



2511 Holman Avenue
P. O. Box 80190
Billings, Montana 59108-0190
p: 406.652.3930; f: 406.652.3944
www.skgeotechnical.com

June 15, 2015

Ms. Cassie Riggan, PE
Great West Engineering



Project 15-3359G

Dear Ms. Riggan:

Re: Geotechnical Reconnaissance, Stillwater River Road Rock Slide, West of Absarokee, Montana

We have completed the geotechnical reconnaissance you requested on June 3, 2015. The purpose of the reconnaissance was to assist Great West Engineering and Stillwater County in evaluating the risks associated with an existing rock slide along Stillwater River Road.

Field Observations

Mr. Brett M. Warren, geotechnical engineer with our firm, and Mr. Chad C. Binstock, engineering assistant with our firm, I traveled to a rock slide located along Stillwater River Road, approximately 10 miles west of Absarokee, Montana. We were accompanied by Ms. Cassie Riggan, PE, with Great West Engineering. We arrived on site at 2:00 p.m. on Wednesday, June 3, and departed at 3:00 p.m.

Upon arrival, we observed a portion of the rock outcrop had fallen onto the roadway. The debris pile extended about 30 feet along the roadway, and covered the entire roadway and shoulder down to the Stillwater River. We then observed the rock slide and rock outcrop from various positions, including from across the river and near the cliff face to the east of the slide. Figures 1 and 2 are photographs of the rock outcrop from two angles. Numbered observations have been included on each figure, which are discussed below.

The rock slide was a wedge-shaped failure approximately 50 feet long, 5 to 10 feet wide and about 5 feet deep. The wedge failure is labeled #1 on the attached photos. The bottom of the failure was about 30 to 40 feet above the roadway. In the area around the rock slide, Stillwater River Road travels beneath the rock face, which is approximately 100 to 150 feet tall and 1/4-mile long in total. There is no shoulder either between the road and the rock face or the road and the slope leading down to the Stillwater River. The Stillwater River is about 15 feet below the road surface elevation with an approximately 1H:1V slope between the river and the road.

In several areas around the rock slide, water was observed seeping from the rock face. These active seeps were located approximately 10 to 15 feet away from the wedge failure and are labeled as #3, #4, and #5. Label #2 is a portion of rock hanging just below the wedge failure. It was observed to be damp and possibly seeping, but dripping water was not observed. While on site, we also observed clouds of dust escaping from joints in the rock near label #2. This suggests very loose rock and active movement was occurring.

Above the wedge failure area, vegetation was observed, which indicates a relative flat spot (perhaps a ledge) above the wedge failure having enough moisture to establish plants. This likely allowed water to accumulate behind the failed wedge. This water can saturate the rock increasing its weight, and when combined with the joint lubrication, likely contributed to the rock wedge failure.

Numerous areas of the outcrop appear to be unstable. In the vicinity of label #2, several suitcase-sized rocks were observed which appeared to be relatively loose. Outside of the immediate wedge failure area, other portions of the rock face appear to have a high risk of wedge failures in the future. Areas #9 and #10 have discontinuities that intersect to create a wedge. They appear to be relatively stable when compared to the loose rocks in area #2, but the risk of failure still exists. A large rock mass is defined by the discontinuity shown with lines labeled #7 and #8. These discontinuities represent failure planes, and although no active movement was observed, there is a risk of future failure. This risk increases due to water saturation and seismic events.

To obtain the photos used in the figures, we crossed the river and were several hundred feet from the rock face. There, we observed rock fragments up to 8 inches in size had been shot across the river due to the impact of the wedge failure. These rock fragments actually had enough energy to leave 1- to 2-inch deep holes in the topsoil. The rock fragments were spaced 4 to 6 feet apart, indicating substantial debris was shot across the river during the failure.

Analysis and Recommendations

During the reconnaissance, it was our opinion the road should remain closed due to the recent movement observed in the vicinity of label #2. We recommended monitoring of the observed seeps to assist in evaluating when to clear the debris and open the road.

In and around the existing wedge failure, portions of the rock face have similar joint conditions and are at risk of failing. Predicting the location and relative timing of a rock slide is extremely difficult. However, experts on the subject of rock mechanics can be hired to evaluate the probabilities of failure. In addition to evaluating the potential risk of failure, these experts can make recommendations for rock fall hazard mitigation. Possible mitigation approaches include rock scaling (removing loose rocks), rock bolting, rock netting, and rock fencing and/or barricades. These types of mitigation are extremely expensive and can likely only be applied to a small portion of the entire rock face, perhaps those areas determined to have the highest risk of failure. Geologic engineering companies that can be consulted include Golder Associates, Landslide Technologies, and Shannon and Wilson, who do a lot of landslide work on the west coast. Given the existing site conditions and limitations, there will always be some risk of rock failure along the 1/4-mile long rock face.

A rock catchment area is typically provided along roadways at the toe of rock slopes along with hazard conditions to improve safety, but not eliminate it. In this area, the road is at the base of a vertical rock face and does not meet any road standards for rock fall catchment. For a rock face of this size, in order to contain 90 percent of the rock fall, a rock catchment ditch approximately 30 feet wide would be required. Without a rock catchment area, there is an extremely high risk of rocks falling onto the roadway, and as such, the road is unsafe and should be considered hazardous to travelers. Additionally, houses within 200 to 300 feet of the rock face are also in a hazard zone. Flying rock fragments created during a rock fall event could result in property damage or loss of life.

The proximity of this rock face to Stillwater County Road and residences represents a significant hazard to people and property. It should be noted, the rock face has always had a risk of failure and subsequent hazardous conditions. The risk of failure increases seasonally with the highest risk coming in the spring with heavy snow melt and spring rains. A seismic event (earthquake) is one of the highest risks for rock slides to occur along the rock face. It is our opinion the rock face is currently at a slightly higher risk of failure than it was one day before failure due to the visible seeps. When these seeps are no longer visible, then it is our opinion the risk of failure is basically the same as it was before the recent rock slide. Assuming some risk is acceptable, then it is our opinion the road can be cleared and opened when the visible seeps are no longer apparent.

The only way to eliminate these risks is to close or relocate the roadway. Closing the roadway would force residents west of the failure area to take an alternate route, while relocating the road would require building two bridges and a new section of County road. Residents living in the area should be informed of the risk of rock slides and the hazardous condition they create. We recommend "rock fall" signage be placed along the road to warn the public of the risk. Great West Engineering can assist in determining the proper signage.

General

Thank you for using SK Geotechnical.

Sincerely,



Brett M. Warren, PE
Geotechnical Engineer



Gregory T. Staffileno, PE
Reviewing Engineer

Attachments:
Sketches (2)

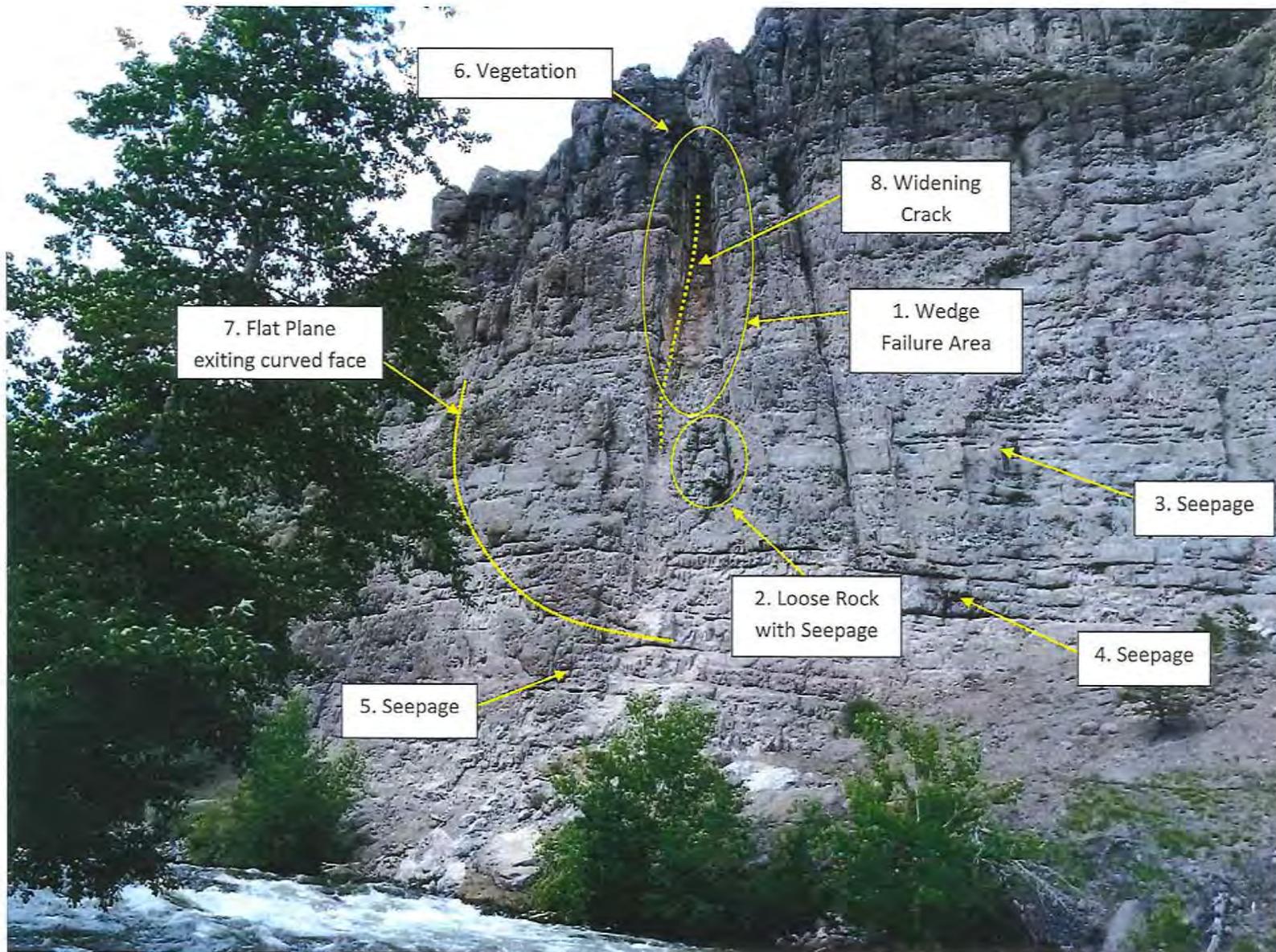


Figure 1

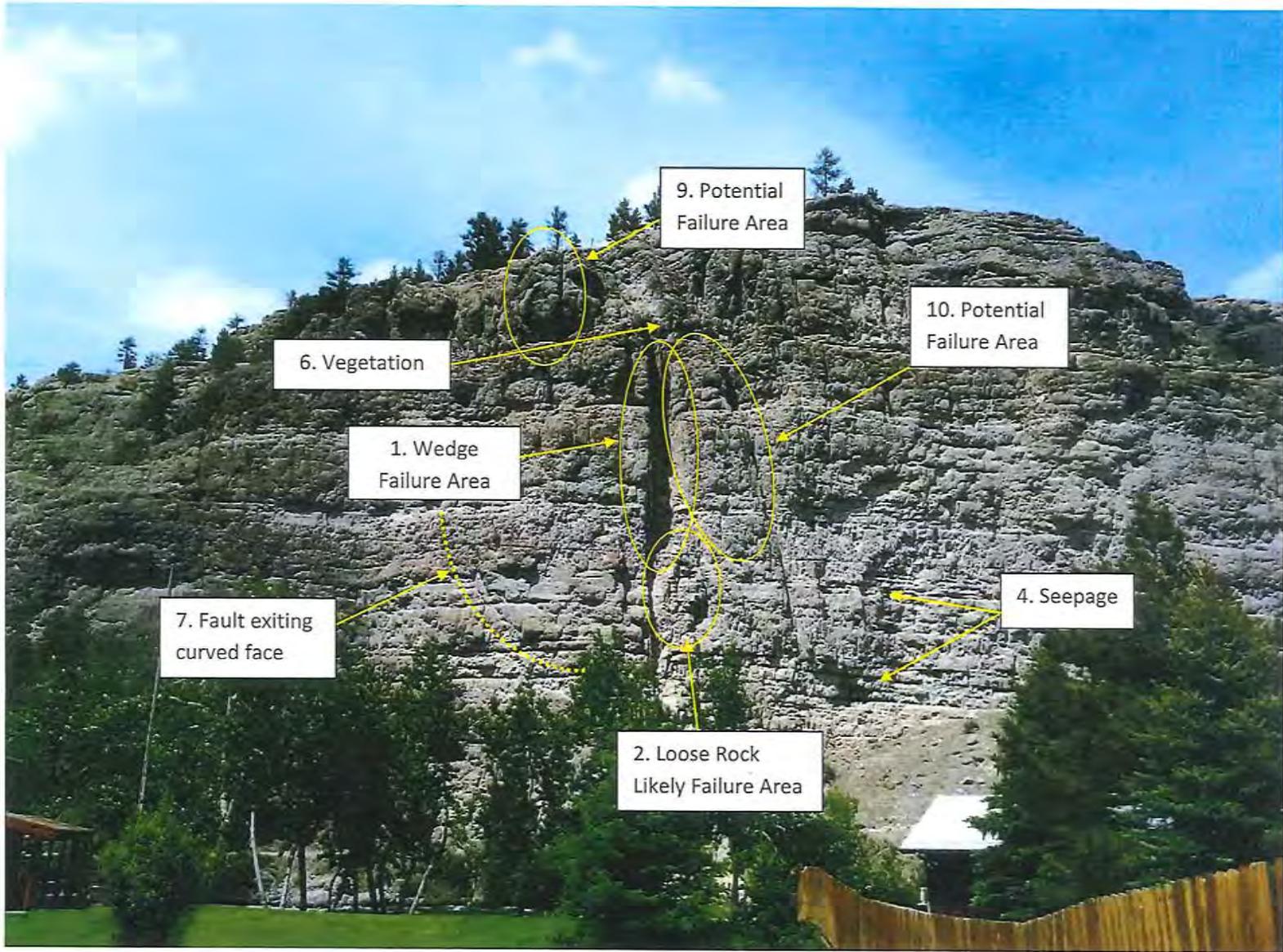


Figure 2