Chokecherry and Sierra Madre Wind Energy Project

Road Design Manual

Prepared for

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1.0 INTRODUCTION

Power Company of Wyoming LLC (PCW) proposes to construct, operate, maintain and decommission the Chokecherry and Sierra Madre Wind Energy Project (CCSM Project), located in Carbon County, Wyoming. The CCSM Project consists of up to 1,000 wind turbines capable of generating approximately 2,000 to 3,000 megawatts (MW) of clean, renewable wind energy. The primary components of the CCSM Project include the wind turbine generators, an internal road network, a rail facility, a quarry, an internal electrical collection and transmission system, substations, and operations and maintenance buildings.

The CCSM Project is located south of the city of Rawlins, primarily within the bounds of the Overland Trail Ranch (Ranch). The Ranch is owned and operated by PCW affiliate, The Overland Trail Cattle Company LLC (TOTCO). The Ranch is situated within an area of alternating sections of private and Federal lands commonly referred to as the "checkerboard." The vast majority of the private lands are owned by TOTCO and the Federal lands are administered by the Bureau of Land Management (BLM) Rawlins Field Office (RFO). A small percentage of the land within the Ranch is owned by the State of Wyoming and is administered by the State Board of Land Commissioners. Finally, Anadarko Land Corporation owns some sections located on the periphery of the northwest boundary of the Ranch.

In 2008, PCW applied to BLM for right-of-way grants to construct, operate, maintain and decommission the CCSM Project on Federal land within the CCSM Project Area. On June 29, 2012, the Notice of Availability for the Final EIS concerning the CCSM Project was published in the Federal Register (77 FR 63328). On October 9, 2012 the Secretary of the Interior signed the Record of Decision (ROD). In the ROD, BLM determined that over 200,000 acres within the CCSM Project Area are suitable for wind energy development subject to the requirements described under the Selected Alternative in the ROD. The area that was determined to be suitable for wind energy development consists of two wind development areas (WDAs) in which turbines would be located. The northern WDA is known as Chokecherry and the southern WDA is known as Sierra Madre. The WDAs are located approximately 9 miles apart.

Prior to issuing right-of-way grants for the CCSM Project, BLM will conduct subsequent environmental analysis of site-specific plans of development submitted by PCW. The site-specific plans of development will be screened against the analysis conducted in the EIS and the requirements described under the Selected Alternative in the ROD. PCW anticipates submitting five (5) site-specific plans of development to BLM, consisting of the following:

1. Phase I Haul Road and Facilities
2. West Sinclair Rail Facility
3. Road Rock Quarry
4. Phase I Wind Development
5. Phase II Wind Development (including Phase II Haul Road and Facilities)

A common element in each site-specific plan of development is establishment of the roads necessary to access each CCSM Project component. Roads are a critical element of the CCSM Project; therefore, PCW has created this Road Design Manual (Manual) to provide a single reference on the design features and requirements of the CCSM Project Roads. All roads constructed for the CCSM Project will meet the applicable requirements of the BLM Gold Book (BLM 2007), BLM Manual 9112: Bridges and Major Culverts (BLM 2009), and BLM Manual 9113: Roads (BLM 1985; BLM 2011).

2.0 ROAD DESIGN REQUIREMENTS

PCW developed design criteria for the CCSM Project roads based on BLM design guidance and the CCSM Project requirements. PCW used the BLM road classifications as the starting basis for the CCSM Project's road classifications, but tailored each CCSM Project road classification to meet the specific needs of the project. Table 1 summarizes the final design criteria established for each CCSM Project road class.

2.1 BLM ROAD DESIGN GUIDANCE

PCW initially consulted the BLM Gold Book (BLM 2007) and BLM Manual 9113 (BLM 1985; BLM 2011) for guidance on road design on federal lands. The BLM Gold Book is specifically designed for use in oil and gas development; however, it does provide additional guidance and clarification. Together the BLM manuals establish guidance for three primary classes of roads on federal lands. The road classes established by BLM in the guidance are as follows:

- **BLM Collector Roads:** double lane roads with a travelway of 20 to 24 feet serving large land areas. BLM collector roads are designed to be major access routes into major development areas.

- **BLM Local Roads:** single or double lane roads with a travelway of 12 to 24 feet (travelway minimum width is 24 feet for double lane roads) providing access to large areas and for various uses. BLM local roads connect collect traffic from BLM resource roads.

- **BLM Resource Roads:** low volume, single lane roads with a travelway of 12 to 14 feet (preferred travelway width is 14 feet) connected to terminal facilities such as wells.

Table 1. Road Design Parameters

Design Criteria		Haul Road	Arterial Road	Turbine and Facility Roads	Structure Road
BLM Classification Basis		Collector Road	Local Road	Resource Road	Resource Road
Preferred Design Speed[1]		40 mph	20 mph	20 mph	20 mph
Road Width - Permanent		40 feet	24 feet	16 feet	12 feet
Temporary Shoulder Width (both sides) – Construction Stage Only		N/A	6 feet (12 feet total)	10 feet (20 feet total)	0
Tangent Length Between Hor. Curves (min)		140 feet	140 feet	140 feet	N/A
Design Road Profile Grades		0%(min) 10% (max)	0%(min) 16% (max)	0%(min) 16% (max)	0%(min) 16% (max)[2]
Culvert/Water Crossing Design (storm event)		10-25 year	10-25 year	10 year	10 year
Allowable Deflection		6 inches in 50 feet	6 inches in 50 feet	6 inches in 50 feet	N/A
Horizontal Curves (Centerline) (min)		750 feet	300 feet	150 feet	50 feet
Intersection Turning Radius (Edge of Traveled way) (min)		135 feet	135 feet	135 feet	N/A
Tangent Length Between Vertical Curves (min)		100 feet	50 feet	50 feet	0 feet
Vertical Curve Length (min)		100 feet	50 feet	50 feet	25 feet
K-Value (min)	Crest	30	20	12.5	12.5
	Sag	30	20	12.5	12.5
Roadway crown		1% (min) 3% (max)	1% (min) 3% (max)	1%	3%
Roadway cross slope (continuous)		1% (min) 3% (max)	1% (min) 3% (max)	1%	3%
Roadway cross slope (superelevations) (max)		6%	6%	N/A	N/A

[1]The design speeds were adjusted in some locations to accommodate the requirements of crane travel. PCW will post reduced speed limits where necessary.
[2]Locations that exceed the design maximum grade are indicated on the Issued for Permit Plans
max maximum
min minimum
mph miles per hour
N/A not applicable

2.2 CCSM PROJECT REQUIREMENTS

The access roads throughout the CCSM Project Site can be broken down into five general classifications based on the types of traffic and the frequency of use expected. PCW used the BLM road classes as a starting point to develop the design criteria for each CCSM Project road classification. Design criteria were finalized based on anticipated traffic volumes and the CCSM Project load types and schedule requirements. While each road classification has a design speed, as indicated below, in some instances the design speeds may not be achievable due to conflicting design requirements (e.g. due to allowances for both vehicle and crane travel). Appropriate speed limits for each road will be established based on the actual design speed achieved.

1. **Haul Roads:** [*Based on BLM Collector Roads*] Haul class roads are the primary heavy haul routes throughout the CCSM Project, connecting the rail facility, quarry, and laydown yards with the wind development areas. These roads must accommodate 40 mph traffic while allowing for two-way truck passing due to the expected traffic volumes and overall construction schedule requirements.
2. **Arterial Roads:** [*Based on BLM Local Roads*] These roads provide access from haul class roads into wind development areas. Two-way truck traffic is still required; however, the passing speed can be greatly reduced. Overall, arterial roads still have a minimum design speed requirement of 20 mph to accommodate the traffic levels associated with the CCSM Project construction schedule. Arterial roads must also accommodate crane travel and compacted shoulders are planned to achieve adequate width.
3. **Turbine and Facility Roads:** [*Based on BLM Resource Roads*] Any turbines or facilities not directly on the haul or arterial-class roads still require an all-weather access road. The turbine and facility class roads must accommodate turbine component deliveries and significant traffic volumes over short durations. As most of these roads will provide access to wind turbines, they must also be designed to accommodate crane travel using compacted shoulders to achieve adequate width. These roads are designed to allow for two-way pick-up truck traffic at 20 mph; for large delivery trucks, however, passing may require turn-outs in complex terrain.
4. **Structure Roads:** [*Based on BLM Resource Roads*] The construction of the CCSM Project electrical system structures (overhead transmission and select collection line structures) requires access roads for the delivery of large components, assembly of these components using a rough-terrain crane, and all-weather access during operations. While structure class roads are also based on BLM resource roads, there are no minimum speeds required; therefore, structure class roads can be narrower than turbine and facility class roads.
5. **Unimproved Access Routes:** A few elements of the CCSM Project (notably the overhead collection line poles) require construction access by light duty vehicles and infrequent access during operations. For these elements, PCW will endeavor to use existing ranch two-track roads as-is or with minimal improvement. Where two-track roads do not exist and topography, soil, and vegetation conditions allow, PCW may establish unimproved vehicle access routes. These unimproved access routes will be clearly marked using t-posts to contain activity within the route; however, no vegetation

will be removed and grading will not be performed. If site conditions do not allow for an unimproved access route, PCW will build structure roads instead.

2.3 FINAL DESIGN CRITERIA

The following sections describe each road classification in more detail, including how the BLM road guidance was adjusted to meet the specific needs of the CCSM Project.

2.3.1 Haul Roads

Haul roads are designed to allow for two-way semi-truck traffic and to safely accommodate high traffic volumes. PCW utilized the BLM Collector Road designation as the basis of the haul road classification. However, due to the CCSM Project-specific traffic types and volumes, PCW determined it was necessary to expand the driving surface width from 24 feet to 40 feet. Specifically this expanded width is required to meet the high traffic volume and to allow for two-way passing of superload component delivery trucks at the design speed of 40 mph while maintaining acceptable levels of safety. The 8 foot shoulders on each side of the travelway, along with 4:1 safety slopes, create the recovery zone for vehicles that leave the travelway as defined by the AASHTO Roadside Design Guide (ASSHTO 2011) and the Wyoming Department of Transportation (WyDOT) Road Design Manual (WyDOT 2011, Section 3-02 Cross Sectional Elements). Without the 8 foot shoulders more disturbance would be needed from the edge of the road to the back slope of the ditch to provide an equal recovery zone. The increased overall width of the haul roads allows disabled vehicles to stop off the travelway and two way traffic to safely pass the disabled vehicle at a reduced speed. Similarly, due to the high volume of traffic on haul roads, increased maintenance (watering for dust control and blading of aggregate surfacing) of the haul road will be required and the wider overall road width will allow traffic to pass maintenance activities more safely.

Figure 1 shows examples of wind energy project haul roads similar to the CCSM Project haul class roads.

Figure 1. Example Wind Energy Project Haul Roads

2.3.2 Arterial Roads

The purpose of the arterial class roads is to provide access to large areas of turbines. This purpose aligns well with the purpose of the BLM local roads; therefore, PCW based the design of the arterial roads on the BLM local road specifications. The aggregate driving surface width of the arterial roads was set to 24 feet to match the preferred double lane travelway width specified in BLM Manual 9113 (BLM 1985; BLM 2011) for the collector-class roads. In addition to the aggregate driving surface, PCW will install temporary shoulders out of compacted native material for road segments where crane travel is required. Following construction of the CCSM Project, the temporary shoulders will be reclaimed.

2.3.3 Turbine and Facility Roads

Based on the relatively short period in which turbine and facility roads will see high traffic followed by years of lower traffic levels, PCW elected to base the design of these roads on the BLM resource roads. This classification allows for more flexibility to traverse complex terrain by utilizing steeper slopes and tighter turns; however, to align with turbine manufacturer transportation specifications for component deliveries, PCW increased the aggregate driving surface width to 16 feet. As with the arterial roads, in addition to the aggregate driving surface, PCW will install temporary shoulders out of compacted native material as needed to accommodate crane travel and safe two-way passage for construction vehicles. At the conclusion of CCSM Project construction, the compacted shoulders will be reclaimed.

2.3.4 Structure Roads

Structure class roads have been designed based on the BLM resource roads. Structure roads are required to construct the transmission line structures and provide access to the structures for maintenance. Traffic estimates during construction are expected to be high only when construction of the structure is occurring and minimal at other times during construction and operations. Structure class road horizontal designs attempt to minimize effects to drainages, slopes, and highly vegetated areas while also minimizing the overall disturbance footprint. The vertical design of structure class roads generally follows the existing terrain with earthwork required only to grade localized highpoints and low points. A 12 foot road surface width was selected for structure class roads to meet the requirements of construction and operations traffic and minimize the long term disturbance of the roads. Where practicable, structure class roads were routed on existing unimproved ranch roads or other previously disturbed areas. Large track crane travel is not anticipated along these roads so temporary crane shoulders are not required for structure class roads.

2.3.5 Unimproved Access Routes

Unimproved access routes are not intended to be improved and thus do not have specific design criteria or design elements. Unimproved access routes were selected to use existing roads or where cross-country travel is required to avoid steep slopes (16% or more) and drainages. Unimproved access routes will ideally use ground with an existing grade of 16% or less; however, some routes may exceed this grade in localized areas (e.g. existing roads or other disturbed areas). Where cross-country travel is required, a 12 foot wide path will be marked to contain vehicles.

3.0 ROAD DESIGN ELEMENTS

In addition to the road design requirements described above, the primary design elements for all classes of roads are the structural section, alignment, and drainage crossings. The haul road class is the most robust since it will have highest volume of traffic and design speed. The arterial, turbine and facility, and structure roads will be proportionally less based on the volumes of traffic and anticipated use of each road class.

3.1 STRUCTURAL SECTION

The structural section of the road is the design of the material layers that make up the road, including the surface and all supporting layers underneath it. The elements of the structural section are listed below and a typical structural section is shown in Figure 2:

- Aggregate cap - provides driving surface and drainage
- Aggregate base - provides additional strength, stability, and weight distribution
- Lower aggregate base (if needed) - provides additional stability
- Geosynthetic material, such as geotextile fabric or geogrid (if needed) - provides additional stability
- Subgrade/subbase - provides road base in existing soils

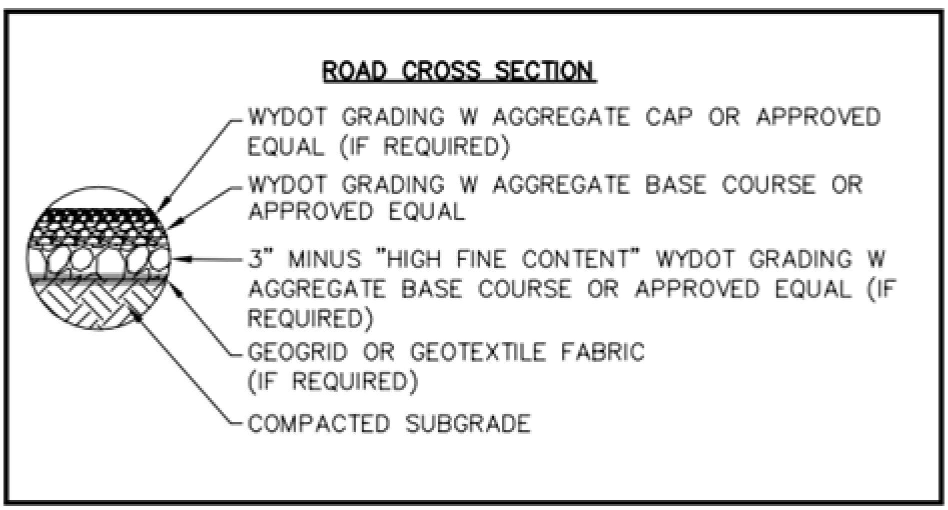


Figure 2. Typical Road Structural Section

The primary factors that impact the design of the structural section of a road are the properties of the existing soil and the anticipated use of the road. PCW has completed geotechnical investigations for the CCSM Project to identify the soil classes (as defined by the Unified Soil Classification System), as well as laboratory investigations to characterize soil (e.g. California Bearing Ratio (CBR), a measure of the compactibility). PCW has also identified the anticipated use of each class of road, as described in Section 2.0. Based on the results of this analysis, PCW determined that the CCSM Project roads are expected to achieve sufficient subgrade compaction without requiring additional stabilization from geotextile fabric or geogrid. PCW also determined that the combined aggregate base and cap thicknesses required for haul and arterial class roads is at least 8 inches, and at least 4 inches for turbine and facility class roads.

During construction of roads, the compaction of the road base will be tested frequently (approximately every 500 feet). If PCW determines that the design compaction has not been achieved, PCW will determine the appropriate solution. The design solutions chosen by PCW may include the following, as appropriate to the specific conditions:

- **Aggregate:** The application of additional aggregate is the most common solution to compaction problems, especially if the achieved CBR values are close to the design requirements. The engineer will specify the additional aggregate thickness required.
- **Geosynthetic (geotextile fabric or geogrid):** The use of geosynthetics is a common design solution for short lengths of road. Geosynthetics are placed over a road subgrade followed by an aggregate base.
- **Subbase replacement:** When design strength cannot be achieved using any other stabilization methods, soft subsoils are excavated and replaced with more suitable fill.
- **Placement of surge material:** When localized soft spots that cannot reach the specified compaction are encountered, some of the soft subsoil is removed and large rock, roughly 3-6 inches in diameter is driven into the ground to provide additional stabilization.

3.2 ALIGNMENT

The alignment of the CCSM Project roads is designed to balance engineering design requirements with constructability and environmental resource considerations. The roads have been aligned to avoid cultural and biological resources to the extent possible, to minimize impacts to drainage patterns, and to comply with other applicable constraints and setbacks defined in the ROD. Where possible, given these constraints, road alignments are designed to follow existing two-track roads to minimize overall disturbance.

3.3 DRAINAGE CROSSINGS

While the CCSM Project roads have been designed to minimize drainage crossings and avoid disturbing existing drainage patterns, it is necessary for the roads to cross natural drainage channels and streams in a number of locations throughout the CCSM Project Site. Where drainage crossings were deemed necessary, each crossing was reviewed to identify the location that would minimize disturbance and impacts to drainage patterns.

3.3.1 Hydrology

The CCSM Project is located within a semi-arid region of Wyoming, receiving approximately 10 inches of precipitation per year. While there are variations in elevation, soil, and rainfall across the CCSM Project Site, the watersheds are generally rather homogeneous from a hydrology perspective. The watershed size is the largest variation within the CCSM Project Site, ranging from as little as 1 acre to over 60 square miles.

Hydrology in the vicinity of the CCSM Project Site is typically dominated by snowmelt conditions during the springtime; however, moderate rainfall events can occur during the spring and summer that generally exceed the peak runoff generated by snowmelt. Snowmelt typically generates long duration runoff events with low to moderate runoff rates. Moderate to large rainfall events typically generate shorter runoff durations, but higher peak flows. Therefore, from an engineering perspective, because the rainfall events have higher runoff rates, they "control" in terms of design. In order to conservatively estimate peak runoffs, published rainfall events were used to model the CCSM Project Site hydrology.

The BLM Road Design Handbook (BLM 2011) states the following:

> *"Culverts are to be designed using the appropriate hydraulic design procedures. Refer to AASHTO "Highway Drainage Guidelines" and State highway agencies for guidance. In addition, other publications are available from FHWA. Use any of the standard hydrologic and hydraulic design methods, but use a second method as a check to ensure that the solution is adequate but not extravagant. Special consideration may be necessary for debris passage."*

PCW used the Wyoming Department of Transportation (WyDOT) and Federal Highway Administration (FHWA) hydraulic design procedures, which are considered industry standards. For hydrologic design, PCW used the Soil Conservation Service (SCS) Curve Number method for smaller watersheds (under approximately 1 square mile) and the United States Geological Survey (USGS) Regression Equations for larger watersheds.

The SCS Curve Number method requires delineation of each small watershed based on existing topography and runoff patterns. Figure 3 shows how a watershed is delineated for a proposed culvert crossing. The SCS Curve Number method uses the following characteristics to evaluate each watershed:

- Watershed area – geographical footprint of the watershed being studied
- Topography – flow path steepness
- Soil type – capacity of soil to infiltrate water
- Precipitation – rainfall depth and intensity
- Design storm event – a less frequent storm event produces a higher rainfall amount
- Land cover – capacity of plants to absorb runoff

Typically for large watersheds over approximately 1 square mile, the USGS regression equations are used to determine peak flows for various storm events. The regression equation is a statistical analysis of other similar watersheds whose runoff discharges have been measured over many years and many rainfall events. That data is reduced down to an equation that uses a limited set of watershed characteristics, such as the watershed area and slope, to calculate the peak discharge for a given storm event. Several different regression equations have been developed for the region of Wyoming where the CCSM Project is located. Consistent with WyDOT recommendations, PCW used engineering judgment to choose the equation that best represents the site conditions, more specifically, the equations used are from USGS report "Peak-Flow Characteristics of Wyoming Streams, Water-Resources Investigations Report 03-4107" (USGS 2003).

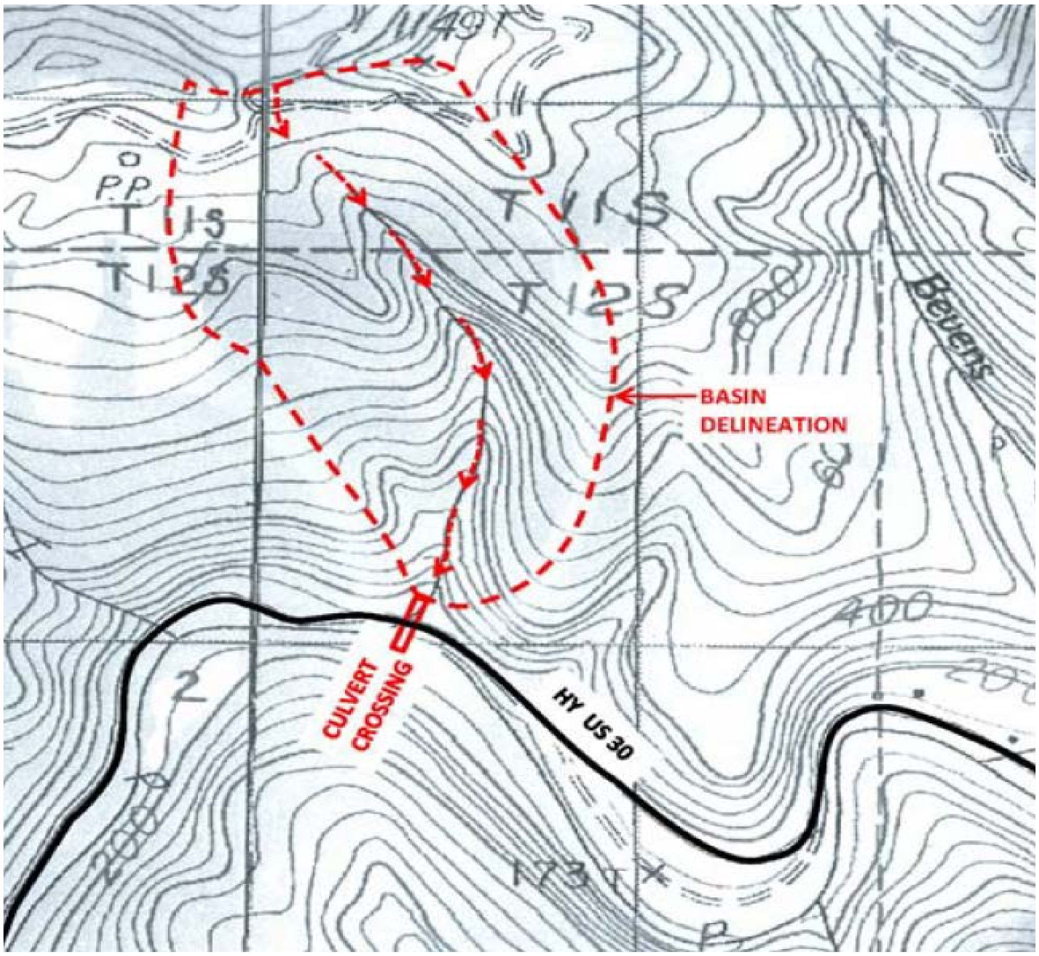


Figure 3. Example Watershed Delineation

3.3.2 Design Storm Event

The CCSM Project haul and arterial class roads are designed to provide access throughout the CCSM Project under various weather conditions. Culverts (round, box, or arch) are used as appropriate on the haul and arterial roads where water crossings occur. These culverts are typically designed for a storm event of between 10 and 25 years, with most culverts designed for a 25-year storm event (approximately 2.1 inches over a 24-hour period). This ensures that the road is not overtopped during most rainfall events. Roads throughout the United States with similar hydrologic design parameters include county roads and low volume state highways.

Drainage crossings on turbine and facility and structure class roads are designed for a lesser storm event due to the lower volumes of traffic and flexibility regarding access. Based on BLM guidance, a minimum 10-year storm event has been used for the project. Culverts will still be used at crossing locations within larger watersheds and where the road design and existing terrain require it; however, at-grade low water crossings (described in the sections below) will be used where watersheds are smaller and the road design and terrain allow for it

3.3.3 Hydraulics

There are multiple drainage crossings and structures associated with the CCSM Project roads. These drainages, crossings, and structures can generally be organized into four crossing types:

- Stream and larger drainage crossings - watersheds greater than 30 square miles, typically crossed with round, box, or open-bottomed arch culverts
- Moderate drainage crossings - watersheds between 3 square miles and 30 square miles, typically crossed with round or box culverts
- Small drainage crossings - watersheds less than 3 square miles, typically crossed at-grade or with a round culvert
- Relief culverts - allow water to flow from one side of a road to the other to follow terrain, typically round culverts

3.3.3.1 Stream and Larger Drainage Crossings

According to BLM's Engineering Manual (BLM 2008), culvert crossings are classified as "major culverts" if they have a design cross sectional area greater than 35 square feet on a 25-year storm event. Hydraulic designs for these crossings must meet the requirements of section ".22-A-3-a" of BLM's Manual 9112 (BLM 2009) which states:

> *"The minimum design flood for permanent bridges is the 50-year flood. At a minimum, major culverts in permanent installations should be designed to pass a 25-year flood with zero head above the pipe and 50-year flood with head above the pipe limited to one-half the rise (or diameter) of the pipe, but not less than 2 feet below the finished travelway shoulder."*

Based upon these requirements, PCW analyzed several types of crossings for the stream and larger drainage crossings. The first type of crossing selected was one or more corrugated metal pipe (CMP) culverts, the most common form of drainage crossings used on rural roads similar to the CCSM Project roads. Box culverts were also reviewed and selected at crossing locations that convey large volumes of water and have height and/or width restrictions within the channel that prevent the usage of multiple large diameter CMP culverts.

BLM expressed a preference for "live bottom" crossing options of Little Sage Creek and Miller Creek, both perennial streams at the crossing locations. PCW evaluated multiple "live bottom" options including traditional bridges, steel arch culverts, and reinforced concrete arch structures. All these options allow for a natural streambed to be maintained. To further develop an optimal solution, PCW evaluated the impacts of each crossing type during construction. All crossing types require diverting water through a temporary culvert while construction is occurring;

however, a prefabricated concrete arch minimizes the duration of construction and the time that the streams would be impacted. PCW chose the prefabricated concrete arch design due to the lower overall cost and reduced duration of construction. Figure 4 shows typical concrete arch structure designs.

Figure 4. Example Perennial Stream Crossing Pre-Cast Concrete Arches

3.3.3.2 Moderate Drainage Crossings

For most moderate drainage crossings for haul and arterial class roads, PCW is using CMP round culverts (Figure 5).CMP culvert sizes typically range from 60 inches to 84 inches in diameter. In a few select locations, PCW is using two or three CMP culverts in parallel to provide adequate drainage. In locations with higher road grade, lower profile CMP culverts were deemed most appropriate.

At six moderate drainage crossings along the northern portion of the Phase I Haul Road, the drainage requirements caused PCW to select concrete box culverts (Figure 6) over CMP culverts. These were selected in areas with wide drainages where round culverts may not have sufficient discharge rates and could increase the potential for ponding.

Figure 5. Example CMP Culvert Crossing

Figure 6. Example Concrete Box Culvert Crossing

3.3.3.3 Small Drainage Crossings

PCW will use round CMP culverts for small drainage crossings on haul and arterial class roads. Round culverts or at-grade low water crossings ("LWC" also referred to as "Arizona crossings") will be used throughout the CCSM Project Site on turbine and facility class roads at crossing locations with low flows. CMP culvert sizes range from 24 inches to 72 inches in diameter with the vast majority being 36 inches or less

A LWC is an at-grade designed low point in the roadway that matches the elevation of the existing drainage channel as closely as possible, and allows storm water to drain across the road surface (Figure 7, Figure 8, and Figure 9). This type of crossing is also effective in minimizing the erosion potential when crossing undefined drainage ways as it prevents channelizing the flows through culverts. Channelizing flow in undefined drainages can increase the velocities and erosion potential across existing vegetation and soils that are not naturally accustomed.

Typical LWCs consist of aggregate surfaces with aggregate sizes large enough to support the water velocity without washing (typically 3 to 6-inch diameter). At crossings where the water velocity is too fast for an aggregate surface, a concrete surfaced LWC may be installed. PCW will determine where concrete surfaces are warranted based on site conditions encountered during construction, such as the subgrade soil conditions and the ability to achieve proper compaction. At crossings where runoff from snow melt or other drainage becomes a nuisance or increases the amount of road maintenance required, PCW may decide to install a small culvert (typically 4-6 inches). The culvert will allow small amounts of water to drain under the road keeping the road surface in a better driving condition. If PCW decides to install the culverts, the culverts will be installed at the end of CCSM Project construction once the majority of the heavy hauling is complete.

LWCs will typically be constructed to the full width of the driving surface, or the width required for cranes if the road is to be used for crane travel (refer to Table 1). The crane travel shoulders may be constructed out of a more coarsely graded aggregate that will support and distribute the weight of the cranes more effectively. Once CCSM Project construction is complete, these shoulders will be reclaimed, leaving behind the permanent roadway surface width. If the existing soils are suitable to support crane travel, PCW may choose not to install the aggregate for the crane shoulders.

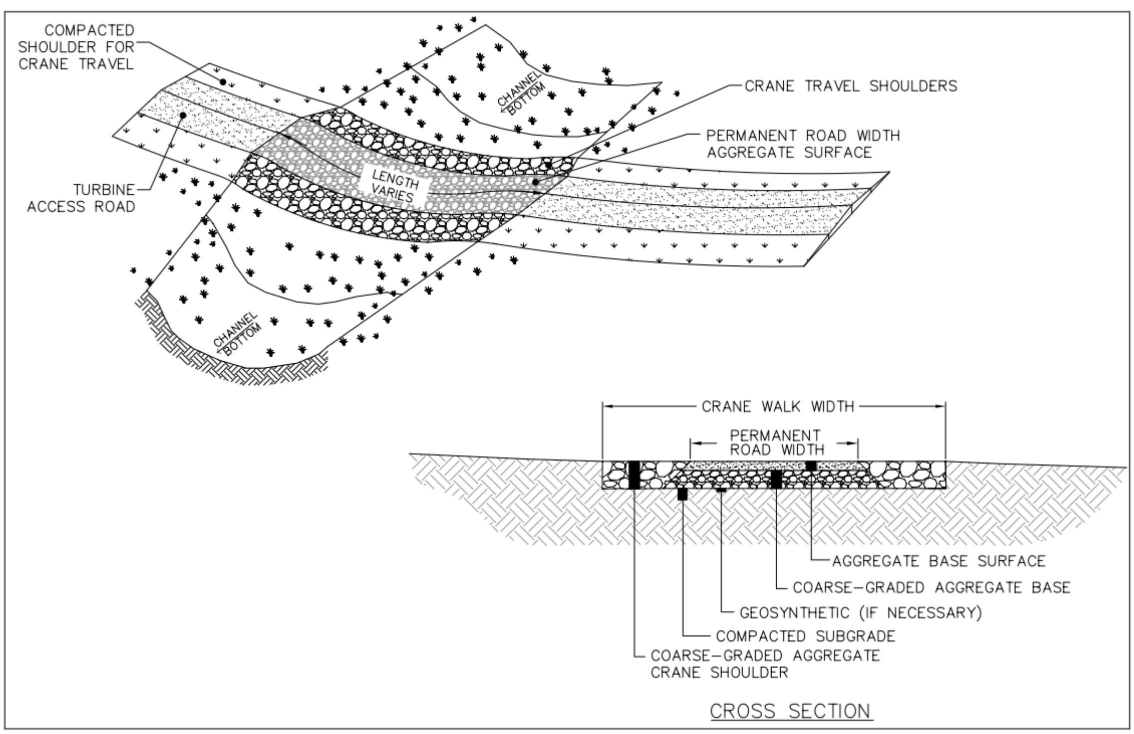


Figure 7. Typical At-Grade Low Water Crossing

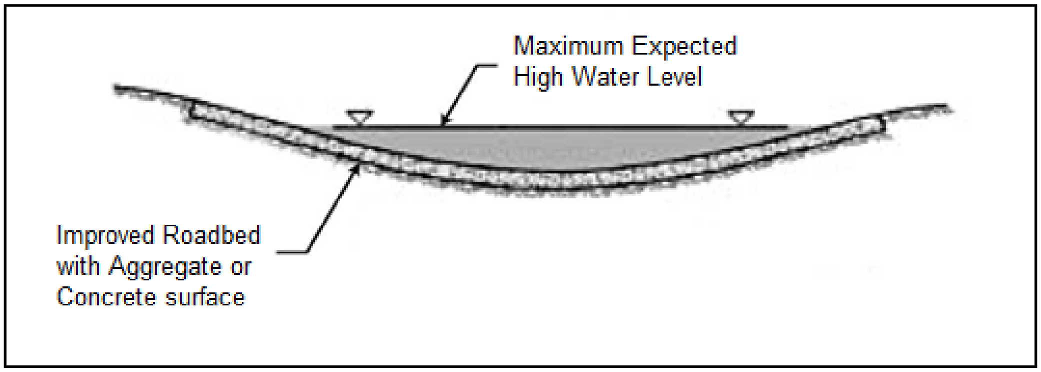


Figure 8. Diagram of At-Grade Low Water Crossing

Figure 9. Examples of At-Grade Low Water Crossings

3.3.3.4 <u>Culvert Placement</u>

All culverts will be placed in a manner that best matches the stream and watercourse morphology, both horizontally and vertically. Horizontally, the culverts will be placed in a manner that closely matches the watercourse orientation (see Figure 10). Vertically, the culvert will match the natural grade of the watercourse when possible (see Figure 11). Where grading is required, the culvert will be placed so there is enough room for runoff to be properly conveyed through the culvert (see Figure 12).

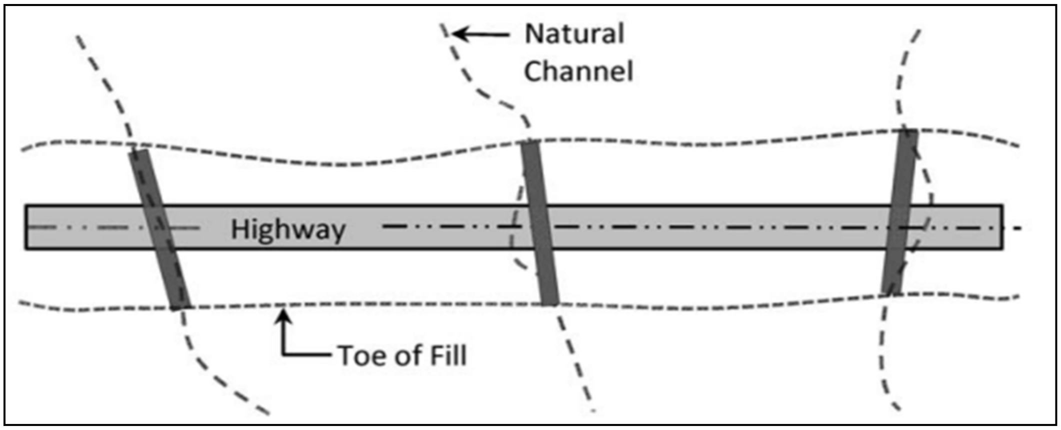


Figure 10. Typical Horizontal Culvert Placement

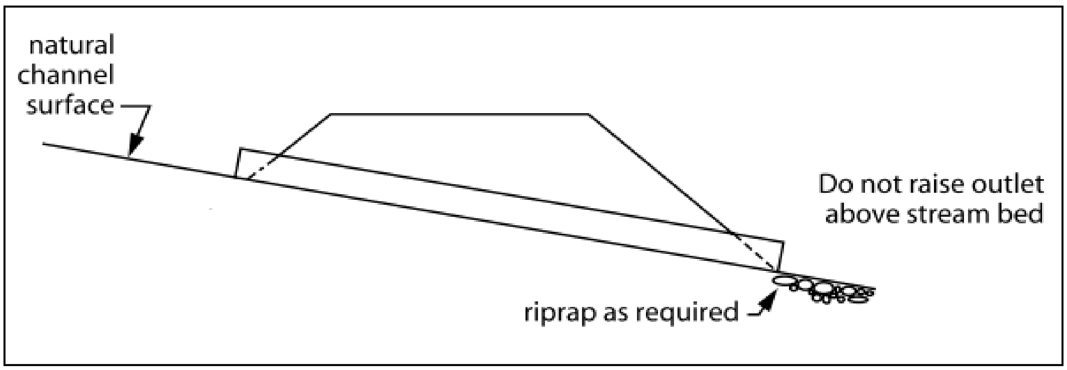


Figure 11. Typical Vertical Culvert Placement in Natural Watercourse

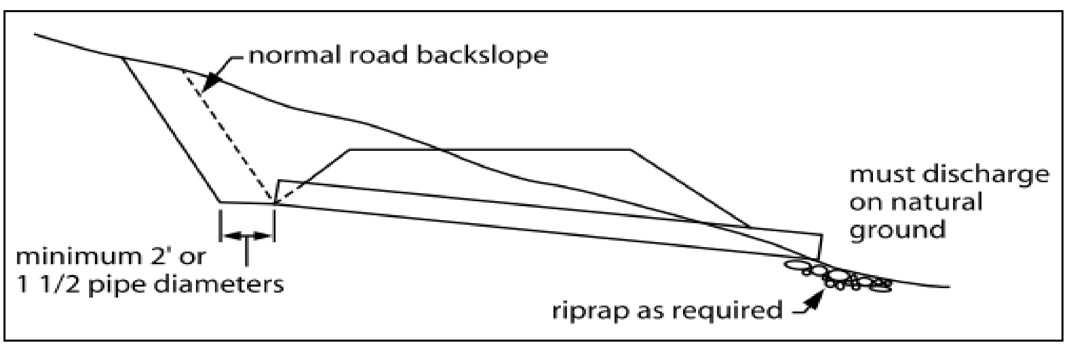


Figure 12. Typical Vertical Culvert Placement with Grading

3.3.4 Drainage Structure Structural Design

All drainage structures will be designed to accommodate the construction and operation traffic that is anticipated to drive on the road surface. The minimum structural design loading for all drainage structures must meet the requirements of section ".1-A-2" of BLM's Bridge Design Manual (BLM 2009) which states:

> *"The minimum design vehicular loading for road crossing structures designed in accordance with the AASHTO LFRD Bridge Design Specifications is load designation HL-93 and for those structures designed in accordance with the Standard Specifications for Highway Bridges, 17th Edition is load class designation HS20."*

The structural design of all drainage structures takes into account any crane travel on the road surface or special delivery truck requirements based on standard wind farm construction practices. If needed to accommodate construction traffic loadings, drainage structures will have increased fill, timber mats, steel plates, or other protection measures for temporary construction loadings that exceed the design capacity of the drainage structure.

3.3.5 Drainage Structure Scour Design

The CCSM Project requires culvert crossings at drainages throughout the CCSM Project Site. The majority of the proposed culvert crossings are classified for scour design as *minor* culverts, with cross-sectional areas less than 35 square feet. Minor culverts include those previously defined in this document as relief or small culverts. The BLM defines the remainder of the culverts (cross-sectional areas greater than 35 square feet) as *major* culverts, those previously defined as moderate or stream crossings.

Measures will be taken to protect the soil around the culvert inlets from erosion, following the BLM Gold Book guidelines (BLM 2007). BLM Manual 9113 indicates that scour should be considered when designing culverts, but doesn't specify a procedure for design. Therefore, minor culvert outlets will be protected from scour using standard WyDOT and FHWA guidelines for outlet aprons. Major culverts will be protected against scour by using BLM, WyDOT and FHWA guidelines and calculations from HEC-14. The Federal Highway Administration publishes HEC-14 as part of its Hydrologic Engineering Center standard publications.

Riprap will be used as the primary means to prevent culvert erosion. However, if PCW determines it is necessary, additional commercially available erosion control products may be used on a limited basis to supplement or replace riprap as a means to protect existing soils around culverts.

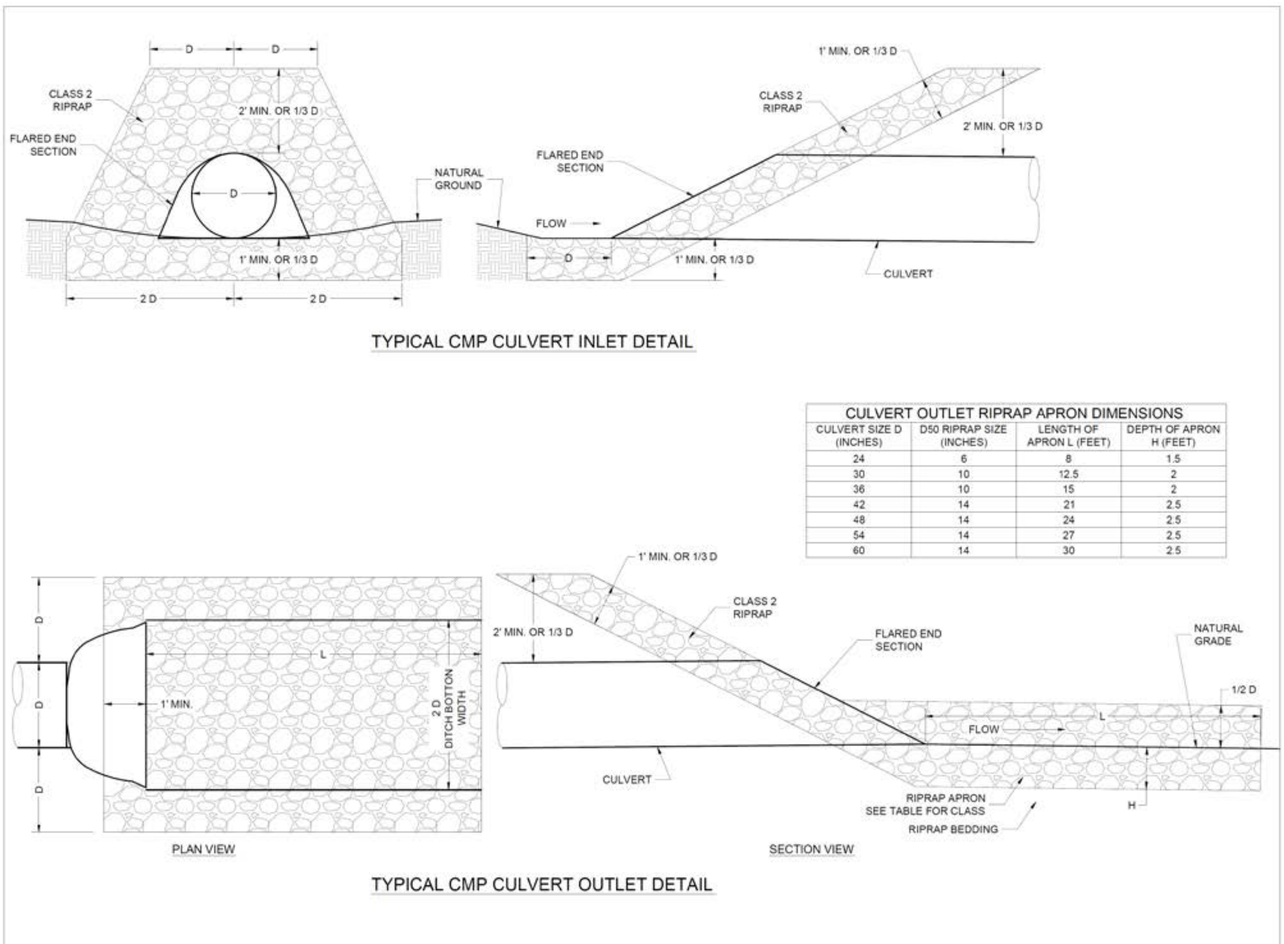
3.3.5.1 Minor Culverts

The FHWA and multiple DOTs throughout the country have developed standard details for riprap placement to prevent erosion and scour. These guidelines are based on research and calculations in HEC-14. These outlet protection details are suitable for culverts up to approximately 72” diameter. The BLM Gold Book further specifies how to place riprap to protect culvert inlets.

The CCSM Project will use the BLM and FHWA guidelines for the minor culverts throughout the project site. Figure 13 gives an example showing how inlet and outlet protection is achieved for a variety of culvert sizes. Figure 14 shows a typical triangular outlet apron. The width is generally around 20 percent wider than the length.

3.3.5.2 Major Cuvlerts

Outlet protection for the CCSM Project’s major culverts will be calculated and designed on an individual basis using HEC-14. The procedures in HEC-14 provide design information for analyzing and mitigating energy dissipation problems at culvert outlets and in open channels. The riprap D_{50} size and apron dimensions are calculated based on the culvert’s shape, dimensions, design discharge, and tailwater elevation. The outlet protection design intent will be similar to the minor culverts as shown in Figure 13 and Figure 14.



CULVERT SIZE D (INCHES)	D50 RIPRAP SIZE (INCHES)	LENGTH OF APRON L (FEET)	DEPTH OF APRON H (FEET)
24	6	8	1.5
30	10	12.5	2
36	10	15	2
42	14	21	2.5
48	14	24	2.5
54	14	27	2.5
60	14	30	2.5

Figure 13. Typical Minor Culvert Inlet and Outlet Protection Detail

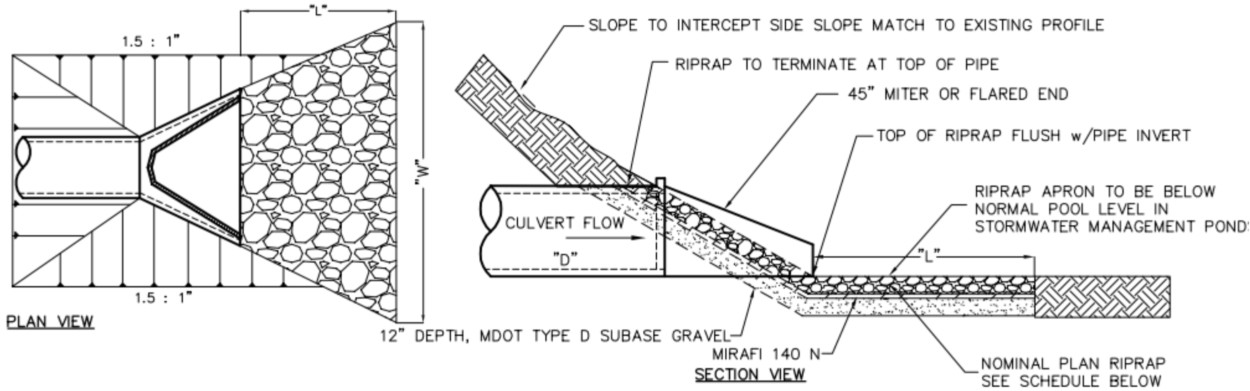


Figure 14. Typical Minor Culvert Outlet Apron

3.3.5.3 Major Natural Bottom Culverts

Two crossings along the Phase I Haul Road are planned to be constructed with long-span, open bottom arch culverts (Contech O-Series or equivalent). The natural channel bottoms will be constructed with the existing native channel material. The arch culvert will have concrete footings to support the structure and roadway over the top of the culvert

Outlet protection will be calculated and designed on an individual basis using HEC-14. The procedures in HEC-14 provide design information for analyzing and mitigating energy dissipation problems at culvert outlets and in open channels. The riprap D_{50} size and apron dimensions are calculated based on the drainage structure's shape, dimensions, design discharge, and tailwater elevation. Riprap or cable concrete will be buried under the native material and will protect the concrete footings from being undermined from excessive scour during a large storm event. A sheet-pile cutoff wall, or other grade control device, on the downstream end will provide protection against a large head-cut undermining the structure Example scour protection options for the arch structure are shown in Figure 15 and Figure 16.

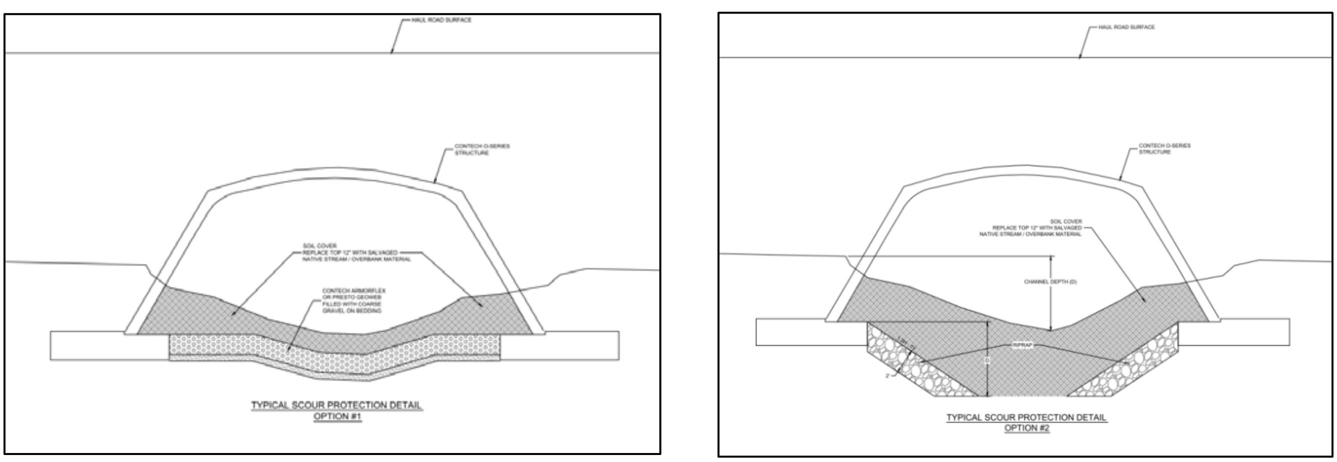


Figure 15. Scour Protection Options for Open Bottom Arch Structure Footings

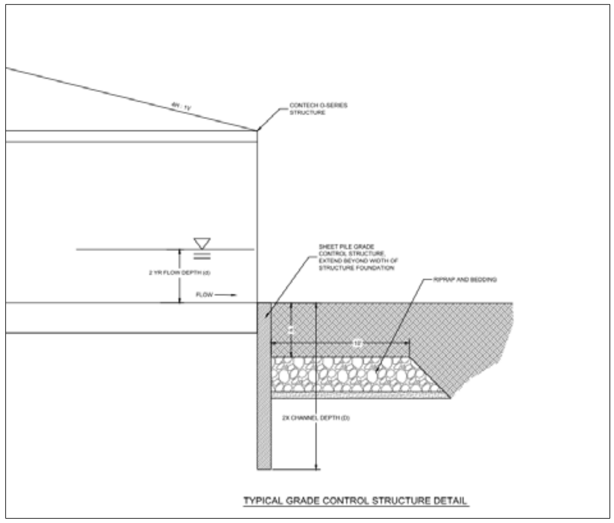


Figure 16. Grade Control Protection for Open Bottom Arch Structure

3.4 DITCHES

CCSM Project roads have been designed to minimize the use of ditches by staying on ridges or flat areas; however, ditches are necessary in several locations. Ditches are designed to protect the road from stormwater runoff, prevent longitudinal flow from conveying on the driving surface, and provide water with a defined location to channelize. While the BLM preference for stormwater management is to direct water to flat, vegetated, stabilized areas, this is not always achievable in the CCSM Project Site and in some instances doing this would increase the CCSM Project disturbance. Where flat, vegetated, stabilized areas are not available or would significantly increase the CCSM Project disturbance, ditches are used to collect water and convey it away from the road toward existing natural drainages. The use of ditches varies based on the road classification. Haul-class roads have significant ditching to maintain the road design requirements. As the road design requirements lessen for each subsequent road type, ditches are needed in fewer locations. Turbine, facility, and structure class roads have limited to no ditches.

3.4.1 Ditch Design

Ditches are designed based on the storm event shown in Table 1 for each of the different road classifications. Each ditch is designed based on the maximum drainage area that will be draining to the ditch at the ditches minimum slope. Based on the design speed of the road class, the ditch fore slope and back slope range from 4:1 on haul-class roads to 2:1 on turbine and facility class roads. The depth of the ditch and the width of the ditch vary based on the hydraulic design requirements of the ditch. All ditches have a minimum bottom width of 2 feet. Ditches will be stabilized using a variety of different methods based on the slope of the ditch and the velocity of the water. The primary sediment control will be rock checks and the primary erosion control will be the establishment of vegetation. More information on stabilization can be found in the SWPP Plan for each site-specific plan of development.

3.4.2 Erosion Control

Appendix 13 of the Rawlins Resource Management Plan (RMP) (BLM 2008a) requires that "road design should encourage the shedding of water from the surface before the water gains enough concentration or velocity to cause erosion." The RMP specifies that, for most roads, this requirement can be met through the use of crowing in the roads, which PCW has incorporated into the design of each road class (see Table 1). For roads with a grade above 8%, the RMP calls for additional measures to be taken to protect the roads and control erosion through water energy dissipation. To achieve this requirement, the RMP lists various options, including "waterbars that shed water from the surface of the road, drainage ditches, wing ditches, and culverts to transport water from the road surface to a location where concentrated flow can be dispersed." Wing ditches are further specified as being used to "direct concentrated flow to a non-erosive location."

PCW has evaluated the options for water energy dissipation along the CCSM Project roads to maintain erosion control. To meet the requirements of the RMP while minimizing disturbance as required in the ROD (BLM 2012), PCW has designed the CCSM Project using the guidance found in BLM Manual 9113 (BLM 2011) and the WyDOT Road Design Manual (WyDOT 2007). PCW is integrating temporary and permanent erosion and sediment control measures into the road side ditches and slopes. As detailed in the design drawings and stormwater pollution prevention plans (SWPPPs), PCW is also incorporating the following best management practices:

- **Rip rap in steep slopes.** PCW is utilizing rip rap within the roadside ditches as the primary energy dissipation solution. Based on WyDOT requirements, rip rap will vary in size between 3 and 24 inches, and vary in length depending upon water velocity and the native soil's potential for erosion. The depth of the rip rap will be at least twice the median rip rap size. The rip rap will convey and protect the slopes by provided a non-erosive means to discharge water at the bottom of a slope to a stable area. The use of rip rap will include a geotextile or fabric underlayment. The use of rip rap may be temporary or permanent based on construction sequencing and field conditions.
- **Ditch stabilization.** PCW will utilize temporary and permanent rock lined channels with a geotextile fabric underlayment, temporary erosion control blankets, permanent turf reinforcement mats, temporary bonded fiber matrices, temporary and permanent vegetation restoration, and other measures to stabilize the ditches during construction and following construction activities.
- **Relief culverts.** PCW will install culverts in strategic locations to allow the water to pass from the high side of the road to re-enter existing drainages on the low side of the road per the RMP that states "culverts can be used to bring water from one side of the road to the other for better dissipation (cross drainage)". More details on these culverts is included in Section 3.4.3.
- **Velocity control at drainage intersections.** Within 200 feet of the intersection points between CCSM Project road ditches and natural drainages, PCW will employ rip rap and geotextile or fabric underlayment and other solutions to protect the drainages from concentrated flow and scour.

- **Energy dissipation within natural drainages.** Where ditches discharge into existing drainages, PCW will place rip rap and geotextile or fabric underlayment within the drainage as necessary to further dissipate energy and protect the drainage from concentrated flows and scour.

Additionally, PCW will minimize sediment laden discharge through application of the following best management practices:

- **Revegation.** The primary method for long-term sediment control is the effective revegetation of areas disturbed during construction, including road ditches. PCW will employ the revegetation techniques outlines in the CCSM Project's Reclamation Plans.
- **Installation of sediment control devices.** PCW will install bio rolls, rock checks, sediment traps, and other measures to catch sediment before it reaches the natural drainages and final energy dissipation areas. Some sediment control devices may be removed when revegetation succeeds to the point the devices are unnecessary.
- **Maintenance of sediment control devices.** PCW will inspect sediment control devices periodically throughout the CCSM Project's construction and operation stages. Accumulated sediment and necessary repairs, maintenance or replacement of the devices will be done as specified in the SWPPPs.

The RMP recommends the use of waterbars within steep road sections to assist the road crowing in shedding water from the road surface. As waterbars can interfere with the road requirements of wind turbine delivery vehicles, PCW intends to install waterbars as needed at the end of the CCSM Project's construction as a permanent runoff control. The RMP also recommends the use of wing ditches. As discussed throughout the site-specific plans of development, the CCSM Project, including the roads, has been designed to minimize ground disturbance to prevent erosion and other impacts. For the road sections with grades above 8%, PCW evaluated the use of wing ditches and found that the use of wing ditches would significantly increase the ground disturbance of the road, with as much as 1 acre or more of new disturbance for each wing ditch installation. Also, wing ditches are required to discharge into non-erosive locations such as flat, vegetated and stabilized areas. PCW evaluated the CCSM Project Site and found that in most areas where wing ditches could be incorporated into the CCSM Project design the nearby terrain did not qualify as stable and non-erosive, i.e. it was not sufficiently flat and the vegetation was sparse. Ultimately PCW determined that wing ditches in these locations may actually increase the erosion potential. As such, PCW concluded that wing ditches were not an ideal solution for erosion control on steep road grades within the CCSM Project.

By using the combination of best management practices described above, PCW will achieve the erosion and sediment control required by the RMP without a significant increase in ground disturbance and subsequent erosion potential.

3.4.3 Relief Culverts

Relief culverts will be used on CCSM Project roads that require a ditch on the uphill side of the road. By design, the road centerlines are above the natural ground to allow for ditches and to balance the earthwork as locally as possible. Relief culverts will be placed periodically to allow runoff to be conveyed underneath the road. BLM Manual 9113 provided guidance for the placement of relief culvert. This guidance has been taken into consideration and relief culverts have either been placed at regular intervals according to BLM guidance or at strategic locations where culverts can outlet into existing drainages. This allows for runoff to outlet culverts in existing concentrated flow areas so the water can continue to follow natural patterns while still reducing the amount of water conveyed by roadside ditches. Relief culverts are typically placed at a 30 degree angle with an upstream berm directing the runoff into the culvert (see Figure 17). PCW plans to use round CMP culverts between 18 and 24 inches for relief culverts.

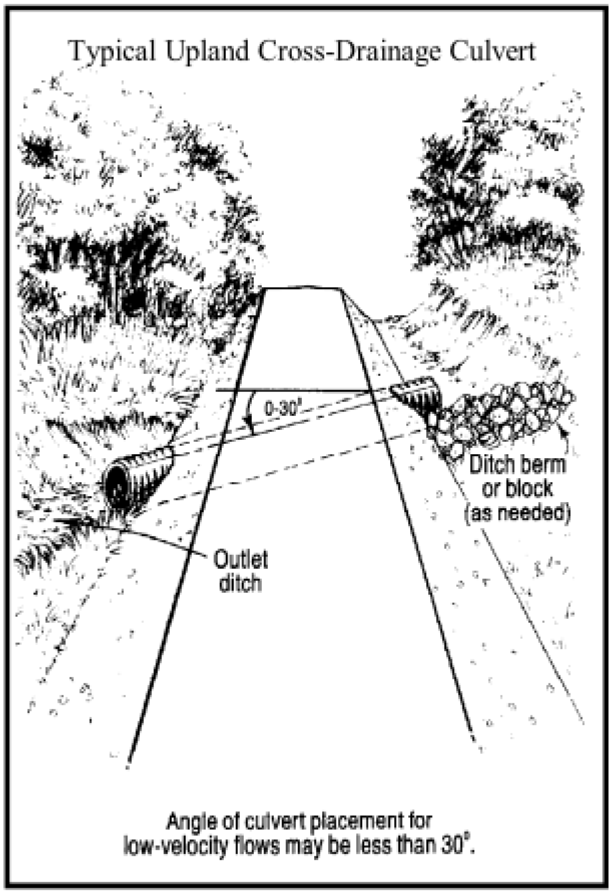


Figure 17. Example Relief Culvert

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