U.S. Department of Transportation
**Federal Highway Administration**

# Technical Memorandum

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**Through**: Matthew DeMarco, Lead Geotechnical Engineer, CFLHD, Lakewood, CO

**Subject:** Geotechnical Recommendations for the Reconstruction of Tarryall Creek Road, Project CO PFH 81 1(4)

## BACKGROUND

This memorandum provides geotechnical recommendations for the reconstruction and rehabilitation of a 16.8-mile long segment of the Tarryall Creek Road, Forest Highway (FH) 81. Tarryall Creek Road is 41.8-miles long, lying mostly within the Pike National Forest in Park County, Colorado. The two-lane roadway begins at the intersection with US Highway 285 in the town of Jefferson, and continues southeasterly past the Tarryall Reservoir and through the town of Tarryall, eventually terminating at US Highway 24 west of the town of Lake George.

The Central Federal Lands Highway Division (CFLHD) of the Federal Highway Administration (FHWA) has been improving roadway geometry along this route since 1997. The first phase, constructed in 1997 under the project CO PFH 81-1(1), began on the southern end of the route at the intersection with County Road 31 and continued approximately 12 miles southeast to the intersection with US Highway 24. The second phase, constructed in 2007 under the project CO PFH 81-1(2), began at the northwest end of the road at the intersection with US Highway 285 and continued for approximately 8 miles to the southeast. The third phase, project CO PFH 81-1(3), was constructed in 2011. This phase began at the termination point of the second phase (Station 790+68) and continued approximately 8.9 miles southeast to the intersection with County Road 23 (Station 1262+400).

The CO PFH 81-1(4) begins at the intersection with County Road 23 (Station 1262+40) and extends southeast for a distance of 16.8 miles, ending at Station 2138+00. The route is comprised of alternating segments of reconstruction (4R) and rehabilitation, restoration, and resurfacing (3R). Other improvements include grading, asphalt pavement, drainage, signing and striping, and other safety-related design necessary to meet current standards. Specifically, proposed improvements include roadway widening, horizontal and vertical alignment shifts through cuts and fills, retaining walls, slope rehabilitation, erosion control, drainage improvement, and other

related features to meet current FHWA design standards. All recommendations provided in this memorandum are based on the 70% projects plans.

This memorandum provides recommendations for stable cutslope ratios, material quality and shrink/swell values for each proposed cutslope, and rockery walls located near Stations 1642+00, 1760+00, and 2095+80.

## REGIONAL AND SITE GEOLOGY

Tarryall Creek Road is located in the South Park Valley, one of the three larger inter-montane valleys in Colorado. While Paleozoic and Mesozoic sedimentary rocks underlie much of South Park Valley, the Tarryall route is mostly underlain by decomposed to moderately weathered granite and granitic gneiss. Most of the route follows alongside water drainages that cross the road through existing culverts at several locations.

The route runs just east and parallel to the Elkhorn thrust fault. Although there is little information on this fault, it does not appear to have significant impacts on the route design. Based on AASHTO –LRFD Seismic Design Guidelines, a peak horizontal ground acceleration of 0.05g and Class C soils were selected for this project. Per AASHTO recommendations, the horizontal ground acceleration at the site does not warrant detailed seismic analysis.

## EVALUATIONS AND RECOMMENDATIONS

The proposed improvements for this segment of the roadway include several horizontal and vertical alignment shifts through cuts and fills. Wetlands and several historic structures exist along the alignment which creates major challenges for the designers during the alignment shifts. Steeper and taller cutslopes exist along the first half of the alignment while the slopes along the second half are generally flatter and shorter.

### CUTSLOPE EVALUATION

An evaluation of the proposed cutslopes to determine safe and stable slope ratios for the materials encountered was conducted by Central Federal Lands (CFL) engineers. Tarryall Creek Road transverses mountain terrains with cutslope heights ranging to 50-feet high, with moderate-to-steep slope ratios ranging from near vertical in bedrock to 1V:2.5H in soil matrix. Outboard fill ratios are locally as steep as 1V:1H. Several areas of the slopes are eroded and boulder size rocks have migrated down the slope by free falling, rolling, or sliding and have accumulated in the existing ditches. The cutslopes along this segment of the roadway are mostly composed of predominantly-to-moderately weathered granitic/gneissic bedrock. The physical and chemical weathering of the bedrock produced rock fragments of various sizes and shapes that accumulate on the slope surface. In areas of sufficient topographic relief and in steep cutslopes, the erosion process and gravitational forces cause the rock to move down to lower portions of the slope mixing with soil and forming colluvial materials. The characteristics of the colluvium are

generally dependent on the bedrock sources and the weathering process. In most cases, however, the colluvial materials in the cutslopes consist of loose, incoherent, heterogeneous mixtures of soil materials and rock fragments. Colluvial deposits range to several feet in thickness and are somewhat unstable in nature requiring regular maintenance. As exposed in cutslopes, colluvial deposits are generally less than five feet thick and in some cases overlay weathered bedrock.

Highly weathered and highly fractured metamorphic (gneiss) and granitic bedrock also outcrops at various locations along Tarryall Creek Road. The metamorphic rock is generally blocky, contains several orthogonal joint sets, and tends to separate into discrete blocks, the size and shape of which is related to the orientation of the joints within each joint set. Road alignment in relation to discontinuity orientation does not appear to cause specific rock slope instability problems. Within granitic rock masses, large rounded boulders or corestones (up to 10 feet) also exist on some cutslopes. These boulders are generally stable unless erosion or slope excavation removes the decomposed soils from around the corestones and the boulders become more exposed and eventually unstable.

Table 1 provides a detailed summary of the materials that will be encountered at each cutslope and provides existing versus recommended stable slope ratios. The data is based on observations only, no drilling or test pit samples were taken. Recommended cut slope ratios are for stable slopes without soil or rock reinforcement.

Anticipated bulking (swelling) or shrinking of each cut materials is also listed in the table for design purposes. Materials bulk or shrink is the percent increase or decrease in volume of an earth material after it has been excavated and recompacted. Typically, intact *rock* bulks when excavated, mechanically broken, and recompacted while intact *soil* shrinks when excavated and recompacted. Catchment ditches widths of existing cutslopes were also measured and are shown in Table 1. In most cases, existing catchment areas were about 3 feet and appeared to have a sufficient width to retain a high percentage of falling debris. It is therefore recommended that a minimum of 3-foot wide catchment is included in the design at most cut location. In areas where proposed cutslope ratios are 2V:1H or steeper and proposed slope heights are greater than 30 feet (Station 1635+50 to 1642+00, Station1425+00 to 1427+25, and Station 1429+50 to1430+50), a 5-foot minimum catchment area is recommended. In steep rock cut areas where the 5-foot minimum catchment is not achieved we recommend slope draping. However, due to the weathered and jointed nature of the rock mass, loose colluvial materials overlaying bedrock, steep terrain, and slope heights, it is not feasible to construct catchment ditches to prevent rockfall debris in the roadway. Cut slope recommendations assume routine maintenance to keep a safe roadway conditions. The materials along the investigated cutslopes can be generalized into the following three categories:

**Material 1**: Colluvial gravel, cobbles and boulder size rock fragments in a silty sand soil matrix.

**Material 2:** Decomposed grading to predominantly decomposed granite and granitic gneiss.

**Material 3**: Predominantly decomposed grading to moderately to slightly weathered granite and granitic gneiss

Cutslopes are planned in both weathered bedrock and colluvial soil materials. Most of the cutslopes will be excavated only a few feet horizontally into the slopes. Design recommendations provided in Table 1 are to improve cutslope stability and reduce rock fall hazard while satisfying other design-specific project criteria. In general it is recommended that slopes in colluvial soils, categorized as *Material 1,* be cut at 1V:1.5H or flatter, where possible, and scaled of loose rock that may present safety hazards. This is possible on many of the lower slopes and should provide for vegetation. Slopes in *Material 2* should be cut at a slope ratio from 1V:1.5H to 1V:1H depending on the weathering of the materials and the slope height. None of the existing slopes with slope ratios of 1V:1H or steeper have revegetated significantly. Slope cuts in *Material 3* can be 1V:1H or steeper and may require blasting during excavation. In areas where rock blasting required for slope excavation, it is also recommended that pre- and post-blast condition surveys and ground motion monitoring (peak particle velocity) be conducted as nearby historic structures could be at risk from blast damage. Blasting should be in accordance with SCR for Section 205. Refer to Table 1 for recommended cutslope rations for specific station intervals and shrink/swell factors for use in design.

Shallow cutslope ratios used to promote vegetation may also benefit from erosion control products such as erosion control blanket or guard bonded fiber matrix. Such products are biodegradable with a design life up to two years. A qualified erosion control engineer should be consulted for specific recommendations regarding slope protection measures.

**TABLE 1.- Summary of Slope Recommendations for Soil and Rock Cuts**

| Begin Station | End Station | Existing Cut Slope Ratio (Max) | Recommended Cut Slope Ratio | Lithology | Slope Height (Max) | Existing Rock fall catchment width | Swell/ Shrink | Material Type Number |
|---|---|---|---|---|---|---|---|---|
| 1262+40 | 1262+85 | NA. | 1V:1.5H | Brown silty sand | NA. | 5 ft | -10% | Material 1 |
| 1262+85 | 1264+50 | NA. | 1.33V:1H | Light yellow brown to gray granitic gneiss, fractured, moderately weathered | NA. | 5 ft | +15% | Material 3 |
| 1264+50 | 1273+50 | 1V:1.5H | 1 V:1.5H | Brown silty sand with cobble to boulder | 10 ft | 5ft | -10% | Material 1 |
| 1273+50 | 1275+00 | 1 V:1H | 1.33 V:1H | Light orange brown to gray granitic gneiss, fractured, moderately weathered | 18 ft | 5ft | +15% | Material 3 |

| Begin Station | End Station | Existing Cut Slope Ratio (Max) | Recommended Cut Slope Ratio | Lithology | Slope Height (Max) | Existing Rock fall catchment width | Swell/ Shrink | Material Type Number |
|---|---|---|---|---|---|---|---|---|
| 1275+00 | 1276+00 | 1 V:1.5H | 1 V:1H | Light yellow brown to gray granitic gneiss, fractured, predominantly decomposed to moderately weathered | 15 ft | 3ft | +10% | Material 3 |
| 1276+00 | 1278+00 | 1 V:1.5H | 1V:1.5H | Brown silty sand with cobble to boulder size rock fragments | <10 ft | 3ft | -10% | Material 1 |
| 1278+00 | 1278+75 | 1 V:1H | 1.33 V:1H | Light orange brown to gray granite knob, fractured, moderately weathered | 15 ft | 3ft | +15% | Material 3 |
| 1278+75 | 1280+60 | 1 V:1.5H | 1 V:1.5H | Brown silty sand with cobble to boulder size rock fragments | <10 ft | 3 ft | -10% | Material 1 |
| 1280+60 | 1281+00 | 1 V:1.5H | 1.33 V:1H | Light orange brown to gray granite knob, fractured, moderately weathered | <10 ft | 3 ft | +15% | Material 3 |
| 1281+00 | 1283+00 | 1 V:2H | 1 V:1.5H | Brown silty sand with cobble to boulder size rock fragments | <10 ft | 3 ft | -10% | Material 1 |
| 1283+00 | 1285+75 | 1 V:1.5H | 1V:2H | Light orange brown to gray granitic gneiss, fractured, predominantly decomposed to moderately weathered | 13 ft | 3 ft | +10% | Material 3 |
| 1285+75 | 1287+50 | 1V:2.5H | 1 V:1.5H | Brown silty sand with cobble size rock fragments overlying decomposed granite | 13 ft | 3 ft | -10% | Material 1 |
| 1287+50 | 1302+50 | 1 V:1.5H | 1 V:1H<br>1V:1.5H Better | Light brown orange decomposed granite | 20 ft | 3 ft | +10% | Material 2 |
| 1304+00 | 1307+50 | 1 V:1.5H | 1.33 V:1H | Light brown orange granite knob, fractured, moderately weathered with some decomposed dikes | 15 ft | 3 ft | +15% | Material 3 |
| 1307+50 | 1309+50 | NA | 1 V:1.5H | Brown silty sand with small rock fragments | NA | 3 ft | -10% | Material 1 |
| 1309+50 | 1311+50 | NA | 1V:1H | Light brown orange granite knob, fractured, moderately weathered | NA | 3 ft | +10% | Material 3 |
| 1319+00 | 1324+50 | 1V:1.5H | 1V:1H | Light brown orange granite, fractured, predominantly decomposed | 12 ft | 3 ft | +10% | Material 2 |
| 1324+50 | 1338+50 | 1V:1.5H | 1V:1.5H | Brown silty sand with cobble to boulder size rock fragments | 12 ft | 3 ft | -10% | Material 1 |
| 1338+50 | 1340+00 | 1V:1H | 1V:1.5H<br>Flatten slope | Brown silty sand with cobble to boulder size rock fragments, very rocky | 25 ft | 3 ft | -10% | Material 1 |
| 1340+00 | 1345+00 | 1V:1H | 1V:1.5H<br>Flatten slope | Brown silty sand with cobble to boulder size rock fragments | 10 ft | 3 ft | -10% | Material 1 |

| Begin Station | End Station | Existing Cut Slope Ratio (Max) | Recommended Cut Slope Ratio | Lithology | Slope Height (Max) | Existing Rock fall catchment width | Swell/ Shrink | Material Type Number |
|---|---|---|---|---|---|---|---|---|
| 1345+00 | 1353+00 | 2V:1H | 2V:1H | Light brown orange granite knob, very fractured, moderately weathered | 30 ft | 3 ft | +10% | Material 3 |
| 1353+00 | 1372+50 | 1V:1H | 1V:1.5H Flatten slope | Brown silty sand with cobble to large boulder size rock fragments | 18 ft | 3 ft | -10% | Material 1 |
| 1372+50 | 1376+50 | 1V:1.5H | 1.33V:1H | Light brown orange granite knob, very fractured, moderately weathered | <10 ft | 3 ft | +10% | Material 3 |
| 1376+50 | 1383+00 | 1V:1H | 1V:1.5H Flatten slope | Brown silty sand with cobble to large boulder size rock fragments | 18 ft | 3 ft | -10% | Material 1 |
| 1383+00 | 1385+00 | 1V:1H | 1V:1H | Gray gneiss, fractured, predominantly decomposed to moderately weathered | 20 ft | 3 ft | +10% | Material 3 |
| 1385+00 | 1390+00 | 1V:1.5H | 1V:1.5H | Brown silty sand with cobble to small boulder size rock fragments, very rocky | 10 ft | 3 ft | -10% | Material 1 |
| 1390+00 | 1393+00 | 1V:1.5H | 1V:1.5H | Brown silty sand overlying gray gneiss, moderately weathered | 20 ft | 3 ft | -5% | Material 1 |
| 1393+00 | 1420+00 | 1V:1H | 1V:1.5H Flatten slope | Brown silty sand with cobble to large boulder size rock fragments, very rocky | 27 ft | 3 ft | -5% | Material 1 |
| 1420+00 | 1425+00 | 1V:1.5H | 1V:1.5H | Brown silty sand with cobble size rock fragments | 10 ft | 2 ft | -10% | Material 1 |
| 1425+00 | 1427+25 | 4V:1H | 2V:1H Flatten slope | Gray gneiss, fractured, moderately weathered | 32 ft | 2 ft | +15% | Material 3 |
| 1427+25 | 1429+50 | 2V:1H | 1V:1H Flatten slope | Brown silty sand with cobble to boulder size rock fragments | 30 ft | 2 ft | -10% | Material 1 |
| 1429+50 | 1430+50 | 2V:1H | 2V:1H 1.33:1 Better | Gray gneiss, fractured, moderately weathered | 25 ft | 2 ft | +10% | Material 3 |
| 1431+00 | 1433+00 | 1V:1H | 1V:1.5H Flatten slope | Brown silty sand with gravel size rock fragments | 20 ft | 2 ft | -10% | Material 1 |
| 1433+00 | 1437+00 | 1V:1H | 1V:1.5H Flatten slope | Brown silty sand and rock fragments overlying gray to white gneiss, moderately weathered | 22 ft | 2 ft | -5% | Material 1 |
| 1437+00 | 1444+00 | 1V:1.5H | 1V:1.5H | Brown silty sand with gravel size rock fragments | <10 ft | 2 ft | -10% | Material 1 |
| 1444+00 | 1447+00 | 4V:1H | 1V:1.5H Flatten slope | Brown silty sand with cobble to boulder size rock fragments | 50 ft | 2 ft | -5% | Material 1 |
| 1447+00 | 1450+00 | 4V:1H | 2V:1H | Gray to white gneiss, moderately to slightly weathered | 50 ft | 2 ft | +15% | Material 3 |

| Begin Station | End Station | Existing Cut Slope Ratio (Max) | Recommended Cut Slope Ratio | Lithology | Slope Height (Max) | Existing Rock fall catchment width | Swell/ Shrink | Material Type Number |
|---|---|---|---|---|---|---|---|---|
| 1450+00 | 1454+50 | 2V:1H | 1V:1.5H Flatten slope | Brown silty sand with cobble to boulder size rock fragments | 25 ft | 2 ft | -10% | Material 1 |
| 1454+50 | 1458+50 | 1V:1.5H | 1V:1.5H | Brown silty sand with gravel size rock fragments | 15 ft | 2 ft | -10% | Material 1 |
| 1458+50 | 1462+60 | 1V:1.5H | 1V:1.5H | Brown silty sand with cobble to boulder size rock fragments, very rocky | 10 ft | 2 ft | -10% | Material 1 |
| 1462+60 | 1469+00 | 1V:1.5H | 1.33V:1H | Gray to white gneiss, fractured, predominantly decomposed to moderately weathered | 12 ft | 2 ft | +10% | Material 3 |
| 1470+00 | 1471+00 | 1V:1.5H | 1V:1H | Light brown orange to gray granitic gneiss, predominantly decomposed to moderately weathered | <10 ft | 2 ft | +10% | Material 3 |
| 1471+00 | 1484+00 | 1V:1.5H | 1V:1.5H Granite outcrop | Brown silty sand with gravel to cobble size rock fragments | 14 ft | 2 ft | -10% | Material 1 |
| 1484+00 | 1486+00 | 1V:2.5H | 1V:1H | Light brown orange granitic gneiss, moderately weathered | <10 ft | 3 ft | +5% | Material 3 |
| 1486+00 | 1499+00 | 1V:1.5H | 1V:1.5H | Brown silty sand with gravel size rock fragments, some predominantly decomposed rock outcrops | <10 ft | 3 ft | -5% | Material 1 |
| 1499+00 | 1505+00 | 1V:1.5H | 1V:1.5H | Brown silty sand with gravel to very large boulder size rock fragments | <10 ft | 3 ft | -10% | Material 1 |
| 1505+00 | 1509+00 | 1V:1H | 1.33V:1H | Gray granitic gneiss, moderately weathered | 20 ft | 3 ft | +10% | Material 3 |
| 1509+00 | 1519+50 | 1V:1H | 1V:1.5H Flatten slope | Light orange brown to brown silty sand with gravel to cobble size rock fragments | 15 ft | 2 ft | -10% | Material 1 |
| 1519+50 | 1520+50 | 1V:1.5H | 1V:1.5H | Light brown orange granitic gneiss, moderately weathered | 12 ft | 2 ft | +10% | Material 3 |
| 1520+50 | 1526+00 | 1V:1H | 1V:1.5H Flatten slope | Brown silty sand with gravel to cobble size rock fragments | 10 ft | 2 ft | -10% | Material 1 |
| 1526+00 | 1528+00 | NA | 4V:1H | Light brown orange granitic gneiss, moderately weathered | NA | none | +15% | Material 3 |
| 1528+00 | 1549+00 | 1V:1.5H | 1V:1H | Brown silty sand with gravel to cobble size rock fragments, some granite outcrops | 20 ft | none | -10% | Material 1 |
| 1549+00 | 1551+00 | 2V:1H | 1.33V:1H | Light brown orange to gray granitic gneiss, moderately weathered | 23 ft | none | +10% | Material 3 |

| Begin Station | End Station | Existing Cut Slope Ratio (Max) | Recommended Cut Slope Ratio | Lithology | Slope Height (Max) | Existing Rock fall catchment width | Swell/ Shrink | Material Type Number |
|---|---|---|---|---|---|---|---|---|
| 1551+00 | 1556+50 | 1V:2H | 1V:1.5H | Brown silty sand with gravel to cobble size rock fragments | <10 ft | 3 ft | -10% | Material 1 |
| 1556+50 | 1558+25 | 1V:1.5H | 1.33V:1H | Light brown orange to gray granitic gneiss, fractured, moderately weathered | 14 ft | 3 ft | +10% | Material 3 |
| 1558+25 | 1569+00 | 1V:2.5H | 1V:1.5H | Brown silty sand with gravel to boulder size rock fragments | <10 ft | 3 ft | -10% | Material 1 |
| 1569+00 | 1571+00 | NA | 1.33V:1H | Light brown orange granitic gneiss, predominantly decomposed to moderately weathered | NA | 3 ft | +10% | Material 3 |
| 1571+00 | 1578+00 | NA | 1V:1.5H | Brown silty sand with gravel size rock fragments | NA | 3 ft | -10% | Material 1 |
| 1578+00 | 1582+00 | 1V:1.5H | 1V:1H | Orange brown silty sand with gravel size rock fragments | 20 ft | 3 ft | -10% | Material 1 |
| 1582+00 | 1583+50 | NA | 1.33V:1H | White to light brown orange granitic gneiss, fractured, moderately weathered | NA | 3 ft | +10% | Material 3 |
| 1583+50 | 1588+00 | NA | 1V:1H | Brown silty sand with gravel to cobble size rock fragments | NA | 3 ft | -10% | Material 1 |
| 1588+50 | 1589+00 | NA | 1V:1H | Gray granitic gneiss, predominantly decomposed to moderately weathered | NA | 3 ft | +5% | Material 3 |
| 1589+00 | 1591+25 | NA | 1V:1.5H | Brown silty sand with gravel to cobble size rock fragments | NA | 3 ft | -10% | Material 1 |
| 1591+25 | 1592+75 | 1V:1H | 1.33V:1H | White to light brown orange granitic gneiss, fractured, moderately weathered | 18 ft | 3 ft | +10% | Material 3 |
| 1592+75 | 1593+50 | NA Over steepened | 1V:1.5H | Brown silty sand with gravel to small boulder size rock fragments | NA | 3 ft | -10% | Material 1 |
| 1593+50 | 1595+00 | NA | 1V:1H | Gray granitic gneiss, highly fractured, moderately weathered | NA | 3 ft | +10% | Material 3 |
| 1595+00 | 1597+50 | 1V:3H | 1V:1H | Brown silty sand with gravel to cobble size rock fragments | <10 ft | 3 ft | -10% | Material 1 |
| 1597+50 | 1607+00 | 1V:3H | 1V:1.5H | Brown silty sand with gravel to cobble size rock fragments | <10 ft | 3 ft | -10% | Material 1 |
| 1607+00 | 1619+00 | 1V:1H | 1V:1H | Light brown orange to gray granitic gneiss, moderately weathered and soil mix | 20 ft | 3 ft | +5% | Material 3 |
| 1619+00 | 1623+00 | NA | 1V:1.5H | Brown silty sand with gravel to cobble size rock fragments | NA | 3 ft | -10% | Material 1 |

| Begin Station | End Station | Existing Cut Slope Ratio (Max) | Recommended Cut Slope Ratio | Lithology | Slope Height (Max) | Existing Rock fall catchment width | Swell/ Shrink | Material Type Number |
|---|---|---|---|---|---|---|---|---|
| 1623+00 | 1626+00 | 1V:1H | 1.33V:1H | Gray to light brown orange granitic gneiss, fractured, moderately weathered | 20 ft | none | +10% | Material 3 |
| 1626+00 | 1629+50 | 1V:1H | 1V:1H | Brown silty sand with gravel to cobble size rock fragments | 25 ft | 3 ft | -10% | Material 1 |
| 1629+50 | 1632+50 | 2V:1H | 2V:1H<br>1.33:1 Better | Gray to light brown orange granitic gneiss, fractured, moderately weathered | 24 ft | 3 ft | +10% | Material 3 |
| 1632+50 | 1635+50 | 1V:1H | 1V:1.5H<br>Flatten slope | Brown silty sand with gravel to cobble size rock fragments | 20 ft | 3 ft | -10% | Material 1 |
| 1635+50 | 1642+00 | 4V:1H | 2V:1H<br>Avoid sliver cut | Gray to light brown orange granitic gneiss, fractured, moderately weathered | 45 ft | 3 ft | +10% | Material 3 |
| 1644+00 | 1661+50 | 1V:1H | 1.33V:1H<br>Avoid sliver cut | Gray to light brown orange granitic gneiss, highly fractured, moderately weathered | 24 ft | 3 ft | +10% | Material 3 |
| 1661+50 | 1672+00 | 1V:1H | 1V:1.5H<br>Flatten slope | Brown silty sand with gravel to cobble size rock fragments | 24 ft | 3 ft | -10% | Material 1 |
| 1672+00 | 1677+00 | 1V:1H | 1V:1.5H<br>Flatten slope | Yellow brown silty sand with cobble to small boulder size rock fragments | 18 ft | 3 ft | -10% | Material 1 |
| 1677+00 | 1689+00 | 1V:1H | 1V:1H | Light brown orange decomposed to predominantly decomposed granite | 18 ft | 3 ft | 0% | Material 2 |
| 1689+00 | 1691+00 | 4V:1H | 1V:1H | Light brown orange granite, highly fractured, moderately weathered | 15 ft | 3 ft | +15% | Material 3 |
| 1691+00 | 1740+00 | 1V:1H | 1V:1H<br>Avoid sliver cut | Light brown orange decomposed to predominantly decomposed granite | 25 ft | 3 ft | +5% | Material 2 |
| 1741+85 | 1744+50 | 2V:1H | 1V:1.5H<br>Or flatter<br>Flatten slope | Light brown orange granite, predominantly decomposed to moderately weathered | 24 ft | 3 ft | +10% | Material 3 |
| 1744+50 | 1754+00 | 1V:1H | 1V:1.5H<br>Flatten slope | Light brown orange decomposed granite to residual soil | 26 ft | 3 ft | 0% | Material 2 |
| 1754+00 | 1755+00 | 1V:1.5H | 1V:1H | Light brown orange predominantly decomposed granite | 15 ft | 3 ft | +5% | Material 2 |
| 1755+00 | 1760+25 | 1V:1H | 1V:1.5H<br>Flatten slope | Light brown orange decomposed granite to residual soil | 23 ft | 3 ft | -5% | Material 2 |
| 1760+25 | 1760+75 | 1V:1H | 2V:1H | Light brown orange decomposed granite to residual soil | 23 ft | 3 ft | -5% | Material 2 |
| 1761+00 | 1769+00 | 1V:1H | 1V:1.5H<br>Flatten Slope | Light brown orange decomposed granite to residual soil | 23 ft | 3 ft | -5% | Material 2 |

| Begin Station | End Station | Existing Cut Slope Ratio (Max) | Recommended Cut Slope Ratio | Lithology | Slope Height (Max) | Existing Rock fall catchment width | Swell/ Shrink | Material Type Number |
|---|---|---|---|---|---|---|---|---|
| 1769+00 | 1770+50 | 1V:1H | 1V:1H | Light brown orange predominantly decomposed granite | 20 ft | 3 ft | +5% | Material 2 |
| 1770+50 | 1777+50 | 1V:1.5H | 1V:1.5H | Light brown orange decomposed granite to residual soil | 15 ft | 3 ft | -10% | Material 2 |
| 1777+50 | 1790+00 | 1V:1H | 1V:1H | Gray to light brown orange predominantly decomposed to moderately weathered granite | 22 ft | 3 ft | +5% | Material 3 |
| 1790+00 | 1808+00 | 1V:1.5H | 1V:1.5H | Brown to light brown orange DG to residual soil | 12 ft | 3 ft | -10% | Material 2 |
| 1808+00 | 1812+00 | 1V:1.5H | 1V:1H | Light brown orange decomposed to moderately weathered granite | <10 ft | 4 ft | +10 | Material 3 |
| 1812+00 | 1823+00 | 1V:1.5H | 1V:1.5H Avoid sliver cut | Light brown orange DG | 15 ft | 4 ft | 0% | Material 2 |
| 1823+00 | 1832+00 | 1V:2H | 1V:1.5H | Brown residual soil (silty sand) | <10 ft | 3 ft | -10% | Material 1 |
| 1832+00 | 1892+00 | 1V:1.5H | 1V:1.5H Avoid sliver cut | Brown residual soil (silty sand) with sporadic harder rock outcrops | 12 ft | 3 ft | -10% | Material 1 |
| 1892+00 | 1895+50 | NA | 1V:1.5H | Brown to light brown orange DG | NA | 3 ft | 0% | Material 2 |
| 1895+50 | 1914+00 | NA | 1V:1.5H | Brown silty sand with gravel size rock fragments | NA | 3 ft | -10% | Material 1 |
| 1914+00 | 1950+00 | 1V:1H | 1V:1.5H Flatten slope | Light brown orange to gray decomposed to predominantly decomposed granite. Rock outcrop at944 to 1946 | 17 ft | 3 ft | 0% | Material 2 |
| 1950+00 | 1957+00 | 1V:3H | 1V:1.5H | Brown silty sand with gravel size rock fragments | <10 ft | 3 ft | -10% | Material 1 |
| 1957+00 | 1960+00 | 1V:2H | 1V:1H | Light brown orange predominantly decomposed granite | <10 ft | 3 ft | 0% | Material 2 |
| 1960+00 | 2032+00 | 1V:1H | 1V:1.5H Flatten slope | Brown silty sand with gravel size rock fragments with sporadic harder rock outcrops | 18 ft | 3 ft | -10% | Material 1 |
| 2032+00 | 2034+00 | 1V:1.5H | 1.33V:1H | Dark gray to light brown orange granite, moderately weathered | <10 ft | 3 ft | +10% | Material 3 |
| 2034+00 | 2039+00 | 1V:2H | 1V:1.5H | Brown silty sand with gravel to boulder size rock fragments with sporadic harder rock outcrops | <10 ft | 3 ft | -10% | Material 1 |

| Begin Station | End Station | Existing Cut Slope Ratio (Max) | Recommended Cut Slope Ratio | Lithology | Slope Height (Max) | Existing Rock fall catchment width | Swell/ Shrink | Material Type Number |
|---|---|---|---|---|---|---|---|---|
| 2039+00 | 2062+00 | 1V:1.5H | 1V:1H | Light brown orange to gray decomposed to moderately weathered granite | <10 ft | 3 ft | +10% | Material 3 |
| 2062+00 | 2079+00 | 2V:1H | 2V:1H<br>1.33V:1H<br>Better | Light brown orange to gray moderately weathered granite | 14 ft | 3 ft | +15% | Material 3 |
| 2079+00 | 2093+00 | 1V:1.5H | 1V:1H | Light brown orange DG | 14 ft | 3 ft | 0% | Material 2 |
| 2093+00 | 2096+00 | 1V:2.5H | 1V.33:1H | Light brown orange to gray moderately weathered granite | <10 ft | 3 ft | +15% | Material 3 |
| 2096+00 | 2110+00 | 1V:1.5H | 1V:1H | Light brown orange DG with sporadic harder rock outcrops | <10 ft | 3 ft | 0% | Material 2 |
| 2110+00 | 2135+00 | 2V:1H | 2V:1H | Light brown orange to gray moderately weathered granite | 18 ft | 3 ft | +15% | Material 3 |
| 2135+00 | 2143+00 | 1V:1H | 1V:1.5H<br>Flatten slope | Light brown orange decomposed granite mixed with brown silty sand and rock fragments | 25 ft | 3 ft | -10% | Material 2 |
| 2143+00 | 2156+00 | 1V:1.5H | 1V:1H<br>Avoid sliver cut | Light brown orange to gray decomposed to moderately weathered granite | 18 ft | 3 ft | +10% | Material 3 |
| 2156+00 | 2159+43 | NA | 1V:1.5H<br>Easy Grading | Brown soil | NA | 3ft | -10% | Material 2 |

## MATERIAL SHRINK / SWELL FACTORS

Anticipated material shrink/swell for cut material is also listed in the table for design purposes. Materials shrink or swell is the percent decrease or increase in volume of an earth material after it has been excavated and recompacted. Shrink/Swell factors are based on experiences from previous projects and published data for similar materials. To accurately determine shrink/swell factors for soil/rock units is complex. Factors that impact earthwork quantities are top soil stripping, clearing and grubbing requirements, boulder stripping, compaction and construction practices. Typically, intact *rock* swells when excavated, mechanically broken, and recompacted, whereas intact *soil* shrinks when excavated and recompacted. Refer to Table 1 for recommended cutslope ratios for specific station intervals and shrink/swell factors for use in design.

## CATCHMENT DITCHES

Catchment ditch widths of existing cutslopes were also measured and are shown in Table 1. In most cases, existing catchment areas were about 3 feet and appeared to have a sufficient width to retain a high percentage of falling debris. It is therefore recommended that a minimum of 3-foot-wide catchment be included in the design at most cut locations. In areas where proposed cutslope ratios are 2V:1H or steeper, and proposed slope heights are greater than 30 feet (Station 1635+50 to 1642+00, Station1425+00 to 1427+25, and Station 1429+50 to1430+50), a 5-foot minimum

catchment area is recommended. In steep rock cut areas where the 5-foot minimum catchment is not achieved we recommend scaling and slope draping from top of the cut to 5 feet above roadway grade elevation. Due to the weathered and jointed nature of the rock mass, loose colluvial materials overlaying bedrock, steep terrain, and high slope heights, it is not feasible to construct catchment ditches with widths to prevent all rockfall debris from reaching the paved surface. Therefore, cutslope recommendations assume routine maintenance to keep a safe roadway condition. Experiences show that rockfall frequencies may increase for a short period following a rock cut. Slopes generally stabilize after couple years.

Cutslope and catchment evaluations consider local precedence and engineering judgment based on observations, experiences and past performance of slopes in the project vicinity. Based on the geological structure in rock cuts, and the fact that most cut depths are within 20-feet existing cut heights/slope ratio do not change appreciably and therefore, significant increase of risk from higher rockfalls are not anticipated.

A specific area of concern is between Station1689+50 and 1690+00. This cutslope mostly consists of highly fractured bedrock existing at a slope ratio of 4V:1H with almost on rockfall catchment area. As shown in the 50% plans, this slope possesses a high safety risk to the public from rock falls. The following alternatives are recommended for this site:

(a) Flatten the slope to a minimum slope ratio of 1.33V:1H with a minimum 5-foot catchment ditch,

(b) Scale and drape the entire slope segment with wire mesh anchored on top of the slope in accordance with SCR Section 651 or,

(c) Shift horizontal alignment a minimum of 5 feet to move away from the cut and to minimize impacts.

**FIGURE 1:- Station 1689+50 Rock Cut**

## SLOPE SCALING AND EROSION CONTROL

Where differential weathering of the slope surface produces a rockfall hazard, as may be the case in some areas along the alignment, scaling can be used as a temporary solution. Scaling can be done by machine or hand to remove potential unstable boulders and detached blocks, thereby reducing the rockfall hazard and maintenance following construction. It is recommended that a minimum of 100 scaling crew hours be budgeted in the project. Slope scaling should be done on slopes with potential rockfalls and will be determined by a geotechnical engineer during construction. Scaling should be conducted in accordance with SCR for Section 623.

Shallow cutslope ratios used to promote vegetation may also benefit from erosion control products such as erosion control blanket or guard bonded fiber matrix. Such products are biodegradable with a design life up to two years. A qualified erosion control engineer should be consulted for specific recommendations regarding slope protection measures.

## BROW SLOPE ROUNDING

A portion of Tarryall Creek Road existing cutslopes have a brow or erosional scarp at the top, where the slope has resisted erosion because of strength contributions by the overlaying root system. As erosion continues on the slope below, the brow will reach a height that exceeds the strength of the root-reinforced material and the brow will fail. Removing the brow and rounding the slope where it catches the natural topography can mitigate this hazard. It is therefore recommended that weathered/eroded top sections of existing and cutslopes are rounded when possible or within equipment reach. Rounding should be minimized to the extent possible to take advantage of the existing vegetation root mass for erosion control. Erosion control matting should also be installed at these rounding locations to promote revegetation. Slope matting quantities should be estimated based on existing slope length and slope ratios. Slope crest (brow) rounding should be in accordance with SCR for Section 623.

**FIGURE 2 Station 1592 Typical Cutslope Brow**

**FIGURE 3:- Station 1672 Typical Cutslope Brow**

## EMBANKMENTS

The rehabilitation and reconstruction of Tarryall Creek Road requires extensive embankment

work and drainage improvements. In general, fill slopes on the outboard side of the roadway are generally stable at existing slope ratio and no retaining structures will be required to support the roadway. It is recommended that fills be constructed, at a slope ratio of 1V:2H or flatter, using on site excavated materials (unclassified borrow) in accordance with Section 704-06. Fill materials must be clean and free of organic debris with rock fragments size less than 24 inches. Fills must be placed in thin horizontal lifts with benching not exceeding two feet loose thickness (or compatible with the type of compaction equipment being used. Granular materials should be adjusted to within 2 percent of optimum moisture. Fill should be compacted to a minimum of 95 percent of standard Proctor maximum dry density.

EMBANKMENT EROSION PROTECTION

Several locations were identified for embankment erosion protection with Class 3 riprap rundown blanket. Embankment erosion was mainly caused by surface water runoff that has created erosional channels along the downslope and encroaching on the roadway shoulder. Special rock embankment for bank armoring is recommended to rehabilitate eroded embankments and to prevent further erosion. Special rock embankment with a minimum bench width of 10 feet should be installed in accordance with Section 252 near approximate stations listed in Table 2.

**TABLE 2:- Areas recommended for Special Rock Embankments**

| Begin Station | End Station | Length, (ft) | Width, (ft) | Riprap Class |
|---|---|---|---|---|
| | | | | |
| 1681+00 | 1681+25 | 10 | 25 | Class 3 |
| 1685+51 | 1685+71 | 40 | 20 | Class 3 |
| 1694+40 | 1694+71 | 20 | 10 | Class 3 |
| 1695+51 | 1695+61 | 35 | 10 | Class 3 |
| 1696+51 | 1697+11 | 20 | 60 | Class 3 |
| 1866+50 | 1866+75 | 20 | 15 | Class 3 |

ROADWAY DISTRESS

The existing asphalt roadway suffers moderate to severe cracking, pavement depressions, potholes, and localized subgrade failures at several locations along the alignment. These areas are considered to have a factor of safety close to failure and may be experiencing creep. Most of these failures are caused by inadequate drainage allowing for material oversaturation, weak subgrade with high fines content, thin/old pavement, or freeze/thaw during the spring months. Roadway distress observed along the alignment is likely a combination of all three factors.

**FIGURE 4:- Typical Roadway Distress, Station 1672**

**FIGURE 5:- Typical Roadway Distress, Station 2040**

Subgrade stabilization is recommended as a mitigation method to improve roadway distress areas. Subgrade stabilization is a repair technique that uses granular backfill compacted in lifts with geotextile reinforcement in accordance with Section 204.11(b). Because of the existing pavement condition it is difficult to determine exact locations of deep patches along the alignment. It is recommended that several areas estimated at a total of 150-feet long be included in the bid documents for subgrade stabilization and should be used as directed by the CO. Stabilization techniques are not a substitute for a proper constructed roadway; however, they are an economical solution for reducing pavement distress and slow reduce settlement. In roadway distressed areas, a minimum of 2 feet of subgrade materials should be excavated with a 2 percent sloping base and replaced with granular free draining backfill materials (Section 704.03) reinforced with biaxial geogrid (Section 207) layers placed at one foot intervals. Sub-excavation should either be full width of the roadway or half width depending on the areas. Drainage should also be improved to prevent water of penetrating the roadway subsurface.

Local springs under the pavement may exist and may require draining and/or stabilization prior to placement of roadway base and pavement. In areas where several springs or water seeps may exist beneath the paved surface, a blanket underdrain should be installed to improve drainage and prevent roadway damage. A granular blanket underdrain is recommended to be installed underneath the paved surface between station 1620+00 and 1690+00. This area borders a flat wetland on the left side and a steep rock cut on the right allowing the surface water to infiltrate and remain beneath the roadway surface and causing severe damage (potholing) during the freeze/thaw cycle. The blanket underdrain should consist of 6-inches of select granular fill placed under the roadway across the entire width of the roadway prism and daylights on the downslope side of the roadway. The select granular fill should be encapsulated by a Type I-A geotextile. An alternative geomembrane material (such as roadrain) may also be used instead of the granular blanket underdrain.

ROCKERY DESIGN

This section provides recommendations for the design of two proposed rockeries along Tarryall Creek Road. Table 3 summarizes the proposed rockery locations and geometries. Cut rockery #W1 is planned to retain a driveway that leads to a historic building. A small diameter culvert installed under the driveway will empty onto the rockery face and is diverted away from the rockery in a paved ditch along the rockery foundation. Cut Rockery #W2 and #W3 is planned to prevent impacts the structure located at the top of the cut slope. Fill rockery #W4 is planned to prevent impacts to an existing residential driveway.

**TABLE 3:- Location and Geometries of Proposed Rockeries**

| Wall | Begin Station | End Station | Side | Length (ft) | Maximum Height (ft) |
|---|---|---|---|---|---|
| | | | | | |
| **Cut Rockery #W1** | 1642+10 | 1643+00 | Right | 90 | 5.9 |
| **Cut Rockery #W2** | 1757+50 | 1760+25 | Right | 275 | ? |
| **Cut Rockery #W3** | 1760+75 | 1761+25 | Right | 50 | ? |
| **Fill Rockery #W4** | 2095+80 | 2096+50 | Left | 70 | 9.0 |

Rockeries are earth retaining structures constructed of large interlocking, dry-stacked rocks typically placed without mortar or reinforcement. These structures rely on the weight, size, shape, and interface friction of the individual rocks to resist earth pressures and provide overall stability. Rockeries have been recently utilized on many projects as context sensitive solutions preserving scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility.

Rockeries were designed in accordance with the guidelines provided in the Central Federal Lands publication, *"Rockery Design and Construction Guidelines"*. No geotechnical investigations were conducted at the wall sites; therefore, a conservative design approach was followed requiring material property verification during wall excavation prior to rockery construction. In lieu of soil testing, presumptive soil strength properties for retained and foundation soils were assumed for observed on-site soils. Both rockeries were designed as gravity retaining walls and a surcharge load of 250 pounds per square foot was applied to simulate traffic loading. Static and seismic lateral earth pressures were applied to the back of the rockery; however passive earth pressure was neglected at the toe of the wall.

The design was checked for adequate factors of safety against sliding, overturning, and bearing capacity. The recommended factors of safety for static and seismic rockery design are presented in the table below:

**TABLE 4:- Recommended Safety Factors for Static and Seismic Design**

| Mode of Failure | Static Factor of Safety | Seismic Factor of Safety |
|---|---|---|
| Sliding | 1.5 | 1.1 |
| Overturning | 2.0 | 1.5 |
| Bearing | 3.0 | 2.0 |

Assumed material properties used in the design of the rockeries are presented in Table 5. Rockery geometries and the calculated rockery design factors of safety for each wall analysis are shown in Table 6 and Table 7.Refer to Figure 6 for illustration of the parameters used in the tables and for design. A presumptive ultimate bearing capacity of the soils is estimated at 5 TSF (10 ksf)

**TABLE 5:- Material Properties used in the Analysis for Both Rockeries**

| Φ Retained Soil Friction Angle | $\gamma_s$ Retained Soil Unit Weight | *C* Soil Cohesion | μ Sliding Friction Factor | $\gamma_r$ Rockery Face Unit Weight | $K_h$ Horizontal Seismic Coefficient | $K_v$ Vertical Seismic Coefficient | Qs Vertical Surcharge |
|---|---|---|---|---|---|---|---|
| 37 degrees | 125 pcf | 50 ksf | 0.8 | 140 pcf | 0.05 | 0 | 250 psf |

**TABLE 6:- Rockery Geometry**

| B Minimum Base Width | H Maximum Height | D Depth at Toe | ß Backslope Angle | (V:H) Face Batter | (V:H) Back Cut Inclination |
|---|---|---|---|---|---|
| 2.0 ft | 4 ft | 1.0 ft | 12 degrees | 4:1 | 8:1 |
| 2.7 ft | 6 ft | 1.0 ft | 12 degrees | 4:1 | 8:1 |
| 3.4 ft | 8 ft | 1.0 ft | 12 degrees | 4:1 | 8:1 |
| 4.2 ft | 10 ft | 1.0 ft | 12 degrees | 4:1 | 8:1 |
| 4.8 ft | 12 ft | 1.0 ft | 12 degrees | 4:1 | 8:1 |
| 5.5 ft | 14 ft | 1.0 ft | 12 degrees | 4:1 | 8:1 |

**TABLE 7:- A Summary of Calculated Factors of Safeties**

| Factors of Safety | Maximum Height | Sliding Factor of Safety | Overturning Factor of Safety | Maximum Bearing Pressure | Bearing Capacity Factor of Safety |
|---|---|---|---|---|---|
| Static | 4 ft | 2.5 | 2.2 | 1.1 ksf | 9.1 |
| Seismic | | 2.0 | 1.8 | 1.3 ksf | 7.7 |
| Static | 6 ft | 2.5 | 2.1 | 1.6 ksf | 6.2 |
| Seismic | | 2.0 | 1.6 | 2.0 ksf | 5.0 |
| Static | 8 ft | 2.5 | 2.0 | 2.1 ksf | 4.7 |
| Seismic | | 2.0 | 1.6 | 2.6 ksf | 3.8 |
| Static | 10 ft | 2.5 | 2.1 | 2.5 ksf | 4.0 |
| Seismic | | 2.0 | 1.6 | 3.2 ksf | 3.1 |
| Static | 12 ft | 2.5 | 2.0 | 2.9 ksf | 3.4 |
| Seismic | | 2.0 | 1.6 | 3.8 ksf | 2.6 |
| Static | 14 ft | 2.5 | 2.1 | 3.2 ksf | 3.1 |

| | | | | | |
|---|---|---|---|---|---|
| Seismic | | 2.0 | 1.6 | 4.2 ksf | 2.3 |

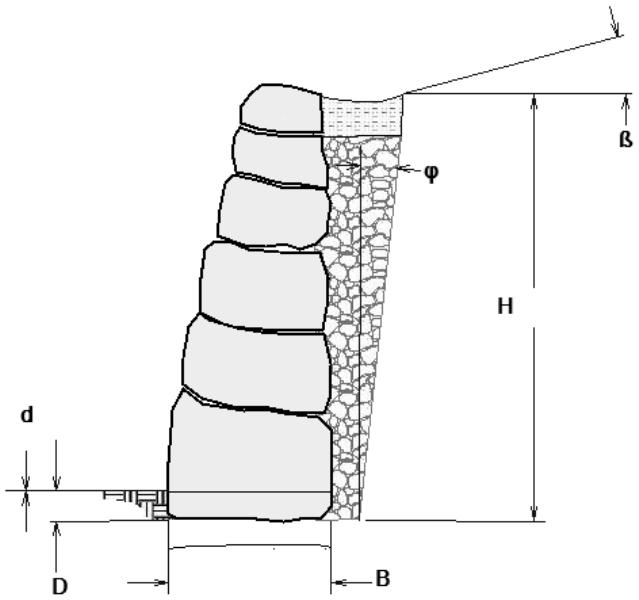


**FIGURE 6:- Illustration of the Parameters used in the design**

## LABORATORY TESTING

Representative bulk soil samples were obtained from different cut locations and tested in the laboratory. Laboratory tests included gradation/classification, Atterberg limits, and resistance (R-value). Table 3 summarizes the laboratory results.

**TABLE 3.- Results of Laboratory Tests on Samples From Various Cuts**

| Sample Location | | Gradation | | | Atterberg | | Classification | | R-Value |
|---|---|---|---|---|---|---|---|---|---|
| Begin Station | End Station | Gravel | Sand | Fines | Liquid Limit | Plasticity Index | AASHTO | USCS | |
| 1338+00 | 1342+00 | 21.0% | 72.4% | 6.6% | NV | NP | A-1-b | SP-SM | 78 |
| 1444+00 | 1448+00 | 28.0% | 61.0% | 11.0% | NV | NP | A-1-b | SP-SM | 78 |
| 1578+00 | 1582+00 | 32.0% | 55.0% | 13.0% | NV | NP | A-1-b | SM | 72 |
| 1744+50 | 1754=00 | 37.0% | 57.9% | 5.1% | NV | NP | A-1-a | SW-SM | 78 |
| 1960+00 | 2032+00 | 40.0% | 49.0% | 11% | NV | NP | A-1-a | SP-SM | 63 |

In general the materials classified as poorly graded sand and gravel with some silt and no plasticity (A1-a and A1-b in accordance AASHTO soil classification system AASHTO M-145 and as SP-SM in accordance with unified soil classification system ASTM D-2487). The percent of fines (passing the #200 sieve) in the tested samples averaged 9 percent. The resistance (R) value was also measured to determine the performance of the soils for use as subgrade or base

for roadways under specified traffic loads. The results indicated R-values averaging 74 which indicates high resistance to plastic deformation of compacted materials. The materials were not tested for L.A. Abrasion and in most areas it is not expected to meet specifications for use as riprap or base.

Based on the laboratory results the excavated materials are suitable for use as unclassified borrow for embankment fill (Section 704.06) and backfill material for culverts (Section 704.03). It may also be crushed and processed to meet the specifications for other uses along on the project.

If you have any questions please do not hesitate to call me at 720 963-3521.

_____ Date_____

Khamis Y. Haramy

Geotechnical Engineer, CFLHD

## Section 623. – GENERAL LABOR

Delete the text of this Section and substitute the following:

### Description

**623.01** This work consists of furnishing workers and hand tools for construction work, survey crews, slope scaling, slope crest overburden rounding, and/or furnishing qualified personnel to perform technical work ordered by the CO and not otherwise provided for under the contract.

**623.02 Workers and Equipment.** Furnish competent workers and appropriate hand tools for the work.

Obtain approval of the length of a workday and workweek before beginning the work. Keep daily records of the number of hours worked. Submit the records along with certified copies of the payroll.

**623.03 Surveying Services.** Furnish personnel, equipment, and material that conform to the requirements of Subsection 152.01. Survey according to Section 152.

Survey and establish controls within the tolerances shown in Table 152-1, or within other tolerances as established by the CO.

Prepare field notes in an approved format. Furnish calculations. All field notes, supporting documentation, and calculations become the property of the Government upon completion of the work.

**623.04 Office Technical Services.** Furnish qualified engineering personnel experienced in highway construction and design, capable of performing in a timely and accurate manner. Provide personnel with a minimum of NICET Level II certification in highway design and construction, or State (SHA) or industry certification-related design and construction equivalent to their intended responsibilities. Personnel with 2 years or more of recent job experience in the type of highway design and construction provided for under the contract may be used in lieu of certifications. Provide the names and relevant experience of all personnel. Furnish supporting tools and equipment (e.g., calculator, computer, and software, and appropriate and commonly-used drafting tools for the assigned task).

All calculations, notes, and supporting documentation become the property of the government upon completion of the work.

**623.05 Slope Scaling.** Remove loose or potentially unstable rock and soil debris and vegetation on the slopes adjacent to the roadway as directed by the CO.

**(a) Submittals.** Two weeks prior to commencing scaling activities, submit to the CO for approval a detailed slope scaling plan that includes the following:

1) Proposed scaling sequence and schedule for each rock slope to be scaled and slope crest overburden rounding;

2) Types of equipment and tools used for slope scaling, including a high-reach excavator capable of removing rock from a cut slope crest 50 vertical feet above the roadway;
3) Personnel Qualifications. The Foreman shall have a minimum of two years and scaling crew a minimum of one year demonstrated experience in rock scaling/crest slope rounding in similar capacities;
4) ) Rock and soil removal and disposal plan for materials generated from the scaling and slope crest preparation work;
5) Devices, measures, and procedures to protect the public, construction personnel, facilities/structures/utilities from danger or damage during the scaling activities; and
6) Traffic control plan as specified in Section 156.

**(b) Pre-Scaling Meeting.** One week prior to commencing scaling activities, schedule an on-site pre-scaling meeting with scaling Forman An FHWA Geotechnical Engineer will be present at the meeting to identify slope scaling locations and specific rocks and boulders to be removed.

**(c) Scaling Crew Requirements.** Provide scaling crews. A crew is defined as one Foreman and two qualified scalers (if a crewmember must leave for any reason that member shall be replaced by a qualified replacement).

**(d) Protection of Property.** Provide devices, measures, and procedures to protect the public, construction personnel, and property/structures/utilities damage caused by scaling and slope crest rounding activities. Any injuries or damages caused by scaling activities are the sole responsibility of the Contractor.

**(e) Sequencing.** Begin slope scaling at the top of the cut slope and proceed downward towards the roadway.

**623.06 Acceptance.** Additional surveying services will be evaluated under Section 152. Hired technical services will be evaluated under Subsections 106.02 and 106.04. Slope scaling will be evaluated under Subsection 106.02.

## Measurement

**623.07** Measure the Section 623 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Round portions of an hour up to the nearest half hour. Measure time in excess of 40 hours per week at the same rate as the first 40 hours.

For surveying services, the minimum field survey crew is two persons. Measure surveying service by the crew hour. Do not measure time spent in making preparations, performing calculations, plotting cross-sections and other data, and processing computer data, and other efforts necessary to successfully accomplish the ordered survey services.

Do not measure time for worker's transportation time to and from the project site.

Measure office technical services by the hour as ordered by the CO for performing calculations, plotting cross-sections and other data, and processing computer data.

Measure slope scaling by the crew hour as ordered by the CO for slope scaling activities.

Work and materials associated with scaling activities, including protecting against danger and removing and disposing of spoil and materials associated with scaling activities are incidental to the scaling and will not be measured for payment.

Removal and disposal of materials generated by scaling and slope rounding, including equipment needed, loading/unloading, and transporting material is incident to the work and will not be measured for payment.

## Payment

**623.08** The accepted quantities will be paid at the contract price per unit of measurement for the Section 623 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this section. See Subsection 109.05.

## Section 205 – ROCK BLASTING

**205.01 Description** Delete and add the following:

The project will require carefully planned and uniquely adapted blasting approaches to achieve engineered road cuts that are both structurally sound and aesthetically pleasing.

Construct cut faces to have a natural, rather than artificial, appearance to the fullest extent practicable. Identify and use specific measures applicable to blasting that will enable the final cut faces to blend with the form, line, color and texture of the existing rock formations of the surrounding landscape. Controlled blasting will be required in order to utilize the existing geologic structure properly and to minimize back-break beyond the trim line.

Following are specific blasting objectives:

**(1)** Minimize blast damage beyond the trim line. Blast damage is defined to include widening and loosening of existing joints or foliation, displacement of blocks of intact rock, and creation of new fractures.
**(2)** Utilize the natural geologic bedding planes and joint structure in a predicted and controlled manner to form the final cut.
**(3)** Blast and scale to the trim lines to produce stable faces such that the subsequent rockfall and associated maintenance costs are minimized.
**(4)** Accomplish the creation of ledges and a rough, natural appearance by incorporation of these features in the blast plan, and not by overshooting and selective removal of damaged rock.
**(5)** Minimize obvious drill hole scars or machine scaling equipment scars in the final cut faces.
**(6)** Prevent damage to the natural environment outside the clearing limits from fly rock, operation of equipment, or other construction related causes in accordance with Subsection 107.02.
**(7)** Conduct all blasting, scaling, and associated bolting and cleanup work in accordance with Sections 108, 156, 260, and 261, ensuring traffic safety at all times.
**(8)** Prevent damage to the existing roadway wear surface from blasted or scaled rock through the use of temporary roadway protection measures.

Controlled blasting consists of the controlled use of explosives and blasting accessories in carefully spaced and aligned drill holes to produce specific free surfaces or shear planes in the rock along the predetermined excavation backslope. Controlled blasting techniques include cushion blasting or variations of cushion blasting, as approved by the CO, but do not generally include pre-splitting. Pre-splitting may only be used for temporary excavations in rock that will eventually be covered (e.g., wall backslope) or further excavated using cushion blasting techniques. The CO may require the use of controlled blasting to form the faces of slopes, even if the slopes could be formed by non-blasting methods. Use controlled blasting methods to minimize damage to the rock backslope to help insure long-term stability.

For cushion blasting, controlled blast holes are defined as the first row of drill holes (normally within 0.6 m of the plane forming the final cut face), as shown on the approved blasting plan.

Production blasting consists of the main fragmentation blasting resulting from more widely spaced production holes drilled through the main excavation area. Detonate production holes in a controlled delay sequence. Use production blasting to prevent escape of material beyond the established construction limits and in accordance with Subsection 107.02.

This work also includes pre- and post-blast condition surveys and ground motion monitoring of nearby historic structures that could be at risk from blasting damage.

**205.04 Blaster-in-Charge** Add the following:

Submit a written resume showing not less than three years of active involvement as blaster-in-charge on projects similar in scope to this contract. Submit a list of five references who can testify to the known qualifications and reliability of the blaster-in-charge.

All crew members must have completed blasting safety training of at least 24 hours and/or have not less than one year of experience acceptable to the contracting officer.

**205.05 Blasting Plans**

**(a) General blasting plan**

Delete the first sentence and add the following:
Submit a general blasting plan for acceptance at least 7 days before drilling operations begin.

Delete (1) and add the following:

(1) Working procedures and safety precautions for storing, transporting, handling, and detonating explosives, including area security plan, signal system, handling of misfires, removal and disposal of unused or excess explosives, and blast records.

Add the following:

(6) Methods for and locations of explosive storage, including storage construction, inventory system to be used, and signage to be applied.
(7) Methods to be employed for traffic control and other public safety precautions in the use, storage, and transportation of explosives.
(8) General methods and approach to blasting which account for the range of geologic settings and physical conditions present on the project. Describe how the specific blasting plans will account for various cut geometries, rock types, access problems, categories of fracturing and jointing, and required face contours.
(9) Equipment intended to be used in support of blasting operations.
(10) Method of containment to prevent rock material from escaping the construction limits and contingency measures for unanticipated rock fall – particularly as rockfall might affect the existing tunnel portal, outboard lane guardwall, and or Hwy 140 immediately below the slope work location.

(11) Include a description and license number of the vehicle(s) to be used, route(s) to be traveled, proposed hours of travel, and qualifications of the driver for all explosives transportation.
(12) Include proposed signing, guard system, signal system, methods of communication, and pre-blast notification procedures as part of the area security planning.
(13) Include a description of the plan for fire watch during and following all blasting related activities, including drilling operations. The CO may require a designated person be detailed to a fire watch for one to two hours after blasting, depending on the degree of fire hazard present. During periods of extreme fire danger, the use of all-electric detonation systems may be required by the CO.
(14) Method for placing, containing, and removing roadway flooding materials (unspecified sand and gravel) used to cushion blasted and scaled rock in order to prevent damage to the existing roadway wear surface.

**(b) Site-specific blasting plans** Add the following:

(5) Specific fly rock control measures.
(6) Estimated quantities of volume of rock in-place and length of both production and controlled blast drill hole.
(7) Location and attitude of significant fracturing, rock type changes, faulting, and any special circumstances to be accounted for in the plan.
(8) Specific pre- and post-blast scaling operation requirements.
(9) Specific roadway surface protection measures to be employed.

The CO may require modifications of any blasting plans during the duration of the project. Obtain approval by the CO for any modifications in the blasting plans, including changes in drilling pattern or depth, loading, or initiation occasioned by the review of the drilling behavior or subsequent blasting performance.

The Contractor is advised that assessment of the areas to be blasted, preparation and review of blasting plans, and subsequent drilling and blasting operations may progress slowly due to the complexity of the work, the possibility of the need for revisions and resubmittals, and the unstable nature of the rock at various project locations.

The safety of personnel shall be the controlling consideration in decisions involving explosive activities. The Contractor shall exercise the utmost care not to endanger life and property, making proper use of blast mats and other protective devices and adopting whatever additional precautions are deemed necessary to prevent damage to trees, shrubs, other landscape features, historic structures, etc. Make every effort to prevent damage to the natural and constructed surroundings. Should damage occur, make restoration as required by the CO at no additional cost to the government.

**205.07 Test blasting** Delete and add the following:

Drill, blast, and scale one or more test sections as proposed in the blasting plan and required for vibration control under 205.06. Test blasts shall be made away from the final slope line, but within the proposed construction limits.

Space blast holes for the cushion (trim) method of controlled blasting no more than 1.5 meters apart for the initial test blast. Space blast holes for the presplitting method of controlled blasting no more than 750 millimeters apart for the initial test blast. Adjust the spacing as approved. Use the approved spacing in the full-scale blasting or subsequent test blasts if necessary.

Do not drill ahead of the test shot area until the test section has been excavated and/or scaled and results evaluated by the CO. If the test blasting results are unsatisfactory, in the opinion of the CO, adopt such revised methods as are necessary to achieve the required results. A test blast is unacceptable when it results in fragmentation beyond the final rock face; fly rock, poor fragmentation requiring rehandling of shot rock, excessive overbreak, damage to the final rock face, overhang, or excessive ground and/or air vibrations. All costs incurred by the Contractor in adopting revised blasting methods necessary to produce an acceptable test shot are considered as a subsidiary obligation to the work.

Only conduct test blasting if it can be accomplished safely at the site. The loose nature of blocks within the confined slope area may require the Contractor to proceed cautiously with production blasting from the onset of work, as determined and approved by the CO. If this is the case, the Contractor shall provide for other acceptable means for estimating ground motions in the blast area, and will provide for added precautions for flyrock, ground vibrations, airblasts, and excessive overbreak.

If at any time during the progress of the work the methods of drilling and blasting do not produce the desired slope and rock face, conduct additional test blasting until a suitable drilling and blasting method is determined. Extra cost resulting from this requirement is considered as a subsidiary obligation to the work.

**205.08 Blasting**

**(a) General** Delete the second sentence and add the following:

Before drilling, remove overburden soil and loose rock along the top of the excavation sufficient to create a safe work location and to provide for pre-blast bolting of the slope crest, as needed.

Add the following after the fourth paragraph:

Blast only during daytime hours. Do not leave loaded holes overnight. Plan daytime blasting schedules, quantities, and clearance times in accordance with maintenance of traffic requirements described in Section 108 and 156.

Delete the seventh paragraph and add the following:

If blasting operations cause fracturing of the final rock face, or uncovers potentially unstable blocks within the final rock face, repair or stabilize the slope in a manner approved by the CO. Repair or stabilization may include additional rock removal, rock bolting (Section 260), rock doweling (Section 261), or other stabilization techniques.

Per direction of the CO, preserve the existing rock mass character to the extent possible. Undulate or roughen cut face slopes to match adjacent rock outcrops and landforms. Manipulate

blasting patterns to create rock surfaces, terraces, and ridges similar to undisturbed rock faces and outcrops. Shape cut faces to blend with adjacent undisturbed rock faces.

**(c) Controlled blasting** Delete the last line from paragraph five, and add the following:

Do not exceed 6 m for the bench height and length of drill holes for any individual lift unless the Contractor can demonstrate the ability to stay within approved tolerances and produce the desired cut face.

**205.09 After blast reports** Delete the first sentence and add the following:

Immediately after a blast and subsequent slope excavation and/or scaling, and before the next blast, submit an after blast report to the CO that includes the following:

Add the following to item (b):

(3) Name of the blasting foreman and the date and time of the blast.

After mucking operations for each blast, measure the excavated slops to determine overbreak quantities. Measurement may be done after each individual blast or after a series of blasts in the cut, as requested by the CO. Incorporate these quantities as part of the final blasting report.

The blasting plan submittal and blasting report are for quality control and record keeping purposes. Review of blast design and techniques by the CO do not relieve the Contractor of responsibility for adequacy, safety, proper supervision, and compliance with these SCRs, when implemented in the field.

Add the following after item (e):

(f) A written statement on completion of the work, countersigned by the blaster-in-charge, certifying that:

(1) All blasting is complete and all explosives materials, including detonators, detonating cord, and explosives have been removed from the Park.
(2) All blast holes loaded with explosives and any other set explosive charges have either been detonated or unloaded and the explosives have been properly disposed of.

## Section 207. — EARTHWORK GEOTEXTILES

Delete the text of this Section and add the following:

### Description

**207.01** This work consists of furnishing and placing a geotextile as a permeable separator, stabilizer, or permanent erosion control measure.

This work also consists of furnishing and placing a geogrid as a soil reinforcement element.

This work also consists of furnishing and placing an impermeable geomembrane liner under the Wetland Mitigation area soil.

Geotextile types are designated as shown in Subsection 714.01.

### Material

**207.02** Conform to the following Subsection:

| | |
|---|---|
| Geotextile | 714.01 |
| Geogrid | 714.03 |
| Geomembrane | 725.19 |

### Construction Requirements

**207.03 General.** Submit test results to the CO verifying the proposed products meet the criteria as outlined in Section 714 and 725.

Where placing a geotextile on native ground, cut the trees and shrubs flush with the ground surface. Do not remove the topsoil and vegetation mat. Remove all sharp objects and large rocks. Fill depressions or holes with suitable material to provide a firm foundation.

Replace or repair all geotextile or geogrid that is torn, punctured, or muddy. Remove the damaged area and place a patch of the same type of geotextile or geogrid by overlapping 0.9 m (3 feet) beyond the damaged area.

Furnish geogrid packaged in a sheathing or container suitable to protect the geogrid from damage due to ultraviolet light during storage and handling. Store, handle, protect, and haul all the materials in accordance with the manufacturer's specifications and as directed by the CO. Furnish geogrid that is visibly labeled with the name of the manufacturer, identification of the geogrid product, date of manufacture, lot number, length, width, and quantity.

**207.04 Separation and Stabilization Applications.** Where placing a geotextile on a subgrade, prepare the subgrade according to Subsections 204.13(c) and (d).

Place the geotextile smooth and free of tension, stress, or wrinkles. Fold or cut the geotextile to conform to curves. Overlap in the direction of construction. Overlap the geotextile a minimum of 0.6 m (2 feet) at the ends and sides of adjoining sheets, or sew the geotextile joints according to the

manufacturer's recommendations. Do not place longitudinal overlaps below anticipated wheel loads. Hold the geotextile in place with pins, staples, or piles of cover material.

End dump the cover material onto the geotextile from the edge of the geo-textile or from previously placed cover material. Do not operate equipment directly on the geotextile. Spread the end-dumped pile of cover material maintaining a minimum lift thickness of 300 mm (12 inches). Compact the cover material with rubber-tired or non-vibratory smooth drum rollers. Avoid sudden stops, starts, or turns of the construction equipment. Fill all ruts from construction equipment with additional cover material. Do not re-grade ruts with placement equipment.

Place subsequent lifts of cover material in the same manner. Vibratory compactors may be used for compacting subsequent lifts. If foundation failures occur, repair the damaged areas and revert to the use of non-vibratory compaction equipment.

**207.05 Permanent Erosion Control Applications.** Place and anchor the geotextile on an approved smooth-graded surface. For slope or wave protection, place the long dimension of the geotextile down the slope. For stream bank protection, place the long dimension of the geotextile parallel to the centerline of the channel.

Overlap the geotextile a minimum of 300 mm (12 inches) at the ends and sides of adjoining sheets or sew the geotextile joints according to the manufacturer's recommendations. Overlap the uphill or upstream sheet over the downhill or downstream sheet. Offset end joints of adjacent sheets a minimum of 1.5 m (5 feet). Pins may be used to hold the geotextile sheets in place. Space pins along the overlaps at approximately 0.9 m (3-foot) centers.

Place aggregate, slope protection, or riprap on the geotextile starting at the toe of the slope and proceed upward. Place riprap onto the geotextile from a height of less than 300 mm (12 inches). Place slope protection rock or aggregate backfill onto the geotextile from a height less than 0.9 m (3 feet). In underwater applications, place the geotextile and cover material in the same day.

**207.06 Soil Reinforcement Applications.** Install the geogrid reinforcement according to the manufacturer’s recommendations. Place the geogrid reinforcement at the elevations and to the extent shown on the plans. Place the geogrid reinforcement in continuous longitudinal strips such that the principle strength (highest strength) axis is perpendicular to the slope or wall face. If unable to complete the required length with a single continuous length of geogrid, a joint may be made with the CO’s approval. Only one joint per length of geogrid will be allowed. Construct this joint for the full width of the strip using a similar material, conforming to the requirements of Subsection 714.03(a), and following the manufacturer’s recommendations. Pull and hold taut joints in geogrid reinforcement during fill placement. Lay flat and pull taut the geogrid reinforcement prior to backfilling. After a layer of geogrid reinforcement has been placed, use suitable means, such as pins or small piles of soil, to hold the geogrid reinforcement in position until the subsequent layer of backfill can be placed. Do not operate track-mounted equipment on the geogrid reinforcement until at least 150 mm (6 inches) of soil has been placed over the geogrid. Keep equipment turning to a minimum to prevent displacement of embankment and damage to the geogrid reinforcement. If approved by the CO, rubber tired equipment may pass over the geogrid reinforcement at speeds less than 16 kph (10 miles per hour). If during

embankment placement waves, wrinkles, or slack develop in the geogrid, remove the embankment and pull geogrid taut to remove slack.

Place only that amount of geogrid reinforcement required for immediately pending work to prevent undue damage. During construction, the surface of the fill should be kept approximately horizontal. Place geogrid reinforcements within 75 mm (3 inches) of the design elevations and extend to the length as shown in the plans unless otherwise directed by the CO. Place primary and secondary geogrid reinforcement as shown on the plans or as directed by the CO. Place and compact embankment soils according to Subsections 204.10 and 204.11. Do not place sharp or angular rock and rock larger than 100 mm (4 inches) in diameter within 150 mm (6 inches) of the geogrid reinforcement. After the specified soil layer has been placed, install the next layer of geogrid reinforcement. Repeat the process for each subsequent layer until final grade is reached.

**207.07 Subgrade preparation.** Do not begin the lining installation until after a proper base has been prepared to accept the Polypropylene membrane. All vegetation, roots and grass must be removed. Fill any cracks or voids. Provide base material that is smooth and free from sharp objects that could puncture the lining. Place a 0.15m (0.5 ft) thick layer of sand on subgrades with a slope less than 1:2.5. Place Geotextile Type IV-E on subgrades with a slope of 1:2.5 or greater according to Section 207.05. Make the surface uniformly sloping per the drawings. Avoid abrupt changes in elevation grade of the prepared surface.

**207.08 Geomembrane Installation**. Place the Polypropylene lining over the prepared surface, as outlined in the drawings in a manner which minimizes handling. The panels should not be unfolded under extreme cold or windy conditions. Install the liner in a relaxed condition, free of stress or tension. Stretching the liner to fit is not permissible.

Use lap joints to seal factory fabricated panels of Polypropylene together in the field. Position the panels so that there is a nominal 4-inch (10.1-centimeter) seam overlap. Wipe clean the contact surfaces of the two sheets to remove all dirt, dust, moisture or other foreign materials.

Field seams are made by thermal fusion bonding. Set the welding machine to the pre-determined temperature and speed. Make a trial seam and tested to verify these settings. Adjust the machine settings accordingly. Throughout the seaming operation, occasional adjustments of temperature or speed as the result of changing ambient conditions may be necessary to maintain a consistent seam. A 1.5 inch (3.8 centimeter) nominal seam width is required for a single track welds. Dual track welds should have two 0.5 inch (1.3 centimeter) nominal seams separated by an air test channel.

**207.09 Earth Fill above Geomembrane**. Do not drive construction equipment on top of geomembrane unless a minimum of 1 meter (3.3 feet) of fill material has been placed on the geomembrane.

**207.10 Joints to Structures**. Seal the polypropylene membrane to all concrete structures and other openings through the lining.

**207.11 Repairs to Polypropylene Liner**. Patch any cuts, rips or tears in the membrane with a piece of the same membrane material. Patches should be cut with rounded corners and should overlap the damaged area a minimum of 3 inches (7.62 centimeters).

Patches are applied with a hand held heat gun and roller. The patch and damaged membrane area should be clean and dry. Insert the heat gun between the patch and the membrane liner heating the surfaces of each to a molten state. A steel roller should be immediately applied smoothing out any wrinkles.

**207.12 Acceptance.** Material for earthwork geotextile will be evaluated under Subsections 106.02, 106.03, and 714.01. Material for the geogrid will be evaluated under Subsections 106.02, 106.03, and 714.03. Material for geomebrane will be evaluated under Susection 106.02, 106.03, and 725.19.
Earthwork geotextile and geomembrane installation will be evaluated under Subsections 106.02 and 106.04.

## Measurement

**207.13** Measure the Section 207 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure geogrid by area in place per lift. Do not measure longitudinal overlaps.

## Payment

**207.14** The accepted quantities will be paid at the contract price per unit of measurement for the Section 207 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

## Section 651. – DRAPED ROCKFALL PROTECTION

Add the following Section:

### Description

**651.01** This Work consists of constructing wire mesh to restrain rock fall as designated on the Plans.

### Material

**651.02** Conform to the following Subsections and requirements:

| | |
|---|---|
| Grout | 725.22 (c) |
| Rock Bolt | 260 |

**(a)** Wire Rope. Supply wire rope with a minimum of diameter of 5/8 inches. The rope should be manufactured from galvanized steel wire strand, common grade, type one coating, conforming to the requirements of ASTM A475 - Zinc Coated Steel Wire Strand with a minimum breaking strength as shown on the plans.

**(b)** Wire Rope Clips. Supply wire rope clips compatible with the cable sizes shown in the plans. The bases should be manufactured from drop forged carbon steel and the nuts will be of the heavy-duty hexagonal type. Galvanize all components in accordance with ASTM A153.

**(c)** Anchors. Conform to the requirements of Section 260, Rock Bolts, and Grade 75 for anchors. Supply epoxy coated bars for corrosion protection. Rope anchors may be used in lieu of threadbars per the mesh or netting manufactures recommendations. Supply epoxy coated bars for corrosion protection. Tension the bolts according to the requirements of Section 260, Rock Bolts.

**(d)** Nuts. Supply heavy duty nuts, conforming to the requirements of ASTM A325 Grade B. Nuts will develop an ultimate strength of not less than 125 percent of the minimum yield strength of the bar. Nuts will be epoxy coated for corrosion protection.

**(e)** Washers. Conform to the requirements of ASTM A325 for washers. Supply washers quenched and tempered to a Rockwell hardness of C38 to C45. The round center hole will be ¼ inch larger in diameter than the anchor to be used. Washers may be flat, beveled, or spherical seat washers as required, and will be placed between the plate and the nut. Washers will be epoxy coated for corrosion protection.

**(f)** Bearing Plates. Steel bearing plates will conform to ASTM A36. Bearing plates will be epoxy coated for corrosion protection.

**(g)** Grout. Non-shrink cement grout will be used for the anchors.

**(h)** Draped Wire Mesh. Supply wire mesh of the 8 x 10 double twist hexagonal netting type, zinc coated in accordance with ASTM A153. Apply a PVC coating to the wire mesh with a minimum film thickness of 15 mils. The color of the PVC coating will be black as approved by the CO. Wire used in the body of the mesh and lacing wire will be U.S. gauge 9 or equivalent in diameter, after coating.

**(i)** Mesh Pins. Mesh pins are expansion anchors used to keep wire mesh within 2 feet of rock face to reduce the height distance which rock fall can occur.

**(j)** Samples. One sample of the type of wire mesh, ground anchor, and hardware to be used will be submitted to the CO from the normal stock of the manufacturer. The samples will be submitted together with mill reports indicating tensile yield point and elongation results of the ground anchors, and the tensile and punching tests of the wire mesh at no additional expense to the Government.

The following certificates will be submitted to the CO at least two weeks prior to beginning work.

1. Certificates stating that samples for testing are from normal stock, which will be used in the work.

2. Manufacturer's certified test results of set time, shelf life, and compressive strength for each type of grout to be used.

3. The Contractor will furnish a certified report, not more than one year old, that the product to be supplied equals or exceeds these specifications.

## Construction Requirements

**651.03 General.** Safety of the work will be the responsibility of the Contractor. The work will be performed in a manner to minimize hazards and exposure of the public, construction personnel, and equipment to hazardous and potentially hazardous conditions. Placement of the wire mesh will be scheduled so as to ensure safety.

**651.04 Installation.**

**(a)** Scaling. The Contractor will scale slope faces and round the slope crest according to Section 623.

**(b)** Anchors. The hole diameter for each anchor installation will be uniform for the entire length of the hole unless otherwise approved by the CO. The minimum hole diameter will be as shown on the Plans.

The drilling equipment will be capable of drilling a straight hole to the depths required, and will be equipped to inject air into the hole through the bit.

Holes will be drilled at the orientations and inclinations shown in the plans or as directed by the CO. Deviation from those orientations and inclinations will not exceed five degrees. The Contractor will use a measuring device to assure the required inclinations in the vertical plane.

**(c)** Clearing of the vegetation, brush and trees is required for the placement of mesh, cable net, and anchors. The clearing of the vegetation will be required on the slopes and brow to be meshed. The cleared material will be disposed of offsite or mulched for distribution on the project or on the seeded slopes.

**(d)** Each hole will be cleaned of all drill cuttings, sludge, and debris by means of compressed air introduced at the back of the hole prior to installation of the cement grout.

After the drill hole is cleaned, a sufficient amount of cement grout will be placed in the drill hole to fully encapsulate the anchor bar.

**(e)** Anchors will be spaced as shown on the plans. Ground conditions encountered as construction progresses may require the lengths of the anchors to be greater than the minimum length shown on the Plans. Where the varied lengths are to be utilized, the use of steel bolt couplings (or other approved methods as recommended by the manufacturer) will be permitted.

A minimum of two centralizers will be placed on each anchor to position the bar within 1 inch of center of the drill hole. The centralizers will be placed within 2.0 feet and 1.0 feet from the top and bottom of the drill hole, respectively. The centralizers will be attached securely to the anchor bar so they will not shift during handling or insertion into the drill hole.

**(f)** Draped mesh will extend down the face to the height specified on the Plans and will be anchored to the top of the slope with anchors.

**(g)** Wire rope will be connected to the end anchors as shown in the Plans. The ends of the wire rope will be secured with wire rope clips. The wire rope clips will be placed in the configuration and torqued as recommended by the manufacturer. The wire mesh will be folded around the anchorage cable and folded upon itself a minimum of 2.0 feet and secured using locking clips or hog rings.

**(h)** The wire mesh will be securely selvedge or bound so that the joints formed by tying the selvedges have minimum strength equal to that of the body of the mesh. Fasteners, ties, connectors, locking clips, or hog rings used for fastening edges will be spaced 6 inches apart or less. Perimeter edges will be laced with binding wire by tightly looping through every mesh opening.

**(i)** Mesh pins will be installed to keep mesh within 2.0 feet of the rock cut face or as directed by the CO. Mesh pins will be installed per manufacture's recommendations for concrete

applications as appropriate.

**651.05 Acceptance.** Draped rockfall protection material and construction will be evaluated as follows:

Material for the Draped rockfall protection will be evaluated under Subsections 106.03 and 106.04.

Construction of Draped rockfall protection will be evaluated under Subsections 106.02 and 106.04.

## Measurement

**651.06** Measure draped wire mesh by the square yard completed in place exclusive of the area of wire mesh used in any overlaps.

Measure slope scaling under Section 623.

## Payment

**651.07** The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the Section 651 items listed in the bid schedule. Payments will be full compensation for the work prescribed in this Section. See subsection 109.05.