**GeoStabilization International**

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July 13, 2015

Ms. Cassie Riggin, P.E.
Great West Engineering
115 North Broadway, Suite 500
Billings, Montana 59101

**Subject: Preliminary Proposal for Rockfall Remediation along Stillwater River Road, Stillwater County, Montana**

Dear Ms. Riggin:

GeoStabilization International (GSI®) is pleased to offer this preliminary proposal to perform rockfall remediation services along Stillwater River Road approximately 20 miles west of Absorokee, Montana. GSI conducted a site reconnaissance with you and Mark Shreiner of Stillwater County on June 26, 2015. We have also reviewed the geotechnical reconnaissance report prepared by SK Geotechnical on June 15, 2015.

## Scope of Work

The GSI rockfall group analyzed the data obtained during our reconnaissance as well as information provided in the SK Geotechnical report. The most critical portion of the slope is approximately ¼ mile long, and can be separated into two remediation plans. An approximate 200 lineal foot portion of the slope contains significant, immediate rockfall hazards that should be mitigated by rock scaling. This is the portion that had the recent rockfall event and presents the largest threat to the travelling public and homes across the river. A temporary rockfall ring net catchment system will be employed to mitigate rock debris deposition into the river; however, an environmental, hydrological, and/or biological assessment of material deposition in the river should be completed.

A flexibile rockfall barrier, installed at the base of the lower angle slopes on either side of the scaled portion, is recommend for the remaining ¼ mile. This section is considered less critical and should be looked at as lower priority than the scaling operation. The flexible rockfall barrier will arrest larger rockfall events to prevent deposition on the road surface or within the Stillwater River.

It is further recommended that the rockfall remediation budget contain an allowance for rock dowel/bolt installation. The rock dowels/bolts are installed to anchor rock formations that can not be removed safely with scaling techniques, but are too large to be arrested by the flexible rock

barrier. The dowels/anchors would be installed as needed during the scaling operation and the budget may or may not be fully required.

## Cost

**The cost outlined in following table are estimated quantities for budgetary purposes. We anticipate the actual scope of work will be established through additional collaboration with Stillwater County and Great West Engineering.**

| Description | Est. Qty | Unit | Unit Price | Total |
|---|---|---|---|---|
| Mobilization | 1 | LS | $20,632.43 | $20,632.43 |
| Scaling | 15 | Days | $21,470.70 | $322,060.50 |
| Rock Bolt/Dowels* | 30 | EA | $5,161.00 | $154,830.00 |
| Flexible Rockfall Barrier** | 1,300 | Feet | $768.89 | $999,557.00 |

*Estimated allowance for budget and would be charge per unit rate on actual quantity.
**Lower priority item to be considered for future work.

## Schedule

GSI can have the scaling crew on site within 3 weeks of receiving the notice to proceed. An exact schedule would be determined after additional collaboration with Stillwater County and Great West Engineering.

**GSI Includes or Excludes the Following Items as Indicated**

| | Exclude | Include | | Exclude | Include |
|---|---|---|---|---|---|
| Manual Scaling | ☐ | ☒ | Construction Permits, if required | ☒ | ☐ |
| Rock Bolt Installation | ☒ | ☒ | Flexible Rockfall Barrier | ☐ | ☒ |
| One Mobilization | ☐ | ☒ | Hauling of Scaled Materials | ☒ | ☐ |
| Traffic Control | ☒ | ☐ | Construction Surveying, if required | ☒ | ☐ |

- The work is assumed to progress as one continuous operation.
- Any retainage is to be released 30-days after the completion of GSI's work.
- Reasonable access to Work area will be provided to GSI at all times during construction for equipment and materials delivery.
- All work will be based on a work schedule of Monday through Saturday, 10 hours per day as daylight and safety permits.
- All invoices are due, in their entirety, upon receipt. Amounts due and unpaid over thirty days shall accrue interest at the rate of 1.5% per month. Owner shall be liable for all costs of collecting amounts due and unpaid, including reasonable attorney's fees.
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This preliminary proposal is contingent on the site not changing significantly prior to our mobilization. If significant change occurs we should be contacted to potentially modify the scope of this proposal.

This offer expires 30 days from the date transmitted. GeoStabilization International is confident that we can construct a quality stabilization system in an efficient manner. This proposal is conditional upon entering a mutually acceptable contract between GSI and the Stillwater County.

Sincerely,
**GeoStabilization International**

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June 15, 2015

Project 15-3359G

Ms. Cassie Riggin, PE
Great West Engineering

Dear Ms. Riggin:

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 Riggin, 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)

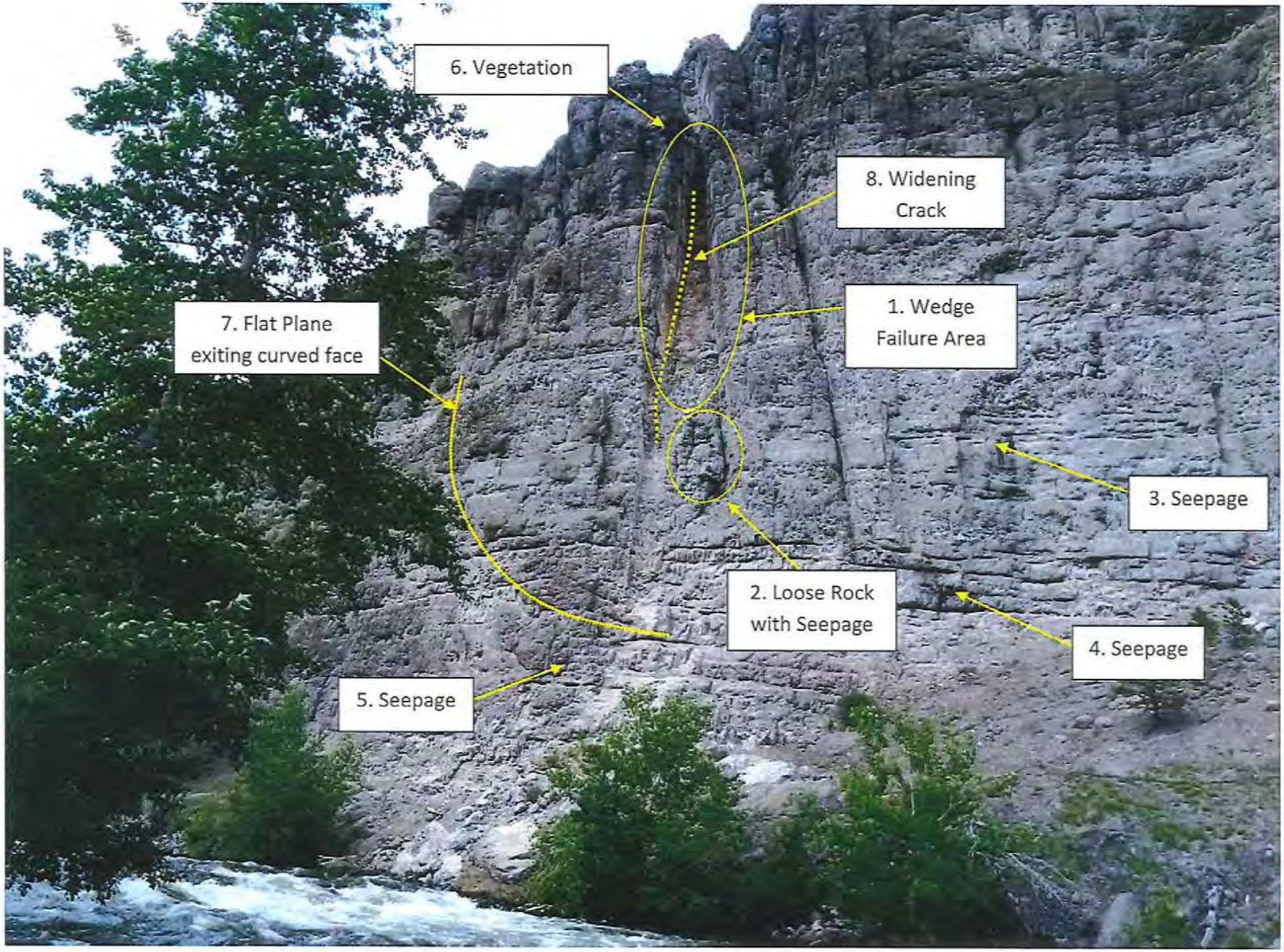
6. Vegetation
8. Widening Crack
1. Wedge Failure Area
7. Flat Plane exiting curved face
3. Seepage
2. Loose Rock with Seepage
4. Seepage
5. Seepage

Figure 1

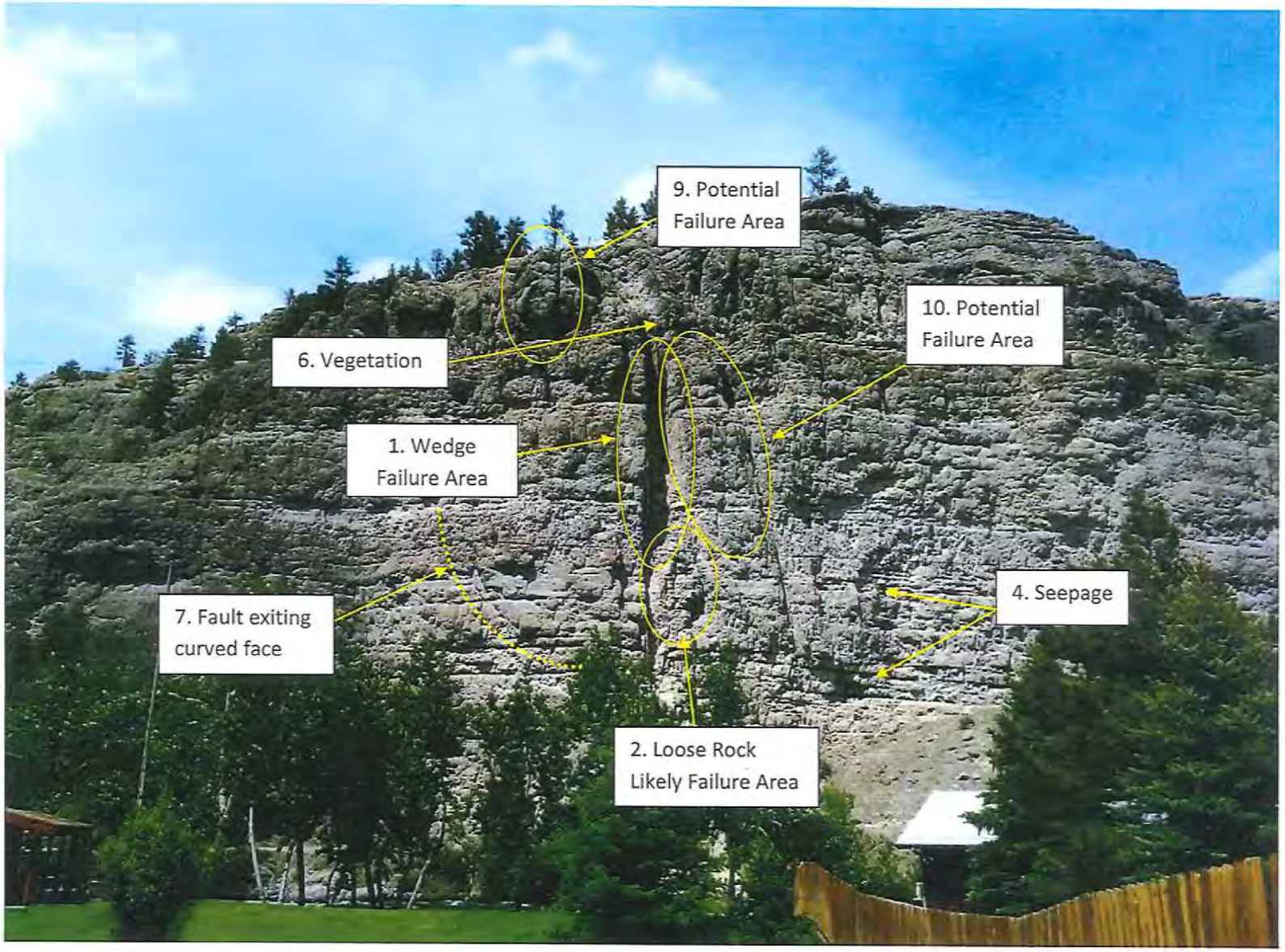
9. Potential Failure Area
10. Potential Failure Area
6. Vegetation
1. Wedge Failure Area
4. Seepage
7. Fault exiting curved face
2. Loose Rock Likely Failure Area

Figure 2