

Site 2 – Barrier Bluffs Rock Slope

This site is located on the east shore of Barrier Lake where the Highway 40 alignment is along the lowermost slopes of Mount Baldy. As shown on Photo 1, the highway is located adjacent to the toe of a large colluvium slope below a near-vertical rock slope known as Barrier Bluffs. The estimated total vertical height of the slope above the highway is 120 m. The colluvium slope angle is around 35°. The inclination of the upper rock slope angle could not be measured directly and was estimated from the highway to be around 75°. The majority of the colluvium slope was treed, however there was one area where an unvegetated colluvium slope extended down to the highway ditch (Photo 1).

There is a hazard of rockfall debris from the upper rock slope rolling down the unvegetated colluvium slope and impacting upon the highway. As shown in Photos 2 and 3, there were a number of large boulders in the ditch in this area that had rolled out beyond the toe of the colluvium slope and come to rest in the ditch adjacent to the highway. The width of the ditch (as measured between the toe of the colluvium slope and the east edge of the pavement) varied with a minimum of approximately 10 m. The depth of the ditch (relative to the pavement surface) was typically 3 to 4 m.

A schematic cross-section of the slope above the highway is shown on Figure E1. This cross-section is based on field measurements made from the highway and along the toe of the colluvium slope as well as data from topographic maps. A minimum “rockfall shadow” angle of 27.5° – defined in Evans and Hungr (1993) as useful for the preliminary estimation of maximum rockfall reach – has been plotted on Figure E1 and shows that the highway could potentially be impacted by rockfall originating from above the colluvium slope. The actual run-out distances of such rockfalls are a function of their source point, the amount of kinetic energy retained by the rocks as they roll down the colluvium slope (including the effects of the rocks breaking apart into smaller pieces), and the ability of the existing ditch to contain rocks that roll out beyond the toe of the colluvium slope. The ditch at the toe of the colluvium slope has a considerable capacity to contain rocks that roll downslope and beyond the toe of the colluvium slope. Based on the observations during the site inspection, it is judged that a minimum “rockfall shadow” angle of 27.5° is likely conservative for this site, and the majority of rockfalls will not roll out beyond the toe of the colluvium slope. However, such a hazard cannot be completely ruled out on the basis of the available information. The risk to the highway from such a rockfall hazard is also a function of how many such rockfalls occur, for which there is essentially no data beyond a judgemental correlation with the number of large rocks noted to have rolled out beyond the toe of the colluvium slope.

AMEC recommends the following Risk Level factors for this site using the rock fall frequency-severity matrix:

- Probability Factor of 6 based on the appearance of the colluvium slope and upper rock slope that shows that boulders have rolled out beyond the toe of the

colluvium slope on at least one occasion since the current alignment of the highway was constructed, i.e. in the order of once a decade or slightly more often.

- Consequence Factor of 4 based on the possibility of a “worst case” rockfall, e.g. a large boulder falling from near the crest of the upper rock slope, rolling out beyond the toe of the colluvium slope and being deposited on the highway.

Therefore, the recommended Risk Level for this site is 24. It is likely that the Consequence Factor listed above is conservative and could be closer to 1, however recommending a lower Consequence Factor based on the currently-available information is not defensible for the following reasons:

- The visual evidence of at least two large boulders rolling out beyond the toe of the colluvium slope and into the ditch.
- A preliminary estimation of the maximum rockfall reach from the application of the minimum “rockfall shadow” angle of 27.5° to the estimated slope profile.

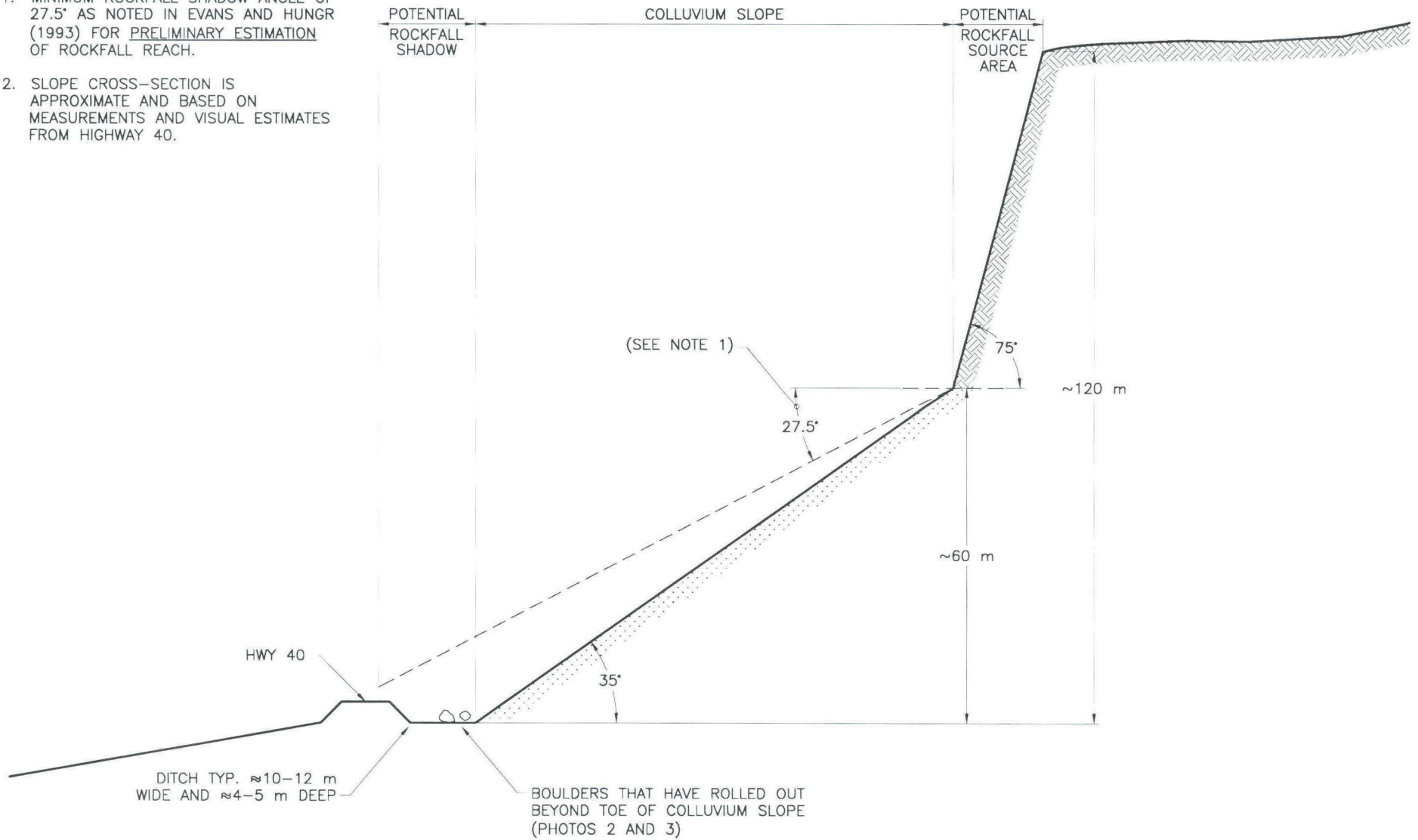
The Risk Level can be clarified, and likely lowered, with the following additional work:

1. Plotting the minimum rockfall shadow angle of 27.5° on a surveyed slope profile to check of whether or not the highway lies within the potential rockfall shadow of this slope. This will affect the recommended Consequence Factor for this site. A survey of the slope profile using AIT’s proposed Thales “Mobilemapper” handheld GPS unit would likely be suitable for this purpose.
2. Noting and documenting any boulders that roll out beyond the toe of the colluvium slope in future years. This data can be used to clarify the Probability Factor for this site. Visual checks by personnel working for the maintenance contractor would be suitable provided there is a procedure in place to contact AIT geotechnical personnel for follow-up inspection when appropriate.

If further work is judged to be necessary to clarify the risk level, then a further literature review regarding rockfall runout distance estimation and comparison to case histories of similar situations would be appropriate.

NOTES:

- 1. MINIMUM ROCKFALL SHADOW ANGLE OF 27.5° AS NOTED IN EVANS AND HUNGR (1993) FOR PRELIMINARY ESTIMATION OF ROCKFALL REACH.
- 2. SLOPE CROSS-SECTION IS APPROXIMATE AND BASED ON MEASUREMENTS AND VISUAL ESTIMATES FROM HIGHWAY 40.



	PROJECT: HWY 40/HWY 541 GEOHAZARDS REVIEW			
	TITLE: SCHEMATIC CROSS-SECTION BARRIER BLUFFS ROCK SLOPE			
CLIENT:		DATE: DECEMBER 2005	JOB No.: CG25211	CAD FILE: 25211N01.dwg
			FIGURE No.: FIGURE E1	REV. A

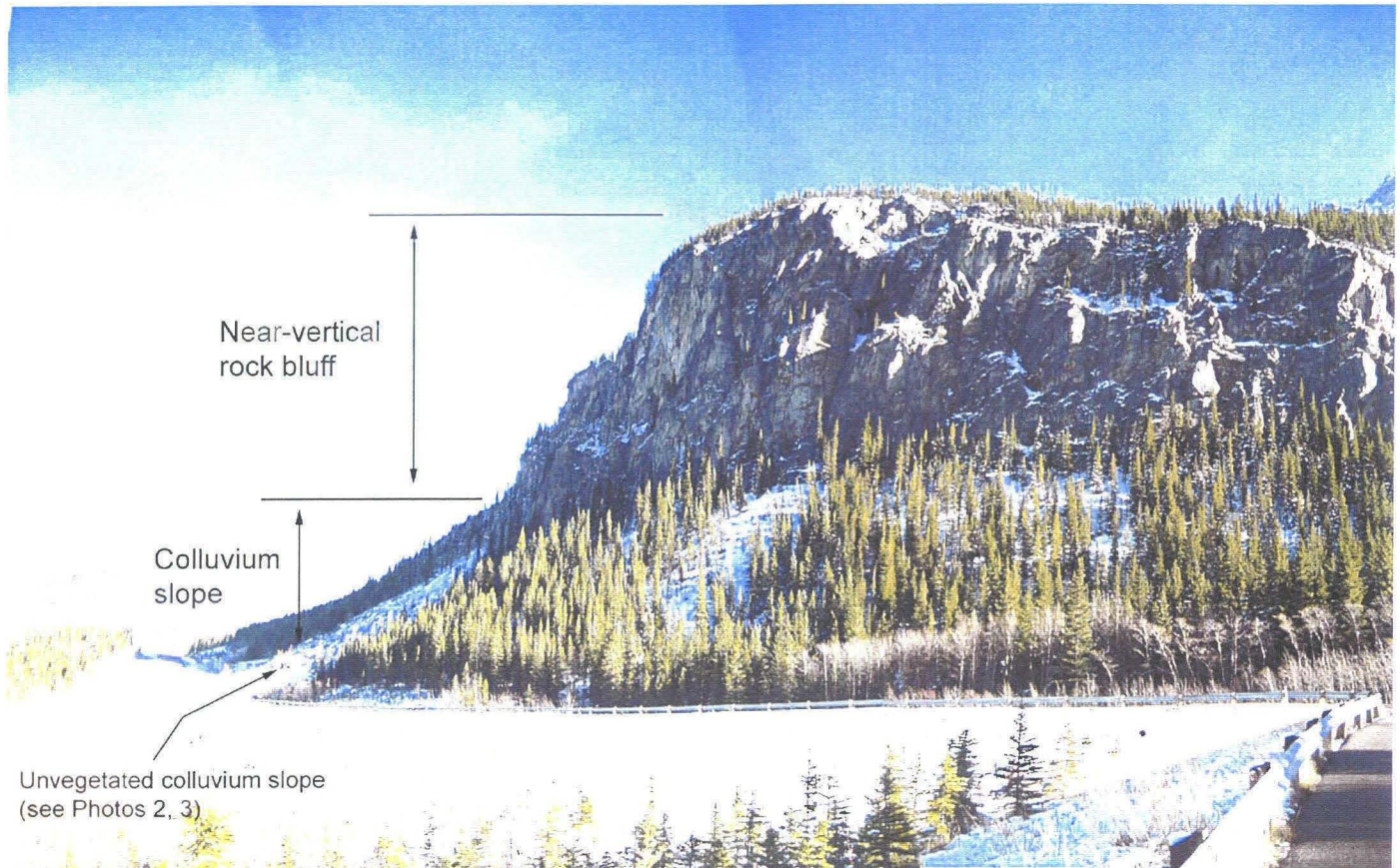


Photo 1 (top) – The Barrier Bluffs rock slope above Highway 40. The highway is located adjacent to the toe of a colluvium slope below a near-vertical rock slope. The colluvium slope is at an angle of around 35°. The ditch between the highway and the toe of the colluvium has a minimum width of approximately 10 m and a depth of approximately 3 to 4 m relative to the road surface.



Photo 2 (bottom) – Closer view of the ditch along the toe of the colluvium slope without trees showing the minimum 10 m offset from the edge of the highway. Note the large boulders that have rolled slightly beyond the toe of the colluvium slope.



Photo 3 (top) – Large boulder that has rolled beyond the toe of the colluvium slope and come to rest in the central portion of the ditch along the highway.