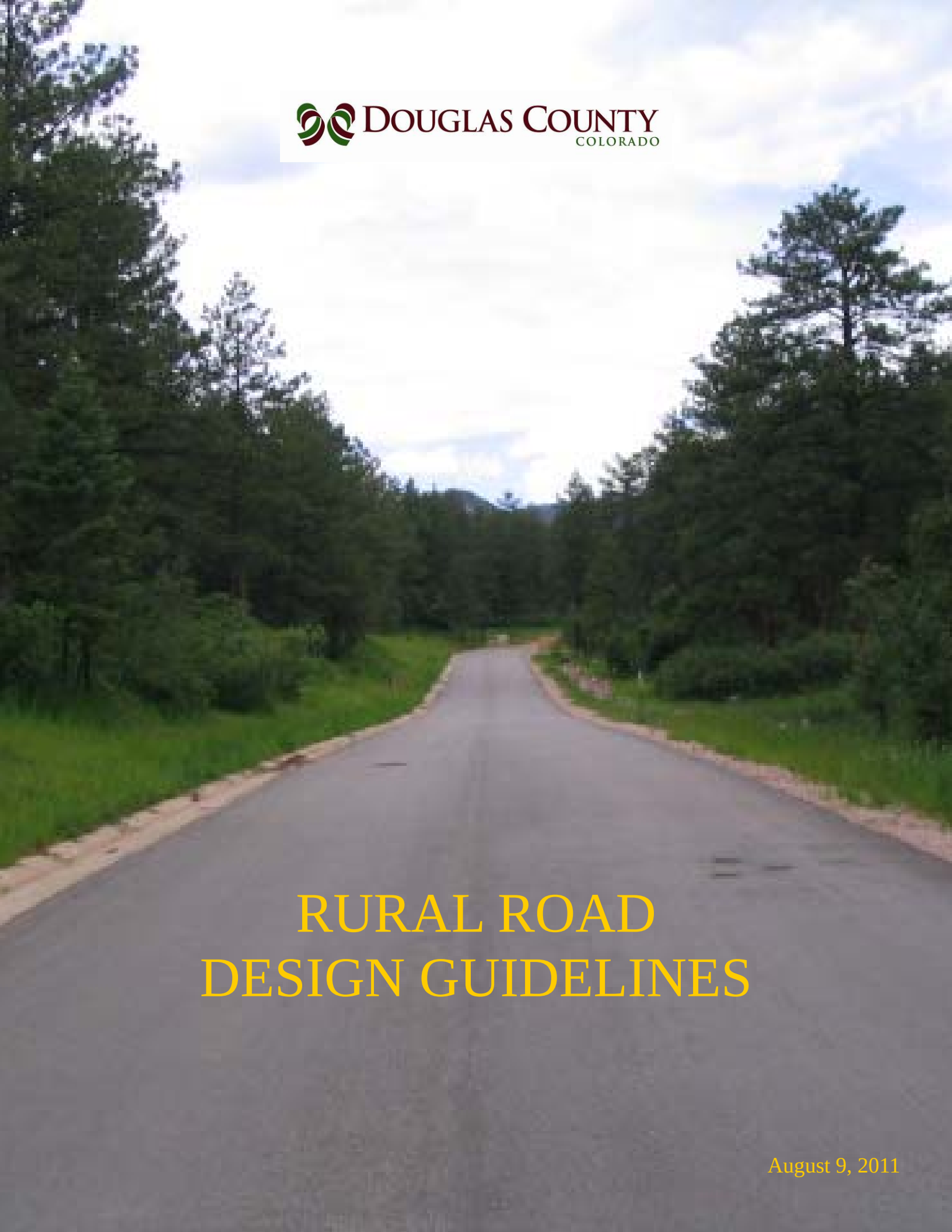


DOUGLAS COUNTY
COLORADO

RURAL ROAD DESIGN GUIDELINES

August 9, 2011

Rural Road Design Guidelines

The rural areas of the County (including open space) account for approximately 83% of the total land area of the County. Although the majority of the population lives in the urban areas of the County, there is still a vast roadway network which serves the rural parts of the County. As the County grows, the majority of that growth will occur in urban designated areas, however, it is anticipated that the rural parts of the County will continue to be developed with large lot residential, churches, schools, fire stations and other uses as allowed by the *Douglas County Zoning Resolution*. As development within the rural parts of the County occurs, it creates the need for certain infrastructure improvements such as utilities (gas, electric, sewer, water, etc.), stormwater conveyance elements (culverts, inlets, storm sewer, ditches, etc.) and roads. The purpose of this document is to outline Best Management Practices (BMP's) and guidelines related to design, construction and maintenance of rural roads in the County.

Avoid locating roads along the base of slopes and sides of hills

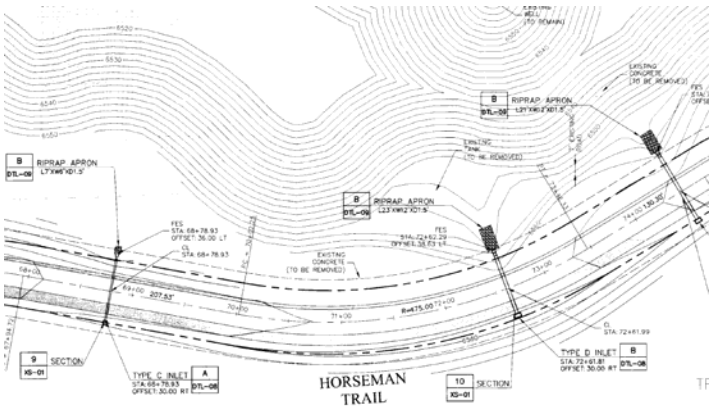
Where possible, avoid locating roads along the base of slopes and sides of hills. This will drastically reduce the costs associated with stormwater conveyance. This practice reduces or eliminates the need for ditch and culvert construction. Since the road will be located on or near the top of a basin, the stormwater runoff will sheet flow off the road down both sides of the hill until it reaches a natural drainageway, as opposed to being collected at the roadside and conveyed to a point discharge location which can

lead to relatively expensive stormwater improvements (culverts, inlets, storm sewer, ditches, etc.).

This practice is also better from a water quality standpoint, as compared to standard roadside ditch or storm sewer construction, assuming the design and construction is done correctly. As mentioned above, the stormwater flows are not collected at the roadside, which reduces stormwater concentration and point discharges, both of which can create erosion problems. Also, as the stormwater sheet flows down the hillsides, the vegetation on those hillsides filters pollutants from the water before it reaches the drainageway.

Another benefit of using this practice is the minimal disturbance to the existing land. Since there would be a limited cut or fill section for the road, the only earthwork required would be creating a bench for the road, possible over-excavation for soil mitigation and transitions from the edge of the new roadside grade to existing grade (i.e. catching grade). The longitudinal grade of the roads may need to be adjusted to minimize cuts and fills and the attendant land disturbance.

Frequently divert stormwater flows from the cut side of the roadway to the fill side



Frequently diverting stormwater flows from the cut side of the roadway to the fill side of the roadway, for a road designed with roadside ditches, is a great way to reduce the amount of stormwater carried in the cut side roadside ditch. Douglas County criteria has maximum depths for ditch conveyance for the minor and major storm design, which relates more to the impact the stormwater flows have on the roads ability to carry vehicular traffic and not the ditches ability to remain stable during these storms. Reducing flow rates and velocities, along with incorporating appropriate ditch stabilization measures and establishing vegetation, are the key to creating stable ditches. At a minimum, the ditches should be designed to meet the County criteria mentioned above; however, designing a smaller secondary drainage system to frequently divert stormwater flows will minimize the concentrated stormwater flows in the cut side roadside ditch. Once the stormwater flows reach the fill side of the road, it is suggested to use a level-spreader with appropriate outlet protection to return the flows to their more natural condition as soon as possible. This approach to ditch design will reduce what would normally be a large amount of flow concentrated at one drainage crossing, and return stormwater to its natural flow path as soon as possible, which minimizes the changes to historic flow patterns.

Consider using existing ranch roads as a starting point

If existing ranch roads are present, they can be a great place to start with the initial layout of the road system. The reason many of these ranch roads are still in existence, or at least traces of them, is because the historic users of the ranch sited the roads such that minimal maintenance would be required for upkeep of the roads. Existing ranch roads often have adequate horizontal curves, avoid relatively steep slopes and are located away from drainageways, hillsides, rock outcroppings, etc. An existing ranch road also creates a good bench for the new roadway to be placed on, which minimizes the disturbance to the existing land. Also, where a ranch road traverses a treed area, much of the tree clearing has already been done.

Maintain the crown of the roadway and keep culverts clear of debris and sediment

One of the most important factors in long-term stability of a roadway is maintaining the roadway drainage system, assuming the roadway was designed and constructed correctly to begin with. Proper maintenance of the roadway drainage system entails preserving the proper crown on the roadway (2%-4%), keeping the culverts clear of debris and sediment and reestablishing the original design characteristics of the roadside ditch (backslope, foreslope, bottom width, etc.).

While maintaining the proper crown on a paved roadway takes little to no effort, the same cannot be said about a gravel road. Preserving the proper crown on a gravel road can involve infrequent maintenance (once every two years) or very frequent maintenance (numerous times a year), depending on the amount and type of traffic using the gravel road, the original design and construction of the road and other factors, such as weather. A motor grader operator can

reshape a gravel road relatively easy, however, if the operator has little experience in maintaining a gravel road, there are several mistakes that can be made which will negatively impact the roads ability to carry traffic and handle drainage. Maintaining a proper crown on the road assures that water will be carried off the road surface to the roadside drainage conveyance element, which is vital in reducing washboarding, potholing and standing water.

Another important part of maintaining a roadways drainage system is keeping the culverts and inlets clear of debris and sediment. Much like the roadside ditch, the culverts and inlets were designed to carry a certain amount of stormwater flow, and as the capacity of the culverts/inlets are reduced by clogging with debris and sediment, so is the ability for the overall stormwater system to adequately convey flows away from the road.

Maintaining the original design characteristics of the roadside ditch is another important part of the on-going functionality of the road. Sediment and debris build-up in a roadside ditch can change numerous characteristics of the roadside ditch (grade, slopes, widths, etc.). If the roadside ditch is not maintained correctly, low spots can occur which hold water, grade of the ditch can increase which increases the potential for erosion and capacity can be reduced which may create increased flooding of the roadway. Another important factor in roadside ditch construction and maintenance is the establishment and preservation of vegetation. Vegetation helps bind soil particles together which helps the soil stabilization of the ditch. This reduces sediment transport and creates a filter for the stormwater which benefits water quality.

Appropriate use of curb and gutter can reduce cost and land disturbance

Curb and gutter is identified in Douglas County criteria as one alternative for roadside drainage conveyance in the rural areas. While many people don't view curb and gutter as looking very "rural", it can serve an important purpose in roadway design in the rural parts of the County.

There are two main reasons why curb and gutter can be useful in the rural parts of the County: cost savings and reduced land disturbance.

Where the lay of the land forces roads to be designed with steeper slopes, roadside ditch stabilization can become very costly. Some of the ditch stabilization measures include riprap lining of the ditch, drop structures and check structures. Depending on the design velocities and Froude number of the stormwater flowing in the ditch, the above-mentioned stabilization measures can become very costly. Where a curb and gutter is used, these stabilization measures are not needed. In many instances, curb and gutter is less expensive to build than the improvements needed to properly stabilize a roadside ditch. If it has been identified that curb and gutter is a less expensive alternative to ditch stabilization, it is not necessary to construct curb and gutter throughout the entire development. It is suggested that curb and gutter be used in lieu of roadside ditch where cost savings will be realized. Where it is more economical to construct roadside ditch, the curb and gutter section can be transitioned to a roadside ditch section. The use of curb and gutter also eliminates the need to construct culverts at driveway locations. It should be noted that the use of curb and gutter may require additional stormwater infrastructure such as inlets, storm sewer, manholes, etc, but in many instances this will not be necessary. It is suggested that the design engineer compare costs between using roadside ditch, curb and gutter or a combination of the two.

Another benefit to using curb and gutter is a possible reduction in land disturbance. In the flat, open areas of the County, the use of curb and gutter will reduce land disturbance by a minimal amount (typically the difference between the extra width needed for a roadside ditch vs. curb and gutter). However, where topography requires a fair amount of cuts and fills to construct the road, the reduction in land disturbance by using curb and gutter can be quite substantial. Because a road section using curb and gutter requires less width (approximately 40') than a road section using a roadside ditch (approximately 60'), the tie-in to existing grade occurs much quicker which obviously reduces the amount of land disturbance. The use of curb and gutter in heavily treed areas is beneficial for the same reasons. It is suggested that curb and gutter be considered in lieu of roadside ditch where a substantial reduction in land disturbance will be realized.