25 mph) to 60 km/h (37 mph) (with exceptions at switchbacks to 23 km/h (14 mph)]
Switchback Radius:	12 m (40 feet) [DEIS proposal is 15 m (50 feet)]
Design Vehicle:	Class C Motorhome with 5.2 m (17 feet) wheelbase and 2.4 m (8 feet) width [DEIS proposal Standard SU Vehicle with 6.1 m (20 feet) wheelbase and 2.6 m (8.5 feet) width]

Superelevation:	6 percent maximum [same as DEIS proposal]
Crown:	2 percent [same as DEIS proposal]
Maximum Grade:	9 percent [same as DEIS proposal]
Clear Zone	2 meters (6.6 feet) [same as DEIS proposal]
Offset to Barrier or Curb:	0.6 m (2 feet) from edge of shoulder, minimum 3.9 m (13 feet) from centerline [DEIS proposal 0.6 m (2 feet) from edge of shoulder, except 0.3 m (1 foot) from edge of shoulder in "Georgetown Switchbacks" section]
Curve Widening:	Based on off-tracking of the Class C Motorhome design vehicle outside the traveled way [DEIS proposal is based on off-tracking of the SU design vehicle]

*Design speed determines horizontal and vertical curvature, and stopping sight distance.

Functional Classification

Roads are grouped for transportation planning purposes into different functional classes according to the character of service they provide. In the DEIS, the functional classification for the Guanella Pass Road was designated as a rural minor collector since it is a transportation link within each County, and one of few public roads that connect Park and Clear Creek Counties with other parts of the State. The road primarily provides access to numerous destinations within the Pike and Arapaho National Forests from US 285 and I-70. A frequent comment received on the DEIS was that the route should not become a major link or encourage through traffic, but instead should only accommodate the current pattern of use, which for the majority of traffic is to a particular destination along the road and then return the same way. Discussions with the local agencies and additional analysis by FHWA indicated that because of the current and intended use of Guanella Pass Road it is better classified as a rural local road than a rural collector road as it was in the DEIS. It is not intended to be a link between two major arterial routes (I-70 and US 285) or to carry substantial commercial traffic.

Rural local roads emphasize the land access function, as opposed to through movement. The rural local road system provides access to land adjacent to a collector network and serves travel over a relatively short distance. The rural local road system constitutes all rural roads not classified as principal arterials, minor arterials, or collector roads. The functional classification and average trip length are important considerations in selecting design speeds. The higher the functional classification and the longer the trip, the greater the desire for expeditious movement, and vice versa. The design criteria for local roads is lower than for the collector classification, and the change in functional classification allows greater flexibility in the selection of a lower design speed and a narrower roadway, which would more closely match the existing road. A caveat to this change is that the Counties and the Forest Service will need to manage the road corridor for local access, and for limited through traffic or commercial traffic. Otherwise, the lower design criteria may not be adequate for traffic operations or safety.

Design Traffic Volume

After Functional Classification, the single factor that most influences the determination of design criteria is the traffic volume, generally measured as the volume per day in both directions of travel. The current traffic volume varies along the route; the highest traffic volume is at the north end of the route near Georgetown, and the traffic volume decreases to 50 percent at the pass, and then it decreases to 25 percent south of the pass, and from there it increases toward Grant with 65 percent of the route and traffic volume. The current annual average daily traffic (AADT or ADT), averaged over the entire length of the route, is 182 and is expected to grow at a 1.5 percent annual rate even if no improvements are made. The actual future traffic that will use the facility is uncertain and the actual traffic may be increasing at a higher or lower rate than is estimated, but is likely to increase at a similar rate as the population of the greater Denver area.

Additional traffic growth is anticipated if the route is improved, depending on the extent of improvement (primarily the extent of additional paving). Under the DEIS alternatives, if the entire route were paved a 40 percent to 80 percent additional increase over the No-Action Alternative is projected. The additional traffic projected for the Preferred Alternative is 20 percent greater than for the No-Action Alternative.

A major investment in a highway facility should consider anticipated future traffic volume in order to avoid wasting time and money on improvements that soon may become inadequate or obsolete. For reconstruction projects the anticipated future traffic demand, usually based on a 20-year projection, is considered for determining design standards. For rehabilitation projects there is usually a shorter anticipated service life of the improvements, and these types of projects may be developed on the basis of a shorter design period. For the proposed Preferred Alternative, which consists of a combination of reconstruction and rehabilitation type improvements, using a 15-year to 20-year projection for design traffic volume is appropriate.

The high seasonal use of the Guanella Pass Road is also a strong consideration in the selection of appropriate design criteria. The projected seasonal average daily traffic (SADT) is listed in the DEIS (Table III-1) although it is not strictly used as the basis of design standards. The high seasonal traffic occurs from June through September and is approximately double the ADT. The weekend use accounts for over half of the total traffic, particularly the summer weekend traffic which is about 3.5 times the ADT. The design of certain elements, such as intersections, should consider the high seasonal and weekend volumes. During the high traffic volume periods, the road shoulders are anticipated to be heavily used by traffic, which will adversely affect pedestrian and bicycle use during these periods.

Design Speed

For highway design purposes, speed is associated with various terminology including legal speed, running speed, design speed and operating speed. Legal speed is the regulatory posted speed that is intended to *limit* the speeds of vehicles for safety, consistency or other reasons. Absent a legal speed, a percentage of drivers would otherwise travel the road at a faster speed. Running speed is a measure of the *observed* speeds of free-moving vehicles at various locations along the highway, and is often expressed either as the arithmetic mean (50^{th} percentile, which approximates the average), or as the 85^{th} percentile (which approximates a reasonable majority) of the observations. A design speed is a theoretically safe and highest *constant* speed that can be maintained throughout the entire length of a specified section of highway, based on the most limiting geometric feature(s) of the roadway design within that section, and absent other limiting conditions (traffic, weather, surface, regulatory, environmental). A design speed may be lower or higher than the observed running speeds, depending on the capabilities of the drivers, vehicles, roadway surface, weather, speed limitations, etc. Operating speed is a theoretically safe and highest *overall* speed that can be attained on the highway (including various sections of differing design speeds) under favorable weather conditions and under the prevailing traffic conditions.

For new construction projects or reconstruction, rehabilitation, and resurfacing (3R) projects, the design speed should meet drivers' expectation for the type and character of the highway. Where a difficult condition (terrain or other physical condition) is obvious, drivers are more apt to conform to lower speed operation than where there is no apparent need. The design speed should be consistent with the typical running speed observed for a majority (85^{th} percentile) of drivers. Once the appropriate design speed is selected, it is important to develop all of the pertinent features of the roadway in relation to the design speed to obtain a balanced design. A benefit of engineering a road utilizing a specific design speed is to provide a consistent geometry within each individual curve and between the curves. This is done by representing the roadway centerline by a series of circular arcs of various radii with interconnecting tangents (straight sections), and through the proper correlation of the superelevation (surface cross slope or banking). Superelevation influences side friction between the vehicle tires and road surface and helps counteract the centrifugal forces of vehicles in curves.

For the Guanella Pass Road, the range of design speeds for the corridor was determined primarily in an attempt to best fit and closely match the existing roadway alignment as much as possible to minimize new impacts. Other lesser considerations were to accommodate the controlling features along the corridor (steep terrain, existing access points, roadside developments, sensitive environmental areas), and accommodate an appropriate range of operating speed that is expected by the majority of drivers. The purpose and need for improvement is not to increase the overall operating speed. The range of design speed of 30 to 50 km/h (19 to 31 mph) has been proposed to best match the existing road and meet the combination of physical limitations of the terrain, current and projected traffic volumes, existing running speeds, driver expectation, safety concerns, and the existing posted speed limits. In the areas proposed for rehabilitation, the primary effect of selecting the design speed is to determine the proper superelevation rates for the resurfacing, and has little or no effect on the other design elements or the physical impacts.

In areas of the Guanella Pass Road that are proposed for reconstruction, the existing road has a number of curves that are much sharper than normal, and the running speed is much lower than the adjacent curves and the posted speed limit. The current road's horizontal alignment is very irregular and inconsistent, with numerous sharp curves intermixed with sections of relatively gentle alignment. It also has a number of sudden crests and dips in the vertical alignment, and steep uphill slopes just adjacent to the roadway around curves, which restrict the driver's ability to see oncoming conditions and react to them. The inconsistent alignment creates sudden limitations in sight distance and speed, and does not conform to driver expectations raised by the adjacent gentler sections, which adversely affects the driver's ability to respond to road conditions. Improving the consistency of the existing roadway involves a combination of softening the sharpest curves and inducing additional curvature in adjacent straighter sections, lowering of the most sudden crests and raising abrupt dips, and extending crests and dips onto adjacent sections of more uniform grade, all of which can only be accomplished by a reconstruction level of improvement. The attempt to provide more consistency is balanced with the competing need to closely match the existing road alignment and to fit other controlling features.

The proposed design speed for Alternative 6 varies along the corridor in response to changes in the terrain, existing road characteristics, and the posted speed limit, with exceptions at the difficult switchbacks. The design speeds for the DEIS alternatives resulted from additional consideration and emphasis placed on a need to address the portion of traffic that is traveling over the entire length of the corridor, consistent with a higher functional classification.

Location	**Km post**	**Design Speed for DEIS Alternatives**	**Design Speed for Alternative 6**
Grant to Falls Hill	1.0 to 8.0	50 km/h (31 mph)	40 km/h (25 mph)
Falls Hill	8.0 to 9.4	40 km/h (25 mph)	30 km/h (19 mph)
Falls Hill to Shelf Road	9.4 to 15.7	60 km/h (37 mph)	50 km/h (31 mph)
Shelf Road to Guanella Pass	15.7 to 22.1	50 km/h (31 mph)	40 km/h (25 mph)
Guanella Pass to Georgetown	22.1 to 39.2	40 km/h (25 mph)	30 km/h (19 mph)

The minimum design speed recommended by AASHTO policy in mountainous terrain is 30 km/hr (19 mph) for ADT less than 400, and 50 km/hr (31 mph) for ADT 400 to 1500. There are no established design criteria for design speeds less than 30 km/h (19 mph). The design speeds proposed for Alternative 6 are between 30 and 50 km/h (19 and 31 mph). This is 10 km/h (6 mph) less than the 40-60 km/h (25-37 mph) design speed for the DEIS build alternatives. The reduction in design speed for Alternative 6 is consistent with the determination that the road better fits a lower functional classification. The change in design speed from 40 to 30 km/hr corresponds to a reduction in the minimum centerline radius for curves from 55 m (180 feet) to 30 m (100 feet). The lower design speed allows a more curvilinear alignment in the proposed reconstruction areas that more closely follows the existing roadway by allowing more closely spaced curves and shorter tangent (straight) sections between the curves. The lower 30 km/h (19 mph) design speed is used for most of the reconstruction segments with the exception of the shelf road area and the area above Duck Lake, both of which are located in areas of fairly uniform alignment. Aside from the difficult switchbacks, there are few curves on the existing road with less than a 55 m overall radius, so this change results in some slight additional curvature of the roadway design, and will likely result in a slight decrease in operating speed in relation to the DEIS alternatives. The change in design speed also results in slight changes in the vertical alignment in relation to the DEIS alternatives. Under the Preferred Alternative, providing more closely spaced curves results in many slight adjustments in the proposed alignment in the reconstruction areas, and results in the addition of a few slight wiggles in the alignment, all of which will allow a slightly closer match with the existing roadway in numerous areas.

There is concern that the overall operating speed will increase, which could influence travelers in selecting the Guanella Pass Road as an alternate route to I-70 or US 285, and encourage additional through traffic. There is also concern that running speeds will increase, which could offset the increase in safety gained by a slightly wider roadway, easing of some of the sharpest curves, and providing additional sight distance in the reconstruction areas. There is also concern that potential higher running speeds will result in increased wildlife mortality. Research has shown that drivers' speeds and operations are largely governed by the physical characteristics of the roadway and roadsides over extended lengths of the highway alignment; specifically, by the topography, the number of curves and extent of curvature, sight distances, and frequency of roadside access points; and also by the weather, the presence of other vehicles, and the speed limitations (either legal or because of control devices). Running speeds may increase slightly as a result of a new roadway surface. The horizontal alignment (which is the primary physical constraint on operating speed) is improved in 9.2 km (5.6 miles) or 24 percent of the overall length. The running speeds for the other 76 percent (18.1 miles) of the route, for which the horizontal alignment is not changed, is not anticipated to increase as a result of these proposed horizontal alignment improvements. The surface conditions, amount of traffic, the posted speed limit, and the level of enforcement are the major factors influencing a possible change in running speed.

Ideally, the design speed should never be selected to be lower than the legal driving speed of the highway. In cases where the design speed of an existing road is less than the legal speed, a higher design speed should be utilized and the substandard elements identified and addressed. Isolated locations where substandard geometric features result in a lower theoretical safe speed than the selected design speed are called exceptions to the design speed. Isolated, reduced legal speed zones are not appropriate for addressing individual substandard features. They would violate the driver's expectations and generate disregard for the reduced legal speed zone signing. Although advance warning signs and advisory speed limits may provide a margin of safety, they may not reduce actual running speed as they are often ignored because they pose no physical constraint.

A caveat with the lower design speed is that the Counties and Georgetown will need to manage running speeds accordingly. Regulatory and warning signs will need to be installed consistent with the design speeds. Pullouts will be provided along the road corridor which can assist in enforcement of the posted speed limit.

Roadway Width

Total roadway (lane and shoulder) width is among the most important cross-section considerations in the safety of a two-lane highway. Wider lanes or shoulders normally result in fewer crashes. For low volume, low speed rural local roads the minimum width consists of 2.7 m (9 feet) travel lanes and 0.6 m (2 feet) shoulders for a total roadway width of 6.6 m (22 feet). This is the width proposed for the Preferred Alternative. This is a reduction from 7.2 m (24 feet) for the DEIS alternatives resulting from the change in functional classification from a rural collector road to a rural local road.

Research on performance of two-lane rural roads is provided in *NCHRP Report 362, Roadway Widths for Low Traffic Volume Roads*. Studies on two-lane rural roads show that inadequate vehicle clearances and edge-of-roadway clearances exist on surfaces less than 6.6 m (22 feet) wide carrying even moderate amounts of traffic. Where volume is such that meeting and passing opposing vehicles is common, an effective width of 6.0 m (20 feet) is considered inadequate. Recreational vehicles are typically 2.4 to 2.6 m (8.0 to 8.5 feet) wide, excluding mirrors, which leaves essentially no room to maneuver within a 2.7 m (9 feet) travel lane. This results in these types of vehicles continuously encroaching into either the oncoming lane or onto the shoulder. On even low-speed facilities, where there is use by recreational (or commercial) vehicles, 3.0 m (10 feet) travel lanes should be provided. The *AASHTO-Geometric Design of Highways and Streets* states: “Where there is appreciable traffic volume, roads with a narrow traveled way and narrow shoulders give poor service, have a relatively higher accident experience, and require frequent and costly maintenance.”

The shoulder on rural roads with narrow travel lanes serves as additional width to permit drivers meeting opposing vehicles to drive on the very edge of the roadway without leaving the surfacing, thus making frequent use of the shoulder itself. In addition to allowing drivers to safely deviate from the travel lane, shoulders provide a variety of other functions. Shoulders provide space to escape potential accidents or reduce their severity, provide additional space for pedestrians and bicyclists, improve sight distance in cut sections provide lateral clearance for signs and guardrails, provide structural lateral support for the surfacing and to reduce edge of surfacing breakup, provide space for maintenance operations such as snow removal and storage. Shoulders also enhance drainage by directing surface runoff and ditch drainage farther from the surfacing, and minimizing seepage adjacent to the roadway which directly reduces pavement breakup. Regardless of width, a shoulder should be continuous. The full benefits of a shoulder are not available unless there is space where a driver can deviate from the travel lane at any point.

The minimum roadway width for local roads is primarily dependent on the design traffic volume, the design speed, and the mix of vehicle size and use. For mountainous terrain such as the Guanella Pass Road, the AASHTO guidelines for lane and shoulder width change when ADT exceeds 600 and/or the design speed exceeds 60 km/h (37 mph). For design ADT less than 600 and low design speeds, the minimum travel lane is 2.7 m (9 feet) and shoulder is 0.6 m (2 feet) for a minimum total roadway width of 6.6 m (22 feet). For design ADT from 600 to 1,500 and low design speed, the minimum travel lane is 3.0 m (10 feet) and the minimum shoulder is 1.5 m (5 feet) for a minimum total roadway width of 9.0 m (30 feet). The higher ADT values would be applicable if the high seasonal traffic volume were the primary consideration and control in determining the design criteria.

Guidance for design of 3(R) projects is provided in TRB Special Report 214, *Designing Safer Roads: Practices or Resurfacing, Restoration and Rehabilitation.* The report provides minimum standards for lane and shoulder width that are suggested for Federal and State funding for 3(R) projects; however, the FS, CDOT, and FHWA have not formally adopted these standards. For two-lane rural highways with design year volume (ADT) less than 750, running speed under 50 mph, less than 10 percent trucks, and on mountainous terrain, the minimum value (lane and shoulder width) recommended is 10 feet, or 20 feet (6.1 m) total roadway width. On the Guanella Pass Road, the most typical existing roadway width for portions of the project that are considered a viable candidate for rehabilitation type work is 6.6 m (22 feet). It would not be appropriate to reduce these sections to a narrower, substandard width when it is feasible to maintain the current width with rehabilitation type construction. Publication No. FHWA-FLP-91-010, *Design Risk Analysis,* documents that the increase in accident potential resulting from narrowing a two-lane roadway by 0.3 m (1 foot) on either side is 12 percent. On 3(R) projects the design should strive to improve the roadway above absolute minimums, and to provide the highest level of safety possible within existing conditions and constraints. Under the Preferred Alternative approximately 64 percent of the route, or 24.6 km (15.3 miles), is proposed for rehabilitation type improvements to provide a 6.6 m (22 feet) roadway width. Of the remaining 36 percent proposed for reconstruction, the road is so substandard that most of this length would still require reconstruction to obtain even a 6.1 m (20 feet) roadway width. Less than 3 km (2 miles) could be simply rehabilitated to provide a 6.1 m (20 feet) roadway width, with alignment and grade close to minimal standards, surfacing foreslopes, ditches, drainage features and guardrail where needed. It would not be appropriate or safe practice to vary the roadway width in rehabilitation sections from 6.6 m (22 feet) to 6.1 m (20 feet) at numerous locations.

In development of the Preferred Alternative, the width of the proposed improvements has been reduced to the absolute minimum that will achieve the purpose and need. The design has been reduced at the request of the public and the cooperating agencies to the lowest practical minimums within the flexibility and exceptions allowed by current highway policy. Selective narrowing of the roadway to a lesser width, or leaving intermittent portions of the roadway at the current narrow width, does not meet the purpose and need for the project and is considered an unsafe practice, and is not considered an acceptable alternative to the Forest Service, the CDOT or the FHWA.

The proposed reduction in roadway width from 7.2 m (24 feet) to 6.6 m (22 feet) under the Preferred Alternative requires several caveats that must be agreed to by the cooperating agencies in order to assure reasonable safety and effectiveness of the improvements. The narrower roadway width will not safely accommodate a substantial volume of trucks, commercial vehicles, or large recreational vehicles, and the Counties and FS will need to manage corridor development accordingly and not encourage high traffic volumes or a larger proportion of through traffic, large RV's, busses or commercial traffic.

Switchback Radius/Design Vehicle

The Guanella Pass Road has numerous 180-degree switchbacks, the majority of which are located on the north side of the pass, which receives the greatest use. The existing switchbacks range from mild bends with 55 m (180 feet) centerline radius to extremely tight crooks with 4.5 m (15 feet) centerline radius. Most of the existing switchbacks are in the 9 to 12 m (30 to 40 feet) radius range, however. For consistency, and to avoid trapping occasional oversize vehicles at an isolated switchback location, the sharper switchbacks should be improved to conform to either the minimum design speed radius or to a minimum radius established for the design exceptions for all of the switchbacks on the corridor. The switchbacks are usually located on the steepest grades in the most precipitous terrain, and typically require sudden deceleration in running speed to negotiate. The switchbacks are significant safety hazards within the corridor (in recent years two fatal accidents have occurred at switchback locations); in addition, they create operational and maintenance problems.

The physical characteristics and proportions of the vehicles using the road are primary controls in establishing the road geometry. Design vehicles are selected motor vehicles that represent a designated class of vehicle types that the road is intended to accommodate. For purposes of controlling the geometric design, each design vehicle represents the larger physical dimensions and larger minimum turning radius of almost all vehicles in its class. General classes of vehicle types, and the dimensions for various design vehicles, have been established and accepted for standard practice by AASHTO. In the switchbacks, the alignment of the roadway centerline is described by a 180 degree circular curve of a particular radius. The outermost path of the design vehicle's body while making the sharpest 180 degree turn it can, with a minimal allowance for clearance, represents a controlling dimension of the minimum centerline radius. In other words, the minimum turning circle of the design vehicle must be able to fit within the switchback centerline radius (inside lane of the road). The determination of the switchback design radius is also influenced by the tracking characteristics of the mix of other vehicles (passenger cars and pickup trucks with trailers, occasional permitted single and dual-unit trucks and large construction vehicles) expected to use the road, as well as operational and safety considerations.

An origin-destination (O-D) survey was performed for the Guanella Pass Road project during a single day in 1995 to develop an indication of the mix of vehicles using the road. The O-D data is supplemented by observations of the vehicle usage provided by the cooperating agencies. The frequently observed vehicles range from cars and pickup trucks pulling trailers (travel, horse, recreational equipment, supplies, etc.), various classes of recreational vehicles (some pulling trailers), commercial trucks carrying equipment and supplies to businesses and residences, and commercial trucks involved in construction or repair of both public and private facilities. Oversize, i.e. greater than 6 m (20 feet) overall length, vehicles use the Guanella Pass road on a daily basis. In all engineering work, including highway engineering, the controlling condition for design purposes is a worst case condition that is likely to be experienced at some anticipated frequency during the service life of the facility. The effects of all likely conditions (e.g., for vehicles other than the design vehicle) need to be analyzed and the operational and safety risks considered. Since the Guanella Pass Road is a public road and open to all users, the agencies responsible for making improvements to the road have an obligation to accommodate all likely users of the facility, as described in the purpose and need. The intent of the project is not to create a facility that will intentionally discriminate against specific classifications of users that have a rightful purpose to use the facility. The switchback design criteria should not be established to regulate the type of vehicle use on the highway, but to improve the safety, operation, and maintenance of the road to the maximum extent possible. The benefits of improving the switchbacks will apply to all vehicles using the road.

In the DEIS, the AASHTO standard SU design vehicle was recommended for design purposes because it represents both single-unit trucks and recreational vehicles (motorhomes), and to some extent vehicles pulling trailers, which use the roadway with some frequency (3 to 5 percent or about 10 to 20 vehicles per day on average), especially on the north side of the pass. The existing switchbacks will not accommodate these type vehicles safely (vehicles must encroach into the oncoming lane). The next smaller standard design vehicle is the passenger car (P design vehicle). The minimum switchback radius of 15 m (50 feet) was proposed in the DEIS to safely and efficiently accommodate the SU design vehicle within its own lane (with some widening for off-tracking), while minimizing impacts of the switchback realignment. The design speed of the 15 m radius switchbacks is 23 km/hr (14 mph). Most single-unit and tractor-trailer trucks and commercial vehicles that use the road are destined to either the Cabin Creek Power Plant or short-term construction sites, and could possibly be accommodated on the road by special permit.

In the Preferred Alternative, a non-AASHTO standard design vehicle is proposed which has a wheelbase shorter than an SU, but longer than a standard passenger car. The recreational vehicles which use the road most frequently are medium size units, less than 9 m (30 feet) in overall length, as the largest size motorhomes are probably discouraged by the existing poor road surface conditions and sharp switchbacks. The smaller and medium size motorhomes are represented by the Class C Motorhome as defined by the recreational vehicle manufacturing industry. This class uses a full size van cab and modified chassis with the living quarters added around the exterior of the cab. This type motorhome typically has up to a 5.2 m (17 foot) wheelbase, which is in between the 6.1 m (20 foot) wheelbase defined by the AASHTO SU design vehicle and the 3.4 m (11 feet) wheelbase of the AASHTO P design vehicle. A representative motorhome of this size class is the “Minnie-Winnie” manufactured by Winnebago. The proposed design vehicle, with a 5.2 m (17 foot) wheelbase, would be used during the design process to represent all oversize (over 6 m (20 foot) overall length) vehicles that the road should safely accommodate. Using the 5.2 m wheelbase for the design vehicle, the minimum switchback radius can be reduced from 15 m to 12 m (40 feet), which allows the proposed alignment to fit much closer to the existing roadway. The 12 m design radius also just accommodates a passenger car-trailer combination standard design vehicle (P/T) with similar widening for off-tracking of the trailer as for the Class C Motorhome. The design speed of the 12 m radius is 20 km/hr (13 mph). Since most of the switchbacks are proposed to be “belled” out using retaining walls, this change from 15 m to 12 m radius results in reduction of these retaining wall heights by at least one-half, and eliminates the need for retaining walls in several locations.

Further reduction of the switchback radius would require substantial additional roadway widening for tracking of a P/T passenger car-trailer standard design vehicle through the switchback, which would then become a control in the switchback design, and would offset any benefit from the further reduction of centerline radius. For example, using a P/T standard design vehicle would allow the centerline radius to be reduced to 9 m (30 feet), but the roadway width through the switchback would need to be enlarged to 15 m (50 feet) wide to accommodate the off-tracking, which would negate any reduction of impact from the smaller centerline radius. Some longer wheelbase vehicles such as an SU vehicle or bus would have to make multiple-point maneuvers by backing up and going forward several times to negotiate the 9 m radius switchbacks, which would be a very unsafe situation. A further reduction in the switchback radius (e.g. from 12 m radius to 9 m radius) would have little benefit, if any, in terms of reduction of the overall physical impacts of construction, and would leave the operational and safety problems of the existing sharp switchbacks unaddressed. From a vehicle size management standpoint, a further reduction in the switchback design would result in many more vehicles (all vehicles over 6 m (20 feet) in length), needing to be managed by special permit, and would significantly add to the Counties’ burden of administering the proposed permit system.

Under the Preferred Alternative, the larger size SU, tractor-trailer, and other similar oversize vehicles can still be accommodated through the reduced radius switchbacks, but only by encroaching into the oncoming lane. For example, a 15.2 m (50 feet) long tractor-trailer (WB-12 design vehicle) will require the entire roadway width (travel lanes and shoulders for both directions) to negotiate the 12 m radius switchback design. If the oversize and commercial vehicles are restricted and allowed only by special permits managed by the County, the safety issue of this change can be mitigated. For practical purposes, any vehicle size restriction should be based on overall length instead of actual wheelbase, although wheelbase is the primary dimension controlling the design. In order to be inclusive of essentially all vehicles with larger wheelbase than the design vehicle, a 7.6 m (25 feet) overall vehicle length should be used as the minimum length for vehicles requiring a special permit. Some vehicles (especially motorhomes) with overall length up to 9.0 m (30 feet) will possess a 5.2 m (17 feet) wheelbase and could safely negotiate the proposed switchback design; however, these vehicles would still be included in the 7.6 m (25 feet) minimum size limit and, therefore, need to be managed under special permit.

Maximum Grades

Design criteria for maximum grades are determined by the operating speed of vehicles and by operational, weather, safety, and maintenance considerations. For rural collector roads, the AASHTO criteria allows a maximum grade of 11 percent for a design speed of 40 km/h (25 mph), which corresponds to the DEIS alternatives. For rural local roads, maximum grades of 14% to 16% can usually accommodate the proposed design speeds of 30 to 50 km/h (19-31 mph) respectively. However, in the case of the Guanella Pass Road, the operational, weather, safety, and maintenance considerations necessitate limiting the maximum design grade to approximately 9 percent, as described below.

Steep grades have an adverse effect on stopping distance and vehicle operation and control, especially when the surface is loose, wet, snow packed, or icy. In combination with sharp horizontal curves, steep grades greatly increase accident potential. During snow packed and icy conditions, vehicles have great difficulty maintaining traction or control when grades exceed 10 percent and this is exacerbated by the superelevation (banking) on curves. In the switchback locations, where sudden decelerations are typical approaching the sharp curves, the maximum grade should not exceed 4 percent or 5 percent. For gravel or alternative stabilized gravel surfaces, the rate of gravel loss and generation of washboard condition greatly increases when grades exceed 6 percent. For grades over 9 percent, the rate of gravel loss and severe washboard condition becomes so great as to make maintenance of aggregate surfacing impractical. The sections of the Guanella Pass Road that are unpaved and currently have grades over 9 percent exhibit severe washboard condition and loss of surface material. Where practical in the reconstruction segments, the sections of steeper grade are proposed to be flattened to 9 percent. This is done by a combination of lowering the crests and raising the adjacent dips, or in combination with minor realignment to lengthen the road.

Roadside Design

Additional guidance for design of features adjacent to the roadway (beyond the shoulders) is provided by the *Roadside Design Guide, January 1996*, published by AASHTO. The design of clear zones, roadside slopes, ditches, retaining walls, barriers (e.g., guardrail), roadside appurtenances (e.g., signs, culvert inlets, etc.), and other roadside features should be consistent with this criteria to provide a forgiving roadside with associated safety benefits. The design of most roadside features is done during the final design phase, following the environmental review process and after a decision is made regarding selection of a preferred alternative. The potential reductions in the footprint of the build alternatives that are discussed in the DEIS in **Section II.3: Possible Further Roadway Cross-Section Reductions** are incorporated in the Preferred Alternative. Some further reductions of the footprint at certain site-specific locations may be possible during the final design process with minor adjustments to the alignment, grade, slopes, ditches, and retaining walls.

Need for Reconstruction versus Rehabilitation in Designated Areas

The Guanella Pass Road was initially constructed without incorporation of currently accepted engineering practices in many locations, and is an accumulation of various maintenance and construction efforts by various entities that were intended to address localized site and field conditions encountered in the past, and did not consider the corridor as a whole. Due to the serious roadway deficiencies located in many areas of the route, a conventional 3(R) type project staying totally within the existing prism for the entire length of the route would not provide reasonably consistent or minimum geometric standards, adequate roadway structure, safety enhancement, service life, or maintenance capabilities. The 3(R)-only concept does not consistently utilize any established guidelines for the geometric design, or achieve improvement of the roadway to some appropriate and consistent standard. The FHWA, FS, and CDOT do not believe that 3(R) improvements alone constitute a reasonable alternative for this route. These agencies believe that making such limited improvements in areas where reconstruction is warranted would create an unsafe condition by giving drivers false impressions and unrealistic expectations of the roadway condition and safety in many locations. Also, there are certain locations where guardrail is desired for safety enhancement but there is currently insufficient platform width available for proper installation unless the road is widened by reconstruction. A 3(R) proposal would not correct the narrow roadway width and substandard horizontal (changes in direction) and vertical (crests and dips) curves in numerous locations. Such a proposal would not address the purpose and need for improvements in these locations, and would leave numerous width transitions along the existing narrow road, which would then become even more potentially hazardous locations, decreasing the overall safety of the road. A simple resurfacing project would not correct any of the problems associated with the narrow road and the sections of poor alignment, and would likely result in an increase in operating speed without improving safety.

Many portions of the route, however, have far fewer, or less serious, deficiencies and are fairly close to meeting the criteria for a candidate 3(R) project (see FEIS **Section II.B.6: Typical Cross Sections**). The DEIS indicated 50 percent of the length can be rehabilitated under Alternatives 4 or 5 to a roadway width of 6.6 m (22 feet). The proportion of the route that falls within the rehabilitation category is increased by breaking down the DEIS reconstruction segments into more discrete sections. Breaking the route into 36 segments results in about 64 percent of the route that can be rehabilitated (as opposed to 50 percent indicated in the DEIS for Alternative 5). Conversely, 36 percent of the route is not a candidate for 3(R) rehabilitation treatment, primarily because the overall platform width needed to provide at least a 6.6 m (22 foot) roadway width is typically not available in those segments.

The determination of the type of improvement proposed for each segment was based on that segment's overall road width, horizontal and vertical alignment, the nature of the existing cut and fill slopes, and its current condition. The sections identified as the most deficient and in the greatest need of reconstruction include one or more of the following problems:

- numerous substandard or inconsistent geometric features
- insufficient width for design vehicles to safely pass in opposite directions

- limited sight distance
- excessive maintenance costs
- severe environmental degradation
- severe slope stability problems
- insufficient ditch width and drainage problems
- hazardous and steep roadside conditions
- steep roadway gradients

To determine the areas included for rehabilitation versus reconstruction, the width of the existing platform was measured from surveyed cross-sections at 20 meter (66 feet) intervals throughout the length of the route. The sections that measured less than 7.9 meters (26 feet) platform width were grouped, and exceptionally narrow areas identified. The existing roadway horizontal and vertical alignments were compared with the minimum criteria for 30 km/hr design speed, and areas that deviated more than 2 meters (6 feet) horizontally or 1 meter (3 feet) vertically from the minimum standards were also grouped, and the exceptions identified. The exceptionally narrow and substandard areas of the route were evaluated in the field to verify if the extent of deficiencies necessitated reconstruction, and the remaining candidate areas for rehabilitation were evaluated to determine if the operational, safety and maintenance conditions could be adequately addressed by a 3(R) approach. The areas identified for reconstruction were evaluated as either being predominantly light reconstruction or full reconstruction (see FEIS **Chapter II.D.4e: Typical Cross Sections**) and the resulting areas grouped into 36 segments. Table II-3 of the FEIS summarizes the improvements by segment for the Preferred Alternative. Figure II-5 of the FEIS shows the mix of improvement work for the Preferred Alternative and for the DEIS alternatives. Each of the segments is discussed in detail below.

Proposed Improvements by Segment

Within the segments proposed for rehabilitation type improvement, there may exist localized areas (less than 30 meters or 100 feet) that are particularly narrow but which have not been identified during the preliminary design process as needing other than rehabilitation type improvements. If specific locations are identified during the final design process which need more than rehabilitation level of improvement to provide the proposed 6.6 meters (22 feet) of roadway width, such locations (if any) will be evaluated and treated individually, either as an exception to the proposed roadway width standard, or as a spot repair for minor widening. Spot repairs, if necessary to provide minor widening, may consist of a short (less than 30 meters or 100 feet) length of grading for a new slope or a short section of retaining wall.

Grant

The 0.77 kilometer (0.48 mile) segment of the route from Grant to near Half Mile Gulch is located adjacent to the Geneva Creek floodplain and runs parallel to the creek along its east bank. The existing roadway generally follows the gradient of the creek with grades averaging less than 3 percent. The roadway is typically 6.6 meters (22 feet) wide with surfacing consisting of a conventional asphalt chip seal with 10 mm (3/8 inch) maximum size aggregate.

Under the Preferred Alternative, this segment of the road would be rehabilitated. The new roadway surfacing would be asphalt or asphalt with a chip seal. Several additional culverts would be installed to improve drainage. The typical width of disturbance would be 8 meters (26 feet).

Geneva Canyon

The 5.23 kilometer (3.25 mile) segment of the route from near Half Mile Gulch to just north of the Tumbling River Ranch (beginning of pavement) is generally located adjacent to the Geneva Creek flood plain and runs parallel to the creek along its east bank. The existing road generally follows the gradient of the creek with grades averaging less than 3 percent. The existing surfacing is gravel/dirt.

Under the Preferred Alternative, the existing roadway would be rehabilitated with 150 mm (6 inches) of gravel. Several sections of substandard roadway geometry (sharp curves and abrupt crests/dips at Stations 2+000, 4+150, and 6+800) would not be improved but would be identified with warning signing. There are also several areas where the existing roadway elevation is at or below the 50-year flood plain elevation which will continue to be subject to periodic inundation by Geneva Creek. At these locations the roadway grade would be raised 150 mm (6 inches) for subgrade repair. The existing roadway varies from 6.0 to 6.6 meters (20 to 22 feet) in width and, with possibly one or two exceptions in the vicinity of 3+500 to 3+640, could be rehabilitated and resurfaced to a 6.6 meters width. Cut walls are proposed for the two exceptions. The total combined length of these cut walls is 130 meters (427 feet) with an average height of 1.2 meters (4 feet). Additional culverts would be installed to improve drainage; however, many existing drainage problems would not be addressed under the Preferred Alternative because the existing ditches and roadway foreslopes are narrow or non-existent, and widening of the existing ditches would require reconstruction type improvements. The stream bank is very close to the roadway in several locations. The steep bank and stream flow may be considered a hazard adjacent to the roadway, but the slope would typically remain unprotected since there is insufficient existing width to install guardrail. Short sections (15 meter or 50 feet) of stream bank stabilization such as rock riprap may be installed at several locations to protect the existing roadway embankment from erosion of the stream and to help restore the stream's natural state. A gravel berm or some form of curb may be placed at selected locations along the roadway to help retain gravel on the road and minimize migration of gravel into the stream. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet).

Falls Hill Segment A

The 1.10 kilometer (0.68 mile) segment from just north of Tumbling River Ranch to the base of Falls Hill is adjacent to Geneva Creek and crosses Scott Gomer Creek. The average grade through this area is 7 percent. The existing roadway is 6.6 meters (22 feet) in width with surfacing consisting of asphalt pavement.

Under the Preferred Alternative, this segment of the road would be rehabilitated. The new roadway surfacing would be asphalt or asphalt with a chip seal. Several additional culverts would be installed to improve drainage. The existing culvert at Scott Gomer Creek would be left in place. The typical width of disturbance would be 8 meters (26 feet).

Falls Hill Segment B

The 1.04 kilometer (0.65 mile) segment climbs out of Geneva Canyon through a series of switchbacks. The average grade through this area is 9 percent. The existing paved roadway varies in width from 6.0 to 6.6 meters (20 to 22 feet) with asphalt pavement. The main deficiency of this segment is the existing unstable cut slopes adjacent to the roadway. The existing cut slopes are 15 to 20 meters (50 to 65 feet) high and have been oversteepened and are unstable. The unstable cut slopes contribute large rockfall into the ditches, exacerbating the drainage problems.

Under the Preferred Alternative, this segment of the road would undergo full reconstruction to repair the unstable slopes. Cut side walls, approximately 3 to 6 meters (10 to 20 feet) high and approximately 170 meters (558 feet) long, are proposed at the two worst oversteepened slopes (e.g., where concrete blocks are now and above the upper switchback) to allow backfilling behind the wall with a flatter slope angle, topsoil placement, and revegetation of the existing slopes. Other cut slopes between the upper switchback and the top of Falls Hill would be laid back at a flatter slope to promote revegetation. Two sections of low (2 to 3 meter or 6 to 10 feet) mechanically stabilized embankment (MSE) fill side wall, 2 to 3 meters (6 to 10 feet) in height and totaling 175 meters (574 feet) in length, are proposed to retain the fill slope at the lower switchback. Another low MSE wall is proposed to retain the fill slope for a section of the road just above the upper switchback. This MSE wall is approximately 100 meters (328 feet) in length. The reconstruction will closely follow the existing alignment and grade. The typical width of disturbance in areas where the existing cut slopes are reconstructed would be 30 meters (100 feet). Extensive revegetation work including topsoil, native seed, mulch, and native container stock (trees and shrubs) will be provided on the stabilized slopes. The new roadway surfacing would be asphalt or asphalt with a chip seal. Several additional culverts would be installed to improve drainage. Enlargement of an existing pullout near the upper switchback at the waterfalls of Scott Gomer Creek is proposed to provide a paved pullout for 6-8 cars. There are high steep fill slopes adjacent to the existing road which are especially hazardous near the top of the switchbacks. This is also an area of sharp curves and inconsistent geometry. The existing guardrail will be replaced and extended. A total length of 535 meters (1,755 feet) of guardrail is proposed for this segment. Approximately 380 meters (1,247 feet) of this length is replacing existing guardrail and the remaining 155 meters (508 feet) will be new sections of guardrail along this segment.

Geneva Park

The 7.00 kilometer (4.35 mile) segment of the route from the top of the Falls Hill area to the upper switchback at the end of Geneva Park (existing end of pavement) generally follows along the east bank of Geneva and Duck Creeks, which form a relatively broad and flat valley in this area. The existing roadway generally follows the gradient of the creeks, with average grades of less than 3.5 percent. There are no high, steep fill slopes adjacent to the existing road that are especially hazardous. There is one section of inconsistent geometry at Station 13+300 which will need to be identified with warning signs. The existing roadway has a consistent 6.6-meter (22 feet) paved width.

Under the Preferred Alternative, the segment would be rehabilitated and resurfaced to 6.6-meter (22 feet) width with asphalt pavement or asphalt pavement with a chip seal. The typical width of disturbance would be 8-9 meters. Most existing drainage problems would be addressed with additional culvert pipes and minor reshaping of the existing ditches. The existing ditches and foreslopes are consistently slightly narrow, but are closer to conformance with the proposed typical section than in other portions of the route. Most existing slopes are relatively stable, so that only a minor amount of slope repair and revegetation is proposed. The existing parking area at Abyss Trailhead (Station 9+300) is proposed to be enlarged with a new paved parking lot for approximately

40 vehicles (separated from the road by an earth berm), and additional restrooms are proposed by the FS.

Shelf Road - Park County

The 1.66 kilometer (1.03 mile) segment from Geneva Park to the Park County line (Station 17+800) is an area where the existing road was cut into the steep and rocky hillside forming a shelf in the slope. This segment has numerous problems and deficiencies. Much of the maintenance efforts of Park County are spent on this segment of the road. The roadway has a gravel/dirt surface varying from less than 4.8 meters (16 feet) to more than 7.2 meters (24 feet) in width, and is typically 5.5 meters (18 feet) wide. This segment of the road has an average grade of 7 percent with long stretches at over 8 percent, which contributes to the loss of gravel and sediment from the road and requires additional maintenance effort and expense. Throughout this area are high (15 to 30 meters or 50 to 100 feet), unstable cut slopes, and large boulders frequently fall onto the roadway. The unstable cut slopes produce extensive rockfall into the ditches and onto the roadway, exacerbating the drainage problems and creating safety hazards. The existing drainage structures are few and too small to accommodate predicted storms. Springs in the existing slopes from 16+300 to 16+600 create drainage problems throughout the year and create ice flows across the road in winter.

Under the Preferred Alternative, this segment of the road would undergo full reconstruction to provide a consistent 6.6 meter (22 feet) roadway width and to repair and stabilize the existing unstable cut slopes to the extent possible. The slope stabilization may consist of scaling loose, unstable rocks and boulders, installing reinforcing rods into the cut to anchor the slope, installing steel reinforcing dowels and placing concrete wedges below unstable boulders, backfilling of the lower portion of existing oversteepened slopes, and use of vegetation to hold the soil surrounding the rocks and boulders and to help stabilize the slopes. A wider (3 meter or 10 feet overall width) rockfall ditch is proposed throughout this segment to mitigate and collect anticipated rockfall that will likely continue despite the stabilization efforts (a 50 percent reduction in rockfall is a reasonable goal). The wider ditch will accommodate equipment such as a front loader to more easily clean up the ditch. Because of anticipated continued rockfall, any retaining wall structures built into the cut slope would likely become damaged or destroyed, and are not proposed. Because the existing slopes are very steep, laying back the existing cut slopes on a flatter slope is not practical. Minimal excavation of the cut slopes is proposed. MSE retaining walls are proposed on the downhill side of the road throughout this entire segment to accommodate the wider roadway and ditch. The average height of the MSE walls would be approximately 3 meters (10 feet). The reconstruction will closely follow the existing alignment and grade.

The typical width of disturbance in this area would be 15 meters (50 feet). Extensive revegetation work including placement of topsoil, native seed, mulch, and container stock (trees and shrubs) will be provided on the stabilized slopes. The new roadway surfacing would be asphalt or asphalt with a chip seal. Several additional culverts would be installed to improve drainage, and subsurface drainage features installed in the area of the springs. There are high, steep, and very hazardous fill slopes adjacent to the existing road throughout this segment. The existing guardrail will be replaced and extended, and additional guardrail added throughout the segment. An approximate total length of 1610 meters (5282 feet) of guardrail is proposed for this segment. Approximately 488 meters (1601 feet) of this length is replacing existing guardrail and the remaining 1122 meters (3681 feet) will be new guardrail along this segment. An existing pullout at the switchback near the start of this segment (16+230) is proposed to be formalized with a paved pullout for 4-6 cars.

Shelf Road - Clear Creek County

The 1.34 kilometer (0.83 mile) segment from the Clear Creek County Line (just south of the entrance to the abandoned ski area [Station 17+800]) to the intersection to the private residence at Duck Lake has very similar problems and deficiencies as the previous segment. The roadway has a gravel/dirt surface typically 5.5 meters (18 feet) wide. This segment of the road has an average grade of 7 percent with long stretches at over 8 percent, which contribute to the loss of gravel and sediment from the road and requires additional maintenance. Within the segment from 17+800 to 18+700 are high (10 to 20 meters or 33 to 66 feet), unstable cut slopes, and large boulders frequently fall onto the roadway in this area. The unstable cut slopes produce extensive rockfall into the ditches and onto the roadway, exacerbating the drainage problems and creating safety hazards. The existing drainage ditches and culverts are undersized and infrequently located.

Under the Preferred Alternative, this segment of the road would undergo full reconstruction to provide a consistent 6.6 meter (22 feet) roadway width and to repair and stabilize the existing unstable cut slopes to the extent possible, similarly as described for the previous segment. A wider (3 meter or 10 feet overall width) rockfall ditch is proposed from 17+800 to 18+650 to mitigate and collect the anticipated rockfall. Minimal excavation of the cut slopes is proposed. MSE retaining walls are proposed on the downhill side of the road for 1015 meters (3,330 feet) in this area to accommodate the wider roadway and ditch. The average height of the MSE walls would be approximately 3.1 meters (10 feet). The reconstruction will closely follow the existing alignment and grade, except from 18+900 to 19+100 where the road would be shifted to eliminate two crossings of Duck Creek and allow restoration of the stream to its approximate original channel location. The typical width of disturbance in this segment would be 15 meters (50 feet). Extensive revegetation with topsoil, seed, mulch, and container stock (trees and shrubs) will be provided on the stabilized slopes. The new roadway surfacing would be asphalt or asphalt with a chip seal. Several additional culverts would be installed to improve drainage. There are high, steep fill slopes adjacent to the existing road from 17+800 to 18+800, which are very hazardous. New sections of guardrail are proposed in this area for a total length of 1055 meters (3,461 feet).

Duck Lake Segment A

The 0.30 kilometer (0.19 mile) segment of the route is located from the entrance to Duck Lake to a sharp curve to the east of Duck Lake. The overall gradient of the road is 5 percent with the lower section approximately 8 percent grade. The existing surfacing is gravel/dirt. The existing roadway is approximately 6.6 meters (22 feet) width.

Under the Preferred Alternative, this segment would be rehabilitated and resurfaced to 6.6 meters width with 150 mm (6 inches) gravel or an alternative stabilized gravel surfacing type. A remnant of abandoned roadway would be regraded to natural contours at 19+400. Additional culverts would be installed to improve drainage. The typical width of disturbance would be 9 meters (30 feet).

Duck Lake Segment B

The 0.09 kilometer (0.06 mile) segment of the route is located at a sharp curve east of Duck Lake.

The overall gradient of the road is 9 percent grade. The existing surfacing is gravel/dirt. The existing roadway varies from 6.0 to 6.6 meters (20 to 22 feet) width. There is one exceptionally sharp curve at 19+500 that is inconsistent with the adjacent alignment in the area. The existing cut slopes in the vicinity of 19+500 to 19+550 are oversteepened and barren of vegetation.

Under the Preferred Alternative, this segment would undergo full reconstruction to 6.6 meters width with gravel or an alternative stabilized gravel surfacing type. The sharp curve at 19+500 would be improved with a smoother curve over a distance of 90 meters (300 feet), and the existing oversteepened cut slope would be backfilled with a flatter slope to promote revegetation. Additional culverts would be installed to improve drainage. The typical width of disturbance would be approximately 18 to 24 meters (60 to 80 feet).

Duck Lake Segment C

The 0.55 kilometer (0.34 mile) segment of the route is located from the sharp curve east of Duck Lake to a point above Duck Lake. The overall gradient of the road is over 8 percent. The existing surfacing is gravel/dirt. The existing roadway is 6.6 meters (22 feet) width.

Under the Preferred Alternative, this segment would be rehabilitated and resurfaced to a 6.6 meters width with 150 mm (6 inches) gravel or an alternative stabilized gravel surfacing type. Additional culverts would be installed to improve drainage. The typical width of disturbance would be 9 meters (30 feet). A short section of new guardrail (10 meters or 33 feet) is proposed for this segment.

Above Duck Lake

The 0.40 kilometer (0.25 mile) segment above Duck Lake is narrower than adjacent segments, and there is insufficient width available for a rehabilitation type level of improvement. The roadway has a gravel/dirt surface that is typically 5.5 meters (18 feet) wide. This segment of the road has an average grade of 8 percent with the lower section approximately 9 percent grade. Throughout the segment are steep and frequently unstable cut slopes, 9 to 12 meters (30 to 40 feet) height. The unstable cut slopes produce slough into the ditches and onto the roadway, causing drainage and maintenance problems. The existing drainage ditches and structures are also inadequate.

Under the Preferred Alternative, this segment of road would undergo light reconstruction to provide a consistent 6.6 meter (22 feet) roadway width and to repair and stabilize the existing unstable cut slopes to the extent possible, using some of the same techniques as for the Shelf Road segment. The light reconstruction would closely follow the existing alignment and grade with minimal (if any) excavation of the cut slopes. MSE retaining walls are proposed on the downhill side of the road for the entire length of this segment to accommodate the wider roadway. The approximate average height of the MSE walls would be 1.8 meters (6 feet). Extensive revegetation work including placement of topsoil, native seed, mulch, and container stock (native trees and shrubs) will be provided on the stabilized slopes. The new roadway surfacing would be gravel or an alternative stabilized gravel surfacing type. Several additional culverts would be installed to improve drainage. The typical width of disturbance in this segment would be 12 meters (40 feet). Guardrail is proposed for the entire length of this segment.

Above Duck Lake to Pass

The 1.39 kilometer (0.86 mile) segment of the route climbs to the top of Guanella Pass with an overall grade of 5 percent and some stretches at over 7 percent. The terrain adjacent the road is relatively gentle with 1:4 (vertical:horizontal) slopes, and the upper 1 kilometer (0.6 mile) is above timberline. The existing surfacing is gravel/dirt.

Under the Preferred Alternative, the existing roadway would be rehabilitated with 150 mm (6 inches) gravel or an alternative stabilized gravel surfacing type. The existing roadway varies from 6.6 to 7.2 meters (22 to 24 feet) in width and could be rehabilitated and resurfaced to 6.6 meters in width. Additional culverts would be installed to improve drainage. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet). Guardrail is proposed for 140 meters (459 feet) of this segment.

Pass to Upper Switchbacks

The 0.58 kilometer (0.36 mile) segment of the route drops from the top of Guanella Pass with an overall grade of 8 percent and some stretches at over 9 percent. The terrain adjacent the road is relatively gentle with 1:4 (vertical:horizontal) slopes and is above timberline. The existing surfacing is gravel/dirt. A pair of switchbacks at 22+100 was eliminated during a past spot reconstruction by the County, and now serves as an informal overflow parking area for the trailheads at the pass.

Under the Preferred Alternative, the existing roadway would be rehabilitated with 150 mm (6 inches) of gravel or an alternative stabilized gravel surfacing type. The existing roadway varies from 6.6 to 7.2 meters (22 to 24 feet) in width and could be rehabilitated and resurfaced to 6.6 meters width. Additional culverts would be installed to improve drainage. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet). An enlarged and formalized trailhead parking lot with 143 parking spaces and restroom facility is proposed by the FS at the summit of Guanella Pass on the east side of the road (see figure III-13 in the previous DEIS).

Upper Switchbacks

The1.73-kilometer (1.08 mile) segment north of the pass drops steeply (average grade of 8 percent and some areas at 10 percent) into the South Clear Creek Valley through a series of four switchbacks. The terrain adjacent to the road is very steep with 1:2 (vertical:horizontal) slopes. The existing surfacing is gravel/dirt and roadway widths vary from 4.5 meters (15 feet) to 6.0 meters (20 feet). This segment has the most serious deficiencies of the entire route. The roadway width is frequently too narrow for two vehicles to pass each other safely. Most of the existing fill slopes are very steep and hazardous, and the edge of the road is being lost to erosion. The switchbacks are too sharp to safely accommodate larger passenger vehicles such as pickup trucks or the design vehicle (Class C recreational vehicle). There are many locations where the existing cut slopes are oversteepened (1:1 or steeper), lack vegetation and are subject to erosion, and frequently slough onto the roadway causing drainage problems. There are few existing culverts and runoff continually erodes the narrow ditches and roadway, and often flows over the road causing erosion of the fill slopes.

Under the Preferred Alternative, this segment of road would undergo light reconstruction to provide a consistent roadway width and to stabilize and repair the existing oversteepened cut slopes where possible, using extensive revegetation techniques. The new roadway surfacing would be asphalt or asphalt with a chip seal. The four switchbacks are proposed to be belled out approximately 3 meters (10 feet), except the 3rd switchback north of the pass would be belled out approximately 6 meters (20 feet) with a MSE retaining wall. The light reconstruction would closely follow the existing alignment and grade with minimal excavation of the cut slopes. New cut slopes would be laid back at a flatter (1:2) slope in four areas approximately 400 meters (1,300 feet) in length. Seven sections of MSE retaining walls are proposed on the downhill side of the road for 1,445 meters (4,740 feet) through most of this segment to accommodate the wider roadway. The average height of the MSE walls would be approximately 3 meters (10 feet). A cut wall is proposed for a portion of this segment between stations 23+780 and 23+845, 65 meters (213 feet) in length. The average height of the cut wall would be 2.6 meters (9 feet). The typical width of disturbance in this segment would be 12 meters (40 feet) in MSE wall areas and 20 meters (60 feet) in areas of new cut slopes. Extensive revegetation work including placement of topsoil, native seed, mulch, and container stock (native trees and shrubs) will be provided on new constructed slopes. Additional culverts would be installed at frequent intervals (typically every 150 meters or 500 feet) to improve drainage. In the steeper grades the ditch slopes would be armored with stable materials such as rock riprap. There are high, steep fill slopes adjacent to the existing road throughout the segment, which are very hazardous. There is no existing guardrail in this segment. New guardrail is proposed in this segment for a total length of 1,546 meters (5,072 feet).

Upper Clear Creek

The 0.30 kilometer (0.19 mile) segment of the route is located between the upper four switchbacks and the Naylor Creek switchbacks. In this segment the horizontal alignment is fairly uniform with slight curves, although the vertical alignment is consistently steep with an overall grade of 8 percent. The terrain adjacent to the road is marginally traversable with 1:3 slopes. The existing surfacing is gravel/dirt.

Under the Preferred Alternative, the existing roadway would be rehabilitated. The new roadway surfacing would be asphalt or asphalt with a chip seal. The existing roadway varies from 6.6 to 7.2 meters (22 to 24 feet) width and could be rehabilitated and resurfaced to 6.6 meters width. Additional culverts would be installed to improve drainage, and ditches would be armored in areas of steep grades. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet). A small portion of guardrail is proposed for 5 meters (16 feet) of this segment.

Naylor Creek

The 0.88 kilometer (0.55 mile) segment is located from just south of the intersection with the Naylor Lake Road to the intersections with the Guanella Pass Campground. The horizontal alignment is poor and includes two sharp curves (essentially switchbacks) south of the Naylor Lake Road and one switchback at the intersection with the Naylor Lake Road. The overall grade of this segment is 7.5 percent; however the area of sharp curves south of the Naylor Lake Road has an extraordinarily steep grade of 12.5 percent, and the surface is very rough and difficult to maintain. The terrain adjacent to the road is relatively gentle with 1:4 slopes. The existing surfacing is gravel/dirt and the roadway width varies from 5 meters (16 feet) to 6.0 meters (20 feet). The sharp curves and switchback are too sharp to safely accommodate the design vehicle (Class C recreational vehicle). There are many locations where the existing cut slopes are oversteepened (1:1 or steeper), lack vegetation and are subject to erosion, and frequently slough onto the roadway causing drainage problems. There are few existing culverts and runoff continually erodes the narrow ditches and roadway, and often flows over the road causing erosion of the fill slopes.

Under the Preferred Alternative, this segment would undergo full reconstruction to improve the alignment and grade to the minimum proposed standards for 30 km/h or 19 mph (curve radius of 30 meters or 100 feet and a 9 percent grade). The full reconstruction would closely follow the existing alignment and grade, except at the 3 sharp curves in the area of steepest grade. In the area south of the Naylor Lake Road intersection, new cut slopes would be laid back at a flatter (1:2) slope in several areas totaling approximately 1,000 meters (3,280 feet) length. Reconstruction of the existing cut and fill slopes and laying them back on a flatter slope creates most of the additional impact, but is necessary if vegetation is to be established. One area of MSE retaining wall is proposed on the downhill side of the road, just north of the Naylor Lake Road intersection, to accommodate the wider roadway and avoid encroachment on a tributary of Naylor Creek. The MSE wall would be 50 meters (164 feet) in length and 1 meter (3.3 feet) in average height. Guardrail is proposed in the vicinity of the MSE wall for a length of 46 meters (150 feet). The typical width of disturbance in this segment would be 24 meters (80 feet) south of Naylor Lake Road and 18 meters (60 feet) north of Naylor Lake Road. Extensive revegetation work including placement of topsoil, native seed, mulch, and container stock (native trees and shrubs) will be provided on new slopes. The new roadway surfacing would be asphalt or asphalt with a chip seal. Additional culverts would be installed at frequent intervals (typically every 150 meters or 500 feet) to improve drainage and ditches would be armored in areas of steep grades. The existing round culvert pipe at Naylor Creek would be replaced with an oversized, open bottom (3-sided) arched drainage structure.

South Clear Creek (SCC) Segment A

The 0.34 kilometer (0.21 mile) segment is located just north of the Guanella Pass Campground. The overall grade is 7.5 percent. The terrain adjacent to the road is relatively gentle with 1:5 slopes. The existing surfacing is gravel/dirt. The existing roadway is located in a wetland and additional wetland encroachment is proposed in this area under the Preferred Alternative (under the existing alignment option). The existing roadway is 6.6 meters (22 feet) in width and could be rehabilitated and resurfaced to 6.6 meters width.

Under the Preferred Alternative (existing alignment option) the existing roadway would be rehabilitated with 150 mm (6 inches) gravel or an alternative stabilized gravel surfacing type. Additional culverts would be installed to improve drainage. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet).

SCC Segment B

The 1.86 kilometer (1.16 mile) segment is located north of the Guanella Pass Campground. The existing surfacing is gravel/dirt, and roadway widths vary from 5 meters (16 feet) to 6.0 meters (20 feet). The horizontal and vertical alignments are inconsistent; but could be improved to minimum standards with minor adjustments. The overall grade of this segment is about 4 percent; however, there are several areas with over 8 percent grade. The terrain adjacent to the road is relatively gentle with 1:4 slopes.

Under the Preferred Alternative, the road would undergo full reconstruction to provide the minimum roadway width and improve the alignment and grade to the minimum proposed standards for 30 km/h or 19 mph. The full reconstruction would closely follow the existing alignment and grade. New cut slopes would be laid back at a flatter (1:2) slope. The typical width of disturbance in this segment would be 18 meters (60 feet). Extensive revegetation work including placement of topsoil, native seed, mulch, and container stock (native trees and shrubs) will be provided on newly constructed slopes. The new roadway surfacing would be gravel or an alternative stabilized gravel surfacing type. Additional culverts would be installed at frequent intervals (typically every 150 meters or 500 feet) to improve drainage.

SCC Segment C

The 0.58 kilometer (0.36 mile) segment is located just south of the southern crossing of South Clear Creek. The overall grade is 5.5 percent, with 100 meter (328 feet) section over 8 percent grade and another 100 meter (328 feet) section over 10 percent grade (from 27+800 to 27+900). With minor grading and subgrade repairs the 10 percent grade section may be reduced to about a 9 percent grade. The terrain adjacent to the road is relatively gentle with 1:5 slopes. The existing surfacing is gravel/dirt. The existing roadway is located adjacent to the west bank of South Clear Creek close to wetland areas; however, no wetland encroachment is anticipated in this area. The existing roadway is 6.6 meters (22 feet) wide and could be rehabilitated and resurfaced to a 6.6 meter width.

Under the Preferred Alternative, the existing roadway would be rehabilitated with 150 mm (6 inches) of gravel or an alternative stabilized gravel surfacing type. Additional culverts would be installed to improve drainage and ditches would armored in areas of steep grades. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet).

SCC Segment D

The 1.26 kilometer (0.78 mile) segment is located from the southerly crossing of South Clear Creek to a point south of Clear Lake Campground. The existing surfacing is gravel/dirt, and roadway widths vary from 5 meters (16 feet) to 6.0 meters (20 feet). The horizontal and vertical alignments are inconsistent. The overall grade of this segment is about 5 percent; however there are several areas over 8 percent grade and one area of 12 percent grade (28+400). The terrain adjacent to the road varies from relatively gentle with 1:4 slopes to very steep areas with 1:1 slopes adjacent to the creek. There are several locations where the existing cut slopes are oversteepened (1:1 or steeper), lack vegetation and are subject to erosion, and frequently slough onto the roadway causing drainage problems. There are few existing culverts and runoff continually erodes the narrow ditches and roadway, and often flows over the road causing erosion of the fill slopes adjacent the creek.

Under the Preferred Alternative, the reconstruction (mix of light reconstruction and full reconstruction) would closely follow the existing alignment, and the road would be reconstructed to provide the minimum roadway width and improve the alignment and grade to the minimum proposed standards for 30 km/h or 19 mph and 9 percent grade. New cut slopes would be laid back at a flatter (1:2) slope. Three sections of MSE retaining walls are proposed on the downhill side of the road for 509 meters (1,670 feet) in this segment to accommodate the wider roadway. The average height of the MSE walls would be 4 meters (13 feet). The typical width of disturbance in this segment would be 12 meters (40 feet) in MSE wall areas and 18 meters (60 feet) in areas of new cut slopes. Extensive revegetation work including placement of topsoil, seed, mulch, and container stock (trees and shrubs) will be provided on new constructed slopes. The new roadway surfacing would be asphalt or asphalt with a chip seal. Additional culverts would be installed at frequent intervals (typically every 150 meters or 500 feet) to improve drainage, and ditches would be armored in areas of steep grades. There are several high, steep fill slopes adjacent to the existing road which are very hazardous. There is no existing guardrail. New guardrail is proposed in this segment for a total length of 614 meters (2014 feet).

SCC Segment E

The 0.30 kilometer (0.19 mile) segment is located south of Clear Lake Campground and is adjacent to the west bank of South Clear Creek. The existing surfacing is gravel/dirt. The overall grade is 5 percent, with a short section over 7 percent grade. The terrain adjacent to the road on the uphill side is relatively gentle with 1:4 slopes on the uphill side, but is steep with 1:1 slopes down to South Clear Creek on the downhill side. The existing roadway is 6.6 meters (22 feet) in width and could be rehabilitated and resurfaced to a 6.6 meter width.

Under the Preferred Alternative, the existing roadway would be rehabilitated with 150 mm (6 inches) of gravel or an alternative stabilized gravel surfacing type. Additional culverts would be installed to improve drainage. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet).

SCC Segment F

The 0.52 kilometer (0.32 mile) segment is located from south of Clear Lake Campground to the beginning of pavement at Cabin Creek Power Plan. The existing surfacing is gravel/dirt and roadway widths varying from 5 meters (16 feet) to 6.0 meters (20 feet). The overall grade of this segment is about 5 percent; however there is one area of 13 percent grade (29+800). The terrain adjacent the road is relatively gentle with 1:6 slopes. Near the Clear Lake Campground the road grade is below the floodplain of South Clear Creek and is subject to periodic inundation and constant wet conditions.

Under the Preferred Alternative, this segment is proposed to undergo light reconstruction to raise the grade through this area approximately 1 meter (3 feet). The steep section of 13 percent grade will be reconstructed at a 9 percent grade in conjunction with the grade raise. Aside from this vertical alignment change, the reconstruction (light reconstruction) would closely follow the existing alignment. The typical width of disturbance in this segment would be 15 meters (50 feet). Extensive revegetation with topsoil, seed, mulch, and container stock (trees and shrubs) will be provided on new constructed slopes. The new roadway surfacing would be gravel or an alternative stabilized gravel surfacing type. Additional culverts would be installed to improve drainage.

Cabin Creek

The 2.04 kilometer (1.27 mile) segment of the route from the Cabin Creek power station (existing beginning of pavement) to the north end of Green Lake is immediately adjacent to the power station facilities. The existing road averages less than 3 percent gradient, with two sections of 8 percent grade adjacent to the powerplant. There is one section of inconsistent geometry at Station 30+500 to 30+600, which will need to be identified with warning signs. The existing roadway has a 6.6 meter (22 feet) to 7.2 meter (24 feet) paved width.

Under the Preferred Alternative, this segment would be rehabilitated and resurfaced to 6.6 meter (22 feet) width with asphalt pavement or asphalt pavement with a chip seal. The typical width of disturbance in this segment would be 9 meters (30 feet). There is an area with severe slope stability problems at Station 31+300 to 31+500; however, this slope would be difficult to stabilize. Approximately 1170 meters (3838 feet) of paved ditch with concrete curb is proposed for this segment. Some existing drainage problems would not be addressed under the Preferred Alternative due to the narrow ditch width in most locations. Also, there would remain insufficient width for snow storage needed for winter maintenance. Approximately 40 meters (131 feet) of new guardrail is proposed for this segment.

Clear Lake

The 0.14 kilometer (0.09 mile) segment is located adjacent to Clear Lake. This location has a narrow (5.5 meters or 18 feet) roadway width and an especially high, steep, and hazardous fill slope adjacent to the roadway just above Clear Lake, at Station 32+300. The grade in this area is 8 percent.

Under the Preferred Alternative, this segment would undergo light reconstruction to achieve a 6.6 meter (22 feet) width with asphalt pavement or asphalt pavement with a chip seal. This entire area is proposed to be widened with MSE retaining wall and protected with additional guardrail for a length of 140 meters (459 feet). There is a slope instability problem at this location; however, this slope would be difficult to stabilize and continued rockfall and raveling of the slope is anticipated to collect in the proposed ditch. Approximately 100 meters (328 feet) of paved ditch with concrete curb is proposed for this segment. Additional rockfall mitigation measures will be evaluated during final design and may be installed on the existing slope if practical. The existing guardrail located on the cut side would be removed, a length of 60 meters (200 feet). The typical width of disturbance for this segment is 12 meters (40 feet). Additional culverts would be installed to improve drainage.

Green Lake

The 1.18 kilometer (0.73 mile) segment of the route from Clear Lake to north of Green Lake averages 3 percent gradient, with a section of 9 percent grade just north of Clear Lake and a section of 8 percent grade north of Green Lake. Along Green Lake the roadway is very close to the steep slopes bordering the lake, which may be considered a hazard. The existing roadway has a 6.6 meter (22 feet) paved width.

Under the Preferred Alternative, this segment would be rehabilitated to a 6.6 meter (22 feet) width with asphalt pavement or asphalt pavement with a chip seal. The typical width of disturbance in this segment would be 9 meters (30 feet). The roadway along Green Lake would remain unprotected under the Preferred Alternative since there is insufficient width to install guardrail. Also, some existing drainage problems would not be addressed under the Preferred Alternative due to the narrow or non-existent ditch width in most locations, and there would remain insufficient width for snow storage needed for winter maintenance. Paved ditches with concrete curb are proposed for approximately 850 meters (2789 feet) of this segment.

Switchbacks

The 0.72 meter (0.45 mile) segment includes two switchbacks and one sharp right-angle curve. The existing paved roadway varies from 4.9 meters (16 feet) to 6.0-meters (20 feet) in width, and is in extremely rough condition. The average grade through this segment is 7.5 percent with several stretches over 8 percent. The upper switchback is tight and requires some belling out to accommodate the design vehicle. The lower switchback has an adequate radius and the roadway would be widened along its existing alignment. Between the two switchbacks the roadway is very narrow with steep, hazardous dropoffs. This area has a northern exposure and is constantly icy and snow-packed in the winter. There is very little existing ditch to handle the drainage or snow storage. There are also several areas where the existing alignment is inconsistent. There are several locations where the existing cut slopes are oversteepened (1:1 or steeper), lack vegetation and are subject to erosion, and frequently slough onto the roadway causing drainage problems. There are few existing culverts, and runoff continually erodes the narrow ditches and roadway, and often flows over the road causing erosion of the fill slopes adjacent the creek.

Under the Preferred Alternative, the road would undergo light reconstruction to achieve a consistent 6.6 meter (22 feet) roadway width and improve the alignment and grade to the minimum proposed standards for 30 km/h or 19 mph. The light reconstruction would closely follow the existing alignment, and the segment would be surfaced with asphalt pavement or asphalt pavement with a chip seal. Four sections of MSE retaining walls are proposed on the downhill side of the road for 454 meters (1,490 feet) in this segment to accommodate the wider roadway. The average height of the MSE walls would be 2.3 meters (7.5 feet). Cut walls are also proposed for approximately 195 meters (640 feet) for this segment. The typical width of disturbance in this segment would be 12 meters (40 feet). Additional culverts would be installed at frequent intervals (typically every 150 meters or 500 feet) to improve drainage. Paved ditches with concrete curb are proposed for 675 meters (2,215 feet) of this segment. There are several high, steep fill slopes adjacent to the existing road which are very hazardous. There is no existing guardrail in this segment. New guardrail is proposed in this segment for a total length of 525 meters (1,722 feet).

South Clear Creek

The 0.38 kilometer (0.24 mile) section of the route from Leavenworth Creek to the upper end of the Georgetown switchbacks (Silverdale area) is generally located adjacent to South Clear Creek on its west bank, and has an average gradient of 6 percent. The existing roadway has a 6.6 meter (22 feet) paved width and a narrow ditch. The segment has numerous sharp curves which will need to be identified with warning signs.

Under the Preferred Alternative, the existing roadway would be rehabilitated and resurfaced to a 6.6 meter (22 feet) width with asphalt pavement or asphalt pavement with a chip seal. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet). Some existing drainage problems would not be addressed due to the narrow ditch width in most locations. Also, there would remain insufficient width for snow storage needed for winter maintenance. The existing ditches and foreslopes are consistently narrow, and grades are relatively steep, and paved ditches with concrete curb are proposed for 225 meters (738 feet). New guardrail is proposed for 35 meters (115 feet) of this segment.

Adjacent to Waldorf Road

The 0.24 kilometer (0.15 mile) segment is located adjacent to Waldorf Road. This location has a narrow (6 meters or 20 feet) roadway width and a narrow or non-existent ditch. The slopes adjacent the downhill side of the road are very high and steep. The grade in this area is over 8 percent. This entire area is proposed to be widened with MSE retaining wall and protected with guardrail.

Under the Preferred Alternative, this segment is proposed to undergo light reconstruction to provide a consistent 6.6 meter (22 feet) roadway width. The light reconstruction would closely follow the existing alignment, and the roadway would be surfaced with asphalt pavement or asphalt pavement with a chip seal. An MSE retaining wall is proposed for the downhill side of the road for 231 meters (758 feet) to accommodate the wider roadway. The approximate average height of the MSE wall would be 2.2 meters (7.5 feet). The typical width of disturbance in this segment would be 12 meters (40 feet). Additional culverts would be installed at frequent intervals to improve drainage. Paved ditches with concrete curb are proposed for most of the length of this segment. There is no existing guardrail in this segment. New guardrail is proposed in this segment for a total length of 245 meters (804 feet).

Silverdale Segment A

The 1.40 kilometer (0.87 mile) section of the route from Waldorf Road to the Georgetown Reservoir Dam (water storage for Public Service Co.) is located adjacent to South Clear Creek on its west bank. The road has an average gradient of 7 percent, and there are several long sections of 9 percent grade. The existing roadway has a 6.6 meter (22 feet) paved width and a narrow ditch. The two Leavenworth Creek switchbacks are adequate for the design vehicle and would remain as they are. The culvert at Leavonworth Creek (Station 35+280) functions poorly and has erosion and sedimentation problems at the inlet and outlet. The existing embankment slopes have become eroded by the stream in the vicinity of Station 36+100, and the elevation of the road is within the stream flood plain at this location.

Under the Preferred Alternative, the existing roadway would be rehabilitated and resurfaced to a 6.6 meter (22 feet) width with asphalt pavement or asphalt pavement with a chip seal. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet). Some existing drainage problems would not be addressed due to the narrow ditch width in most locations. Also, there would remain insufficient width for snow storage needed for winter maintenance. The existing ditches and foreslopes are consistently narrow and grades are relatively steep, and paved ditches with concrete curb are proposed for 980 meters (3,215 feet) of this segment. The existing culvert at Leavonworth Creek would be replaced with a new culvert and designed to address the erosion and sedimentation problems. The embankment slopes in the vicinity of 36+100 would be protected with rock material (riprap) and the road elevation raised approximately 0.6 m (2 feet). Approximately 210 meters (689 feet) of new guardrail is proposed to be installed where there is sufficient existing width. There are several areas with steep fill slopes adjacent to the roadway with no existing guardrail, notably from Station 35+300 to 35+600; however, these areas would remain unprotected since there is insufficient existing width to install guardrail without requiring work to occur outside of the existing roadway.

Silverdale Segment B

The 0.28 kilometer (0.17 mile) section of the route is located just north of the Georgetown Reservoir Dam and is adjacent to South Clear Creek on its west bank. The road has an overall gradient of 9 percent but the south end of the segment has a steep gradient of 12 percent. The existing roadway has a 19.4 to 6.0 meter (18 to 20 feet) paved width, and a narrow ditch. There is one location with relatively inconsistent geometry (Station 36+400 to Station 36+600), which is also in an area of steep grade. The existing embankment slopes have been eroded by the stream in the vicinity of Station 36+300 to 36+500, and the elevation of the road is within the stream flood plain.

Under the Preferred Alternative, this segment is proposed for light reconstruction to provide a consistent 6.6 meter (22 feet) roadway width. The new roadway surfacing would be asphalt or asphalt with a chip seal. The light reconstruction would closely follow the existing alignment with minimal excavation of the cut slopes. The existing eroded slopes adjacent the stream will be repaired and stabilized with rock material (riprap) and the road elevation raised up to 1 meter (3 feet). A section of retaining guard wall (either simulated stone or with natural stone facing) is proposed on the downhill side of the road for approximately 280 meters (919 feet) in this segment to accommodate the wider roadway. The retaining guard walls would be approximately 2 meters

(6 feet) height, not including the traffic barrier. A cut wall, 20 meters (67 feet) in length is also proposed for this segment. The average height of the proposed cut wall is 2 meters (7 feet). The typical width of disturbance would be 12 meters (40 feet). The section of 12 percent grade would be reconstructed to a flatter grade (approximately 9 percent). Due to the confined conditions and steep ditch grade, paved ditches with concrete curb are proposed for most of the length. Additional culverts would be installed at frequent intervals. There is one short (15 meter or 50 feet) location of existing guardrail adjacent the cut slope at 34+420, which protects a water pipeline, otherwise there is no existing guardrail in this segment. Approximately 20 meters (60 feet) of new guardrail is proposed at this same location.

Silverdale Segment C

The 0.60 kilometer (0.37 mile) section of the route from Waldorf Road to the upper end of the Georgetown switchbacks (Silverdale area) is located adjacent to South Clear Creek on its west bank, and has an average gradient of 6 percent. The existing roadway has a 6.6 meter (22 feet) paved width, and a narrow ditch.

Under the Preferred Alternative, the existing roadway would be rehabilitated and resurfaced to a 6.6 meter (22 feet) width with asphalt pavement or asphalt pavement with a chip seal. The typical width of disturbance would be 9 meters (30 feet). Some existing drainage problems would not be addressed due to the narrow ditch width in most locations. Also, there would remain insufficient width for snow storage needed for winter maintenance. The existing ditches and foreslopes are consistently narrow and grades are relatively steep, and paved ditches with concrete curb are proposed for 220 meters (721 feet) of this segment. There are several areas with steep and hazardous fill slopes adjacent to the roadway. Several existing steep fill slopes adjacent to the roadway from Station 36+600 to 36+750 would remain unprotected since there is insufficient existing width to install guardrail without narrowing the roadway. A cut wall is also proposed for this segment. The cut wall is proposed to be 40 meters (131 feet) in length with an average height of 1.2 meters (4 feet).

Georgetown Switchbacks (GS) Segment A

The 0.89 kilometer (0.55-mile) segment descends steeply from the Silverdale area through the uppermost (4th) switchback above Georgetown to a pullout between the 3rd and 4th switchbacks. The average grade through this area is 8 percent, with a grade of over 9 percent between the 3rd and 4th switchbacks. The terrain adjacent the road is very steep with 1:2 slopes. This area was the site of a fatal accident within the last 2 years, when a vehicle left the roadway. The existing paved roadway varies in width from 5.5 to 6.0 meters (18 to 20 feet). The existing cut slopes are 4 to 8 meters (13 to 26 feet) high and are oversteepened and have not fully revegetated. There are several locations where the existing cut slopes are oversteepened (1:1 or steeper), lack vegetation and are subject to erosion, and ravel onto the roadway causing drainage problems. Most of the existing fill slopes are very steep and hazardous, and the edge of the road is being lost to erosion. There are few existing culverts and runoff continually erodes the narrow ditches and roadway, and often flows over the road causing erosion of the fill slopes. The 4th switchback is too tight to safely accommodate the design vehicle (Class C recreational vehicle).

Under the Preferred Alternative, this segment is proposed for light reconstruction to provide a consistent 6.6 meter (22 feet) roadway width. The new roadway surfacing would be asphalt or asphalt with a chip seal. The light reconstruction would closely follow the existing alignment and grade with minimal excavation of the cut slopes. The 4th switchback is proposed to be belled out approximately 3 meters (10 feet). A new cut slope at the beginning of the segment (station 7+260) would be laid back at a 1:2 slope in for approximately 30 meters (100 feet) length. The existing oversteepened cut slopes will be stabilized and repaired where possible, using extensive revegetation techniques. Three sections of retaining/guard walls (either simulated stone or with natural stone facing) are proposed on the downhill side of the road for approximately 720 meters (2,362 feet) in this segment to accommodate the wider roadway. The average height of the retaining walls would be 2 meters (6 feet), not including the traffic barrier. One of the retaining/guard walls is proposed to retain the fill slope at the 4th switchback. The typical width of disturbance would be 12 meters (40 feet) in concrete wall areas and 20 meters (60 feet) in the area of new cut slopes. Extensive revegetation work including placement of topsoil, native seed, mulch, container stock - native trees and shrubs would be provided on the downhill slopes adjacent the retaining walls. Additional culverts would be installed at frequent intervals (typically every 150 meters or 500 feet) to improve drainage. Paved ditches with concrete curb are proposed for 995 meters (3264 feet) of this segment. There are high steep fill slopes adjacent to the existing road, which are especially hazardous. Masonry faced guardwalls are proposed instead of metal guardrail and will be installed where the retaining walls are constructed. As a result, three sections of guardwall are proposed for a total length of approximately 720 meters (2,362 feet). A paved pullout for 3-4 cars is proposed between the 3rd and 4th switchback.

GS Segment B

The 0.29 kilometer (0.15 mile) section of the route is located from the pullout between the 3rd and 4th switchbacks to the 3rd switchback above Georgetown. The existing roadway has a 6.6 meter (22 feet) paved width, a narrow ditch, and an average gradient of over 9 percent.

Under the Preferred Alternative, the existing roadway would be rehabilitated and resurfaced to a 6.6 meter (22 feet) width with asphalt pavement or asphalt pavement with a chip seal. The typical width of disturbance would be 8 to 9 meters (26 to 30 feet). Some existing drainage problems would not be fully addressed due to the narrow ditch width in most locations. Also, there would remain insufficient width for snow storage needed for winter maintenance. The existing ditches and foreslopes are consistently narrow and grades are relatively steep, and paved ditches with concrete curb are proposed for the entire length of the segment.

GS Segment C

The 0.34 kilometer (0.21 mile) segment descends steeply between the 3rd and 4th switchbacks above Georgetown. The average grade through this area is 9 percent. The terrain adjacent the road is very steep with 1:2 (vertical:horizontal) slopes. The existing paved roadway varies in width from 4.9 to 6.0 meters (16 to 20 feet). The existing cut slopes are 4 to 8 meters (13 to 26 feet) high and are oversteepened and have not fully revegetated. There are several locations where the existing cut slopes are oversteepened (1:1 or steeper) which lack vegetation and are subject to erosion, and ravel onto the roadway causing drainage problems. Most of the existing fill slopes are very steep and hazardous, and the edge of the road is being lost to erosion. There are few existing culverts and runoff continually erodes the narrow ditches and roadway, and often flows over the road causing erosion of the fill slopes.

Under the Preferred Alternative, this segment of road would undergo light reconstruction to provide a consistent 6.6 meter (22 feet) roadway width. The new roadway surfacing would be asphalt or asphalt with a chip seal. The light reconstruction would closely follow the existing alignment and grade with minimal excavation of the cut slopes. The existing oversteepened cut slopes will be stabilized and repaired where possible, using extensive revegetation techniques. To avoid exacerbating the existing steep cut slopes, a section of cut side walls, 1 to 2 meters (3 to 6 feet) high for a total length of approximately 29 meters (95 feet), is proposed. The exterior facing of the cut side wall would consist of dry stacked stone masonry. A section of retaining/guard wall (either simulated stone or with natural stone facing) is proposed on the downhill side of the road for approximately 295 meters (968 feet) in this segment to accommodate the wider roadway. The retaining/guard wall would be 1 to 2 meters (3 to 6 feet) in height, not including the traffic barrier. The typical width of disturbance would be 12 meters (40 feet). Extensive revegetation work including placement of topsoil, seed, mulch, container stock - native trees and shrubs will be provided on the downhill slopes adjacent the retaining walls. Additional culverts would be installed at frequent intervals to improve drainage. Paved ditches with concrete curb are proposed for 305 meters (1001 feet) of this segment.

GS Segment D

The 0.16 kilometer (0.10 mile) section of the route is located from a point between the 2nd and 3rd switchbacks to the 2nd switchback above Georgetown. The existing roadway has a 6.6 meter (22 feet) paved width, and a narrow ditch, and has an average gradient of 9 percent. The 2nd switchback is adequate for the design vehicle.

Under the Preferred Alternative, the existing roadway would be rehabilitated and resurfaced to a 6.6 meter (22 feet) width with asphalt pavement or asphalt pavement with a chip seal Two sections of retaining wall (either simulated stone or with natural stone facing) is proposed for the downhill side of the road for approximately 105 meters (345 feet) in this segment to accommodate the wider roadway. The retaining wall would be 1 to 2 meters (3 to 6 feet) in height not including the traffic barrier. The typical width of disturbance would be 12 meters (40 feet). Extensive revegetation work including placement of topsoil, seed, mulch, and container stock (native trees and shrubs) will be provided on the downhill slopes adjacent to the retaining walls. Some existing drainage problems would not be fully addressed due to the narrow ditch width in most locations. Also, there would remain insufficient width for snow storage needed for winter maintenance. The existing ditches and foreslopes are consistently narrow and grades are relatively steep, and paved ditches with concrete curb are proposed for 110 meters (361 feet) of the segment.

GS Segment E

The 0.40 kilometer (0.25 mile) segment descends steeply from the 2nd switchback above Georgetown to the end of the route at 2nd and Rose Streets. The average grade through this area is 8 percent. The terrain adjacent the road is very steep with 1:2 slopes. The existing paved roadway is 6 meters (20 feet) width. The existing cut slopes are 4 to 8 meters (13 to 26 feet) high and are oversteepened and have not fully revegetated. There are several locations where the existing cut slopes are oversteepened (1:1 or steeper) which lack vegetation and are subject to erosion, and ravel onto the roadway causing drainage problems. Most of the existing fill slopes are very steep and hazardous, and the edge of the road is being lost to erosion. There are few existing culverts and runoff continually erodes the narrow ditches and roadway, and often flows over the road causing erosion of the fill slopes.

Under the Preferred Alternative, this segment would undergo light reconstruction to provide a consistent 6.6 meter (22 feet) roadway width. The new roadway surfacing would be asphalt or asphalt with a chip seal. The light reconstruction would closely follow the existing alignment and grade with minimal excavation of the cut slopes, except just above the 1st switchback. The existing oversteepened cut slopes will be stabilized and repaired where possible, using extensive revegetation techniques. To avoid exacerbating the existing steep cut slopes, one section of a cut side wall, with an average height of 2 meters (6 feet) high for a total length of approximately 70 meters (230 feet), is proposed. The exterior facing of the cut side wall would consist of dry stacked stone masonry. One section of retaining wall (either simulated stone or with natural stone facing) is proposed on the downhill side of the road for approximately 20 meters (66 feet) in this segment to accommodate the wider roadway. The retaining wall would be 2 to 3 meters (6 to 10 feet) height, not including the traffic barrier. The typical width of disturbance would be 12 meters (40 feet). Extensive revegetation work including placement of topsoil, native seed, mulch, container stock - native trees and shrubs would be provided on the downhill slopes adjacent the retaining walls. Additional culverts would be installed at frequent intervals to improve drainage. Paved ditches with concrete curb are proposed for 345 meters (1,132 feet) of this segment.

Rose Street

A connection will be made to match the existing roadway at Rose Street in Georgetown. The existing roadway is paved and is approximately 6.0 meters (20 feet) wide. The drainage along Rose Street is inadequate, as there is little roadside ditch. Drainage improvements may be made to the connection, probably through the use of a curb and gutter system.

Caveat

In providing less reconstruction and more rehabilitation under the Preferred Alternative, the cooperating agencies acknowledge that the safety and long-term performance of that portion of the road is compromised. A tradeoff in safety enhancement results from simply rehabilitating portions of the road instead of reconstructing, primarily as a result of less modification to the road geometry (horizontal and vertical alignment) and adjacent roadside. There is also some tradeoff in the desired long-term service life, primarily as a result of the reduced roadway structural capacity that can be provided under rehabilitation versus reconstruction, and less improvement to the ditches and foreslopes than is desired to optimally convey drainage and support the road surface. For example, there are some locations where additional ditch-relief culverts are needed but there is insufficient width for a standard metal end section installation, so it would be necessary to use less effective drop inlets under rehabilitation. There may also be some locations where there is insufficient cover to provide a single pipe to optimally convey the design discharge, and multiple smaller pipes may need to be substituted under rehabilitation versus reconstruction.

Safety and Liability

The over-riding engineering consideration when performing a roadway improvement is the safety of the improved road for the traveling public. A risk is involved in designing and implementing a highway construction project. If improvements are made as part of a Federal action, then safety has to be designed into the project. To not do so would create a liability for both the engineer and the owner of the facility. After careful analysis of the safety risks involved, the FHWA, FS, and CDOT believe that the improvements included under the Preferred Alternative represent the minimum design standards and criteria applicable for the Guanella Pass Road. These agencies must consider the accountability for the safety risk to the public, risk of investment of funds in repairs with potentially short service life, potential liability of unaddressed hazardous conditions, and potential liability for the maintaining agency (i.e., leaving too many unaddressed operational issues and maintenance problems). Although increased safety risks can sometimes be partially mitigated, any requirements for selection of alternatives which deviate from established design guidelines must be fully justified and detailed by the originator of the decision. It is important that the reason and necessity for any design exception are documented, including the party responsible for the decision, in the event of future tort claims based on allegations of defective design.

Definitions of Cross-Section Elements

Barrier Offset - The lateral distance from the outside edge of shoulder to the face of the roadside barrier.

Base - The layer, or layers, of specified or selected material of designed thickness placed on a subbase or a subgrade to support a surface course.

Centerline - For a two-lane highway the centerline is the middle of the traveled way, and for a divided highway the centerline may be the center of the median. For a divided highway with independent roadways, each roadway has its own centerline.

Cross Section - The transverse profile of a road showing horizontal and vertical dimensions.

Cutslope - In excavation sections, the roadway side slope from the bottom of the ditch to the top of the cut. Also known as backslope.

Ditch - A long narrow trench used to transport water. Located at the bottom of cuts.

Ditch Foreslope - The slope from the edge of the subgrade to the bottom of the ditch in cuts.

Embankment - A raised earth structure on which the roadway pavement structure is placed.

Excavation - (1) The act of taking out material. (2) The materials taken out. (3) The cavity remaining after materials have been removed.

Fillslope - In embankment sections, the roadway side slopes from the edge of the subgrade to the existing ground.

Off-tracking - The width of tracking of the vehicle's rear wheels beyond the track of the front wheels, when negotiating a curve.

Original Ground - The existing ground surface present prior to construction.

Pavement Structure - The combination of subbase, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.

Roadside - The area between the outside shoulder edge and the right-of-way limits, or clearing limits. The area between roadways of a divided highway may also be considered roadside.

Roadside Barrier - A longitudinal barrier used to shield roadside obstacles or non-traversable terrain features.

Roadway - The portion of a highway, including shoulders, for vehicular use. (A divided highway has two or more roadways.)

Rounding - The removal of the angle where cut and fill slopes intersect the natural ground, and the substitution of a gradual transition, or rounded surface.

Seasonal ADT (SADT) - The average daily traffic (ADT) over a specified portion of the year.

Shoulder - The portion of the roadway contiguous to the traveled way for accommodation of stopped vehicles, for emergency use, for support of the travel lanes, for lateral support of base and surface edges, and for extension of drainage away from the travel lanes.

Side Slopes - Slopes along the side of the roadway identified by their distance from the traveled way, their slope rate, and their height.

Subbase - The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base course.

Subgrade - The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.

Surface Course - One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and the disintegrating effects of climate. The top layer is sometimes called *wearing course*.

Surfacing Foreslope - The slope from the edge of the surfaced shoulder to the top of the subgrade.

Traveled Way - The portion of the roadway for the movement of vehicles, exclusive of shoulders.

Travel Lane - The portion of the roadway designated for a single line of vehicles traveling in the same direction, excluding shoulders.