March 30, 2023

Jackie Noblitt, P.E.
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Suite 100
Phoenix, AZ 85016

SUBJECT: Geotechnical Assessment
State Route 88 (Apache Trail), MP 222 to 229
Design Concept Report & Environmental Overview Study
ADOT TRACS No. F0494 01L
ADOT Contract No. 2022-020
Pinal County, Arizona

Dear Jackie:

As requested, Ethos Engineering, LLC (Ethos) is pleased to present this assessment of the geotechnical/geologic conditions observed at the project site along State Route 88 (Apache Trail) from milepost (MP) 222 to MP 229. This letter report addresses efforts as indicated in the Request for Qualifications (RFQ) Package dated May 2022. Included is a discussion of the observed site conditions, general site geology as it relates to improvement alternatives, recommendations for planned improvements, and an estimate of costs.

1.0 PROJECT INFORMATION

ADOT selected Stanley Consultants, Inc. (Stanley), to prepare a Design Concept Report (DCR) and Environmental Overview Study (EO). The DCR and EO will address the feasibility of repairing and re-opening the closed section of SR 88, from milepost (MP) 222 (east of Tortilla Flat) to 229 (Apache Lake Marina Road).

The ADOT Transportation Asset Management Plan (TAMP), indicates at least three events where storm water damaged the road and repairs were required. The latest event was in September 2019 where severe flooding damaged the road enough to make it impassable and as such a section of the road remains closed for public safety reasons.

The September 2019 event is directly related to the Woodbury Fire which consumed nearly 124,000 acres of the Tonto National Forest. In September 2019, a storm dumped up to approximately six inches of rain onto the fire scar causing the runoff to severely damage large portions of the road, with the most damage being in the area between Fish Creek Hill Overlook and Apache Lake Marina. The damage included a large rockslide that left that a section of the road unpassable. Runoff from the Woodbury fire burn scar is considered an ongoing risk with future storms.

The DCR and EO study will identify and analyze hydrologic, geologic, road design, and environmental considerations anticipated to reconstruct the road in the area of the current damage. ADOT is the lead agency, in partnership with other organizations including the US Forest Service (the landowner).

Ethos has been retained by Stanley to provide an evaluation of the site conditions and to provide recommended alternative solutions for repair of damaged areas along Apache Trail in anticipation of a re-opening of this road, which is currently closed to traffic.

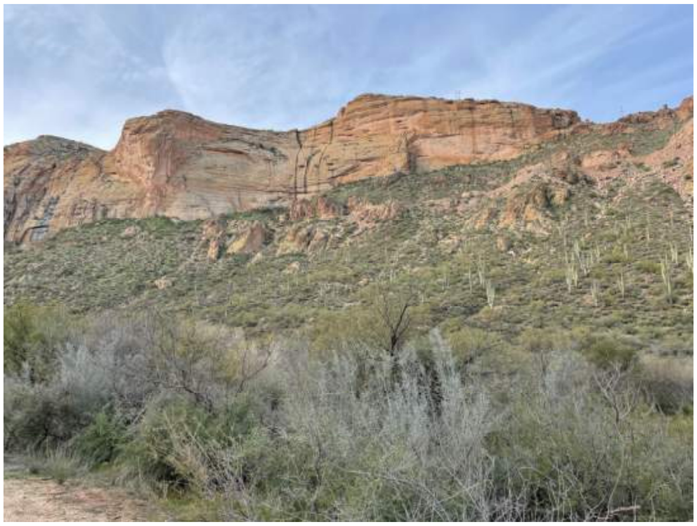
2.0 FIELD OBSERVATIONS

Keith Dahlen, PE and Daniel Fréchette, PhD, PE, both with Ethos, attended the project site kickoff meeting which was held on January 6, 2023, to get an initial look at the site conditions which prompted the road to be closed to traffic in 2019. A second site visit was made by Mr. Dahlen and Dr. Fréchette on January 27, 2023, to further observe the field conditions, with an emphasis on the damage which had occurred west of MP 222.5 (the Fish Creek Hill slope.

Apache Trail, from the Fish Creek Hill Overlook (MP 222) going east, was constructed mainly as a winding side-hill cut/fill unpaved road on steeply ascending terrain dropping roughly 700 feet over a distance of approximately 1.5 miles to the single-lane bridge at Fish Creek Canyon. East of the bridge, SR 88 is relatively flat, running along the east bank of Fish Creek to about MP 224.3 where it then mainly hugs the side hills as a cut/fill constructed roadway either to the north or south sides of Lewis and Pranty Creek. At MP 227 and extending east to MP 229 (just west of the Apache Lake Turnoff), the roadway veers from the creek and climbs roughly 50 feet, traversing higher ground.

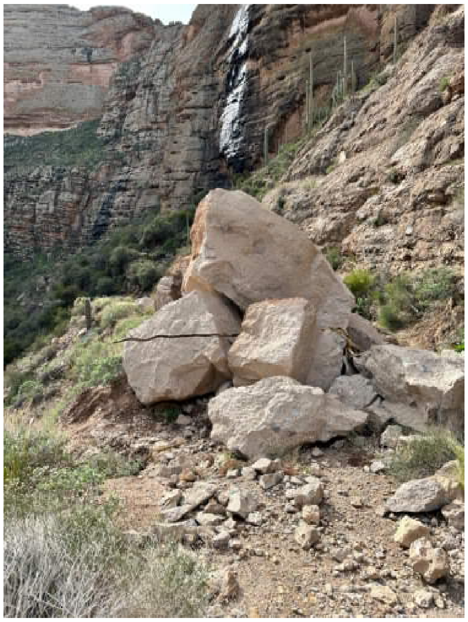
The section of roadway from Fish Creek Hill to about MP 222.6 is a moderately ascending section of winding road, with cuts typically varying from 10 to 30 feet and fills which vary from roughly 5 to 15 feet. Considerable erosion of the unpaved surface has occurred within this section where the roadside ditch has either plugged or is undersized to handle the high influx of water which occurred in and subsequent to 2019. Exposed rock immediately adjacent to the roadway from Fish Creek Hill to about MP 222.4 consists of massively bedded sedimentary units of sandstone, siltstone and conglomerates which appear to be predominantly horizontally bedded. This orientation is generally relatively stable and fracture induced rockfall does not appear to be an issue. From MP 222.4 to 222.6, the exposed rock within cuts adjacent to the roadway appears to be moderately to widely fractured volcanic rock. Erosion of the roadway surface appears to be the larger issue within this segment.

The majority of roadway damage is concentrated in the steep section of roadway west of Fish Creek Canyon (approximate MP 222.6 to 223.6). This stretch of road is characterized by a variety of steep overlying rock faces, and rock debris and colluvial slopes which contain loose rock with sizes varying from cobble to large vehicle-size boulders immediately adjoining the road. Higher, near vertical canyon forming rock walls are set back from the road generally a few hundred feet. Photograph No. 1 shows the steeply faced canyon walls set above SR 88 within this section.



Photograph No. 1 – High rock walls west of SR 88 at MP 223 (looking west)

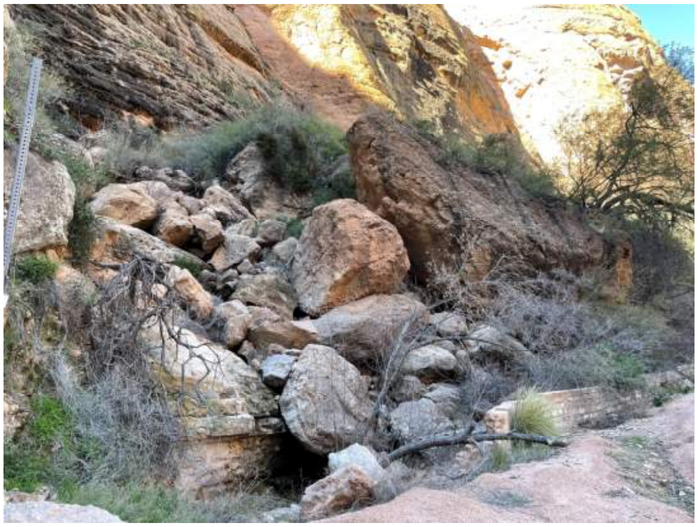
Bedrock within this stretch of road and in the slopes high above the road, consists of volcanic rock, primarily andesite, dacite and tuff, extending from the west project limits to about MP 223.2. A southeast to northwest trending fault separates this volcanic rock from sedimentary sandstone, siltstone, and conglomerate rock. It is apparent from review of aerial photos that faulting has tilted this once horizontally bedded rock unit to a near vertical orientation along the canyon walls. It further appears that the large rock fragments, which closed the road at MP 223.3, detached from the vertically oriented bedding planes. Photograph No. 2 shows the location where falling rock completely blocked the road. Photograph No. 3 shows the rock wall where the rock blocking the road likely originated.



Photograph No. 2 – Large rockfall that closed SR 88 at MP 222.3 (looking south)

Photograph No. 3 – Fresh face of rock slope where large rock in road likely originated (looking west)

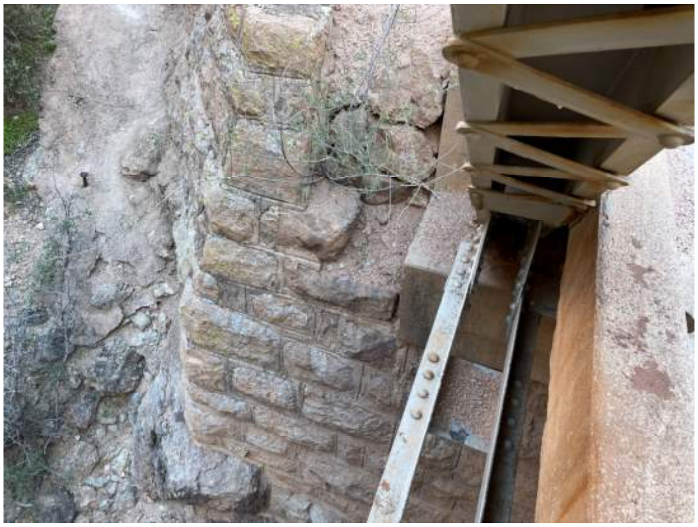
Other damage in this section includes rock debris flows which have infilled drainages with variably sized rock, often blocking cross-road culverts. This is indicative of large storm flows concentrated into natural drainages. It is evident the roadside ditch on the cut side of the road overtopped at many locations resulting in surface overflows, which often eroded the existing roadbed, outboard fills and in some cases existing rock walls. Erosion on the roadbed exposed the underlying rock cut surface. The fills were, at some locations, extensively eroded on the outboard slopes causing significant erosion of the slope and edge of road. Storm induced erosion of exposed colluvial and rock debris slopes also deposited rock onto the road at many locations. Photograph No. 4 shows a debris flow and Photograph No. 5 shows erosion of the roadbed and the outboard slope.



Photograph No. 4 – Rock debris flow near MP 222.4 (looking west)

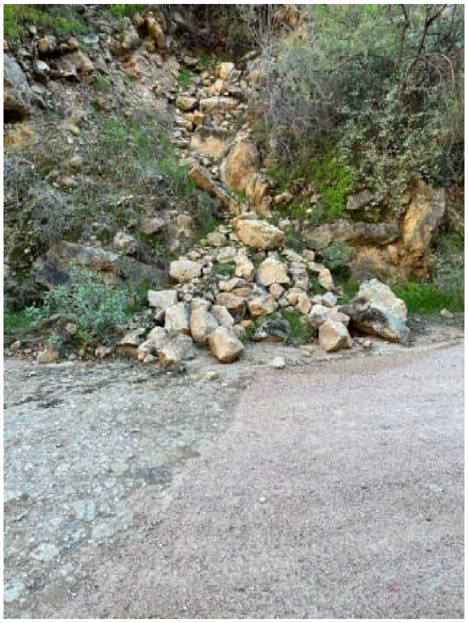
Photograph No. 5 – Erosion of roadbed and outboard slope at approximately MP 223 (looking north)

As-built plans were not available for any of the three single-lane, single-span bridges located within the project limits. The bridge, which crosses Fish Creek Canyon at approximate MP 223.6, appears to be supported directly on intact rock at the west abutment. The east abutment appears to be supported on a stacked block/mortar system which extends up from intact rock several feet. The overall foundation system appears to be in good condition. Photograph No. 6 shows the north corner of the east bridge abutment.

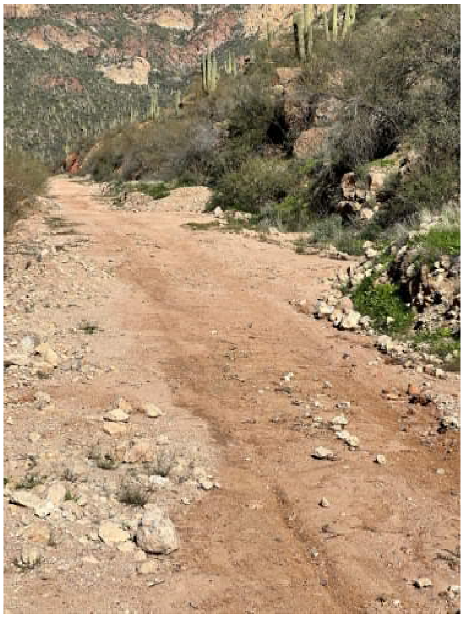


Photograph No. 6 – Northeast corner of Fish Creek Hill Bridge, East Abutment at MP 223.6 (looking east)

SR 88 follows the east bank of Fish Creek from the bridge to about MP 224.3. This relatively flat section of road sits several feet above the adjacent creek bed. Though some damage was noted along the roadways outboard slope more significant damage in the form of debris flows are apparent along the east side of the road from uphill water induced erosion. Much of the uphill slope within this stretch consists of highly fractured rock, colluvium and rockfall debris. These loosely held materials, when inundated with water, dislodge and collect as rock and soil debris within the natural drainages. At least four debris flows were observed which required some earthmoving by ADOT Maintenance to make the road passible to the bridge. Photograph No. 7 shows one of the partially removed debris flows.



Photograph No. 7 – Rock debris within drainage at MP 223.9 (looking south)



Photograph No. 8 – Series of debris flows adjacent to road at MP 223.9 (looking south)

From MP 224.3 to MP 225, the road ascends east adjacent to Lewis & Pranty Creek, crossing to the north side of the creek at the Lewis Pranty Creek Bridge at about MP 224.9. At the time of our initial site visit the road was not passible just east of the bridge due to a debris flow. This location was easily made passible with the ADOT front-end loader. Another debris flow impacting the road was noted just east of MP 225. Most of this section is characterized as highly fractured volcanics in nominal 15- to 30-foot-high cuts.

From MP 225 to 226 the road ascends to the east typically with 10- to 15- foot cuts and lesser cuts up to about 40 feet, mainly within fractured volcanics and colluvium. The road was constructed in a side hill cut with fills extending to the creek bed. Rockfall and erosional damage, though present in some areas, is much less compared to the area west of the Fish Creek Hill Bridge. Though the road is typically more than 20 feet wide in most areas, it does narrow to about 15 to 17 feet adjacent to an approximate 220-foot-long creek side rock wall near MP 225.4. The easternmost single-span, single-lane bridge is located at about MP 225.5. Both this bridge and the Lewis Pranty Creek Bridge appear to have one abutment founded on rock and the other on alluvial materials (or possibly piles which extend to rock). There were a few areas noted during the initial site visit where hillside generated flows had eroded the roadbed surface, and in a couple instances, the outboard slope causing head cutting back into the slope and roadway surface. Heavy flows within the creek also damaged (eroded) portions of the roadway embankment, oversteepening and in some locations cutting into the roadbed surface.

East of MP 226 the road continues to ascend adjacent to the north side of the creek with cuts transitioning from fractured volcanics to granitics at roughly MP 226.7. At MP 227 the road alignment departs from the creek and heads north towards MP 229 (the northern project limits) and the road to Apache Lake Marina. Cuts and fills within this area are generally less than 15 feet. Storm related damage in this section appeared limited to minor erosion that could likely be repaired by ADOT Maintenance.

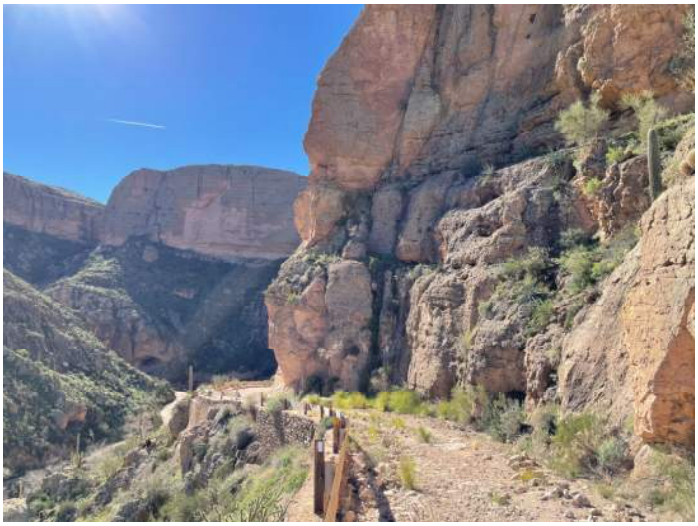
3.0 DISCUSSION OF ALTERNATIVES

Based on site observations, we anticipate the majority of work will concentrate to the west of the Fish Creek Hill Bridge where the majority of damage has occurred. It appears east of this bridge that repairs would focus on laying back some slopes, scaling of others and increasing the size of drainage culverts to increase flow capacities, hopefully preventing future overtopping of the road. At a minimum, repair of the creek side slopes with some form of armoring will be needed to re-establish stability at localized spots where water overtopped the road or where stream flows impacted the roadway fill slopes. More elaborate measures could include the installation of debris flow barriers upslope of SR 88 to prevent rock debris which collects in the natural drainages from entering the road during flood events.

The damage west of Fish Creek Hill Bridge in the section of road extending to about MP 222.6, as described in Section 2.0, varies from minimal in some areas to extensive in others. The degree to which the damage is addressed and to what improvements are made could have widely varying impacts in terms of visual impacts and cost.

Through project team development, it was determined that possible repairs to this segment of SR 88 be categorized as three alternatives, with Alternatives 1 to 3 varied by the degree of intended resiliency. Alternative 1 is considered to provide the lowest level of resiliency for potential future issues and Alternative 3 is considered to provide the lowest level of improvements and highest potential for future maintenance and needed repairs. Though many of the possible improvements could apply to more than one alternative, the improvements and alternatives selected all consider cost, degree of safety, and potential future maintenance.

The most significant cost impact to the project will be the determination of a final roadway width. In localized areas, the existing road is less than 20 feet in width. Creating extra width in areas west of Fish Creek Hill Bridge will have significant cost impacts to widen either to the cut or fill sides of the road. Photograph No. 9 shows an existing rock face where the existing road measures close to 15 feet. Though these instances are localized generally to bends in the road, consideration of whether to widen to the cut or fill side (or both) will have large cost and visual impacts.



Photograph No. 9 – Narrow Road at base of cliff at approximate MP 223 (looking south)

The attached Table 1 provides a listing of those items considered by the project team as Alternative 1 through 3 improvements to be evaluated as part of this DCR effort. Variables considered address roadway widening with Alternatives 1 and 2 and the associated need to excavate into existing slopes or to widen to the fill side with fills or retaining walls. Rock slope stability has been considered with the knowledge that safety improvements could include slope flattening as appropriate, rock bolting, draped mesh, and/or debris flow barriers in combination with improved drainage measures. The attached Table 2 provides preliminary recommended minimum cut slopes based on project MP and stationing developed by the Stanley design team.

The potential for slope improvements, provided in Table 2, is based on our observation of the existing geologic conditions which dictates the viability of either changing the existing slope ratios and/or just shifting the existing slopes back into the hillsides to create more roadway width. Typically, blasting or other means of breaking sound rock would be required where intact, competent volcanics or sedimentary rock exists. In general, these slopes can be maintained relatively steep (no more than ½H:1V). Rock bolting should be considered as an allowance to address securing rocks with unfavorable jointing which becomes exposed within the face of newly exposed cut surfaces.

Highly fractured rock and colluvium, where present, can be maintained relatively steep though some flattening (up to 1H:1V) with scaling might be preferred to lessen future maintenance. Similarly, rockfall debris slopes could be flattened from 1/2H:1V to 1H:1V for similar reasons. Rockfall mesh can be considered, particularly if steeper slopes are preferred.

From a geotechnical standpoint, none of the bridge foundations appeared to be damaged from recent flooding. However, the support conditions for the Lewis Pranty Creek Bridge and the bridge at MP 225.5 would be in question at the abutments where not supported on rock. Should replacement of these bridges be deemed necessary, test drilling would need to be performed to ascertain the foundation conditions.

4.0 PRELIMINARY COST ESTIMATES

Costing for a project of this potential magnitude will vary greatly depending on the selected alternative. We anticipate the majority of improvement costs will be incurred to the west of the Fish Creek Bridge at MP 223.6. Widening of the road to a constant width with Alternatives 1 and 2 will have the largest overall cost and visual impacts. Portions of the road from approximate MP 222.6 to 223.4 are currently limited in width due to the presence of near vertical rock slopes on the cut side and often steep slopes on the downhill side. One costly element would be the Alternative 1 bolting or rock removal (near MP 223.4) where rockfall emanating from the near vertical rock face hundreds of feet above the road would be difficult and expensive. This element could be included or removed from the Alternative 1 estimate should it be deemed too expensive to mitigate what is considered a rare event.

Table 3 presents estimated costs for geotechnical related improvements to be considered for the three alternatives. Although Alternative 3 focuses on restoration of existing conditions, rock scaling, at a minimum, would be recommended to minimize the amount of loose rock with the potential to impact the road during and following moderate storm events. The items shown for Alternatives 1 and 2 are similar but typically of a reduced quantity for Alternative 2 versus that shown for Alternative 1.

5.0 LIMITATIONS

The geotechnical services were performed in a manner consistent with that level of care and skill ordinarily exercised by other members of the geotechnical profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions and recommendations are based on information collected by Ethos and provided by others. No subsurface explorations were performed by Ethos as part of this project. Ethos makes no guarantee or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

5.0 CLOSING

We appreciate the opportunity to submit this letter report to the Stanley design team. If you have any questions or require additional information pertaining to this proposal, we would be pleased to discuss them with you.

Sincerely,
ETHOS ENGINEERING, LLC **Reviewed By:**

Keith H. Dahlen, PE
Principal/Senior Geotechnical Engineer

Daniel Fréchette, PhD. PE
Senior Geotechnical Engineer

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Table 1 - Design Alternatives Summary

Issues	Alternative 1 (Lower Risk)	Alternative 2 (Medium Risk)	Alternative 3 (Higher Risk)
Bridge Foundations	Bridge Replacement	Only Deck Replacement	No Improvements
-Bridge No. 3 across Fish Creek	Support on spread footings most likely, but could consider rock-socketed drilled shafts or micro-piles to limit disturbance.	No Improvements or Rehab Bridge Deck	No Improvements
-Bridge No. 4 across Lewis and Pranty Creek	Support on spread footings on most likely, but could consider rock-socketed drilled shafts or micro-piles to limit disturbance.	No Improvements or Rehab Bridge Deck	No Improvements
-Bridge No. 5 Beam Bridge (Dry Wash)	Support on spread footings on most likely, but could consider rock-socketed drilled shafts or micro-piles to limit disturbance.	No Improvements or Rehab Bridge Deck	No Improvements
Roadway Surface	AC Pavement	Lime Stabilized AB	Maintain Dirt Road
Fill (Embankment) Slopes - Downslope			
- Erosion Protection	Areas immediately adjacent to the creeks and with slopes steeper than 2H:1V. Consisting primarily of gabions with isolated zones of riprap.	Eroded (impacted) areas immediately adjacent to the creeks. Consisting of riprap and/or gabions.	Only in areas over steepened due to scour from Lewis and Pranty Creek.
- Slope Criteria	2H:1V or use of walls.	Angle of repose with continued ongoing maintenance.	Angle of repose with continued ongoing maintenance.
Cut Slopes - Upslope			
- Colluvium	Flatten to 0.75H:1V to 1H:1V (where feasible). Scaling and possible netting.	Flatten to 0.5H:1V; Scaling	Scaling only as needed
- Rockfall Debris	Flatten to 0.25H:1V to 0.5H:1V and install debris flow barriers upslope.	Flatten to 0.25H:1V and install isolated debris flow barriers.	Scaling only as needed
- Rock Slopes	Flatten to 0.25H:1V with scaling.	Flatten to 0.25H:1V with scaling.	Scaling only as needed
Roadway Widening			
- 20'	N/A	Would require limited widening of the existing roadway through a combination of cut slopes and fill slopes.	N/A
- 24'	Would require moderate widening of the existing roadway through a combination of cut widening, cut slope treatments and fill slopes.	Would require moderate widening of the existing roadway through a combination of cut slopes and fill slopes.	N/A
Rockfall Containment			
- Rock Bolts	Identify potentially unstable/ metastable rocks < 50 feet setback from the road. Isolated rockfall from high slopes could be evaluated but likely not practical to treat.	Limited to isolated rocks < 20 feet setback from the road that shouldn't be removed to maintain overall slope stability.	N/A
- Draped Mesh	Limited to areas dominated by rock debris slopes.	Limited to areas dominated by rock debris slopes.	N/A
- Scaling	Yes	Yes	As needed
- Ditches	Increase the width to that needed for drainage to retain 90% of rocks less than 2 feet in diameter.	Only to the extent needed for drainage. Control rockfall through cut slope modifications or isolated rock bolts.	Only to the extent needed for drainage.
Slope Treatment (Erosion)	Install debris barriers at major drainages with history of events impacting the roadway.	Install debris barriers at major drainages with history of events impacting the roadway.	Maintenance to remove debris flows when they happen.
Walls	More prevalent to establish wider roadway section. Could consist of MSE, shored MSE, soldier pile, or cantilever walls.	To establish wider roadway section. Could consist of MSE, shored MSE, soldier pile, or cantilever walls.	Limited use only to reestablish eroded roadway. Could consist of MSE, shored MSE, soldier pile, or cantilever walls.
Culverts/Headwalls/Outlet Protection	Upsize pipes as needed to allow sediment to more easily pass through the system. Include debris flow barriers to retain cobbles and boulders.	Upsize pipes as needed to allow sediment to more easily pass through the system.	Clean Inlets/Pipes as needed. Will require on going maintenance

Table 2 - Prelim Slope Recommendations

Milepost	Distance (mi)	STA	Distance (ft)	Material	Preliminary Recommended Slope (H:V)	Possible Rock Bolts			Possible Rockfall Netting			Possible Scaling	Possible Blasting			Notes
					Alternative>>>	1	2	3	1	2	3	1,2 & 3	1	2	3	
222.00		880		Sedimentary Rock - Horizontal Bedding	1/4:1	N	N	N	N	N	N	Y	Y	Y	N	
222.40	0.40	901	2100													
222.40		901		Moderate to Widely Fractured Volcanic Rock	1/2:1	Y	Y	N	N	N	N	Y	Y	Y	N	
222.53	0.13	908	700													
222.60		908		Widely to Closely Fractured Volcanic Rock	1/2:1	Y	Y	N	N	N	N	Y	Y	Y	N	Rock debris mid slope STA 910+40 to 911+20
222.92	0.32	925	1700													Can consider walls on outboard side if needed from STA 916 to 919 Can consider walls on outboard side if needed from STA 923+50 to 924+50
222.92		925		Widely to Closely Fractured Volcanic Rock	1:1	N	N	N	N	N	N	Y	Y	Y	N	Flatter orientation of major jointing
223.00	0.08	929	400													
223.00		929		Moderate to Widely Fractured Volcanic Rock	1/2:1	Y	Y	N	N	N	N	Y	Y	Y	N	Can consider walls on outboard side if needed from STA 931 to 932
223.06	0.06	932	300													
223.06		932		Tuff - Varied Volcanics Overlain by Rock Debris	3/4:1	N	N	N	N	N	N	Y	*	*	N	*Boulder Busting of Larger Loose Rock
223.09	0.03	933.5	150													
223.09		933.5		Widely to Massive Fractured Volcanics (Competent Tuff)	1/4:1	Y	N	N	N	N	N	Y	Y	Y	N	Some debris in natural drainage STA 934+50. Lay this back to 1:1
223.15	0.06	936.5	300													
223.15		936.5		Colluvium and Rockfall Debris	1:1	N	N	N	Y	Y	N	Y	Y	N	N	Mix of more intact colluvium and less intact rockfall debris…some large rock
223.27	0.12	943	650													
223.27		943		Widely to Closely Fractured Volcanic Rock	1/4:1	Y	Y	N	N	N	N	Y	Y	Y	N	
223.36	0.09	948	500													Cut at STA 947 made along orientation of exposed joints (roughly 1/4 to 1/2:1)
223.36		948		Colluvium and Rockfall Debris	1:1	N	N	N	Y	Y	N	Y	N	N	N	Car sized boulders (STA 949)
223.38	0.02	949	100													Boulder Busting Possible
223.38		949		Medium to Thickly Bedded Sedimentary Rock	1/4:1	Y	N	N	N	N	N	Y	Y	Y	N	
223.40	0.01	949.7	70													
223.40		949.7		Colluvium and Rockfall Debris	1:1	N	N	N	Y	Y	N	Y	N	N	N	
223.44	0.04	952	230													
223.44		952		Medium to Thickly Bedded Sedimentary Rock	1/4:1	N	N	N	N	N	N	Y	Y	Y	N	Includes rockfall from cliff face which closed road
223.49	0.05	954.5	250													
223.49		954.5		Colluvium and Rockfall Debris	1:1	N	N	N	Y	Y	N	Y	N	N	N	Some Sandstone exposed at base of cut STA 955
223.61	0.12	961	650													Large (Car-sized) rock debris from STA 956 south Other local intact rock exposures, but minor

Table 2 - Prelim Slope Recommendations Cont'd.

Milepost	Distance (mi)	STA	Distance (ft)	Material	Preliminary Recommended Slope (H:V)	Possible Rock Bolts			Possible Rockfall Netting			Possible Scaling	Possible Blasting			Notes
					Alternative>>>	1	2	3	1	2	3	1,2 & 3	1	2	3	
223.61		961		Medium to Thickly Bedded Sedimentary Rock	1/4:1	N	N	N	N	N	N	Y	Y	Y	N	
223.63	0.02	962	100													
<<<<Fish Creek Bridge>>>>																
223.63		962		Highly Fractured Volcanics and Rockfall Debris	3/4:1	N	N	N	Y	Y	N	Y	N	N	N	Possible debris flow barriers in natural drainages
224.20	0.57	993	3100													
224.20		993		Highly Fractured Volcanics & Some Colluvium	1:1	Y	N	N	Y	Y	N	Y	Y	N	N	Some 1/2:1 slopes likely in more competent volcanics
225.00	0.80	1031	3800													Lewis Pranty Creek Bridge at MP 224.9
225.00		1031		Highly fractured Volcanics and Colluvium	1/2:1 (Volcanics)	Y	Y	N	N	N	N	Y	Y	Y	N	Cuts in volcanics noted at MP 225, 225.05, 225.3 & 225.8
226.00	1.00	1083.5	5250		1:1 (Colluvium)	N	N	N	Y	Y	N	Y	N	N	N	Debris flow noted at MP 225.05
																Single-lane bridge at MP 225.5
																Powerline foundation at top of ridge at MP 225.1
226.00		1083.5		Volcanics & Granite Rock (Generally Small Cuts)	3/4:1	N	N	N	N	N	N	Y	N	N	N	Minimal cuts and limited existing damage
227.00	1.00	1136	5250													
227.00		1136		Mainly Old Alluvium	1:1	N	N	N	N	N	N	N	N	N	N	Damage limited to minor erosion.
229.00	2.00	1241	10500													

Table 3 - Preliminary Cost Estimate

Alternative 1

Item	Item	Unit of Measure	Units	Unit Cost	Cost
Debris Flow Barrier	9240117	sq. ft.	2,560	$125	$320,000
Rockfall Netting	9240118	sq. ft.	48,000	$60	$2,880,000
Rock Scaler	2030002	hr.	2,500	$160	$400,000
Rock Excavation	2030305	cu. yd.	111,845	$200	$22,369,000
Rock Bolts	9240111	ln. ft.	1,200	$750	$900,000
High Slope Rock Bolts	9240112	ln. ft.	800	$5,000	$4,000,000
Riprap (Gabions)	9130030	cu. yd.	1,000	$125	$125,000
				Total	**$30,994,000**

Alternative 2

Item	Item	Unit of Measure	Units	Unit Cost	Cost
Debris Flow Barrier	9240117	sq. ft.	1,600	$125	$200,000
Rockfall Netting	9240118	sq ft.	25,000	$60	$1,500,000
Rock Scaler	2030002	hr.	2,000	$160	$320,000
Rock Excavation	2030305	cu. yds.	76,700	$200	$15,340,000
Rock Bolts	9240111	ln. ft.	600	$750	$450,000
High Slope Rock Bolts	9240112	ln. ft.	0	$5,000	$0
Riprap (Gabions)	9130030	cu. yd.	400	$125	$50,000
				Total	**$17,860,000**

Alternative 3

Item	Item	Unit of Measure	Units	Unit Cost	Cost
Debris Flow Barrier	9240117	sq. ft.	0	$125	$0
Rockfall Netting	9240118	sq ft.	0	$60	$0
Rock Scaler	2030002	hr.	2,500	$160	$400,000
Rock Excavation	2030305	cu. yds.	0	$200	$0
Rock Bolts	9240111	ln. ft.	0	$750	$0
High Slope Rock Bolts	9240112	ln. ft.	0	$5,000	$0
Riprap (Gabions)	9130030	cu. yd.	0	$125	$0
				Total	**$400,000**

Note: Costs limited to above listed items only. These costs do not include earthwork (beyond rock excavation), fill slopes, walls, bridges, drainage elements, etc.